DIEL PERIODICITIES OF CERTAIN CARRION BEETLES (COLEOPTERA: SILPHIDAE)

PAUL P. SHUBECK

Biology Department, Montclair State College,
Upper Montclair, New Jersey 07043

ABSTRACT

A study to determine the diel periodicities of certain carrion beetles was conducted at 2 locations in New Jersey. Beetles were attracted to decomposing chicken leg bait in concealed cans suspended above the ground. This design required olfaction for bait location. Data from 19 diurnal collections and 18 nocturnal collections were recorded. *Silpha americana*, *S. noveboracensis*, *S. inaequalis*, and *Nicrophorus tomentosus* were either primarily or completely diurnal in finding carrion. *Necrodes surinamensis* and *Nicrophorus orbicollis* were all taken nocturnally. Leptodiridae, Staphylinidae, and Histeridae that were attracted to this carrion were primarily diurnal.

INTRODUCTION

A number of observations have been published on the nocturnal and diurnal activities of carrion beetles. These indicate that certain species are nocturnal or diurnal, or both. When referring to the Nicrophori, Milne and Milne (1944) wrote, "Difficulty was reported in observing the burying behavior because of its nocturnal nature . . ." Although they stated that " . . . the burying activities had been watched repeatedly in daylight at Irondale (Canada) . . ." They commented further about " . . . the preference shown by *Nicrophorus* for work in the shade or at twilight or night . . ."

Abbott (1927), in discussing his work with *Nicrophorus tomentosus* and *N. orbicollis*, stated, "The very fact that the beetles are nocturnal, and work in almost absolute darkness, sufficiently demonstrates the importance of the olfactory sense."

These and other similar observations had been noted, but I was struck by the complete absence of any quantitative data on diel periodicity of carrion beetles. During portions of the summers of 1969 and 1970 I made an effort to collect such data. The projects were set up in Hutcheson Memorial Forest, near East Millstone, Somerset County, New Jersey, and Stokes State Forest, Sussex County, New Jersey.

The 24 hour diel period is usually divided into the crepuscular period (twilight), the diurnal period (daylight), and the nocturnal period (darkness). In this study I distinguished only diurnal and nocturnal activity. No attempt was made to delimit a crepuscular period nor to capture beetles during this period.

In addition to recording capture data on all species of Silphidae, data also were recorded on individuals of the families Leptodiridae, Histeridae, and Staphylinidae. A previous study showed that these 4 families are very important members of the carrion community in New Jersey (Shubeck 1969).

ACKNOWLEDGMENTS: I would like to thank the Hutcheson Memorial Forest Committee of Rutgers University for encouraging my research on Silphidae in Hutcheson Memorial Forest.

METHODS

A pilot study was conducted at the New Jersey State School of Conservation at Stokes State Forest from 11 to 14 June 1969. Two of my students, Celeste Lupi and Bonnie Stroger, carried out the collecting duties as part of an assigned ecology project. A one-gallon air can (Shubeck 1968a), suspended 1.5 meters above the ground, was baited with a fresh chicken leg and periodically checked for 3 days. The diurnal collection included beetles attracted between 7:30 AM and 7:30 PM and collected at 7:30 PM; the nocturnal collection included beetles apparently attracted since 7:30 PM and collected at 7:30 AM the following morning.

In June 1970, a more elaborate trapping arrangement was devised. Each one-gallon can was inserted up into a box having a 1/2 inch wire mesh at the top. Two inches above this mesh opening was a flat cover which kept out rain but allowed ingress of insects. This entire unit, attached to a stake, was situated so the opening was 3/4 meter above the ground. Four such traps, each baited with a fresh chicken leg, were set up in a single line about 3 meters apart. This experiment, also at Stokes State Forest, ran from 3 June, when the traps were baited, to 12 June. Collections began on the second day after baiting and continued until the morning of the ninth day. In order to exclude crepuscular data, the traps were closed after 7:45 PM and opened again at 9:00 PM when it was completely dark. The nocturnal collection was then taken at 7:00 AM the following morning and the traps were left undisturbed during the rest of the day. After being collected, identified, and recorded, all beetles were released about 10 meters from the traps.

Later in the month these box traps were set up in Hutcheson Memorial Forest, where previous collecting had shown that silphids could be taken in much larger numbers than in Stokes State Forest. The 4 traps were set up so that there was a north, east, south, and west trap, each 5 meters distant from a central stake. They were baited on 19 June, and collections were made daily from the fourth to the eighth day. Diurnal collections included beetles attracted from 7:00 AM to 7:30 PM, and nocturnal collections included beetles attracted from 8:30 PM to 7:00 AM. After being collected, identified, and recorded, all beetles were released about 40 meters from the traps.

The traps were left in the forest, and later in the summer (7 August) they were baited again. Collections were made from the third to the eighth day. Since the period of daylight was getting shorter, diurnal collections were made at 7:00 PM, the traps were covered, and then opened at 8:10 PM for the nocturnal catch. The nocturnal collections were made at 7:00 AM. As in June, beetles were released about 40 meters from the traps.

RESULTS AND DISCUSSION

The total number of silphids collected during the pilot study in 1969 was disappointingly small (Table 1). The results suggested that *Nicrophorus orbicollis* was nocturnal and that members of the genus *Silpha* might be diurnal. These meager, but interesting, results served as the stimulus for work the following summer.

TABLE 1. CARRION BEETLES COLLECTED AT STOKES STATE FOREST BETWEEN 11 AND 14 JUNE 1969. DAY NUMBER ABOVE EACH COLUMN APPLIES TO THE NUMBER OF DAYS AFTER BAIT WAS SET.

Diurnal Data (7:30 AM to 7:30 PM)
(Collections at 7:30 PM)

Day	1	2	3	Total
Silpha americana	1	1	–	2
S. noveboracensis	–	1	–	1
Nicrophorus orbicollis	–	–	–	0
Histeridae	–	1	1	2

Nocturnal Data (7:30 PM to 7:30 AM)
(Collections at 7:30 AM)

	2	3	Total
Silpha americana	–	–	0
S. noveboracensis	–	–	0
Nicrophorus orbicollis	6	3	9
Histeridae	–	–	0

In the 1970 study at Stokes, the use of more traps and the greater number of collecting days increased the total number of beetles taken (Table 2). *Silpha americana* and *S. noveboracensis* seemed to be primarily diurnal (only 1 of the latter was taken nocturnally). Only 2 *Nicrophorus orbicollis* were taken, but as in the previous year, they were taken nocturnally only. The results concerning Staphylinidae and Histeridae were most interesting. Of 76 staphylinids taken, 74 were diurnal, and 209 of 211 histerids were diurnal.

TABLE 2. CARRION BEETLES COLLECTED AT STOKES STATE FOREST BETWEEN 3 AND 12 JUNE 1970. DAY NUMBER ABOVE EACH COLUMN APPLIES TO THE NUMBER OF DAYS AFTER BAIT WAS SET.

Diurnal Data (7 AM to 7:45 PM)
(Collections at 7:45 PM)

Day	2	3	4	5	6	7	8	Total
Silpha americana	–	–	1	–	2	–	2	5
S. noveboracensis	–	–	–	3	7	5	6	21
Nicrophorus orbicollis	–	–	–	–	–	–	–	0
Staphylinidae	–	–	–	16	17	19	22	74
Histeridae	–	–	–	52	81	37	39	209

Nocturnal Data (9 PM to 7 AM)
(Collections at 7 AM)

	3	4	5	6	7	8	9	Total
Silpha americana	–	–	–	–	–	–	–	0
S. noveboracensis	–	–	–	–	1	–	–	1
Nicrophorus orbicollis	1	–	–	1	–	–	–	2
Staphylinidae	–	–	–	1	–	–	1	2
Histeridae	–	–	–	–	2	–	–	2

The data in Table 3, from Hutcheson Memorial Forest in late June, were especially important because of the large numbers of insects taken. There seems to be no question that *Silpha noveboracensis* is diurnal; 1713 of 1720 individuals were taken diurnally. Much smaller numbers of *Silpha americana* and *Silpha inaequalis* were taken, and they were exclusively diurnal. *Nicrophorus orbicollis* was taken in very small numbers, but it was exclusively nocturnal as in the case of the 2 previously mentioned experiments. *Nicrophorus tomentosus* was taken for the first time, and interestingly all 9 individuals were diurnal. The other species of this genus was never taken diurnally. Once again, the staphylinids and histerids

were taken in the diurnal collections in overwhelming numbers. Small numbers of Leptodiridae were taken for the first time, and they were also diurnal.

TABLE 3. CARRION BEETLES COLLECTED AT HUTCHESON MEMORIAL FOREST BETWEEN 19 AND 28 JUNE 1970. DAY NUMBER ABOVE EACH COLUMN APPLIES TO THE NUMBER OF DAYS AFTER BAIT WAS SET.

Diurnal Data (7 AM to 7:30 PM)
(Collections at 7:30 PM)

Day	4	5	6	7	Total
Silpha americana	5	–	1	–	6
S. noveboracensis	492	528	665	28	1713
S. inaequalis	9	9	6	–	24
Nicrophorus orbicollis	–	–	–	–	0
N. tomentosus	2	3	3	1	9
Leptodiridae	2	–	1	1	4
Staphylinidae	3	20	10	4	37
Histeridae	5	1	7	–	13

Nocturnal Data (8:30 PM to 7 AM)
(Collections at 7 AM)

	5	6	7	8	Total
Silpha americana	–	–	–	–	0
S. noveboracensis	2	1	–	4	7
S. inaequalis	–	–	–	–	0
Nicrophorus orbicollis	2	–	1	–	3
N. tomentosus	–	–	–	–	0
Leptodiridae	–	–	–	–	0
Staphylinidae	–	2	1	–	3
Histeridae	–	–	–	–	0

Table 4 shows the results of the final experiment which was run in August. These results provided further evidence that *Silpha americana* and *Nicrophorus tomentosus* were diurnal, and that *N. orbicollis* was nocturnal. Further evidence of the diurnal activity of the families Leptodiridae, Staphylinidae, and Histeridae also was present. One new silphid species was taken. Unfortunately only 3 *Necrodes surinamensis* were captured, but each was taken in separate nocturnal collections.

TABLE 4. CARRION BEETLES COLLECTED AT HUTCHESON MEMORIAL FOREST BETWEEN 7 AND 15 AUGUST 1970. DAY NUMBER ABOVE EACH COLUMN APPLIES TO THE NUMBER OF DAYS AFTER BAIT WAS SET.

Diurnal Data (7 AM to 7 PM)
(Collections at 7 PM)

Day	3	4	5	6	7	Total
Silpha americana	–	1	3	9	4	17
Nicrophorus orbicollis	–	–	–	–	–	0
N. tomentosus	2	3	2	2	2	11
Necrodes surinamensis	–	–	–	–	–	0
Leptodiridae	–	1	2	2	–	5
Staphylinidae	16	20	17	10	18	81
Histeridae	–	2	2	11	5	20

Nocturnal Data (8:10 PM to 7 AM)
(Collections at 7 AM)

	4	5	6	7	8	Total
Silpha americana	–	–	1	–	–	1
Nicrophorus orbicollis	15	6	3	2	1	27
N. tomentosus	1	–	–	–	–	1
Necrodes surinamensis	–	1	1	–	1	3
Leptodiridae	–	–	–	–	–	0
Staphylinidae	3	–	2	1	–	6
Histeridae	–	–	–	–	–	0

The data from the 4 experiments were totaled and tabulated under diurnal and nocturnal columns in Table 5. All 41 *Nicrophorus orbicollis* taken during the 4 trial periods were nocturnal, and 20 of 21 *N. tomentosus* were diurnal. *Silpha inaequalis* was exclusively diurnal, and 30 of 31 *S. americana* were diurnal. Over 99% of the 1743 *S. noveboracensis* were active diurnally. Although no firm conclusion can be based on the 3 *Necrodes surinamensis* taken, the data suggest that this species is nocturnal. The data for leptodirids, staphylinids, and histerids found on carrion with Silphidae in Hutcheson Memorial Forest and Stokes State Forest indicate clearly that they are active during the day. In a study of Coleoptera associated with pig carrion in South Carolina, Payne and King (1969) found the Staphylinidae active both day and night. They also found that the Histeridae hid beneath the pig carcasses during the day and became active at night. I cannot explain these differences between the diel periodicities of rove and hister beetles in New Jersey as compared with South Carolina.

TABLE 5. TOTAL NUMBERS OF CARRION BEETLES COLLECTED AT HUTCHESON MEMORIAL FOREST AND STOKES STATE FOREST DURING THE SUMMERS OF 1969 AND 1970.

	Diurnal	Nocturnal
Silpha americana	30	1
S. noveboracensis	1735	8
S. inaequalis	24	0
Necrodes surinamensis	0	3
Nicrophorus orbicollis	0	41
N. tomentosus	20	1
Leptodiridae	9	0
Staphylinidae	192	11
Histeridae	244	2

On the other hand, there was a great similarity between my results with silphids in New Jersey and those obtained by Ratcliffe and Luedtke (1969) in Nebraska. The Nebraska study compared the species of Silphidae taken on exposed carrion versus those taken on carrion covered by bark. If the *covered* carrion can be thought of as an artificial nocturnal carrion microhabitat, this can explain why 2 species common to both studies (*Nicrophorus orbicollis* and *Necrodes surinamensis*) manifested similar nocturnal results. Also, if it can be assumed that diurnal beetles are active during the day but hide in the leaf litter during the night, this can explain why 2 silphids captured on the exposed carcass in Nebraska (*Silpha inaequalis* and *S. noveboracensis*) manifested results similar to the diurnal captures in New Jersey. In addition, Ratcliffe and Luedtke captured 2 other *Silpha* species almost exclusively on exposed carrion and *S. americana* was almost exclusively diurnal in New Jersey. This raises the possibility that *Silpha* may be diurnal, whereas in the New Jersey study, 1 *Nicrophorus* species is apparently diurnal and a second is nocturnal.

In addition to the diurnal-nocturnal information gained in this study, 2 other observations can be made. First, even diurnal carrion beetles apparently use their sense of olfaction to locate carrion; the bait (chicken legs) was placed in the bottom of cans completely concealed within wooden boxes suspended above ground. Although evidence has been pub-

lished that random movement is involved (Shubeck 1968b), it is now clear that the final clueing in on carrion can be based on olfaction alone. This apparently applies also to carrion beetles of the families Staphylinidae, Histeridae, and Leptodiridae.

A second interesting point is that the diurnal *Nicrophorus tomentosus* bears a striking resemblance to a bumblebee, even to its buzz. Milne and Milne (1944) stated that, "The resemblance to *Bombus* [spp.] is enhanced by the golden body hair, the yellow inner surfaces of the elytra (which are held back to back over the midline) and the creamy cast to the flying wings." If most species of *Nicrophorus* are eventually found to be nocturnal, it is possible that *N. tomentosus* evolved away from the nocturnal behavior pattern of the genus through the mechanism of mimicry. If, on the other hand, *Silpha* is more primitive than *Nicrophorus*, as Arnett (1944) believes, then it can be conjectured that *Nicrophorus* (other than *N. tomentosus*) evolved away from the diurnal niche and into the nocturnal one. *N. tomentosus* might then be assumed to be the most primitive species of the genus and the species most closely related to *Silpha*.

I am planning an experimental study on the possible mimicry of the bumblebee by *N. tomentosus*. The major problem will undoubtedly be obtaining an adequate supply of specimens since I have never collected this species in large numbers.

Conclusions

Six species of Silphidae were captured on carrion on 22 collecting days during the summers of 1969 and 1970 in New Jersey. One species was exclusively diurnal and 2 others were exclusively nocturnal (Table 5). The 3 others were primarily diurnal. *Nicrophorus orbicollis* and *Necrodes surinamensis* were active during the nocturnal hours, while *N. tomentosus*, *Silpha inaequalis*, *S. noveboracensis*, and *S. americana* were active during the diurnal hours. Virtually all Leptodiridae, Staphylinidae, and Histeridae captured on carrion were diurnal. Furthermore, the carrion-inhabiting members of these 3 families are apparently capable of locating carrion through olfaction, as are the silphids, since the carrion was completely concealed and above the ground.

Literature Cited

Abbott, C. E. 1927. Further observations on the olfactory powers of the Necrophori. Ann. Ent. Soc. Amer. 20:550-553.

Arnett, R. H., Jr. 1944. A revision of the Nearctic Silphini and Nicrophorini based upon the female genitalia (Coleoptera, Silphidae). J. New York Ent. Soc. 52:1-25.

Milne, L. J. and M. J. 1944. Notes on the behavior of burying beetles (*Nicrophorus* spp.). J. New York Ent. Soc. 52:311-327.

Payne, J. A., and E. W. King. 1969. Coleoptera associated with pig carrion. Ent. Monthly Mag. 105:224-232.

Ratcliffe, B. C., and R. J. Luedtke. 1969. A comparison of silphids taken from covered and uncovered carrion (Coleoptera: Silphidae). Coleopt. Bull. 23:103-105.

Shubeck, P. P. 1968a. Trapping Fabre's "sexton" beetles. Amer. Biol. Teacher 30:564-565.

Shubeck, P. P. 1968b. Orientation of carrion beetles to carrion: random or non-random? J. New York Ent. Soc. 76:253-265.

Shubeck, P. P. 1969. Ecological studies of carrion beetles in Hutcheson Memorial Forest. J. New York Ent. Soc. 77:138-151.