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Lepidoptera as Prey of Robber Flies (Diptera: Asilidae) with Unpublished Records

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ABSTRACT

Lepidoptera as prey of robber flies and other insects have been frequently observed and documented in literature. However, these observations have not been based on such an extensive database as the Predator-Prey Database for Asilidae. An evaluation of this database and literature indicates that Lepidoptera do not make up as many prey as one would expect based on the number of described species. Potential explanations for this are discussed. Numbers of Lepidoptera prey are examined based on their associated families, genera and species, and the most frequently preyed upon genera. New records of Lepidoptera prey are presented. In both the database and the new records, more moths were preyed upon than butterflies.

Key words: Lepidoptera, Diptera, Asilidae, prey, robber flies.

INTRODUCTION

Notes concerning adult Lepidoptera being preyed upon by robber flies (Hexapoda: Diptera: Asilidae) and other insects have been published previously (Price, 1961; Neilsen, 1977). However these authors did not have access to an extensive database, so their comments were necessarily brief.

The web-based Predator-Prey Database for Asilidae (Hexapoda: Diptera) created by Lavigne (2003) currently contains approximately 58,024 prey records. However, these records do not necessarily provide exact numbers, since in many cases authors

have simply stated that "several", "multiple" or "many" of any given species were taken as prey. For the purposes of the present summary, where 'several', 'multiple' or 'many' prey are indicated, this is conservatively interpreted as two prey. On this basis, 3,072 of the records in the database are for adult Lepidoptera with only a very few representing larval records, ie. Caterpillars taken as prey. Thus, Lepidoptera represent only 5.3%, in relation to the total number of prey listed in the database. Because Lepidoptera is the second largest order of insects in terms of the number of species described, one would have expected them to have a larger representation. Fifty families, 281 genera and 332 species, as shown in Table 1, are represented; however, the total number of families of Lepidoptera in the database represent only half of the 131 described families (Pitkin & Jenkins, 2005). The purpose of the present paper is to record additional Lepidoptera prey records and to discuss the role Lepidoptera play as robber fly prey.

MATERIALS AND METHODS

Asilids and their prey were collected at various locations in the United States of America (USA), but primarily in the states of Colorado and Wyoming. The asilids were netted while feeding and the prey were separated from the asilids. Both predator and prey were subsequently pinned and placed in the University of Wyoming Insect Collection. Observations are also included where both the predator and prey were readily recognized in the field, but not collected. Asilids were identified by the authors, while prey were subsequently submitted for specific identification to taxonomists in various institutions.

RESULTS

Listed below are unpublished records of additional species of Lepidoptera that were taken as prey of robber flies during this study, for a total of 38 additions. An additional five genera and eight species of butterflies, and five genera and six species of moths can thus be added to the database: butterflies – Hesperiidae (one new species), Lycaenidae (four new genera and four new species), Nymphalidae (one new genus and two new species), and Pieridae (one new species); moths – Elachistidae (one new genus), Gelechiidae (two new species), Noctuidae (three new genera and 3 new species), Pyralidae (one new genus and one new species).

In the following prey records the scientific name of the Lepidoptera prey is presented first followed by that of the asilid predator and collection date. The sex of the predator, if known, is presented in parentheses at the end of the record.

Butterflies

HESPERIIDAE

Hesperia harpalus (Edwards)

prey of *Efferia bicaudata* (Hine). Wyoming: Platte County (Co), Douglas; 25-VIII-69; R.J. Lavigne collector (coll.)

Hesperia uncas uncas Edwards

prey of *Proctacanthus micans* Schiner. Colorado: Pawnee National Grasslands, Nunn, ?km South (S); 6-VII-69; L. Rogers (coll.) (Rogers & Lavigne 1972, as Hesperiidae)

Polites peckius (W. Kirby)

prey of *Stenopogon inquinatus* Loew. Wyoming: Fremont Co., Shoshoni, 16 km S; 25-VI-72; R. Lavigne (coll.) (female)

LYCAENIDAE

Epidemia dorcas florus (Edwards)

prey of *Scleropogon neglectus* (Bromley). Wyoming: Teton Co., Grand Teton National (Nat'l) Park, Teton Point (Pt.) overlook; 13-VIII-71; R.J. Lavigne (coll.) (female)

Chalceria heteronea (Boisduval)

prey of *Scleropogon neglectus* (Bromley). Wyoming: Teton Co., Grand Teton Nat'l Park, Teton Pt. overlook; 13-VIII-71; R.J. Lavigne (coll.) (male)

Lycaeides melissa melissa (Edwards)

prey of *Heteropogon wilcoxi* James. Wyoming: Platte Co., Hartville, 11.2 km N; 19-VII-68; R.J. Lavigne (coll.) (male)

prey of *Stenopogon inquinatus* Loew. Wyoming: Albany Co., Township (T)15North (N) Range (R)73West (W), 2,286 m; 15-VI-74; C. Ferris (coll.) (male)

prey of *Scleropogon neglectus* (Bromley). Colorado: Teller Co., Florissant Fossil Beds, T13S R71W Sec 12, 2,576 m; 13-VII-77; F.M. Brown (coll.) (male)

prey of *Stenopogon inquinatus* Loew. Wyoming: Albany Co.; 24-VI-78; R. Lavigne (coll.)

Philotes enoptes ancilla Barnes & McDunnough

prey of *Efferia pallida* (Hine). Wyoming: Platte Co., Guernsey; 29-VII-64; F.R. Holland (coll.)

NYMPHALIDAE

Cercyonis oetus charon (Edwards)

prey of *Scleropogon neglectus* (Bromley). Wyoming: Albany Co., T15N R73W, 2,286 m; 17-VII-71; R. Lavigne (coll.) (female)

prey of *Scleropogon neglectus* (Bromley). Wyoming: Teton Co., Grand Teton Nat'l Park, Teton Pt. overlook; 10-VIII-71; R.J. Lavigne (coll.) (female)

Neominois ridingsii ridingsii (Edwards)

prey of *Stenopogon inquinatus* Loew. Wyoming: Albany Co., Laramie; 26-VI-78; F. Lawson (coll.) (female)

prey of *Stenopogon neglectus* (Bromley). Wyoming: Albany Co., Laramie; 4-VII-69; R. Lavigne (coll.) (male)

Speyeria zerene ssp.

prey of *Efferia helenae* (Bromley). Wyoming: Platte Co., Wheatland; 8-IX-64; F.R. Holland (coll.) (female)

PIERIDAE

Colias alexandra alexandra Edwards

prey of *Scleropogon neglectus* (Bromley). Wyoming: Albany Co., Pole Mt., 2,591 m; 7-VIII-71; R. Lavigne (coll.) (female)

Moths

ELACHISTIDAE

Scythris sp.

prey of *Proctacanthella cacopiloga* (Hine). Wyoming: Platte Co., Guernsey, Register Cliff; 31-VII-71; R.J. Lavigne (coll.) (female)

GELECHIIDAE

Filatima xanthurus (Meyr)

prey of *Efferia frewingi* Wilcox. Wyoming: Fremont Co., Shoshoni, 16 km S; 9-IX-65; R. Lavigne (coll.)

Lita sp., prob. *variabilis*

prey of *Efferia frewingi* Wilcox. Wyoming: Fremont Co., Shoshoni, 16 km S; 9-IX-65; R. Lavigne (coll.) (female)

unidentified

prey of *Efferia helenae* (Bromley) Wyoming: Platte Co., Wheatland, 16 km NW; 21-VIII-72; D.S. Dennis (coll.) (male)

NOCTUIDAE

Apamea inordinata (Morrison)

prey of *Scleropogon inquinatus* Loew. Wyoming: Albany Co., T15N R73W, 2286 m; 15-VI-74; C. Ferris (coll.) (male)

Crymodes devastator (Brace),

prey of male Efferia frewingi Wilcox. Wyoming: Fremont Co., Shoshoni, 16 km S.; 19-VIII-92; R. Lavigne (coll.) (male)

Spaelotis sp.

prey of *Stenopogon inquinatus* Loew. Wyoming: Fremont Co., Shoshoni, 16 km S; 15-VI-72; R.J. Lavigne (coll.) (female)

Tarachidia tortricina (Zeller)

prey of *Efferia helenae* (Bromley). Wyoming: Platte Co., Wheatland, 10-IX-64; F.R. Holland (coll.) (male)

PYRALIDAE

Loxostege commixtalis (Walker)

prey of *Efferia helenae* (Bromley). Colorado: Weld Co., Nunn, 8 km N, International Biological Program (IBP) site; 23-VIII-81; E. Schreiber (coll.) (4 males, 4 females); 27-VIII-81; E. Schreiber (coll.) (female); 02-IX-81; E. Schreiber (coll.) (female)

prey of *Efferia pallida* (Hine). Wyoming: Platte Co., Guernsey, Oregon Trail Park; 30-VI-72; D.S. Dennis (coll.) (female)

Peoria sp.

prey of *Efferia helenae* (Bromley). Wyoming: Platte Co., Wheatland, 31-VIII-65; F.R. Holland (coll.)

Thaumatopsis coloradellus Kft.

prey of *Efferia helenae* (Bromley). Wyoming: Platte Co., Wheatland, 10-IX-65; F.R. Holland (coll.) (female)

Thaumatopsis sp.

prey of *Efferia frewingi* Wilcox. Wyoming: Fremont Co., Shoshoni, 16 km S.; 19-VIII-92; R. Lavigne (coll.)

Table 1. Lepidoptera in the Asilidae Predator - Prey Database (Lavigne 2005).

Families of Butterflies	**Unidentified**	**Number of Genera**	**Number of Species**
Apaturidae	0	3	4
Danaidae	0	2	2
Hesperiidae	14	18	24
Lycaenidae	26	31	39
Nymphalidae	7	38	39
Papilionidae	0	6	13
Pieridae	10	20	44
Riodinidae	0	1	1
Satyridae	7	10	12
Total	64	129	178
Families of Moths	**Unidentified**	**Number of Genera**	**Number of Species**
Acrolophidae	0	1	1
Adelidae	0	1	1
Aegeriidae	3	0	0
Agaristidae	1	0	0
Amatidae	0	1	1
Arctiidae	4	4	3
Bombycidae	0	1	1
Castanidae	2	1	1
Cochylidae	0	2	1
Coleophoridae	0	1	0
Crambidae	1	0	0
Ctenuchidae	2	0	0
Elachistidae	1	1	0
Eriocronidae	1	0	0
Ethmiidae	0	1	1
Eucosmidae	0	1	1
Gelechiidae	3	9	5
Geometridae	17	25	28
Glyphipterigidae	0	1	2
Gracillariidae	0	1	0
Hepialidae	0	1	1
Lymantridae	0	3	4
Lyonetiidae	0	1	0
Noctuidae	37	36	45
Oecophoridae	0	2	1
Olethreutidae	7	5	2
Phalonidae	1	1	0
Pterophoridae	1	2	1
Phycitidae	1	0	0
Pyralidae	28	20	32
Pyraustidae	1	2	2
Saturniidae	1	1	1
Scythrididae	0	1	0
Sesiidae	1	2	1
Sesiidae	0	3	2
Sytomidae	0	1	1
Thyrididae	0	1	1
Tineidae	10	10	6
Tortricidae	9	6	6
Yponomeutidae	0	1	1
Zygaenidae	0	2	2
Total	132	152	154
Undetermined			
Family	120		
Butterflies	12		
Moths	54		
Larvae	35		

When the new data is added to that in the Predator - Prey Database, an analysis shows that, in general, members of the same families, genera and species of adult Lepidoptera are consistently preyed upon. As shown in Table 1, the largest number of species of butterflies preyed upon belong to the families Hesperiidae, Lycaenidae, Nymphalidae, Pieridae, and Satyridae all of which frequent flowers in large numbers in the arid/semi-arid grasslands. The largest number of moth species taken as prey belong to the families Geometridae, Gelechiidae, Noctuidae, Pyralidae, and Tineidae. However, within these families the largest number of prey are represented by only a few genera and species. Table 2 provides data on families with 10 or more genera and/or species, and the genera and species with 10 or more prey records. Not surprisingly, some of the families represented (e.g., Lycaenidae, Nymphalidae, Noctuidae and Pyralidae) contain the largest number of species of Lepidoptera. Despite the fact that most moths fly at twilight or after dark, moths predominate over butterflies as prey suggesting that some species of Asilidae hunt at twilight. This is borne out by the relatively large number of robber fly specimens in collections with the notation "collected at light." Also, in Table 2, specimens representing the families and genera of Lepidoptera preyed upon are generally small to medium sized.

Table 2. Lepidoptera families with the largest number of robber fly genera and/or species prey records in the Asilidae Predator-Prey Database.

Families of Butterflies	**Genera**
Hesperiidae	*Hesperia*
Lycaenidae	*Lycaena*
Nymphalidae	*Limenitis, Melitaea, Vanessa*
Pieridae	*Colias, Eurema, Pieris, Pontia*
Satyridae	No one genus with 10 or more species and/or prey records.
Families of Moths	**Genera**
Gelechiidae	No one genus with 10 or more species and/or prey records.
Geometridae	*Aspilates, Eubolia, Ideaea, Minoa, Siona*
Noctuidae	*Agrotis, Alabama, Emmelia, Euxoa, Heliothis, Plusia*
Pyralidae	*Crambus, Nymphula, Salebria, Synophe, Titanio*
Tineidae	No one genus with 10 or more species and/or prey records.

In Table 3 are listed by subfamily and genera, robber flies preying upon Lepidoptera in the Asilidae Predator-Prey Database (using the classification scheme of Artigas and Papavero (1988) so as to be consistent with that of Londt (1993)). All 10 subfamilies of robber flies are represented among the 92 species. Members of the Asilinae took the largest number of Lepidoptera as prey (1,230) followed by those in the subfamilies Apocleinae (759), Stenopogoninae (293), Dasypogoninae (51), Leptogastrinae (39),

Table 3. Subfamilies and genera of robber flies in the Asilidae Predator-Prey Database preying upon Lepidoptera.

Subfamily Apocleinae	**Number of Prey Records**
Alcimus	142
Amblyonychus	1
Apoclea	3
Efferia Group	239
Glaphyropyga	6
Lochmorhynchus	1
Mallophora	1
Megaphorus	1
Neolophonotus	37
Philodicus	6
Proctacanthella	7
Proctacanthus	170
Promachus	130
Triorla	15
Total	759
Subfamily Asilinae	
Aneomochtherus	20
Asilus	47
Asiola	1
Astochia	4
Caenoura	1
Cerdistus	9
Clephydroneura	1
Colepia	34
Dicropaltum	3
Didysmachus	4
Dolopus	3
Dysmachus	19
Dystolmus	2
Echthistus	125
Engelepogon	20
Erebunus	2
Eremisca	14
Esatanas	1
Eutolmus	41
Filiolus	1
Heligmoneura	1
Machimus	712
Mauropteron	1
Neocerdistus	1
Neoepitriptus	1
Neoitamus	44
Neomochtherus	2
Philonicus	20
Polysarca	3
Porasilus	1
Reburrus	1
Rhadiurgus	1
Satanas	13
Threnia	1
Tolmerus	42
Trichomachimus	3
Turkiella	16
Valiraptor	2
Wyliea	1
Zosteria	12
Total	1,230

Subfamily Dasypogoninae	**Number of Prey Records**
Allopogon	1
Comantella	27
Dakinomyia	2
Dasypogon	5
Diogmites	12
Pegesimallus	4
Total	51
Subfamily Laphriinae	
Atomosia	13
Cerotainia	3
Choerades	3
Laphria	9
Laxenecera	3
Nusa	2
Oidardis	2
Proagonistes	1
Smeryngolaphria	1
Total	37
Subfamily Laphystiinae	
Laphystia	1
Total	1
Subfamily Leptogastrinae	
Euscelidia	1
Leptogaster	36
Psilonyx	2
Total	39
Subfamily Ommatiinae	
Ommatius	10
Total	10
Subfamily Stenopogoninae	
Bathypogon	10
Cyrtopogon	9
Daspletis	4
Dioctria	8
Eucyrtopogon	5
Eudioctria	1
Gonioscelis	1
Habropogon	3
Microstylum	1
Nannocyrtopogon	1
Oratostylum	1
Ospriocerus	1
Scleropogon	17
Stenopogon	231
Total	293
Subfamily Stichopogoninae	
Lasiopogon	1
Rhadinus	1
Stichopogon	1
Total	3
Subfamily Trigonomiminae	
Holcocephala	3
Total	3

Laphriinae (37), Ommatiinae (10), Stichopogoninae (3), Trigonomiminae (3) and Laphystiinae (1). Most genera within these subfamilies had less than five

Lepidoptera as prey, with many only one. Members of seven genera, however, had each collected over 100 Lepidoptera as prey: *Machimus* (712), *Efferia* Group (239), *Stenopogon* (231), *Proctacanthus* (170), *Alcimus* (142), *Promachus* (130) and *Echthistus* (125). In general, these genera contain some of the largest robber flies and their size probably contributes to their ability to capture Lepidoptera.

It is of interest to note that in the Predator-Prey Database, 35 Lepidoptera larvae were recorded as prey. This is unusual, since the majority of robber flies capture their prey in flight (Lavigne & Holland, 1969; Dennis & Lavigne, 1975; Londt, 1999). These records suggest that some asilids will capture moving prey whenever it is seen. It also implies that the larvae were captured when actively moving across the ground or vegetation, or as Londt (1999) suggests, caterpillars may have been captured when they were suspended from their silken threads.

DISCUSSION

That adult Lepidoptera consistently are less preferred as robber fly prey is shown by the following studies in which a number of researchers have noted that robber flies often concentrate their predatory efforts on members of certain orders of insects. Hobby (1931) observed that for several species of robber flies in Great Britain the order in which prey were captured was, (1) Diptera, (2) Hymenoptera, (3) Coleoptera, and (4) Lepidoptera followed by other orders. Poulton (1906) and Brues (1946) stated that robber flies prey almost exclusively on Hymenoptera, Diptera, Coleoptera, and Lepidoptera. Cole & Lovett (1921) in Oregon, USA and Melin (1923) in Sweden made similar observations. More recently, Lavigne & Holland (1969) showed that for eight species of robber flies with more than 61 prey records/species, the average number of prey consisted of, (1) Hymenoptera (35.2%), (2) Diptera (27.4%), (3) Homoptera (10.6%), (4) Coleoptera (8.5%), and (5) Ephemeroptera (8.1%). Lepidoptera and seven other insect orders each were represented by less than 3% of the prey. For 10 species of robber flies on the Pawnee National Grasslands in Colorado, USA, the average number of Lepidoptera preyed upon ranged from 0% to 11% with an overall average of 2.3% based on a total of 302 prey records and 5 to 81 prey per species (Rogers & Lavigne, 1972). Dennis & Lavigne (1975) observed that the ten species of robber flies in their study fed primarily on Hymenoptera and Homoptera, followed by Diptera, Coleoptera, and Hemiptera; Lepidoptera averaged only 4.3% of

the prey. Hespenheide and Rubke (1977), and Hespenheide (1978) showed that Lepidoptera are a small part of the prey of *Holopogon wilcoxi* Martin and *Nannocyrtopogon neoculatus* Wilcox and Martin, respectively. Out of 739 prey, Scarbrough (1978) only reported 3 Lepidoptera prey for *Cerotainia albipilosa* Curran. Lavigne & Dennis (1985) compared the feeding activity of three species of *Efferia* showing that they preyed primarily on Diptera and Homoptera followed by Lepidoptera. Dennis *et al.* (1986) reported that *Efferia cressoni* fed mostly on Diptera and Homoptera. Only 3 of 143 prey records were for Lepidoptera and it was female asilids that took them. Lavigne *et al.* (1994) indicated that 91% of the prey of *Proctacanthus* consisted of Orthoptera, Hymenoptera, and Diptera. Lepidoptera made up only 1.6% of the prey. For 16 species of robber flies in Turkey, Hayat (1997) noted that prey consisted of Hymenoptera (57.4%), Diptera (19.1%), Coleoptera (10.3%), Hemiptera (7.3%), Homoptera (4.4%), and Lepidoptera (1.5%). Other authors also have shown that Lepidoptera make up a relatively small percentage of prey of individual species of robber flies, ranging from 0% to 17%, with an average of 5.3% (Bullington & Lavigne, 1992; Dennis, 1979; Dennis & Lavigne, 1976, 1979; Lavigne, 1970, 1979, 1982, 1984; Lavigne & Bullington, 1984, 1999; Lavigne & Dennis, 1975, 1979, 1985; Lavigne *et al.* 1976, 1983; Scarbrough 1979, 1981, 1982; Scarbrough and Sraver 1979).

Conversely, in Londt's (1999) analysis of asilid prey in the Natal Museum of Africa, of which 138 were Lepidoptera records (out of a total of 1,645 prey), butterflies were chosen more often than moths. Of these, 81 were adult butterflies from the families Nymphalidae (26), Lycaenidae (23), Pieridae (22), Papilionidae and Hesperiidae (5 each).

Based on these records and the wide variety of species taken, Londt commented that "…robber flies are capable of catching virtually any butterfly." He additionally suggested that diurnal or crepuscular species of moths were taken when light levels were adequate for robber fly predation.

In his evaluations, Londt (1993, 1999) showed Lepidoptera to be prey of representatives of thirteen genera of robber flies within six subfamilies (Apocleinae, Asilinae, Dasypogoninae, Laphriinae, Leptogastrinae and Stenopogoninae) as follows, with the indicated number of prey records in parentheses: *Alcimus* (93), *Neolophonotus* (22), *Promachus* (5), *Daspletis* (4), *Pegesimallus* (3), *Neomochtherus* (2), *Nusa* (2), *Philodicus* (2), and *Euscelidia*, *Gonioscelis*, *Heligmoneura*, *Oratostylum* and *Proagonistes* (1 each).

Possible explanations for the paucity of Lepidoptera in the diet of asilids are as follows. Because approximately 95% of Lepidoptera are moths, most of which are active during the night, they may not be available.

Also, many Lepidoptera, in particular butterflies, are considerably larger (in terms of wing spread) in relation to robber flies and robber flies perceive them as being larger than they actually are. This might reduce their potential availability as prey. Body length predator to prey ratios have been analyzed by Lavigne & Holland (1969), Dennis & Lavigne (1975), and Lavigne & Dennis (1985). These authors recorded average predator to prey ratios of 3.05, 2.6, and 2.3, respectively. This data suggests that an asilid attacks prey that is considerably smaller than itself by approximately 2 to 3 times. Scarbrough (1978) commented that *Cerotainia albipilosa* prey were soft bodied, weak flyers and averaged 6 mm in length with an average predator to prey ratio of 3.7. Thus, size may preclude many species of butterflies and moths from becoming prey.

Additionally, there may be fewer Lepidoptera in the areas where robber flies more frequently occur, although this is unlikely. On a worldwide basis, the majority of robber fly species occur in semi-arid and arid grassland habitats. These areas may have fewer Lepidoptera in comparison to warmer, tropical areas and areas with more vegetation. Therefore, the types of habitat where robber flies occur and the lower relative abundance of Lepidoptera would result in fewer Lepidoptera being preyed upon in relation to insects in other Orders.

Lepidoptera and robber flies may occupy different zones within a habitat. Among others, Lehr (1969) and Londt (1994) have commented on zonation in habitat exhibited by foraging robber flies. It has been noted by Lavigne & Dennis (1985) that three species of *Efferia* in Mexico made prey selections from the separate zones they inhabited. This explanation is highly unlikely since both Lepidoptera and asilids frequent flowers in great numbers where asilids prey on visiting Hymenoptera.

Some researchers have commented on robber flies utilizing color to select prey (Bohart, 1958; Linsley, 1960). Dennis *et al.* (1975) showed that *Efferia frewingi* Wilcox preferred black, oblong models. Thus, color may play a role in the Lepidoptera that are selected as prey, in particular those of darker color such as many moths.

It is probable that a combination of factors has led to the evolution of the ability of Lepidoptera to avoid capture, just as certain species have evolved mimicry for avian predator avoidance. Flight patterns of Lepidoptera may preclude them as prey items;

certainly the 'Literature' is replete with instances of moth evasion as it relates to bats. Lepidoptera may be just as capable of avoiding predatory flies, even though Londt (1999) has suggested that asilids prey on any available butterfly.

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