NAT. CROAT. | VOL. 7 | No 1 | 19–29 | ZAGREB | March 31, 1998

ISSN 1330-0520
UDK 599.323.2:591.52

24-HOUR ACTIVITY IN THE FOREST DORMOUSE (*DRYOMYS NITEDULA*).

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Nowakowski, W. K.: 24-hour activity in the forest dormouse (*Dryomys nitedula*), Nat. Croat., Vol. 7, No 1., 19–29, 1998, Zagreb

Five forest dormice (*Dryomys nitedula* Pallas, 1778) were studied in cage conditions. The level of activity was measured in terms of the percentage of time spent by an animal out of the nest, with 24-hour period taken as 100 %. Air temperatures were measured in the course of the research. The dormice were shown to be mainly active at night, though with limited daytime activity. The close relationship between level of activity and mean 24-hour temperature was established.

Key words: forest dormouse (*Dryomys nitedula*), 24-hour activity

Nowakowski, W. K.: 24-satna aktivnost gorskog puha, (*Dryomys nitedula*), Nat. Croat., Vol. 7, No 1., 19–29, 1998, Zagreb

Pet gorskih puhova (*Dryomys nitedula* Pallas, 1778) pručavano je u uvjetima zarobljeništva. Razina aktivnosti mjerena je usporedbom količine vremena koje je životinja provela izvan gnijezda, pri čemu je 24 sata iznosilo 100 %. Tijekom istraživanja mjerena je i temperatura zraka. Pokazalo se da su puhovi aktivni većinom noću, iako postoji i ograničena dnevna aktivnost. Utvrđena je tijesna povezanost između razine aktivnosti i srednje temperature u 24 sata.

Ključne riječi: gorski puh (*Dryomys nitedula*), 24-satna aktivnost

INTRODUCTION

The breakdown and conditioning of 24-hour activity and its variability in the different seasons would seem to be fundamental to the precise definition of the ecological niche of a species. Among dormice, the breakdown of activity may be explained at least in part by the avoidance of competition from both other more ecologically- flexible and stronger rodents (like the yellow-necked mouse, *Apodemus flavicollis*) and birds living in tree-holes, as well as the avoidance of predation.

The literature on the subject is lacking in any more in-depth treatment of the 24-hour activity of the forest dormouse (*Dryomys nitedula* Pallas, 1778). The only work on the subject (Saint Girons & Lenkiewicz 1965) involved research done over a year on just one caged female of the species, the results having no more than orientational significance.

The aim of the study described here was thus to determine the breakdown of activity in the forest dormouse in captivity at different times of the day, and hence also the mean 24-hour activity. A further subject of interest was the variation in this breakdown in the different seasons of the year and the environmental conditioning of this variation.

METHODS

The research made use of a large metal cage of dimensions 100 × 50 × 30 cm. Placed within it were two birdboxes in which the studied dormice could hide. The cage also contained branches, a source of drinking water and a container of food (mainly sunflower seeds, maize and acorns, as well as fruit and insects), while the floor had hay, dry leaves and moss. The cage was placed outside a building, on the

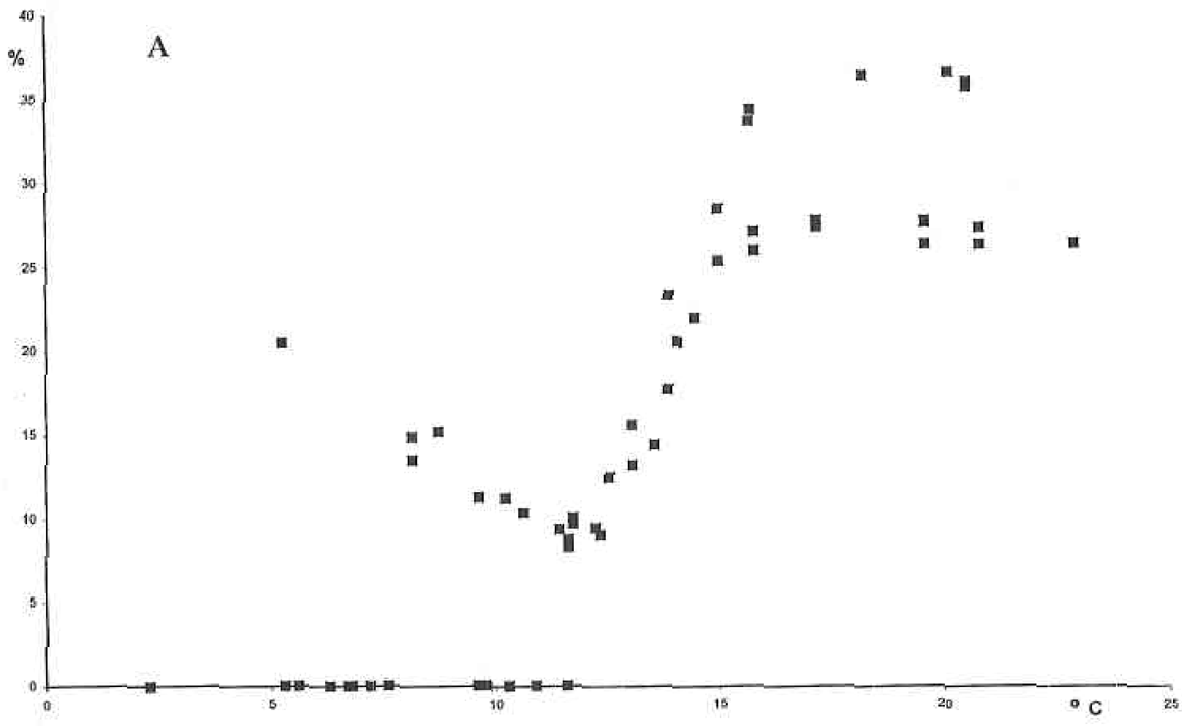
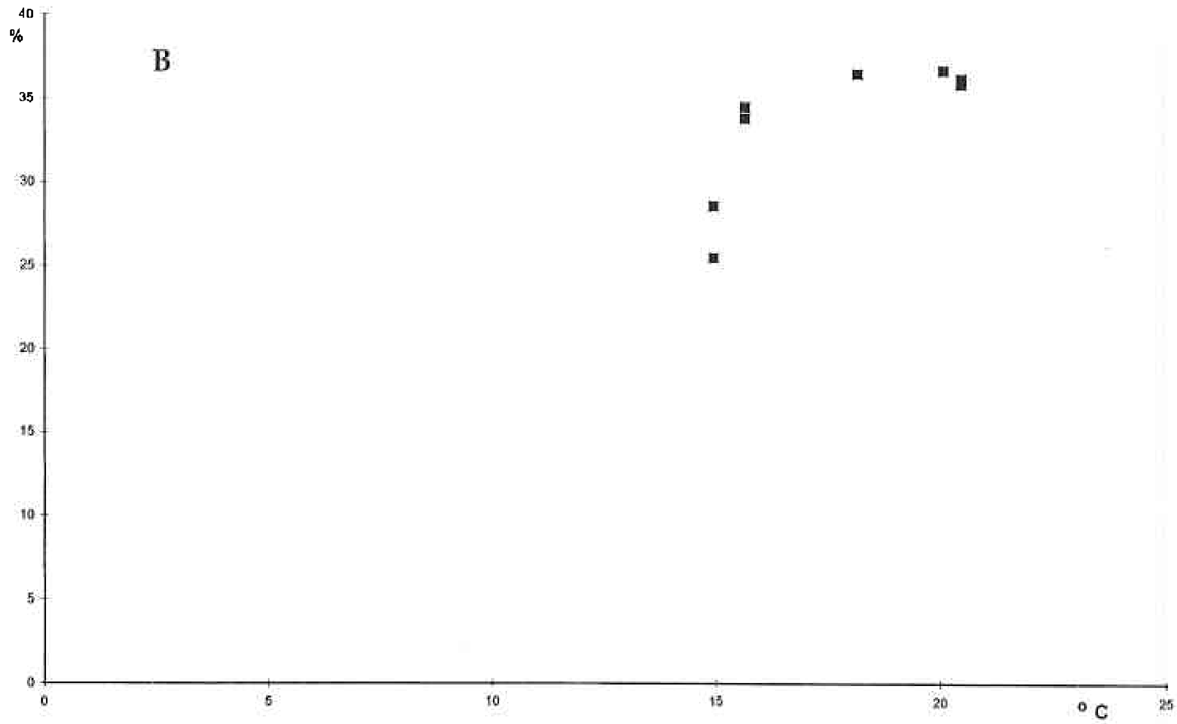
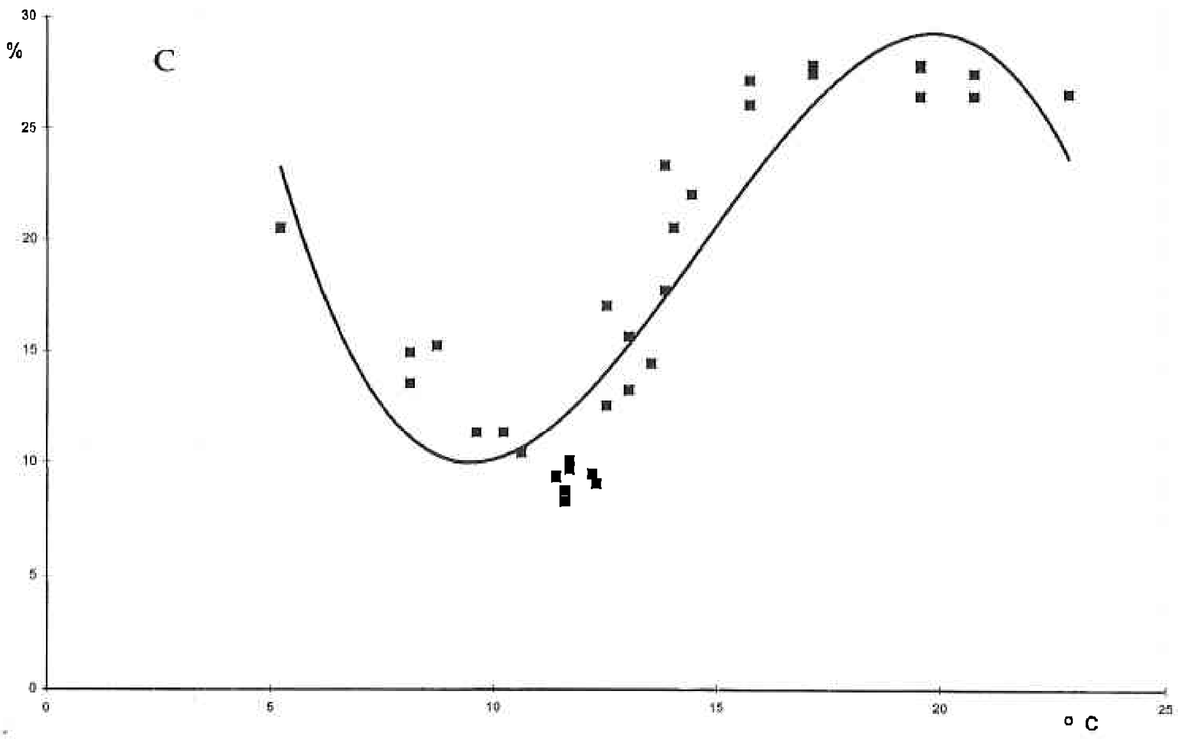


Fig. 1. Relationship between mean daily levels of activity among forest dormice and mean 24-hour temperatures – a. all data, b. data from the second half of August and September, c. data from other parts of the year without 0 % activity, with the trend line and equation written in.





balcony of the author's flat. During the observations, use was made of a light reflected from a wall (the lamp was shaded by a metal shield). It had a 20-watt bulb at a distance of 3 m from the cage.

The research was carried out between August 1994 and March 1996, on 5 individuals (2 males and 3 females) but only 2–4 individuals were observed at the same time. Observations using the »snapshot method« (every 5 minutes) were made throughout the day. The air temperature was recorded every hour and the pressure once a day at 20.00. Information was gained from a total of sixty 24-hour periods (with 9–16 such days of observation for each individual and a total of 29 for males and 31 for females). In addition, between March 21st 1995 and March 20th 1996, note was made on a daily basis of the activity (albeit with no definition of its level) or inactivity of individuals in the course of the day and night, as well as the temperature at 22.00 and the pressure at 20.00.

The mean level of activity in a 24-hour period was measured by reference to the percentage of time spent by an animal outside the nest (birdbox), assuming that the whole 24-hour period was equal to 100 %. The mean 24-hour temperature was calculated from the temperatures noted in the course of the observations. It was anticipated that the breakdown of activity over 24 hours might differ with low and high levels of mean activity, so 5 breakdowns of day and night activity (Fig. 2) were obtained by grouping data from days with similar mean levels of activity. Different figures give the breakdown of 24-hour activity where mean daily levels of activity were 8–12 % (Fig. 2a), 13–17 % (Fig. 2b), 19–23 % (Fig. 2c), 25–29 % (Fig. 2d) and 33–37 % (Fig. 2e). Added for the days within the different classes were the numbers of observations with animal activity in each successive hour as well as all observations in the given hour. Following this, the percentage of observations with activity was calculated.

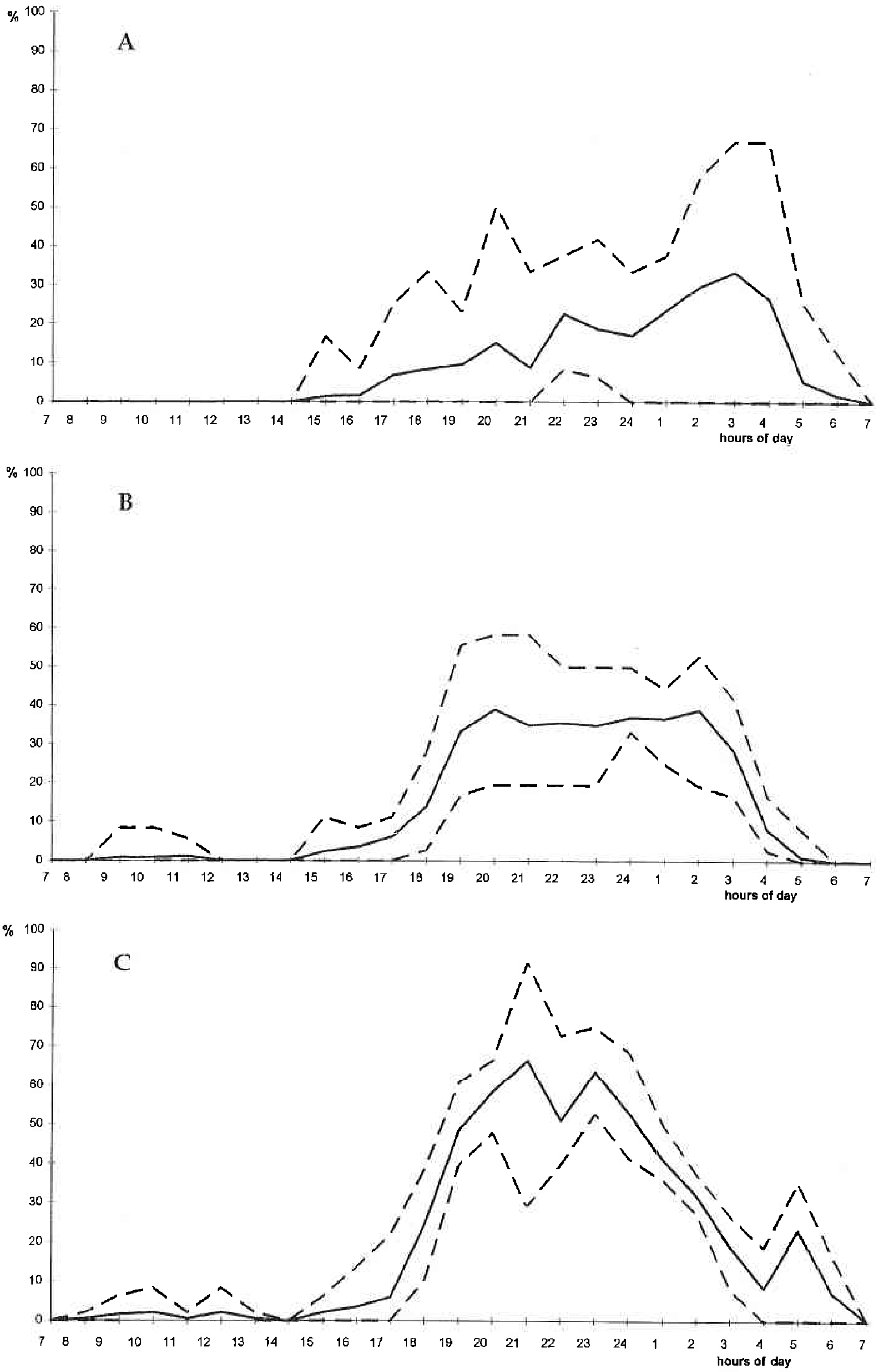
The forest dormouse was often observed to be active during daylight hours: during mid-day, after sunrise, as well as before sunset, so the authors find it difficult to define the beginning and the end of nocturnal activity. Accordingly, they took the time of the onset of nocturnal activity as being that of the first observation featuring activity followed by mean activity at a level greater than the mean for the 24-hour period. Similarly, the time of the cessation of nocturnal activity was considered to be that of the first observation followed by mean activity below the level of the mean for the 24-hour period.

On the basis of the supposition that nocturnal and diurnal activity might either occur or not occur at the same mean temperature, the percentage figures for days with daytime activity and night-time activity were calculated in relation to classes of mean 24-hour temperature involving 3 °C intervals.

The χ^2 test was used to determine the degree of similarity between the breakdowns obtained and those expected. In turn, the links between temperature and activity were examined using non-linear trend equations and correlation coefficients, r.

RESULTS

Considerable variations in the level of activity were observed in the course of the year, as well as in different months. Activity accounted for between 8.3 and 36.6 % of the day and was thus capable of increasing 4.4-fold. Forest dormice also hiber-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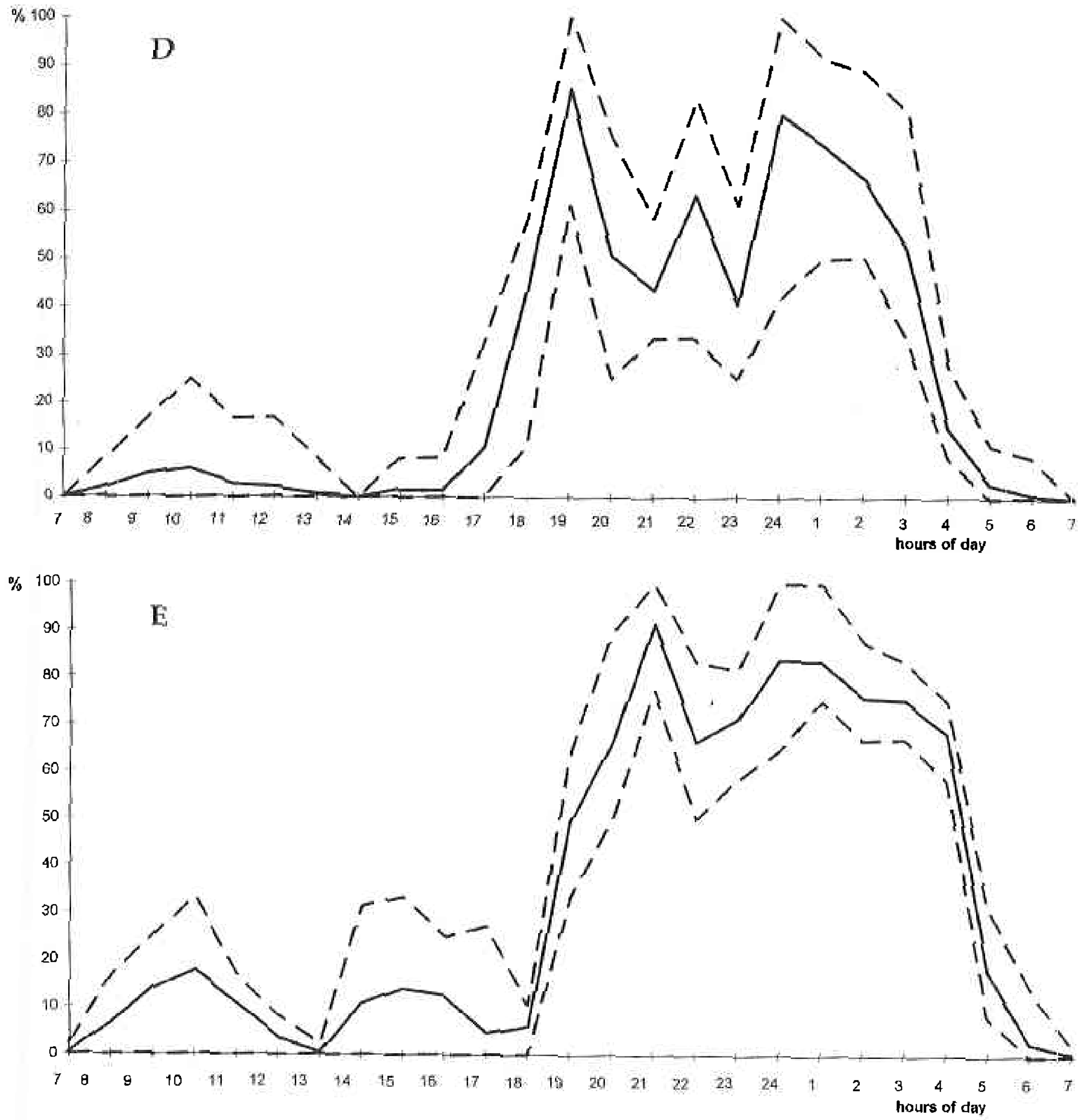

Fig. 2. Breakdown of activity among forest dormice at different times of the day, with a division into classes for mean levels of activity – a. 8–12 %, b. 13–17 %, c. 19–23 %, d. 25–29 %, e. 33–37 %.

nated, showing 0 % activity. The lowest temperature at which activity occurred was 3.5 °C – on 12.04.95. At low temperatures, the animals employed two strategies: hibernation or activity declining with decreasing temperature from 20.5 % (at a 24-hour mean temperature of 5.2 °C) to 8.3 % (where the mean was 11.6 °C). Above 11.6 °C, the activity increased again to 28.5 % at 14.9 °C (Fig. 1a). Above this temperature, the level of activity remained constant, except in the second half of August and September when there was a linear increase to 36.6 % at 18.1 °C (Fig. 1b). For results with activity varying from zero, but not deriving from the second half of August or from September, an equation with r equal to 0.92 (Fig. 1c) was obtained.

Such a high value for the correlation coefficient points to a strong link between activity and temperature.

Where the level of activity was at its highest, the dormice showed two or three peaks of activity, with the highest level of all being at 21.00 (Figs. 2d and 2e). Where the level of activity was lowest there were two peaks, the greater one being at 03.00 (Fig. 2a). Within the range of temperatures at which dormice had the alternatives of hibernating or activity, the frequency with which one or the other was chosen was dependent on temperature (the higher the temperature, the more often activity was opted for) (Fig. 3) and on the season of the year – with activity being chosen three times more often in spring than in autumn (23 times cf. 8), even though temperatures were lower. The mean temperature of spring days on which activity occurred was 8.5 °C, while the corresponding figure for autumn was 10.1 °C. This difference was statistically significant at $p = 0.0083$, t Student test). The frequency of occurrence of daytime activity was also linked with air temperature (and not with daylength), rising from 0 % at 2 °C to 56 % at 21 °C. Above this temperature, activity remained constant (Fig. 3). These results were compared with an S-type curve and degrees of concordance at the levels $0.5 < p < 0.9$ and $0.2 < p < 0.3$ were obtained for activity at night and in the day respectively.

The time of commencement of activity was constant in the course of the year and was dependent on neither the length of the day nor the temperature. A similar lack of any relationship was observed in relation to the time at which activity

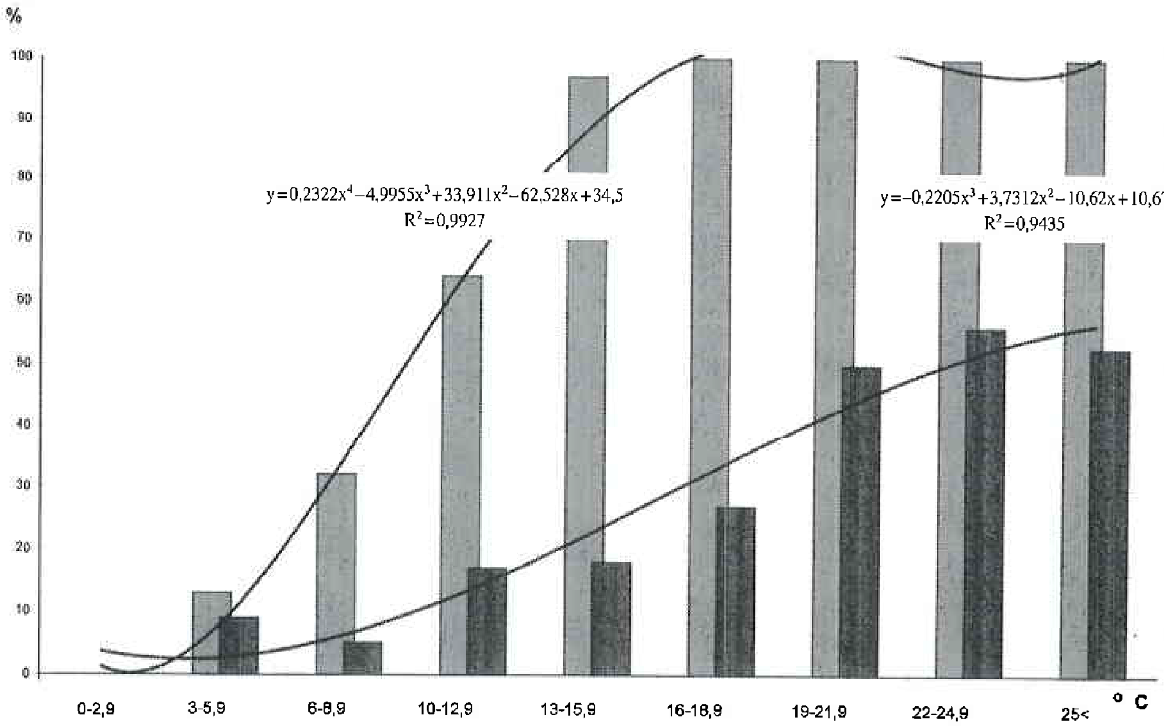

Fig. 3. Frequency of occurrence of nocturnal and daytime activity in temperature classes at 3C intervals, along with the curves with which the distributions were compared.

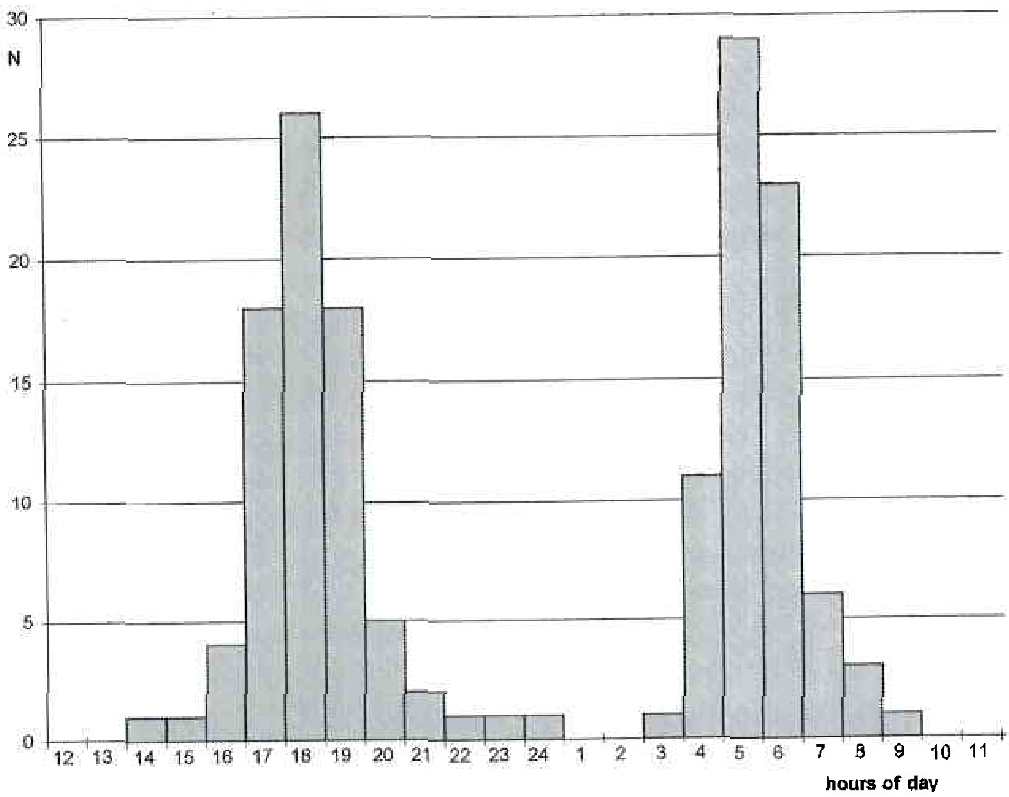

Fig. 4. Frequencies with which activity commenced and ceased at different times in a 24-hour period, along with the normal distributions with which these were compared.

ceased (Fig. 4). The results obtained were compared with a normal distribution, and degrees of concordance of $0.9 < p < 0.95$ and $0.5 < p < 0.9$ were obtained for the commencement and cessation of activity respectively. The normal-type distribution of the breakdown confirms the lack of a relationship between the observed behaviour and sunrise and sunset. Irrespective, the commencement of activity occurred between 17.00 and 19.00, most often at 18.00 and the cessation of activity between 04.00 and 06.00, most often at 05.00.

In the autumn/winter and early spring period, hibernation was observed to last between 1 and 126 days. Aestivation was also observed in one individual on 31.08.95 (at 22.00 and a temperature of 12 °C).

DISCUSSION

The available literature has so far been lacking in any analysis of the level and breakdown of activity in forest dormice. The data that are to be found speak of the nocturnal activity of these animals on the basis of direct data (e.g. ANGERMANN 1963), as well as of their disappearance from nestboxes in October and their reappearance in April (GAISLER *et al.* 1977).

Information on the influence of air temperature on these animals tends to be found in work of a physiological, rather than ecological nature (e.g. LOZAN *et al.* 1990). Lozan points to a temperature for entry into hibernation of about 12 °C, although there is a certain arbitrariness in the data provided by his work. One of his animals still maintained a normal body temperature of about 34 °C (probably normal activity), where the temperature of the surroundings was 8 °C. Subsequently (a month later) a temperature of the surroundings of 10 °C was associated with a dormouse body temperature of just over 10 °C (probably indicating hibernation).

These data would seem to confirm the present author's hypothesis concerning possible alternative kinds of behaviour of animals in the same conditions within a temperature range below 12 °C. The lower limit of this »field of choice« would appear to be a temperature in the range of 0–3 °C (Fig. 2).

The only work so far devoted to the analysis of activity among forest dormice is the paper of SAINT GIRONS and LENKIEWICZ 1965. Their results are of limited significance as the study was based only one individual (a female). The authors established by an actograph event recorder that the forest dormouse is a nocturnal animal with bimodal activity patterns (featuring a highest peak of activity at 21.00). Night-time movements were usually divided into 1–2 periods, and diurnal activity would also occur. The species was found to be active between March and October, though the months of March and September were characterized by very considerable variations in levels of activity, including multiple shortlived declines to 0 %. As in the present study, the individual observed was in captivity. The authors did not analyze the relationship between activity levels and temperature, applying rather different methods of analysis and presentation to those employed here. Nevertheless, it is possible to speak of concordance between the results obtained, with differences arising from the different methods used. The only fundamental difference is in fact the lack in the earlier work of a clear increase in the activity of the studied dormouse in August and September. In the present study, such an observed rise is linked to the essential need to prepare for hibernation through the laying-down of fat and the construction of a nest. The animal in the earlier study did show very high levels of activity from April onwards, and it may be that this masked an August-September peak. Alternatively, it may simply be that increased activity of the kind reported here was not necessary for the animal studied by Saint Girons and Lenkiewicz.

A controversial result would seem to be the independence of the commencement and cessation of night-time activity on the one hand and the time of sunrise and sunset on the other (Fig. 4). Doubts are raised by the positioning of the cage and the light used for observation, and there arises a question as to whether the dormice studied did not react to the monotonous and constant times of intensification and moderation of the noise of the city, to the rhythm of the lives of the inhabitants of the flat, or else to other »permanent disturbances« which do not occur in natural conditions. The work of Saint Girons and Lenkiewicz did not give a detailed analysis of the results, but the authors suggested that activity usually commenced at sunset with the possibility of an hour's fluctuation. However, from the diagrams they presented it can be seen that activity could begin even 3 hours before or after sunset, and that this was not an exceptional but an ordinary situation. The author of the present work therefore carried out an analysis of data from the work under discussion obtained from the aforementioned diagrams (the authors did not publish tables of results). In 44.2 % of cases, activity commenced more than one hour after sunset, and in 12.5 % of cases before sunset. Thus a total of 56.7 % of commencements of activity took place with a difference from the sunset time of at least one hour (data from March, April, August and September). The total number of times that activity commenced before sunset represented 26 % of all occasions (data from March, April and September). In the author's view, these data do not allow for the time of the onset of activity to be linked with the setting of the sun. The results presented here also support the author's field observations (Nowakowski in prep.). In the course of field research in Poland's Bialowieza Forest, forest dormice were twice observed in the day leaving birdboxes in which they could often be met. This happened once at 18.23 on May 24th 1993 (cf. sunset at 19.40) and again at 17.48 on June 17th 1994 (cf. sunset at 19.59).

To confirm the data obtained in captivity, the author checked nest boxes a second time in the course of a given day. Twenty-one boxes in which forest dormice had been found in the course of the morning" check (i.e. between 09.00 and 15.00) were revisited on the same day. If this happened before 17.00 (but not earlier than 16.00), it was usual (on 8 out of 10 occasions) to re-encounter the animal noted. However, if the second check was made later than 17.00, then repeat observation was less common (4 out of 11). Double checks were made in May and June when the sun sets between 19.09 and 20.01. There was a fall (44 % !) in the number of repeat encounters after 17.00, from 80 % to 36 %. In spite of the limited number of replicates, the differences in question do achieve statistical significance at $p < 0.001$. The possibility that stress during the opening of the nestboxes could cause the checked dormice to leave the nestboxes earlier cannot be excluded, however it does not seem probable. It does not explain why stress didn't cause the dormice leave the nestboxes before 17.00, but it did cause them to leave at about 18.00, which was still about 4 hours before sunset.

Received October 23, 1997

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SUMMARY

24-hour activity in the forest dormouse (*Dryomys nitedula*).

Wojciech K. Nowakowski

Five forest dormice (*Dryomys nitedula* Pallas, 1778) were studied in cage conditions. The level of activity was measured in terms of the percentage of time spent by an animal out of the nest, with a 24-hour period taken as 100 %. Air temperatures were measured in the course of the research. The dormice were shown to be mainly active at night, though with limited daytime activity. Levels of activity in a 24-hour period varied widely from 8.3 to 36.6 %, and hibernation (0 % activity) was observed to last between 1 and 126 days in winter. There was a close relationship between level of activity and mean 24-hour temperature, with 11.6 °C constituting a boundary between increasing activity at higher temperatures and the possibility of a choice between hibernation and activity at lower temperatures.

SAŽETAK

24-satna aktivnost gorskog puha (*Dryomys nitedula*)

Wojciech K. Nowakowski

Pet gorskih puhova (*Dryomys nitedula* Pallas, 1778) pručavano je u uvjetima zarobljeništva. Razina aktivnosti mjerena je usporedbom količine vremena koje je životinja provela izvan gnijezda, pri čemu je 24 sata iznosilo 100 %. Tijekom istraživanja mjerena je i temperatura zraka. Pokazalo se da su puhovi aktivni većinom noću, iako postoji i ograničena dnevna aktivnost. Razina aktivnosti tijekom 24 sata varirala je od 8.3 do 36.6 %, a hibernacija (0 % aktivnosti) trajala je od 1 do 126 dana zimi. Utvrđena je uska povezanost izmedu razine aktivnosti i srednje temperature u 24 sata, pri čemu je 11.6 °C bila granica izmedu povećanja aktivnosti na višim temperaturama i mogućnosti izbora hibernacije ili aktivnosti na nižim temperaturama.