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A Survey of the Robber Flies (Diptera: Asilidae) of Ira and Reatha T. Post Wildlife Sanctuary, McDonough County, Illinois USA

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ABSTRACT

Robber flies (Diptera: Asilidae) represent a diverse family of predatory insects of potential importance to conservation biology. Diversity and vertical distribution of forest robber flies were studied at Western Illinois University's Ira and Reatha T. Post Wildlife Sanctuary from May to October 2008. Canopy traps were used to collect robber flies in the lower and upper understory. *Leptogaster flavipes* Loew was the most abundant robber fly collected, comprising 43.5% of total captures. Overall, robber flies were significantly more abundant in the lower traps, but diversity and species composition/relative abundance were similar in lower and upper traps. Robber flies were most abundant in June, due primarily to the abundance of *L. flavipes* during that month. These results indicate that *L. flavipes* is a substantial component of the robber fly fauna at Post Wildlife Sanctuary. Robber flies are present and active in the upper understory, but the upper understory does not harbor a robber fly fauna distinct from the lower understory.

INTRODUCTION

Robber flies (Diptera: Asilidae) represent a large family of predatory insects with roughly 1,000 North American species and over 7,000 species worldwide (Borror et al., 1989; Ghahari et al., 2007). They are found throughout most of the world on all continents except Antarctica (Wood, 1981). Robber flies are aerial predators that usually capture insects in flight. Strong raptorial legs are used in capturing prey, which is stabbed with a piercing proboscis. The robber fly then injects paralyzing saliva and proteolytic enzymes into its victim, and the liquefied contents of the prey are sucked out (Kahan, 1964). Some robber flies can successfully prey on well defended insects such as bees and wasps (Wood, 1981). Greatest robber fly species richness is found in dry, open environments; relatively few species inhabit forests (Ghahari et al., 2007). Forest robber flies are relatively poorly studied compared to those of more open, arid environments.

Robber flies are top insect predators, and many species have specialized habitat associations which can make them vulnerable to habitat destruction but also valuable bioindicators (van Veen and Zeegers, 1998; Barnes et al., 2007). Microclimatic conditions appear to have a strong effect on activity patterns of some robber fly species as well (O'Neill et al., 1990; O'Neill and Kemp, 1992). Their distinctive appearance and relatively large size make robber flies one of the few dipteran groups with potential for targeting by nonspecialist collectors, making it possible to obtain adequate sample sizes over large geographic areas. Robber flies thus have potential importance as subjects of conservation research (Larsen and Meier, 2004).

The Ira and Reatha T. Post Wildlife Sanctuary is a 57 ha property acquired by Western Illinois University in 2003. The Sanctuary is primarily upland oak-hickory forest that surrounds the former site of a small resort town known as Vishnu Springs that existed in the late 1800s-early 1900s (Taylor, 2008). The site has remained relatively undisturbed for several decades, and now represents a large tract of forest habitat surrounded by agricultural lands. The site represents an excellent opportunity to document the insect diversity of a relatively undisturbed west-central Illinois forest. The objectives of this study were to: 1) assess the diversity of forest robber flies at Post Wildlife Sanctuary, 2) compare abundance and diversity of robber flies between the lower and upper forest understory, and 3) examine seasonal patterns of robber fly abundance and diversity.

MATERIALS AND METHODS

This study was conducted from May to October 2008 at the Ira and Reatha T. Post Wildlife Sanctuary (N 40° 25' 59", W 90° 53' 49"), which is located ca. 6.5 km northwest of the town of Tennessee, in McDonough Co., Illinois USA. The sanctuary is primarily upland oak-hickory forest with common overstory species including shagbark hickory (*Carya ovata* (Miller) K. Koch.), black walnut (*Juglans nigra* L.), black oak (*Quercus velutina* Lam.), white oak (*Quercus alba* L.), and northern red oak (*Quercus rubra* L.). Elm (*Ulmus* sp. L.), wild black cherry (*Prunus serotina* Ehrh.), and ironwood (*Ostrya* sp. Scop.) are common understory species. Plant nomenclature follows that of Gleason and Cronquist (1991).

Canopy traps were used to collect robber flies. These are a form of malaise trap (Malaise, 1937), which is a flight interception trap with a mesh barrier that allows insects to fly into the barrier, move upward due to phototactic behavior, and become trapped in a collection container. They are effective in capturing active flying insects including Diptera (Ozanne, 2005). Each trap had an effective trapping surface on each side of 1.45 m high and 1.30 m wide, with an open bottom and a collection bottle located at the top of the trap. Six of these traps were set, with three located in the lower understory near the forest floor (lower edge of the traps 0.5 m from the ground) and three located in the upper understory (lower edge of the traps 3.5 m from the ground). Traps were arranged in pairs, with lower and upper traps within 25 m of each other. Pairs were arranged in a transect, with the midpoint of trap pairs 75 m apart. Collection bottles were filled with 75% EtOH. These bottles were collected weekly and replaced with a bottle containing fresh EtOH. Robber flies were collected from the samples, pinned, labeled, and identified. Traps were operated continuously from 26 May to 20 October 2008.

Robber fly species richness was determined for each understory level. Because species richness is associated with sample size, rarefaction was used to evaluate species richness of the two levels. Rarefaction provides an estimate of the expected number of species for a given sample size (Krebs, 1999). The University of Alberta Department of Biology online rarefaction calculator (http://www.biology.ualberta.ca/jbrzusto/rarefact.php #Calculator, last accessed 10 August 2009) was used to obtain rarefaction estimates and 95% confidence intervals. The binomial test was used to compare numbers of robber flies collected in the lower vs. upper traps. For all species combined, expected values were based on a 50/50 distribution of captures in lower vs. upper traps. Binomial tests were also used to compare numbers of the two most common species of robber flies captured in lower vs. upper traps. This was done 1) using expected values based on a 50/50 distribution of captures in lower vs. upper traps, and 2) using expected values based on the overall distribution of robber flies captured in lower vs. upper traps (70.2% vs. 29.8%). Fisher's exact test was used to examine potential associations between sex and understory level.

Simpson's diversity index (Simpson, 1949) was used to measure robber fly diversity at each understory level. Simpson's index considers the number of species (species richness) as well as the evenness in the proportion of the total that occurs for each species. It represents the probability that two randomly selected individuals will belong to different species, and can range from 0 to 1. Simpson's indices of lower and upper traps were compared using a *t*-test, with variances for each sample approximated based on the proportions of the total number of individuals occurring in each species. The test statistic is compared to 1.96, the critical value of Student's t, for infinity degrees of freedom at alpha = 0.05. The above method is described in Keefe and Bergersen (1977) and Brower et al. (1998).

The multi-response permutation procedure (MRPP) was used to compare robber fly species composition/relative abundance between the two understory levels and to examine heterogeneity of robber fly species composition/relative abundance within each level. MRPP is a nonparametric statistical technique for testing the hypothesis of no difference in two or more groups, such as species composition/relative abundance between two or more habitats (McCune and Grace, 2002). MRPP provides a measure of within-group homogeneity (A), which increases as the communities in different groups deviate, to a maximum of 1. An A value greater than 0.3 suggests substantial differences between groups (McCune and Grace, 2002). MRPP also provides a "distance measure" of within-group heterogeneity. This distance measure ranges from 0 to 1, with higher values reflecting greater heterogeneity of species composition/relative abundance among traps at a particular level.

RESULTS

A total of 131 robber flies, representing fourteen species and ten genera, were collected during the study (Table 1). All 14 species were collected in lower traps, whereas 10 species were collected in upper traps. Observed species richness was within 95% confidence intervals of expected richness based on rarefaction for each trap level (Table 1). Simpson's diversity index was 0.769 for the lower traps and 0.807 for the upper traps. There was no significant difference in diversity indices between lower and upper traps (t = 0.5770, df = ∞, $P > 0.5$).

Across the entire season, mean numbers of robber flies collected per trap (± SE) were 30.7 ± 10.1 for the lower traps (min = 16, max = 50) and 13.0 ± 2.5 for the upper traps (min = 8, max = 16). Overall, there was a significantly greater number of robber flies collected in the lower traps (92) than in the upper traps (39) ($P = 0.000004$, binomial test). *Leptogaster flavipes* Loew and *Ommatius gemma* Brimley were the most abundant species, representing 56.5 % of total captures. Species identifications of *Leptogaster* are generally done by examining male genitalia; females are difficult to identify to species level. Since all 28 male *Leptogaster* were identified as *L. flavipes*, we assumed that female *Leptogaster* were *L. flavipes* as well. Both *L. flavipes* and *O. gemma* were significantly more abundant in lower than upper traps ($P = 0.0013$ and $P = 0.013$, respectively, binomial test), however in neither case was the relative frequency between trap levels different from that of all robber flies ($P = 0.8851$ and $P = 0.4267$, respectively, binomial test). The proportion of males vs. females collected did not vary significantly between trap levels for all species ($P = 0.4327$, Fisher's exact test) nor for *L. flavipes* ($P = 0.3786$, Fisher's exact test). There was a small but significant difference in species composition/relative abundance between trap levels based on results of MRPP ($A = 0.0796$, $P = 0.0295$). Distance measures for lower and upper traps were 0.5739 and 0.4311, respectively.

The earliest robber flies, *Laphria index* McAtee, *Machimus* sp. Loew, and *Neoitamus flavofemoratus* (Hine), were collected on 9 June, and the latest, *Neomochtherus auricomus* (Hine) on 29 September. June was the most active month for robber fly captures with 52, and the peak collection occurred on 23 June (Fig. 1). In general, lower traps collected substantially more robber flies than upper traps throughout the season, but greater numbers were captured in upper than lower traps in mid-July collections (Fig. 1). With regard to the two most common robber fly species, captures of *L. flavipes* occurred from the 16 June to 4 August collection dates, peaking on the 23 June collection date. Captures of *O. gemma* occurred from the 21 July to 15 September collection dates (Fig. 2).

DISCUSSION

Our results revealed no significant differences in species diversity or richness (based on rarefaction) in relation to trap height, but robber fly abundance was greater in the lower understory traps, with 70.2% of captures occurring there. The more dense vegetation near ground level probably provides more perching locations for robber flies, and many robber fly species also use stones, logs, or the ground itself as perching surfaces (Wood, 1981). However, our results also show that robber flies are not uncommon in the upper understory. Little research has been done comparing insect abundance and diversity at different understory levels. Hill and Cermak (1997) found nearly 30-fold greater abundance of Diptera at ground level vs. 5 m above ground level in a northern Queensland, Australia rain forest, using flight interception traps, versus our 2.4-fold difference. Their study did not include species-level identifications, and included all dipterans (except nematoceran flies), meaning that many small, weakly flying species were included. Many of these species are probably unlikely to fly very far above ground level, unlike robber flies which are generally strong fliers. There was little difference in species composition/relative species abundance between upper and lower traps in our study, based on MRPP. This suggests that individual robber fly species have vertical distributions that encompass at least the height differential of our traps.

The two most common species of robber flies found at Post Wildlife Sanctuary were *L. flavipes* and *O. gemma* (Table 1). *Leptogaster flavipes* is a member of the subfamily Leptogastrinae, commonly known as "grass flies." Leptogastrines possess several morphological and behavioral characteristics that differ from other asilids. Leptogastrines capture primarily stationary prey, whereas other asilids generally capture moving prey (Martin, 1968). In a study using malaise traps and aerial nets, Scarbrough and Sipes (1973) found *L. flavipes* to be common in a hardwood forest in Baltimore Co., Maryland, and suggested that these flies tend to be associated with humid areas with dense undergrowth. Post Wildlife Sanctuary has received little or no management for control of understory vegetation and consequently has a relatively dense understory which appears to provide favorable habitat for *L. flavipes*. Scarbrough and Sipes (1973) observed that *L. flavipes* generally fly at "a height of 1 to 2 feet below and between branches of low plants covering the forest floor," but their study evidently did not include collection attempts higher in the understory. Our results show that *L. flavipes*, while most abundant in the lower understory, can be found higher in the understory as well.

McAtee and Banks (1920) reported *L. flavipes* to be active in the Washington, D.C. area from late May to early September, and Scarbrough and Sipes (1973) found this species to be most abundant in July in Maryland, with lower numbers in June and August. Our results agreed most closely with those of Scarbrough and Sipes (1973), although we found *L. flavipes* to be most abundant in late June (Fig. 2). Overall abundance of robber flies in June in our study was driven primarily by the abundance of *L. flavipes* (Figs. 1 and 2). Along with much of the Midwestern USA, west-central Illinois received large amounts of rainfall that resulted in substantial flooding during June 2008. In light of the apparent association of *L. flavipes* with high humidity environments (Scarbrough and Sipes, 1973), it is possible that wet conditions during June were favorable for increased *L. flavipes* abundance and activity. We collected *O. gemma* from mid-July to early September (Fig. 2), which is consistent with previous collections of this species in west-central Illinois (McCravy et al., in press).

Species composition of robber flies collected at Post Wildlife Sanctuary differed somewhat from that of previous collections in west-central Illinois. Two species collected in the present study, *N. flavofemoratus* and *N. auricomus*, were not found in malaise trap collections of over 300 robber flies in oak-hickory forests at Alice L. Kibbe Life Science Station in Hancock Co., approximately 65 km east of Post Wildlife Sanctuary (K. W. McCravy and K. A. Baxa, unpublished data). Conversely, the leptogastrine *Psilonyx annulatus* was relatively abundant at Kibbe Life Science Station, but uncommon in the present study. Unlike Post Wildlife Sanctuary, Kibbe Life Science Station consists of a mosaic of forest and prairie habitats that are intensively managed with prescribed fire (McCravy et al., 2009), which may produce environmental conditions conducive to a somewhat different robber fly species composition. More research on the habitat requirements of robber flies and effects of habitat disturbance on robber flies is needed.

In summary, *L. flavipes* was by far the most abundant robber fly species found at Post Wildlife Sanctuary, with *O. gemma* also being relatively abundant. Robber flies were most abundant in the lower understory, but robber fly diversity and species composition/relative abundance were similar in lower and upper traps. These results suggest that robber flies are most abundant at lower levels, but still may be present at substantial distances above ground level. However, the upper understory does not appear to harbor a distinct robber fly fauna. Robber flies are probably ecologically important components of the upper understory environment, but our results suggest that information obtained from robber fly studies in the lower understory for ecological monitoring purposes would be representative of the upper understory as well in the hardwood forests of the Midwest.

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Table 1. Numbers, species richness, rarefaction estimates of species richness (with 95% confidence intervals) and species diversity of robber flies captured in lower and upper understory canopy traps in a west-central Illinois upland oak-hickory forest. Traps were operated continuously from 26 May to 20 October 2008 in McDonough Co., Illinois USA. Percentages do not sum to 100.0 due to rounding error.

Species	Lower Traps	Upper Traps	Total	% of Total
Diogmites neoternatus (Bromley)	2	0	2	1.5
Heteropogon macerinus (Walker)	5	2	7	5.3
Laphria divisor (Banks)	1	0	1	0.8
Laphria index McAtee	6	2	8	6.1
Laphria thoracica Fabricius	1	0	1	0.8
Leptogaster flavipes Loew	41	16	57	43.5
Machimus antimachus (Walker)	3	3	6	4.6
Machimus sp. Loew	5	1	6	4.6
Neoitamus flavofemoratus (Hine)	5	3	8	6.1
Neomochtherus auricomus (Hine)	4	4	8	6.1
Nerax aestuans (L.)	1	0	1	0.8
Ommatius gemma Brimley	14	3	17	13.0
Ommatius ouachitensis Bullington & Lavigne	2	4	6	4.6
Psilonyx annulatus (Say)	2	1	3	2.3
Total Captured	92	39	131	100.1
Species Richness	14	10	14	
Rarefaction Estimate	12.99 ± 0.845 (11.32 – 14.66)	10.47 ± 1.1974 (8.12 – 12.82)		
Simpson's Diversity	0.7688	0.8070		

Figure 1. Weekly collections of robber flies captured in lower and upper understory canopy traps in a west-central Illinois upland oak-hickory forest. Traps were operated continuously from 26 May to 20 October 2008 at Ira and Reatha T. Post Wildlife Sanctuary in McDonough Co., Illinois USA.

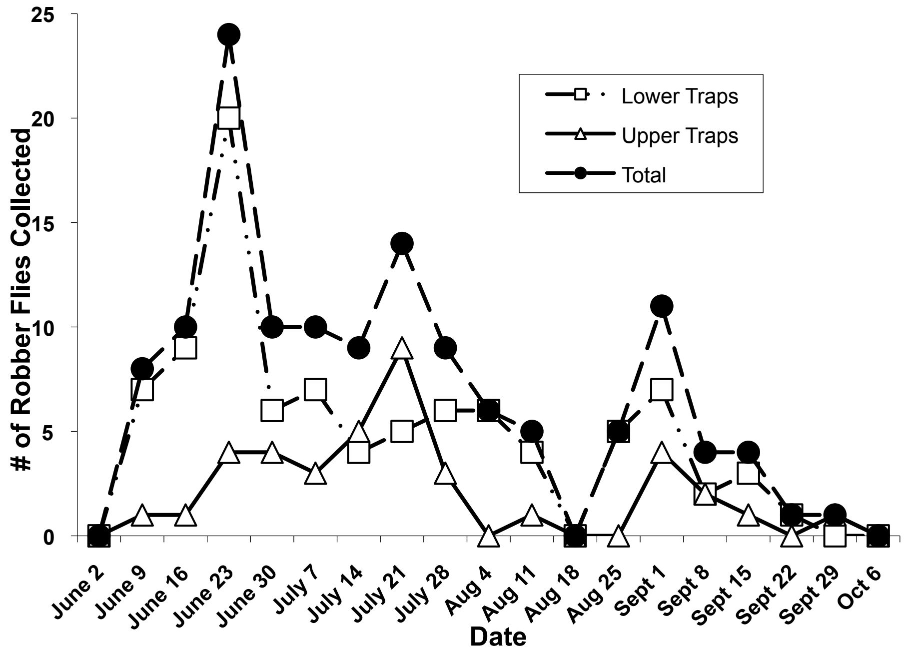
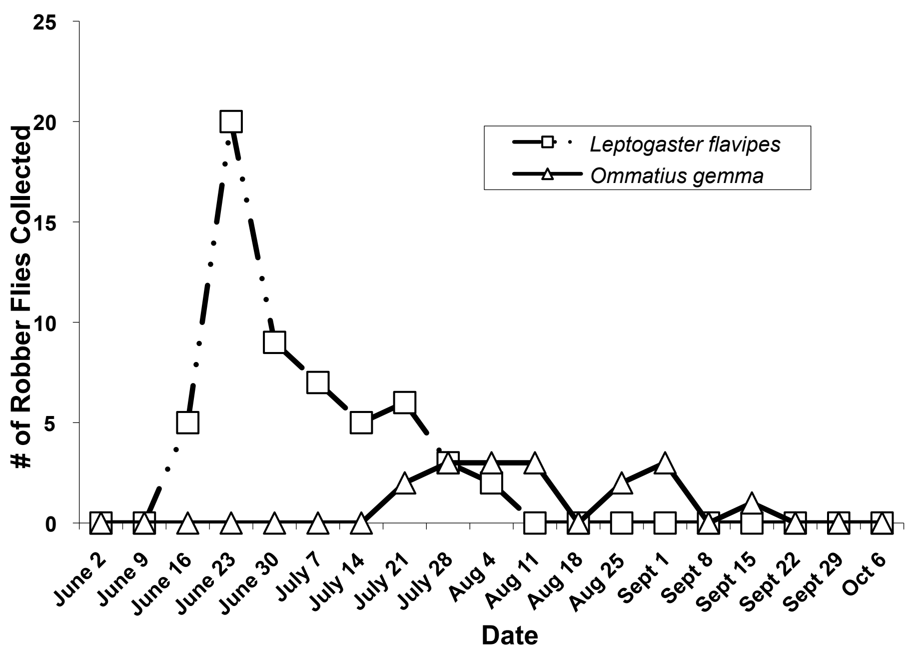


Figure 2. Weekly collections of two species of robber flies captured in canopy traps in a west-central Illinois upland oak-hickory forest. Traps were operated continuously from 26 May to 20 October 2008 at Ira and Reatha T. Post Wildlife Sanctuary in McDonough Co., Illinois USA.



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