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Diurnal/Nocturnal Activity of Rove Beetles (Coleoptera: Staphylinidae) on Barro Colorado Island, Panama Assayed by Flight Intercept Trap

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Abstract

A flight intercept trap was used for 12 days on Barro Colorado Island, Panama, to assay the diversity of staphylinid beetles, and to provide data on which are diurnal and/or nocturnal. The trap was sampled twice over a 24 h period, providing data for diurnal/nocturnal activity for these beetles. In total 1,349 specimens and 35 genera of Staphylinidae were caught, representing nine subfamilies. Of these 1,349 specimens, 1036 (76.8%, $P < 0.01$ *t*-test) were caught during the day, and 313 (23.2%) were caught during the night. Aleocharinae is the most abundant subfamily (57.5%), followed by Staphylininae (13.1%). Details are given for the diurnal/nocturnal activity of each taxon captured.

The rove beetle family Staphylinidae is one of the two largest families of beetles with over 46,200 described species in almost 3,200 genera (Newton *et al.* 2001). These beetles can be found in almost every conceivable habitat where they utilize a huge variety of food sources (Hanley 2001). Staphylinidae most often occur in association with decaying organic materials, as parasites of birds and mammals, as inquilines of social insects, in fungi, leaf litter, caves, under the bark of fallen trees, and numerous other habitats. Staphylinid beetles are most frequently predators of other insects where both adults and larvae ingest solid food or ingest liquid food after a process of pre-oral digestion (Chatzimanolis 2003). Even though some taxonomic attention has been given to the family over the last 20 years, especially at higher taxonomic levels, the group remains very poorly known, and few studies have focused on the behavior or the ecology of these beetles. In spite of their abundance and ecological importance, little is known regarding the daily activity patterns of this important group of beetles. Herein, we present an analysis of diurnal/nocturnal activity patterns of rove beetles over a 12 day period on Barro Colorado Island as assayed with flight intercept traps, and discuss the differences in day/night activity among different subfamilies and genera within the Staphylinidae.

The flight intercept trap (FIT) is one of the most effective collecting techniques for the adult beetles of family Staphylinidae (Peck and Davies 1980; Masner and Goulet 1981; Chandler and Peck 1992; Hill and Cermak 1997; Grove 2000; Gnaspini *et al.* 2000; Khen *et al.* 2002). This method for collecting arthropods is a modification of the classic windowpane trap (Chapman and Kinghorn 1955; Nijholt and Chapman 1968; Wilson 1969; Canaday 1987; Muirhead-Thomson 1991), which uses a central "pane" of fine woven insect netting instead of a pane of glass as a barrier to flying insects. Over

Fig. 1. A set up for the flight intercept trap. Photograph by R. S. Hanley.

the years it has been modified from its original design to serve collecting areas such as the forest canopy (see for example Hill and Cermak 1997), and to be more light and compact (see methods). Today, FITs are commonly used all over the world to sample flying insects in a wide variety of systematic and ecological studies.

Materials and Methods

Flight Intercept Trap Design and Setup. The FIT (Fig. 1) consisted of screen netting, a plastic rainhood and eight aluminum baking pans. We put up traps in the following order: we selected the site with attention to space needed and possible attachment sites for the screen netting and the rainhood. We attached the screen netting (180 cm width × 120 cm length) to appropriate trees and staked down the bottom corners using sticks cut from available undergrowth. The screen was perpendicular to the ground and tight after it was staked down, with just enough room for the pans. We then attached the rainhood (usually 3 × 4 meters) to trees such that it was suspended about 10–20 cm above the trap. One side of the rainhood was set to be lower than the other so that rain would run off rather than puddling in the hood. We cleaned the space under the trap to put the pans. The pans (20.3 cm × 20.3 cm × 4.4 cm) were arranged side by side and filled with 50:50 mix propylene glycol ("radiator coolant" or "antifreeze") and water; a small amount of formaldehyde was added to prevent animals from drinking the mixture. It usually took three liters of fluid to fill an eight-pan trap. We added a few drops of liquid dishwashing soap to the fluid to break the surface tension so that beetles would sink rather than float on the surface film.

It took about 20–30 minutes for one person to setup a FIT and about 15 minutes to collect the specimens from the trap. The advantage of this setup in contrast with previous setups found in the literature was that it was very lightweight and compact, easily set up in a diversity of habitats, and could be transferred easily from one area to another.

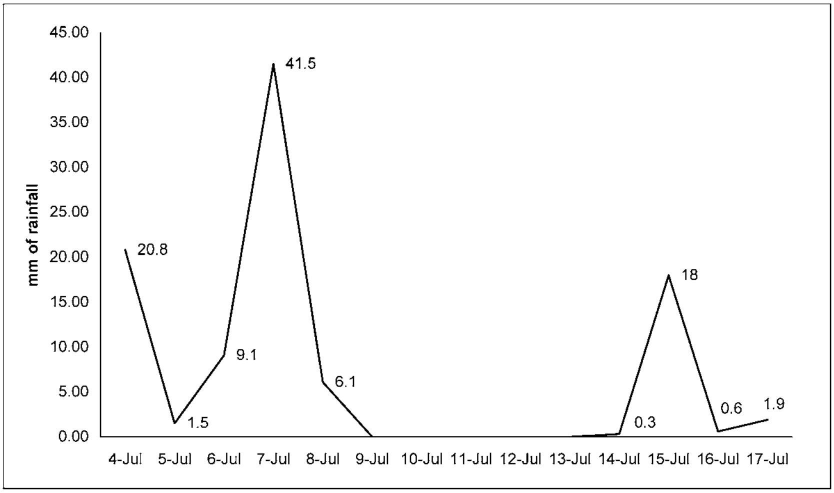

Fig. 2. Daily rainfall (mm) on BCI for the period of study recorded at 900 h.

Study Site and Sampling. Barro Colorado Island is located in the middle of the Panama Canal and has been an area of extensive ecological work. A FIT was set up on Barro Colorado Island (BCI), Panama, 09°10′N 79°51′W, from the night of July 5th until July 16th 2000. The FIT was set up approximately 150 m from the beginning of the Donato trail, in secondary-growth rainforest, at approximately 35 m above sea level. The minimum average shaded air temperature for July 2000 was 24.2°C and the maximum average shaded air temperature was 27.5°C. The average relative humidity for July 2000 was 95.9% (measured at 12:30 pm). Daily rainfall for the period of the study is reported in Figure 2. Samples were collected twice during a 24-hour period for 12 days. The first collecting event was from 5:55 am ±5 m to 6:25 pm ±5 m ("day"), and the second collecting event was to 6:25 pm ±5 m to 5:55 am ±5 m ("night"), which corresponds roughly with the sunrise and sunset periods, respectively. The taxa caught in the FIT were transferred to NascoWhirl-Pak® plastic bags with 95% alcohol. The taxa were sorted later in the laboratory into families, subfamilies, and genera. Voucher specimens have been deposited in the Snow Entomological Collection, Natural History Museum, University of Kansas.

Results

In total, 1,349 specimens and 35 genera of Staphylinidae were caught in the FIT over a 12 day and night period (Table 1). Of these 1,349 specimens, 1,036 (76.8%, $P < 0.01$ *t*-test) were caught during the day, and 313 (23.2%) were caught during the night. The 35 genera belong to nine different subfamilies (Table 1). The relative abundance and the percentage of each subfamily is presented in Figure 3. The total number of specimens of staphylinids caught per collection event is shown in Figure 4. We also provide figures for the most speciose subfamilies of this study. The total number of specimens of Staphylininae caught per collection event is shown in Figure 5 and that of Aleocharinae in Figure 6.

Most specimens belonging to the subfamily Staphylininae (88.7%, $P < 0.01$ *t*-test) were caught during the day. Only one genus (*Paederomimus*) was sampled exclusively

Table 1. List of genera and subfamilies caught by FIT divided between day and night traps.

Taxon	Day traps	Night traps	Total
STAPHYLININAE			
Eulissus chalybaeus	35	0	35
Nausicotus spectabilis	32	0	32
Nordus fungicola	41	0	41
Elmas sp.	1	0	1
Dysanellus sp.	14	0	14
Philothalpus sp	13	0	13
Quedius sp.	2	0	2
Paederomimus sp.	0	2	2
Xenopygus analis	2	0	2
Atanygnathus sp.	6	2	8
Scytalinus sp.	2	0	2
Tesba sp.	1	0	1
Misc. Xantholinini	9	16	25
TOTAL STAPHYLININAE	158	20	178
TACHYPORINAE			
Coproporus sp.	118	8	126
Sepedophilus sp.	2	1	3
Bryoporus sp.	4	0	4
Vatesus sp.	0	7	7
TOTAL TACHYPORINAE	124	16	140
PAEDERINAE			
Neolindus sp.	4	0	4
Dibelonetes sp.	0	1	1
Palaminus sp.	5	1	6
Monista sp.	4	0	4
Misc. Paederinae	23	90	113
TOTAL PAEDERINAE	36	92	128
ALEOCHARINAE			
Zyrastilbodes sp.	36	5	41
Zyras sp.	3	0	3
Hoplandria sp.	141	41	182
Aleochara sp.	46	0	46
Orphnebius sp.	26	2	28
Ophioglossa sp.	6	1	7
Probrachida sp.	1	0	1
Misc. Aleocharinae	364	109	473
TOTAL ALEOCHARINAE	623	158	781
OSORIINAE			
Espeson sp.	2	0	2
Lispinus sp.	1	1	2
Clavilispinus sp.	8	1	9
Nacaeus sp.	0	3	3
TOTAL OSORIINAE	11	5	16
OXYTELINAE			
Anotylus sp.	65	15	80
Carpelimus sp.	1	4	5
TOTAL OXYTELINAE	66	19	85

Table 1. Continued.

Taxon	Day traps	Night traps	TOTAL
MEGALOPSIDIINAE			
Megalopinus sp.	9	0	9
SCAPHIDIINAE			
Cyparium sp.	5	0	5
Misc. Scaphidiinae	1	0	1
TOTAL SCAPHIDIINAE	15	0	15
PSELAPHINAE			
Misc. Pselaphinae	3	3	6
GRAND TOTAL	1,036	313	1,349

at night and only one other genus (*Atanygnathus*) was partially sampled (2/6) during the night. Most Aleocharinae (79.7%, $P < 0.01$ t-test) were collected during the day, although in this case only three of seven genera (*Zyras*, *Aleochara* and *Probrachida*) were collected exclusively during the day. The subfamilies Megalopsidiinae and Scaphidiinae were sampled exclusively during the day, while the subfamily Pselaphinae was sampled equally during day and night. The subfamily Tachyporinae was sampled primarily during the day (88.57%), but only four genera were sampled and the vast majority of the specimens belong to the genus *Coproporus* (90%). The genus *Vatesus* was sampled exclusively during the night, while the genus *Bryoporus*

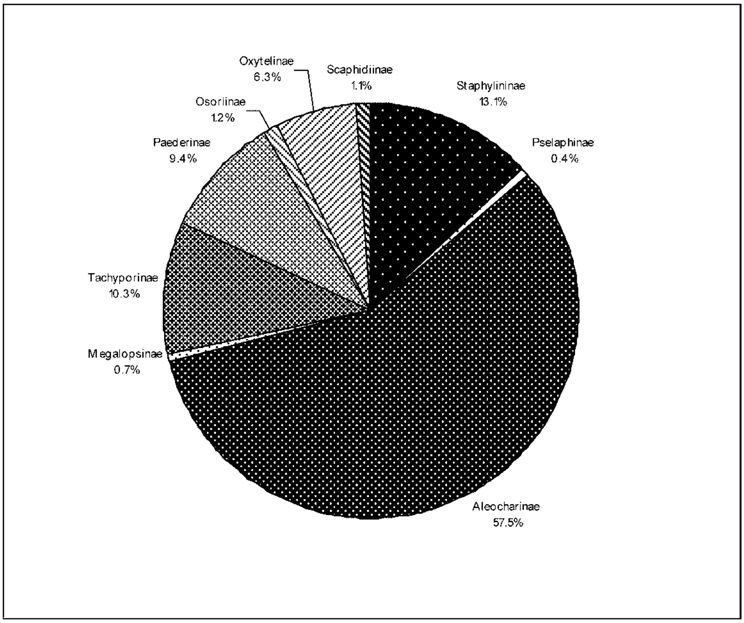

Fig. 3. Relative abundance of different subfamilies of Staphylinidae.

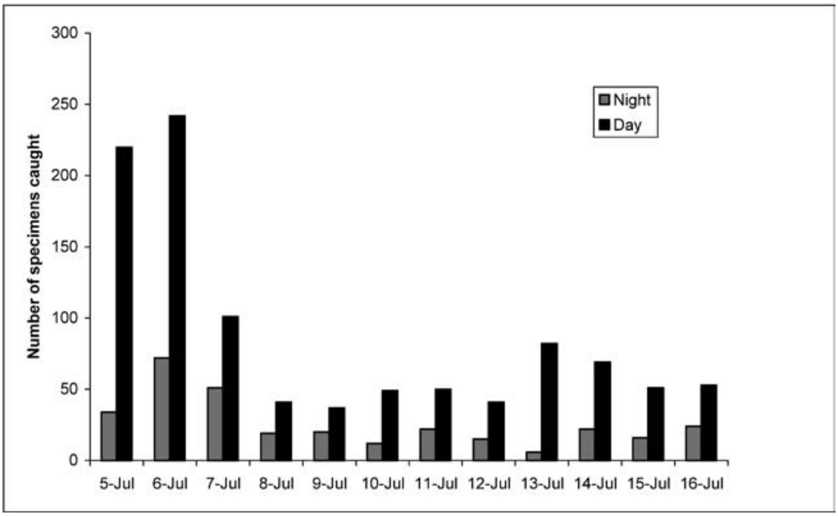

Fig. 4. Total number of Staphylinidae collected per collection event.

exclusively during the day. The subfamily Osoriinae was sampled primarily during the day (68.75%), the genus *Espeson* was sampled only during the day and the genus *Nacaeus* only during night. The subfamily Oxytelinae was sampled primarily during day (77.64%) with the vast majority of specimens belonging to the genus *Anotylus* (94.11%). The Paederinae was the only subfamily that showed more activity during the night (71.87%) than day. Two genera were sampled only during the day (*Neolindus* and *Monista*) and one only during the night (*Dibelonetes*). The majority of unidentified Paederinae were caught during the night (79.64%).

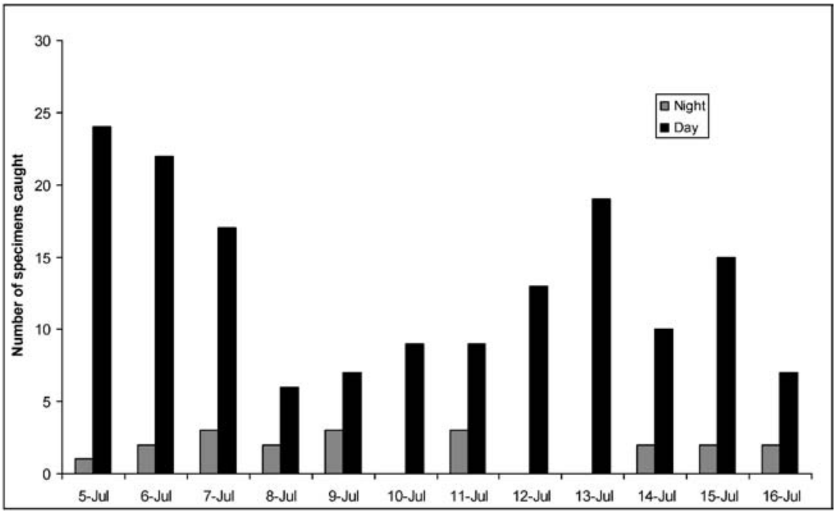

Fig. 5. Total number of Staphylininae collected per collection event.

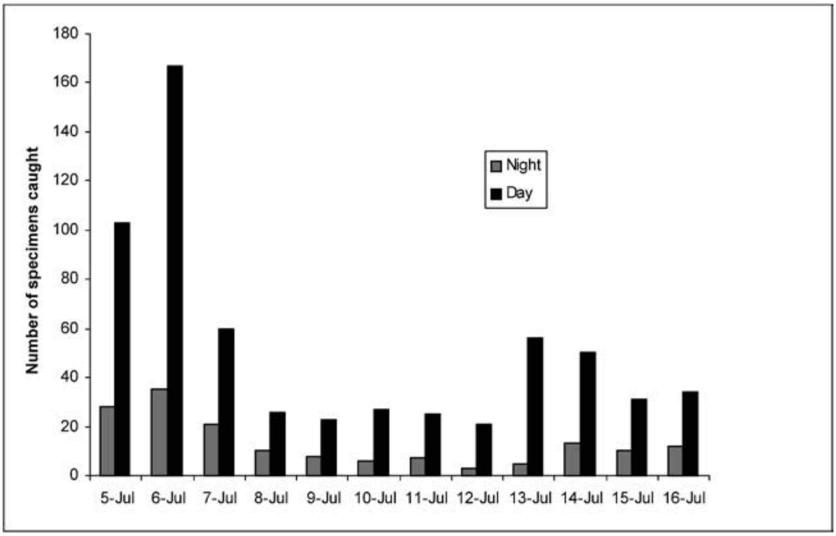

Fig. 6. Total number of Aleocharinae collected per collection event.

Discussion

In the past there have been a few studies (see Introduction) that assayed the abundance of staphylinid beetles with flight intercept traps but none of these studies sampled differences between day and night or even to identify material to the generic level. The data presented here provide a first look at the diurnal/nocturnal activities of a poorly known, but extremely important group of beetles.

Flight intercept traps are designed to sample the diversity of those staphylinid beetles that fly. There are representatives of many groups of Staphylinidae with nonfunctional, greatly reduced wings, or that have sedentary behaviors that are certainly present on Barro Colorado Island but were not sampled for obvious reasons. In addition, species that live primarily in the forest canopy or that are obligate hosts of ants or other insects are rarely caught in FIT.

More than half (781 out of 1,349, 57.9%) the specimens caught belong to the subfamily Aleocharinae; for the majority of these we are unable to provide a more specific identification. Many aleocharines are impossible to distinguish without detailed preparation of the male and female genitalia and comparison with type specimens. Many of these specimens represent undescribed genera and species. The same is true for the miscellaneous specimens of the subfamily Paederinae and the tribe Xantholinini (subfamily Staphylininae) that we did not identify to the generic level.

The number of specimens caught each day varied drastically (Figs. 4–6), but the general pattern is that more specimens were caught during the day than the night. This was true for the subfamilies Staphylininae (Fig. 5) and Aleocharinae (Fig. 6) and the family as a whole. Gnaspini *et al.* (2000) mentioned that "Staphylinidae numbers increase during the hot and rainy season and although distribution does not follow rainfall variation along the year, their number seems to be influenced by the season." Our study was done on a much smaller scale, and although there is not a direct link between rainfall and species abundance, it seems as though there were two abundance peaks just before heavy rainfall peaks. From the data presented here, one can conclude that there is fluctuation on the abundance of Staphylinidae on a much smaller scale than season that is likely caused by variations of rainfall and humidity.

The genera *Dysanellus*, *Elmas*, *Nausicotus*, *Nordus*, *Philothalpus*, and *Xenopygus* are members of the subtribe Xanthopygina (Staphylininae: Staphylinini). Most xanthopygines are conspicuously colored and some species have been observed to be active during the day. This study confirms the diurnal activity of these genera and indicates that at least these genera are not active during the night (Table 1). Laboratory observations of *Nordus fungicola* also confirm that this genus is not active during the night (Chatzimanolis 2003).

Twenty-six out of the 35 genera sampled were solely or primarily diurnal (with none or very few individuals caught at night). Although we do not have sufficient data to explain this pattern, there are some interesting remarks to make. Species that were active primarily during the day had larger eyes, for example members of the subtribe Xanthopygina, the genus *Megalopinus* (Megalopsidiinae), or the aleocharine genera *Aleochara*, *Hoplandria*, *Orphnebius*, and *Zyrastilbodes*. Primarily nocturnal Staphylinidae [for example the genera *Vatesus* (Tachyporinae), *Dibelonetes* (Paederinae), and *Nacaeus* (Osoriinae)] tend to have smaller eyes and they may rely more on chemical cues to feed or mate. Another reason that the majority of Staphylinidae sampled were diurnal might have to do with the greater availability of food during the day (especially for predacious forms), but currently there are no data supporting this hypothesis.

Although the taxonomic issues for this group of insects are far from being completely resolved, there is much needed ecological and behavioral work to be done. We hope that ecologists interested in the structure of insect communities and behavioral ecologists interested in making observations on particular taxa will benefit from this data set.

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