

Seasonal Fluctuations in the Exploratory Behaviour and in the Activity of Wild Wood Mice

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Lodewijckx E., 1984: Seasonal fluctuations in the exploratory behaviour and in the activity of wild wood mice. *Acta theriol.*, 29, 22: 273—282 [With 4 Tables & 2 Figs.]

During two years the exploratory activity of more than 1000 wild wood mice, *Apodemus sylvaticus* (Linnaeus, 1758) was studied in a modified open field test situation and the activity of more than 450 animals was recorded in semi-natural conditions. There is no correlation between both forms of activity. Since there are insufficient data on juveniles and subadults for most two-month periods, the seasonal changes in these behavioural patterns are described for adults only. Although significant differences in the amount of activity are only rarely found (due to the high interindividual variation), there exists a clear seasonal pattern in the mean activity scores/24-h. Wood mice, males as well as females, are more active during the summer than during the winter months. Seasonal fluctuations in the exploratory behaviour are observed for adult males only. Their exploratory behaviour is characterized by a remarkable increase in spring, high scores during summer and autumn, a decline at the end of autumn and finally by very low scores during the winter. On the other hand, the exploratory activity of adult females remains on a rather constant level throughout the year. As for the amount of activity, the interindividual variation in the exploratory behaviour is very large for both adult males and females in all two-month periods.

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1. INTRODUCTION

Broadhurst (1957) made a distinction between the exploratory activity and the general activity of an animal. The first mentioned form of activity, which is measured by the open field method, is externally rather than internally stimulated, especially by novel environmental conditions. On the other hand, general activity is a spontaneous activity stimulated externally as well as internally (e.g. by hunger). Usually this activity is studied by measuring the over-all motility of an animal (e.g. in a stabilimeter or activity wheel).

Seasonal variations in the general activity of *Rodentia* and *Insectivora*, living under natural conditions, have been described on some occasions (Stebbins, 1971; Buchalczyk, 1972; Herman, 1977). Reports on the exploratory behaviour of wild rodents are scarce (Krebs, 1970).

The general activity as well as the exploratory activity of *Apodemus sylvaticus* was observed in an etho-ecological study, which formed part of a long-term multidisciplinary project on the population regulation of rodents. During a period of more than two years, general activity

(briefly mentioned as "activity" in the text) of more than 450 wood mice was recorded and exploratory data of more than 1000 animals were collected. In this paper we describe and discuss the seasonal fluctuations in these activities of both adult males and adult females.

2. METHODS

About once a month, wood mice were caught on three successive nights in a reserve near Turnhout (Province: Antwerp; Belgium) using Sherman live traps. Immediately after capture, a number of ecological parameters were noted, ethological tests on social and exploratory behaviour were performed and activity was recorded during 24-h or 48-h periods. Eventually the animals were released on the spot of their capture. The mice were never kept in captivity for more than four hours except those whose activity was registered.

The locomotory activity outside the nest of individual mice was measured using fifteen actographs (40×70×25 cm), fitted with a light source, producing a beam of red light, and a photo-electric recorder. The interruptions of the lightbeam were noted by means of a multi-channel chart recorder. A detailed description of the experimental set-up is given in Lodewijckx *et al.* (1984).

Activity was registered under semi-natural conditions, the actographs being placed in a hangar. Consequently, natural light- and temperature conditions could still influence the activity of the mice tested; however possible direct effects of precipitation were excluded.

All wood mice were kept for at least twelve hours in the actographs before registration of their activity started. Activity was measured during the period between two hours before sunset and two hours after sunrise. This was justified by the strict nocturnal life of *A. sylvaticus* (Miller, 1955; Brown, 1956; Kikkawa, 1964; Gurnell, 1975; Greenwood, 1978).

The number of times the signal of the photo-electric cell was interrupted in a 24-h period was regarded as a measure of the amount of activity displayed. Using lined graphic paper it was preferred to count the number of squares in which one or more signals were noted instead of the exact number of signals, as it was often extremely difficult to separate different signals from each other.

An animal was considered to have been active during every half-hour interval in which at least one signal had been recorded. The number of these intervals for every 24-h period was used as a second measure of activity ($\Sigma^{1/2}$ -h active/24-h).

Exploratory activity was studied in a modified open field test situation, type "free exploration" as described by Welker (1957). Wood mice were introduced into a main box (80×50×40 cm) via a small entry tunnel through a vertical sliding door. The main box was divided into eight compartments, of which the floor was ruled into 10 by 10 cm squares. Five parameters were noted: 1. the latency to enter the main box from the entry tunnel, 2. the number of squares crossed in five minutes in the main box, 3. the number of compartments transversed, 4. the farthest compartment that the mouse explored and 5. the frequencies of the behavioural elements. Finally the mean number of crossed squares/minute was withheld as the most suitable measure of the exploratory behaviour. A detailed description of the test situation and the different parameters studied is given in Lodewijckx (1984).

The observation pen was placed in a room without windows. Natural temperature conditions were still able to influence the exploratory activity of the tested mice. All observations were made by means of a camera and a video

installation during the night period under red illumination, since mice are believed to be in different to this part of the spectrum (Southern, 1955; Marten, 1973).

Normality of the activity as well as of the exploratory data was checked by means of a Kolmogorov-Smirnov one sample test (Sokal & Rohlf, 1969), while Bartlett's test for homogeneity of variances (Sokal & Rohlf, 1969) was used to examine the homogeneity of variances. From the results of these tests it could be concluded that the conditions necessary to apply a one way analysis of variance (Sokal & Hohlif, 1969) were fulfilled. When a significant *F*-value was generated in a one way analysis of variance, it was further examined between which groups a significant difference existed by means of the Student-Newman-Keuls (SNK-) test (Sokal & Rohlf, 1969).

The method described by Vandorpe & Verhagen (1980) was used to determine the age of the wood mice. Three age classes were delimited: juveniles, subadults and adults. Since there were insufficient data on juveniles and subadults for most two-month periods, we studied the seasonal variation in the activity and the exploratory behaviour of adults only. Data for males and females were analyzed separately. Sexual condition of the animals was not considered, since there was no influence of the reproductive condition on the amount of activity (Lodewijckx et al., 1984) or on the exploratory activity (Lodewijckx, 1984).

3. RESULTS

Of some animals the exploratory behaviour as well as the activity was measured in the same month. As a result of this the correlation between these data could be studied. Four periods were distinguished: spring, summer, autumn and winter. Data of males and females were analyzed separately. Table 1 summarizes the results. From this, it can be concluded that activity, recorded in the actograph during a 24-h cycle, is not correlated with the exploratory activity, as measured in the modified open field during five minutes.

Table 1
Correlation between the amount of activity and the exploratory behaviour.

Item	Spring		Summer		Autumn		Winter	
	M	F	M	F	M	F	M	F
n	22	17	28	25	32	25	68	44
r	.47	.05	.11	.10	.17	.03	.17	.10
Sign.	s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

n=number of mice tested; r=correlation coefficient; sign.=level of significance (s. — significant, n.s. — non-significant); M=males; F=females.

Tables 2a, 2b and 2c summarize the results of the analyses of variance concerning the seasonal fluctuations in the Σ scores/24-h, the Σ scores/30 min and the Σ 1/2-h active/24-h respectively. Since the activity was measured in a different way during the first three months (lower recording speed of the multichannel chart recorder) the data of these months cannot be compared directly with those of the following months. These activity scores are not represented in the figure and they are not used in the analyses.

Table 2a

Summary of the analyses of variance concerning the seasonal variation in the Σ scores/24-h.

	Source of variation	d.f.	SS	MS	F	Sign.
Adult M	Among groups	10	32689.779	3268.978	1.276	n.s.
	Within groups	156	399563.958	2561.307		
	Total	166	432253.737			
Adult F	Among groups	8	31548.075	3943.509	1.374	n.s.
	Within groups	110	315819.505	2871.086		
	Total	118	347367.580			

n.s.=not significant; M=males; F=females.

Table 2b

Summary of the analyses of variance concerning the seasonal variation in the Σ scores/30 min.

	Source of variation	d.f.	SS	MS	F	Sign.
Adult M	Among groups	10	391.789	39.179	6.323	***
	Within groups	156	966.626	6.196		
	Total	166	1358.415			
Adult F	Among groups	8	317.434	39.679	4.738	***
	Within groups	110	921.236	8.375		
	Total	118	1238.670			

***= $p < 0.001$; M=males; F=females.

Table 2c

Summary of the analyses of variance concerning the seasonal variation in the Σ 1/2-h active/24-h.

	Source of variation	d.f.	SS	MS	F	Sign.
Adult M	Among groups	10	122.368	12.237	0.554	n.s.
	Within groups	156	3446.962	29.876		
	Total	166	3569.329			
Adult F	Among groups	8	351.518	43.940	2.432	*
	Within groups	110	1987.053	18.064		
	Total	118	2338.571			

n.s.=not significant; *= $p < 0.05$; M=males; F=females.

Mean daily activity is higher in summer than in winter (Fig. 1A). Taking into account that summer nights are shorter than winter nights (Fig. 1D), this phenomenon becomes even more pronounced when the mean activity/30 minutes is calculated (Fig. 1B). A significant F -value is only found for the mean amount of activity/30 minutes (Table 2b). The SNK-test shows significant differences between summer and winter months (Table 3A, B).

Wood mice are active during more half-hour intervals in winter than in summer (Fig. 1C). The F -value of the analysis of variance is signifi-

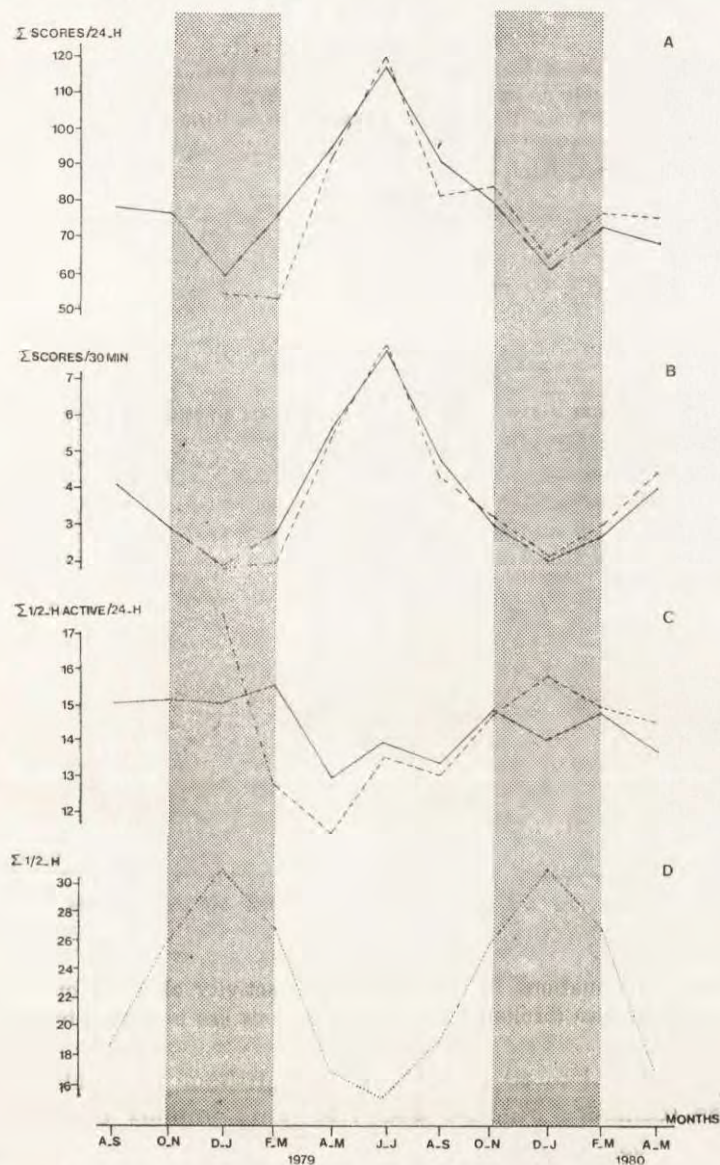


Fig. 1. Seasonal variation in the activity of adult males (solid line) and adult females (broken line).

A — the mean daily activity, B — the mean amount of activity/30 minutes (explanation see text), C — the mean number of half-hour intervals in which the mice were active/24-h, D — the number of half-hours in the dark part of the 24-h cycle (explanation see text). Winter periods are indicated by shading.

cant only for adult females. The SNK-test indicates a significant difference between the period 12-1/1980 and 4-5/1979. Between all other periods no significant differences exist (Table 3C). They are active during 70 to 80% of the number of nightly half-hour intervals in summer, whe-

Table 3
Results of the SNK-tests.

A. Σ scores/30 min — adult males:
12-1/79 12-1/80 2-3/80 2-3/79 10-11/78 10-11/79 4/80 8-9/78 8-9/79 4-5/79 6-7/79
B. Σ scores/30 min — adult females:
12-1/79 2-3/79 12-1/80 2-3/80 10-11/79 8-9/79 4/80 4-5/79 6-7/79
C. Σ 1 1/2-h active/24-h — adult females:
4-5/79 2-3/79 8-9/79 6-7/79 4/80 10-11/79 2-3/80 12-1/80 12-1/79
D. Crossed squares/min — adult males:
12-1/79 2-3/79 12-1/80 4/80 10-11/79 2-3/80 10-11/78 6-7/79 4-5/78 6-7/78 8-9/79 8-9/78 4-5/79

There is no significant difference between groups connected with each other by means of a line.

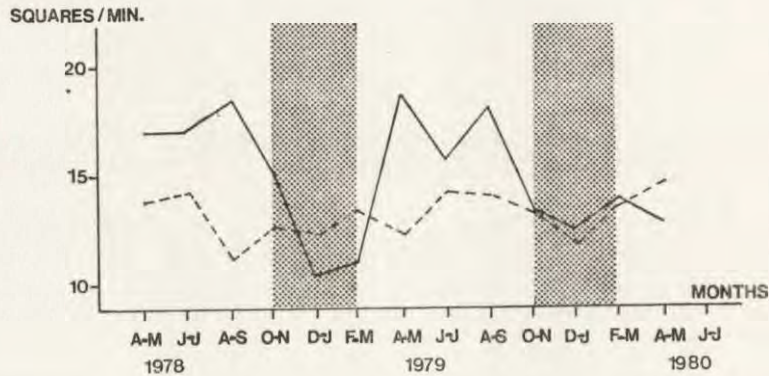


Fig. 2. Seasonal fluctuations in the exploratory activity of adult males (solid line) and adult females (broken line). Winter periods are indicated by shading.

reas this is reduced to 40 to 50% of the half-hour intervals during winter months (compare Fig. 1C and 1D). This implies that the animals are active almost all night in summer while in winter the periods of activity are alternated with periods of inactivity.

To summarize, we can conclude that although only few significant differences could be pointed out by the analyses of variance — for the most part due to the high interindividual variation within each two-month period — a seasonal pattern in the amount of activity can be observed for the mean values.

Figure 2 represents the seasonal variation in the exploratory activity of adult males and adult females. Table 4 gives the results of the analyses of variance. The changes in the exploratory behaviour are more pronounced for adult males than for adult females. Only for males a

significant F -value is found. The SNK-test marks significant differences between summer and winter months (Table 3D).

In conclusion, exploratory behaviour of adult males is characterized by a remarkable increase in spring, high scores during summer and most part of autumn, a decline at the end of the autumn period and finally by low exploratory activity scores in winter. Females however show no clear seasonal variations in their behaviour in the open field test-situation. For both adult males and adult females the interindividual variation in the exploratory activity scores is very high for all two-month periods.

Table 4

Summary of the analyses of variance concerning the seasonal variation in the exploratory activity (crossed squares/min.)

	Source of variation	d.f.	SS	MS	F	Sign.
Adult M	Among groups	12	3090.225	257.519	2.740	***
	Within groups	357	33546.602	93.968		
	Total	369	36636.827			
Adult F	Among groups	12	267.597	22.300	0.394	n.s.
	Within groups	295	16681.031	56.546		
	Total	307	16948.628			

n.s.=not significant; ***= $p < 0.001$; M=males; F=females.

4. DISCUSSION

The fact that there is no correlation between the crossed squares in the open field test situation and the activity, measured in the actograph, was already noticed by Anderson in 1938. As mentioned earlier, Broadhurst (1957) among others made a distinction between the exploratory activity and the general activity of a species.

A number of abiotic variables such as light intensity, length of the photo-period, temperature, precipitation, moonlight... affect the activity of certain *Rodentia* and *Insectivora* (Gębczyński, 1964; Hammer, 1969; Pankakoski, 1979; Lehmann & Sommersberg, 1980; Vickery & Bider, 1981). Most of these variables fluctuate seasonally so that corresponding changes in the activity can be expected. Nevertheless, variations in the amount of activity displayed by rodents throughout the year were seldom described. Stebbins (1971), Buchalczyk (1972) and Herman (1977) reported seasonal differences in the activity of *Peromyscus maniculatus*, *Sorex araneus* and *Clethrionomys gapperi* respectively. They all noted a strong increase of the activity in spring, high scores in summer and a minimal activity in winter. These results are supported by our own observations on the activity of *Apodemus sylvaticus*. Müller (1973) suggested that at least part of the variation in the spontaneous activity of wood mice was caused by seasonal differences.

Seasonal variation in the open field behaviour of wild rodents were seldom reported in the literature. Krebs (1970) measured the exploratory activity of male *Microtus* spp. from February 1966 to September 1967. Apparently he found no clear differences in the vole's behaviour between summer and winter periods.

The higher activity scores of *Apodemus sylvaticus* and the more intense exploratory behaviour in summer than in winter are possibly due to the fact that 1. summer is the reproductive period of the wood mice, 2. the intraspecific relations between the mice are possibly changed with respect to the winter and 3. because of the shorter nights in summer and their strict nocturnal life the wood mice are forced to gather their food and to explore their home range in a smaller time interval. Moreover, a high activity in winter is energetically unfavourable. McNab (1963) has shown that energy used for activities other than thermoregulation is greatly decreased in winter by *Peromyscus* spp. As a result, energy requiring activities other than thermoregulation, such as growth, reproduction and high levels of activity are postponed until cold stress is diminished.

Home range size changes in *Apodemus* populations were described by Crawley (1969) and Randolph (1977). Verhagen (pers. communication) also noted seasonal fluctuations in the range size of our wood mice. At the same time he observed seasonal changes in the distances, that the mice travelled on the field (Verhagen, 1980). Males travel more in spring and summer than in winter. The fluctuations in the female's behaviour are less pronounced. This movement pattern and the home range size changes are identical to the seasonal pattern observed in the exploratory behaviour and in a lesser degree to that in the activity. However we found no correlation between the home range size or distance travelled in the field and the activity scores or the exploratory behaviour of the mice.

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SEZONOWE WAHANIA BEHAVIORU ZWIADOWCZEGO I AKTYWNOŚCI
APODEMUS SYLVATICUS

Streszczenie

W ciągu 2 lat badano aktywność zwiadowczą ponad 1000 *A. sylvaticus* w doświadczeniach terenowych oraz aktywność ponad 450 osobników w warunkach półnaturalnych. Nie stwierdzono korelacji między oboma formami aktywności (Tabela 1). Opisano sezonowe zmiany wzorców behawioralnych tylko u dorosłych myszy z uwagi na zbyt małą liczbę danych o zwierzętach młodszych klas wiekowych. Wystąpiła wyraźna sezonowa zmienność wzorca aktywności dobowej, jakkolwiek różnice nie były istotnie różne z uwagi na wysoką zmienność międzysobniczą (Tabela 2a, b, c; 3). Zarówno samce jak i samice *A. sylvaticus* są bardziej aktywne w ciągu lata niż w ciągu zimy (Ryc. 1). Sezonowe wahania w behawiorze zwiadowczym wystąpiły tylko u dorosłych samców (Ryc. 2). Ich behawior zwiadowczy charakteryzuje się istotnym wzrostem na wiosnę, wysoką wartością w lecie i jesieni a następnie spadkiem pod koniec jesieni i w końcu bardzo niskim poziomem w zimie (Tabela 4). Aktywność zwiadowcza dorosłych samic jest zasadniczo stała w ciągu roku. Podobnie jak aktywność międzysobnicza zmienność behawioru zwiadowczego jest u dorosłych samców i samic we wszystkich badanych okresach bardzo duża.