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NOCTURNAL ACTIVITY OF CARABUS HORTENSIS L. (COLEOPTERA, CARABIDAE) IN TWO FOREST SITES STUDIED WITH HARMONIC RADAR METHOD*

ABSTRACT: The paper deals with a study of the nocturnal activity rhythm of Carabus hortensis L. with applying a harmonic radar system. Beetles with a diode attached to their elytra were set into the terrain and tracked by help of a portable radar. The studies were carried out in a pine forest in which Carabus hortensis L. occurs regularly and in a beech forest in which this species was completely absent. The data show that Carabus hortensis L. is active mainly at the first hours after sunset, independently from time of sunset. A small peak of activity exists at about 9–10 hours after sunset. The nocturnal activity rhythm is similar in both forest sites, but the individuals show significantly higher activity in the beech forest. Based on the assumption that activity is connected with hunger level, the total activity may be useful as indicator of habitat quality (feeding conditions) for Carabus hortensis L.

KEY WORDS: Carabidae, radar tracking, nocturnal activity rhythm, forest site

Several studies deal with the daily activity of carabid beetles in Middle Europe in different biotopes (e.g. Thiele 1967, Thiele and Weber 1968, Luff 1978, Barndt 1982, Gruschwitz 1983, Kegel 1990, Chapman et al. 1999). According to the majority of these studies carabid beetles living in forests are ascertained to be active mainly in the night (e.g. Thiele and Weber 1968, Gruschwitz 1983). One of these species is Carabus hortensis L., the object of this study. This species prefers coniferous forests and shows the activity from the middle of the summer to the middle of the autumn (Larsson 1939). It has a range of body size of about 22–30 mm (Freude et al. 1976) and is unable to fly.

The major goal of this paper is to describe the nocturnal activity rhythm of Carabus hortensis in two forest habitats. The focus was set on number and time of peaks of activity during the night and changes in these peaks in the run of the study. Moreover, we try to assess whether the nocturnal activity can be used as indicator for habitat quality. Differences among the study sites with respect to activity may indicate differences in habitat quality for Carabus hortensis. Concerning carabid beetles hungry individuals may be more active because of searching for prey (e.g. Fournier and Loreau 2002). Therefore, higher activity may indicate worse feeding conditions in the habitat.

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The study was carried out in two forest sites (located in the Tuczno commune in the Regional Directorate of State Forests in Piła, Central Poland): a pine forest of about 25 years growing on brown rusty soils formed from poor loamy sands and loose sands with a high density of this species and a beech forest of about 76 years growing on post-agricultural podsol-brown soil formed from loose sands in which _Carabus hortensis_ was absent completely in spite of its occurrence in the close surrounding. The soil surface of the pine forest was covered with a growth of grass plants to almost 100% whereas in the beech forest the soil cover was insignificant (Szyszko et al. 2004). A high density of a carabid species indicates good conditions for reproduction and survival. Therefore, the selected sites seem to be of different habitat quality for _Carabus hortensis_.

The observation of the beetles was carried out in the period of two years (1992–1993) by application of harmonic radars (Mascalzoni and Wallin 1986) according to the methodology described by Van der Ent and Van Dijk (1991). AA 109 diodes and copper antennas 4 cm long were attached to the elytra. Each beetle marked in this way could be tracked directly in the terrain by help of a portable harmonic radar system. The individuals for the studies were collected in the pine forest by help of live traps. They were taken from the traps every morning and stored in the laboratory at 6°C.

The observations were carried out alternatively once in the pine forest site and once in the beech forest site. In each experiment we tried to use four marked specimens simultaneously. In 1992 all beetles were satiated, but in 1993 hungry beetles were studied, too. Overall, 71 night observations were carried out in the pine forest (57 with satiated and 14 with hungry individuals) and 65 night observations were carried out in the beech forest (55 with satiated and 10 with hungry individuals). Individuals were set in the field at dusk, observed until dawn, and transported back to the laboratory. During the observations every 20 minutes walking distances and turning angles were recorded as described in detail in Szyszko et al. (2004). The research was carried out in the period of the most intense activity of _Carabus hortensis_ in the pine forest. Observation periods ranged from August 21 to October 5 in 1992, and from August 7 to September 28 in 1993.

To ensure comparable data the 20-minute intervals were calibrated with respect to time of sunset using sunset data from Poznań (Thorsen 2004). Daylight saving time (DST) was corrected to normal time. The 20-minute interval covering the time of sunset at the respective day was determined as first interval, the following intervals were numbered consecutively.

Whenever an individual changed its location during an interval of 20 minutes the recording was assessed as “active sample”, else as “inactive sample”. “Active samples” as well as “inactive samples” were summed up with respect to the intervals. In a second step data of each three 20-minute intervals were comprised to 1-hour intervals for the respective groups.

In order to detect differences in nocturnal activity rhythm in the run of the study the data were divided further into three phases. The first phase comprises the data with the sunset being after 18:39 (before September 2), the second phase comprises the data with the sunset falling within 18:00 and 18:39 (September 2 to September 18), and the third phase comprises the data with the sunset being before 18:00 (after September 18).

Differences concerning proportions of “active samples” and “inactive samples” were tested using Chi-square-tests. In order to test differences in nocturnal activity rhythm percentages of “active samples” for the 1-hour intervals were subjected to statistical analysis using Spearman’s rank correlation coefficient (Sachs 1984).

In the studied period of 1992 and 1993 a total of 136 night observations and almost 2750 samples on _Carabus hortensis_ were elaborated (Szyszko et al. 2004). In both forest sites a high activity in the beginning of the night observations was found. In general, beetle activity is higher for the beech forest (Chi-square-test, _P_ <0.05). There is a tendency to a very small second peak at the hours 9 (beech forest) and 10 (pine forest) after sunset.

Data concerning the activity expressed as the percentage share of “active samples” in the total of 1-hour intervals at the three
phases during the study are shown in Fig. 1. The graphs show a rather similar pattern indicating that the activity rhythm is independent from time of sunset. The data suggest that the second small peak of activity is caused mainly by an increase of activity during the last third of the study period (time of sunset before 18:00). In the beech forest an increase of activity at the end of the night observation time can be seen for the first phase, too.

A highly significant correlation (Spearman’s rank correlation coefficient, \( P < 0.001 \)) exists between the percentages of “active samples” for the 1-hour intervals in the beech forest and in the pine forest indicating a very similar activity rhythm. There is a trend that the data pairs show higher percentage values for the beech forest due to the higher activity in this forest.

According to literature the activity rhythm of carabid beetles seems to be a complicated phenomenon and depends on many different factors. A dominance of nocturnal activity seems to exist in autumn breeders (e.g. Thiele and Weber 1968, Barndt 1982, Kegel 1990), big sized species (Luff 1978), south palaeartic species (Thiele and Weber 1968), and species typical for forests (e.g. Thiele 1968, Gruschwitz 1983). On the other hand, Luff (1978) observed an intensive nocturnal activity in a strawberry field.

The night activity of carabids seems to be influenced mainly by the “lightness” factor, whereas in day activity the moisture plays an important role, too (Thiele 1968, Thiele and Weber 1968, Kegel 1990). Similar, for Staphilinidae from the genus *Tachyporus* Pedersen *et al*. (1990) assume the importance of moisture particularly in June.

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Fig. 1. Nocturnal (between dusk and dawn) activity rhythm of *Carabus hortensis* L. expressed as % of “active samples” in the total of 1-hour intervals split into 1-hour intervals at three phases depending on the time of sunset for (A) pine forest and (B) beech forest. Phases of study: circles – sunset after 18:39 (before September 2), squares – sunset within 18:00 and 18:39 (September 2 to September 18), triangles – sunset before 18:00 (after September 18). Data taken with harmonic radar method (see text).
Concerning night active species like *Carabus hortensis* a dependence on the time of sunset seems to exist. Luff (1978) showed a shifting of the peak in nocturnal activity depending on sunset time for *Harpalus rufipes* (Degeer). Associated with an earlier time of sunset an earlier peak of activity was found in this study. In field studies, Thiele and Weber (1968) found for almost all night active carabids an activity maximum at about 1–2 hours after beginning of darkness. There was only one exception, namely *Abax parallelus* (Duft.). In laboratory experiments these authors could demonstrate that the beginning of nocturnal activity of *Carabus* species depends on the starting time of “darkness” and that activity in the dark is greatly independent from the duration of the dark phase. Our data are in accordance with these results.

There is some indication for a second peak of activity at about 9–10 hours after sunset late in the year. Novak (1972) supposes that spring breeders show two peaks of activity whereas autumn breeders show only one. Our data point that – at least for the autumn breeding species *Carabus hortensis* – it seems to be important to take into account the time of the year.

A significant difference in total activity between the two forest sites exists, with a higher activity in the beech forest. As shown by Szyszko *et al.* (2004) this result is due to a higher activity of satiated individuals in the beech forest after set them into the field. The higher activity may point to worse feeding conditions for *Carabus hortensis* in this forest site, because it is more difficult for the individuals to keep the level of satiation. The assumption is confirmed by the male-to-female ratios, too. Szyszko *et al.* (2004) demonstrated that lower male-to-female ratios, as found for the beech forest, indicate worse feeding conditions. Therefore, the total activity may be useful as indicator of habitat quality for *Carabus hortensis*.

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