The diversity, intercorrelation, and macroevolutionary consequences of insect life histories

Adam Thomas Bakewell

Doctor of Philosophy

Biology
University of York

September 2020

Abstract

The life history of an organism describes its pattern of growth, reproduction, and survival, and thus is closely linked to fitness. Between species, life history traits vary widely and one of the major goals of life history theory is to explain how natural selection gives rise to this variation. However, there has been a lack of comparative life history studies focussing on insects, which comprise over half of the currently described macroscopic species. I conduct a class-level analysis of insect life history traits, and explore the associations between life history strategies, ecology, metamorphosis, and macroevolutionary processes.

In Orthoptera (grasshoppers, crickets and kin), I identify mostly 'fast-slow' variation in life history traits, except that larger (and otherwise 'slower') species have smaller, not larger, clutches of eggs. I find that this type of variation is closer to that of reptiles than that of either mammals or birds and discuss potential reasons for this similarity.

Across the whole of the insects, I find that the primary axes of life history variation are related to a) amount of reproductive investment, and b) how this investment is divided into clutches. Further orthogonal axes contain variables related to development time, then adult lifespan. I show associations between life histories and diet (parasitoids and ecto-parasitoids are particularly fast-lived), metamorphosis (ametabolous species have longer lifespans), but not habitat (no difference between aquatic and terrestrial species).

Finally, I find links between life history traits and diversification. Species richness is higher in orders and families with fast development times, and higher in families with high fecundity. Diversification rates are higher in families with high fecundity and those with short egg stages.

Together, my work raises questions about the generality of widely invoked patterns of life history covariation and highlights the need to test these patterns in a taxonomically broad sense.

Table of contents

List of figures vi

List of tables vii

1 General introduction 1

1.1 Life history theory 2

1.1.1 Demography 3

1.1.2 Trade-offs 5

1.1.3 Lineage specific effects 7

1.2 Empirical generalisations of life history theory 9

1.3 Insect life histories 11

1.3.1 Development 12

1.3.2 Reproduction 14

1.4 Correlates of life history strategies 16

1.5 The role of life history traits in diversification 17

1.6 Thesis outline 21

2 Life histories of Orthoptera, and comparisons with vertebrates 22

2.1 Abstract 23

2.2 Introduction 24

2.3 Methods 28

2.3.1 Orthoptera data collection and imputation 28

2.3.2 Phylogenetic PCA of Orthoptera 30

2.3.3 Analyses across taxonomic groups 32

2.4 Results 33

2.4.1 The ‘fast-slow continuum’ hypothesis in Orthoptera 33

2.4.2 The ’fast-slow continuum’ across taxonomic groups 36

2.5 Discussion 40

3 Life histories of insects, and effects of ecology and metamorphosis 47

3.1 Abstract 48

3.2 Introduction 49
3.3 Methods 53
3.3.1 Data collection and imputation 53
3.3.2 Data analysis 57
3.4 Results 59
3.5 Discussion 71

4 Effect of life history traits on diversification in insects 77
4.1 Abstract 78
4.2 Introduction 79
4.3 Methods 83
4.3.1 Data collection 83
4.3.2 Data analysis 85
4.4 Results 86
4.4.1 Species richness 86
4.4.2 Diversification rate 92
4.5 Discussion 94

5 General Discussion 98
5.1 Orthopteran life history covariation & differences with vertebrates 100
5.2 Insect life history covariation: associations with ecology & metamorphosis 104
5.3 Impact of life history traits on diversification 108
5.4 Overall strengths and weaknesses 111
5.5 Further work 115
5.6 Conclusions 118

References 120

Appendix A Supporting information for Chapter 2 137
A.1 Supplementary methods 137
A.1.1 Selecting an evolutionary model 137
A.1.2 Data collection 138
A.1.3 Phylogeny 141
A.1.4 Calculating variance explained across taxonomic groups . . 141
A.2 Supplementary results 143

Appendix B Supporting information for Chapter 3 149
B.1 Supplementary methods 149
B.1.1 Constructing species-level insect phylogeny 149
B.2 Supplementary results 152

Appendix C Supporting information for Chapter 4 **164**
C.1 Supplementary results 164
C.1.1 Order level analyses 165
C.1.2 Family level analyses 171

Appendix D Dataset of insect life history traits **177**
D.1 Data 177
D.2 Dataset References 315

List of figures

1.1 The Lack clutch 7

2.1 Orthoptera life history biplot 35
2.2 Distribution of taxonomic groups along the major life history axis 37
2.3 Biplot placing vertebrate groups into orthopteran life history space 39

3.1 PGLS models of effect of order on position on life history axes . . 65
3.2 PGLS models of effect of metamorphosis on life history axes . . . 67
3.3 PGLS models of effect of habitat on life history axes 68
3.4 PGLS models of effect of larval diet on life history axes 69
3.5 PGLS models of effect of adult diet on life history axes 70

4.1 Family richness plotted against fecundity/development time . . . 93

A.1 Distance-clustering dendrogram of orthopteran PCA loadings with varying levels of imputation 146

B.1 Distance-clustering dendrogram of insect PCA loadings with varing levels of impuation 155

List of tables

2.1 Relationship between body length and life history traits in Orthoptera 34
2.2 Phylogenetic PCA of orthopteran life history data 34
2.3 Comparing life history covariation between orthopterans and vertebrates 38

3.1 Definitions of the diet categories used in this study, based on Rainford and Mayhew (2015). 56
3.2 Covariation between life history traits in insects 61
3.3 Covariation between size corrected life history traits in insects . . . 62
3.4 Phylogenetic PCA of insect life history data 63
3.5 Phylogenetic PCA of hemi-/holometabolous insect life history data 66

4.1 Order richness and life history traits 88
4.2 Family richness and life history traits 90

A.1 Testing alternative evolutionary models 139
A.2 Phylogenetic PCA of orthopterans, with varying levels of imputation 143
A.3 Phylogenetic PCA of vertebrates and orthopterans, with varying levels of imputation 147
A.4 Comparing life history covariation between orthopterans and vertebrates, with varying levels of impuation 148

B.1 Origination dates of insect orders according to different phylogenies 151
B.2 Phylogenetic PCA of insects, with varying levels of imputation . . 152
B.3 Cluster means of insect PCA axes 156
B.4 Phylogenetic PCA of insects, resampled with fewer orthopterans and hymenopterans 157
B.5 PGLS models of effect of order on life history axes 158
B.6 PGLS models of effect of metamorphosis on life history axes . . . 161
B.7 PGLS models of effect of habitat media on life history axes 161
B.8 PGLS models of effect of larval diet on life history axes 162
B.9 PGLS models of effect of adult diet on life history axes 163

C.1 Order diversification rate ($\epsilon = 0$) and life history traits 165
C.2 Order diversification rate ($\epsilon = 0.5$) and life history traits 167
C.3 Order diversification rate ($\epsilon = 0.9$) and life history traits 169
C.4 Family diversification rate ($\epsilon = 0$) and life history traits 171
C.5 Family diversification rate ($\epsilon = 0.5$) and life history traits 173
C.6 Family diversification rate ($\epsilon = 0.9$) and life history traits 175

D.1 Dataset of insect life history traits 178

Declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References.

This thesis involved collaboration with Peter Mayhew (PJM), Katie Davis (KED), Nick Isaac (NJBI) and Rob Freckleton (RPF).

Chapter 2

This chapter has been published as:

Bakewell, A. T., K. E. Davis, N. J. B. Isaac, R. P. Freckleton, & P. J. Mayhew, 2020. Comparing life histories across taxonomic groups in multiple dimensions: how mammal-like are insects? *The American Naturalist*, **195**: 70–81.

This chapter is reproduced in full in this thesis, with minor changes to the text and formatting. ATB., PJM, RPF, and NJBI designed the study; ATB designed the data-collection protocols, collected the data, and conducted the analyses; KED created the expanded orthopteran phylogeny; ATB wrote the manuscript; and all authors revised the manuscript; PJM supervised all stages of the research.

Adam Thomas Bakewell
September 2020

Acknowledgements

Thanks are due firstly to my main supervisor, Dr Peter Mayhew. I feel very fortunate that I shared this experience with a supervisor who is as enthusiastic, knowledgeable, and caring as Peter, and without his support completing my PhD would have been a much less rewarding and enjoyable process. I would also like to thank my two co-supervisors, Professor Rob Freckleton and Dr Nick Isaac, for informative discussions about the methodology of the project and being a friendly face in large conference halls. In addition, I am grateful to the members of my Thesis Advisory Panel, Dr Elva Robinson, Dr Dan Franks, and Dr Colin Beale, whose comments, ideas and discussions throughout my PhD.

I was also lucky to work with Dr Katie Davis, who provided the Orthoptera supertree used for analyses in Chapter 2. Katie has been an invaluable source for any and all phylogeny construction questions that I have had throughout my PhD. I would also like to thank the undergraduate project students who contributed data for my project for their hard work: Anna Middlemiss, Lucy Cross, Abi Enston and Josh Churchman.

I also owe an enormous debt of gratitude to Dr Isabella Capellini, who was my undergraduate dissertation and MSc by Research supervisor. Her patience and incisive critiques helped me to become a better scientist, and her support and encouragement in applying to PhDs is a big part of what got me to York in the first place.

I wish to thank the members of the J2 lab, who helped to make my time in York so enjoyable. Katie, who lived with me for these past three years with surprsingly few complaints, deserves a particular mention. I want to thank my family – Mum, Nan, Charlotte, Joe, and Freya – and friends – Ben, Harvey, Jay, Laura, and Sara – for always believing in me and encouraging me to aim high. Thanks again to my sister, Charlotte, and my friend, Sara, who proof read the final version of my thesis.

Chapter 1

General introduction

The female burrowing mayfly, *Dolania americana*, spends only five minutes in its adult stage (Sweeney and Vanote, 1982); whereas the queen of a colony of *Lasius niger* ants can live for 20-30 years (Kutter and Stumper, 1969). The entire life cycle of the mosquito *Psorophora confinnis*, from egg to egg, lasts only a week (Azawi and Chew, 1959); whereas periodical cicadas, such as *Magicicada septendecium*, emerge and reproduce once every seventeen years (Simon, 1988). Evolution by natural selection has shaped these life histories: each is a combination of rates of development, reproduction and survival optimized to maximize fitness (Stearns, 1992). The examples mentioned above illustrate the vast array of possible combinations of fitness-linked traits that have evolved in the insects.

Insects constitute more than half of the described fauna of Earth (Roskov et al., 2019) and show correspondingly huge variation in their life histories. They dominate terrestrial ecosystems in terms of biomass and play crucial roles within them – cycling nutrients, pollinating plants and dispersing their seeds, maintaining soil structure and fertility, controlling populations of other organisms, and acting as a food source for a diverse range of predators (Scudder, 2009). Despite this, their range of life history strategies is poorly understood at a comparative level. The aim of this thesis is to describe how life history traits are associated across the insects, evaluate to what extent this is consistent with different life history theories, and to identify what the macroevolutionary consequences of life history variation may be. In this introduction, a primer on life history theory will be presented. This is followed by an introduction to insect life histories, the major divisions within insects according to development type, and the range of reproductive strategies that require explaining as variations of general life history strategies. Finally, the importance of life history data in generating diverse macroevolutionary hypotheses is explained and exemplified.

1.1 Life history theory

Life history theory attempts to explain how natural selection has shaped the broad features of an organism's life cycle to optimise fitness given ecological conditions. Explaining the enormous variation in life cycles across the tree of life remains one of the major goals of evolutionary ecology (Roff, 2002). The life history of a species can be summarised using quantifiable life history traits, including: size at birth; growth pattern; age and size at maturity; number, size, and sex ratio of offspring; age- and size-specific reproductive and mortality schedules; and length of life (Stearns, 1992).

For natural selection to occur there must be heritable variation in the genotype, which results in variation in fitness of the phenotype (Braendle et al., 2011). Critically, the same genotype can differ in fitness under different conditions (Stearns, 1992). Life history theory can be used to predict phenotypes at equilibrium and ask how phenotypes are designed for survival and reproduction.

Life history evolution is difficult to understand because of the innumerable ways that organisms have combined investments into their life history traits to affect fitness. Indeed, Cole (1954) concluded that 'the number of theoretical combinations of life history phenomena must greatly exceed the number of known species of organisms'. However, not all combinations are possible. The life history traits are bound together by trade-offs, and investment into alternative traits is restricted by genetic, developmental, physiological and phylogenetic limits (Braendle et al., 2011). Furthermore, even fewer of the theoretically possible combinations will ever prove to be successful under selection because of, for example, competition between species, resource availability throughout the course of life cycles, or environmental stochasticity.

The enormous amount of variation and complexity in life histories can be understood using a framework built from three elements, explained over the course of this section: demography, trade-offs, and lineage-specific effects.

1.1.1 Demography

Demography is the statistical study of the size, structure and development of populations, and was originally developed to forecast human population growth (Nam, 1979). Classic questions in demography ask how changing life history traits, such as age at maturity, affect the population growth rate and thus total population size, and vice versa. By applying simplifying assumptions to demography – that age-specific birth and death rates remain constant – the consequence is that populations reach a stable-age distribution (i.e. the proportion of individuals in each age class remain the same) and then continue to grow at an exponential rate, *r*, which can be calculated by solving the Euler-Lotka equation:

$$1 = \int_{\alpha}^{\omega} e^{-rx} l_x m_x dx$$

Here α and ω represent the age at first and last reproduction, respectively, l_x is the probability of surviving from birth to age x, m_x is the expected number of offspring per female in age class x, and r is the instantaneous rate of natural increase (Brommer, 2000). By summing the probabilities of reproduction and survival across each age class for all individuals in the population, r can be calculated.

In the context of life history theory, the equations of demography can be reapplied to measure fitness instead of population growth rate (Charlesworth, 1994, Brommer, 2000). Small changes to a life history trait are created by the average effects of allele substitutions, which will also have effects on the other life history traits (Stearns, 1992). By modifying the parameters in the Euler-Lotka equation and observing the effects, one can calculate which substitutions will have the greatest effect on fitness (Brommer, 2000) – i.e., which allele substitutions have the highest rate of spreading through a population (highest r), and thus are most likely to become fixed (Charlesworth, 1994).

Some demographic models also try to maximise R_0, lifetime reproductive success (or the expected number of daughters produced by a female over her lifetime), which with discrete generations can be calculated as:

$$R_0 = \sum_{\alpha}^{\omega} l_x m_x$$

As R_0 is a per generation rate of increase the assumption is made that the time it takes to produce offspring does not matter, only how many offspring are produced. Effectively then, it is equivalent to assuming that r is zero or near-zero, as it would be in a stationary (non-growing) population (Brommer, 2000).

Using demography, the fitness of proposed combinations of life history traits can be calculated and one can ask how much fitness is affected when one of these traits is changed. The sensitivity of fitness to changes in life history traits can inform us about the strength of selection on them (Stearns, 1992).

1.1.2 Trade-offs

Physiological trade-offs are one of the key concepts of life history theory, they are the links between two or more life history traits which provide constraints to their evolution. Individuals must invest energy and resources competitivity into the various aspects of their life history – growth, maintenance, and reproduction – and therefore they cannot all be maximised at once. Thus, the apocryphal Darwinian demon, living forever and reproducing at an infinite rate, cannot exist in reality due to the presence of these trade-offs (Law, 1979). One of the goals of life history theory is to identify and understand these trade-offs, and establish, given the ecological circumstances, the best way to partition energy to the various components of life histories to increase fitness.

Some 45 trade-offs between life history traits were identified by Stearns (1989), including between reproduction and growth, current and future reproduction, and the number and size of offspring. Evidence for trade-offs comes from a number of different approaches.

Experimental manipulations of life history traits have been greatly influenced by the Lack (1947) hypothesis that clutch size should have evolved towards that which produces the most surviving offspring. The trade-off here involves investment into individual eggs and investment into the number of eggs. Given a fixed energetic budget for reproduction, increasing clutch size results in fewer resources allocated to each individual egg and therefore reduced fitness for each individual. The optimal clutch size is that where the summed fitness of the clutch is highest (Figure 1.1). The results of studies using experimental manipulation to test Lack's hypothesis are mixed, even within the bird lineage. As examples, Gustafsson and Sutherland (1988), in collared flycatchers (*Ficedula albicollis*), and Dijkstra et al. (1990), in kestrels (*Falco tinnunculus*), showed that increasing the number of eggs in a clutch increased the mortality rate of juveniles. These studies are consistent with Lack's theory, clutch size appears to have evolved to an optimum where increasing it results in lower fitness. However, other studies including Lessells (1986), using Canada geese (*Branta canadensis*), and Rohwer (1985), in blue winged teal (*Anas discors*), found no effect of increased clutch size on juvenile survival, or indeed the fledging weights of individual birds. Studies such of these demonstrate that, in at least some species, the realised clutch size is in fact lower than the optimum (as more individuals could have fledged). A commonly invoked explanation for clutch sizes below the optimum is another trade-off: that between current and future reproduction, which which was shown to be negatively impacted by increased clutch size in collard flycatchers (Gustafsson and Sutherland, 1988).

Insects are ideal for experiments involving the manipulation of life history traits because of their fast life cycles. Some of the best evidence for genetically based trade-offs comes from selection experiments in *Drosophila* (reviewed in: Stearns and Partridge, 2001, Flatt and Schmidt, 2009, Flatt, 2011). These experiments have repeatedly found evidence for: a positive correlation between body size and development time; a positive correlation between body size/development time with fecundity; a negative correlation between fecundity and adult lifespan; and a negative correlation between fecundity early and late in life. That said, some studies find contrasting results. For example, Mair et al. (2004) suppressed reproduction in some *D. melanogaster* females, observed the response of lifespan and age-specific mortality to a set of conditions (dietary restriction), and found that lifespans could be extended without a reduction in reproduction.

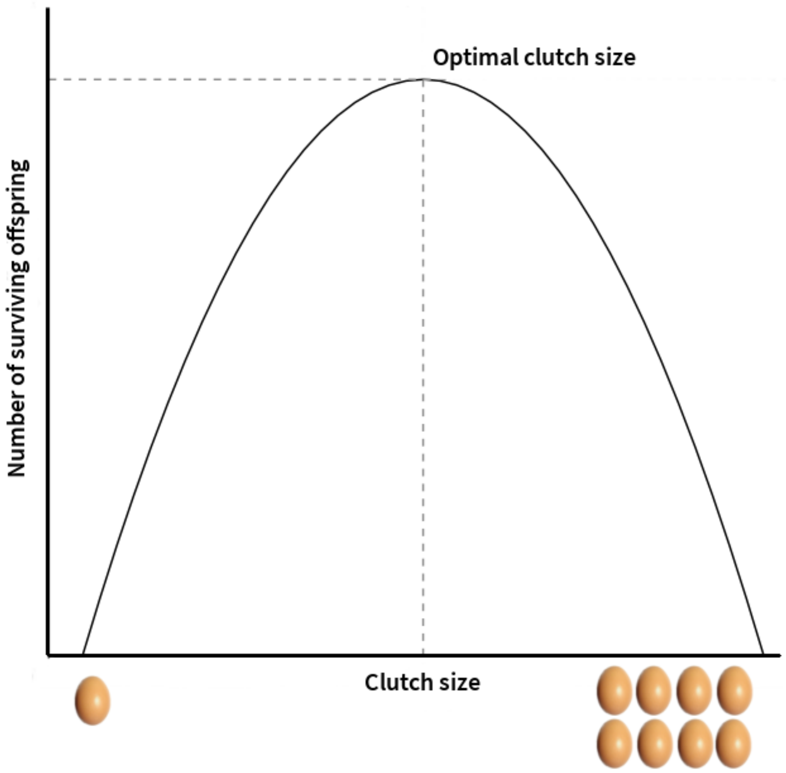


Fig. 1.1 The Lack clutch

Studies considering one organism can be useful for identifying trade-offs in life history traits, but they cannot evaluate the generality of these trade-offs as a common feature across taxa. For this an interspecific comparative approach, and an understanding of how lineage specific effects shape life histories, is required.

Investigations into single traits can identify how selective pressures affect each trait in turn. However, since life history traits are evolutionary correlated, all traits need to be considered simultaneously to build a full understanding of the life history of an organism. Approaches to this are discussed below (Section 1.2).

1.1.3 Lineage specific effects

Species are not independent of each other in many important ways. From a statistical point of view this can cause problems when attempting to identify trade-offs and constraints between life history traits. Evolution imparts a structure to comparative datasets; species are more similar to other species with which they have shared more of their evolutionary history with than they would be expected to be by chance. Phylogenies allow us to identify the relationships between species, and phylogenetic comparative methods allow us to use this information to control for ancestry in statistical models. At least some variance and covariance in species' observed phenotypes can usually be attributed to their phylogenetic relatedness, and once that portion of variance has been accounted for the remaining trait variation is the result of selection or other evolutionary processes that causes closely related species to be different from each other (Felsenstein, 1985, Harvey and Pagel, 1991). Crucially, one can find evidence for adaptation where the same trait has repeatedly evolved, independently, in different lineages under similar conditions (Harvey and Pagel, 1991).

Lineage specific effects are important features of life history evolution. Some traits are fixed at higher taxonomic levels (e.g. all mammals, except the monotremes which belong to their own subclass, are viviparous), removing the genetic variation on which natural selection can operate (Stearns, 1992). Moreover, the relationships between key life history traits, and how these relationships scale with body size, differs between higher taxonomic groups (Stearns, 1992). In order to understand how selection has optimised investment into life history traits to maximise fitness, one first has to understand the local (taxonomic) relationships between life history traits.

Insect life histories are yet to be analysed comprehensively at a comparative Class level. By looking for patterns of covariation in life history traits across multiple taxonomic levels within the insects, we will be able to identify both the general trade-offs and constraints and also understand how the different lineages have evolved their own methods of increasing reproductive success.

1.2 Empirical generalisations of life history theory

The theory of r-K selection was one of the earliest predictive models for life history evolution, and has been one of the most influential concepts in life history theory to date. Macarthur and Wilson (1967), imagining an island with abundant resources, deduced that individuals causing the greatest increase in population size should be selected for initially upon arrival. As the environment becomes occupied and the population approaches its carrying capacity, selection should focus on individuals who come out ahead in terms of intraspecific competition or that can outlive periods of scarce resources. These two groups of individuals they referred to as 'r-selected' and 'K-selected', respectively. The essence of r-K selection theory is density dependence. Pianka (1970) proposed that environments varied in the degree to which they imposed r- or K-selection pressures on organisms, and that because of this species should fall along a continuum from absolute r-selection to absolute K-selection. Pianka (1970) then considered which traits would be affected by density dependence and highlighted the life history traits. In r-selected species the goal of rapid increase in population size should lead to fast development, early reproduction, and high fecundity. The correlation of life history traits further means that they will also have small adult and offspring sizes, and short lives.

Over time r-K selection theory has come to be viewed as a naïve oversimplification of natural selection (Stearns, 1977). The focus on density dependence, lack of consideration for other factors which must also play a role in life history evolution – including environmental variability, and predation – led to the concept being largely abandoned in favour of new, demographics based paradigms focussing on age-specific mortality and reproductive rates, which provide a better causative link between the environment and life histories (Wilbur et al., 1974, Reznick et al., 2002). Despite their criticisms, r-K models continue to be updated and remain important in the development of ideas around life history evolution (Engen and Sæther, 2016, Lande et al., 2017).

The trait patterns predicted by r-K selection have been shown to be pervasive in comparative studies of life history traits. The term 'fast-slow continuum', thought to be originated by Sæther (1987), is now applied to those patterns. The life history traits of r-selected species and K-selected species would now instead be called 'fast' or 'slow' life history strategies, respectively. The idea of the 'fast-slow continuum' concept is that species can be arranged along an axis between those extremes; at one end (fast) species with high fecundity, short generation times, early reproduction, short lifespans, and small offspring and adult body size; and at the other (slow) end species with the opposite set of traits. Models of life history evolution explain this pattern through trade-offs and co-adaptations between the traits themselves and to mortality rates (Charnov, 1991, 1993, Harvey and Purvis, 1999, Kozłowski and Wiener, 1997, Promislow and Harvey, 1990), and often incorporate elements of metabolic scaling theory (Brown et al., 2004). For example, species with low mortality can live longer lives. They can then be selected to mature later and at a larger size, because larger size increases the energy available to allocate to reproduction as an adult. In mammals, offspring size increases with body size at a faster rate than reproductive potential, so the result is fewer, but larger, higher quality offspring (Charlesworth, 1994, Stearns, 1992).

Support for a 'fast-slow' continuum of life histories has been found using comparative studies in a number of higher taxa, including mammals (Oli, 2004, Bielby et al., 2007), birds (Sæther, 1987, Bennett and Owens, 2002), reptiles (Bauwens and Díaz-Uriarte, 1997, Clobert et al., 1998), fish (Beukhof et al., 2019), and vascular plants (Franco and Silvertown, 1996, Salguero-Gómez et al., 2016, Salguero-Gómez, 2017). That said, the exact nature of the 'fast-slow continuum', the traits which are significantly correlated and the amount of variance that these relationships explain in the data, appears to vary across taxonomic groups. The continuum is best exemplified by mammals, on which Charnov (1991) based his model, but even in mammals including additional dimensions (as opposed to a one dimensional continuum from slow to fast involving all life history traits) improves predictive power (Galliard et al., 1989). Bielby et al. (2007), in mammals, found that life histories were structured around two independent axes, one involving the timing of reproductive events, and another reflecting the balance between the number and size of offspring. Similarly, in vascular plants, Salguero-Gómez (2017) identified two axes of life history variation: one a 'fast-slow continuum', between fast-growing short-lived plants and their opposites; and the second a reproductive strategy axis, ranging from highly reproductive, iteroparous species at one extreme to poorly reproductive, semelparous species at the other.

There is a lack of understanding about the relevance of the 'fast-slow continuum' for invertebrates, particularly insects. Recent analyses at a very broad taxonomic level, the whole of animals, suggest that life history strategies can in general be explained by two axes – the 'fast-slow continuum', and a second related to age-specific mortality and the spread of reproductive events (Healy et al., 2019). However, just 8 of the 121 species included in this analysis were invertebrates, and none of them were insects. Considering the diversity, richness, and importance of insects, any study which seeks to describe animal life histories in general terms must surely first confirm these patterns in insects.

1.3 Insect life histories

At least 1,053,578 species of insects are known to science (Zhang, 2013), and though there is considerable debate about the number, recent estimates indicate that the true diversity is closer to 5.5 million (Stork, 2018). In line with this, insects exhibit tremendous variation in life history strategies. In this first section I will first introduce the broad development modes of insects and how they fit into life history theory, and then review some of the major innovations related to reproduction and their potential effects on life histories.

1.3.1 Development

Insects can, for the most part, be categorised into three groups based on their broad growth pattern. The ancestral condition is ametabolous development, today represented by Zygentoma (silverfish) and Archaeognatha (jumping bristletails). Ametabolous insects eclose from their eggs resembling miniature versions of their adult forms, but without functional genitalia (Resh and Cardé, 2009). Aside from growing larger and attaining reproductive maturity, individuals do not undergo dramatic changes in appearance or habits from moult to moult (Truman and Riddiford, 1999). Moulting continues throughout adult life in the ametabolous insects, which means that they can also continue to grow as adults.

Most insects, however, cease moulting once they reach adulthood, and so are mostly constrained in size to that attained at the final moult. The hemimetabolous insects hatch out of their eggs as small, wingless forms of the adults (called nymphs, or sometimes naïads for those with aquatic immature stages), and in most cases the habits and habitats of the adults and nymphs are shared or broadly similar. Wing buds typically can be seen from the first or second instar and then increase in size with subsequent moults until they are transformed into functional, articulated wings during the final moult into adulthood. Only one extant group of insects, the mayflies (order Ephemeroptera), moult after the development of functional wings. Mayfly nymphs develop in water, moult into a subimago and use their wings to reach shelter in vegetation before undertaking a final moult into the adult stage (the imago). Moulting is thought to halt once adult, winged forms are reached because wings are relatively large, delicate structures which could easily be damaged during ecdysis.

In contrast, the majority of insect species eclose from their eggs as larvae, which can be morphologically very different from their adult forms and lack any trace of external wings. Ninety per cent of insect species belong to the holometabolous orders, which constitute a monophyletic group (the Holometabola). Following the larval period, they undergo complete metamorphosis during a pupal stage where their larval bodies are broken down and reorganised into the adult form. Over an evolutionary timescale, such reorganisation has led to divergence between larvae, which are primarily adapted for feeding and growth, and the adults, primarily adapted for dispersal and reproduction.

There has been considerable debate over which of the immature stages of the holometabolous and hemimetabolous insects are homologous. Traditionally, the larva of holometabolous insects was thought to have arisen from the embryonic stage – i.e. that the larva represents a free-living, feeding embryo (or a "walking egg"). The nymphal stages, freed up from feeding and growth thanks to the larva, subsequently became reduced into a single instar specialised for reorganisation into the adult form. The other main hypothesis instead considers larvae as homologous to nymphs. This view states that during the evolution of the Holometabola disparity between the adult and immature forms became so pronounced that the pupal stage arose, either de novo or from the final nymphal stage, to bridge the gap. The second hypothesis has received much attention, but recent developments from embryology and developmental endocrinology have reasserted the traditional view (larva as homologous to embryonic stage). Truman and Riddiford (1999, 2019) specifically relate the larva to a crypic embryonic stage of hemimetabolous insects, the pronymph, which provided the precursor to the larva of the Holometabola.

It is likely that each of the three broad developmental categorisations (ametabolous, hemimetabolous, and holometabolous) impose a different set of constraints on the life history of organisms. Only the ametabolous insects, for example, are able to continue to grow after reaching maturity (they have indeterminate growth). Since fecundity often increases with body size, this growth could potentially increase reproductive output (Honěk, 1993). Since they have indeterminate growth the allocation of energy between growth and reproduction continues throughout adult life. In contrast the hemimetabolous and holometabolous insects are limited in size to that attained at reproductive maturity, and so adults stop investing in growth. Clearly these could be the basis for major differences in the organisation of life histories, although this has yet to be tested.

1.3.2 Reproduction

Even greater diversity exists in relation to the reproductive strategies of insects than to developmental ones, and many strategies appear to have evolved independently several times – providing the perfect conditions to test hypotheses about adaptations. Many insect species leave their eggs exposed, while a myriad of methods to protect them from desiccation, predators and parasites have evolved in other taxa (e.g. egg cases and pods, nests and brood-chambers, oviposition inside plant or animal tissues, live birth) (Gilbert and Manica, 2015). In life history theory, greater investment in each individual offspring is thought to trade-off with fecundity (Stearns, 1992, Braendle et al., 2011). Take for instance the tsetse fly *Glossina palpalis* (Diptera: Muscidae) in which a single larva develops inside the mother and is born ready to pupate virtually immediately (Krafsur and Ernst, 1983). This offers protection for the larvae and leads to high survivorship but comes at a cost of fecundity, as females can only produce between six and twelve larvae over the course of their life (Krafsur and Ernst, 1983).

In contrast, species with high juvenile mortality may produce many thousands of eggs over their lifetime. The ghost moth *Trictena atripalpis* (Lepidoptera: Hepialidae) is reported have a lifetime fecundity of over 30,000 eggs (Tindale, 1933). The females of this species oviposit while in flight, the eggs drop to the ground, and when they hatch larvae must make their own way to the roots of their host plant (Resh and Cardé, 2009). Their risky oviposition strategy means that juvenile mortality is high, which in turn puts strong selection on high fecundity (Stearns, 1992, Charlesworth, 1994).

Reproductive division of labour has also evolved several times in insects, specifically in all ants and termites, many species of bees, and some species of wasps, aphids and thrips (Nowak and Tarnita, 2010). Eusocial societies are headed by single egg-laying female, or a small number of egg-laying females (Keller, 1995). Other colony members provide food for her, care for the eggs, and take on the roles of foraging and nest defence (Thorne, 1997, Nowak and Tarnita, 2010). Eusocial insects have intensive care of offspring, but not by the mother, and over an evolutionary timescale this has led to queens with extreme specialisation in fecundity (Thorne, 1997). Queens of the driver ant *Dorylus wilverthi*, for example, can lay up to 4 million eggs every 25 days (Brueland, 1995).

In most cases, the parent determines the number of offspring that they produce – but some insects exhibit polyembryony. The best studied insects with obligate polyembryony are parasitoid wasps such as *Copidosoma floridanum*, but it also exists in Strepsiptera (Grbic et al., 1999). In *C. floridanum* the mother lays a single, yolkless egg into the egg of a lepidopteran host (Strand and Grbic, 1997, Grbic et al., 1999). The wasp uses the nutrients provided by the moth egg to develop and proliferate, with up to 2000 larvae forming from a single *Copsidosoma* egg (Strand and Grbic, 1997).

The examples introduced above illustrate the enormous variety in terms of insect reproduction strategies. The aim of this work is to understand how adaptations such as these evolved to increase fitness, and why different species and clades have evolved such different modes of life.

1.4 Correlates of life history strategies

Empirical generalisations of life histories are increasingly viewed as useful predictive tools. Once the major axes of variation in life histories have been identified, and phylogenetic effects are accounted for, species' positions relative to each other along these axes can predict other ecological and community traits. This is not surprising given the impact of life history on fitness and demography. The following section outlines some examples of where life histories have been used to predict other traits.

Extinction is, fundamentally, a demographic process, and therefore life history traits play an important role in determining which species face extinction (Morris and Doak, 2002). Using life history data to predict extinctions could be very useful in assigning conservation strategies to taxa – potentially providing conservation biologists with a tool to predict extinction long before it happens. In plants, the 'fast-slow continuum' and 'reproductive strategy' axes developed by Salguero-Gómez (2017) could together be successfully used to predict the IUCN threat level of species. They showed that increasingly 'slow' species along the 'fast-slow continuum' (i.e. lower reproduction and growth rate, and higher longevity) are associated with higher threat of extinction according to IUCN classifications.

Their reproductive strategy axis also explains threat level, with species towards the semelparous end of the spectrum having higher extinction risk.

Life history traits have also been used to predict invasion success in different taxa. Allen et al. (2017) demonstrated that fast life history traits promote invasion success in reptiles and amphibians. Capellini et al. (2015) find similar results for invasive mammals, where fast traits such as large litter size and frequent litters bias the introduction, establishment and spread of aliens. Salguero-Gómez (2017) also find complementary results in vascular plants, showing that the invasive plants usually have 'fast' life histories and high investment, iteroparous reproductive strategies. In contrast, successfully invasive alien birds are generally associated with 'slow' life history traits that prioritise future over current reproduction, such as small clutches and low brood value (Sol et al., 2012). Low brood value in successful aliens suggests a form of bet-hedging; reproductive effort is divided into many attempts each with low fitness consequences of failure.

Predicting the extinction and invasiveness of insect species by life history traits would be a major achievement. It is likely that insects follow the general pattern (those with slow life histories are at risk of extinction, those with fast life histories make better invaders), as most lack the long lifespans to make use of bet-hedging strategies across seasons or years like in birds. However, to understand which life history traits are important in predicting extinction and invasiveness, a large-scale comparative analysis is required.

1.5 The role of life history traits in diversification

If trait covariation follows a 'fast-slow' structure, then species with 'fast' life histories may have higher population growth rates and the ability to evolve at a faster rate (Marzluff and Dial, 1991). It follows that these species may speciate faster, or be more adaptable to changing environments and thus have lower extinction rates, which would lead to 'fast' clades having higher species richness than 'slow' clades. Isaac et al. (2005) showed that species richness was negatively correlated with gestation time in mammalian carnivores and positively correlated with litter size in marsupials. In both lineages the results fit with the life history model of diversification: relatively 'fast' clades are more species rich. One of the most pervasive questions in entomological research is: why are there so many species of insects? Life history theory may be able to help answer this question.

The diversification rate (i.e. the balance between speciation and extinction rates) of a clade over a period of time defines its species richness. Given this definition we would expect species to accumulate, and a high species richness to form, in clades with high speciation rates and (at least relative to the speciation rate) low extinction rates (Mayhew, 2007). But high speciation rates are not a prerequisite for high species richness, clades may persist with a low rate of speciation for a long period of time and accumulate high richness.

Hexapods are an ancient group; the true age of the clade is debated but molecular data indicate their origin to be 479 million years ago in the Early Ordovician (Misof et al., 2014). They were among the first animals to leave behind the marine realm and colonise terrestrial ecosystems; their proposed sister taxon the Remipedia are rare, blind crustaceans inhabiting coastal anchialine or marine cave systems (Neiber et al., 2011, Schwentner et al., 2017). All of the major extant insect lineages had appeared long before the angiosperm radiation of the Cretaceous (Misof et al., 2014). Over such a long timescale, even small differences in net diversification rates have the potential to create huge disparity in richness between lineages.

Indeed, McPeek and Brown (2007) showed that clade age, and not differences in diversification rate, is the principal determinant of species richness in animals. Their analysis compared diversification rates between three animal phyla: Arthropoda, Mollusca, and Chordata. Despite arthropods having 12.5 times more species than molluscs and 20 times more species than chordates (Roskov et al., 2019), their average diversification rates did not differ (McPeek and Brown, 2007). Nevertheless, a large amount of variation between clades of similar ages of course exists. For example, Lepidoptera (butterflies and moths) and Trichoptera (caddisflies) are sister clades but lepidopterans are an order of magnitude more diverse than trichopterans. Hemiptera (true bugs) and Thysanoptera (thrips) similarly share origins, and yet the diversity of thrips is more than twelve times less than that of hemipterans. Understanding why this should be the case is an important unanswered question in biology.

Though it is possible that the distribution of richness across the tree of life has originated mostly through chance alone (e.g. Raup et al., 1973, Ricklefs, 2003), it seems likely that that some lineages possess traits that facilitate their diversification (Cracraft, 1982). In insects, several hypotheses have been formally tested within a phylogenetic framework (as reviewed by Mayhew (2007, 2018)).

One major hypothesis suggests that the small size of insects (and other taxa) is responsible for their richness. Small size may promote richness because niches can be subdivided on a finer scale and have ultimately higher carrying capacities (Hutchinson and MacArthur, 1959). Clades with small taxa may be predisposed to higher levels of speciation, or may better able to withstand environmental perturbations, because short generation times and large population sizes confer a faster rate of evolution (see below; Purvis et al. 2003). However, Rainford et al. (2016) showed in a family level analysis that insect body sizes are not strongly skewed when on a log scale, and that diversification rate and body size are independent. This suggests that body size itself is not the main cause of species richness in insects, and at higher taxonomic levels there appears to be no consistent relationship between size and diversification rate (Orme et al., 2002). Much of the reasoning behind size–biased diversification relies on the relationships between body size and other life history traits, which are less well understood for insects and may not be in common with vertebrate groups (Klingensberg and Spence, 2003). Investigation is still required into if and how life history traits are related to diversification in insects (Mayhew, 2018).

The insects, through the course of their evolution, have developed several key innovations which may have driven diversification, including flight and the evolution of folding wings, parasitism, sociality, and metamorphosis (Mayhew, 2007). Rainford et al. (2016) found evidence for a substantial upshift in diversification following the evolution of metamorphosis, though the mechanism for this is still as yet unconfirmed. One idea is that metamorphosis allows evolution to optimise juvenile and adult life stages for distinct purposes (i.e. larvae primarily adapted to feed and grow, and adults primarily adapted to disperse and reproduce; Ebenman 1992). This may open up novel ecological niches, and so promote diversification (Yang 2001; Rainford et al. 2016). It is plausible, though, that the ultimate reason for high diversification in holometabolous lineages is that metaphophosis enabled a shift in the basic features of species' life histories, such as an increased rate of development or shorter generation times. This possibility remains largely unexplored in a formal sense.

Few insect life history traits, besides body size, have received attention in the context of their effects on diversification. Voltinism (or the number of generations per year) was found to be unrelated to species richness in dragonflies (Odonata; Misof 2002), despite short generation times increasing the rate of molecular evolution in invertebrates (Thomas et al., 2010). Similarly, while we might expect that high fecundity would facilitate diversification, Katzourakis et al. (2001) found no relationship between species richness and ovariole number in hoverflies (Diptera: Syphridae). The association between these traits and diversification has not been tested for the majority of insect taxa, and it is still unclear which life history traits are related to diversification in the insect lineage as a whole.

1.6 Thesis outline

This thesis addresses life history evolution of the insects. In Chapter 2 the ‘fast-slow continuum’ hypothesis is evaluated for orthopterans (grasshoppers, crickets, katydids, and kin) and the principal axes of life history variation are compared with those of well-studied vertebrate groups. In Chapter 3 the relationships between life history traits on the class level and below for insects are investigated, along with the associations between life history strategies, aspects of ecology, and type of metamorphosis. In Chapter 4 the life history hypothesis of diversification is evaluated in the insects. Finally, Chapter 5 presents a summary of the work and discusses future avenues for research in life history evolution given the results.

Chapter 2

Comparing life histories across taxonomic groups in multiple dimensions: how mammal-like are insects?

2.1 Abstract

Explaining variation in life histories remains a major challenge because they are multi-dimensional and there are many competing explanatory theories and paradigms. An influential concept in life history theory is the ‘fast-slow continuum’, exemplified by mammals. Determining the utility of such concepts across taxonomic groups requires comparison of the groups’ life histories in multidimensional space. Insects display enormous species richness and phenotypic diversity, but testing hypotheses like the ′fast-slow continuum′ has been inhibited by incomplete trait data. We use phylogenetic imputation to generate complete datasets of seven life history traits in orthopterans (grasshoppers and crickets) and examine the robustness of these imputations for our findings. Three phylogenetic principal components explain 83-96% of variation in these data. We find consistent evidence of an axis mostly following expectations of a ‘fast-slow continuum’, except that ‘slow’ species produce larger, not smaller, clutches of eggs. We show that the principal axes of variation in orthopterans and reptiles are mutually explanatory, as are those of mammals and birds. Essentially, trait covariation in Orthoptera, with ‘slow’ species producing larger clutches, is more reptile-like than mammal-or-bird-like. We conclude that the ′fast-slow continuum′ is less pronounced in Orthoptera than in birds and mammals, reducing the universal relevance of this pattern, and the theories that predict it.

2.2 Introduction

The life history of an organism describes the way it develops, reproduces, and its expected lifespan. Life histories represent much phenotypic diversity and are strongly related to ecology and organismal fitness, and so the explanation of life history variation has been one of the major challenges in ecology and evolutionary biology (Stearns, 1992, Charnov, 1993, Roff, 2002). A central tenet of life history theory is the operation of trade-offs between the various life history components; individuals must invest resources competitively into growth, maintenance and reproduction (Stearns, 1992, Braendle et al., 2011). One of the major aims of life history research is to understand how, given different ecological challenges, trade-offs in investment have formed patterns of covariation between life history traits (Stearns, 1992). Some 45 possible trade-offs among life history traits were listed in Stearns' (1992) influential book, and many more potentially exist. These include balances between investment in traits (e.g. current reproduction vs. survival, or parental growth), and investment within the same traits over time (e.g. current reproduction vs. future reproduction).

Over evolutionary time, selection should optimise investment into different life history traits to increase fitness. Many classical questions about life history variation focus on a single trait, such as clutch size (Lack, 1947), lifespan (Medawar, 1952), or frequency of reproductive events (Cole, 1954). However, it has also long been recognised that organismal life histories can be quantified in multiple dimensions, and that broad explanations of co-varying “suites" of traits may also be possible. Attempted explanations include r/K selection theory, which posits that variation in life history strategies is a consequence of density dependent vs. independent selection (Macarthur and Wilson, 1967, Pianka, 1970); ‘CSR’ theory in plants, which explains variation as adaptations to environments with combinations of either high or low levels of stress and disturbance leading to three extreme strategies (competitors, stress-tolerators and ruderals; Grime, 1977, Grime and Pierce, 2012); and Charnov's theory for mammals (details below) (Charnov, 1991, Harvey and Purvis, 1999). There is also a suite of "demographic models" which predict how the rate and timing of investment in reproduction responds to forces such as extrinsic mortality, resource availability, the form of population regulation, and stochasticity in vital rates (Stearns, 1992, Reznick et al., 2002).

Parallel with these explanatory paradigms and theories has been the development of empirical generalisations of life history co-variation, which describe how life history traits are expected to intercorrelate. Prominent amongst interspecific paradigms has been the 'fast-slow continuum', which suggests that species fall somewhere between: the 'fast' with high fecundity, short generation times, early reproduction, short lifespans, and small offspring and adult body sizes; and 'slow' species with the opposite suite of traits (Braendle et al., 2011, Stearns, 1983). The term 'fast-slow continuum' is thought to have first been coined by Sæther (1987). It largely replaced the term 'r/K selected' after r/K selection theory fell out of favour as an explanation of trait covariation, but where researchers still needed to refer to trait patterns predicted by that theory (Jeschke and Kokko, 2009). Some prominent models explain these patterns through trade-offs and co-adaptations between the traits themselves and to mortality rates (Charnov, 1991, 1993, Promislow and Harvey, 1990, Kozłowski and Wiener, 1997, Harvey and Purvis, 1999), often incorporating elements of metabolic scaling theory (Brown et al., 2004).

Support for the 'fast-slow continuum' has been reported in a variety of taxa, including mammals (Oli, 2004, Bielby et al., 2007), birds (Sæther, 1987, Bennett and Owens, 2002), reptiles (Bauwens and Díaz-Uriarte, 1997, Clobert et al., 1998) and vascular plants (Franco and Silvertown, 1996, Salguero-Gómez, 2017). Recently, studies have moved away from using single traits to represent speed of life history as they may not accurately represent a species' position on the 'fast-slow continuum’ (Bielby et al., 2007). Instead studies attempt to reduce dimensionality in large multivariate datasets, and find evidence for the ’fast-slow continuum’ if life history traits load strongly and in the expected direction onto a first principal component axis (Jeschke and Kokko, 2009).

Across taxonomic groups the ‘fast-slow continuum’ of life histories has been shown to vary considerably, with some traits not following the pattern expected from Stearns’ (1992) full continuum (e.g. Bauwens and Díaz-Uriarte, 1997, Jeschke and Kokko, 2009, Mayhew, 2016). The continuum is best exemplified by mammals on which Charnov (1991) based his model, though even for mammals variations of the continuum including additional dimensions show greater predictive power (Galliard et al., 1989, Bielby et al., 2007). Few studies have attempted to quantify to what extent different clades deviate from the idealised ‘fast-slow continuum’, or from each other. This lack of quantitative comparisons makes it difficult to understand the relevance to different taxa of theories based on mammalian trait covariation.

Compared with vertebrates and plants, there is a lack of understanding about the relevance of the ‘fast-slow continuum’ for invertebrates, particularly insects, which make up over half of all described species (Grimaldi and Engel, 2005). That said, the ‘fast-slow continuum’ has been shown to be general and versatile enough to explain variation in groups only distantly related to the mammals in which it was originally proposed. Much interspecific comparative work on insect life histories so far concentrated on finding relationships between pairs of traits: for example positive correlations between body size and fecundity (Honěk, 1993), and body size and longevity (Holm et al., 2016), or the trade-off between egg size and number (Berrigan, 1991). Some studies have addressed multiple traits in specific subtaxa of insects: Blackburn (1991a) described evidence of a ’fast-slow continuum’ in parasitoid Hymenoptera, although the set of patterns found was limited by comparison with vertebrate taxa (Mayhew, 2016). Specifically, some relationships predicted by the ‘fast-slow continuum’ - such as smaller eggs laid in high fecundity species - were upheld, but not others - such as the relationship between body size and lifespan (Blackburn, 1991a). The application of multivariate methods, such as PCA, was prevented by gaps in the data across species (Mayhew, 2016). Advances in phylogenetically-based imputation mean that it is now feasible to conduct multivariate analyses even with missing data (Goolsby et al., 2017).

Orthoptera (grasshoppers, katydids, crickets and their kin) are an ideal insect group on which to assess patterns of covariation between life history traits. They are the most diverse order of polyneopteran insects, containing over 22,500 species (Grimaldi and Engel, 2005). They have a worldwide distribution and are largely phytophagous, and are relatively well studied, both in life history and phylogeny, with some species considered important crop pests (Jago, 1998). They are hemimetabolous insects; they lack complete metamorphosis and instead have successive moults through nymphal stages which resemble the adult stage (Grimaldi and Engel, 2005). Orthopterans are diverse with respect to their life histories, for example spanning 4.5 orders of magnitude in body mass (Whitman, 2008). As in other insect groups, to date there has been no multivariate analysis of life history variation in Orthoptera.

Here we assess the extent to which orthopteran life histories follow a ’fast-slow continuum’ using a multivariate approach. We compile a dataset of life history traits for this ecologically important insect group and apply phylogenetic imputation techniques to compare the life histories of a broad taxonomic sample of species. We predict that if orthopterans exhibit a ‘fast-slow continuum’ then all traits will load onto a principal component with the following loadings: positive for body size, offspring size, development time, adult lifespan; negative for clutch size, clutch frequency, generations per year. We make direct comparisons between life history trait associations for Orthoptera and those from other taxonomic groups to quantify their similarity in multidimensional space. This allows us to visualise the extent to which life history theories devised around one taxonomic group might also be successful in explaining variation in other groups. Should the 'fast-slow continuum' be general to all organisms, then we should expect that across taxonomic groups the structure of variation (as indicated by dimensionality reduction techniques like PCA) should remain consistent.

2.3 Methods

2.3.1 Orthoptera data collection and imputation

We compiled data from the literature on body length (mean, where available, of male and female, excluding ovipositor and antennae as they can substantially increase length and distort estimates of body size; mm), egg size (at widest/longest part of egg; mm), juvenile development time (duration from hatching to adult eclosion; days), adult lifespan (duration from adult eclosion to death; days), clutch size (number of eggs laid in a single pod/bout of laying), clutch frequency (number of pods/bouts of laying per year), and voltinism (or number of generations per year; semivoltine, univoltine, bivoltine, multivoltine or variable across geographic range). Where sources reported different values for the same species, the mean was calculated. For some species that live less than one year, if lifetime fecundity and either clutch size or frequency was reported the missing variable was calculated by dividing lifetime fecundity by the relevant variable for which data existed. Egg size was chosen as the measure of offspring size because it was most frequently reported, but to compare between taxonomic groups we also collected body length at first instar (i.e. after parental investment in the egg stage; Appendix A). Voltinism was coded quantitatively as 0.5 (generations per year) for semivoltine, univoltine as 1, bivoltine as 2, and multivoltine conservatively as 3. For species where voltinism was variable the mean of the relevant above scores was taken. Continuous variables were natural-log transformed to fit the assumptions of normality in the PCA. The full dataset contained 610 species but was very sparsely populated. All data are deposited in the Dryad Digital Repository: http://dx.doi.org/10.5061/dryad.sb307mm (Bakewell et al., 2019).

Exploring orthopteran life histories in multivariate space requires a dataset containing complete cases for each species. Unfortunately, this would leave us with a very small and taxonomically-unrepresentative dataset. To fill in gaps in our dataset we used a phylogenetic imputation method in the package 'Rphylopars' (Goolsby et al., 2017) in R (Team, 2017). The 'phylopars' function estimates the evolutionary covariance between species using the existing data, a phylogeny and a model of evolution. Ancestral states and missing data with variances are imputed as the best linear predictions, maximising the log-likelihood of the covariance patterns in the original data (Goolsby et al., 2017). We tested several alternative models of evolution and selected a model fitting lambda (Appendix A). In order to determine the sensitivity of any qualitative results to the amount of imputation in the dataset, we first performed the analyses described below on a subset of data with zero unknown traits and then repeated the analyses in series, each time expanding the subset of data allowing it to contain extra species with an additional unknown trait. This resulted in seven datasets with increasing coverage of taxa. For each dataset we imputed missing values using the Davis et al. (2018) phylogeny and a model fitting lambda. We then extracted the imputed trait values and their estimated variances. Using these imputed values and variances we generated normal distributions for each trait in each species, and randomly sampled from these distributions to create 10,000 versions of each dataset.

2.3.2 Phylogenetic PCA of Orthoptera

To assess the extent to which orthopteran life histories conform to the ‘fast-slow continuum’ we conducted phylogenetic principal components analysis (pPCA; Revell, 2009) across our distribution of datasets using custom code (available via Dryad) in R (Team, 2017), developed from the functions in the package ‘phytools’ (Revell, 2012). PCA represents multivariate data by creating composite variables, measured along new axes, from the original data. The first principal component axis (PC1) encompasses the greatest amount of variance in the data, and subsequent orthogonal axes explain the second, third, and so on, greatest amount of variance in the data (Jolliffe and Cadima, 2016). In this way PCA can be used to reduce the dimensionality of the dataset, as fewer axes, each influenced by different variables, can explain a large amount of variance in the underlying data. Standard PCA methods assume that the dataset is composed of independent data points, which is not the case with species level data as closely related species are likely to be more similar in phenotype to each other than to distant relatives. To account for this, pPCA instead uses phylogenetic covariance to calculate the principal component axes (Revell, 2009).

At each level of imputation, we calculated phylogenetic covariance matrices using the Davis et al. (2018) Orthoptera phylogeny for each of the 10,000 datasets containing samples generated from the imputed trait values and their variances. We conduced PCA on these covariance matrices and recorded the eigenvectors and eigenvalues for each run. PCA produces singular vectors with arbitrary signs (i.e. in each eigenvector all signs could be switched from positive to negative or vice-versa and the interpretation would be identical), but since we used bootstrapping over many models, each calculated on slightly different data, the sign of the eigenvectors becomes important to compare models (Bro et al., 2008). We used the procedure of Bro et al. (2008) to resolve ambiguity in the signs of the singular vectors, by comparing their signs to the individual data vectors that they represent and reversing them if necessary. This is achieved by examining the sign of the inner product of the singular vector and the individual data vectors (Bro et al., 2008). After correcting signs, we used a resampling procedure to produce bootstrapped median eigenvectors, randomly selecting with replacement 10,000 sets of eigenvectors and calculating the median over 1000 bootstraps.

As proposed in other taxonomic groups (Jeschke and Kokko, 2009), if life history trait covariation in Orthoptera strictly follows the 'fast-slow continuum' concept then all life history traits should load strongly and in the hypothesised direction onto the first principal component of a multivariate dataset, and subsequent axes should explain little additional variance. We retained PC axes according to the Guttman-Kaiser criterion, where the axes with an eigenvalue greater than the mean of all eigenvalues are interpreted (Jolliffe and Cadima, 2016). To assess the consistency of principal components calculated from each subset of data with increasing levels of imputation, we used hierarchical clustering on the variable loadings of each PC axis, based on euclidean distances. If PC axes are consistent across analyses with varying levels of imputation, then hierarchical clustering should resolve them as a clear separate group.

We also use bivariate correlations on the raw, non-imputed, data to evaluate the robustness of our conclusions from the pPCA, testing for relationships between body length (our most common variable) and the other life history traits. We used phylogenetic generalized least squares (PGLS) models (Freckleton et al., 2002, Pagel, 1999) in the R package 'caper' (Orme et al., 2013) to test for these relationships while accounting for the non-independence of data due to shared ancestry. PGLS uses a maximum likelihood approach to estimate λ - a measure of phylogenetic signal, or how strongly phylogeny predicts the pattern of model residuals (Pagel, 1999). Sample sizes are listed with the results.

2.3.3 Analyses across taxonomic groups

For analyses across taxonomic groups, we built a dataset from existing large-scale life history databases that contained traits comparable to the orthopteran life history traits: for mammals (Capellini et al., 2015, Jeschke and Kokko, 2009, Myhrovld et al., 2015), reptiles (Allen et al., 2017, Myhrovld et al., 2015) and birds (de Magalhães and Costa, 2009, Jeschke and Kokko, 2009, Lislevand et al., 2007, Myhrovld et al., 2015). We collected six life history traits for species across the four clades, the full details of which are in Appendix A, briefly: body size (mass), offspring size (mass at independence from parent), development time (time from independence from adult until sexual maturity), adult (reproductive) lifespan, clutch size (number of eggs/offspring per clutch/litter) and clutch frequency (number of clutches/litters per year). Voltinism was not present in any of the source datasets, and so it was excluded from this analysis. This dataset contained 932 mammals, 430 reptiles, 136 birds, and between 8 (at 0 traits imputed) and 339 orthopteran species (at a maximum of six traits imputed per species). For phylogenetic analyses we merged six existing phylogenies (Fritz et al., 2009, Jaffe et al., 2011, Oaks, 2011, Jetz et al., 2012, Pyron et al., 2013, Davis et al., 2018), full details and internal node dates are in Appendix A.

We first performed pPCA on the combined datasets of orthopteran, mammals, reptiles, and birds using our composite phylogeny, in an attempt to explore patterns of covariation at a broad taxonomic scale. We then assessed how much variance in each of the groups' data could be explained by the principal component axes of the other groups. Unfortunately, this is non-trivial in pPCA, since the scores for species are based on differences in trait values from an ancestral state (which will change with the addition of extra taxa). Therefore, we performed the analysis without phylogenetic correction, effectively assuming that the impact of phylogenetic non-independence is similar in all four groups. We took each taxonomic group (orthopterans, mammals, birds, and reptiles) in turn to be the baseline group, and then calculated the amount of variance explained in the other groups' data by the retained axes of the baseline group (see Appendix A). Each trait in the data for this baseline group was standardised to have a mean of 0 and standard deviation of 1. We then scaled the data for the other groups using these same scaling attributes, i.e. species from different taxonomic groups with the same trait values would have the same scaled values. Scaling within groups does not affect the variance overlap calculations, but it gives more realistic relative scores along the resulting axes.

2.4 Results

2.4.1 The 'fast-slow continuum' hypothesis in Orthoptera

The presence of a 'fast-slow' axis encompassing body size in the data is strongly suggested by the results of the bivariate PGLS analyses (Table 2.1), which do not use any imputation. Body size is strongly positively associated with offspring size, development time, and adult lifespan, although it is not significantly associated with generations per year or clutch frequency. However, in contrast to the standard 'fast-slow' expectations, larger body size is strongly associated with larger clutch size in Orthoptera.

Three principal component axes, explaining 83.27-95.61% of the variance, were extracted per analysis on subsets of the data containing a maximum of 0, 1, 2, 3, or 4 missing values per species (Table A.2). Hierarchical clustering revealed consistency among some of these axes, with one axis (PC2 for 0 or 1 imputed value subsets, PC1 for the others; Table A.2) from each subset forming a distinct group with characteristics of a 'fast-slow continuum' (Figure A.1), matching the

Table 2.1 Phylogenetic Generalized Least Squares models of natural-log body length against a series of (natural-logged) life history traits from Orthoptera data.

Response variable	$\beta \pm$ SE	t	p	λ	n	R^2
Offspring Size	0.359 ± 0.036	10.083	<0.001	0.964	159	0.389
Development Time	0.425 ± 0.155	2.741	0.008	0.768	82	0.074
Adult Lifespan	1.102 ± 0.293	3.765	<0.001	0.000	29	0.320
Clutch Size	1.452 ± 0.169	8.618	<0.001	0.919	110	0.402
Clutch Frequency	-0.197 ± 0.329	-0.598	0.565	0.000	28	0.014
Generations per Year	0.270 ± 0.143	1.893	0.062	0.602	92	0.028

PGLS results above. Table 2.2 shows the results of pPCA on the subset of data with maximum 4 imputed values, which is fairly typical of the others (Table A.2). In this case PC1 is the 'fast-slow' axis, with positive loadings of body size, offspring size, adult lifespan and clutch size (Figure 2.1). The axis explains 41.40% of variance in the data, and increasing values indicate species with larger adult body size, larger eggs, longer adult lives, and more eggs per clutch (Table 2.2).

Table 2.2 Bootstrapped median loadings from a phylogenetic PCA of orthopteran life history data, imputed with a maximum 4 missing values per species (results of analyses at other levels of imputation can be found in Table A.2).

Trait	PC1	PC2	PC3
Body Size	**0.763** (0.762, 0.764)	0.135 (0.129, 0.141)	0.011 (0.006, 0.016)
Offspring Size	**0.514** (0.513, 0.516)	0.048 (0.044, 0.053)	0.002 (0.000, 0.005)
Development Time	0.223 (0.220, 0.226)	-0.036 (-0.041, -0.031)	-0.110 (-0.127, -0.089)
Adult Lifespan	**0.922** (0.921, 0.922)	-0.002 (-0.006, 0.002)	-0.255 (-0.262, -0.245)
Clutch Size	**0.646** (0.644, 0.649)	0.310 (0.298, 0.322)	**0.428** (0.407, 0.446)
Clutch Frequency	0.268 (0.262, 0.275)	**-0.833** (-0.839, -0.828)	0.084 (0.065, 0.103)
Generations per Year	-0.197 (-0.200, -0.194)	0.075 (0.068, 0.083)	0.350 (0.327, 0.368)
% variance	41.40%	24.79%	17.08%

Note: 95% confidence intervals for bootstrapped medians are presented in parenthesis below the medians. **Boldface** indicates that the trait was significantly loaded onto the axis.

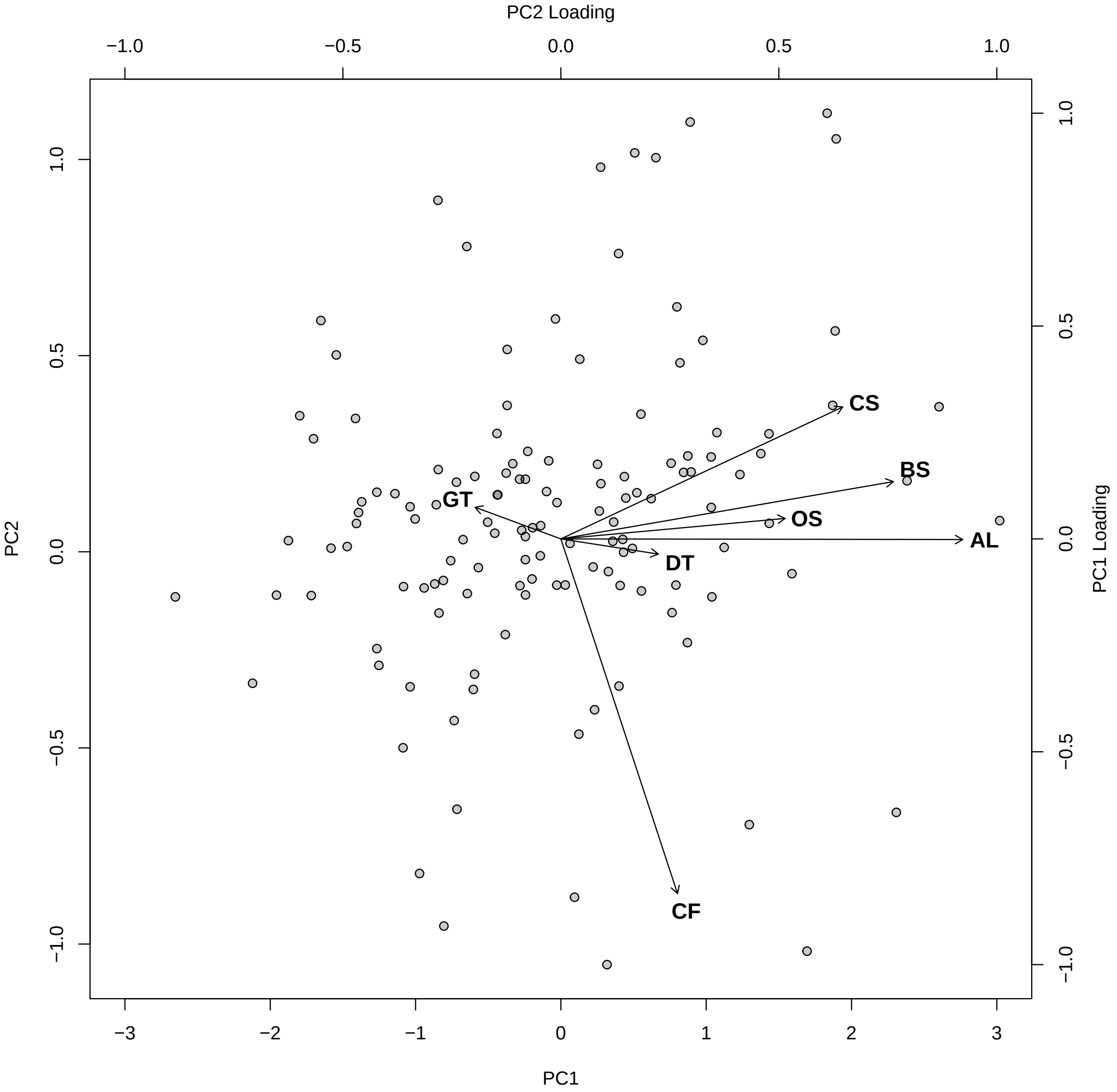


Fig. 2.1 Biplot from the PCA orthopteran life histories (Table 2.2), produced using the imputed orthopteran data with a maximum of four missing traits. BS = body size, OS = offspring size, DT = development time, AL = adult lifespan, CS = clutch size, CF = clutch frequency, GT = generation time.

Other axes retained in at each level of imputation appear to be more sensitive to imputation, as they change more according to the amount of missing data and do not sit together under hierarchical clustering (Figure A.1). However, with caution, other patterns may be interpreted. PC2 (Table 2.2) is strongly loaded by clutch frequency alone. Clutch frequency is also a primary contributor to retained axes in analyses at lower levels of imputation (Table A.2). We note that the bivariate relationship between body length and clutch frequency was not significant, and had zero phylogenetic signal (Table 2.1).

2.4.2 The 'fast-slow continuum' across taxonomic groups

Only the first axis of the phylogenetic PCA across Orthoptera, Mammalia, Reptilia and Aves was retained according to the Guttman-Kaiser criterion, regardless of the amount of imputed data included for orthopterans. These first principal component axes explained 67.0-70.1% of variance in the combined dataset (Table 2.3: column 'All (pPCA)'; Table A.3). The axis was heavily loaded by adult body mass, offspring mass, development time, and adult lifespan, but not clutch size or frequency. These associations were found to be robust to the amount of imputed orthopteran data included in the analyses (Table A.3). Increasing values of PC1 here represent species with larger body masses and offspring at independence, longer developmental and adult/reproductive periods (Table 2.3: column 'All (pPCA)'). The vertebrate clades cluster much closer to each other than Orthoptera, which have the fastest life history traits of the groups being compared, and of the three vertebrate groups, reptiles showed the most overlap in scores with orthopterans (Figure 2.2).

When computing life history principal components for each group separately, in the vertebrate clades only PC1 was retained according to the Guttman-Kaiser criterion, while in Orthoptera the first two axes were retained (which combined

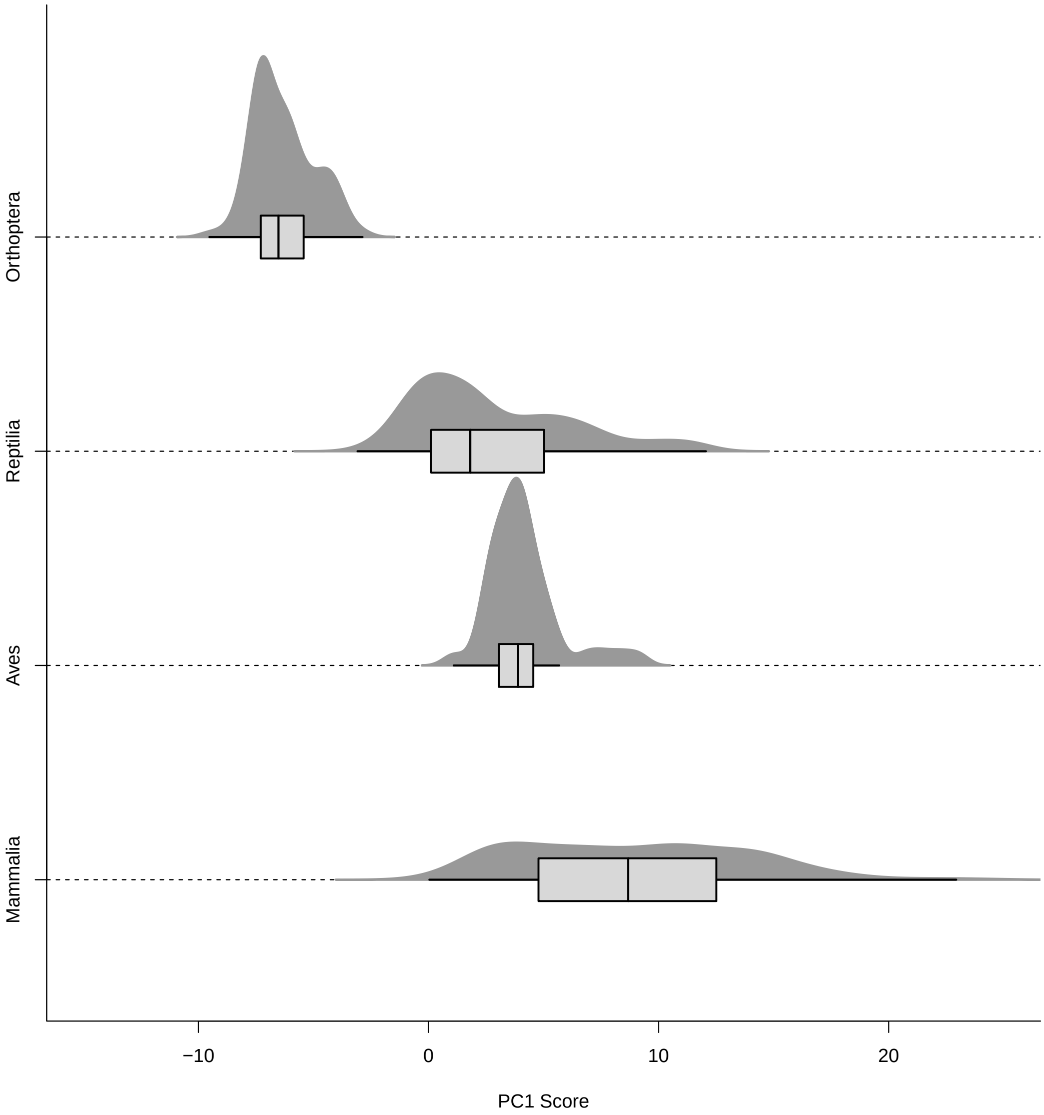


Fig. 2.2 The distribution of species' scores on PC1 of the phylogenetic PCA of life histories across taxonomic groups (with Orthoptera data imputed with a maximum of four missing species: Table 2.3). Boxplots show the median scores, quartiles and 95% confidence limits.

Table 2.3 PCA of life history traits between and within taxonomic groups, and the amount of variance that each set of axes explains for each group. Orthoptera data is included imputed at the level of maximum four traits per species missing, results for other levels of imputation can be found in Table A.3 (phylogenetic cross-clade PCA's) and Table A.4 (within Orthoptera PCA's).

	All (pPCA)*	Mammal	Bird	Reptile	Orthoptera	
Trait	PC1	PC1	PC1	PC1	PC1	PC2
Body Size	**0.976**	**0.431**	**0.457**	**0.484**	**0.531**	0.160
Offspring Size	**0.942**	**0.444**	**0.460**	**0.471**	**0.463**	-0.020
Development Time	**0.418**	**0.412**	**0.451**	**0.420**	0.297	0.057
Adult Lifespan	**0.490**	**0.409**	0.362	0.393	**0.510**	-0.257
Clutch Size	0.161	-0.364	-0.369	0.370	0.390	0.346
Clutch Frequency	-0.213	-0.384	-0.330	-0.276	0.105	**-0.886**
% variance mammals	**67.8%**	**69.9%**	69.4%	40.7%	29.4%	10.4%
% variance birds		69.5%	**70.0%**	40.8%	31.5%	11.6%
% variance reptiles		37.1%	37.1%	**62.3%**	53.9%	19.8%
% variance orthopterans		25.1%	26.0%	46.1%	**51.8%**	**19.0%**

* λ = 0.976

Note: All (pPCA) column shows the loadings from a phylogenetically controlled PCA incorporating data from across mammals, birds, reptiles and orthopterans (variance explained = 60.2%). Subsequent columns show the loadings of standard PCAs on data from each of the listed groups, along with the variance explained in these axes by these axes in each of the taxonomic groups. **Bold** indicates a significant loading, or the amount of variance explained in the clade used to generate the loadings. Definitions of traits are provided in Appendix 1.

explained 70.8-89.2% of variation in the orthopteran data; Table A.4). The loading of traits was broadly similar across groups; the main differences occurred with fecundity related traits. Specifically, in mammals and birds clutch size loaded in the opposite direction to body size, offspring size, development time and adult lifespan; while in reptiles and orthopterans it loaded in the same direction (Table 2.3). When other groups' life history data were projected onto the axis of each individual group, the mammal and bird axes best explained variance in each other, performing poorer for reptiles and orthopterans (Table 2.3; Table A.4). The reptile axes better explained variance in Orthoptera than any of the other groups, and vice versa (Table 2.3, Figure 2.3; Table A.4).

Clutch frequency did not significantly load onto PC1 in any of the groups, but in Orthoptera, regardless of the amount of imputation used in the analysis, it

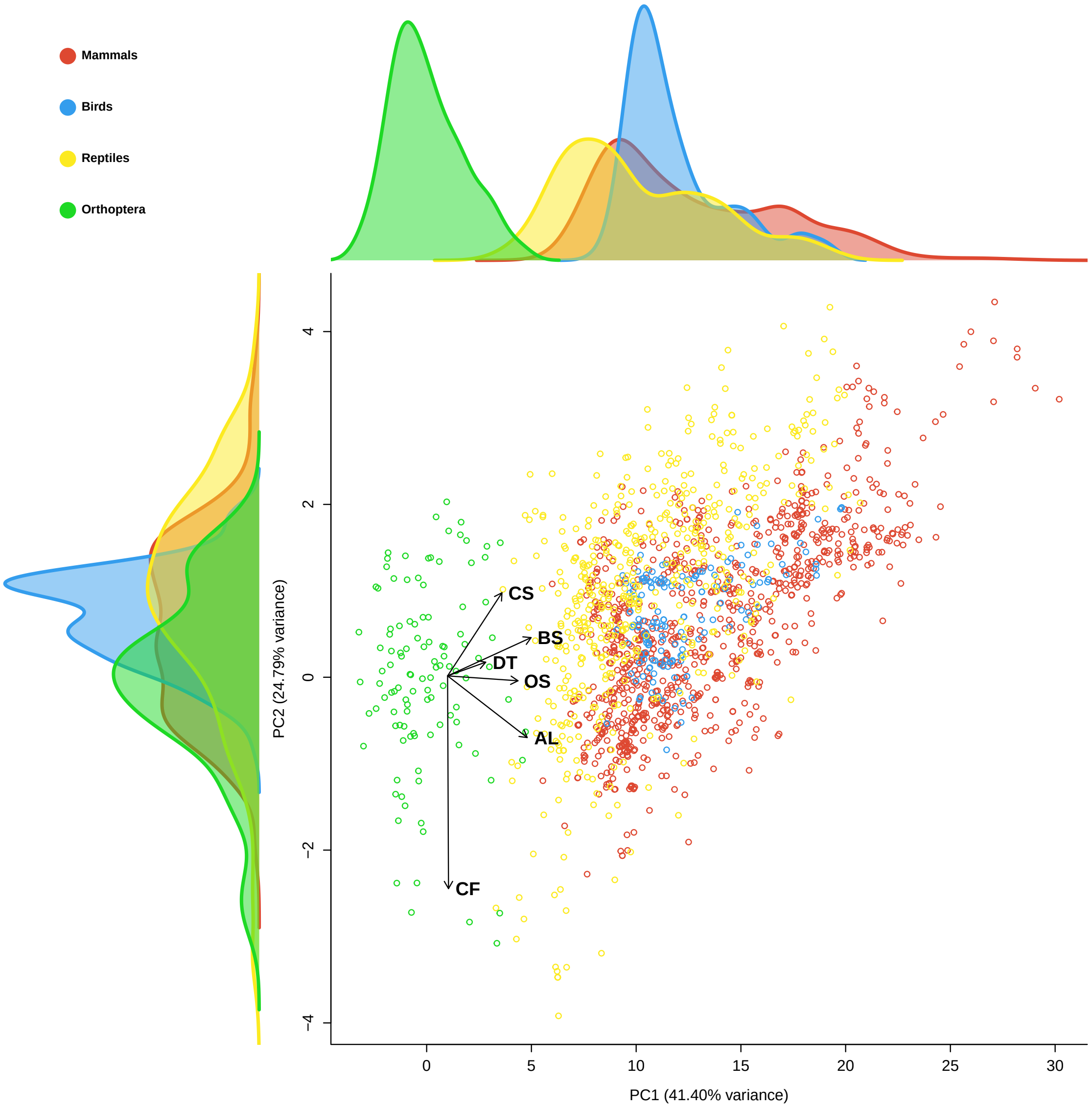


Fig. 2.3 Biplot of PCA of orthopteran life histories (green; left side), with mammals (red; right side), birds (blue), and reptiles (yellow) projected into the same life history space (Table 2.3: column 'Orthoptera'). Outer plots show the density of PC scores for each group. Arrows show the direction of trait loadings on these axes: BS = body size, OS = offspring size, DT = development time, AL = adult lifespan, CS = clutch size, CF = clutch frequency.

is very heavily loaded onto the second axis. All three vertebrate clades scored similarly to Orthoptera in the amount of variance explained by this axis, though this is not surprising considering that it was largely influenced by a single trait. Figure 2.3 shows the distribution of species' scores along the axes proposed here for Orthoptera (Table 2.3: columns 'Orthoptera').

2.5 Discussion

Understanding the causes of differences between species is a fundamental question in biology, and life history traits represent some of the most prominent and important sources of phenotypic diversity (Stearns, 1992, Charnov, 1993, Roff, 2002). Theories and paradigms that can be applied to multiple life history traits (e.g. Charnov, 1991, Kozłowski and Wiener, 1997) have the potential to explain this diversity, but the extent to which each one can depends on the extent to which associations between traits across organisms in general are similar (Jeschke and Kokko, 2009). Problematically, attempts to quantify invertebrate life histories in multivariate space have been hindered by incomplete trait data (Mayhew, 2016). Here we have used phylogenetic imputation methods to generate complete datasets of seven key life history traits for a large number of Orthoptera species, and used these to test associations between traits and find similarities across taxa. Without imputation, or with low-to-moderate levels of imputation, we find consistent evidence in our results of a ′fast-slow continuum′ axis. This axis is supported by bivariate PGLS analyses which only consider real (non-imputed) data. On these axes, we find evidence for some, but not all, of the relationships predicted by the fast-slow continuum. Moreover, we find that orthopteran trait variation resembles that of reptiles better than birds or mammals. Below we put these findings in the context of other work and assess their significance for life history theory and ecology.

In orthopterans, larger values along the ′fast-slow′ axis (Table 2.2: PC1) indicate species with larger body lengths, larger egg lengths, longer adult lifespans, and more eggs per clutch. These results largely conform to the ′fast-slow continuum′ hypothesis, except that ′fast′ species have smaller clutches than ′slow′ species. Previous intraspecific studies in insects, including orthopterans, showed that larger size is associated with higher, not lower, fecundity (Honěk, 1993, Strum, 2016). Since most orthopterans are ′income breeders′ (they acquire and invest resources for reproduction during their adult stage; Branson, 2008) there is no reason *a priori* to believe that their reproductive budgets are fixed. Being income breeders might help larger insects to acquire more resources for reproduction. Taxa, like insects, which sit more towards the ′fast′ end of a fast-slow continuum, might favour allocation more towards number than size of offspring for many reasons: for example, a lack of density-dependent population regulation (as in the original r/K selection theory); or if offspring lifetime fitness does not strongly depend on initial offspring size (Smith and Fretwell, 1974); or if habitats for offspring development are not limiting (Godfray, 1994).

Our results show that a single ′fast-slow′ axis does not adequately reflect the variation in orthopteran life histories, something that has been acknowledged in previous analyses in other taxonomic groups. The ′fast-slow continuum′ also makes predictions about development time (longer in ′slow′ species) and the number of generations per year (fewer in ′slow′ species). We do not consistently find these patterns in our analyses, though development time is loaded in the predicted direction (Table 2.2; Table A.2). Though not as consistently as the ′fast-slow′ axis, we find evidence of a secondary axis describing the frequency of clutches (Table 2.2; Table A.2) - which is similar to results from other groups. Salguero-Gómez et al. (2016) found support for the ′fast-slow continuum′ in plants, but with a second ′reproductive strategy′ axis further resolving variation in fecundity traits. Even in mammals, Bielby et al. (2007) concluded that the life history data did not support the concept of a single ′fast-slow′ axis, instead two axes were required - one describing the trade-off between offspring size and number and the other reflecting the timing of reproductive events (longer inter-birth intervals associated with slower development). Mayhew (2016) described the life history associations of parasitoid Hymenoptera as a ′reduced fast-slow continuum′, and similar conclusions can be drawn for fish, birds, reptiles, and plants where some, but not all, of the expected patterns are found (Bauwens and Díaz-Uriarte, 1997, Franco and Silvertown, 1996, Jeschke and Kokko, 2009).

Despite this, in our analysis conducted at the highest taxonomic level, the phylogenetic PCA across mammals, birds, reptiles and orthopterans, we retained only one axis that explains 67.03-70.05% of the variance (Table 2.3: pPCA; Table A.3). The traits that are significantly loaded on this axis all fit the expectations of the 'fast-slow continuum': larger values indicate larger adult and offspring size, slower development, and a longer adult lifespan. Neither clutch size or frequency were loaded onto this axis, which may reflect disparity in how these traits load at lower taxonomic levels. It is interesting that at this very broad taxonomic scale a single 'fast-slow' axis can be resolved, and this result is robust to the amount of imputed orthopteran data included in the analysis (Table A.3). PCAs in the vertebrate groups also recover a single axis (Table 2.3), although these do not necessarily contradict previous findings such as Bielby et al.'s (2007) because of differences in the traits used between analyses.

Quantifying the fit of one taxonomic group to multidimensional axes of variation described by others could clarify the similarity in trait covariation across taxa. We showed that Orthoptera most closely follow the axes of trait covariation described by the reptiles (Table 2.3), specifically resembling 'fast' reptile species (Figure 2.2; Figure 2.3). In the amount of variance reciprocally explained by their principal components, reptiles and orthopterans are more similar to each other than to mammals and birds (Table 2.3; Table A.4), though the vertebrate clades cluster closer together in life history trait space than reptiles do to orthopterans due to the disparity in body size (Figure 2.2; Figure 2.3). The primary difference between orthopterans/reptiles and the other vertebrate clades is the loading of clutch size. Bauwens and Díaz-Uriarte (1997), in lacertid lizards, found that species with larger body sizes and offspring sizes also have larger clutches. These authors identify a trade-off between clutch size and frequency, which was negatively loaded (though not significantly) compared to the other traits in our reptile PCA (Table 2.3).

What might cause the similarity of trait covariation in reptiles and orthopterans? One possible driver is their body sizes, because as explained above, this might lead species towards the fast end of a fast-slow continuum to prioritize investment in number rather than size of offspring. Another obvious similarity is the range of possible clutch sizes. The range of clutch sizes in our dataset is much smaller in mammals (with 20.1 fold variation across species) and birds (10.5 fold) than in reptiles and orthopterans (131 and 172 fold, respectively). Reptiles and orthopterans are ectothermic, while mammals and birds are endothermic. Ectotherms have lower metabolic rates than endotherms (White and Seymour, 2003) and expend a much larger proportion of their metabolic energy on reproduction and early growth stages (Wieser, 1985). Due to their lower metabolic power endotherms may be more constrained in the timing of embryonic development and early growth, which have to be synchronised with external schedules of environmental temperature (Wieser, 1985). Accordingly, they will be more affected by factors such as seasonality and latitude, compared to endotherms. This may select for similar covariation in life histories. As outlined above, if lifetime offspring fitness is not strongly affected by initial offspring size, dividing the total resource pool allocated to reproduction between a greater number of offspring would result in higher fitness (Smith and Fretwell, 1974). Post-hatching/birth parental care is extensive in birds and obligate via lactation in mammals, while in reptiles and orthopterans it is far less common (Clutton-Brock, 1991). If in species with parental care individual offspring fitness is more dependent on their size, this may explain why orthopteran trait covariation is typically more similar to reptiles, particularly in the tendency for larger bodied species to lay larger, rather than smaller, clutches. Indeed, Gilbert and Manica (2015) show that in insects with no parental care (or care limited to low-cost egg guarding) larger species produce more and larger eggs, while in those that provision offspring (similarly to birds and mammals) larger species produce fewer, larger eggs.

Multivariate studies of invertebrate life histories of the type conducted here are rare because in PCA species with data omissions are excluded, and trait data are typically incomplete across broad taxonomic groupings of invertebrates. However, without multivariate studies, it is difficult to assess how similar life history trait covariation is across taxa, and hence how powerful explanatory paradigms might be. Similarly, without such studies on invertebrates, which comprise the vast majority of described species richness, it is hard to assess how broadly relevant any theory or paradigm might be to biodiversity. Here we used recent methods of phylogenetic imputation to create a rich dataset in a higher taxon of insects that is suitable for multivariate analysis. Though such methods have been tested in a limited way before, and found to be generally robust, our study has applied them in a dataset that is more incomplete than usual. Scepticism about the imputed values is both healthy and legitimate, and it was incumbent upon us to demonstrate the robustness of findings based on them. We have done this in three ways. First, the associations between pairs of traits were first tested by analyses of datasets without imputed values - and these agree with those based on PCA of imputed data (Table 2.1). Secondly, the uncertainty in imputed values has been incorporated into our analyses by bootstrapping the imputed data and re-running the multivariate analyses. We find very little variation in the results. Thirdly, we re-ran our models with restricted datasets requiring less imputation, and are able to identify consistency in the results by employing hierarchical clustering (Figure A.1; Table A.2; Table A.3; Table A.4). This potentially opens up the possibility of many more such analyses on other taxonomic groups with incomplete datasets. However, the robustness of the findings to uncertainty in the imputed data should be addressed in each specific case.

The aim of life history theory is to encompass a set of realistic evolutionary assumptions that allow the observed patterns of trait associations and values to be predicted. Based on previous work in other taxa, these assumptions might include growth rates and their scaling with temperature and body size, apportionment of energy to reproduction in the adult stage, and extrinsic and intrinsically imposed mortality rates (Charnov, 1991, 2001, 2004, Kozłowski and Wiener, 1997). Though there are doubtless some data on these variables already in the published literature for Orthoptera and other insects and invertebrates, particularly on pest or other model species, there has yet to be a concerted effort to compile these data as has been done in some vertebrate or plant groups (e.g. Jones et al., 2009, Salguero-Gómez et al., 2015, 2016).

Previous studies on other taxonomic groups have found that multivariate axes of life history variation can help predict other ecological and community traits, which is not surprising given their impact on fitness and demography (Allen et al., 2017, Grime and Pierce, 2012). Based on findings in other taxa, we expect that the axes identified for Orthoptera might predict the invasiveness of species or their pest status, their conservation status, and their spatial distribution in different habitats. Given the extensive ecological and economic impact of insects and other invertebrates in natural ecosystems, realising this potential would have enormous practical application. However, the idea that life histories can be classified along a single axis applicable to all organisms is ambitious, and our results indicate the limitations of such a framework. Life history evolution is addressed by many diverse hypotheses with different predictions; bet-hedging, for example, predicts that with increased environmental stochasticity organisms should favour variable development (e.g. through egg diapause in insects) and iteroparity (Evans and Dennehy, 2005, Wilbur and Rudolf, 2006). Without proxies of environmental uncertainty, however, it is hard to interpret the results of our analyses in this context. Ordination of life histories with ecological traits may be able to uncover more interesting and ecologically relevant patterns of association. In flying insects, using geometrid moths as an example, Davis et al. (2016) classified species along an axis following the degree of capital breeding (the proportion of adult acquired resources devoted to reproduction), and found correlates of this axis with larval diet breadth, reproductive season, and sexual size dimorphism.

To conclude, we have used phylogenetic imputation to conduct multivariate analyses of life histories in an insect group and found evidence of a 'fast-slow continuum', though not as marked as in mammals and birds since clutch size loads in the same direction as body size. We demonstrate that, in terms of both absolute trait values and in their trait covariation, orthopterans resemble reptiles more than birds and mammals. These findings suggest that we need new theories to help us understand the reasons for these differences and similarities across taxa, and investigations to understand their ecological consequences. They further suggest that similar studies in invertebrate groups will be enlightening.

Chapter 3

The covariation of life history traits in insects and the effects of ecology and metamorphosis

3.1 Abstract

Understanding life history variation is a core challenge for ecology and evolutionary biology, and has produced many competing theories and hypotheses. The 'fast-slow continuum' in particular has become a prominent concept in the field, largely due to work on mammals and other vertebrates. To understand the general relevance of these ideas to life as a whole, a concerted effort is needed to understand variation in the life histories of invertebrates, which comprise the majority of described species. We created a taxonomically broad dataset of life history traits for over 3000 species of insects, and test how traits covary evolutionarily, and what drives that variation. We find little strong evidence in support of a 'fast-slow continuum' across the insects: the main axes of variation in life histories in the group (explaining just under 50% of the variance) are related to reproductive investment, and how this is spread over a lifetime. Ametabolous (primitively wingless) species have distinct life history strategies (longer adult lifespans) than other insects, but hemi- and holometabolous species show similar trait covariation. We find that diet predicts life history, with parasitoids showing lower clutch size, fecundity, development time and adult lifespan than other diets, but we do not find significant effects of broad habitat (terrestrial versus aquatic). We conclude that any 'fast-slow continuum' in insects is quite far removed from the vertebrate pattern of covariation, and that therefore these patterns are not as universal as has been suggested previously.

3.2 Introduction

Life history theory attempts to explain the variation in life cycles between species: how fast they grow, when they become mature, how often they reproduce, and how long they survive (Stearns, 1992, Roff, 1992). These features directly influence population dynamics and individual fitness, and so explaining the high level of phenotypic diversity in life histories has been a major challenge at the intersection of ecology and evolutionary biology. An important postulate of the theory is that trade-offs operate between components of an organism's life history; that compromises must be reached due to competitive investment of energy and resources between growth, maintenance and reproduction (Stearns, 1992, Braendle et al., 2011). These trade-offs place constraints upon the range of possible life history strategies. Our understanding of how these trade-offs, combined with selection, create patterns of life history variation is, despite widening taxonomic coverage of studies, mostly limited to vertebrates and a small number of other taxonomic groups, such as angiosperms. Until we know how life history traits covary in invertebrates, which comprise the majority of extant described species, a broad understanding of life history evolution will be lacking.

Empirical studies of covariation between life history traits have revealed, in many cases, a few prominent 'axes' (combinations of co-varying traits) that can explain much of the variation among taxa. One of the most prominent generalisations of life history is the idea that species can be placed along a 'fast-slow continuum'. This concept grew out of r/K selection theory, which explained variation in life history strategies as the consequences of density-independent versus density-dependent selection (Macarthur and Wilson, 1967, Pianka, 1970), but the 'fast-slow continuum' is a description of the patterns predicted by this theory and observed in nature and does not invoke any particular explanation of their causes (Jeschke and Kokko, 2009). Towards the fast end of this continuum, species are characterised by small body size, early maturity and reproduction, small offspring produced at a fast rate, high fecundity, and short lifespans; while species towards the slow end of the continuum have the opposite set of traits (Stearns, 1992, Braendle et al., 2011). Fast-slow continua have been documented in many animal groups, including mammals (Oli, 2004, Bielby et al., 2007), fish (Winemiller and Rose, 1992, Beukhof et al., 2019), birds (Sæther, 1987, Bennett and Owens, 2002), and reptiles (Bauwens and Díaz-Uriarte, 1997, Clobert et al., 1998), and remarkably similar patterns of covariation have also been demonstrated in plants (Franco and Silvertown, 1996, Salguero-Gómez et al., 2016). Indeed, recent analyses spanning diverse phyla from basal animal lineages to higher animals indicate that patterns could generally be applicable to all metazoan taxa (Healy et al., 2019). Broad comparative life history studies have been made possible because of large aggregations of life history data within these taxa (e.g. mammals: Jones et al. (2009), amniotes: Myhrovld et al. (2015), plants: Salguero-Gómez et al. (2015)). In this paper we aim to fill the gap in the literature for a trait database of similar scope to address questions about life history evolution for insects.

The covariation of life history traits in insects has been the subject of less attention than for vertebrates and plants. This probably in part caused by a lack of trait data compared to these groups (Mayhew, 2016) reflecting a study bias. Where these studies have been carried out they rarely manage to recover the full set of patterns described by the 'fast-slow continuum' (Blackburn, 1991a)(Chapter 2). Insects constitute more than half of the currently described fauna of Earth (Mora et al., 2011) and show correspondingly vast variation in their life histories. They dominate terrestrial ecosystems in terms of biomass and play crucial roles within them – cycling nutrients, pollinating plants and dispersing their seeds, maintaining soil structure and diversity, controlling populations of other organisms, acting as a food source for a diverse range of predators, and as a habitat for microbial symbionts (Grimaldi and Engel, 2005, Scudder, 2009). Despite this, their range of life histories is poorly understood at a comparative level, certainly compared to other groups. Considering the far-reaching consequences of life histories, and their ability to aid decision making in areas as diverse as conservation biology, fisheries management, and invasive species biology, extending our understanding of life history evolution in insects is likely to be beneficial. One of the principal objectives of this chapter is to identify the major axes of life history variation across the Class Insecta, and to evaluate the extent to which they conform to a 'fast-slow continuum'.

Aside from the likely utility of understanding the broad causes of life history variation (i.e. why 'fast' or 'slow' strategies evolve), it also provides an understanding of species' evolved adaptations and the ecological challenges that underpin them. The insects are a famously diverse group and provide an excellent opportunity to test hypotheses about life history evolution in the context of ecology, but previously this has largely been inhibited by incomplete trait data.

Over 80% of insect species undergo complete metamorphosis, or holometaboly. These insects have an ecologically inactive life stage, the pupa, in which transformation between the larval and adult forms takes place. There are several hypotheses about the adaptive benefits of metamorphosis (reviewed in Rolff et al. (2019)), but they are predominantly related to the idea of decoupling the larval and adult stages so that they can occupy different niches. Over evolutionary time, the remarkable divergence of larval and adult forms (compared to juvenile hemimetabolous insects, which look like small, wingless versions of the adult) is thought to reflect specialization of the various life stages to different tasks; the larvae are primarily adapted for feeding and growth, while the adults are primarily adapted for dispersal and reproduction (Istock, 1967). Understanding the consequences of the evolution of metamorphosis, particularly complete metamorphosis, for life history covariation is paramount to assessing the universal applicability of any generalisations of life history theory.

Though insects dominate terrestrial ecosystems, there are almost 100,000 species (a conservative estimate) that are present in aquatic habitats for a portion of their lives, and here they also play key ecological roles (Dijkstra et al., 2014). Southwood (1977) suggested that the observed diversity of life history strategies is related to the habitat that an organisms occupies, particularly the stability of the habitat and the level of predictability of its resources. Terrestrial and aquatic habitats have strong environmental differences: food sources are often suspended abundantly throughout water; it is denser than air, weakening the effects of gravity; and desiccation is rarely a risk (Strathmann, 1990, Steele et al., 2019). It is also notable that the daily and seasonal temperatures are more stable in aquatic environments than terrestrial ones (Dijkstra et al., 2014). High environmental stochasticity has classically been associated with the evolution of 'fast' life histories, to ensure completion of life stages while the environment is conducive to the organism (Engen and Sæther (2016), but see Morris et al. (2008)). Aquatic insects represent a return to water from terrestrial ancestors, so identifying whether this has reshaped life histories will provide important evidence about how ecology can affect life history. In an analysis of animal and plant life histories, Capdevila et al. (2020) found that the terrestrial species in their dataset spanned from 'fast' to 'slow' in a 'fast-slow continuum', but that aquatic species were constrained towards the 'faster' end of this axis. These authors interpret the greater diversity of life history strategies in terrestrial environments as reflecting the greater species richness and biomass of the terrestrial realm, and the many innovations needed to adapt to life on land, for example, for water retention or dispersal (Capdevila et al., 2020).

Finally, diet has proven to be a robust correlate of life history in some groups of mammals (e.g. Sæther (1994), Geffen et al. (1996), Fisher et al. (2001)).

Fisher et al. (2001) suggested that, in marsupials, the mechanism for life history differences according to diet is related to energy constraints: relative to their size, species feeding on more energy rich substrates can invest more energy into reproduction, and the other life history traits are then traded-off against this increase in investment. Insects and their relatives have considerable variety in terms of dietary ecology (Grimaldi and Engel, 2005), including species that change substrate (or even cease feeding altogether) across the different stages of their lives. Again, identifying correlations between life history and diet in insects will inform our perspectives on how ecology can shape life histories.

In this paper we aim to identify and interpret the life history patterns of the insects: a largely neglected taxonomic group from this perspective but an essential one for determining to what extent theories are general. To address questions about life history evolution we present a dataset, broad in terms of both taxonomy and trait data, containing 3,604 species from across all continents on Earth. We identify the main axes of variation among insect life history traits and use this information to evaluate the relevance of the 'fast-slow continuum' to groups with more complex life cycles than those traditionally considered in comparative analyses. Following this, we test for associations between life history strategies, metamorphosis, and major transitions in ecology.

3.3 Methods

3.3.1 Data collection and imputation

We created a dataset of insect traits using data from the published literature. The key life history parameters collected were: adult body length (excluding ovipositor and antennae; mm), egg size (at longest/widest part of the egg; mm), egg development time (time from laying to hatching; days), nymph development time (for hemimetabolous species, time from egg eclosion to eclosion of the adult stage; days), larval development time (for holometabolous species, from egg eclosion to formation of the pre-pupa; days), pupal development time (for holometabolous species, time from pupation to adult eclosion; days), adult lifespan (time from adult ecolsion to death; days), clutch size (number of eggs laid in a single mass/bout of laying), and lifetime fecundity (total eggs laid over a female's life). Where we had the information, we summed larval and pupal development time to represent the time from hatching to the adult stage (functionally equivalent to nymph development time for hemimetabolous species), and we summed egg, nymph/larval and (if holometabolous) pupal development time to give total (hereafter egg to adult) development time. We searched for scientific literature with relevant trait data on Web of Science, using the name of the order and the name of the trait, as well as more general searches such as "insecta", "insects", "life history", etc. The results of these searches led thorough references to many other sources including grey literature, books, and websites. Where a species had only one or two missing traits we searched, again on Web of Science, using the species name and the names of the missing traits. We were to some extent limited by time in the data collection process (and by whether books, journal articles etc. could be accessed), and so there is doubtlessly more data available in the literature. On the other hand, some traits and taxonomic groups had previously been studied in some depth, and life history traits were available for a large number of taxa in these cases - we assured that this does not bias our results as outlined in section 3.3.2. All variables were log-transformed prior to analysis. The data used for these analyses are presented in Appendix D, along with a full reference list.

Our complete dataset contains some trait information for 3,604 insect species from across the globe. All extant orders of insects are represented by at least one species in our dataset, though some did not have enough data for us to perform the specific analyses we present below (e.g. a small number of Protura, Mantophasmatodea). Most of the species lack some trait data, but we hope that this resource can be used for other purposes and expanded by others in future. The analytical sample sizes (reported herein) are, in some cases, considerably smaller than the total dataset, due in part to missing trait data and in part to inadequate information on phylogeny for some species/groups. We compiled information on taxonomy for each species as we were collecting the data, this was afterwards checked using the R package ′taxise′ (Chamberlain and Szocs, 2013) and the taxonomy provided by the Tree of Life Web Project (Maddison and Shulz, 2007). The majority of the differences between our taxonomies were due to repeated typos or differences in definitions (e.g. we take Blattodea, Isoptera and Mantodea as one order, Dictyoptera, but the Tree of Life taxonomy treats them as three orders), but other differences were verified on a case by case basis using the Integrated Taxonomic Information System (ITIS) (http://www.itis.gov).

In addition to the continuous life history traits, we categorised species according to their type of metamorphosis (ametabolous, hemimetabolous, or holometabolous), and according to taxonomic order (the only major taxonomic sublevel at which our analyses were reasonably complete). We categorised any insect which has an aquatic stage as aquatic, and the remaining species as terrestrial, according to major reference works (Thorp and Rogers, 2015, Hamada et al., 2018) and other published literature sources (Appendix D). This classification also considers parasitoids that attack aquatic stages as aquatic, although our results are consistent whether we consider them alternatively as non-aquatic. We collected information on diet according to published literature sources (Appendix D), and then categorised the species for which we had information according to the larval and adult diet classifications of Rainford and Mayhew (2015), which

Table 3.1 Definitions of the diet categories used in this study, based on Rainford and Mayhew (2015).

Diet	Defintion
Detritivory	Taxa which feed on decaying substrates and/or the microbial communities associated with decaying substrates. Includes scavenging/corpse feeding, dung feeding, and filter feeders.
Ecto-parasitism	Taxa which feed on blood, flesh or other animal products.
Fungivory	Taxa which either a) feed on living fungal tissue, or b) use symbiotic fungi to externally digest their food. We exclude spore feeders from this group and instead class them as detritvores.
Liquid-feeding	Taxa which feed on liquid substrates e.g. nectar, honeydew, haemolymph.
Non-feeding	Taxa which are incapable of feeding as adults.
Parasitoidism	Taxa which use a single arthropod host (which dies as a result) to complete their larval development.
Phytophagy	Taxa which feed on living plant material, including vegetative parts, roots, wood and seeds. Taxa feeding on dead plant material (e.g. dead wood), and seeds not taken in situ (e.g. stored grain) are treated as detritivores.
Predation	Taxa which kill and feed upon multiple other individual animals.

has a similar taxonomic scope to our study. Definitions of the diet classifications are outlined in Table 3.1

We created a species-level phylogeny of insects with good overlap with our dataset using an informal supertree approach, more fully outlined in Appendix B. We searched the literature for recent, comprehensive, and time-calibrated trees, usually covering entire orders but some focussing on families. We then assembled the trees into an overall phylogeny using the tree of Rainford et al. (2014) as a backbone. This phylogeny was chosen because the divergence dates of orders were mostly compatible with the individual source trees, and so we were more inclined to trust them (see Appendix B for a full discussion and methodology). After assembling the tree, there were still a significant number of species with life history data but without representation on the tree, so we used taxonomy to insert those species via the 'tip pinning' approach described by Bennett et al. (2017).

To increase the number of species and taxonomic breadth of our multivariate analyses (see below) we followed the phylogenetic imputation procedure described in Chapter 2, which uses the phylopars function implemented in the R (Team, 2017) package 'Rphylopars' (Goolsby et al., 2017) to fill in gaps in the dataset. This function uses the existing data for species, a phylogeny, and a model of evolution (in our case models that perform Pagel's lambda transformation (Pagel, 1999) on the tree) to estimate the best linear predictions for missing data and ancestral states, maximising the log-likelihood of the covariance patterns in the original data (Goolsby et al., 2017). As in Chapter 2, we first performed our analyses without imputed values and then repeated the analyses several times, each time increasing the maximum number of imputed traits per species by one. To account for uncertainty in the imputed values we extracted the variances of estimates and generated normal distributions of each imputed trait for each species, and then we randomly sampled from these distributions to create 10,000 versions of the dataset for each level of imputation.

3.3.2 Data analysis

We first tested the association between body length and other traits by constructing pairwise phylogenetic generalised least squares (PGLS) models of each life history trait against body length, using the R package 'caper' (Orme et al., 2013). PGLS accounts for the non-independence of species' data due to shared evolutionary history and estimates λ, which functions as a measure of phylogenetic signal in the data (Pagel, 1999). Since the other life history traits show strong correlations with body size, and because under the strictest form of the fast-slow continuum the patterns of covariation between them should be robust to elimination of these effects, we then conducted analyses with body length factored out. For these we calculated the residuals of each life history trait with adult body length and then used PGLS to assess the relationships between the residual trait values.

Next, we used phylogenetic PCA (Revell, 2009) to take a multivariate approach to assessing insect life history traits associations. PCA represents multivariate data on a new set of axes, each representing composite variables, which explain the greatest amount of variance in the data (Jolliffe and Cadima, 2016). Standard PCA approaches assume that the data rows are independent of each other, which is not the case for comparative species data due to shared ancestry, so in a phylogenetic PCA the phylogenetic covariance of traits is used to calculate the principal component axes (Revell, 2009). We followed the approach outlined in Chapter 2 to conduct phylogenetic PCA while incorporating uncertainty from imputed values. Briefly, we calculated the phylogenetic covariance matrices using our phylogeny and each of the 10,000 versions of our dataset created from the imputed trait values and their variances; assured that the signs for the eigenvectors and loadings are oriented in the direction most representative of the original data vectors (as in Bro et al. (2008)); and resampled to produce bootstrapped estimates of eigenvectors, loadings and scores. We retained axes according to the Guttman-Kaiser criterion, where axes whose eigenvalue is greater than the mean of all eigenvalues are interpreted (Jolliffe and Cadima, 2016).

To assess the consistency of the principal components with differing levels of imputation, we used hierarchical clustering of the variable loadings based on euclidean distances. We followed this up using k-means clustering with a range of potential group sizes. If varying the amount of imputed data in the analysis does not greatly change the variable loadings, then these clustering methods should identify similar axes at each level of imputation and group them together. The results from these analyses are presented in Figure B.1 and Table B.3.

Some taxonomic groups are represented more than others in our life history dataset, particularly Orthoptera and Hymenoptera. To assure that our results were not driven primarily by the data in these groups, we resampled reducing the number of orthopterans and hymenopterans to match the numbers of hemipterans and coleopterans respectively. For this, the probability of a species being sampled was equal to the proportion of richness that the species' family makes up of the order, divided by the number of species in the dataset for that family. This approach means that large but poorly covered families are still represented in the resampled dataset. Results from these analyses are presented in Table B.4.

We took the scores along each of the retained principal component axes for each species and subjected them to further analysis to test for associations across orders, levels of metamorphosis, habitat media (terrestrial vs. aquatic realms), and diet types. For these analyses we used PGLS with scores along the principal components axes as the response variable, and each of our categorical traits of insects as the predictor. We present these results here as figures for easier interpretation, with the estimated score for each factor level and the standard error of the estimate taken from PGLS models, but the full models are available in Appendix B.

3.4 Results

We find little consistent evidence to support the idea of a 'fast-slow continuum' in insects using our data. All of the life history traits in our dataset showed a strong correlation with adult body length, and many had strong positive relationships with each other (Table 3.2). As a summary, larger species have larger eggs, take longer to develop, have longer adult lifespans, and, contrary to the predictions of the 'fast-slow continuum', larger clutches and higher lifetime fecundities. After accounting for the effects of adult body length we recovered some interesting correlations between the life history traits (Table 3.3). All of the traits relating to development time were strongly correlated with each other (note that some of these, i.e. hatching/egg to adult development time are autocorrelated with their component variables, but we present them here for the sake of completeness), species with longer egg stages have longer larval and pupal stages and so forth (Table 3.3). The development traits were not strongly correlated with either adult lifespan or traits related to fecundity, the exception to this being that small eggs were associated with short egg and larval development times (Table 3.3). Clutch size and lifetime fecundity were significantly positively correlated, species which lay more eggs in a clutch achieve higher lifetime fecundity. Egg length was unrelated to clutch size, yet species with smaller eggs had greater lifetime fecundity (Table 3.3). Adult lifespan showed few associations with the other life history traits, though long lived species had smaller clutches of eggs, and those eggs tend to be larger than in short lived species (Table 3.3) - both of which conform to the predictions of a ‘fast-slow continuum’.

The results of the PGLS analyses above (which are not based on imputed trait data) generally concur with the results of our phylogenetic PCAs even at the highest levels of imputation, so we present those PCA results here (Table 3.4; results from lower levels of imputation can be found in the Table B.2). Perhaps surprisingly, given its strong associations with all traits in the PGLS analyses (Table 3.2), adult body length was not strongly loaded on any of the retained principal components (Table 3.4). The most prominent axis of variation in the data, regardless of the level of imputation, was consistently a reproductive investment axis ranging from species with small clutches and low lifetime fecundity to large clutches and high lifetime fecundity (Table 3.4). This axis explained 29–41% of variance in our data, generally decreasing as the amount of imputation increases. PC2 was also strongly loaded only by clutch size and lifetime fecundity, but

Table 3.2 Covariation between (logged) life history traits, accounting for phylogeny. In the lower left triangle: values are the t-values from a PGLS models, with the column variable as the predictor and the row variable as the response; asterisks denote the level of significance with * < 0.05, ** < 0.01, *** < 0.001; sample sizes are in parentheses. In the upper right triangle: values are slopes and standard errors; R^2 values for the model are in parentheses. Abbreviations are as follows: adult body length (ABL), egg length (EL), egg development time (EDT), hatching to adult development time (HADT), nymph/larva development time (LDT), pupa development time (PDT), egg to adult development time (EADT), adult lifespan (AL), clutch size (CS), lifetime fecundity (LF).

	ABL	EL	EDT	HADT	NDT	PDT	EADT	AL	CS	LF
ABL		0.62±0.03 (0.33)	0.27±0.06 (0.03)	0.35±0.06 (0.06)	0.37±0.06 (0.06)	0.26±0.05 (0.07)	0.35±0.05 (0.10)	0.20±0.07 (0.01)	0.42±0.08 (0.04)	0.20±0.09 (0.01)
EL	18.93** (713)		0.11±0.06 (0.00)	0.16±0.05 (0.01)	0.12±0.06 (0.01)	0.18±0.04 (0.04)	0.14±0.05 (0.02)	0.33±0.06 (0.06)	0.08±0.08 (0.00)	-0.19±0.08 (0.01)
EDT	4.33*** (516)	1.93 (665)		0.27±0.03 (0.14)	0.31±0.03 (0.13)	0.21±0.03 (0.08)	0.37±0.02 (0.29)	-0.04±0.04 (0.00)	0.05±0.08 (0.00)	0.08±0.05 (0.00)
HADT	6.03*** (534)	3.07** (593)	10.60*** (683)		1.00±0.02 (0.78)	0.58±0.03 (0.42)	0.91±0.01 (0.90)	-0.00±0.05 (0.00)	0.12±0.09 (0.00)	0.09±0.08 (0.00)
LDT	5.95*** (573)	2.18* (649)	10.52*** (750)	55.87*** (888)		0.25±0.03 (0.13)	0.70±0.02 (0.76)	0.00±0.05 (0.00)	0.07±0.08 (0.00)	0.02±0.07 (0.00)
PDT	5.65*** (398)	4.42*** (475)	7.53*** (614)	20.78*** (597)	9.44*** (597)		0.64±0.03 (0.42)	-0.01±0.07 (0.00)	0.03±0.14 (0.00)	-0.11±0.10 (0.00)
EADT	7.00*** (451)	3.00** (486)	16.93*** (685)	76.99*** (668)	45.97*** (679)	20.77*** (600)		-0.06±0.06 (0.00)	0.15±0.11 (0.00)	0.04±0.08 (0.00)
AL	2.86** (480)	5.39*** (477)	-1.01 (529)	-0.09 (456)	0.09 (489)	-0.14 (432)	-1.04 (509)		-0.14±0.07 (0.01)	0.16±0.05 (0.02)
CS	4.90*** (490)	0.97 (498)	0.69 (384)	1.34 (352)	0.86 (390)	0.23 (263)	1.40 (323)	-1.94 (320)		0.45±0.05 (0.21)
LF	2.21* (361)	-2.30* (438)	1.67 (452)	1.04 (386)	0.31 (410)	-1.19 (359)	0.47 (423)	2.99** (476)	8.80*** (283)	

Table 3.3 Covariation between (logged) life history traits, after accounting for phylogeny and body length. In the lower left triangle: values are the t-values from a PGLS model of the linear residuals of each trait against body length; asterisks denote the level of significance with * < 0.05, ** < 0.01, *** < 0.001; sample sizes are in parentheses. In the upper right triangle: values are slopes and standard errors; R2 values for the model are in parentheses. Abbreviations follow Table 3.2.

	EL	EDT	HADT	NDT	PDT	EADT	AL	CS	LF
EL		-0.24±0.08 (0.02)	-0.05±0.08 (0.00)	-0.21±0.08 (0.01)	0.02±0.07 (0.00)	-0.10±0.07 (0.00)	0.34±0.09 (0.04)	-0.10±0.01 (0.00)	-0.72±0.13 (0.11)
EDT	-2.97** (399)		0.28±0.04 (0.13)	0.29±0.04 (0.09)	0.24±0.04 (0.09)	0.43±0.03 (0.34)	-0.08±0.05 (0.00)	0.14±0.09 (0.01)	-0.03±0.08 (0.00)
HADT	-0.57 (416)	7.81*** (387)		0.96±0.02 (0.74)	0.54±0.04 (0.39)	0.90±0.02 (0.89)	-0.02±0.07 (0.00)	-0.04±0.10 (0.00)	-0.17±0.13 (0.00)
LDT	2.77** (445)	6.71*** (421)	38.99*** (534)		0.19±0.04 (0.08)	0.67±0.02 (0.74)	0.00±0.006 (0.00)	-0.03±0.09 (0.00)	-0.00±0.11 (0.00)
PDT	0.30 (291)	5.94*** (329)	13.83*** (303)	5.31*** (303)		0.65±0.04 (0.41)	0.05±0.08 (0.00)	0.13±0.19 (0.00)	-0.25±0.14 (0.01)
EADT	-1.40 (306)	13.89*** (378)	55.45*** (368)	32.68*** (371)	14.73*** (312)		0.02±0.08 (0.00)	0.12±0.14 (0.00)	-0.12±0.13 (0.00)
AL	3.68*** (311)	-1.38 (334)	-0.25 (302)	0.02 (325)	0.57 (264)	0.22 (310)		-0.26±0.08 (0.04)	0.11±0.07 (0.00)
CS	-0.91 (317)	1.54 (223)	-0.43 (254)	-0.31 (279)	0.71 (165)	0.86 (210)	-3.12** (230)		0.36±0.07 (0.13)
LF	-5.59*** (240)	-0.32 (237)	-1.37 (216)	-0.02 (229)	-1.85 (182)	-0.89 (216)	1.44 (265)	5.35*** (182)	

this time in opposition – high values of PC2 indicated species that had small clutches but high lifetime fecundities (Table 3.4). Taken together these first two axes suggest that the predominant differences in insect life histories are a) how many offspring are produced per lifetime and per reproductive bout, and b) whether lifetime fecundity is spread over many or few reproductive bouts. PC3 was most strongly loaded by egg development time (Table 3.4), but the time from hatching to adult eclosion is also associated with these axes (particularly with less imputation; Table B.2), mirroring the results from the PGLS analyses. Finally, PC4 was strongly loaded by adult lifespan, and is therefore mostly independent of the other life history component axes (Table 3.4).

The order that an insect belongs to was a significant predictor of its score along the reproductive investment axes (PC1: F = 2.671, $p < 0.001$; PC2: F = 2.419, $p < 0.001$; Table B.5) and the axis representing mainly adult lifespan (PC4: F = 3.425, $p < 0.001$; Table B.5), but not its score along the development time

Table 3.4 Bootstrapped median loadings from a phylogenetic principal components analysis of insect life history data, imputed with a maximum of six missing values per species (results from lower levels of imputation can be found in Appendix B). Trait abbreviations follow Table 3.2. Significant loadings are in bold. %NA refers to the percentage of missing values for that particular trait. For this analysis n=2271 and λ=0.806.

Trait	PC1	PC2	PC3	PC4	%NA
ABL	0.209 (0.209, 0.210)	-0.038 (-0.039, -0.036)	0.165 (0.163, 0.167)	0.180 (0.180, 0.182)	42.08
EL	-0.005 (-0.006, -0.005)	-0.077 (-0.078, -0.076)	0.068 (0.066, 0.070)	0.268 (0.267, 0.269)	45.11
EDT	0.133 (0.132, 0.134)	0.030 (0.022, 0.037)	**0.907** (0.905, 0.911)	0.012 (0.010, 0.014)	57.17
HADT	0.082 (0.081, 0.083)	-0.046 (-0.049, -0.043)	-0.037 (-0.040, -0.033)	0.031 (0.029, 0.033)	60.83
AL	0.055 (0.054, 0.056)	0.226 (0.223, 0.228)	-0.037 (-0.040, -0.033)	**0.943** (0.943, 0.944)	61.62
CS	**0.770** (0.769, 0.771)	**-0.595** (-0.596, -0.593)	0.023 (0.017, 0.028)	0.069 (0.067, 0.070)	65.54
LF	**0.754** 0.753, 0.755)	**0.606** (0.605, 0.608)	-0.093 (-0.096, -0.089)	-0.133 (-0.135, -0.132)	67.39
% var.	28.56%	19.96%	18.41%	15.18%	

axis (PC3: F = 1.178, p = 0.254; Table B.5). Hymenoptera (wasps, bees, ants and sawflies) and Psocodea (lice, bark lice and book lice) on average scored low on PC1 (Figure 3.1), indicating low lifetime fecundity and small clutches, while Odonata (dragonflies and damselflies) and Ephemeroptera (mayflies) are at the other extreme (Figure 3.1). Megaloptera (alderflies and dobsonflies) and Trichoptera (caddisflies) had the lowest scores on PC2 (Figure 3.1), which represents large clutches relative to lifetime fecundity, while Zygentoma (silverfish and firebrats) and Siphonaptera (fleas) were at the other end of this axis (Figure 3.1). Siphonaptera and Diptera (true flies) had low scores on PC3, indicating fast development, and Archaeognatha (jumping bristletails) and Phasmida (stick and leaf insects) were located at the other extreme (Figure 3.1). Unsurprisingly, Ephemeroptera (mayflies), well known for their brief adult lives, had much lower scores on PC4, the adult lifespan axis, than any other group, with Trichoptera the next lowest. Zygentoma had high scores on PC4, as did groups such as Phasmida and Dermaptera (earwigs) (Figure 3.1).

The scores along our principal component axes were largely unrelated to their form of metamorphosis (PC1: F = 0.457, p = 0.633; PC2: F = 1.748, p = 0.174; PC3: F = 0.823, p = 0.439; Figure 3.2). Type of metamorphosis was however a significant predictor of scores along the adult lifespan axis (PC4: F = 4.063, p = 0.017): the basal insects (and their close hexapod relatives) lacking metamorphosis had significantly longer lifespans than the remainder of the class (Figure 3.2). Separate PCAs of the Holometabola and the Hemimetabola showed some differences between these groups (Table 3.5). The Holometabola show a similar pattern of axes to the overall analysis, with clutch size and lifetime fecundity being strongly loaded on the first axis, a second axis with these same traits but opposing each other, and a third axis denoting survival or development time (Table 3.5). In the Hemimetabola the first axis of variation is instead strongly influenced by the rate of development, and the second is strongly influenced by

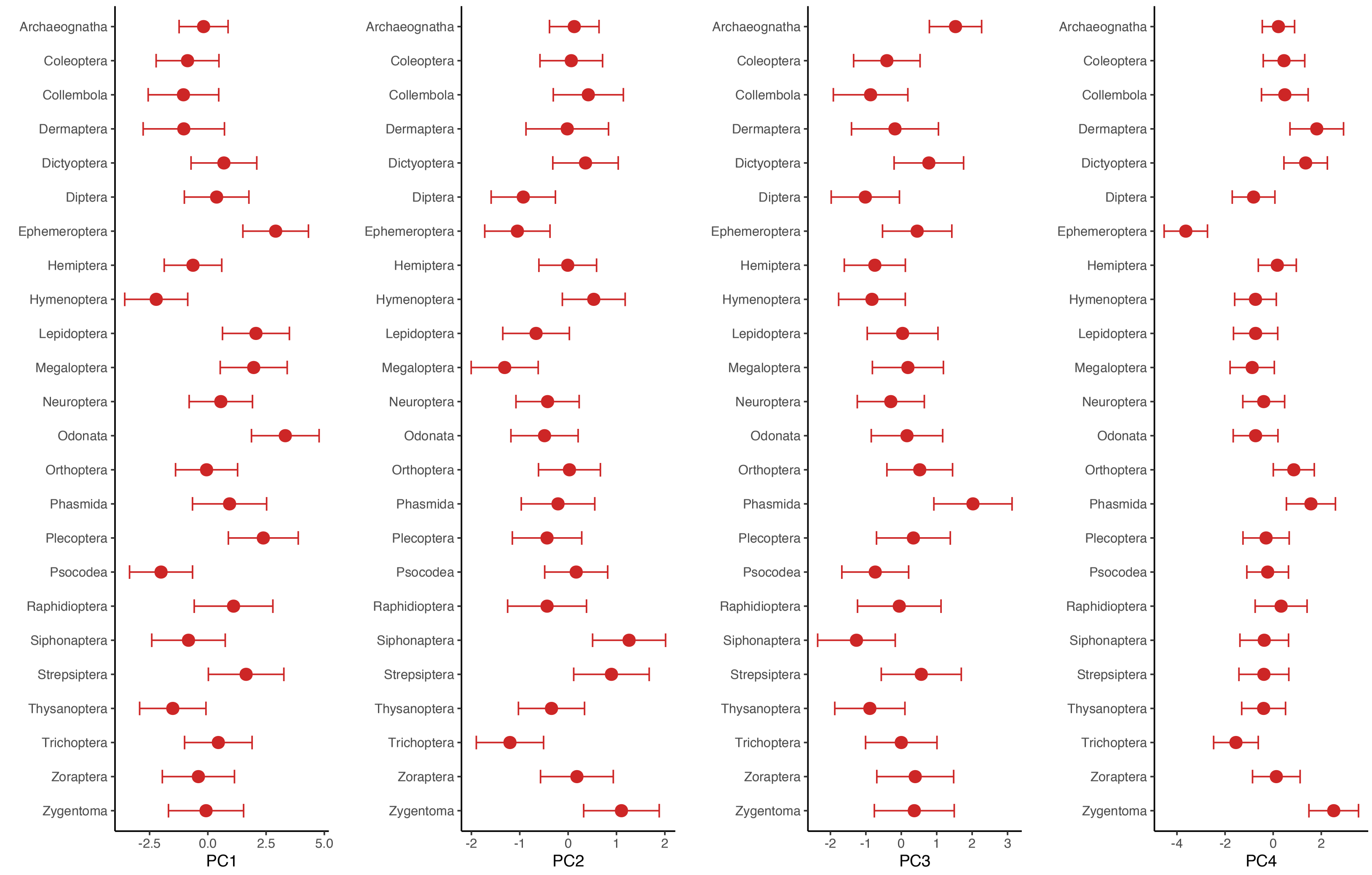


Fig. 3.1 Estimates and standard errors from PGLS models of the phylogenetic principal component scores of each order of insects (Table B.5)

clutch size and lifetime fecundity. Interestingly, body size figures on this fecundity axis in the Hemimetabola but not the Holometabola (Table 3.5), indicating the possibility that reproductive success is more strongly tied to adult size in the former than in the latter.

After accounting for shared ancestry, we found no significant difference between aquatic and terrestrial species on any of the principal component axes (PC1: F = 3.448, p = 0.063; PC2: F = 1.120, p = 0.290; PC3: F = 0.537, p = 0.464; PC4: F = 0.260, p = 0.610; Figure 3.3; Table B.6). The aquatic species appeared to occupy a more narrowly restricted range of values on the axes than non-aquatic species (e.g. generally being towards the higher end of the clutch size and lifetime fecundity axis, PC1; Figure 3.3), but whether this is an artefact of the differences in species richness is unclear. PGLS analyses suggested that species with an aquatic life stage have significantly smaller eggs (t = -2.167, p = 0.030) and shorter

Table 3.5 Bootstrapped median loadings from a phylogenetic principal components analyses of holometabolous and hemimetabolous insect life history data. Imputed with a maximum of six missing values per species (results with less imputation can be found in Appendix B). Trait abbreviations follow Table 3.2, significant loadings are indicated in bold. For the holometabola n=1424 and λ=0.730, for the hemimetabola n=986 and λ=0.881.

	Holometabola			Hemimetabola	
Trait	PC1	PC2	PC3	PC1	PC2
ABL	0.103 (0.103, 0.104)	-0.013 (-0.014, -0.012)	0.027 (0.012, 0.042)	0.243 (0.243, 0.244)	0.396 (0.395, 0.397)
EL	-0.048 (-0.049, -0.047)	-0.112 (-0.113, -0.111)	0.220 (0.199, 0.256)	0.128 (0.127, 0.128)	0.125 (0.124, 0.126)
EDT	0.087 (0.085, 0.088)	0.071 (0.068, 0.072)	-0.166 (-0.174, -0.159)	**0.977** (0.977, 0.977)	-0.172 (-0.174, -0.171)
HADT	0.056 (0.055, 0.057)	-0.051 (-0.053, -0.050)	-0.166 (-0.174, -0.159)	0.358 (0.358, 0.359)	-0.014 (-0.016, -0.013)
AL	-0.003 (-0.005, -0.002)	0.216 (0.213, 0.218)	**0.633** (0.576, 0.710)	-0.009 (-0.011, -0.009)	0.181 (0.179, 0.183)
CS	**0.866** (0.865, 0.867)	**-0.471** (-0.469, -0.472)	0.018 (0.014, 0.021)	0.257 (0.256, 0.259)	**0.675** (0.674, 0.677)
LF	**0.615** (0.613, 0.616)	**0.754** (0.752, 0.755)	-0.009 (-0.014, -0.003)	0.178 (0.176, 0.180)	**0.855** (0.854, 0.856)
% var.	30.06%	21.80%	15.15%	38.06%	22.74%

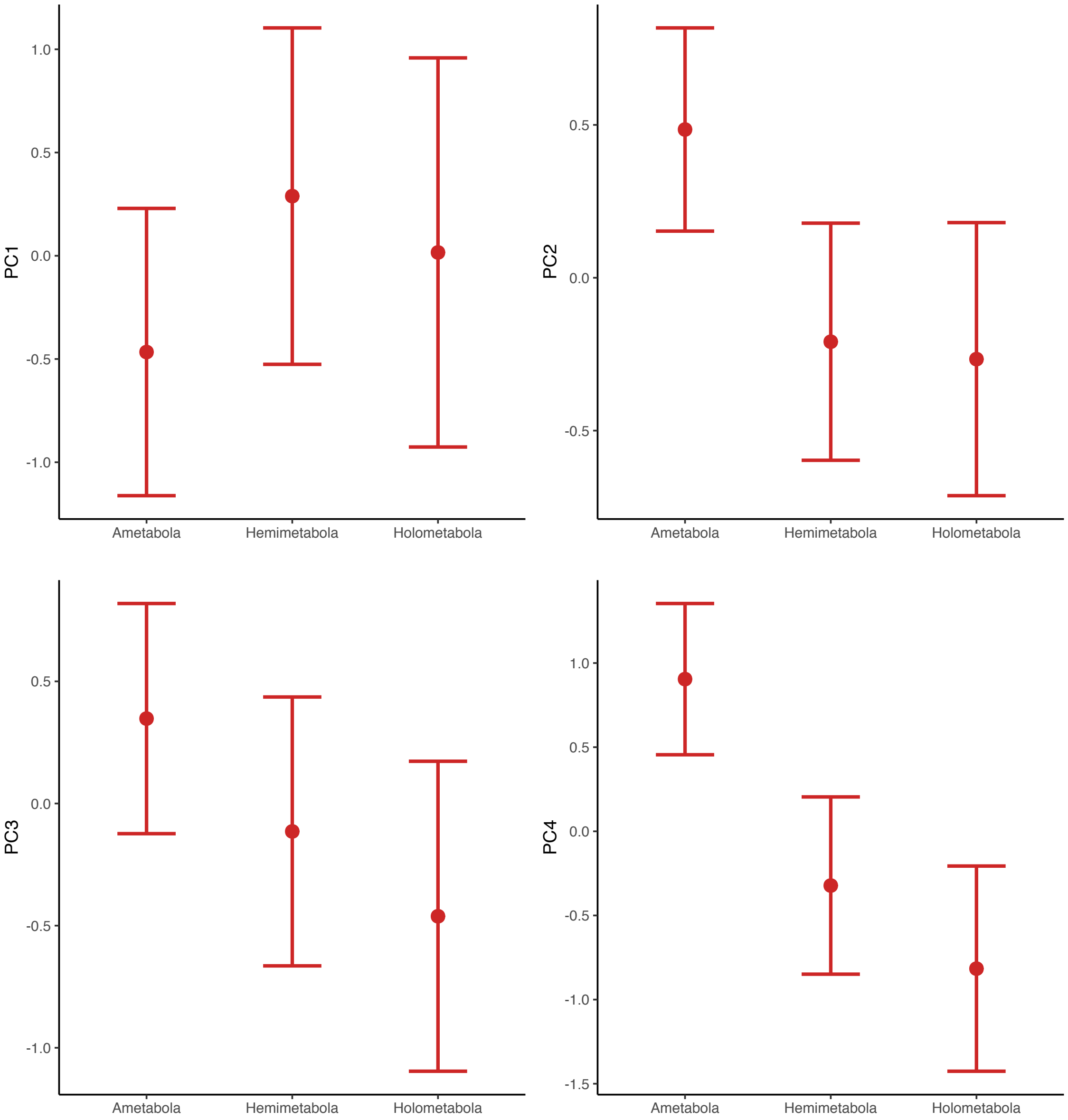


Fig. 3.2 Estimates and standard errors from PGLS models of the principal component scores of insects according to their form of metamorphosis (Table B.6).

pupal periods (t = -3.429, $p < 0.001$), but there was no significant difference in any of the other traits.

There was overall a strong effect of diet on some of the principal component axes. Larval diet appeared to influence the overall level of reproductive investment (PC1: F = 3.181, p = 0.008), but not how that investment is balanced between clutch size and lifetime fecundity (PC2: F = 1.013, p = 0.409). We note that the only dietary type with significantly different scores along PC1 is parasitoidism,

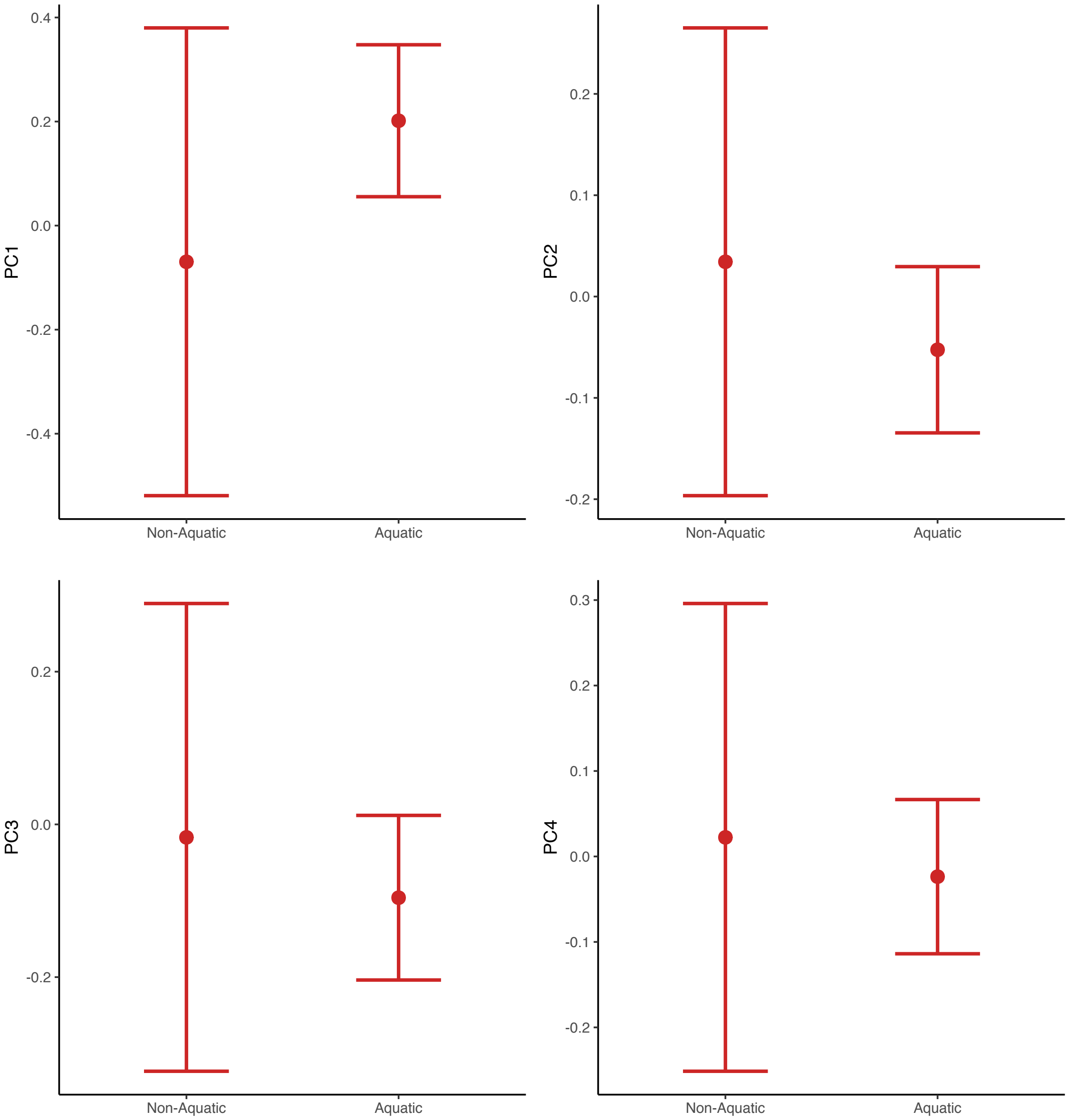


Fig. 3.3 Estimates and standard errors from PGLS models of the principal component scores of insects from different habitat media (Table B.7).

which was related to lower clutch size and lifetime fecundity (Figure 3.4). Adult diet does not have a significant effect on either of these axes (PC1: F = 1.818, $p = 0.093$; PC2: F = 1.084, $p = 0.369$). Both larval and adult diet were significant predictors of scores along PC3, the development time axis, (larval: F = 8.214, $p < 0.001$; adult: F = 3.464, $p = 0.002$). The only significant difference in the larval dataset was again between parasitoids and species with other types of diet, where parasitoids have shorter development times (Figure 3.4), and while there was more variation between adult diet types liquid feeders had the lowest scores overall (Figure 3.5). Larval and adult diet were also both significant predictors of species' positions along the adult lifespan axis, PC4 (larval: F = 2.440, p = 0.033; adult: F = 4.548, p < 0.001). Species that are parasitoids as larvae have significantly shorter adult lifespans, and those that are ecto-parasites as larvae have significantly longer adult lifespans, than species with other dietary types (Figure 3.4). Non-feeding adults have the shortest adult lifespans, and species that feed only on liquid diets as adults also have significantly shorter lifespans than those feeding on most other substrates (Figure 3.5).

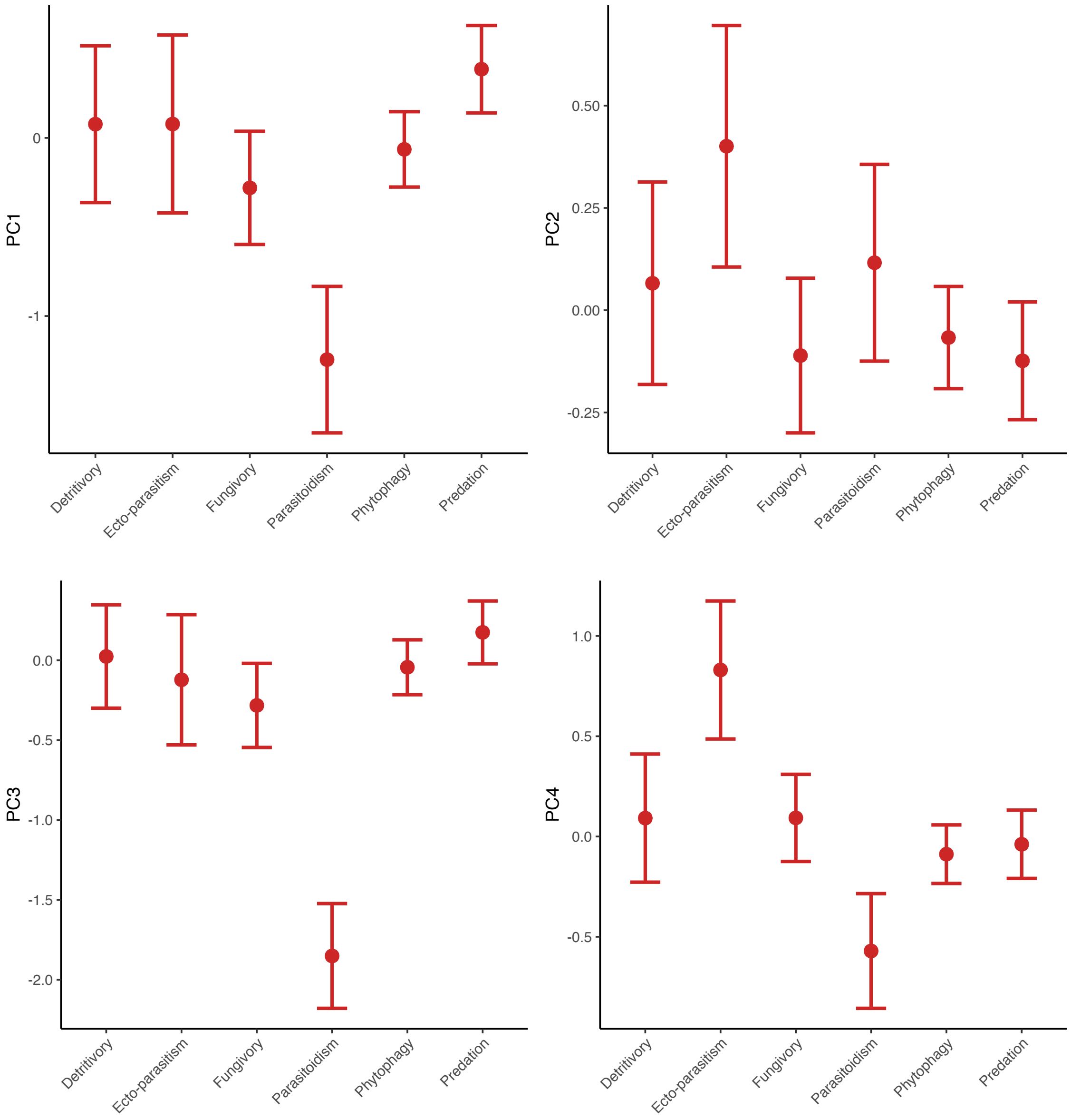


Fig. 3.4 Estimates and standard errors from PGLS models of the principal component scores of insects according to their larval diet (Table B.8).

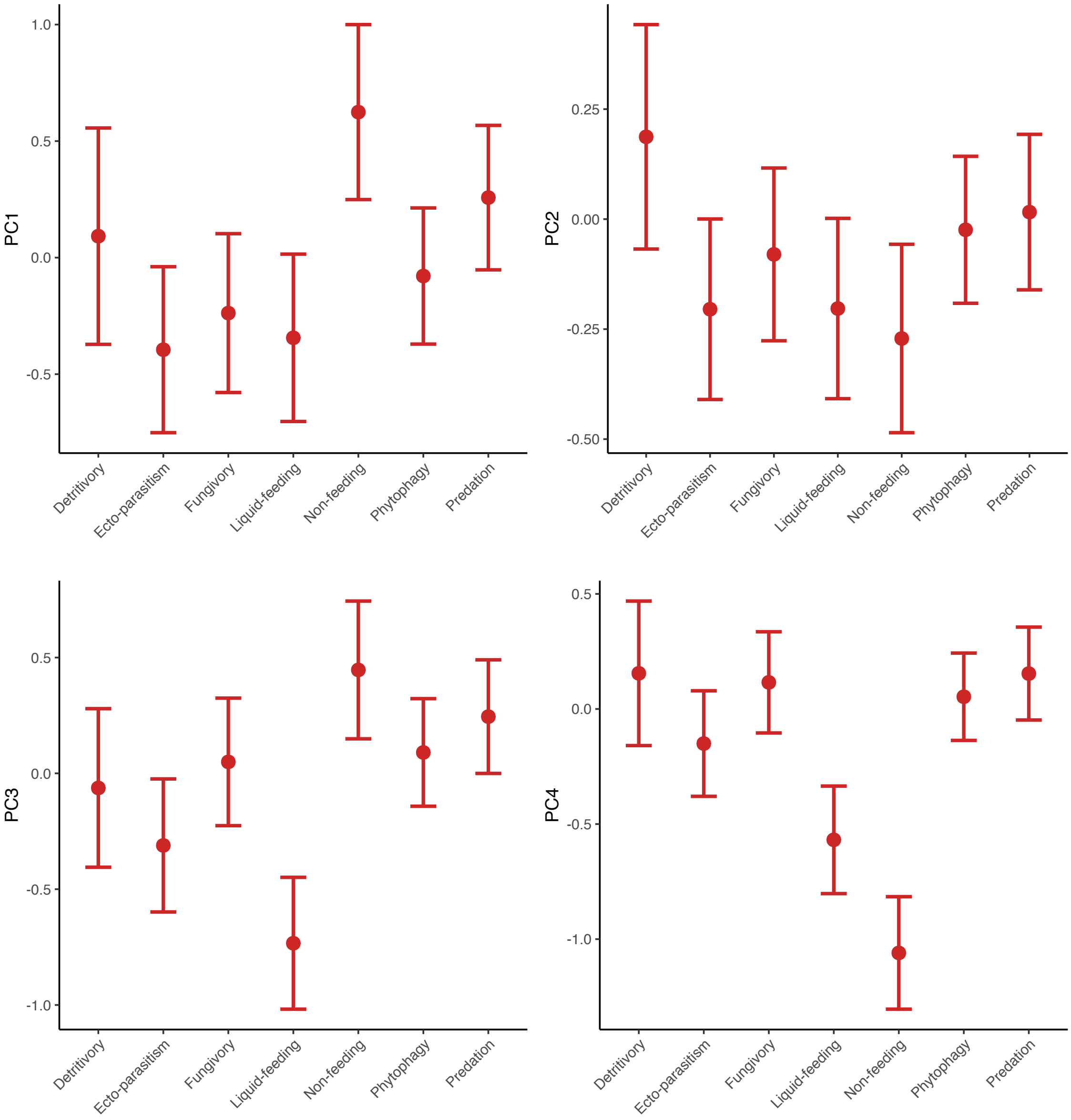


Fig. 3.5 Estimates and standard errors from PGLS models of the principal component scores of insects according to adult diet (Table B.9).

3.5 Discussion

Many studies have found evidence supporting the idea of covariation in life history traits leading to a 'fast-slow continuum', and though the breadth of these studies is ever increasing (Healy et al., 2019) insects have remained largely understudied compared to other groups, due in a large part to incomplete trait data (Mayhew, 2016). Without knowledge on how traits associate in hyperdiverse groups, like the insects, our understanding of life history evolution cannot be complete or representative. Here we developed a taxonomically broad dataset of multiple key life history traits for insects and tested for their covariation, and also used phylogenetic imputation to enrich our dataset and test associations at a large scale using multivariate methods. Our results show that some of the expected patterns of 'fast-slow' variation, particularly those evidencing trade-offs between growth, survival, and reproduction, may not be applicable to insects at broad taxonomic scales, and we show that trait covariation differs between orders. Finally, we find evidence suggesting that diet, and to some extent metamorphosis, but not broad habitat medium influence life histories in insects.

Across insects, the major axes of variation appear to be related to how many offspring are produced at one time and over the full course of life. A large amount of variation (almost 50%; Table 3.3) is explained by axes only significantly loaded by clutch size and lifetime fecundity. This suggests that the main way that insect life histories differ from each other is in whether species lay many or few eggs, and whether they lay them in large or small batches.

Neither of the other axes that we retain contain the characteristic patterns of the 'fast-slow continuum' either. PC3 differentiates slow and fast developing species, but it is unrelated to other traits which life history theory would predict these traits to be correlated with. Similarly, PC4 differentiates the short from the long lived, but again this appears unrelated to most other traits. Our PGLS analyses (Table 3.3), which do not use imputed data, largely confirm these weak associations. Life history theory predicts that age at maturity is a major trait correlated with other aspects of life history: species that can afford to mature later can mature at a larger size, and thus invest more resources in survival and reproduction (Stearns, 1992, Charlesworth, 1994). Hatching (or egg) to adult development time represents this trait in our dataset, and species that take longer to mature indeed have larger adult stages (Table 3.2), but after accounting for body size and phylogeny we find none of the other predicted patterns.

Body size was positively correlated with all of our other life history traits in the PGLS analyses (Table 3.2), yet it did not load significantly on any of the principal component axes. Body size undoubtedly constrains the potential values of other traits: an insect cannot, for example, mature a clutch of eggs the volume of which is greater than their own body volume. Our measure of body size, length, is imperfect given that insect taxa that can vary in other size dimensions so much (e.g. stick insects vs. weta), though across the full dataset it varied over several orders of magnitude and is a highly significant predictor in our PGLS models. Body mass may have been a more appropriate measure to use, and it figures centrally in life history models, but unfortunately this information is rarely reported for insects. Some of the patterns that could be interpreted as 'fast-slow' covariation in the results not accounting for body length – for example, larger offspring (eggs) being associated with longer periods of development (Table 3.2) – are reversed when allometric effects are removed (Table 3.3). Meanwhile some of the patterns that are contrary to the 'fast-slow continuum' in the raw data (e.g. the positive relationship between clutch size and lifetime fecundity) remain in evidence after accounting for the effects of body length (Table 3.3). All this suggests that body length does perform adequately as a size measure for our purposes.

We failed to recover significant differences along any of the principal component axes between hemi- and holometabolous species. However, ametabolous species have significantly higher scores on PC4, signifying greater longevity (Figure 3.2). The ametabolous species (including primitive wingless insects, and closely related non-insect hexapods) do not undergo metamorphosis. Instead, they continue to moult and grow during life (Belles, 2011), and so continue to have to allocate resources competitively to growth, maintenance and reproduction throughout their lifetimes. Although the differences are not significant, they also appear to grow more slowly, and be less fecund than the hemi- and holometabolous groups (Figure 3.2), which may be a reflection of the constraints required to evolve determinate growth (Charnov, 2001).

After accounting for phylogeny, we found no clear evidence of differences in the life history traits of aquatic and non-aquatic species. The binary system that we used to classify species is coarse, and it is possible that more subtle differences have been masked by this. Not all terrestrial and aquatic habitats are equal, even if aquatic ones tend to be more stable because of differences between primary producers (Shurin et al., 2006). A mosquito larva developing in a water-filled tree hole is aquatic, but its environment is inherently ephemeral, as are the habitats of many insects developing in small bodies of water. Freshwater habitats are clearly heterogenous in terms of connectivity and permanence; seasonality drives changes in their extent, with some becoming completely dry for periods, separating and reconnecting wetlands (Dijkstra et al., 2014). Thus, to expect broad patterns to result from such a simple definition is perhaps naïve, though other studies have found or suggested differences before. Similarly, insects inhabit most of the terrestrial biomes on Earth (including deserts and the polar regions), which differ greatly in their environmental stability and the amount of resources that they contain.

Nevertheless, the return to water for insects appears in many cases to have converged on a particular type of life history – high fecundity, with large clutches, and shorter adult lifespans (Figure 3.3) – even if this strategy is not universal amongst aquatic taxa nor unavailable to non-aquatic taxa. Although this result is not significant it is similar to previous results showing that aquatic taxa form a 'faster' subset of terrestrial combinations of life history traits (Capdevila et al., 2020), despite this study containing only a small number of arthropods. Interestingly, among just the animals, Capdevila et al. (2020) also find no significant difference in species' pace-of-life, but do find aquatic animals are closer to iteroparity than their terrestrial counterparts. Figure 3.3 perhaps hints of a similar trend here. It would be interesting to further investigate these patterns in the future using a finer grade of habitat types, with particular reference to features such as stability, to test the diverse predictions of life history theory (Morris et al., 2008, Engen and Sæther, 2016, Lande et al., 2017).

While we find no significant effects of habitat, the other aspect of ecology that we consider, diet, shows more promising links to life history. Ecological traits can be subdivided into alpha niche traits, those related to how resources are utilised at a local level, and beta niche traits, those related to large-scale distribution (Wiens, 2017). Using these definitions diet is an alpha niche trait, whereas habitat medium is a beta niche trait. We may speculate, given the caveats related to our habitat analyses listed above, that alpha niche traits have more effect on life histories than beta niche traits, but such a conclusion requires broader testing using other ecological traits and other taxa.

Though we have shown that diet is a significant predictor of life histories in insects, the only group which consistently shows differences is the parasitoids. These have low fecundity (PC1), fast development (PC3) and short adult lifespans (PC4) compared to other types of larval diets. As adults most Hymenoptera, and parasitoids are largely represented by wasps in our dataset, are liquid feeding

(Krenn et al., 2005), which explains some of the matching patterns between Figure 3.4 and Figure 3.5 (though there is considerably more taxonomic diversity represented in the liquid feeding category than in the parasioid category). The parasitoids have in common that they develop by feeding on a single host (Quicke, 1997), and so the environment of juvenile parasitoids is broadly uniform across taxa (Blackburn, 1991b). Considering the peculiarities of the parasitoid life cycle, that it has to develop inside of a host, and share the limited resources which that host has to offer with any other developing larvae, it is unsurprising that they have low fecundity and fast development when compared to other insect taxa. More curious is why parasitoids should have shorter adult lifespans than species with other types of diet (Figure 3.4). It could be simply that the act of finding and attacking hosts to lay eggs in is inherently risky, and that lifespans have been shortened as a result of these risks. Some adult parasitoids (especially specialist species) are unable to synthesise and accumulate lipids; they acquire lipids from their host as larvae but do not form fat themselves leaving them with limited reserves (Visser et al., 2010). These fat reserves have to be competitively invested in survival or reproduction, and excessive investment toward a longer lifespan (e.g. making fat bodies) would leave species without eggs for the later part of their lives (Pexton and Mayhew, 2002). At the opposite end of the adult lifespan axis to parasitoids, species that are ecto-parasitic as larvae (i.e. feeding on blood, flesh, etc.) have longer adult lifespans than species with other types of diets (Figure 3.4). Perhaps this reflects the time required to disperse between hosts, particularly in groups with less mobile adults (e.g. flightless species). However species that are ecto-parasites as adults do not seem to have particularly longer lifespans (Figure 3.5).

We are aware that the diversity of species in this dataset does not approach the full diversity of insects. There is perhaps an overrepresentation of Hymenoptera and Orthoptera, both groups with a good deal of life history data already collated into datasets, but we have shown the results of our analyses to be mostly robust to these by resampling with fewer representatives of these groups (Table B.4). Besides that, there is good reason to believe that the Hymenoptera are in fact more species rich than even beetles, but that many of these species are as yet undescribed (Forbes et al., 2018). We have endeavoured to increase the taxonomic scope of the analyses presented here by using a phylogenetic imputation method to predict the missing elements of species' life histories where there is some data available. Though these results must be treated with a degree of caution, for the most part they agree well with our PGLS analyses that do not rely on imputed data. Furthermore, the scores which the various orders of insects received along our principal component axes, even with maximal imputation, largely conform to the accepted notions of each groups' life history (Grimaldi and Engel, 2005).

In conclusion, we have investigated patterns of covariation between the life history traits of insects and found little positive evidence for a strong 'fast-slow continuum'. The main ways that the life history of insects differ are in a) the amount of reproductive investment, and b) how to delimit that investment over reproductive bouts. We find no strong evidence of covariation between development times, lifespan, and reproductive traits. Hemi- and holometabolous species largely overlap in terms of their life histories, but the more primitive ametabolous species have more distinct strategies with longer lifespans. We find no significant differences in life histories between species that are aquatic and compared to those that are terrestrial, but diet, and particularly the parasitoid habit, appears to influence species along most of the main axes of variation in life history. Future challenges include understanding how traits that are so intricately coupled in some other organisms can apparently evolve more independently in insects, what selective pressures underpin the variation seen, and what consequences this variation has for applied ecological problems.

Chapter 4

High fecundity and rapid development increase richness and diversification rate in insects

4.1 Abstract

Many authors have speculated that variation in the fundamental life history traits, such as age at maturity, fecundity and lifespan, may explain variation in species richness across taxa. However, empirical evidence for this has been mixed. Here we use a large novel dataset on life history traits across the insects to assess to what extent life history variation explains species richness and diversification rate at the order and family level. We find that, after accounting for important key innovations such as wings, metamorphosis and herbivory, species richness is significantly higher in families and orders with rapid development, and is higher in families with higher fecundity. Similarly, diversification rate is higher in families with higher lifetime fecundity and rapid development. The proportion variance explained by these traits is always low. Nonetheless these trends mirror those predicted by several population-level processes affecting speciation and extinction rates across a range of taxa, and suggest that life history traits will contribute to an overall understanding of past and current macroevolutionary change.

4.2 Introduction

Taxa vary greatly in the number of species that they contain, and this leads to an uneven distribution of species richness across the tree of life (Mooers and Heard, 1997, Purvis and Agapow, 2002). Understanding the causes of this imbalanced diversity remains a major challenge in biology, especially given the pace of species losses due to anthropogenic climate change. Many authors have suggested that particular lineages have a higher probability of diversifying by virtue of the traits that they have evolved (Cracraft, 1982). One approach has been to evaluate idiosyncratic 'key innovations' in speciose taxa (e.g. the evolution of flight in bats, toe pad evolution in anole lizards). However, evidence that such traits have consistent effects on diversification rates at higher taxonomic levels is scant, whilst the ubiquity of imbalance in species richness across the tree of life has led authors to seek more generalisable explanations of diversity (Marzluff and Dial, 1991).

Another approach has been using life history models of diversification, and these have had mixed success overall. In their analysis of the effect of life history on diversification, Marzluff and Dial (1991) showed that highly diverse taxa were characterised by species with short generation times (early reproduction and short lifespans) in addition to those with high mobility and resource availability. Similarly, short gestation times in carnivores (Mammalia: Carnivora) are correlated with high species richness (Isaac et al., 2005), as are short turnover times among trees in the Amazon rainforest (Baker et al., 2014). In Australian mammals litter size correlates with species richness, but other life history traits including age at first reproduction and body size were not correlated (Cardillo et al., 2003, Isaac et al., 2005). Studies in other taxonomic groups show no association between life history and diversity, including studies on birds (Owens et al., 1999), agamid lizards (Stuart-Fox and Owens, 2003), polychaetae annelids (McHugh and Fong, 2002), and hoverflies (Katzourakis et al., 2001) – although the life history traits tested vary across studies, and multiple life history traits are only rarely tested together. Cardillo et al. (2003), who found mixed support for the life history hypothesis, suggest that diversification rate is not elevated by overall life history strategy, rather that particular aspects of life history are important in different lineages while others have little effect – which highlights the need to rigorously test life history variables for relationships with diversity across a range of taxa.

The insects contain some of Earth’s most hyperdiverse lineages; more than half of the species currently described to science are insects (Mora et al., 2011). From their origins as primitive wingless creatures, similar to today’s Zygentoma (silverfish and firebrats), they have undergone a vast adaptive radiation to become arguably the most successful group of extant organisms (Resh and Cardé, 2009). Several hypotheses have been proposed to explain why insects have been able to reach such tremendous species richness, including: the adaptability of the arthropod body plan; that they were among the first animal groups to transition from aquatic environments to land, where there were many unfilled niches; small size allowing for high carrying capacities and the subdivision of niches; their intricate coevolution with plants; the evolution of the insect wing and flight; and the evolution of complete metamorphosis (Wiens et al., 2015, Ferns and Jervis, 2016, Mayhew, 2018). Some of these factors are common to all arthropods, which are themselves the most species-rich animal phylum, and some of them are adaptations within the insect lineage ratcheting diversification even higher. The final three of these factors (wings, herbivory and metamorphosis) have been shown to explain a large amount of variance (50-60% depending on the phylogeny used in the analysis; Wiens et al. (2015)) in diversification rates across orders of insects, although the relative importance of these factors and the causal mechanisms for their effects on diversification remain debated (Nicholson et al., 2014, Rainford et al., 2014, 2016).

The mechanisms and evidence for how adaptations such as these may influence diversification rates and raise species richness have been discussed in several reviews (e.g. Mayhew, 2007, Mayhew, 2018), but we will briefly explain the rationale here. Wings enhance dispersal ability, and so may allow the colonization of new geographic regions and increase the number of niches available for exploitation, which would increase speciation rate. The transition from the ancestral Palaeopteran-like wings to folding wings then allowed them to exploit concealed niches as adults without incurring wing damage. The dispersal ability conferred by wings may also decrease extinction rates by increasing metapopulation persistence (Mayhew, 2007). Plants offer an enormous amount of biomass as food, which offers potential high population and species carrying capacity to any organisms that can consume them, whilst conversely feeding on plants has allowed insects to exploit very specialised niches (Nyman, 2010, Wiens et al., 2015). The evolution of a pupal stage between the larval and adult forms (holometaboly) has led to more specialised life histories in each of the stages (Rolff et al., 2019), and some authors have argued a more 'efficient' life history. Over evolutionary time, the main function of the larval stages has become feeding and growth, while the adults have become specialised in dispersal and reproduction (Istock, 1967). For some species holometaboly has led to the consumption of different food sources between the larvae and adults, and in some species the adults have totally lost the ability to feed. This differential specialisation between juvenile and adult forms has been suggested to increase speciation rates by some authors (Truman and Riddiford, 1999). In addition to allowing the transformation from larval to adult forms pupae are often robust stages to overwinter or outlast unfavourable conditions, and so the evolution of the metamorphosis may reduce extinction rates through this mechanism.

In addition to the traits discussed above, several other traits have been hypothesized to explain species richness variation in insects. Life history traits such as age at maturity, fecundity and lifespan describe the way an organism grows, develops, reproduces and when it can expect to die, and are intimately connected to fitness. There are intuitive links between life history and diversification, which may be able to explain some of the observed patterns of species richness (Marzluff and Dial, 1991). A common observation is that species most prone to extinction share low reproductive rates and long generation times, while on the other hand species with high reproductive rates and short generation times have been shown to be more effective at colonising and establishing in new geographic ranges (as invasive species). These links suggest an influence on life history and ecology on diversity and diversification dynamics.

In comparing insects to many other macroscopic taxa, most would fall at the 'fast' end of a fast-slow continuum (species mature and begin reproducing quickly, produce small offspring at a fast rate, and have low longevity) of life histories (Chapter 2), but within the class there is a considerable amount of variation (Chapter 3). A faster life history, with production of large numbers of eggs, could imply a greater potential to generate novel genetic variation compared to taxa with slower life histories. This might allow rapid adaptation to environmental conditions, and rapid reproductive isolation between incipient species. The fast rates of evolution and population growth in taxa with fast life histories likely makes them better able to cope with harsh or changing environmental conditions, allowing them to have higher speciation rates and/or lower extinction rates than their 'slow' counterparts (Marzluff and Dial, 1991).

Here we use a taxonomically broad dataset of insect life history traits, containing data for over 3500 insect species to test the associations between life histories, species richness and diversification rate. Using previously generated phylogenetic principal components scores which represent insect life histories across several dimensions we test for relationships between life history strategy and species richness, while controlling for herbivory, wings, and metamorphosis, which previous authors have identified as strong potential predictors of diversity. We use PGLS models for this purpose, which allow us to test for relationships between traits while accounting for the non-independence of lineages due to shared ancestry (Harvey and Pagel, 1991) - and generate λ values for each model indicating phylogenetic signal, or how closely the phylogeny predicts the model residuals. After identifying life history traits that may have correlate with species richness/diversification rate using the phylogenetic principal component scores we follow up with tests of the individual traits to produce an overall picture of how life history traits are related to diversification in insects.

4.3 Methods

4.3.1 Data collection

Our analyses utilised a taxonomically broad life history dataset for insects, which contains some trait information for 3604 species from across the globe, from 372 different families. This is the same dataset outlined in Chapter 3, and is available in Appendix D. In these analyses we use the following variables: adult body length (excluding ovipositor and antennae; mm), egg size (at longest/widest part of the egg; mm), egg development time (time from laying to hatching; days), nymph development time (for hemimetabolous species, time from egg eclosion to eclosion of the adult stage; days), larval development time (for holometabolous species, from egg eclosion to formation of the pre-pupa; days), pupal development time (for holometabolous species, time from pupation to adult eclosion; days), adult lifespan (time from adult ecolsion to death; days), clutch size (number of eggs laid in a single mass/bout of laying), and lifetime fecundity (total eggs laid over a female's life).

Chapter 3 presented phylogenetic principal components analyses using this dataset to find the most important axes of variation in the insect life history data. The four axes extracted were, in order of decreasing variance explained: a reproductive investment axis (PC1: + clutch size, + lifetime fecundity), an axis describing how lifetime fecundity is spread across reproductive bouts (PC2: − clutch size, + lifetime fecundity), a development time axis (PC3: + egg development time, + hatching to adult development time), and an adult lifespan axis (PC4: + adult lifespan). Here we extract the scores for each species across each of these axes and calculate the mean score for each axis in each order/family.

We classified orders and families for which we had data into binary groups representing the presence of wings, herbivory, and metamorphosis, according to a range of published literature sources (Resh and Cardé, 2009, Rainford et al., 2014, Rainford and Mayhew, 2015)(Appendix D). As in Chapter 3, herbivory (phytophagy) was defined following Rainford and Mayhew (2015) as taxa which feed on living plant material, including vegetative parts, roots, wood and seeds, but not decaying plant matter. Since we had already previously classified species according to diets in Chapter 3, and these are the species representing the families in this analysis, we used these classifications. Where there is considerable variety within orders/families for these traits (particularly herbivory), we scored these taxa differently in two separate datasets first as herbivorous and then as non-herbivorous, but our results remain largely robust to these reclassifications.

We took the species richness of each of the insect orders and families in our dataset as the number of described species in Catalogue of Life (Roskov et al., 2019), and log transformed those numbers prior to analysis. To estimate diversification rates for each family, we used the stem group ages from Rainford et al. (2014), the species richness' from Catalogue of Life, and the well-established methods-of-moments estimator (Magallón and Sanderson, 2001). This method uses the richness of a group and its age along with the ratio of speciation to extinction to produce an estimate of net diversification rate. Following previous authors (e.g. Wiens et al. 2015, Varga et al. 2019), we used three ratios of speciation to extinction, effectively creating no-extinction ($\epsilon = 0$), moderate ($\epsilon = 0.5$), and high extinction ($\epsilon = 0.9$) scenarios.

4.3.2 Data analysis

We constructed phylogenetic generalised least squares (PGLS) models in R (Team, 2017) using the package 'caper' (Orme et al., 2013) to test for relationships between life histories and species richness/diversification rates. This is important because at least some similarity in trait values can be attributed to shared ancestry over adaptation (Harvey and Pagel, 1991). PGLS estimates the parameter λ, which varies between 0 and 1 and describes how strongly the phylogeny predicts the pattern in the model residuals and thus functions as a measure of phylogenetic signal. We conducted PGLS analyses of our data using the family-level insect phylogeny of Rainford et al. (2014), and trimmed this tree to produce an appropriate phylogeny for order-level analyses. In each of our models the response variable was either the species richness of the order/family, or the diversification rate of the order/family which we calculated as described above.

Firstly, we used the scores from the phylogenetic principal components analyses described above as a predictor, along with our binary variables (wings, herbivory, and metamorphosis), with full interactions. However, none of the interactions significantly improved the fit of our models, and so we do not present them here but present the 'full' model as that without any interactions. We then created reduced models by stepwise deletion of non-significant predictors starting with that with the highest p-value (Crawley, 2005). We then examined these results and used them to select candidate life history traits which may have an effect on diversification, and then replaced the principal components scores with these traits.

Since there are a large number of hypothesis tests in this study, we alter the alpha significance level for our tests using the False Detection Rate (FDR) control test described by Benjamini and Hochberg (1995). The FDR method evaluates the proportion of type I errors across all significant results, and has lower type II error rates than the commonly used Bonferroni correction, even with a high number of tests (Verhoeven et al., 2005). We evaluate the effect of the life history trait by conducting a likelihood ratio test between the simplest model containing the life history trait, and the next simplest model (with the life history trait dropped from the model).

4.4 Results

Our results show that some of the variance in species richness and diversification rates across the insects can be explained by the life history model of diversification, although a large amount of variance remains unexplained even in our best models.

4.4.1 Species richness

At an order level, we find no evidence of a relationship between life history and species richness for the majority of variables tested (Table 4.1). However, the development time axis from the principal components analysis (PC3) remains highly significant in a model also including the presence of wings and herbivory. Similarly, the average egg to adult development time of orders is a significant predictor of order level diversity (this time with only wings in the model; Table 4.1). However, after applying the False Detection Rate control test this result does not pass the alpha-level of significance. Both of these results suggest that, accounting for the higher richness observed in winged and/or herbivorous taxa, orders in which the pre-adult stages are shortened achieve higher diversity. However, at this level, there appears to be no effect of fecundity on species richness (Table 4.1).

Two of our composite life history variables (principal component scores) were significant predictors of species richness at a family level. PC2, which represents the balance between clutch size and lifetime fecundity (i.e. a high PC2 score means small clutches to relative to lifetime fecundity), was positively correlated with species richness after accounting for the presence of wings and herbivory (Table 4.2, Figure 4.1). PC3, which represents development time (i.e. a high score on PC3 means longer development in the egg and pre-adult stages), was negatively correlated with species richness after accounting for the presence of wings and herbivory (Table 4.2, Figure 4.1). Metamorphosis was not a significant predictor in any of the models that we constructed for species richness, and neither were PC1 or PC4 (Table 4.2).

The results above implicated fecundity and development time traits as potential correlates of species richness, and so we tested for relationships using the raw (logged) life history traits. Clutch size was not a significant predictor of species richness and was dropped as a variable during model reduction (Table 4.2). Lifetime fecundity was however significant, even after accounting for the presence of wings which also remained significant in the reduced model (Table 4.2). Taking into account the result that winged families have higher species richness than non-winged families, those with higher lifetime fecundity have significantly higher species richness (Table 4.2).

The development times of each the nymph/larval and pupal stages were not significantly correlated with species richness, but both of our overall measures of juvenile development (egg to adult/hatching to adult) were significant predictors, as was egg development time (Table 4.2). This result mirrors that found at the order level, accounting for the greater richness of herbivorous families, those with shorter development times from either laying or hatching to adult eclosion had significantly greater species richness (Table 4.2). We did not find a significant relationship between nymph/larva development time and species richness, but the result was in the expected direction (species with faster development have more species) and close to significance (Table 4.2). Egg development time did significantly predict species richness, accounting for higher richness in herbivorous families, families with shorter egg development times had greater species richness (Table 4.2). Pupal development time did not predict species richness, although again this relationship is trending in the hypothesised direction.

Table 4.1 PGLS models at an order level, the dependent variable in each model is log-species richness of the order. We present the full and reduced (red.) models, before the life history trait is dropped during model reduction. Models where the life history trait is significant after applying the False Detection Rate control test are indicated by bold model numbers. β is the regression beta coefficients, i.e. the degree of change in dependent variable for one unit change in the dependent variable.

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
1.1 (full)	PC1	-0.270±0.270	-1.000	0.330	0.001	24	0.435
	Wings	2.586±1.016	2.545	0.020			
	Metamorphosis	1.686±1.008	1.673	0.112			
	Herbivory	2.049±0.928	2.208	0.040			
	Log Stem Age	5.803±3.153	1.840	0.082			
1.2 (full	PC2	0.558±0.632	0.883	0.389	0.000	24	0.428
	Wings	2.578±1.035	2.490	0.023			
	Metamorphosis	1.862±0.972	1.915	0.072			
	Herbivory	2.538±0.890	2.852	0.011			
	Log Stem Age	7.062±2.859	2.470	0.024			
1.3 (full)	PC3	-0.848±0.431	-1.965	0.065	0.000	24	0.509
	Wings	2.130±0.888	2.397	0.028			
	Metamorphosis	0.875±1.061	0.825	0.420			
	Herbivory	2.169±0.815	0.661	0.016			
	Log Stem Age	4.354±3.011	1.446	0.165			
1.3 (red.)	PC3	-1.104±0.358	-3.083	0.006	0.000	24	0.504
	Wings	1.830±0.858	2.133	0.045			
	Herbivory	1.953±0.805	2.425	0.025			

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
1.4 (full)	PC4	-0.045±0.358	-0.126	0.901	0.000	24	0.404
	Wings	2.194±1.017	2.158	0.045			
	Metamorphosis	1.985±1.027	1.932	0.069			
	Herbivory	2.400±0.904	2.655	0.016			
	Log Stem Age	7.113±2.956	2.406	0.027			
1.5 (full)	Log Clutch Size	-0.079±0.305	-0.259	0.799	0.000	21	0.302
	Wings	1.999±1.215	1.65	0.121			
	Metamorphosis	1.878±1.332	1.409	0.179			
	Herbivory	2.176±0.965	2.255	0.040			
	Log Stem Age	5.613±4.267	1.325	0.205			
1.6 (full)	Log Lifetime Fecundity	0.152±0.360	0.421	0.608	0.000	20	0.462
	Wings	0.619±1.291	0.408	0.639			
	Metamorphosis	1.891±1.291	0.480	0.639			
	Herbivory	2.233±0.852	2.619	0.020			
	Log Stem Age	7.374±3.094	2.383	0.032			
1.7 (full)	Log Egg Development Time	-0.353±0.415	-0.850	0.407	0.000	24	0.426
	Wings	2.254±0.959	2.351	0.030			
	Metamorphosis	1.447±1.174	1.233	0.233			
	Herbivory	2.356±0.873	2.697	0.014			
	Log Stem Age	6.367±3.014	2.113	0.049			
1.8 (full)	Log Nymph/Larva Development Time	-0.356±0.312	-1.720	0.104	0.000	23	0.478
	Wings	2.074±0.971	2.136	0.047			
	Metamorphosis	1.707±0.940	1.815	0.087			
	Herbivory	2.092±0.851	2.457	0.025			
	Log Stem Age	6.181±2.964	2.085	0.052			
1.9 (full)	Log Pupa Development Time	1.208±2.029	0.595	0.573	0.00	11	0.125
	Wings	-1.158±3.445	-0.336	0.748			
	Herbivory	3.538±1.741	2.032	0.088			
	Log Stem Age	6.113±9.465	0.646	0.542			
1.9 (red.)	Log Pupa Development Time	0.854±1.620	0.527	0.615	0.000	11	0.236
	Herbivory	3.410±1.588	2.148	0.069			
	Log Stem Age	4.169±7.002	0.595	0.570			
1.10 (full)	Log Hatching to Adult Development Time	-0.561±0.330	-1.697	0.108	0.000	23	0.476
	Wings	2.036±0.971	2.096	0.051			
	Metamorphosis	1.776±0.934	1.902	0.074			
	Herbivory	2.106±0.852	2.473	0.024			
	Log Stem Age	6.221±2.966	2.098	0.051			
1.11 (full)	Log Egg to Adult Development Time	-0.682±0.413	-1.651	0.121	0.000	20	0.471
	Wings	2.123±1.070	1.984	0.067			
	Metamorphosis	1.415±1.070	1.322	0.207			
	Herbivory	2.278±1.025	2.223	0.043			

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
	Log Stem Age	6.035±3.279	1.840	0.087			
1.11 (red.)	Log Egg to Adult Development Time	-1.121±0.411	-2.728	0.014	0.000	20	0.354
	Wings	2.724±1.107	2.461	0.025			

Table 4.2 PGLS models at family level, the dependent variable in each model is log-species richness of the family. We present the full and reduced (red.) models, before the life history trait is dropped during model reduction. Models where the life history trait is significant after applying the False Detection Rate control test are indicated by bold model numbers. β is the regression beta coefficients, i.e. the degree of change in dependent variable for one unit change in the dependent variable.

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
2.1 (full)	PC1	-0.050±0.121	-0.410	0.682	0.927	281	0.022
	Wings	0.963±0.504	1.912	0.057			
	Metamorphosis	-0.489±0.707	-0.692	0.489			
	Herbivory	0.807±0.367	2.197	0.029			
	Log Stem Age	-0.202±0.289	-0.702	0.483			
2.2 (full)	PC2	0.642±0.239	2.688	0.008	0.935	281	0.046
	Wings	1.203±0.505	2.381	0.018			
	Metamorphosis	-0.636±0.703	-0.903	0.367			
	Herbivory	0.853±0.363	2.348	0.020			
	Log Stem Age	-0.179±0.285	-0.630	0.529			
2.2 (red.)	PC2	0.567±0.237	2.396	0.017	0.895	281	0.045
	Wings	1.197±0.507	2.359	0.019			
	Herbivory	0.868±0.360	2.413	0.016			
2.3 (full)	PC3	-0.525±0.160	-3.279	0.001	0.926	281	0.058
	Wings	1.000±0.494	2.024	0.044			
	Metamorphosis	-0.639±0.695	-0.920	0.358			
	Herbivory	0.878±0.361	2.435	0.016			
	Log Stem Age	-0.177±0.283	-0.627	0.531			
2.3 (red.)	PC3	-0.527±0.153	-3.449	0.001	0.899	281	0.065
	Wings	1.035±0.494	2.097	0.037			
	Herbivory	0.855±0.356	2.401	0.017			
2.4 (full)	PC4	-0.019±0.154	-0.123	0.903	0.933	281	0.021
	Wings	0.949±0.509	1.864	0.063			
	Metamorphosis	-0.494±0.710	-0.695	0.487			
	Herbivory	0.811±0.367	2.206	0.028			
	Log Stem Age	-0.195±0.288	-0.675	0.500			
2.5 (full)	Log Clutch Size	-0.062±0.131	-0.470	0.639	0.776	145	0.000
	Wings	1.153±0.706	1.633	0.105			
	Metamorphosis	0.088±0.884	0.099	0.921			
	Herbivory	0.545±0.528	1.031	0.304			
	Log Stem Age	-0.048±0.420	-0.114	0.910			

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
2.5 (red.)	Log Clutch Size	-0.076±0.129	-0.558	0.558	0.668	145	0.010
	Wings	1.136±0.701	1.620	0.108			
	Herbivory	-0.520±0.518	-1.005	0.316			
2.6 (full)	Log Lifetime Fecundity	0.301±0.116	2.602	0.010	0.934	176	0.045
	Wings	1.261±0.668	1.889	0.061			
	Metamorphosis	-0.524±0.745	-0.703	0.483			
	Herbivory	0.687±0.384	1.788	0.076			
	Log Stem Age	0.006±0.326	0.019	0.0985			
2.6 (red.)	Log Lifetime Fecundity	0.270±0.113	2.388	0.018	0.935	176	0.041
	Wings	1.465±0.659	2.223	0.027			
2.7 (full)	Log Egg Development Time	-0.331±0.144	-2.295	0.023	0.894	223	0.028
	Wings	0.725±0.581	1.250	0.213			
	Metamorphosis	-0.414±0.706	-0.586	0.559			
	Herbivory	0.797±0.387	2.062	0.040			
	Log Stem Age	0.169±0.306	0.554	0.580			
2.7 (red.)	Log Egg Development Time	-0.320±0.140	-2.286	0.023	0.845	223	0.035
	Herbivory	0.858±0.376	2.273	0.024			
2.8 (full)	Log Nymph/Larva Development Time	-0.313±0.153	-2.051	0.042	0.878	211	0.021
	Wings	0.872±0.610	1.430	0.154			
	Metamorphosis	-0.382±0.813	-0.470	0.639			
	Herbivory	0.623±0.383	1.625	0.106			
	Log Stem Age	0.016±0.313	0.051	0.959			
2.8 (red.)	Log Nymph/Larva Development Time	-0.297±0.153	-1.940	0.054	0.899	211	0.013
2.9 (full)	Log Pupa Development Time	-0.573±0.292	-1.962	0.052	1.000	141	0.014
	Wings	0.039±0.847	0.046	0.963			
	Herbivory	0.758±0.481	1.577	0.117			
	Log Stem Age	0.251±0.411	0.610	0.543			
2.9 (red.)	Log Pupa Development Time	-0.481±0.281	-1.712	0.089	1.000	141	0.014
2.10 (full)	Log Hatching to Adult Development Time	-0.399±0.170	-2.341	0.020	0.909	201	0.041
	Wings	0.653±0.611	1.069	0.286			
	Metamorphosis	-0.287±0.829	-0.345	0.730			
	Herbivory	0.876±0.389	2.255	0.025			
	Log Stem Age	0.268±0.319	0.840	0.403			
2.10 (red.)	Log Hatching to Adult Development Time	-0.400±0.170	-2.356	0.019	0.909	201	0.045
	Herbivory	0.938±0.382	2.455	0.015			
2.11 (full)	Log Egg to Adult Development Time	-0.418±0.184	-2.273	0.024	0.959	176	0.035
	Wings	0.804±0.608	1.321	0.188			
	Metamorphosis	-0.443±0.866	-0.511	0.610			
	Herbivory	0.776±0.404	1.921	0.056			

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
	Log Stem Age	0.120±0.348	0.344	0.731			
2.11 (red.)	Log Egg to Adult Development Time	-0.415±0.183	-2.273	0.024	0.966	176	0.040
	Herbivory	0.843±0.398	2.119	0.036			

4.4.2 Diversification rate

At an order level, regardless of the ratio of speciation to extinction that we use to calculate net diversification rate, none of the life history traits were significant predictors of diversification rates (Tables C.1, C.2, C.3). However, at a family level the results were more similar to those shown in the previous section.

At a family level, out of our composite life history variables only PC3 was a significant predictor of diversification rate (Tables C.4, C.5, C.6). Accounting for the faster diversification rates of herbivorous families, families which achieve higher scores (slower development) on the development time principal component have smaller diversification rates than those with low scores along this axis (fast development). This result becomes more significant as the estimated extinction rate is increased (Tables C.4, C.5, C.6). PC1, PC3, and PC4, do not significantly improve the fit of models compared to those containing just herbivory (Tables C.4, C.5, C.6).

Again, we tested separately the relationships between diversification rate and clutch size and lifetime fecundity, because those were the variables loaded onto the principal components axes which had significant relationships above. As in the analyses of species richness, clutch size was not a significant predictor and was dropped early in the model reduction process (Tables C.4, C.5, C.6). From a full model including lifetime fecundity, wings, metamorphosis and herbivory the

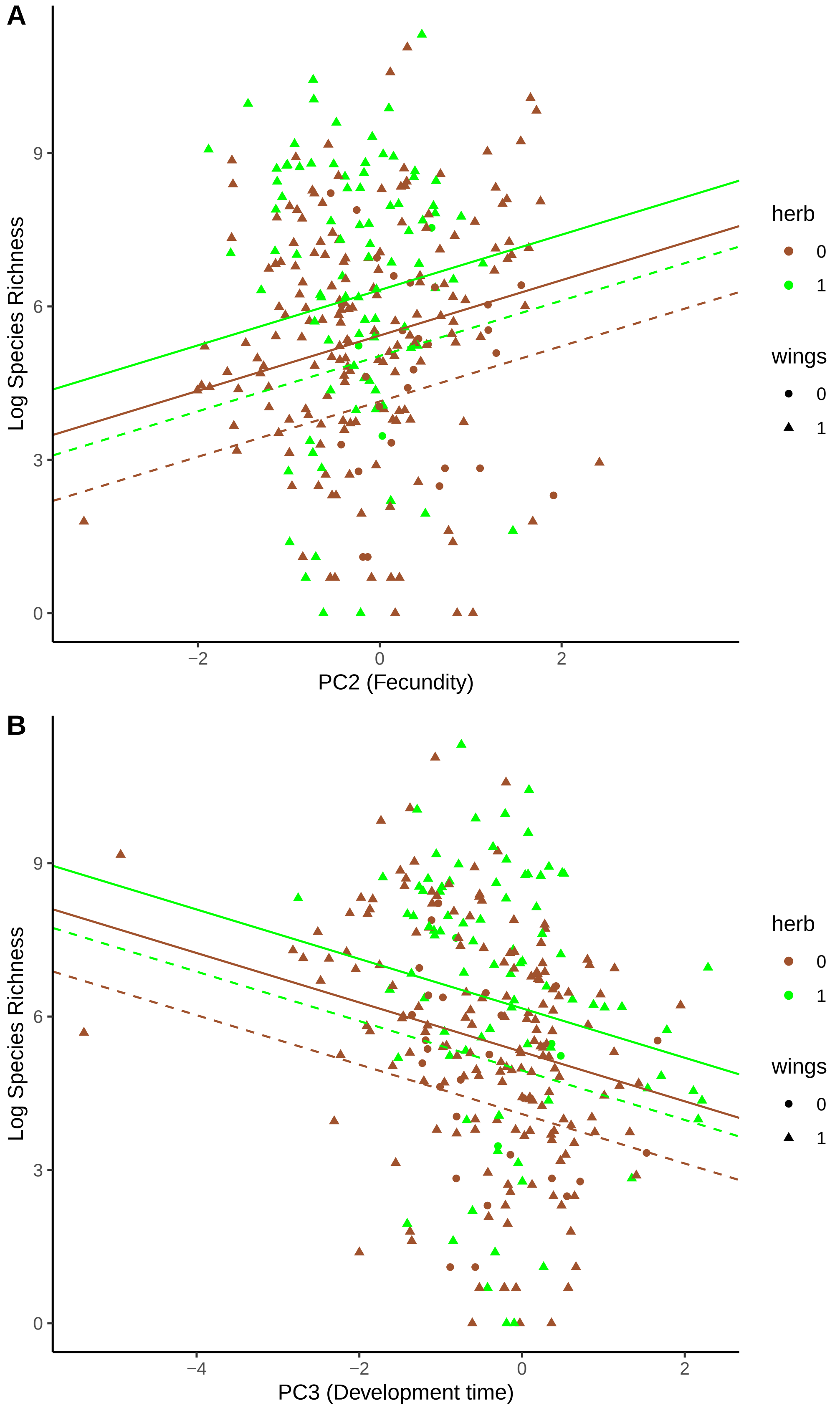


Fig. 4.1 The relationship between life history traits and log family richness, accounting for the effects of wings and herbivory. Dashed lines represent wingless species, and solid lines winged species. In A) low values indicate families with low lifetime fecundity, but relatively large clutches, while high values indicate the opposite. In B) low values indicate families with fast development times, and high values those with slow development times.

maximally reduced model contains just lifetime fecundity: families with greater lifetime fecundity have faster net diversification rates (Tables C.4, C.5, C.6). The amount of variance in diversification rates explained by lifetime fecundity (and indeed the amount explained by all of our models) is low (<4%), but our results seem to suggest that it is a more important predictor than even herbivory.

Of the development time traits that we tested for an association with diversification rate only the time spent in the egg period was a significant predictor (Tables C.4, C.5, C.6). The reduced models include only egg development time, and show that families where eggs hatch in a shorter time tend to have higher diversification rates than those that spend longer in the egg stage.

4.5 Discussion

Insects are undoubtably among the world's most species-rich animal lineages. As we approach a sixth mass extinction as a result of human activities (Ceballos et al., 2017, Cardoso et al., 2020), it is arguably more important than ever that we understand the dynamics of speciation and extinction. Hypotheses relating life histories and diversification have shown some success in the past, and here we add to that body of evidence. After controlling for several adaptations demonstrated to increase diversity in insects, the taxa that produce large quantities of eggs have a greater species richness and a faster diversification rates than taxa that make fewer eggs. Lineages in which species undergo fast development, across all of the juvenile stages or in the egg stage, also reach greater species richness and have higher diversification rates. Similarly, high lifetime fecundity also predicts higher species richness at a family, but not an order, level, while the effect of fast juvenile growth on diversification rates appears to be limited to the egg stage. These patterns remain robust after accounting for the greater richness of herbivorous taxa, and of taxa better able to disperse thanks to wings. The evolution of metamorphosis has also been suggested to increase diversification rates, but when we construct models with life history traits, wings, herbivory, and metamorphosis we find that the latter trait has little effect. Below we discuss what might drive these new patterns, their implications, and their relationship to previous work.

Our study provides evidence that higher species richness and diversification rates are associated with lifetime fecundity in insects. The two explanations for this are a reduction in extinction rate, or an increase in speciation rate. Species that produce more eggs may have a reduced risk of extinction because they have high rates of intrinsic population growth which could allow populations to recover from perturbations (Pimm, 1991). Similarly, species with large number of eggs may be able to colonise and become established in new areas. Because of this, highly fecund species may expand their ranges faster, and subsequently diverge and diversify as the separated members of a population interact with new habitats and resources. Producing more eggs may also be a way to increase the genetic variation available for adaptation to work on. There is already some evidence that clutch size is associated with the rate of molecular evolution in at least reptiles (Bromham, 2002), which could potentially allow species to become genetically isolated from each other in a shorter time. However we do not see a direct effect of clutch size in our analyses (Tables 4.1, 4.2, C.4, C.5, C.6).

We find a negative correlation between diversification rate of a clade and its development time, as well as a negative correlation between the duration of the juvenile stages and species richness. Short generation times (early reproduction and short lifespans) have been found to correlate with high species richness in several studies (Marzluff and Dial, 1991, Isaac et al., 2005, Baker et al., 2014), but other studies fail to find such a pattern (McHugh and Fong, 2002, Cardillo et al., 2003). This mixture of positive and negative evidence in different lineages has led some to conclude that particular aspects of life history are important in some lineages but not others (Cardillo et al., 2003). In the case of insects, our results suggest that a shorter juvenile period has a positive effect on species richness. The likely mechanism for this is that the probability of survival to adulthood and reproduction is higher in species which spend less time as juveniles. Short generation times also give rise to more genetic variability per unit time, as species with short generation times replicate their genomes more per unit time than those with long generation times (Thomas et al., 2010). However, we do not see any association between species richness and adult lifespan in our dataset (included as the main component of PC4; Tables 4.1, 4.2, C.4, C.5, C.6).

High fecundity and short development time are both components of a ‘fast’ life history strategy. Across many different taxa, fast life histories have been shown to reduce the risk of extinction and increase the probability of successful biological invasions (Capellini et al., 2015, Allen et al., 2017). If successful invaders become geographically isolated from their former ranges this could increase richness through allopatric speciation. However, this is not a foregone conclusion, several demographic models predict that slow life histories may be advantageous for establishing in new regions, as they allow individuals to delay reproduction to match environmental conditions, and buffers populations from stochastic events that can lead to extinction (Morris et al., 2008, Jeppsson and Forslund, 2012).

In most cases, the amount of variation explained by our models is modest, and the life history traits are often shown to be less important than the ‘key innovations’ that we also tested. Wiens et al. (2015) speculated that the diversity of insects can be explained by the build-up of successive factors that increase diversification, starting with factors common to all arthropods, then wings and herbivory, and finally metamorphosis. Once we include life history traits into our models of species richness and diversification rates, metamorphosis shows little association with higher levels of either. It has been suggested that holometaboly promotes species richness because of the differential adaptability of the larval and adult stages, potentially leading to more ‘efficient’ life cycles (Truman and Riddiford, 1999, Yang, 2001). Though the four most diverse insect orders (Coleoptera, Diptera, Hymenoptera, and Lepidoptera) all have complete metamorphosis, the remaining holometabolous orders are not particularly species rich (Ferns and Jervis, 2016). In addition, we showed in Chapter 3 that differences in broad life history traits (fecundity, development time and adult lifespan) between holo- and hemimetabolous species are relatively modest, but that ametabolous species occupy different regions of trait space.

Our dataset has limitations that should be considered when assessing our findings. We attempted to construct our dataset to achieve the highest possible phylogenetic breadth, but the sampling within families and orders is highly variable. As more data become available, particularly for poorly sampled families/orders, the exact results may change. It is also important to note that our principle components scores were generated using a process of phylogenetic imputation, and although averaging the scores across orders and families should smooth out anomalies, scepticism about these scores is very reasonable. However, the results from the analyses of principal components scores mirror those using raw data well, and so we are confident that the issues are not too great.

In summary, we show that certain life history traits can help explain differences in species richness and diversification rates between insect orders and families. Specifically, ‘fast’ life history traits, including short development times and high lifetime fecundities, appear to be characteristics predisposing certain lineages to become more diverse. These effects remain significant when taking into account other traits purported to increase diversification in insects. Our findings now imply a need for further work to pin down the mechanisms driving these patterns.

Chapter 5

General Discussion

Understanding life histories provides a framework for understanding the diversity of life, because life histories have strong links with aspects of evolution, ecology, and behaviour. Life histories form an important part of an organism's phenotype, and so understanding the broad diversity of life histories and what promoted them to evolve should help us to understand the diversity of life itself. Evolutionary theory predicts that natural selection should shape the attributes of organisms to maximise fitness, attaining an optimal life history strategy to contribute genes to the next generation. However, since it is impossible to maximise investment in all life history components simultaneously, because of limited resources, trade-offs form. A vast literature has emerged examining these trade-offs and understanding the structure of life history covariation at higher taxonomic levels.

Despite making up the majority of species described to science thus far, insects are conspicuously absent from comparative studies of life history evolution. In this thesis I attempted to remedy this by conducting a class level analysis of insect life histories and exploring how life histories are linked with ecology and macroevolutionary processes. I find that life history covariation in insects deviates somewhat from patterns established in other taxonomic groups, which mainly consist of a primary 'fast-slow continuum' of life histories and a secondary reproductive strategy axis. In orthopterans, which were the focal taxonomic group in Chapter 2, while variation could be generally described as 'fast-slow', I showed that life history covariation was more 'reptile-like' than 'mammal-or-bird-like' – in that they key expected trade-offs between an otherwise 'slow' life history and fecundity were not apparent. Across insects as a whole (Chapter 3) I find that the primary axes of life history variation are related to the reproductive investment, how that investment is spread over a lifetime, and then further orthogonal axes related to development time and adult lifespan. Overall, the results suggest that the intricate relationships between traits in some taxonomic groups may not be applicable in others, and highlight the need to test evolutionary hypotheses in a wide variety of taxonomic groups. I test for differences in life history traits according to species' diets, broad habitats, and whether they have metamorphosis, and identify some interesting further work. The results of these tests identify parasitoids and ecto-parasitic species as fast lived, but with low fecundity, ametabolous species as longer lived than species with metamorphosis, but show no association between life history traits and whether the species is aquatic in any part of its life. Finally, in Chapter 4, I investigate the macroevolutionary consequences of life history variation, and demonstrate that taxa with some 'fast' life history traits are more species rich and have higher diversification rates.

Below I present brief summaries of Chapters 2, 3, and 4, and discuss the wider implications of this work. In section 5.4 I evaluate the strengths and weaknesses of my thesis and the approaches that I have taken to answering macroevolutionary questions. In section 5.5 I suggest potential avenues for future research and ways to use the large dataset generated for this thesis, before finally recapitulating my main conclusions in section 5.6.

5.1 Chapter 2: Orthopteran life history trait covariation, and differences with vertebrate taxa

I started, in Chapter 2, by collecting life history trait data for orthopterans (grasshoppers, crickets, katydids, and their kin). The aim of Chapter 2 was to evaluate how strongly orthopterans conformed to the life history trait correlations predicted by a 'fast-slow continuum', and to evaluate differences in how traits are intercorrelated between the orthopterans and three well-studied vertebrate groups (mammals, birds, and reptiles). These aims are valuable because life history traits represent important sources of phenotypic diversity, and generalisations like the 'fast-slow continuum' can help us to explain this diversity. Importantly, even among vertebrates, associations between life history traits are not always the same in different taxonomic groups (Jeschke and Kokko, 2009), and these associations have been less thoroughly investigated in invertebrates. This deficit is due in part to incomplete trait data, which prevents multivariate analyses. I constructed a dataset of over 600 orthopteran species, but few species had complete cases of life history data. To overcome this, I used phylogenetic imputation to amplify the signal in the data and developed a type of sensitivity analyses to ensure the robustness of imputations for the results. The results of this chapter revealed that orthopterans, for the most part, follow the patterns expected by a 'fast-slow continuum', but with an important difference: species on the 'slow' end of this continuum produce larger clutches of eggs, not smaller clutches. These results remained consistent even with moderate levels of imputation and were supported by phylogenetic generalised least squares (PGLS) models that used only non-imputed data.

I then took advantage of large-scale life history datasets constructed for mammals, birds, and reptiles (Lislevand et al., 2007, Jeschke and Kokko, 2009, de Magalhães and Costa, 2009, Capellini et al., 2015, Myhrovld et al., 2015, Allen et al., 2017) to evaluate the generality of the 'fast-slow continuum', that is, if and how the trait correlations differed between groups. I reduced the dimensionality of the aggregated life history dataset using phylogenetic PCA, which revealed a single axis explaining 67-70% of variance. This axis showed the strong positive correlations between adult and offspring size, development time, and adult lifespan, but the traits related to fecundity (hypothesised to be negatively correlated with the previous set of traits) were unrelated to the axis. I then assessed the fit of each taxonomic group to the multidimensional axes of variation generated using data in the other groups. I showed that mammals and birds are similar in their trait covariation, as are reptiles and orthopterans

– and that while the former group, as might be expected, was well consistent with the expectations of the 'fast-slow continuum', the latter group was different. Specifically, the reptiles share with orthopterans a pattern where otherwise 'slow' species produce more eggs per clutch than otherwise 'fast' species.

Together, these results challenge the notion of a universal and general 'fast-slow continuum'. This is perhaps unsurprising, however, as Jeschke and Kokko (2009) note, this is a point that has been rarely made. Charnov's (2001) evolutionary model predicted 'fast-slow' variation using a series of assumptions specific to mammals, including three-quarter power scaling exponents between body size and growth rate, and body size and offspring size per year, and that size at weaning is proportional to size at maturity. Even in mammals the data challenges these assumptions, particularly the latter (Purvis and Harvey, 1995). Nevertheless, previous studies have found that the many of the trait patterns predicted by Charnov's model are general enough to be detected in taxa quite different, and more distantly related than insects, to mammals (Salguero-Gómez et al., 2016, Healy et al., 2019). I show that reptiles and orthopterans differ from mammals, birds, and the predictions of the 'fast-slow continuum' in terms of fecundity: larger, generally 'slower' species produce more eggs than small, 'fast', species. In the discussion to Chapter 2 I suggest reasons why this may be the case, including the apparent differences in maximum clutch size, metabolism, and parental care between reptiles and orthopterans on the one hand and mammals and birds on the other. A similar result has been shown in fish, where the direction of relationship between fecundity and the other life history variables is positive rather than negative (Jeschke and Kokko, 2009), which like orthopterans and reptiles are (contrasting to mammals and birds) ectothermic, more limited in parental care, and have high maximum clutch sizes.

The imputation procedure and sensitivity analyses developed for this chapter mean that further groups with incomplete trait data can be analysed in a multivariate sense (as I do for insects as a whole in Chapter 3). This is important because while well-studied taxa can furnish us with ideas about how evolution operates, the vast majority of taxa are not well-studied and cannot be assumed to behave in the same way. Previous studies acknowledge that taxonomic groups differ in their trait covariations, however, most comparisons between taxonomic groups have been qualitative rather than quantitative. Jeschke and Kokko (2009) tabulated their results showing the differences between principal components of life history traits in mammals, birds, and fish, but did not quantitatively assess the similarity between them. In mammals, at order level the correlations of life history traits differs between groups – Bielby et al. (2007) used hierarchical clustering to conclude that two axes (one denoting timing or reproduction and one the trade-off between offspring size and number) are consistent across groups, but nevertheless some of the traits differ. For example, in Artiodactyla the 'timing' axis is informed by interbirth interval and age at sexual maturity (species with longer gaps between litters reach adulthood in a longer time), but in Carnivora the same axis is informed by interbirth interval, weaning age, and neonatal body mass (species with longer gaps between adulthood wean their offspring for longer, and have smaller offspring at birth). The methods used in this chapter provide a way to assess the differences between taxonomic groups in a simple metric, which can be used to evaluate the similarity between groups. Finally, this chapter is useful in providing a reasonably large dataset of insect life history traits in a group where previously none existed. This dataset can be used to assess questions from many disparate fields, and some suggestions are made below.

5.2 Chapter 3: Insect life history trait covariation, and associations with ecology and metamorphosis

In Chapter 3, I collected life history trait data across the entire insect class and used the methods developed in Chapter 2 to study it. My aims were to identify the structure of the correlation of life history traits across insects, and how ecological factors and metamorphosis can affect the range of life history strategies that evolve. The results strengthen those from Chapter 2, showing little support for the 'fast-slow continuum' as it has been exemplified across vertebrate classes and plants. Instead, the primary axes of life history variation in insects are related to the amount of reproductive investment, and how that reproductive investment is spread through life. Additional principal components then explain development time and adult lifespan, but all of these axes are orthogonal and independent of each other. As shown in Chapter 2 for orthopterans, the PGLS analyses across the insect class indicate that larger bodied species (with otherwise 'slow' life history trait values) have larger clutches and higher lifetime fecundities.

Using the principal component scores calculated for each insect, I show how the average life history differs between orders. The results from this analysis are consistent with what is known about the biology of orders, and I highlight orders at the extremes of the principal components axes. I then show that the range of life history strategies represented in ametabolous (primitively wingless) species is different from that of hemi- or holometabolous species, which show similar trait covariation. The only significant result in these tests was that ametabolous species have longer adult lifespans than hemi- or holometabolous species, something that I propose is related to the nature of ametabolous species, which can continue to grow and moult throughout their adult lives unlike the other insects. I found that diet was a significant predictor of life history, but that the differences are mainly between parasitoids, ecto-parasites, and other diet types. I show that the parasitoid lifestyle appears to predispose species to a similar life history strategy (low clutch size, low fecundity, short development time and short adult lifespan). I go on to discuss why this may be the case. Finally in Chapter 3, I predicted that insects leaving land and returning to aquatic habitats would have a bearing on life history trait covariation. Contrary to my predictions however, there was no signal to differentiate life histories of species based on their broad habitat type.

The results from Chapter 3 open up several new questions. Many previous analyses of this kind have shown consistent patterns across the tree of life, particularly two axes of life history variation: one a 'fast-slow continuum' and the second a 'reproductive strategy' axis (Bielby et al., 2007, Salguero-Gómez et al., 2016, Healy et al., 2019). My results show that instead insect life histories largely differ in terms of reproductive investment, and that other life history variables (development time, lifespan etc.) load on orthogonal axes. However, these results are not unique: fish, for example, also miss some of the characteristics of a 'fast-slow continuum', and they show a similar pattern to that shown in orthopterans (Chapter 2) whereby otherwise 'slow' species achieve higher fecundity than otherwise 'fast' species (Jeschke and Kokko, 2009). I have discussed some reasons why this may be the case above. Orthopterans do appear to be different from the overall pattern across the insects according to the phylogenetic PCAs, but interpreting this is difficult because different life history traits were used for the two sets of analyses. Egg development time was for the most part unavailable for orthopterans, and conversely voltinism was available for many orthopterans but less so for other taxa. However, the bivariate PGLS analyses run in Chapter 2 and Chapter 3 do lead to similar conclusions. It is important that we understand the causes of variation between taxonomic groups, and the reasons why life history traits can evolve in a more independent fashion in insects than in other groups. I propose that this could be achieved using experiments artificially altering key life history traits and measuring the changes in resulting offspring fitness. More needs to be learned about the interaction between genes and environment during insect development in determining adult fitness, though such studies exist for some species already (see Beukeboom, 2018).

One of the most commonly invoked benefits of complete metamorphosis is that larval and adult stages of the same species can inhabit different areas and consume different resources, thus taking them out of direct competition with each other (Istock, 1967, Truman and Riddiford, 1999, Rolff et al., 2019). Some authors have argued that this has led to a more 'efficient' life history in species with holometaboly. Interestingly, although in my analyses (Chapter 3) ametabolous, hemimetabolous and holometabolous species are not significantly different from each other, it appears that hemimetabolous species are intermediate in development time between the ametabolous (longest) and holometabolous (shortest) species. I think that this warrants further investigation and may provide some support for the notion that complete metamorphosis facilitates more efficient juvenile stages.

Although I show that life history trait covariation is affected by metamorphosis, and by diet, there remain many key innovations and other ecological variables to be studied. The evolution of wings, for example, almost certainly had a great impact on life histories by enhancing their ability for displacement and imposing some constraints upon, for example, maximum adult body size (much as has been proposed in birds; Galliard et al., 1989). Since adult body size is a strong predictor of the other life history traits, a reduction of maximum body size could reduce egg sizes, development times and fecundity. However, this is complicated by the fact that non-flying morphs or sexes exist in many insects. The later evolution of folding wings may also have had an effect: wing membranes are thin and delicate, being able to fold them opens up new niches and allows individuals to navigate through foliage or burrow underground, but these niches impose new constraints upon the organism. And then adaptations idiosyncratic to orders, or even lower taxonomic groups, may have their own effects.

The evolution of sociality must fundamentally change the structure of life history covariation. Queens of social colonies are often incredibly fecund, and yet live for a long time (Thorne, 1997). In 'fast-slow' considerations of life history covariation this would seem to go against the pattern, although as we have shown in Chapters 2 and 3 it seems that this pattern is not uncommon across the insects.

Polyembryony is an adaptation where a single egg can divide and form separate individuals, as in monozygotic twins. Some insects have the ability to do this to extraordinary lengths, producing as many as one hundred thousand offspring from a single egg, which usually replicates at the expense of a host organism rather than the mother. This poses a problem in terms of finding values of clutch size and lifetime fecundity in these taxa which are comparable to the vast majority of insects. One could consider the clutch size of a polyembryonic species laying one egg in a host as one, of defined size, which would represent the investment from the mother. On the other hand one could count the total number of offspring resulting from the single egg, but for other insects we collect the number of eggs laid, rather than the number hatched (which is often information that is unavailable).

Finally, some insects do not lay eggs but are viviparous (e.g. tsetse flies, aphids, some cockroaches etc.) or ovoviviparous, which again causes complications in collecting data comparable at broad scales. In *Zootoca vivipara*, a lizard which has some viviparous and some oviparous populations, the viviparous females have larger bodies, smaller offspring and clutch sizes, but higher hatching success than oviparous females (Recknagel & Elmer, 2019). There are several species of facultatively viviparous insects which would be ideal candidates for a study similar to this which could test whether the evolution of viviparity has similar consequences across the tree of life, for example some thrips (Crespi, 1989) and dipterans (Meier et al., 2007).

In summary of Chapter 3, I use a large amount of life history data with phylogenetic imputation to be able to find the broad structure of life history covariation in a group where previously missing trait data would have prevented such an analysis. I test for associations between life histories, key innovations, and ecological variables, but there are many ideas that still await investigation, and future studies will be improved as more trait data and better phylogenies become available.

5.3 Chapter 4: The impact of life history traits on diversification

In Chapter 4, my aim was to identify what role life history traits have in diversification dynamics. The imbalance of taxonomic groups across the tree of life is a widely known phenomenon requiring a generalisable explanation (Purvis and Agapow, 2002), and yet most explanations for diversity in richness rest on idiosyncratic 'key innovations' within a particular lineage. Life history traits provide an intuitive link between population level processes and diversification dynamics, as has been shown in a number of previous studies (e.g. Marzluff and Dial, 1991, Isaac et al., 2005). After accounting for key innovations, such as wings, metamorphosis, and herbivory, which have been previously shown to be important drivers of insect diversity, I show that species richness is significantly higher in families and orders with fast development and higher in families with high fecundity. I also show that diversification rates are higher in families with high fecundity and rapid egg development periods.

There are several limitations to Chapter 4 related to the dependent variables. I use order or family level data on species richness, however only a fraction of all species have yet been described. The results should remain similar as long as newly described species increase clade richness in similar proportions to their current richness – although this is not a given, as there is still debate, for instance, on which insect order is the most speciose (Mora et al., 2011, Forbes et al., 2018). Furthermore, there may be biases in the likelihood that a species has of being described, for example: small species may be less likely to be described than large species, and those in tropical areas less likely than those in temperate regions (Gaston, 1994, Blackburn and Gaston, 1995, Blackburn et al., 2019). Secondly, we cannot be sure that families are truly comparable taxonomic units across groups. Higher taxa are designated by systematists and are non-random subsets of clades across the tree of life, but the particular properties that cause us to distinguish between them are neither clear nor consistent. It has been suggested that higher taxa may represent clades that have either accumulated vast phenotypic distinctness relative to other clades, or clades in which a substantial shift in the tempo and mode of phenotype evolution has occurred (Rabosky, 2010, Venditti et al., 2011, Rabosky et al., 2012). In either case, this could lead to statistical artefacts in the relationship between clade age and diversity.

I estimated diversification rates using Magallón and Sanderson (2001) methods-of-moments estimator, which calculates the rate using species richness, clade age, and a relative extinction rate. Thus, diversification rates inherit some of the problems of species richness explained above, plus some more issues. The model is based on constant diversification rates, which leads to exponential growth, however this is unlikely to be the truth. Condamine et al. (2016) inferred that insects underwent a rapid initial burst of diversification followed by a decline to a low, steady, rate before upshifting in Coleoptera, Diptera, Hymenoptera, and Lepidoptera. Rainford et al. (2014) find that there is stability in diversification rate across the hexapods, but identify major shifts corresponding to the evolutionary origins of flight (Pterygota) and complete metamorphosis (Holometabola). If diversification rate changes through time, this may lead to unreliable estimates of average rate based on a constant rate model; for example, if the true rate decreases the model will underestimate the rate of diversification early in the clades history, but overestimate it later (Magallón and Sanderson, 2001). There are many other methods for estimating evolutionary rate parameters, some of which directly infer speciation and extinction rates (Rabosky, 2014, Revell, 2018). In the future, methods such as these could be used to correlate insect life history traits with speciation and extinction rates from phylogenies, although this would require a much better resolved phylogeny and more extensive data than are currently available. An advantage of the method used here is that it does not require full species-level phylogenies, but an obvious disadvantage is that averaging life history traits across families (and especially orders) loses some of the variation. There are also issues around dating the ages of clades, which will change the diversification rate using this method – these issues will be discussed in the overall strengths and weaknesses section below.

To reiterate, in this chapter I find that higher diversification rates were associated with high lifetime fecundity and rapid egg development. I think that possibly the most likely explanation for this is that these traits reduce the risk of extinction. Large numbers of fast-hatching eggs contribute to a high intrinsic rate of population increase, which could allow for rapid recovery in disturbed populations or fast establishments of new populations by colonists. On the other hand, the life history traits identified here could increase speciation rate if, for example, post-establishment populations adapted to new resources (Marzluff and Dial, 1991), or if larger numbers of eggs increases the total genetic variation available (Lehtonen and Lanfear, 2014, Thomas et al., 2010). These ideas show how population-level processes can be mirrored by diversification dynamics, but there is much fascinating work to be done on the role of life history traits in speciation itself. Selection experiments have demonstrated that changing life history traits can induce speciation through reproductive isolation. There are various mechanisms proposed in the literature, including due to a genetic correlation between development time and behaviour (time of mating) in *Bactrocera cucurbitae* (Miyatake and Shimizu, 1999). In *Drosophila melanogaster*, males selected for fast development and small size attain few matings when paired with females from (large, slow developing) ancestral populations, while conversely females selected for the same traits suffer high mortality when paired with males from the ancestral population – offering two unidirectional barriers to mating as a result of selection for a life history trait (Ghosh and Joshi, 2012).

In my analyses, the amount of variation explained by life history traits remains relatively modest compared to wings and herbivory (Wiens et al., 2015), and many of the life history traits that I tested did not show any association with either species richness or diversification rate. I am inclined to agree with Cardillo et al. (2003) who suggest that instead of suites of fast life history traits together enhancing diversification particular aspects of life history in different taxonomic groups affect diversification, while others do not. Further work in this area should seek to address the specific causal roles of wings and herbivory in the diversification of insects and could investigate how changes in life history lead to genetic isolation.

5.4 Overall strengths and weaknesses

Among the novel contributions of this thesis are the datasets generated, which ties into probably its greatest weakness, that these datasets are sparsely populated with trait data. However, in its favour, this is the first dataset of this size and scope in terms of traits and higher taxa coverage in the insects. Where studies of this kind have been conducted before, they have benefitted from a great deal of data compiled across species of charismatic taxa such as mammals and birds. No such resource existed for insects, certainly not on a scale adequate for the analyses presented here, and one of my principal aims was to collate this data. This dataset will be released open access and be downloadable by anyone who wishes to view or use it. In the longer term, this resource would be of even further utility if submissions were accepted for new data, or if these data were integrated into an existing collection of trait data, for example TraitBank (Parr et al., 2016).

To solve the problem of missing data, I used phylogenetic imputation. My aim here was not to predict the individual traits values of individual species using phylogeny, but to amplify the signal in the available data to be able to test hypotheses across a much larger sample of insects than would have otherwise been possible. If there are systematic reasons for missing trait data (as a trivial example, if small bodied species are generally underrepresented in terms of adult lifespans because they are harder to track over a lifetime) then this could cause errors in the correlation structure of life history traits, and imputed values to be less reliable for certain species. I have attempted to satisfy these concerns by taking a systematic approach to testing the sensitivity of my results. In both Chapter 2 and Chapter 3, I start by running my analyses on a subset of the data with no missing values. In both cases this means beginning with modest sample sizes, and some families (even orders!) are completely cut out of the analysis. I then allow each species to be missing a maximum of one, then two, then three (*et cetera*) traits and rerun the analysis, expanding the sample size but increasing the level of imputation. The results remain broadly similar, and in all cases do not contradict the pairwise PGLS analyses that I conduct which contain no missing data. Together these convince me that my conclusions are generally valid, and that this approach could be used by researchers in the future working in groups with missing data.

Even without imputation, there are a number of potential sources of error in the data itself. My dataset is made up of observations from different types of studies, some from laboratory experiments, some from field assessments, and a good deal of observations from natural history literature. Laboratory experiments have certain benefits (e.g. they often have larger sample sizes, and environmental factors such as temperature and humidity are known), but we cannot be sure that they represent the true state of a particular variable in nature. Field studies and general entomological observations vary much more widely in terms of precision in recording, and some traits are easier to measure in the field than others – an obvious example being clutch size vs lifetime fecundity, which in the latter requires observing a female throughout adulthood. Though my dataset contains species from across the globe, there is a geographic bias towards temperate species. This is due in part to a study bias in temerate regions, tropical regions have a much higher insect richness but there are far more species with scant life history information, and in part due to biases resulting from my literature sources, which were almost all published in English. There are also taxonomic gaps in my dataset: most notably, there are no species belonging to Grylloblattodea (ice crawlers), Mantophasmatodea (gladiators), or Protura (coneheads) in the analyses in Chapter 3. Hymenoptera and Orthoptera are perhaps overrepresented in my dataset, in the latter because I concentrated on them for Chapter 2 and in the former because several large datasets previously existed, however the results remained robust when subsampling these groups. Finally, there are trait-level biases: during the data collection period of this study a dataset of insect egg morphology traits was published covering over 6,000 species (Church et al., 2019), no such dataset existed for the other traits. To prevent an overwhelming bias of egg lengths I only integrated data from Church et al. (2019) when a species already had at least one other trait in my dataset, but the coverage of egg length is still much better than the other traits.

The phylogeny is another source of error in the analyses. I attempted to use the most recent and best available phylogenetic information to create an overall informal supertree structure for the insects, following studies such as Wiens (2017). However, I maintain that this is a reasonable estimate of the insect phylogeny given the information available. Even the most fastidiously constructed trees are hypotheses, and I imagine that few phylogeneticists would ardently claim that their trees are 'correct' in both topology and dating. The informal approach taken here also has some benefits in terms of future use, and the code used to construct the phylogeny will be made available upon publication. As new species level phylogenies of insects become available, which is frequently, it will be relatively simple to replace the phylogeny currently representing the group with a more up-to-date version. Some may also critique my choice to use the Rainford et al. (2014) phylogeny as the backbone for dates of each order, rather than the more widely used Misof et al. (2014) tree. As I explained in Chapter 3, the origination dates of the major orders in Misof et al. (2014) are for the most part incompatible with the dates according to our selection of order-level trees. Misof et al. (2014) consistently date order-level nodes younger than the order level trees indicate, and indeed some of these individual trees are produced using very similar methods by those of Misof et al. (2014). The sum total of fossils used to date the individual order level trees well exceeds those used to calibrate the Misof et al. (2014) tree, and since the pattern exists in most of the orders I am inclined to suspect Misof et al.'s dates are rather younger than the 'true' dates. The Rainford et al. (2014) phylogeny on the other hand accommodates the order level trees remarkably well, so I chose to use this.

I have attempted to use the available data to test hypotheses about how life history traits associate with each other, using the comparative approach. The comparative itself has strengths and weaknesses (Harvey and Pagel, 1991, Stearns, 1992). On the one hand, comparative methods are the only way to establish whether experimentally derived results are generally true. To find solid evidence of adaptation and its effects we must demonstrate that a certain state has evolved and had certain effects in several different lineages. This makes the comparative method powerful for ruling out some hypotheses, however it cannot establish cause. This is because comparative analyses are by their nature correlational. Experimental manipulations, with controls, could be used to support claims of causality, but on the scale of (for example) the whole of the insects, obviously an experiment of this kind would be highly impractical. There is an essential trade-off between the rigour of experiments and the phylogenetic generality that comparative methods allow us to sense.

5.5 Further work

Some suggestions have been made throughout the thesis and this discussion as to directions in which work could progress given the results presented here. I stress to any readers the importance of continuing to collect data on fundamental traits of understudied groups. Finding values within the literature that represent 'natural' values of insect life history traits has been a difficult task, though I have synthesised as much information as I was able to in the time-frame there are doubtless many observations that I have missed or been unable to access or translate. One would like to imagine that with the rise of open source libraries and the development of artificial intelligence software for parsing scientific literature the researchers who follow me in trying to establish datasets of this kind may have an easier time of things! The creation of an insect trait database with the breadth and depth approaching that in vertebrate groups, such as PANtheria for mammals (Jones et al., 2009) or FishBase for fish (Froese and Pauly, 2019), is an optimistic goal. After all, the insects accrue newly described species, of which very little is known, at a much faster rate than those other groups. The creation of a dataset of this kind would benefit from a formalised ontogeny for insect trait data, however my experience with the literature leads me to believe that any strict rules would cause a significant number of observations to be omitted. A slightly alternative approach may be to follow the work of Salguero-Gómez et al. (2015), who have used age-structured population matrices to derive life history traits and then analyse them. Insect life tables make up only a small proportion of the COMADRE database at present. Many life tables for insects exist in the literature, although many of them would not fit the criteria for inclusion.

In this thesis I studied how life histories are linked to several ecological variables (Chapter 3), key innovations (Chapter 3), and macroevolutionary processes (Chapter 4), however there are many other promising avenues for future research and many proposed associations between life history traits and other variables from other taxonomic groups still to be tested for insects. This dataset will hopefully provide researchers with a starting point for comparative investigations, although this will rely on the availability of new data in most cases.

Metabolic rate is likely to be important in determining where a species sits in life history space, as the rate of energy use by an organism helps determine the rate at which it can grow, or the rate at which it can invest into offspring (Brown et al., 2004). Recent analyses indeed suggest that at broad scales species with high metabolic rates (relative to body size) have fast life histories (Healy et al., 2019). Collating data on metabolic rates of species in my dataset would allow researchers to evaluate this in insects, which may be fundamentally different to other groups considered thus far. In insects this will be dependent body size and the temperature of the micro-environment, and perhaps other variables.

In Chapter 3 I proposed that broad habitat type, in terms of aquatic compared to terrestrial habitats, may have restructured insect life history covariation, but I found no evidence to support this, despite results from other taxa (Capdevila et al., 2020). Broad habitat, in terms of latitude, or temperate compared to tropical regions, may be a more promising avenue of research. Early treatments of variation in life history strategies proposed that, since they are more stable, tropical environments should favour the evolution of slow life histories (Dobzhansky, 1950, Macarthur and Wilson, 1967), however for ectothermic species like insects one would expect warm temperatures to boost vital rates and speed up life histories. Some support has been found for this idea using differences in metabolic rate (Wiersma et al., 2007), but it has also been challenged in birds (Martin, 2015), frogs (Sinsch and Dehling, 2017). I did not concentrate on collecting data on latitude, or biogeographic region, in this project, although I have recorded some of it in the dataset where it was presented in the literature with life history data. This area of the resource could be expanded in future and be used to test the hypothesis that tropical climates promote slow life histories in insects, although I would speculate that any relationship with latitude will have a large amount of variation in it.

Life histories are also good predictors of invasion success, and in the opposite sense, the extinction risk level of species (Capellini et al., 2015, Salguero-Gómez, 2017, Allen et al., 2017). Here, I have shown how the same processes affect the diversification of insects (Chapter 5), but I do not explicitly consider hypotheses about conservation/invasion biology. Based on previous studies, life history could be used to predict pest status, and importantly, how pests and other organisms will respond to changing global conditions (Walter et al., 2018). Our understanding of current biodiversity change is built upon our understanding of past biodiversity change, and with evidence for global insect declines (Hallmann et al., 2017, Sánchez-Bayo and Wyckhuys, 2019) attracting huge attention and claims of “insectaggedon”, understanding these dynamics is likely to be important. Life history data may go some way to predicting which insects are likely to be winners and losers due to anthropogenic climate change. Indeed, studies about extinction risk or conservation concern already provides some evidence to support this (Mayhew, 2007, 2018). There is a great deal of variety, between taxonomic groups and across the world, in how many insects have been classified according to schemes such as the IUCN Red List, and there are significant challenges to practitioners in classifying invertebrates in this manner (Fox et al., 2018). However, the important ecological roles of insects and their risk of extinction is being better appreciated today than previously, and hopefully this will lead to data becoming available to formally test whether species with ‘slow’ life histories are more likely to be endangered, as has been shown in plants (Salguero-Gómez, 2017).

5.6 Conclusions

In this thesis, I start to fill a gap in our understanding in life history evolution caused by an underrepresentation of insects in life history studies. Using a taxonomically and geographically broad dataset of insect traits, I examine the covariation of life history traits at a class level and find that they do not firmly fit the idea of a ‘fast-slow continuum’ of interlinked traits. This raises questions about the generality of these widely invoked patterns. I then explore how aspects of life history are correlated with ecology and evolutionary innovations in insects and concur with the body of literature suggesting that individual adaptations may affect individual life history traits, but rarely shift ‘suites’ of traits together. Finally, I find evidence in favour for the hypothesis that changes in life history have impacts on diversification, something which may inform our understanding of current and future biodiversity change. Though it has been shown previously, future researchers should be wary of universal paradigms in life history evolution, and appreciate the nuances produced by lineage specific effects. The dataset presented here will hopefully form the basis of a number of new comparative investigations of life history evolution, and I suggest that many of the hypotheses considered in other groups should be specifically tested across insects, since effects across taxonomic groups seem to vary.

References

W. L. Allen, S. E. Street, and I. Capellini. Fast life history traits promote invasion success in amphibians and reptiles. *Ecology Letters*, 20:222–230, 2017.

A. A. Azawi and R. W. Chew. Notes on the ecology of the dark rice field mosquito, *Psorophora confinnis*, in coachella valley, california (diptera: Culicidae). *Annals of the Entomological Society of America*, 52:345–351, 1959.

T. R. Baker, R. T. Pennington, S. Magallon, E. Gloor, W. F. Laurance, M. Alexiades, E. Alvarez, A. Araujo, E. J. M. M. Arets, G. Aymard, A. A. de Oliveira, I. Amaral, L. Arroyo, D. Bonal, R. J. W. Brienen, J. Chave, K. G. Dexter, A. Di Fiore, E. Eler, T. R. Feldpausch, L. Ferreira, G. Lopez-Gonzalez, G. van der Heijden, N. Higuchi, E. Honorio, I. Huamantupa, T. J. Killeen, S. Laurance, C. Leaño, S. L. Lewis, Y. Malhi, B. S. Marimon, B. H. Marimon Jr., A. Monteagudo Mendoza, D. Neill, M. C. Peñuela-Mora, N. Pitman, A. Prieto, C. A. Quesada, F. Ramírez, H. Ramírez Angulo, A. Rudas, A. R. Ruschel, R. P. Salomão, A. S. de Andrade, J. N. M. Silva, M. Silveira, M. F. Simon, W. Spironello, H. T. Steege, J. Terborgh, M. Toledo, A. Torres-Lezama, R. Vasquez, I. C. G. Vieira, E. Vilanova, V. A. Vos, and O. L. Phillips. Fast demographic traits promote high diversification rates of amazonian trees. *Ecology Letters*, 17:527–536, 2014.

A. T. Bakewell, K. E. Davis, R. P. Freckleton, N. J. B. Isaac, and P. J. Mayhew. Data from: Comparing life histories across taxonomic groups in multiple dimensions: how mammal-like are insects? http://dx.doi.org/10.5061/dryad.sb307mm, 2019.

D. Bauwens and R. Díaz-Uriarte. Covariation of life-history traits in lacertid lizards: a comparative study. *The American Naturalist*, 149:91–111, 1997.

X. Belles. Origin and evolution of insect metamorphosis. http://dx.doi.org/10.1002/9780470015902.a0022854, 2011.

Y. Benjamini and Y. Hochberg. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society, Series B (Methodological)*, 57:289–300, 1995.

D. J. Bennett, M. D. Sutton, and S. T. Turvey. treeman: an r package for efficient and intuitive manipulation of phylogenetic trees. *BMC Research Notes*, 10:e30, 2017.

P. M. Bennett and I. P. F. Owens. *Evolutionary Ecology of Birds: Life Histories, Mating Systems and Extinction*. Oxford University Press, Oxford, UK, 2002.

D. Berrigan. The allometry of egg size and number in insects. *Oikos*, 60:313–321, 1991.

E. Beukhof, R. Frelat, L. Peuchet, A. Maureaud, T. Spaanheden Dencker, J. Sólmundsson, A. Punzón, R. Primicerio, M. Hidalgo, C. Möllmann, and M. Lindegren. Marine fish traits follow fast-slow continuum across oceans. *Scientific Reports*, 9:e17878, 2019.

J. Bielby, G. M. Mace, O. R. P. Bininda-Emonds, M. Cardillo, J. L. Gittleman, K. E. Jones, C. D. L. Orme, and A. Purvis. The fast-slow continuum in mammalian life history: an empirical reevaluation. *The American Naturalist*, 169:748–757, 2007.

D. C. Blackburn, G. Giribet, D. E. Soltis, and E. L. Stanley. Predicting the impact of describing new species on phylogenetic patterns. *Integrative Organismal Biology*, 1:obz028, 2019.

T. M. Blackburn. Evidence for a 'fast-slow continuum' of life history traits among parasitoid hymenoptera. *Functional Ecology*, 5:65–74, 1991a.

T. M. Blackburn. A comparative examination of life-span and fecundity in parasitoid hymenoptera. *Journal of Animal Ecology*, 60:151–164, 1991b.

T. M. Blackburn and K. J. Gaston. What determines the probability of discovering a species?: a study of south american oscine passerine birds. *Journal of Biogeography*, 22:7–14, 1995.

C. Braendle, A. Heyland, and T. Flatt. Integrating mechanistic and evolutionary analysis of life history variation. In T. Flatt and A. Heyland, editors, *Mechanisms of Life History Evoluton: The Genetics and Physiology of Life History Traits and Trade-Offs*. Oxford University Press, New York, NY, 2011.

D. H. Branson. Influence of individual body size on reproductive traits in melanopline grasshoppers (orthoptera: Acrididae). *Journal of Orthoptera Research*, 17:259–263, 2008.

R. Bro, E. Acar, and T. G. Kolda. Resolving the sign ambiguity in the singular value decomposition. *Journal of Chemometrics*, 22:135–140, 2008.

L. Bromham. Molecular clocks in reptiles: life history influences rate of molecular evolution. *Molecular Biology and Evolution*, 19:302–309, 2002.

J. E. Brommer. The evolution of fitness in life-history theory. *Biological Reviews*, 75:377–404, 2000.

J. H. Brown, J. F. Gillooly, A. P. Allen, V. M. Savage, and G. B. West. Toward a metabolic theory of ecology. *Ecology*, 85:1771–1789, 2004.

H. Brueland. *Highest Lifetime Fecundity*. University of Florida, Gainsville, FL, 1995.

P. Capdevila, M. Berger, S. P. Blomberg, B. Hereu, C. Linares, and R. Salguero-Gómez. Longevity, body dimension and reproductive mode drive differences in aquatic versus terrestrial life-history strategies. *Functional Ecology*, 34:1613–1625, 2020.

I. Capellini, J. Baker, W. L. Allen, S. E. Street, and C. Venditti. The role of life history traits in mammalian invasion success. *Ecology Letters*, 18:1099–1107, 2015.

M. Cardillo, J. S. Huxtable, and L. Bromham. Geographic range size, life history and rates of diversification in australian mammals. *Journal of Evolutionary Biology*, 16:282–288, 2003.

Pedro Cardoso, Philip S. Barton, Klaus Birkhofer, Filipe Chichorro, Charl Deacon, Thomas Fartmann, Caroline S. Fukushima, René Gaigher, Jan C. Habel, Caspar A. Hallmann, Matthew J. Hill, Axel Hochkirch, Mackenzie L. Kwak, Stefano Mammola, Jorge Ari Noriega, Alexander B. Orfinger, Fernando Pedraza, James S. Pryke, Fabio O. Roque, Josef Settele, John P. Simaika, Nigel E. Stork, Frank Suhling, Carlien Vorster, and Michael J. Samways. Scientists' warning to humanity on insect extinctions. *Biological Conservation*, 242:108426, 2020.

G. Ceballos, P. R. Ehrlich, and R. Dirzo. Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proceedings of the National Academy of Sciences of the United States of America*, 114: E6089–E6096, 2017.

Pierfilippo Cerretti, John O. Stireman, III, Thomas Pape, James E. O'Hara, Marco A. T. Marinho, Knut Rognes, and David A. Grimaldi. First fossil of an oestroid fly (diptera: Calyptratae: Oestroidea) and the dating of oestroid divergences. *PLoS ONE*, 12:e0182101, 2017.

S. Chamberlain and E. Szocs. taxize - taxonomic search and retrieval in r. *F1000Research*, 2:191, 2013.

B. Charlesworth. *Evolution in Age Structured Populations*. Cambridge University Press, Cambridge, UK, 1994.

E. L. Charnov. Evolution of life history variation among female mammals. *Proceedings of the National Academy of Sciences of the United States of America*, 88: 1134–1137, 1991.

E. L. Charnov. *Life History Invariants*. Oxford University Press, Oxford, UK, 1993.

E. L. Charnov. Evolution of mammalian life histories. *Evolutionary Ecology Research*, 3:521–535, 2001.

E. L. Charnov. The optimal balance between growth rate and survival in mammals. *Evolutionary Ecology Research*, 6:307–313, 2004.

Samuel H. Church, Seth Donoughe, Bruno A. S. de Medeiros, and Cassandra G. Extavour. A dataset of egg size and shape from more than 6,700 insect species. *Scientific Data*, 6:e104, 2019.

J. Clobert, T. Garland Jr., and R. Barbault. The evolution of demographic tactics in lizards: a test of some hypotheses concerning life history evolution. *Journal of Evolutionary Biology*, 11:329–364, 1998.

T. H. Clutton-Brock. *The Evolution of Parental Care*. Princeton University Press, Princeton, NJ, 1991.

L. C. Cole. The population consequences of life history phenomena. *Quarterly Review of Biology*, 29:103–137, 1954.

F. L. Condamine, M. E. Clapham, and G. J. Kergoat. Global patterns of insect diversification: towards a reconciliation of fossil and molecular evidence? *Scientific Reports*, 6:e19208, 2016.

J. Cracraft. A nonequilibrium theory for the rate-control of speciation and extinction and the origin of macroevolutionary patterns. *Systematic Biology*, 31: 348–365, 1982.

M. J. Crawley. *Statistics: An Introduction Using R*. John Wiley & Sons, Ltd., Chichester, UK, 2005.

K. E. Davis, A. T. Bakewell, J. Hill, H. Song, and P. J. Mayhew. Global cooling & the rise of modern grasslands: revealing cause & effect of environmental change on insect diversification dynamics. http://dx.doi.org/10.1101/392712, 2018.

R. B. Davis, J. Javoiš, A. Kaasik, E. Õunap, and T. Tammaru. An ordination of life histories using morphological proxies: capital vs. income breeding in insects. *Ecology*, 97:2112–2124, 2016.

J. P. de Magalhães and J. Costa. A database of vertebrate longevity records and their relation to other life-history traits. *Journal of Evolutionary Biology*, 22: 1770–1774, 2009.

C. Dijkstra, A. Bult, S. Daan, T. Meijer, and M. Zijlstra. Brood size manipulations in the kestrel (*Falco tinnunculus*): effects on offspring and parent survival. *Journal of Animal Ecology*, 59:269–285, 1990.

K.-D. B. Dijkstra, M. T. Monaghan, and S. U. Pauls. Freshwater biodiversity and insect diversification. *Annual Review of Entomology*, 59:143–163, 2014.

Shuangmei Ding, Weihai Li, Ying Wang, Stephen L Cameron, Dávid Murányi, and Ding Yang. The phylogeny and evolutionary timescale of stoneflies (insecta: Plecoptera) inferred from mitochondrial genomes. *Molecular Phylogenetics and Evolution*, 135:123–135, 2019.

T. Dobzhansky. Evolution in the tropics. *American Scientist*, 38:209–221, 1950.

Netta Dorchin, Keith M Harris, and John O Stireman III. Phylogeny of the gall midges (diptera, cecidomyiidae, cecidomyiinae): Systematics, evolution of feeding modes and diversification rates. *Molecular Phylogenetics and Evolution*, 140:e106602, 2019.

B. Ebenman. Evolution in organisms that change their niches during the life cycle. *The American Naturalist*, 139:990–1021, 1992.

S. Engen and B.-E. Sæther. r- and k-selection in fluctuating populations is determined by the evolutionary trade-off between two fitness measures: growth rate and lifetime reproductive success. *Evolution*, 71:167–173, 2016.

Marianne Espeland, Jesse Breinholt, Keith R Willmott, Andrew D Warren, Roger Vila, Emmanuel FA Toussaint, Sarah C Maunsell, Kwaku Aduse-Poku, Gerard Talavera, Rod Eastwood, Marta A. Jarzyna, Robert Guralnick, David J. Lohman, Naomi E. Pierce, and Akito Y. Kawahara. A comprehensive and dated phylogenomic analysis of butterflies. *Current Biology*, 28(5):770–778, 2018.

Dominic A. Evangelista, Benjamin Wipfler, Olivier Béthoux, Alexander Donath, Mari Fujita, Manpreet K. Kohli, Frédéric Legendre, Shanlin Liu, Ryuichiro Machida, Bernhard Misof, Ralph S. Peters, Lars Podsiadlowski, Jes Rust, Kai Schuette, Ward Tollenaar, Jessica L. Ware, Torsten Wappler, Xin Zhou, Karen Meusemann, and Sabrina Simon. An integrative phylogenomic approach illuminates the evolutionary history of cockroaches and termites (blattodea). *Proceedings of the Royal Society B: Biological Sciences*, 286(1895):20182076, 2019.

M. E. K. Evans and J. Dennehy. Germ banking: bet-hedging and variable release from egg and seed dormancy. *The Quarterly Review of Biology*, 80:431–451, 2005.

J. Felsenstein. Phylogenies and the comparative method. *The American Naturalist*, 125:1–15, 1985.

P. N. Ferns and M. A. Jervis. Ordinal species richness in insects - a preliminary study on the influence of morphology, life history, and ecology. *Entomogia Experimentalis et Applicata*, 159:270–284, 2016.

D. O. Fisher, I. P. F. Owens, and C. N. Johnson. The ecological basis of life history variation in marsupials. *Ecology*, 82:3531–3540, 2001.

T. Flatt. Survival costs of reproduction in *Drosophila*. *Experimental Gerontology*, 46: 369–375, 2011.

T. Flatt and P. S. Schmidt. Integrating evolutionary and molecular genetics of aging. *Biochima et Biophysica Acta*, 1790:951–962, 2009.

A. A. Forbes, R. K. Bagley, M. A. Beer, A. C. Hippee, and H. A. Widmayer. Quantifying the unquantifiable: why hymenoptera, not coleoptera, is the most speciose animal order. *BMC Ecology*, 18:21, 2018.

R. Fox, C. A. Harrower, J. R. Bell, C. R. Shortall, I. Middlebrook, and R. J. Wilson. Insect population trends and the iucn red list process. *Journal of Insect Conservation*, 23:269–278, 2018.

M. Franco and J. Silvertown. Life history variation in plants: an exploration of the fast-slow continuum hypothesis. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 351:1314–1348, 1996.

R. P. Freckleton, P. H. Harvey, and M. Pagel. Phylogenetic analysis and comparative data: a test and review of evidence. *The American Naturalist*, 160:712–726, 2002.

S. A. Fritz, O. R. P. Bininda-Emonds, and A. Purvis. Geographical variation in predictors of mammalian extinction risk: big is bad, but only in the tropics. *Ecology Letters*, 12:538–549, 2009.

R. Froese and D. Pauly. Fishbase. http://www.fishbase.org, 2019.

J.-M. Galliard, D. Pointer, D. Allainé, J. D. Lebreton, J. Trouvilliez, and J. Clobert. An analysis of demographic tactics in birds and mammals. *Oikos*, 56:59–76, 1989.

K. J. Gaston. Spatial patterns of species description: How is our knowledge of the global insect fauna growing? *Biological Conservation*, 67:37–40, 1994.

E. Geffen, M. E. Gompper, J. L. Gittleman, H.-K. Luh, D. W. MacDonald, and R. K. Wayne. Size, life-history traits, and social organization in the canidae: a reevaluation. *The American Naturalist*, 147:140–160, 1996.

S. M. Ghosh and A. Joshi. Evolution of reproductive isolation as a by-product of divergent life-history evolution in laboratory populations of *drosophila melanogaster*. *Ecology and Evolution*, 2:3214–3226, 2012.

J. D. J. Gilbert and A. Manica. The evolution of parental care in insects: a test of current hypotheses. *Evolution*, 69:1225–1270, 2015.

H. C. J. Godfray. *Parasitoids: Behavioural and Evolutionary Biology*. Princeton University Press, Princeton, NJ, 1994.

E. W. Goolsby, J. Bruggeman, and C. Ané. Rphylopars: fast multivariate phylogenetic comparative methods for missing data and within-species variation. *Methods in Ecology and Evolution*, 8:22–27, 2017.

M. Grbic, L. M. Nagy, and M. R. Strand. Development of polyembryonic insects: a major departure from typical insect embryogenesis. *Development, Genes and Evolution*, 208:69–81, 1999.

D. Grimaldi and M. S. Engel, editors. *Evolution of the Insects*. Cambridge University Press, New York, NY, 2005.

J. P. Grime. Evidence for existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. *The American Naturalist*, 111: 1169–1194, 1977.

J. P. Grime and S. Pierce. *The Evolutionary Strategies that Shape Ecosystems*. Wiley-Blackwell, Chichester, UK, 2012.

L. Gustafsson and W. J. Sutherland. The costs of reproduction in the collard flycatcher, *Ficedula albicollis*. *Nature*, 335:813–815, 1988.

C. A. Hallmann, M. Sorg, E. Jongejans, H. Siepel, N. Hofland, H. Schwan, W. Stenmans, A. Müller, H. Sumser, T. Hörren, D. Goulson, and H. de Kroon. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PLoS ONE*, 12:e0185809, 2017.

N. Hamada, J. H. Thorp, and D. C. Rogers. *Keys to Neotropical Hexapoda*. Academic Press, London, UK, 2018.

Ho-Yeon Han and Kyung-Eui Ro. Molecular phylogeny of the superfamily tephritoidea (insecta: Diptera) reanalysed based on expanded taxon sampling and sequence data. *Journal of Zoological Systematics and Evolutionary Research*, 54: 276–288, 2016.

P. H. Harvey and M. Pagel. *The comparative method in evolutionary biology*. Oxford University Press, Oxford, UK, 1991.

P. H. Harvey and A. Purvis. Understanding the ecological and evolutionary reasons for life history variation: mammals as a case study. In J. McGlade, editor, *Advanced Ecological Theory: Principles and Applications*. Blackwell Science, Oxford, UK, 1999.

K. Healy, T. H. G. Ezard, O. R. Jones, R. Salguero-Gómez, and Y. M. Buckley. Animal life history is shaped by the pace of life and the distribution of age-specific mortality and reproduction. *Nature Ecology and Evolution*, 3:1217–1224, 2019.

S. Holm, R. B. Davis, J. Javoiš, E. Õunap, A. Kaasik, F. Molleman, and T. Tammaru. A comparative perspective on longevity: the effect of body size dominates over ecology in moths. *Journal of Evolutionary Biology*, 29:2422–2435, 2016.

A. Honěk. Intraspecific variation in body size and fecundity in insects: a general relationship. *Oikos*, 66:483–492, 1993.

GE Hutchinson and Robert H MacArthur. A theoretical ecological model of size distributions among species of animals. *The American Naturalist*, 93(869): 117–125, 1959.

N. J. B. Isaac, K. E. Jones, J. L. Gittleman, and A. Purvis. Correlates of species richness in mammals: body size, life history, and ecology. *The American Naturalist*, 165:600–607, 2005.

C. A. Istock. The evolution of complex life cycle phenomena: an ecological perspective. *Evolution*, 21:592–605, 1967.

A. L. Jaffe, G. J. Slater, and M. E. Alfaro. The evolution of island gigantism and body size variation in tortoises and turtles. *Biology Letters*, 7:558–561, 2011.

N. D. Jago. The world-wide magnitude of orthoptera as pests. *Journal of Orthoptera Research*, 7:117–124, 1998.

T. Jeppsson and P. Forslund. Can life history predict the effect of demographic stochasticity on extinction risk? *The American Naturalist*, 179:706–720, 2012.

J. M. Jeschke and H. Kokko. The roles of body size and phylogeny in fast and slow life histories. *Evolutionary Ecology*, 23:867–878, 2009.

W. Jetz, G. H. Thomas, J. B. Joy, K. Hartmann, and A. O. Moores. The global diversity of birds in space and time. *Nature*, 15:444–448, 2012.

Kevin P. Johnson, Christopher H. Dietrich, Frank Friedrich, Rolf G. Beutel, Benjamin Wipfler, Ralph S. Peters, Julie M. Allen, Malte Petersen, Alexander Donath, Kimberly K. O. Walden, Alexey M. Kozlov, Lars Podsiadlowski, Christoph Mayer, Karen Meusemann, Alexandros Vasilikopoulos, Robert M. Waterhouse, Stephen L. Cameron, Christiane Weirauch, Daniel R. Swanson, Diana M. Percy, Nate B. Hardy, Irene Terry, Shanlin Liu, Xin Zhou, Bernhard Misof, Hugh M. Robertson, and Kazunori Yoshizawa. Phylogenomics and the evolution of hemipteroid insects. *Proceedings of the National Academy of Sciences of the United States of America*, 115(50):12775–12780, 2018.

I. T. Jolliffe and J. Cadima. Principal component analysis: a review and recent developments. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374:20150202, 2016.

K. E. Jones, J. Bielby, M. Cardillo, S. A. Fritz, J. O'Dell, C. D. L. Orme, K. Safi, W. Sechrest, E. H. Boakes, C. Carbone C. A. Plaster, S. A. Price, E. A. Rigby, J. Rist, A. Teacher, O. R. P. Bininda-Emonds, J. L. Gittleman, G. M. Mace, and A. Purvis. Pantheria: a species-level database of life history, ecology, and geography of extant and recently extinct mammals. *Ecology*, 90:2648, 2009.

A. Katzourakis, A. Purvis, S. Azmeh, G. Rotheray, and F. Gilbert. Macroevolution of hoverflies (diptera: Syrphidae): the effect of using higher-level taxa in studies of biodiversity, and correlates of species richness. *Journal of Evolutionary Biology*, 14:219–227, 2001.

Akito Y Kawahara, David Plotkin, Marianne Espeland, Karen Meusemann, Emmanuel FA Toussaint, Alexander Donath, France Gimnich, Paul B Frandsen, Andreas Zwick, Mario dos Reis, et al. Phylogenomics reveals the evolutionary timing and pattern of butterflies and moths. *Proceedings of the National Academy of Sciences of the United States of America*, 116(45):22657–22663, 2019.

Laurent Keller. Social life: the paradox of multiple-queen colonies. *Trends in Ecology and Evolution*, 10:355–360, 1995.

J. Kozłowski and J. Wiener. Interspecific allometries are by-products of body size optimization. *The American Naturalist*, 149:352–380, 1997.

E. S. Krafsur and C. M. Ernst. Physiological age composition and reproductive biology of horn fly populations, *Haematobia irritans irritans* (diptera, muscidae), in iowa, usa. *Journal of Medical Entomology*, 20:664–669, 1983.

H. W. Krenn, J. D. Plant, and N. U. Szucsich. Mouthparts of flower-visiting insects. *Arthropod Structure & Development*, 34:1–40, 2005.

S. Kumar, G. Stecher, M. Suleski, and S. B. Hedges. Timetree: a resource for timelines, timetrees, and divergence times. *Molecular Biology and Evolution*, 34: 1812–1819, 2017.

H. Kutter and R. Stumper. Hermann appel, ein leidgeadelter entomologe (1892-1966). *Proceedings of the Sixth International Congress of the International Union for The Study of Social Insects (Bern)*, 6:275–279, 1969.

D. Lack. The significance of clutch size. *Ibis*, 89:302–352, 1947.

R. Lande, S. Engen, and B.-E. Sæther. Evolution of stochastic demography with life history tradeoffs in density-dependent age-structured populations. *Proceedings of the National Academy of Sciences of the United States of America*, 114:11582–11590, 2017.

R. Law. Ecological determinants in the evolution of life histories. In R. M. Anderson, B. D. Turner, and L. R. Taylor, editors, *Population Dynamics*. Blackwell Scientific, Oxford, UK, 1979.

J. Lehtonen and R. Lanfear. Generation time, life history and the substitution rate of neutral mutations. *Biology Letters*, 10:e20140801, 2014.

C. M. Lessells. Brood size in canada geese: a manipulation experiment. *Journal of Animal Ecology*, 55:669–689, 1986.

T. Lislevand, J. Figureola, and T. Székely. Avian body sizes in relation to fecundity, mating system, display behavior, and resource sharing. *Ecology*, 88:1605, 2007.

R. H. Macarthur and E. O. Wilson. *The Theory of Island Biogeography*. Princeton University Press, Princeton, NJ, 1967.

D. R. Maddison and K.-S. Shulz. The tree of life web project. https://tolweb.org, 2007.

S. Magallón and M. Sanderson. Absolute diversification rates in angiosperm clades. *Evolution*, 55:1762–1780, 2001.

W. Mair, C. M. Sgrò, A. P. Johnson, T. Chapman, and L. Partridge. Lifespan extension by dietary restriction in female drosophila melanogaster is not caused by a reduction in vitellogenesis or ovarian activity. *Experimental Gerontology*, 39: 1011–1019, 2004.

Tobias Malm, Kjell Arne Johanson, and Niklas Wahlberg. The evolutionary history of t richoptera (i nsecta): A case of successful adaptation to life in freshwater. *Systematic Entomology*, 38(3):459–473, 2013.

T. E. Martin. Age-related mortality explains life history strategies of tropical and temperate songbirds. *Science*, 349:966–970, 2015.

J. M. Marzluff and K. P. Dial. Life history correlates of taxonomic diversity. *Ecology*, 72:428–439, 1991.

Yoko Matsumura, Rolf G. Beutel, José A. Rafael, Izumi Yao, Josenir T. Câmara, Sheila P. Lima, and Kazunori Yoshizawa. The evolution of zoraptera. *Systematic Entomology*, 45(2):349–364, 2020.

P. J. Mayhew. Why are there so many insect species? perspectives from fossils and phylogenies. *Biological Reviews*, 82:424–454, 2007.

P. J. Mayhew. Comparing parasitoid life histories. *Entomogia Experimentalis et Applicata*, 159:147–162, 2016.

P. J. Mayhew. Explaining global insect species richness: lessons from a decade of macroevolutionary entomology. *Entomogia Experimentalis et Applicata*, 166: 225–250, 2018.

D. McHugh and P. P. Fong. Do life history traits account for diversity of polychaete annelids? *Invertebrate Biology*, 121:325–338, 2002.

Dino P. McMahon, Alexander Hayward, and Jeyaraney Kathirithamby. The first molecular phylogeny of strepsiptera (insecta) reveals an early burst of molecular evolution correlated with the transition to endoparasitism. *PLoS ONE*, 6:e21206, 2011.

M. A. McPeek and J. M. Brown. Clade age and not diversification rate explains species richness among animal taxa. *The American Naturalist*, 169(4):E97–E106, 2007.

P. B. Medawar. *An Unsolved Problem of Biology*. H. K. Lewis, London, UK, 1952.

B. Misof. Diversity of anisoptera (odonata): Infering speciation processes from patterns of morphological diversity. *Zoology*, 105:355–365, 2002.

B. Misof, S. Liu, K. Meusemann, R. S. Peters, A. Donath, C. Mayer, P. B. Frandsen, J. Ware, T. Flouri, R. G. Beutel, O. Niehuis, M. Petersen, F. Izquierdo-Carrasco, T. Wappler, J. Rust, A. J. Aberer, U. Aspöck, H. Aspöck, D. Bartel, A. Blanke, S. Berger, A. Böhm, T. R. Buckley, B. Calcott, J. Chen, F. Friedrich, M. Fukui, M. Fujita, C. Greve, P. Grobe, S. Gu, Y. Huang, L. S. Jermiin, A. Y. Kawahara, L. Krogmann, M. Kubiak, R. Lanfear, H. Letsch, Y. Li, Z. Li, J. Li, H. Lu, R. Machida, Y. Mashimo, P. Kapli, D. D. McKenna, G. Meng, Y. Nakagaki, J. L. Navarrete-Heredia, M. Ott, Y. Ou, G. Pass, L. Podsiadlowski, H. Pohl, B. M. von Reumont, K. Schütte, K. Sekiya, S. Shimizu, A. Slipinski, A. Stamatakis, W. Song, X. Su, N. U. Szucsich, M. Tan, X. Tan, M. Tang, J. Tang, G. Timelthaler, S. Tomizuka, M. Trautwein, X. Tong, T. Uchifune, M. G. Walzl, B. M. Wiegmann, J. Wilbrandt, B. Wipfler, T. K. F. Wong, Q. Wu, G. Wu, Y. Xie, S. Yang, Q. Yang, D. K. Yeates, K. Yoshizawa, Q. Zhang, R. Zhang, W. Zhang, Y. Zhang, J. Zhao, C. Zhou, L. Zhou, T. Ziesmann, S. Zou, Y. Li, X. Xu, Y. Zhang, H. Yang, J. Wang, J. Wang, K. M. Kjer, and X. Zhou. Phylogenomics resolves the timing and pattern of insect evolution. *Science*, 346:763–767, 2014.

T. Miyatake and T. Shimizu. Genetic correlations between life-history and behavioral traits can cause reproductive isolation. *Evolution*, 53:201–208, 1999.

A. O. Mooers and S. B. Heard. Inferring evolutionary process from phylogenetic tree shape. *The Quarterly Review of Biology*, 72:31–54, 1997.

C. Mora, D. P. Tittensor, S. Adi, A. G. B. Simpson, and B. Worm. How many species are there on earth and in the ocean? *PLOS Biology*, 9:e1001127, 2011.

W. F. Morris and D. F. Doak. *Quantitative Conservation Biology: Theory and Practice of Population Viability Analysis*. Sinauer Associates, Sunderland, MA, 2002.

W. F. Morris, C. A. Pfister, S. Tuljapurkar, C. V. Haridas, C. L. Boggs, M. S. Boyce, E. M. Bruna, D. R. Church, T. Coulson, D. F. Doak, S. Forsyth, J.-M. Galliard, C. C. Horvitz, S. Kalisz, B. E. Kendall, T. M. Knight, C. T. Lee, and E. S. Menges. Longevity can buffer plant and animal populations against changing climatic variability. *Ecology*, 89:19–25, 2008.

N. P. Myhrovld, E. Baldridge, B. Chan, D. Divam, D. L. Freeman, and S. K. M. Ernest. An amniote life-history database to perform comparative analyses with birds, mammals, and reptiles. *Ecology*, 96:3109, 2015.

C. B. Nam. The progress of demography as a scientific discipline. *Demography*, 16:485–492, 1979.

M. T. Neiber, T. R. Hartke, T. Stemme, A. Bergmann, J. Rust, T. M. Iliffe, and S. Koenemann. Global biodiversity and phylogenetic evaluation of remipedia (crustacea). *PLOS ONE*, 6:1–12, 2011.

D. B. Nicholson, A. J. Ross, and P. J. Mayhew. Fossil evidence for key innovations in the evolution of insect diversity. *Proceedings of the Royal Society B: Biological Sciences*, 281:e20141823, 2014.

M. A. Nowak and C. E. Tarnita. The evolution of eusociality. *Nature*, 466:1057–1062, 2010.

T. Nyman. To speciate, or not to speciate? resource heterogeneity, the subjectivity of similarity, and the macroevolutionary consequences of niche-width shifts in plant-feeding insects. *Biological Reviews*, 85:393–411, 2010.

J. R. Oaks. A time-calibrated species tree of crocodylia revals a recent radiation of the true crocodiles. *Evolution*, 65:3285–3297, 2011.

M. K. Oli. The fast-slow continuum and mammalian life-history patterns: an empirical evalution. *Basic and Applied Ecology*, 5:449–463, 2004.

C. D. L. Orme, D. L. J. Quicke, J. M. Cook, and A. Purvis. Body size does not predict species richness among the metazoan phyla. *Journal of Evolutionary Biology*, 15(2):235–247, 2002.

C. D. L. Orme, R. P. Freckleton, G. H. Thomas, T. Petzold, S. A. Fritz, N. J. B. Isaac, and W. Pearse. caper: Comparative analyses of phylogenetics and evolution in r. https://CRAN.R-project.org/package=caper, 2013.

I. P. F. Owens, P. M. Bennett, and P. H. Harvey. Species richness among birds: body size, life history, sexual selection or ecology? *Proceedings of the Royal Society B: Biological Sciences*, 266:933–939, 1999.

M. Pagel. Inferring the historical patterns of biological evolution. *Nature*, 401: 877–884, 1999.

E. Paradis, J. Claude, and K. Strimmer. Ape: analyses of phylogenetics and evolution in r language. *Bioinformatics*, 30:2216–2218, 2004.

C. S. Parr, K. S. Schulz, J. Hammock, N. Wilson, P. Leary, J. Rice, and R. J. Corrigan Jr. Traitbank: Practical semantics for organism attribute data. *Semantic Web*, 7: 577–588, 2016.

M. W. Pennell, J. M. Eastman, G. J. Brown, J. C. Uyeda, R. G. FitzJohn, M. E. Alfaro, and L. J. Harmon. geiger v2.0: an expanded suite of methods for fitting macroevolutionary models to phylogenetic trees. *Bioinformatics*, 30:2216–2218, 2014.

Ralph S. Peters, Lars Krogmann, Christoph Mayer, Alexander Donath, Simon Gunkel, Karen Meusemann, Alexey Kozlov, Lars Podsiadlowski, Malte Petersen, Robert Lanfear, Patricia A. Diez, John Heraty, Karl M. Kjer, Seraina Klopfstein, Rudolf Meier, Carlo Polidori, Thomas Schmitt, Shanlin Liu, Xin Zhou, Torsten Wappler, Jes Rust, Bernhard Misof, and Oliver Niehuis. Evolutionary history of the hymenoptera. *Current Biology*, 27(7):1013 – 1018, 2017. ISSN 0960-9822.

J. J. Pexton and P. J. Mayhew. Siblicide and life-history evolution in parasitoids. *Behavioral Ecology*, 13:690–695, 2002.

E. R. Pianka. On r- and k-selection. *The American Naturalist*, 104:592–597, 1970.

S. Pimm. *The Balance of Nature?* University of Chicago Press, Chicago, IL, 1991.

D. E. L. Promislow and P. H. Harvey. Living fast and dying young: a comparative analysis of life-history variation among mammals. *Journal of Zoology*, 220: 417–437, 1990.

A. Purvis and P.-M. Agapow. Phylogeny imbalance: taxonomic level matters. *Systematic Biology*, 51:844–854, 2002.

A. Purvis and P. H. Harvey. Mammal life-history evolution: a comparative test of charnov's model. *Journal of Zoology*, 237:259–283, 1995.

A. Purvis, C. D. L. Orme, and K. Dolphin. Why are most species small-bodied? a phylogenetic view. In T. M. Blackburn and K. J. Gaston, editors, *Macroecology: concepts and consequences*, pages 155–172. Blackwell Science, Oxford, UK, 2003.

R. A. Pyron, F. T. Burbrink, and J. J. Wiens. A phylogeny and revised classification of squamata, including 4161 species of lizards and snakes. *BMC Evolutionary Biology*, 13:93, 2013.

D. L. J. Quicke. *Parasitic Wasps*. Chapman & Hall, New York, NY, 1997.

D. L. Rabosky. Primary controls on species richness in higher taxa. *Systematic Biology*, 59:634–645, 2010.

D. L. Rabosky. Automatic detection of key innovations, rate shifts, and diversity-dependence on phylogenetic trees. *PLoS ONE*, 9:e89543, 2014.

D. L. Rabosky, G. J. Slater, and M. E. Alfaro. Clade age and species richness are decoupled across the tree of life. *PLoS Biology*, 10:e1001381, 2012.

J. L. Rainford and P. J. Mayhew. Diet evolution and clade richness in hexapoda: a phylogenetic study of higher taxa. *The American Naturalist*, 186:777–791, 2015.

J. L. Rainford, M. Hofreiter, D. B. Nicholson, and P. J. Mayhew. Phylogenetic distribution of extant richness suggests metamorphosis is a key innovation driving diversification in insects. *PLOS One*, 9:e109085, 2014.

J. L. Rainford, M. Hofreiter, and P. J. Mayhew. Phylogenetic analyses suggest that diversification and body size evolution are independent in insects. *BMC Evolutionary Biology*, 16(1):8, 2016.

D. M. Raup, S. J. Gould, T. J. M. Schopf, and D. S. Simberloff. Stochastic models of phylogeny and the evolution of diversity. *The Journal of Geology*, 81(5):525–542, 1973.

Jerome C Regier, Jeffrey W Shultz, and Robert E Kambic. Phylogeny of basal hexapod lineages and estimates of divergence times. *Annals of the Entomological Society of America*, 97(3):411–419, 2004.

K. R. Reidenbach, S. Cook, M. A. Bertone, R. E. Harbach, B. M. Wiegmann, and N. J. Besansky. Phylogenetic analysis and temporal diversification of mosquitoes (diptera: Culicidae) based on nuclear genes and morphology. *BMC Evolutionary Biology*, 9:e298, 2009.

V. H. Resh and R. T. Cardé, editors. *Encyclopedia of Insects*. Academic Press, Burlington, MA, 2009.

L. J. Revell. Size-correction and principal components for interspecific comparative studies. *Evolution*, 63:3258–3268, 2009.

L. J. Revell. phytools: an r pacakge for phylogenetic comparative biology (and other things). *Methods in Ecology and Evolution*, 3:217–223, 2012.

L. J. Revell. Comparing rates of speciation and extinction between phylogenetic trees. *Ecology and Evolution*, 8:5303–5312, 2018.

D. Reznick, M. J. Bryant, and F. Bashey. r- and k-selection revisited: the role of population regulation in life-history evolution. *Ecology*, 83:1509–1520, 2002.

R. E. Ricklefs. Global diversification rates of passerine birds. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 270(1530):2285–2291, 2003.

James A. Robertson, Sven Bradler, and Michael F. Whiting. Evolution of oviposition techniques in stick and leaf insects (phasmatodea). *Frontiers in Ecology and Evolution*, 6:e216, 2018.

D. A. Roff. *The Evolution of Life Histories: Theory and Analysis*. Chapman & Hall, New York, NY, 1992.

D. A. Roff. *Life History Evolution*. Sinauer Associates, Sunderland, MA, 2002.

L. E. Rogers, R. L. Buschbom, and C. R. Watson. Length-weight relationships of shrub-steppe invertebrates. *Annals of the Entomological Society of America*, 70: 51–53, 1977.

F. C. Rohwer. The adaptive significance of clutch size in prairie ducks. *Auk*, 209: 354–361, 1985.

J. Rolff, P. R. Johnston, and S. Reynolds. Complete metamorphosis of insects. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 374:2010063, 2019.

Y. Roskov, G. Ower, T. Orrell, D. Nicolson, N. Bailly, P. M. Kirk, T. Bourgoin, R. E. DeWalt, W. Decock, E. van Nieukerken E., J. Zarucchi, and L. Penev. Species 2000 and itis catalogue of life, 2019 annual checklist. www.catalogueoflife.org/annual-checklist/2019, 2019.

D. Rubolini, A. Liker, L. Garamszegi, A. P. Møller, and N. Saino. Using the birdtree.org website to obtain robust phylogenies for avian comparative studies: a primer. *Current Zoology*, 61:959–965, 2015.

B.-E. Sæther. The influence of body weigt on the covariation between reproductive traits in european birds. *Oikos*, 48:79–99, 1987.

B.-E. Sæther. Food provisioning in relation to reproductive strategy in altricial birds: a comparison of two hypotheses. *Evolution*, 48:1397–1406, 1994.

R. Salguero-Gómez. Applications of the fast-slow continuum and reproductive strategy framework of plant life histories. *New Phytologist*, 213:1618–1624, 2017.

R. Salguero-Gómez, O. R. Jones, C. R. Archer, Y. M. Buckley, J. Che-Castaldo, H. Caswell, D. Hodgeson, A. Scheuerlein, D. A. Conde, E. Brinks, H. de Buhr, C. Farack, F. Gottschalk, A. Hartmann, A. Henning, G. Hoppe, G. Römer, J. Runge, T. Ruoff, J. Wille, S. Zeh, R. Davison, D. Vieregg, A. Baudish, R. Altwegg, F. Colchero, M. Dong, H. de Kroon, J.-D. Lebreton, C. J. E. Metcalf, M. M. Neel, I. M. Parker, T. Takada, T. Valverde, L. A. Vélez-Espino, G. A. Wardle, M. Franco, and J. W. Vaupel. The compadre plant matrix database: an open online repository for plant demography. *Journal of Ecology*, 103:208–218, 2015.

R. Salguero-Gómez, O. R. Jones, E. Jongejans, S. P. Blomberg, D. J. Hodgson, C. Mbeau-Ache, P. A. Zuidema, H. De Kroon, and Y. M. Buckley. Fast-slow continuum and reproductive strategies structure plant life-history variation worldwide. *Proceedings of the National Academy of Sciences of the United States of America*, 113:230–235, 2016.

F. Sánchez-Bayo and K. A. G. Wyckhuys. Worldwide decline of the entomofauna: a review of its drivers. *Biological Conservation*, 232:8–27, 2019.

M. Schwentner, D. J. Combosch, J. P. Nelson, and G. Giribet. A phylogenomic solution to the origin of insects by resolving crustacean-hexapod relationships. *Current Biology*, 27:1818–1824, 2017.

G. G. E. Scudder. The importance of insects. In R. G. Foottit and P. H. Alder, editors, *Insect Biodiversity: Science and Society*. Wiley-Blackwell, West Sussex, UK, 2009.

Seunggwan Shin, Dave J Clarke, Alan R Lemmon, Emily Moriarty Lemmon, Alexander L Aitken, Stephanie Haddad, Brian D Farrell, Adriana E Marvaldi, Rolf G Oberprieler, and Duane D McKenna. Phylogenomic data yield new and robust insights into the phylogeny and evolution of weevils. *Molecular Biology and Evolution*, 35(4):823–836, 2018.

J. B. Shurin, D. S. Gruner, and H. Hillebrand. All wet or dried up? real differences between aquatic and terrestrial food webs. *Proceedings of the Royal Society B: Biological Sciences*, 273:1–9, 2006.

C. Simon. Evolution of 13- and 17-year periodical cicadas (homoptera: Cicadidae: *Magicicada*). *Bulletin of the Entomological Society of America*, 34:163–176, 1988.

U. Sinsch and J. M. Dehling. Tropical anurans mate early and die young: evidence from eight afromontane *hyperolius* species and a meta-analysis. *PLoS ONE*, 12: e0171666, 2017.

C. C. Smith and S. D. Fretwell. The optimal balance between size and number of offspring. *The American Naturalist*, 108:499–506, 1974.

D. Sol, J. Maspons, M. Vall-Ilosera, L. Bartomeus, G. E. Garcia-Peña, J. Piñol, and R. P. Freckleton. Unravelling the life history of successful invaders. *Science*, 337: 580–583, 2012.

T. R. E. Southwood. Habitat, the template for ecological strategies. *Journal of Animal Ecology*, 46:336–365, 1977.

S. C. Stearns. The evolution of life history traits: a critique of the theory and review of the data. *Annual Review of Ecology and Systematics*, 8:145–171, 1977.

S. C. Stearns. The influence of size and phylogeny on patterns of covariation among life-history traits in the mammals. *Oikos*, 41:173–187, 1983.

S. C. Stearns. Trade-offs in life-history evolution. *Functional Ecology*, 3:259–268, 1989.

S. C. Stearns. *The Evolution of Life Histories*. Oxford University Press, Oxford, UK, 1992.

S. C. Stearns and L. Partridge. The genetics of aging in *Drosophila*. In E. Masoro and S. Austad, editors, *Handbook of Aging*. Academic Press, San Diego, CA, 2001.

J. H. Steele, H. K. Brink, and B. E. Scott. Comparison of marine and terrestrial ecosystems: suggestions of an evolutionary perspective influenced by environmental variation. *ICES Journal of Marine Science*, 76:50–59, 2019.

N. E. Stork. How many species of insects and other terrestrial arthropods are there on earth? *Annual Review of Entomology*, 53:31–45, 2018.

M. R. Strand and M. Grbic. The life history and development of postembryonic parasitoids. In N. E. Beckage, editor, *Parasites and Pathogens*. Springer, Boston, MA, 1997.

R. R. Strathmann. Why life histories evolve differently in the sea. *American Zoologist*, 30:197–207, 1990.

R. Strum. Relationship between body size and reproductive capacity in females of the black field cricket (orthoptera, gryllidae). *Linzer Biologische Beiträge*, 48: 1823–1834, 2016.

D. Stuart-Fox and I. P. F. Owens. Species richness in agamid lizards: chance, body size, sexual selection or ecology? *Journal of Evolutionary Biology*, 16:659–669, 2003.

J. Sukumaran and M. T. Holder. Dendropy: a python library for phylogenetic computing. *Bioinformatics*, 26:1569–1571, 2010.

J. Sukumaran and M. T. Holder. Sumtrees: Phylogenetic tree summarization, version 4.4.0. http://github.com/jeetsukumaran/DendroPy, 2015.

B. W. Sweeney and R. L. Vanote. Population synchrony in mayflies: a predator satiation hypothesis. *Evolution*, 36:810–821, 1982.

R Core Team. A language and environment for statistical computing. http://www.R-project.org/, 2017.

J. A. Thomas, J. J. Welch, R. Lanfear, and L. Bromham. A generation time effect on the rate of molecular evolution in invertebrates. *Molecular Biology and Evolution*, 27:1173–1180, 2010.

J. A. Thomas, J. H. W. Trueman, A. Rambaut, and J. J. Welch. Relaxed phylogenetics and the palaeoptera problem: resolving deep ancestral splits in the insect phylogeny. *Systematic Biology*, 62:285–297, 2013.

B. L. Thorne. Evolution of eusociality in termites. *Annual Review of Ecology and Systematics*, 28:27–54, 1997.

J. H. Thorp and D. C. Rogers. *Ecology and General Biology*. Academic Press, London, UK, 2015.

N. B. Tindale. Revision of the australian ghost moths (lepidoptera homoneura, family hepialidae). part ii. *Records of the South Australian Museum*, 5:13–43, 1933.

J. W. Truman and L. M. Riddiford. The origins of insect metamorphosis. *Nature*, 401:447–452, 1999.

J. W. Truman and L. M. Riddiford. The evolution of insect metamorphosis: a developmental and endocrine view. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 374:20190070, 2019.

J. C. Uyeda, D. S. Caetano, and M. W. Pennell. Comparative analysis of prinicpal components can be misleading. *Systematic Biology*, 64:677–689, 2015.

Torda Varga, Krisztina Krizsán, Csenge Földi, Bálint Dima, Marisol Sánchez-García, Santiago Sánchez-Ramírez, Gergely J Szöllősi, János G Szarkándi, Viktor Papp, László Albert, William Andreopoulos, Claudio Angelini, V. Antonin, K. W. Barry, N. L. Bougher, P. Buchanan, B. Buycl, V. Bense, P. Catcheside, M. Chovatia, J. Cooper, W. Dämon, D. Desjardin, P. Finy, J. Geml, S. Haridas, K. Hughes, A. Justo, D. Karasiński, I. Kautmanova, B. Kiss, S. Kocsubé, H. Kotiranta, K. M. LaButti, B. E. Lechner, K. Liimatainen, A. Lipzen, Z. Lukács, S. Mihaltcheva, L. N. Morgado, T. Niskanen, M. E. Noordeloos, R. A. Ohm, B. Ortiz-Santana, C. Ovrebo, N. Rácz, R. Riley, A. Savchenko, A. Shiryaev, K. Soop, V. Spirin, C. Szebenyi, M. Tomšovský, R. E. Tulloss, J. Uehling, I. V. Grigoriev, C. Vágvölgyi, P. Papp, F. M. Martin, O. Miettinen, D. S. Hibbert, and L. G. Nagy. Megaphylogeny resolves global patterns of mushroom evolution. *Nature ecology & evolution*, 3(4):668–678, 2019.

C. Venditti, A. Meade, and M. Pagel. Multiple routes to mammalian diversity. *Nature*, 479:393–396, 2011.

K. J. F. Verhoeven, K. L. Simonsen, and L. M. McIntyre. Implementing false discovery rate control: increasing your power. *Oikos*, 108:643–647, 2005.

B. Visser, C. Le Lann, F. J. Den Blanken, J. A. Harvey, J. J. M. Van Alphen, and J. Ellers. Loss of lipid synthesis as an evolutionary consequence of a parasitic lifestyle. *Proceedings of the National Academy of Sciences of the United States of America*, 107:8677–8682, 2010.

Niklas Wahlberg, Julien Leneveu, Ullasa Kodandaramaiah, Carlos Peña, Sören Nylin, André V. L. Freitas, and Andrew V. Z. Brower. Nymphalid butterflies diversify following near demise at the cretaceous/tertiary boundary. *Proceedings of the Royal Society B: Biological Sciences*, 276(1677):4295–4302, 2009.

J. T. Waller and E. I. Svensson. Body size evolution in an old insect order: No evidence for cope's rule in spite of fitness benefits of large size. *Evolution*, 71: 2178–2193, 2017.

J. A. Walter, A. R. Ives, J. F. Tooker, and D. M. Johnson. Life history and habitat explain variation among insect pest populations subject to global change. *Ecosphere*, 9:e02274, 2018.

C. R. White and R. S. Seymour. Mammalian basal metabolic rate is proportional to body mass(2/3). *Proceedings of the National Academy of Sciences of the United States of America*, 100:4046–4049, 2003.

D. W. Whitman. The significance of body size in orthoptera: a review. *Journal of Orthoptera Research*, 17:117–134, 2008.

Brian M. Wiegmann, Michelle D. Trautwein, Isaac S. Winkler, Norman B. Barr, Jung-Wook Kim, Christine Lambkin, Matthew A. Bertone, Brian K. Cassel, Keith M. Bayless, Alysha M. Heimberg, Benjamin M. Wheeler, Kevin J. Peterson, Thomas Pape, Bradley J. Sinclair, Jeffrey H. Skevington, Vladimir Blagoderov, Jason Caravas, Sujatha Narayanan Kutty, Urs Schmidt-Ott, Gail E. Kampmeier, F. Christian Thompson, David A. Grimaldi, Andrew T. Beckenbach, Gregory W. Courtney, Markus Friedrich, Rudolf Meier, and David K. Yeates. Episodic radiations in the fly tree of life. *Proceedings of the National Academy of Sciences of the United States of America*, 108(14):5690–5695, 2011.

J. J. Wiens. What explains patterns of biodiversity across the tree of life? *Bioessays*, 38:e1600128, 2017.

J. J. Wiens, R. T. Lapoint, and N. K. Whiteman. Herbivory increases diversification across insect clades. *Nature Communications*, 6:e8370, 2015.

P. Wiersma, A Muñoz-Garcia, A. Walker, and J. B. Williams. Tropical birds have a slow pace of life. *Proceedings of the National Academy of Sciences of the United States of America*, 104:9340–9345, 2007.

W. Wieser. A new look at energy-conversion in ectothermic and endothermic animals. *Oecologia*, 66:506–510, 1985.

H. M. Wilbur and V. H. W. Rudolf. Life history evolution in uncertain environments: bet hedging in time. *The American Naturalist*, 168:398–411, 2006.

H. M. Wilbur, D. W. Tinkle, and J. P. Collins. Evironmental uncertainty, trophic level, and resource availability in life history evolution. *The American Naturalist*, 108:805–817, 1974.

K. O. Winemiller and K. A. Rose. Patterns of life-history diversification in north american fishes: implications for population regulation. *Canadian Journal of Fisheries and Aquatic Sciences*, 49:2196–2218, 1992.

Shaun L Winterton, Nate B Hardy, and Brian M Wiegmann. On wings of lace: phylogeny and bayesian divergence time estimates of neuropterida (insecta) based on morphological and molecular data. *Systematic Entomology*, 35(3): 349–378, 2010.

A. S. Yang. Modularity, evolvability, and adaptive radiations: a comparison of the hemi- and holometabolous insects. *Evolution & Development*, 3:59–72, 2001.

Shao-Qian Zhang, Li-Heng Che, Yun Li, Dan Liang, Hong Pang, Adam Ślipiński, and Peng Zhang. Evolutionary history of coleoptera revealed by extensive sampling of genes and species. *Nature Communications*, 9:e205, 2018.

Z.-Q. Zhang. Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. *Zootaxa*, 3703:1–82, 2013.

Q. Zhu, M. W. Hastriter, M. F. Whiting, and K. Dittmar. Fleas (siphonaptera) are cretaceous, and evolved with theria. *Molecular Phylogenetics and Evolution*, 90: 129–139, 2015.

Appendix A

Supporting information for Chapter 2

A.1 Supplementary methods

A.1.1 Selecting an evolutionary model

The path of evolution imparts a structure to interspecific data: species, on average, share more characteristics with close relatives as a result of shared ancestry. The most common evolutionary model for accounting for the autocorrelation resulting from this is Brownian motion - which assumes that trait values change randomly over any time interval. Under this model, evolution has a constant tempo; species that are closely related to each other have less time to diverge, and thus are on average more similar to their close relatives than to distant ones. While this model is extremely helpful, there are situations (such as strong directional selection) where it is unrealistic, and can in fact mislead interpretation (Uyeda et al., 2015).

'Rphylopars' can implement several types of evolutionary model including Brownian motion, Ornstein-Uhlenbeck (OU), early burst (EB), and a model fitting lambda. OU models basically represent evolution under stabilising selection with a constant optimum, if traits deviate from this optimum then selection functions to shift it back. EB models assume that traits evolve through rapid exploitation of newly available niche and trait space (perhaps when a species colonises a new area, or competitors become extinct), and as those novel opportunities are used up diversification returns to a background rate. Models fitting lambda transform the tree, extending the terminal branches: the lambda parameter is estimated using maximum likelihood and varies between 0 and 1, where a value of 1 is identical to the Brownian motion model across the phylogeny and a value of 0 is equivalent to a Brownian motion model instead using a star phylogeny (Pagel, 1999). The lambda parameter therefore functions as a measure of how strongly the phylogeny predicts the pattern of the residual data, or the phylogenetic signal of the trait (Freckleton et al., 2002, Pagel, 1999).

We used the package 'geiger' (Pennell et al., 2014) in R (Team, 2017) to test alternative evolutionary models on our full set of natural-log body length data (n = 271), which is the most completely known variable and with which most of the other life history traits are highly correlated (Table 2.1). The model fitting lambda, with the parameter estimated as 0.965, was the best fit to the data (Table A.1).

A.1.2 Data collection

We sought variables from large scale datasets of mammalian, reptilian and avian life histories that were analogous to the traits that we had collected in orthopterans:

Table A.1 Fit of alternative evolutionary models to the orthopteran natural-logged body length (mm; n = 272) data and the Davis et al. (2018) supertree. σ^2 is the evolutionary rate parameter, larger values indicate traits which accumulate change through time faster (i.e. have faster random walks), and z_0 is the mean ancestral trait value. Conducted using the 'fitContinuous' function of the package 'geiger' (Pennell et al., 2014).

Model	σ^2	z_0	AICc	ΔAICc
Pagel's lambda[a]	0.003	2.840	207.539	0
Ornstein-Uhlenbeck[b]	1.288	3.220	434.661	227.122
Brownian motion	0.032	2.839	637.613	430.074
Early burst[c]	0.032	2.839	639.662	432.123

[a] λ = 0.965

[b] α = 2.174 (in OU models α represents the strength of evolutionary force returning traits back to the optimum)

[c] a = -0.000 (in EB models this parameter describes the change in the evolutionary rate parameter (σ^2) over time, a=0 is essentailly Brownian)

Body size: Across the vertebrate clades the most common measure of adult body size was adult body mass. We converted all measures to grams. For orthopterans, we did not have body mass data so we used the length to mass scaling equation by Rogers et al. (1977).

Offspring size: Again, mass was a much more common measure of offspring size than length in the vertebrate data. As mentioned in the methods of Chapter 2 we collected length at first instar in orthopterans, which could then be transformed into mass using the equation by Rogers et al. (1977). The length (or mass) of orthopterans in their first instar is indicative of their size soon after they have left the egg, and therefore the resources provided by the parent. Therefore, in mammals we took the body mass at weaning, in birds we used the body mass at fledging, and in reptiles we used the body mass at hatching/birth. All data were converted to grams.

Development time: : In orthopterans our data on development time measured the duration between hatching (i.e. independence from parent) and the final adult moult. We compare this to measures from independence to maturity in the other groups, converting all to days. In mammals, we calculate this interval as age at sexual maturity minus age at weaning. In birds, we calculate it as age at sexual maturity minus age at fledging. In reptiles, we use the age at sexual maturity.

Adult lifespan: Adult lifespan in orthopterans refers to the length of the adult, or reproductive stage. We calculate an analogous trait for the vertebrate clades by subtracting age at sexual maturity from maximum lifespan. All measures are converted to days.

Clutch size: In orthopterans number of eggs laid in a pod or bout of laying. In reptiles and birds we use the average number of eggs laid per clutch. In mammals we use the number of offspring per litter.

Clutch frequency: In all cases, clutch frequency is measured as the number of clutches (or litters, as outlined above) per year.

In our analyses focussing solely on Orthoptera we also used the variable voltinism, which indicates the number of generations per year that a species has. Voltinism is commonly referred to in the insect literature, but comparable measures are not so easy to come across in the vertebrate literature. Number of generations per year was not included as a trait in any of the life history databases that we used for the vertebrate clades (Lislevand et al., 2007, Jeschke and Kokko, 2009, de Magalhães and Costa, 2009, Capellini et al., 2015, Myhrovld et al., 2015, Allen et al., 2017) and so it was excluded from the analysis.

After choosing the variables to collect, we combined the datasets. Some of these datasets contain a mixture of real data and estimates, however we excluded any estimated values. Data from the most contemporary datasets - Myhrovld et al. (2015) for birds; Capellini et al. (2015) for mammals; and Allen et al. (2017) for reptiles - took precedence over data from older datasets, which were used to fill in gaps and add additional species. We then restricted the dataset to include only species with complete cases, as this is required for multivariate analysis. Prior to analysis all data were natural log-transformed.

A.1.3 Phylogeny

In analyses focussing solely on Orthoptera we built upon the extensive Davis et al. (2018) supertree. The Davis et al. (2018) supertree contains 1,519 species which were supplemented with an additional 992 taxa, resulting in a 2,511 taxon phylogeny. For analyses comparing taxonomic groups we merged six separate phylogenies: Mammalia (Fritz et al., 2009), Crocodilia (Oaks, 2011), Testudines (Jaffe et al., 2011), Squamata (Pyron et al., 2013), Orthoptera (Davis et al., 2018) and a consensus tree of Aves. To produce the avian consensus tree we used a distribution of trees from Jetz et al. (2012) and followed the method described by Rubolini et al. (2015) using the Python libraries 'DendroPy' (Sukumaran and Holder, 2015) and 'SumTrees' (Sukumaran and Holder, 2010). We constructed a backbone to link the trees and grafted them together using the package 'APE' (Paradis et al., 2004) in R (Team, 2017), using topology and node takes taken from the 'TimeTree' resource (Kumar et al., 2017). The most recent common ancestor between clades was dated as follows: Aves and Crocodilia at 237Ma; Testudines and previous 138 clades at 254Ma; Squamata and previous clades at 280Ma; Mammalia and previous clades at 313Ma; and Orthoptera and previous clades at 797Ma. The phylogenies are available via Dryad.

A.1.4 Calculating variance explained across taxonomic groups

Standard PCA procedure decomposes the correlation matrix (A) of a multivariate dataset into three simple matrices, two orthogonal (U and V) and one diagonal

(S). This is also referred to as a 'singular value decomposition' (SVD) of matrix A, which can mathematically be expressed as

$$A = U \cdot S \cdot V^T \tag{A.1}$$

Matrix U contains the eigenvectors of A$\cdot$A^T, and matrix V contains the eigenvectors of A$^T \cdot$ A. Since A is square and symmetrical its transpose is identical to itself (i.e. A = A^T), thus the resulting eigenvectors in columns of U and V are also the same. The diagonal matrix S contains the eigenvalues of A$\cdot$A^T and A$^T \cdot$A (which, again, are the same). Columns of U and V essentially contain the direction of orthogonal axes through multivariate space which explain the most variance, and the diagonal of S contains corresponding scalar values for each column of eigenvectors. Dividing the value in S corresponding to a certain set of eigenvectors by the sum of S gives the proportion of variance explained by that set of eigenvectors (or the axis through multivariate space which they represent). By rearranging the formula above, we can express S in terms of our correlation matrix and eigenvectors, i.e.:

$$S = U^{-1} \cdot A \cdot V \tag{A.2}$$

We take U and V for some baseline group (x) and A as the correlation matrix for different group (y). S therefore represents the amount of variation in y explained in the direction of the orthogonal eigenvectors of x. R code implementing these calculations is provided via Dryad.

A.2 Supplementary results

Table A.2 Bootstrapped median loadings from a phylogenetic PCA of orthopteran life history data at increasing levels of imputation.

	PC1	PC2	PC3	% missing^a
0 imputed values (n = 9)^b		*^{c}		
Body Size	0.309	**0.852**	0.183	0%
Offspring Size	-0.001	**0.672**	0.243	0%
Development Time	**-0.699**	0.383	**-0.542**	0%
Adult Lifespan	**-0.491**	**0.759**	**-0.405**	0%
Clutch Size	0.375	**0.871**	0.305	0%
Clutch Frequency	**-0.916**	-0.091	0.360	0%
Generations per Year	**-0.456**	0.236	**0.777**	0%
% variance	39.70%	36.62%	19.29%	—
1 imputed values (n = 20 species)		*		
Body Size	**0.572** (0.571, 0.574)	**0.516** (0.515, 0.519)	0.176 (0.169, 0.184)	0%
Offspring Size	-0.040 (-0.041, -0.039)	**0.525** (0.524, 0.527)	0.102 (0.093, 0.110)	5%
Development Time	**-0.427** (-0.428, -0.426)	**0.540** 0.538, 0.542	-0.074 (-0.077, -0.070)	5%
Adult Lifespan	-0.111 (-0.112, -0.109)	**0.959** (0.958, 0.960)	-0.054 (-0.062, -0.047)	25%
Clutch Size	**0.959** (0.959, 0.960)	0.243 (0.242, 0.244)	-0.012 (-0.013, -0.011)	0%
Clutch Frequency	-0.370 (-0.370, -0.369)	0.309 (0.304, 0.313)	**-0.770** (-0.774, -0.767)	0%
Generations per Year	**0.594** (0.592, 0.595)	-0.294 (-0.298, -0.290)	**-0.470** (-0.470, -0.453)	20%
% variance	46.84%	23.14%	19.53%	—
2 imputed values (n = 51 species)	*			
Body Size	**0.797** (0.796, 0.797)	-0.054 (-0.058, -0.050)	0.002 (-0.004, 0.015)	1.96%
Offspring Size	0.398 (0.398, 0.399)	-0.017 (-0.019, -0.014)	0.001 (-0.003, 0.004)	7.84%
Development Time	-0.034 (-0.036, -0.032)	0.315 (0.298, 0.328)	0.000 (-0.009, 0.010)	9.80%
Adult Lifespan	**0.562** (0.559, 0.565)	**0.452** (0.430, 0.473)	-0.109 (-0.222, 0.214)	52.94%
Clutch Size	**0.942** (0.941, 0.943)	-0.122 (-0.138, 0.101)	-0.003 (-0.005, -0.001)	3.92%
Clutch Frequency	0.219 (0.212, 0.226)	**0.589** (0.566, 0.608)	0.189 (-0.288, 0.296)	47.06%
Generations per Year	0.259 (0.256, 0.262)	-0.147 (-0.170, -0.119)	0.046 (-0.225, 0.237)	19.61%
% variance	42.82%	28.70%	15.36 %	—
3 imputed values (n = 99 species)	*			
Body Size	**0.691** (0.689, 0.693)	-0.145 (-0.154, -0.137)	-0.006 (-0.010, -0.003)	3.03%

	PC1	PC2	PC3	% missing
Offspring Size	0.384 (0.383, 0.386)	-0.036 (-0.041, -0.031)	-0.006 (-0.007, -0.004)	6.06%
Development Time	0.292 (0.289, 0.294)	0.054 (0.048, 0.061)	-0.085 (-0.133, -0.001)	23.23%
Adult Lifespan	**0.830** (0.828, 0.831)	0.067 (0.062, 0.073)	-0.239 (-0.276, -0.113)	73.74%
Clutch Size	**0.713** (0.711, 0.716)	-0.304 (-0.323, -0.287)	0.076 (0.003, 0.125)	4.04%
Clutch Frequency	**0.408** (0.403, 0.415)	**0.576** (0.565, 0.588)	0.027 (0.004, 0.051)	69.70%
Generations per Year	0.056 (0.053, 0.059)	-0.099 (-0.108, -0.090)	0.151 (0.036, 0.199)	39.39%
% variance	38.73%	26.80%	18.09%	—
4 imputed values (n = 131 species)	*			
Body Size	**0.763** (0.762, 0.764)	0.135 (0.129, 0.141)	0.011 (0.006, 0.016)	6.11%
Offspring Size	**0.514** (0.513, 0.516)	0.048 (0.044, 0.053)	0.002 (0.000, 0.005)	7.63%
Development Time	0.233 (0.220, 0.226)	-0.036 (-0.041, -0.031)	-0.110 (-0.127, -0.089)	37.40%
Adult Lifespan	**0.922** (0.921, 0.922)	-0.002 (-0.006, 0.002)	-0.255 (-0.262, -0.245)	78.63%
Clutch Size	**0.646** (0.644, 0.649)	0.310 (0.298, 0.322)	**0.428** (0.407, 0.446)	10.69%
Clutch Frequency	0.268 (0.262, 0.275)	**-0.833** (-0.839, -0.828)	0.084 (0.065, 0.103)	76.34%
Generations per Year	-0.197 (-0.200, -0.194)	0.075 (0.068, 0.083)	0.350 (0.327, 0.368)	46.56%
% variance	41.40%	24.79%	17.08%	—
5 imputed values (n = 242 species)				
Body Size	-0.155 (-0.166, -0.145)	—	—	16.53%
Offspring Size	**0.770** (0.765, 0.773)	—	—	18.60%
Development Time	-0.422 (-0.450, -0.386)	—	—	65.29%
Adult Lifespan	-0.396 (-0.428, -0.359)	—	—	86.78%
Clutch Size	-0.414 (-0.455, -0.380)	—	—	38.43%
Clutch Frequency	-0.274 (-0.316, -0.232)	—	—	87.19%
Generations per Year	-0.019 (-0.077, 0.040)	—	—	59.09%
% variance	76.07%	—	—	—
6 imputed values (n = 339 species)				
Body Size	**-0.421** (-0.439, -0.401)	-0.023 (-0.031, -0.013)	—	19.76%
Offspring Size	0.288 (0.272, 0.303)	0.023 (0.012, 0.034)	—	37.76%

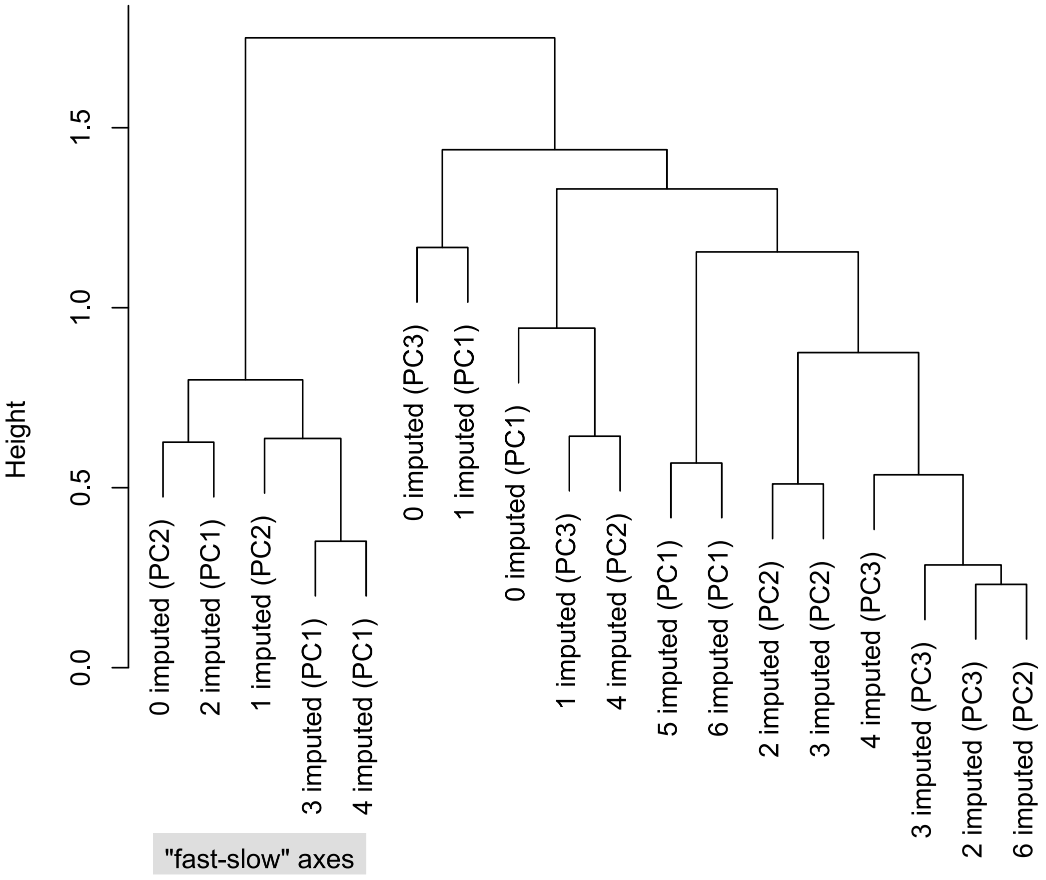
	PC1	PC2	PC3	% missing
Development Time	-0.344 (-0.372, -0.321)	0.018 (0.004, 0.033)	—	75.22%
Adult Lifespan	-0.367 (-0.392, -0.341)	-0.008 (-0.022, 0.006)	—	90.23%
Clutch Size	-0.313 (-0.341, -0.288)	-0.005 (-0.019, 0.009)	—	56.05%
Clutch Frequency	-0.330 (-0.356, -0.292)	-0.010 (-0.021, 0.004)	—	90.86%
Generations per Year	-0.013 (-0.035, 0.011)	-0.002 (-0.016, 0.010)	—	67.26%
% variance	56.14%	22.67%	—	—

[a] % missing refers to the percentage of species missing the trait on that row.

[b] x imputed values refers to the maximum number of traits missing and imputed for each species.

[c] PC axes marked with an asterisk are those which were grouped together in the cluster analysis (see Figure A.1).

Note: **Boldface** indicates that a trait was significantly loaded onto an axis. 95% confidence intervals for bootstapped medians are presented in parenthesis below the medians.



.

Fig. A.1 Distance-clustering dendrogram of phylogenetic PCA loadings for Orthoptera data imputed at different levels of missingness. x imputed refers to the maximum number of missing traits per species of orthopteran included in the analysis, see Table A.2.

Table A.3 Loadings of phylogenetic PCA of a combined dataset of mammals, birds, reptiles and orthopterans - with varying levels of imputation for the orthopterans. Each column contains the single retained axis from the pPCA including orthopterans with a maximum number of missing (and imputed traits) equal to or less than the value referenced in the column header. **Boldface** indicates that a trait is significantly loaded on an axis.

	0	1	2	3	4	5	6
Body Size	**0.976**	**0.974**	**0.976**	**0.976**	**0.976**	**0.975**	**0.976**
Offspring Size	**0.949**	**0.948**	**0.949**	**0.945**	**0.942**	**0.937**	**0.929**
Development Time	**0.432**	**0.436**	**0.435**	**0.425**	**0.418**	**0.440**	**0.449**
Adult Lifespan	**0.453**	**0.461**	**0.464**	**0.477**	**0.490**	**0.516**	**0.551**
Clutch Size	0.096	0.106	0.119	0.149	0.161	0.188	0.237
Clutch Frequency	-0.244	-0.256	-0.249	-0.223	-0.213	-0.226	-0.238
% variance	70.05%	70.05%	69.38%	68.27%	67.81%	67.13%	67.03%
Pagel's λ	0.978	0.975	0.975	0.976	0.976	0.978	0.982

Table A.4 Loadings of non-phylogenetic PCA of Orthoptera data with increasing levels of missingness and imputation, and the amount of variance that each set of axes explains for the vertebrate groups (see Table 3 for vertebrate loadings). Upper column headings refer to the maximum number of missing (and imputed) traits in each analysis. **Boldface** indicates that a trait is significantly loaded on an axis.

	0		1		2		3		4		5		6	
Trait	PC1	PC2	PC1	PC2	PC1	PC2	PC1	PC2	PC1	PC2	PC1	PC2	PC1	PC2
Body Size	**0.456**	-0.162	**0.526**	-0.108	**0.520**	-0.115	**0.524**	-0.198	**0.531**	-0.160	**0.509**	-0.084	**0.506**	-0.068
Offspring Size	**0.430**	-0.361	**0.430**	-0.439	**0.469**	-0.142	**0.446**	-0.178	**0.463**	0.020	**0.477**	0.074	**0.475**	0.059
Development Time	**0.402**	-0.176	0.377	-0.078	**0.423**	0.095	0.336	0.114	0.297	-0.057	0.334	-0.323	0.362	-0.022
Adult Lifespan	**0.449**	0.116	**0.485**	0.306	**0.427**	**0.409**	**0.495**	0.273	**0.510**	0.257	**0.501**	0.174	**0.496**	0.172
Clutch Size	**0.472**	0.116	0.392	0.145	0.366	-0.070	**0.404**	-0.128	0.380	-0.346	0.368	-0.216	0.375	-0.190
Clutch Frequency	0.118	**0.829**	0.085	**0.822**	-0.076	**0.887**	0.068	**0.908**	0.105	**0.886**	0.120	**0.898**	0.001	**0.962**
% variance orthopterans	67.31%	21.93%	52.01%	23.29%	57.41%	19.85%	53.46%	18.87%	51.84%	19.01%	57.74%	18.32%	60.56%	17.50%
% variance mammals	24.90%	24.51%	30.00%	23.24%	39.62%	9.96%	29.76%	12.79%	29.44%	10.38%	29.89%	15.75%	33.80%	11.45%
% variance birds	26.52%	26.03%	31.87%	24.65%	38.04%	12.37%	31.58%	14.57%	31.49%	11.57%	31.99%	15.01%	35.37%	12.71%
% variance reptiles	54.03%	17.78%	55.39%	16.20%	60.19%	13.98%	55.62%	17.30%	53.94%	19.77%	52.97%	20.84%	57.90%	17.20%

Appendix B

Supporting information for Chapter 3

B.1 Supplementary methods

B.1.1 Constructing species-level insect phylogeny

To create a phylogenetic tree that had good overlap with our life history data, we searched the literature for the most comprehensive and recent time-calibrated trees. We assembled these trees into an overall phylogeny for the insects for use in comparative analyses. We evaluated the suitability of two trees to use as backbones, those of Misof et al. (2014) and Rainford et al. (2014). Table B.1 shows how the origination dates of orders according to our species-level source trees, and those of Misof et al. and Rainford et al.. Misof et al. (2014) tend to produce origination dates that are younger than our source trees, meaning that these trees cannot be accomodated on the order-level brances of the Misof et al. tree. For this reason we instead used Rainford et al.'s phylogeny as our backbone. The branch lengths of all trees shared the same unit, time in MYA, so it was possible to bind trees together. We pruned the Rainford et al. phylogeny to contain only one species per order and then bound the source trees to these branches so that the result was an ultrametric tree. All tree editing was done using the 'ape' package (Paradis et al., 2004) in R (Team, 2017).

Where they could be accessed for taxa (usually families) particularly well represented in our dataset that were below the order level, we further pruned this tree and inserted species-level phylogenies that were constructed for families. The phylogenies added in this way were as follows:

- **Diptera:** Culicidae (Reidenbach et al., 2009); Tephritidae (Han and Ro, 2016); Cecidomyiidae (Dorchin et al., 2019); Oestroidea (Cerretti et al., 2017).
- **Lepidoptera**: Papilionoidea (Espeland et al., 2018); Nymphalidae (Wahlberg et al., 2009).
- **Coleoptera**: Curculionidae (Shin et al., 2018).

We used the 'tip pinning' approach outlined in Bennett et al. (2017) to add species to our phylogeny, prioritising species with the most complete sets of trait data. The 'treeman' package searches for named tip labels using the Global Names Resolver in NCBI and uses this information to name higher nodes in the phylogeny. Using the same procedure it produces a taxonomy for a list of species that are not found in the tree. The 'pinTips' function then uses the taxonomy of the tree and of the species missing from the tree to find the correct node to add the new species to, using taxonomically constrained random placement (Bennett et al., 2017).

Table B.1 Stem and crown group ages of insect orders according to Misof et al. (2014), Rainford et al. (2014) and phylogenies specific to each order. All ages are in MYA.

Clade	Tree	Stem Age	Crown Age	Misof et al. (2014)		Rainford et al. (2014)	
				Stem Age	Crown Age	Stem Age	Crown Age
Diptera	Wiegmann et al. (2011)	N/A	247.163	242.743	157.834	320.851	301.479
Mecoptera	N/A	N/A	N/A	167.549	108.558	260.774	225.859
Siphonaptera	Zhu et al. (2015)	129.430	94.440	167.549	86.089	260.774	168.148
Lepidoptera	Kawahara et al. (2019)	356.178	343.779	207.201	141.465	302.412	269.103
Trichoptera	Malm et al. (2013)	233.960	225.780	207.201	154.320	302.412	276.294
Coleoptera	Zhang et al. (2018)	324.650	279.340	286.473	269.976	309.317	307.186
Strepsiptera	McMahon et al. (2011)	118.100	97.940	286.473	107.559	309.317	N/A
Neuroptera	Winterton et al. (2010)	317.00	294.000	259.034	224.709	284.832	254.651
Megaloptera	N/A	N/A	N/A	259.034	212.386	284.382	192.843
Raphidioptera	N/A	N/A	N/A	276.257	95.129	300.354	124.869
Hymenoptera	Peters et al. (2017)	386.777	281.205	344.680	239.527	389.691	257.290
Psocodea	Johnson et al. (2018)	404.000	328.000	361.532	187.326	426.793	401.422
Hemiptera	Johnson et al. (2018)	407.000	386.000	339.128	290.838	404.611	391.728
Thysanoptera	Johnson et al. (2018)	407.000	267.000	339.128	119.931	404.611	286.638
Dictyoptera	Evangelista et al. (2019)	346.422	263.670	231.271	197.320	340.562	307.235
Phasmida	Robertson et al. (2018)	124.559	95.000	164.221	124.707	259.648	221.505
Embioptera	N/A	N/A	N/A	164.221	43.473	259.648	175.617
Grylloblattodea	N/A	N/A	N/A	152.669	37.576	220.491	N/A
Mantophasmatodea	N/A	N/A	N/A	152.669	N/A	220.491	N/A
Orthoptera	Davis et al. (2018)	N/A	299.100	247.845	202.696	387.347	308.877
Plecoptera	Ding et al. (2019)	255.010	181.450	269.115	167.411	356.655	251.175
Dermaptera	N/A	N/A	N/A	168.523	79.386	356.655	245.103
Zoraptera	Matsumura et al. (2020)	N/A	270.000	168.523	N/A	340.562	N/A
Ephemeroptera	Thomas et al. (2013)	351.400	250.300	362.454	110.647	373.261	268.740
Odonata	Waller and Svensson (2017)	N/A	237.000	362.454	234.730	373.261	243.109
Zygentoma	Regier et al. (2004)	370.000	302.500	420.549	214.104	449.197	296.306
Archaeognatha	Regier et al. (2004)	370.000	132.000	440.339	145.645	462.318	N/A
Diplura	Regier et al. (2004)	456.500	373.500	461.580	303.400	440.935	278.875
Collembola	Regier et al. (2004)	486.500	335.000	430.065	242.695	463.988	336.582
Protura	N/A	N/A	N/A	430.065	N/A	440.935	372.540

B.2 Supplementary results

Table B.2 Bootstrapped median loadings from a phylogenetic PCA of insect life history data at increasing levels of imputation. Abbreviations are as follows: adult body length (ABL), egg length (EL), egg development time (EDT), hatching to adult development time, (HADT), adult lifespan (AL), clutch size (CS), lifetime fecundity (LF).

	PC1	PC2	PC3	PC4	% missing
0 imputed values ($n=67$, $\lambda=0.751$)					
ABL	0.278	**0.824**	0.017	—	0%
EL	0.055	**0.861**	-0.175	—	0%
EDT	0.253	0.265	0.137	—	0%
HADT	0.297	**0.449**	0.010	—	0%
AL	-0.248	**0.510**	**0.524**	—	0%
CS	**0.932**	0.010	-0.297	—	0%
LF	**0.658**	-0.172	**0.698**	—	0%
% variance	38.97%	19.21%	17.38%	—	—
1 imputed values ($n = 217$, $\lambda=0.762$)					
ABL	0.280 (0.279, 0.282)	0.191 (0.188, 0.194)	**0.567** (0.565, 0.568)	—	6.45%
EL	0.106 (0.104, 0.107)	0.083 (0.079, 0.087)	**0.567** (0.565, 0.568)	—	4.61%
EDT	0.211 (0.211, 0.213)	0.017 0.016, 0.019	**0.082** (0.080, 0.085)	—	3.69%
HADT	0.184 (0.182, 0.185)	0.010 (0.008, 0.012)	0.387 (0.385, 0.389)	—	7.37%
AL	-0.015 (-0.017, -0.013)	**0.692** (0.689, 0.695)	**0.465** (0.461, 0.469)	—	4.15%
CS	**0.916** (0.915, 0.916)	-0.293 (-0.295, -0.291)	**0.105** (0.103, 0.107)	—	28.57%
LF	**0.558** (0.556, 0.561)	**0.644** (0.641, 0.647)	**-0.442** (-0.444, -0.439)	—	14.29%
% variance	32.51%	21.18%	18.14%	—	—
2 imputed values ($n = 485$, $\lambda=0.764$)					
ABL	0.305 (0.304, 0.306)	0.237 (0.234, 0.239)	**0.510** (0.508, 0.511)	0.103 (0.099, 0.106)	21.03%
EL	0.141 (0.140, 0.142)	0.210 (0.208, 0.213)	**0.459** (0.457, 0.462)	**0.467** (0.464, 0.470)	14.43%
EDT	0.083 (0.081, 0.085)	**0.468** (0.466, 0.471)	**0.498** (0.494, 0.502)	**-0.509** (-0.513, -0.506)	6.80%
HADT	0.034 (0.032, 0.035)	**0.518** (0.516, 0.520)	**0.502** (0.499, 0.505)	-0.148 (-0.151, -0.145)	13.20%
AL	0.166 (0.165, 0.168)	**-0.469** (-0.471, -0.466)	**0.555** (0.551, 0.560)	**0.517** (0.513, 0.522)	15.88%
CS	**0.858** (0.858, 0.859)	0.368 (0.366, 0.370)	-0.212 (-0.214, -0.211)	0.216 (0.214, 0.218)	40.41%

	PC1	PC2	PC3	PC4	% missing
LF	**0.708** (0.707, 0.709)	**-0.541** (-0.543, -0.539)	0.064 (0.062, 0.067)	-0.389 (-0.391, -0.388)	26.69%
% variance	31.60%	20.15%	16.57%	14.82%	—
3 imputed values (n = 847, λ=0.775)					
ABL	0.318 (0.318, 0.319)	0.143 (0.139, 0.146)	-0.035 (-0.037, -0.033)	—	27.65%
EL	0.029 (0.028, 0.029)	0.016 (0.014, 0.018)	0.092 (0.089, 0.095)	—	21.18%
EDT	0.216 (0.214, 0.218)	**0.894** 0.891, 0.897	0.092 (0.089, 0.095)	—	18.94%
HADT	0.125 (0.124, 0.126)	**0.541** (0.538, 0.544)	-0.040 (-0.043, -0.038)	—	23.06%
AL	0.151 (0.150, 0.152)	-0.081 (-0.087, -0.075)	0.385 (0.381, 0.388)	—	31.29%
CS	**0.815** (0.814, 0.815)	-0.010 (-0.014, -0.007)	**-0.528** (-0.529, -0.527)	—	44.82%
LF	**0.786** (0.786, 0.787)	-0.061 (-0.067, -0.055)	**0.511** (0.509, 0.513)	—	42.59%
% variance	32.05%	20.73%	46.70%	—	—
4 imputed values (n = 1204, λ=0.780)					
ABL	0.282 (0.281, 0.283)	0.207 (0.205, 0.208)	-0.024 (-0.026, -0.021)	—	33.64%
EL	-0.011 (-0.011, -0.010)	0.098 (0.097, 0.100)	-0.087 (-0.089, -0.086)	—	26.99%
EDT	0.189 (0.187, 0.190)	**0.877** 0.874, 0.880	0.141 (0.133, 0.149)	—	28.57%
HADT	0.121 (0.119, 0.122)	**0.543** (0.543, 0.545)	-0.027 (-0.033, -0.022)	—	33.80%
AL	0.060 (0.059, 0.061)	-0.124 (-0.128, -0.120)	0.377 (0.374, 0.380)	—	43.44%
CS	**0.828** (0.828, 0.829)	-0.006 (-0.011, -0.001)	**-0.499** (-0.500, -0.498)	—	50.25%
LF	**0.753** (0.752, 0.754)	-0.161 (-0.168, -0.155)	**0.549** (0.547, 0.551)	—	49.83%
% variance	31.67%	19.48%	17.98%	—	—
5 imputed values (n = 1718, λ=0.792)					
ABL	0.230 (0.230, 0.231)	0.162 (0.159, 0.165)	-0.059 (-0.063, -0.055)	0.228 (0.227, 0.230)	40.05%
EL	-0.026 (-0.027, -0.026)	0.077 (0.074, 0.079)	-0.066 (-0.068, -0.064)	0.355 (0.354, 0.356)	33.12%
EDT	0.152 (0.151, 0.154)	**0.713** (0.702, 0.724)	-0.105 (-0.120, -0.089)	0.002 (0.001, 0.004)	44.41%
HADT	0.099 (0.098, 0.100)	0.386 (0.379, 0.394)	-0.136 (-0.145, -0.127)	0.043 (0.041, 0.045)	49.42%
AL	0.055 (0.053, 0.056)	-0.109 (-0.117, -0.102)	0.302 (0.298, 0.308)	**0.869** (0.867, 0.871)	53.72%

	PC1	PC2	PC3	PC4	% missing
CS	**0.807** (0.807, 0.808)	0.045 (0.035, 0.056)	**-0.449** (-0.455, -0.443)	0.122 (0.120, 0.124)	56.29%
LF	**0.751** (0.750, 0.752)	-0.169 (-0.180, -0.158)	**0.489** (0.484, 0.493)	-0.203 (-0.205, -0.200)	58.50%
% variance	29.67%	19.26%	18.26%	15.11%	—
6 imputed values (n = 2271, λ=0.806)					
ABL	0.209 (0.209, 0.210)	-0.038 (-0.039, -0.036)	0.165 (0.163, 0.167)	0.180 (0.180, 0.182)	42.08%
EL	-0.005 (-0.006, -0.005)	-0.077 (-0.078, -0.076)	0.068 (0.066, 0.070)	0.268 (0.267, 0.269)	45.11%
EDT	0.133 (0.132, 0.134)	0.030 (0.022, 0.037)	**0.907** (0.905, 0.911)	0.012 (0.010, 0.014)	57.17%
HADT	0.082 (0.081, 0.083)	0.226 (0.223, 0.228)	0.363 (0.362, 0.365)	0.031 (0.029, 0.033)	60.83%
AL	0.055 (0.054, 0.056)	0.226 (0.223, 0.228)	-0.037 (-0.040, -0.033)	**0.943** (0.943, 0.944)	61.62%
CS	**0.770** (0.769, 0.771)	**-0.595** (-0.596, -0.593)	0.023 (0.017, 0.028)	0.069 (0.067, 0.070)	64.54%
LF	**0.754** (0.753, 0.755)	**0.606** (0.605, 0.608)	-0.093 (-0.096, -0.089)	-0.133 (-0.135, -0.132)	67.39%
% variance	28.56%	19.96%	18.41%	15.18%	—

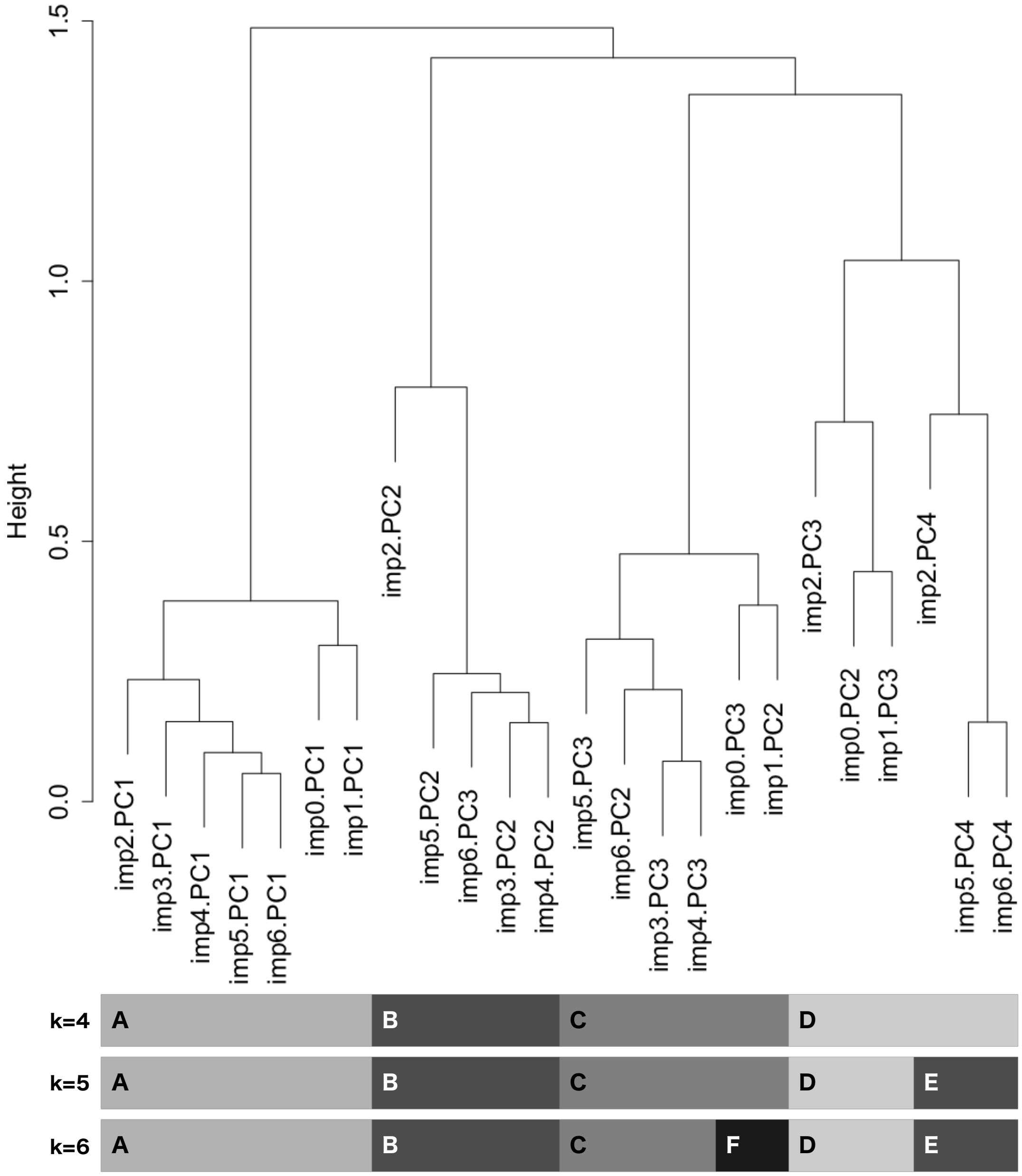


Fig. B.1 Distance-clustering dendrogram of phylogenetic PCA loadings for insect data imputed at different levels of missingness. x imp refers to the maximum number of missing traits per species of insect included in the analysis, see Table B.2. Bars beneath the dendrogram shows grouping of axes according to k-means clustering, with the number of groups set as either 4, 5, or 6 - average loadings of these groups are given in Table B.3.

Table B.3 Cluster means identified using k-means clustering, significant loads are highlighted in bold. Letters match these means with the groups in the distance-clustering dendrogram, Figure B.1. Abbreviations follow Table B.2.

k=4	ABL	EL	EDT	HADT	AL	CS	LF
A	0.272	0.049	0.177	0.135	0.032	**0.847**	**0.710**
B	0.183	0.094	**0.772**	**0.470**	-0.164	0.084	-0.205
C	0.009	-0.051	0.052	-0.038	**0.418**	**-0.444**	**0.583**
D	**0.402**	**0.530**	0.058	0.211	**0.643**	0.052	-0.213
k=5							
A	0.272	0.049	0.177	0.135	0.032	**0.847**	**0.710**
B	0.183	0.094	**0.772**	**0.470**	-0.164	0.084	-0.205
C	0.009	-0.051	0.052	-0.038	**0.418**	**-0.444**	**0.583**
D	**0.634**	**0.697**	0.282	**0.446**	**0.510**	-0.032	-0.183
E	0.170	0.363	-0.165	-0.025	**0.776**	0.136	-0.242
k=6							
A	0.272	0.049	0.177	0.135	0.032	**0.847**	**0.710**
B	0.183	0.094	**0.772**	**0.470**	-0.164	0.084	-0.205
C	-0.012	0.050	-0.070	-0.079	0.361	-0.371	0.353
D	**0.634**	**0.697**	0.282	**0.446**	**0.510**	-0.032	-0.183
E	0.204	0.312	0.007	0.037	**0.906**	0.096	-0.168
F	0.010	-0.046	0.077	0.010	**0.608**	-0.295	**0.671**

Table B.4 Bootstrapped median loadings from a phylogenetic PCA of insect life history data at increasing levels of imputation, with resampling of Orthoptera and Hymenoptera so that their numbers were the same as Hemiptera and Coleoptera, respectively. There were (at 0, 3, and 6 imputed traits) 12, 34, and 58 orthopterans, and 27, 63, and 74 hymenopterans. Abbreviations follow Table B.2.

	PC1	PC2	PC3	% missing
0 imputed values (n=52, λ=0.845)				
ABL	0.235	**0.808**	0.183	0%
EL	-0.012	**0.818**	0.236	0%
EDT	0.374	**0.432**	0.301	0%
HADT	0.088	**0.646**	0.175	0%
AL	-0.196	**0.696**	**-0.555**	0%
CS	**0.956**	0.001	0.230	0%
LF	**0.727**	-0.065	**-0.647**	0%
% var	44.95%	21.62%	16.80%	—
3 imputed values (n=491, λ=0.803)				
ABL	0.342	0.199	0.150	25.87
	(0.342, 0.343)	(0.198, 0.200)	(0.149, 0.152)	
EL	-0.055	0.148	0.068	23.63
	(-0.056, -0.054)	(0.147, 0.149)	0.065, 0.070	
EDT	0.240	**0.902**	0.025	14.26
	(0.237, 0.242)	(0.901, 0.903)	(0.023, 0.027)	
HADT	0.217	**0.627**	0.143	19.14
	(0.216, 0.219)	(0.625, 0.628)	(0.141, 0.146)	
AL	-0.137	-0.038	**0.756**	27.90
	(-0.139, -0.136)	(-0.040, -0.036)	(0.754, 0.758)	
CS	**0.933**	-0.098	-0.207	51.93
	(0.933, 0.933)	(-0.100, -0.097)	(-0.208, -0.205)	
LF	**0.664**	-0.238	**0.499**	44.60
	(0.662, 0.665)	(-0.240, -0.236)	(0.497, 0.502)	
% var	36.05%	22.82%	15.09%	—
6 imputed values (n=1095, λ = 0.821)				
ABL	0.268	0.101	0.077	44.93
	(0.268, 0.269)	(0.098, 0.105)	(0.074, 0.080)	
EL	-0.032	0.099	0.008	47.31
	(-0.033, -0.031)	(0.097, 0.101)	(0.007, 0.009)	
EDT	0.205	**0.827**	0.033	51.05
	(0.204, 0.207)	(0.869, 0.877)	(0.028, 0.038)	
HADT	0.132	**0.430**	0.053	54.61
	(0.131, 0.133)	(0.426, 0.436)	(0.048, 0.059)	
AL	-0.151	-0.033	**0.508**	56.99
	(-0.153, -0.150)	(-0.037, -0.030)	(0.502, 0.515)	
CS	**0.956**	-0.043	-0.149	74.34
	(0.955, 0.956)	(-0.046, -0.039)	(-0.151, -0.146)	
LF	**0.479**	-0.086	**0.636**	67.85
	(0.478, 0.480)	(-0.093, -0.080)	(0.630, 0.643)	
% var	33.45%	19.68%	16.70%	—

Table B.5 PGLS models of PC scores as the response and insect order as the predictor variable, Archaeognatha are treated as the intercept. n = 2271.

	Order	$\beta\pm$ S.E.	t	p	λ	R^2
PC1	Intercept	-0.182±1.051	-0.173	0.862	0.825	0.017
	Coleoptera	-0.689±1.348	-0.511	0.609		
	Collembola	-0.866±1.514	-0.571	0.568		
	Dermaptera	-0.849±1.745	-0.487	0.626		
	Dictyoptera	0.872±1.411	0.618	0.567		
	Diptera	0.559±1.385	0.404	0.686		
	Ephemeroptera	3.093±1.407	2.198	0.028		
	Hemiptera	-0.455±1.234	-0.369	0.712		
	Hymenoptera	-2.033±1.352	-1.504	0.133		
	Lepidoptera	2.247±1.436	1.565	0.118		
	Megaloptera	2.151±1.437	1.467	0.135		
	Neuroptera	0.739±1.359	0.544	0.586		
	Odonata	3.506±1.452	2.416	0.016		
	Orthoptera	0.128±1.331	0.096	0.923		
	Phasmida	1.114±1.590	0.701	0.484		
	Plecoptera	2.563±1.450	1.709	0.088		
	Psocodea	-1.826±1.352	-1.351	0.177		
	Raphidioptera	1.285±1.688	0.762	0.446		
	Siphonaptera	-0.648±1.577	-0.411	0.681		
	Strepsiptera	1.825±1.620	1.127	0.260		
	Thysanoptera	-1.322±1.423	-0.929	0.353		
	Trichoptera	0.632±1.449	0.436	0.663		
	Zoraptera	-0.223±1.548	-0.144	0.886		
	Zygentoma	0.105±1.612	0.065	0.948		
PC2	Intercept	0.127±0.512	0.248	0.804	0.756	0.014
	Coleoptera	-0.062±0.647	-0.095	0.924		
	Collembola	0.291±0.725	0.401	0.688		
	Dermaptera	-0.145±0.853	-0.170	0.865		
	Dictyoptera	0.233±0.676	0.344	0.731		
	Diptera	-1.054±0.664	-1.586	0.113		
	Ephemeroptera	-1.176±0.675	-1.743	0.081		
	Hemiptera	-0.135±0.596	-0.226	0.821		
	Hymenoptera	0.403±0.649	0.621	0.535		
	Lepidoptera	-0.790±0.688	-1.147	0.251		
	Megaloptera	-1.438±0.693	-2.076	0.038		
	Neuroptera	-0.552±0.653	-0.845	0.398		
	Odonata	-0.615±0.695	0.885	0.376		
	Orthoptera	-0.099±0.640	-0.155	0.877		
	Phasmida	-0.336±0.760	-0.442	0.658		
	Plecoptera	-0.563±0.718	-0.785	0.433		
	Psocodea	0.040±0.651	0.061	0.951		
	Raphidioptera	-0.562±0.816	-0.690	0.491		
	Siphonaptera	1.134±0.755	1.502	0.133		
	Strepsiptera	0.769±0.780	0.985	0.325		

	Order	β± S.E.	t	p	λ	R^2
PC2 (cont.)	Thysanoptera	-0.471±0.683	-0.689	0.491		
	Trichoptera	-1.330±0.695	-1.912	0.056		
	Zoraptera	0.055±0.752	0.073	0.942		
	Zygentoma	0.976±0.781	1.249	0.211		
PC3	Intercept	1.531±0.737	2.076	0.038	0.785	0.002
	Coleoptera	-1.938±0.938	-2.067	0.039		
	Collembola	-2.367±1.051	-2.280	0.023		
	Dermaptera	-1.708±1.227	-1.392	0.164		
	Dictyoptera	-0.753±0.981	-0.767	0.443		
	Diptera	-2.546±0.963	-2.643	0.008		
	Ephemeroptera	-1.082±0.978	-1.106	0.269		
	Hemiptera	-2.277±0.862	-2.643	0.008		
	Hymenoptera	-2.358±0.941	-2.507	0.012		
	Lepidoptera	-1.494±0.998	-1.496	0.135		
	Megaloptera	-1.344±1.002	-1.341	0.180		
	Neuroptera	-1.826±0.946	-1.930	0.054		
	Odonata	-1.370±1.008	-1.359	0.174		
	Orthoptera	-1.010±0.927	-1.090	0.276		
	Phasmida	0.493±1.103	0.447	0.655		
	Plecoptera	-1.189±1.041	-1.141	0.254		
	Psocodea	-2.266±0.942	-2.404	0.016		
	Raphidioptera	-1.587±1.179	-1.347	0.178		
	Siphonaptera	-2.796±1.095	-2.553	0.011		
	Strepsiptera	-0.966±1.129	-0.856	0.392		
	Thysanoptera	-2.418±0.990	-2.442	0.015		
	Trichoptera	-2.418±1.008	-1.519	0.129		
	Zoraptera	-1.137±1.084	-1.048	0.295		
	Zygentoma	-1.164±1.128	-1.032	0.302		
PC4	Intercept	0.219±0.671	0.326	0.744	0.836	0.024
	Coleoptera	0.231±0.863	0.268	0.789		
	Collembola	0.266±0.969	0.274	0.784		
	Dermaptera	1.593±1.114	1.431	0.153		
	Dictyoptera	1.132±0.903	1.253	0.210		
	Diptera	-1.033±0.887	-1.165	0.244		
	Ephemeroptera	-3.851±0.901	-4.273	<0.001		
	Hemiptera	-0.047±0.789	-0.059	0.953		
	Hymenoptera	-0.954±0.865	-1.102	0.271		
	Lepidoptera	-0.949±0.919	-1.032	0.302		
	Megaloptera	-1.090±0.920	-1.186	0.236		
	Neuroptera	-0.612±0.870	-0.703	0.482		
	Odonata	-0.950±0.930	-1.022	0.307		
	Orthoptera	0.639±0.852	0.750	0.482		
	Phasmida	1.351±1.019	1.326	0.185		
	Plecoptera	-0.513±0.961	-0.534	0.593		
	Psocodea	-0.448±0.865	-0.518	0.605		
	Raphidioptera	0.112±1.079	0.104	0.918		
	Siphonaptera	-0.590±1.010	-0.584	0.559		

	Order	$\beta\pm$ S.E.	t	p	λ	R^2
PC4 (cont.)	Strepsiptera	-0.605±1.036	-0.584	0.559		
	Thysanoptera	-0.616±0.911	-0.676	0.499		
	Trichoptera	-1.766±0.928	-1.904	0.057		
	Zoraptera	-0.088±0.989	-0.089	0.929		
	Zygentoma	2.299±1.030	2.231	0.024		

Table B.6 PGLS models with PC scores as the response and metamorphosis as the predictor variable, ametabolous species are treated as the intercept. n = 2271.

	Metamorphosis	$\beta\pm$ S.E.	t	p	λ	R^2
	Intercept	-0.466±0.696	-0.670	0.509		
PC1	Hemimetabola	0.755±0.815	0.927	0.354	0.848	0.000
	Holometabola	0.482±0.942	0.512	0.609		
	Intercept	0.485±0.332	1.459	0.145		
PC2	Hemimetabola	-0.694±0.388	-1.790	0.074	0.784	0.001
	Holometabola	-0.751±0.447	-1.682	0.093		
	Intercept	0.348±0.471	0.738	0.461		
PC3	Hemimetabola	-0.462±0.550	-0.839	0.401	0.801	0.000
	Holometabola	-0.809±0.635	-1.275	0.202		
	Intercept	0.905±0.449	2.013	0.044		
PC4	Hemimetabola	-1.227±0.527	-2.329	0.020	0.861	0.003
	Holometabola	-1.721±0.610	-2.822	0.005		

Table B.7 PGLS models with PC scores as the response and habitat media (terrestrial vs. aquatic) as the predictor variable, terrestrial habitats are treated as the intercept. n = 1992.

	Habitat	$\beta\pm$ S.E.	t	p	λ	R^2
PC1	Intercept	-0.080±0.450	-0.178	0.858	0.855	0.001
	Aquatic	0.279±0.146	1.909	0.056		
PC2	Intercept	0.038±0.231	0.164	0.870	0.805	0.000
	Aquatic	-0.090±0.082	-1.090	0.276		
PC3	Intercept	-0.007±0.306	-0.022	0.982	0.811	0.000
	Aquatic	-0.087±0.108	-0.806	0.421		
PC4	Intercept	0.022±0.274	0.081	0.935	0.847	0.000
	Aquatic	-0.046±0.090	-0.507	0.612		

Table B.8 PGLS models with PC scores as the response and larval diet as the predictor variable, detritivores are treated as the intercept. n = 812.

	Larval Diet	$\beta\pm$ S.E.	t	p	λ	R^2
PC1	Intercept	0.077±0.440	0.176	0.861	0.748	0.015
	Ecto-parasites	0.001±0.450	0.002	0.999		
	Fungivores	-0.358±0.318	-1.126	0.260		
	Parasitoids	-1.323±0.411	-3.216	0.001		
	Phytophages	-0.142±0.212	-0.669	0.504		
	Predators	0.309±0.245	1.258	0.209		
PC2	Intercept	0.066±0.247	0.266	0.790	0.701	0.000
	Ecto-parasites	0.335±0.295	1.135	0.257		
	Fungivores	-0.177±0.189	-0.935	0.350		
	Parasitoids	0.050±0.240	0.209	0.835		
	Phytophages	-0.133±0.125	-1.063	0.288		
	Predators	-0.190±0.144	-1.318	0.188		
PC3	Intercept	0.023±0.324	0.073	0.942	0.646	0.043
	Ecto-parasites	-0.146±0.408	-0.358	0.721		
	Fungivores	-0.306±0.263	-1.165	0.245		
	Parasitoids	-1.875±0.328	-5.716	<0.001		
	Phytophages	-0.068±0.172	-0.394	0.694		
	Predators	0.151±0.197	0.767	0.443		
PC4	Intercept	0.092±0.319	0.287	0.774	0.795	0.009
	Ecto-parasites	0.739±0.344	2.147	0.032		
	Fungivores	0.001±0.217	0.006	0.996		
	Parasitoids	-0.663±0.286	-2.316	0.021		
	Phytophages	-0.180±0.146	-1.232	0.218		
	Predators	-0.130±0.170	-0.766	0.444		

Table B.9 PGLS models with PC scores as the response and adult diet as the predictor variable, detritivores are treated as the intercept. n = 890.

	Adult Diet	$\beta\pm$ S.E.	t	p	λ	R^2
PC1	Intercept	0.092±0.464	0.198	0.843	0.773	0.005
	Ecto-parasites	-0.487±0.356	-1.368	0.172		
	Fungivores	-0.330±0.341	-0.968	0.333		
	Liquid-feeders	-0.436±0.359	-1.215	0.225		
	Non-feeders	0.532±0.375	1.418	0.156		
	Phytophages	-0.171±0.292	-0.585	0.559		
	Predators	0.166±0.310	0.534	0.593		
PC2	Intercept	0.187±0.255	0.734	0.463	0.728	0.001
	Ecto-parasites	-0.392±0.205	-1.910	0.056		
	Fungivores	-0.267±0.196	-1.361	0.174		
	Liquid-feeders	-0.390±0.204	-1.905	0.057		
	Non-feeders	-0.458±0.214	-2.141	0.033		
	Phytophages	-0.211±0.167	-1.265	0.206		
	Predators	-0.171±0.177	-0.968	0.333		
PC3	Intercept	-0.063±0.342	-0.184	0.854	0.684	0.016
	Ecto-parasites	-0.311±0.287	-1.084	0.279		
	Fungivores	0.049±0.275	0.180	0.857		
	Liquid-feeders	-0.733±0.285	-2.578	0.010		
	Non-feeders	0.446±0.297	1.502	0.134		
	Phytophages	0.090±0.232	0.388	0.698		
	Predatros	0.245±0.245	0.999	0.318		
PC4	Intercept	0.155±0.314	0.494	0.622	0.815	0.023
	Ecto-parasites	-0.150±0.229	-0.655	0.513		
	Fungivores	0.116±0.220	0.526	0.599		
	Liquid-feeders	-0.568±0.234	-2.434	0.015		
	Non-feeders	-1.060±0.244	-4.337	<0.001		
	Phytophages	0.053±0.190	0.281	0.779		
	Predators	0.154±0.202	0.762	0.446		

Appendix C

Supporting information for Chapter 4

C.1 Supplementary results

C.1.1 Order level analyses

Table C.1 PGLS models at an order level, the dependent variable in each model is the diversification rate of the order with the ratio of speciation to extinction $\epsilon = 0$. We present the full and reduced models, before the life history trait is dropped during model reduction.

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
1.1 (full)	PC1	-0.000±0.001	-0.574	0.573	0.000	24	0.561
	Wings	0.063±0.003	1.983	0.062			
	Metamorphosis	0.007±0.002	2.955	0.008			
	Herbivory	0.008±0.003	2.835	0.011			
1.2 (full)	PC2	0.001±0.002	0.736	0.471	0.000	24	0.566
	Wings	0.006±0.003	2.055	0.054			
	Metamorphosis	0.006±0.002	2.794	0.012			
	Herbivory	0.008±0.003	3.217	0.005			
1.3 (full)	PC3	-0.001±0.001	-0.031	0.975	0.000	24	0.585
	Wings	0.005±0.003	2.008	0.059			
	Metamorphosis	0.006±0.002	2.488	0.022			
	Herbivory	0.008±0.003	3.135	0.005			
1.4 (full)	PC4	-0.000±0.001	-0.031	0.975	0.000	24	0.553
	Wings	0.005±0.003	1.826	0.084			
	Metamorphosis	0.007±0.002	2.846	0.010			
	Herbvivory	0.008±0.003	3.034	0.007			
1.5 (full)	Log Clutch Size	0.000±0.001	0.167	0.869	0.000	21	0.541
	Wings	0.004±0.003	1.201	0.247			
	Metamorphosis	0.007±0.002	3.086	0.007			
	Herbivory	0.007±0.003	2.521	0.023			
1.6 (full)	Log Lifetime Fecundity	0.001±0.001	0.533	0.602	0.000	20	0.454
	Wings	0.001±0.004	0.350	0.731			
	Metamorphosis	0.006±0.002	2.737	0.153			
	Herbivory	0.008±0.003	3.014	0.009			
1.6 (red.)	Log Lifetime Fecundity	0.000±0.001	0.496	0.627	0.000	20	0.483
	Metamorphosis	0.006±0.002	2.811	0.013			
	Herbivory	0.008±0.002	3.240	0.005			
1.7 (full)	Log Egg Development Time	-0.001±0.001	-0.472	0.642	0.000	24	0.559
	Wings	0.005±0.003	1.939	0.067			
	Metamorphosis	0.006±0.003	2.300	0.033			
	Herbivory	0.008±0.003	3.112	0.006			
1.8 (full)	Log Nymph/Larva Development Time	-0.001±0.001	-1.358	0.191	0.000	23	0.554
	Wings	0.005±0.003	1.726	0.101			
	Metamorphosis	0.006±0.002	2.926	0.009			
	Herbivory	0.007±0.003	2.916	0.009			

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
1.9 (full)	Log Pupa Development Time	0.005±0.004	1.183	0.275	0.000	11	0.216
	Wings	-0.006±0.008	-0.733	0.487			
	Herbivory	0.012±0.005	2.384	0.049			
1.9 (red.)	Log Pupa Development Time	0.005±0.004	1.094	0.306	0.000	11	0.261
	Herbivory	0.011±0.005	2.338	0.048			
1.10 (full)	Log Hatching to Adult Development Time	-0.001±0.001	-1.371	0.187	0.000	23	0.554
	Wings	0.005±0.003	1.702	0.106			
	Metamorphosis	0.007±0.002	2.996	0.008			
	Herbivory	0.007±0.003	2.929	0.009			
1.11 (full)	Log Egg to Adult Development Time	-0.002±0.001	-1.309	0.210	0.000	20	0.559
	Wings	0.005±0.003	1.583	0.134			
	Metamorphosis	0.005±0.003	2.174	0.046			
	Herbviory	0.009±0.003	2.880	0.011			

Table C.2 PGLS models at an order level, the dependent variable in each model is the diversification rate of the order with the ratio of speciation to extinction $\epsilon = 0.5$. We present the full and reduced models, before the life history trait is dropped during model reduction.

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
2.1 (full)	PC1	-0.000±0.001	-0.680	0.505	0.000	24	0.549
	Wings	0.006±0.003	2.007	0.059			
	Metamorphosis	0.006±0.002	2.780	0.012			
	Herbivory	0.007±0.003	2.793	0.012			
2.2 (full)	PC2	0.001±0.002	0.749	0.463	0.000	24	0.551
	Wings	0.006±0.003	2.038	0.056			
	Metamorphosis	0.006±0.002	2.616	0.017			
	Herbivory	0.008±0.003	3.199	0.005			
2.3 (full)	PC3	-0.002±0.001	-1.330	0.199	0.000	24	0.577
	Wings	0.005±0.003	2.003	0.060			
	Metamorphosis	0.005±0.002	2.292	0.033			
	Herbivory	0.008±0.002	3.130	0.006			
2.4 (full)	PC4	-0.000±0.001	-0.074	0.942	0.000	24	0.538
	Wings	0.005±0.003	1.792	0.089			
	Metamorphosis	0.006±0.002	2.664	0.015			
	Herbivory	0.008±0.003	3.021	0.007			
2.5 (full)	Log Clutch Size	0.000±0.001	0.117	0.908	0.000	21	0.523
	Wings	0.004±0.003	1.195	0.250			
	Metamorphosis	0.007±0.002	2.888	0.011			
	Herbivory	0.007±0.003	2.560	0.021			
2.6 (full)	Log Lifetime Fecundity	0.001±0.001	0.488	0.632	0.000	20	0.435
	Wings	0.001±0.004	0.356	0.727			
	Metamorphosis	0.006±0.002	2.596	0.020			
	Herbivory	0.007±0.002	2.981	0.009			
2.6 (red.)	Log Lifetime Fecundity	0.000±0.001	0.448	0.660	0.000	20	0.466
	Metamorphosis	0.006±0.002	2.665	0.017			
	Herbivory	0.008±0.002	3.207	0.005			
2.7 (full)	Log Egg Development Time	-0.001±0.001	-0.550	0.589	0.000	24	0.545
	Wings	0.005±0.003	1.925	0.069			
	Metamorphosis	0.005±0.003	2.113	0.048			
	Herbivory	0.008±0.003	3.096	0.006			
2.8 (full)	Log Nymph/Larva Development Time	-0.001±0.001	-1.441	0.167	0.000	23	0.544
	Wings	0.005±0.003	1.736	0.100			
	Metamorphosis	0.006±0.002	2.757	0.013			
	Herbivory	0.007±0.003	2.892	0.010			
2.9 (full)	Log Pupa Development Time	0.005±0.004	1.123	0.298	0.000	11	0.217
	Wings	-0.005±0.008	-0.671	0.524			
	Herbivory	0.012±0.005	2.395	0.048			

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
2.9 (red.)	Log Development Time	0.004±0.004	1.049	0.325	0.000	11	0.271
	Herbivory	0.011±0.005	2.383	0.044			
2.10 (full)	Log Hatching to Adult Development Time	-0.001±0.001	-1.453	0.163	0.000	23	0.545
	Wings	0.005±0.003	1.711	0.104			
	Metamorphosis	0.006±0.002	2.831	0.011			
	Herbivory	0.007±0.003	2.906	0.009			
2.11 (full)	Log Egg to Adult Development Time	-0.002±0.001	-1.400	0.182	0.000	20	0.551
	Wings	0.005±0.003	1.600	0.131			
	Metamorphosis	0.005±0.002	2.026	0.061			
	Herbivory	0.008±0.003	2.845	0.012			

Table C.3 PGLS models at an order level, the dependent variable in each model is the diversification rate of the order with the ratio of speciation to extinction $\epsilon = 0.9$. We present the full and reduced models, before the life history trait is dropped during model reduction.

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
3.1 (full)	PC1	-0.001±0.001	-0.924	0.367	0.000	24	0.516
	Wings	0.006±0.003	2.033	0.056			
	Metamorphosis	0.005±0.002	2.355	0.029			
	Herbivory	0.007±0.003	2.685	0.014			
3.2 (full)	PC2	0.001±0.002	0.766	0.453	0.000	24	0.509
	Wings	0.006±0.003	1.960	0.065			
	Metamorphosis	0.005±0.002	2.189	0.041			
	Herbivory	0.008±0.003	3.133	0.005			
3.3 (full)	PC3	-0.002±0.001	-1.638	0.118	0.000	24	0.557
	Wings	0.005±0.003	1.959	0.065			
	Metamorphosis	0.004±0.002	1.817	0.085			
	Herbivory	0.008±0.002	3.107	0.006			
3.4 (full)	PC4	-0.000±0.001	-0.178	0.861	0.000	24	0.495
	Wings	0.005±0.003	1.678	0.110			
	Metamorphosis	0.005±0.002	2.226	0.038			
	Herbivory	0.008±0.003	2.972	0.008			
3.5 (full)	Log Clutch Size	0.000±0.001	0.002	0.999	0.000	21	0.478
	Wings	0.004±0.003	1.175	0.257			
	Metamorphosis	0.006±0.002	2.418	0.028			
	Herbivory	0.007±0.003	2.638	0.018			
3.6 (full)	Log Lifetime Fecundity	0.000±0.001	0.379	0.710	0.000	20	0.382
	Wings	0.001±0.004	0.366	0.720			
	Metamorphosis	0.005±0.002	2.241	0.041			
	Herbivory	0.007±0.002	2.870	0.012			
3.6 (red.)	Log Lifetime Fecundity	0.000±0.001	0.332	0.744	0.000	20	0.416
	Metamorphosis	0.005±0.002	2.299	0.035			
	Herbivory	0.007±0.002	3.092	0.007			
3.7 (full)	Log Egg Development Time	-0.001±0.001	-0.724	0.478	0.000	24	0.508
	Wings	0.005±0.003	1.858	0.079			
	Metamorphosis	0.004±0.003	1.665	0.112			
	Herbivory	0.008±0.003	3.043	0.007			
3.8 (full)	Log Nymph/Larva Development Time	-0.001±0.001	-1.623	0.122	0.000	23	0.518
	Wings	0.005±0.003	1.723	0.102			
	Metamorphosis	0.005±0.002	2.346	0.031			
	Herbivory	0.007±0.002	2.823	0.011			
3.9 (full)	Log Pupa Development Time	0.004±0.004	0.981	0.359	0.000	11	0.223
	Wings	-0.004±0.008	-0.521	0.618			
	Herbivory	0.012±0.005	2.413	0.047			

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
3.9 (red.)	Log Pupa Development Time	0.004±0.004	0.941	0.374	0.000	11	0.293
	Herbivory	0.011±0.005	2.479	0.038			
3.10 (full)	Log Hatching to Adult Development Time	-0.002±0.001	-1.634	0.120	0.000	23	0.519
	Wings	0.005±0.003	1.694	0.108			
	Metamorphosis	0.005±0.002	2.427	0.026			
	Hebivory	0.007±0.002	2.838	0.011			
3.11 (full)	Log Egg to Adult Development Time	-0.002±0.001	-1.602	0.130	0.000	20	0.527
	Wings	0.005±0.003	1.604	0.129			
	Metamorphosis	0.004±0.002	1.665	0.117			
	Herbivory	0.008±0.003	2.750	0.015			

C.1.2 Family level analyses

Table C.4 PGLS models at an family level, the dependent variable in each model is the diversification rate of the order with the ratio of speciation to extinction $\epsilon = 0$. We present the full and reduced models, before the life history trait is dropped during model reduction.

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
4.1 (full)	PC1	0.003±0.003	1.096	0.274	0.574	281	0.007
	Wings	0.008±0.012	0.641	0.522			
	Metamorphosis	0.014±0.014	1.031	0.304			
	Herbivory	0.014±0.008	1.667	0.097			
4.1 (red.)	PC1	0.003±0.003	1.136	0.257	0.592	281	0.009
	Herbivory	0.015±0.008	1.814	0.071			
4.2 (full)	PC2	0.006±0.005	1.136	0.256	0.565	281	0.007
	Wings	0.012±0.012	0.985	0.325			
	Metamorphosis	0.012±0.014	0.851	0.395			
	Herbivory	0.014±0.008	1.702	0.090			
4.2 (red.)	PC2	0.006±0.005	1.064	0.288	0.581	281	0.008
	Herbivory	0.015±0.008	1.887	0.060			
4.3 (full)	PC3	-0.011±0.004	-2.689	0.008	0.550	281	0.029
	Wings	0.010±0.011	0.892	0.373			
	Metamorphosis	0.009±0.014	0.683	0.495			
	Herbivory	0.015±0.008	1.897	0.059			
4.3 (red.)	PC3	-0.011±0.004	-2.753	0.006	0.562	281	0.031
	Herbivory	0.017±0.008	2.085	0.038			
4.4 (full)	PC4	0.002±0.004	0.564	0.573	0.563	281	0.004
	Wings	0.010±0.012	0.856	0.393			
	Metamorphosis	0.014±0.014	1.008	0.314			
	Herbivory	0.013±0.008	1.608	0.109			
4.5 (full)	Log Clutch Size	0.001±0.003	0.280	0.780	0.623	145	0.000
	Wings	0.009±0.015	0.562	0.575			
	Metamorphosis	0.016±0.018	0.892	0.374			
	Herbivory	0.007±0.011	0.581	0.562			
4.6 (full)	Log Lifetime Fecundity	0.008±0.003	2.337	0.021	0.570	176	0.015
	Wings	0.013±0.018	0.709	0.479			
	Metamorphosis	0.002±0.018	0.111	0.912			
	Herbivory	0.011±0.011	1.078	0.282			
4.6 (red.)	Log Lifetime Fecundity	0.007±0.003	2.177	0.031	0.591	176	0.021
4.7 (full)	Log Egg Development Time	-0.011±0.003	-3.184	0.002	0.585	223	0.040
	Wings	0.004±0.012	0.317	0.752			
	Metamorphosis	0.006±0.013	0.420	0.675			
	Herbivory	0.014±0.008	1.663	0.098			
4.7 (red.)	Log Egg Development Time	-0.011±0.003	-3.167	0.002	0.623	223	0.039
4.8 (full)	Log Nymph/Larva Development Time	-0.005±0.004	-1.371	0.172	0.579	211	0.000
	Wings	0.006±0.015	0.379	0.705			

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
	Metamorphosis	0.003±0.018	0.175	0.861			
	Herbivory	0.007±0.010	0.709	0.479			
4.8 (red.)	Log Nymph/Larva Development Time	-0.005±0.004	-1.332	184	0.600	211	0.004
4.9 (full)	Log Pupa Development Time	-0.002±0.008	-0.293	0.770	0.758	141	0.000
	Wings	-0.013±0.023	-0.564	0.574			
	Herbivory	0.004±0.013	0.283	0.283			
4.9 (full)	Log Pupa Development Time	-0.002±0.008	-0.233	0.816	0.786	141	0.000
	Wings	-0.013±0.023	-0.549	0.584			
4.10 (full)	Log Hatching to Adult Development Time	-0.006±0.004	-1.321	0.188	0.596	201	0.000
	Wings	0.003±0.016	0.192	0.848			
	Metamorphosis	0.005±0.018	0.254	0.799			
	Herbivory	0.010±0.010	1.068	0.287			
4.10 (red.)	Log Hatching to Adult Development Time	-0.006±0.004	-1.283	0.186	0.624	201	0.003
4.11 (full)	Log Egg to Adult Development Time	-0.006±0.004	-1.373	0.172	0.560	176	0.002
	Wings	0.003±0.014	0.207	0.836			
	Metamorphosis	0.009±0.016	0.574	0.566			
	Herbivory	0.012±0.009	1.353	0.178			
4.11 (red.)	Log Egg to Adult Development Time	-0.006±0.004	-1.352	0.178	0.583	176	0.004

Table C.5 PGLS models at an family level, the dependent variable in each model is the diversification rate of the order with the ratio of speciation to extinction $\epsilon = 0.5$. We present the full and reduced models, before the life history trait is dropped during model reduction.

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
5.1 (full)	PC1	0.003±0.003	1.052	0.294	0.569	281	0.008
	Wings	0.008±0.011	0.724	0.469			
	Metamorphosis	0.013±0.013	1.057	0.291			
	Herbivory	0.013±0.008	1.721	0.086			
5.1 (red.)	PC1	0.003±0.003	1.102	0.272	0.588	281	0.009
	Herbivory	0.014±0.007	1.882	0.061			
5.2 (full)	PC2	0.006±0.005	1.190	0.235	0.560	281	0.235
	Wings	0.012±0.011	1.075	0.283			
	Metamorphosis	0.011±0.013	0.873	0.384			
	Herbivory	0.013±0.008	1.763	0.079			
5.2 (red.)	PC2	0.005±0.005	1.104	0.271	0.577	281	0.009
	Herbivory	0.015±0.007	1.961	0.051			
5.3 (full)	PC3	-0.010±0.004	-2.820	0.005	0.544	281	0.033
	Wings	0.010±0.011	0.981	0.328			
	Metamorphosis	0.009±0.012	0.696	0.487			
	Herbivory	0.015±0.007	1.971	0.050			
5.3 (red.)	PC3	-0.010±0.004	-2.882	0.004	0.556	281	0.034
	Herbivory	0.016±0.007	2.173	0.031			
5.4 (full)	PC4	0.002±0.003	0.554	0.580	0.558	281	0.006
	Wings	0.010±0.011	0.933	0.352			
	Metamorphosis	0.013±0.013	1.037	0.301			
	Herbivory	0.013±0.008	1.664	0.097			
5.5 (full)	Log Clutch Size	0.001±0.003	0.223	0.824	0.611	145	0.000
	Wings	0.009±0.014	0.660	0.510			
	Metamorphosis	0.015±0.016	0.913	0.363			
	Herbivory	0.006±0.010	0.609	0.543			
5.6 (full)	Log Lifetime Fecundity	0.007±0.003	2.344	0.020	0.571	176	0.016
	Wings	0.012±0.016	0.760	0.448			
	Metamorphosis	0.002±0.016	0.121	0.904			
	Herbivory	0.011±0.010	1.123	0.263			
5.6 (red.)	Log Lifetime Fecundity	0.007±0.003	2.175	0.031	0.592	176	0.021
5.7 (full)	Log Egg Development Time	-0.010±0.003	-3.267	0.001	0.575	223	0.043
	Wings	0.005±0.011	0.406	0.685			
	Metamorphosis	0.005±0.012	0.422	0.674			
	Herbivory	0.013±0.008	1.724	0.086			
5.7 (red.)	Log Egg Development Time	-0.010±0.003	-3.242	0.001	0.615	223	0.041
5.8 (full)	Log Nymph/Larva Development Time	-0.005±0.004	-1.437	0.152	0.577	211	0.000
	Wings	0.006±0.014	0.465	0.642			
	Metamorphosis	0.003±0.016	0.189	0.850			
	Herbivory	0.007±0.009	0.754	0.452			

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
5.8 (red.)	Log Nymph/Larva Development Time	-0.005±0.004	-1.390	0.166	0.601	211	0.004
5.9 (full)	Log Pupa Development Time	-0.002±0.008	-0.309	0.757	0.786	141	0.000
	Wings	-0.010±0.021	-0.492	0.624			
	Herbivory	0.037±0.012	0.317	0.752			
5.10 (full)	Log Hatching to Adult Development Time	-0.006±0.004	-1.401	0.163	0.599	201	0.000
	Wings	0.004±0.014	0.273	0.785			
	Metamorphosis	0.004±0.017	0.262	0.794			
	Herbivory	0.010±0.009	1.106	0.270			
5.10 (red.)	Log Hatching to Adult Development Time	-0.005±0.004	-1.359	0.176	0.629	201	0.004
5.11 (full)	Log Egg to Adult Development Time	-0.006±0.004	-1.470	0.144	0.554	176	0.004
	Wings	0.004±0.013	0.307	0.759			
	Metamorphosis	0.009±0.015	0.572	0.568			
	Herbivory	0.012±0.008	1.393	0.165			
5.11 (red.)	Log Egg to Adult Development Time	-0.006±0.004	-1.441	0.152	0.579	176	0.006

Table C.6 PGLS models at an family level, the dependent variable in each model is the diversification rate of the order with the ratio of speciation to extinction $\epsilon = 0.9$. We present the full and reduced models, before the life history trait is dropped during model reduction.

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
6.1 (full)	PC1	0.002±0.002	0.904	0.367	0.548	281	0.019
	Wings	0.008±0.009	0.947	0.344			
	Metamorphosis	0.0112±0.010	1.154	0.249			
	Herbivory	0.011±0.006	1.880	0.061			
6.2 (full)	PC2	0.005±0.004	1.291	0.198	0.541	281	0.015
	Wings	0.011±0.009	1.305	0.193			
	Metamorphosis	0.010±0.010	0.958	0.339			
	Herbivory	0.012±0.006	1.938	0.054			
6.2 (red.)	PC2	0.005±0.004	1.171	0.243	0.560	281	0.013
	Herbivory	0.013±0.006	2.172	0.031			
6.3 (full)	PC3	-0.009±0.003	-3.184	0.002	0.522	281	0.045
	Wings	0.010±0.008	1.215	0.225			
	Metamorphosis	0.007±0.010	0.749	0.455			
	Herbivory	0.013±0.006	2.189	0.029			
6.3 (red.)	PC3	-0.009±0.003	-3.245	0.001	0.535	281	0.045
	Herbivory	0.014±0.006	2.430	0.016			
6.4 (full)	PC4	0.001±0.003	0.542	0.588	0.537	281	0.011
	Wings	0.010±0.009	1.139	0.256			
	Metamorphosis	0.011±0.010	1.141	0.255			
	Herbivory	0.011±0.006	1.832	0.068			
6.5 (full)	Log Clutch Size	0.000±0.002	0.061	0.952	0.567	145	0.000
	Wings	0.010±0.011	0.916	0.361			
	Metamorphosis	0.013±0.008	1.000	0.319			
	Herbivory	0.006±0.007	0.712	0.477			
6.6 (full)	Log Lifetime Fecundity	0.006±0.003	2.321	0.021	0.565	176	0.019
	Wings	0.012±0.013	0.909	0.364			
	Metamorphosis	0.002±0.013	1.727	0.863			
	Herbivory	0.010±0.008	1.265	0.208			
6.6 (red.)	Log Lifetime Fecundity	0.005±0.002	2.125	0.035	0.589	176	0.020
6.7 (full)	Log Egg Development Time	-0.009±0.003	-3.513	0.005	0.540	223	0.055
	Wings	0.005±0.009	0.640	0.523			
	Metamorphosis	0.004±0.010	0.438	0.662			
	Herbivory	0.012±0.006	1.922	0.056			
6.7 (red.)	Log Egg Development Time	-0.009±0.002	-3.633	<0.001	0.550	223	0.060
	Herbivory	0.012±0.006	2.058	0.041			
6.8 (full)	Log Nymph/Larva Development Time	-0.005±0.003	-1.629	0.105	0.563	211	0.001
	Wings	0.008±0.011	0.695	0.488			
	Metamorphosis	0.003±0.013	0.246	0.806			
	Herbivory	0.006±0.007	0.910	0.364			

Model No.	Independent Variable(s)	$\beta \pm$ SE	t	p	λ	n	R^2
6.8 (red.)	Log Nymph/Larva Development Time	-0.004±0.003	-1.561	0.120	0.593	211	0.007
6.9 (full)	Log Pupa Development Time	-0.002±0.006	-0.370	0.712	0.795	141	0.000
	Wings	-0.005±0.017	-0.286	0.775			
	Herbivory	0.004±0.009	0.439	0.661			
6.9 (full)	Log Pupa Development Time	-0.002±0.006	-0.332	0.740	0.794	141	0.000
	Herbivory	0.004±0.009	0.422	0.673			
6.10 (full)	Log Hatching to Adult Development Time	-0.005±0.003	-1.628	0.105	0.599	201	0.004
	Wings	0.006±0.0114	0.491	0.623			
	Metamorphosis	0.004±0.014	0.301	0.764			
	Herbivory	0.009±0.007	1.24	0.216			
6.10 (red.)	Log Hatching to Adult Development Time	-0.005±0.003	-1.574	0.117	0.634	201	0.007
6.11 (full)	Log Egg to Adult Development Time	-0.005±0.003	-1.740	0.084	0.529	176	0.013
	Wings	0.006±0.010	0.571	0.569			
	Metamorphosis	0.007±0.012	0.582	0.561			
	Herbivory	0.010±0.007	1.522	0.130			
6.11 (red.)	Log Egg to Adult Development Time	-0.005±0.003	-1.689	0.093	0.559	176	0.010

Appendix D

Dataset of insect life history traits

D.1 Data

Table D.1 Dataset of life history traits in insects. ABL = adult body length (mm), EL = egg length (mm), EDT = egg development time (days), NDT = nymph/larval development time (days), PDT = pupa development time (days), AL = adult lifespan (days), CS = clutch size (eggs per clutch), LF = lifetime fecundity (eggs per female). References can be found after the dataset, in Appendix D.2.

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Archaeognatha									
Machilidae									
Pedetontus_unimaculatus	NA	1.30	305.00	NA	NA	NA	NA	NA	15
Petrobius_brevistylis	NA	1.15	36.00	NA	NA	NA	11.78	NA	19
Coleoptera									
Anobiidae									
Falsogastrallus_sauteri	2.05	NA	14.80	248.00	12.30	34.85	NA	19.10	175, 275
Lasioderma_serricorne	2.85	0.45	5.60	65.10	11.45	14.50	NA	29.10	276, 277
Anthribidae									
Araecerus_fasciculatus	3.70	0.57	6.50	NA	6.50	71.25	NA	79.00	316, 336, 342
Attelabidae									
Heterapoderopsis_bicallosicollis	NA	NA	4.10	6.10	3.80	114.50	1.50	50.00	307, 309
Omolabus_piceus	NA	NA	NA	15.10	NA	23.80	NA	NA	308
Bostrichidae									
Dinapate_wrighti	42.00	1.74	NA	NA	NA	NA	NA	NA	261
Prostephanus_truncatus	3.75	0.67	4.10	16.10	4.70	52.91	20.00	161.25	260, 262, 336, 342
Rhyzopertha_dominica	2.50	0.55	9.00	31.00	8.00	150.50	NA	396.50	263
Bothrideridae									
Dastarcus_helophoroides	6.83	0.94	13.00	21.10	15.80	1460.00	8.00	NA	321, 322, 342
Brachyceridae									
Coniatus_tamarisci	4.70	NA	6.75	13.32	14.72	261.98	1.00	174.70	62
Lissorhoptrus_oryzophilus	2.90	0.99	NA	NA	NA	31.20	NA	42.40	220

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Neochetina_affinis	5.65	1.01	12.80	48.00	NA	NA	NA	NA	89
Neochetina_bruchi	4.39	0.82	7.60	32.40	60.00	52.15	NA	133.15	95, 196
Stenopelmus_rufinasus	1.73	0.32	1.50	5.50	6.00	NA	1.00	NA	194
Brentidae									
Apion_aestivum	NA	NA	NA	NA	8.00	NA	NA	NA	70
Apion_dichroum	NA	NA	10.00	18.00	10.00	NA	NA	48.00	70
Coelocephalapion_camarae	NA	0.46	6.00	22.50	6.50	152.08	NA	NA	274
Coelocephalapion_gandolfoi	NA	NA	15.50	32.50	11.00	NA	NA	NA	272
Ischnopterapion_virens	2.20	NA	7.50	28.00	7.00	360.00	1.00	42.50	273
Buprestidae									
Agrilus_anxius	9.50	1.50	14.00	NA	17.50	24.50	7.50	75.00	182
Agrilus_bilineatus	8.50	NA	NA	NA	11.07	37.80	2.50	NA	164
Agrilus_difficilis	NA	NA	NA	NA	NA	43.50	NA	30.00	162
Agrilus_fleischeri	10.46	1.12	12.83	NA	26.40	34.60	NA	218.00	147
Agrilus_planipennis	10.50	1.12	12.71	100.00	25.63	26.60	1.00	70.97	165, 232; 233; 336
Chrysobothris_orono	NA	NA	NA	NA	NA	NA	1.00	NA	180
Cisseis_fascigera	7.75	NA	NA	NA	30.42	NA	NA	NA	181
Nascioides_enysi	NA	1.00	34.00	NA	29.00	55.00	NA	NA	163
Pachyschelus_psychotriae	NA	NA	NA	NA	27.00	NA	2.95	NA	183
Cantharidae									
Chauliognathus_lugubris	NA	NA	11.00	205.40	30.42	60.83	90.00	NA	323
Carabidae									
Amara_fulva	NA	NA	7.85	253.90	13.20	NA	NA	NA	292
Anisodactylus_sanctaecrucis	NA	NA	5.70	23.80	7.10	NA	NA	92.00	116
Carabus_dufouri	NA	NA	12.13	44.84	NA	NA	3.44	34.50	29, 120
Carabus_ghilianii	NA	3.50	13.50	NA	NA	NA	NA	NA	293
Carabus_ulrichii	28.00	5.85	NA	NA	NA	NA	1.84	NA	221, 340

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Cicindela_cursitans	NA	1.13	NA	NA	NA	NA	NA	NA	168
Cicindela_scutellaris	NA	NA	NA	NA	NA	NA	NA	105.00	291
Cicindela_sexguttata	12.00	1.80	NA	NA	NA	NA	NA	45.00	291, 336, 342
Colliuris_batesii	NA	NA	6.00	26.00	7.00	410.63	1.00	56.00	119
Cychrus_cordicollis	NA	2.00	41.00	NA	NA	NA	1.00	18.50	118
Elaphrus_sugai	8.00	1.15	3.30	22.50	4.00	NA	NA	131.00	222
Feronia_melanaria	NA	2.70	14.00	NA	NA	NA	NA	NA	115
Harpalus_aeneus	NA	2.00	NA	NA	NA	NA	NA	NA	115
Harpalus_pensylvanicus	NA	2.50	9.00	NA	NA	NA	1.00	10.40	117
Harpalus_rufipes	NA	2.80	NA	NA	17.00	NA	NA	84.00	116
Harpalus_signaticornis	NA	NA	8.50	38.00	NA	NA	NA	NA	122
Pterostichus_melanarius	15.00	2.00	9.00	NA	NA	NA	7.00	125.00	118, 335
Siagona_europaea	13.50	3.27	NA	NA	NA	NA	NA	NA	134
Trichognatha_marginipennis	17.25	NA	NA	NA	NA	NA	NA	NA	121
Cerambycidae									
Acalolepta_vastator	24.20	NA	NA	31.50	20.55	42.20	1.25	13.25	215
Anoplophora_glabripennis	NA	6.25	NA	NA	NA	30.40	NA	NA	142, 342
Anoplophora_malasiaca	NA	NA	NA	NA	NA	77.60	NA	193.80	216
Coenopoeus_palmeri	NA	4.35	NA	NA	NA	NA	NA	NA	158
Colobothea_distincta	9.92	1.65	10.00	42.00	13.00	45.50	NA	19.00	157
Dectes_texanus	NA	NA	4.00	288.96	10.00	34.00	NA	NA	214
Gaurotes_virginea	10.10	1.19	14.50	NA	NA	28.00	4.00	23.00	141
Goes_debilis	13.00	NA	NA	NA	15.50	NA	1.00	NA	156
Goes_pulverulentus	23.00	4.00	NA	NA	14.50	27.00	17.00	12.00	177
Megacyllene_mellyi	NA	NA	14.00	NA	NA	36.90	1.00	63.00	240
Monochamus_carolinensis	NA	NA	NA	NA	NA	61.40	1.00	200.00	154
Nyphasia_apicalis	NA	1.70	17.50	287.00	42.00	NA	6.00	NA	178
Oberea_schaumii	14.60	NA	14.50	1095.00	NA	NA	1.00	NA	155

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Obrium_cantharinum	7.50	1.00	21.00	577.92	19.25	NA	NA	30.00	290, 340
Oncideres_pustulatus	NA	NA	NA	NA	NA	NA	NA	30.40	179
Osphranteria_coerulescens	19.00	NA	9.00	334.58	14.80	NA	1.00	51.70	143
Phytoecia_coerulescens	12.50	2.50	7.00	NA	NA	NA	NA	NA	231
Plagiohammus_spinipennis	NA	4.00	7.50	258.54	22.00	76.04	1.00	55.00	289
Plagithmysus_bilineatus	NA	2.50	3.50	NA	37.00	NA	1.00	NA	248
Pronocera_angusta	12.30	1.35	NA	NA	14.00	NA	NA	NA	213
Saperda_inornata	NA	NA	14.50	NA	NA	66.00	1.00	NA	176
Semanotus_litigiosus	NA	1.90	12.00	121.67	21.00	NA	1.50	58.00	144
Styloxus_bicolor	NA	1.19	17.50	1095.00	NA	NA	NA	22.50	247
Cerylonidae									
Murmidius_ovalis	1.30	0.72	13.30	45.90	5.30	NA	NA	NA	324
Chrysomelidae									
Acanthoscelides_obtectus	3.00	0.66	NA	NA	NA	NA	NA	NA	24, 336
Ageniosa_electoralis	6.90	1.80	7.90	NA	NA	NA	2.70	321.00	129
Aphthona_abdominalis	2.00	0.52	4.70	20.00	10.50	183.12	NA	53.50	126
Argopistes_tsekooni	2.29	0.62	13.00	20.00	11.50	30.00	2.00	27.80	281
Callosobruchus_analis	NA	0.89	NA	NA	NA	NA	NA	NA	24
Callosobruchus_chinensis	NA	0.57	NA	NA	NA	NA	NA	NA	24
Callosobruchus_maculatus	NA	0.65	NA	NA	NA	NA	NA	NA	24
Callosobruchus_phaseoli	NA	0.66	NA	NA	NA	NA	NA	NA	24
Callosobruchus_rhodesianus	NA	0.58	NA	NA	NA	NA	NA	NA	24
Callosobruchus_subinnotatus	NA	0.72	NA	NA	NA	NA	NA	NA	24
Caryedon_serratus	6.00	1.05	7.25	20.95	17.25	24.90	1.00	59.50	24, 25; 27
Cassida_enervis	NA	NA	6.25	14.00	3.50	NA	NA	40.00	171
Cassida_hemisphaerica	4.50	1.25	3.00	17.50	NA	91.25	2.50	NA	242, 340
Cassida_rubiginosa	6.75	NA	9.40	23.40	8.00	262.15	263.70	815.00	150, 340
Charidotis_auroguttata	NA	NA	9.80	23.40	9.60	182.50	1.00	NA	227

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Chelymorpha_alternans	6.00	1.88	11.15	19.08	5.33	334.58	24.69	NA	124
Chlamisus_cribripennis	NA	1.05	10.00	NA	NA	NA	NA	NA	282
Chlamisus_malvernensis	2.80	1.17	14.70	89.60	22.70	NA	1.00	NA	284
Chrysomela_crotchi	NA	1.70	10.70	26.00	6.00	NA	37.60	149.00	243
Chrysomela_rossia	9.67	1.60	11.40	51.10	16.40	394.80	NA	441.30	207
Chrysomela_scripta	NA	NA	NA	NA	NA	NA	64.30	510.00	241
Colaspis_crinicornis	NA	0.71	8.20	NA	9.60	12.23	57.50	81.04	128
Conchyloctenia_hybrida	8.54	NA	8.17	20.02	8.44	166.50	6.90	NA	226
Crioceris_duodecimpunctata	5.80	NA	8.50	21.00	8.50	NA	NA	360.00	244, 340
Diabrotica_barberi	NA	NA	NA	NA	NA	74.25	28.00	274.00	174, 175
Diabrotica_tibialis	NA	NA	10.00	NA	NA	333.00	NA	1044.00	151
Diabrotica_vittata	NA	NA	8.00	16.50	10.50	NA	NA	276.00	228
Disonycha_argentinensis	4.50	1.18	4.00	10.00	NA	147.00	39.60	409.00	172
Galeruca_rufa	5.25	NA	11.40	18.70	7.00	NA	NA	NA	173, 340
Gastrophysa_viridula	5.00	1.30	5.00	12.00	4.50	31.75	40.00	NA	125
Gonioctena_americana	NA	NA	NA	19.50	14.00	NA	11.70	NA	209
Lema_daturaphila	NA	1.22	4.50	8.00	6.50	3.75	30.80	NA	170
Lioplacis_elliptica	NA	NA	25.00	40.00	NA	91.25	NA	NA	224
Metallactus_patagonicus	6.40	1.00	20.00	182.50	30.42	118.00	NA	234.50	223, 339
Monolepta_australis	NA	NA	11.70	34.00	9.10	NA	2.25	NA	225
Odontota_dorsalis	NA	NA	10.00	17.60	9.60	NA	4.00	110.60	169
Ophraella_notulata	NA	0.69	5.10	9.50	3.90	NA	21.30	NA	136
Paraselenis_dichroa	NA	NA	12.70	24.90	10.40	NA	27.30	NA	135
Phratora_hudsonia	NA	1.00	NA	NA	NA	NA	11.00	NA	210
Plagiodera_versicolora	3.50	NA	5.50	14.00	4.61	24.50	16.68	NA	123, 340
Podontia_congregata	NA	1.87	6.50	21.50	22.50	106.46	12.00	NA	127
Pyrrhalta_nymphaea	NA	0.90	6.03	7.01	5.53	NA	9.00	51.57	208
Sumitrosis_rosea	NA	0.87	8.30	17.00	6.00	NA	1.00	72.80	169

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Trirhabda_bacharidis	NA	1.18	NA	37.50	10.00	61.20	51.70	517.80	152
Yingaresca_holosericea	NA	0.90	3.25	16.50	4.00	NA	25.00	NA	283
Zabrotes_subfasciatus	2.15	0.56	NA	NA	NA	NA	NA	NA	24, 340
Coccinellidae									
Adalia_10-punctata	4.60	NA	NA	NA	NA	NA	10.80	NA	23, 31
Adalia_bipunctata	4.90	1.00	3.64	11.99	6.77	55.67	30.00	824.33	23, 31; 32
Adonia_11-notata	NA	NA	NA	NA	NA	NA	30.00	NA	23
Aiolocaria_hexaspilota	9.70	NA	NA	NA	NA	NA	26.00	881.00	31
Anatis_ocellata	8.50	2.00	NA	NA	NA	NA	NA	300.00	31
Anegleis_cardoni	3.70	NA	NA	NA	NA	NA	NA	287.33	31
Anovia_punica	2.95	0.64	5.27	10.84	8.14	92.21	2.00	366.00	218
Axinoscymnus_cardilobus	NA	NA	NA	NA	NA	NA	NA	118.67	31
Brumoides_suturalis	NA	NA	NA	NA	NA	NA	NA	139.00	31
Callicaria_superba	NA	NA	NA	NA	NA	NA	NA	237.00	31
Calvia_decemguttata	6.60	NA	NA	NA	NA	NA	NA	209.60	31
Calvia_duodecimmaculata	NA	NA	NA	NA	NA	NA	NA	161.67	31
Calvia_quatuordecimguttata	5.40	NA	NA	NA	NA	NA	18.00	149.83	31
Ceratomegilla_undecimnotata	6.60	NA	NA	NA	NA	NA	30.00	106.00	31
Chilocorus_bipustulatus	3.50	NA	NA	NA	NA	NA	NA	594.00	31
Chilocorus_nigritus	4.00	NA	NA	NA	NA	NA	NA	302.54	31
Clitostethus_arcuatus	2.11	NA	NA	NA	NA	NA	NA	181.00	31, 340
Clitostethus_oculatus	1.26	0.41	3.50	20.26	4.50	72.40	NA	55.33	31, 33
Coccinella_novemnotata	NA	NA	3.00	11.95	5.35	NA	18.00	538.60	31, 236
Coccinella_septempunctata	7.20	1.30	3.99	15.92	7.58	45.78	50.00	884.31	31, 34; 35; 236
Coccinella_transversalis	6.93	1.09	NA	NA	NA	NA	15.33	NA	29
Coccinella_trifasciata	4.90	NA	NA	NA	NA	NA	10.20	NA	23, 31; 340
Coccinella_undecimpunctata	3.58	1.06	8.60	19.50	5.10	53.70	21.00	540.72	30, 31
Coelophora_biplagiata	NA	NA	NA	NA	NA	NA	20.00	NA	31

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Coelophora_bissellata	5.30	NA	NA	NA	NA	NA	10.00	NA	31
Coelophora_inaequalis	NA	NA	NA	NA	NA	NA	9.00	NA	31
Coelophora_saucia	NA	NA	NA	NA	NA	NA	NA	649.09	31
Cryptolaemus_montrouzieri	NA	NA	6.79	16.09	6.31	59.31	NA	228.63	28, 36
Delphastus_catalinae	NA	NA	5.77	11.94	6.48	138.20	NA	242.90	239
Delphastus_pusillus	1.39	0.43	NA	NA	NA	NA	NA	NA	31
Diomus_flavifrons	1.66	0.49	5.10	17.80	5.90	NA	NA	146.90	219
Diomus_terminatus	2.00	0.65	4.00	5.00	5.00	NA	1.00	NA	238
Epilachna_virgintisexpunctata	NA	NA	NA	NA	NA	NA	26.00	NA	31
Exochomus_quadripustulatus	4.30	NA	NA	NA	NA	NA	NA	125.00	31
Harmonia_axyridis	6.50	NA	NA	NA	NA	NA	27.40	942.59	23, 31
Harmonia_yedoensis	NA	NA	NA	NA	NA	NA	24.00	401.00	31
Henosepilachna_argus	NA	1.70	NA	NA	NA	NA	NA	NA	31
Henosepilachna_sumbana	NA	NA	NA	NA	NA	NA	26.50	NA	31
Henosepilachna_vigintioctopunctata	6.90	NA	NA	NA	NA	NA	26.00	NA	31
Hippodamia_conglobata	NA	NA	NA	NA	NA	NA	4.70	NA	23
Hippodamia_convergens	5.90	NA	NA	NA	NA	NA	19.10	720.00	23, 31; 336
Hippodamia_tredecimpunctata	5.90	NA	NA	NA	NA	NA	25.00	323.92	31
Hippodamia_variegata	4.80	NA	NA	NA	NA	NA	20.00	962.67	23, 31
Hyperaspis_jucunda	2.85	0.56	5.11	13.80	7.13	100.58	NA	456.00	285, 338
Lioadalia_flavomaculata	5.20	1.00	4.00	13.20	4.80	44.50	13.10	858.50	245
Menochilus_sexmaculatus	5.20	1.04	7.30	22.10	3.60	32.30	8.83	910.50	29, 30; 31
Micraspis_discolor	NA	NA	NA	NA	NA	NA	NA	580.00	31
Nephus_includens	NA	NA	NA	NA	NA	NA	NA	151.00	31
Nephus_reunioni	NA	NA	NA	11.90	6.40	NA	NA	177.00	31, 286
Oenopia_conglobata	4.60	NA	NA	NA	NA	NA	11.50	452.50	31
Oenopia_lyncea	3.75	NA	NA	NA	NA	NA	NA	40.00	31, 340
Olla_v-nigrum	NA	NA	NA	NA	NA	NA	27.10	217.50	23, 31

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Propylea_dissecta	NA	NA	NA	NA	NA	NA	NA	659.75	31
Propylea_japonica	NA	NA	NA	NA	NA	NA	8.00	644.00	31
Propylea_quatuordecimpunctata	4.10	NA	3.30	9.00	4.70	NA	12.00	863.31	23, 31; 170
Psyllobora_confluens	NA	NA	NA	NA	NA	NA	NA	440.00	31
Rhyzobius_forestieri	NA	0.60	NA	17.40	6.30	NA	1.00	NA	246
Rhyzobius_lophanthae	NA	0.51	5.55	14.60	4.64	66.00	NA	891.00	234
Rhyzobius_ventralis	NA	0.70	NA	18.70	8.00	NA	1.00	NA	246
Sasajiscymnus_tsugae	NA	NA	NA	NA	NA	NA	NA	280.00	31
Scymnus_frontalis	2.50	NA	NA	NA	NA	NA	NA	151.00	31
Scymnus_hoffmanni	NA	NA	NA	NA	NA	NA	NA	127.00	31
Scymnus_interruptus	2.20	NA	NA	NA	NA	NA	NA	245.00	31
Scymnus_levaillanti	NA	NA	NA	NA	NA	NA	NA	340.00	31
Scymnus_louisianae	NA	0.50	NA	NA	NA	NA	NA	122.00	31
Scymnus_marginicollis	NA	NA	NA	NA	NA	NA	NA	75.00	31
Scymnus_marinus	NA	NA	NA	NA	NA	NA	NA	602.00	31
Scymnus_sinuanodulus	NA	NA	NA	NA	NA	NA	NA	130.00	31
Scymnus_subvillosus	NA	NA	NA	NA	NA	NA	NA	165.50	31
Scymnus_syriacus	NA	NA	NA	NA	NA	NA	NA	623.00	31
Stethorus_japonicus	NA	NA	3.30	6.50	2.60	66.40	NA	736.20	190
Stethorus_punctum	1.40	0.37	5.17	12.00	5.30	NA	5.00	NA	235
Stethorus_pusillus	1.35	0.40	NA	NA	NA	NA	NA	NA	31, 340
Stethorus_siphonulus	1.33	0.33	2.90	6.80	3.00	31.00	1.00	170.00	236, 237
Cryptophagidae									
Telmatophilus_typhae	2.25	NA	3.50	17.50	5.00	NA	15.00	NA	327
Curculionidae									
Acythopeus_burkhartorum	NA	NA	8.50	25.00	27.50	24.00	NA	NA	42
Anthonomus_monostigma	NA	NA	7.00	NA	NA	63.00	NA	NA	64
Anthonomus_musculus	1.75	0.45	NA	NA	NA	NA	1.00	20.00	200

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Anthonomus_santacruzi	2.50	0.30	NA	NA	6.00	110.30	NA	37.60	240
Apocnemidophorus_pipitzi	6.00	0.70	8.00	NA	NA	52.70	1.00	50.60	86
Argentinorhynchus_breyeri	3.23	0.57	4.74	17.96	NA	NA	1.00	NA	55
Artipus_floridanus	NA	0.80	8.00	45.00	NA	NA	39.80	1220.00	55
Balaninus_nucum	6.50	0.80	NA	29.50	NA	NA	NA	NA	59
Brachycerus_ornatus	34.75	8.70	NA	121.67	NA	699.58	6.00	NA	198
Ceutorhynchus_geographicus	4.25	NA	NA	NA	NA	NA	NA	NA	204
Ceutorhynchus_litura	3.75	NA	6.00	NA	17.50	NA	3.00	123.00	94, 204
Ceutorhynchus_pleurostigma	2.76	0.35	6.00	70.00	35.00	273.75	NA	60.00	201
Ceutorhynchus_subpubescens	NA	0.61	NA	NA	NA	NA	NA	NA	80
Ceutorhynchus_trimaculatus	3.25	NA	NA	NA	NA	NA	NA	300.00	84
Conotrachelus_neomexicanus	6.00	0.90	4.50	NA	NA	NA	3.50	NA	203
Conotrachelus_perseae	NA	NA	NA	NA	16.33	NA	4.50	NA	195
Conotrachelus_schoofi	NA	1.10	6.50	29.90	7.20	NA	1.00	12.00	61
Cryptohynchus_melastomae	NA	1.16	27.00	136.00	18.00	NA	1.00	59.00	41
Curculio_caryae	15.00	NA	9.00	45.60	18.50	22.50	3.00	45.00	50
Cyrtobagous_singularis	2.49	0.50	9.80	23.00	12.60	NA	1.00	NA	90
Dendroctonus_micans	8.00	NA	11.90	40.55	9.76	NA	NA	NA	334, 340
Dendroctonus_murrayanae	5.93	1.20	NA	NA	NA	NA	56.00	NA	46
Diaprepes_abbreviatus	NA	NA	NA	377.50	15.30	141.00	69.20	6517.00	44
Dusmoecetes_similis	6.54	0.69	56.48	657.01	51.47	NA	9.50	111.00	192
Epimechus_canoides	2.12	0.43	2.21	NA	NA	NA	NA	NA	85
Eudiagogus_pulcher	NA	0.65	7.00	22.00	6.40	NA	1.50	NA	79
Eudiagogus_rosenschoeldi	NA	0.66	7.12	22.00	7.70	NA	1.50	NA	79
Heilipous_ventralis	9.50	1.40	14.70	150.60	23.72	112.20	1.00	116.65	37
Hylobitelus_xiaoi	15.05	2.90	12.60	128.90	19.70	217.60	1.00	35.70	40, 108
Hypera_postica	4.65	0.56	10.00	12.00	8.00	NA	10.90	NA	58, 77; 340
Hypolixus_truncatulus	12.14	1.05	3.30	32.60	6.80	NA	NA	NA	53

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Larinus_filiformis	NA	NA	12.60	40.00	16.60	NA	NA	NA	191
Larinus_latus	NA	NA	14.00	30.50	12.50	NA	1.00	NA	65
Larinus_vulpes	12.00	1.45	NA	NA	NA	NA	NA	NA	279
Linogeraeus_urbanus	3.00	0.50	NA	NA	NA	NA	NA	NA	81
Listronotus_latiusculus	5.50	0.75	1.00	14.00	8.00	NA	NA	NA	59
Listronotus_oregonensis	6.25	0.83	4.50	12.40	5.40	NA	1.50	156.00	199
Lixus_bardanae	NA	NA	14.50	60.83	NA	NA	1.00	NA	66
Lixus_circumcinctus	NA	NA	NA	NA	14.00	NA	1.00	NA	193
Lixus_incanescens	NA	NA	NA	NA	NA	21.06	NA	116.03	63
Lixus_nordmanni	NA	NA	14.00	NA	12.50	NA	2.00	NA	280
Microlarinus_lareynii	NA	NA	2.20	14.50	4.50	NA	1.00	193.00	78
Microlarinus_lypriformis	NA	NA	2.70	27.50	4.30	NA	1.00	247.00	76
Nanophyes_nigritulus	NA	0.42	6.00	11.50	4.50	111.67	1.00	107.33	68
Neohydronomus_affinis	2.00	NA	2.50	20.00	NA	91.25	NA	NA	38
Neohydronomus_pulchellus	1.95	0.40	3.60	12.50	NA	NA	NA	NA	91
Odoiporus_longicollis	NA	NA	3.60	32.20	18.60	74.20	4.50	NA	52
Otiorhynchus_ovatus	5.00	0.47	12.60	NA	22.60	121.69	NA	NA	73
Otiorhynchus_sulcatus	5.00	0.80	8.40	NA	NA	NA	NA	NA	56, 340
Pachylobius_picivorus	NA	NA	NA	NA	19.50	NA	NA	61.50	67
Paramecops_stapeliae	NA	1.40	6.50	17.50	21.00	NA	NA	NA	202
Phlyctinus_callosus	NA	NA	7.00	100.00	14.00	NA	NA	NA	97
Phytobius_leucogaster	2.71	0.53	4.50	10.00	3.00	55.30	NA	514.30	93
Pissodes_engelmanni	NA	1.00	NA	NA	NA	NA	1.00	NA	83
Pissodes_fasciatus	NA	1.20	NA	NA	NA	NA	3.50	NA	74
Pityophthorus_pulchellus	1.90	0.60	NA	NA	NA	NA	4.70	NA	326
Pseudanthonomus_hamamelidis	NA	0.45	2.50	42.00	8.00	NA	1.00	90.00	25, 197
Pseudocoeliodes_rubricus	3.00	0.25	7.75	NA	19.00	NA	1.50	NA	39
Rhinocyllus_conicus	5.00	NA	NA	7.50	11.00	NA	NA	192.00	96

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Scolytus_kashmirensis	3.97	0.78	12.00	43.00	15.00	52.50	NA	46.00	48
Sitona_discoideus	NA	0.40	NA	NA	NA	NA	NA	1009.00	87, 88
Sitona_humeralis	4.25	NA	NA	NA	NA	NA	NA	1098.00	88, 340
Sitophilus_oryzae	3.47	0.37	4.99	27.00	8.16	89.69	1.00	110.19	43, 51
Sitophilus_zeamais	3.79	0.65	5.25	22.02	6.55	NA	NA	121.62	47, 342
Sophrorhinus_gbanjaensis	NA	0.75	5.90	26.50	7.70	71.60	1.00	52.50	72
Sphenophorus_inaequalis	NA	NA	9.70	NA	11.50	NA	NA	NA	57
Sphenophorus_minimus	NA	NA	8.80	45.60	10.30	NA	NA	NA	57
Sphenophorus_parvulus	NA	1.40	7.70	41.17	10.80	NA	NA	NA	57, 92
Sphenophorus_venatus	NA	NA	8.00	71.10	12.80	NA	NA	NA	57
Temnoschoita_quadrimaculata	12.77	1.08	3.60	36.00	7.50	106.00	NA	325.50	69
Thecesternus_hirsutus	NA	1.40	NA	NA	18.00	304.17	NA	NA	45
Trichobaris_trinotata	4.35	0.65	7.40	57.70	12.10	74.00	1.00	95.70	82
Trichosirocalus_horridus	4.50	NA	NA	NA	NA	NA	NA	NA	80
Wagnerinus_costatus	NA	0.42	NA	NA	NA	NA	1.00	NA	60
Xylosandrus_compactus	1.32	0.55	4.50	7.50	8.50	NA	NA	9.00	54
Dermestidae									
Dermestes_ater	7.00	1.90	4.50	27.50	7.80	NA	NA	NA	254
Dermestes_erichsoni	6.95	1.78	NA	NA	NA	NA	NA	50.00	255
Dermestes_maculatus	7.75	1.30	2.00	33.50	11.00	NA	6.00	200.00	253, 340
Reesa_vespulae	3.30	0.69	NA	NA	NA	NA	NA	NA	22, 340
Thylodrias_contractus	3.65	0.70	26.40	348.35	10.90	24.10	NA	NA	256
Trogoderma_glabrum	3.10	0.58	NA	NA	NA	NA	NA	NA	22, 340
Trogoderma_granarium	2.35	0.59	NA	NA	NA	13.90	NA	41.20	22, 252; 340
Derodontidae									
Laricobius_kangdingensis	NA	NA	12.90	22.90	20.40	219.50	NA	196.40	315
Laricobius_nigrinus	2.59	0.44	11.80	19.00	17.80	NA	1.20	100.80	316, 317
Dytiscidae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Desmopachria_convexa	NA	0.33	4.50	16.40	3.60	NA	NA	NA	251
Dytiscus_dauricus	NA	NA	NA	NA	22.90	NA	NA	NA	21
Ilybius_angustior	9.00	NA	11.10	NA	NA	NA	NA	NA	20, 340
Ilybius_discedens	NA	NA	12.90	NA	NA	NA	NA	NA	20
Ilybius_pleuriticus	NA	NA	17.00	NA	NA	NA	NA	NA	20
Elateridae									
Agriotes_obscurus	9.16	0.57	22.50	841.00	15.40	NA	20.50	NA	184
Conoderus_amplicollis	NA	NA	NA	309.00	14.30	NA	NA	NA	186
Conoderus_exsul	NA	NA	NA	286.50	18.40	NA	NA	NA	186
Conoderus_falli	NA	NA	NA	299.00	16.30	NA	NA	NA	186
Cormybites_cupreus	NA	NA	34.00	1780.00	21.00	NA	NA	82.00	185
Elmidae									
Ancyronyx_variegatus	NA	NA	18.00	334.58	14.00	NA	NA	NA	270
Lara_avara	NA	0.54	24.50	1780.00	NA	NA	NA	125.00	269
Stenelmis_crenata	NA	NA	NA	304.17	NA	NA	NA	NA	271
Erotylidae									
Acropteroxys_gracilis	9.00	1.84	5.00	44.00	13.00	35.00	1.00	12.00	302
Dacne_picta	3.05	NA	3.80	24.70	NA	7.00	NA	NA	303, 340
Mycotretus_apicalis	NA	NA	NA	15.14	6.46	89.70	NA	522.00	304
Geotrupidae									
Bolborhachium_recticorne	18.90	9.00	NA	79.00	41.50	NA	NA	NA	297
Histeridae									
Carcinops_pumilio	3.83	NA	3.50	11.00	6.00	NA	NA	NA	267, 340
Teretriosoma_nigrescens	3.00	1.10	7.00	30.00	21.00	NA	1.00	NA	268
Hydraenidae									
Hydraena_decui	NA	0.37	NA	NA	NA	NA	NA	NA	278
Hydraena_franklyni	NA	0.42	NA	NA	NA	NA	NA	NA	278
Hydraena_perkinsi	NA	0.44	4.00	NA	NA	NA	1.00	NA	278

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Hydrophilidae									
Hemiosus_bruchi	NA	0.62	NA	NA	NA	NA	2.50	NA	258
Hydramara_argentina	NA	1.30	11.50	27.50	9.00	NA	16.00	NA	258
Phaenonotum_exstriatum	NA	1.00	6.50	15.50	2.50	NA	4.00	500.00	257
Lampyridae									
Pyractomena_borealis	NA	NA	30.00	329.00	5.00	NA	100.00	NA	265
Pyractomena_lucifera	NA	0.80	15.00	NA	6.60	31.80	60.00	102.00	264
Leiodidae									
Zearagytodes_maculifer	NA	0.52	6.00	20.70	4.60	NA	1.00	NA	266
Melandryidae									
Serropalpus_coxalis	10.80	NA	NA	NA	NA	NA	NA	NA	338
Meloidae									
Gnathium_minimum	NA	0.70	8.00	NA	NA	NA	57.50	NA	187
Gnathium_obscurum	NA	0.70	8.80	NA	NA	NA	10.50	NA	187
Lytta_vesicatoria	17.00	1.13	17.80	NA	NA	NA	941.00	5542.00	188, 337
Meloe_decorus	15.00	0.87	12.10	NA	NA	NA	1128.00	NA	188, 340
Meloe_proscarabaeus	23.00	1.13	21.40	NA	NA	NA	6194.00	39950.00	188, 340
Meloe_rufiventris	24.00	1.24	19.80	NA	NA	NA	2960.00	NA	188, 340
Meloe_rugosus	12.00	0.61	18.50	NA	NA	NA	2404.00	25175.00	188, 340
Meloe_scabriusculus	15.50	0.71	22.80	NA	NA	NA	3433.00	39733.00	188, 340
Meloe_uralensis	16.00	0.93	15.60	NA	NA	NA	1398.00	NA	188, 340
Meloe_violaceus	21.00	1.76	124.20	NA	NA	NA	1093.00	NA	188, 340
Mylabris_phalerata	28.50	NA	40.56	182.50	22.60	NA	NA	NA	217
Nemognatha_lurida_lurida	NA	0.75	7.30	31.70	NA	NA	200.00	NA	187
Nemognatha_nigripennis	NA	0.70	7.50	34.10	6.00	NA	150.00	NA	187
Nemognatha_nitidula	NA	1.00	9.80	21.90	NA	NA	150.00	NA	187
Pseudozonitis_brevis	NA	0.80	6.70	32.70	NA	NA	269.00	NA	187
Sitaris_muralis	10.25	0.88	29.20	NA	NA	NA	1700.00	NA	188, 340

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Tetraonyx_fulvus	NA	0.70	9.00	NA	NA	NA	150.00	NA	187
Zonitis_artipennis_flavida	NA	0.94	10.30	44.50	NA	NA	150.00	NA	187
Zonitis_dunniana	NA	1.00	9.00	NA	NA	NA	248.00	NA	187
Zonitis_punctipennis	NA	0.90	11.00	NA	NA	NA	150.00	NA	187
Melyridae									
Collops_georgianus	NA	NA	8.00	156.50	6.30	NA	12.90	NA	205, 305
Malachius_prolongatus	6.65	1.05	9.50	NA	NA	NA	20.50	NA	306
Monotomidae									
Rhizophagus_grandis	5.00	NA	6.19	19.21	13.64	NA	NA	NA	334, 340
Mycetophagidae									
Triphyllus_minor	NA	NA	7.50	29.40	7.40	35.00	6.00	46.00	325
Nitidulidae									
Carpophilus_dimidiatus	2.50	0.71	3.17	17.00	5.10	97.14	NA	98.01	294, 340, 342
Lobiopa_insularis	NA	NA	4.33	18.75	9.22	122.08	NA	1655.35	295, 296
Stelidota_geminata	2.50	0.74	2.50	8.00	5.00	58.40	NA	346.00	249, 340
Oedemeridae									
Nacerdes_melanura	11.70	NA	8.00	365.00	11.50	NA	33.70	NA	306, 317; 336
Phalacridae									
Acylomus_pugetanus	1.85	NA	NA	10.50	17.50	NA	NA	NA	320
Olibrus_aeneus	2.25	0.75	10.50	42.00	NA	NA	1.00	NA	319, 340
Psephenidae									
Psephenus_montanus	NA	0.30	NA	NA	14.00	10.50	NA	NA	311
Sclerocyphon_secretus	5.00	NA	NA	669.17	14.00	28.00	NA	NA	310
Ptilodactylidae									
Paralichus_trivittus	7.62	NA	8.00	NA	NA	NA	NA	NA	332
Tetraglossa_papais	9.83	NA	NA	NA	4.00	NA	NA	NA	333
Ptinidae									
Niptus_hololeucus	NA	0.64	NA	NA	NA	NA	NA	NA	22

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Ptinus_fur	3.45	0.55	NA	NA	NA	NA	NA	NA	22, 335
Ptinus_tectus	3.25	0.44	NA	NA	NA	NA	NA	NA	22, 340
Ripiphoridae									
Pelecotoma_fennica	4.25	0.55	18.00	NA	10.00	NA	NA	NA	330, 340
Scarabaeidae									
Adoryphorus_couloni	12.50	1.90	30.50	49.00	28.74	NA	1.00	NA	139, 175
Anomala_kansana	11.75	2.25	12.20	332.24	12.50	NA	NA	NA	131
Copris_laeviceps	NA	3.28	6.60	23.90	13.20	210.00	NA	NA	211
Cyclocephala_verticalis	NA	1.80	17.20	195.70	14.80	37.50	NA	NA	287
Dynastes_neptunus	NA	5.30	44.50	NA	NA	NA	NA	NA	229
Euoniticellus_intermedius	8.00	2.30	2.00	NA	NA	48.60	NA	NA	138
Euphoria_areata	NA	2.30	14.00	NA	NA	NA	NA	NA	153
Heliocopris_dilloni	47.25	19.50	6.00	NA	NA	NA	4.90	NA	133
Holotrichia_longipennis	21.76	1.39	13.10	285.90	9.50	31.55	1.00	23.60	288
Oplostomus_fuligineus	NA	2.08	7.60	56.00	25.00	NA	1.50	5.80	140
Pachnoda_interrupta	NA	1.40	8.00	45.30	NA	NA	1.00	NA	132
Phoxomeloides_gedyei	NA	NA	9.90	79.90	284.30	31.20	NA	34.50	130
Protaetia_fusca	NA	2.20	9.00	276.50	28.00	NA	1.00	117.00	137
Strategus_fascinus	30.10	NA	NA	NA	NA	NA	NA	NA	212
Silphidae									
Ablattaria_arenaria	10.85	1.90	9.40	12.30	5.70	182.50	29.50	168.50	259
Silvanidae									
Cathartus_quadricollis	NA	0.77	5.00	NA	NA	NA	NA	NA	301
Oryzaephilus_acuminatus	NA	NA	3.00	21.60	4.15	NA	NA	45.00	298
Oryzaephilus_mercator	2.70	0.70	5.50	22.20	5.70	NA	NA	232.00	300, 342
Oryzaephilus_surinamensis	3.00	0.74	3.65	14.10	5.88	NA	NA	NA	299, 340, 342
Staphylinidae									
Acylophorus_wagenschieberi	8.72	1.34	9.00	NA	9.50	NA	NA	NA	205, 340

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Aleochara_bilineata	5.84	NA	6.00	NA	NA	126.00	NA	637.38	108, 340
Aleochara_bipustulata	3.98	NA	7.20	NA	NA	169.00	NA	1139.12	108, 340
Astrapaeus_ulmi	NA	1.89	10.00	21.00	12.70	NA	NA	NA	99
Atheta_coriaria	3.70	NA	3.10	7.33	8.41	NA	NA	NA	106
Bisnius_nitidulus	NA	1.00	NA	NA	NA	NA	NA	NA	104
Bledius_nanus	2.95	0.64	NA	NA	NA	NA	2.00	NA	98
Creophilus_maxillosus	20.00	3.00	3.10	21.64	11.12	NA	NA	NA	112, 340, 342
Dalotia_coriaria	NA	NA	2.20	7.10	7.80	54.05	NA	90.20	111
Gabrius_osseticus	6.25	1.23	NA	NA	NA	NA	NA	NA	104, 340
Gabrius_splendidulus	5.00	1.71	NA	NA	NA	NA	NA	NA	104, 335
Gabrius_trossulus	4.85	1.72	NA	NA	NA	NA	NA	NA	104, 335
Hesperus_rufipennis	9.25	1.74	6.60	17.50	9.50	NA	1.00	39.00	110
Heterothops_niger	4.10	1.43	NA	NA	NA	NA	NA	NA	104, 340
Neobisnius_villosulus	NA	0.75	NA	NA	NA	NA	NA	NA	104
Ocypus_fulvipennis	NA	2.33	70.00	49.00	NA	NA	1.00	42.00	166
Oxyporus_stygicus	NA	1.50	1.00	4.50	8.50	NA	NA	NA	103
Oxyporus_vittatus	NA	1.50	NA	7.72	7.50	NA	NA	NA	101
Paederus_fuscipes	7.00	NA	4.25	9.12	3.60	50.95	NA	132.01	113, 340
Philonthus_alpinus	5.40	1.12	NA	NA	NA	NA	NA	NA	104, 340
Philonthus_atratus	9.25	1.66	NA	NA	NA	NA	NA	NA	104, 340
Philonthus_corvinus	7.50	1.16	NA	NA	NA	NA	NA	NA	104, 340
Philonthus_cruentatus	10.00	1.35	1.72	3.10	5.85	79.00	NA	74.30	109, 340
Philonthus_flavolimbatus	5.00	0.95	1.68	3.76	6.38	65.50	NA	118.50	109, 337
Philonthus_fumarius	8.25	1.41	7.60	20.00	NA	NA	NA	21.00	149, 340
Philonthus_lepidus	6.50	1.33	NA	NA	NA	NA	NA	NA	104, 340
Philonthus_micans	8.72	1.11	NA	NA	NA	NA	NA	NA	104, 340
Platydracus_tomentosus	18.00	2.50	7.90	17.50	13.30	NA	NA	NA	167
Pleurotobia_tristigmata	NA	NA	1.20	8.70	5.00	NA	1.00	NA	100

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Quedius_brevicornis	10.75	1.82	NA	NA	NA	NA	NA	NA	104, 335
Quedius_brevis	6.00	2.07	NA	NA	NA	NA	NA	NA	104, 335
Quedius_microps	NA	1.44	NA	NA	NA	NA	NA	NA	104
Rabigus_tenuis	NA	0.95	6.00	15.10	6.70	NA	1.00	101.00	148
Scaphisoma_castaneum	NA	0.45	0.50	9.50	10.50	NA	NA	NA	107
Stenus_comma	5.50	0.72	8.40	16.40	8.40	NA	6.21	62.67	206, 340
Stenus_juno	5.50	0.70	7.80	14.60	6.90	NA	15.42	189.00	206, 340
Stenus_pubescens	NA	0.81	10.50	13.60	7.60	NA	3.91	29.12	206
Tachyporus_hypnorum	3.50	0.75	9.50	13.57	19.43	NA	NA	86.75	105,340
Tasgius_melanarius	NA	2.78	NA	NA	NA	NA	NA	NA	104
Tenebrionidae									
Alphitobius_diaperinus	6.45	NA	6.60	68.80	8.40	486.67	NA	1483.20	159, 340
Blaps_kollari	27.50	3.15	9.38	80.00	15.00	NA	NA	650.00	145
Gnathocerus_cornutus	4.21	0.66	4.60	33.00	5.60	140.40	NA	479.90	146, 340, 342
Microdera_punctipennis	11.41	6.83	7.35	49.27	9.95	459.25	1.00	568.00	161
Tribolium_freemani	NA	NA	3.65	28.45	6.25	NA	NA	NA	160
Trogossitidae									
Nemozoma_championi	5.85	1.37	NA	NA	NA	NA	NA	NA	318
Zopheridae									
Aulonium_ruficorne	3.83	0.95	2.90	26.70	6.60	33.50	NA	NA	328
Lasconotus_subcostulatus	NA	0.66	3.50	20.00	7.50	NA	1.00	NA	329
Collembola									
Arrhopalitidae									
Arrhopalites_caecus	1.00	0.15	22.20	28.90	NA	NA	3.50	NA	8, 1
Cyphoderidae									
Cyphoderus_javanus	1.21	0.13	5.49	17.27	NA	103.69	11.77	67.42	14
Entomobryidae									
Alloscopus_tetracantha	1.50	0.14	5.60	15.94	NA	114.31	14.88	99.16	14, 3

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Cryptopygus_thermophilus	1.26	0.10	3.90	13.38	NA	113.56	50.04	665.90	14
Lepidocyrtus_suborientalis	1.80	0.13	5.11	18.40	NA	132.59	17.00	182.43	14
Pseudosinella_alba	1.00	0.14	17.51	56.27	NA	NA	11.00	NA	12, 9
Pseudosinella_petterseni	1.00	0.16	13.54	55.63	NA	NA	10.50	NA	11, 9
Pseudosinella_violenta	NA	0.16	7.81	14.76	NA	NA	11.00	45.00	11
Hypogastruridae									
Hypogastrura_tullbergi	1.80	NA	26.23	55.20	NA	NA	19.68	NA	3
Hypogastrura_viatica	1.55	NA	NA	44.37	NA	NA	NA	NA	13
Xenylla_welchi	1.00	NA	8.60	12.88	NA	61.52	17.62	141.00	1
Isotomidae									
Desoria_trispinata	1.00	NA	7.00	17.50	NA	NA	NA	NA	6
Folsomia_candida	1.00	0.10	8.50	22.50	NA	175.50	40.00	703.33	7
Folsomia_similis	1.00	0.11	15.25	59.50	NA	NA	8.50	NA	10, 9
Isotoma_notabilis	1.00	0.13	17.87	57.74	NA	NA	12.00	NA	9
Proisotoma_minuta	1.00	NA	8.20	16.80	NA	NA	NA	NA	5
Neanuridae									
Lobella_corallina	NA	0.25	7.00	NA	NA	NA	20.50	NA	2
Yuukianura_szeptyckii	1.55	0.26	15.18	31.02	NA	237.72	NA	NA	4
Tomoceridae									
Tomocerus_vulgaris	1.00	0.24	14.60	NA	NA	182.50	NA	9.00	13, 10
Dermaptera									
Anisolabididae									
Anisolabis_littorea	27.10	1.68	21.50	165.00	NA	NA	NA	54.50	380, 425, 343
Euborellia_annulipes	13.50	1.00	14.32	80.71	NA	212.92	NA	47.00	356
Euborellia_cincticollis	14.00	1.15	9.83	86.50	NA	204.75	15.90	65.80	379
Forficulidae									
Forficula_auricularia	13.50	1.00	34.55	69.39	NA	NA	49.25	NA	375, 357
Labiduridae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Forcipula_trispinosa	21.25	1.00	14.70	61.58	NA	NA	63.48	NA	381
Nala_lividipes	NA	NA	6.50	47.93	NA	NA	NA	35.00	377, 376
Pygidicranidae									
Tagalina_papua	32.50	1.50	22.50	186.71	NA	15.00	60.00	114.50	378
Dictyoptera									
Acanthopidae									
Callibia_diana	22.70	NA	46.00	195.00	NA	24.00	22.00	NA	399, 449
Blaberidae									
Blaberus_craniifer	NA	4.75	NA	267.00	NA	450.00	34.30	NA	342, 403, 401
Byrsotria_fumigata	NA	NA	NA	257.00	NA	NA	NA	NA	403, 390
Diploptera_punctata	20.03	1.50	63.00	57.00	NA	NA	13.00	NA	398
Nauphoeta_cinerea	NA	NA	35.50	78.50	NA	NA	32.80	NA	403
Panesthia_angustipennis	88.80	NA	NA	NA	NA	NA	NA	NA	394
Pycnoscelus_surinamensis	25.30	NA	35.20	139.88	NA	307.00	31.20	NA	390, 403
Rhyparobia_maderae	NA	NA	NA	135.50	NA	NA	33.80	NA	403
Salganea_matsumotoi	35.75	NA	NA	NA	NA	NA	NA	NA	395
Blattidae									
Blatta_lateralis	24.70	NA	40.10	223.00	NA	390.00	16.70	NA	396, 390
Blatta_orientalis	22.00	NA	48.04	305.82	NA	105.03	16.00	NA	392, 393, 397, 403, 404
Eurycotis_floridana	NA	NA	48.40	NA	NA	NA	20.90	NA	403
Neostylopyga_rhombifolia	NA	NA	NA	294.00	NA	156.00	NA	NA	403
Periplaneta_americana	NA	NA	44.33	278.20	NA	406.00	NA	NA	397, 403
Periplaneta_australasiae	NA	NA	NA	205.50	NA	NA	NA	NA	403
Periplaneta_brunnea	NA	NA	39.50	NA	NA	253.50	23.90	NA	403
Periplaneta_fuliginosa	31.50	NA	51.00	238.00	NA	250.00	19.70	NA	405, 397, 403
Cryptocercidae									
Cryptocercus_punctulatus	30.00	NA	NA	NA	NA	NA	19.20	NA	391

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Ectobiidae									
Aglaopteryx_gemma	9.66	NA	NA	NA	NA	NA	NA	NA	404, 390
Balta_longicercata	13.50	NA	25.91	81.30	NA	98.40	26.00	NA	390
Blattella_biligata	14.20	NA	22.00	76.09	NA	186.60	42.64	NA	390, 421
Blattella_germanica	NA	NA	21.73	77.85	NA	188.50	36.70	NA	397, 403, 391
Blattella_lituricollis	10.60	NA	15.69	40.20	NA	191.38	31.66	NA	390
Blattella_vaga	NA	NA	19.80	50.05	NA	150.00	27.70	NA	403, 453
Cariblatta_lutea	7.90	NA	26.05	62.45	NA	NA	NA	NA	404, 403, 390
Lobopterella_dimidiatipes	9.80	NA	34.41	63.83	NA	106.57	20.18	NA	390
Margattea_nimbata	10.70	NA	22.86	79.35	NA	158.75	23.28	NA	390
Parcoblatta_divisa	15.79	NA	NA	NA	NA	NA	NA	NA	404
Parcoblatta_fulvescens	15.89	NA	NA	NA	NA	NA	NA	NA	404
Parcoblatta_lata	21.51	NA	NA	NA	NA	124.75	41.00	517.00	404
Parcoblatta_pensylvanica	NA	NA	34.00	383.00	NA	150.00	NA	NA	397
Scalida_latiusvittata	12.20	NA	31.07	100.31	NA	108.18	29.36	NA	390
Supella_supellectilium	NA	NA	51.97	149.50	NA	178.00	15.50	NA	397, 403
Mantidae									
Hierodula_ventralis	63.73	NA	24.80	59.50	NA	60.75	NA	NA	409
Litaneutria_minor	30.00	NA	195.00	91.00	NA	101.50	NA	NA	414, 406
Mantis_religiosa	64.03	NA	18.10	61.60	NA	65.08	NA	NA	411
Miomantis_caffra	41.50	3.50	167.29	152.08	NA	304.17	180.00	NA	401
Miomantis_paykullii	NA	NA	20.10	59.45	NA	61.00	NA	336.20	412
Orthodera_ministralis	35.53	NA	37.15	77.00	NA	NA	34.30	NA	410
Orthodera_novaezealandiae	39.50	4.50	150.00	136.88	NA	NA	40.00	NA	401
Sphodromantis_viridis	80.00	NA	92.60	100.10	NA	190.50	NA	NA	415
Stagmomantis_carolina	55.25	7.43	58.30	78.25	NA	NA	NA	NA	342, 416, 417
Stagmomantis_limbata	53.50	NA	178.00	114.20	NA	98.50	NA	NA	413
Tenodera_angustipennis	76.45	NA	NA	94.10	NA	100.80	NA	NA	400

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Tenodera_aridifolia	80.80	NA	NA	104.70	NA	108.20	NA	NA	400
Tenodera_sinensis	82.00	NA	NA	77.50	NA	NA	NA	NA	417
Mastotermitidae									
Mastotermes_darwiniensis	NA	1.04	NA	NA	NA	NA	15.00	NA	407
Tarachodidae									
Tarachodes_afzelii	NA	3.00	22.29	89.40	NA	180.40	129.00	NA	408
Diptera									
Acroceridae									
Acrocera_bimaculata	NA	NA	NA	NA	16.87	NA	NA	NA	546, 418
Ogcodes_adaptatus	NA	NA	NA	NA	3.89	NA	NA	NA	546
Ogcodes_borealis	NA	NA	NA	NA	4.00	NA	NA	NA	546
Ogcodes_dispar	NA	NA	NA	NA	3.40	NA	NA	NA	546
Ogcodes_eugonatus	NA	NA	NA	NA	5.50	NA	NA	NA	546
Ogcodes_pallidipennis	NA	NA	NA	NA	7.12	NA	NA	NA	546
Turbopsebius_diligens	NA	NA	NA	NA	9.50	NA	NA	NA	546
Agromyzidae									
Agromyza_frontella	NA	0.35	5.50	NA	NA	NA	NA	NA	505, 418
Liriomyza_brassicae	1.31	0.28	3.33	6.56	11.17	NA	NA	NA	NA, 501
Liriomyza_trifoliearum	1.48	0.24	3.00	4.12	9.83	17.50	NA	213.50	504
Ophiomyia_centrosematis	1.42	NA	3.75	12.75	14.02	13.90	NA	63.25	NA, 503
Phytomyza_lanati	0.93	NA	11.50	5.92	25.05	27.50	NA	NA	NA, 502
Asilidae									
Leptogaster_flavipes	NA	0.34	NA	12.00	NA	NA	NA	53.40	418
Mallophora_media	12.38	NA	NA	12.00	23.00	NA	NA	NA	517
Neolophonotus_dichaetus	NA	0.88	NA	NA	NA	NA	44.20	NA	419
Blephariceridae									
Liponeura_cinerascens	NA	NA	NA	109.09	NA	NA	NA	NA	549
Calliphoridae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Calliphora_peruviana	NA	NA	0.62	14.25	12.00	NA	125.00	NA	481, 427
Calliphora_vicina	10.78	1.60	1.03	9.88	10.57	96.50	4.20	474.30	NA, 483, 431
Chrysomya_chloropyga	NA	NA	0.65	3.58	4.00	NA	175.00	NA	481
Cochliomyia_macellaria	NA	1.30	0.80	4.81	5.33	NA	87.50	NA	342, 481
Compsomyiops_boliviana	NA	NA	2.23	11.44	9.50	NA	162.50	NA	481
Compsomyiops_verena	6.54	NA	0.77	8.22	8.00	NA	225.00	NA	NA, 481
Hemilucilia_flavifacies	NA	NA	0.92	4.54	4.50	NA	100.00	NA	481
Hemilucila_hermanlenti	NA	NA	0.68	5.69	5.70	NA	125.00	NA	481
Hemipyrellia_ligurriens	NA	NA	NA	9.04	NA	21.75	NA	NA	511
Lucillia_cuprina	NA	NA	0.63	5.88	8.38	NA	65.00	NA	481
Lucillia_eximia	NA	NA	0.53	7.36	15.00	NA	50.00	NA	481
Lucillia_iris	NA	NA	1.05	12.85	13.75	NA	35.00	NA	481
Paralucilia_fulvinota	NA	NA	1.04	7.47	5.00	NA	97.50	NA	481
Protocalliphora_azurea	NA	1.22	NA	NA	8.40	NA	NA	NA	342, 482
Protocalliphora_maruyamensis	NA	NA	NA	7.00	8.10	NA	NA	NA	482
Sarconesia_chlorogaster	NA	NA	1.21	11.69	11.33	NA	100.00	NA	481
Sarconesia_magellanica	NA	NA	1.06	12.42	12.50	NA	115.00	NA	481
Sarconesia_splendida	NA	NA	1.26	10.83	9.67	NA	85.00	NA	481
Sarconesia_versicolor	NA	NA	0.93	9.38	11.00	NA	50.00	NA	481
Cecidomyiidae									
Aphidoletes_aphidimyza	NA	0.30	3.50	8.50	14.00	40.00	NA	100.00	439, 418
Clinodiplosis_rhododentri	NA	0.29	3.00	NA	11.00	2.00	6.66	34.50	468
Contarinia_sorghicola	5.00	NA	NA	NA	NA	1.01	NA	150.00	562
Cystiphora_schmidti	NA	0.14	NA	NA	11.50	NA	NA	120.00	440
Cystiphora_sonchi	NA	NA	NA	NA	NA	0.38	NA	NA	561
Diadiplosis_multifila	NA	NA	1.00	11.50	6.50	NA	NA	50.30	429
Dicrodiplosis_manihoti	NA	NA	1.00	11.50	4.00	NA	NA	47.40	429
Geromyia_penniseti	NA	NA	3.00	NA	2.00	NA	NA	NA	563

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Mayetiola_rigidae	6.69	0.46	NA	NA	NA	NA	NA	335.00	564
Mycodiplosis_fungicola	0.92	0.24	1.25	NA	5.50	NA	NA	NA	471
Pinyonia_edulicola	NA	0.38	7.00	NA	17.50	NA	10.80	85.50	438
Prodiplosis_longifila	1.50	0.26	1.40	9.00	4.11	8.30	NA	NA	469
Taxodiomyia_cupressiananassa	NA	0.60	3.00	NA	NA	1.50	15.00	120.00	470
Trisopsis_tyroglyphi	NA	NA	1.00	11.00	4.00	NA	NA	17.70	429
Chamaemyiidae									
Leucopis_annulipes	2.50	NA	NA	NA	NA	NA	NA	NA	530
Chironomidae									
Chironomus_decorus	NA	0.28	2.96	NA	2.50	NA	600.00	NA	467
Chironomus_plumosus	12.00	0.50	7.00	NA	4.00	NA	1676.00	NA	428
Einfeldia_synchrona	NA	0.30	3.50	NA	NA	NA	516.00	NA	427
Glyptotendipes_barbipes	NA	NA	1.25	NA	6.50	NA	1674.00	NA	437
Paratendipes_albimanus	NA	0.21	NA	NA	NA	NA	350.00	NA	466
Saunderia_clavicornis	NA	NA	14.00	NA	NA	NA	120.00	NA	465
Saunderia_matinus	NA	NA	14.00	NA	NA	NA	120.00	NA	465
Telmatogeton_alaskensis	NA	0.40	NA	NA	NA	NA	NA	NA	465
Xylotopus_par	NA	0.57	NA	NA	3.50	NA	NA	NA	560
Chloropidae									
Calamoncosis_aprica	NA	0.79	NA	NA	NA	NA	NA	NA	529, 418
Hippelates_collusor	NA	0.47	NA	NA	NA	NA	NA	NA	527
Hippelates_pallipes	NA	NA	4.30	11.10	9.60	NA	NA	NA	528
Thaumatomyia_elongatula	2.30	NA	NA	NA	NA	NA	NA	NA	530
Conopidae									
Physocephala_bimarginipennis	21.00	NA	NA	135.00	133.50	NA	NA	NA	541
Culicidae									
Aedes_aegypti	NA	NA	NA	NA	NA	35.01	62.88	82.84	451, 418, 450

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Aedes_albopictus	NA	0.61	14.00	12.09	NA	NA	NA	NA	342, 552, 475, 418
Aedes_caspius	NA	NA	NA	8.18	1.57	NA	NA	NA	461, 420
Aedes_geniculatus	NA	0.69	NA	NA	NA	NA	67.80	NA	431, 418
Aedes_novoniveus	NA	NA	NA	12.60	3.50	16.05	NA	NA	453, 494
Aedes_polynesiensis	NA	NA	NA	NA	NA	NA	NA	99.80	420
Aedes_sierrensis	NA	NA	NA	136.07	9.95	NA	NA	NA	553, 420
Aedes_subniveus	NA	NA	NA	13.20	3.20	18.00	NA	NA	453, 418
Anopheles_sinensis	NA	0.50	2.48	8.16	2.00	6.00	NA	NA	460, 418
Armigeres_subalbatus	NA	NA	2.00	9.50	3.50	NA	NA	NA	421, 420
Chaetorellia	NA	NA	NA	NA	NA	NA	48.73	53.60	420
Culex_nigripalpus	NA	NA	1.23	NA	1.67	NA	NA	NA	446
Culex_pipiens	NA	NA	NA	NA	NA	45.97	NA	NA	477
Culex_quinquefasciatus	NA	0.63	6.25	41.35	7.27	42.80	88.41	195.99	551, 342, 451, 477
Culex_restuans	NA	NA	NA	NA	NA	31.36	NA	NA	477
Culex_tarsalis	NA	NA	NA	8.78	2.74	NA	NA	NA	478, 477
Culiseta_longiareolata	NA	0.71	NA	NA	NA	NA	279.85	NA	422
Toxorhynchites_brevipalpis	NA	0.60	NA	NA	NA	NA	4.50	NA	452
Toxorhynchites_rutilus_septentrionalis	NA	0.78	NA	NA	NA	NA	5.90	NA	452
Drosophilidae									
Drosophila_hydei	NA	0.53	NA	NA	NA	67.67	NA	NA	342, 474
Drosophila_melanogaster	2.5	0.49	0.70	4.00	4.000	61.64	5.00	400	342, 474
Drosophila_nigrosparsa	NA	NA	NA	NA	NA	52.33	NA	NA	474
Drosophila_obscura	NA	NA	NA	NA	NA	47.96	NA	NA	474
Drosophila_suzukii	NA	0.60	1.40	6.00	5.80	86.00	NA	480.70	342, 473
Glossinidae									
Glossina_morsitans	NA	1.57	NA	NA	NA	91.80	NA	8.00	342, 531

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Keroplatidae									
Arachnocampa_flava	7.82	0.40	8.00	NA	6.50	2.50	NA	129.00	566, 430
Arachnocampa_luminosa	12.32	0.75	22.00	NA	NA	NA	NA	130.40	548, 418
Chetoneura_shennonggongensis	NA	0.40	25.00	273.75	8.00	5.00	NA	85.00	547
Lauxaniidae									
Camptoprosopella_confusa	NA	0.64	NA	22.00	12.25	76.50	NA	233.00	544, 543, 418
Homoneura_americana	NA	0.66	12.00	40.00	12.00	89.75	NA	274.50	544, 543
Lyciella_browni	NA	0.66	7.00	27.00	11.00	115.50	NA	161.00	544, 543
Minettia_lupulina	4.50	0.72	NA	NA	13.00	89.75	NA	516.50	543, 544
Minettia_lyraformis	NA	0.80	8.00	45.50	NA	NA	NA	362.50	544, 543
Poecilominettia_ordinaria	NA	0.74	NA	NA	NA	NA	NA	NA	544
Pseudocalliope_flaviceps	NA	0.76	NA	NA	NA	NA	NA	NA	544
Pseudogriphoneura_gracilipes	NA	0.80	8.50	31.50	10.50	67.00	NA	207.00	544, 543
Limoniidae									
Lipsothrix_fenderi	NA	0.45	NA	NA	13.50	NA	138.00	NA	537
Lipsothrix_nigrilinea	NA	0.50	NA	NA	13.50	NA	185.00	NA	537
Muscidae									
Atherigona_varia_soccata	NA	1.30	3.50	13.00	10.40	2.50	NA	NA	443, 425
Coenosia_tigrina	NA	NA	7.83	24.73	20.02	45.96	17.86	131.88	516
Haematobia_irritans	NA	1.20	NA	NA	NA	6.60	18.41	78.00	342, 442
Musca_autumnalis	8.83	3.10	NA	4.00	8.50	35.00	20.00	100.00	342, 430
Musca_fergusoni	NA	2.35	NA	6.50	21.88	NA	NA	NA	444
Stomoxys_calcitrans	8.27	1.20	2.33	21.00	11.00	21.00	43.00	292.00	342, 441
Phoridae									
Apocephalus_paraponerae	NA	NA	0.28	5.30	21.10	NA	NA	NA	508, 420
Megaselia_scalaris	NA	0.60	1.26	12.53	13.70	34.05	NA	467.80	342, 509
Rhynchomicropteron_nudiventer	NA	NA	0.72	5.00	23.00	NA	NA	NA	507
Rhyncophoromyia_maculineura	NA	NA	NA	6.25	21.50	NA	NA	NA	506

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Psilidae									
Psila_rosae	NA	NA	9.56	35.67	25.18	NA	NA	109.00	565
Psychodidae									
Lutzomyia_anthophora	NA	0.35	10.07	31.27	10.75	NA	NA	34.96	342, 500
Phlebotomus_californicus	NA	0.38	7.25	26.25	11.00	NA	NA	22.00	496
Phlebotomus_duboscqui	NA	NA	8.90	36.10	12.00	NA	NA	NA	498
Phlebotomus_langeroni	NA	NA	8.37	25.30	9.60	10.80	NA	55.50	499
Phlebotomus_martini	NA	NA	8.90	31.80	13.80	NA	NA	NA	498
Phlebotomus_neglectus	NA	NA	8.50	26.00	10.00	19.00	NA	NA	495
Phlebotomus_perniciosus	NA	NA	6.06	18.83	8.97	NA	NA	47.03	497
Phlebotomus_stewarti	NA	0.43	7.00	23.50	12.50	36.00	NA	26.00	496
Phlebotomus_vexator	NA	0.43	10.17	27.83	13.67	36.00	NA	40.50	496
Sergentomyia_adleri	NA	NA	6.20	24.10	12.10	NA	NA	NA	498
Sergentomyia_africana	NA	NA	6.40	22.40	7.70	NA	NA	NA	498
Sergentomyia_antennata	NA	NA	6.30	22.00	9.60	NA	NA	NA	498
Sergentomyia_bedfordi	NA	NA	6.40	21.10	10.10	NA	NA	NA	498
Sergentomyia_garnhami	NA	NA	24.50	41.87	12.00	NA	NA	NA	498
Sergentomyia_ingrami	NA	0.27	5.80	24.60	9.70	NA	NA	NA	342, 498
Sergentomyia_schwetzi	NA	0.27	7.30	23.60	10.40	NA	NA	NA	342, 498
Sergentomyia_wynnae	NA	NA	7.70	23.80	10.20	NA	NA	NA	498
Sarcophagidae									
Boettcherisca_formosensis	NA	NA	NA	7.79	NA	36.75	17.50	NA	511, 432
Fletcherimyia_celarata	10.00	NA	NA	NA	NA	NA	NA	NA	512
Fletcherimyia_fletcheri	9.00	NA	NA	NA	NA	NA	NA	11.00	512
Fletcherimyia_folkertsi	9.75	NA	NA	NA	17.50	NA	NA	NA	512
Fletcherimyia_jonesi	9.25	NA	NA	NA	20.00	NA	NA	NA	512
Fletcherimyia_oreophilae	11.25	NA	NA	NA	NA	NA	NA	NA	512
Fletcherimyia_papei	7.50	NA	NA	NA	NA	NA	NA	NA	512

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Fletcherimyia_rileyi	11.75	NA	NA	13.00	20.75	NA	NA	NA	512
Fletcherimyia_abdita	11.00	NA	NA	NA	NA	NA	NA	NA	512
Ravinia_lherminieri	NA	NA	NA	6.30	7.10	48.00	NA	46.00	472
Sarcophaga_argyrostoma	NA	NA	NA	6.50	10.00	NA	NA	47.00	514
Sarcophaga_bisetosa	NA	NA	NA	18.50	10.00	NA	NA	8.00	514
Sarcophaga_bullata	NA	NA	NA	5.85	11.30	NA	NA	62.80	514
Sarcophaga_cimbicis	NA	NA	NA	7.17	10.33	NA	NA	10.00	514
Sarcophaga_cingarus	NA	NA	NA	6.00	15.00	NA	NA	12.00	514
Sarcophaga_crassipalpis	NA	2.10	NA	5.00	11.00	NA	NA	103.00	342, 514
Sarcophaga_haemorrhoidalis	NA	NA	NA	4.60	11.75	NA	NA	24.60	514
Sarcophaga_l'herminieri	NA	NA	NA	4.75	8.25	NA	NA	20.40	514
Sarcophaga_latisetosa	NA	NA	NA	4.47	9.33	NA	NA	19.60	514
Sarcophaga_latisterna	NA	NA	NA	11.80	10.60	NA	NA	19.00	514
Sarcophaga_melanura	NA	NA	NA	4.77	11.63	NA	NA	37.50	514
Sarcophaga_pusiola	NA	NA	NA	5.20	11.23	NA	NA	23.20	514
Sarcophaga_rapax	NA	NA	NA	5.30	8.60	NA	NA	12.20	514
Sarcophaga_sarraceniae	11.75	NA	NA	16.00	18.90	NA	NA	NA	512
Sarcophaga_scoparia	NA	NA	NA	6.40	11.30	NA	NA	37.30	514
Sarcophaga_tibialis	NA	2.50	NA	4.00	17.32	NA	NA	NA	510
Sarcophaga_ventricosa	NA	NA	NA	6.00	10.00	NA	NA	20.00	514
Scathophagidae									
Cleigastra_apicalis	NA	1.60	NA	NA	9.22	NA	NA	NA	540
Scathophaga_stercoraria	10.00	1.45	31.53	5.00	10.00	44.47	60.00	NA	539
Scatopsidae									
Coboldia_fuscipes	NA	0.30	3.72	17.57	5.28	3.56	NA	282.00	550
Sciaridae									
Bradysia_impatiens	2.32	0.22	5.67	14.10	5.00	5.90	NA	75.00	518, 418
Bradysia_odoriphaga	NA	NA	3.35	23.19	3.42	3.20	NA	47.59	519, 418

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Hybosciara_gigantea	NA	0.27	NA	NA	14.50	NA	NA	1408.00	520
Sepsidae									
Sepsis_fulgens	NA	0.55	NA	NA	NA	NA	56.62	84.53	542
Stratiomyidae									
Camptopteromyia_fractipennis	3.30	NA	NA	NA	NA	NA	NA	NA	526, 425
Hermetia_illucens	NA	NA	NA	NA	8.17	NA	NA	NA	525
Inopus_flavus	NA	1.00	7.00	NA	21.00	NA	NA	275.00	521
Inopus_rubriceps	NA	1.00	11.58	684.38	24.60	5.25	110.00	275.00	521, 522
Ptecticus_testaceus	NA	NA	NA	NA	36.00	NA	NA	NA	524
Syrphidae									
Cheilosia_fasciata	NA	0.80	NA	NA	NA	NA	1.00	47.00	489
Eumerus_obliquus	NA	NA	NA	NA	15.50	NA	NA	NA	490
Eumerus_pulchellus	NA	NA	NA	11.00	9.50	NA	NA	NA	490
Eumerus_pusillus	NA	NA	NA	38.00	19.00	NA	NA	NA	490
Mallota_posticata	NA	1.50	NA	3.00	13.50	20.30	17.70	382.40	492
Merodon_luteihumerus	NA	1.93	5.00	NA	30.50	NA	NA	NA	427, 490
Microdon_piperi	NA	NA	8.00	NA	NA	NA	NA	NA	493
Paragus_borbonicus	NA	0.75	2.00	5.00	8.00	NA	NA	NA	494
Portevinia_maculata	NA	1.35	NA	NA	NA	NA	4.50	124.00	489
Pseudomicrodon_biluminiferus	10.00	NA	NA	NA	NA	NA	NA	NA	490
Tabanidae									
Apatolestes_actites	NA	1.64	7.00	NA	NA	7.15	NA	NA	533, 420
Hybomitra_daeckei	NA	NA	6.00	NA	NA	NA	418.00	NA	532
Tachinidae									
Drino_munda	NA	NA	0.00	5.05	10.00	19.00	NA	19.00	487
Drino_solennis	NA	NA	0.16	4.80	7.26	17.00	NA	196.40	515
Exorista_japonica	NA	NA	NA	NA	11.66	49.47	NA	474.10	484
Exorista_mella	8.58	NA	NA	NA	NA	35.05	NA	150.00	486

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Lespesia_archippivora	NA	NA	NA	15.25	NA	19.25	3.00	105.80	488
Voria_ruralis	NA	NA	NA	NA	8.22	15.50	NA	310.00	485
Tephritidae									
Acanthiophilus_helianthi	5.10	1.00	3.00	7.00	6.00	7.00	NA	NA	462, 457
Aciurina_ferruginea	NA	1.26	NA	NA	NA	67.05	NA	NA	435, 419
Aciurina_thoracica	NA	0.87	NA	NA	NA	74.50	NA	NA	425, 418
Acrotaeniostola_spiralis	NA	2.10	NA	NA	11.50	NA	NA	NA	559, 418
Anastrepha_interrupta	4.70	NA	NA	NA	22.00	177.00	NA	NA	NA, 423, 427
Bactrocera_cucurbitae	7.10	NA	1.25	6.62	13.05	187.28	NA	120.65	NA, 557, 420
Bactrocera_dorsalis	5.60	NA	2.30	8.47	15.00	108.58	NA	379.90	NA, 557, 440
Carpomya_vesuviana	5.00	NA	NA	NA	NA	NA	NA	NA	447, 418
Ceratitis_capitata	3.53	NA	2.46	7.38	12.46	79.46	NA	491.44	NA, 464, 557, 443
Chaetorellia_carthami	5.75	1.00	3.40	NA	6.80	NA	3.00	NA	434
Chaetorellia_hexachaeta	NA	0.96	3.00	NA	NA	NA	NA	NA	479
Chaetostomella_undosa	NA	1.35	NA	NA	NA	27.40	NA	NA	426
Dacus_cucurbitae	NA	NA	1.30	7.60	9.60	108.10	NA	880.60	464
Dacus_dorsalis	5.52	NA	1.60	7.80	10.30	78.70	NA	1428.20	NA, 464
Dacus_latifrons	NA	NA	2.30	8.50	10.20	64.10	NA	256.20	455
Dacus_oleae	NA	NA	2.50	14.00	9.00	NA	NA	225.00	480
Euleia_fratria	NA	0.72	7.00	13.00	15.50	NA	NA	NA	458
Gymnocarena_diffusa	NA	NA	7.00	30.60	129.50	30.00	NA	NA	436
Icterica_circinata	NA	1.15	5.50	28.50	16.00	NA	NA	NA	432
Icterica_seriata	NA	1.40	4.50	NA	17.50	NA	NA	NA	432
Jamesomyia_geminata	NA	1.23	NA	NA	NA	NA	NA	NA	457
Neotephritis_finalis	NA	1.15	3.00	12.00	9.00	91.30	NA	54.15	456, 478
Paracantha_cultaris	NA	0.93	NA	NA	12.00	54.20	NA	NA	555
Paracantha_gentilis	NA	1.25	8.50	NA	NA	NA	4.00	NA	342, 449

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Paroxyna_genalis	NA	0.64	NA	NA	NA	NA	NA	NA	454
Rhagoletis_cerasi	3.38	1.00	NA	NA	NA	51.22	NA	176.58	342, 424
Tephritis_dilacerata	NA	0.70	5.50	9.50	14.00	NA	6.83	NA	450
Tephritis_teerinki	NA	0.80	NA	NA	NA	48.50	NA	NA	554
Trupanea_bisetosa	NA	0.72	4.00	NA	10.00	58.90	NA	89.50	463
Trupanea_signata	NA	0.69	NA	NA	NA	61.00	NA	NA	556
Urophora_cardui	6.00	NA	5.13	NA	3.50	10.45	NA	80.47	448
Urophora_sirunaseva	NA	0.79	8.40	NA	25.50	30.95	NA	167.10	558
Zonosemata_vittigera	5.05	1.16	7.50	18.00	153.65	36.00	NA	52.00	NA, 433
Tipulidae									
Tipula_sacra	21.35	1.00	NA	NA	NA	4.50	NA	1000.00	538
Tipula_simplex	NA	NA	NA	NA	NA	NA	96.00	96.00	536
Ephemeroptera									
Ameletidae									
Ameletus_lineatus	11.00	0.32	NA	NA	NA	NA	NA	NA	535, 512
Ameletus_ludens	NA	0.18	60.83	NA	NA	NA	NA	402.20	536, 544, 510, 542
Ameletus_subnotatus	11.50	0.26	NA	NA	NA	NA	NA	NA	535, 523
Ametropodidae									
Ametropus_neavei	15.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Arthropleidae									
Arthroplea_bipunctata	6.00	NA	NA	NA	NA	NA	NA	NA	535, 624
Baetidae									
Baetis_adonis	5.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_akateleptos	2.50	NA	NA	NA	NA	NA	NA	NA	535, 517
Baetis_amplus	7.00	NA	NA	NA	NA	NA	NA	NA	535, 517
Baetis_austalis	5.00	NA	NA	NA	NA	NA	NA	NA	535, 517
Baetis_bicaudatus	4.50	NA	NA	NA	NA	NA	NA	NA	535, 629

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Baetis_brunneicolor	6.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_cingulatus	5.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_dardanus	5.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_devinctus	5.00	NA	NA	NA	NA	NA	NA	NA	535, 528
Baetis_dorieri	NA	0.16	NA	NA	NA	NA	NA	NA	517, 510
Baetis_enymion	5.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_ephippiatus	4.25	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_erebus	4.75	NA	NA	NA	NA	NA	NA	NA	535, 580
Baetis_flavistriga	4.50	NA	NA	NA	NA	NA	NA	NA	535, 580
Baetis_frivolus	5.00	NA	NA	NA	NA	NA	NA	NA	535, 584
Baetis_frondalis	5.00	NA	NA	NA	NA	NA	NA	NA	535, 514
Baetis_gemellus	NA	0.16	NA	NA	NA	NA	NA	NA	517, 510
Baetis_harti	2.50	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_incertans	4.50	NA	NA	NA	NA	NA	NA	NA	535, 527
Baetis_insignificans	4.00	NA	NA	NA	NA	NA	NA	NA	535, 512
Baetis_intercalaris	4.50	NA	NA	NA	NA	NA	NA	NA	535
Baetis_intermedius	6.00	NA	NA	NA	NA	NA	NA	NA	535, 512
Baetis_levitans	4.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_macani	6.80	NA	NA	NA	NA	NA	NA	201.00	527, 581
Baetis_minimus	5.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_moffati	7.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_nanus	3.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_niger	NA	0.15	NA	NA	NA	NA	NA	592.00	517, 510
Baetis_pallidulus	4.50	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_parvus	5.50	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_phoebus	5.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_piscatoris	6.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_pluto	4.50	NA	NA	NA	NA	NA	NA	NA	535, 510

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Baetis_posticatus	8.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_propaniquus	4.50	NA	NA	NA	NA	NA	NA	NA	535, 512
Baetis_pumilus	NA	0.16	NA	NA	NA	NA	NA	1104.50	517, 510
Baetis_pygmaeus	3.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_quilleri	4.00	NA	NA	NA	NA	0.60	NA	NA	535, 545, 510
Baetis_rhodani	NA	0.17	14.36	NA	NA	NA	NA	2350.00	517, 516, 510, 528
Baetis_rusticans	3.50	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_scambus	NA	0.17	NA	NA	NA	NA	NA	NA	517, 510
Baetis_spinosus	4.50	NA	NA	NA	NA	NA	NA	NA	535, 512
Baetis_subatrebatinus	NA	0.17	NA	NA	NA	NA	NA	735.00	517, 512
Baetis_thermophilos	3.50	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_tricaudatus	7.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_unicolor	4.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_vagans	6.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetis_vernus	NA	0.14	NA	150.00	NA	NA	NA	NA	517, 538, 521
Callibaetis_americanus	7.50	NA	NA	NA	NA	NA	NA	NA	535, 510
Callibaetis_californicus	7.00	NA	NA	NA	NA	NA	NA	NA	535, 575
Callibaetis_carolus	8.00	NA	NA	NA	NA	NA	NA	NA	535, 573
Callibaetis_coloradensis	7.00	NA	NA	NA	NA	NA	NA	NA	535, 573
Callibaetis_doddsi	6.50	NA	NA	NA	NA	NA	NA	NA	535, 573
Callibaetis_ferrugineus	8.50	0.12	NA	NA	NA	NA	NA	NA	342, 535, 573
Callibaetis_floridanus	6.00	NA	NA	NA	NA	3.44	NA	NA	535, 546, 557
Callibaetis_fluctuans	6.50	0.12	NA	NA	NA	NA	NA	500.00	342, 535, 557, 536
Callibaetis_fuscus	8.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Callibaetis_hageni	12.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Callibaetis_montanus	6.00	NA	NA	NA	NA	NA	NA	NA	535, 631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Callibaetis_pacificus	7.50	NA	NA	NA	NA	NA	NA	NA	535, 510
Callibaetis_pallidus	9.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Callibaetis_pictus	5.75	NA	NA	NA	NA	NA	NA	NA	535, 538
Callibaetis_skokianus	9.50	NA	NA	NA	NA	NA	NA	NA	535, 634
Centroptilum_luteolum	NA	0.19	NA	NA	NA	NA	NA	1236.50	517, 510
Centroptilum_pennulatum	NA	0.19	NA	NA	NA	NA	NA	1868.50	517, 510
Centroptilum_rufostigatum	NA	NA	NA	NA	NA	NA	NA	333.33	510, 542
Cloeon_dipterum	NA	0.17	NA	136.80	NA	NA	NA	904.00	517, 530
Cloeon_inanum	6.00	NA	NA	NA	NA	NA	NA	NA	535
Cloeon_ingens	8.00	NA	NA	NA	NA	NA	NA	NA	535
Cloeon_insignificans	3.00	NA	NA	NA	NA	NA	NA	NA	535
Cloeon_mendax	4.00	NA	NA	NA	NA	NA	NA	NA	535
Cloeon_minor	3.00	NA	NA	NA	NA	NA	NA	NA	535
Cloeon_rubropictum	3.00	NA	NA	NA	NA	NA	NA	NA	535
Cloeon_simile	NA	0.19	NA	NA	NA	NA	NA	2896.50	517
Cloeon_simplex	4.50	NA	NA	NA	NA	NA	NA	NA	535
Cloeon_triangulifer	5.20	NA	28.08	66.20	NA	NA	650.00	810.50	524, 535
Cloeon_vicnum	4.00	NA	NA	NA	NA	NA	NA	NA	535
Baetiscidae									
Baetisca_lacustris	7.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Baetisca_obesa	7.50	0.18	NA	NA	NA	NA	NA	NA	535, 512
Behningiidae									
Dolania_americana	NA	0.78	NA	NA	NA	0.03	NA	90.06	541
Caenidae									
Brachycercus_nitidus	4.50	0.24	NA	NA	NA	NA	NA	NA	535, 573
Caenis_amica	2.00	0.14	NA	NA	NA	NA	NA	941.00	535, 510, 547
Caenis_anceps	2.00	NA	NA	NA	NA	NA	NA	1117.50	535, 510, 547
Caenis_delicata	4.50	NA	NA	NA	NA	NA	NA	NA	535, 510

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Caenis_diminuta	3.00	NA	NA	NA	NA	NA	NA	NA	535, 510
Caenis_forcipata	4.00	NA	NA	NA	NA	NA	NA	NA	535, 517
Caenis_hilaris	2.25	0.14	NA	NA	NA	NA	NA	610.00	535, 517, 547
Caenis_horaria	NA	0.15	NA	NA	NA	NA	NA	556.00	517, 510
Caenis_jocosa	3.00	0.14	NA	NA	NA	NA	NA	NA	535, 510
Caenis_macrura	NA	0.16	NA	NA	NA	NA	NA	675.00	517, 512
Caenis_moesta	NA	0.16	NA	NA	NA	NA	NA	934.00	517, 518
Caenis_punctata	3.00	NA	NA	NA	NA	NA	NA	NA	535, 520
Caenis_ridens	2.75	NA	NA	NA	NA	NA	NA	NA	535, 510
Caenis_simulans	3.75	0.16	NA	NA	NA	NA	NA	NA	535, 576
Caenis_tardata	3.00	NA	NA	NA	NA	NA	NA	NA	535, 513
Ephemerellidae									
Ephemerella_attenuata	6.00	0.24	NA	NA	NA	NA	NA	NA	535
Ephemerella_aurivillii	10.00	0.19	NA	NA	NA	NA	NA	NA	535
Ephemerella_belgica	NA	0.21	NA	NA	NA	NA	NA	1689.00	517
Ephemerella_cognata	7.50	0.19	NA	NA	NA	NA	NA	NA	535
Ephemerella_cornuta	9.00	0.20	NA	NA	NA	NA	NA	NA	535
Ephemerella_deficiens	5.00	0.18	NA	NA	NA	NA	NA	NA	535
Ephemerella_doddsi	13.00	0.20	NA	NA	NA	NA	NA	NA	535
Ephemerella_dorothea	5.50	0.18	NA	NA	NA	NA	NA	NA	535
Ephemerella_euterpe	10.50	0.19	NA	NA	NA	NA	NA	NA	515, 535
Ephemerella_excrucians	6.50	0.20	NA	273.75	NA	NA	NA	1950.00	535, 536, 525
Ephemerella_funeralis	NA	NA	NA	NA	NA	NA	NA	820.00	542
Ephemerella_grandis	14.00	0.19	NA	NA	NA	NA	NA	NA	535
Ephemerella_hecuba	15.00	0.27	NA	NA	NA	NA	NA	NA	535
Ephemerella_ignita	NA	0.19	238.88	NA	NA	NA	322.75	1006.50	517, 518
Ephemerella_krieghoffi	NA	0.18	NA	NA	NA	NA	NA	1450.50	517
Ephemerella_maculata	8.00	0.20	NA	NA	NA	NA	NA	NA	535

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Ephemerella_micheneri	NA	0.19	NA	NA	NA	NA	NA	NA	535
Ephemerella_septentrionalis	8.00	0.20	NA	NA	NA	NA	NA	NA	535
Ephemerella_simplex	6.00	0.23	NA	NA	NA	NA	NA	NA	535
Ephemerella_subvaria	NA	NA	NA	254.00	NA	NA	NA	423.25	538, 542
Ephemerella_temporalis	8.00	0.24	NA	NA	NA	NA	NA	NA	535
Ephemerella_tuberculata	9.00	0.18	NA	NA	NA	NA	NA	NA	535
Ephemeridae									
Ephemera_danica	NA	0.26	NA	NA	NA	NA	NA	3517.00	517
Ephemera_glaucops	NA	0.25	NA	NA	NA	NA	NA	2787.00	517
Ephemera_varia	11.00	0.22	15.00	NA	NA	NA	NA	NA	535
Ephemera_vulgata	NA	0.29	10.50	NA	NA	NA	NA	NA	517, 536
Hexagenia_rigida	19.50	0.28	15.96	NA	NA	NA	NA	NA	535, 519
Heptageniidae									
Cinygma_integrum	11.00	0.14	NA	NA	NA	NA	NA	NA	535
Ecdyonurus_dispar	NA	0.25	77.95	NA	NA	NA	NA	NA	324, 520
Ecdyonurus_fluminum	NA	0.25	NA	NA	NA	NA	NA	1798.50	517
Ecdyonurus_forcipula	NA	0.22	NA	NA	NA	NA	NA	NA	517
Ecdyonurus_helveticus	NA	0.21	NA	NA	NA	NA	NA	4222.50	517
Ecdyonurus_insignis	NA	0.20	NA	NA	NA	NA	NA	NA	517
Epeorus_alpicola	NA	0.20	NA	NA	NA	NA	NA	NA	517
Epeorus_assimilis	NA	0.23	NA	NA	NA	NA	NA	9341.00	517
Epeorus_pleuralis	8.58	0.14	212.92	NA	NA	NA	NA	3280.00	539
Heptagenia_coerulans	NA	0.20	NA	NA	NA	NA	NA	NA	517
Heptagenia_hebe	6.00	0.17	12.00	NA	NA	NA	NA	NA	535
Heptagenia_lateralis	NA	0.20	NA	NA	NA	NA	NA	2014.00	517
Heptagenia_sulphurea	NA	0.17	NA	NA	NA	NA	NA	NA	517
Rhithrogena_loyolaea	NA	NA	202.00	NA	NA	NA	NA	NA	521
Rhithrogena_semicolorata	NA	NA	56.25	NA	NA	NA	NA	NA	521

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Stenonema_interpunctatum	7.50	0.20	14.00	NA	NA	NA	NA	NA	535
Stenonema_vicarium	13.00	0.20	NA	NA	NA	NA	NA	NA	342, 535
Isonychiidae									
Isonychia_bicolor	11.00	0.20	40.83	NA	NA	NA	NA	834.50	342, 535, 523, 542
Leptohyphidae									
Tricorythodes_atartus	NA	NA	NA	49.00	NA	NA	NA	364.67	538, 542
Tricorythodes_minutus	2.50	NA	NA	67.60	NA	NA	NA	NA	535, 522, 538
Leptophlebiidae									
Choroterpes_basalis	4.75	0.18	NA	NA	NA	NA	NA	NA	535, 536
Choroterpes_picteti	NA	0.21	NA	NA	NA	NA	NA	724.00	517
Habrophlebia_auberti	NA	0.26	NA	NA	NA	NA	NA	1548.50	517
Habrophlebia_lauta	NA	0.21	NA	NA	NA	NA	NA	620.00	517
Habrophlebia_modesta	NA	0.24	NA	NA	NA	NA	NA	1628.00	517
Leptophlebia_cupida	10.57	0.23	63.02	273.75	NA	2.00	NA	2209.50	531, 525, 544, 537, 542
Leptophlebia_marginata	10.70	0.20	NA	NA	NA	NA	NA	1380.00	526, 517, 527
Leptophlebia_vespertina	8.70	0.21	23.50	316.00	NA	NA	NA	1196.50	527, 517, 529
Paraleptophlebia_adoptiva	7.00	0.19	NA	NA	NA	NA	NA	NA	535
Paraleptophlebia_mollis	8.00	0.19	NA	273.75	NA	NA	NA	NA	535, 525
Paraleptophlebia_submarginata	NA	0.23	NA	NA	NA	NA	NA	NA	517
Paraleptophlebia_vaciva	7.50	NA	NA	NA	NA	NA	NA	NA	535
Thraulodes_speciosus	8.00	NA	NA	NA	NA	NA	NA	NA	535
Thraulus_bellus	NA	0.20	NA	NA	NA	NA	NA	1371.00	517
Metropodidae									
Siphloplecton_basale	15.50	0.21	NA	273.75	NA	NA	NA	2179.57	526
Siphloplecton_interlineatum	12.75	NA	NA	NA	NA	NA	NA	NA	535
Oligoneuriidae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Oligoneuriella_rhenana	NA	0.41	NA	NA	NA	NA	NA	1610.00	517
Polymitarcyidae									
Tortopus_incertus	NA	0.48	41.00	NA	NA	NA	NA	950.00	543
Ephoron_album	12.00	0.37	258.54	91.25	NA	0.02	NA	908.00	535, 514
Ephoron_eophilum	NA	0.25	NA	NA	NA	NA	NA	1107.50	512
Ephoron_shigae	NA	0.16	NA	NA	NA	NA	NA	2027.00	512
Ephoron_virgo	NA	0.27	NA	NA	NA	NA	NA	625.00	517
Potamanthus_luteus	NA	0.17	NA	NA	NA	NA	NA	NA	517
Potamanthus_rufus	15.00	0.22	NA	NA	NA	NA	NA	NA	535
Pseudironidae									
Pseudiron_centralis	NA	0.30	NA	NA	NA	NA	NA	NA	535
Siphlonuridae									
Siphlonurus_aestivalis	NA	0.27	NA	NA	NA	NA	NA	1805.50	517
Siphlonurus_lacustris	13.20	0.19	NA	NA	NA	NA	NA	1922.75	527, 517
Hemiptera									
Acanaloniidae									
Acanalonia_bivittata	NA	1.08	148.10	64.20	NA	NA	NA	NA	612, 546
Acanalonia_conica	NA	1.31	218.50	92.60	NA	NA	NA	NA	612, 548
Anthocoridae									
Orius_insidiosus	1.88	0.54	5.46	17.54	NA	34.40	NA	45.28	584, 581, 582
Aphelocheiridae									
Aphelocheirus_aestivalis	9.75	1.40	60.83	NA	NA	NA	NA	8.00	590, 546
Aphididae									
Schizaphis_graminum	NA	NA	NA	13.68	NA	37.83	NA	44.84	630
Aphrophoridae									
Philaenus_spumarius	6.00	1.00	NA	50.00	NA	NA	NA	375.00	550
Aradidae									
Mezira_granulata	5.42	NA	NA	NA	NA	NA	NA	NA	576

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Berytidae									
Jalysus_spinosus	6.00	0.85	4.00	32.35	NA	NA	NA	300.00	551, 552
Blissidae									
Ischnodemus_falicus	6.64	2.97	16.69	42.63	NA	49.05	12.00	136.75	553, 554
Caliscelidae									
Bruchomorpha_oculata	NA	0.96	18.80	49.10	NA	NA	NA	NA	614, 546
Ceratocombidae									
Ceratocombus_vagans	1.25	0.45	NA	52.00	NA	NA	NA	NA	606
Cercopidae									
Prosapia_bicincta	NA	1.09	12.00	47.00	NA	42.00	NA	39.60	611
Cicadellidae									
Dalbulus_maidis	NA	NA	13.59	22.08	NA	35.06	NA	NA	610
Empoasca_fabae	NA	0.82	10.27	11.56	NA	113.00	NA	104.33	342, 609, 608
Cimicidae									
Cimex_lectularis	6.00	NA	8.00	49.00	NA	273.75	NA	350.00	585
Corixidae									
Corixa_punctata	NA	0.60	15.00	NA	NA	NA	NA	NA	342, 598
Trichocorixa_reticulata	4.10	NA	14.00	NA	NA	NA	NA	NA	594
Trichocorixa_verticalis	4.40	NA	10.00	36.88	NA	NA	NA	31.00	595, 597, 596
Cydnidae									
Sehirus_cinctus	NA	0.66	10.21	43.00	NA	NA	135.00	NA	574
Datylopiidae									
Dactylopius_coccus	4.12	0.70	0.01	65.50	NA	NA	NA	430.00	627
Dactylopius_austrinus	3.75	NA	67.00	35.50	NA	60.25	NA	1145.00	627, 625
Dactylopius_confusus	2.75	NA	NA	NA	NA	NA	NA	NA	627
Dactylopius_opuntiae	2.20	NA	0.04	16.78	NA	53.97	NA	567.58	627, 624
Delphacidae									
Nilaparvata_lugens	NA	NA	7.30	14.60	NA	15.30	14.00	244.20	617

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Diaspididae									
Chrysomphalus_aonidum	NA	NA	NA	48.49	NA	NA	NA	NA	620
Unaspis_euonymi	NA	NA	1.00	46.48	NA	NA	NA	70.80	621, 622
Dictyopharidae									
Dictyophara_europaea	9.25	0.93	NA	34.50	NA	NA	NA	41.90	615
Phylloscelis_pallescens	NA	1.04	NA	NA	NA	NA	NA	NA	616
Flatidae									
Anormenis_septentrionalis	NA	1.22	135.30	53.10	NA	NA	NA	NA	613, 595
Metcalfa_pruinosa	NA	0.84	NA	NA	NA	NA	NA	NA	613
Gelastocoridae									
Gelastocoris_oculatus	NA	1.34	9.21	64.41	NA	NA	NA	NA	592
Gerridae									
Aquarius_paludum	NA	NA	NA	30.25	NA	55.00	NA	316.20	599, 584
Hydrometridae									
Hydrometra_hungerfordi	NA	1.90	8.81	16.75	NA	NA	NA	NA	602
Hydrometra_martini	11.00	2.00	12.00	16.00	NA	NA	NA	NA	603
Largidae									
Largus_californicus	14.08	NA	13.70	77.50	NA	136.88	132.70	199.40	568
Lygaeidae									
Geocoris_floridanus	NA	NA	8.10	22.40	NA	47.42	NA	46.67	558
Geocoris_proteus	NA	NA	11.35	30.93	NA	73.28	NA	105.30	556
Geocoris_punctipes	NA	0.90	10.56	42.14	NA	67.14	NA	103.84	559, 557, 555
Lygaeus_equestris	NA	1.30	NA	44.06	NA	NA	NA	414.67	563, 562, 342
Lygaeus_turcicus	NA	1.34	7.24	33.79	NA	60.91	NA	NA	561
Oncopeltus_fasciatus	15.50	1.41	4.33	32.43	NA	32.51	29.87	431.43	566, 565
Malcidae									
Chauliops_fallax	2.94	0.78	11.00	23.10	NA	50.00	NA	45.00	567, 560
Mesoveliidae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Mesovelia_mulsanti	NA	NA	NA	13.38	NA	NA	NA	NA	605
Miridae									
Lygus_lineolaris	NA	1.00	14.29	22.02	NA	39.00	NA	134.60	342, 577, 578
Naucoridae									
Ilyocoris_cimicoides	12.00	NA	29.10	61.46	NA	NA	NA	NA	591
Nepidae									
Ranatra_quadridentata	NA	3.00	17.50	46.00	NA	63.50	NA	NA	593
Notonectidae									
Notonecta_glauca	15.27	1.98	NA	NA	NA	NA	NA	NA	342, 589
Peloridiidae									
Xenophyes_metoponcus	2.44	NA	NA	NA	NA	NA	NA	NA	618
Xenophysella_greensladeae	3.07	NA	NA	NA	NA	NA	NA	NA	619
Pentatomidae									
Chinavia_hilaris	16.00	NA	9.90	38.40	NA	NA	32.00	NA	573
textitPhymatidae									
Phymata_pennsylvanica	NA	1.60	334.58	42.75	NA	128.50	15.50	235.36	587, 588
Plataspidae									
Megacopta_cribraria	4.17	0.86	4.00	35.50	NA	178.70	15.64	NA	571, 572
Pseudococcidae									
Planococcus_citri	1.82	NA	6.09	22.96	NA	20.32	NA	72.40	628, 629
Pyrrhocoridae									
Pyrrhocoris_apterus	9.12	1.08	9.52	49.73	NA	212.92	60.00	NA	570, 569
Reduviidae									
Arilus_cristatus	31.00	3.70	60.00	93.99	NA	NA	116.25	NA	586, 587, 546
Rhodnius_neglectus	2.21	1.67	14.15	123.18	NA	316.40	NA	821.74	549, 548, 546, 547
Rhodnius_robustus	NA	1.61	17.50	204.70	NA	NA	NA	NA	548, 547
Thyreocoridae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Corimelaena_lateralis	NA	0.84	10.90	NA	NA	NA	NA	NA	575
Tingidae									
Corythucha_ciliata	3.60	0.53	8.77	12.59	NA	305.85	NA	270.40	583, 580, 579
Veliidae									
Rhagovelia_obesa	6.03	1.50	11.00	46.00	NA	NA	NA	NA	600
Velia_caprai	NA	NA	NA	41.67	NA	NA	NA	NA	601
Hymenoptera									
Agaonidae									
Apocryptophagus_agraensis	NA	NA	NA	NA	NA	1.90	NA	59.00	728, 631
Apocryptophagus_stratheni	NA	NA	NA	NA	NA	1.30	NA	261.60	728, 768
Apocryptophagus_testaceus	NA	NA	NA	NA	NA	5.80	NA	263.13	728, 631
Ceratosolen_fusciceps	NA	NA	NA	NA	NA	1.00	NA	193.53	728
Alloxystidae									
Alloxysta_megourae	NA	NA	3.00	10.00	7.00	NA	1.00	NA	631, 633
Ampulicidae									
Ampulex_compressa	28.50	2.66	2.00	6.00	NA	55.85	1.00	27.00	694, 695, 638
Ampulicidae									
Syntexis_libocedrii	12.00	0.82	17.00	NA	25.00	NA	NA	NA	754
Andrenidae									
Andrena_accepta	NA	2.50	NA	NA	NA	NA	NA	NA	720, 639
Andrena_candida	9.00	1.80	4.00	11.00	11.00	NA	NA	NA	752, 639
Andrena_crataegi	NA	1.80	NA	NA	NA	NA	NA	NA	724, 633
Andrena_dunningi	NA	2.50	NA	NA	NA	NA	NA	NA	721, 647
Andrena_fulva	NA	NA	NA	NA	NA	14.00	NA	5.00	751, 631
Andrena_nivalis	11.80	3.00	NA	NA	NA	NA	NA	NA	725, 631
Nomadopsis_larreae	NA	1.40	NA	NA	14.50	NA	NA	NA	723
Perdita_opuntiae	6.00	NA	NA	NA	NA	NA	NA	NA	722
Perdita_portalis	NA	NA	NA	7.80	9.00	NA	NA	NA	726

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Aphelinidae									
Aphelinus_asychis	0.91	0.22	NA	NA	NA	19.71	NA	159.00	342, 631
Aphelinus_flavus	1.00	0.22	NA	NA	NA	NA	1.00	81.00	631
Aphelinus_jucundus	NA	0.26	3.00	12.00	14.00	NA	1.00	NA	631
Aphelinus_nigra	NA	0.18	1.58	9.25	3.50	47.00	NA	NA	631
Aphelinus_semiflavus	0.80	NA	NA	NA	NA	19.58	1.00	281.00	631, 688
Aphytis_chilensis	0.90	0.19	2.50	10.50	6.50	NA	NA	NA	631, 732
Aphytis_chrysomphali	0.80	NA	3.00	5.50	5.00	14.00	NA	76.00	631
Aphytis_coheni	1.04	NA	NA	NA	NA	25.00	NA	26.00	631
Aphytis_diaspidis	1.10	0.16	4.50	14.00	9.00	NA	1.00	NA	631
Aphytis_maculicornis	1.00	NA	3.00	11.79	7.58	NA	NA	21.00	631, 633
Aphytis_melinus	1.00	NA	4.08	7.58	6.00	29.79	NA	189.00	631
Aphytis_mytilaspidis	NA	NA	NA	NA	NA	NA	NA	42.50	631, 632
Aphytis_proclia	NA	NA	NA	NA	NA	NA	NA	32.50	639, 632
Centrodora_scolypopae	NA	0.27	9.00	NA	NA	NA	2.50	NA	734, 633
Centrodora_speciosissima	0.80	0.17	NA	NA	NA	NA	7.00	NA	631
Coccophagus_basalis	1.00	NA	3.50	12.50	13.00	21.00	NA	NA	631
Encarsia_citrina	NA	0.08	NA	NA	NA	NA	NA	97.50	342, 632
Encarsia_formosa	0.60	0.08	4.00	14.00	10.00	30.50	1.00	194.00	631, 632
Encarsia_leucaspidis	NA	NA	NA	NA	NA	NA	NA	67.50	632
Encarsia_pergandiella	0.45	0.07	3.00	8.00	3.50	39.50	1.00	86.00	631
Encarsia_perniciosi	NA	NA	NA	NA	NA	NA	NA	120.00	632
Encarsia_quaintancei	0.59	NA	NA	NA	NA	NA	1.00	NA	631
Encarsia_tricolor	NA	NA	NA	NA	NA	22.50	NA	83.80	632
Marietta_leopardina	0.71	NA	NA	NA	NA	50.60	1.00	205.00	631
Pteroptrix_parvipennis	0.39	NA	3.00	NA	5.50	5.00	1.00	NA	631
Pteroptrix_smithi	NA	0.11	4.00	9.50	7.50	26.00	NA	NA	631
Apidae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Anthophorula_nitens	NA	2.00	NA	NA	NA	NA	NA	NA	757, 631
Anthophorula_sidae	NA	2.25	NA	NA	NA	NA	NA	NA	757, 631
Anthophorula_uncicornis	NA	1.61	NA	NA	NA	NA	NA	NA	757, 631
Apis_mellifera	NA	1.60	3.12	6.48	6.44	380.00	NA	NA	741, 742, 743, 744, 631
Bombus_impatiens	NA	NA	NA	11.53	11.98	NA	NA	NA	746, 644
Bombus_terricola	NA	3.06	NA	9.21	NA	NA	NA	NA	727, 644, 342
Centris_tarsata	NA	1.27	2.70	11.40	49.80	NA	NA	NA	342, 748, 633
Ceratina_calcarata	NA	NA	4.10	15.47	19.27	NA	NA	6.90	747, 749, 631
Chilimalopsis_parvula	NA	1.44	NA	NA	NA	NA	NA	NA	757
Epeolus_compactus	NA	1.50	NA	13.00	NA	NA	NA	NA	712
Eremapis_parvula	NA	1.65	NA	NA	NA	NA	NA	NA	757
Euglossa_melanotricha	13.00	NA	NA	NA	NA	NA	NA	NA	738
Exomalopsis_solani	NA	2.60	NA	NA	NA	NA	NA	NA	757
Exomalopsis_solidaginis	NA	2.52	NA	NA	NA	NA	NA	NA	757
Teratognatha_modesta	NA	1.38	NA	NA	NA	NA	NA	NA	757
Xylocopa_violacea	NA	10.50	NA	NA	NA	NA	7.43	NA	753
Argidae									
Aproceros_leucopoda	NA	NA	9.12	22.40	6.72	5.28	NA	21.54	691, 631
Aprosthema_melanurum	NA	NA	4.50	10.50	7.00	NA	NA	NA	686, 631
Arge_captiva	NA	1.57	NA	16.50	21.50	NA	NA	NA	342, 686, 631
Arge_humeralis	9.55	1.50	13.40	19.90	10.45	3.75	NA	47.00	654, 631
Arge_indicura	NA	NA	10.00	15.50	15.50	NA	NA	NA	686, 631
Arge_nigrinodosa	NA	NA	NA	NA	NA	NA	NA	40.00	631, 655
Arge_pagana	7.72	1.22	10.75	17.38	7.38	5.50	NA	NA	689, 656, 633
Arge_pullata	NA	NA	10.00	27.00	19.50	NA	NA	NA	686, 631
Arge_simlaensis	8.11	NA	NA	21.00	NA	NA	5.00	NA	652, 634
Arge_suspicax	NA	NA	6.50	16.00	12.00	NA	NA	NA	686, 631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Arge_suzukii	NA	NA	10.00	15.50	17.00	NA	NA	NA	686, 631
Arge_xanthogaster	NA	NA	7.60	16.30	10.10	6.40	27.00	187.00	656, 631
Cibdela_janthina	NA	NA	18.07	27.87	30.30	NA	NA	56.00	687, 657
Didymia_unifasciata	7.62	NA	NA	NA	20.00	NA	NA	NA	653
Digelasinus_diversipes	NA	NA	30.00	NA	NA	5.20	76.00	76.00	688
Manaos_kimseyae	7.03	NA	NA	NA	14.00	NA	NA	NA	653
Sericoceros_gibbus	NA	NA	NA	22.00	21.00	NA	NA	NA	653
Sericoceros_mexicanus	10.50	2.00	2.50	NA	NA	NA	37.00	37.00	690
Bethylidae									
Cephalonomia_hyalinipennis	NA	NA	NA	NA	NA	57.00	NA	87.70	632, 631
Cephalonomia_stephanoderis	NA	0.37	NA	NA	NA	46.00	NA	66.00	342, 632, 634
Cephalonomia_tarsalis	1.33	NA	1.00	4.25	13.00	35.00	2.00	85.00	631, 634
Cephalonomia_utahenis	NA	NA	NA	13.00	14.00	NA	4.00	NA	631, 633
Cephalonomia_waterstoni	1.56	NA	2.21	4.02	15.00	37.50	NA	102.00	631
Goniozus_columbianus	2.50	0.60	3.00	4.67	13.71	NA	NA	NA	631
Goniozus_emigratus	NA	NA	1.00	5.50	6.50	52.58	NA	300.00	631
Goniozus_gallicola	NA	0.80	1.25	7.50	NA	62.42	NA	NA	631
Goniozus_indicus	2.75	1.00	3.00	4.92	11.50	5.08	7.00	24.00	631
Goniozus_legneri	NA	0.45	1.25	4.38	9.26	96.92	14.00	289.69	342, 631, 632
Goniozus_nephantidis	3.58	0.55	1.25	6.75	4.50	30.00	9.00	106.00	631, 632
Goniozus_nigrifemur	NA	NA	NA	NA	NA	90.20	NA	184.42	632
Laelius_anthrenivorus	3.50	0.45	1.50	9.00	NA	39.00	2.00	26.00	631
Laelius_pedatus	3.20	0.45	3.71	7.00	30.00	27.42	3.00	71.00	631, 632
Laelius_utilis	2.29	NA	NA	NA	33.00	48.00	NA	81.00	631
Parasierola_cellularis	NA	0.68	1.50	5.00	4.50	30.71	NA	104.00	631
Pristocera_rufa	6.05	0.82	4.00	6.00	16.60	20.25	NA	NA	631
Prorops_nasuta	2.30	0.53	3.00	3.50	21.00	47.00	1.00	66.00	631
Braconidae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Adelius_subfasciatus	NA	NA	NA	NA	NA	NA	1.00	NA	631
Agathis_anglica	5.00	NA	NA	NA	NA	NA	NA	NA	633, 631
Agathis_artemesiana	3.50	NA	NA	NA	NA	2.90	NA	NA	633, 631
Agathis_asteris	3.50	NA	NA	NA	NA	NA	NA	NA	633, 631
Agathis_breviseta	3.50	NA	NA	NA	NA	NA	NA	NA	633, 631
Agathis_calcarata	5.60	NA	NA	NA	NA	NA	1.00	NA	631, 634
Agathis_gibbosa	3.80	0.11	3.50	8.50	3.00	10.79	1.00	451.00	631, 633
Agathis_laticincta	4.40	NA	NA	NA	10.00	NA	1.00	NA	631, 633
Agathis_unicolorata	4.70	0.10	5.00	10.00	3.00	17.08	1.00	470.00	631, 633
Aleiodes_circumscriptus	5.00	NA	NA	NA	NA	NA	NA	NA	633, 631
Aleiodes_gastritor	NA	0.60	NA	NA	NA	48.00	NA	NA	633, 670
Aleiodes_tristis	NA	NA	NA	NA	8.58	29.00	NA	NA	631
Alienoclypeus_insolitus	10.10	NA	NA	NA	NA	NA	NA	NA	633, 631
Alysia_manducator	6.25	NA	NA	NA	12.00	3.50	1.00	549.00	631
Apanteles_ater	2.25	NA	NA	NA	NA	NA	NA	NA	631
Apanteles_bordagei	1.81	NA	NA	NA	NA	0.62	NA	NA	631
Apanteles_carpatus	2.50	NA	NA	NA	6.00	NA	1.00	NA	633, 694
Apanteles_congregatus	2.47	0.14	2.00	NA	4.50	NA	NA	NA	631
Apanteles_corvinus	2.40	NA	NA	NA	NA	NA	1.00	NA	633, 631
Apanteles_dignus	2.23	0.35	1.00	7.50	9.00	10.21	1.00	182.00	631
Apanteles_dilectus	2.71	NA	NA	NA	NA	NA	NA	NA	631
Apanteles_epinotiae	1.23	NA	NA	NA	NA	NA	1.00	NA	631, 681
Apanteles_etiellae	2.57	0.50	2.00	7.00	7.00	6.00	1.00	NA	631, 645
Apanteles_flavipes	1.72	0.14	3.50	11.50	8.50	3.00	42.60	262.00	631
Apanteles_forbesi	3.63	NA	NA	NA	NA	NA	NA	NA	631, 694
Apanteles_fumiferanae	3.50	0.29	NA	20.00	10.50	26.00	NA	NA	631, 633
Apanteles_galleriae	2.70	NA	NA	NA	NA	NA	NA	239.00	633, 631
Apanteles_maculitarsis	3.29	NA	NA	9.00	7.50	NA	NA	NA	631, 729

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Apanteles_marginiventris	NA	0.88	1.12	4.75	4.00	5.00	1.00	NA	631, 633
Apanteles_milleri	2.80	NA	NA	NA	NA	NA	NA	NA	633, 631
Apanteles_morrisi	2.80	NA	NA	NA	NA	NA	NA	NA	633, 631
Apanteles_murinanae	2.86	NA	NA	NA	11.00	20.00	NA	NA	631
Apanteles_obliquae	2.09	0.04	3.00	9.42	5.00	NA	NA	103.00	631, 694
Apanteles_sesamiae	2.40	NA	NA	NA	6.00	3.50	33.00	NA	631, 694
Apanteles_solitarius	2.67	0.31	5.00	11.00	7.00	24.50	1.00	1000.00	631, 633
Apanteles_subandinus	3.86	0.32	0.92	9.50	4.50	17.00	1.00	345.00	631, 633
Apanteles_syleptae	3.00	NA	NA	NA	5.50	11.21	1.00	NA	631, 633
Apanteles_targamae	3.50	NA	NA	7.00	11.00	NA	1.00	NA	631, 633
Apanteles_thompsoni	3.00	0.18	5.00	NA	14.00	2.00	23.00	262.00	631, 633
Apanteles_xanthostigma	2.75	NA	NA	NA	NA	NA	1.00	NA	631, 633
Aphaereta_aotea	2.25	NA	NA	NA	NA	NA	NA	NA	633, 635
Aphaereta_apicalis	2.00	NA	NA	NA	NA	NA	NA	NA	633, 644
Aphaereta_colei	NA	NA	NA	NA	NA	NA	1.00	NA	644
Aphaereta_genevensis	2.90	NA	NA	NA	14.50	16.94	1.00	175.00	633, 632, 631
Aphaereta_lonchaeae	2.50	NA	NA	NA	NA	NA	1.00	NA	633, 631
Aphaereta_minuta	1.78	NA	NA	NA	NA	9.53	NA	NA	633
Aphaereta_pallipes	2.13	NA	4.29	6.50	5.71	4.00	11.20	NA	631
Aphidius_avenae	2.70	0.06	5.00	14.50	NA	24.00	1.00	382.00	631
Aphidius_colemani	NA	NA	NA	NA	9.96	NA	NA	NA	763, 656
Aphidius_ervi	1.50	0.05	NA	7.00	6.00	5.00	1.00	101.00	633, 638
Aphidius_matricariae	1.95	NA	NA	NA	11.24	NA	NA	NA	631, 763
Aphidius_nigripes	NA	NA	NA	NA	NA	15.34	1.00	NA	633, 631
Aphidius_pisivorus	1.35	NA	NA	NA	NA	NA	1.00	NA	633, 634
Aphidius_rhopalosiphi	1.66	NA	4.00	3.00	7.00	9.66	1.00	212.40	633, 632
Aphidius_rosae	NA	NA	NA	NA	NA	10.00	NA	750.00	632, 640
Aphidius_smithi	NA	0.10	NA	NA	NA	NA	1.00	NA	342, 631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Aphidius_sonchi	2.09	NA	NA	NA	NA	9.92	1.00	215.00	631, 633
Aphrastobracon_flavipennis	NA	1.26	2.08	13.42	11.00	38.50	1.00	NA	631
Aridelus_cameroni	NA	NA	NA	NA	19.00	NA	1.00	NA	631, 694
Aridelus_rufus	NA	NA	NA	NA	19.00	NA	1.00	NA	631
Ascogaster_quadridentata	4.42	NA	2.50	NA	7.00	24.50	1.00	NA	631, 633
Ascogaster_reticulatus	4.17	0.21	1.50	14.00	NA	12.00	1.00	170.00	631, 633
Aspicolpus_hudsoni	10.10	NA	NA	NA	NA	NA	NA	NA	633, 637
Asobara_tabida	1.50	NA	NA	NA	NA	34.10	1.00	607.00	633, 632, 736
Baeacis_abietis	3.15	NA	NA	NA	NA	NA	NA	NA	633, 631
Baeognatha_armeniaca	4.00	NA	NA	NA	NA	NA	NA	NA	633, 644
Baeognatha_nigra	3.00	NA	NA	NA	NA	NA	NA	NA	633, 701
Bassus_arthurellus	4.40	NA	NA	NA	NA	NA	NA	NA	633, 638
Bassus_dimidiator	5.25	NA	NA	NA	NA	NA	NA	NA	631, 633
Binodoxys_communis	NA	NA	NA	NA	NA	NA	NA	342.40	631, 632
Biosteres_arisanus	3.00	NA	NA	NA	NA	NA	NA	NA	633, 650
Biosteres_melleus	NA	NA	NA	NA	30.00	NA	NA	NA	633
Biosteres_vandenboschi	3.46	NA	NA	NA	NA	NA	NA	NA	633, 631
Blacus_exilis	1.86	NA	NA	NA	NA	NA	NA	NA	633, 631
Blacus_koenigi	1.80	NA	NA	NA	NA	NA	NA	NA	633, 716
Blacus_nigricornis	1.82	NA	NA	NA	NA	NA	NA	NA	633, 631
Bracon_cajani	3.27	0.80	1.08	3.50	9.50	14.00	NA	NA	631, 633
Bracon_gelechiae	3.00	NA	NA	NA	NA	NA	NA	NA	633
Bracon_greeni	NA	NA	1.08	1.54	6.00	32.00	NA	NA	631, 633
Bracon_hebetor	NA	NA	NA	NA	NA	27.00	NA	1200.00	632, 633
Bracon_kirkpatricki	2.60	0.81	0.83	3.00	3.00	NA	6.00	132.00	633, 631
Bracon_lissogaster	3.50	0.74	2.75	7.00	8.00	19.00	NA	NA	631, 633
Bracon_mellitor	3.80	1.10	1.00	5.50	4.50	21.58	1.00	213.00	631, 673
Bracon_pineti	3.32	NA	NA	4.00	NA	NA	NA	NA	633, 651

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Bracon_thurberiphagae	NA	0.72	1.08	3.50	9.50	14.00	6.50	NA	633, 631
Bracon_vulgaris	8.00	0.60	5.50	NA	10.50	0.71	1.00	258.00	631
Campyloneurus_mutator	6.70	1.56	2.50	13.50	13.50	35.00	1.00	NA	631, 666
Cardiochiles_hymeniae	4.07	0.53	1.00	9.00	4.00	4.00	1.00	NA	631
Cardiochiles_nigriceps	7.15	NA	NA	NA	NA	NA	1.00	NA	631
Cardiochiles_nigricollis	5.81	NA	NA	11.50	14.00	NA	NA	NA	631
Cedria_paradoxa	0.70	NA	NA	NA	NA	NA	NA	NA	633, 665
Charmon_extensor	4.18	NA	NA	NA	NA	NA	NA	NA	633
Chasmodon_apterus	1.58	NA	NA	NA	NA	NA	NA	NA	633
Chelonus_annulipes	6.50	0.20	NA	23.21	9.29	70.00	1.00	393.00	631
Chelonus_curvimaculatus	3.32	0.16	1.50	14.75	5.50	8.21	1.00	1537.00	631
Chelonus_heliopae	3.29	0.15	0.84	12.50	6.00	22.00	1.00	1270.00	631
Chelonus_inanitus	5.20	0.26	NA	NA	10.50	NA	1.00	NA	342, 631
Chelonus_insularis	NA	NA	NA	NA	NA	NA	1.00	NA	
Chelonus_kellieae	3.00	0.18	1.17	16.00	9.00	62.21	1.00	316.00	631
Chelonus_phthorimaeae	2.95	0.20	1.04	15.00	6.00	39.58	1.00	568.00	631
Chelonus_texanus	5.00	NA	NA	NA	15.00	NA	1.00	NA	631
Choeras_tedellae	1.23	NA	NA	NA	NA	NA	1.00	NA	633
Choeras_tiro	2.10	NA	NA	NA	14.00	NA	NA	NA	633
Chremylus_elaphus	2.00	0.45	1.42	9.50	6.58	10.50	NA	33.00	631
Clinocentrus_gracilpes	3.08	NA	NA	NA	NA	NA	NA	NA	633
Coeloides_dendroctoni	5.17	NA	3.96	20.00	17.00	24.00	1.00	NA	631
Coeloides_pissodis	5.00	NA	NA	NA	NA	NA	NA	NA	633
Coeloides_scolyticida	4.38	NA	NA	NA	NA	NA	NA	NA	633
Colastes_braconius	1.13	NA	NA	NA	NA	NA	1.00	NA	633
Cotesia_congregata	2.47	0.14	2.00	NA	4.50	11.00	NA	NA	633, 632
Cotesia_euphydryidis	2.20	NA	NA	NA	7.00	NA	28.10	NA	633
Cotesia_flavipes	1.72	0.14	3.50	11.50	8.50	5.45	NA	203.10	633, 632

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Cotesia_glomerata	3.00	NA	NA	NA	7.80	14.00	14.00	1200.00	633, 632
Cotesia_jucunda	3.00	NA	NA	NA	NA	NA	NA	NA	633
Cotesia_kariyai	1.20	NA	NA	NA	NA	NA	NA	NA	633
Cotesia_kazak	3.50	NA	NA	NA	NA	NA	NA	NA	633
Cotesia_marginiventris	3.00	0.88	1.13	4.75	4.00	11.55	1.00	362.70	633, 632
Cotesia_medicaginis	5.00	NA	NA	NA	NA	NA	1.00	NA	633
Cotesia_melanoscela	2.67	0.31	5.00	11.00	7.00	24.50	1.00	1000.00	633
Cotesia_melitaearum	4.00	NA	NA	NA	15.00	NA	7.03	NA	633
Cotesia_ocneriae	2.20	NA	NA	NA	NA	NA	NA	NA	633
Cotesia_phobetri	1.80	NA	NA	NA	NA	NA	NA	NA	633
Cotesia_rubecula	3.10	NA	NA	NA	NA	NA	NA	NA	633
Cotesia_schizurae	1.80	NA	NA	NA	NA	NA	NA	NA	633
Cotesia_scitula	2.50	NA	NA	NA	NA	NA	93.00	NA	633
Cotesia_vestalis	NA	0.17	NA	NA	NA	5.00	1.00	470.00	342, 632
Cotesia_yakutatensis	1.90	NA	NA	NA	NA	NA	NA	NA	633
Cremnops_desertor	8.00	NA	NA	NA	NA	NA	NA	NA	633
Dacnusa_areolaris	1.36	NA	NA	NA	NA	NA	NA	NA	633
Dacnusa_nipponica	1.62	NA	NA	NA	NA	NA	NA	NA	631
Dacnusa_sibirica	1.50	NA	NA	NA	NA	NA	NA	NA	633
Dendrosoter_protuberans	3.00	0.90	2.00	7.50	30.50	NA	1.00	8.00	631
Diachasmimorpha_kraussi	3.10	NA	NA	NA	NA	27.60	NA	111.70	633
Diachasmimorpha_longicaudata	3.05	NA	NA	NA	NA	NA	NA	NA	633
Diaeretiella_rapae	1.30	0.07	NA	NA	16.00	20.00	1.00	300.00	342, 633
Dinocampus_coccinellae	2.43	NA	NA	NA	NA	NA	NA	NA	633
Diospilus_capito	2.15	NA	NA	NA	NA	NA	NA	NA	633
Dolichogenidea_absona	2.80	NA	NA	NA	NA	NA	NA	NA	633
Dolichogenidea_evonymellae	3.30	NA	NA	NA	NA	4.00	NA	NA	633
Doryctobracon_areolatus	5.00	NA	NA	NA	NA	NA	NA	NA	633

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Doryctobracon_crawfordi	4.80	NA	NA	NA	NA	NA	NA	NA	633
Dyscritulus_planiceps	1.88	NA	NA	NA	NA	NA	NA	NA	633
Earinus_elator	8.00	NA	NA	NA	NA	NA	NA	NA	633
Earinus_gloriatorius	5.00	NA	NA	NA	NA	NA	NA	NA	633
Earinus_limitaris	6.42	NA	NA	NA	NA	NA	NA	NA	633
Earinus_transversus	6.50	NA	NA	NA	NA	NA	NA	NA	633
Earinus_zeirapherae	4.25	NA	NA	NA	NA	NA	NA	NA	633
Ephedrus_californicus	NA	NA	NA	NA	7.22	14.00	NA	1200.00	633
Ephedrus_plagiator	1.63	NA	NA	NA	14.50	18.00	1.00	87.00	631, 633
Eubazus_semirugosus	5.00	NA	NA	NA	NA	NA	NA	NA	633
Fopius_arisanus	NA	0.30	NA	NA	6.50	23.23	1.00	133.40	342, 632
Fopius_ceratitivorus	NA	NA	NA	NA	NA	16.20	NA	131.80	632
Fopius_vandenboschi	NA	NA	NA	NA	NA	22.00	NA	67.20	632
Glyptapanteles_militaris	1.30	NA	NA	NA	NA	NA	NA	NA	633
Glyptapanteles_porthetriae	2.50	NA	NA	NA	NA	NA	NA	NA	633
Gnamptodon_pumilio	0.80	NA	NA	NA	NA	NA	NA	NA	633
Habrobracon_hebetor	2.87	0.50	2.00	NA	NA	40.00	10.00	614.00	631, 633
Habrobracon_instabilis	2.29	NA	NA	NA	NA	29.12	2.00	324.00	631
Habrobracon_lineatellae	NA	0.54	1.10	2.46	5.46	72.00	7.00	854.00	631
Habrobracon_politiventris	NA	0.53	1.00	4.50	7.00	52.00	28.00	220.00	631
Habrobracon_stabilis	2.81	2.50	2.50	16.00	21.50	NA	8.00	NA	631
Heterospilus_coffeicola	2.50	0.38	6.00	19.00	NA	NA	1.00	NA	631
Heterospilus_prosopidis	NA	NA	NA	NA	NA	9.00	1.00	37.00	633, 632
Homolobus_truncator	4.80	NA	NA	NA	NA	NA	NA	NA	633
Hormius_moniliatus	1.20	NA	NA	NA	NA	NA	NA	NA	633
Hybogaster_varipalpis	10.68	NA	7.00	6.58	12.00	28.00	4.00	232.00	631
Hypomicrogaster_tiro	NA	NA	NA	NA	14.00	NA	NA	NA	631
Ichneutes_levis	1.90	NA	NA	NA	NA	NA	NA	NA	633

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Iphiaulax_kimballi	NA	NA	11.50	4.08	0.71	28.58	NA	106.00	631
Lysiphlebus_fabarum	1.08	NA	NA	NA	NA	NA	NA	NA	631
Lysiphlebus_testaceipes	2.00	NA	NA	NA	NA	NA	NA	NA	633
Macrocentrus_ancylivorus	3.50	NA	NA	NA	NA	NA	NA	NA	633
Macrocentrus_cingulum	NA	0.09	NA	NA	NA	7.00	NA	200.00	342, 633
Macrocentrus_gifuensis	4.50	0.10	NA	NA	13.00	16.71	21.00	NA	631
Macrocentrus_instabilis	NA	NA	NA	NA	11.00	NA	1.00	NA	631
Macrocentrus_iridescens	7.00	NA	NA	NA	NA	NA	NA	NA	633
Macrocentrus_linerais	4.74	NA	NA	NA	14.00	NA	13.00	NA	631
Meteorus_campestris	NA	NA	6.00	NA	6.00	62.00	NA	240.00	631
Meteorus_pallipes	NA	NA	19.00	16.00	NA	NA	1.00	NA	631
Meteorus_ruficeps	4.44	NA	NA	NA	6.50	NA	1.00	NA	631
Meteorus_unicolor	5.23	NA	NA	NA	9.00	NA	1.00	NA	631
Microbracon_chilonis	NA	1.01	1.12	6.50	6.00	16.50	NA	84.00	631
Microbracon_pygmaeus	NA	0.62	1.54	8.00	4.50	NA	1.00	160.00	631
Microbracon_variabilis	NA	0.69	4.50	9.00	6.00	NA	NA	NA	631
Microcotonus_aethiopides	4.00	NA	NA	NA	NA	NA	NA	NA	633
Microcotonus_caudatus	NA	NA	NA	NA	NA	NA	20.80	NA	
Microcotonus_colesi	3.00	NA	NA	NA	NA	NA	NA	NA	633
Microcotonus_hyperodae	2.10	NA	NA	NA	15.58	21.00	1.00	48.00	631, 632
Microcotonus_sitonae	NA	0.55	5.00	10.42	10.58	NA	NA	NA	631
Microcotonus_stelleri	2.75	0.19	3.50	NA	14.00	14.00	1.00	NA	631
Microcotonus_vittatae	NA	NA	NA	NA	NA	NA	NA	132.00	632
Microdus_acrobasidis	3.14	0.14	NA	NA	NA	NA	1.00	NA	631
Microdus_dimidiator	5.00	NA	NA	NA	NA	NA	NA	NA	633
Microdus_pumilus	2.00	0.08	7.00	NA	8.00	22.00	1.00	140.00	631
Microdus_rufipes	5.00	NA	NA	NA	NA	NA	NA	NA	633
Microgaster_tibialis	3.50	0.50	2.50	26.50	NA	NA	1.00	292.00	631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Microplitis_croceipes	4.40	0.76	1.75	NA	6.00	19.00	1.00	466.00	631, 632
Microplitis_demolitor	2.50	0.89	NA	NA	6.00	NA	1.00	NA	342, 633
Microplitis_feltiae	NA	0.36	NA	NA	6.40	NA	NA	NA	631
Microplitis_mediator	2.86	0.35	1.54	11.30	NA	NA	1.00	NA	633, 632
Microplitis_naenia	3.20	NA	NA	NA	NA	NA	NA	NA	633
Microplitis_ocellatae	2.80	NA	NA	NA	NA	NA	NA	NA	633
Microplitis_plutellae	1.50	NA	NA	NA	NA	20.00	1.00	232.00	633, 631
Microplitis_rufiventris	3.08	0.24	2.00	4.50	6.50	9.95	1.00	170.10	631, 632
Microplitis_tuberculifer	3.60	NA	NA	NA	NA	NA	NA	NA	633
Mirax_minuta	NA	NA	NA	NA	NA	NA	1.00	NA	
Mirax_rufilabris	1.14	NA	NA	NA	NA	NA	1.00	NA	633
Monoctonus_paulensis	NA	0.14	3.17	5.33	6.00	NA	1.00	NA	631
Oncophanes_laevigatus	NA	NA	NA	NA	NA	NA	15.00	NA	
Opius_lectus	NA	NA	NA	NA	30.00	NA	NA	NA	633
Opius_rhagoleticola	2.28	NA	NA	NA	NA	NA	NA	NA	633
Opthalmobracon_kirkpatricki	4.00	0.88	1.08	5.58	6.42	52.00	3.00	175.00	631
Orgilus_jennieae	NA	0.28	2.88	7.17	3.50	26.29	NA	375.00	631
Orgilus_lepidus	4.50	0.27	1.50	8.00	9.00	17.58	1.00	791.00	631
Orgilus_obscurator	4.02	NA	NA	NA	NA	NA	1.00	122.50	631, 632
Orgilus_parcus	3.76	0.19	3.00	11.25	6.00	5.79	NA	127.00	631
Parallorhogas_pyralophagus	NA	NA	NA	NA	NA	38.00	NA	75.15	632
Pelecystoma_harrisinae	2.00	0.59	2.00	6.00	8.00	9.50	NA	84.00	631, 633
Perilitus_dubius	2.86	NA	NA	NA	NA	17.00	3.00	58.00	631
Peristenus_digoneutis	NA	0.17	NA	NA	NA	25.00	NA	385.00	342, 632
Peristenus_relictus	NA	NA	NA	NA	14.40	32.10	NA	782.00	632
Phanerotoma_bennetti	NA	0.20	2.00	13.00	9.00	8.00	1.00	NA	631
Phanerotoma_phyllotomae	3.73	0.66	1.75	7.75	NA	48.00	NA	NA	631
Phanerotoma_toreutae	4.50	0.11	NA	NA	NA	16.00	1.00	NA	631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Phanomeris_catenator	1.50	NA	NA	NA	NA	NA	NA	NA	633
Phanomeris_dimidiata	NA	NA	NA	NA	NA	NA	1.00	NA	
Phanomeris_laevis	1.80	NA	NA	NA	NA	NA	NA	NA	633
Phanomeris_phyllotomae	1.25	0.66	2.00	8.00	NA	48.00	NA	NA	633
Pholetesor_circumscriptus	2.20	NA	NA	NA	NA	NA	NA	NA	633
Praon_exsoletum	1.70	0.07	2.88	3.88	4.00	47.00	1.00	174.50	631, 632
Praon_pequodorum	2.00	0.63	NA	NA	NA	NA	NA	NA	342, 633
Praon_volucre	2.07	NA	4.00	18.00	8.50	NA	1.00	NA	631
Protapanteles_immunis	3.50	NA	NA	NA	NA	NA	NA	NA	633
Psyttalia_incisi	2.58	NA	NA	NA	NA	NA	NA	NA	633
Psyttalia_lounsburyi	NA	NA	NA	NA	NA	31.00	NA	26.80	632
Pygostolus_falcatus	3.59	0.31	5.00	11.50	7.50	15.70	1.00	71.50	631, 632
Rhaconotus_roslinensis	3.69	1.00	1.04	9.00	7.00	47.00	15.00	47.00	631
Rhysipolis_decorator	3.10	NA	NA	NA	NA	NA	NA	NA	633
Rhysipolis_hariolator	2.63	NA	NA	NA	NA	NA	NA	NA	633
Rhysipolis_meditator	2.66	NA	NA	NA	NA	NA	NA	NA	633
Rogas_malacosomatos	5.00	NA	NA	NA	NA	NA	NA	NA	633
Rogas_nolophanae	NA	0.28	NA	NA	8.17	NA	1.00	NA	631
Rogas_stigmator	2.90	NA	NA	NA	NA	NA	29.00	NA	633
Rogas_terminalis	6.71	0.18	NA	NA	16.71	32.50	NA	NA	631
Rogas_testaceus	4.60	0.44	1.50	7.00	11.50	18.00	1.00	322.00	631
Spathius_brevicaudis	2.35	NA	NA	NA	NA	NA	NA	NA	633
Spathius_vulnificus	4.05	0.88	1.96	12.58	9.79	40.58	NA	89.00	631
Stenobracon_deesae	11.87	NA	1.10	5.40	16.79	29.50	1.00	58.00	631
Stenobracon_nicevillei	12.99	3.50	1.10	6.50	7.00	16.00	NA	11.00	631
Stenocorse_bruchivora	4.50	NA	NA	NA	NA	100.00	NA	67.00	633
Toxoneuron_nigriceps	7.15	0.57	NA	NA	NA	NA	1.00	NA	342, 633
Triaspis_pallipes	1.75	NA	NA	NA	NA	NA	1.00	NA	633

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Triaspis_thoracica	2.35	NA	NA	NA	NA	NA	NA	NA	633
Trioxys_complanatus	1.30	0.07	2.19	4.73	3.04	20.50	1.00	179.00	631, 632
Cephidae									
Cephus_cinctus	NA	1.12	NA	NA	21.00	NA	1.00	50.00	646, 631
Janus_rufiventris	NA	NA	NA	NA	NA	NA	1.00	NA	
Ceraphronidae									
Aphanogmus_fijiensis	1.16	0.26	2.50	9.25	12.25	28.00	4.00	36.00	631
Lygocerus_testaceiannus	3.20	NA	NA	NA	NA	NA	NA	NA	631
Chalcididae									
Brachymeria_lasus	NA	0.99	1.06	6.69	5.00	55.40	NA	270.00	342, 631, 632, 694
Brachymeria_nephantidis	NA	NA	0.96	4.77	11.00	60.00	1.00	NA	631
Brachymeria_nosatoi	4.57	NA	NA	NA	NA	55.00	1.00	NA	631
Brachymeria_podagrica	4.50	0.89	3.00	10.00	11.00	11.00	1.00	80.00	342, 631
Dirhinus_pachycerus	NA	0.65	2.00	10.50	12.00	NA	1.00	NA	631
Spilochalcis_albifrons	3.80	NA	NA	15.00	12.00	59.58	NA	NA	631
Spilochalcis_hirtifemora	NA	0.53	1.58	5.33	9.50	60.00	NA	NA	631
Spilochalcis_side	NA	0.55	1.58	5.21	9.00	60.00	NA	NA	631
Chrysididae									
Hedychridium_solierellae	3.00	0.45	1.00	NA	17.50	NA	NA	NA	715
Praestochrysis_shanghaiensis	NA	NA	NA	NA	NA	60.00	NA	28.70	632
Pseudolopyga_taylori	3.00	0.06	NA	NA	12.10	NA	NA	NA	715
Cimbicidae									
Abia_sericea	NA	NA	4.30	23.60	20.30	4.70	NA	86.10	643, 636
Cimbex_quadrimaculatus	16.32	NA	NA	NA	NA	NA	NA	NA	642
Corynis_similis	NA	NA	NA	25.00	NA	NA	NA	NA	644
Colletidae									
Cadeguala_albopilosa	NA	2.00	NA	NA	NA	NA	NA	NA	713, 631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Colletes_kincaidii	NA	NA	NA	NA	6.00	NA	NA	NA	711
Hylaeus_bisinuatus	NA	1.35	NA	NA	12.00	NA	NA	NA	710
Ptiloglossa_matutina	NA	2.80	NA	NA	NA	NA	NA	NA	713
Ptiloglossa_tarsata	NA	3.00	NA	NA	NA	NA	NA	NA	713
Zikanapis_tucumana	NA	2.30	NA	NA	NA	NA	NA	NA	713
Crabonidae									
Astata_immigrans	5.50	1.05	NA	NA	NA	NA	NA	NA	750, 638
Astata_unicolor	NA	2.00	3.00	8.00	NA	NA	NA	NA	749, 632
Psenulus_interstitialis	NA	1.95	NA	NA	17.00	NA	NA	NA	714
Solierella_blaisdelli	4.00	NA	2.00	7.80	14.81	NA	NA	NA	715
Solierella_peckhami	4.00	1.00	2.50	NA	20.50	NA	1.00	NA	715
Diapriidae									
Basalys_tritoma	1.86	0.25	2.00	4.00	6.00	10.40	NA	NA	631, 643
Trichopria_atrichomelinae	NA	0.20	1.50	10.50	14.00	NA	5.70	25.00	631
Trichopria_popei	NA	0.19	1.50	7.50	10.00	70.00	10.00	70.00	631
Diprionidae									
Neodiprion_fulviceps	NA	NA	NA	22.50	28.00	NA	NA	NA	662
Neodiprion_nigroscutum	7.97	0.63	14.00	NA	NA	NA	8.87	99.75	658
Neodiprion_pinetum	NA	NA	NA	NA	NA	3.26	126.90	116.00	660
Neodiprion_rugifrons	NA	NA	17.50	NA	NA	NA	85.50	98.18	659
Nesodiprion_biremis	NA	NA	5.50	26.50	13.60	NA	NA	146.67	661
Dryinidae									
Aphelopus_holomelas	NA	NA	NA	NA	NA	NA	1.00	NA	638
Aphelopus_melaleucus	NA	NA	NA	NA	NA	NA	1.00	NA	639
Aphelopus_serratus	NA	NA	NA	NA	NA	NA	1.00	NA	631
Dicondylus_bicolor	NA	NA	NA	NA	NA	3.80	NA	NA	717
Dryinus_pyrillae	NA	NA	NA	NA	NA	NA	NA	42.00	631
Gonatopus_sepsoides	3.27	NA	NA	NA	30.29	18.50	1.00	NA	631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Neodryinus_typhlocybae	NA	NA	NA	NA	NA	NA	1.00	NA	
Pachygonatopus_minimus	2.38	0.18	7.50	NA	NA	7.15	1.00	79.00	716
Pseudogonatopus_distinctus	3.08	NA	NA	NA	NA	21.00	NA	NA	631
Encyrtidae									
Anagryus_pseudococci	1.80	NA	1.50	5.50	5.00	13.50	1.00	65.00	631, 668
Anagyrus_kamali	NA	NA	NA	NA	NA	9.40	NA	100.00	632, 640
Cheiloneurus_noxius	1.34	0.20	4.50	9.50	5.00	NA	1.00	NA	631, 632
Cheiloneurus_paralia	1.57	NA	NA	NA	NA	48.50	1.00	100.00	631
Clausenia_josefi	1.29	NA	NA	NA	NA	36.00	NA	107.00	631
Coccidoxenoides_perminutus	NA	NA	NA	NA	NA	5.40	NA	239.20	632
Comperia_merceti	1.87	NA	NA	NA	NA	NA	15.00	NA	631
Comperiella_bifasciata	0.61	0.14	4.50	10.00	7.00	10.00	1.00	136.00	342, 631
Comperiella_unifasciata	1.30	NA	5.00	16.00	6.00	7.00	1.00	NA	631
Copidosoma_floridanum	NA	0.04	NA	NA	NA	NA	NA	40.00	342, 632
Copidosoma_koehleri	NA	0.07	NA	NA	13.00	10.00	NA	100.00	342, 632
Diversinervus_cervantesi	1.38	NA	5.50	8.00	8.50	45.50	4.00	195.00	631
Diversinervus_elegans	2.00	1.20	5.00	14.00	5.00	NA	4.00	148.00	631
Encyrtus_infidus	2.97	0.32	NA	NA	NA	NA	6.40	140.00	631
Epidinocarsis_lopezi	1.58	NA	2.00	10.00	6.00	13.00	1.00	101.00	631
Leptomastidea_abnormis	1.00	0.15	NA	NA	NA	NA	1.00	NA	342, 631
Leptomastix_epona	NA	NA	NA	NA	NA	NA	NA	138.60	632
Metaphycus_flavus	NA	NA	NA	NA	NA	44.85	NA	NA	632
Metaphycus_helvolus	1.00	NA	3.00	4.00	6.00	66.69	1.00	645.50	631, 632
Metaphycus_insidiosus	NA	0.11	2.00	7.00	5.00	22.00	NA	NA	631
Metaphycus_luteolus	NA	0.18	1.83	NA	NA	63.86	19.00	NA	342, 631, 632
Microterys_flavus	0.95	NA	2.92	7.00	8.00	32.00	12.00	212.00	631
Microterys_nietneri	NA	0.23	NA	NA	NA	40.00	NA	NA	342, 632
Ooencyrtus_johnsoni	NA	0.18	NA	NA	NA	21.20	NA	NA	342, 632

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Ooencyrtus_pyrillae	0.85	NA	NA	NA	NA	NA	NA	NA	631
Ooencyrtus_trinidadensis	NA	0.15	1.75	5.25	7.00	NA	NA	NA	631
Ooencyrtus_utetheisae	0.91	0.18	1.50	4.50	9.92	19.79	1.68	92.00	631
Paraleurocerus_bicoloripes	0.88	NA	NA	NA	NA	NA	25.00	NA	631
Plagiomerus_diaspidis	0.88	NA	2.00	8.00	6.00	35.00	1.00	NA	631
Spaniopterus_crucifer	0.49	NA	NA	NA	6.50	7.00	1.00	NA	631
Syrphophagus_inquisitor	NA	0.17	4.00	9.50	6.00	NA	1.00	NA	631
Tachinaephagus_zealandicus	3.20	0.21	3.50	15.00	6.50	36.60	6.00	NA	631
Thomsonisca_pakistanensis	NA	NA	2.00	7.42	4.58	9.42	NA	52.00	631
Eucharitidae									
Ancylotropus_manipurensis	NA	NA	NA	NA	NA	NA	NA	1000.00	646, 632
Orasema_simplex	NA	NA	NA	NA	NA	3.60	NA	613.50	632
Pseudometagea_schwarzii	NA	0.11	NA	NA	NA	NA	NA	450.00	342, 632
Stilbula_tenuicornis	NA	NA	NA	27.00	7.00	3.00	NA	1230.00	631
Eulophidae									
Achrysocharoides_bipunctatus	1.16	NA	NA	NA	NA	NA	6.00	NA	631
Aprostocetus_ceroplastae	NA	0.38	3.60	11.00	6.50	12.00	1.00	65.00	631
Aprostocetus_hagenowii	2.00	0.35	NA	NA	10.00	38.50	37.50	168.00	631
Aprostocetus_leucopterae	0.83	NA	NA	NA	NA	63.00	2.00	NA	631
Chrysocharis_albipes	2.92	NA	NA	NA	NA	NA	NA	NA	631
Chrysocharis_gemma	2.08	0.28	8.50	32.00	38.00	NA	1.00	NA	631
Chrysocharis_laomedon	1.54	NA	NA	NA	NA	NA	1.00	NA	631
Chrysocharis_laricinellae	1.58	0.27	2.00	6.00	9.00	30.00	1.00	NA	631, 632
Chrysocharis_lepelleyi	1.51	NA	NA	NA	NA	95.00	1.00	NA	631
Chrysocharis_milleri	1.14	NA	NA	NA	NA	NA	1.00	NA	631
Chrysocharis_pentheus	1.26	NA	NA	NA	NA	15.20	NA	80.00	631, 632
Chrysocharis_phryne	1.49	NA	NA	NA	NA	NA	NA	NA	631
Chrysocharis_pubens	1.89	NA	NA	NA	NA	NA	NA	NA	631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Chrysocharis_pubicornis	1.62	0.28	3.50	NA	20.50	NA	NA	NA	631
Chrysonotomyia_formosa	NA	0.22	3.00	6.00	NA	56.00	NA	NA	631
Chrysonotomyia_ritchiei	1.30	NA	NA	NA	NA	34.00	NA	NA	631
Chrysonotomyia_ruforum	1.06	0.22	3.00	6.00	NA	56.00	NA	NA	631
Chrysonotomyia_violaceus	0.66	NA	NA	NA	NA	25.00	NA	NA	631
Cirrospilus_cinctiventris	0.82	NA	NA	NA	NA	79.00	NA	NA	631
Cirrospilus_diallus	2.00	NA	NA	NA	NA	NA	NA	NA	631
Cirrospilus_inimicus	2.10	1.00	2.00	9.00	8.50	7.00	NA	100.00	631
Cirrospilus_pictus	1.89	0.35	1.25	6.50	7.00	33.00	2.00	NA	631
Cirrospilus_variegatus	1.17	NA	NA	NA	NA	90.00	3.00	NA	631
Cirrospilus_vittatus	1.70	0.29	1.75	9.00	7.00	NA	2.00	NA	631
Citrostichus_phyllocnistoides	NA	0.18	0.71	4.00	7.00	NA	1.00	NA	631
Closterocerus_africanus	1.39	NA	NA	NA	NA	85.00	NA	NA	631
Closterocerus_trifasciatus	1.30	NA	NA	NA	NA	NA	1.00	NA	631
Clotterellia_japonica	2.04	NA	NA	NA	NA	NA	NA	NA	631
Dahlbominus_fuscipennis	2.86	0.34	2.50	10.50	7.50	12.00	72.50	NA	631
Diglyphus_intermedius	NA	NA	1.00	4.00	6.00	24.50	1.00	40.00	631
Diglyphus_isaea	NA	NA	NA	NA	8.40	21.00	NA	263.00	632
Diglyphus_minoeus	1.39	NA	NA	NA	NA	NA	NA	NA	631
Edovum_puttleri	NA	0.29	NA	NA	11.54	43.90	NA	228.00	342, 632
Elachertus_cacoeciae	NA	NA	NA	NA	10.00	90.10	NA	96.80	632
Elasmus_albicoxa	NA	NA	NA	NA	NA	NA	1.00	NA	
Elasmus_bellicaput	2.77	NA	1.17	4.00	5.79	NA	NA	NA	631
Elasmus_broomensis	2.43	0.44	1.17	5.46	5.79	18.42	1.00	NA	631
Elasmus_leucopterae	1.70	NA	NA	NA	NA	64.17	NA	NA	631
Entedon_ergias	NA	0.32	NA	NA	NA	NA	1.00	NA	631
Euderus_agromyzae	NA	0.48	2.50	9.00	7.00	4.00	1.00	NA	631
Euderus_lividus	2.75	0.60	1.00	5.50	4.50	NA	NA	NA	631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Eulophus_larvarum	2.50	NA	NA	NA	NA	NA	NA	NA	631
Eulophus_pennicornis	NA	NA	NA	NA	7.00	17.00	NA	99.60	632
Euplectrus_parvulus	1.21	0.12	0.92	2.71	3.29	24.00	NA	NA	631
Euplectrus_puttleri	2.16	NA	NA	NA	6.60	14.25	NA	100.50	631, 632
Euplectrus_spodopterae	NA	0.18	1.62	3.71	5.50	34.00	NA	75.00	631
Goetheana_shakespearei	NA	NA	1.00	8.00	10.50	4.50	1.00	NA	631
Hemiptarsenus_fulvicollis	2.60	0.47	2.00	8.00	8.50	NA	6.00	NA	631
Hemiptarsenus_varicornis	NA	NA	NA	NA	NA	NA	NA	497.00	632
Horismenus_fraternus	2.14	NA	NA	NA	NA	NA	1.00	NA	631
Hyssopus_pallidus	NA	0.34	NA	NA	7.73	19.00	NA	172.00	342, 632
Hyssopus_thymus	1.76	0.32	1.50	7.00	8.50	NA	NA	130.00	631
Melittobia_australica	1.30	0.30	3.50	9.00	3.50	NA	NA	NA	631
Minotetrastichus_ecus	NA	0.35	2.00	11.00	7.00	NA	2.00	NA	631
Necremnus_breviramulus	NA	NA	NA	NA	NA	NA	9.00	NA	
Nesolynx_albiclavus	1.56	0.42	2.00	8.00	10.00	NA	34.00	NA	631
Notanisomorphella_borborica	1.70	NA	NA	NA	NA	35.00	NA	NA	631
Oomyzus_incertus	1.40	0.25	2.25	8.79	8.00	27.92	5.00	593.00	631
Oomyzus_scaposus	1.40	0.24	4.00	11.50	10.00	32.00	NA	NA	631
Parachrysocharis_pyrillae	0.84	NA	NA	NA	NA	NA	NA	NA	631
Pediobius_acantha	1.62	NA	NA	NA	NA	NA	NA	NA	631
Pediobius_coffeicola	1.63	NA	NA	NA	NA	58.00	NA	NA	631
Pediobius_foveolatus	1.60	0.20	1.50	12.00	7.00	NA	15.00	50.00	631
Pediobius_furvus	1.50	0.33	1.00	9.00	10.00	8.50	100.00	NA	631
Pnigalio_agraules	NA	0.40	2.00	6.00	9.00	NA	NA	NA	631
Pnigalio_longulus	2.65	NA	NA	NA	NA	NA	1.00	NA	631
Pnigalio_maculipes	NA	NA	NA	NA	NA	NA	1.00	NA	
Pnigalio_minio	1.90	NA	NA	NA	NA	NA	1.00	NA	631
Pnigalio_pallipes	NA	NA	NA	NA	NA	NA	1.00	NA	

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Pnigalio_soemius	NA	NA	NA	NA	7.50	31.80	NA	131.50	632
Psephenivorus_mexicanus	1.55	NA	NA	NA	NA	NA	39.00	NA	631
Semielacher_petiolatus	NA	NA	NA	NA	NA	18.70	NA	112.60	632
Stenomesius_rufescens	2.04	NA	NA	NA	NA	NA	2.00	NA	631
Sympiesis_marylandensis	NA	NA	NA	NA	NA	NA	1.00	NA	
Sympiesis_sericeicornis	NA	NA	NA	NA	NA	NA	1.00	NA	
Sympiesis_viridula	NA	NA	1.00	5.00	8.00	27.42	16.50	NA	631
Tamarixia_radiata	NA	NA	NA	NA	NA	19.40	NA	265.00	632
Teleopterus_erxias	0.83	NA	NA	NA	NA	NA	NA	NA	631
Tetrastichus_atriclavus	NA	NA	NA	NA	NA	14.00	NA	227.00	632
Tetrastichus_coerulens	1.75	0.24	NA	NA	8.92	7.79	5.00	41.00	631
Tetrastichus_howardi	NA	0.30	1.00	9.00	6.50	37.00	NA	98.00	631
Tetrastichus_julis	NA	0.29	NA	NA	NA	14.00	NA	NA	342, 631
Tetrastichus_krishnieri	2.50	0.36	0.58	6.00	8.50	30.00	NA	NA	631
Thripobius_javae	NA	NA	NA	NA	9.92	8.00	NA	78.80	632
Thripobius_semiluteus	NA	NA	4.20	11.73	NA	36.45	NA	78.80	769
Trichospilus_pupivora	1.10	0.20	1.00	6.00	9.00	4.00	94.00	464.00	631
Zagrammosoma_americanum	NA	NA	NA	NA	NA	NA	5.00	NA	
Zagrammosoma_multilineatum	1.44	NA	NA	NA	NA	NA	1.00	NA	631
Eupelmidae									
Anastatus_albitarsis	NA	0.68	4.00	NA	14.00	NA	NA	64.00	631
Anastatus_amarus	NA	NA	NA	NA	NA	6.71	NA	NA	631
Anastatus_colemani	3.41	0.45	3.00	NA	8.00	8.79	1.00	46.00	631
Anastatus_floridanus	3.19	NA	NA	NA	NA	3.00	306.00	NA	631
Anastatus_japonicus	NA	NA	NA	NA	NA	12.00	NA	NA	631, 734
Anastatus_ramakrishnai	NA	NA	NA	NA	NA	9.08	NA	NA	631
Eupelmus_vuilleti	NA	NA	NA	NA	NA	18.00	NA	150.00	632
Eupelmus_australiensis	NA	NA	0.75	9.25	6.00	6.00	1.00	NA	631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Eurytomidae									
Eurytoma_goidanichi	NA	NA	NA	NA	NA	NA	NA	150.00	632
Eurytoma_nesiotes	NA	0.73	0.54	7.50	4.50	NA	1.00	NA	631
Evaniidae									
Evania_appendigaster	6.87	1.30	NA	NA	NA	17.50	1.00	NA	631
Prosevania_fuscipes	NA	1.26	NA	NA	NA	NA	1.00	NA	631
Figitidae									
Hexacola_websteri	NA	0.13	2.00	9.00	6.50	NA	NA	NA	631
Leptopilina_boulardi	NA	0.16	NA	NA	NA	12.60	NA	350.00	342, 632
Trybliographa_rapae	NA	NA	NA	NA	7.00	14.40	NA	74.00	632
Formicidae									
Acromyrmex_rugosus	5.00	0.40	17.70	27.40	19.80	39.67	NA	NA	772, 766, 632
Acromyrmex_subterraneus	NA	NA	21.27	21.40	17.07	NA	NA	NA	766, 644
Aphaenogaster_picea	3.80	NA	NA	NA	NA	3182.80	NA	NA	772, 758, 764
Atta_insularis	9.68	NA	15.50	17.00	14.00	NA	NA	NA	772, 766, 631
Atta_sexdens	12.71	0.57	25.00	22.00	10.00	NA	NA	NA	772, NA, 766, 633
Atta_texana	NA	NA	15.00	NA	14.00	NA	NA	NA	766, 633
Camponotus_clarithorax	8.70	NA	33.00	NA	NA	NA	NA	NA	772, 761, 631
Camponotus_festinatus	9.41	NA	NA	NA	NA	NA	NA	NA	772, 631
Camponotus_laevigatus	11.16	NA	22.50	13.00	23.00	NA	NA	NA	772, 761, 631
Camponotus_modoc	10.56	NA	21.00	13.00	21.00	NA	NA	NA	772, 761, 634
Camponotus_planatus	6.50	NA	28.00	12.00	NA	57.00	NA	NA	772, 761, 634
Camponotus_vicinus	11.02	NA	22.33	13.50	25.50	NA	NA	NA	772, 761, 654
Camponotus_vittatus	8.18	1.18	NA	NA	NA	NA	NA	NA	772, 770, 644
Cardiocondyla_obscurior	1.50	NA	NA	NA	NA	140.00	NA	499.00	756, 757, 631
Iridomyrmex_purpureus	8.02	NA	NA	NA	16.50	NA	NA	NA	772, 760
Lasius_neglectus	2.36	0.55	12.10	9.30	14.50	NA	NA	NA	772, 735

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Lasius_niger	4.98	NA	25.91	13.95	NA	NA	NA	NA	772, 736
Linepithema_humile	4.30	0.30	26.40	66.52	14.01	NA	NA	NA	342, 772, 737
Myrmecia_gulosa	16.32	NA	NA	NA	NA	608.33	NA	NA	772, 759
Myrmecia_nigriceps	12.64	NA	NA	NA	NA	821.25	NA	NA	772, 759
Myrmecia_nigrocincta	13.17	NA	NA	NA	NA	456.25	NA	NA	772, 759
Myrmecia_pilosula	6.35	NA	NA	NA	NA	486.67	NA	NA	772, 759
Myrmecia_vindex	12.56	NA	NA	NA	NA	1551.25	NA	NA	772, 759
Pheidole_megacephala	8.89	NA	14.75	23.25	15.00	NA	44.00	NA	772, 762
Rhytidoponera_purpurea	5.76	NA	NA	NA	NA	942.92	NA	NA	772, 759
Solenopsis_invicta	3.11	0.29	7.12	16.82	13.03	240.29	NA	NA	772, NA, 764, 765
Ibaliidae									
Ibalia_drewensi	12.50	0.34	15.00	67.50	21.50	37.00	1.00	NA	631
Ibalia_leucospoides	NA	NA	NA	NA	NA	NA	NA	500.00	632
Ichneumonidae									
Acaenitus_dubitator	11.50	NA	NA	NA	NA	NA	NA	NA	633, 631
Aclastus_gracilis	NA	NA	NA	NA	NA	NA	1.00	NA	631
Acrodactyla_degener	3.94	NA	NA	NA	15.00	NA	NA	NA	631, 633
Acrodactyla_quadrisculpta	4.73	NA	NA	NA	18.00	NA	NA	NA	631, 633
Acrolyta_nens	NA	NA	NA	NA	NA	32.00	NA	158.00	632, 651
Acropimpla_pictipes	7.77	NA	NA	NA	NA	NA	NA	NA	631
Adelognathus_brevicornis	3.00	NA	0.25	NA	NA	NA	NA	NA	633, 631
Adelognathus_granulatus	3.00	NA	0.50	3.20	13.80	21.00	2.50	19.20	633, 670, 631
Adelognathus_laevicollis	3.00	NA	0.25	NA	NA	NA	NA	NA	633, 631
Adelognathus_pusillus	3.00	NA	0.25	NA	NA	NA	NA	NA	633, 631
Afromelanichneumon_transvaalensis	12.75	NA	NA	NA	NA	82.00	NA	NA	631
Agriotypus_armatus	6.76	NA	7.00	NA	NA	9.00	1.00	51.00	631
Agriotypus_changbaishanus	7.50	NA	NA	NA	NA	NA	NA	NA	633, 631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Agriotypus_chaoi	6.00	NA	NA	NA	NA	NA	NA	NA	633, 718
Agriotypus_gracilis	6.50	0.85	NA	NA	NA	NA	NA	NA	342, 633, 718
Agriotypus_himalensis	9.00	NA	NA	NA	NA	NA	NA	NA	633, 718
Agriotypus_jilinensis	7.00	NA	NA	NA	NA	NA	NA	NA	633, 631
Agriotypus_kambaitensis	4.50	NA	NA	NA	NA	NA	NA	NA	633
Agriotypus_lui	7.80	NA	NA	NA	NA	NA	NA	NA	633
Agriotypus_maculiceps	6.50	NA	NA	NA	NA	NA	NA	NA	633
Agriotypus_masneri	7.20	NA	NA	NA	NA	NA	NA	NA	633
Agriotypus_silvestris	6.00	NA	NA	NA	NA	NA	NA	NA	633
Agriotypus_succinctus	6.00	NA	NA	NA	NA	NA	NA	NA	633, 631
Agriotypus_tangi	4.50	NA	NA	NA	NA	NA	NA	NA	633, 631
Agriotypus_townesi	5.20	NA	NA	NA	NA	NA	NA	NA	633, 631
Agriotypus_zhejiangensis	4.70	NA	NA	NA	NA	NA	NA	NA	633, 631
Agriotypus_zhengi	7.20	NA	NA	NA	NA	NA	NA	NA	633, 631
Agrothereutes_abbreviatus	8.00	1.28	1.75	6.00	11.00	NA	NA	NA	633, 631, 652
Agrothereutes_adustus	8.25	1.65	1.88	9.50	60.00	NA	1.00	NA	631, 656
Agrothereutes_exteremalis	NA	1.25	1.50	7.50	9.00	15.00	33.00	48.00	631
Agrothereutes_hospes	NA	NA	NA	NA	NA	25.21	NA	NA	632, 631
Agrothereutes_lanceolatus	10.00	NA	NA	NA	NA	23.91	1.00	67.86	633, 632, 672
Agrothereutes_minousubae	10.25	NA	NA	NA	NA	NA	1.00	NA	633, 638
Agrothereutes_tunetanus	9.50	1.25	1.54	7.29	8.00	42.50	NA	308.00	631
Agrypon_flaveolatum	13.55	NA	NA	NA	NA	NA	NA	NA	633, 631
Apechthis_ontario	9.50	NA	NA	NA	NA	NA	1.00	NA	633, 646
Apechthis_quadridentata	11.33	NA	NA	NA	NA	NA	NA	NA	631, 655
Aptesis_nigrocincta	NA	NA	NA	NA	NA	58.60	NA	20.20	632, 639
Australoglypta_latrobei	9.06	NA	NA	NA	4.00	6.29	1.00	NA	631
Banchus_flavescens	10.71	0.53	2.00	26.00	NA	NA	1.00	NA	631
Bathyplectes_anurus	3.41	0.23	4.00	19.50	NA	35.11	1.00	1200.00	631, 632, 638

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Bathyplectes_contracta	3.53	NA	NA	NA	NA	NA	1.00	NA	633, 658
Bathyplectes_curculionis	3.50	0.20	NA	NA	10.00	14.00	1.00	850.00	633, 660, 632
Bathyplectes_stenostigma	4.00	0.20	4.00	10.00	NA	13.00	1.00	996.00	633, 631, 659, 632
Bathyplectes_tristis	5.00	NA	NA	NA	NA	NA	1.00	NA	631, 719
Calliephialtes_notanda	9.50	NA	NA	NA	NA	NA	NA	NA	633, 631
Calliephialtes_grapholithae	10.34	1.85	1.50	13.00	7.50	NA	NA	65.00	631, 644
Campoletis_flavicincta	5.79	0.26	1.75	7.50	6.50	10.00	1.00	NA	631
Campoletis_grioti	6.00	NA	NA	NA	NA	NA	1.00	NA	633, 631
Campoletis_sonorensis	4.50	0.35	1.75	6.50	6.00	NA	1.00	NA	633, 733, 631
Campoplex_cursitans	5.00	NA	NA	NA	NA	NA	NA	NA	633, 631
Campoplex_dubitator	NA	NA	NA	NA	NA	16.50	NA	61.00	632, 631
Campoplex_frustranae	5.00	NA	NA	NA	NA	NA	1.00	NA	633, 631
Campoplex_haywardi	4.84	0.27	2.50	7.50	9.00	10.50	1.00	143.00	631
Campoplex_mutabilis	7.82	NA	NA	NA	NA	NA	NA	NA	631
Campoplex_punctulatus	6.00	NA	NA	NA	NA	NA	NA	NA	633
Centeterus_alternecoloratus	8.80	1.09	2.00	14.50	8.00	65.00	1.00	48.00	631
Cephaloglypta_murinanae	NA	NA	NA	NA	18.00	35.00	NA	NA	631, 678
Collyria_coxator	7.50	0.25	NA	NA	NA	NA	NA	NA	342, 633
Cratichneumon_sublatus	11.55	NA	NA	NA	NA	NA	NA	NA	631
Dentichasmias_busseolae	10.44	0.94	1.00	7.00	10.00	40.00	NA	157.00	631
Diadegma_chrysostictos	7.25	0.25	2.50	10.50	NA	14.00	1.00	NA	633
Diadegma_fenestrale	NA	0.32	1.25	14.50	3.50	5.50	1.00	NA	631
Diadegma_insulare	6.00	NA	NA	NA	NA	32.20	1.00	664.50	633, 632, 631
Diadegma_mollipla	NA	0.25	2.00	8.00	8.00	5.21	NA	54.00	631
Diadegma_ruficeps	6.14	NA	NA	NA	NA	NA	NA	NA	631
Diadegma_semiclausum	4.12	0.28	1.75	6.50	7.50	45.70	NA	376.00	342, 631, 632
Diadromus_collaris	NA	0.75	NA	NA	NA	19.60	NA	96.30	342, 632

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Diadromus_pulchellus	6.00	NA	1.50	NA	NA	NA	NA	NA	633
Diadromus_subtilicornis	NA	NA	NA	NA	NA	49.00	NA	114.40	632
Diaparsis_carinifer	3.88	NA	NA	NA	NA	NA	1.00	NA	631
Diplazon_laetatorius	5.94	0.64	3.50	22.50	11.00	37.00	NA	NA	342, 631, 633
Diplazon_pectoratorius	7.20	NA	NA	NA	NA	NA	NA	NA	633
Diplazon_tetragonus	5.50	1.39	NA	NA	NA	NA	NA	NA	342, 633
Diplazon_tibiatorius	7.43	NA	NA	NA	NA	NA	NA	NA	633
Diradops_bethunei	11.00	NA	NA	NA	NA	NA	NA	NA	633
Dirophanes_hariolus	7.25	NA	NA	NA	NA	NA	NA	NA	633
Dirophanes_maculicornis	8.03	NA	NA	NA	NA	NA	NA	NA	633
Dolophron_pedella	4.58	0.31	17.50	NA	NA	NA	NA	NA	631
Dusona_contumax	10.00	0.85	NA	8.00	NA	10.25	NA	NA	633
Eiphosoma_dentator	10.20	0.40	4.00	13.50	13.00	10.00	1.00	NA	631
Eiphosoma_vitticolle	14.50	NA	NA	9.00	NA	NA	1.00	NA	633
Endasys_subclavatus	7.25	NA	NA	NA	NA	NA	1.00	NA	633
Enizemum_ornatum	7.35	NA	NA	NA	NA	NA	NA	NA	633
Eriborus_terebrans	8.50	NA	NA	NA	NA	NA	1.00	NA	633
Eriborus_trochanteratus	7.50	NA	NA	NA	NA	NA	NA	NA	633
Euceros_albitarsus	10.00	NA	NA	NA	NA	NA	NA	NA	633
Euceros_frigidus	7.60	NA	NA	NA	NA	NA	NA	1000.00	633
Exenterus_abruptorius	9.25	0.35	9.00	31.50	NA	NA	1.00	NA	631
Exenterus_adspersus	7.70	0.50	6.00	26.50	17.50	NA	NA	NA	631
Exenterus_amictorius	9.02	0.52	4.71	25.00	37.50	NA	4.00	NA	631
Exenterus_canadensis	9.50	NA	9.79	NA	13.00	NA	1.00	NA	631
Exenterus_tricolor	6.80	0.50	15.00	13.00	4.50	NA	NA	NA	631
Exeristes_comstockii	9.50	NA	NA	NA	NA	NA	NA	NA	633
Exeristes_roborator	15.00	NA	NA	NA	NA	NA	NA	NA	633
Exochus_nigripalpis	6.50	NA	NA	NA	NA	NA	NA	NA	633

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Gambroides_javensis	13.50	1.50	1.94	5.50	10.50	10.58	1.00	NA	631
Gambrus_ultimus	9.50	NA	NA	NA	NA	NA	1.00	NA	633
Gelis_acarorum	4.59	NA	NA	NA	NA	NA	NA	NA	633
Gelis_agilis	4.59	NA	NA	NA	NA	62.50	NA	40.00	633, 632
Gelis_tenellus	3.70	NA	NA	NA	NA	NA	NA	NA	633
Glabridorsum_stokesii	NA	0.96	1.29	9.00	5.50	41.00	NA	224.00	631
Glypta_fufiscutellaris	5.70	0.35	6.00	15.00	NA	NA	1.00	NA	631
Glypta_fumiferanae	8.00	0.43	NA	NA	9.50	20.00	NA	103.00	631, 633
Glypta_haesitator	5.50	0.44	3.50	NA	7.00	24.50	1.00	NA	631
Gonotypus_melanostoma	5.00	NA	NA	NA	NA	NA	1.00	NA	633
Goryphus_nursei	7.15	1.55	1.62	13.50	8.60	49.00	1.00	105.00	631
Gregopimpla_inquisitor	NA	NA	NA	NA	22.50	NA	NA	NA	631
Grotea_anguina	15.50	NA	NA	NA	NA	NA	NA	NA	633
Grypocentrus_albipes	3.10	0.31	4.50	13.50	15.00	15.58	NA	96.00	631
Grypocentrus_apicalis	4.00	NA	NA	NA	NA	NA	NA	NA	633
Homaspis_interrupta	10.00	NA	NA	NA	NA	NA	1.00	NA	633
Hoplocryptus_signatorius	7.22	NA	NA	NA	NA	40.00	NA	NA	633
Hyposoter_didymator	6.49	0.30	NA	NA	6.50	NA	1.00	NA	342, 631
Hyposoter_exiguae	7.10	NA	2.00	8.58	5.50	16.70	1.00	NA	633, 631
Hyposoter_fugitivus	7.00	NA	NA	NA	NA	NA	1.00	NA	633
Hyposoter_horticola	7.50	NA	NA	NA	25.00	22.00	1.00	NA	633
Hyposoter_rivalis	NA	NA	NA	NA	11.00	14.00	NA	96.00	631
Ichneumon_caloscelis	11.50	NA	NA	NA	NA	NA	NA	NA	633
Ichneumon_gracilicornis	13.00	NA	NA	NA	NA	72.00	1.00	NA	633
Itamoplex_australis	11.83	NA	NA	NA	16.50	102.00	NA	NA	631
Itamoplex_inornatus	NA	1.75	1.50	6.50	5.50	46.08	1.00	113.00	631
Itoplectis_alternans	NA	1.10	NA	NA	NA	29.10	NA	NA	342, 632
Itoplectis_conquisitor	10.00	NA	NA	NA	NA	NA	NA	NA	633

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Itoplectis_cristatae	7.15	1.35	1.50	14.50	4.00	76.00	1.00	NA	631
Itoplectis_maculator	8.01	NA	NA	NA	NA	35.00	NA	NA	631
Itoplectis_naranyae	9.90	1.37	NA	NA	NA	33.10	1.00	NA	342, 633, 632
Itoplectis_quadricingulata	11.00	NA	NA	NA	NA	NA	1.00	NA	633
Lamachus_eques	9.52	0.70	15.00	NA	NA	NA	1.00	NA	631, 633
Lathrolestes_ensator	7.25	NA	14.00	8.00	NA	11.00	1.00	32.00	633
Lathrolestes_luteolator	6.50	NA	20.00	30.00	NA	NA	1.00	NA	633
Lathrolestes_nigricollis	4.20	NA	NA	NA	NA	19.00	NA	300.00	633, 632
Lathrostizus_euurae	4.90	0.46	NA	NA	6.00	NA	NA	NA	631
Lemophagus_curtus	4.73	0.21	8.00	NA	NA	37.00	1.00	NA	342, 631
Liotryphon_strobilellae	8.30	NA	NA	NA	NA	NA	NA	NA	633
Lissonota_dubia	5.00	NA	NA	NA	NA	NA	NA	NA	633
Lissonota_complicator	5.50	NA	NA	NA	NA	NA	6.00	NA	631
Lophyroplectus_oblongopunctatus	10.57	0.54	20.00	30.00	NA	9.50	1.00	194.00	631
Lysibia_nanus	NA	NA	NA	NA	NA	27.00	NA	178.00	632
Lytarmes_maculipennis	18.25	NA	NA	NA	NA	NA	NA	NA	633
Mastrus_ridibundus	7.00	NA	NA	NA	NA	26.00	4.00	40.00	633, 632
Megarhyssa_atrata	40.00	NA	NA	NA	NA	NA	1.00	NA	633
Melanichneumon_rubicundus	7.50	1.02	1.33	8.00	6.00	NA	1.00	86.00	631
Mesochorus_agilis	1.50	0.12	3.00	18.40	10.00	31.40	1.00	102.00	631, 633
Mesochorus_nigripes	NA	0.14	3.02	NA	7.50	22.60	1.00	NA	631
Mesostenus_gracilis	9.00	NA	NA	NA	NA	NA	NA	NA	633
Metopius_discolor	13.43	NA	NA	NA	NA	NA	NA	NA	631
Netelia_vinulae	17.00	NA	NA	NA	NA	NA	NA	NA	633
Oedemopsis_scabricula	6.75	NA	NA	NA	NA	NA	1.00	NA	633
Olesicampe_benefactor	7.00	NA	2.00	NA	NA	19.00	1.00	350.00	631
Olesicampe_geniculata	7.00	NA	NA	NA	NA	25.00	1.00	323.00	633
Olesicampe_macellator	8.00	NA	NA	NA	NA	NA	NA	NA	633

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Olesicampe_melanogaster	7.00	NA	2.00	NA	19.00	19.00	1.00	350.00	633
Olesicampe_monticola	8.16	NA	NA	NA	NA	19.00	1.00	NA	631
Olesicampe_ratzeburgi	11.50	0.74	NA	14.50	2.50	NA	NA	NA	631
Ophion_flavidus	17.50	NA	NA	NA	NA	NA	NA	NA	633
Parania_prima	9.34	NA	NA	NA	NA	NA	NA	NA	633
Perithous_divinator	8.75	2.20	NA	NA	NA	20.00	1.00	NA	633
Phaedroctonus_moderator	6.25	NA	NA	NA	NA	NA	NA	NA	633
Phaenolobus_terebrator	12.00	NA	NA	NA	NA	NA	NA	NA	633
Phaeogenes_maculicornis	8.03	NA	NA	NA	NA	NA	NA	NA	631
Phaeogenes_nigridens	8.00	1.00	2.00	7.50	4.50	43.00	1.00	NA	631
Phaeogenes_semivulpinus	7.34	NA	NA	NA	NA	NA	1.00	NA	631
Phobocampe_bicingulata	6.00	NA	NA	NA	NA	NA	NA	NA	633
Phobocampe_lymantriae	5.50	NA	NA	NA	NA	NA	NA	NA	633
Phobocampe_pallida	8.00	NA	NA	NA	NA	NA	1.00	NA	633
Phygadeuon_elegans	3.50	NA	NA	NA	NA	NA	1.00	NA	633
Phygadeuon_exiguus	5.00	NA	NA	NA	NA	NA	1.00	NA	633
Phygadeuon_trichops	4.25	0.75	2.50	18.50	NA	29.50	1.00	72.00	631
Phygadeuon_wiesmanni	3.40	NA	NA	NA	NA	NA	1.00	NA	633
Phytodietus_fumiferanae	7.50	NA	NA	NA	NA	NA	NA	NA	633
Pimpla_alboannulata	NA	1.43	NA	NA	NA	38.20	NA	NA	342, 632
Pimpla_luctuosa	NA	2.69	NA	NA	NA	38.20	NA	NA	342, 632
Pimpla_nipponica	NA	NA	NA	NA	NA	42.70	NA	57.90	632
Pimpla_pluto	NA	2.41	NA	NA	NA	41.50	NA	NA	342, 632
Pimpla_turionellae	8.81	1.62	3.00	8.00	8.00	40.00	NA	192.00	342, 631, 633
Pleolophus_basizonus	7.50	1.30	2.21	14.50	8.00	18.00	1.00	NA	631
Pleolophus_indistinctus	5.75	NA	3.00	21.00	11.79	28.71	1.00	54.00	633, 631
Pleolophus_larvicola	7.50	1.30	2.21	14.50	8.00	18.00	1.00	NA	633
Poecilostictus_cothurnatus	10.71	NA	NA	NA	NA	NA	1.00	NA	631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Polysphincta_tuberosa	6.08	NA	NA	NA	13.00	NA	NA	NA	631
Pristomerus_rufiabdominalis	7.50	NA	NA	NA	NA	NA	NA	NA	633
Pristomerus_vulnerator	9.00	NA	NA	NA	NA	3.80	NA	NA	633
Pseudorhyssa_maculicoxis	18.46	NA	2.00	12.50	NA	28.00	1.00	NA	631
Pseudorhyssa_sternata	20.84	NA	2.00	12.50	NA	28.00	3.00	NA	633
Pterocormus_suspiciosus	20.00	NA	NA	NA	11.00	NA	NA	NA	631
Rhyssa_persuasoria	28.15	NA	2.00	NA	NA	NA	1.00	NA	631
Scambus_atrocoxalis	5.25	NA	NA	NA	NA	NA	NA	NA	633
Scambus_brevicornis	6.73	1.40	1.50	6.83	6.50	42.00	1.00	NA	631
Scambus_canadensis	3.93	NA	NA	NA	NA	NA	NA	NA	633
Scambus_foliae	6.38	1.40	1.75	7.00	4.50	NA	NA	166.00	631, 633
Scambus_hispae	7.50	NA	NA	NA	NA	NA	NA	NA	633
Schizopyga_frigida	7.46	NA	NA	NA	14.71	NA	NA	NA	633
Sericompimpla_sericata	12.00	2.00	3.75	21.00	10.00	70.00	1.00	31.00	631
Sinophorus_crassifemur	10.67	NA	NA	NA	11.00	70.00	1.00	NA	631
Sinophorus_megalodontis	NA	0.97	NA	NA	NA	NA	1.00	NA	631
Sozites_kerichoensis	3.26	NA	NA	NA	NA	4.60	1.60	NA	631
Sphecophaga_vesparum	6.50	NA	NA	NA	NA	21.00	NA	NA	633
Stenichneumon_scutellator	11.72	NA	NA	NA	12.00	NA	1.00	44.00	631
Stilbops_limneriaeformis	5.00	NA	NA	NA	NA	NA	NA	NA	633
Stilbops_ruficornis	7.25	NA	NA	NA	NA	NA	NA	NA	633
Stilbops_vetulus	5.65	NA	NA	NA	NA	NA	NA	NA	633
Strictopisthus_laticeps	3.66	NA	NA	NA	NA	NA	NA	NA	633
Syrphoctonus_maculifrons	6.05	NA	3.00	25.00	12.50	33.00	1.00	NA	631
Syrphophilus_tricinctorius	5.58	NA	NA	NA	NA	NA	1.00	NA	633
Trathala_flavoorbitalis	7.80	0.51	3.50	15.00	7.00	NA	1.00	NA	631
Theronia_atalantae	10.50	2.22	NA	NA	NA	NA	1.00	NA	342, 633
Tranosema_pedella	3.66	0.31	21.00	NA	NA	NA	NA	NA	633

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Tranosema_rostrale	6.00	NA	NA	NA	NA	NA	1.00	NA	631
Trathala_flavoorbitalis	7.80	0.51	3.50	15.00	7.00	NA	1.00	NA	633
Triclistus_crassus	5.95	NA	NA	NA	NA	NA	NA	NA	633
Triclistus_emarginalus	3.00	NA	NA	NA	NA	NA	NA	NA	633
Triclistus_podagricus	4.50	NA	NA	NA	NA	NA	NA	NA	633
Triclistus_xylostellae	5.70	NA	NA	NA	NA	NA	NA	NA	633
Tycherus_nigridens	8.00	1.00	2.00	7.50	4.40	43.00	1.00	NA	633
Tycherus_osculator	6.31	NA	NA	NA	NA	390.00	1.00	NA	633
Venturia_canescens	7.00	NA	NA	NA	NA	36.00	NA	2700.00	633
Xanthocryptus_novozealandicus	12.50	NA	NA	NA	NA	NA	1.00	NA	633
Xanthopimpla_citrina	10.13	1.20	1.50	9.50	10.00	30.00	1.00	22.00	631
Xanthopimpla_stemmator	11.29	1.20	1.50	9.50	13.00	30.00	1.00	NA	631
Xorides_brachylabis	11.50	NA	NA	NA	NA	NA	NA	NA	633
Xorides_corcyrensis	16.50	NA	4.00	11.00	33.50	NA	1.00	NA	631
Zatypota_albicoxa	5.00	0.69	NA	NA	20.00	NA	NA	NA	342, 631
Zatypota_bohemani	4.12	NA	NA	NA	17.67	NA	NA	NA	631
Zatypota_percontatoria	4.71	NA	NA	NA	12.33	NA	NA	NA	631
Megachilidae									
Osmia_aurantiaca	NA	NA	NA	NA	25.00	NA	NA	NA	768
Osmia_latreillei	NA	NA	NA	23.50	27.00	NA	NA	NA	768
Osmia_lignaria	NA	NA	7.54	NA	30.78	3.39	NA	NA	740
Megaspilidae									
Dendrocerus_carpenteri	NA	0.25	NA	NA	NA	NA	NA	75.00	342, 632
Melittidae									
Dasypoda_thoracica	13.79	5.32	6.50	7.50	NA	NA	NA	NA	700
Hesperapis_rhodocerata	NA	2.83	NA	NA	NA	NA	NA	NA	703
Macropis_europaea	NA	3.70	3.50	14.00	NA	NA	2.00	NA	701
Macropis_fulvipes	NA	3.95	3.50	15.00	NA	NA	2.50	NA	701

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Melitta_leporina	NA	2.74	3.50	15.50	NA	NA	10.50	NA	702
Mymaridae									
Anagrus_epos	NA	NA	NA	NA	NA	NA	1.00	NA	631
Anagrus_incarnatus	NA	0.22	1.00	5.00	5.50	NA	NA	NA	731, 631
Anaphes_behmani	NA	NA	NA	NA	NA	NA	1.00	NA	696
Anaphes_calendrae	0.95	0.22	0.21	11.79	6.62	NA	1.00	NA	631
Anaphes_iole	NA	NA	NA	NA	NA	10.80	NA	62.00	632, 631
Anaphes_nitens	0.73	NA	NA	NA	NA	14.36	1.00	32.60	631, 632, 633
Anaphes_ovijenatus	0.60	NA	NA	NA	NA	NA	1.00	NA	631, 633
Anaphes_sordidatus	NA	NA	NA	NA	NA	6.50	1.00	90.00	631, 633
Gonatocerus_ashmeadi	NA	0.33	NA	NA	NA	13.80	NA	139.30	342, 632
Gonatocerus_deleoni	NA	NA	NA	NA	NA	9.00	NA	150.00	632
Polynema_striaticorne	1.60	0.25	NA	NA	NA	NA	1.00	NA	631
Pamphiliidae									
Acantholyda_erythrocephala	NA	NA	14.00	NA	NA	NA	15.00	NA	636, 689
Cephalcia_arvensis	NA	1.65	16.00	37.50	17.50	NA	NA	23.64	638, 631
Cephalcia_californica	9.30	2.50	24.00	33.00	NA	NA	9.00	24.00	640, 631
Cephalcia_fascipennis	NA	2.30	21.00	30.00	14.00	6.50	NA	23.00	641, 631
Cephalcia_frontalis	NA	2.30	29.00	50.00	NA	NA	NA	NA	640, 631
Cephalcia_fulviceps	NA	2.00	25.00	29.00	NA	NA	NA	NA	640, 631
Cephalcia_isshikii	NA	NA	NA	38.50	25.39	NA	NA	NA	637, 631
Cephalcia_provancheri	NA	NA	NA	30.00	NA	NA	NA	NA	640, 633
Cephalcia_semidea	NA	1.80	18.00	37.00	NA	8.00	NA	NA	640, 633
Pamphilius_ishikawai	NA	NA	9.50	18.50	NA	NA	NA	NA	635
Pamphilius_vafer	NA	1.70	NA	16.05	14.00	NA	NA	NA	639
Pergidae									
Haplostegus_epimelas	9.25	NA	10.00	29.00	21.55	2.50	NA	90.50	650
Haplostegus_nigricrus	10.10	NA	9.00	30.00	NA	NA	27.25	72.67	648

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Heteroperreyia_hubrichi	NA	NA	13.00	NA	60.83	7.50	NA	116.50	651
Lophyrotoma_zonalis	NA	NA	24.50	35.00	NA	5.00	25.00	140.00	649
Phylacteophaga_froggatti	NA	0.67	11.00	15.00	10.00	10.00	NA	NA	704
Tequus_schrottkyi	NA	NA	NA	NA	9.00	NA	NA	NA	647
Perilampidae									
Perilampus_tristis	3.00	NA	NA	NA	NA	NA	NA	NA	631
Platygastridae									
Amitus_bennetti	NA	NA	NA	NA	NA	6.82	NA	78.80	632, 644
Amitus_burrelli	NA	NA	NA	NA	NA	NA	NA	565.00	724, 632
Amitus_hesperidum	NA	NA	NA	NA	NA	4.10	NA	NA	632, 638
Platygaster_demades	NA	NA	NA	NA	NA	NA	NA	1380.00	632
Platygaster_foersteri	1.64	NA	NA	NA	NA	3.50	4.00	220.00	631
Platygaster_hiemalis	NA	NA	NA	NA	NA	NA	NA	3322.00	632
Platygaster_oryzae	0.95	NA	NA	NA	NA	1.50	60.00	900.00	631
Pompilidae									
Anoplius_cylindricus	8.00	NA	NA	NA	NA	NA	NA	NA	707, 631
Anoplius_marginalis	15.00	NA	NA	NA	NA	NA	1.00	NA	707, 658
Dipogon_sayi	NA	1.00	2.00	9.50	11.50	NA	NA	NA	706
Pepsis_cerberus	20.40	4.25	3.40	20.60	16.20	NA	1.00	12.74	708
Pepsis_mexicana	21.30	4.31	3.40	22.00	16.20	NA	1.00	11.82	708
Pompilus_scelestus	13.50	2.00	NA	NA	NA	NA	NA	NA	342, 707
Priochilus_captivum	NA	NA	NA	NA	NA	90.00	NA	NA	709
Proctotrupidae									
Codrus_carolinensis	NA	NA	NA	NA	6.00	NA	4.00	NA	631
Pteromalidae									
Anisopteromalus_schwenkei	1.80	0.38	1.17	6.00	3.50	23.00	1.00	50.00	631, 633
Apocrypta_westwoodi	NA	NA	NA	NA	NA	12.90	NA	103.75	728, 667
Asaphes_lucens	NA	0.25	4.00	11.50	5.50	NA	NA	NA	631, 633

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Asaphes_vulgaris	3.30	NA	2.50	NA	15.00	NA	NA	NA	631
Callitula_bicolor	1.70	0.38	2.00	9.50	8.00	37.70	1.00	50.00	631, 633
Catolaccus_aeneoviridis	NA	0.40	1.17	3.67	7.50	24.83	NA	NA	631
Catolaccus_grandis	NA	NA	NA	NA	NA	19.40	NA	680.00	632, 633
Dibrachoides_druso	3.00	0.42	1.75	5.33	5.00	62.00	3.70	122.00	631
Dibrachys_boarmiae	2.90	0.36	1.96	7.08	6.50	31.08	51.70	501.00	631
Dibrachys_cavus	1.30	NA	NA	NA	NA	28.00	2.40	66.00	631
Dinarmus_acutus	2.75	0.51	2.40	12.83	8.67	67.80	NA	35.00	631
Dinarmus_basalis	NA	NA	NA	NA	12.00	64.40	NA	392.80	632
Hypopteromalus_tabacum	2.26	0.32	1.25	4.00	4.50	NA	1.00	NA	631
Lariophagus_distinguendus	NA	NA	NA	NA	NA	39.73	NA	100.00	632
Mesopolobus_bruchophagi	NA	NA	1.50	5.00	4.00	30.42	1.00	486.00	631
Mesopolobus_subfumatus	1.75	0.45	NA	NA	2.50	NA	9.50	NA	631
Nasonia_vitripennis	2.35	0.39	NA	NA	NA	20.50	20.00	203.50	342, 631, 632
Pachycrepoideus_vindemmiae	NA	0.29	0.67	10.25	7.50	26.02	1.00	122.00	631, 632
Pachyneuron_albutius	NA	NA	3.50	10.50	7.00	28.00	18.00	NA	631
Pachyneuron_muscarum	1.22	NA	NA	NA	NA	33.50	1.00	NA	631
Pteromalus_cerealellae	NA	0.55	1.50	5.50	6.50	44.00	1.00	676.00	631
Pteromalus_hunteri	NA	NA	NA	NA	NA	47.20	NA	466.35	632
Pteromalus_veneris	3.30	NA	2.00	5.00	4.50	NA	17.00	NA	631
Roptrocerus_xylophagorum	3.14	NA	1.08	NA	NA	7.92	1.00	76.00	631
Sisyridivora_cavigena	2.85	0.40	1.00	7.00	6.00	NA	1.00	NA	631
Spalangia_cameroni	2.63	NA	NA	NA	NA	11.40	1.00	28.00	631
Spalangia_drosophilae	1.16	0.17	3.00	8.50	6.50	15.40	1.00	NA	631
Sphegigaster_flavicornis	2.41	0.34	5.50	18.50	5.50	NA	1.00	NA	631
Theocolax_formiciformis	2.55	NA	10.50	40.00	32.50	25.00	NA	17.00	631
Trichomalopsis_americanus	NA	0.36	2.60	9.40	7.40	NA	NA	244.00	631
Trichomalus_fasciatus	NA	NA	NA	12.29	7.71	NA	1.00	NA	631

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Sapygidae									
Sapyga_luteomaculata	NA	2.03	NA	NA	NA	NA	1.00	NA	696
Scelionidae									
Ascolus_seychellensis	NA	NA	NA	NA	NA	51.00	NA	84.00	631
Eumicrosoma_beneficum	0.75	0.23	1.00	7.00	12.00	11.00	1.00	54.00	631
Gryon_ajax	1.40	0.21	0.79	5.50	9.50	12.00	1.00	16.00	631
Gryon_antestiae	1.08	NA	NA	NA	NA	6.00	1.00	34.00	631
Gryon_gnidus	1.21	NA	NA	NA	NA	18.00	1.00	28.00	631
Platytelenomus_busseolae	0.77	0.14	1.50	8.75	14.50	20.50	1.00	81.00	631
Scelio_aegypticus	NA	NA	2.50	10.50	7.50	20.00	1.00	135.00	631
Scelio_hieroglyphi	NA	NA	1.50	12.00	7.50	35.00	1.00	30.00	631
Telenomus_alsophilae	NA	NA	NA	NA	NA	NA	1.00	NA	
Telenomus_calvus	NA	NA	NA	NA	NA	33.71	1.00	54.00	631
Telenomus_chloropus	NA	NA	NA	NA	NA	8.50	1.00	94.00	631
Telenomus_coelodasidis	NA	NA	NA	NA	NA	10.50	1.00	NA	631
Telenomus_cosmopeplae	0.85	0.20	0.46	4.54	4.50	NA	1.00	NA	631
Telenomus_costalima	NA	NA	0.71	6.29	13.00	NA	1.00	NA	631
Telenomus_remus	0.54	NA	0.62	11.79	5.00	NA	1.00	NA	631
Telenomus_sechellensis	1.19	NA	NA	NA	NA	4.00	1.00	12.00	631
Telenomus_ulyetti	0.45	NA	NA	NA	NA	NA	1.00	NA	631
Trissolcus_plautiae	NA	NA	NA	NA	NA	NA	NA	172.00	632
Signiphoridae									
Signiphora_borinquensis	NA	NA	NA	NA	NA	25.00	NA	25.00	632
Siricidae									
Sirex_noctilio	18.65	NA	NA	NA	NA	NA	NA	88.00	664
Tenthredinidae									
Aneugmenus_merida	6.05	NA	5.40	22.10	7.30	3.50	NA	35.00	680, 631
Athalia_rosae	7.00	0.80	5.00	8.50	5.50	14.00	NA	100.00	666, 632

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Caliroa_matsumotonis	4.05	0.80	9.50	19.50	13.50	4.50	NA	23.00	679, 633
Caliroa_quercuscoccineae	5.08	NA	10.50	15.55	9.10	8.00	24.00	NA	671, 668, 631
Dineura_stilata	4.63	NA	NA	NA	NA	NA	NA	NA	672
Dineura_testaceipes	4.16	NA	NA	NA	NA	NA	NA	NA	672
Dineura_virididorsata	5.98	NA	NA	NA	NA	NA	NA	NA	672
Eriocampa_ovata	8.00	NA	8.00	21.93	22.83	7.50	NA	76.29	673
Erythraspides_interstitalis	NA	NA	NA	15.00	10.00	NA	NA	NA	653
Euura_lasiolepis	NA	0.57	19.00	101.00	15.00	4.65	NA	NA	676
Fenusella_nana	NA	0.60	NA	NA	NA	NA	NA	NA	667
Formosempria_varipes	6.62	NA	7.00	11.00	NA	NA	NA	NA	693
Heterarthrus_ochropoda	5.25	NA	NA	NA	NA	NA	NA	NA	683
Nematus_medunai	8.38	1.80	12.00	32.00	14.00	NA	NA	50.00	682
Nematus_oligospilus	6.55	NA	7.00	21.50	9.78	NA	NA	31.00	685
Nematus_salicis	8.75	1.46	NA	NA	NA	NA	NA	NA	681
Pristiphora_subarctica	6.17	1.14	4.50	NA	8.00	3.25	NA	44.20	684
Profenusa_alumna	3.65	0.70	15.00	37.00	12.00	NA	NA	NA	675
Profenusa_lucifex	NA	0.70	NA	NA	NA	NA	NA	NA	669
Rhadinoceraea_bensoni	NA	1.20	12.00	19.00	NA	NA	NA	NA	674
Xenapates_braunsi	9.42	NA	NA	NA	NA	NA	NA	NA	692
Xenapates_gaullei	7.94	NA	NA	NA	NA	NA	NA	NA	692
Tetracampidae									
Dipriocampe_diprioni	1.20	0.25	NA	NA	NA	28.00	1.00	NA	631
Thynnidae									
Pterombrus_piceus	NA	1.00	5.00	10.50	20.00	NA	1.00	NA	697
Tiphiidae									
Tiphia_berbereti	NA	NA	NA	NA	NA	NA	1.00	NA	
Tiphia_pygidialis	NA	NA	6.00	NA	NA	32.00	NA	22.00	698
Torymidae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Monodontomerus_aereus	2.90	NA	NA	NA	NA	66.50	3.00	NA	631
Monodontomerus_dentipes	3.13	0.70	NA	24.50	21.00	NA	4.50	NA	631
Trichogrammatidae									
Oligositoides_semicinctum	0.83	NA	NA	NA	NA	5.50	1.00	NA	631
Trichogramma_brevicapillum	NA	0.14	1.00	4.00	5.00	7.00	1.00	47.00	631
Trichogramma_evanescens	0.56	0.10	NA	NA	NA	8.91	1.00	59.38	342, 631, 755
Trichogramma_minutum	0.45	0.11	0.83	3.96	2.96	6.92	1.00	NA	631
Trichogramma_nubilale	NA	NA	NA	NA	NA	12.10	NA	78.55	632
Trichogramma_platneri	NA	0.11	0.83	3.96	2.96	6.71	1.00	NA	631
Trichogramma_semifumatum	0.45	NA	NA	NA	NA	NA	2.00	NA	631
Trichogrammatoidea_armigera	0.48	0.15	1.00	3.00	4.00	11.00	1.00	118.00	631
Trichogrammatoidea_bactrae	0.34	NA	NA	NA	NA	8.71	NA	133.00	631
Trigonalidae									
Bareogonalos_canadensis	NA	NA	NA	NA	NA	8.84	NA	NA	729, 643
Taeniogonalos_thwaitesii	NA	0.12	NA	0.07	NA	NA	NA	10641.00	730
Vespidae									
Ancistrocerus_catskill	NA	NA	NA	8.50	NA	NA	NA	NA	705, 631
Ancistrocerus_tigris	NA	NA	NA	9.00	24.50	NA	NA	NA	705, 631
Eumenes_mediterraneus	NA	NA	2.00	NA	NA	NA	1.00	NA	768
Polistes_canadensis	NA	NA	NA	NA	NA	193.86	NA	NA	767
Rhynchium_oculatum	NA	4.30	NA	NA	NA	NA	NA	17.50	768
Rygchium_lecucomelas	NA	NA	5.00	10.00	NA	NA	NA	NA	705
Symmorphus_cristatus	NA	NA	NA	12.50	NA	NA	NA	NA	705
Vespula_germanica	NA	NA	5.50	10.50	NA	NA	NA	NA	745
Vespula_maculifrons	NA	NA	5.20	13.50	NA	NA	NA	NA	745
Vespula_vidua	NA	NA	7.00	11.00	NA	NA	NA	NA	745
Vespula_vulgaris	NA	NA	4.00	NA	NA	NA	NA	NA	745
Xyelidae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Xyela_gallicaulis	NA	0.76	NA	35.00	NA	NA	NA	NA	634
Lepidoptera									
Crambidae									
Loxostege_sticticalis	12.00	NA	3.83	95.50	16.00	NA	NA	346.00	NA, 792
Ostrinia_nubilalis	NA	NA	NA	NA	NA	13.00	NA	NA	781
Pleuroptya_ruralis	NA	NA	NA	NA	NA	37.00	NA	NA	781
Erebidae									
Estigmene_acrea	NA	NA	4.88	21.79	10.69	9.05	NA	789.00	803
Histioea_cepheus	20.39	1.50	5.00	35.00	13.00	NA	NA	NA	815
Hyphantria_cunea	NA	NA	12.75	42.52	20.29	NA	NA	484.20	807, 808
Pararctica_subnebulosa	12.40	NA	NA	NA	23.00	NA	NA	NA	809
Pareuchaetes_insulata	NA	NA	4.80	18.88	10.62	5.71	NA	387.62	806
Gelechiidae									
Pectinophora_gossypiella	NA	NA	6.03	25.61	9.70	17.85	NA	75.45	803
Phthorimaea_operculella	9.40	1.00	4.71	13.09	9.01	22.00	NA	164.00	784, 781
Geometridae									
Biston_betularia	NA	0.75	NA	NA	NA	4.40	NA	NA	342, 781, 773
Biston_pinarius	NA	NA	NA	NA	NA	9.90	NA	NA	781, 773
Hepialidae									
Aenetus_virescens	NA	NA	19.00	800.00	162.00	NA	NA	1700.00	775, 773
Dumbletonius_enysii	42.75	0.80	NA	NA	NA	NA	NA	9500.00	779
Endoclita_signifer	53.50	0.60	15.00	471.46	60.83	7.00	NA	9161.00	777, 773
Oncopera_parva	NA	NA	NA	NA	25.73	NA	NA	NA	776
Oxycanus_fuscomaculatus	NA	0.78	131.53	81.90	70.00	NA	NA	1797.00	778
Hesperiidae									
Amblyscirtes_simius	NA	NA	NA	NA	NA	9.18	NA	NA	798, 773
Carcharodus_alceae	NA	NA	NA	NA	NA	21.00	NA	NA	798, 773
Carcharodus_lavatherae	NA	NA	NA	NA	NA	16.00	NA	NA	798, 773

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Carterocephalus_palaemon	12.40	0.60	10.00	291.00	42.00	16.00	NA	NA	NA, 773, 797
Carterocephalus_silvicola	NA	NA	NA	NA	NA	16.00	NA	NA	798, 805
Erynnis_tages	10.50	0.50	14.00	NA	34.00	14.00	NA	NA	NA, 773, 798
Hesperia_comma	16.10	0.90	NA	100.00	14.00	22.33	NA	NA	NA, 773, 798
Heteropterus_morpheus	NA	NA	17.50	NA	NA	16.00	NA	NA	773, 797
Ochlodes_faunus	NA	NA	NA	NA	NA	22.50	NA	NA	798
Ochlodes_sylvanus	NA	0.80	14.00	330.00	21.00	NA	NA	NA	773
Pyrgus_alveus	NA	NA	NA	NA	NA	26.00	NA	NA	798
Pyrgus_armoricanus	NA	NA	NA	NA	NA	16.00	NA	NA	798
Pyrgus_carthami	NA	NA	NA	NA	NA	16.00	NA	NA	798
Pyrgus_cirsii	NA	NA	NA	NA	NA	26.00	NA	NA	798
Pyrgus_malvae	9.90	0.60	9.00	60.83	273.75	14.00	NA	NA	NA, 773, 798
Pyrgus_serratulae	NA	NA	NA	NA	NA	16.00	NA	NA	798
Spialia_sertorius	NA	NA	NA	NA	NA	16.00	NA	NA	798
Thymelicus_acteon	12.20	1.60	21.00	NA	14.00	19.67	NA	NA	NA, 773, 798
Thymelicus_lineola	12.30	0.80	21.00	65.00	21.00	26.00	NA	NA	NA, 773, 798
Thymelicus_sylvestris	12.40	0.85	21.00	311.00	14.00	23.00	NA	NA	NA, 773, 798
Lycaenidae									
Arhopala_aurea	NA	NA	NA	NA	NA	20.20	NA	NA	798, 797
Aricia_agestis	9.79	0.50	7.00	NA	NA	26.00	NA	NA	NA, 773, 798, 790
Aricia_artaxerxes	9.70	NA	NA	NA	NA	23.00	NA	NA	NA, 798, 794, 795
Aricia_eumedon	NA	NA	NA	NA	NA	19.90	NA	NA	798, 836
Bindahara_phocides	NA	NA	NA	NA	NA	12.35	NA	NA	798, 773
Caleta_elna	NA	NA	NA	NA	NA	6.55	NA	NA	798, 773
Callophrys_mossii	NA	NA	NA	NA	NA	10.03	NA	NA	798, 780
Callophrys_rubi	10.90	0.65	10.50	NA	304.17	29.50	NA	NA	NA, 773, 798

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Callophrys_xami	NA	NA	NA	NA	NA	25.18	NA	NA	798, 857
Celastrina_argiolus	10.60	0.60	14.00	26.00	17.50	16.00	NA	NA	NA, 773, 798, 807
Cupido_argiades	NA	0.40	6.00	NA	12.00	23.00	NA	NA	773, 798
Cupido_minimus	8.09	0.40	14.00	NA	14.00	13.00	NA	NA	NA, 773, 798
Cyaniris_semiargus	11.00	0.60	10.50	NA	21.00	19.00	NA	NA	NA, 773, 798
Discolampa_ethion	NA	NA	NA	NA	NA	3.50	NA	NA	798
Eumaeus_minyas	NA	NA	NA	NA	NA	14.00	NA	NA	798
Euphilotes_battoides	NA	NA	NA	NA	NA	8.32	NA	NA	798
Euphilotes_enoptes	NA	NA	NA	NA	NA	9.43	NA	NA	798
Favonius_quercus	NA	0.80	132.17	45.00	28.00	NA	NA	NA	773
Glaucopsyche_alexis	NA	NA	NA	NA	NA	16.00	NA	NA	798
Jalmenus_avagoras	NA	NA	NA	NA	NA	23.50	NA	NA	781
Jalmenus_evagoras	NA	NA	NA	NA	NA	28.00	NA	NA	798
Jamides_pura	NA	NA	NA	NA	NA	4.35	NA	NA	798
Lampides_boeticus	10.22	0.50	7.00	24.50	10.00	26.00	NA	NA	NA, 773, 798
Leptotes_pirithous	NA	NA	NA	NA	NA	21.00	NA	NA	798
Lycaena_alciphron	NA	NA	NA	NA	NA	16.00	NA	NA	798
Lycaena_dispar	14.70	0.65	14.00	319.38	24.50	29.50	NA	NA	NA, 773, 798
Lycaena_helle	NA	NA	NA	NA	NA	16.31	NA	NA	798
Lycaena_hippothoe	NA	NA	NA	NA	NA	19.40	NA	NA	798
Lycaena_phlaeas	11.80	0.60	10.50	NA	24.50	21.00	NA	NA	NA, 773, 798
Lycaena_tityrus	NA	NA	NA	NA	NA	15.99	NA	NA	798
Lycaena_virgaureae	NA	NA	NA	NA	NA	37.00	NA	NA	798
Lycaena_xanthoides	NA	NA	NA	NA	NA	11.25	NA	NA	798
Lysandra_coridon	10.90	0.50	243.33	66.50	28.00	NA	NA	NA	NA, 773
Neozephyrus_quercus	NA	NA	NA	NA	NA	37.00	NA	NA	798
Phengaris_alcon	NA	NA	NA	NA	NA	12.00	NA	NA	798

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Phengaris_arion	NA	0.50	7.50	NA	20.50	10.67	NA	NA	773, 798
Phengaris_nausithous	NA	NA	NA	NA	NA	11.84	NA	NA	798
Phengaris_rebeli	NA	NA	NA	NA	NA	4.31	NA	NA	798
Phengaris_teleius	NA	NA	NA	NA	NA	8.80	NA	NA	798
Plebejus_argus	9.93	0.60	243.33	NA	17.50	20.80	NA	NA	NA, 773, 798
Plebejus_argyrognomon	NA	NA	NA	NA	NA	19.00	NA	NA	798
Plebejus_icarioides	NA	NA	NA	NA	NA	9.72	NA	NA	798
Plebejus_idas	NA	NA	NA	NA	NA	22.50	NA	NA	798
Plebejus_optilete	NA	NA	NA	NA	NA	12.00	NA	NA	798
Polyommatus_amandus	NA	NA	NA	NA	NA	20.25	NA	NA	798
Polyommatus_bellargus	NA	0.50	10.50	1.00	21.00	20.94	NA	NA	773, 798
Polyommatus_coridon	NA	NA	NA	NA	NA	24.65	NA	NA	798
Polyommatus_damon	NA	NA	NA	NA	NA	29.50	NA	NA	798
Polyommatus_daphnis	NA	NA	NA	NA	NA	29.50	NA	NA	798
Polyommatus_dorylas	NA	NA	NA	NA	NA	29.50	NA	NA	798
Polyommatus_icarus	12.00	0.60	7.00	42.00	14.00	15.85	NA	NA	NA, 773, 798
Polyommatus_thersites	NA	NA	NA	NA	NA	23.00	NA	NA	798
Prosotas_nora	NA	NA	NA	NA	NA	4.60	NA	NA	798
Pseudophilotes_baton	NA	NA	NA	NA	NA	13.40	NA	NA	798
Rapala_dieneces	NA	NA	NA	NA	NA	14.35	NA	NA	798
Satyrium_acaciae	NA	NA	NA	NA	NA	16.00	NA	NA	798
Satyrium_ilicis	NA	NA	NA	NA	NA	21.00	NA	NA	798
Satyrium_pruni	10.10	0.80	273.75	10.00	21.00	16.00	NA	NA	NA, 773, 798
Satyrium_spini	NA	NA	NA	NA	NA	26.00	NA	NA	798
Satyrium_w-album	11.00	0.80	NA	53.00	24.50	37.00	NA	NA	NA, 773, 798
Scolitantides_orion	NA	NA	NA	NA	NA	12.00	NA	NA	798
Thecla_betulae	12.80	0.65	NA	NA	28.00	52.50	NA	40.00	NA, 773, 798
Lymantriidae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Lymantria_dispar	NA	0.85	NA	NA	NA	10.50	NA	NA	342, 781
Lymantria_monacha	NA	0.86	NA	NA	NA	10.00	NA	NA	342, 781
Orgyia_antiqua	NA	0.95	NA	NA	NA	7.00	NA	NA	342, 781
Orgyia_leucostigma	12.00	NA	NA	38.50	14.00	NA	NA	175.00	817
Micropterigidae									
Epimartyria_pardella	3.50	0.44	21.00	NA	NA	13.50	NA	NA	774
Noctuidae									
Achaea_janata	24.75	0.88	3.15	15.45	11.00	8.00	NA	525.00	811, 812, 773
Aucula_franclemonti	NA	1.02	4.00	NA	NA	NA	NA	NA	780, 816
Calyptra_canadensis	NA	0.73	NA	31.50	14.00	NA	NA	NA	816, 773
Diparopsis_castanea	NA	NA	NA	NA	NA	10.80	NA	NA	781
Euxoa_messoria	NA	0.59	14.00	87.00	22.13	13.55	NA	1298.20	802, 801
Gonodonta_pyrgo	NA	NA	2.50	12.00	7.50	4.00	NA	NA	818
Helicoverpa_zea	NA	0.57	3.31	20.15	12.76	16.46	NA	859.00	804, 803
Heliothis_virescens	NA	0.56	3.25	15.95	13.70	17.84	NA	863.50	804, 803, 781
Melipotis_indomita	NA	0.70	5.00	24.70	13.75	9.65	NA	746.00	813, 814
Panolis_flammea	NA	0.54	NA	NA	NA	19.00	NA	NA	342, 781
Spodoptera_exempta	NA	NA	3.08	12.30	7.06	11.64	NA	936.83	803, 781
Spodoptera_exigua	NA	NA	NA	NA	NA	13.00	NA	NA	781
Trichoplusia_ni	15.90	0.40	3.15	12.68	7.49	15.03	NA	552.67	342, 803
Zale_phaeograpta	17.90	0.80	4.10	35.90	14.50	29.10	NA	281.00	810
Nymphalidae									
Actinote_pellenea	NA	NA	NA	NA	NA	9.60	NA	NA	798, 780
Actinote_zikani	NA	NA	NA	NA	NA	6.35	NA	NA	798, 836
Aeria_olena	NA	NA	NA	NA	NA	67.75	NA	NA	798, 773
Aglais_io	20.25	0.80	14.00	27.00	21.00	NA	NA	NA	NA, 773, 775
Aglais_urticae	28.50	NA	14.00	27.00	21.00	51.50	NA	1000.00	NA, 773, 798
Amnosia_decora	NA	NA	NA	NA	NA	11.00	NA	NA	798, 773

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Anetia_jaegeri	NA	NA	4.00	14.00	12.00	NA	NA	NA	805, 844
Apatura_ilia	NA	NA	NA	NA	NA	26.00	NA	NA	798, 774
Apatura_iris	20.00	1.00	9.50	300.00	14.00	26.00	NA	NA	NA, 773, 798, 786
Aphantopus_hyperantus	13.20	0.80	17.50	NA	14.00	23.00	NA	NA	NA, 773, 798, 775
Araschnia_levana	NA	NA	NA	NA	NA	11.30	NA	NA	798, 775
Archaeoprepona_demophon	NA	NA	NA	NA	NA	31.00	NA	NA	798, 773
Arethusana_arethusa	NA	0.80	NA	NA	NA	26.00	NA	NA	342, 798, 773
Argynnis_adippe	23.40	0.80	243.33	63.00	21.00	37.00	NA	NA	NA, 773, 798, 775
Argynnis_aglaja	20.60	1.00	17.50	287.00	24.50	23.00	NA	NA	NA, 773, 798
Argynnis_mormonia	NA	NA	NA	NA	NA	21.20	NA	NA	798, 773
Argynnis_niobe	NA	NA	NA	NA	NA	21.00	NA	NA	798, 773
Argynnis_paphia	20.77	1.00	15.00	NA	17.50	44.00	NA	NA	NA, 773, 798
Aterica_galene	NA	NA	NA	NA	NA	68.00	NA	NA	798, 774
Athyma_perius	NA	NA	NA	NA	NA	23.00	NA	NA	798, 774
Bassarona_dunya	NA	NA	NA	NA	NA	84.67	NA	NA	798, 773
Bassarona_teuta	NA	NA	NA	NA	NA	101.00	NA	NA	798, 780
Bebearia_absolon	NA	NA	NA	NA	NA	36.00	NA	NA	798, 802
Bebearia_sophus	NA	NA	NA	NA	NA	63.00	NA	NA	798, 773
Bicyclus_anynana	NA	NA	NA	NA	NA	28.80	NA	NA	798, 844
Bicyclus_auricruda	NA	NA	NA	NA	NA	171.00	NA	NA	798, 773
Bicyclus_graueri	NA	NA	NA	NA	NA	87.67	NA	NA	798, 775
Bicyclus_mandanes	NA	NA	NA	NA	NA	92.00	NA	NA	798, 773
Bicyclus_mollitia	NA	NA	NA	NA	NA	89.00	NA	NA	798, 775
Bicyclus_sebetus	NA	NA	NA	NA	NA	172.00	NA	NA	798, 775
Boloria_aquilonaris	NA	NA	NA	NA	NA	16.00	NA	NA	798, 773

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Boloria_dia	NA	NA	NA	NA	NA	19.00	NA	NA	798, 773
Boloria_eunomia	NA	NA	NA	NA	NA	13.37	NA	NA	798, 850
Boloria_euphrosyne	17.30	0.80	14.00	324.00	21.00	19.00	NA	NA	NA, 773, 798, 850
Boloria_selene	16.80	0.60	14.00	317.00	17.50	16.00	NA	NA	NA, 773, 798
Brassolis_sophorae	NA	NA	NA	NA	NA	9.00	NA	NA	781, 773
Brenthis_daphne	NA	NA	NA	NA	NA	21.35	NA	NA	798, 775
Brenthis_ino	NA	NA	NA	NA	NA	19.00	NA	NA	798, 773
Brintesia_circe	NA	NA	NA	NA	NA	41.55	NA	NA	798, 773
Caligo_atreus	NA	NA	NA	NA	NA	102.00	NA	NA	798, 785
Caligo_eurilochus	NA	NA	NA	NA	NA	84.00	NA	NA	798, 773
Caligo_memnon	NA	NA	NA	NA	NA	64.25	NA	NA	798, 773
Catonephele_numilia	NA	1.00	NA	NA	NA	22.00	NA	NA	342, 798, 841
Cethosia_biblis	NA	NA	NA	NA	NA	13.50	NA	NA	798
Cethosia_hypsea	NA	NA	NA	NA	NA	15.00	NA	NA	798
Charaxes_bipunctatus	NA	NA	NA	NA	NA	22.00	NA	NA	798
Charaxes_candiope	NA	NA	NA	NA	NA	48.50	NA	NA	798
Charaxes_cynthia	NA	NA	NA	NA	NA	63.00	NA	NA	798
Charaxes_etheocles	NA	NA	NA	NA	NA	5.00	NA	NA	798
Charaxes_fulvescens	NA	NA	NA	NA	NA	93.38	NA	NA	798
Charaxes_numenes	NA	NA	NA	NA	NA	34.75	NA	NA	798
Charaxes_pollux	NA	NA	NA	NA	NA	16.25	NA	NA	798
Charaxes_tiridates	NA	NA	NA	NA	NA	40.50	NA	NA	798
Chazara_briseis	NA	0.99	NA	NA	NA	29.80	NA	NA	342, 798
Cirrochroa_tyche	NA	NA	NA	NA	NA	5.00	NA	NA	798
Coelites_euptychioides	NA	NA	NA	NA	NA	16.50	NA	NA	798
Coenonympha_arcania	NA	0.95	NA	NA	NA	16.00	NA	NA	342, 798
Coenonympha_glycerion	NA	NA	NA	NA	NA	16.00	NA	NA	798

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Coenonympha_hero	NA	NA	NA	NA	NA	14.00	NA	NA	798
Coenonympha_oedippus	NA	NA	NA	NA	NA	14.00	NA	NA	798
Coenonympha_pamphilus	11.30	0.70	14.00	178.00	21.00	20.82	NA	NA	NA, 773, 798
Coenonympha_tullia	NA	0.80	14.00	NA	21.00	12.00	NA	NA	773, 798
Colobura_dirce	NA	NA	NA	NA	NA	25.00	NA	NA	798
Cymothoe_herminia	NA	NA	NA	NA	NA	25.67	NA	NA	798
Cymothoe_lurida	NA	NA	NA	NA	NA	36.67	NA	NA	798
Cynthia_cardui	NA	NA	NA	NA	NA	51.50	NA	NA	798
Danaus_affinis	NA	NA	NA	NA	NA	9.00	NA	NA	798
Danaus_chrysippus	NA	NA	NA	NA	NA	13.00	NA	NA	798
Danaus_gilippus	NA	NA	NA	NA	NA	7.00	NA	NA	798
Danaus_plexippus	34.00	1.30	3.50	16.00	14.00	39.83	NA	NA	NA, 773, 781, 798
Dircenna_dero	NA	NA	NA	NA	NA	23.07	NA	NA	798
Discophora_necho	NA	NA	NA	NA	NA	24.00	NA	NA	798
Doleschallia_bisaltide	NA	NA	NA	NA	NA	11.50	NA	NA	798
Dophla_evelina	NA	NA	NA	NA	NA	6.00	NA	NA	798
Dryadula_phaetusa	NA	1.61	NA	NA	NA	29.00	NA	NA	342, 798
Dryas_iulia	NA	1.19	NA	NA	NA	39.70	NA	NA	342, 798
Erebia_aethiops	14.40	1.30	17.50	329.00	17.50	19.00	NA	NA	NA, 773, 798
Erebia_epiphron	11.96	1.00	17.50	288.00	21.00	9.35	NA	70.00	NA, 773, 798
Erebia_ligea	NA	1.10	NA	NA	NA	26.00	NA	NA	342, 798
Erebia_manto	NA	NA	NA	NA	NA	14.00	NA	NA	798
Erebia_medusa	NA	0.95	NA	NA	NA	16.00	NA	NA	342, 798
Erebia_meolans	NA	1.16	NA	NA	NA	19.00	NA	NA	342, 798
Erebia_sudetica	NA	NA	NA	NA	NA	4.00	NA	NA	798
Eryphanis_polyxena	NA	NA	NA	NA	NA	37.00	NA	NA	798
Eueides_isabella	NA	NA	NA	NA	NA	22.00	NA	NA	798

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Euphaedra_alacris	NA	NA	NA	NA	NA	110.00	NA	NA	798
Euphaedra_christyi	NA	NA	NA	NA	NA	32.00	NA	NA	798
Euphaedra_eusemoides	NA	NA	NA	NA	NA	64.00	NA	NA	798
Euphaedra_harpalyce	NA	NA	NA	NA	NA	218.00	NA	NA	798
Euphaedra_hollandi	NA	NA	NA	NA	NA	69.00	NA	NA	798
Euphaedra_kakamegae	NA	NA	NA	NA	NA	65.00	NA	NA	798
Euphaedra_medon	NA	NA	NA	NA	NA	121.33	NA	NA	798
Euphaedra_preussi	NA	NA	NA	NA	NA	70.00	NA	NA	798
Euphaedra_spatiosa	NA	NA	NA	NA	NA	38.25	NA	NA	798
Euphaedra_uganda	NA	NA	NA	NA	NA	86.17	NA	NA	798
Euphydryas_aurinia	15.30	0.80	24.50	NA	21.00	12.35	300.00	NA	NA, 773, 798
Euphydryas_chalcedona	NA	NA	NA	NA	NA	12.87	NA	NA	798
Euphydryas_editha	NA	NA	NA	NA	NA	12.56	NA	NA	781, 798
Euphydryas_maturna	NA	NA	NA	NA	NA	14.00	NA	NA	798
Euphydryas_minuta	NA	NA	NA	NA	NA	7.00	NA	NA	798
Euploea_core	NA	NA	NA	NA	NA	48.50	NA	NA	798
Euploea_mulciber	NA	NA	NA	NA	NA	67.50	NA	NA	798
Euptoieta_hegesia	NA	NA	NA	NA	NA	9.05	NA	NA	798
Euriphene_ribensis	NA	NA	NA	NA	NA	36.00	NA	NA	798
Euryphura_chalcis	NA	NA	NA	NA	NA	35.00	NA	NA	798
Euxanthe_crossleyi	NA	NA	NA	NA	NA	21.50	NA	NA	798
Faunis_gracilis	NA	NA	NA	NA	NA	20.50	NA	NA	798
Gnophodes_betsimena	NA	NA	NA	NA	NA	119.00	NA	NA	798
Gnophodes_chelys	NA	NA	NA	NA	NA	98.00	NA	NA	798
Gnophodes_grogani	NA	NA	NA	NA	NA	31.83	NA	NA	798
Greta_oto	NA	NA	NA	NA	NA	8.00	NA	NA	798
Hamadryas_amphinome	NA	0.91	NA	NA	NA	22.00	NA	NA	342, 798
Hamadryas_februa	NA	1.21	NA	NA	NA	70.00	NA	NA	342, 798

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Hamadryas_fornax	NA	NA	NA	NA	NA	21.00	NA	NA	798
Hamadryas_guatemalena	NA	1.37	NA	NA	NA	19.00	NA	NA	342, 798
Harma_theobene	NA	NA	NA	NA	NA	54.33	NA	NA	798
Heliconius_charithonia	NA	NA	NA	NA	NA	75.26	NA	NA	781, 798
Heliconius_cydno	NA	NA	NA	NA	NA	47.20	NA	NA	781, 798
Heliconius_eleuchia	NA	NA	NA	NA	NA	45.00	NA	NA	798
Heliconius_erato	NA	1.49	NA	NA	NA	93.00	NA	NA	342, 798
Heliconius_ethilla	NA	1.44	NA	NA	NA	106.00	NA	NA	342, 798
Heliconius_hecale	NA	NA	NA	NA	NA	125.70	NA	NA	781, 798
Heliconius_ismenius	NA	NA	NA	NA	NA	147.00	NA	NA	798
Heliconius_melpomene	NA	NA	NA	NA	NA	150.00	NA	NA	798
Heliconius_sapho	NA	NA	NA	NA	NA	21.00	NA	NA	798
Heliconius_sara	NA	NA	NA	NA	NA	56.00	NA	NA	798
Heterosais_edessa	NA	NA	NA	NA	NA	32.60	NA	NA	798
Hipparchia_alcyone	NA	NA	NA	NA	NA	45.85	NA	NA	798
Hipparchia_fagi	NA	1.07	NA	NA	NA	37.00	NA	NA	342, 798
Hipparchia_fidia	NA	NA	NA	NA	NA	69.45	NA	NA	798
Hipparchia_semele	17.40	0.80	17.50	NA	28.00	37.00	NA	NA	NA, 773, 798
Hipparchia_statilinus	NA	NA	NA	NA	NA	55.15	NA	NA	798
Historis_odius	NA	NA	NA	NA	NA	23.00	NA	NA	798
Hypna_clytemnestra	NA	NA	NA	NA	NA	29.00	NA	NA	798
Hypolimnas_bolina	NA	NA	NA	NA	NA	32.45	NA	NA	798
Hyponephele_lycaon	NA	0.82	NA	NA	NA	29.50	NA	NA	342, 798
Hypothyris_ninonia	NA	NA	NA	NA	NA	33.77	NA	NA	798
Idea_leuconoe	NA	NA	NA	NA	NA	90.50	NA	NA	798
Ideopsis_juventa	NA	NA	NA	NA	NA	34.00	NA	NA	798
Ideopsis_vulgaris	NA	NA	NA	NA	NA	23.00	NA	NA	798
Inachis_io	NA	NA	NA	NA	NA	32.50	NA	NA	798

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Issoria_lathonia	16.60	6.00	7.00	24.50	NA	21.00	NA	NA	NA, 773, 798
Ithomia_drymo	NA	NA	NA	NA	NA	17.82	NA	NA	798
Junonia_atlites	NA	NA	NA	NA	NA	98.00	NA	NA	798
Kallima_limborgii	NA	NA	NA	NA	NA	165.00	NA	NA	798
Kallimoides_rumia	NA	NA	NA	NA	NA	74.00	NA	NA	798
Lasiommata_maera	NA	1.14	NA	NA	NA	19.00	NA	NA	342, 798
Lasiommata_megera	14.40	0.91	10.00	28.00	14.00	16.73	NA	NA	NA, 773, 798
Lasiommata_petropolitana	NA	0.92	NA	NA	NA	14.00	NA	NA	342, 798
Lexias_dirtea	NA	NA	NA	NA	NA	27.27	NA	NA	798
Lexias_pardalis	NA	NA	NA	NA	NA	56.00	NA	NA	798
Limenitis_camilla	17.70	0.91	7.00	NA	17.50	28.50	NA	NA	NA, 773, 798
Limenitis_populi	NA	NA	NA	NA	NA	23.00	NA	NA	798
Limenitis_reducta	NA	NA	NA	NA	NA	23.00	NA	NA	798
Lopinga_achine	NA	1.07	NA	NA	NA	14.00	NA	NA	342, 798
Lycorea_cleobaea	NA	NA	NA	NA	NA	21.00	NA	NA	798
Maniola_jurtina	18.00	0.50	21.00	252.00	24.50	27.38	NA	NA	NA, 773, 798
Mechanitis_lysimnia	NA	NA	NA	NA	NA	43.20	NA	NA	798
Mechanitis_polymnia	NA	NA	NA	NA	NA	41.00	NA	NA	798
Melanargia_galathea	17.00	1.00	21.00	340.00	21.00	20.78	NA	NA	NA, 773, 798
Melanitis_leda	NA	NA	NA	NA	NA	56.00	NA	NA	798
Melinaea_ethra	NA	NA	NA	NA	NA	13.70	NA	NA	798
Melinaea_ludovica	NA	NA	NA	NA	NA	14.10	NA	NA	798
Mellicta_athalia	17.00	0.51	14.00	315.00	14.00	23.50	NA	NA	NA, 773, 798
Melitaea_aurelia	NA	0.50	NA	NA	NA	21.00	NA	NA	342, 798
Mellicta_britomartis	NA	NA	NA	NA	NA	16.00	NA	NA	798
Melitaea_cinxia	13.40	0.50	17.50	NA	21.00	14.00	NA	NA	NA, 773, 798
Melitaea_diamina	NA	NA	NA	NA	NA	16.00	NA	NA	798
Melitaea_didyma	NA	0.71	NA	NA	NA	18.17	NA	NA	342, 798

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Mellicta_parthenoides	NA	NA	NA	NA	NA	16.00	NA	NA	798
Melitaea_phoebe	NA	NA	NA	NA	NA	26.00	NA	NA	798
Minois_dryas	NA	0.82	NA	NA	NA	29.50	NA	NA	342, 798
Morpho_catenarius	NA	NA	NA	NA	NA	23.00	NA	NA	798
Morpho_peleides	NA	NA	NA	NA	NA	25.50	NA	NA	798
Morpho_polyphemus	NA	NA	NA	NA	NA	26.00	NA	NA	798
Mycalesis_maianeas	NA	NA	NA	NA	NA	24.45	NA	NA	798
Mycalesis_perseus	NA	NA	NA	NA	NA	15.93	NA	NA	781, 798
Mycalesis_sirius	NA	NA	NA	NA	NA	17.33	NA	NA	781, 798
Mycalesis_terminus	NA	NA	NA	NA	NA	19.76	NA	NA	781, 798
Myscelia_cyaniris	NA	NA	NA	NA	NA	184.00	NA	NA	798
Myscelia_ethusa	NA	NA	NA	NA	NA	232.00	NA	NA	798
Neominois_ridingsii	NA	NA	NA	NA	NA	13.10	NA	NA	798
Neorina_lowii	NA	NA	NA	NA	NA	66.00	NA	NA	798
Neptis_hylas	NA	NA	NA	NA	NA	44.00	NA	NA	798
Nymphalis_antiopa	23.60	0.91	20.00	NA	21.00	NA	NA	450.00	NA, 773
Nymphalis_polychloros	11.30	0.80	21.00	1.00	14.00	NA	166.00	NA	NA, 773
Oeneis_chryxus	NA	NA	NA	NA	NA	9.00	NA	NA	798
Pararge_aegeria	14.50	0.80	14.00	116.00	18.50	25.14	NA	NA	NA, 773, 798
Parthenos_sylvia	NA	NA	NA	NA	NA	91.50	NA	NA	798
Placidina_euryanassa	NA	NA	NA	NA	NA	20.90	NA	NA	798
Polygonia_c-album	24.70	0.80	17.50	35.00	14.00	51.50	NA	275.00	NA, 773, 798
Precis_coenia	NA	NA	NA	NA	NA	22.95	NA	NA	798
Prothoe_franck	NA	NA	NA	NA	NA	69.00	NA	NA	798
Pseudacraea_lucretia	NA	NA	NA	NA	NA	12.33	NA	NA	798
Pseudoscada_erruca	NA	NA	NA	NA	NA	17.45	NA	NA	798
Pyronia_tithonus	12.30	0.65	17.50	240.00	21.00	29.50	NA	150.00	NA, 773, 798
Ragadia_makuta	NA	NA	NA	NA	NA	10.55	NA	NA	798

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Siproeta_epaphus	NA	NA	NA	NA	NA	21.00	NA	NA	798
Siproeta_stelenes	NA	NA	NA	NA	NA	32.00	NA	NA	798
Speyeria_mormonia	NA	NA	NA	NA	NA	21.20	NA	NA	781
Tanaecia_T_sp	NA	NA	NA	NA	NA	10.35	NA	NA	798
Thauria_aliris	NA	NA	NA	NA	NA	10.75	NA	NA	798
Tirumala_hamata	NA	NA	NA	NA	NA	10.00	NA	NA	798
Tirumala_limniace	NA	NA	NA	NA	NA	18.00	NA	NA	798
Tirumala_septentrionis	NA	NA	NA	NA	NA	96.00	NA	NA	798
Tithorea_harmonia	NA	NA	NA	NA	NA	22.00	NA	NA	798
Vanessa_atalanta	22.10	0.80	7.00	24.50	17.50	51.50	NA	NA	NA, 773, 798
Vanessa_cardui	21.30	0.65	7.00	27.50	14.00	NA	NA	NA	NA, 773
Vindula_arsinoe	NA	NA	NA	NA	NA	21.00	NA	NA	798
Vindula_dejone	NA	NA	NA	NA	NA	21.00	NA	NA	798
Xanthotaenia_busiris	NA	NA	NA	NA	NA	6.70	NA	NA	798
Oecophoridae									
Hofmannophila_pseudospretella	NA	0.54	32.37	71.00	35.86	13.24	NA	381.50	793
Papilionidae									
Atrophaneura_alcinous	NA	NA	NA	NA	NA	8.29	NA	NA	798, 781
Atrophaneura_polyeuctes	NA	NA	NA	NA	NA	18.00	NA	NA	798, 773
Battus_polydamas	NA	NA	NA	NA	NA	35.00	NA	NA	798, 773
Chilasa_clytia	NA	NA	NA	NA	NA	4.00	NA	NA	798
Graphium_agamemnon	NA	NA	NA	NA	NA	6.50	NA	NA	798
Graphium_doson	NA	NA	NA	NA	NA	7.00	NA	NA	798
Graphium_evemon	NA	NA	NA	NA	NA	4.05	NA	NA	798
Graphium_sarpedon	NA	NA	NA	NA	NA	3.40	NA	NA	798
Iphiclides_podalirius	NA	1.18	NA	NA	NA	19.00	NA	NA	342, 798
Pachliopta_aristolochiae	NA	NA	NA	NA	NA	20.00	NA	NA	798
Pachliopta_kotzebuea	NA	NA	NA	NA	NA	5.00	NA	NA	798

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Papilio_anchisiades	NA	NA	NA	NA	NA	25.00	NA	NA	798
Papilio_bianor	NA	NA	NA	NA	NA	9.00	NA	NA	798
Papilio_cresphontes	NA	NA	NA	NA	NA	14.00	NA	NA	798
Papilio_dardanus	NA	NA	NA	NA	NA	5.00	NA	NA	798
Papilio_demetrius	NA	NA	NA	NA	NA	15.00	NA	NA	798
Papilio_dialis	NA	NA	NA	NA	NA	5.00	NA	NA	798
Papilio_glaucus	NA	NA	NA	NA	NA	18.00	NA	NA	798
Papilio_machaon	20.60	9.00	7.00	28.00	NA	20.00	NA	NA	NA, 773, 798
Papilio_palamedes	NA	NA	NA	NA	NA	7.00	NA	NA	798
Papilio_palinurus	NA	NA	NA	NA	NA	26.00	NA	NA	798
Papilio_paris	NA	NA	NA	NA	NA	14.00	NA	NA	798
Papilio_polymnestor	NA	NA	NA	NA	NA	11.00	NA	NA	798
Papilio_polytes	NA	NA	NA	NA	NA	39.00	NA	NA	798
Papilio_protenor	NA	NA	NA	NA	NA	9.00	NA	NA	798
Papilio_thaiwanus	NA	NA	NA	NA	NA	3.00	NA	NA	798
Papilio_thoas	NA	NA	NA	NA	NA	12.00	NA	NA	798
Papilio_troilus	NA	NA	NA	NA	NA	10.00	NA	NA	798
Papilio_xuthus	NA	NA	NA	NA	NA	20.00	NA	NA	798
Parides_anchises	NA	NA	NA	NA	NA	20.77	NA	NA	798
Parides_arcas	NA	NA	NA	NA	NA	103.00	NA	NA	798
Parides_eurimedes	NA	NA	NA	NA	NA	30.00	NA	NA	798
Parides_iphidamas	NA	NA	NA	NA	NA	56.00	NA	NA	798
Parides_montezuma	NA	NA	NA	NA	NA	26.00	NA	NA	798
Parides_photinus	NA	NA	NA	NA	NA	28.00	NA	NA	798
Parnassius_apollo	NA	0.85	NA	NA	NA	26.00	NA	NA	342, 798
Parnassius_mnemosyne	NA	0.88	NA	NA	NA	20.18	NA	NA	342, 798
Troides_brookiana	NA	NA	NA	NA	NA	10.80	NA	NA	798
Pieridae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Anteos_clorinde	NA	NA	NA	NA	NA	16.00	NA	NA	798, 783
Anthocharis_cardamines	15.50	1.21	10.50	24.50	NA	13.43	NA	NA	NA, 773, 798, 775
Aporia_crataegi	20.20	0.94	17.50	NA	21.00	12.00	NA	NA	NA, 773, 798
Appias_lyncida	NA	NA	NA	NA	NA	8.85	NA	NA	798, 786
Ascia_monuste	NA	1.37	NA	NA	NA	18.00	NA	NA	342, 798, 773
Cepora_iudith	NA	NA	NA	NA	NA	3.80	NA	NA	798, 773
Colias_alfacariensis	20.00	NA	8.50	NA	14.00	21.00	NA	NA	NA, 773, 798
Colias_crocea	NA	NA	NA	NA	NA	29.50	NA	NA	798
Colias_croceus	17.20	1.10	7.00	31.50	17.50	NA	NA	500.00	NA, 773
Colias_eurytheme	NA	1.26	NA	NA	NA	15.62	NA	NA	342, 781, 798
Colias_hyale	17.70	1.10	10.00	1.00	14.00	21.00	NA	NA	NA, 773, 798
Colias_myrmidone	NA	NA	NA	NA	NA	21.00	NA	NA	798
Colias_palaeno	NA	1.50	NA	NA	NA	16.00	NA	NA	342, 798
Eurema_andersoni	NA	NA	NA	NA	NA	4.75	NA	NA	798
Eurema_elathea	NA	NA	NA	NA	NA	53.60	NA	NA	798
Eurema_hecabe	NA	NA	NA	NA	NA	13.00	NA	NA	798
Eurema_nicevillei	NA	NA	NA	NA	NA	4.20	NA	NA	798
Eurema_simulatrix	NA	NA	NA	NA	NA	4.55	NA	NA	798
Gandaca_harina	NA	NA	NA	NA	NA	4.75	NA	NA	798
Gonepteryx_rhamni	19.70	1.30	10.50	1.00	14.00	NA	NA	NA	NA, 773
Leptidea_juvernica	13.40	NA	14.00	NA	NA	NA	NA	NA	NA, 773
Leptidea_reali	NA	NA	NA	NA	NA	12.80	NA	NA	798
Leptidea_sinapis	14.20	1.30	14.00	30.00	156.08	13.47	NA	NA	NA, 773, 798
Leptidea_sinapis/reali	NA	NA	NA	NA	NA	17.35	NA	NA	798
Phoebis_philea	NA	1.24	NA	NA	NA	15.00	NA	NA	342, 798
Phoebis_sennae	NA	1.12	NA	NA	NA	18.00	NA	NA	342, 798

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Pieris_brassicae	20.80	1.21	10.50	30.00	128.67	41.33	NA	600.00	NA, 773, 781, 798
Pieris_napi	15.30	1.00	7.00	24.50	10.00	27.25	NA	NA	NA, 773, 781, 798
Pieris_rapae	16.60	1.04	7.00	21.00	NA	18.33	NA	NA	342, 773, 781, 798
Pontia_daplidice	18.30	0.86	7.00	24.50	NA	19.00	NA	NA	NA, 773, 798
Plutellidae									
Plutella_xylostella	6.00	0.44	7.36	12.12	10.21	25.83	NA	149.41	783, 782, 781
Pyralidae									
Cadra_cautella	8.20	0.46	7.07	50.03	10.12	11.25	NA	116.70	342, 789, 790, 781, 773
Ephestia_kuehniella	8.80	0.52	4.03	42.08	8.68	9.21	NA	266.16	342, 791, 781
Plodia_interpunctella	6.43	0.49	2.75	12.20	6.00	11.50	NA	127.84	342, 799, 781, 800, 801
Riodinidae									
Apodemia_mormo	NA	NA	NA	NA	NA	13.22	NA	NA	798, 773
Hamearis_lucina	10.10	0.60	14.00	42.00	NA	12.00	NA	NA	NA, 773, 798
Laxita_teneta	NA	NA	NA	NA	NA	7.15	NA	NA	798
Menander_felsina	NA	NA	NA	NA	NA	24.00	NA	NA	798
Paralaxita_telesia	NA	NA	NA	NA	NA	8.30	NA	NA	798
Sesiidae									
Synanthedon_pictipes	NA	0.62	9.00	NA	25.00	9.20	NA	65.00	786, 781
Synanthedon_tipuliformis	NA	0.64	12.51	NA	20.88	5.74	NA	71.60	785
Tineidae									
Dasyses_rugosella	7.10	0.80	5.10	42.35	11.90	5.88	NA	107.40	797
Opogona_sacchari	7.49	0.52	6.35	22.61	16.62	17.92	NA	332.04	795, 794
Tineola_bisselliella	6.50	0.50	15.00	NA	NA	25.50	NA	95.00	796

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Torticidae									
Zeiraphera_canadensis	NA	NA	NA	22.50	18.15	13.00	NA	27.35	787, 781, 788
Mantophasmatodea									
Austrophasmatidae									
Karoophasma_biedouwense	15.76	2.20	NA	21.00	NA	NA	11.00	75.00	388, 387, 386
Mantophasmatidae									
Tyrannophasma_gladiator	32.00	NA	NA	NA	NA	NA	28.00	NA	389
Mecoptera									
Bittacidae									
Bittacus_stigmaterus	17.00	0.60	226.84	28.00	16.90	5.00	NA	60.00	836, 839
Harpobittacus_tillyardi	NA	0.55	57.00	193.50	32.00	NA	NA	NA	837
Boreidae									
Boreus_notoperates	3.30	0.55	24.00	NA	53.23	19.00	NA	32.00	834, 821
Caurinus_dectes	NA	0.60	NA	25.00	NA	79.50	NA	32.20	835, 821
Panorpidae									
Panorpa_nuptialis	NA	1.07	8.00	27.00	20.00	30.42	16.00	NA	833
Megaloptera									
Corydalidae									
Nigronia_fasciatus	25.00	1.23	14.00	1095.00	21.00	10.00	NA	NA	342, 831
Protohermes_grandis	40.00	1.29	13.75	547.50	9.59	21.43	NA	NA	830, 829
Protohermes_immaculatus	NA	1.12	13.90	730.00	10.25	31.70	NA	NA	830
Sialidae									
Sialis_californica	NA	NA	8.40	266.70	6.60	5.00	550.00	NA	832
Sialis_cornuta	NA	1.00	12.00	NA	30.42	7.00	592.85	NA	828
Sialis_rotunda	NA	NA	8.30	224.84	5.40	5.00	400.00	NA	832
Neuroptera									
Ascalaphidae									
Ascaloptynx_furciger	NA	2.25	NA	96.00	NA	NA	40.00	NA	844, 852

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Ululodes_mexicanus	NA	1.80	15.50	NA	18.00	NA	41.00	NA	844, 845
Ululodes_quadripunctatus	24.10	NA	NA	NA	47.00	NA	NA	NA	850, 849
Berothidae									
Lomamyia_latipennis	NA	0.60	7.00	36.30	20.00	NA	NA	NA	847, 846
Mucroberotha_vesicaria	4.50	0.74	NA	NA	NA	NA	NA	NA	853, 848
Chrysopidae									
Italochrysa_insignis	NA	1.56	NA	NA	NA	NA	NA	NA	854
Nothochrysa_californica	9.00	1.32	NA	NA	NA	NA	NA	NA	342, 855
Coniopterygidae									
Conwentzia_pineticola	NA	0.44	8.00	11.00	9.00	42.00	NA	140.00	856
Cryptoscenea_australiensis	NA	0.40	NA	NA	NA	NA	NA	NA	883
Semidalis_vicina	2.75	0.61	12.23	17.82	12.93	27.50	NA	150.67	857, 860, 858
Spiloconis_picticornis	NA	0.53	16.00	17.50	15.50	56.00	NA	NA	861
Dilaridae									
Nallachius_americanus	NA	0.37	15.33	NA	NA	NA	NA	NA	863, 862
Nallachius_pulchellus	3.50	NA	NA	NA	NA	NA	NA	NA	864
Hemerobiidae									
Drepanepteryx_phalaenoides	10.60	NA	NA	NA	17.50	NA	NA	NA	866, 867
Notiobiella_viridis	3.75	NA	NA	NA	NA	NA	NA	NA	865
Psychobiella_sordida	6.00	NA	NA	NA	NA	NA	NA	NA	865
Ithonidae									
Oliarces_clara	0.64	NA	NA	NA	NA	NA	NA	NA	868
Mantispidae									
Ditaxis_biseriata	21.00	0.83	12.00	NA	NA	NA	120.00	NA	869
Mantispa_capeneri	NA	0.38	NA	NA	NA	NA	723.50	NA	848
Plega_dactylota	10.93	NA	NA	NA	NA	NA	NA	NA	873
Zeugomantispa_minuta	9.75	NA	10.00	21.75	15.00	5.50	528.00	NA	871, 872, 869, 870

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Myrmeleontidae									
Aeropteryx_brocki	53.00	NA	NA	NA	NA	NA	NA	NA	874, 844
Stilbopteryx_costalis	44.50	NA	NA	NA	NA	NA	NA	NA	875
Nemopteridae									
Austrocroce_attenuata	10.00	NA	NA	NA	NA	NA	NA	NA	876, 844
Chasmoptera_huttii	14.50	NA	NA	NA	NA	NA	NA	NA	879, 882
Croce_filipennis	7.00	0.52	10.86	NA	20.00	NA	NA	NA	882, 880
Dielocroce_ephemera	15.00	0.75	NA	NA	NA	NA	NA	NA	878, 877
Dielocroce_hebraea	NA	NA	NA	NA	36.00	NA	NA	NA	877
Lertha_barbara	14.00	NA	NA	NA	NA	NA	NA	NA	882
Lertha_extensa	13.10	0.98	NA	NA	NA	NA	NA	NA	881, 882, 877
Lertha_sheppardi	13.25	0.78	NA	NA	NA	NA	NA	NA	882, 877
Nemoptera_bipennis	15.00	0.84	NA	NA	NA	NA	NA	NA	882, 877
Nemoptera_coa	13.00	NA	NA	NA	NA	NA	NA	NA	882
Odonata									
Aeshnidae									
Aeshna_affinis	46.00	NA	13.00	2.95	NA	NA	NA	NA	897, 913; 914; 919; 923; 932; 965; 990
Aeshna_caerulea	61.75	NA	NA	36.00	NA	NA	NA	NA	897, 913; 923; 932; 965; 990; 1030
Aeshna_cyanea	70.75	1.88	243.00	27.00	NA	NA	NA	NA	913, 923; 932; 965; 966; 990; 1030; 1048
Aeshna_grandis	64.12	1.60	NA	42.00	NA	NA	NA	NA	897, 913; 932; 965; 943; 990; 1030; 1048

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Aeshna_juncea	65.62	1.60	289.00	42.00	NA	NA	NA	NA	897, 913; 923; 926; 932; 965; 990; 1001; 1030; 1048
Aeshna_mixta	55.25	1.52	35.00	10.50	NA	NA	NA	NA	913, 919; 932; 965; 990; 1030; 1048
Aeshna_viridis	50.50	1.65	NA	24.00	NA	NA	NA	NA	897, 923; 932; 965; 1048
Anacia_isosceles	57.88	1.65	44.25	18.00	NA	NA	NA	NA	897, 913; 923; 926; 932; 965; 990; 1030; 1048
Anaciaeschna_jaspidea	40.75	NA	NA	NA	NA	NA	NA	NA	903, 923; 1030
Anax_epiphiger	52.25	NA	NA	NA	NA	NA	NA	NA	903, 919; 932; 942; 990; 1021
Anax_guttatus	57.50	1.65	16.00	NA	NA	NA	NA	NA	903, 1023; 1024; 1025; 1026
Anax_immaculifrons	68.50	NA	NA	NA	NA	NA	NA	NA	903, 923
Anax_imperator	66.50	1.77	30.00	6.40	NA	60.00	NA	NA	897, 912; 913; 932; 942; 943; 965; 990; 1030; 1048; 1065
Anax_junius	75.50	1.51	6.50	11.50	NA	30.00	NA	NA	884, 897; 923; 942; 983; 989; 990; 1001; 1029; 1056
Anax_parthenope	49.50	1.50	49.00	24.00	NA	NA	NA	NA	1048

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Boyeria_vinosa	11.80	NA	NA	NA	NA	NA	NA	NA	897, 901; 990; 1010; 1012; 1030
Brachytron_pratense	49.25	1.50	35.00	18.00	NA	NA	NA	NA	897, 913; 932; 943; 965; 990; 1030; 1048
Caliaeschna_microstigma	59.50	NA	NA	NA	NA	NA	NA	NA	919, 932; 943; 990
Gynacantha_bayadera	45.50	NA	NA	NA	NA	NA	NA	NA	903, 1030
Gynacantha_dravida	53.00	NA	NA	NA	NA	NA	NA	NA	903, 1030
Calopterygidae									
Calopteryx_maculata	47.00	NA	NA	NA	NA	12.50	269.50	1810.00	942, 945; 975; 990; 991; 992; 1005; 1012; 1016; 1061; 1068; 1070
Calopteryx_splendens	37.00	NA	NA	NA	NA	12.00	NA	NA	913, 916; 917; 918; 919; 920; 923; 928; 932; 943; 966; 990; 1002; 1005; 1048; 1065
Calopteryx_splendens_xanthostoma	46.50	NA	NA	NA	NA	NA	NA	NA	949, 976
Calopteryx_virgo	36.50	1.44	52.50	24.00	NA	11.00	NA	NA	913, 919; 923; 943; 982; 990; 1005; 1048; 1070
Hetaerina_americana	42.50	NA	NA	NA	NA	14.30	NA	NA	897, 923; 980; 1012; 1030; 1046; 1065
Vestalis_beryllae	77.50	NA	NA	NA	NA	NA	NA	NA	942, 1030

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Coenagrionidae									
Ceriagrion_coromandelianum	NA	0.87	NA	2.60	NA	NA	NA	NA	903, 910; 988; 1011
Ceriagrion_tenellum	27.00	NA	NA	NA	NA	5.00	NA	NA	886, 897; 913; 932; 943; 990; 1030; 1066
Coenagrion_hastulatum	24.00	1.19	17.00	12.00	NA	NA	NA	NA	913, 925; 982; 990; 1030; 1048
Coenagrion_lunulatum	24.00	NA	NA	NA	NA	NA	NA	NA	913, 990
Coenagrion_mercuriale	27.25	0.98	21.00	24.00	NA	7.00	NA	NA	886, 897; 913; 932; 943; 973; 990; 1030
Coenagrion_ornatum	23.00	1.00	NA	NA	NA	NA	NA	NA	1048
Coenagrion_puella	26.62	0.97	28.50	12.00	NA	5.51	265.30	618.25	897, 913; 919; 932; 943; 945; 952; 990; 997; 1004; 1008; 1032; 1045; 1048; 1050
Coenagrion_pulchellum	27.00	1.07	28.00	12.00	NA	NA	NA	NA	886, 897; 913; 932; 990; 1030; 1048
Coenagrion_scitulum	24.00	NA	NA	NA	NA	NA	NA	NA	919, 932; 943; 990
Enallagma_civile	34.50	0.76	22.00	NA	NA	3.30	249.46	NA	974, 975; 990; 1001; 1015; 1063

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Enallagma_cyathigerum	30.25	NA	20.00	10.50	NA	11.00	NA	NA	897, 913; 919; 923; 932; 943; 990; 1001; 1030; 1048; 1064
Enallagma_ebrium	NA	NA	NA	NA	NA	6.50	NA	NA	1041
Enallagma_hageni	29.00	NA	17.80	NA	NA	2.80	262.15	578.50	897, 943; 945; 946; 990; 995; 1001; 1031
Erythromma_najas	32.00	0.90	NA	12.00	NA	NA	NA	NA	897, 913; 932; 990; 1030; 1048
Erythromma_viridulum	24.75	NA	NA	NA	NA	NA	NA	NA	913, 932; 990; 1048
Ischnura_elegans	29.00	0.98	NA	NA	NA	7.85	NA	742.00	897, 913; 919; 932; 943; 982; 990; 994; 1003; 1036; 1039; 1048
Ischnura_graellsii	29.40	NA	NA	NA	NA	5.50	NA	1019.00	1033, 1072
Ischnura_pumilio	25.75	NA	23.00	NA	NA	NA	NA	NA	897, 913; 932; 943; 990; 1030; 1036; 1048
Ischnura_verticalis	26.25	NA	NA	2.60	NA	6.30	363.00	NA	897, 902; 923; 934; 943; 990; 1011; 1012
Pseudagrion_rubriceps	NA	0.99	NA	1.20	NA	NA	NA	NA	897, 903; 910; 911; 986; 1011

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Pyrrhosoma_nymphula	30.75	1.03	24.75	18.00	NA	21.70	297.80	1447.00	886, 897; 913; 923; 932; 943; 945; 990; 1030; 1045; 1048; 1065
Cordulegastridae									
Cordulegaster_boltonii	69.50	0.78	NA	54.00	NA	NA	NA	NA	913, 932; 943; 990; 1030; 1048
Cordulegaster_maculata	17.50	NA	NA	NA	NA	NA	NA	NA	901, 990; 1010; 1012
Corduliidae									
Cordulephya_pygmaea	NA	0.40	18.50	NA	NA	NA	NA	NA	897, 960
Cordulia_aenea	37.50	0.72	32.75	30.00	NA	35.00	NA	NA	897, 913; 927; 928; 932; 990; 1030; 1048
Epitheca_bimaculata	41.00	0.84	28.00	30.00	NA	NA	NA	NA	1048
Epitheca_cynosura	40.50	NA	NA	NA	NA	NA	1571.00	NA	897, 944; 1012; 1030; 1037
Hemicordulia_australiae	NA	0.49	13.00	30.00	NA	NA	NA	NA	897, 960; 998
Hemicordulia_tau	NA	0.47	15.00	NA	NA	NA	NA	NA	897, 960
Hesperocordulia_berthoudi	NA	0.45	NA	NA	NA	NA	NA	NA	960
Pentathemis_membranulata	NA	0.40	NA	NA	NA	NA	NA	NA	960
Procordulia_grayi	NA	0.78	NA	NA	NA	NA	NA	NA	960
Procordulia_jacksoniensis	NA	0.46	15.50	NA	NA	NA	NA	NA	960
Procordulia_smithii	NA	0.60	NA	NA	NA	NA	NA	NA	897, 960
Somatochlora_arctica	43.25	NA	NA	NA	NA	NA	NA	NA	897, 913; 923; 932; 990; 1030

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Somatochlora_metallica	45.75	0.62	49.62	30.00	NA	NA	NA	NA	897, 913; 923; 932; 943; 969; 990; 1030; 1048
Epiophlebiidae									
Epiophlebia_laidlawi	NA	NA	NA	78.00	NA	NA	NA	NA	897, 942; 1060
Epiophlebia_superstes	NA	1.09	NA	NA	NA	NA	NA	NA	897, 942; 964; 978
Euphaeidae									
Epallage_fatime	45.00	NA	NA	NA	NA	NA	NA	NA	897, 919; 923; 932; 990
Gomphidae									
Aphylla_williamsoni	NA	0.43	NA	NA	NA	NA	NA	NA	983
Gomphidia_t-nigrum	53.00	NA	NA	NA	NA	NA	NA	NA	903
Gomphidia_williamsoni	54.00	NA	NA	NA	NA	NA	NA	NA	903
Gomphus_exilis	NA	0.55	NA	NA	NA	NA	NA	NA	932, 983; 990; 1010; 1012
Gomphus_pulchellus	36.00	0.50	49.00	NA	NA	NA	NA	NA	1048
Gomphus_vulgatissimus	42.00	0.60	50.75	42.00	NA	NA	NA	NA	897, 913; 990; 1030; 1048
Heliogomphus_promelas	40.50	NA	NA	NA	NA	NA	NA	NA	903
Ictinogomphus_australis	NA	0.70	NA	NA	NA	NA	NA	NA	972
Ictinogomphus_rapax	51.00	NA	NA	NA	NA	NA	NA	NA	897, 903
Macrogomphus_annulatus	53.00	NA	NA	NA	NA	NA	NA	NA	903
Onychogomphus_forcipatus	50.52	0.52	NA	54.00	NA	NA	NA	NA	897, 919; 932; 933; 943; 981; 990; 1048
Onychogomphus_uncatus	51.69	0.54	NA	36.00	NA	NA	NA	NA	897, 932; 939; 943; 990; 1052

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Ophiogomphus_mainensis	13.80	NA	NA	NA	NA	NA	NA	NA	901, 990
Paragomphus_lineatus	34.00	NA	NA	NA	NA	NA	NA	NA	897, 903
Progomphus_obscurus	18.20	NA	NA	NA	NA	NA	NA	NA	897, 901; 957; 990; 1012
Stylogomphus_albistylus	9.70	NA	NA	NA	NA	NA	NA	NA	901, 943; 990
Lestidae									
Chalcolestes_viridis	41.25	1.45	228.00	2.15	NA	NA	NA	NA	897, 913; 919; 923; 943; 967; 1048; 1061
Lestes_barbarus	30.50	NA	NA	8.90	NA	NA	NA	NA	990, 1051
Lestes_disjunctus	37.00	NA	NA	NA	NA	NA	NA	NA	897, 943; 990; 1001; 1013; 1035
Lestes_dryas	32.00	1.80	NA	4.80	NA	NA	NA	NA	897, 913; 943; 990; 1001; 1013; 1051
Lestes_eurinus	46.75	NA	45.50	9.00	NA	NA	NA	NA	897, 915; 923; 990; 1011; 1013
Lestes_sponsa	32.75	1.40	NA	2.50	NA	NA	NA	NA	897, 913; 915; 923; 943; 990; 996; 1003; 1031; 1035; 1050; 1053; 1068
Sympecma_fusca	28.00	1.00	30.00	12.00	NA	NA	NA	NA	1048, 1055
Libellulidae									
Acisoma_panorpoides	28.00	0.29	7.50	3.55	NA	NA	NA	NA	897, 903; 910; 923; 962; 987; 1011; 1017; 1051
Aethriamanta_brevipennis	22.25	NA	NA	NA	NA	NA	NA	NA	903, 923; 1017

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Brachydiplax_chalybea	21.00	NA	NA	NA	NA	NA	NA	NA	903
Brachydiplax_farinosa	18.00	NA	NA	NA	NA	NA	NA	NA	903
Brachydiplax_sobrina	20.00	NA	NA	NA	NA	NA	NA	NA	903
Brachythemis_contaminata	19.00	0.48	9.00	3.70	NA	NA	NA	NA	897, 900; 904; 911; 1011; 1054
Celithemis_eponina	37.50	NA	NA	NA	NA	NA	NA	NA	921, 943; 1037
Celithemis_fasciata	33.50	0.36	NA	NA	NA	NA	NA	NA	897, 921; 983; 990; 1010
Crocothemis_erythraea	38.75	0.46	NA	5.60	NA	30.50	831.25	NA	897, 898; 919; 923; 929; 930; 932; 933; 943; 948; 951; 955; 990; 1049; 1062
Diplacodes_bipunctata	NA	0.39	19.00	2.40	NA	NA	NA	NA	897, 960; 998; 1003
Diplacodes_haematodes	NA	0.39	24.00	NA	NA	NA	NA	NA	342, 960, 1053; 1054
Diplacodes_melanopsis	NA	NA	35.00	NA	NA	NA	NA	NA	960
Diplacodes_trivialis	30.50	0.30	10.00	1.50	NA	NA	NA	NA	897, 910; 911; 985; 1011; 1018; 1025
Erythemis_simplicicollis	44.50	0.47	NA	2.00	NA	NA	620.30	NA	897, 921; 922; 943; 983; 990; 1010; 1011; 1037
Erythrodiplax_minuscula	NA	0.39	NA	NA	NA	NA	NA	NA	983, 990; 1010
Ladona_deplanata	NA	0.40	NA	NA	NA	NA	NA	NA	983, 990; 1010; 1012

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Ladona_julia	42.50	NA	NA	NA	NA	NA	NA	NA	921, 943; 958; 990; 1037
Leucorrhinia_albifrons	31.75	NA	NA	NA	NA	NA	327.00	NA	932, 961; 990; 1048
Leucorrhinia_caudalis	23.50	0.57	42.00	24.00	NA	NA	NA	NA	1048
Leucorrhinia_dubia	31.00	0.40	28.25	30.00	NA	12.90	405.20	NA	912, 913; 923; 924; 932; 990; 1030; 1048; 1066
Leucorrhinia_intacta	34.60	NA	NA	NA	NA	NA	NA	NA	897, 921; 959; 1001; 1037
Leucorrhinia_proxima	35.20	NA	NA	NA	NA	NA	NA	NA	921, 990; 1037
Libellula_cyanea	43.50	NA	NA	NA	NA	NA	1366.00	NA	921, 922; 943; 990
Libellula_depressa	34.75	0.70	20.00	18.00	NA	NA	984.30	NA	897, 912; 913; 919; 923; 924; 990; 1030; 1048; 1065
Libellula_fulva	35.75	0.60	11.00	24.00	NA	NA	NA	NA	897, 912; 914; 919; 923; 943; 990; 1003; 1030; 1048
Libellula_incesta	55.00	NA	NA	NA	NA	NA	935.00	NA	897, 921; 922; 943; 990; 1010
Libellula_luctuosa	45.50	NA	5.00	NA	NA	NA	NA	NA	897, 921; 943; 1010; 1037
Libellula_pulchella	49.75	NA	NA	NA	NA	NA	NA	NA	897, 921; 943; 1001; 1037

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Libellula_quadrimaculata	36.80	0.50	39.00	30.00	NA	NA	NA	NA	897, 912; 913; 921; 923; 932; 943; 959; 990; 1001; 1003; 1030; 1037; 1048; 1065
Nannodiplax_rubra	NA	0.40	NA	NA	NA	NA	NA	NA	960
Nannophlebia_risi	NA	0.35	23.50	NA	NA	NA	NA	NA	960
Nannophya_dalei	NA	0.61	25.00	NA	NA	NA	NA	NA	960
Nannophya_pygmaea	15.25	0.48	NA	NA	NA	13.90	NA	NA	942, 978; 1003; 1047; 1059; 1070
Orthetrum_albistylum	22.00	0.43	NA	NA	NA	NA	NA	NA	342, 897, 919; 923; 928; 978; 990; 1003
Orthetrum_brunneum	36.50	0.40	8.00	36.00	NA	NA	NA	NA	897, 919; 923; 932; 984; 990; 999; 1003; 1048
Orthetrum_caledonicum	NA	0.45	16.50	NA	NA	NA	NA	NA	897, 960
Orthetrum_cancellatum	41.00	0.48	35.00	36.00	NA	NA	1132.80	NA	897, 912; 913; 919; 923; 924; 943; 954; 969; 990; 1000; 1030; 1048; 1065
Orthetrum_chrysostigma	42.50	NA	NA	1.50	NA	NA	1337.65	NA	897, 898; 923; 924; 932; 943; 955; 990; 1043; 1050

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Orthetrum_coerulescens	35.00	0.55	NA	NA	NA	NA	222.50	3081.00	899, 912; 913; 923; 941; 943; 990; 1003; 1030; 1048
Orthetrum_nitidinerve	48.00	NA	NA	NA	NA	2.55	974.41	NA	932, 953; 990
Pachydiplax_longipennis	39.50	NA	NA	NA	NA	NA	NA	NA	897, 921; 943; 990; 1001; 1006; 1010; 1012; 1037
Pantala_flavescens	48.52	0.46	NA	1.60	NA	40.00	1114.30	NA	897, 898; 903; 910; 911; 924; 932; 942; 947; 948; 954; 955; 990; 1003; 1011; 1037; 1048
Perithemis_tenera	24.62	0.41	NA	NA	NA	6.50	718.00	NA	897, 921; 922; 943; 983; 990; 1003; 1010; 1012; 1037; 1067
Plathemis_lydia	46.00	0.53	NA	NA	NA	7.46	NA	NA	897, 907; 921; 936; 942; 983; 990; 1010; 1012; 1037; 1040; 1066
Rhyothemis_phyllis_phyllis	NA	0.25	NA	NA	NA	NA	NA	NA	937

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Sympetrum_danae	26.50	0.55	243.50	12.00	NA	13.00	506.75	NA	897, 912; 913; 923; 924; 932; 940; 943; 950; 951; 990; 1001; 1003; 1030; 1037; 1038; 1048
Sympetrum_depressiusculum	21.75	0.54	274.00	12.00	NA	NA	NA	NA	1048
Sympetrum_flaveolum	34.00	0.58	36.00	NA	NA	NA	123.00	NA	897, 912; 932; 951; 990; 1030
Sympetrum_fonscolombii	39.50	0.50	21.00	4.70	NA	NA	835.10	NA	897, 898; 912; 923; 924; 948; 951; 955; 990; 1030
Sympetrum_internum	32.00	NA	NA	NA	NA	NA	NA	NA	897, 909; 921; 990; 1037
Sympetrum_meridionale	31.25	0.50	NA	NA	NA	NA	NA	NA	897, 919; 923; 990; 1048
Sympetrum_obtrusum	34.50	NA	NA	NA	NA	NA	NA	NA	921, 923; 979; 990; 1001; 1037
Sympetrum_sanguineum	29.00	0.96	132.50	12.00	NA	NA	202.00	NA	912, 913; 919; 932; 951; 969; 990; 1003; 1030; 1048
Sympetrum_striolatum	34.00	0.57	36.50	12.00	NA	8.00	432.40	1041.00	899, 912; 913; 919; 924; 932; 941; 951; 990; 1030; 1048

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Sympetrum_vicinum	32.75	NA	NA	NA	NA	NA	NA	NA	897, 921; 923; 943; 990; 1001; 1014; 1037
Sympetrum_vulgatum	25.50	0.57	NA	12.00	NA	NA	NA	NA	1048
Tholymis_tillarga	33.75	NA	NA	NA	NA	NA	NA	NA	906, 923; 959
Trithemis_annulata	35.50	0.42	NA	1.70	NA	NA	924.20	NA	897, 898; 923; 932; 955; 990; 1020
Trithemis_festiva	34.50	0.38	NA	NA	NA	NA	NA	NA	903, 910; 911; 923; 932; 1003; 1017; 1019
Trithemis_kirbyi	34.25	0.41	NA	2.00	NA	NA	729.40	NA	897, 898; 923; 924; 932; 948; 955; 1020; 1049
Zygonyx_natalensis	51.00	0.50	21.00	NA	NA	NA	NA	NA	979, 1022
Megapodagrionidae									
Rhipidolestes_hiraoi	NA	1.43	NA	NA	NA	NA	NA	NA	982
Petaluridae									
Petalura_ingentissima	125.00	NA	NA	NA	NA	NA	NA	NA	942, 943; 1030
Platycnemididae									
Copera_annulata	NA	NA	NA	NA	NA	NA	NA	250.00	14, 89; 95
Platycnemis_pennipes	33.00	0.90	NA	NA	NA	NA	NA	NA	886, 897; 913; 919; 943; 990; 1030; 1048
mm *Pseudostigmatidae*									
Megaloprepus_caerulatus	NA	NA	32.60	NA	NA	33.90	195.00	NA	1007, 1009; 1043
Synthemistidae									
Eusynthemis_brevistyla	NA	0.52	19.50	NA	NA	NA	NA	NA	960

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Synthemis_eustalacta	NA	0.55	NA	NA	NA	NA	NA	NA	960
Synthemis_regina	NA	0.62	NA	NA	NA	NA	NA	NA	960
Orthoptera									
Acrididae									
Abisares_viridipennis	NA	4.30	NA	NA	NA	NA	55.00	NA	1079
Acanthacris_ruficornis	62.35	6.00	NA	64.50	NA	NA	151.00	2053.60	1079, 1148
Acanthoxia_gladiator	97.70	5.45	NA	NA	NA	NA	35.00	NA	1077, 1079
Acrida_acuminata	66.00	NA	NA	NA	NA	NA	NA	NA	1197
Acrida_bicolor	55.20	6.04	NA	NA	NA	NA	59.50	NA	1077, 1079
Acrida_conica	70.00	NA	NA	NA	NA	NA	NA	NA	1123
Acrida_gigantea	NA	4.88	NA	NA	NA	NA	58.50	NA	1080
Acridium_fulvum	NA	6.50	NA	134.00	NA	NA	100.00	NA	1078
Acrolophitus_hirtipes	37.50	7.11	NA	NA	NA	NA	11.00	NA	1125, 1156
Acrotylus_angulatus	20.50	3.50	NA	87.00	NA	NA	20.00	NA	1078, 1185
Acrotylus_patruelis	NA	3.60	NA	NA	NA	NA	17.00	NA	1079
Aeoloplides_turnbulli	20.57	4.24	NA	55.00	NA	NA	18.50	NA	1071, 1125
Aeropedellus_arcticus	15.50	NA	NA	NA	NA	NA	NA	NA	1154
Aeropedellus_clavatus	18.75	5.05	NA	36.00	NA	NA	6.50	NA	1071
Afroxyrrhepes_acuticercus	NA	5.75	NA	NA	NA	NA	69.50	NA	1079
Afroxyrrhepes_procera	NA	5.75	NA	NA	NA	NA	62.50	NA	1079
Ageneotettix_deorum	19.18	4.95	46.00	44.00	NA	23.00	4.50	12.00	1071, 1125
Aiolopus_longicornis	NA	3.85	NA	NA	NA	NA	31.00	NA	1079
Aiolopus_thalassinus	20.00	3.92	NA	44.12	NA	NA	19.25	45.52	1072, 1078; 1079; 1193
Amblytropidia_mysteca	NA	4.25	NA	NA	NA	NA	27.00	NA	1125
Amphitornus_coloradus	21.15	4.95	NA	53.00	NA	NA	4.00	NA	1071
Anacridium_melanorhodon	NA	NA	NA	NA	NA	NA	150.00	450.00	1129
Apotropis_vittata	27.00	NA	NA	NA	NA	NA	NA	NA	1123

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Arcyptera_fusca	32.50	5.95	NA	NA	NA	NA	NA	NA	342, 1072
Arcyptera_microptera	23.50	5.40	NA	NA	NA	NA	NA	NA	342, 1072
Arphia_conspersa	27.00	5.17	NA	NA	NA	NA	18.55	NA	1071, 1125
Arphia_pseudonietana	24.88	4.70	NA	49.00	NA	NA	29.00	NA	1071
Arphia_simplex	36.50	5.26	NA	NA	NA	NA	32.70	NA	1125, 1156
Aulocara_elliotti	19.88	4.92	36.00	39.00	NA	20.00	8.10	15.00	1071, 1165
Aulocara_femoratum	19.27	4.95	NA	NA	NA	NA	10.00	NA	1071
Austracris_basalis	63.00	NA	NA	NA	NA	NA	NA	NA	1123
Austracris_guttulosa	63.00	NA	NA	NA	NA	NA	NA	NA	1123
Austracris_proxima	58.50	NA	NA	NA	NA	NA	NA	NA	1123
Austroicetes_cruciata	19.50	NA	NA	NA	NA	NA	NA	NA	1123
Austroicetes_frater	20.50	NA	NA	NA	NA	NA	NA	NA	1123
Austroicetes_pusilla	17.00	NA	NA	NA	NA	NA	NA	NA	1123
Austroicetes_vulgaris	17.50	NA	NA	NA	NA	NA	NA	NA	1123
Bermius_brachycerus	29.00	NA	NA	NA	NA	NA	NA	NA	1123
Boopedon_gracile	34.75	6.39	NA	NA	NA	NA	30.60	NA	1125, 1156
Boopedon_nubilum	29.62	7.10	NA	32.67	NA	62.00	50.00	NA	1071
Bootettix_argentatus	21.50	4.70	NA	NA	NA	NA	NA	NA	1125, 1156
Brachyexarna_lobipennis	14.00	NA	NA	NA	NA	NA	NA	NA	1123
Bruneria_brunnea	17.38	5.95	NA	43.00	NA	NA	6.00	NA	1701
Bryodema_tuberculata	31.25	NA	NA	NA	NA	NA	NA	NA	1702
Buforania_crassa	48.00	NA	NA	NA	NA	NA	NA	NA	1123
Caledia_captiva	26.50	NA	NA	NA	NA	NA	NA	NA	1123
Calephorops_viridis	17.50	NA	NA	NA	NA	NA	NA	NA	1123
Calliptamus_italicus	25.25	4.50	NA	NA	NA	NA	NA	NA	342, 1702, 1180
Camnula_pellucida	22.00	4.89	NA	33.00	NA	60.25	21.15	168.14	1071, 1125; 1126
Campylacantha_olivacea	27.25	4.23	NA	NA	NA	NA	43.00	NA	1125, 1156
Cataloipus_oberthuri	NA	5.72	NA	NA	NA	NA	62.50	NA	1079

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Catantops_melanostictus	NA	3.85	NA	NA	NA	NA	50.00	NA	1079
Cedarinia_limbatella	21.50	NA	NA	NA	NA	NA	NA	NA	1123
Ceracris_deflorata	NA	4.88	NA	NA	NA	NA	18.00	NA	1080
Chloealtis_abdominalis	22.00	NA	NA	NA	NA	NA	NA	NA	1154
Chloealtis_conspersa	20.75	5.00	NA	NA	NA	NA	NA	NA	342, 1156
Chloroplus_cactocaetes	NA	4.07	NA	NA	NA	NA	9.50	NA	1125
Choroedocus_capensis	48.85	5.40	NA	76.75	NA	NA	79.50	NA	1080, 1122
Chorthippus_albomarginatus	16.75	4.10	27.30	NA	NA	NA	NA	NA	342, 1072
Chorthippus_apricarius	16.75	4.05	NA	NA	NA	NA	NA	NA	342, 1072
Chorthippus_biguttulus	16.75	4.05	30.20	NA	NA	NA	NA	NA	342, 1072
Chorthippus_brunneus	19.00	4.25	28.30	NA	NA	36.50	10.10	228.26	342, 1072, 1077; 1120
Chorthippus_curtipennis	18.65	4.20	NA	30.00	NA	NA	5.00	NA	1071
Chorthippus_dorsatus	19.00	NA	NA	NA	NA	NA	NA	NA	1072
Chorthippus_mollis	15.62	3.75	34.50	NA	NA	NA	NA	NA	342, 1072
Chorthippus_parallelus	17.25	3.90	22.50	51.09	NA	NA	NA	NA	342, 1072, 1147
Chorthippus_pullus	17.25	NA	NA	NA	NA	NA	NA	NA	1072
Chorthippus_vagans	16.25	4.50	NA	NA	NA	NA	NA	NA	342, 1072
Chortoicetes_terminifera	31.25	NA	NA	NA	NA	NA	NA	NA	1180
Chortophaga_viridifasciata	23.10	4.25	NA	NA	NA	NA	24.01	NA	1071, 1125
Chrysochraon_dispar	21.75	5.25	NA	NA	NA	NA	NA	NA	342, 1072
Cirphula_pyrrhocnemis	24.00	NA	NA	NA	NA	NA	NA	NA	1123
Collitera_variegata	24.50	NA	NA	NA	NA	NA	NA	NA	1123
Cordillacris_crenulata	14.00	5.25	NA	36.00	NA	NA	2.50	NA	1071
Cordillacris_occipitalis	19.88	5.00	NA	NA	NA	NA	2.50	NA	1071
Coryphistes_ruricola	44.70	NA	NA	NA	NA	NA	NA	NA	1123
Crucinotacris_werneriana	NA	3.70	NA	NA	NA	NA	14.50	NA	1079
Cryptobothrus_chrysophorus	23.00	NA	NA	NA	NA	NA	NA	NA	1123

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Cyrtacanthacris_aeruginosa	NA	6.92	NA	NA	NA	NA	108.50	NA	1079
Dactylotum_bicolor	26.50	5.27	NA	NA	NA	NA	13.85	NA	1125, 1150
Derotmema_haydenii	19.38	4.45	NA	40.00	NA	NA	14.25	NA	1071, 1125
Diabolocatantops_axillaris	43.60	5.05	NA	NA	NA	NA	49.50	NA	1071, 1077; 1079
Dichromorpha_viridis	22.25	4.56	NA	NA	NA	NA	26.80	NA	1125, 1156
Dichroplus_maculipennis	NA	NA	NA	NA	NA	52.70	24.65	60.89	1121
Dissosteira_carolina	34.12	5.30	NA	47.50	NA	NA	53.50	NA	1071
Dissosteira_longipennis	36.50	5.00	NA	44.50	NA	NA	65.00	NA	1071
Dnopherula_pictipes	NA	3.65	NA	NA	NA	NA	19.00	NA	1079
Dociostaurus_maroccanus	26.25	5.25	NA	NA	NA	NA	25.00	NA	324, 1129, 1180
Drymophilacris_bimaculata	16.35	NA	NA	NA	NA	NA	NA	NA	1191
Duronia_chloronota	NA	4.70	NA	NA	NA	NA	33.00	NA	1709
Ecphantus_quadrilobus	29.00	NA	NA	NA	NA	NA	NA	NA	1123
Encoptolophus_costalis	20.12	4.20	NA	61.00	NA	NA	17.00	NA	1071
Encoptolophus_sordidus	NA	3.94	NA	NA	NA	NA	16.40	NA	1125
Eritettix_abortivus	16.75	3.58	NA	NA	NA	NA	12.00	NA	1125, 1156
Eritettix_simplex	19.25	4.40	NA	273.80	NA	NA	18.00	NA	1071
Eumecistes_gratiosus	37.00	NA	NA	NA	NA	NA	NA	NA	1123
Eupropacris_cylindricollis	29.50	NA	NA	NA	NA	NA	NA	NA	1150
Euthystira_brachyptera	18.50	4.50	NA	NA	NA	NA	5.50	NA	342, 1071, 1072
Exopropacris_decipiens	NA	5.60	NA	NA	NA	NA	19.00	NA	1079
Eyprepocnemis_capitatus	NA	5.45	NA	NA	NA	NA	55.00	NA	1079
Eyprepocnemis_roseus	23.00	5.15	NA	46.25	NA	NA	14.00	NA	1080, 1122
Faureia_milanjica	NA	4.75	NA	NA	NA	NA	11.50	NA	1079
Froggattina_australis	23.50	NA	NA	NA	NA	NA	NA	NA	1123
Gastrimargus_africanus	31.68	4.75	NA	NA	NA	NA	50.00	NA	1079, 1122
Gastrimargus_marmoratus	36.62	4.88	NA	NA	NA	NA	84.00	NA	1080, 1122
Gastrimargus_musicus	43.00	NA	NA	NA	NA	NA	NA	NA	1123

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Gesonula_punctifrons	18.06	6.10	NA	41.43	NA	NA	NA	32.70	342, 1192, 1193
Gomphocerippus_rufus	17.75	NA	NA	NA	NA	NA	NA	NA	1072
Gomphocerus_sibiricus	21.25	5.15	NA	NA	NA	NA	NA	NA	342, 1072
Goniaea_australasiae	43.50	NA	NA	NA	NA	NA	NA	NA	1123
Goniaea_opomaloides	37.50	NA	NA	NA	NA	NA	NA	NA	1123
Goniaea_vocans	51.50	NA	NA	NA	NA	NA	NA	NA	1123
Goniaeoidea_rufotestacea	34.00	NA	NA	NA	NA	NA	NA	NA	1123
Gymnobothrus_gracilis	NA	3.70	NA	NA	NA	NA	11.00	NA	1079
Gymnobothrus_temporalis	NA	3.70	NA	NA	NA	NA	11.00	NA	1079
Hadrotettix_trifasciatus	28.88	7.34	NA	59.00	NA	NA	22.00	NA	1071, 1125
Heliastus_subroseus	NA	6.28	NA	NA	NA	NA	14.50	NA	1125
Hesperotettix_speciosus	27.75	5.41	NA	NA	NA	NA	16.60	NA	1125, 1156
Hesperotettix_viridis	20.50	4.96	NA	48.25	NA	NA	9.00	NA	1071, 1125
Heteropternis_obscurella	29.00	NA	NA	NA	NA	NA	NA	NA	1123
Hieroglyphodes_assamensis	NA	5.58	NA	NA	NA	NA	28.00	NA	1080
Hippiscus_ocelote	40.00	6.07	NA	NA	NA	NA	49.00	NA	1125, 1156
Humbe_tenuicornis	NA	5.30	NA	NA	NA	NA	29.00	NA	1079
Hypochlora_alba	17.52	4.36	NA	45.00	NA	NA	9.55	NA	1071, 1125
Kosciuscola_cognatus	19.50	NA	NA	NA	NA	NA	NA	NA	1123
Lactista_azteca	NA	4.27	NA	NA	NA	NA	13.00	NA	1125
Laxabilla_smaragdina	15.00	NA	NA	NA	NA	NA	NA	NA	1123
Leptysma_marginicollis	37.40	7.50	32.00	91.25	NA	319.40	6.41	34.61	1125, 1189
Locusta_migratoria	48.75	6.56	NA	NA	NA	NA	71.50	NA	1077, 1079; 1180
Locustana_pardalina	43.75	NA	NA	NA	NA	NA	42.00	189.00	1129, 1180
Macrotona_australis	23.00	NA	NA	NA	NA	NA	NA	NA	1123
Macrotona_securiformis	20.00	NA	NA	NA	NA	NA	NA	NA	1123
Mecostethus_alliaceus	25.00	NA	NA	NA	NA	NA	NA	NA	1072
Melanoplus_alpinus	20.12	4.65	NA	32.50	NA	NA	10.00	NA	1071

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Melanoplus_angustipennis	21.73	4.62	NA	39.00	NA	NA	16.13	NA	1071, 1125
Melanoplus_bispinosus	28.25	4.54	NA	NA	NA	NA	29.94	NA	1125, 1156
Melanoplus_bivittatus	33.75	5.30	NA	40.00	NA	NA	59.85	490.77	1071, 1125
Melanoplus_borealis	21.99	3.95	54.60	41.65	NA	71.47	14.60	78.84	1071, 1128
Melanoplus_bowditchi	23.12	4.70	NA	35.00	NA	NA	12.50	NA	1071
Melanoplus_bruneri	22.25	4.05	NA	33.00	NA	NA	21.50	NA	1071
Melanoplus_confusus	21.00	4.72	NA	43.00	NA	NA	11.69	NA	1071, 1125
Melanoplus_dawsoni	18.20	4.10	NA	43.50	NA	NA	10.90	NA	1071, 1125
Melanoplus_devastator	21.12	4.15	NA	70.00	NA	NA	25.50	NA	1071
Melanoplus_differentialis	34.00	4.87	NA	32.00	NA	NA	108.25	757.75	1071, 1125
Melanoplus_dodgei	NA	5.77	NA	NA	NA	NA	8.00	NA	1125
Melanoplus_fasciatus	20.50	NA	NA	NA	NA	NA	NA	NA	1156
Melanoplus_femurrubrum	23.12	4.32	NA	40.00	NA	NA	22.50	NA	1071, 1125
Melanoplus_foedus	28.50	4.95	NA	37.67	NA	NA	23.00	NA	1071
Melanoplus_frigidus	22.50	4.85	NA	NA	NA	NA	NA	NA	342, 1154
Melanoplus_gladstoni	21.70	4.45	NA	56.00	NA	NA	22.50	NA	1071
Melanoplus_glaucipes	NA	4.26	NA	NA	NA	NA	10.58	NA	1125
Melanoplus_infantilis	17.12	4.05	NA	30.50	NA	18.50	11.50	NA	1071
Melanoplus_keeleri	20.43	4.15	NA	46.00	NA	NA	21.00	NA	1071
Melanoplus_kennicottii	21.25	4.40	NA	33.50	NA	NA	12.00	NA	1071
Melanoplus_lakinus	19.50	4.16	NA	28.00	NA	NA	21.25	NA	1071, 1125
Melanoplus_mexicanus	NA	4.27	NA	NA	NA	NA	19.30	NA	1125
Melanoplus_occidentalis	21.55	4.90	NA	42.50	NA	NA	9.00	NA	1071
Melanoplus_packardii	31.62	4.90	NA	55.00	NA	NA	22.50	NA	1071
Melanoplus_plebejus	NA	4.09	NA	NA	NA	NA	16.80	NA	1125
Melanoplus_rugglesi	22.88	4.50	NA	42.00	NA	NA	19.50	NA	1071
Melanoplus_sanguinipes	23.75	4.50	56.00	45.00	NA	75.00	21.40	375.57	1071, 1127; 1142
Melanoplus_scudderi	20.50	4.13	NA	NA	NA	NA	23.80	NA	1125, 1156

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Mermiria_bivittata	32.33	7.12	NA	NA	NA	NA	17.95	NA	1071, 1125
Mesopsera_filum	44.40	NA	NA	NA	NA	NA	NA	NA	1077
Mesopsis_laticornis	NA	5.95	NA	NA	NA	NA	30.50	NA	1079
Metator_pardalinus	27.75	6.62	NA	36.00	NA	NA	16.00	NA	1071, 1125
Metaxymecus_gracilipes	NA	4.75	NA	NA	NA	NA	34.00	NA	1079
Miramella_alpina	23.00	NA	NA	NA	NA	NA	NA	NA	1072
Morphacris_fasciata	NA	4.55	NA	NA	NA	NA	24.00	NA	1079
Myrmeleotettix_maculatus	13.25	4.30	NA	NA	NA	NA	4.10	26.24	342, 1072, 1120
Nebulatettix_subgracilis	NA	4.15	NA	NA	NA	NA	15.70	NA	1125
Nomadacris_septemfasciata	49.25	5.90	NA	63.00	NA	243.30	133.00	345.80	1077, 1079; 1173; 1180
Oedaleonotus_enigma	20.50	5.00	NA	46.00	NA	NA	19.00	NA	1071
Oedaleus_abruptus	18.05	3.70	NA	NA	NA	NA	22.50	NA	1080, 1122
Oedaleus_australis	26.50	NA	NA	NA	NA	NA	NA	NA	1123
Oedaleus_nigeriensis	NA	4.40	NA	NA	NA	NA	27.00	NA	1079
Oedaleus_nigrofasciatus	29.75	4.50	NA	80.00	NA	NA	22.50	NA	1078, 1186
Oedaleus_senegalensis	26.32	4.80	NA	25.00	NA	NA	22.50	56.25	342, 1129, 1175; 1176
Oedipoda_caerulescens	21.50	4.25	NA	NA	NA	NA	NA	NA	342, 1072
Omocestus_haemorrhoidalis	14.75	4.05	NA	NA	NA	NA	NA	NA	342, 1072
Omocestus_rufipes	17.00	4.20	NA	NA	NA	NA	NA	NA	342, 1072
Omocestus_viridulus	18.50	4.30	28.40	NA	NA	NA	5.00	22.50	1072, 1120; 1172
Opeia_obscura	16.55	4.14	NA	43.00	NA	NA	9.00	NA	1071
Ornithacris_cyanea	NA	5.70	NA	NA	NA	NA	161.00	NA	1079
Orphulella_pelidna	22.25	4.54	NA	NA	NA	NA	8.30	NA	1125, 1156
Orphulella_speciosa	16.00	3.95	NA	45.00	NA	NA	11.10	NA	1071, 1125
Orthacanthacris_humilicrus	NA	5.75	NA	NA	NA	NA	126.00	NA	1079
Orthochtha_dasycnemis	22.00	5.15	NA	NA	NA	NA	31.50	NA	1079, 1197

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Oxya_chinensis	20.57	4.15	NA	68.58	NA	NA	32.30	NA	1192, 1195; 1196
Oxya_japonica	27.35	NA	NA	61.97	NA	70.00	24.21	119.84	1075, 1122
Oxya_velox	24.50	NA	NA	NA	NA	NA	NA	NA	1182
Oxycatantops_adustus	NA	5.55	NA	NA	NA	NA	52.50	NA	1079
Paracinema_tricolor	28.77	4.35	NA	NA	NA	NA	96.50	NA	1079, 1177
Parahieroglyphus_bilineatus	NA	4.15	NA	NA	NA	NA	34.00	NA	1080
Paraidemona_mimica	NA	3.97	NA	NA	NA	NA	12.00	NA	1125
Paraidemona_punctata	NA	3.92	NA	NA	NA	NA	11.10	NA	1125
Pardalophora_phoenicoptera	44.50	6.37	NA	NA	NA	NA	58.50	NA	1125, 1156
Pardillana_limbata	50.00	NA	NA	NA	NA	NA	NA	NA	1154
Paulinia_acuminata	22.60	NA	NA	37.09	NA	67.88	NA	209.03	1190, 1194
Peakesia_brunnea	27.50	NA	NA	NA	NA	NA	NA	NA	1123
Peakesia_hospita	25.25	NA	NA	NA	NA	NA	NA	NA	1123
Perala_viridis	23.00	NA	NA	NA	NA	NA	NA	NA	1123
Perbellia_brevialata	21.50	NA	NA	NA	NA	NA	NA	NA	1123
Percassa_rugifrons	29.50	NA	NA	NA	NA	NA	NA	NA	1123
Perelytrana_rana	29.50	NA	NA	NA	NA	NA	NA	NA	1123
Perunga_ochracea	24.00	NA	NA	NA	NA	NA	NA	NA	1123
Phaedrotettix_accola	NA	4.12	NA	NA	NA	NA	8.00	NA	1125
Phaedrotettix_dumicola	NA	4.25	NA	NA	NA	NA	8.80	NA	1125
Phaedrotettix_gracilis	NA	3.96	NA	NA	NA	NA	9.30	NA	1125
Phaeocatantops_decoratus	NA	4.35	NA	NA	NA	NA	37.00	NA	1079
Phaulacridium_vittatum	13.75	NA	NA	NA	NA	NA	NA	NA	1137
Phlaeoba_panteli	NA	4.72	NA	NA	NA	NA	27.00	NA	1080
Phlibostroma_quadrimaculatum	17.38	4.99	NA	48.00	NA	NA	9.50	NA	1071, 1125
Phoetaliotes_nebrascensis	20.05	4.25	NA	55.00	NA	NA	25.00	NA	1071
Pnorisa_squalus	NA	3.85	NA	NA	NA	NA	19.00	NA	1079
Podisma_pedestris	22.50	4.80	NA	NA	NA	NA	NA	NA	342, 1072

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Poecilocerastis_striata	NA	4.45	NA	NA	NA	NA	18.00	NA	1079
Praxibulus_insolens	17.00	NA	NA	NA	NA	NA	NA	NA	1123
Pseudopomala_brachyptera	26.75	6.10	NA	NA	NA	NA	NA	NA	342, 1156
Psinidia_amplicornus	26.50	5.46	NA	NA	NA	NA	11.60	NA	1125, 1156
Psinidia_fenestralis	28.50	5.34	NA	NA	NA	NA	NA	NA	1125, 1156
Psoloessa_delicatula	16.50	4.90	NA	NA	NA	NA	18.00	NA	1071
Psoloessa_texana	NA	NA	NA	NA	NA	NA	12.00	NA	1125
Psophus_stridulus	28.50	6.50	NA	NA	NA	NA	NA	NA	342, 1072
Pycnostictus_seriatus	22.00	NA	NA	NA	NA	NA	NA	NA	1123
Qualetta_maculata	28.00	NA	NA	NA	NA	NA	NA	NA	1123
Rectitropis_australis	16.50	NA	NA	NA	NA	NA	NA	NA	1123
Rhaphotittha_leai	NA	4.00	NA	NA	NA	NA	16.00	NA	1079
Ronderosia_bergii	20.77	NA	NA	30.80	NA	127.40	7.60	125.02	1146, 1181
Schistocerca_americana	48.62	7.01	NA	NA	NA	NA	108.00	NA	1125, 1131; 1171
Schistocerca_cancellata	51.82	NA	NA	33.24	NA	88.70	73.00	NA	1129, 1140; 1187
Schistocerca_gregaria	51.75	7.22	NA	NA	NA	NA	62.63	156.57	1129, 1135; 1150; 1180
Schistocerca_lineata	34.50	6.09	NA	NA	NA	NA	85.60	NA	1125, 1150
Schizobothrus_flavovittatus	28.00	NA	NA	NA	NA	NA	NA	NA	1123
Scotussa_cliens	24.80	NA	NA	NA	NA	NA	NA	NA	1195
Scotussa_lemniscata	22.40	NA	NA	NA	NA	NA	NA	NA	1195
Scotussa_liebermanni	25.25	NA	NA	NA	NA	NA	NA	NA	1195
Spathosternum_prasiniferum	17.25	4.10	NA	NA	NA	NA	22.50	NA	1080, 1122
Spharagemon_collare	24.12	5.10	NA	42.00	NA	NA	24.75	NA	1071, 1125
Spharagemon_equale	28.20	5.25	NA	55.00	NA	NA	25.00	NA	1071
Sphingonotus_caerulans	22.75	NA	NA	NA	NA	NA	NA	NA	1072
Stauroderus_scalaris	22.25	4.80	NA	NA	NA	NA	NA	NA	342, 1072
Stenacris_vitreipennis	30.25	5.30	NA	NA	NA	NA	14.00	NA	1156, 1189

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Stenobothrus_lineatus	20.25	4.10	27.00	NA	NA	NA	6.35	23.50	342, 1072, 1144
Stenobothrus_nigromaculatus	18.50	5.00	NA	NA	NA	NA	NA	NA	342, 1072
Stenobothrus_stigmaticus	15.25	NA	40.00	NA	NA	NA	NA	NA	1072
Stethophyma_grossum	25.50	6.55	NA	NA	NA	NA	40.00	NA	1072, 1172
Stethophyma_lineatum	31.00	NA	NA	NA	NA	NA	NA	NA	1154
Stropis_maculosa	38.00	NA	NA	NA	NA	NA	NA	NA	1123
Syrbula_admirabilis	34.25	4.69	NA	NA	NA	NA	41.80	NA	1125, 1156
Syrbula_montezuma	32.25	4.85	NA	NA	NA	NA	40.00	NA	1125, 1156
Tolgadia_bivittata	32.00	NA	NA	NA	NA	NA	NA	NA	1123
Trachyrhachys_aspera	20.32	4.90	NA	51.00	NA	NA	NA	NA	1071
Trachyrhachys_kiowa	18.50	4.58	NA	45.00	NA	NA	12.85	NA	1071, 1125
Trilophidia_conturbata	NA	3.83	NA	NA	NA	NA	18.00	NA	1078, 1079
Trimerotropis_pallidipennis	26.12	4.75	15.50	55.00	NA	80.00	37.00	NA	1071, 1125
Tristria_pallida	NA	4.15	NA	NA	NA	NA	17.50	NA	1079
Truxalis_burtti	NA	6.50	NA	NA	NA	NA	23.50	NA	1079
Tylotropidius_didymus	NA	5.60	NA	NA	NA	NA	41.50	NA	1079
Urnisa_guttulosa	27.00	NA	NA	NA	NA	NA	NA	NA	1123
Valanga_irregularis	75.50	NA	NA	NA	NA	NA	NA	NA	1123
Vitticatantops_humeralis	22.50	NA	NA	NA	NA	NA	NA	NA	1197
Xanthippus_brooksi	30.00	NA	NA	NA	NA	NA	NA	NA	1154
Xanthippus_corallipes	32.50	6.04	NA	NA	NA	NA	53.00	NA	1071, 1125
Xenocatantops_humilis	26.90	3.95	NA	91.25	NA	NA	27.00	NA	1080, 1122
Zebratula_flavonigra	26.50	NA	NA	NA	NA	NA	NA	NA	1123
Anostostomatidae									
Anisoura_nicobarica	21.50	NA	NA	NA	NA	NA	NA	NA	1093
Cratomelus_armatus	35.83	3.50	NA	NA	NA	NA	NA	NA	1093
Deinacrida_carinata	40.00	NA	NA	NA	NA	NA	NA	NA	1093
Deinacrida_connectens	45.00	NA	NA	NA	NA	NA	NA	NA	1093

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Deinacrida_elegans	46.25	9.30	NA	NA	NA	NA	NA	NA	1184
Deinacrida_fallai	73.00	7.00	127.00	395.40	NA	279.00	27.00	258.00	1194
Deinacrida_heteracantha	55.00	7.00	127.00	547.50	NA	175.50	27.00	209.00	1086, 1094
Deinacrida_mahoenui	43.80	6.95	304.00	394.00	NA	169.00	NA	NA	1094, 1132; 1183; 1184
Deinacrida_parva	28.00	NA	NA	NA	NA	NA	NA	NA	1086
Deinacrida_pluvialis	44.30	9.00	NA	NA	NA	NA	NA	NA	1184
Deinacrida_rugosa	54.50	6.70	NA	NA	NA	NA	NA	NA	1086, 1093
Deinacrida_talpa	47.40	9.40	NA	NA	NA	NA	NA	NA	1184
Deinacrida_tibiospina	33.00	NA	NA	NA	NA	NA	NA	NA	1093
Hemiandrus_electra	19.70	NA	NA	NA	NA	NA	NA	NA	1083
Hemiandrus_maia	21.73	NA	NA	NA	NA	NA	NA	NA	1083
Hemiandrus_pallitarsis	11.43	NA	NA	NA	NA	NA	45.10	NA	1084, 1182
Hemideina_armiger	40.00	NA	NA	NA	NA	NA	NA	NA	1086
Hemideina_broughi	85.00	NA	NA	NA	NA	NA	NA	NA	1093
Hemideina_crassidens	NA	4.46	NA	274.00	NA	NA	21.00	NA	1093, 1094
Hemideina_femorata	40.00	NA	NA	NA	NA	NA	NA	NA	1086
Hemideina_maculifrons	NA	3.10	NA	NA	NA	NA	NA	NA	1093
Hemideina_maori	25.00	NA	NA	NA	NA	212.00	NA	NA	1085, 1086
Hemideina_megacephala	40.00	NA	NA	NA	NA	NA	NA	NA	1086
Hemideina_ricta	40.00	5.91	NA	243.50	NA	NA	NA	NA	1086, 1093; 1094
Hemideina_subantarcticus	NA	4.03	NA	NA	NA	NA	NA	NA	1093
Hemideina_thoracica	33.00	NA	NA	NA	NA	NA	NA	NA	1086
Libanasidus_vittatus	65.00	NA	NA	NA	NA	NA	NA	NA	1197
Motuweta_isolata	70.00	NA	NA	NA	NA	NA	NA	153.00	1093, 1094
Cooloolidae									
Cooloola_dingo	26.65	NA	NA	NA	NA	NA	NA	NA	1081
Cooloola_pearsoni	21.00	NA	NA	NA	NA	NA	NA	NA	1082

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Cooloola_propator	26.00	NA	NA	NA	NA	NA	NA	NA	1081
Cooloola_ziljan	33.01	4.54	NA	NA	NA	NA	NA	NA	1081, 1082
Cylindrachetidae									
Cylindracheta_campbellii	73.25	NA	NA	NA	NA	NA	NA	NA	1097
Cylindraustralia_arenivaga	46.50	NA	NA	NA	NA	NA	NA	NA	1097
Cylindraustralia_centricola	35.75	NA	NA	NA	NA	NA	NA	NA	1097
Cylindraustralia_cookensis	44.00	NA	NA	NA	NA	NA	NA	NA	1097
Cylindraustralia_granulata	53.75	NA	NA	NA	NA	NA	NA	NA	1097
Cylindraustralia_karumbensis	43.00	NA	NA	NA	NA	NA	NA	NA	1097
Cylindraustralia_kochii	52.75	7.00	NA	NA	NA	NA	NA	NA	342, 1097
Cylindraustralia_longaeva	25.00	NA	NA	NA	NA	NA	NA	NA	1097
Cylindroryctes_spegazzinii	42.50	NA	NA	NA	NA	NA	NA	NA	1097
Episactidae									
Episactus_brunneri	13.63	NA	NA	NA	NA	NA	NA	NA	1091
Episactus_tristani	13.64	NA	NA	NA	NA	NA	NA	NA	1091
Lethus_nicaraguae	17.77	NA	NA	NA	NA	NA	NA	NA	1091
Paralethus_insolitus	16.16	NA	NA	NA	NA	NA	NA	NA	1091
Pielomastax_cladopygidium	17.00	NA	NA	NA	NA	NA	NA	NA	1090
Eumastacidae									
Caenomastax_bimaculata	12.65	NA	NA	NA	NA	NA	NA	NA	1092
Caenomastax_insignis	14.60	NA	NA	NA	NA	NA	NA	NA	1092
Caenomastax_magdalenensis	15.50	NA	NA	NA	NA	NA	NA	NA	1092
Caenomastax_similis	13.10	NA	NA	NA	NA	NA	NA	NA	1092
Gryllacrididae									
Arrolla_rotamah	NA	NA	NA	NA	NA	NA	45.00	NA	1093
Pareremus_callabonnensis	NA	NA	NA	NA	NA	NA	35.50	NA	1093
Gryllidae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Acheta_domesticus	18.00	2.50	48.50	41.51	NA	70.00	28.20	987.03	1072, 1145; 1166; 1167
Gryllodes_sigillatus	15.50	NA	NA	NA	NA	47.23	NA	750.32	1156, 1171
Gryllus_bimaculatus	30.00	2.40	NA	39.35	NA	45.32	NA	NA	342, 1161, 1162; 1183
Gryllus_campestris	23.00	NA	NA	NA	NA	NA	NA	NA	1072
Gryllus_firmus	NA	2.77	NA	NA	NA	NA	NA	NA	1136
Gryllus_integer	NA	NA	NA	NA	NA	31.77	NA	NA	1130
Gryllus_pennsylvanicus	NA	3.10	NA	NA	NA	32.17	NA	NA	342, 1130
Modicogryllus_frontalis	12.50	NA	NA	NA	NA	NA	NA	NA	1072
Neoxabea_bipunctata	16.00	3.98	NA	NA	NA	NA	NA	NA	1152
Oecanthus_exclamationis	14.50	2.85	NA	NA	NA	NA	NA	NA	1152
Oecanthus_latipennis	NA	3.00	NA	NA	NA	NA	NA	NA	1152
Oecanthus_nigricornis	14.00	2.90	NA	NA	NA	NA	32.00	NA	1152
Oecanthus_niveus	14.00	2.83	NA	NA	NA	NA	NA	49.00	1152
Oecanthus_pellucens	12.00	NA	NA	NA	NA	NA	NA	NA	1072
Oecanthus_pini	15.50	3.14	NA	NA	NA	NA	NA	NA	1152
Oecanthus_quadripunctatus	14.50	2.80	NA	NA	NA	NA	NA	NA	1152
Pteronemobius_heydenii	6.50	NA	NA	NA	NA	NA	NA	NA	1072
Teleogryllus_emma	31.20	2.90	NA	85.36	NA	67.65	NA	730.17	342, 1119, 1175
Truljalia_hibinonis	16.67	NA	NA	NA	NA	NA	5.60	183.15	1169, 1170
Lathiceridae									
Crypsicerus_cubicus	16.60	NA	NA	NA	NA	NA	NA	NA	1098
Lentulidae									
Leatettix_denticornis	12.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_derula	9.25	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_emole	9.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_emota	14.00	NA	NA	NA	NA	NA	NA	NA	1099

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Leatettix_erymna	9.50	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_fala	12.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_laticornis	10.50	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_limbi	12.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_monto	11.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_moraki	14.50	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_nama	17.50	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_nasuta	9.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_noteta	14.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_pota	11.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_ratoza	11.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_selupa	12.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_selupina	12.50	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_sipina	13.75	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_sopika	12.17	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_sulefa	12.50	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_timusa	18.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_tiono	11.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_tsaoba	10.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_ukami	11.33	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_vume	11.50	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_wiga	13.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_wotafa	12.00	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_zetti	11.50	NA	NA	NA	NA	NA	NA	NA	1099
Leatettix_zomana	14.12	NA	NA	NA	NA	NA	NA	NA	1099
Mastacideidae									
Mastacides_pterolepis	13.50	NA	NA	NA	NA	NA	NA	NA	1100
Mastacides_pupaeformis	14.00	NA	NA	NA	NA	NA	NA	NA	1100

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Mastacides_vaginalis	14.00	NA	NA	NA	NA	NA	NA	NA	1100
Myrmecophilidae									
Myrmecophilus_orientalis	2.80	NA	NA	NA	NA	NA	NA	NA	1101
Pamphagidae									
Acinipe_segurensis	36.50	NA	NA	NA	NA	NA	NA	NA	1117
Acrostira_euphorbiae	56.00	NA	NA	NA	NA	NA	NA	NA	1202
Eotmethis_indigotibialis	26.10	NA	NA	NA	NA	NA	NA	NA	1116
Eotmethis_shizuishanensis	29.52	NA	NA	NA	NA	NA	NA	NA	1116
Eunapiodes_granosus	46.75	NA	NA	NA	NA	NA	NA	NA	1150
Prionotropis_hystrix	37.00	NA	NA	60.83	NA	45.60	16.00	24.00	1118, 1133
Pneumoridae									
Bullacris_membracioides	50.49	NA	NA	NA	NA	32.50	NA	NA	1113, 1114
Mohavacris_timberlakei	10.00	NA	NA	NA	NA	NA	NA	NA	1096
Pneumora_inanis	74.00	NA	NA	182.50	NA	NA	NA	NA	1197
Tanaocerus_koebelei	13.88	NA	NA	NA	NA	NA	NA	NA	1086
Proscopiidae									
Anchocoema_bidentata	NA	5.60	NA	NA	NA	NA	27.60	NA	1110
Astroma_saltense	NA	NA	NA	NA	NA	NA	20.20	NA	1110
Pyrgomorphidae									
Atractomorpha_australis	28.00	NA	NA	NA	NA	NA	NA	NA	1123
Atractomorpha_crenulata	21.05	NA	NA	NA	NA	NA	NA	NA	1150
Atractomorpha_similis	33.00	NA	NA	NA	NA	NA	NA	NA	1123
Atractomorpha_hypoestes	25.50	NA	NA	NA	NA	NA	NA	NA	1123
Aularches_miliaris	51.75	7.12	NA	169.00	NA	NA	96.40	NA	1080, 1122
Chrotogonus_hemipterus	NA	4.20	NA	NA	NA	NA	27.00	NA	1079
Chrotogonus_homalodemus	21.30	NA	NA	NA	NA	NA	NA	NA	1077
Colemania_sphenarioides	37.50	NA	NA	NA	NA	NA	NA	NA	1150
Dictyophorus_griseus	49.25	NA	NA	NA	NA	NA	NA	NA	1150

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Dictyophorus_spumans	53.50	NA	NA	NA	NA	NA	NA	NA	1150
Greyacris_profundesulcata	28.00	NA	NA	NA	NA	NA	NA	NA	1123
Maura_rubroornata	29.50	NA	NA	NA	NA	NA	NA	NA	1150
Monistria_concinna	30.00	NA	NA	NA	NA	NA	NA	NA	1123
Monistria_pustulifera	32.50	NA	NA	NA	NA	NA	NA	NA	1123
Phymateus_baccatus	61.50	NA	NA	NA	NA	NA	NA	NA	1150
Phymateus_iris	54.50	NA	NA	NA	NA	NA	NA	NA	1150
Phymateus_leprosus	70.00	NA	NA	NA	NA	NA	NA	NA	1150
Phymateus_madagassus	56.00	NA	NA	NA	NA	NA	NA	NA	1150
Phymateus_morbillosus	66.00	NA	NA	730.00	NA	NA	NA	NA	1150, 1197
Phymateus_saxosus	58.75	NA	NA	NA	NA	NA	NA	NA	1150
Phymateus_viridipes	64.50	7.80	NA	NA	NA	NA	NA	NA	342, 1150
Poekilocerus_bufonius	46.25	NA	NA	NA	NA	NA	NA	NA	1150
Poekilocerus_pictus	62.30	8.10	NA	NA	NA	NA	NA	NA	342, 1077
Pyrgomorpha_conica	21.25	NA	NA	NA	NA	NA	NA	NA	1150
Pyrgomorpha_vignaudii	NA	4.45	NA	NA	NA	NA	79.50	NA	1079
Rubellia_nigrosignata	24.50	NA	NA	NA	NA	NA	NA	NA	1150
Sphenarium_purpurascens	NA	4.10	NA	NA	NA	NA	27.00	40.50	342, 1129
Stibarosterna_serrata	26.70	NA	NA	NA	NA	NA	NA	NA	1077
Taphronota_calliparea	37.00	NA	NA	NA	NA	NA	NA	NA	1150
Zonocerus_elegans	39.38	6.50	NA	75.50	NA	91.25	70.00	300.00	1078, 1150; 1174
Zonocerus_variegatus	37.29	6.65	NA	137.00	NA	152.00	57.50	345.00	342, 1129, 1134; 1150
Raphidophoridae									
Ischyroplectron_isolatum	31.50	NA	NA	NA	NA	NA	NA	NA	1086
Isoplectron_armatum	12.00	NA	NA	NA	NA	NA	NA	NA	1086
Isoplectron_calcaratum	13.00	NA	NA	NA	NA	NA	NA	NA	1086
Macropathus_huttoni	17.00	NA	NA	NA	NA	NA	NA	NA	1086

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Neonetus_pilosus	11.00	NA	NA	NA	NA	NA	NA	NA	1086
Neonetus_variegatus	10.00	NA	NA	NA	NA	NA	NA	NA	1086
Pachyrhamma_edwardsii	25.67	NA	NA	NA	NA	NA	NA	NA	1086
Pharmacus_montanus	11.00	NA	NA	NA	NA	NA	NA	NA	1086
Pleioplectron_diversum	17.00	NA	NA	NA	NA	NA	NA	NA	1086
Pleioplectron_hudsoni	12.00	NA	NA	NA	NA	NA	NA	NA	1086
Pleioplectron_pectinatum	15.00	NA	NA	NA	NA	NA	NA	NA	1086
Pleioplectron_simplex	16.00	NA	NA	NA	NA	NA	NA	NA	1086
Tachycines_asynamorus	16.00	NA	NA	NA	NA	NA	NA	NA	1072
Talitropsis_crassicruris	23.00	NA	NA	NA	NA	NA	NA	NA	1086
Talitropsis_irregularis	12.00	NA	NA	NA	NA	NA	NA	NA	1086
Talitropsis_sedilloti	16.00	NA	NA	NA	NA	NA	NA	NA	1086
Ripipterygidae									
Ripipteryx_diegoi	8.10	NA	NA	NA	NA	NA	NA	NA	1103
Ripipteryx_gorgonaensis	6.29	NA	NA	NA	NA	NA	NA	NA	1103
Ripipteryx_guacharoensis	7.30	NA	NA	NA	NA	NA	NA	NA	1103
Romaleidae									
Acrydium_latreillei	120.00	NA	NA	NA	NA	NA	NA	NA	1077
Brachystola_magna	48.62	10.41	NA	45.00	NA	NA	36.84	NA	1071, 1125
Chromacris_speciosa	31.00	NA	NA	NA	NA	NA	NA	NA	1150
Romalea_microptera	53.00	9.50	167.30	55.00	NA	108.65	63.85	255.40	1141, 1149; 1150
Taeniopoda_eques	50.50	NA	NA	NA	NA	NA	NA	NA	1150
Taeniopoda_reticulata	54.75	NA	NA	NA	NA	NA	NA	NA	1150
Tropidacris_collaris	80.50	NA	NA	NA	NA	NA	NA	NA	1150
Tropidacris_cristata	71.50	NA	NA	NA	NA	NA	NA	NA	1150
Schizodactylidae									
Schizodactylus_minor	27.21	NA	NA	NA	NA	NA	NA	NA	1088
Schizodactylus_monstrosus	47.26	NA	NA	NA	NA	NA	23.10	NA	1089

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Stenopelmatidae									
Stenopelmatopterus_sartorianus	27.00	NA	NA	NA	NA	NA	NA	NA	1095
Stenopelmatus_guatemalae	16.50	NA	NA	NA	NA	NA	NA	NA	1095
Stenopelmatus_minor	16.00	NA	NA	NA	NA	NA	NA	NA	1095
Tetrigidae									
Tetrix_bipunctata	9.50	2.30	NA	NA	NA	NA	NA	NA	342, 1072
Tetrix_ceperoi	8.50	NA	NA	NA	NA	NA	NA	NA	1072
Tetrix_subulata	9.50	2.10	NA	NA	NA	NA	25.90	NA	342, 1072, 1138; 1201
Tetrix_tenuicornis	9.00	NA	NA	NA	NA	NA	NA	NA	1072
Tetrix_tuerki	8.50	NA	NA	NA	NA	NA	NA	NA	1072
Tetrix_undulata	9.50	2.20	NA	NA	NA	NA	NA	NA	342, 1072
Tettigoniidae									
Aerotegmina_kilimandjarica	20.30	NA	NA	NA	NA	NA	NA	NA	1157
Anabrus_simplex	42.75	7.50	NA	75.00	NA	NA	35.00	160.00	1072, 1142
Anterastes_anatolicus	19.50	NA	NA	NA	NA	NA	NA	NA	1160
Anterastes_antitauricus	19.38	NA	NA	NA	NA	NA	NA	NA	1160
Anterastes_babadaghi	17.12	NA	NA	NA	NA	NA	NA	NA	1160
Anterastes_burri	15.65	NA	NA	NA	NA	NA	NA	NA	1160
Anterastes_niger	13.50	NA	NA	NA	NA	NA	NA	NA	1160
Anterastes_serbicus	14.82	NA	NA	NA	NA	NA	NA	NA	1160
Anterastes_tolunayi	18.95	NA	NA	NA	NA	NA	NA	NA	1160
Anterastes_turcicus	18.07	NA	NA	NA	NA	NA	NA	NA	1160
Anterastes_ucari	17.88	NA	NA	NA	NA	NA	NA	NA	1160
Anterastes_uludaghensis	13.80	NA	NA	NA	NA	NA	NA	NA	1160
Barbitistes_constrictus	17.00	NA	NA	NA	NA	NA	NA	NA	1072
Barbitistes_serricauda	17.50	NA	NA	NA	NA	NA	NA	NA	1072
Clonia_wahlbergi	52.50	NA	NA	NA	NA	NA	NA	NA	1197

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Conocephalus_dorsalis	14.50	5.25	NA	NA	NA	NA	NA	NA	1072, 1124
Conocephalus_fuscus	14.50	6.00	NA	NA	NA	NA	NA	NA	1072, 1124
Conocephalus_nigropleurum	14.25	5.00	NA	NA	NA	NA	NA	NA	1076, 1199
Decticus_verrucivorus	33.00	5.00	NA	NA	NA	NA	NA	NA	1072, 1124
Ephippiger_ephippiger	25.25	NA	NA	NA	NA	NA	NA	NA	1072
Euconocephalus_incertus	33.51	NA	NA	NA	NA	NA	NA	NA	1179
Euconocephalus_indicus	31.59	NA	NA	NA	NA	NA	NA	NA	1179
Euconocephalus_mucro	31.40	NA	NA	NA	NA	NA	NA	NA	1179
Euconocephalus_nasutus	32.08	NA	NA	NA	NA	NA	NA	NA	1179
Euconocephalus_pallidus	31.04	NA	NA	NA	NA	NA	NA	NA	1178
Gampsocleis_glabra	23.00	NA	NA	NA	NA	NA	NA	NA	1072
Isophya_pyrenaea	21.00	NA	NA	NA	NA	NA	NA	NA	1072
Jamaicana_flava	NA	8.00	NA	NA	NA	NA	NA	NA	1163
Leptophyes_albovittata	12.75	NA	NA	NA	NA	NA	NA	NA	1072
Leptophyes_punctatissima	14.25	3.37	NA	NA	NA	NA	NA	NA	342, 1072
Meconema_thalassinum	13.50	3.00	NA	NA	NA	NA	NA	NA	1072, 1124
Metrioptera_bicolor	16.50	NA	NA	NA	NA	NA	NA	NA	1072
Metrioptera_brachyptera	15.00	4.00	NA	NA	NA	NA	NA	NA	1072, 1124
Mygalopsis_marki	35.20	NA	NA	NA	NA	228.00	NA	NA	1163, 1164
Neoconocephalus_aduncus	44.00	NA	NA	NA	NA	NA	NA	NA	1178
Neoconocephalus_affinis	57.00	NA	NA	NA	NA	NA	NA	NA	1178
Neoconocephalus_ensiger	54.00	NA	NA	NA	NA	NA	NA	NA	1156
Neoconocephalus_maxillosus	56.25	NA	NA	NA	NA	NA	NA	NA	1178
Neoconocephalus_occidentalis	49.00	NA	NA	NA	NA	NA	NA	NA	1178
Neoconocephalus_palustris	46.25	NA	NA	NA	NA	NA	NA	NA	1156
Neoconocephalus_pinicola	46.50	NA	NA	NA	NA	NA	NA	NA	1178
Neoconocephalus_pipulus	50.00	NA	NA	NA	NA	NA	NA	NA	1178
Neoconocephalus_punctipes	47.00	NA	NA	NA	NA	NA	NA	NA	1178

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Neoconocephalus_retusiformis	49.00	NA	NA	NA	NA	NA	NA	NA	1178
Neoconocephalus_retusus	44.50	NA	NA	NA	NA	NA	NA	NA	1156
Neoconocephalus_robustus	63.50	NA	NA	NA	NA	NA	NA	NA	1156
Neoconocephalus_saturatus	56.00	NA	NA	NA	NA	NA	NA	NA	1178
Neoconocephalus_spiza	55.50	NA	NA	NA	NA	NA	NA	NA	1178
Neoconocephalus_susurrator	40.00	NA	NA	NA	NA	NA	NA	NA	1178
Neoconocephalus_triops	55.25	NA	NA	49.00	NA	NA	NA	NA	1156
Neoconocephalus_velox	60.50	NA	NA	NA	NA	NA	NA	NA	1178
Orophus_conspersus	62.00	NA	NA	NA	NA	NA	NA	NA	1178
Phaneroptera_falcata	15.00	NA	NA	NA	NA	NA	NA	NA	1072
Phaneroptera_nana	NA	4.50	NA	NA	NA	NA	NA	NA	1124
Pholidoptera_aptera	22.00	5.60	NA	NA	NA	NA	NA	NA	342, 1072
Pholidoptera_griseoaptera	15.25	4.25	NA	NA	NA	NA	NA	NA	1072, 1124
Platycleis_albopunctata	20.00	4.00	NA	NA	NA	NA	NA	NA	1072, 1124
Platycleis_montana	16.00	NA	NA	NA	NA	NA	NA	NA	1072
Platycleis_tessellata	15.00	NA	NA	NA	NA	NA	NA	NA	1072
Polysarcus_denticauda	34.00	NA	NA	NA	NA	NA	NA	NA	1072
Requena_verticalis	16.69	3.70	NA	48.94	NA	NA	17.00	NA	1197, 1198; 1200
Roeseliana_roeselii	16.00	4.65	NA	NA	NA	NA	NA	NA	1072, 1124
Ruspolia_differens	NA	6.00	NA	62.00	NA	268.00	30.79	NA	1202
Ruspolia_nitidula	24.50	NA	NA	NA	NA	NA	NA	NA	1072
Tettigonia_cantans	27.00	5.60	NA	NA	NA	NA	NA	NA	342, 1072
Tettigonia_viridissima	34.50	5.30	NA	NA	NA	NA	NA	NA	1072, 1124
Zitsikama_tessellata	25.00	NA	NA	NA	NA	NA	NA	NA	1197
Thericledidae									
Chromothericles_keniensis	15.40	NA	NA	NA	NA	NA	NA	NA	1104
Chromothericles_manyara	15.05	NA	NA	NA	NA	NA	NA	NA	1104
Chromothericles_ngongensis	9.50	NA	NA	NA	NA	NA	NA	NA	1104

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Chromothericles_uguenoensis	15.20	NA	NA	NA	NA	NA	NA	NA	1104
Tridactylidae									
Xya_capensis	5.60	NA	NA	NA	NA	NA	NA	NA	1106
Xya_pfaendleri	5.00	NA	NA	NA	NA	NA	NA	NA	1105
Xya_variegata	5.00	NA	NA	NA	NA	NA	NA	NA	1105
Trigonidiidae									
Allonemobius_allardi	NA	1.91	NA	NA	NA	NA	NA	NA	1136
Allonemobius_fasciatus	NA	1.83	NA	NA	NA	NA	NA	NA	1136
Allonemobius_socius	10.50	NA	NA	NA	NA	NA	NA	NA	1156
Argizala_brasiliensis	11.08	NA	NA	NA	NA	NA	NA	NA	1107
Eunemobius_carolinus	NA	1.75	NA	NA	NA	NA	NA	NA	1136
Nemobius_sylvestris	8.50	NA	NA	NA	NA	NA	NA	NA	1072, 1168
Neonemobius_eurynotus	11.05	NA	NA	NA	NA	NA	NA	NA	1108
Tristiridae									
Elasmoderus_wagenknechti	32.95	NA	NA	NA	NA	NA	NA	NA	1090
Xyronotidae									
Axyronotus_cantralli	23.35	NA	NA	NA	NA	NA	NA	NA	1087
Xyronotus_aztecus	22.82	NA	NA	NA	NA	NA	NA	NA	1087
Xyronotus_cohni	22.18	NA	NA	NA	NA	NA	NA	NA	1087
Xyronotus_hubbelli	23.45	NA	NA	NA	NA	NA	NA	NA	1087
Phasmida									
Anisacanthidae									
Parectatosoma_hystrix	70.00	NA	NA	95.00	NA	91.25	NA	NA	361
Aschiphasmatidae									
Dinophasma_guttigera	55.69	3.40	NA	NA	NA	NA	NA	NA	369
Bacillidae									
Phalces_brevis	63.75	2.14	152.08	182.50	NA	NA	NA	NA	342, 359
Diapheromeridae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Centrophasma_hadrillum	86.50	6.80	121.67	NA	NA	NA	NA	NA	370, 467
Heteropterygidae									
Aretaon_asperrimus	70.50	5.50	87.50	NA	NA	NA	NA	NA	363, 362
Theramenes_mandirigma	55.65	6.75	83.00	NA	NA	NA	NA	NA	374
Lonchodidae									
Lonchodes_abbreviatus	91.75	2.70	NA	NA	NA	NA	NA	NA	362
Lonchodes_spinulosus	54.25	2.30	136.88	NA	NA	NA	NA	250.00	367
Phasmatidae									
Acanthomenexenus_exiguus	35.50	2.70	106.46	136.88	NA	365.00	NA	NA	373, 356
Acanthoxyla_inermis	104.00	NA	NA	NA	NA	182.50	NA	250.00	366, 343
Eurycnema_versirubra	167.50	6.00	319.38	NA	NA	NA	NA	NA	365
Megacrania_tsudai	114.80	7.60	163.67	NA	NA	NA	NA	130.50	342, 353
Phasma_gigas	153.50	4.00	182.50	NA	NA	118.71	NA	350.00	360
Phobaeticus_serratipes	188.75	5.00	152.08	NA	NA	NA	NA	NA	368
Phylliidae									
Phyllium_bioculatum	81.25	NA	NA	NA	NA	45.50	NA	92.50	358, 355
Phyllium_celebicum	73.50	5.00	NA	NA	NA	NA	NA	NA	364
Phyllium_giganteum	102.50	6.00	212.92	304.17	NA	NA	NA	NA	371
Pseudophasmatidae									
Malacomorpha_jamaicana	47.00	3.00	152.08	136.88	NA	212.92	NA	NA	372
Metriophasma_diocles	75.93	NA	71.22	103.90	NA	53.34	NA	NA	354
Plecoptera									
Capniidae									
Capnia_atra	NA	NA	NA	NA	NA	NA	NA	450.00	361, NA
Zwicknia_bifrons	NA	0.28	0.00	NA	NA	74.00	NA	713.00	350, 395
Chloroperlidae									
Alloperla_onkos	NA	NA	113.00	NA	NA	NA	42.50	NA	344, 343
Chloroperla_tripunctata	NA	0.31	NA	NA	NA	13.00	NA	NA	350

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Isoptena_serricornis	NA	0.32	NA	NA	NA	NA	NA	50.00	349
Siphonoperla_torrentium	NA	0.38	25.00	NA	NA	19.50	28.00	56.00	350
Leuctridae									
Leuctra_fusca	NA	0.18	27.50	NA	NA	38.00	154.50	673.00	342, 350
Leuctra_geniculata	NA	NA	21.00	NA	NA	32.50	590.50	2089.00	350
Leuctra_hippopus	NA	0.18	18.00	NA	NA	56.00	319.00	928.00	342, 350
Leuctra_inermis	NA	NA	12.25	NA	NA	25.50	251.00	620.00	350
Leuctra_moselyi	NA	0.42	25.00	NA	NA	20.00	193.50	1294.00	350
Leuctra_nigra	NA	NA	NA	NA	NA	35.00	NA	NA	350
Nemouridae									
Amphinemura_standfussi	NA	0.41	139.92	NA	NA	43.00	200.00	802.50	350, 343, NA
Amphinemura_sulcicollis	NA	0.20	16.00	NA	NA	61.00	NA	1208.00	350, 343
Nemoura_avicularis	NA	0.40	19.00	NA	NA	52.00	NA	650.00	350, NA
Nemoura_cambrica	NA	0.18	17.00	NA	NA	49.50	386.00	1357.00	350
Nemoura_cinerea	NA	0.43	83.60	NA	NA	34.50	545.50	1443.00	350, NA
Nemoura_erratica	NA	NA	NA	NA	NA	42.00	NA	NA	350
Nemoura_trispinosa	NA	NA	NA	NA	NA	NA	514.00	NA	
Nemurella_pictetii	NA	0.66	33.64	NA	NA	23.50	450.00	1079.00	350, 352
Protonemura_meyeri	NA	0.23	18.00	NA	NA	29.50	400.00	2000.00	350
Protonemura_praecox	NA	0.26	18.00	NA	NA	55.00	500.00	2000.00	350
Perlidae									
Agnetina_capitata	NA	NA	42.00	NA	NA	NA	295.00	NA	344, 343
Dinocras_cephalotes	NA	0.61	44.00	766.50	NA	13.00	802.00	2069.00	350, 347
Neoperla_clymene	NA	0.40	29.00	NA	NA	NA	173.00	646.00	343
Paragnetina_media	16.45	0.53	35.00	730.00	NA	12.50	532.70	2067.50	348, 344
Perlodidae									
Diura_bicaudata	NA	0.69	NA	NA	NA	27.00	179.00	710.25	350, NA
Isogenus_nubecula	NA	0.48	34.00	NA	NA	31.50	NA	NA	350

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Isoperla_clio	NA	NA	91.25	212.92	NA	NA	441.70	NA	344
Isoperla_cotata	NA	NA	47.00	NA	NA	NA	273.00	NA	344
Isoperla_frisoni	NA	NA	49.00	NA	NA	NA	146.00	NA	344
Isoperla_grammatica	NA	0.40	30.00	NA	NA	32.00	85.50	339.00	350
Isoperla_transmarina	NA	NA	41.25	NA	NA	NA	95.00	NA	344
Perlodes_microcephalus	NA	0.67	33.00	NA	NA	24.00	NA	375.00	350
Pteronarcyidae									
Pteronarcys_dorsata	NA	0.59	30.50	NA	NA	31.50	97.50	242.00	346
Taeniopterygidae									
Brachyptera_risi	NA	0.67	139.00	NA	NA	49.00	407.00	1466.00	350, 343
Taeniopterix_nebulosa	NA	0.22	46.25	NA	NA	27.00	600.00	1811.00	351, 350
Protura									
Acerentomidae									
Baculentulus_densus	NA	0.13	60.83	NA	NA	NA	NA	NA	12, 3
Psocodea									
Caeciliusidae									
Caecilius_fuscopterus	NA	0.43	9.30	27.90	NA	NA	NA	86.00	1208, 1276
Valenzuela_burmeisteri	NA	0.43	8.67	27.50	NA	NA	5.35	79.00	1208
Valenzuela_flavidus	NA	0.44	8.33	32.53	NA	NA	6.90	113.00	1208
Valenzuela_kolbei	NA	0.42	9.27	31.40	NA	NA	NA	86.00	1208
Ectopsocidae									
Ectopsocus_briggsi	NA	0.34	9.53	25.07	NA	NA	7.95	84.00	1208
Ectopsocus_pumilis	1.85	0.39	6.00	17.30	NA	30.00	6.00	NA	1206, 1207
Haematomyzidae									
Haematomyzus_elephantis	2.50	NA	NA	NA	NA	NA	NA	NA	1213
Liposcelididae									
Embidopsocus_enderleini	1.45	0.51	17.50	23.00	NA	NA	NA	NA	1223
Liposcelis_bostrychophila	1.00	0.34	15.58	22.04	NA	80.34	NA	69.64	1218, 1219

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Menoponidae									
Menopon_gallinae	1.81	0.50	4.50	NA	NA	NA	NA	NA	342, 1216, 1217
Pediculidae									
Pediculus_humanus	2.85	NA	8.50	8.45	NA	19.32	NA	NA	1216, 1212
Peripsocidae									
Peripsocus_quadrifasciatus	1.80	0.37	12.30	16.12	NA	16.50	NA	132.88	1206, 1205
Philopteridae									
Campanulotes_compar	1.31	NA	NA	NA	NA	NA	NA	NA	1216, 1205
Chelopistes_meleagridis	3.82	NA	3.81	25.55	NA	27.00	NA	28.00	1216, 1215
Columbicola_columbae	2.48	0.70	4.15	20.22	NA	35.00	NA	NA	1214
Philotarsidae									
Aaroniella_eertmoedi	NA	0.53	NA	NA	NA	NA	5.00	NA	1209
Aaroniella_maculosa	3.04	0.57	NA	NA	NA	NA	5.00	NA	1210, 1209
Stenopsocidae									
Graphopsocus_cruciatus	2.12	0.46	9.72	29.67	NA	NA	7.29	102.00	1206, 1208
Stenopsocus_immaculatus	1.38	0.63	9.50	29.50	NA	NA	7.76	78.00	1209, 1208
Stenopsocus_stigmaticus	NA	0.58	9.80	29.67	NA	NA	7.18	94.00	1208
Trichopsocidae									
Trichopsocus_dalii	NA	0.48	10.33	37.67	NA	NA	NA	57.00	1208
Trogiidae									
Lepinotus_reticulatus	1.30	0.37	8.05	22.05	NA	48.67	NA	34.70	342, 1222, 1221, 1220
Raphidioptera									
Raphidiidae									
Agulla_astuta	12.52	1.46	11.00	393.81	19.20	60.83	45.00	183.00	839, 819
Agulla_bractea	17.90	1.72	9.50	198.70	18.10	38.02	115.75	463.00	838, 821
Siphonaptera									
Ceratophyllidae									

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Ceratophyllus_gallinae	NA	NA	4.75	33.00	NA	NA	NA	NA	842
Ctenophthalmidae									
Ctenophthalmus_nobilis	NA	NA	5.42	11.00	14.67	NA	3.00	NA	843
Hectopsyllidae									
Tunga_penetrans	0.77	0.60	4.00	7.00	12.00	NA	NA	NA	822
Leptopsyllidae									
Caenopsylla_laptevi	NA	NA	5.50	10.50	18.50	26.00	6.00	NA	823, 819, 832
Pulicidae									
Ctenocephalides_felis	1.87	0.50	2.80	21.00	0.91	81.50	NA	1745.00	342, 820, 819, 821
Parapulex_chephrenis	1.78	NA	NA	NA	NA	NA	NA	NA	826
Spilopsyllus_cuniculi	NA	NA	4.60	16.90	NA	NA	NA	NA	825
Synosternus_cleopatrae	1.75	NA	NA	NA	NA	NA	NA	NA	826
Xenopsylla_cunicularis	NA	NA	7.50	8.50	23.50	NA	NA	NA	825
Xenopsylla_ramesis	1.50	NA	NA	NA	NA	NA	NA	NA	826
Strepsiptera									
Corioxenidae									
Blissoxenos_esakii	2.40	NA	91.25	NA	NA	NA	NA	544.00	840, 867
Corioxenos_antestiae	3.42	NA	52.50	157.25	42.00	44.25	NA	3500.00	841
Halictophagidae									
Halictophagus_silwoodensis	1.93	NA	NA	NA	NA	NA	NA	1000.00	827
Thysanoptera									
Aeolothripidae									
Aeolothrips_intermedius	NA	NA	5.25	7.70	5.07	NA	NA	29.00	1224, 1225
Cycadothrips_chadwicki	2.05	NA	NA	NA	NA	NA	NA	NA	1226
Dactuliothrips_boharti	1.80	NA	NA	NA	NA	NA	NA	NA	1227
Desmothrips_propinquus	1.60	NA	NA	NA	NA	NA	NA	NA	1228
Franklinothrips_orizabensis	NA	NA	9.66	4.50	7.50	9.17	NA	71.70	1229

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Franklinothrips_vespiformis	2.75	0.38	10.28	14.47	NA	NA	NA	NA	1231, 1230
Orothrips_kelloggi	2.25	NA	NA	NA	NA	NA	NA	NA	1232
Melanthripidae									
Ankothrips_yuccae	0.41	NA	NA	NA	NA	NA	NA	NA	1233, 1224
Melanthrips_fuscus	NA	0.27	NA	NA	NA	NA	NA	NA	1237
Phlaeothripidae									
Adrothrips_aureus	2.30	NA	NA	NA	NA	NA	NA	NA	1265, 1224
Bactrothrips_brevitubus	NA	0.55	5.00	7.50	4.00	NA	22.00	NA	1262, 1226
Cartomothrips_browni	2.76	NA	NA	NA	NA	NA	NA	NA	1266, 1224
Haplothrips_brevitubus	NA	NA	4.50	9.60	3.80	34.90	NA	120.10	1234
Haplothrips_niger	1.90	0.47	4.60	7.33	5.10	29.20	NA	31.10	1270
Haplothrips_victoriensis	1.73	0.38	3.50	10.00	5.00	109.70	NA	NA	1267
Leptothrips_fasciculatus	NA	0.44	NA	NA	NA	NA	NA	NA	1269
Leptothrips_mali	2.36	0.42	8.20	12.40	6.73	46.35	NA	24.45	1271
Phaulothrips_kranzae	4.26	NA	NA	NA	NA	NA	NA	NA	1264
Thripidae									
Aptinothrips_rufus	NA	NA	19.00	14.00	6.00	NA	NA	NA	1241, 1226
Arorathrips_mexicanus	NA	NA	NA	NA	NA	NA	NA	35.00	1224, 1242
Echinothrips_americanus	NA	NA	11.37	7.29	3.02	35.35	NA	82.35	1243, 1244
Frankliniella_australis	NA	NA	2.93	5.06	2.19	9.48	NA	54.37	1245
Frankliniella_fusca	NA	0.05	3.32	4.40	2.35	29.08	NA	55.50	342, 1247
Frankliniella_occidentalis	NA	NA	13.04	16.30	10.30	NA	NA	35.00	1236
Frankliniella_schultzei	NA	NA	5.99	6.02	2.71	20.50	NA	22.10	1246
Frankliniella_tritici	NA	NA	6.71	5.82	2.63	21.42	NA	41.25	1247
Heliothrips_haemorrhoidalis	NA	NA	27.46	14.61	4.30	53.22	NA	52.33	1236
Limothrips_cerealium	NA	NA	11.50	15.00	6.50	NA	NA	NA	1241
Pezothrips_kellyanus	NA	NA	6.65	7.30	3.42	19.54	NA	155.81	1248, 1249
Pseudodendrothrips_mori	0.77	0.25	5.60	6.60	2.50	5.00	NA	27.00	1235

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Scirtothrips_aurantii	NA	NA	15.00	10.55	6.00	NA	NA	NA	1250
Scirtothrips_perseae	NA	NA	13.04	6.18	NA	11.84	NA	27.75	1240
Sericothrips_staphylinus	0.95	0.30	26.82	NA	NA	44.25	NA	76.20	1239, 1238
Stenchaetothrips_biformis	NA	NA	6.43	7.72	3.73	9.71	NA	26.92	1252
Taeniothrips_inconsequens	NA	NA	6.50	NA	NA	10.50	NA	6.98	1254, 1253
Thrips_nigropilosus	1.12	0.25	9.00	7.37	3.70	14.07	NA	31.59	1258, 1256, 1257
Thrips_obscuratus	NA	NA	5.26	7.63	3.94	13.32	NA	NA	1255
Thrips_simplex	1.55	0.30	5.28	9.74	13.47	29.78	NA	130.94	1259, 1260, 1261
Thrips_tabaci	NA	0.06	4.24	5.06	2.58	15.11	NA	35.88	342, 1246, 1247
Trichoptera									
Anomalopsychidae									
Contulma_paluguillensis	NA	0.08	NA	NA	NA	NA	NA	NA	1283
Apataniidae									
Apatania_fimbriata	NA	NA	26.07	NA	NA	2.00	108.50	NA	1274, 1273
Brachycentridae									
Brachycentrus_subnubilus	NA	NA	11.17	NA	NA	NA	244.10	NA	1278, 1289
Calamoceratidae									
Anisocentropus_kirramus	NA	NA	6.50	NA	NA	NA	90.00	NA	1273, 1271
Glossosomatidae									
Agapetus_fuscipes	NA	NA	36.00	NA	NA	NA	NA	NA	1272, 1271
Culoptila_cantha	NA	0.20	NA	NA	19.40	2.50	17.50	64.62	342, 1284
Glossosoma_nigrior	8.05	NA	NA	NA	NA	NA	NA	NA	1291
Helicopsychidae									
Helicopsyche_borealis	NA	0.23	16.50	73.50	NA	NA	217.00	NA	1292, 1293
Hydropsychidae									
Arctopsyche_grandis	NA	NA	12.50	NA	NA	NA	NA	NA	1275, 1271
Cheumatopsyche_analis	NA	NA	NA	106.46	NA	NA	NA	NA	1280
Hydropsyche_slossonae	NA	NA	13.00	329.00	18.00	NA	235.60	NA	1295

Species	ABL	EL	EDT	NDT	PDT	AL	CS	LF	References
Leptoceridae									
Ceraclea_ancylus	NA	0.10	NA	NA	31.50	1.50	150.00	NA	1279, 1271
Ceraclea_transversa	NA	0.10	7.00	NA	NA	NA	300.00	NA	1279, 1393
Limnephilidae									
Dicosmoecus_atripes	NA	1.00	30.42	NA	14.00	NA	NA	NA	1287
Limnephilus_indivisus	NA	NA	NA	22.98	13.53	90.55	NA	133.58	1297
Molannidae									
Molanna_tryphena	NA	0.36	NA	NA	30.42	NA	NA	76.20	1298
Philopotamidae									
Chimarra_ambulans	NA	0.30	21.95	NA	NA	NA	NA	NA	1281
Phryganeidae									
Banksiola_crotchi	NA	NA	20.00	NA	NA	NA	95.00	NA	1276, 1271
Uenoidae									
Neophylax_rickeri	NA	0.40	NA	NA	NA	10.50	645.00	NA	1300
Neophylax_splendens	NA	NA	NA	NA	28.00	NA	NA	NA	1299
Zoraptera									
Zorotypidae									
Zorotypus_caudelli	2.33	0.60	40.00	77.28	NA	NA	NA	NA	384, 383, 385
Zorotypus_hubbardi	NA	0.61	NA	NA	NA	NA	NA	NA	382
Zygentoma									
Lepismatidae									
Ctenolepisma_longicaudata	13.50	1.15	34.33	1003.75	NA	1460.00	11.00	NA	17, 16
Thermobia_domestica	NA	1.04	15.00	66.50	NA	NA	NA	NA	18

D.2 Dataset References

D.2 Dataset references

[1] I. Bandyopadhyaya and D. K. Choudhuri. Laboratory observations on the biology of Xenylla welchi (Collembola: Hexapoda). *Pedobiologia*, 46(3-4):311–315, 2002.

[2] S. K. Mitra. Behaviour during ecdysis and the mode of eclosion from egg in Lobella (Propeanura) corallina (Imms, 1912) (Collembola: Neanuridae). *Journal of the Bombay Natural History Society*, 72:868–870, 1975.

[3] T. Birkemoe and H. P. Leinaas. Effects of temperature on the development of an arctic Collembola (Hypogastrura tullbergi). *Functional Ecology*, 14:693–700, 2000.

[4] Y.-S. Lee, N.-H. Yang, J. Son, Y. Kim, K.-H. Park, and K. Cho. Effects of temperature on development, molting, and population growth of Yuukianura szeptyckii Deharveng & Weiner, 1984 (Collembola: Neanuridae). *Applied Soil Ecology*, 108:325–333, 2016.

[5] E.-K. Park. Effect of laboratory culture conditions on population growth of Proisotoma minuta (Tullberg) (Collembola: Isotomidae). *Entomological Science*, 10:135–140, 2007.

[6] O. Roithmeier, U. Burkhardt, E. Daghighi, and J. Filser. Desoria trispinata (MacGillivray, 1896), a promising model Collembola species to study biological invasions in soil communities. *Pedobiologia*, 67:45–56, 2018.

[7] M. T. Fountain and S. P. Hopkin. Folsomia candida (Collembola): a "standard" soil arthropod. *Annual Review of Entomology*, 50:201–222, 2005.

[8] J. C. Moore, P. Saunders, G. Selby, H. Horton, M. K. Chelius, A. Chapman, and R. D. Horrocks. The distribution and life history of Arrhopalites caecus (Tullberg): Order: Collembola, in Wind Cave, South Dakota, USA. *Journal of Cave and Karst Studies*, 67(2):110–119, 2005.

[9] G. D. Sharma. *The biology of four species of soil-inhabiting Collembola*. Thesis, McGill University, 1962.

[10] G. D. Sharma. Bionomics of Tomocerus vulgaris Tullberg (Collembola: Entomobryidae). *Proceedings of the Royal Entomological Society of London Series A: General Entomology*, 42(1):30–34, 1967.

[11] R. Davis and H. M. Harris. The biology of Pseudosinella violenta (Folsom), with some effects of temperature and humidity on its life stages (Collembola: Entomobryidae). *Iowa State College Journal of Science*, 10:421–430, 1936.

[12] R. Machida and I. Takahashi. Embryonic development of a proturan Baculentulus densus (Imadaté): reference to some developmental stages (Hexapoda: Protura, Acerentomidae). *Proceedings of the Arthropodan Embryological Society of Japan*, 38:13–17, 2003.

[13] J. Johnsen. *The thermal effects on selected life history traits in an arctic and a temperate population of Collembola Hypogastrura viatica*. Thesis, University of Oslo, 2014.

[14] N. Chandrasekhara Kurup. *Some aspects of the reproductive biology of Collembola [Apterygota: Insecta]*. Thesis, University of Kerala, 1982.

[15] R. Machida. External features of embryonic development of a jumping bristletail, Pedetontus unimaculatus Machida (Insecta, Thysanura, Machilidae). *Journal of Morphology*, 168:339–355, 1981.

[16] E. Lindsay. The biology of the silverfish, Ctenolepisma longicaudata Esch. with particular reference to its feeding habits. *Proceedings of the Royal Society of Victoria*, 52(1):35–79, 1940.

[17] E. Thomsen, S. Kongsstovu, H. A. Dahl, and S.-O. Mikalsen. Ctenolepisma longicaudata (Escherich, 1905): a common, but previously unregistered, species of silverfish in the Faroe Islands. *BioInvasions Records*, 8(3):540–550, 2019.

[18] J. A. Adams. Biological notes upon the firebrat, Thermobia domestica Packard. *Journal of the New York Entomological Society*, 41(4):557–562, 1933.

[19] M. J. Delany. The life histories and ecology of two species of Petrobius Leach, P. brevistylis and P. maritimus. *Transactions of the Royal Society of Edinburgh*, 63(3):501–533, 1959.

[20] B. J. Hicks and D. J. Larson. Life history patterns of Ilybius Erichson from Newfoundland (Coleoptera: Dytiscidae). *The Coleopterists Bulletin*, 49(3):281–287, 1995.

[21] J. R. Holomunzki. Life history aspects of the predaceous diving beetle, Dytiscus dauricus (Gebler), in Arizona. *The Southwestern Naturalist*, 30(4):485–490, 1985.

[22] Z. Kučerovà, J. Hromádková, and V. Stejskal. External egg morphology of common stored-product pests from families Anobiidae (Ptininae) and Dermestidae (Coleopera). In *10th International Working Conference on Stored Product Protection*, pages 135–138.

[23] L. A. Stewart, A. F. G. Dixon, Z. Ruzicka, and G. Iperti. Clutch and egg size in ladybird beetles. *Entomophaga*, 36(3):329–333, 1991.

[24] J. A. Wightman and B. J. Southgate. Egg morphology, host, and probable regions of origin of the bruchids (Coleoptera: Bruchidae) that infest stored pulses - an identification aid. *New Zealand Journal of Experimental Agriculture*, 10:95–99, 1982.

[25] A. Sharma, A. Sharma, S. K. Khinchi, and K. C. Kumawat. Studies on biology of Carydeon serratus (Oliver) on groundnut Arachis hypogaea (L.). *Journal of Entomology and Zoology Studies*, 5(3):579–582, 2017.

[26] P. F. Prevett. The larva of Caryedon serratus (Ol.): the groundnut seed beetle (Coleoptera: Bruchidae). *Journal of Stored Products Research*, 3(2):117–123, 1967.

[27] D. R. Devi and N. V. Rao. Some observations on the biology of groundnut seed beetle Caryedon serratus (Oliver) (Coleoptera; Bruchidae). *Legume Reaearch*, 28(3):229–230, 2005.

[28] H.-S. Li, C. Pan, P. De Clercq, A. Ślipiński, and H. Pang. Variation in life history traits and transcriptome associated with adaptation to diet shifts in the ladybird Cryptolaemus montrouzieri. *BMC Genomics*, 17(281), 2016.

[29] B. K. Agarwala, S. Bhattacharya, and P. Bardhanroy. Who eats whose eggs? Intra- versus inter-specific interactions in starving ladybird beetles predaceous on aphids. *Ethology Ecology & Evolution*, 10(4):361–368, 1998.

[30] J. M. Mari, S. M. Nizamani, M. K. Lohar, and R. D. Khuhro. Biology of Menochilus sexamculatus Fab. and Coccinella undecimpunctata L. (Coccinellidae: Coleoptera) on alfalfa aphid Therioaphis trifolii Monell. *Journal of Asia-Pacific Entomology*, 7(3):297–300, 2004.

[31] O. Nedvěd and A. Honěk. Life history and development. In I. Hodek, H. F. van Emden, and A. Honěk, editors, *Ecology and Behaviour of the Ladybird Beetles (Coccinellidae)*, pages 54–109. Blackwell Publishing Ltd., Oxford, UK, 1 edition, 2012.

[32] M. A. Jalali, L. Tirry, and P. De Clercq. Effects of food and temperature on development, fecundity and life-table parametrs of Adalia bipunctata (Coleoptera: Coccinellidae). *Journal of Applied Entomology*, 133:615–625, 2009.

[33] M. Yazdani and M. Zarabi. Studies on developmental stages of Clithostethus arcuatus (Coleoptera: Coccinellidae) on ash whitefly with note on a new hots, Aleyrodes singularis. *Hexopoda*, 16(1):14–17, 2009.

[34] G. D. Butler. Development time of Coccinella septempunctata in relation to constant temperatures (Col.: Coccinellidae). *Entomophaga*, 27(3):349–353, 1982.

[35] M. Rauf, E. ul Haq, J. Khan, A. Rehman, W. A. Gillani, and A. Ali. Biology and predatory potential of Coccinella septempunctata Linn. on Schizaphis graminum aphid under controlled conditions. *Pakistan Journal of Agricultural Research*, 26(2):124–129, 2013.

[36] P. R. Shinde, S. S. Shetgar, and S. H. Mhaske. Biology of Cryptolaemus montrouzieri (Mulsant) on Maconellicoccus hirsutus (Green) at different temperature levels. *Journal of Biological Control*, 30(2):124–127, 2016.

[37] H. A. Cordo, C. J. DeLoach, and D. H. Habeck. Biology of Heilipodus ventralis (Coleoptera: Curculionidae), an Argentine weevil for biological control of snakeweeds (Gutierrezia spp.) in the United States. *Biological Control*, 15:210–227, 1999.

[38] C. R. Thompson and D. H. Habeck. Host specificity and biology of the weevil Neohydronomus affinis (Coleoptera: Curculionidae) a biological control agent of Pistia stratiotes. *Entomophaga*, 34(3):299–306, 1989.

[39] M. E. Tzanakakis. The biology of Pseudocoeliodes rubricus (Col. Curculionidae) on pistachio. *Journal of Applied Entomology*, 64(2):266–276, 1969.

[40] X. Wen, Y. Kuang, M. Shi, H. Li, Y. Luo, and R. Deng. Biology of Hylobitelus xiaoi (Coleoptera: Curculionidae), a new pest of the slash pine, Pinus elliottii. *Journal of Economic Entomology*, 97(6):1958–1964, 2004.

[41] E. Reichert, M. T. Johnson, E. Chacón, R. S. Anderson, and T. A. Wheeler. Biology and host preferences of Cryptohynchus melastomae (Coleoptera: Curculionidae), a possible biocontrol agent for Miconia calvescens (Melastomataceae) in Hawaii. *Environmental Entomology*, 36(6):1848–1857, 2010.

[42] A. Raman, Z. T. Cruz, R. Muniappan, and G. V. P. Reddy. Biology and host specificity of gall-inducing Acytopeus burkhartorum (Coleoptera: Curculionidae), a biological-control agent for the invasive weed Coccinia grandis (Cucurbitaceae) in Guam and Saipan. *Tijdschrift voor Entomologie*, 150(1):181–191, 2007.

[43] G. R. Bhanderi. *Biology and management of rice weevil, Sitophilus oryzae (Linnaeus) on stored sorghum*. Thesis, Navsari Agricultural University, 2012.

[44] J. B. Beavers. Biology of Diaprepes abbreviatus (Coleoptera: Curculionidae) reared on an artificial diet. *Florida Entomologist*, 65(2):263–269, 1982.

[45] A. S. McClay and D. M. Anderson. Biology and immature stages of Thecesternus hirsutus Pierce (Coleoptera: Curculionidae) in north-eastern Mexico. *Proceedings of the Entomological Society of Washington*, 87(1):207–215, 1985.

[46] M. M. Furniss and S. J. Kegley. Biology of Dendroctonus murrayanae (Coleoptera: Curculionidae: Scotlytinae) in Idaho and Montana and comparative taxonomic notes. *Annals of the Entomological Society of America*, 101(6):1010–1016, 2008.

[47] J. A. Ojo and A. A. Omoloye. Development and life history of Sitophilus zeamais (Coleoptera: Curculionidae) on cereal crops. *Advances in Agriculture*, page 7836379, 2016.

[48] A. L. Khanday and A. A. Buhroo. Life history and biolog of the elm bark beetle Scolytus kashmirensis Schedl (Coleoptera: Curculionidae: Scolytinae) infesting Ulmus villosa in Kashmir. *Open Journal of Forestry*, 5:443–453, 2015.

[49] K. Sezen, Ö. Ertürk, and Z. Demirbag. Investigations of the biolog of hazlenut beetle, Balaninus nucum L. (Coleoptera: Curculionidae) and its damage to hazlenut. *Pakistan Journal of Biological Sciences*, 2(4):1497–1500, 1999.

[50] J. Mulder, Philip G., M. K. Harris, and R. A. Grantham. Biology and management of the pecan weevil (Coleoptera: Curculionidae). *Journal of Integrated Pest Management*, 3(1):A1–A9, 2012.

[51] K. C. Narayana Swamy, G. P. Mutthuraju, E. Jagadeesh, and G. T. Thirumalaraju. Biology of Sitophilus oryzae (L.) (Coleoptera: Curculionidae) on stored maize grains. *Current Biotica*, 8(1):76–81, 2014.

[52] G. I. Priyadarshini, U. Mukherjee, and N. Kumar. Biology and seasonal incidence of pseudostem weevil, Odoiporus longicollis Oliver (Coleoptera: Curculionidae) in banana. *Pest Management in Horticultural Ecosystems*, 20(1):8–13, 2014.

[53] S. Rajeshkanna, N. Sivaraga, and G. Mikunthan. Biology and management of Amaranthus stem borer (Hypolixus truncatulus) (Coleoptera: Curculionidae). *Annals of Sri Lanka Department of Agriculture*, 19:258–266, 2017.

[54] E. B. Greco and M. G. Wright. Ecology, biology, and management of Xylosandrus compactus (Coleoptera: Curculionidae: Scolytinae) with emphasis on coffee in Hawaii. *Journal of Integrated Pest Management*, 6(1):7, 2015.

[55] H. A. Cordo and A. Sosa. The weevils Argentinorhynchus breyeri, A. bruchi and A. squamosus (Coleoptera: Curculionidae), candidates for biological control of waterlettuce (Pistia stratiotes). In *Proceedings of the X International Symposium on Biological Control of Weeds*, pages 325–335.

[56] E. R. Moorhouse, A. K. Charnley, and A. T. Gillespie. A review of the biology and control of the vine weevil Otiorhynchus sulcatus (Coleoptera: Curculionidae). *Annals of Applied Biology*, 121(2):431–454, 1992.

[57] J. M. Johnson-Cicalese, G. M. Wolfe, and C. R. Funk. Biology, distribution, and taxonomy of billbug turf pests (Coleoptera: Curculionidae). *Environmental Entomology*, 19(4):1037–1046, 1990.

[58] F. Whitford and S. S. Quisenberry. Population dynamics and seasonal biology of the alfalfa weevil (Coleoptera: Curculionidae) on alfalfa in Louisiana. *Environmental Entomology*, 19(5):1443–1451, 1990.

[59] A. M. Boyce. A study of the biology of the parsely stalk-weevil Listronotus latiusculus Boheman Coleoptera: Curculionidae. *Journal of Economic Entomology*, 20:814–821, 1927.

[60] S. Sugiura, K. Yamazaki, and Y. Fukasawa. Weevil parasitism of ambrosia gall. *Annals of the Entomological Society of America*, 97(1):184–193, 2004.

[61] W. L. Tedders and J. A. Payne. Biology, life history, and control of Conotrachelus schoofi (Coleoptera: Curculionidae) on pecans. *Journal of Economic Entomology*, 79(2):490–496, 1986.

[62] L. Fornasari. Biology, ethology, and impact on the host by Coniatus tamarisci (F.)(Coleoptera: Curculionidae), a natural enemy of Tamarix spp. (Tamaricaceae, saltcedar) in France. *Biological Control*, 13(1):25–40, 1998.

[63] S. A. A. Fathi and A. A. Abedi. Ovipositional preference and life history parameters of Lixus incanescens (Coleoptera: Curculionidae) on selected sugar beet cultivars. *International Journal of Pest Management*, 60(4):293–299, 2014.

[64] E. Chacón-Madrigal, M. T. Johnson, and P. Hanson. The life history and immature stages of the weevil Anthonomus monostigma Champion (Coleoptera: Curculionidae) on Miconia calvescens DC (Melastomataceae). *Proceedings of the Entomological Society of Washington*, 114(2):173–185, 2012.

[65] L. Gültekin, S. Güçlü, and O. N. Nikulina. The life history of the capitulum weevil, Larinus latus (Herbst) (Coleoptera, Curculionidae). *New Zealand Journal of Agricultural Research*, 46(3):271–274, 2003.

[66] L. Gültekin, H. Zengin, and R. Hayat. Life history of Lixus bardanae on curly dock (Rumex crispus) in Turkey. *Phytoparasitica*, 32(1):97–99, 2004.

[67] R. T. Franklin and J. Taylor, John W. Biology of Pachylobius picivorus (Coleoptera: Curculionidae) in the Georgia piedmont. *The Canadian Entomologist*, 102(8):962–968, 1970.

[68] T. Sankaran and K. Krishna. Biology of Nanophyes sp (Col Curculionidae) infesting Jussieua repens in India. *Bulletin of Entomological Research*, 57(3):337–341, 1967.

[69] S. K. Asante and R. Kumar. Biology of Temnoschoita quadrimaculata Gly. (Coleoptera: Curculionidae) on oil palm in Ghana. *Insect Science and Its Application*, 7(2):129–134, 1986.

[70] B. E. Freeman. The biology of the white clover seed weevil Apion dichroum Bedel (Col. Curculionidae). *Journal of Applied Ecology*, 4(2):535–552, 1967.

[71] C. C. Bowling. Note on the biology of the rice water weevil, Lissorhoptrus oryzophilus. *Annals of the Entomological Society of America*, 65(4):990–991, 1972.

[72] A. M. Daramola. The biology and ecology of the kola weevil, Sophrorhinus gbanjaensis D. & T. (Coleoptera: Curculionidae). *Journal of Natural History*, 12(6):661–680, 1978.

[73] D. B. Emenegger and R. E. Berry. Biology of strawberry root weevil on peppermint in western Oregon. *Environmental Entomology*, 7(4):495–498, 1978.

[74] M. A. Deyrup. Notes on the biology of Pissodes fasciatus LeConte and its insect associates (Coleoptera: Curculionidae). *The Pan-Pacific Entomologist*, 54(2):103–106, 1978.

[75] C. W. McCoy, C. Segretain, G. M. Beavers, and C. Tarrant. Laboratory rearing and some aspects of the biology of Artipus floridanus Horn (Coleoptera: Curculionidae). *The Florida Entomologist*, 68(3):379–385, 1985.

[76] R. L. Kirkland and R. D. Goeden. Biology of Microlarinus lypriformis (Col: Curculionidae) on puncturevine in southern California. *Annals of the Entomological Society of America*, 71(1):65–69, 1978.

[77] C. D. F. Miller and J. C. Guppy. Biology of alfalfa weevil, Hypera postica (Gyllenhal) (Coleoptera: Curculionidae) in southern Ontario. *Proceedings of the Entomological Society of Ontario*, 102(1):42–46, 1971.

[78] R. L. Kirkland and R. D. Goeden. Biology of Microlarinus lareynii (Col.: Curculionidae) on puncturevine in southern California. *Annals of the Entomological Society of America*, 71(1):13–18, 1978.

[79] P. W. Kovarik and H. R. Burke. Observations on the biology and ecology of two species of Eudiagogus (Coleoptera: Curculionidae). *The Southwestern Naturalist*, 34(2):196–212, 1989.

[80] L. M. Dosdall, B. J. Ulmer, and P. Bouchard. Life history, larval morphology, and nearctic distribution of Ceutorhynchus subpubescens (Coleoptera: Curculionidae). *Annals of the Entomological Society of America*, 100(2):178–186, 2007.

[81] B. M. May. The immature stages of Linogeraeus urbanus (Coleoptera: Curculionidae: Baridinae) and its biology in Aukland, New Zealand. *New Zealand Entomologist*, 8(1):29–35, 1984.

[82] J. P. Cuda and H. R. Burke. Reproduction and development of the potato stalk borer, (Coleoptera: Curculionidae) with notes on field biology. *Journal of Economic Entomology*, 79(6):1548–1554, 1986.

[83] R. E. Stevenson. Notes on biology of Englemann spruce weevil Pissodes engelmanni (Curculionidae - Coleoptera) and its parasites and predetors. *The Canadian Entomologist*, 99(2):201–213, 1967.

[84] P. E. Boldt and G. Campobasso. Biology of two weevils, Ceutorhynchus trimaculatus and Trichosirocalus horridus, on Carduus spp. in Europe. *Environmental Entomology*, 10(5):691–696, 1981.

[85] P. E. Boldt and T. O. Robbins. Life history of Epimechus canoides Fall (Coleoptera: Curculionidae) on seepwillow, Baccharis salicifolia (R.&P.) Pers. (Asteraceae). *Proceedings of the Entomological Society of Washington*, 94(3):309–313, 1992.

[86] J. P. Cuda, J. L. Gillmore, A. O. Mitchell, J. Bricker, R. A. Watson, B. R. Garcete-Barrett, and A. Mukherjee. Laboratory biology and impact of a stem-boring weevil Apocnemidophorus pipitzi (Coleoptera: Curculioniade) on Schinus terebinthifolia. *Biocontrol Science and Technology*, 26(9):1249–1266, 2016.

[87] S. L. Goldson, E. R. Frampton, B. I. P. Barratt, and C. M. Ferguson. The seasonal biology of Sitona discoideus Gyllenhal (Coleoptera: Curculionidae), an introduced pest of New Zealand lucerne. *Bulletin of Entomological Research*, 74(2):249–259, 1984.

[88] J. P. Aeschlimann. Distribution, host plants, and reproductive biology of the Sitona humeralis Stephens group of species (Coleoptera: Curculionidae). *Journal of Applied Entomology*, 98(3):298–309, 1984.

[89] C. J. Deloach and H. A. Cordo. Biology and host range of the weevil Neochetina affinis, which feeds on pontederiaceae in Argentina. *Annals of the Entomological Society of America*, 74(1):14–19, 1981.

[90] I. W. Forno, D. P. A. Sands, and W. Sexton. Distribution, biology and host specificity of Cyrtobagous singularis Hustache (Coleoptera, Curculionidae) for the biological control of Salvinia molesta. *Bulletin of Entomological Research*, 73(1):85–95, 1983.

[91] C. J. DeLoach, A. D. DeLoach, and H. A. Cordo. Neohydronomus pulchellus, a weevil attacking Pistia stratiotes in South America: biology and host specificity. *Annals of the Entomological Society of America*, 69(5):830–834, 1976.

[92] S. D. Kindler and S. M. Spomer. Observations of the biology of the bluegrass billbug, Sphenophorus parvulus Gyllenhal (Coleoptera: Curculionidae), in an eastern Nebraska sod field. *Journal of the Kansas Entomological Society*, 59(1):26–31, 1986.

[93] G. R. Buckingham and C. A. Bennett. Laboratory biology and behavior of Litodactylus leucogaster, a Ceutorhynchine weevil that feeds on watermilfoils. *Annals of the Entomological Society of America*, 74(5):451–458, 1981.

[94] D. P. Peschken and R. W. Beecher. Ceutorhynchus litura (Coleoptera: Curculionidae): biology and first releases for biological control of the weed Canada thistle (Cirsium arvense) in Ontario, Canada. *The Canadian Entomologist*, 105(12):1489–1494, 1973.

[95] C. J. DeLoach and H. A. Cordo. Life cycle and biology of Neochetina bruchi, a weevil attacking waterhyacinth in Argentina, with notes on N. eichhorniae. *Annals of the Entomological Society of America*, 69(4):643–652, 1976.

[96] H. Zwölfer and P. Harris. Biology and host specificity of Rhinocyllus conicus (Froel) (Col, Curculionidae), a successful agent for biocontrol of the thistle, Carduus nutans L. *Journal of Applied Ecology*, 97(1):36–62, 1984.

[97] B. N. Barnes. Embryonic and immature stages of Phlyctinus callosus Boh (Coleoptera, Curculionidae) - aspects of biology and behavior with respect to control in deciduous fruit orchards. *Journal of the Entomological Society of Southern Africa*, 52(1):165–178, 1989.

[98] B. Staniec. A description of the preimaginal stages and notes on the biology of Bledius nanus Erichson, 1840 (Coleoptera, Staphylinidae). *Deutsche Entomologische Zeitschrift*, 45(1):95–109, 1998.

[99] E. Pietrykowska-Tudruj, B. Staniec, T. Wojas, and A. Solodovnikov. Immature stages and phylogenetic importance of Astrapaeus, a rove beetle genus of puzzling systematic position (Coleoptera, Staphylinidae, Staphylinini). *Contributions to Zoology*, 83(1):41–65, 2014.

[100] J. S. Ashe. Natural history, development and immatures of Pleurotobia tristigmata (Erichson) (Coleoptera: Staphylinidae: Aleocharinae). *The Coleopterists Bulletin*, 44(4):445–460, 1990.

[101] R. A. B. Leschen and R. T. Allen. Immature stages, life histories and feeding mechanisms of three Oxyporus spp. (Coleoptera: Staphylinidae: Oxyporinae). *The Coleopterists Bulletin*, 42(4):321–333, 1988.

[102] S. Nasir and W. Akram. Study of bionomics of skirt and blouse beetle (Paederus fuscipes Curtis), 1826 (Coleoptera: Staphylnidae, Paederinae). *Pakistan Journal of Agricultural Sciences*, 49(4):447–450, 2012.

[103] R. S. Hanley and M. A. Goodrich. Natural history, development and immature stages of Oxyporus stygicus Say (Coleoptera: Staphylinidae: Oxyporinae). *The Coleopterists Bulletin*, 48(3):213–225, 1994.

[104] B. Staniec and E. Pietrykowska-Tudruj. Comparative morphology of the eggs of sixteen Central European species of Staphylininae (Coleoptera, Staphylinidae). *Deutsche Entomologische Zeitschrift*, 54(2):235–252, 2007.

[105] T. F. Kennedy, G. O. Evans, and A. M. Feeney. Studies on the biology of Tachyporus hypnorum F (Col Staphylinidae), associated with cereal fields in Ireland. *Irish Journal of Agricultural Research*, 25(1):81–95, 1986.

[106] K. V. Miller and R. N. Willaims. Biology and host preference of Atheta coriaria (Coleoptera: Staphylinidae), an egg predetor of Nitulidae and Muscidae. *Annals of the Entomological Society of America*, 76(2):158–161, 1983.

[107] R. S. Hanley. Immature stages of Scaphisoma castaneum Motschulsky (Coleoptera: Staphylinidae: Scaphidiinae), with observations on natural history, fungal hosts and development. *Proceedings of the Entomological Society of Washington*, 98(1):36–43, 1996.

[108] S. Fournet, J. O. Stapel, N. Kacem, J. P. Nenon, and E. Brunel. Life history comparison between two competetive Aleochara species in the cabbage root fly, Delia radicum: implications for their use in biological control. *Entomologia Experimentalis et Applicata*, 96(3):205–211, 2000.

[109] I. Hunter, J. S., D. E. Bay, and G. T. Fincher. StLaboratory and field observations on the life history and habits of Philonthus cruentatus and Philonthus flavolimbatus. *Southewestern Entomologist*, 14(1):41–47, 1989.

[110] B. Staniec. Description of the developmental stages of Hesperus rufipennis (Gravenhorst, 1802) (Coleoptera: Staphylinidae), with comments on its biology. *Annales Zoologici*, 54(3):529–539, 2004.

[111] E. R. Echegaray and R. A. Cloyd. Life history characteristics of the rove beetle, Dalotia coriaria (Coleoptera: Staphylinidae) under laboratory conditions. *Journal of the Kansas Entomological Society*, 86(2):145–154, 2013.

[112] E. J. Watson-Horzelski. Survival and time of development for Creophilus maxillosus (L.) (Coleoptera: Staphylinidae) at three constant temperatures. *The Coleopterists Bulletin*, 66(4):365–370, 2012.

[113] L.-J. Bong, K.-B. Neoh, Z. Jaal, and C.-Y. Lee. Life table of Peaderus fuscipes (Coleoptera: Staphylinidae). *Journal of Medical Entomology*, 49(3):451–460, 2012.

[114] E. Pietrykowska-Tudruj and B. Staniec. The morphology of the pupae of six species of Philonthina (Coleoptera, Staphylinindae, Staphylinini) with taxonomic remarks. *Zootaxa*, (2865):53–67, 2011.

[115] J. B. Briggs. Biology of some ground beetles (Col Carabidae) injurious to strawberries. *Bulletin of Entomological Research*, 56(1):79–93, 1965.

[116] V. M. Kirk. Notes on the biology of Anisodactylus sanctaecrucis, a ground beetle of cropland. *Annals of the Entomological Society of America*, 70(4):596–598, 1977.

[117] A. D. Tomlin. Notes on the biology and rearing of two species of ground beetles, Pterostichus melanarius and Harpalus pensylvanicus (Coleoptera: Carabidae). *The Canadian Entomologist*, 107(1):67–74, 1975.

[118] E. Busato. Biological cycle and larval morphology of Cychrus cordicollis Chaudoir 1835 (Coleoptera: Carabidae). *Annales de la Société Entomologique de France*, 45(2):177–186, 2009.

[119] J. Adis, M. A. Amorim, T. L. Erwin, and T. Bauer. On ecology, life history and survival strategies of a wing-dimorphic ground beetle (Col.: Carabidae: Odacanthini: Colliuris) inhabiting central Amazonian inundation forests. *Studies on Neotropical Fauna and Environment*, 32(3):174–192, 1997.

[120] A. M. Cardenas and J. M. Hidalgo. Seasonal activity and reproductive biology of the ground beetle Carabus dufouri (Coleoptera: Carabidae). *European Journal of Entomology*, 97(3):329–338, 2000.

[121] G. I. M. d. Santos. On immature and adult forms of Trichognathus marginipennis Letreille, 1829 (Coleoptera, Carabidae, Galeritini). *ZooKeys*, 212:45–62, 2012.

[122] K. Hůrka. The taxonomic status of Semiophonus (Col., Carabidae, Harpalini) and description of the larva of Harpalus (Semiophonus) signaticornis. *Acta Entomologica Bohemoslovaca*, 89(1):29–34, 1992.

[123] M. J. Wade and F. Breden. Life history of natural populations of the imported willow leaf beetle, Plagiodera versicolora (Coleoptera: Chrysomelidae). *Annals of the Entomological Society of America*, 79(1):73–79, 1986.

[124] C. R. Morrison and D. M. Windsor. The life history of Chelymorpha alternans (Coleoptera: Chrysomelidae: Cassidinae) in Panamá. *Annals of the Entomological Society of America*, 111(1):31–41, 2018.

[125] Z. Martinková and A. Honěk. Gastrophysa viridula (Coleoptera: Chrysomelidae) and biocontrol of Rumex - a review. *Plant Soil and Environment*, 50(1):1–9, 2004.

[126] L. Fornasari. Life history of the flea beetle, Aphthona abdominalis Duftschmid, on Euphorbia esula L. (leafy spurge) in Italy. *Biological Control*, 3(3):161–175, 1993.

[127] K. D. Prathapan and C. S. Chaboo. Biology of Blepharida-group flea beetles with first notes on natural history of Podontia congregata Baly, 1865 an endemic flea beetle from southern India (Coleoptera, Chrysomelidae, Galerucinae, Alticini). *ZooKeys*, (157):95–130, 2011.

[128] K. Miwa and L. J. Meinke. Developmental biology and effects of adult diet on consumption, longevity, and fecundity of Colaspis crinicornis (Coleoptera: Chrysomelidae). *Journal of Insect Science*, 15(1):78, 2015.

[129] R. J. Adair and J. K. Scott. Biology and host specificity of Ageniosa electoralis (Coleoptera: Chrysomelidae), a prospective biological control agent for Chrysanthemoides monilifera (Asteraceae). *Biological Control*, 3(3):191–198, 1993.

[130] D. M. Mutyambai, J. M. Mutunga, and A. T. Fombong. Notes on the natural history of Phoxomeloides gedyei Schein (Coleoptera: Scarabaeidae) in Kenya. *The Coleopterists Bulletin*, 69(3):504–506, 2015.

[131] W. P. Hayes and J. W. McColloch. The biology of Anomala kansana (Scarabaeidae, Coleop.). *Journal of Economic Entomology*, 17(5):589–594, 1924.

[132] J. P. Grunshaw. Field studies on the biology and economic importance of Pachnoda interrupta (Coleoptera: Scarabaeidae) in Mali, West Africa. *Bulletin of Entomological Research*, 82(1):19–27, 1992.

[133] T. J. Kingston and M. Coe. The biology of a giant dung-beetle (Heliocopris dilloni) (Coleoptera: Scarabaeidae). *Journal of Zoology*, 181(2):243–263, 1977.

[134] T. Bauer, F. Talarico, A. Mazzei, A. Giglio, T. Zetto-Brandmayr, P. Brandmayr, and O. Betz. Hunting ants in Mediterranean clay soils: life history of Siagona europaea (Coleoptera, Carabidae). *Italian Journal of Zoology*, 72(1):33–42, 2005.

[135] M. D. Cuozzo, F. A. Frieiro-Costa, and B. Souza. Life history of Paraselenis (Spaethiechoma) dichroa (Germar, 1824) (Coleoptera: Chrysomelidae: Cassidinae) in natural conditions of Atlantic Forest from Brazil. *Journal of Natural History*, 51(9):531–543, 2017.

[136] K. A. Welch. Biology of Ophraella notulata (Coleoptera: Chrysomelidae). *Annals of the Entomological Society of America*, 71(1):134–137, 1978.

[137] G. B. Simpson. Immature stages of Protaetia fusca (Herbst) (Coleoptera: Scarabaeidae: Cetoniinae) with notes on biology. *Journal of the Australian Entomological Society*, 29(1):67–73, 1990.

[138] R. R. Blume. Euoniticellus intermedius (Coleoptera: Scarabaeidae): description of adults and immatures and biology of adults. *Environmental Entomology*, 13(4):1064–1068, 1984.

[139] R. J. Hardy. Some aspects of the biology and behaviour of Adoryphorus couloni (Burmeister) (Coleoptera: Scarabaeidae: Dynastinae). *Journal of the Australian Entomological Society*, 20(1):64–74, 1981.

[140] J. M. I. Donaldson. Oplostomus fuligineus (Coleoptera: Scarabaeidae): life cycle and biology under laboratory conditions, and its occurence in bee hives. *The Coleopterists Bulletin*, 43(2):177–182, 1989.

[141] J. R. Starzyk. Morphology, biology and life history of Carilia (= Neogaurotes Pod.) virginea (L.) (Col., Cerambycidae). *Zeitschrift fur Angewandte Entomologie*, 83(3):269–281, 2009.

[142] M. Faccoli, R. Favaro, M. T. Smith, and J. Wu. Life history of the Asian longhorn beetle Anoplophora glabripennis (Coleoptera Cerambycidae) in southern Europe. *Agricultural and Forest Entomology*, 17(2):188–196, 2015.

[143] S. Sharifi, I. Javadi, and J. A. Chemsak. Biolog of the rosaceae branch borer, Osphranteria coerulescens (Coleoptera: Cerambycidae). *Annals of the Entomological Society of America*, 63(6):1515–1520, 1970.

[144] B. E. Wickman. The biology of the fir tree borer, Semanotus litigiosus (Coleoptera: Cerambycidae), in California. *The Canadian Entomologist*, 100(2):208–220, 1968.

[145] M. Menon and S. J. Putmam. Some aspects of the developmental biology of Blaps kollari (Coleoptera: Tenebrionidae) under laboratory conditions. *Annals of the Entomological Society of America*, 81(5):836–843, 1988.

[146] Y. Tsuda and T. Yoshida. Population biology of the broad-horned flour beetle, Gnathocerus cornutus (F.) (Coleoptera, Tenebrionidae) 1. Life table and population parameters. *Applied Entomology and Zoology*, 19(1):129–131, 1984.

[147] K. Zang, X.-Y. Wang, Z.-Q. Yang, K. Wei, and J. J. Duan. Biology and natural enemies of Agrilus fleischeri (Coleoptera: Buprestidae), a newly emerging destructive buprestid pest in Northeast China. *Journal of Asia-Pacific Entomology*, 20(1):47–52, 2017.

[148] B. Staniec and E. Pietrykowska-Tudruj. Immature stages of Rabigus tenuis (Fabricius, 1792) (Coleoptera, Staphylinidae, Staphylininae) with observations on its biology and taxonomic comments. *Belgian Journal of Zoology*, 138(1):22–39, 2008.

[149] B. Staniec and E. Pietrykowska-Tudruj. Morphology of developmental stages of Philonthus fumarius (Gravenhorst, 1806) (Coleoptera, Staphylinidae) with notes on biology. *Acta Zoologica Acadamiae Scientarum Hungaricae*, 54(3):213–234, 2008.

[150] R. H. Ward and R. L. Pienkowski. Biology of Cassida rubiginosa, (Coleoptera - Chrysomelidae) a thistle-feeding shield beetle. *Annals of the Entomological Society of America*, 71(4):585–591, 1978.

[151] T. F. Branson and J. L. Krysan. Laboratory biology of Diabrotica tibialis and a closely related Diabrotica species (Coleoptera: Chrysomelidae). *Journal of the Kansas Entomological Society*, 60(3):446–450, 1987.

[152] P. E. Boldt. Biology and host specificity of Trirhabda bacharidis (Coleoptera: Chrysomelidae) on Baccharis (Asteracea: Astereae). *Environmental Entomology*, 18(1):78–84, 1989.

[153] P. E. Skelley. Observations on the biology of Stephanucha thoracica Casey (Coleoptera: Scarabidae) Cetoniinae). *The Coleopterists Bulletin*, 45(2):176–188, 1991.

[154] K. D. Walsh and M. J. Linit. Oviposition biology of the pine sawyer, Monochamus carolinensis (Coleoptera: Cerambycidae). *Annals of the Entomological Society of America*, 78(1):81–85, 1985.

[155] J. C. Nord, D. G. Grimble, and F. B. Knight. Biology of Oberea schaumii (Coleoptera: Cerambycidae) in trembling aspen, Populus tremuloides. *Annals of the Entomological Society of America*, 65(1):114–119, 1972.

[156] J. D. Solomon. Biology and habits of the oak branch borer (Goes debilis). *Annals of the Entomological Society of America*, 70(1):57–59, 1977.

[157] E. F. Lara and R. D. Shenefelt. Colobothea distincta (Coleoptera: Cerambycidae) on cacao: notes on its morphology and biology. *Annals of the Entomological Society of America*, 59(3):453–458, 1966.

[158] A. G. Raske. Immature stages, genetalia, and notes on the biology of Coenopoeus palmeri (Coleoptera: Cerambycidae). *The Canadian Entomologist*, 104(1):121–128, 1972.

[159] R. Dass, A. V. N. Paul, and R. A. Agarwal. Feeding potential and biology of lesser meal worm, Alphitobius diaperinus (Panz.) (Col., Tenebrionidae), preying on Corcyra cephalonica St. (Lep., Pyralidae). *Zeitschrift fur Angewandte Entomologie*, 98(4):445–447, 2009.

[160] H. Nakakita, O. Imura, and R. G. Winks. Hybridization between Tribolium freemani Hinton and Tribolium castaneum (Herbst), and some preliminary studies on the biology of Tribolium freemani (Coleoptera: Tenebrionidae). *Applied Entomology and Zoology*, 16(3):209–215, 1981.

[161] Y. Wang, X. Liu, J. Zhao, K. Rexili, and J. Ma. The rearing and biology of the desert beetle, Microdera punctipennis, under laboratory conditions. *Journal of Insect Science*, 11(39), 2011.

[162] R. C. Akers, D. A. Herms, and D. G. Nielsen. Emergence and adult biology of Agrilus difficilis (Coleoptera: Buprestidae), a pest of honeylocust, Gleditsia triacanthos. *The Great Lakes Entomologist*, 19(1):27–30, 1986.

[163] F. D. Morgan. The biology and behaviour of the beech buprestid, Nascioides enysi (Sharp) (Coleoptera: Buprestidae) with notes on its ecology and possibilities for control. *Transactions of the Royal Society of New Zealand: Zoology*, 7(11), 1966.

[164] R. A. Haack and D. M. Benjamin. The biology and ecology of the twolined chestnut borer, Agrilus bilineatus (Coleoptera: Buprestidae), on oaks, Quercus spp., in Wisconsin. *The Canadian Entomologist*, 114(5):385–396, 1982.

[165] D. A. Herms and D. G. McCullough. Emerald ash borer invasion of North America: history, biology, ecology, impacts, and management. *Annual Review of Entomology*, 59:13–30, 2014.

[166] B. Staniec, J. Pilipczuck, and E. Pietrykowska-Tudruj. Morphology of immature stages and notes on biology of Ocypus fulvipennis Erichson, 1840 (Coleoptera: Staphylinidae). *Annales Zoologici*, 59(1):47–66, 2009.

[167] D. A. Schmidt. Notes on the biology and a description of the egg, third instar larva and pupa of Platydracus tomentosus (Gravenhorst) (Coleoptera: Staphylinidae). *The Coleopterists Bulletin*, 48(4):310–318, 1994.

[168] M. L. Brust, W. W. Hoback, and C. B. Knisley. Biology, habitat preference, and larval description of Cicindela cursitans Leconte (Coleoptera: Carabidae: Cicindelinae). *The Coleopterists Bulletin*, 59(3):379–390, 2005.

[169] J. Wheeler, A. G. and I. Snook, W. Alan. Biology of Sumitrosis rosea (Coleoptera: Chrysomelidae), a leafminer of black locust, Robina pseudoacacia (Leguminosae). *Proceedings of the Entomological Society of Washington*, 88(3):521–530, 1986.

[170] M. Kogan and R. D. Goeden. The biology of Lema trilineata daturaphila, (Coleoptera: Chrysomelidae) with notes on the efficiency of food utilization by larvae. *Annals of the Entomological Society of America*, 63(2):537–546, 1970.

[171] J. P. Singh, H. S. Rose, and Sangita. Biology of Cassida enervis Boh. (Coleoptera: Chrysomedlidae: Cassidinae) - a serious pest on Celosia argentea, an ornamental plant. *Entomon*, 10(2):107–110, 1985.

[172] H. A. Cordo, C. J. DeLoach, and M. Ferrer. Biology and larval host range of the flea beetle Disonycha argentinensis (Coleoptera: Chyrsomelidae) on alligatorweed in Argentina. *Annals of the Entomological Society of America*, 77(2):134–141, 1984.

[173] S. S. Rosenthal and J. Carter. Host specificity and biology of Galeruca rufa, a potential biological control agent for field bindweed. *Environmental Entomology*, 6(1):155–158, 1977.

[174] S. E. Naranjo and A. J. Sawyer. Reproductive biology and survival of Dabrotica barberi (Coleoptera: Chyrsomelidae): effect of temperature, food, and seasonal time of emergence. *Annals of the Entomological Society of America*, 80(6):841–848, 1987.

[175] M. W. Stufkens and J. A. Farrell. Life history and distribution of Adoryphorus coluoni Burmeister (Coleoptera: Scarabaeidae) in Canterbury, New Zealand. *New Zealand Journal of Agricultural Research*, 23(4):569–573, 1980.

[176] J. C. Nord, D. G. Grimble, and F. B. Knight. Biology of Saperda inornata (Coleoptera: Cerambycidae) in trembling aspen, Populus tremuloides. *Annals of the Entomological Society of America*, 65(1):127–135, 1972.

[177] J. D. Solomon. Biology and habits of the living beech borer in red oaks. *Journal of Economic Entomology*, 65(5):1307–1310, 1972.

[178] T. N. Khan and T. Khan. Biology of Nyphasia apicalis Gahan (Coleoptera: Cerambycidae) with particular emphasis on emergence and imaginal life. *Proceedings of the Indian Academy of Sciences: Animal Sciences*, 96(4):403–415, 1987.

[179] M. E. Rice. Branch girdling and oviposition biology of Oncideres pustulatus (Coleoptera: Cerambycidae) on Acacia farnesiana. *Annals of the Entomological Society of America*, 82(2):181–186, 1989.

[180] L. F. Wilson. Life history, habits, and damage of Chrysobothris orono (Coleoptera: Buprestidae) on red pine in Michigan. *The Canadian Entomologist*, 101(3):291–298, 1969.

[181] R. J. Hooper, A. Willis, B. L. Shearer, and K. Sivasithamparam. A redescription and notes on biology of Cisseis fascigera Obenberger (Coleoptera: Buprestidae) on declining Eucalyptus wandoo in south-western Australia. *Australian Journal of Entomology*, 49(3):234–244, 2010.

[182] V. L. Muilenburg and D. A. Herms. A review of bronze birch borer (Coleoptera: Buprestidae) life history, ecology, and management. *Environmental Entomology*, 41(6):1372–1385, 2012.

[183] H. A. Hespenheide and C. O. Kim. Clutch size, survivorship, and biology of larval Pachyscheuls psychotriae Fisher (Coleoptera: Buprestidae). *Annals of the Entomological Society of America*, 85(1):48–52, 1992.

[184] M. Sufyan, D. Neuhoff, and L. Furlan. Larval development of Agriotes obscurus under laboratory and semi-natural conditions. *Bulletin of Insectology*, 67(2):227–235, 2014.

[185] E. E. Edwards and J. R. Evans. Observations on the biology of Corymbites cupreus (Coleoptera, Elateridae). *Annals of Applied Biology*, 37(2):249–259, 1950.

[186] M. W. Stone. Notes on the life-history of three Conoderus species of wireworms in California (Coleoptera: Elateridae). *The Pan-Pacific Entomologist*, 56(2):157–160, 1980.

[187] E. H. Erickson and F. G. Werner. Binomics of nearctic bee-associated Meloidae (Coleoptera); life histories and nutrition of certain Nemognathinae. *Annals of the Entomological Society of America*, 67(3):401–406, 1974.

[188] J. Lückmann and T. Assmann. Reproductive biology and strategies of nine meloid beetles from central Europe (Coleoptera: Meloidae). *Journal of Natural History*, 39(48):4010–4125, 2006.

[189] C. E. Rogers, H. B. Jackson, G. W. Angalet, and R. D. Eikenbary. Biology and life history of Propylea 14-punctata (Coleoptera: Coccinellidae), an exotic predetor of aphids. *Annals of the Entomological Society of America*, 65(3):648–650, 1972.

[190] K. Mori, M. Nozawa, K. Arai, and T. Gotoh. Life-history traits of the acarophagous lady beetle, Stethorus japonicus at three constant temperatures. *BioControl*, 50(1):35–51, 2005.

[191] L. Gültekin, M. Cristofaro, C. Tronci, and L. Smith. Natural history studies for the preliminary evaluation of Larinus filiformis (Coleoptera: Curculionidae) as a prospective biological control agent of yellow starthistle. *Environmental Entomology*, 37(5):1185–1199, 2008.

[192] S. L. Chown and C. H. Scholtz. Biology and ecology of Dusmoecetes Jeannel (Col. Curculionidae) species complex on Marion Island. *Oecologia*, 80(1):93–99, 1989.

[193] L. Gültekin and B. A. Korotyaev. Natural history of the Crambe feeder, Lixus circumcinctus (Coleoptera: Curculionidae). *The Florida Entomologist*, 94(4):987–992, 2011.

[194] P. J. Richerson and A. A. Grigarick. The life history of Stenopelmus rufinasus (Coleoptera: Curculionidae). *Annals of the Entomological Society of America*, 60(2):351–354, 1967.

[195] Á. Castañeda-Vildózola, O. Franco-Mora, J. C. Reyes Alemán, C. Ruiz-Montiel, J. Váldez-Carrasco, and A. Equihua-Martínez. New distribution records of the small avocado seed weevil, Conotrachelus perseae Barber (Coleoptera: Curculionidae), in Mexico and notes on its biology. *The Coleopterists Bulletin*, 69(2):267–271, 2015.

[196] Z. E. El Abjar and M. O. Bashir. Biology and life tables of Neochetina bruchi Hustache (Coleoptera, Curculionidae) introduced to the White Nile, Sudan, for the biological control of water hyacinth. *Zeitschrift für Angewandte Entomologie*, 97(3):282–286, 2009.

[197] D. De Steven. Observations on the life history of Pseudanthonomus hamamelidis Pierce (Coleoptera: Curculionidae). *Journal of the Kansas Entomological Society*, 55(3):519–524, 1982.

[198] S. Louw. The life history and immature stages of Brachycerus ornatus Drury (Coleoptera: Curculionidae). *Journal of the Entomological Society of Southern Africa*, 53(1):27–40, 1990.

[199] P. Martel, H. J. Svec, and C. R. Harris. The life history of the carrot weevil Listronotus oregonensis (Coleoptera: Curculionidae) under controlled conditions. *The Canadian Entomologist*, 108(9):931–934, 1976.

[200] D. S. Lacroix. The life history and control of cranberry weevil, Anthonomus musculus Say (Coleoptera: Curculionidae). *Journal of Economic Entomology*, 19(6):819–829, 1926.

[201] P. V. Isaac. I. The turnip gall weevil. Ceuthorrhynchus pleurostigma, Marsh. (Coleoptera, Curculionidae). Part I. Life-history and bionomics. *Annals of Applied Biology*, 10(2):151–170, 1923.

[202] R. G. Oberprieler. The life history of Paramecops stapeliae (Marshall), with a review of the genus Paramecops (Coleoptera: Curculionidae: Molytinae). *Journal of Natural History*, 22(6):1451–1464, 1988.

[203] J. Bodenham, R. E. Stevens, and T. O. Thatcher. A cone weevil, Conotrachelus neomexicanus, on ponderosa pine in Colorado: life history, habits, and ecological relationships (Coleoptera: Curculionidae). *The Canadian Entomologist*, 108(7):693–699, 1976.

[204] J. F. Vayssières and A. J. Wapshire. Life histories and host specificities of Ceutorhynchus geographicus (Goeze) and Ceutorhynchus larvatus Schultze (Coleoptera, Curculionidae), potential biological control agents for Echium. *Bulletin of Entomological Research*, 73(3):431–440, 1983.

[205] B. Staniec. A description of the developmental stages of Acylophorus wagenschieberi Kiesenwetter, 1850 (Coleoptera, Staphylinidae), with comments on its biology, egg parasite and distribution in Poland. *Deutsche Entomologische Zeitschrift*, 52(1):97–113, 2005.

[206] O. Betz and S. Fuhrmann. Life history traits in different life forms of predaceous Stenus beetles (Coleoptera: Staphylinidae), living in waterside environments. *Netherlands Journal of Zoology*, 51(4):371–393, 2001.

[207] A. Rizza and P. Pecora. Biology and host specificity of Chrysomela rossia, a candidate for the biological control of Dalmatian toadflex, Linaria dalmatica. *Annals of the Entomological Society of America*, 73(1):95–99, 1980.

[208] T. Kaufmann. Studies on the biology and ecology of Pyrrhalta nymphaea (Col. Chrysomelidae) in Alaska with special reference to population dynamics. *The American Midland Naturalist*, 83(2):496–509, 1970.

[209] M. L. Mason and F. A. Lawson. Biology of the American aspen beetle (Coleoptera: Chyrsomelidae: Gonioctena americana (Schaeffer)) in the Medicine Bow National Forest, Wyoming. *Journal of the Kansas Entomological Society*, 55(4):779–788, 1982.

[210] O. H. Lindquist and C. N. Davis. The biology of a birch leaf beetle, Phratora hudsonia (Coleoptera: Chrysomelidae), with a larval key to forest Chrysomelinae in Ontario. *The Canadian Entomologist*, 103(4):622–626, 1971.

[211] H. G. Klemperer. Life history and parental behaviour of a dung beetle from neotropical rainforest, Copris laeviceps (Coleoptera, Scarabaeidae). *Journal of Zoology*, 209(3):319–326, 1986.

[212] J. C. Neita Moreno and B. C. Ratcliffe. Description of the adult female, larva, pupa, and distribution of Strategus fascinus Burmeister (Scarabaeidae: Dynastinae: Oryctini). *The Coleopterists Bulletin*, 63(3):367–379, 2009.

[213] J. R. Starzyk and M. Lessaer. Studies on the distribution, morphology, biology and ecology of Pronocera angusta (Kriechb.) (Coleoptera, Cerambycidae). *Zeitschrift für Angewandte Entomologie*, 97(4):347–360, 2009.

[214] J. H. Hatchett, R. D. Jackson, and R. M. Barry. Rearing a weed cerambycid, Dectes texanus, on an artificial medium, with notes on biology. *Annals of the Entomological Society of America*, 66(3):519–522, 1973.

[215] S. Goodwin and M. A. Pettit. Acalolepta vastator (Newman) (Coleoptera: Cerambycidae) infesting grapevines in the Hunter Valley, New South Wales 2. Biology and Ecology. *Austral Entomology*, 33(4):391–397, 1994.

[216] I. Adachi. Reproductive biology of the white-spotted longicorn beetle, Anoplophora malasiaca Thomson (Coleoptera: Cerambycidae), in citrus trees. *Applied Entomology and Zoology*, 23(3):256–264, 1988.

[217] F. Zhu, C.-L. Lei, and F. Xue. The morpohology and temperature-dependent development of Mylabris phalerata Pallas (Coleopeta: Meloidae). *The Coleopterists Bulletin*, 59(4):521–527, 2005.

[218] E. C. Pinchao, P. Sotelo, G. González, and T. Kondo. Biological data on Anovia punica Gordon (Coleoptera: Coccinellidae), a predetor of Crypticerya multicicatrices Kondo & Unruh (Hemiptera: Monophlebidae). *Neotropical Entomology*, 47(3):385–394, 2018.

[219] D. E. Meyerdirk. Biology of Diomus flavifrons (Blackburn) (Coleoptera: Coccinellidae), a citrus mealybug predator. *Environmental Entomology*, 12(4):1275–1277, 1983.

[220] Y. Huang, Y. Ao, M. Jiang, and M. O. Way. Variation in body size in the rice water weevil (Coleoptera: Curculionidae) and its association with population biology. *Journal of Insect Science*, 18(1):1–7, 2018.

[221] F. Kádár, R. Andorkó, and Z. Elek. Reproductive characteristics and habitat selection of Carabus ulrichii (Coleoptera, Carabidae) in woodland habitats in Hungary. *Acta Zoologica Acadamiae Scientarum Hungaricae*, 63(3):343–354, 2017.

[222] K. Sasakawa. Notes on the reproductive ecology and description of the preimaginal morphology of Elaphrus sugai Nakane, the most endangered species of Elaphrus Fabricius (Coleoptera: Carabidae) ground beetle worldwide. *PLoS ONE*, 11(7):e0159164, 2016.

[223] P. J. McFadyen. Host-specificity and biology of Metallactus patagonicus [Col.: Chrysomelidae) introduced into Australia for the biological control of Baccharis halimifolia [Compositae]. *Entomophaga*, 32(4):329–331, 1987.

[224] P. J. McFadyen. Host specificity and biology of Lioplacis elliptica [Col.: Chrysomelidae] introduced into Australia for the biological control of Baccharis halimifolia [Compositae]. *Entomophaga*, 32(1):19–21, 1987.

[225] D. A. H. Murray. Life history of Monolepta australis (Jacoby) (Coleoptera: Chrysomelidae). *Journal of the Australian Entomological Society*, 21(2):119–122, 1982.

[226] T. T. Ghebremariam, K. Krüger, and C. F. Reinhardt. Biology of Conchyloctenia hybrida (Coleoptera: Chrysomelidae: Cassidinae) on Solanum campylacanthum subsp. panduriforme. *Annals of the Entomological Society of America*, 107(4):818–825, 2014.

[227] H. E. Williams. Life history and laboratory host range of Charidotis auroguttata (Boheman) (Coleoptera: Chyrsomelidae), the first natural enemy released against Macfadyena unguiscati (L.) Gentry (Bignoniaceae) in South Africa. *The Coleopterists Bulletin*, 56(2):299–307, 2002.

[228] H. L. Sweetman. The life history of Diabrotica vittata Fabr. in Iowa (Chysomelidae, Coleoptera). *Journal of Economic Entomology*, 18(6):795–807, 1925.

[229] G. Onore and M.-A. Morón. Dynastes neptunus Quenzel (Coleoptera: Scarabidae: Dynastinae); descriptions of the third instar larva and pupa, with notes on biology. *The Coleopterists Bulletin*, 58(1):103–110, 2004.

[230] P. J. McFadyen. Host specificity and biology of Megacyllene mellyi [Col.: Cerambycidae] introduced into Australia for the biological control of Baccharis halimifolia [Compositae]. *Entomophaga*, 28(1):65–72, 1983.

[231] A. A. Kirk and A. J. Wapshire. The life history and host specificity of the Echium borer, Phytoecia coerulescens [Col.: Cerambycidae). *Entomophaga*, 24(4):423–430, 1979.

[232] X. Wei, Y. Wu, R. Reardon, T.-H. Sun, M. Lu, and J.-H. Sun. Biology and damage traits of emerald ash borer (Agrilus planipennis Fairmaire) in China. *Insect Science*, 14(5):367–373, 2007.

[233] X.-Y. Wang, Z.-Q. Yang, J. R. Gould, Y.-N. Zhang, G.-J. Liu, and E.-S. Liu. The biology and ecology of the emerald ash borer, Agrilus planipennis, in China. *Journal of Insect Science*, 10(128), 2010.

[234] B. Branco, L. Dalmau, I. Borges, and A. O. Soares. Life-history traits of the predetor Rhyzobius lophanthae reared on the scale Chrysomphalus dictyospermi. *Bulletin of Insectology*, 70(2):231–235, 2017.

[235] R. Colburn and D. Asquith. Observations on the morphology and biology of the ladybird beetle Stethorus punctum. *Annals of the Entomological Society of America*, 64(6):1217–1221, 1971.

[236] T. A. Ugine and J. E. Losey. Development times and age-specific life table parameters of the native lady beetle species Coccinella novemnotata (Coleoptera: Coccinellidae) and its invasive congener Coccinella septempunctata (Coleoptera: Coccinellidae). *Environmental Entomology*, 43(4):1067–1075, 2014.

[237] E. S. Raros and F. H. Haramoto. Biology of Stethorus siphonulus Kapur (Coccinellidae: Coleoptera), a predetor of spider mites, in Hawaii. *Proceedings of the Hawaiian Entomological Society*, 21(3):457–465, 1974.

[238] M. G. Hentz and G. S. Nuessly. Morphology and biology of Diomus terminatus (Coleoptera: Coccinellidae), a predetor of Sipha flava (Homoptera: Aphidae). *Florida Entomologist*, 85(1):276–278, 2002.

[239] J. C. Legaspi, J. Legaspi, Benjamin C., A. M. Simmons, and M. Soumare. Life table analysis for immatures and female adults of the predetory beetle, Delphastus catalinae, feeding on whiteflies under three constant temperatures. *Journal of Insect Science*, 8(7), 2008.

[240] T. Olckers. Assessing the risks associated with the release of a flowerbud weevil, Anthonomus santacruzi, against the invasive tree Solanum mauritianum in South Africa. *Biological Control*, 28(3):302–312, 2003.

[241] T. R. Burkot and D. M. Benjamin. The biology and ecology of the cottonwood leaf beetle, Chrysomela scripta (Coleoptera: Chyrsomelidae), on tissue cultured hybrid Aigerios (Poplus x Euramericana) subclones in Wisconsin. *The Canadian Entomologist*, 111(5):551–556, 1979.

[242] M. G. Maw. Biology of the tortoise beetle, Cassida hemisphaerica (Coleoptera: Chyrsomelidae), a possible biological control agent for bladder campion, Silene cucubalus (Caryophyllaceae), in Canada. *The Canadian Entomologist*, 108(9):945–954, 1976.

[243] E. P. Smereka. The life history and habits of Chrysomela crotchi Brown (Coleoptera: Chrysomelidae) in northwestern Ontario. *The Canadian Entomologist*, 97(5):541–549, 1965.

[244] H. L. Sweetman. Results of life history studies of Diabrotica 12-punctata Fabr. (Chrysomelidae, Coleoptera). *Journal of Economic Entomology*, 19(3):484–490, 1926.

[245] H. D. Brown. On the biology of Lioadalia flavomaculata (Deg.) (Col., Coccinellidae), a predetor of wheat aphid (Schizaphis graminum (Rond.)) in South Africa. *Bulletin of Entomological Research*, 61(4):673–679, 1972.

[246] A. M. Richards. Rhyzobius ventralis (Erichson) and R. forestieri (Mulsant) (Coleoptera: Coccinellidae), their biology and value for scale insect control. *Bulletin of Entomological Research*, 71(1):33–46, 1981.

[247] J. K. Itami and T. P. Craig. Life history of Styloxus bicolor (Coleoptera: Cerambycidae) on Juniperus monosperma in northern Arizona. *Annals of the Entomological Society of America*, 82(5):582–587, 1989.

[248] R. P. Papp and G. A. Samuelson. Life history and ecology of Plagithmysus bilineatus, an endemic Hawaiian borer associated with ohia lehua (Myrtaceae). *Annals of the Entomological Society of America*, 74(4):387–391, 1981.

[249] R. G. Weber and W. A. Connell. Stelidota geminata (Say): studies on its biology (Coleoptera: Nitidulidae). *Annals of the Entomological Society of America*, 68(4):649–653, 1975.

[250] A. N. Nilsson. Larval morphology, biology and distribution of Agabus setulosus (Coleoptera: Dytiscidae). *Entomolgica Scandinavica*, 19(3):381–391, 1988.

[251] E. H. Barman. Biology and immature stages of Desmopachria convexa (Anue) - (Coleoptera - Dytiscidae). *Proceedings of the Entomological Society of Washington*, 75(2):233–239, 1973.

[252] J. P. Chaudhary and R. P. Kapil. Reproductive biology of the khapra beetle, Trogoderma granarium Ev. (Col., Dermestidae). *Zeitschrift fur Angewandte Entomologie*, 81(1):30–37, 2009.

[253] F. N. C. Osuji. Some aspects of the biology of Dermestes maculatus DeGeer (Coleoptera, Dermestidae) in dried fish. *Journal of Stored Products Research*, 11(1):25–31, 1975.

[254] P. Kumar, C. A. Jayaprakas, B. D. Singh, and K. Sengupta. Studies on the biology of Dermestes ater (Coleoptera: Dermestidae) - a pest of silkworm pupae and adults. *Current Science*, 57(22):1253–1253, 1988.

[255] S. V. Pushkin. Dermestes erichsoni (Ganglbauer, 1903) (Coleoptera: Dermestidae) - rare beetles of the south of Russia. *Entomology and Applied Science Letters*, 2(4):19–21, 2015.

[256] J. W. Mertins. Life history and morphology of the odd beetle, Thylodrias contractus. *Annals of the Entomological Society of America*, 74(6):576–581, 1981.

[257] M. Archangelsky and M. E. Durand. Description of the immature stages and biology of Phaenonotum exstriatum (Say 1835) (Coleoptera: Hydrophilidae: Sphaeridiine). *The Coleopterists Bulletin*, 46(3):209–215, 1992.

[258] M. Archangelsky. Immature stages of neotropical Hydrophilidae (Coleoptera): Hydramara argentina (Knisch, 1925) and Hemiosus bruchi Knisch, 1924. *Proceedings of the Entomological Society of Washington*, 102(2):280–291, 2000.

[259] T. Colkesen and E. Sekeroglu. Biology and population development of Ablattaria arenaria (Coleoptera: Silphidae), a snail predetor. *Entomophaga*, 34(2):219–226, 1989.

[260] R. J. Hodges. The biology and control of Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae) - a destructive storage pest with an increasing range. *Journal of Stored Products Research*, 22(1):1–14, 1986.

[261] N. W. Baker. Observations on the biology of the giant palm-boring beetle, Dinapte wrighti Horn (Coleoptera: Bostrichidae). *Journal of the New York Entomological Society*, 79(1):31–42, 1971.

[262] S. W. Shires. Life history of Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae) at optimum conditions of temperature and humidity. *Journal of Stored Products Research*, 16(3):147–150, 1980.

[263] P. A. Edde. A review of the biology and control of Rhyzopertha dominica (F.) the lesser grain borer. *Journal of Stored Products Research*, 48:1–18, 2012.

[264] L. L. Buschman. Biology of the firefly Pyractomena lucifera (Coleoptera: Lampyridae). *The Florida Entomologist*, 67(4):529–542, 1984.

[265] M. Archangelsky and M. A. Branham. Description of the preimaginal stages of Pyractomena borealis (Randell, 1838) (Coleoptera: Lampyridae) and notes on its biology. *Proceedings of the Entomological Society of Washington*, 100(3):421–430, 1998.

[266] K. Kadowaki, R. A. B. Leschen, and J. R. Beggs. Spore consumption and life history of Zearagytodes maculifer (Broun) (Coleoptera: Leiodidae) on Ganoderma, its fungal host. *New Zealand Journal of Ecology*, 35(1):61–68, 2011.

[267] K. A. Achiano and J. H. Giliomee. Biology of the house fly predetor Carcinops pumilio (Erichson) (Coleoptera: Histeridae). *BioControl*, 50(6):899–910, 2005.

[268] D. P. Rees. Life history of Teretriosoma nigrescens Lewis (Coleoptera: Histeridae) and its ability to supress populations of Prostephanus trucatus (Horn) (Coleoptera: Bostrichidae). *Journal of Stored Products Research*, 21(3):115–118, 1985.

[269] R. J. Steedman and N. H. Anderson. Life history and ecological role of the xylophageous aquatic beetle, Lara avara LeConte (Dryopoidea: Elmidae). *Freshwater Biology*, 15(5):535–546, 1985.

[270] E. C. Phillips. Life history and energetics of Ancyronyx variegata (Coleoptera: Elmidae) in northwest Arkansas and southeast Texas. *Annals of the Entomological Society of America*, 90(1):54–61, 1997.

[271] D. M. Stagliano and M. R. Whiles. Life history and production of the riffle beetle, Stenelmis crenata (Say, 1824) (Coleoptera: Elmidae), in a tallgrass prairie stream. *Aquatic Insects*, 30(3):197–204, 2008.

[272] F. Mc Kay, D. Gandolfo, and A. B. R. Witt. Biology and host range of Coelocephalapion gandolfoi Kissinger (Brentidae), a promising candidate for the biological control of invasive Prosopis species (Leguminosae) in South Africa. *African Entomology*, 20(2):281–291, 2012.

[273] E. R. Hoebeke, R. A. Byers, A. Alonso-Zarazaga, and J. F. Stimmel. Ischnopterapion (Chlorapion) virens (Herbst) (Coleoptera: Curculionidea: Brentidae: Apioninae), a palearctic clover pest new to North America: recognition features, distribution, and bionomics. *Proceedings of the Entomological Society of Washington*, 102(1):151–161, 2000.

[274] J.-R. Baars, M. P. Hill, F. Heystek, S. Neser, and A. J. Urban. Biology, oviposition preference and impact of quarantine of the petiole-galling weevil, Coelocephalapion camarae Kissinger, a promising candidate agent for biological control of Lantana camara. *Biological Control*, 40(2):187–195, 2007.

[275] X.-z. Xiong. Laboratory rearing method and life history of Falsogastrallus sauteri Pic (Coleoptera: Anobiidae). *The Coleopterists Bulletin*, 46(3):321–324, 1992.

[276] R. M. Mahroof and T. W. Phillips. Life history parameters of Lasioderma serricorne (F.) as influenced by food sources. *Journal of Stored Products Research*, 44(3):219–226, 2008.

[277] J. R. Ashworth. The biology of Lasioderma serricorne. *Journal of Stored Products Research*, 29(4):291–303, 1993.

[278] A. Deler-Hernández and J. A. Delgado. The Hydraenidae of Cuba (Insecta: Coleoptera) II: Morphology of preimaginal stages of six species and notes on their biology. *Zootaxa*, 4238(4):451–498, 2017.

[279] J. Skuhrovec, S. Volovnik, and R. Gosik. Description of the immature stages of Larinus vulpes and notes on its biology (Coleoptera, Curculionidae, Lixinae). *ZooKeys*, (679):107–137, 2017.

[280] L. Gültekin. Host plant range and biology of Lixus nordmanni Hochhuth (Coleoptera, Curculionidae) on hogweed Heracleum L. in eastern Turkey. *Journal of Pest Science*, 79(1):23–25, 2006.

[281] Y. Zhang, J. Sun, and J. L. Hanula. Biology and life history of Argopistes tsekooni (Coleoptera: Chrysomelidae) in China, a promising biological control agent of Chinese privet. *Annals of the Entomological Society of America*, 102(3):508–516, 2009.

[282] G. W. Wood. Life history and control of a casebearer, Chlamisus cribripennis (Coleoptera: Chrysomelidae), on blueberry. *Journal of Economic Entomology*, 59(4):823–825, 1966.

[283] C. N. Duckett and L. de Azevedo Moura. First descriptions of immature stages of Yingaresca holosericea (Bowditch) (Coleoptera: Chrysomelidae: Galerucinae) and notes on their biology. *The Coleopterists Bulletin*, 56(2):161–169, 2002.

[284] A. B. R. Witt, S. Docherty, and W. A. Palmer. Distribution and aspects of the biology of Chlamisus malvernensis Bryant (Coleoptera: Chrysomelidae) collected on Acacia nilotica (L.) Willd. ex Del. ssp. kraussiana (Benth.) Brenan (Mimosaceae) in South Africa. *African Entomology*, 13(2):376–379, 2005.

[285] H. D. Nsiama She, J. A. Odebiyi, and H. R. Herren. The biology of Hyperaspis jucunda (Col.: Coccinellidae) an exotic predetor of the cassava mealybug Phenacoccus manihoti (Hom.: Pseudococcidae) in southern Nigeria. *Entomophaga*, 29(1):87–93, 1984.

[286] S. S. Izhevsky and A. D. Orlinsky. Life history of the imported Scymnus (Nephus) reunioni (Col.: Coccindellidae) predator of mealybugs. *Entomophaga*, 33(1):101–114, 1988.

[287] S. R. Rodrigues, G. A. L. Nogueira, R. R. Echeverria, and V. S. Oliveira. Aspectos biológicos de Cyclocephala verticalis Burmeister (Coleoptera: Scarabaeidae). *Neotropical Entomology*, 39(1):15–18, 2010.

[288] M. Pathania, R. Singh Chandel, K. Singh Verma, and P. Kumar Mehta. Seasonal life history of Holotrichia longipennis (Blanchard) (Coleoptera: Scarabaediae: Melolonthinae): a serious foliage and root feeding pest in India. *Phytoparasitica*, 44(5):615–629, 2016.

[289] K. L. S. Harley. Assessment of suitability of Plagiohammus spinipennis (Thoms) (Col., Cerambycidae) as an agent for control of weeds of the genus Lantana (Verbenaceae). I. Life-history and capacity to damage L. camara in Hawaii. *Bulletin of Entomological Research*, 58(3):567–574, 1969.

[290] J. R. Starzyk and M. Partyka. Study on the morphology, biology and distribution of Obrium cantharinum (L.) (Col., Cerambycidae). *Journal of Applied Entomology*, 116(4):333–344, 1993.

[291] M. L. Brust, C. B. Knisley, S. M. Spomer, and K. Miwa. Observations of oviposition behavior among North American tiger beetle (Coleoptera: Carabidae: Cicindelinae) species and notes on mass rearing. *The Coleopterists Bulletin*, 66(4):309–314, 2012.

[292] F. N. Kolesnikov and E. V. Malueva. Life history of Amara fulva (Coleoptera: Carabidae) in the southwest forest zone of the east european plain. *European Journal of Entomology*, 112(1):127–134, 2015.

[293] J. D. Gilgado and V. M. Ortuño. Biological notes and description of egg and first instar larva of Carabus (Oreocarabus) ghilianii La Ferté-Sénectère 1847 (Coleoptera: Carabidae). *Annales de la Société Entomologique de France*, 47(3):444–456, 2011.

[294] J. Porter. Some studies on the life history and oviposition of Carpophilus dimidiatus (F.) (Coleoptera: Nitidulidae) at various temperatures and humidities. *Journal of Stored Products Research*, 22(3):135–139, 1986.

[295] L. C. Bortoli, J. Machota, Ruben, and M. Botton. Biologia e tabela de vida de fertilidade da broca-do-morangueiro criada em dieta artificial. *Pesquisa Agropecuária Brasileira*, 49(2):144–147, 2014.

[296] N. Greco, N. Cluigt, A. Cline, and G. Liljesthröm. Life history traits and life table analysis of Lobiopa insularis (Coleoptera: Nitidulidae) fed on strawberry. *PLoS ONE*, 12(7):e0180093, 2017.

[297] T. F. Houston. Brood cells, life-cycle stages and development of some earth-borer beetles in the genera Bolborhachium, Blackburnium and Bolboleaus (Coleoptera: Geotrupidae), with notes on captive rearing and a discussion of larval diet. *Austral Entomology*, 55(1):49–62, 2016.

[298] T. A. Jacob. Observations on the biology of Oryzaphilus acumintus Halstead with comparative notes on the common species of Oryzaphilus (Coleoptera; Silvanidae). *Journal of Stored Products Research*, 17(1):17–23, 1981.

[299] P. J. Collins, J. C. Mulder, and D. Wilson. Variation in life history parameters of Oryzaephilus surinamensis (L). (Coleoptera: Silvanidae). *Journal of Stored Products Research*, 25(4):193–199, 1989.

[300] S. N. Okiwelu, P. O. Dudu, and N. E. S. Lale. The effects of photoperiod on some aspects of the biology of Oryzaephilus mercator (Fauvel) (Coleoptera: Silvanidae). *Journal of Stored Products Research*, 34(2):189–193, 1998.

[301] J. Allotey and J. G. Morris. Biology of Cathartus quadricollis Guerin-Meneville (Coleoptera: Silvanidae) on some selected food media. *Insect Science and Its Application*, 14(1):61–68, 1993.

[302] G. L. Piper. Life history of Acropteroxys gracilis (Coleoptera: Languriidae) on common ragweed in northeastern Ohio. *Ohio Journal of Science*, 78(6):304–309, 1978.

[303] T. Sato. Effects of photoperiod and temperature on development and larval diapause of Dacne picta (Coleoptera: Erotylidae). *Applied Entomology and Zoology*, 38(1):117–123, 2003.

[304] G. F. Moreira, C. C. Moreira, V. Andaló, J. Moino, Alcides, M. M. Cardoso-Freire, and E. Souza Dias. Laboratory rearing technique and biology of Mycotretus apicalis (Coleoptera: Erotylidae) on dried Pleurotus sajor-caju mushrooms. *Revista Colombiana de Entomología*, 36(2):342–345, 2010.

[305] P. Smith King. Natural history of Collops georgianus (Coleoptera: Melyridae). *Annals of the Entomological Society of America*, 78(1):131–136, 1985.

[306] M. Asano. Morphology and biology of Malachius prolongatus (Coleoptera: Melyridae: Malachiinae). *Acta Entomologica Musei Nationalis Pragae*, 57(2):603–615, 2017.

[307] M. S. Steininger, S. A. Wright, J. Ding, and G. S. Wheeler. Biology and host range of Heterapoderopsis bicallosicollis: a potential biological control agent for Chinese tallow Triadica sebifera. *Biocontrol Science and Technology*, 23(7):816–828, 2013.

[308] G. S. Wheeler, F. Mc Kay, M. D. Vitorino, and D. A. Williams. Biology and host range of Omolabus piceus, a weevil rejected for biological control for Schinus terebinthifolius in the USA. *BioControl*, 58(5):693–702, 2013.

[309] Y. Wang, J. Ding, G. S. Wheeler, M. F. Purcell, and G. Zhang. Heterapoderopsis bicallosicollis (Coleoptera: Attelabidae): a potential biological control agent for Triadica sebifera. *Environmental Entomology*, 38(4):1135–1144, 2009.

[310] J. A. Smith. Two Tasmanian species of Sclerocyphon Blackburn (Coleoptera: Psephenidae) with notes on their life history. *Journal of the Australian Entomological Society*, 20(4):277–288, 1981.

[311] C. M. Murvosh. Microdistribution of the water penny Psephenus montanus (Coleoptera: Psephenidae), with notes on life history and zoogeography. *The Southwestern Naturalist*, 38(2):119–126, 1993.

[312] H. A. Gatton, G. M. G. Zilahi-Balogh, S. M. Salom, and L. T. Kok. Biology and development of Laricobius kangdingensis Zilahi-Belogh and Jelínek, a newly discovered predator of Adelges tsugae. *BioControl*, 54(2):219–228, 2009.

[313] G. M. G. Zilahi-Balogh, L. M. Humble, L. T. Kok, and S. M. Salom. Morphology of Lacicobius nigrinus (Coleoptera: Derodontidae), a predator of the hemlock woolly adelgid. *The Canadian Entomologist*, 138(5):595–601, 2006.

[314] G. M. G. Zilahi-Balogh, S. M. Salom, and L. T. Kok. Development and reproductive biology of Laricobius nigrinus, a potential biological control agent of Adelges tsugae. *BioControl*, 48(3):293–306, 2003.

[315] G. M. G. Zilahi-Balogh, L. M. Humble, A. B. Lamb, S. M. Salom, and L. T. Kok. Seasonal abundance and synchrony between Laricobius nigrinus (Coleoptera: Derodontidae) and its prey, the hemlock woolly adelgid (Hemiptera: Adelgidae). *The Canadian Entomologist*, 135(1):103–115, 2003.

[316] M. T. El Sayed. On the biology of Araecerus fasciculatus De Geer (Col., Anthribidae), with special reference to the effects of variations in the nature and water content of the food. *Annals of Applied Biology*, 22(3):557–577, 1935.

[317] A. J. Pitman, E. B. G. Jones, M. A. Jones, and P. Oevering. An overview of the biology of the wharf borer beetle (Nacerdes melanura L., Oedemeridae) a pest of wood in marine structures. *Biofouling*, 19(S1):239–248, 2003.

[318] K. R. Hinson and R. J. Buss. Observations on the life history of Nemozoma championi (Wickham) (Coleoptera: Trogossitidae). *The Coleopterists Bulletin*, 70(2):305–308, 2016.

[319] A. Freese and W. Günther. Olibrus aeneus Fab. (Col., Phalacridae), a species associated with Tripleurospermum perforatum (Mérat) Wagenitz and other Anthemideae (Asteraceae) and its potential for biological control. *Journal of Applied Entomology*, 111(4):499–505, 1991.

[320] J. Steiner, Warren E. and B. P. Singh. Redescription of an ergot beetle, Acylomus pugetanus Casey, with immature stages and biology (Coleoptera: Phalacridae). *Proceedings of the Entomological Society of Washington*, 89(4):744–758, 1987.

[321] K. Rim, J. R. Golec, and J. J. Duan. Host selection and potential non-target risk of Dastarcus helophoroides, a larval parasitoid of the Asian longhorned beetle, Anoplophora glabripennis. *Biological Control*, 123(1):120–126, 2018.

[322] N. Ogura, K. Tabata, and W. Wang. Rearing of the colydiid beetle predator, Dastarcus helophoroides, on artificial diet. *BioControl*, 44(3):291–299, 1999.

[323] D. Shohet and A. R. Clarke. Life history of Chauliognathus lugubris (F.) (Coleoptera: Cantharidae) in Tasmanian forests. *Australian Journal of Entomology*, 36(1):37–44, 1997.

[324] D. G. H. Halstead. Observations on the biology of Murmidius ovalis (Beck) (Coleoptera: Cerylonidae). *Journal of Stored Products Research*, 4(1):13–21, 1968.

[325] G. N. Wallage and H. A. Rose. Some aspects of the biology of Triphyllus minor (Lea) (Coleoptera: Mycetophagidae). *Journal of the Australian Entomological Society*, 21(2):111–112, 1982.

[326] M. M. Furniss and S. J. Kegley. Biology of Pityophthorus pulchellus tuberculatus (Coleoptera: Curculionidae: Scolytinae) in lodgepole pine in northern Idaho. *Environmental Entomology*, 47(4):775–780, 2018.

[327] E. R. Hoebeke and J. Wheeler, A. G. Telmatophilus typhae (Fallén) (Coleoptera: Crytophagidae), a palearctic cattail specialist established in the Canadian maritime provinces. *Proceedings of the Entomological Society of Washington*, 102(2):398–402, 2000.

[328] H. Podoler, Z. Mendel, and H. Livne. Studies on the biology of a bark beetle predator, Aulonium ruficorne (Coleoptera: Colydiidae). *Environmental Entomology*, 19(4):1010–1016, 1990.

[329] G. A. Hackwell. Biology of Lasconotus subcostulatus (Coleoptera: Colydiidae) with special reference to feeding behavior. *Annals of the Entomological Society of America*, 66(1):62–65, 1973.

[330] P. Švácha. Bionomics, behaviour and immature stages of Pelecotoma fennica (Paykull) (Coleoptera: Rhipiphoridae). *Journal of Natural History*, 28(3):585–618, 1994.

[331] E. R. Hoebeke and T. L. McCabe. The life history of Serropalpus coxalis, with a description of the larva and pupa (Coleoptera: Melandryidae). *The Coleopterists Bulletin*, 31(1):57–63, 1977.

[332] D. H. Funk and H. Fenstermacher. Description of the aquatic larva and pupa of Paralichas trivittis (Coleoptera: Ptilodactylidae), with notes on its biology. *Entomological News*, 113(5):344–354, 2002.

[333] P. J. Spangler. Immature stages and biology of Tetraglossa palpalis Champion (Coleoptera: Ptilodactylidae). *Entomological News*, 94(5):161–175, 1983.

[334] C. A. Gent, D. Wainhouse, K. R. Day, A. J. Peace, and D. J. G. Inward. Temperature-dependent development of the great European spruce bark beetle Dendroctonus micans (Kug.) (Coleoptera: Curculionidae: Scolytinae) and its predator Rhizophagus grandis Gyll. (Coleoptera: Monotomidae: Rhizophaginae). *Agricultural and Forest Entomology*, 19(3):321–331, 2017.

[335] M. A. K. Gillespie, T. Birkemoe, and A. Sverdrup-Thygeson. Interactions between body size, abundance, seasonality, and phenology in forest beetles. *Evolutionary Ecology*, 7(4):1091–1100, 2017.

[336] P. Bouchard, Y. Bousquet, C. Carton, M. Lourdes Chamorro, H. E. Escalona, A. V. Evans, A. Konstantinov, R. A. B. Leschen, S. Le Tirant, and S. W. Lingafelter. *The Book of Beetles*. University of Chicago Press, Chicago, IL, 2014.

[337] R. E. Blackwelder. Monograph of the West Indian beetles of the family Staphylinidae. *Bulletin of the United States National Museum*, 182:1–658, 1943.

[338] T. H. Dobzhansky. Beetles of the genus Hyperaspis inhabiting the United States. *Smithsonian Miscellaneous Collections*, 101(6):1–94, 1941.

[339] D. Sassi. Revision of the Metallactus kollari species-group with a new diagnosis of the genus (Coleoptera: Chrysomelidae: Cryptocephalinae). *Zootaxa*, 4413(1):57–110, 2018.

[340] A. Lompe. Käfer Europas. http://coleonet.de/, 2009.

[341] C.-F. Lee and M. Satô. Nipponeubria yoshitomii Lee and Satô, a New Species in a New Genus of Eubriinae from Japan, with Notes on the Immature Stages and Description of the Larva of Ectopria opaca (Kiesenwetter) (Coleoptera: Psephenidae). *The Coleopterists Bulletin*, 50(2):122–134, 1996.

[342] S. H. Church, S. Donoughe, A. S. de Medeiros, and C. G. Extavour. A dataset of egg size and shape from more than 6,700 insect species. *Scientific Data*, 6:104, 2019.

[343] G. L. Vaught and K. W. Strewart. The life history and ecology of the stonefly Neoperla clymene (Newman) (Plecoptera: Perlidae). *Annals of the Entomological Society of America*, 67(2):167–178, 1974.

[344] P. P. Harper. Emergence, reproduction, and growth of setipalpian Plecoptera in southern Ontario. *Oikos*, 24(1):94–107, 1973.

[345] R. A. Lechleitner and B. C. Kondratieff. The life history of Pteronarcys dorsata (Say) (Plecoptera: Pteronarcyidae) in southwestern Virginia. *Canadian Journal of Zoology*, 61(9):1981–1985, 1983.

[346] A. Frutiger. Investigations on the life-history of a stonefly Dinocras cephalotes Curt. (Plecoptera: Perlidae). *Aquatic Insects*, 9(1):51–63, 1987.

[347] D. C. Tarter and L. A. Krumholz. Life history and ecology of Paragnetia media (Walker) (Insecta: Plecoptera) in Doe Run, Meade County, Kentucky. *The American Midland Naturalist*, 86(1):169–180, 1971.

[348] J. M. Tierno de Figueroa and T. Derka. Egg description of Isoptena serricornis (Plecoptera: Chloroperlidae). *Entomological Problems*, 33(1):55–57, 2003.

[349] S. G. Khoo. *Studies on the biology of stoneflies*. Thesis, University of Liverpool, 1964.

[350] J. E. Brittain. The effect of temperature on the egg incubation period of Taeniopteryx nebulosa (Plecoptera). *Oikos*, 29(2):302–305, 1977.

[351] J. E. Brittain. Semivoltinism in mountain populations of Nemurella pictetii (Plecoptera). *Oikos*, 30(1):1–6, 1978.

[352] S. Kobayashi, R. Usui, K. Nomoto, M. Ushirokita, T. Denda, and M. Izawa. Population dynamics and the effects of temperature on the eggs of the seawater-dispersed stick insect Megacrania tsudai (Phasmida: Phasmatidae). *Zoological Studies*, 55(20):1–10, 2016.

[353] J. Berger. *Ecology of phasmids (Phasmatodea) in a moist neotropical forest: a study on life history, host-range and bottom-up versus top-down regulation*. Thesis, Technischen Universität Kaiserlautern, 2004.

[354] R. J. Lamb and W. G. Wellington. Life history and population characteristics of the european earwig, Foricula auricularia (Dermaptera: Forficulidae) at Vancouver, British Columbia. *The Canadian Entomologist*, 107(819-824), 1975.

[355] E. C. Klostermeyer. The life history and habits of the ringlegged earwig, Euborellia annulipes (Lucas) (Order Dermaptera). *Journal of the Kansas Entomological Society*, 15(1):13–18, 1942.

[356] H. Dib, B. Sauphanor, and Y. Capowiez. Report on the life history of the generalist predator Forficula auricularia (Dermaptera: Forficulidae) in organic apple orchards in southeastern France. *The Canadian Entomologist*, 149(1):56–72, 2016.

[357] H. S. Leigh. Preliminary account of the life-history of the leaf-insect, Phyllium crurifolium Serville. *Proceedings of the Zoological Society of London*, 79(1):103–113, 1909.

[358] P. D. Brock. Studies on the genus Phalces Stål. *Phasmid Studies*, 8(1-2):1–8, 1992.

[359] M. Bushell. A report on a culture of Phasma gigas from New Ireland. *Phasmid Studies*, 8(1-2):20–24, 1992.

[360] J. Roget. A very pretty phasmid: Parectatosoma hystrix. *Phasmid Studies*, 2(1):7–9, 1993.

[361] P. Bragg. PSG 109, Carausius abbreviatus (Brunner). *Phasmid Studies*, 1(1):10–13, 1992.

[362] P. Jennings. PSG 118, Aretaon asperrimus (Redtenbacher). *Phasmid Studies*, 1(2):26–30, 1992.

[363] F. Hennemann. PSG 128, Phyllium celebicum de Haan. *Phasmid Studies*, 1(1):31–33, 1992.

[364] F. Hennemann. PSG 28, Eurycnema herculeana. *Phasmid Studies*, 1(2):34–37, 1992.

[365] M. Lee. A survey of the distribution of the unarmed stick insect Acanthoxyla inermis in Port Garverne and Port Isaac, North Cornwall in 1992. *Phasmid Studies*, 2(1):25–32, 1993.

[366] P. E. Bragg. PSG 121, Phenacephorus spinulosus (Hausleithner). *Phasmid Studies*, 2(2):41–44, 1993.

[367] F. Hennemann. Pharnacia serratipes (Gray). *Phasmid Studies*, 2(2):45–50, 1993.

[368] P. E. Bragg. Some notes on Dinophasma guttigera (Westwood) from Borneo. *Phasmid Studies*, 2(2):62–65, 1993.

[369] P. E. Bragg. PSG 146, Centema hadrillus (Westwood). *Phasmid Studies*, 3(2):23–27, 1994.

[370] F. Hennemann. PSG 72, Phyllium giganteum Hausleithner. *Phasmid Studies*, 4(2):64–66, 1995.

[371] I. C. Brey. Species report PSG 213: Malacomorpha jamaicana (Redtenbacher, 1906). *Phasmid Studies*, 10(1):1–5, 2001.

[372] P. E. Bragg. Menexenus exiguus alienigena Günther, 1939 from Sulawesi. *Phasmid Studies*, 10(2):35–40, 2001.

[373] F. Seidenschwarz. Description of the female and egg of Theramenes mandirigma Zompro & Eusebio, 2001 (Phasmatodea: Heteropterygidae: Orbriminae: Obrimini). *Phasmid Studies*, 19(1):2–7, 2018.

[374] R. J. Orpet, D. W. Crowder, and V. P. Jones. Biology and management of european earwig in orchards and vineyards. *Journal of Integrated Pest Management*, 10(1):21, 2019.

[375] G. B. Simpson and L. N. Robertson. Effects of germinating seeds on the development and reproduction of Nala lividipes (DuFour) (Dermaptera: Labiduridae). *Journal of the Australian Entomological Society*, 32(2):169–175, 1993.

[376] G. B. Simpson. Effects of soil type and moisture on development and reproduction of Nala lividipes (DuFour) (Dermaptera: Labiduridae). *Journal of the Australian Entomological Society*, 30(4):281–287, 1991.

[377] D. Matzke and K.-D. Klass. Reproductive biology and nymphal development in the basal earwig Tagalina papua (Insecta: Dermaptera: Pygidicranidae), with a comparison of brood care in Dermaptera and Embioptera. *Entomologische Abhandlungen*, 62(2):99–116, 2005.

[378] J. J. Knabke and A. A. Grigarick. Biology of the african earwig, Euborellia cincticollis (Gerstaecker), in California and comparative notes on Euborellia annulipes (Lucas). *Hilgardia*, 41(7):157–194, 1971.

[379] E. T. Giles. The biology of Anisolabis littorea (White) (Dermaptera: Labiduridae). *Transactions and Proceedings of the Royal Society of New Zealand*, 80(3):383–398, 1953.

[380] A. Kumar Shah. The biology of Forcipula trispinosa (Dohrn) (Dermaptera: Labiduridae). *Records of the Zoological Survey of India*, Miscellaneous Publication(53):1–38, 1984.

[381] A. Buell Gurney. A synopsis of the order Zoraptera, with notes on the biology of Zorotypus hubbardi Caudell. *Proceedings of the Entomological Society of Washington*, 40(3):57–87, 1938.

[382] Y. Mashimo, R. Machida, R. Dallai, M. Gottardo, D. Mercati, and R. G. Beutel. Egg structure of Zorotypus caudelli Karny (Insecta, Zoraptera, Zorotypidae). *Tissue and Cell*, 43(4):230–237, 2011.

[383] Y. Mashimo, R. G. Beutel, R. Dallai, C.-Y. Lee, and R. Machida. Postembryonic developement of the ground louse Zorotypus caudelli Karny (Insecta: Zoraptera: Zorotypidae). *Arthropod Systematics & Phylogeny*, 72(1):55–71, 2014.

[384] Y. Mashimo, R. G. Beutel, R. Dallai, C.-Y. Lee, and R. Machida. Embryonic development of Zoraptera with special reference to external morphology, and its phylogenetic implications (Insecta). *Journal of Morphology*, 275(3):295–312, 2014.

[385] K. Tojo, R. Machida, K.-D. Klass, and M. D. Picker. Biology of South African heel-walkers, with special reference to reproductive biology (Insecta: Mantophasmatodea). *Proceedings of the Arthropodan Embryological Society of Japan*, 39(1):15–21, 2004.

[386] R. Machida, K. Tojo, T. Tsutsumi, T. Uchifune, K.-D. Klass, M. D. Picker, and L. Pretorius. Embryonic development of heel-walkers: reference to some prerevolutionary stages (Insecta: Mantophasmatodea). *Proceedings of the Arthropodan Embryological Society of Japan*, 39(1):31–39, 2004.

[387] K.-D. Klass, M. D. Picker, J. Damgaard, S. van Noort, and K. Tojo. The taxonomy, genitalic morphology, and phylogenetic relationships of Southern African Mantophasmatodea (Insecta). *Entomologische Abhandlungen*, 61(1):3–67, 2003.

[388] O. Zompro, J. Adis, P. E. Bragg, P. Naskrecki, K. Meakin, M. Wittneben, and V. Saxe. A new genus and species of Mantophasmatidae (Insecta: Mantophasmatodea) from the Branberg Massif, Namibia, with notes on behaviour. *Cimbebasia*, 19:13–24, 2003.

[389] S. Roth, J. Molina, and R. Predel. Biodiversity, ecology, and behavior of the recently discovered insect order Mantophasmatodea. *Frontiers in Zoology*, 11(1):70, 2014.

[390] S. Boyer and C. Rivault. Life history traits of cockroaches in sugar cane fields in La Réunion (Blattodea: Blattellidae and Blaberidae). *Oriental Insects*, 38(1):373–388, 2004.

[391] C. A. Nalepa. Colony composition, protozoan transfer and some life history characteristics of the woodroach Cryptocercus punctulatus Scudder (Dictyoptera: Cryptocercidae). *Behavioral Ecology and Sociobiology*, 14(4):273–279, 1984.

[392] M. A. H. Qadri. The life-history and growth of the cockroach Blatta orientalis, Linn. *Bulletin of Entomological Research*, 29(3):263–276, 1938.

[393] J. E. Short and J. P. Edwards. Reproductive and developmental biology of the oriental cockroach Blatta orientalis. *Medical and Veterinary Entomology*, 5(4):385–394, 1991.

[394] C. A. Nalepa, K. Maekawa, K. Shimada, Y. Saito, C. Arellano, and T. Matsumoto. Altricial development in subsocial wood-feeding cockroaches. *Zoological Science*, 25(12):1190–1198, 2008.

[395] K. Maekawa, M. Kon, and K. Araya. New species of the genus Salganea (Blattaria, Blaberidae, Panesthiinae) from Myanmar, with molecular phylogenetic analyses and notes on social structure. *Entomological Science*, 8(1):121–129, 2005.

[396] T. Kim and M. K. Rust. Life history and biology of the invasive Turkestan cockroach (Dictyoptera: Blattidae). *Journal of Economic Entomology*, 106(6):2428–2432, 2013.

[397] G. E. Gould. The effect of temperature upon the development of cockroaches. *Proceedings of the Indiana Academy of Sciences*, 50:242–248, 1940.

[398] E. Marchal, E. F. Hult, J. Huang, B. Stay, and S. S. Tobe. Diploptera punctata as a model for studying the endocrinology of arthropod reproduction and development. *General and Comparative Endocrinology*, 188:85–93, 2013.

[399] J. Avendaño and C. E. Sarmiento. Allometry and ontogeny in Callibia diana Stål (Mantodea: Acanthopidae). *Neotropical Entomology*, 40(4):462–469, 2011.

[400] T. Iwasaki. Comparative studies on the life history of two praying mantises, Tenodera aridifolia (Stoll) and Tenodera angustipennis Saussure (Mantodea: Mantidae). *Applied Entomology and Zoology*, 31(3):345–356, 1996.

[401] G. W. Ramsay. *Mantodea (Insecta), with a review of aspects of functional morphology and biology*, volume 19 of *Fauna of New Zealand*. DSIR Publishing, Wellington, New Zealand, 1990.

[402] L. M. Roth and W. Hahn. Size of new-born larvae of cockroaches incubating eggs internally. *Journal of Insect Physiology*, 10(1):65–70, 1964.

[403] E. R. Willis, G. R. Riser, and L. M. Roth. Observations on reproduction and development in cockroaches. *Annals of the Entomological Society of America*, 51(1):53–69, 1958.

[404] S. Horn and J. L. Hanula. Life history and habitat associations of the broad wood cockroach, Parcoblatta lata (Blattaria: Blattellidae) and other native cockroaches in the coastal plain of South Carolina. *Annals of the Entomological Society of America*, 95(6):665–671, 2002.

[405] A. G. Appel and I. Smith, Lane M. Biology and management of the smokybrown cockroach. *Annual Review of Entomology*, 47:33–55, 2002.

[406] R. A. Cannings. The ground mantis, Litaneutria minor (Dictuoptera: Mantidae) in British Colombia. *Journal of the entomological Society of British Columbia*, 84:64–65, 1987.

[407] L. Sacchi, C. A. Nalepa, E. Bigliardi, M. Lenz, C. Bandi, S. Corona, A. Grigolo, S. Lambiase, and U. Laudani. Some aspects of intracellular symbiosis during embryo development of Mastotermes darwiniensis (Isoptera: Mastotermitidae). *Parassitologia*, 40:309–316, 1998.

[408] J. C. Ene. The distribution and post-embryonic development of Tarachodes afzelii (Stål), (Mantodea: Eremiaphilidae). *Annals and Magazine of Natural History: Series 13*, 7(80):493–511, 1964.

[409] G. A. Raut, G. P. Bhawane, and S. M. Gaikwad. Laboratory studies on the life history of Hierodula ventralis Giglio-Tos, 1912 (Mantodea: Mantidae). *Journal of Entomology and Zoology Studies*, 2(6):147–152, 2014.

[410] D. K. Suckling. Laboratory studies on the praying mantis Orthodera ministralis (Mantodea: Mantidae). *New Zealand Entomologist*, 8(1):96–101, 1984.

[411] G. A. Raut and S. M. Gaikwad. Observations on the life cycle, mating and cannibalism of Mantis religosa religosa Linnaeus, 1758 (Insecta: Mantodea: Mantidae). *Journal of Entomology and Zoology Studies*, 4(6):478–482, 2016.

[412] T. E. Ata. Laboratory studies on the Egyptian praying mantis Miomantis paykullii Stål, (Mantodea: Mantidae). *Mansoura Journal of Plant Protection and Pathology*, 3(11):1235–1240, 2012.

[413] R. A. Roberts. Biology of the bordered mantid, Stagmomantis limbata Hahn (Orthoptera, Mantidae). *Annals of the Entomological Society of America*, 30(1):96–109, 1937.

[414] R. A. Roberts. Biology of the minor mantid, Litaneutria minor Scudder (Orthoptera, Mantidae). *Annals of the Entomological Society of America*, 30(1):111–121, 1937.

[415] N. Zohdy and A. A. Younes. Biological study on the praying mantis (Sphodromantis viridis Forskal) Mantodea — Mantidae. *Journal of the Egyptian-German Society of Zoology*, 40:63–76, 2003.

[416] S. J. Harris and M. D. Moran. Life history and population characteristics of the mantid Stagmomantis carolina (Mantodea: Mantidae). *Environmental Entomology*, 29(1):64–68, 2000.

[417] M. Didlake. Observations on the life-histories of two species of praying mantis (Orthopt.: Mantidae). *Entomological News*, 37(1):169–175, 1926.

[418] A. G. Scarbrough and G. Sipes. The biology of Leptogaster flavipes Loew in Maryland (Diptera: Asilidae). *Proceedings of the Entomological Society of Washington*, 75(4):441–448, 1973.

[419] J. G. Londt. Notes on the biology and immature stages of Neolophonotus dichaetus Hull in South Africa (Diptera: Asilidae). *Journal of the Entomological Society of Southern Africa*, 50(2):427–434, 1987.

[420] T.-M. Tesfa-Yohannes. Reproductive biology of Aedes (S.) malayensis (Diptera: Culicidae). *Journal of Medical Entomology*, 19(1):29–33, 1982.

[421] A. R. Barr. Notes on the colonization and biology of Armigeres subalbatus (Diptera, Culicidae). *Annals of Tropical Medicine & Parasitology*, 58(2):171–179, 1964.

[422] R. van Pletzen and T. C. d. K. van der Linde. Studies on the biology of Culiseta longiareolata (Macquart) (Diptera: Culicidae). *Bulletin of Entomological Research*, 71(1):71–79, 1981.

[423] R. Pereira, G. J. Steck, E. Varona, and J. Sivinski. Biology and natural history of Anastrepha interrupta (Diptera: Tephritidae). *Florida Entomologist*, 90(2):389–391, 2007.

[424] C. A. Moraiti, C. T. Nakas, K. Köppler, and N. T. Papadopoulos. Geographical variation in adult life-history traits of the European cherry fruit fly, Rhagoletis cerasi (Diptera: Tephritidae). *Biological Journal of the Linnean Society*, 107(1):137–152, 2012.

[425] D. H. Headrick and R. D. Goeden. Life history and description of immature stages of Aciurina thoracica (Diptera: Tephritidae) on Baccharis sarothroides in Southern California. *Annals of the Entomological Society of America*, 86(1):68–79, 1993.

[426] G. J. Steck. Chaetostomella undosa (Diptera: Tephritidae): biology, ecology, and larval description. *Annals of the Entomological Society of America*, 77(6):669–678, 1984.

[427] H. V. Danks. Life history and biology of Einfeldia synchrona (Diptera: Chironomidae). *The Canadian Entomologist*, 103(11):1597–1606, 1971.

[428] W. L. Hilsenhoff. The biology of Chironomus plumosus (Diptera: Chironomidae) in Lake Winnebago, Wisconsin. *Annals of the Entomological Society of America*, 59(3):465–473, 1966.

[429] I. Hayon, Z. Mendel, and N. Dorchin. Predatory gall midges on mealybug pests - diversity, life history, and feeding behavior in diverse agricultural settings. *Biological Control*, 99(1):19–27, 2016.

[430] L. G. Pickens and R. W. Miller. Biology and control of the face fly, Musca autumnalis (Diptera: Muscidae). *Journal of Medical Entomology*, 17(3):195–210, 1980.

[431] M. G. Yates. The biology of the tree-hole breeding mosquito Aedes geniculatus (Olivier) (Diptera: Culicidae) in southern England. *Bulletin of Entomological Research*, 69(4):611–628, 1979.

[432] B. A. Foote. Biology and immature stages of fruit flies: the genus Icterica (Diptera: Tephritidae). *Annals of the Entomological Society of America*, 60(6):1295–1305, 1967.

[433] R. D. Goeden and D. W. Ricker. Biology of Zonosemata vittigera relative to silverleaf nightshade. *Journal of Economic Entomology*, 64(2):417–421, 1971.

[434] A. S. Ali-Ali, S. A. Abbas, I. K. Al-Neamy, and A. M. E. Abdul-Masih. On the biology of the yellow safflower-fly Chaetorellia carthami Stack. (Dipt., Tephritidae) in Iraq. *Journal of Applied Ecology*, 86(4):439–445, 1978.

[435] M. J. Tauber and C. A. Tauber. Reproductive behaviour and biology of gall-former Aciurina ferruginea (Doanne) (Diptera: Tephritidae). *Canadian Journal of Zoology*, 45(6):907–913, 1967.

[436] K. Kamali and J. T. Schulz. Biology and ecology of Gymnocarena diffusa (Diptera: Tephritidae) on sunflower in North Dakota. *Annals of the Entomological Society of America*, 67(4):695–699, 1974.

[437] E. B. Fagan and W. R. Enns. The distribution and biology of aquatic midges in Missouri lagoons (Diptera: Chironomidae). *Proceedings of the Entomological Society of Washington*, 68(4):277–289, 1966.

[438] M. W. Housewart and J. W. Brewer. Biology of a pinyon spindle gall midge (Diptera: Cecidomyiidae). *Annals of the Entomological Society of America*, 65(2):331–336, 1972.

[439] K. M. Harris. Aphidophagous Cecidomyiidae (Diptera): taxonomy, biology and assessments of field populations. *Bulletin of Entomological Research*, 63(2):305–325, 1973.

[440] L. A. Caresche and A. J. Wapshire. The Chondrilla gall midge, Cystiphora schmidti (Rübsaamen) (Diptera, Cecidomyiidae). II. Biology and host specificity. *Bulletin of Entomological Research*, 65(1):55–64, 1975.

[441] D. L. Bailey, T. L. Whitfield, and G. C. LaBrecque. Laboratory biology and techniques for mass producing the stable fly, Stomoxys calcitrans (L.) (Diptera: Muscidae). *Journal of Medical Entomology*, 12(2):189–193, 1975.

[442] E. S. Krafsur and C. M. Ernst. Physiological age composition and reproductive biology of horn fly populations, Haematobia irritans irritans (Diptera, Muscidae), in Iowa, USA. *Journal of Medical Entomology*, 20(6):664–669, 1983.

[443] D. Barry. Notes on life history of a sorghum shoot fly, Atherigona varia soccata. *Annals of the Entomological Society of America*, 65(3):586–594, 1972.

[444] P. Ferrar. Life-history and larviparous reproduction of Musca fergusoni J. & B. (Diptera, Muscidae). *Bulletin of Entomological Research*, 65(2):187–198, 1975.

[445] J. D. Charlwood and K. Galgal. Observations on the biology and behaviour of Armigeres milnensis (Diptera: Culicidae) in Papua New Guinea. *Journal of the Australian Entomological Society*, 24(4):313–319, 1985.

[446] J. K. Nayar. Biology of Culex nigripalpus Theobald (Diptera: Culicidae): Part 1: Effects of rearing conditions on growth and diurnal rhythm of pupation and emergence. *Journal of Medical Entomology*, 5(1):39–46, 1968.

[447] A. Pollini and P. Cravedi. Carpomya vesuviana A. Costa (Diptera Tephritidae Trypetinae Carpomyini) from jujube tree in Emilia-Romagna (Northern Italy). *Redia - Giornale di Zoologia*, 97(1):117–118, 2014.

[448] D. P. Peschken and P. Harris. Host specificity and biology of Urophora cardui (Diptera: Tephritidae). A biocontrol agent ofor Canada thistle (Cirsium arvense). *The Canadian Entomologist*, 107(10):1101–1110, 1975.

[449] D. H. Headrick and R. D. Goeden. Life history of Paracantha gentilis (Diptera: Tephritidae). *Annals of the Entomological Society of America*, 83(4):776–785, 1990.

[450] D. E. Berube. Larval descriptions and biology of Tephritis dilacerata [Dip.: Tephritidae], a candidate for the biocontrol of Sonchus arvensis in Canada. *Entomophaga*, 23(1):69–82, 1978.

[451] F. K. Kasule. A comparison of the life history components of Aedes aegypti (L.) and Culex quinquefasciatus Say (Diptera: Culicidae). *International Journal of Tropical Insect Science*, 7(2):143–147, 1986.

[452] R. J. Lamb and S. M. Smith. Comparison of egg size and related life-history characteristics for two predaceous tree-hole mosquitoes (Toxorhynchites). *Canadian Journal of Zoology*, 58(11):2065–2070, 1980.

[453] R. T. Furumizo and A. Rudnick. Laboratory observations on the life history of two species of the Aedes (Finlaya) niveus subgroup (Diptera: Culicidae) in Malaysia. *Journal of Medical Entomology*, 15(5):573–575, 1979.

[454] R. D. Goeden, D. H. Headrick, and J. A. Teerink. Life history and description of immature stages of Paroxyna genalis (Thomson) (Diptera: Tephritidae) on native Asteraceae in Southern California. *Proceedings of the Entomological Society of Washington*, 96(4):612–629, 1994.

[455] R. I. Vargas and T. Nishida. Life history and demographic parameters of Dacus latifrons (Diptera: Tephritidae). *Journal of Economic Entomology*, 78(6):1242–1244, 1985.

[456] A. P. Arthur and P. G. Mason. Description of the immature stages and notes on the biology of Neotephritis finalis (Loew.) (Diptera: Tephritidae), a pest of sunflowers in Saskatchewan, Canada. *The Canadian Entomologist*, 121(9):729–735, 1989.

[457] W. B. Stoltzfus. Life history and descriptions of the immature stages of Jamesomyia geminata (Diptera: Tephritidae). *Proceedings of the Entomological Society of Washington*, 80(1):87–90, 1978.

[458] M. J. Tauber and C. A. Toschi. Bionomics of Euleia fratria (Loew) (Diptera: Tephritidae): I. Life history and mating behavior. *Canadian Journal of Zoology*, 43(2):369–379, 1965.

[459] D. R. Barton, C. W. Pugsley, and H. B. N. Hynes. The life history and occurence of Parachaetocladius abnobaeus (Diptera: Chironomidae). *Aquatic Insects*, 9(4):189–194, 1987.

[460] X. Feng, S. Zhang, F. Huang, L. Zhang, J. Feng, Z. Xia, H. Zouh, W. Hu, and S. Zhou. Biology, bionomics and molecular biology of Anopholes sinensis Wiedemann 1828 (Diptera: Culicidae), main malaria vector in China. *Frontiers in Microbiology*, 8:e1473, 2017.

[461] A. Carron, L. Bichaud, N. Platz, and D. J. Bicout. Life history traits of Aedes caspius (Diptera: Culicidae): a laboratory study of larval stages. *Bulletin of Entomological Research*, 98(5):431–436, 2008.

[462] A. S. Al-Ali, I. K. Al-Neamy, S. A. Abbas, and A. M. E. Abdul-Masih. On the life-history of the safflower fly Acanthiophilus helianthi Rossi (Dipt., Tephritidae) in Iraq. *Zeitschrift fur Angewandte Entomologie*, 83(2):216–223, 2009.

[463] G. L. Cavender and R. D. Goeden. Life history of Trupanea bisetosa (Diptera: Tephritidae) on wild sunflower in southern California. *Annals of the Entomological Society of America*, 75(4):400–406, 1982.

[464] R. I. Vargas, D. Miyashita, and T. Nishida. Life history and demographic parameters of three laboratory-reared tephritids (Diptera: Tephritidae). *Annals of the Entomological Society of America*, 77(6):651–656, 1984.

[465] R. L. Morley and R. A. Ring. The intertidal Chironomidae (Diptera) of British Columbia: II. Life history and population dynamics. *The Canadian Entomologist*, 104(7):1099–1121, 1972.

[466] G. M. Ward and K. W. Cummins. Life history and growth pattern of Paratendipes albimanus in a Michigan headwater stream. *Annals of the Entomological Society of America*, 71(2):272–284, 1978.

[467] K. J. Maier, P. Kosalwat, and A. W. Knight. Culture of Chironomus decorus (Diptera: Chironomidae) and the effect of temperature on life history. *Environmental Entomology*, 19(6):1681–1688, 1990.

[468] D. R. Specker and W. T. Johnson. Biology and immature stages of the rhododendron gall midge, Clinodiplosis rhododendri Felt (Diptera: Cecidomyiidae). *Proceedings of the Entomological Society of Washington*, 90(3):343–355, 1988.

[469] J. E. Peña, R. J. Gagné, and R. Duncan. Biology and characterization of Prodiplosis longifila (Diptera: Cecidomyiidae) on lime in Florida. *The Florida Entomologist*, 72(3):444–450, 1989.

[470] C.-N. Chen and J. E. Appleby. Biology of cypress twig gall midge, Taxodiomyia cupressiananassa (Diptera: Cecidomyiidae), in central Illinois. *Annals of the Entomological Society of America*, 77(2):203–207, 1984.

[471] J. R. Parnell. Biology and morphology of all stages of Toxomyia fungicola Felt (Diptera - Cecidomyiidae) in Jamaica. *Proceedings of the Royal Entomological Society of London Series A: General Entomology*, 44(7):113–122, 1969.

[472] L. G. Pickens. The life history and predatory efficiency of Ravinia lherminieri (Diptera: Sarcophagidae) on the face fly (Diptera: Muscidae). *The Canadian Entomologist*, 113(6):523–526, 1981.

[473] L. M. Emiljanowicz, G. D. Ryan, A. Langille, and J. Newman. Development, reproductive output and population growth of the fruit fly pest Drosophila suzukii (Diptera: Drosophilidae) on artifical diet. *Journal of Economic Entomology*, 107(4):1392–1398, 2014.

[474] M.-C. Kinzer, P. Krapf, M. Nindl, C. Heussler, S. Eisenkölbl, A. A. Hoffmann, J. Seeber, W. Arthofer, B. C. Schlick-Steiner, and F. M. Steiner. Life-history traits and physiological limits of the alpine fly Drosophila nigrosparsa (Diptera: Drosophilidae): a comparative study. *Ecology and Evolution*, 8(4):2006–2020, 2018.

[475] P. Armbruster and J. E. Conn. Geographic variation of larval growth in North American Aedes albopictus (Diptera: Culicidae). *Annals of the Entomological Society of America*, 99(6):1234–1243, 2006.

[476] L. B. Carrington, S. N. Seifert, N. H. Willits, L. Lambrechts, and T. W. Scott. Large diurnal temperature fluctuations negatively influence Aedes aegypti (Diptera: Culicidae) life-history traits. *Journal of Medical Entomology*, 50(1):43–51, 2013.

[477] A. T. Ciota, A. C. Matacchiero, A. M. Kilpatrick, and L. D. Kramer. The effect of temperature on life history traits of Culex mosquitoes. *Journal of Medical Entomology*, 51(1):55–62, 2014.

[478] B. L. Dodson, L. D. Kramer, and J. L. Rasgon. Effects of larval rearing temperature on immature development and West Nile virus vector competence of Culex tarsalis. *Parasites & Vectors*, 5:199, 2012.

[479] R. D. Goeden, T. D. Cadatel, and G. A. Cavender. Life history of Neotephritis finalis (Loew) on native Asteraceae in Southern California (Diptera: Tephritidae). *Proceedings of the Entomological Society of Washington*, 89(3):552–558, 1987.

[480] R. Sobhian and I. S. Pittara. A contribution to the biology, phenology and host specificity of Chaetorellia hexachaeta Loew (Dipt., Tephritidae), a possible candidate for biological control of yellow starthistle (Centaurea solstitialis L.). *Journal of Applied Entomology*, 106:444–450, 1988.

[481] N. S. Sharaf. Life history of the olive fruit fly, Dacus oleae Gmel. (Diptera: Tephritidae), and its damage to olive fruits in Tripolitania. *Zeitschrift fur Angewandte Entomologie*, 89:390–400, 1980.

[482] B. Greenberg and M. L. Szyska. Immature stages and biology of fifteen species of Peruvian Calliphoridae (Diptera). *Annals of the Entomological Society of America*, 77(5):488–517, 1984.

[483] K. Hori, M. Iwasa, and R. Ogawa. Biology of two species on the Protocalliphora (Diptera: Calliphoridae) in Tokachi, Hokkaido, Japan: Feeding behaviour of larvae, larval and pupal durations, voltinism and host specificity. *Applied Entomology and Zoology*, 25(4):475–482, 1990.

[484] C. Pérez, N. A. Segura, M. A. Patarroyo, and F. J. Bello. Evaluating the biological cycle and reproductive population parameters of Calliphora vicina (Diptera: Calliphoridae) reared on three different diets. *Journal of Medical Entomology*, 53(6):1268–1275, 2016.

[485] S. Nakamura. Parasitization and life history parameters of Exorista japonica (Diptera: Tachinidae) using the common armyworm, Pseudaletia separata (Lepidoptera: Noctuidae) as a host. *Applied Entomology and Zoology*, 29(2):133–140, 1994.

[486] K. D. Elsey and R. L. Raab. Biology of Voria ruralis (Diptera: Tachinidae). *Annals of the Entomological Society of America*, 63(1):216–222, 1970.

[487] D. S. Adam and T. F. Watson. Adult biology of Exorista mella. *Annals of the Entomological Society of America*, 64(1):146–149, 1971.

[488] A. R. Chauthani and J. J. Hamm. Biology of the exotic parasite Drino munda (Diptera: Tachinidae). *Annals of the Entomological Society of America*, 60(2):373–376, 1967.

[489] J. B. Etchegaray and T. Nishida. Biology of Lespesia archippivora (Diptera: Tachinidae). *Proceedings of the Hawaiian Entomological Society*, 22(1):41–49, 1975.

[490] K. Hövemeyer. Tropic links, nutrient fluxes, and natural history in the Allium ursinum food web, with particular reference to life history traits of two hoverfly herbvores (Diptera: Syrphidae). *Oecologia*, 102:86–94, 1995.

[491] A. Ricarte, M. Á. Marcos-García, and G. E. Rotheray. The early stages and life histories of three Eumerus and two Merodon species (Diptera: Syrphidae) from the Mediterranean region. *Entomologica Fennica*, 19(3):129–141, 2008.

[492] V. S. Schmid, M. N. Morales, L. Marinoni, R. Kamke, J. Steiner, and A. Zillikens. Natural history and morphology of the hoverfly Pseudomicrodon biluminiferus and its parasitic relationship with ants nesting in bromeliads. *Journal of Insect Science*, 14(38), 2014.

[493] C. T. Maier. The immature stages and biology of Mallota posticata (Fabricius) (Diptera: Syrphidae). *Proceedings of the Entomological Society of Washington*, 80(3):424–440, 1978.

[494] R. D. Akre, W. B. Garnett, and R. S. Zack. Biology and behavior of Microdon piperi in the Pacific Northwest (Diptera: Syphridae). *Journal of the Kansas Entomological Society*, 61(4):441–452, 1988.

[495] T. Kaufmann. Biology of Paragus borbonicus (Diptera: Syrphindae) as predetor of Toxoptera aurantii. *The American Midland Naturalist*, 90(1):252–256, 1973.

[496]

[497] R. D. Goeden. Life history and descriptions of adults and immatures stages of Tephritis teerinki, new species (Diptera: Tephritidae) on Hulsea vistita A. Gray (Asteraceae) in Southern California. *Proceedings of the Entomological Society of Washington*, 103(4):807–825, 2001.

[498] G. L. Cavender and R. D. Goeden. The life history of Paracantha cultaris (Coquillett) on wild sunflower, Helianthus annuus L. ssp. lenticularis (Douglas) Cockerell, in Southern California (Diptera: Tephritidae). *The Pan-Pacific Entomologist*, 60(3):213–218, 1984.

[499] R. D. Goeden and J. A. Teerink. Life history and description of immature stages of Trupanea signata Foote (Diptera: Tephritidae) on Gnaphalium luteo-album L. in Southern California. *Proceedings of the Entomological Society of Washington*, 99(4):748–755, 1997.

[500] R. I. Vargas, W. A. Walsh, D. Kanehisa, J. D. Stark, and T. Nishida. Comparative demography of three Hawaiian fruit flies (Diptera: Tephritidae) at alternating temperatures. *Annals of the Entomological Society of America*, 93(1):75–81, 2000.

[501] R. Sobhian. Life history and host specificity of Urophora sirunaseva (Hering) (Dipt., Tephritidae), a candidate for biological control of yellow starthistle, with remarks on the host plant. *Journal of Applied Entomology*, 116(4):381–390, 1993.

[502] D. Kovac, A. Schneider, A. Freidberg, and D. Wiwatwitaya. Life history and description of the larva of Acrotaenistola spiralis (Diptera: Tephritidae: Dacinae: Gastrozonini), an oriental fruit fly inhabiting bamboo twigs. *Raffles Bulletin of Zoology*, 65:154–167, 2017.

[503] M. G. Kaufman and R. H. King. Colonization of wood substrates by the aquatic xylophage Xylotopus par (Diptera: Chironomidae) and a description of its life history. *Canadian Journal of Zoology*, 65(9):2280–2286, 1987.

[504] D. P. Peschken. Host specificity and biology of Cystiphora sonchi [Dip.: Cecidomyiidae], a candidate for the biological control of Sonchus species. *Entomophaga*, 27(4):405–416, 1982.

[505] A. M. Alghali. Studies on the biology, damage and crop loss assessment of the sorghum midge, Contarinia sorghicola Coq. (Diptera: Cecidomyiidae). *International Journal of Tropical Insect Science*, 5(4):253–258, 1984.

[506] R. Coutin and K. M. Harris. The taxonomy, distribution, biology and economic importance of the millet grain midge, Geromyia penniseti (Felt), gen. n., comb. n. (Dipt., Cecidomyiidae). *Bulletin of Entomological Research*, 59(2):259–273, 1968.

[507] L. F. Wilson. Life history and habits of the willow beaked gall midge, Mayetiola rigidae (Diptera: Cecidomyiidae), in Michigan. *The Canadian Entomologist*, 100(2):202–206, 1968.

[508] D. G. R. McLeod, J. W. Whistlecraft, and C. R. Harris. An improved rearing procedure for the carrot rust fly (Diptera: Psilidae) with observations on life history and conditions controlling diapause induction and termination. *The Canadian Entomologist*, 117(8):1017–1024, 1985.

[509] C. H. Baker and D. J. Merritt. Life cycle of an Australian glow-worm Arachnocampa flava Harrison (Diptera: Keroplatidae: Arachnocampinae). *Australian Entomologist*, 30(2):45–55, 2003.

[510] H. F. Clifford and D. R. Barton. Observations on the biology of Ametropus neavei (Ephemeroptera: Ametropodidae) from a large river in northern Alberta, Canada. *The Canadian Entomologist*, 111(7):855–858, 1979.

[511] D. R. Barton. Observations on the life histories and biology of Ephemeroptera and Plecoptera in northeastern Alberta. *Aquatic Insects*, 2(2):97–111, 1980.

[512] I. Aoyagi, M. Tetsuka, and K. Nakamura. Morphology of early instar larvae and life history of Ephoron eophilum (Ephemeroptera: Polymitarcyidae). *Journal of Japanese Limnology*, 59(2):185–198, 1998.

[513] P. A. Bradbeer and A. A. Savage. Some observations on the distribution and life history of Caenis robusta Eaton (Ephemeroptera) in Cheshire and North Shropshire, England. *Hydrobiologia*, 68(1):87–90, 1980.

[514] N. W. Britt. The life history and ecology of the white may fly, Ephoron album Say, in Lake Erie. *Abstracts of Doctoral Dissertations*, 64:85–86, 1953.

[515] J. E. Brittain. Life history strategies in Ephemeroptera and Plecoptera. In I. C. Campbell, editor, *Mayflies and Stoneflies: Life histories and biology*, pages 1–12. Kluwer Academic Publishers, Dordrecht, Netherlands, 1990.

[516] V. Benech and J. C. Vignes. Etude expérimentale de l'incubation des oeufs de Baetis rhodani Pictet. *Freshwater Biology*, 2(3):243–252, 1972.

[517] C. Degrange. Recherches sur la reproduction des Éphémeroptères. *Travaux du Laboratoire d'Hydrobiologie et de Pisciculture de l'Université de Grenoble*, 50/51:7–193, 1960.

[518] J. M. Elliott. Effect of temperature on the hatching time of eggs of Ephemerella ignita (Poda) (Ephemeroptera: Ephemerellidae). *Freshwater Biology*, 8(1):51–58, 1978.

[519] M. K. Friesen, J. F. Flannagan, and S. G. Lawrence. Effects of temperature and cold storage on development time and viability of eggs of the burrowing mayfly Hexagenia rigida. *The Canadian Entomologist*, 111(6):665–673, 1979.

[520] U. H. Humpesch. Effect of temperature on the hatching time of five Ecdyonurus spp. (Ephemeroptera) from Austrian streams and English streams, rivers and lakes. *Journal of Animal Ecology*, 49(1):317–333, 1980.

[521] U. H. Humpesch and J. M. Elliott. Effect of temperature on the hatching time of eggs of three Rhithogena spp. (Ephemeroptera) from Austrian streams and an English stream and river. *Journal of Animal Ecology*, 49(2):643–661, 1980.

[522] R. L. Newell and G. W. Minshall. Effect of temperature on the hatching time of Trichorythodes minutus (Ephemeroptera: Tricorythidae). *Journal of the Kansas Entomological Society*, 51(3):504–506, 1978.

[523] B. W. Sweeney. Bioenergetic and developmental response of a mayfly to thermal variation. *Limnology and Oceanography*, 23(3):461–477, 1978.

[524] B. W. Sweeney. Influence of food quality and temperature on life history characteristics of the parthogenetic mayfly, Cloeon traingulifer. *Freshwater Biology*, 14(6):621–630, 1984.

[525] M. J. Coleman and H. B. N. Hynes. The life histories of some Plecoptera and Ephemeroptera in a southern Ontario stream. *The Canadian Entomologist*, 48(6):1333–1339, 1970.

[526] H. F. Clifford. Observations on the life cycle of Siphloplectron basale (Walker) (Ephemeroptera: Meteropodidae). *The Pan-Pacific Entomologist*, 52(4):265–271, 1976.

[527] J. E. Brittain. Mayfly strategies in a Norwegian subalpine lake. In J. F. Flannigan and K. E. Marshall, editors, *Advances in Ephemeroptera Biology*, pages 179–186. Plenum Press, Dordrecht, Netherlands, 1980.

[528] V. Benech. La fécondité de Baetis rhodani Pictet. *Freshwater Biology*, 2(4):337–354, 1972.

[529] J. E. Brittain. Experimental studies on nymphal growth in Leptophlebia vespertina (L.) (Ephemeroptera). *Freshwater Biology*, 6(5):445–449, 1976.

[530] S. Cianciara. Food preference of Cloëon dipterum (L) larvae and dependence of their development and growth on the type of food. *Polskie Archiwum Hydrobiologii*, 27(1):143–160, 1980.

[531] H. F. Clifford, H. Hamilton, and B. A. Killins. Biology of the mayfly Leptophlebia cupida (Say) (Ephemeroptera: Leptophlebiidae). *Canadian Journal of Zoology*, 57(5):1026–1045, 1979.

[532] L. D. Corkum. The nymphal development of Paraleptophlebia adoptiva (McDunnough) and Paraleptophlebia mollis (Eaton) (Ephemeroptera: Leptophlebiidae) and the possible influence of temperature. *Canadian Journal of Zoology*, 56(8):1842–1846, 1978.

[533] J. M. Elliott and U. H. Humpesch. Eggs of Ephemeroptera. *Annual Report of the Freshwater Biological Association*, 48:41–52, 1980.

[534] J. G. Needham, J. R. Traver, and Y.-C. Hsu. *The Biology of Mayflies*. Comstock Publishing Company, Inc., Ithaca, NY, 1935.

[535] A. H. Morgan. A contribution to the biology of may-flies. *Annals of the Entomolocial Society of America*, 6(3):371–413, 1913.

[536] V. Landa. Developmental cycles of central european Ephemeroptera and their interrelations. *Acta Entomologica Bohemoslovaca*, 65:276–284, 1968.

[537] D. A. McCullough, G. W. Minshall, and C. E. Cushing. Bioenergetics of a stream "collector" organism, Tricorythodes minutus. *Limnology and Oceanography*, 24(1):45–58, 1979.

[538] J. N. Minshall. Life history and ecology of Epeorus pleuralis (Banks) (Ephemeroptera: Heptageniidae). *The American Midland Naturalist*, 78(2):369–388, 1967.

[539] W. D. Pearson and R. H. Kramer. Drift and production of two aquatic insects in a mountain stream. *Ecological Monogaphs*, 42(3):365–385, 1972.

[540] W. L. Peters and J. G. Peters. Adult life and emergence of Dolania americana in northwestern Florida (Ephemeroptera: Behningiidae). *Internationale Revue der gesamten Hydrobiologie und Hydrographie*, 62(3):409–438, 1977.

[541] B. W. Sweeney and R. L. Vannote. Size variation and the distribution of hemimetabolous aquatic insects: two thermal equilibrium hypotheses. *Science*, 200(4340):444–446, 1978.

[542] P. T. P. Tsui and W. L. Peters. Embryonic development, early instar morphology, and behavior of Tortopus incertus (Ephemeroptera: Polymitarcidae). *The Florida Entomologist*, 57(4):349–356, 1974.

[543] D. J. Giberson and R. J. Mackay. Life history and distribution of mayflies (Ephemeroptera) in some acid streams in south central Ontario, Canada. *Canadian Journal of Zoology*, 69:899–910, 1991.

[544] J. K. Jackson. Diel Emergence, Swarming and Longevity of Selected Adult Aquatic Insects from a Sonoran Desert Stream. *The American Midland Naturalist*, 119(2):344–352, 1988.

[545] L. M. W. Trost and L. Berner. The Biology of Callibaetis floridanus Banks (Ephemeroptera: Baetidae). *The Florida Entomologist*, 46(4):285–299, 1963.

[546] J. E. Rabinovich and E. L. Nieves. Vital statistics of Triatominae (Hemiptera: Reduviidae) under laboratory conditions: III. Rhodnius neglectus. *Journal of Medical Entomology*, 48(4):775–787, 2011.

[547] D. Barreto-Santana, J. Starling, R. Gurgel-Gonçalves, and C. A. Cuba Cuba. Biologia comparativa e comportamento alimentar de Rhodnius neglectus e Rhodnius robustus (Triatominae) sob condições de laboratório. *Revista da Sociedade Brasileira de Medicina Tropical*, 44(4):490–495, 2011.

[548] J. M. Soares Barata. Aspectos morfológicos de ovos de triatominae. II – Características macroscópicas e exocoriais de dez espécies do gênero Rhodnius Stal, 1859 (Hemiptera – Reduviidae). *Revista de Saúde Pública*, 15(5):490–542, 1981.

[549] R. P. Pinto Soares, S. E. Barbosa, J.-P. Dujardin, C. J. Schofield, A. M. Siqueira, and L. Diotaiuti. Characterization of Rhodnius neglectus from two regions of Brazil using isoenzymes, genitalia morphology and morphometry. *Memórias do Instituto Oswaldo Cruz*, 94(2):161–166, 1999.

[550] S. Yurtsever. On the polymorphic meadow spittlebug, Philaenus spumarius (L.) (Homoptera: Cercopidae). *Turkish Journal of Zoology*, 24(4):447–459, 2000.

[551] R. M. Faust and F. P. Harrison. The life history and habits of the stilt bug, Jalysus spinosus, in Maryland. *Journal of Economic Entomology*, 61(4):1110–1110, 1968.

[552] P. A. Readio. The life history of Jalysus spinosus (Say.) (Neididae, Heteroptera). *The Canadian Entomologist*, 55(10):230–236, 1923.

[553] R. Diaz, W. A. Overholt, J. P. Cuda, P. D. Pratt, and A. Fox. Temperature-dependent development, survival, and potential distribution of Ischnodemus variegatus (Hemiptera: Blissidae) a herbivore of West Indian marsh grass. *Annals of the Entomolocial Society of America*, 101(3):604–612, 2008.

[554] R. Diaz, W. A. Overholt, T. A. Heard, A. Samayoa, and R. D. van Klinken. Characterizing the host specificity of Ischnodemus variegatus (Signoret) (Hemiptera: Blissidae) on two congeneric grass species. *Biological Control*, 55(3):219–224, 2010.

[555] V. H. P. Bueno, A. M. Calixto, F. C. Montes, and J. C. van Lenteren. Reproduction and population parameters of the Nearctic predator Geocoris punctipes at constant and varying temperature regimes. *Journal of Applied Entomology*, 140(5):323–333, 2016.

[556] Y. Tsuchida, M. Doi, A. Tatara, and S. Masui. Effects of alternative foods provided by living-mulch on the life history traits of the predetory bug, Geocoris proteus (Heteroptera: Geocoridae). *Japanese Journal of Applied Entomology and Zoology*, 59(1):23–29, 2015.

[557] A. M. Calixto, V. H. P. Bueno, F. C. Montes, and J. C. van Lenteren. Development and thermal requirements of the nearctic predator Geocoris punctipes (Hemiptera: Geocoridae) reared at constant and alternating temperatures and fed on Anagasta kuehniella (Lepidoptera: Pyralidae) eggs. *European Journal of Entomology*, 111(4):521–528, 2014.

[558] J. B. Torres, C. S. A. Silva-Torres, and J. R. Ruberson. Effect of two prey types on life-history characteristics and predation rate of Geocoris floridanus (Heteroptera: Geocoridae). *Environmental Entomology*, 33(4):964–974, 2004.

[559] R. A. Champlain and L. L. Sholdt. Life history of Geocoris punctipes (Hemiptera: Lygaeidae) in the laboratory. *Annals of the Entomolocial Society of America*, 60(5):881–883, 1967.

[560] Y. Suzaki, U. Koizumi, and T. Miyatake. Seasonal abundance and reproductive season of Chauliops fallax (Heteroptera: Malcidae) on kudzu Pueraria lobata. *Applied Entomology and Zoology*, 46(3):429–433, 2011.

[561] J. A. Slater. On the biology and food plants of Lygaeus turcicus (Fabr.) (Hemiptera: Lygaeidae). *Journal of the New York Entomological Society*, 91(1):48–56, 1983.

[562] B. Sillén-Tullberg and C. Solbreck. Population dynamics of a seed feeding bug, Lygaeus equestris. 2. Temporal dynamics. *Oikos*, 58(2):210–218, 1990.

[563] O. Kugelberg. Larval development of Lygaeus equestris (Heteroptera, Lygaeidae) on different natural foods. *Entomogia Experimentalis et Applicata*, 16(2):165–177, 1973.

[564] C. Solbreck and B. Sillén-Tullberg. Control of diapause in a “monovoltine” insect, Lygaeus equestris (Heteroptera). *Oikos*, 36(1):68–74, 1981.

[565] J. D. Baldwin and H. Dingle. Geographic variation in the effects of temperature on life-history traits in the large milkweed bug Oncopeltus fasciatus. *Oecologia*, 69(1):64–71, 1986.

[566] F. Andre. Notes on the biology of Oncopeltus fasciatus (Dallas). *Iowa State College Journal of Science*, 9(1):73–87, 1934.

[567] O. P. Lal. A contribution to the knowledge of ecology, biology, host range and control of the lygaeid bug Chauliops fallax Scott (Hemiptera: Lygaediae). *Rivista di Agricoltura Subtropicale e Tropicale*, 75:381–403, 1981.

[568] C. L. Booth. Biology of Largus californicus (Hemiptera: Largidae). *The Southwestern Naturalist*, 35(1):15–22, 1990.

[569] E. B. Lopatina, D. Kutcherov, and S. V. Balashov. The influence of diet on the duration and thermal sensitivity of development in the linden bug Pyrrhocoris apterus L. (Heteroptera: Pyrrhocoridae). *Physiological Entomology*, 39(3):208–216, 2014.

[570] R. Socha. Pyrrhocoris apterus (Heteroptera) - an experimental model species: a review. *European Journal of Entomology*, 90(3):241–286, 1993.

[571] Y. Zhang, J. L. Hanula, and S. Horn. The biology and preliminary host range of Megacopta cribraria (Heteroptera: Plataspidae). *Environmental Entomology*, 41(1):40–50, 2012.

[572] J. R. Golec. *Biology and management of Megacopta cribraria (Fabricius) (Heteroptera: Plataspidae): a recent invader to the United States*. Thesis, Auburn University, 2014.

[573] R. L. Koch, D. T. Pezzini, A. P. Michel, and T. E. Hunt. Identification, biology, impacts and management of stink bugs (Hemiptera: Heteroptera: Pentatomidae) of soybean and corn in the midwestern United States. *Journal of Integrated Pest Management*, 8(1):1–14, 2017.

[574] R. W. Sites and J. E. McPherson. Life history and laboratory rearing of Sehirus cinctus cinctus (Hemiptera: Cydnidae) with descriptions of immature stages. *Annals of the Entomolocial Society of America*, 75(2):210–215, 1982.

[575] J. E. McPherson. Life history of Corimelaena lateralis lateralis (Hemiptera: Thyreocoridae) with descriptions of the immature stages and list of other species of Scutelleroidea found with it on wild carrot. *Annals of the Entomolocial Society of America*, 65(4):906–911, 1972.

[576] N. A. Kormilev. On Mezira granulata (Say) group (Hemiptera: Aradidae). *Journal of Natural History*, 16(5):775–779, 1982.

[577] R. L. Ridgway and G. G. Gyrisco. Effect of temperature on the rate of development of Lygus lineolaris (Hemiptera: Miridae). *Annals of the Entomolocial Society of America*, 53(5):691–694, 1960.

[578] P. H. Slaymaker and N. P. Tugwell. Low-labor method for rearing the tarnished plant bug (Hemiptera: Miridae). *Journal of Economic Entomology*, 75(3):487–488, 1982.

[579] R.-T. Ju, L. Gao, X.-H. Zhou, and B. Li. Tolerance to high temperatures in an invasive lace bug, Corythucha ciliata (Hemiptera: Tingidae) in subtropical China. *PLoS ONE*, 8(1):e54372, 2013.

[580] R.-T. Ju, H.-Y. Zhu, L. Gao, X.-H. Zhou, and B. Li. Increases in both temperature means and extremes likely facilitate invasive herbivore outbreaks. *Scientific Reports*, 5(15715), 2015.

[581] C. D. Butler and R. J. O'Neil. Life history characteristic of Orius insidiosus (Say) fed Aphis glycines Matsumura. *Biological Control*, 40(3):333–338, 2007.

[582] C. D. Butler and R. J. O'Neil. Life history characteristics of Orius insidiosus (Say) fed diets of soybean aphid, Aphis glycines Matumura and soybean thrips, Neohydatothrips variabilis (Beach). *Biological Control*, 40(3):339–346, 2007.

[583] A. Supatashvili, N. Goginashvili, and M. Kereselidze. Distribution and some biological data of sycamore lace bug - Corythucha ciliata Say (Heteroptera, Tingidae) in Georgia. *Annals of Agrarian Science*, 14(2):42–45, 2016.

[584] D. J. Isenhour and K. V. Yeargan. Effect of temperature on the development of Orius insidiosus, with notes on laboratory rearing. *Annals of the Entomolocial Society of America*, 74(1):114–116, 1981.

[585] A. Kolb, G. R. Needham, K. M. Neyman, and W. A. High. Bedbugs. *Dermatologic Therapy*, 22:347–352, 2009.

[586] A. M. Hagerty and J. E. McPherson. Life history and laboratory rearing of Arilus cristatus (Heteroptera: Reduviidae) in Southern Illinois. *The Florida Entomologist*, 83(1):58–63, 2000.

[587] P. A. Readio. Studies on the biology of the Reduviidae of America north of Mexico. *Kansas University Science Bulletin*, 17(1):1–291, 1927.

[588] W. V. Balduf. Life history of Phymata pennsylvanica americana Melin (Phymatidae, Hemiptera). *Annals of the Entomolgiocal Society of America*, 34(1):204–214, 1941.

[589] B. G. Svensson, B. Tallmark, and E. Petersson. Habitat heterogeneity, coexistence and habitat utilization in five backswimmer species (Notonecta spp.; Hemiptera, Notonectidae). *Aquatic Insects*, 22(2):81–98, 2000.

[590] L. M. Sættem. The life history of Apheloceirus aestivalis Fabricius (Hemiptera) in Norway. *Archiv für Hydrobiologie*, 106(2):245–250, 1986.

[591] H. Kaneda and Y. Yoshiyasu. Effects of temperature on the development and survival of the creeping water bug Ilycoris cimicoides exclamationis (Scott) (Hemiptera: Naucoridae). *Proceedings of the Entomological Society of Washington*, 109(3):689–695, 2007.

[592] L. N. Brown and J. E. McPherson. Life history and laboratory rearing of Gelastocoris oculatus oculatus (Fabricus) (Hemiptera: Gelastocoridae) with descriptions of immature stages. *Proceedings of the Entomological Society of Washington*, 96(3):516–526, 1994.

[593] J. R. de la Torre Bueno. Life-histories of North American water bugs: II. Life-history of Ranatra quadridentata, Stal. *The Canadian Entomologist*, 38(7):242–252, 1906.

[594] S. S. Balling and V. H. Resh. Life history variability in the water boatman, Trichorixa reticulata (Hemiptera: Corixidae), in San Francisco Bay salt marsh ponds. *Annals of the Entomolocial Society of America*, 77(1):14–19, 1984.

[595] L. J. Kelts. Ecology of a tidal marsh corixid, Trichocorixa verticalis (Insecta, Hemiptera). *Hydrobiologia*, 64(1):37–57, 1979.

[596] R. B. Aiken and N. Malatestinic. Life history, gonad state, and changes in functional sex ratio in the salt-marsh waterboatman, Trichocorixa verticalis (Fieber) (Heteroptera: Corixidae). *Canadian Journal of Zoology*, 73(3):552–556, 1995.

[597] V. Céspedes, C. Coccia, J. A. Carbonell, M. I. Sánchez, and A. J. Green. The life cycle of the alien boatman Trichocorixa verticalis (Hemiptera, Corixidae) in saline and hypersaline wetlands of south-west Spain. *Hydrobiologia*, 827(1):309–324, 2019.

[598] C. J. Banks. The absorption of water by the eggs of Corixa punctata Illig. (Hemiptera-Corixidae) under experimental conditions. *Journal of Experimental Biology*, 26(2):131–136, 1949.

[599] M. Kishi, T. Harada, and K. Fujisaki. Responses of life-history traits of brackish- and freshwater populations of the water strider to NaCl Aquarius paludum (Hemiptera: Gerridae). *European Journal of Entomology*, 106(1):43–48, 2009.

[600] L. Cheng and C. H. Fernando. Life history and biology of the riffle bug Rhagovelia obesa Uhler (Heteroptera: Veliidae) in Southern Ontatio. *Canadian Journal of Zoology*, 49(4):435–442, 1971.

[601] A. M. Murray and P. S. Giller. Life history and overwintering tactics of Velia caprai Tam. (Hemiptera: Veliidae) in Southern Ireland. *Aquatic Insects*, 13(4):229–243, 1991.

[602] D. L. Wood and J. E. McPherson. Life history and laboratory rearing of Hydrometra hungerfordi Torre-Bueno (Heteroptera: Hydrometridae) with descriptions of immature stages. *Proceedings of the Entomological Society of Washington*, 97(3):717–728, 1995.

[603] I. B. Sprague. The biology and morphology of Hydrometra martini Kirkaldy. *The University of Kansas Science Bulletin*, 38(1):579–660, 1956.

[604] S. J. Taylor and J. E. McPherson. Comparison of two population sampling methods used in field life history studies of Mesovelia mulsanti (Heteroptera: Gerromorpha: Mesoveliidae) in southern Illinois. *The Great Lakes Entomologist*, 33(3):223–230, 2000.

[605] C. A. Lanciani. Rearing immature Mesovelia mulsanti (Hemiptera: Mesoveliidae) on a substratum of duckweed. *The Florida Entomologist*, 70(2):286–288, 1987.

[606] J. D. Lattin. Life history of Ceratocombus vagans (Hemiptera: Heteroptera: Ceratocombidae) with notes on the immature stages. *The Great Lakes Entomologist*, 33(2):131–139, 2000.

[607] R. Sergel. On the occurrence and ecology of the rhododendron-leafhopper, Graphocephala fennahi Young 1997, in the western Palaearctic region (Homoptera, Cicadellidae). *Anzeiger für Schädlingskunde Pflanzenschutz Umweltschutz*, 60(7):134–136, 1987.

[608] G. D. Hoffman, D. B. Hogg, and G. M. Boush. Potato leafhopper (Homoptera: Cicadellidae) life history traits on water-stressed alfalfa in the early stage regrowth and bud stage. *Environmental Entomology*, 20(4):1058–1066, 1991.

[609] D. B. Hogg. Potato leafhopper (Homoptera: Cicadellidae) immature development, life tables and population dynamics under fluctuating temperature regimes. *Environmental Entomology*, 14(3):349–355, 1985.

[610] G. A. Van Nieuwenhove, E. A. Frías, and E. G. Virla. Effects of temperature on the development, performance and fitness of the corn leafhopper Dalbulus maidis (DeLong) (Hemiptera: Cicadellidae): implications on its distribution under climate change. *Agricultural and Forest Entomology*, 18(1):1–10, 2016.

[611] B. C. Pass and J. K. Reed. Biology and control of the spittlebug Prosapia bicincta in coastal bermuda grass. *Journal of Economic Entomology*, 58(2):275–278, 1965.

[612] S. W. Wilson and J. E. McPherson. Life histories of Acanalonia bivittata and A. conica with descriptions of immature stages. *Annals of the Entomological Society of America*, 74(3):289–298, 1981.

[613] S. W. Wilson and J. E. McPherson. Life histories of Anormenis septentrionalis, Metcalfa pruinosa, and Ormenoides venusta with descriptions of immature stages. *Annals of the Entomological Society of America*, 74(3):299–311, 1981.

[614] S. W. Wilson and J. E. McPherson. Descriptions of the immature stages of Bruchomorpha oculata with notes on laboratory rearing. *Annals of the Entomolocial Society of America*, 74(4):341–344, 1981.

[615] O. Krstić, T. Cvrković, M. Mitrović, I. Toševski, and J. Jović. Dictyophara europea (Hemiptera: Fulgomorpha: Dictyophaidae): description of immatures, biology and host plant associations. *Bulletin of Entomological Research*, 106(3):395–405, 2016.

[616] K. R. McPherson and S. W. Wilson. Life history and descriptions of immatures of the dictyopharid planthopper Phylloscelis pallescens (Homoptera: Fulgoroidea). *Journal of the New York Entomological Society*, 103(2):170–179, 1995.

[617] S. H. Bae and M. D. Pathak. Life history of Nilaparvata lugens (Homoptera: Delphacidae) and susceptibility of rice varieties to its attacks. *Annals of the Entomolocial Society of America*, 63(1):149–155, 1970.

[618] D. Burckhardt, E. Bochud, J. Damgaard, G. W. Gibbs, V. Hartung, M.-C. Larivière, D. Wyniger, and I. Zürcher. A review of the moss bug genus Xenophyes (Hemiptera: Coleorrhyncha: Peloridiidae) from New Zealand: systematics and biogeography. *Zootaxa*, (2923):1–26, 2011.

[619] D. Burckhardt. Taxonomy and phylogeny of the Gondwanan moss bugs or Peloridiidae (Hemiptera, Coleorrhyncha). *Deutsche Entomologische Zeitschrift*, 56(2):173–235, 2009.

[620] O. Campolo, A. Malacrinò, F. Laudani, V. Maione, L. Zappalá, and V. Palmeri. Population dynamics and temperature-dependent development of Chrysomphalus aonidum (L.) to aid sustainable pest management decisions. *Neotropical Entomology*, 43(5):453–464, 2014.

[621] Ö. Özyurt and S. Ülgentürk. Biology of euonymus scale Unaspis euonymi (Hemiptera: Diaspididae) in urban areas of Ankara, Turkey. *Tarim Bilimleri Dergisi*, 13(1):47–53, 2007.

[622] M. Savopoulou-Soultani. Laboratory rearing of euonymus scale (Homoptera: Diaspididae) at different temperatures. *Journal of Economic Entomology*, 90(4):955–960, 1997.

[623] M. Savopoulou-Soultani. Seasonal development and distribution of Unaspis euonymi (Comstock) on Euonymus japonica L. shrubs. *Anzeiger für Schädlingskunde Pflanzenschutz Umweltschutz*, 69(5):103–105, 1996.

[624] J. A. Palafox-Luna, E. Rodríguez-Leyva, J. R. Lomeli-Flores, A. L. Vigueras-Guzmán, and J. M. Vanegas-Rico. Ciclo de vida y fecundidad de Dactylopius opuntiae (Hemiptera: Dactylopiidae) en Opuntia ficus-indica (Caryophyllales: Cactaceae). *Agrociencia*, 52(1):103–114, 2018.

[625] V. C. Moran and B. S. Cobby. On the life-history and fecundity of the cochineal insect, Dactylopius austrinus De Lotto (Homoptera: Dactylopiidae), a biological control agent for the cactus Opuntia aurantiaca. *Bulletin of Entomological Research*, 69(4):629–636, 1979.

[626] J. B. Torres and J. A. Giorgi. Management of the false carmine cochineal Dactylopius opuntiae (Cockerell): perspective from Pernambuco state, Brazil. *Phytoparasitica*, 46(3):331–340, 2018.

[627] G. M. d. C. Pérez Guerra. *Biosystematics of the family Dactylopiidae (Homoptera: Coccinea) with emphasis on the life cycle of Dactylopius coccus Costa*. Thesis, Virginia Polytechnic Institute and State University, 1991.

[628] A. Cocco, A. Mura, E. Muscas, and A. Lentini. Comparative development and reproduction of Planococcus ficus and Planococcus citri (Hemiptera: Pseudococcidae) on grapevine under field conditions. *Agricultural and Forest Entomology*, 20(1):104–112, 2018.

[629] S. Goldasteh, A. A. Talebi, Y. Fathipour, H. Ostovan, A. A. Zamani, and R. V. Shoushtari. Effect of temperature on life history and population growth parameters of Planococcus citri (Homoptera, Pseudococcidae) on coelus [Solenostemon scutellarioidea (L.) Codd.]. *Archives of Biological Sciences*, 61(2):329–336, 2009.

[630] N. Tofangsazi, K. Kherdamnd, S. Shahrokhi, and A. A. Talebi. Temperature-dependent life history of Schizaphis graminum on barley. *Bulletin of Insectology*, 63(1):79–84, 2010.

[631] T. M. Blackburn. *Comparative and experimental studes of aninal life histories*. Thesis, University of Oxford, 1990.

[632] M. A. Jervis and P. N. Ferns. Towards a general perspective on life-history evolution and diversification in parasitoid wasps. *Biological Journal of the Linnean Society*, 104(2):443–461, 2011.

[633] R. E. Traynor. *Life history evolution in the parasitoid Hymenoptera*. Thesis, University of York, 2004.

[634] I. Yates, Harry O. and D. R. Smith. History, distribution, damage and life cycle of a pine shoot gall sawfly, Xyela gallocaulis (Hymenoptera: Xyelidae). *Journal of Entomological Science*, 44(3):276–283, 2009.

[635] A. Shinohara, Y. Kameda, S.-I. Ibuki, T. Kitoshi, T. Kakuda, and H. Kojima. Pamphilius ishikawi feeds on Astilbe: the first record of Pamphiliidae (Hymenoptera) associated with Saxifragacae. *Zootaxa*, (4098), 2016.

[636] C. Asaro and D. C. Allen. Biology of pine false webworm (Hymenoptera: Pamphiliidae) during an outbreak. *The Canadian Entomologist*, 131(6):729–742, 1999.

[637] K. Maetô and K. Ozaki. Two-year life cycle of the red-headed spruce web-spinning sawfly, Cephalcia isshikii. *Applied Entomology and Zoology*, 28(4):557–568, 1993.

[638] A. Battisti. Bionomics of the spruce web-spinning sawfly Cephalcia arvensis Panzer (Hym., Pamphiliidae) in northeastern Italy. *Journal of Applied Entomology*, 115(1):52–61, 1993.

[639] B. Pieronek. On the morphology, biology and behaviour of the larval Pamphilius vafer (Linnaeus) (Hymenoptera: Pamphiliidae). *Zeitschrift fur Angewandte Entomologie*, 87(3):255–261, 2009.

[640] D. C. Eidt. The life histories, distribution, and immature forms of the North American sawflies of the genus Cephalicia (Hymenoptera: Pamphiliidae). *Memoirs of the Entomological Society of Canada*, 101(S59):5–56, 1969.

[641] D. C. Eidt. The life history of a web-spinning sawfly of spruce, Cephalcia fascipennis (Cresson) (Hymenoptera: Pamphiliidae). *The Canadian Entomologist*, 97(2):148–153, 1965.

[642] H. Bolu. Distribution, life history and biology of almond sawfly (Cimbex quadrimaculata (Müller, 1766), Hymenoptera: Cimbicidae). *Scientific Papers: Series A: Agronomy*, 59:219–222, 2016.

[643] V. Harizanova, A. Stoeva, and B. G. Rector. Host range testing and biology of Abia sericea (Cimbicidae), a candidate for biological control of invasive teasels (Dipsacus spp.) in North America. *Journal of Hymenoptera Research*, 28:1–11, 2012.

[644] D. J. Greathead. The larvae and notes on the life history of Corynis similis (Mocsáry) (Hymenoptera: Cimbicidae). *Journal of Natural History*, 12(1):107–111, 1978.

[645] P. E. Hanson. Biology of Janus rufiventris (Hymenoptera: Cephidae). *Annals of the Entomological Society of America*, 79(3):488–490, 1986.

[646] B. L. Beres, L. M. Dosdall, D. K. Weaver, H. A. Cárcamo, and D. M. Spaner. Biology and integrated management of wheat stem sawfly and the need for continuing research. *The Canadian Entomologist*, 143(2):105–125, 2011.

[647] P. Altesor, A. González, and S. Schmidt. First report of Tequus schrottkyi (Konow) (Hymenoptera: Pergidae) in Uraguy, and information about its host plant and biology. *Biodiversity Data Journal*, 4:e7538, 2016.

[648] A. I. A. Pereira, D. R. Smith, J. C. Zanuncio, and J. E. Serrão. Life history notes on the sawfly Haplostegus nigricrus Conde (Hymenoptera: Pergidae) on Psidium guajava (Myrtaceae) in Minas Gerais State, Brazil. *Proceedings of the Entomological Society of Washington*, 111(4):795–806, 2009.

[649] D. W. Burrows and J. K. Balciunas. Biology, distribution and host-range of the sawfly, Lophyrotoma zonalis (Hym., Pergidae), a potential biological control agent for the paperbark tree, Melaleuca quinquenervia. *Entomophaga*, 42(3):299–313, 1997.

[650] J. H. Pedrosa-Macedo. Biology and behavior of the strawberry guava sawfly, Haplostegus epimelas Konow 1901 (Hymenoptera: Pergidae), in Southern Brazil. *Proceedings of the Entomological Society of Washington*, 102(1):129–134, 2000.

[651] S. D. Hight, I. Horiuchi, M. D. Vitorino, C. Wikler, and J. H. Pedrosa-Macedo. Biology, host specificity tests, and risk assessment of the sawfly Heteroperreyia hubrichi, a potential biological control agent of Schinus terebinthifolius in Hawaii. *BioControl*, 48(4):461–476, 2003.

[652] K. Mahmood and M. Ullah. Additions to the knowledge of taxonomy and biology of Arge simlaensis (Cameron) (Argidae: Hymenoptera) in rain fed conditions of Punjab (Pakistan). *Pakistan Journal of Zoology*, 43(4):821–823, 2011.

[653] L. S. Kimsey and D. R. Smith. Two new species, larval descriptions, and life history notes of some Panamanian sawflies (Hymenoptera: Agridae, Tenthredinidae). *Proceedings of the Entomological Society of Washington*, 87(1):191–201, 1985.

[654] K. A. Regas-Williams and D. H. Habeck. Life history of a poison-ivy sawfly Arge humeralis (Beauvois) (Hymenoptera: Agridae). *The Florida Entomologist*, 62(4):356–363, 1979.

[655] M. Kawasaki, M. Fujita, A. Sakurai, and K. Mateo. Trimodal adult emergence in summer generations of the rose sawfly Arge nigrinodosa (Hymenoptera, Agridae). *Journal of Hymenoptera Research*, 25:1–14, 2012.

[656] D. M. Firake, G. T. Behere, P. D. Firake, D. J. Rajkhoa, N. S. Azad Thakur, M. S. Saini, Z. Rahmann, and S. V. Ngachan. Arge xanthogaster (Hymenoptera: Agridae): a new threat to rose plants in Meghalaya, India. *The Florida Entomologist*, 96(4):1298–1304, 2013.

[657] C. van Achterberg and R. Desmier de Chenon. The first report of the biology of Proterops borneoensis Szépligeti (Hymenoptera: Braconidae: Ichneutinae), with description of a new species form China. *Journal of Natural History*, 43(11):619–633, 2009.

[658] G. C. Becker and D. M. Benjamin. The biology of Neodiprion nigroscutum (Hymenoptera: Diprionidae) in Wisconsin. *The Canadian Entomologist*, 99(2):146–159, 1967.

[659] R. C. Wilkinson, G. C. Becker, and D. M. Benjamin. The biology of Neodiprion rugifrons (Hymenoptera: Diprionidae), a sawfly infesting jack pine in Wisconsin. *Annals of the Entomological Society of America*, 59(4):786–792, 1966.

[660] A. Rauf and D. M. Benjamin. The biology of the white-pine sawfly, Neodiprion pinetum (Hymenoptera, Diprionidae) in Wisconsin. *The Great Lakes Entomologist*, 13(4):219–224, 1980.

[661] R. A. Beaver and D. Laosunthorn. Biology and control of pine sawfly, Nesodiprion biremis (Konow) (Hymenoptera, Diprionidae), in northern Thailand. *Bulletin of Entomological Research*, 65(1):117–128, 1975.

[662] M. R. Wagner, D. G. McCullough, and J. M. Di Matteo. Life history of Neodiprion fulviceps (Cresson), a ponderosa pine feeding sawfly (Hymenoptera: Diprionidae). *Proceedings of the Entomological Society of Washington*, 88(2):221–226, 1986.

[663] W. M. Ciesla. Observations on the life history and habits of a pine sawfly, Neodiprion nanulus contortae (Hymenoptera: Diprionidae). *Annals of the Entomological Society of America*, 69(3):391–394, 1976.

[664] M. J. Lombardero, M. P. Ayres, F. E. Krivak-Tetley, and K. N. E. Fitza. Population biology of the european woodwasp, Sirex noctilio, in Galicia, Spain. *Bulletin of Entomological Research*, 106(5):569–580, 2016.

[665] A. D. Liston. Aspects of the biology of Euura amerinae (Linnaeus) (Hymenoptera, Tenthredinidae). *Zeitschrift fur Angewandte Entomologie*, 94(1):56–61, 2009.

[666] M. Sawa, A. Fukunaga, T. Naito, and K. Oishi. Studies on the sawfly, Athalia rosae (Insecta, Hymenoptera, Tenthredinidae). I. General Biology. *Zoological Science*, 6(3):541–547, 1989.

[667] O. H. Lindquist and M. J. Thomson. The biology of a birch leaf miner, Messa nana (Hymenoptera: Tenthredinidae), new to Canada. *The Canadian Entomologist*, 102(1):108–111, 1970.

[668] G. L. Nordin and E. L. Johnson. Biology of Caliroa quercuscoccineae (Dyar) (Hymenoptera: Tenthredinidae) in central Kentucky II. Development and behavior. *Journal of the Kansas Entomological Society*, 57(4):569–579, 1984.

[669] O. H. Lindquist. Notes on the biology of the oak leaf-mining sawfly, Profenusa lucifex (Hymenoptera: Tenthredinidae) in Ontario. *The Canadian Entomologist*, 105(1):127–128, 197.

[670] G. M. Rahoo and M. L. Luff. The biology of Adelognathus granulatus Perkins (Hym., Ichneumonidae) a parasitoid of the small gooseberry sawfly, Pristiphora pallipes (Lep.) (Hym., Tenthredinidae). *Journal of Applied Entomology*, 104(5):480–484, 1987.

[671] G. L. Nordin and E. L. Johnson. Biology of Caliroa quercuscoccinae (Dyar) (Hymenoptera: Tenthredinidae) in central Kentucky I. Observations on the taxonomy of principal life stages. *Journal of the Kansas Entomological Society*, 56(3):305–314, 1983.

[672] J. Macek. Descriptions and key to larvae of central European Dineura (Hymenoptera: Symphyta: Tenthredinidae). *Acta Entomologica Musei Nationalis Pragae*, 55(2):787–796, 2015.

[673] P. A. Mackay and W. G. Wellington. Notes on the life history and habits of the red-backed sawfly, Eriocampa ovata (Hymenoptera: Tenthredinidae). *The Canadian Entomologist*, 109(1):53–58, 1977.

[674] K. Beneš. The life history and juvenile stages of Rhadinoceraea bensoni Beneš (Hymenoptera, Tenthredinidae). *Acta Entomologica Bohemoslovaca*, 70(1):49–54, 1973.

[675] G. A. Labonte and L. J. Lipovsky. Life history of a red oak leaf-mining sawfly, Profenusa alumna MacGillivray (Hymenoptera: Tenthredinidae). *Journal of Economic Entomology*, 77(2):350–356, 1984.

[676] P. W. Price and T. P. Craig. Life history, phenology, and survivorship of a stem-galling sawfly, Euura lasiolepis (Hymenoptera: Tenthredinidae), on Arroyo Willow, Salix lasiolepis, in northern Arizona. *Annals of the Entomological Society of America*, 77(6):712–719, 1984.

[677] J. Macek. Descriptions of larvae of Birka annulitarsis and B. cinereipes (Hymenoptera: Symphyta: Tenthredinidae). *Acta Entomologica Musei Nationalis Pragae*, 53(2):815–819, 2013.

[678] J. Macek. Descriptions of larvae of the central European Eutomostethus species (Hymenoptera: Symphyta: Tenthredinidae). *Acta Entomologica Musei Nationalis Pragae*, 54(2):685–692, 2014.

[679] H. Hara and A. Shinohara. A slug sawfly, Caliroa matsumotonis (Hymenoptera: Tenthredinidae), injurious to peach and pear trees in Japan and Korea. *Applied Entomology and Zoology*, 48(3):379–386, 2013.

[680] J. L. Avila-Núñez, L. D. Otero, S. Silmi, and M. P. Calcagno-Pisarelli. Life history of Aneugmenus merida Smith (Hymenoptera: Tenthredinidae) in the Venezuelan Andes. *Neotropical Entomology*, 36(1):22–27, 2007.

[681] Ö. Çalmasur and H. Özbek. A willow sawfly, Nematus salicis (Linnaeus) (Hymenoptera: Tenthredinidae), a new record and new pest of Salix spp. in Turkey. *Proceedings of the Entomological Society of Washington*, 108(1):139–144, 2006.

[682] K. Beneš and M. Abai. A new species of Croesus injurious to birch in Iran (Hymenoptera, Tenthredinidae). *Acta Entomologica Bohemoslovaca*, 88(3):253–263, 1991.

[683] Ö. Çalmasur and H. Özbek. Heterarthrus ochropoda (Klug) (Hymenoptera: Tenthredinidae), a new record and new pest of Populus spp. (Salicaceae) in Turkey. *Proceedings of the Entomological Society of Washington*, 106(3):717–721, 2004.

[684] S. A. Astapenko and A. V. Gurov. Bioecological characters of the sawfly Pristiphora subarctica (Hymenoptera, Tenthredinidae) in spruce plantations of Krasnoyarsk territory. *Entomological Review*, 96(1):85–91, 2016.

[685] L. A. Malagón-Aldana, F. Serna, and D. R. Smith. On the natural history of the willow sawfly Nematus oligospilus (Hymenoptera, Tenthredinidae) inhabiting Salix humboldtiana, in Colombia. *Journal of Hymenoptera Research*, 55:189–199, 2017.

[686] S. M. Blank, H. Hara, J. Mikulás, G. Csóka, C. Ciornei, R. Constantineanu, I. Constantineanu, L. Roller, E. Altenhofer, T. Huflejt, and G. Vétek. Aproceros leucopoda (Hymenoptera: Argidae): an east Asian pest of elms (Ulmus spp.) invading Europe. *European Journal of Entomology*, 107(3):357–367, 2010.

[687] A. Mathieu, Y. Dumont, F. Chiroleu, P.-F. Duyck, O. Flores, G. Lebreton, B. Reynaud, and S. Quilici. Predicting the altitudinal distribution of an introduced phytophageous insect against an invasive alien plant from laboratory controlled experiments: case of Cibdela janthina (Hymenoptera: Argidae) and Rubus alceifolius (Rosaceae) in La Réunion. *BioControl*, 59(4):461–471, 2014.

[688] D. Boraschi, R. C. Preuquetti, and M. A. Del Lama. Biologia, comportamento social e alocação sexual de Digelasinus diversipes (Kirby, 1882) (Hymenoptera, Argidae). *Revista Brasileira de Entomologia*, 49(2):253–263, 2005.

[689] Y.-G. Zhao and B.-Z. Hua. Morphology and immature stages of Arge pagana (Panzer, 1798) (Hymenoptera: Argidae) with notes on its biology. *Journal of Asia-Pacific Entomology*, 19(4):903–909, 2016.

[690] W. M. Ciesla. Observations on the life history and habits of a tropical sawfly, Sericoceros mexicanus (Kirby), (Hymenoptera: Argidae) on Roatan Island, Honduras. *Forestry Chronicle*, 78(4):515–521, 2002.

[691] V. Papp, M. Ladányi, and G. Vétek. Temperature-dependent development of Aproceros leucopoda (Hymenoptera: Argidae), an invasive pest of elms in Europe. *Journal of Applied Entomology*, 142(6):589–597, 2008.

[692] A. D. Liston, G. Goergen, and F. Koch. The immature stages and biology of Xenapates species in West Africa (Hymenoptera, Tenthredinidae). *Deutsche Entomologische Zeitschrift*, 62(1):9–17, 2015.

[693] D. R. Smith, P. D. Pratt, and J. Makinson. Studies on the Asian sawflies of Formosempria Takeuchi (Hymenoptera, Tenthredinidae), with notes on the suitability of F. varipes Takeuchi as a biological control agent for skunk vine, Paederia foetida L. (Rubiaceae) in Florida. *Journal of Hymenoptera Research*, 39:1–15, 2014.

[694] E. G. Paterson Fox, S. Bressan-Nascimento, and R. Eizemberg. Notes on the biology and behaviour of the jewel wasp, Ampulex compressa (Fabricius, 1781) (Hymenoptera; Ampulicidae), in the laboratory, including first record of gregarious reproduction. *Entomological News*, 120(4):430–437, 2009.

[695] W. Gnatzy, W. Volknandt, and A. Dzwoneck. Egg-laying behavior and morphological and chemical characterization of egg surface and egg attachment glue of the digger wasp Ampulex compressa (Hymenoptera, Ampulicidae). *Arthropod Stucture & Development*, 47(1):74–81, 2018.

[696] J. G. Rozen and S. M. Kamel. Hospicidal behvaior of the cleptoparasitic wasp Sapyga luteomaculata and investigation into ontogenetic changes in its larval anatomy (Hymenoptera: Vespoidea: Sapygidae). *American Museum Novitates*, (3644):1–24, 2009.

[697] M. Palmer. Notes on the biology of Pterombrus piceus Krombein (Hymenoptera: Tiphidae). *Proceedings of the Entomological Society of Washington*, 78(3):369–375, 1976.

[698] M. E. Rogers and D. A. Potter. Biology of Tiphia pygidialis (Hymenoptera: Tiphiidae), a parasitoid of masked chafer (Coleoptera: Scarabaeidae) grubs, with notes on the seasonal occurrence of Tiphia vernalis in Kentucky. *Environmental Entomology*, 33(3):520–527, 2004.

[699] R. C. Berberet and T. J. Helms. Notes on the biology of Tiphia berbereti (Hymenoptera: Tiphiidae), a parasite of larval Phyllophaga anaxia. *Annals of the Entomological Society of America*, 63(2):471–473, 1970.

[700] W. Celary. The ground-nesting solitary bee, Dasypoda thoracica Baer, 1853 (Hymenoptera: Apoidea: Melittidae) and its life history. *Folia Biologica (Kraków)*, 50(3):191–198, 2002.

[701] W. Celary. A comparative study on the biology of Macropis fulvipes (Fabricius, 1804) and Macropis europaea Warncke, 1973 (Hymenoptera: Apoidea: Melittidae). *Folia Biologica (Kraków)*, 52(1):81–85, 2004.

[702] W. Celary. Biology of the solitary ground-nesting bee Melitta leporina (Panzer, 1799) (Hymenoptera: Apoidea: Melittidae). *Journal of the Kansas Entomological Society*, 79(2):136–145, 2006.

[703] J. Rozen, Jerome G. Hesperapis rhodocerata: behavioral biology, egg, and larval instars, including behavioral and larval comparisons with H. larreae (Hymenoptera: Melittidae: Dasypodainae). *American Museum Novitates*, (3856):1–18, 2016.

[704] G. S. Farrell and T. R. New. Some aspects of the biology of the eucalypt-mining sawfly Phylacteophaga froggatti Riek (Hymenoptera: Pergidae). *Australian Journal of Zoology*, 28(1):83–90, 1980.

[705] R. E. Fye. The biology of Vespidae, Pompilidae, and Sphecidae (Hymenoptera) from trap nests in northwestern Ontario. *The Canadian Entomologist*, 97(7):716–744, 1965.

[706] J. T. Medler and T. W. Koerber. Biology of Dipogon sayi Banks (Hymenoptera, Pompilidae) in trap-nests in Wisconsin. *Annals of the Entomological Society of America*, 50(6):621–625, 1957.

[707] D. T. Gwynne. Nesting biology of the spider wasps (Hymenoptera: Pompilidae) which prey on burrowing wolf spiders (Araneae: Lycosidae: Geolycosa). *Journal of Natural History*, 13(6):681–692, 1979.

[708] F. Punzo. Studies on the natural history, ecology, and behavior of Pepsis ceberus and P. mexicana (Hymenoptera: Pompilidae) from Big Bend National Park, Texas. *Journal of the New York Entomological Society*, 113(2):84–95, 2005.

[709] T. H. Auko, R. Silvestre, and J. P. Pitts. Nest camouflage in the spider wasp Priochilus captivum (Fabricius, 1804) (Hymenoptera: Pompilidae), with notes on the biology. *Tropical Zoology*, 26(3):140–144, 2013.

[710] P. F. Torchio. The nesting biology of Hylaeus bisinuatus Forster and development of its immature forms (Hymenoptera: Colletidae). *Journal of the Kansas Entomological Society*, 57(2):276–297, 1984.

[711] P. F. Torchio, G. E. Trostle, and D. J. Burdick. The nesting biology of Colletes kincaidii Cockerell (Hymenoptera: Colletidae) and development of its immature forms. *Annals of the Entomological Society of America*, 81(4):605–625, 1988.

[712] P. F. Torchio and D. J. Burdick. Comparative notes on the biology and development of Epeolus compactus Cresson, a celptoparasite of Colletes kincaidii Cockerell (Hymenoptera: Anthophoridae, Colletidae). *Annals of the Entomological Society of America*, 81(4):626–636, 1988.

[713] L. C. Sarzetti, J. F. Genise, M. V. Sánchez, J. L. Farina, and M. A. Molina. Nesting behavior and ecological preferences of five Diphaglossinae species (Hymenoptera, Apoidea, Colletidae) from Argentina and Chile. *Journal of Hymenoptera Research*, 33:63–82, 2013.

[714] R. W. Matthews. Nesting biology of the stem-nesting wasp Psenulus interstitialis Cameron (Hymenoptera: Crabronidae: Pemphredoninae) on Magnetic Island, Queensland. *Australian Journal of Entomology*, 39(1):25–28, 2000.

[715] J. L. Carrillo and L. E. Caltagirone. Observations on the biology of Solierella peckhami, S. blaisdelli (Sphecidae), and two species of Chrysididae (Hymenoptera). *Annals of the Entomological Society of America*, 63(3):672–681, 1970.

[716] C. F. Barrett, P. H. Westdal, and H. P. Richardson. Biology of Pachygonatopus minimus Fenton (Hymenoptera: Dryinidae) a parasite of the six-spotted leafhopper, Macrosteles fascifrons (Stål), in Manitoba. *The Canadian Entomologist*, 97(2):216–221, 1965.

[717] N. Waloff. Biology and behaviour of some species of Dryinidae (Hymenoptera). *Journal of Entomology Series A - Physiology & Behaviour*, 49(7):97–109, 1974.

[718] M. A. Jervis. Life history studies on Aphelopus species (Hymenoptera, Dryinidae) and Chalarus species (Diptera, Pipunculidae), primary parasites of typhlocybine leafhoppers (Homoptera, Cicadellidae). *Journal of Natural History*, 14(6):769–780, 1980.

[719] A. Guglielmino and C. Bückle. Description of larval instars of Neodryinus typhlocybae (Ashmead, 1893) (Hymenoptera Dryinidae), with remarks on its biology. *Deutsche Entomologische Zeitschrift*, 50(1):143–150, 2003.

[720] J. Rozen, Jerome G. Biology notes on the bee Andrena accepta Viereck (Hymenoptera, Andrenidae). *Journal of the New York Entomological Society*, 81(1):54–61, 1973.

[721] M. D. Johnson. Observations on the biology of Andrena (Melandrena) dunningi Cockerell (Hymenoptera: Andrenidae). *Journal of the Kansas Entomological Society*, 54(1):32–40, 1981.

[722] B. Bennett and M. D. Breed. The nesting biology, mating behavior, and foraging ecology of Perdita opuntiae (Hymenoptera: Andrenidae). *Journal of the Kansas Entomological Society*, 58(2):185–194, 1985.

[723] R. W. Rust. Biology of Nomadopsis larreae (Hymenoptera: Andrenidae) with an analysis of yearly appearance. *Annals of the Entomological Society of America*, 81(1):99–104, 1988.

[724] E. A. Osgood. Biology of Andrena crataegi Robertson (Hymenoptera: Andrenidae), a communally nesting bee. *Journal of the New York Entomological Society*, 97(1):56–64, 1989.

[725] E. R. Miliczky, D. F. Mayer, and J. D. Lunden. Notes on the nesting biology of Andrena (Melandrena) nivalis Smith (Hymenoptera: Andrenidae). *Journal of the Kansas Entomological Society*, 63(1):166–174, 1990.

[726] B. N. Danforth. Female foraging and intranest behavior of a communal bee, Perdita portalis (Hymenoptera: Andrenidae). *Annals of the Entomological Society of America*, 84(5):537–548, 1991.

[727] R. C. Plowright and B. A. Pendrel. Larval growth in bumble bees (Hymenoptera: Apidae). *The Canadian Entomologist*, 109:967–973, 1977.

[728] M. Ghara and R. M. Borges. Comparative life-history traits in a fig wasp community: implications for community structure. *Ecological Entomology*, 35(2):139–148, 2010.

[729] D. Carman. Biology of the Trigonalyidae (Hymenoptera), with notes on the vespine parasitoid Bareogonalos canadensis. *New Zealand Journal of Zoology*, 18(2):209–214, 1991.

[730] C. P. Clausen. Biological studies on Poecliogonalos thwaitesii (Westw.), parasitic in the cocoons of Henicospilus (Hymen: Trigonalidae). *Proceedings of the Entomological Society of Washington*, 31(4):67–79, 1929.

[731] Y. S. Yeo, Y. D. Chang, and H. G. Goh. A morphological observation of an egg parasitoid, Anagrus incarnatus Haliday (Hymenoptera: Mymaridae), of the rice planthoppers. *Korean Journal of Applied Entomology*, 29(1):1–5, 1990.

[732] D. Rosen and A. Eliraz. Biological and systematic studies of developmental stages in Aphytis (Hymenoptera: Aphelinidae): I. Development history of Aphytis chilensis Howard. *Hilgardia*, 46(3):77–95, 1978.

[733] D. D. Wilson and R. L. Ridgway. Morphology, development, and behavior of the immature stages of the parasitoid, Campoletis sonorensis (Hymenoptera: Ichneumonidae). *Annals of the Entomological Society of America*, 68(2):191–196, 1975.

[734] P. J. Gerard. Biology and morphology of immature stages of Centrodora scolylbopae (Hymenoptera: Aphelinidae). *New Zealand Entomologist*, 12(1):24–29, 1989.

[735] X. Espadaler and S. Rey. Biological constraints and colony founding in the polygynous invasive ant Lasius neglectus (Hymenoptera, Formicidae). *Insectes Sociaux*, 48:159–164, 2001.

[736] V. E. Kipyatkov, E. B. Lopatina, A. A. Imamgaliev, and L. A. Shirokova. Effect of temperature on rearing of the first brood by the founder females of the ant Lasius niger (Hymenoptera, Formicidae): latitude-dependent variability of the response norm. *Journal of Evolutionary Biochemistry and Physiology*, 40(2):165–175, 2004.

[737] S. Abril, J. Oliveras, and C. Gómez. Effect of temperature on the development and survival of the Argentine ant, Linepithema humile. *Journal of Insect Science*, 10(1):97, 2010.

[738] A. C. R. Andrade-Silva and F. S. Nascimento. Multifemale nests and social behavior in Euglossa melanotricha (Hymenoptera, Apidae, Euglossini). *Journal of Hymenoptera Research*, 26:1–6, 2012.

[739] H. Ali, A. S. Alquarni, M. Shebl, and M. S. Engel. Notes on the nesting biology of the small carpenter bee Ceratina smaragdula (Hymenoptera: Apidae) in northwestern Pakistan. *Florida Entomologist*, 99(1):89–93, 2016.

[740] J. Bosch and W. P. Kemp. Development and emergence of the orchard pollinator Osmia lignaria (Hymenoptera: Megachilidae). *Environmental Entomology*, 29(1):8–13, 2000.

[741] J. Woyke. Comparison of the size of eggs from Apis mellifera L queens and laying workers. *Apidologie*, 25:179–187, 1994.

[742] A. M. Collins. Variation in time of egg hatch by the honey bee, Apis mellifera (Hymenoptera: Apidae). *Annals of the Entomological Society of America*, 97(1):140–146, 2004.

[743] H. Rembold, J.-P. Kremer, and G. Ulrich. Characterization of postembryonic developmental stages of the female castes of the honey bee, Apis mellifera L. *Apidologie*, 11(1):29–38, 1980.

[744] J. Page, Robert E. and C. Y.-S. Peng. Aging and development in social insects with empahsis on the honey bee, Apis mellifera L. *Experimental Gerontology*, 36:695–711, 2001.

[745] R. W. Matthews, K. G. Ross, and R. A. Morse. Comparative development of four species of yellowjackets (Hymenoptera: Vespidae) reared under identical conditions. *Annals of the Entomological Society of America*, 75(2):123–129, 1982.

[746] J. Cnaani, R. Schmid-Hempel, and J. O. Schmit. Colony development, larval development and worker reproduction in Bombus impatiens Cresson. *Insectes Sociaux*, 49:164–170, 2002.

[747] S. P. Lawson, S. L. Helmreich, and S. M. Rehan. Effects of nutritional deprivation on development and behavior of the subsocial bee Ceratina calcarata (Hymenoptera: Xylocopinae). *Journal of Experimental Biology*, 220(23):4456–4462, 2017.

[748] M. L. T. Buschini and L. L. Wolff. Nesting biology of Centris (Hemisiella) tarasta Smith in southern Brazil (Hymenoptera, Apidae, Centridini). *Brazilian Journal of Biology*, 66(4):1091–1101, 2006.

[749] H. E. Evans. Ethological studies on digger wasps of the genus Astata (Hymenoptera, Sphecidae). *Journal of the New York Entomological Society*, 65(3/4):159–185, 1957.

[750] S. M. Rehan and M. H. Richards. Nesting biology and subsociality in Ceratina calcarata (Hymenoptera: Apidae). *The Canadian Entomologist*, 142(1):65–74, 2010.

[751] F. X. Williams. Two new species of Astatinae, with notes on the habits of the group. *Proceedings of the Hawaiian Entomological Society*, 12:641–650, 1946.

[752] R. J. Paxton. Profile of a solitary bee: Andrena fulva. *Bee World*, 72(1):11–18, 1991.

[753] N. N. Youssef and G. E. Bohart. The nesting habits and immature stages of Andrena (Thysandrena) candida Smith (Hymenoptera, Apoidea). *Journal of the Kansas Entomological Society*, 41(4):442–455, 1968.

[754] S. Vicidomini. Biology of Xylocopa violacea (Hymenoptera): in-nest ethology. *Italian Journal of Zoology*, 63:237–242, 1996.

[755] B. E. Wickman. Life history of the incense-cedar wood wasp, Syntexis libocedrii (Hymenoptera: Syntexidae). *Annals of the Entomological Society of America*, 60(6):1291–1295, 1967.

[756] H. O. Lund. Studies on longevity and productivity in Trichogramma evanescens. *Journal of Agricultural Research*, 56:421–439, 1938.

[757] A. Schrempf, J. Heinze, and S. Cremer. Sexual cooperation: mating increases longevity in ant queens. *Current Biology*, 15:267–270, 2005.

[758] J. G. Rozen. Immatures of exomalopsine bees with notes on nesting biology and a tribal key to mature larvae of noncorbiculate, nonparasitic Apinae (Hymenoptera: Apidae). *American Museum Novitates*, (3726):1–52, 2011.

[759] C. P. Haskins. Note on the natural longevity of fertile females of Aphaenogaster picea. *Journal of the New York Entomological Society*, 68(2):66–67, 1960.

[760] C. P. Haskins and E. F. Haskins. Notes on female and worker survivorship in the archaic ant genus Myrmecia. *Insectes Sociaux*, 27(4):345–350, 1980.

[761] B. Hölldobler and N. F. Carlin. Colony founding, queen dominance and oligogyny in the Australian meat ant Iridomyrmex purpureus. *Behavioral Ecology and Sociobiology*, 18(1):45–58, 1985.

[762] A. Mintzer. Colony foundation and pleometrosis in Camponotus (Hymenoptera: Formicidae). *The Pan-Pacific Entomologist*, 55(2):81–89, 1979.

[763] V. C. S. Chang. Colony revival, and notes on rearing and life history of the big-headed ant. *Proceedings of the Hawaiian Entomological Society*, 25:53–58, 1985.

[764] A. A. Zamani, A. Talebi, Y. Fathipour, and V. Baniameri. Effect of temperature on life history of Aphidius colemani and Aphidius matricariae (Hymenoptera: Braconidae), two parasitoids of Aphis gossypii and Myzus persicae (Homoptera: Aphididae). *Environmental Entomology*, 36(2):263–271, 2007.

[765] S. D. Porter. Impact of temperature on colony growth and development rates of the ant, Solenopsis invicta. *Journal of Insect Physiology*, 34(12):1127–1133, 1988.

[766] P. Calabi and S. D. Porter. Worker longevity in the fire ant Solenopsis invicta: ergonomic considerations of correlations between temperature, size and metabolic rates. *Journal of Insect Physiology*, 35(8):643–649, 1989.

[767] S. S. Verza, R. M. Mussury, R. S. Camargo, A. P. P. Andrade, and L. C. Forti. Oviposition, life cycle, and longevity of the leaf-cutting ant Acromyrmex rugosus rugosus. *Insects*, 8(80), 2017.

[768] R. J. Southon, E. F. Bell, P. Graystock, and S. Sumner. Long live the wasp: adult longevity in captive colonies of the eusocial paper wasp Polistes canadensis (L.). *PeerJ*, 3:e843, 2015.

[769] K. V. Krombein. Life history notes on some Egyptian solitary wasps and bees and their associates (Hymenoptera: Aculeata). *Smithsonian Contributions to Zoology*, 19:1–18, 1969.

[770] U. Bernardo, G. Viggiani, and R. Sasso. Biological parameters of Thripobius semiluteus Bouček (Hym., Eulophidae), a larval endoparasitoid of Heliothrips haemorrhoidalis (Bouché) (Thysan., Thripidae). *Journal of Applied Entomology*, 129(5):250–257, 2005.

[771] D. Russ Solis, E. Gonçalves Paterson Fox, M. Lanzoni Rossi, T. De Carvalho Moretti, and O. Correa Bueno. Description of the immature of workers of the ant Camponotus vittatus (Hymenoptera: Formicidae). *The Florida Entomologist*, 93(2):265–276, 2010.

[772] AntWeb. https://www.antweb.org/, 2010. California Academy of Science.

[773] P. Eeles. http://www.ukbutterflies.co.uk/, 2020.

[774] P. M. Tuskes and N. J. Smith. The life history and behavior of Epimartyria pardella (Micropterigidae). *Journal of the Lepidopterists' Society*, 38(1):40–46, 1984.

[775] J. R. Grehan. Life cycle of the wood-borer Aenetus virescens (Lepidoptera: Hepilaidae). *New Zealand Journal of Zoology*, 14(2):209–217, 1987.

[776] R. J. Elder. Notes on the biology and descriptions of the life stages of Oncopera parva Tindale (Lepidoptera: Hepialidae). *Journal of the Australian Entomological Society*, 71(1):5–11, 1978.

[777] X.-H. Yang, Y.-H. Yu, Y.-J. Wu, J.-L. Qun, and Y.-Q. Luo. First report of Endoclita signifer (Lepidoptera: Hepialidae) as a new pest on Eucalyptus. *Journal of Economic Entomology*, 106(2):866–873, 2013.

[778] R. J. Hardy. The biology and pest status of Oxycanus fuscomaculatus Walker (Lepidoptera: Hepialidae) in Tasmania. *Journal of the Australian Entomological Society*, 13(4):317–328, 1974.

[779] J. R. Grehan, A. Moeed, and M. J. Meads. Observations on Trioxycanus enysii (Butler) (sensu Meyrick, 1890) (Lepidoptera: Hepialidae) on Kapiti Island, New Zealand, with a description of larval chaetotaxy. *New Zealand Entomologist*, 7(4):408–413, 1983.

[780] J. E. Rawlins. Life history and systematics of the west Andesan moth Aucula franclemonti with description of a new species from Ecuador. *Journal of the New York Entomological Society*, 100(2):286–310, 1992.

[781] M. A. Jervis, C. A. Boggs, and P. N. Ferns. Egg maturation strategy and its associated trade-offs: a synthesis focusing on Lepidoptera. *Ecological Entomology*, 30(4):359–375, 2005.

[782] B. V. Ngowi, H. E. Z. Tonnang, E. M. Mwangi, T. Johansson, J. Ambale, P. N. Ndegwa, and S. Subramanian. Temperature-dependent phenology of Plutella xylostella (Lepidoptera: Plutellidae): simulation and visualization of current and future distributions along the eastern afromontane. *PLoS ONE*, 12(3):e0173590, 2017.

[783] C. R. Philips, Z. Fu, T. P. Kuhar, A. M. Shelton, and R. J. Cordero. Natural history, ecology, and management of the diamondback moth (Lepidoptera: Plutellidae) with emphasis on the United States. *Journal of Integrated Pest Management*, 5(3):D1–D11, 2014.

[784] S. I. Rondon. The potato tuberworm: a literature review of its biology, ecology and control. *American Journal of Potato Research*, 87(2):149–166, 2010.

[785] R. R. Scott and R. A. Harrison. The biology and life history of currant clearing, Synanthedon tipuliformis (Lepidoptera: Sesiidae), in Canterbury. *New Zealand Journal of Zoology*, 6(1):145–163, 1979.

[786] G. I. Gilbertson. The plumb tree borer: its distribution, life history, economic importance and control. *Bulletins of the South Dakota State Agricultural Experiment Station*, 228:1–22, 1934.

[787] J. J. Turgeon. Life cycle and behavior of the spruce budmoth, Zeiraphera canadensis (Lepidoptera: Olethreutidae), in New Brunswick. *The Canadian Entomologist*, 117(10):1239–1247, 1985.

[788] J. J. Turgeon. Reproductive biology of the spruce budmoth, Zeiraphera canadenis Mut. & Free. (Lepidoptera: Torticidae: Olethreutinae), in New Brunswick. *The Canadian Entomologist*, 119(4):361–364, 1987.

[789] H. D. Burges and K. P. F. Haskins. Life-cycle of the tropical warehouse moth, Cadra cautella (Wlk.), at controlled temperatures and humidities. *Bulletin of Entomological Research*, 55(4):775–789, 1965.

[790] M. Husain, W. S. Alwaneen, K. Mehmood, K. G. Rasool, M. Tufail, and A. S. Aldawood. Biological traits of Cadra cautella (Lepidoptera: Pyralidae) reared on Khodari date fruits under different temperature regimes. *Journal of Economic Entomology*, 110(4):1923–1928, 2017.

[791] P. Tarlack, F. Mehrkhou, and M. Mousavi. Life history and fecundity rate of Ephestia kuehniella (Lepidoptera: Pyralidae) on different wheat flour varieties. *Archives of Phytopathology and Plant Protection*, 48(1):95–103, 2015.

[792] H. O. Marsh. Note on the life cycle of the sugar-beet webworm. *Journal of Economic Entomology*, 10(6):543–544, 1917.

[793] G. E. Woodroffe. A life history study of the brown house moth, Hofmannophila pseudospretella (Staint.) (Lep., Oecophoridae). *Bulletin of Entomological Research*, 41(3):529–553, 1951.

[794] J. Coelho, A., J. M. Milanez, R. de Andrade Morel, C. G. B. Demétrio, and J. R. P. Parra. Selection of an artificial diet for laboratory rearing of Opogona sacchari (Lepidoptera: Tineidae) (Bojer, 1856). *Neotropical Entomology*, 47(2):199–204, 2018.

[795] D. R. Davis and J. E. Peña. Biology and morphology of the banana moth, Opogona sacchari (Bojer), and its introduction into Flordia (Lepidoptera: Tineidae). *Proceedings of the Entomological Society of Washington*, 92(4):592–618, 1990.

[796] P. D. Cox and D. B. Pinniger. Biology, behaviour and environmentally sustainable control of Tineola bisselliella (Hummel) (Lepidoptera: Tineidae). *Journal of Stored Products Research*, 43(1):2–32, 2005.

[797] M. O. Ashamo. Life history studies of the yam moth, Dasyses rugosella Stainton (Lepidoptera: Tineidae). *Journal of Stored Products Research*, 42(3):302–312, 2006.

[798] J. Beck and K. Fiedler. Adult life spans of butterflies (Lepidoptera: Papilionidea + Hesperioidea): broadscale contingencies with adult and larval traits in multi-species comparisons. *Biological Journal of the Linnean Society*, 96(1):166–184, 2009.

[799] D. L. Silhacek and G. L. Miller. Growth and development of the Indian meal moth, Plodia interpunctella (Lepidoptera: Phycitidae), under laboratory mass-rearing conditions. *Annals of the Entomolocial Society of America*, 65(5):1084–1087, 1972.

[800] F. N. Vukajlović and S. B. Pešić. Contribution to the studies of the indianmeal moth Plodia interpunctella Hbn. (Lepidoptera: Pyralidae) fecundity depending on diet type. *Kragujevac Journal of Science*, 34:107–115, 2012.

[801] J. Allotey and L. Goswami. Comparative biology of two Phycitid moths, Plodia interpunctella (Hubn.) and Ephestia cautella (Wlk.) on some selected food media. *Insect Science and Its Application*, 11(2):209–215, 1990.

[802] H. H. Cheng. Observations on the bionomics of the dark-sided cutworm, Euxoa messoria (Lepidoptera: Noctuidae), in Ontario. *The Canadian Entomologist*, 105(2):311–322, 1973.

[803] R. E. Fye and W. C. McAda. Laboratory studies on the development, longevity, and fecundity of six Lepidopterous pests of cotton in Arizona. *Bulletins of the Arizona Agricultural Experiment Station*, (1454):1–73, 1972.

[804] H. H. Neunzig. The eggs and early-instar larvae of Heliothis zea and Heliothis virescens (Lepidoptera: Noctuidae). *Annals of the Entomolocial Society of America*, 57(1):98–102, 1964.

[805] A. Sourakov and T. C. Emmel. Notes on the life history of Anetia jaegeri from Hispaniola (Lepidoptera: Nymphalidae: Danainae). *Tropical Lepidoptera*, 7(2):155–159, 1996.

[806] O. O. Uyi, C. Zachariades, and M. P. Hill. The life history traits of the arctiine moth Parauchaetes insulata, a biological control agent of Chromolaena odorata in South Africa. *African Entomology*, 22(3):611–624, 2014.

[807] K. J. Lowey, A. L. Flansburg, K. Grenis, M. K. Kjeldgaard, J. MaCarty, L. Montesano, J. Vernick, and S. M. Murphy. Life history traits and rearing techniques for fall webworms (Hyphantria cunea Drury) in Colorado. *Journal of the Lepidopterists' Society*, 67(3):196–205, 2013.

[808] T. Gomi and M. Takeda. Changes in life-history traits in the fall webworm within half a century of introduction to Japan. *Functional Ecology*, 10(3):384–389, 1996.

[809] I. N. Bolotov, A. G. Tatarinov, B. V. Filippov, M. Y. Gofarov, A. V. Kondakov, O. I. Kulakova, G. S. Potapov, N. A. Zubryi, and V. M. Spitsyn. The distribution and biology of Pararctica subnebulosa (Dyar, 1899) (Lepidoptera: Erebidae: Arctiinae), the largest tiger moth species in the high arctic. *Polar Biology*, 38(6):905–911, 2015.

[810] Y.-M. Vázquez, A.-M. Martínez, J.-M. Valdez, J.-I. Figueroa, Á. Rebollar, J. M. Chavarrieta, J.-A. Sánchez, E. Viñuela, and S. Pineda. Life history, diagnosis, and parasitoids of Zale phaeograpta (Lepidoptera: Erebidae). *Annals of the Entomolocial Society of America*, 107(1):170–177, 2014.

[811] T. M. Leong. Final instar caterpillar and metamorphosis of Achaea janata (Linneaus, 1758) in Singapore (Lepidoptera: Erebidae: Erebinae). *Nature in Singapore*, 3:297–303, 2010.

[812] V. B. Yawad. *Effect of fenitrothion [O, O-dimethyl-O-(3 methyl-4-nitrophenyl) Phosphorothioata] on the physiology of the castor semilooper Achaea janata (L).* Thesis, Karnatak University, 1986.

[813] C. S. Oda and R. F. L. Mau. Description and life cycle of the monkeypod-kiawe caterpillar, Melipotis indomita Walker (Lepidoptera: Noctuidae). *Proceedings of the Hawaiian Entomological Society*, 21(3):435–441, 1974.

[814] J. P. Cuda, C. J. DeLoach, and T. O. Robbins. Population dynamics of Melipotis indomita (Lepidoptera: Noctuidae), an indigenous natural enemy of mesquite, Prosopis spp. *Environmental Entomology*, 19(2):415–422, 1990.

[815] H. B. P. E. Gernaat, J. Van Den Heuvel, F. Barten, and T. Van Andel. Lecotype designation and life history of Histioea cepheus cepheus (Erebidae: Arctiinae) in Suriname. *Journal of the Lepidopterists' Society*, 72(3):192–202, 2018.

[816] J. L. Snyder, G. S. Powell, R. S. Behring, A. M. Alford, M. E. Mccarty, and J. M. Zaspel. Distribution, phenology, and notes on the life history of Calyptra canadensis (Bethune) (Erebidae: Calpinae). *Journal of the Lepidopterists' Society*, 70(4):253–259, 2016.

[817] T. D. Schowalter. Biology and management of the whitemarked tussock moth (Lepidoptera: Erebidae). *Journal of Integrated Pest Management*, 9(1):1–8, 2018.

[818] J. M. Pinzón-García, L. M. Hernández-Fuentes, G. Luna-Esquivel, N. Isiordia-Aquino, and M. Ortiz-Catón. Biología y hábitos de Gonodonta pyrgo Cramer en Annona muricata. *Southewestern Entomologist*, 41(1):251–258, 2016.

[819] M. K. Rust and M. W. Dryden. The biology, ecology, and management of the cat flea. *Annual Review of Entomology*, 42(1):451–473, 1997.

[820] J. Silverman, M. K. Rust, and D. A. Reierson. Influence of temperature and humidity on survival and development of the cat flea, Ctenocephalides felis (Siphonaptera: Pulicidae). *Journal of Medical Entomology*, 18(1):78–83, 1981.

[821] M. W. Dryden. Host association, on-host longevity and egg production of Ctenocephalides felis felis. *Veterinary Parasitology*, 34(1):117–122, 1989.

[822] N. Nagy, E. Abari, J. D'Haese, C. Calheiros, J. Heukelbach, N. Mencke, H. Feldmeier, and H. Mehlhorn. Investigations on the life cycle and morphology of Tunga penetrans in Brazil. *Parasitology Research*, 101(Supplement 2):233–242, 2007.

[823] B. D. Cooke. Notes on the life-history of the rabbit flea Ceanopsylla laptevi iberia Beaucournu & Marquez, 1987 (Siphonaptera: Ceratophyliidae) in Eastern Spain. *Parasite - Journal de la Societe Francaise de Parasitologie*, 6(4):347–354, 1999.

[824] B. D. Cooke and M. A. Skewes. The effects of temperature and humidity on the survival and development of the european rabbit flea, Spilopsyllus cuniculi (Dale). *Australian Journal of Zoology*, 36:649–659, 1988.

[825] B. D. Cooke. Notes on the comparative reproductive biology and the laboratory breeding of the rabbit flea Xenopsylla cunicularis Smit (Siphonaptera, Pulicidae). *Australian Journal of Zoology*, 38(5):527–534, 1990.

[826] D. Kiefer, E. M. Warburton, I. S. Khokhlova, and B. R. Krasnov. Reproductive consequences of female size in haematophageous ectoparasites. *Journal of Experimental Biology*, 219:2368–2376, 2016.

[827] N. Waloff. The life history and descriptions of Halictophagus silwoodensis sp. n. (Strepsiptera) and its host Ulopa reticulata (Cicadellidae) in Britain. *Systematic Entomology*, 6(1):103–113, 1981.

[828] G. Pritchard and T. G. Leischner. The life history and feeding habits of Sialis cornuta Ross in a series of abandoned beaver bonds (Insecta; Megaloptera). *Canadian Journal of Zoology*, 51(2):121–131, 1973.

[829] F. Hayashi. Life history variation in a dobsonfly, Protohermes grandis (Megaloptera: Corydalidae): effects of prey availability and temperature. *Freshwater Biology*, 19(2):205–216, 1988.

[830] F. Hayashi. Intra- and interspecific variation in body size of Protohermes (Megaloptera: Corydalidae). *Ecological Research*, 7(2):171–178, 1992.

[831] D. C. Tarter, W. D. Watkins, and M. L. Little. Life history of the fishfly, Nigronia fasciatus (Megaloptera: Corydalidae). *Psyche*, 82(1):81–88, 1975.

[832] K. M. Azam. *Life history and production studies of Sialis californica Banks and Sialis rotunda Banks (Megaloptera: Sialidae).* Thesis, Oregon State University, 1969.

[833] G. W. Byers. The life history of Panorpa nuptialis (Mecoptera: Panorpidae). *Annals of the Entomological Society of America*, 56(2):142–149, 1963.

[834] K. W. Cooper. Sexual biology, chromosomes, development, life histories and parasites of Boreus, especially of B. notoperates. A southern Californian Boreus II. (Mecoptera: Boreidae). *Psyche*, 81(1):84–120, 1974.

[835] L. K. Russell. The life history of Caurinus dectes Russell, with a description of the immature stages (Mecoptera: Boreidae). *Insect Systematics & Evolution*, 13(2):225–235, 1982.

[836] L. R. Setty. *Biology and morphology of Bittacus stigmaterus (Mecoptera, Bittacusidae)*. Thesis, University of Kansas, 1930.

[837] G. A. Currie. Some notes on the biology and morphology of the immature stages of Harbobittacus tillyardi (Order Mecoptera). *Proceedings of the Linnean Society of New South Wales*, 57:116–122, 1932.

[838] R. S. Woglum and E. A. McGregor. Observations on the life history and morphology of Agulla bractea Carpenter (Neuroptera: Raphidiodea: Raphidiidae). *Annals of the Entomological Society of America*, 51(2):129–141, 1958.

[839] R. S. Woglum and E. A. McGregor. Observations on the life history and morphology of Agulla astuta (Banks) (Neuroptera: Raphidiodea: Raphidiidae). *Annals of the Entomological Society of America*, 52(5):489–502, 1959.

[840] Y. Nakase and M. Kato. Life history and host utilization pattern of a strepsipteran parasite (Insecta: Strepsiptera) on the Blissine bugs (Hemiptera: Lygaeidae) living under dwarf bamboo leaf sheaths. *Journal of Natural History*, 45(17):1089–1099, 2011.

[841] T. W. Kirkpatrick. Studies on the ecology of coffee plantations in East Africa. II. The autecology of Antestia spp. (Pentatomidae) with a particular account of a strepsipterous parasite. *Transactions of the Royal Entomological Society of London*, 86(14):247–343, 1937.

[842] M. J. Cotton. The life history of the hen flea, Ceratophyllus gallinae (Schrank) (Siphonaptera, Ceratophyllidae). *Entomologist*, 103(1281):45–48, 1970.

[843] M. J. Cotton. The reproductive biology of Ctenophthalmus nobilis (Rothchild) (Siphonaptera). *Proceedings of the Royal Entomological Society of London Series A: General Entomology*, 45(10):141–148, 1970.

[844] C. S. Henry. Eggs and rapagula of Ululodes and Ascaloptynx (Neuroptera: Ascalaphidae): a comparative study. *Psyche*, 79(1):1–22, 1972.

[845] C. S. Henry. The behavior and life histories of two North American ascalaphids. *Annals of the Entomological Society of America*, 70(2):179–195, 1977.

[846] C. A. Tauber and M. J. Tauber. Lomayia latipennis (Neuroptera: Berothidae) life history and larval descriptions. *The Canadian Entomologist*, 100(6):623–629, 1968.

[847] C. A. Toschi. Observations on Lomamyia latipennis, with a description of the first instar larva. *The Pan-Pacific Entomologist*, 40(1):21–26, 1964.

[848] L. R. Minter. *A comparison of the eggs and first-instar larvae of Mucroberotha vesicaria Tjeder with those of other species in the families Berothidae and Mantispidae (Insecta: Neuroptera)*. Advances in Neuropterology. Proceedings of the Third International Symposium on Neuropterology. Berg en Dal, Kruger National Park, South Africa, 1990.

[849] R. C. Froeschner. Notes and keys to the Neuroptera of Missouri. *Annals of the Entomological Society of America*, 40:123–136, 1947.

[850] J. A. Garland and B. D. Marshall. Confirmation of Ululodes quadrimaculata in Canada (Neuroptera: Ascalaphidae). *The Canadian Entomologist*, 112:637–683, 1980.

[851] C. S. Henry. Some aspects of the external morphology of larval owlflies (Neuroptera: Ascalaphidae), with particular reference to Ululodes and Ascaloptynx. *Psyche*, 83(1):1–31, 1976.

[852] B. Tjeder. The Ascalaphidae of the Afrotropical Region (Neuroptera). 1. External morphology and bionomics of the family Ascalaphidae, and taxonomy of the subfamily Haplogleniinae including the tribes Proctolyrini n. tribe, Melambrotini n. tribe, Campylophlebini n. tribe, Tmesibasini n. tribe, Allocormodini n. tribe, and Ululomyiini n. tribe of Ascalaphidae. *Entomologica Scandinavica, Supplement*, 41:3–169, 1992.

[853] B. Tjeder. The genus Murcoberotha Tjed. and its systematic position (Neuroptera). *Entomologisk Tidskrift*, 89:3–18, 1968.

[854] T. R. New. The egg and first instar of Italochrysa insignis (Neuroptera, Chrysopidae). *Australian Entomological Magazine*, 10:29–32, 1983.

[855] A. D. MacGillivray. New species of Nothochrysa. *The Canadian Entomologist*, 26:169–171, 1894.

[856] E. Collyer. The seperation of Conwentzia pineticola End. from Conwentzia psociformis (Curt.), and notes on their biology. *Bulletin of Entomological Research*, 42(3):555–564, 1951.

[857] N. Banks. A revision of the nearctic Coniopterygidae. *Proceedings of the Entomological Society of Washington*, 8:77–86, 1906.

[858] J. H. Emerton. Cocoons and young of Coniopteryx vicina. *Psyche*, 13:74–75, 1906.

[859] M. Meinander. The larvae of two North American species of Coniopterygidae (Neuroptera). *Notulae Entomologicae*, 54:12–16, 1974.

[860] M. H. Muma. Biological notes on Coniopteryx vicina (Neuroptera: Coniopterygidae). *The Florida Entomologist*, 50:285–293, 1967.

[861] M. E. Badgley, C. A. Fleschner, and J. C. Hall. The biology of Spiloconis picticornis Banks (Neuroptera: Coniopterygidae). *Psyche*, 62:75–81, 1955.

[862] E. G. MacLeod and P. E. Spiegler. Notes on the larval habitat and developmental peculiarities of Nallachius americanus (McLachlan). *Proceedings of the Entomological Society of Washington*, 63(4):281–286, 1961.

[863] A. B. Gurney. Notes on the Dilaridæ and Berothidæ, with special reference to the immature stages of the nearctic genera (Neuroptera). *Psyche*, 54(3):145–169, 1947.

[864] P. Alayo Dalmau. Los Neurópteros de Cuba. *Poeyana*, 2:1–127, 1968.

[865] T. R. New. A revision of the Australian Hemerobiidae (Insecta: Neuroptera). *Invertebrate Taxonomy*, 2:339–411, 1988.

[866] E. Mjöberg. Svensk insektfauna: 8. Neuroptera. I. Första underordningen Planipennia. *Entomologisk Tidskrift*, 30:129–161, 1909.

[867] K. J. Morton and M. Standfuss. Life-history of Drepanepteryx phalaenoides, Linn. *Entomologist's Monthly Magazine*, 46:54–62, 1910.

[868] J. N. Belkin. Additional records of Oliarces clara in California and Arizona (Neuroptera, Ithonidae). *Bulletin of the Southern California Academy of Sciences*, 53(2):65–68, 1954.

[869] J. A. Davidson. Rearing Mantispa viridis Walker in the laboratory (Neuroptera, Mantispidae). *Entomological News, Philadelphia*, 80:29–31, 1969.

[870] C. E. Valerio. Parasitismo en huevos de araña Achaearanea tepidariorum (Koch) (Aranea: Theridiidae) en Costa Rica. *Revista de Biología Tropical*, 18(1):99–106, 1971.

[871] N. D. Penny. Neuroptera of the Amazon basin. Part 6. Mantispidae. *Acta Amazonica*, 12:415–463, 1982.

[872] H. Stitz. Mantispiden der Sammlung des Berliner Museums. *Mitteilungen aus dem Zoologischen Museum in Berlin*, 7(1):1–49, 1913.

[873] J. W. H. Rehn. Studies in North American Mantispidae. *Transactions of the American Entomological Society*, 65:237–263, 1939.

[874] M. J. Manski. Australian Neuroptera. *The Queensland Entomologist*, 13:114–115, 1948.

[875] H. W. van der Weele. Ascalaphiden. *Collections Zoologiques du Baron Edm. de Selys Longchamps, Catalouge Systématique et Descriptif*, 8:1–326, 1908.

[876] W. W. Froggatt. Notes on the Neuroptera and descriptions of new species. *Proceedings of the Linnean Society of New South Wales*, 29:671–676, 1904.

[877] V. J. Monseratt. Nuevos datos sobre algunas especies de Neompteridae y Crocidae (Inecta: Neuroptera). *Heteropterus Revista de Entomología*, 8(1):1–33, 2008.

[878] A. Satar, S. Canbulat, and C. Özbay. Rediscovery and redescription of Dielocroce ephemera (Gerstaecker, 1894) in Turkey (Insecta: Neuroptera). *Zoology in the Middle East*, 31:107–110, 2004.

[879] L. E. Koch. The genus Chasmoptera (Neuroptera: Nemopteridae), with a description of a new species from Wetern Australia. *Proceedings of the Royal Entomological Society of London Series B: Taxonomy*, 36(9):137–146, 1967.

[880] A. D. Imms. Contibutions to the knowledge and the structure and biology of some Indian insects — I. On the life-history of Croce filipennis, Westw. (Order Neuroptera, Fam. Hemerobiidae). *Transactions of the Linnean Society of London, Zoology*, 11:151–160, 1908.

[881] A. Satar and C. Özbay. Eggs, first instar larvae and distribution of the neuropterids Lertha extensa and L. sheppardi (Neuroptera: Nemopteridae) in south-eastern Turkey. *Zoology in the Middle East*, 32:91–96, 2004.

[882] L. Navás. Monografia de los Nemoptéridos (Insectos Neurópteros). *Memorias de al Real Academia de Ciencias y Artes de Barcelona*, 8:341–408, 1910.

[883] D. E. Kimmins and K. A. J. Wise. A record of Cryptoscenea australiensis (Enderlein) (Neuroptera: Coniopterygidae) in New Zealand, with a re-description of species. *Transactions of the Royal Society of New Zealand*, 2(4):35–39, 1962.

[884] S. J. Brooks and R. Lewington. *Field Guide to the Dragonflies and Damselflies of Great Britain and Ireland*. British Wildlife Publishing, Dorset, UK, revised edition edition, 2007.

[885] J. d'Aguilar, J. L. Dommanget, and R. Préchac. *A field guide to the dragonflies of Britain, Europe and North Africa*. Collins, London, UK, 1986.

[886] P. S. Corbet and S. J. Brooks. *Dragonflies*. Collins, London, UK, 2008.

[887] C. O. Hammond. *The dragonflies of Great Britain and Ireland*. Harley Books, Essex, UK, 1983.

[888] D. Powell. *A guide to the dragonflies of Great Britain*. Arlequin Press, Essex, UK, 1999.

[889] D. Smallshire and A. Swash. *Britain's Dragonflies: A field guide to the damselflies and dragonflies of Britain and Ireland*. WILDGuides, Old Basing, Hampshire, UK, 2010.

[890] C. Daguet, G. French, and P. Taylor. The Odonata Red List for Great Britain. Report, Joint Nature Conservation Committee, 2008.

[891] K.-D. B. Dijkstra and R. Lewington. *Field Guide to the Dragonflies of Britain and Europe*. British Wildlife Publishing, Gillingham, Dorset, UK, 2006.

[892] *British Red Data Books: 2. Insects*. Nature Conservancy Council, Peterborough, UK, 1987.

[893] S. Cham. *Zygoptera*, volume 2 of *Field guide to the larvae and exuviae of British Dragonflies*. British Dragonfly Society, Peterborough, UK, 2009.

[894] S. Cham. *Anisoptera*, volume 1 of *Field guide to the larvae and exuviae of British Dragonflies*. British Dragonfly Society, Peterborough, UK, 2007.

[895] R. Merritt, N. W. Moore, and B. C. Eversham. *Atlas of the dragonflies of Britain and Ireland*. Her Majesty's Stationary Office, London, UK, 1996.

[896] S. J. Brooks, 2013.

[897] P. S. Corbet, F. Suhling, and D. Soendgerath. Voltinism in Odonata: a review. *International Journal of Odonatology*, 9:1–44, 2006.

[898] F. Koch and F. Suhling. Do behavoiural abd life-history traits vary with mate-guarding intensity in libelluid odonates? *Canadian Journal of Zoology*, 83:1631–1637, 2005.

[899] F. Koch. Lifetime egg production of captive libellulis (Odonata). *International Journal of Odonatology*, 18(3):193–204, 2015.

[900] R. Weterings, C. Umponstira, and H. L. Buckley. Predation rates of mixed instar Odonata naiads feeding on Aedes aegypti and Armigeres moultoni (Diptera: Culicidae) larvae. *Journal of Asia-Pacific Entomology*, 18(1):1–8, 2015.

[901] W. B. Worthen and H. J. Horacek. The distribution of dragonfly larvae in a South Carolina stream: relationships with sediment type, body size, and the presence of other larvae. *Journal of Insect Science*, 15(31):1–7, 2015.

[902] O. M. Fincke. Female monogamy in the damselfly Ischnura verticalis Say (Zygoptera: Coenagrionidae). *Odonatologica*, 16(2):129–143, 1987.

[903] M. V. Nair. *Dragonflies & Damselflies of Orissa and Eastern India*. Orissa Wildlife Organisation, Bhubaneswar, Odisha, India, 2011.

[904] A. Begum, M. A. Bashar, and B. R. Biswas. Life history and external egg and larval morphology of Brachythemis contaminata (Fabricus) (Anisoptera: Libellulidae). *Odonatologica*, 11(2):89–97, 1982.

[905] R. Cammaerts. Taxonomic studies on African Gomphidae (Anisoptera) 1. Malgassogomphus robinsoni gen. nov., spec. nov. from Madagascar. *Odonatologica*, 16(4):335–346, 1987.

[906] P. L. Miller and A. K. Miller. Rates of oviposition and some other aspects of reproductive behaviour in Tholymis tillarga (Fabricius) in Kenya (Anisoptera: Libellulidae). *Odonatologica*, 14(4):287–299, 1985.

[907] V. E. McMillan. Variable mate-guarding behaviour in the dragonfly Plathemis lydia (Odonata: Libellulidae). *Animal Behaviour*, 41(6):979–987, 1991.

[908] J. Alcock. Post-copulatory mate guarding by males of the damselfly Hetaerina vulnerata Selys (Odonata: Calopterygidae). *Animal Behaviour*, 30(1):99–107, 1982.

[909] T. M. Latty. Flexible mate guarding tactics in the dragonfly Sympetrym internum (Odonata: Libellulidae). *Journal of Insect Behavior*, 19(4):469–477, 2006.

[910] T. Vattakaven, R. George, D. Balasubramanian, M. Réjou-Méchain, G. Muthusankar, B. Ramesh, and R. Prabhakar. India Biodiversity Portal: An integrated, interactive and participatory biodiversity informatics platform. *Biodiversity Data Journal*, 4:e10279, 2016.

[911] K. A. Subramanian. *Dragonflies of India: A Field Guide*. Indian Academy of Science, Bangalore, India, 2009.

[912] A. McGeeney. *A Complete Guide to British Dragonflies*. Jonathan Cape Ltd., London, UK, 1986.

[913] G. D. Powney, S. J. Brooks, L. J. Barwell, P. Bowles, R. N. L. Fitt, A. Pavitt, R. A. Spriggs, and N. J. Isaac. Morpohological and geographical traits of British Odonata. *Biodiversity Data Journal*, 2:e1041, 2014.

[914] C. Utzeri and R. Raffi. Observations on the behaviour of Aeshna affinis (Vander Linden) at a dried-up pond (Anisoptera: Aeshnidae). *Odonatologica*, 12(2):141–151, 1983.

[915] P. E. Lutz. Life-history studies on Lestes eurinus Say (Odonata). *Ecology*, 49(3):576–579, 1968.

[916] V. Beschovski. Odonata from the Bulgarian Black Sea Coast. *Bulletin de l'institute de zoologie et musée*, 15:115–129, 1964.

[917] S. Asahina. The Odonata of Iraq. *Japanese Journal of Zoology*, 17:17–36, 1973.

[918] H. Steinmann. *World Catalouge of Odonata I: Zygoptera*. Das Tierreich. Berlin, UK, de Gruyter, 1997.

[919] G. J. Van Pelt. On dragonflies of Greece in the RMNH collection. *Libellula*, 2(Supplement):77–90, 1999.

[920] A. Miroglu and V. Kartal. Additional notes on the Odonata fauna of Kurupelit (Samsun, Turkey). *Turkish Journal of Zoology*, 32:33–41, 2008.

[921] S. J. McCauley, C. J. Daivs, E. E. Werner, and M. S. R. II. Dispersal, niche breadth and population extinction: colonization ratios predict range size in North American dragonflies. *Journal of Animal Ecology*, 83(4):858–865, 2014.

[922] P. E. Lutz and A. Rogers. Thermal effects on embryonic development in four summer species of Libellulidae (Anisoptera). *Odonatologica*, 20(3):281–292, 1991.

[923] S. Miller. Odonata Measurements. https://eol.org/content_partners/814/resources/981, 2016.

[924] K. Schenk and D. Söndgerath. Influence of egg size differences within egg clutches on larval parameters in nine libellulid species (Odonata). *Ecological Entomology*, 30(4):456–463, 2005.

[925] F. Johansson and U. Norling. A five year study of the larval life history of Coenagrion hastulatum (Charpentier) and C. armatum (Charpentier) in northern Sweden (Zygoptera: Coenagrionidae). *Odonatologica*, 23(4):355–364, 1994.

[926] J. Van Buskirk. Competition, cannibalism, and size class dominance in a dragonfly. *Oikos*, 65(3):445–464, 1992.

[927] H. Ubukata. Life history and behavior of a Corduliid dragonfly Cordulia aenea amurensis Selys. Reproductive period with special reference to territoriality. *Journal of the Faculty of Science, Hokkaido University*, 19(4):812–833, 1975.

[928] Y. Ito. Temtorialism and Residentiality in a Dragonfly, Orthetrum albistylum speciosum Uhler (Odonata: Anisoptera). *Annals of the Entomological Society of America*, 53(6):851–853, 1960.

[929] British Dragonflies. https://british-dragonflies.org.uk/, 2020. British Dragonfly Society.

[930] G. E. Rehfeldt. Site-Specific Mate-Finding Strategies and Oviposition Behavior in Crocothemis erythraea (Brullé) (Odonata: Libellulidae). *Journal of Insect Behavior*, 4(3):293–303, 1991.

[931] P. Convey. Predation risks associated with mating and oviposition for female Crocothemis erythraea (Brullé) (Anisoptera: Libellulidae). *Odonatologica*, 21(3):343–350, 1992.

[932] R. R. Askew. *The Dragonflies of Europe*. Harley Books, Essex, UK, 1988.

[933] P.-C. Augesse. *Les odonates de l'Europe Occidentale, du Nord de l'Afrique et des Iles Atlantiques*, volume 4 of *Faune de l'Europe et du Bassin m'editerranéen*. Masson, Paris, France, 1968.

[934] D. Campbell. American Insects; Body Length. http://eol.org/collections/102567, 2013. Encyclopedia of Life.

[935] R. Gabb. Dragonfly Prime. http://dragonflyprime.co.uk/, 2020.

[936] T. D. Manolis. *Dragonflies and Damselflies of California*, volume 72 of *California Natural History Guides*. University of California Press, Berkeley, CA, 2003.

[937] All Odonata. http://www.allodonata.com/, 2019. All Odonata.

[938] Y. Takahashi and M. Kawata. Alternative trait combinations and secondary resource partitioning in sexually selected color polymorphism. *Ecology and Evolution*, 3(7):2038–2046, 2013.

[939] C. Schütte, P. Schridde, and F. Suhling. Life history patterns of Onychogomphus uncatus (Charpentier) (Anisoptera: Gomphidae). *Odonatologica*, 27(1):71–86, 1998.

[940] J. Waringer. A study on embryonic development and larval growth of Sympetrum danae (Sulzer) at two artificial ponds in lower Austria (Anisoptera: Libellulidae). *Odonatologica*, 12(4):331–343, 1983.

[941] K. Koch. Lifetime egg production of captive libelluids (Odonata). *International Journal of Odonatology*, 18(3):193–204, 2015.

[942] J. Silsby. Dragonflies at four very different South African sites (Anisoptera). *Notulae Odonatologicae*, 3(4):62–63, 1989.

[943] A. Córdoba-Aguilar. *Dragonflies and Damselflies: Model organisms for ecological and evolutionary research*. Oxford, UK, Oxford University Press, 2008.

[944] K. R. Hopper, P. H. Crowley, and D. Kielman. Density dependence, hatching synchrony, and within-cohort cannibalism in young dragonfly larvae. *Ecology*, 77(1):191–200, 1996.

[945] S. Bennett and P. J. Mill. Lifetime egg production and egg mortality in the damselfly Pyrrhosoma nymphula (Sulzer) (Zygoptera: Coenagrionidae). *Hydrobiologia*, 310(1):71–78, 1995.

[946] O. M. Fincke. Underwater oviposition in a damselfly (Odonata: Coenagrionidae) favors male vigilance, and multiple mating by females. *Behavioral Ecology and Sociobiology*, 18(6):405–412, 1986.

[947] F. Johansson and F. Suhling. Behaviour and growth of dragonfly larvae along a permanent to temporary water habitat gradient. *Ecological Entomology*, 29(2):196–202, 2004.

[948] J. A. Day. Environmental correlates of aquatic faunal distribution in the Namib desert. *Transvaal Museum Monograph*, 7:99–107, 1990.

[949] M. T. Siva-Jothy, D. W. Gibbons, and D. Pain. Female oviposition-site preference and egg hatching success in the damselfly Calopteryx splendens xanthostoma. *Behavioral Ecology and Sociobiology*, 37(1):39–44, 1995.

[950] N. Michiels and A. A. Dhondt. Direct and indirect estimates of sperm precedence and displacement in the dragonfly Sympetrum danae (Odonata: Libellulidae). *Behavioral Ecology and Sociobiology*, 23:257–263, 1988.

[951] G. Sahlén and F. Suhling. Relationships between egg size and clutch size among European species of Sympetrinae (Odonata: Libellulidae). *International Journal of Odonatology*, 5(2):181–191, 2002.

[952] M. J. Banks and D. J. Thompson. Lifetime mating success in the damselfly Coenagrion puella. *Animal Behaviour*, 33(4):1175–1183, 1985.

[953] R. Khelifa, R. Zebsa, A. Kahalerras, and H. Mahdjoub. Clutch size and egg production in Orthetrum nitidinerve Selys, 1841 (Anisoptera: Libellulidae): effect of body size and age. *International Journal of Odonatology*, 15(2):51–58, 2012.

[954] M. T. Siva-Jothy. Variation in copulation duration and the resultant degree of sperm removal in Orthetrum cancellatum (L.) (Libellulidae: Odonata). *Behavioral Ecology and Sociobiology*, 20:147–151, 1987.

[955] K. Schenk, F. Suhling, and A. Martens. Egg distribution, mate-guarding intensity and offspring characteristics in dragonflies (Odonata). *Animal Behaviour*, 68(3):599–606, 2004.

[956] P. L. Miller. The duration of copulation correlates with other aspects of mating behaviour in Orthetrum chrysostigma (Burmeister) (Anisoptera: Libellulidae). *Odonatologica*, 12(3):227–238, 1983.

[957] F. Suhling and O. Müller. *Die Flußjungfern Europas*. Neue Brehm-Bücheri. Westarp-Wissenschaften, Magdeburg, Germany, 1996.

[958] S. W. Dunkle. *Dragonflies through Binoculars: A field guide to the dragonflies of North America*. Oxford University Press, New York, NY, 2000.

[959] J. Ware, M. Karlsson, G. Sahlén, and K. Koch. Evolution of reproductive strategies in libellulid dragonflies (Odonata: Anisoptera). *Organisms Diversity & Evolution*, 12(3):313–323, 2012.

[960] J. W. H. Trueman. Egg chorionic structures in Corduliidae and Libellulidae (Anisoptera). *Odonatologica*, 20(4):411–452, 1991.

[961] K. Reinhardt. Reproductive behaviour of Leucorrhinia albifrons (Burmeister) in a non-territorial situation (Anisoptera: Libellulidae). *Odonatologica*, 27(2):201–211, 1998.

[962] A. T. Hassan. Reproductive behaviour of Acisoma panorpoides inflatum Selys (Anisoptera: Libellulidae). *Odonatologica*, 7(3):237–245, 1978.

[963] C. Johnson. Breeding behavior and oviposition in Calopteryx maculatum (Beauvais) (Odonata: Calopterygidae). *The American Midland Naturalist*, 68(1):242–247, 1962.

[964] S. Shimura. 近畿地方のトンボ雑記. http://tombon.com/index.htm, 2020.

[965] F.-J. Schiel and R. Buchwald. How to survive the brief water-coverage of vernal ponds: Early hatching date and rapid larval development in Aeshna affinis (Odonata: Aeshnidae). *Odonatologica*, 45(3):155–177, 2016.

[966] K. Tynkkynen, J. S. Kotiaho, M. Luojumäki, and J. Suhonen. Interspecific territoriality in Calopteryx damselflies: the role of secondary sexual characters. *Animal Behaviour*, 71(2):299–306, 2006.

[967] M. De Block and R. Stoks. Life-history variation in relation to time constraints in a damselfly. *Oecologia*, 140(1):68–75, 2004.

[968] P. S. Corbet. The life-history of the emperor dragonfly Anax imperator Leach (Odonata: Aeshnidae). *Journal of Animal Ecology*, 26(1):1–69, 1957.

[969] G. Sahlén. Ultrastructure of the eggshell and micropylar apparatus in Somatochlora metallica (Vander L.), Orthetrum cancellatum (L.) and Sympetrum sanguineum (Müll.) (Anisoptera: Corduliidae, Libellulidae). *Odonatologica*, 23(3):255–269, 1994.

[970] J. W. H. Trueman. Unusual eggshell structures in Ictinogomphus australis (Selys) (Anisoptera: Gomphidae). *Odonatologica*, 19(3):293–296, 1990.

[971] M. Watanabe and S. Matsu'ura. Fecundity and oviposition Mortonagrion hirosei Asahina, M. selenion (Ris), Ischnura asiatica (Brauer) and I. senegalensis (Rambur), coexisting in estuarine landscapes of the warm temperate zone of Japan (Zygoptera: Coenagrionidae). *Odonatologica*, 35(2):159–166, 2006.

[972] M. Watanabe and Y. Adachi. Number and size of eggs in the three Emerald Damselflies, Lestes sponsa, L. temporalis and L. japonicus (Odonata: Lestidae). *Zoological Science*, 4:575–577, 1987.

[973] B. V. Purse and D. J. Thompson. Reproductive morphology and behaviour in Coenagrion mercuriale (Charpentier) (Zygoptera: Coenagrionidae). *Odonatologica*, 32(1):29–37, 2003.

[974] K. S. Baker. *Local and landscape factors influencing diversity and fitness in Odonates at Playa Wetlands*. Thesis, Texas Tech University, 2011.

[975] OdonataCentral: An online resource for the distribution and identification of Odonata. http://www.odonatacentral.org/, 2020.

[976] P. Hillman. One With Nature: Insects. http://www.lightscapes.info/onewithnature/natures-garden/insects/, 2016.

[977] S. Bennett and P. J. Mill. Lifetime egg production and egg mortality in the damselfly Pyrrhosoma nymphula (Sulzer) (Zygoptera: Coenagrionidae). *Hydrobiologia*, 310:71–78, 1995.

[978] H. Andō. *The comparative embryology of Odonata with special reference to a relic dragonfly Epiophlebia superstes Selys.* Japan Society for the Promotion of Science, Tokyo, Japan, 1962.

[979] A. Martens. Plasticity of mate-guarding and oviposition behaviour in Zygonyx natalensis (Martin) (Anisoptera: Libellulidae). *Odonatologica*, 20(3):292–302, 1991.

[980] M. A. Serrano-Meneses, A. Cordoba-Aguilar, V. Mendez, S. J. Layen, and T. Szekely. Sexual size dimorphism in the American rubyspot: male body size predicts male competition and mating success. *Animal Behaviour*, 73(6):987–997, 2007.

[981] G. Sahlén. Eggshell ultrastructure in Onychogomphus forcipatus unguiculatus (Vander Linden) (Odonata: Gomphidae). *International Journal of Insect Morphology and Embryology*, 24(3):281–286, 1995.

[982] G. Sahlén. Transmission electron microscopy of the eggshell in five damselflies (Zygoptera: Coenagrionidae, Megapodagrionidae, Calopterygidae). *Odonatologica*, 24(3):311–318, 1995.

[983] R. K. Ivey, J. C. Bailey, B. P. Stark, and D. L. Lentz. A preliminary report of egg chorion features in dragonflies (Anisoptera). *Odonatologica*, 17(4):393–399, 1988.

[984] A. Kumar. The larval stages of Orthetrum brunneum brunneum (Fonscolombe) with a description of the last instar larva of Orthetrum taeniolatum (Schneider) (Odonata: Libellulidae). *Journal of Natural History*, 5(2):121–132, 1971.

[985] A. Kumar. Studies on the life history of Indian dragonflies Diplacodes trivalis (Rambur, 1842) (Libellulidae: Odonata). *Zoological Survey of India*, 81(3):13–22, 1984.

[986] A. Kumar. Studies on the life history of Indian dragonflies, Pseudagion rubriceps Selys (Coenagrionidae: Odonata). *Zoological Survey of India*, 75(3):371–381, 1979.

[987] A. Kumar. Studies on the life history of Indian gragonflies, Acisoma panorpoides panorpoides Rambur, 1842 (Libellulidae: Odonata). *Zoological Survey of India*, 81(3):203–213, 1984.

[988] A. Kumar. Studies on the life history of Indian Dragonflies, Ceriagrion Coromandelianum (Fabricius)(Coenagriidae: Odonata). *Zoological Survey of India*, 76(3):249–258, 1980.

[989] A. Miller. "Anax junius", Animal Diversity Web. https://animaldiversity.org/accounts/Anax_junius/, 2014.

[990] C. Hof, M. Brändle, and R. Brandl. Lentic odonates have larger and more northern ranges than lotic species. *Journal of Biogeogrpahy*, 33(1):63–70, 2006.

[991] A. Sarfaty and S. Pruett-Jones. Coloration indicates body size in Calopteryx maculata (Odonata:Calopterygidae). *International Journal of Odonatology*, 13(2):167–180, 2012.

[992] J. K. Waage. Oviposition duration and egg deposition rates in Calopteryx maculata (P. de Beauvois) (Zygoptera: Calopterygidae). *Odonatologica*, 7(1):77–88, 1978.

[993] J. A. Andres and A. Cordero. The inheritance of female colour morphs in the damselfly ceriagrion tenellum (Odonata, Coenagrionidae). *Heredity*, 82(3):328–335, 1999.

[994] A. Cordero. The inheritance of female polymorphism in the damselfly Ischnura graellsii (Rambur) (Odonata: Coenagrionidae). *Heredity*, 64(3):341–346, 1990.

[995] A. Barnard, O. M. Fincke, M. Shields, and M. Xu. Melanic individuals in color polymorphic Enallagma damselflies result from phenotypic, not genetic, variation. *International Journal of Odonatology*, 18(1):3–14, 2015.

[996] D. Outomuro, L. Söderquist, S. Rodríguez-Martinez, and F. Johansson. A preliminary study on female-limited colour polymorphism in Lestes sponsa. *International Journal of Odonatology*, 17(2):89–93, 2014.

[997] G. Joop, A. Gillen, and D. J. Mikolajewski. Colour polymorphism in female Coenagrion puella: differences in egg shape (Odonata: Coenagrionidae). *International Journal of Odonatology*, 10(1):71–80, 2007.

[998] M. J. Winterbourn and S. R. Pohe. Life histories of four dragonfly species (Odonata: Anisoptera) in northern New Zealand. *New Zealand Entomologist*, 36(10):8–14, 2013.

[999] R. Bernard and P. Ivinskis. Orthetrum brunneum (Fonscolombe, 1837), A New Dragonfly Species in Lithuania (Odonata: Libellulidae). *Acta Zoologica Lituanica*, 14(3):31–36, 2004.

[1000] I. Flenner, O. Richter, and F. Suhling. Rising temperature and development in dragonfly populations at different latitudes. *Freshwater Biology*, 55(2):397–410, 2009.

[1001] R. A. Cannings and K. Stuart. *The Dragonflies of British Colombia*. British Columbia Provincial Museum, Victoria, Canada, 1997.

[1002] G. De Marchi. Precopulatory reproductive isolation and wing colour dimorphism in Calopteryx splendens females in southern Italy (Zygoptera: Calopterygidae). *Odonatologica*, 19(3):243–250, 1990.

[1003] M. J. Parr. An analysis of territoriality in Libellulid dragonflies (Anisoptera: Libellulidae). *Odonatologica*, 12(1):39–57, 1983.

[1004] D. J. Thompson. Sexual size dimorphism in Coenagrion puella (L.) (Zygoptera: Coenagrionidae). *Advances in Odonatology*, 4(1):123–131, 1989.

[1005] K. Miyakawa. Reproductive behaviour and life span of adult Calopteryx atrata Selys and C. virgo japonica Selys (Odonata: Zygoptera). *Odonatologica*, 1(1):193–203, 1982.

[1006] B. I. McKinnon and M. L. May. Mating habitat choice and reproductive success of Pachydiplax longipennis (Burmeister) (Anisoptera: Libellulidae). *Advances in Odonatology*, 6(1):59–77, 1994.

[1007] O. M. Fincke. Giant damselflies in a tropical forest: reproductive biologyof Megaloprepus coerulatus with notes on Mecistogaster (Zygoptera: Pseudostigmatidae). *Advances in Odonatology*, 2(1):13–27, 1984.

[1008] D. J. Thompson. Lifetime reproductive success in andromorph females of the damselfly Coenagrion puella (L.) (Zygoptera: Coenagrionidae). *Odonatologica*, 18(2):209–213, 1989.

[1009] O. M. Fincke. Population regulation of a tropical damselfly in the larval stage by food limitation, cannibalism, intraguild predation and habitat drying. *Oecologia*, 100(2):118–127, 1994.

[1010] B. C. Kondratieff and C. J. Pyott. The Anisoptera of the Savannah River Plant, South Carolina, United States: thirty years later. *Odonatologica*, 16(1):9–23, 1987.

[1011] P. S. Corbet. *Dragonflies: Behaviour and Ecology of Odonata*. Harley Books, Essex, UK, 1999.

[1012] D. R. Paulson and C. E. Jenner. Population structure in overwintering larval Odonata in North Carolina in relation to adult flight season. *Ecology*, 52(1):96–107, 1971.

[1013] W. W. Sawchyn and C. Gillott. The life histories of three species of Lestes (Odonata: Zygoptera) in Saskatchewan. *The Canadian Entomologist*, 106(12):1283–1293, 1974.

[1014] V. E. McMillan. Notes on tandem oviposition and other aspects of reproductive behaviour in Sympetrum vicinum (Hagen) (Anisoptera: Libellulidae). *Odonatologica*, 24(2):187–195, 1995.

[1015] S. P. Moss. Oviposition site selection in Enallagma civile (Hagen) and the consequences of aggregating behaviour (Zygoptera: Coenagrionidae). *Odonatologica*, 21(2):153–164, 1992.

[1016] P. H. Crowley and D. M. Johnson. Co-occurrence of Odonata in the Eastern United States. *Advances in Odonatology*, 1(1):15–37, 1982.

[1017] Trithemis festiva. https://lkcnhm.nus.edu.sg/dna/organisms/details/772, 2015. Lee Kong Chian Natural History Museum.

[1018] H. B. Tang, L. K. Wang, and M. Hämäläinen. *A Photographic Guide to the Dragonflies of Singapore*. Raffles Museum of Biodiversity Research, National University of Singapore, Singapore, 2010.

[1019] A. Kumar. Studies on the life history of Trithemis festiva (Rambur, 1842) (Odonata: Libellulidae). *Odonatologica*, 1(2):103–112, 1972.

[1020] K. Kock. Effects of male harassment on females' oviposition behaviour in Libellulidae (Odonata). *International Journal of Odonatology*, 9(1):71–80, 2016.

[1021] S. Silsby. Dragonflies at four very different South African sites (Anisoptera). *Notulae Odonatologicae*, 3(4):62–63, 1989.

[1022] M. J. Samways. *Dragonflies and Damselflies of South Africa*. Pensoft Publishers, Sofia, Bulgaira, 2008.

[1023] R. J. Andrew and D. B. Tembhare. The post-ovarian genital complex in Anax guttatus (Burmeister) (Anisoptera: Aeshnidae). *Odonatologica*, 26(4):385–394, 1997.

[1024] A. Mitra. Annotated Odonata inventory of the Asan Reservoir, Dehra Dun, India. *Notulae Odonatologicae*, 5(5):57–60, 2000.

[1025] W. H. Wain, C. B. Wain, and T. Lambert. Odonata of North Island, Seychelles Archipelago. *Notulae Odonatologicae*, 5(4):47–50, 1999.

[1026] M. J. Samways. Conservation of an endemic odonate fauna in the Seychelles archipelago. *Odonatologica*, 32(2):117–182, 2003.

[1027] A. G. Orr. *Dragonflies of Peninsular Malaysia and Singapore*. Natural History Publications (Borneo), Kota Kinabalu, Sabah, Malaysia, 2005.

[1028] P. S. Cort. Orientation and reproductive condition of migrating dragonflies (Anisoptera). *Odonatologica*, 13(1):81–88, 1984.

[1029] A. M. Young. Oviposition behaviour in two species of dragonflies. *Ohio Journal of Science*, 67(5):313–316, 1967.

[1030] P. S. Corbet, C. Longfield, and N. W. Moore. *Dragonflies*. Collins New Naturalist Library, London, UK, 1960.

[1031] O. M. Fincke. Underwater oviposition in a damselfly (Odonata: Coenagrionidae) favors male vigilance, and multiple mating by females. *Behavioral Ecology and Sociobiology*, 18(6):405–412, 1985.

[1032] D. J. Thompson. The effects of survival and weather on lifetime egg production in a model damselfly. *Ecological Entomology*, 15(4):455–462, 1990.

[1033] A. Cordero. Fecundity of Ischnura graellsii (Rambur) in the laboratory (Zygoptera: Coenagrionidae). *Odonatologica*, 20(1):37–44, 1990.

[1034] M. Watanabe and Y. Adachi. Number and size of eggs in the three emerald damselflies, Lestes sponsa, L. temporalis and L. japonicus (Odonata: Lestidae). *Zoological Science*, 4:575–578, 1987.

[1035] B. Anholt. Sexual size dimorphism and sex-specific survival in adults of the damselfly Lestes disjunctus. *Ecological Entomology*, 22(2):127–132, 1997.

[1036] G. Cooper, P. W. H. Holland, and P. L. Miller. Captive breeding of Ischnura elegans (Vander Linden): observations on longevity, copulation and oviposition (Zygoptera: Coenagrionidae). *Odonatologica*, 25(3):261–273, 1996.

[1037] E. Walker and P. S. Corbet. *The Odonata of Canada and Alaska: The Anisoptera - Three Families.* University of Toronto Press, Toronto, Canada, 1975.

[1038] N. K. Michiels and A. A. Dhondt. Effects of emergence characteristics on longevity and maturation in the dragonflySympetrum danae (Anisoptera : Libellulidae). *Hydrobiologia*, 171(2):149–158, 1987.

[1039] A. Cordero, S. S. Carbone, and C. Utzeri. Male mating success in a natural population of Ischnura elegans (Vander Linden) (Odonata: Coenagrionidae). *Odonatologica*, 26(4):459–465, 1997.

[1040] W. D. Koenig and S. S. Albano. Lifetime reproductive success, selection, and the opportunity for selection in the white-tailed skimmer Plathemis lydia (Odonata: Libellulidae). *Evolution*, 41(1):22–36, 1987.

[1041] M. R. L. Forbes and R. L. Baker. Susceptibility to parasitism: experiments with the damselfly Enallagma ebrium (Odonata: Coenagrionidae) and larval water mites, Arrenurus spp. (Acari: Arrenuridae). *Oikos*, 58(1):61–66, 1990.

[1042] E. Kasuya, K. Edanami, and I. Ohno. Territorial conflicts in males of the dragonfly, Orthetrum japonicum japonicum (Odonata: Libellulidae): the role of body size. *Zoological Science*, 14(3):505–509, 1997.

[1043] P. L. Miller. The duration of copulation correlates with other aspects of mating behaviour in Orthetrum chrysostigma (Burmeister) (Anisoptera: Libellulidae). *Odonatologica*, 12(3):227–238, 1983.

[1044] O. M. Fincke. Consequnces of larval ecology for territoriality and reproductive success of a neotropical damselfly. *Ecology*, 73(2):449–462, 1992.

[1045] S. D. Gribbin and D. J. Thompson. Egg size and clutch size in Pyrrhosoma nymphula (Sulzer) (Zygoptera: Coenagrionidae). *Odonatologica*, 19(4):347–357, 1990.

[1046] G. F. Grether. Sexual selection and survival selection on wing coloration and body size in the rubyspot damselfly Hetaerina americana. *Evolution*, 50(5):1939–1948, 1996.

[1047] Y. Tsubaki and T. Ono. Effects of age and body size on the male territorial system of the dragonfly, Nannophya pygmaea Rambur (Odonata: Lihbellulidae). *Animal Behaviour*, 35(2):518–525, 1987.

[1048] P.-A. Robert. *Les Libellules*. Beautés de la nature. Delachaux et Niestlé, Neuchâtel, Switzerland, 1958.

[1049] F. Suhling, K. Schenk, T. Padeffke, and A. Martens. A field study of larval development in a dragonfly assemblage in African desert ponds (Odonata). *Hydrobiologia*, 528(1):75–85, 2004.

[1050] J. A. Waringer and U. H. Humpesch. Embryonic development, larval growth and life cycle of Coenagrion puella (Odonata: Zygopter) from an Austrian pond. *Freshwater Biology*, 14(4):385–399, 1984.

[1051] F.-J. Schiel and R. Buchwald. Contrasting life-history patterns between vernal pond specialists and hydroperiod generalists in Lestes damselflies (Odonata: Lestidae). *Odonatologica*, 45(3):349–374, 2015.

[1052] M. Ferreras-Romero, M. D. Atienzar, and P. S. Corbet. The life cycle of Onychogomphus uncatus (Charpentier, 1840) (Odonata: Gomphidae) in the Sierra Morena Mountains (southern Spain): An example of protracted larval development in the Mediterranean basin. *Archiv für Hydrobiologie*, 144(2):215–228, 1999.

[1053] J. H. Hawking and T. R. New. Development of eggs of dragonflies (Odonata: Anisoptera) from two streams in north-eastern Victoria, Australia. *International Journal of Freshwater Entomology*, 17(3):175–180, 1995.

[1054] J. H. Hawking and T. R. New. The development of dragonfly larvae (Odonata: Anisoptera) from two streams in north-eastern Victoria, Australia. *Hydrobiologia*, 317(1):13–30, 1996.

[1055] F. Harabis, A. Dolny, and J. Sipos. Enigmatic adult overwintering in damselflies: coexistence as weaker intraguild competitors due to niche separation in time. *Population Ecology*, 54(4):549–556, 2012.

[1056] P. P. Calvert. The rates of growth, larval development and seasonal distribution of dragonflies of the genus Anax (Odonata: Æshnidæ). *Proceedings of the American Philosophical Society*, 73(1):1–70, 1934.

[1057] D. G. Kim, J. W. Yum, T. J. Yoon, and Y. J. Bae. Life history of an endangered dragonfly, Nannophya pygmaea Rambur, in Korea (Anisoptera: Libellulidae). *Odonatologica*, 39(1):39–46, 2010.

[1058] T. Brockhaus and A. Hartman. New records of Epiophlebia laidlawi Tillyard in Bhutan, with notes on its biology, ecology, distribution, zoogeography and threat status (Anisozygoptera: Epiophlebiidae). *Odonatologica*, 38(3):203–215, 2009.

[1059] J. K. Waage. Longevity and mobility of adult Calopteryx maculata (Beauvois, 1805) (Zygoptera: Calopterygidae). *Odonatologica*, 1(3):155–162, 1972.

[1060] J. Ott. The expansion of Crocothemis erythraea (Brullé, 1832) in Germany - an indicator of climatic changes. In B. K. Tyagi, editor, *Odonata: Biology of Dragonflies*, pages 201–222. Scientific Publishers (India), Jodhpur, India, 2007.

[1061] G. H. Bick and J. C. Bick. Behavior and population structure of the damselfly, Enallagma civile (Hagen) (Odonata: Coenagriidae). *The Southwestern Naturalist*, 8(2):57–84, 1963.

[1062] P. L. Miller. *Dragonflies*, volume 7 of *Naturalist Handbook*. The Richmond Publishing Co. Ltd., Slough, UK, 1995.

[1063] J. E. Veron. Age determination of adult Odonata. *Odonatologica*, 2(1):21–28, 1973.

[1064] T. N. Sherratt, C. Hassall, R. A. Laird, D. J. Thompson, and A. Cordero-Rivera. A comparative analysis of senescence in adult damselflies and dragonflies (Odonata). *Journal of Evolutionary Biology*, 24(4):810–822, 2011.

[1065] P. V. Switzer. Factors affecting site fidelity in a territorial animal, Perithemis tenera. *Animal Behaviour*, 53(4):865–877, 1997.

[1066] R. Nevin. A study of the larva of Calopteryx (Agrion) maculata (Odonata: Agrionidae). *Transactions of the American Entomological Society*, 55(4):425–448, 1929.

[1067] E. Goretti, D. Ceccagnoli, G. La Porta, and M. V. Di Giovanni. Larval development of Aeshna cyanea (Müller, 1764) (Odonata: Aeshnidae) in Central Italy. *Hydrobiologia*, 457(1):149–154, 2001.

[1068] A. Córdoba-Aguilar and A. Cordero-Rivera. Evolution and ecolgy of Calopterygidae (Zygoptera: Odonata): status of knowledge and research perspectives. *Neotropical Entomology*, 34(6):861–879, 2005.

[1069] Y. Tsubaki and T. Ono. Competition for territorial sites and alternative mating tactics in the dragonfly, Nannophya pygmaea Rambur (Odonata: Libellulidae). *Behaviour*, 97(3):234–252, 1985.

[1070] A. Cordero. Correlaes of male mating success in two natural populations of the dameselfly Ischnura graellsii (Odonat: Coenagrionidae). *Ecological Entomology*, 20(3):213–222, 1995.

[1071] R. Pfadt. *Field Guide to Common Western Grasshoppers*. The University of Wyoming, Laramie, WY, third edition, 2002.

[1072] H. Bellman. *A Field Guide to the Grasshoppers and Crickets of Britain and Northern Europe*. Collins, London, UK, 1988.

[1073] G. Morris. Mating systems, parental investment and aggressive behavior of acoustic Orthoptera. *The Florida Entomologist*, 62(1):9–17, 1979.

[1074] F. Dziock, M. Gerisch, M. Siegert, I. Hering, M. Scholz, and R. Ernst. Reproducing or dispersing? Using trait based habitat templet models to analyse Orthoptera response to flooding and land use. *Agriculture, Ecosystems & Environment*, 145(1):85–94, 2011.

[1075] M. Tajamul and S. Ahmad. Life history statistics and comparative morphometric assessment of rice grasshopper, Oxya japonica (Orthoptera: Acrididae). *International Jouranl of Pure and Applied Zoology*, 4(1):92–98, 2016.

[1076] D. Gwynne. *Katydids and Bush-Crickets: Reproductive Behavior and Evolution of the Tettigonidae*. Cornell University Press, Ithaca, NY, 2001.

[1077] B. Uvarov. *Grasshoppers and Locusts: A Handbook of General Acridology*, volume Volume I. Cambridge University Press, London, UK, 1966.

[1078] J. Chesler. Observations on the biology of some South African Acrididae (Orthoptera). *Transactions of the Royal Entomological Society of London*, 87(14):313–351, 1938.

[1079] R. Chapman and I. Robertson. The egg pods of some tropical African grasshoppers. *The Journal of the Entomological Society of Sourthern Africa*, 21(1):85–112, 1958.

[1080] K. Katityar. Ecology of oviposition and the structure of egg-pods and eggs in some Indian Acrididae. *Records of the Indian Museum*, 55(1):29–69, 1960.

[1081] D. Rentz. The Orthoptera family Cooloolidae, including description of two new species and observations on biology and food preferences. *Systematic Entomology*, 11(2):231–246, 1986.

[1082] D. Rentz. Pearson's Monster, a new species of Cooloola Rentz from Queensland (Orthoptera: Cooloolidae). *Journal of Orthoptera Research*, 8(1):22–35, 1999.

[1083] B. Taylor Smith, M. Morgan-Richards, and S. Trewick. New Zealand ground weta (Anostostomatidae: Hermiandrus): descriptions of two species with notes on their biology. *New Zealand Journal of Zoology*, 40(4):314–329, 2013.

[1084] D. Gwynne. Reproductive behavior of ground weta (Orthoptera: Anostomatidae): Drumming behavior, nuptual feeding, post-copulatory guarding and maternal care. *Journal of the Kansas Entomological Society*, 77(4):414–428, 2004.

[1085] P. Leisnham, C. Cameron, and I. Jamieson. Life cycle, survival rates and longevity of an alpine weta Hemideina maori (Orthoptera: Anostostomatidae) determined using mark-recapture analysis. *New Zealand Journal of Zoology*, 27(2):191–200, 2003.

[1086] F. Hutton. The Stenopelmatidae of New Zealand. *Transactions and Proceedings of the Royal Society of New Zealand*, 29(14):208–242, 1896.

[1087] V. Dirsh and J. Mason. Systematic and phylogenetic position of the family Xyronotidae (Acridomorpha, Insecta). *Journal of Zoological Systematics and Evolutionary Research*, 17(3):201–210, 1979.

[1088] S. Channa, R. Sultana, and M. Wagan. Morphology and burrowing behaviour of Schizodactylus minor (Ander, 1938) (Grylloptera: Scizodactylidae: Orthoptera) of Pakistan. *Pakistan Journal of Zoology*, 45(5):1191–1196, 2013.

[1089] S. Channa, R. Sultana, and M. Wagan. Studies on the immature stages and burrow excavating behavior of Schizodactylus monstrous (Drury) (Grylloptera: Gryllodea: Schizodactylidae) from Sindh, Pakistan. *African Journal of Biotechnology*, 10(12):2328–2333, 2011.

[1090] L. Lin, Z. Zheng, R. Yang, and S. Zu. A review of the genus Pielomastax Chang (Orthoptera: Eumastacoidea) from China with description of a new species. *Neotropical Entomology*, 43(4):350–356, 2014.

[1091] C. Rowell and D. Perez-Gelabert. The status of Espagnolinae (Rehn 1948) and other subfamilies of the Episactidae (Descamps 1973) (Eumastacoidea, Caelifera, Orthoptera), with description of two new genera, Paralethus and Neibamastax. *Journal of Orthoptera Research*, 15(2):191–240, 2006.

[1092] C.-C. O.J., A. Garay, D. Castañeda M., J. Cardona-Granda, and A. García García. Systematics and phylogeny of the genus Caenomastax Hebard, 1923 (Orthoptera: Eumastacidae: Eumastacinae). *Zootaxa*, 4417(2):241–264, 2016.

[1093] L. Field. *The Biology of Wetas, King Crickets and their Allies*. CABI Publishing, Wallingford, UK, 2001.

[1094] A. Richards. A comparative study of the biology of the giant wetas Deinacrida heteracantha and D. fallai (Orthoptera: Henicidae) from New Zealand. *Journal of Zoology*, 169(2):195–236, 1973.

[1095] A. Gorochov and O. Cadena-Castañeda. New and little known Stenopelmatoidea (Orthoptera: Ensifera) from America. *Zoosystematica Rossica*, 25(1):98–143, 2016.

[1096] J. Rhen. The locust genus Tanaocerus as found in the United States, and the description of a related new genus (Orthoptera: Acridoidea). *Proceedings of the Academy of Natural Scences of Philadelphia*, 100(1):1–22, 1948.

[1097] K. Günther. Revision der familie Cylindrachetidae Giglio-Tos, 1914 (Orthoptera, Tridactyloidea). *Deutsche Entomologische Zeitschrift*, 39(4):233–291, 1992.

[1098] H. Brown. The male of Crypsiceru cubicus Saussure, 1888 (Orthoptera: Lathiceridae). *Scientific Paper of the Namib Desert Research Station*, 1963(21):192–197, 1963.

[1099] D. Otte. Twenty-nine new species in the genus Leatettix (Acridoidea: Lentulidae) from the Southern, Western and Northern Cape, South Africa. *Transactions of the American Entomological Society*, 140(1):349–401, 2014.

[1100] W. Kirby. *Orthoptera: Acridiidæ*. The Fauna of British India including Ceylon and Burma. Taylor and Francis, London, UK, 1914.

[1101] T. Stalling. A new species of ant-loving cricket, Mymecophilus Berthold, 1827, and comments on M. nigricornis (Chopard, 1963) from the Middle East. *Zoology in the Middle East*, 49(1):89–94, 2010.

[1102] N. Baena-Bejarano. Aspects of the natural history of Ripipteryx (Orthoptera: Ripipterygidae) species in Columbia. *Journal of Insect Behavior*, 28(1):44–54, 2015.

[1103] N. Baena-Bejarano and S. Heads. Three new species of the genus Ripipteryx from Colombia (Orthoptera, Ripipterygidae). *ZooKeys*, (502):129–143, 2015.

[1104] C. Hemp. Review of the East African genus Chromothericles (Orthoptera: Eumastacoidea: Thericleidae): data on morphology, distribution and habitat, with the description of four new species. *Journal of Orthoptera Research*, 18(1):127–136, 2009.

[1105] K. Kuřavová and P. Kočárek. Mandibular morphology and dietary preferences in two pygmy mole crickets of the genus Xya (Orthoptera: Tridactylidae). *Turkish Journal of Zoology*, 40(5):720–728, 2016.

[1106] M. Burrows and M. Picker. Jumping mechanisms and performance of pygmy mole crickets (Orthoptera, Tridactylidae). *Journal of Experimental Biology*, 213(14):2386–2398, 2010.

[1107] M. Pereira, L. Martins, M. Fernandes, E. Zefa, and C. Sperber. Redescription of Argizala brasiliensis Walker, 1869 (Orthoptera: Grylloidea: Trigonidiidae: Nemobiinae: Pteronemobiini) and consideration of its morphological proximity to other Pteronemobiini Nearctic genera. *Zootaxa*, 3974(1):49–58, 2015.

[1108] V. Vickery and D. Weissman. Neonemobius eurynotus (Rehn and Hebard) (Grylloptera: Trigonidiidae: Nemobiinae), a cricket of the San Francisco Bay Area, California. *Pan-Pacific Entomologist*, 65(1):68–73, 1989.

[1109] S. Hugel. Endemic grasshoppers from the Mascarene Islands: a critically endangered island fauna. *Journal of Insect Conservation*, 19(1):87–96, 2015.

[1110] G. Logarzo and M. Casalinuovo. Biology and nymph host range of Anchocoema bidentata and Astroma saltense (Orthopeta: Proscopiidae), potential biocontrol agents for creosotebush, Larrea tridentata (Zygophyllacea) in the U.S.A. *Biocontrol Science and Technology*, 14(1):39–50, 2004.

[1111] J. Spooner. Sound production in Cyphoderris monstrosa (Orthoptera: Prophalangopsidae). *Annals of the Entomological Society of America*, 66(1):4–5, 1973.

[1112] V. Couldridge and M. Gordon. Diel variation in signalling and signal transmission in the bladder grasshopper, Bullacris unicolor (Orthoptera; Pneumoridae). *Behaviour*, 152(12):1706–1723, 2015.

[1113] N. Donelson and M. van Staaden. Alternate tactics in male bladder grasshoppers Bullacris membraciodes (Orhoptera: Pneumoridae). *Behaviour*, 142(6):761–778, 2005.

[1114] N. Donelson, A. Smith, and M. van Staaden. Variation in adult longevity in a polymorphic grasshopper species. *Journal of Orthoptera Research*, 17(2):279–282, 2008.

[1115] H. López, M. Nogales, E. Morales, and P. Oromí. Habitat use and phenology of the large insular endemic grasshopper Acrostira euphorbiae (Orthoptera: Pamphagidae). *Bulletin of Entomological Research*, 97(2):117–127, 2007.

[1116] X.-J. Li, J.-P. Shi, and Y. Ding. A review of the genus Eotmethis (Orthoptera, Acridoidea, Pamphagidae) with to new species and key to known species of the genus from China. *Zootaxa*, 4144(1):138–144, 2016.

[1117] M.-D. García, R. Gómez, M.-E. Clemente, and J.-J. Presa. Sound production in the genus Acinipe Rambur, 1832 (Orthoptera: Pampagidae). *Italian Journal of Zoology*, 81(2):264–270, 2014.

[1118] A. Foucart and M. Lecoq. Major threats to a protected grasshopper, Prionotropis hystrix rhodanica (Orthoptera, Pamphagidae, Akicerinae), endemic to southern France. *Journal of Insect Conservation*, 2(3):187–193, 1998.

[1119] S. Masaki. Geographic variation and climatic adaptation in a field cricket (Orthoptera: Gryllidae). *Evolution*, 21(4):725–741, 1967.

[1120] S. Willott and M. Hassall. Life-history responses of British grasshoppers (Orthoptera: Acrididae) to temperature change. *Functional Ecology*, 12(2):232–241, 1998.

[1121] Y. Mariottini, M. De Wysiecki, and C. Lange. Longevity and fecundity of Dichroplus maculipennis (Orthoptera: Acrididae) at non-outbreaking and outbreaking situations. *Revista Brasileira de Entomologia*, 55(3):435–438, 2011.

[1122] J. Roffey. *Locusts and grasshoppers of economic importance in Thailand*, volume Anti-Locust Memoir 14. Centre for Overseas Pest Research, London, UK, 1979.

[1123] D. Rentz, R. Lewis, Y. Su, and M. Upton. *A Guide to Australian Grasshoppers and Locusts*. Natural History Publications (Borneo), Kota Kinabalu, Sabah, Malaysia, 2003.

[1124] J. Hartley. The structure of the eggs of the British Tettigoniidae (Orthoptera). *Proceedings of the Royal Entomological Society of London. Series A, General Entomology*, 39(7):111–117, 1964.

[1125] J. Hilliard. *The Specificity of Acridian Egg Pods and Eggs with Biological Notes*. Thesis, 1959.

[1126] R. Pickford. Development, survival and reproduction of Camnula pellucida (Scudder) (Orthoptera: Acrididae) in relation to climatic conditions. *The Canadian Entomologist*, 98(2):158–169, 1966.

[1127] D. Smith. Fecundity and oviposition in the grasshoppers Melanoplus sanguinipes (F.) and Melanoplus bivittatus (Say). *The Canadian Entomologist*, 98(6):617–621, 1966.

[1128] T. Kaufmann. Biology and ecology of Melanoplus borealis (Orthoptera: Acrididae) in Fairbanks, Alaska with special reference to feeding habits. *The Michigan Entomologist*, 4(1):3–13, 1971.

[1129] M. Hernández-Zul, J. Quaijano-Carranza, R. Yañez-López, I. Torres-Pacheco, R. Guevara-Gónzalex, E. Rico-García, A. Castro-Ramírez, and R. Ocampo-Velázquez. Elements for the sustainable management of acridoids of importance in agriculture. *African Journal of Agricultural Research*, 7(2):142–152, 2012.

[1130] D. Gray and W. Cade. Senescence in field crickets (Orthoptera; Gryllidae): examining the effects of sex and a sex-biased parasitoid. *Canadian Journal of Zoology*, 78(1):140–143, 2000.

[1131] L. Kuitert and R. Connin. Biology of the American grasshopper in the southeastern United States. *The Florida Entomologist*, 35(1):22–33, 1952.

[1132] G. Richards. *Ecology and behaviour of the Mahoenui Giant weta (Deinacrida nov. sp.)*. Msc thesis, Massey University, 1994.

[1133] A. Hochkirch, L. Tatin, and M. Stanley Price. Crau plain grasshopper, A Strategy for its Conservation 2015-2020. Report, IUCN-SSC & CEN PACA, 2014.

[1134] A. Anya. Ecology of the variegated grasshopper, Zonocerus variegatus, (Orthoptera: Acridoidea, Pygromorphidae) on the Nsukka Plateau, Nigeria. *Entomologia Experimentalis et Applicata*, 16(1):64–76, 1973.

[1135] K. Maeno, C. Piou, M. Ould Babah, and S. Nakamura. Eggs and hatchlings variations in desert locusts: phase related characteristics and starvation tolerance. *Frontiers in Physiology*, 4(345), 2013.

[1136] M. Bradford, P. Guerette, and D. Roff. Testing hypotheses of adaptive variation in cricket ovipositor lengths. *Oecologia*, 93(2):263–267, 1993.

[1137] R. Harris, P. McQuillan, and L. Hughes. A test of the thermal melanism hypothesis in the wingless grasshopper Phaulacridium vittatum. *Journal of Insect Science*, 13(51), 2013.

[1138] S. Caesar, M. Karlsson, and A. Forsman. Diversity and relatedness enhance survival in colour polymorphic grasshoppers. *PLoS ONE*, 5(5):e10880, 2010.

[1139] A. Mohammadbeigi and G. Port. Effect of infection by Beauveria bassiana and Metarhizium anisopliae on the feeding of Uvarovista zebra. *Journal of Insect Science*, 15(88), 2015.

[1140] N. Sanchez, E. Wittenstein, M. de Wysiecki, and C. Lange. Life histroy parameters of the gregarious phase of the South American locust, Schistocerca cancellata (Serville) (Orthoptera: Acrididae), under laboratory conditions. *Journal of Orthoptera Research*, 6:121–124, 1997.

[1141] P. Hunter-Jones. The life-history of the Eastern Lubber Grasshopper, Romalea microptera (Beauvois), (Orthoptera: Acrididae) under laboratory conditions. *Physiological Entomology*, 42(1):18–24, 1967.

[1142] J. L. Capinera. *Encyclopedia of Entomology*. Springer, Heidelberg, Germany, 2008.

[1143] N. Wedell, T. Tregenza, and L. Simmons. Nuptial gifts fail to resolve a sexual conflict in an insect. *BMC Evolutionary Biology*, 8(204), 2008.

[1144] J. Samietz and G. Köhler. A fecundity cost of (walking) mobility in an insect. *Ecology and Evolution*, 2(11):2788–2793, 2012.

[1145] K. McClundey and R. Date. The effects of hydration on growth of the house cricket, Acheta domesticus. *Journal of Insect Science*, 8(32), 2008.

[1146] Y. Mariottini, M. De Wysiecki, and C. Lange. The biology and some population parameters of the grasshopper, Ronderosia bergi, under labratory conditions. *Journal of Insect Science*, 10(92), 2010.

[1147] S. Unsicker, A. Oswald, G. Köhler, and W. Weisser. Complementarity effects through dietary mixing enhance the performance of a generalist insect herbivore. *Oecologia*, 156(7):313–324, 2008.

[1148] W. de Villers. Studies on the general biology of Acanthacris ruficornis (Orthoptera: Acrididae) in South Africa. *Phytophylactica*, 21(4):385–389, 1989.

[1149] S. Sundberg, M. Luong-Skovmand, and D. Whitman. Morphology and development of oocyte and follicle resorption bodies in the lubber grasshopper, Romalea microptera (Beauvois). *Journal of Orthoptera Research*, 10(1):39–51, 2001.

[1150] D. Whitman and S. Vincent. Large size as an antipredator defense in an insect. *Journal of Orthoptera Research*, 17(2):353–371, 2008.

[1151] K. Ercit. Temporal variation in selection on male and female traits in wild tree crickets. *Ecology and Evolution*, 6(15):5118–5128, 2016.

[1152] B. Fulton. The tree crickets of New York: life history and bionomics. *New York Agrigultural Experiment Station Technical Bulletin*, 42:3–47, 1915.

[1153] T. Sun, Z. Liu, L. Qin, and R. Long. Grasshopper (Orthoptera: Acrididae) community composition in the rangeland of the northern slopes of the Quilian Mountains in northwestern China. *Journal of Insect Science*, 16(1), 2015.

[1154] V. Vickery. Orthopteroid insects (Orthoptera) of the Yukon. In H. Danks and J. Downes, editors, *Insects of the Yukon*, pages 223–239. Biological Survey of Canada (Terrestrial Arthropods), Ottawa, Canada, 1997.

[1155] R. Snyder, K. Frederick-Hudson, and J. Schul. Molecular phylogenetics of the genus Neoconocephalus (Orthoptera, Tettingoniidae) and the evolution of temperate life histories. *PLoS ONE*, 4(9):e7203, 2009.

[1156] J. Capinera, R. Scott, and T. Walker. *Field Guide to Grasshoppers, Katydids and Crickets of the United States*. Cornell University Press, Ithaca, NY, 2004.

[1157] C. Hemp. Aerotegmina, a new genus of African Listroscelidinae (Orthoptera: Tettigoniidae, Listroscelidindae, Hexacentrini). *Journal of Orthoptera Research*, 10(1):121–128, 2001.

[1158] M. Bradford and D. Roff. Genetic and phenotypic sources of life history variation along a cline in voltinism in the cricket Allonemobius socius. *Oecologia*, 103(3):319–326, 1995.

[1159] Y. Mariottini, M. De Wysiecki, and C. Lange. Seasonal occurance of life stages of grasshoppers (Orthoptera: Acridoidea) in the Southern Pampas, Argentina. *Zoological Studies*, 50(6):737–744, 2011.

[1160] B. Çıplak. Systematics, phylogeny and biogeography of Anterastes (Orthoptera, Tettigoniidae, Tettigoniinae): evolution within a refugium. *Zoologica Scripta*, 33(1):19–44, 2004.

[1161] L. Simmons. The contribution of multiple mating and spermatophore consumption to the lifetime reproductive success of female field crickets (Gryllus bimaculatus). *Ecological Entomology*, 13(1):57–69, 1988.

[1162] T. Tregenza and N. Wedell. Benefits of multiple mates in the cricket Gryllus bimaculatus. *Evolution*, 52(6):1726–1730, 1998.

[1163] W. Bailey and D. e. Rentz. *The Tettigoniidae: Biology, Systematics and Evolution*. Springer-Verlag, Heidelberg, Germany, 1990.

[1164] W. Bailey. A review of Australian Copiphorini (Orthoptera: Tettigoniidae: Conocephalinae). *Australian Journal of Zoology*, 27(6):1015–1049, 1979.

[1165] G. Roemhild. *Studies of the eggs of the grasshopper species Aulocara elliotti Thos.* Thesis, Montana State College, 1961.

[1166] P. Furneaux, C. James, and S. Potter. The egg shell of the house cricket (Acheta domesticus): An electron-microscope study. *Journal of Cell Science*, 5(2):227–249, 1969.

[1167] I. Ismail. Biological and ecological studies on the house cricket, Acheta domesticus L. (Orthopt., Gryllidae) in Giza region, Egypt. *Journal of Applied Entomology*, 85(2):230–235, 1978.

[1168] O. Dangles, C. Magal, D. Pierre, A. Olivier, and J. Casas. Variation in morphology and performance of predetor-sensing system in wild cricket populations. *The Journal of Experimental Biology*, 208(4):461–468, 2005.

[1169] T. Ono, F. Hayakawa, Y. Matsuura, Shiraishi, H. M., Yasui, T. Nakamura, and M. Arakwara. Reproductive biology and function of multiple mating in the mating system of a tree cricket, Truljalia hibinosis (Orthoptera: Podoscritinae). *Journal of Insect Behavior*, 8(6):813–824, 1995.

[1170] L. Ma and Y. Zhang. The Chinese cricket genus Truljalia Gorochov (Gryllidae, Podoscirtinae) with description of new species, including morphological and acoustical infromation. *Zoologischer Anzeiger - A Journal of Comparative Zoology*, 257:10–21, 2015.

[1171] T. Ivy and S. Sakaluk. Polyandry promotes enhanced offspring survival in decorated crickets. *Evolution*, 59(1):152–159, 2005.

[1172] K. Holst. *The Saltatoria (Bush-crickets, crickets and grasshoppers) of Northern Europe*. Fauna Entomologica Scandinavica. Scandinavian Science Press Ltd., Leiden, Netherlands, 1986.

[1173] A. Franc and M. Luong-Skovmand. Life cycle, reproductive maturaion, and wing color changes in Nomadacris septemfasciata (Othoptera: Acrididae) in Madagascar. *Environmental Entomology*, 38(3):569–576, 2009.

[1174] W. Wickler and U. Seibt. Reproductive behaviour in Zonocerus elegans (Orthoptera: Pyrgomorphidae) with special reference to nuptual gift guarding. *Ethology*, 69(3):203–223, 1985.

[1175] A. Elamin, A. Abdalla, and A. El Naim. The biology of the Senegalese grasshopper (Oedaleus senegalensis, Krauss, 1877)(Orthoptera: Acrididae). *International Journal of Advances in Life Science and Technology*, 1(1):6–15, 2014.

[1176] B. Bughio and S. Channa. Morphological observtion on the Oedaleaus senegalensis Krauss (Orthoptera) with special reference to its phallic complex. *Sindh University Research Journal (Science Series)*, 48(2):323–326, 2016.

[1177] V. Dirsh. The Acridoidea (Orthoptera) of Madacascar II. Acrididae, Acridinae. *Bulletin of the British Museum (Natural History) Entomology*, 13(8):243–286, 1963.

[1178] T. Walker and M. Greenfield. Songs and systematics of Caribbean Neoconocephalus (Orthoptera: Tettigoniidae). *Transactions of the American Entomological Society*, 109(4):357–389, 1983.

[1179] W. Panhwar, R. Sultana, M. Wagan, Y. Wagan, S. Kumar, and F. Solangi. Taxonomy and ecology of the genus Euconocephalus Karny, 1907 (Orthoptera: Tettigonioidea: Conocephalinae) from Pakistan. *International Journal of Advanced Research*, 2(2):268–277, 2014.

[1180] A. Latchininsky. Locusts. In M. Breed and J. Moore, editors, *Encyclopedia of Animal Behavior*, volume 2, pages 288–297. Academic Press, Oxford, 2010.

[1181] M. Cigliano. Ronderosia, a new genus of South American Melanoplinae (Orthoptera: Acrididae). *Journal of Orthoptera Research*, 6:1–19, 1997.

[1182] E. Chappell. *Behaviour of a New Zealand Ground Weta, Hemiandrus pallitarsis*. Thesis, Massey University, 2008.

[1183] T. Mito and S. Noji. The two-spotted cricket Gyrllus bimaculatus: an emerging model for development and regulation studies. *Cold Spring Harbor Protocols*, 3(12):1–14, 2008.

[1184] G. Gibbs. Four new species of giant weta, Deinacrida (Orthoptera: Anostostomatidae: Deinacridinae) from New Zealand. *Journal of the Royal Society of New Zealand*, 29(4):307–324, 1999.

[1185] D. Nolte. A comparative study of seven species of Transvaal Acrididae, with special reference to the chromosome complex. *Journal of the Entomological Society of Sourthern Africa*, 1(2):196–260, 1939.

[1186] J. Ritchie. A taxonomic revision of the genus Oedaleus Fieber (Orthoptera: Acrididae). *Bulletin of the British Museum (Natural History) Entomology*, 42(3):83–183, 1982.

[1187] B. Terra, F. Gatti, M. Carneiro, and M. da Costa. The grasshoppers (Orthoptera: Caelifera) of the grasslands in the sourthern portion of the Espinhaço Range, Minas Gerais, Brazil. *Check List*, 13(1):2052, 2017.

[1188] H. Braker. Evolution and ecology of oviposition on host plants by acridoid grasshoppers. *Biological Journal of the Linnean Society*, 38(4):389–406, 1989.

[1189] J. Hilliard. Endophytic oviposition by Leptysma marginicollis marginicollis and Stenacris vitreipennis (Orthoptera: Acrididae: Leptysminae) with life history notes. *Transactions of the American Entomological Society*, 108(1/2):153–180, 1982.

[1190] P. Thomas. Life-cycle studies on Paulinia acuminata (DeGeer) (Orthoptera: Pauliniidae) with particular reference to the effects of constant temperature. *Bulletin of Entomological Research*, 70(3):381–389, 1980.

[1191] J. Rhen. A contribution to the knowledge of Acrididae (Orthoptera) in Costa Rica. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 57(2):400–454, 1905.

[1192] M. Khan, M. Usmani, and S. Usmani. Studies on the taxonomy of Oxyinae (Orthoptera: Acridoidea: Acrididae) from north-eastern states of India. *Munis Entomology & Zoology*, 11(1):202–218, 2016.

[1193] K. Sanjayan and K. Murugan. Nutritional influence on the growth and reproduction in two species of acridids (Orthoptera: Insecta). *Proceedings of the Indian Academy of Sciences (Animal Science)*, 96(3):229–237, 1987.

[1194] M. Cigliano and R. Ronderos. Revision of the South American grasshopper genera Leiotettix Bruner and Scotussa Gigliotos (Orthoptera, Acrididae, Melanoplinae). *Transactions of the American Entomological Society*, 120(2):145–180, 1994.

[1195] M. Hebard. Studies in the Demmaptera and Orthoptera of Colombia. *Transactions of the American Entomological Society*, 49(3):164–314, 1923.

[1196] S. Kawano and Y. Ando. Effects of photoperiod on nymphal development, pre-oviposition period and egg diapause in the subtropical rice grasshopper, Oxya chinensis formosana Shiraki (Orthoptera: Catantopidae). *Applied Entomology and Zoology*, 32(3):465–470, 1997.

[1197] W. Haichuan, W. Qingchuan, L. Zhibin, and Z. Zheming. Comparative study on two popultions of Oxya chinensis (Thunberg) in Shaanxi province. *Acta Entomologica Sinica*, 40(4):374–378, 1997.

[1198] D. Gwynne and A. Snedden. Paternity and female remating in Requena verticalis (Orhoptera: Tettigoniidae). *Ecological Entomology*, 20:191–194, 1995.

[1199] D. Rentz. *Tettigonidae of Australia Volume 3*. CSIRO Publishing, Collingwood, Victoria, Australia.

[1200] L. Bruner. Ten new species of Orthoptera from Nebraska. Notes on habits, wing variation etc. *The Canadian Entomologist*, 23(2):58–59, 1891.

[1201] D. Gwynne. Courtship feeding and the fitness of female katydids (Orthoptera: Tettigoniidae). *Evolution*, 42(3):545–555, 1988.

[1202] A. Forsman. Reproductive life history variation among colour morphs of the pygmy grasshopper Tetrix subulata. *Biological Journal of the Linnean Society*, 67:247–261, 1999.

[1203] H. López, H. Contreras, E. Morales, M. Báez, and P. Oromí. Distribución de Acrostira euphorbiae (Orthoptera, Pamphagidae) en la Palma (Islas Canarias). *Revista de la Academia Canaria de Ciencias*, 15(3):43–51, 2003.

[1204] N. Matojo and M. Njau. Plasticity and biosystematics of swarming of the conehead Ruspolia differens Serville (Orthoptera: Conocephalidae). *International Journal of Integrative Biology*, 9(2):97–103, 2010.

[1205] G. E. Eertmoed. The life history of Peripsocus quadrifasciatus (Psocoptera: Peripsocidae). *Journal of the Kansas Entomological Society*, 39(1):54–65, 1966.

[1206] P. J. Chapman. Corrodentia of the United States of America: I. Suborder Isotecnomera. *Journal of the New York Entomological Society*, 38(4):219–290; 319–404, 1930.

[1207] K. M. Sommerman. Bionomics of Ectopsocus pumilis (Banks) (Corrodentia, Ca. *Psyche*, 50(3):53–64, 1943.

[1208] T. R. New. *Biology of some British Psocoptera, with particular reference to species frequenting foliage*. Thesis, University of London, 1968.

[1209] R. M'Lachlan. A monograph of the British Psocidae. *The Entomologist's Monthly Magazine*, 3:226–264, 1867.

[1210] E. L. Mockford. Diagnoses, distribution, and comparative life history notes on Aaroniella maculosa (Aaron) and A. eertmoedi n. sp. (Psocoptera: Philotarsidae). *The Great Lakes Entomologist*, 12(1):1979, 1979.

[1211] E. L. Mockford. On two North American philotarsids (Psocoptera). *Psyche*, 58(3):102–107, 1951.

[1212] M. Takano-Lee, K. S. Yoon, J. D. Edman, B. A. Mullens, and J. M. Clark. In vivo and in vitro rearing of Pediculus humanus capitis (Anoplura: Pediculidae). *Journal of Medical Entomology*, 40(5):628–635, 2003.

[1213] G. F. Ferris. The louse of elephants. Haematomyzus elephantis Piaget (Mallophaga: Haematomyzidae). *Parasitology*, 23(1):112–128, 1931.

[1214] M. L. Martin. *Life history and habits of the pigeon louse (Columbicola columbae [Linnaeus])*. Thesis, William Marsh Rice Institute, 1933.

[1215] R. Maturano and E. Daemon. Reproduction, development and habits of the large turkey louse Chelopistes meleagridis (Phthiraptera: Ischnocera) under laboratory conditions. *Brazilian Journal of Biology*, 74(3):712–719, 2014.

[1216] R. L. Palma. *Phthiraptera (Insecta): A catalogue of parasitic lice from New Zealand*, volume 76 of *Fauna of New Zealand*. Landcare Research, Lincoln, New Zealand, 2017.

[1217] A. K. Saxena, Surman, S. K. Singh, and A. Kumar. Description of life history stages of poultry shaft louse, Menopon gallinae (Phthiraptera: Amblycera, Menoponidae). *Rudolstädter Naturhistorische Schriften*, 9:81–85, 1998.

[1218] B. D. Turner. Liposcelis bostrychophila (Psocoptera: Liposcelididae), a stored food pest in the UK. *International Journal of Pest Management*, 40(2):179–190, 1994.

[1219] J.-J. Wang, J. H. Tsai, Z.-M. Zhao, and L.-S. Li. Development and reproduction of the psocid Liposcelis bostrychophila (Psocoptera: Liposcelididae) as a function of temperature. *Annals of the Entomolocial Society of America*, 93(2):261–270, 2000.

[1220] G. P. Opit, J. E. Throne, and M. E. Payton. Reproductive parameters of the parthenogenetic psocid Lepinotus reticulatus (Psocoptera: Trogiidae) at constant temperatures. *Environmental Entomology*, 39(3):1004–1011, 2010.

[1221] G. P. Opit and J. E. Throne. Population growth and development of pscocid Lepinotus reticulatus at constant temperatures and relative humidities. *Journal of Economic Entomology*, 101(2):605–615, 2008.

[1222] G. Enderlein. Morphologie, systematik und biologie der Atropiden und Troctiden, sowie Zusammenstellung aller bisher bekannten recenten und fossilen Formen. *Results of the Swedish Zoological Expedition to Egypt and the White Nile, 1901, under the direction of L. A. Jägerskiöld*, 1:1–124, 1905.

[1223] E. Broadhead. The life-history of Embidopsocus enderleini (Ribaga) (Corrodentia, Liposcelidae). *Entomologist's Monthly Magazine*, 83:200–203, 1947.

[1224] B. Conti. Notes on the presence of Aeolothrips intermedius in northwestern Tuscany and on its development under laboratory conditions. *Bulletin of Insectology*, 62(1):107–112, 2009.

[1225] A. Bournier, A. Lacasa, and Y. Pivot. Biologie d'un thrips prédateur Aeolothrips intermedius [Thys.: Aeolothripidae]. *Entomophaga*, 23(4):403–410, 1978.

[1226] L. Mound. The first thrips species (Insecta, Thysanoptera) from cycad male cones, and its family level significance. *Journal of Natural History*, 25(3):647–652, 1991.

[1227] S. F. Bailey. The genus Dactuliothrips Moulton. *The Pan-Pacific Entomologist*, 13(1):121–126, 1937.

[1228] L. Mound. A taxonomic revision of the Australian Aeolothripidae (Thysanoptera). *Bulletin of the British Museum (Natural History)*, 20(2):41–74, 1967.

[1229] M. S. Hoddle, J. Jones, K. Oishi, D. Morgan, and L. Robinson. Evaluation of diets for the development and reproduction of Franklinothrips orizabensis (Thysanoptera: Aeolothripidae). *Bulletin of Entomological Research*, 91(4):273–280, 2001.

[1230] E. Larentzaki, G. Powell, and M. J. W. Copland. Effect of temperature on development, overwintering and establishment potential of Franklinothrips vespiformis in the UK. *Entomogia Experimentalis et Applicata*, 124(2):143–151, 2007.

[1231] N. Arakaki and S. Okajima. Notes on the biology and morphology of a predatory thrips, Franklinothrips vespiformis (Crawford) (Thysanoptera: Aeolothripidae): first record from Japan. *Entomological Science*, 1(3):359–363, 1998.

[1232] D. Moulton. Thysanoptera—new species and notes. *Bulletin of the Brooklyn Entomological Society*, 22(4):181–201, 1927.

[1233] D. Moulton. New American Thysanoptera. *Transactions of the American Entomological Society*, 52(2):119–128, 1926.

[1234] K. Kakimoto, H. Inoue, N. Hinomoto, T. Noda, K. Hirano, T. Kashio, K. Kusigemati, and S. Okajima. Potential of Haplothrips brevitubus (Karny) (Thysanoptera: Phlaeothripidae) as a predator of mulberry thrips Pseudodendrothrips mori (Niwa) (Thysanoptera: Thripidae). *Biological Control*, 37(3):314–319, 2006.

[1235] T. Geetha, C. A. Mahalingam, and N. Murgan. Biology of mulberry thrips, (Pseudodendrothrips mori Niwa) under Tamindau climatic condition. *International Journal of Agricultural Science and Research*, 5(2):19–26, 2015.

[1236] G. Del Bene, E. Gargani, and S. Landi. Heliothrips haemorrhoidalis (Bouché) and Frankiniella occidentalis (Pergande)(Thysanoptera Trhipidae): life cycle, hamfulness, control. *Advances in Horticultural Science*, 12(1):31–37, 1998.

[1237] G. D. Morison. Thysanoptera of the London area. *The London Naturalist*, 29(Supplement):1–131, 1949.

[1238] J. E. Ireson, R. J. Holloway, and W. S. Chatterton. Phenology and development of the gorse thrips, Sericothrips staphylinus Haliday (Thysanoptera: Thripidae), a biological control agent for gorse, Ulex europaeus L. (Fabaceae), in Tasmania. *Biological Control*, 45(1):64–71, 2008.

[1239] R. L. Hill, G. P. Markin, A. H. Gourlay, S. V. Fowler, and E. Yoshioka. Host range, release, and establishment of Sericothrips staphylinus Haliday (Thysanoptera: Thripidae) as a biological control agent for gorse, Ulex europaeus L. (Fabaceae), in New Zealand and Hawaii. *Biological Control*, 21:63–74, 2001.

[1240] M. S. Hoddle. Developmental and reproductive biology of Scirtothrips perseae (Thysanoptera: Tripidae): a new avocado pest in California. *Bulletin of Entomological Research*, 92(4):279–285, 2002.

[1241] U. S. Sharga. Biology and life history of Limothrips cerealium Haliday and Aptinothrips rufus Gmelin feeding on Gramineae. *Annals of Applied Biology*, 20(2):308–326, 1933.

[1242] T. N. Ananthakrishnan and G. Thirumalai. Population fluctuations of three species of anthophilous Thysanoptera with notes on the biology of the seed feeding species Chirothrips mexicanus Crawford. *Bulletin of the Zoological Survey of India*, 1(2):197–201, 1978.

[1243] L. Zhu, Z.-H. Wang, Y.-J. Gong, L.-J. Cao, and S.-J. Wei. Effect of temperature on the development of Echinothrips americanus Morgan (Thysanoptera: Thripidae) with special reference to the number of generations. *Journal of Asia-Pacific Entomology*, 20(4):1197–1203, 2017.

[1244] X.-W. Li, X.-C. Zhang, H.-X. Jiang, and J.-N. Feng. Comparisons of developmental and reproductive biology between parthogenetic and sexual Echinothrips americanus (Thysanoptera: Thripidae). *Environmental Entomology*, 41(3):706–713, 2012.

[1245] Z.-J. Zhang, Q.-J. Wu, X.-F. Li, Y.-J. Zhang, B.-Y. Xu, and G.-R. Zhu. Life history of western flower thrips, Frankliniella occidentalis (Thysan., Thripae), on five different vegetable leaves. *Journal of Applied Entomology*, 131(5):347–354, 2007.

[1246] P. C. J. van Rijn, C. Mollema, and G. M. Steenhuis-Broers. Comparative life history studies of Frankliniella occidentalis and Thrips tabaci (Thysanoptera: Thripidae) on cucumber. *Bulletin of Entomological Research*, 85(2):285–297, 1995.

[1247] J. G. Watts. A comparison of the life cycles of Frankliniella tritici (Fitch), F. fusca (Hinds) and Thrips tabaci Lind. (Thysanoptera: Thripidae) in South Carolina. *Journal of Economic Entomology*, 27(6):1158–1159, 1934.

[1248] K. Varikou, I. Tsitsipis, V. Alexandrakis, and M. Hoddle. Effect of temperature on the development and longevity of Pezothrips kellyanus (Thysanoptera: Thripidae). *Annals of the Entomolocial Society of America*, 102(5):835–841, 2009.

[1249] K. Varikou, A. Birouraki, I. Tsitsipis, and C. Sergentani. Effect of temperature on the fecundity of Pezothrips kellyanus (Thysanoptera: Thripidae). *Annals of the Entomolocial Society of America*, 105(1):60–65, 2012.

[1250] E. C. G. Bedford. The biology and economic importance of the South African citrus thrips, Scirtothrips aurantii Faure. *Publications, University of Pretoria*, 7:3–68, 1943.

[1251] M. S. Hoddle. Oviposition preferences of Scirtothrips perseae Nakahara (Thysanoptera: Thripidae) in Southern California avocado orchards. *The Pan-Pacific Entomologist*, 78(3):177–183, 2002.

[1252] L. Nugaliyadde and E. A. Heinriches. Biology of rice thrips, Stenchaetothrips biformis (Bagnall) (Thysanoptera: Thripidae) and a greenhouse rearing technique. *Journal of Economic Entomology*, 77(5):1171–1175, 1984.

[1253] T. C. Leskey, D. A. J. Teulon, and E. A. Cameron. Effects of temperature and sugar maple pollen on oviposition and longevity of pear thrips (Thysanoptera: Thripidae). *Environmental Entomology*, 26(3):566–571, 1997.

[1254] M. Skinner, B. L. Parker, and S. H. Wilmot. The life cycle of pear thrips, Taeniothrips inconsequens (Uzel) in Vermont. In B. L. Parker, M. Skinner, and T. Lewis, editors, *Towards Understanding Thysanoptera*, pages 435–444. US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Radnor, PA, 1991.

[1255] D. A. J. Teulon and D. R. Penman. Effects of temperature and diet on oviposition rate and development time of the New Zealand flower thrips, Thrips obscuratus. *Entomogia Experimentalis et Applicata*, 60(2):143–155, 1991.

[1256] H. Kucharczyk, M. Kucharczyk, K. Winiarcyzk, M. Lubiarz, and D. Tchórzewska. Effects of temperature on the development of Thrips nigropilosus Uzel (Thysanoptera: Thripidae) on Mentha × piperita L. and the impact of pest on the host plant. *Acta Scientarum Polonorum: Hortorum Cultus*, 18(3):219–233, 2019.

[1257] T. Ganaha-Kikumura and K. Kijima. Effects of temperature on the development and fecundity of Thrips nigropilosus (Thysanoptera: Thripidae) on Chrysanthemum morifolium (Asterales: Asteraceae). *Applied Entomology and Zoology*, 51(4):623–629, 2016.

[1258] J. J. Anyango. The life history of the chrysanthemum thrips, Thrips nigropilosus Uzel (Thripidae: Thysanoptera) and an evaluation of the effects of temperature and its life cycle. *International Journal of Tropical Insect Science*, 13(1):41–44, 1992.

[1259] M. Miyazaki and I. Kudo. Occurence of the gladiolus thrips, Thrips simplex (Morison), in Japan (Thysanoptera: Thripidae). *Applied Entomology and Zoology*, 22(2):230–232, 1987.

[1260] F. F. Smith and R. H. Nelson. Life-history studies of the gladiolus thrips (Taeniothrips gladioli M. & S.). *Journal of Economic Entomology*, 26(3):528–536, 1933.

[1261] K. Sakimura. Life history of Thrips tabaci L. on Emilia sagittata and its host plant range in Hawaii. *Journal of Economic Entomology*, 25(4):884–891, 1932.

[1262] T. Shibata, B. D. Kranz, and K. Tsuchida. Rearing method for the sporophageous thrips Bactrothrips brevitubus (Thysanoptera: Phaeothripidae: Idolothripinae). *Entomological Science*, 10(2):129–133, 2007.

[1263] B. D. Kranz, T. Shibata, K. Tsuchida, and S. Okajima. Reproductive mode and split sex ratios in the facultitively ovoviviparous thrips, Bactrothrips brevitubus. *Evolutionary Ecology Research*, 4(7):1075–1092, 2002.

[1264] L. A. Mound and D. J. Tree. Australian spore-feeding thrips of the genus Phaulothrips (Thysanoptera, Idolothripinae). *Zootaxa*, 3608(4):239–252, 2013.

[1265] L. A. Mound. Convoluted maxilliary stylets and the systematics of some Phlaeothripine Thysanoptera from Casuarina trees in Australia. *Australian Journal of Zoology*, 18(4):439–463, 1970.

[1266] L. A. Mound and A. K. Walker. Faunal relationships between Australia and New Zealand as indicated by Cartomothrips species (Thysanoptera: Phlaeothripidae). *Journal of Natural History*, 16(3):305–313, 1982.

[1267] L. C. Luong. *Investigation into aspects of the biology of tubular black thrips, Haplothrips victoriensis Bagnall (Thysanoptera: Phlaeothripidae) in South Australia*. Thesis, The University of Adelaide Australia, 2008.

[1268] T. D. Paine. Cuban laurel thrips (Thysanoptera: Phlaeothripidae) biology in southern Califronia: seasonal abundance, temperature dependent development, leaf suitability, and predation. *Annals of the Entomolocial Society of America*, 85(2):164–172, 1992.

[1269] W. D. Wiesenborn. Life stages of the anthophilous thrips Leptothrips fasciculatus (Crawford) (Thysanoptera: Phlaeothripidae). *Journal of the Kansas Entomological Society*, 85(4):332–339, 2012.

[1270] C. Loan and F. G. Holdaway. Biology of the red clover thrips, Haplothrips niger (Osborn) (Thysanoptera: Phloeothripidae). *The Canadian Entomologist*, 87(5):210–219, 1955.

[1271] M. P. Parrella, D. J. Rowe, and R. L. Horsburgh. Biology of Leptothrips mali, a common predator in Virginia apple orchards. *Annals of the Entomolocial Society of America*, 75(2):130–135, 1982.

[1272] G. Becker. Life cycle of Agapetus fuscipes (Trichoptera, Glossosomatidae) in a first-order upland stream in central Germany. *Limnologica*, 35(1):52–60, 2005.

[1273] R. Nijboer. The ecological requirements of Agapetus fuscipes Curtis (Glossosomatidae), a characteristic species in unimpacted streams. *Limnologica*, 34(3):213–223, 2004.

[1274] J. A. Nolen and R. G. Pearson. Life history studies of Anisocentropus kirramus Neboiss (Trichoptera: Calamoceratidae) in a tropical Australian rainforest stream. *Aquatic Insects*, 14(4):213–221, 1992.

[1275] M. Aurich. The life-cycle of Apatania fimbriata Pictet in the Breitenbach. *Hydrobiologia*, 239(2):65–78, 1992.

[1276] T. F. Cuffney and G. W. Minshall. Life history and bionomics of Arctopsyche grandis (Trichoptera) in a central Idaho stream. *Holarctic Ecology*, 4(4):252–262, 1981.

[1277] M. J. Winterbourn. An ecological study of Banksiola crotchi Banks (Trichoptera, Phryganeidae) in Marion Lake, British Columbia. *Canadian Journal of Zoology*, 49(5):637–645, 1971.

[1278] J. Majecki, M. Grzybkowska, and R. Reddy. Density, production and life cycle of Brachycentrus subnubilus Curtis (Trichoptera: Brachycentridae) in a lowland river, central Poland. *Hydrobiologia*, 354(1):51–56, 1997.

[1279] R. J. M. Gunn. The biology of Brachycentrus subnubilus Curtis (Trichoptera) in the River Frome, Dorset. *Hydrobiologia*, 120(2):133–140, 1985.

[1280] V. H. Resh. Life histories of coexisting species of Ceraclea caddisflies (Trichoptera: Leptoceridae): the operation of independent functional units in a stream ecosystem. *The Canadian Entomologist*, 108(12):1303–1318, 1976.

[1281] S. Alexander and L. A. Smock. Life histories and production of Cheumatopsyche analis and Hydropsyche betteni (Trichoptera: Hydropsychidae) in an urban Virginia stream. *Northeastern Naturalist*, 12(4):433–446, 2005.

[1282] V. Ross-Gillespie, M. D. Picker, H. F. Dallas, and J. A. Day. The role of temperature in egg development of three aquatic insects Lestagella penicillata (Ephemeroptera), Aphanicercella scutata (Plecoptera), Chimarra ambulans (Trichoptera) from South Africa. *Journal of Thermal Biology*, 71:158–170, 2018.

[1283] R. W. Holzenthal, R. J. Blahnik, A. L. Prather, and K. M. Kjer. Order Trichoptera Kirby, 1813 (Insecta), caddisflies. *Zootaxa*, (1668):639–698, 2007.

[1284] R. W. Holzenthal and B. Ríos-Touma. Contulma paluguillensis (Trichoptera: Anomalopsychidae), a new caddisfly from the high Andes of Ecuador, and its natural history. *Freshwater Science*, 31(2):442–450, 2012.

[1285] D. C. Houghton and K. W. Stewart. Life history and case-building behavior of Culoptila cantha (Trichoptera: Glossosomatidae) in the Brazos River, Texas. *Annals of the Entomolocial Society of America*, 91(1):59–70, 1998.

[1286] Z. B. Johnson and J. H. Kennedy. Description of the pupa of Cyrnellus fraternus (Trichoptera: Polycentropodidae), with notes on variation in pupal case construction. *Entomological News*, 108(4):253–258, 1997.

[1287] Z. B. Johnson, A. K. Riggs, and J. H. Kennedy. Microdistribution and secondary production of Cyrnellus fraternus (Trichoptera: Polycentropodidae) from snag habitats in the Elm Fork of the Trinity River, Texas. *Annals of the Entomological Society of America*, 91(5):641–646, 1998.

[1288] V. Gotceitas and H. F. Clifford. The life history of Dicosmoecus atripes (Hagen) (Limnephilidae: Trichoptera) in a Rocky Mountain stream of Alberta, Canada. *Canadian Journal of Zoology*, 61(3):586–596, 1983.

[1289] R. M. Cushman, J. W. Elwood, and S. G. Hildebrand. Life history and production dynamics of Alloperla mediana and Diplectrona modesta in Walker Branch, Tennessee. *The American Midland Naturalist*, 98(2):354–364, 1977.

[1290] J. N. Hogue and C. P. Hawkins. Morphological variation in adult aquatic insects: associations with developmental temperature and seasonal growth patterns. *Journal of the North American Benthological Society*, 10(3):309–321, 1991.

[1291] H.-S. Jin and G. M. Ward. Life history and secondary production of Glossosoma nigrior Banks (Trichoptera: Glossosomatidae) in two Alabama streams with different geology. *Hydrobiologia*, 575(1):245–258, 2007.

[1292] D. A. Wymer and J. C. Morse. Larva, pupa, and adults of Glossosoma nigrior (Trichoptera: Glossosomatidae) with a review of the eastern North American species of Glossosoma. *Entomological News*, 111(3):149–158, 2000.

[1293] C. C. Davis. A study of the hatching process in aquatic invertebrates. XVIII. Eclosion in Helicopsyche borealis (Hagen) (Trichoptera: Helicopsychidae). XIX. Hatching in Psephenus herricki (De Kay) (Coleoptera, Psephenidae). *The American Midland Naturalist*, 74(2):443–450, 1965.

[1294] C. C. Vaughn. Life history of Helicopsyche borealis (Hagen) (Trichoptera: Helicopsychidae) in Oklahoma. *The American Midland Naturalist*, 113(1):76–83, 1985.

[1295] M. A. Floyd. The larva and pupa of the caddisfly species, Helicopsyche paralimnella Hamilton (Trichoptera: Helicopsychidae). *Proceedings of the Entomological Society of Washington*, 97(1):46–49, 1995.

[1296] J. Willis, Lawrence D. and A. C. Hendricks. Life history, growth, survivorship, and production of Hydropsyche slossonae in Mill Creek, Virginia. *Journal of the North American Benthological Society*, 11(3):290–303, 1992.

[1297] H. V. S. Azvedo-Pereira, M. A. S. Graça, and J. M. González. Life history of Lepisostoma hirtum in an Iberian stream and its role in organic matter processing. *Hydrobiologia*, 559:183–192, 2006.

[1298] J. E. Jannot. Life history plasticity and fitness in a caddisfly in response to proximate cues of pond-drying. *Oecologia*, 161(2):267–277, 2009.

[1299] T. S. Gupta and K. W. Stewart. Life history and case building behavior of Molanna tryphena (Trichoptera: Molannidae) in two east Texas spring-fed streams. *Annals of the Entomolocial Society of America*, 93(1):65–74, 2000.

[1300] B. M. Hoemsen, I. D. Phillips, D. W. Parker, A. J. Bell, J. A. Bergsveinson, J. S. Armstrong, and D. P. Chivers. Extended family: a caddisfly new to Saskatchewan, Canada with notes on the life history of Neophylax splendens (Trichoptera: Thremmatidae). *The Canadian Entomologist*, 147(7):425–431, 2014.

[1301] P. K. Mendez and V. H. Resh. Life history of Neophylax rickeri (Trichoptera: Uenoidae) in two northern California streams. *Annals of the Entomolocial Society of America*, 101(3):573–584, 2008.

[1302] W. Linklater and M. J. Winterbourn. Life histories and production of two trichopteran shredders in New Zealand streams with different riparian vegetation. *New Zealand Journal of Marine and Freshwater Research*, 27(1):61–70, 1993.