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Effect of long laboratory rearing on the hibernation pattern in the garden dormouse, Eliomys quercinus

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Hibernation in garden dormice originating from a French population has been followed in the laboratory in constant undisturbed conditions at a T_A of 4 °C for 10 years (1969—79). The mean duration of the hibernation periods of the females has shortened by about half and that of the males by more than half, the original difference between the sexes disappearing. These changes in the hibernation pattern are ascribed to ageing and to the long rearing of the stock in laboratory conditions. In spite of the great changes in periodicity, the relative weight loss during the hibernation seasons has remained about the same.

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1. Introduction

A previous paper (Pajunen 1974) reported parameters of hibernation in representatives of the French population of the garden dormouse, *Eliomys quercinus* L., maintained in constant undisturbed laboratory conditions at a T_A of 4 °C. This stock was then kept under observation to see whether the hibernation pattern would undergo any changes.

2. Material and methods

Garden dormice captured in France in autumn 1968 (cf. Pajunen 1974) were reared in the laboratory by non-sib mating. During summertime the animals were fed as described by Pajunen (1974); however, from summer 1977 the amount of animal food was increased (larvae of *Tenebrio molitor,* kidney, liver and meat).

Hibernation was studied at a T_A of 4.2 ± 0.5 °C during seven winters: 1969—71 (Pajunen 1974) and 1974—79. This T_A is believed to be near the optimal T_A for hibernation in the garden dormouse (Pajunen 1976b, 1978). The animals were kept undisturbed in continuous darkness without food or water. The results of winters 1969—71 are given as averages. In 1975—76 a light-dark period of 12:12 was used. In each animal the lengths of the hibernation periods were measured by the sawdust technique and confirmed by continuous measurements of subcutaneous temperature (Pajunen 1974); the total weight loss during each hibernation season was also measured.

In Table 1 the animals are classified by age and sex, and the mean age of the animals at the start of each winter is given. The average age changed in the course of the present study from under 1 year to about 4.5 years during the last winter studied. The last successful breeding was

Table 1. Sex and age (years) of the garden dormice studied.

	♀♀	♂♂	<1	1	2	3	4	5	6	7	8	$\bar{x}$
1969—71	16	14	20	6	4	—	—	—	—	—	—	<1
1974—75	19	27	17	7	9	—	12	1	—	—	—	2
1975—76	14	24	1	17	4	10	—	6	—	—	—	2
1976—77	9	25	6	1	14	3	7	—	3	—	—	2.5
1977—78	7	21	—	5	1	11	2	7	—	2	—	3.5
1978—79	5	10	—	—	3	1	4	1	5	—	1	4.5

Table 2. The mean initial weights and weight ranges (g) of the garden dormice studied.

	♀ ♀	♂ ♂
1969—71	107.0 (65.5—161.0)	98.5 (72.5—151.0)
1974—75	145.8 (88.0—205.5)	147.9 (65.0—257.5)
1975—76	155.8 (85.5—251.5)	153.1 (85.0—254.5)
1976—77	178.0 (94.5—252.5)	190.4 (102.0—270.5)
1977—78	157.9 (102.0—224.5)	187.9 (117.5—296.5)
1978—79	190.0 (140.5—232.0)	199.1 (126.5—306.0)

in 1976. The increase in the initial weights year after year (Table 2) reflects the ageing of the group and the effect of the long rearing in the laboratory.

In all, there are records for 46 males and 29 females. Almost all animals were followed for two winters, 11 for three, 12 for four, nine for five, and one for six winters.

3. Results

Subcutaneous temperature measurements showed that the anterior T_B was maximally 1 °C higher than the T_A throughout each period of deep hibernation (bout of hibernation). Fig. 1 shows the mean values, standard errors of the means and standard deviations for the lengths of the hibernation periods calculated at 10-day intervals for males and females separately throughout the hibernation seasons. Below are given the dates of the first and last counting points of the different study winters.

1969—71	29.X —17.IV
1974—75	18.XI — 7.V ♂♂, 27.IV♀♀
1975—76	29.X —27.IV♂♂, 17.IV♀♀
1976—77	18.XI —27.IV
1977—78	18.XII—28.III
1978—79	18.XI —18.III

During 10 years in the laboratory the hibernation pattern of the garden dormouse changed significantly. The mean duration of the hibernation periods of the females shortened by about half and that of the males still more.

Table 3 shows the effect of ageing on the length of the hibernation periods in animals that were followed for two to six different winters. As a measure the mean of three midwinter hibernation periods (the 7th, 8th and 9th counting points) was selected. The means are expressed as proportions of the value for the first winter in the cold. For eight animals the first winter value was not available, so the third winter mean value was used and the proportions for the other winters were then adjusted to the average value for the third winter (0.72). The hibernation periods shortened with increasing age from the first to the third winter and then became stable. Thus the shortening of the hibernation periods is not wholly explained by increasing age. Another factor contributing to the change was the long rearing of the stock in the laboratory. The shortening was not influenced by the change in the summer feeding.

During the first 2 years of the study the males exhibited a longer duration of the hibernation periods throughout the seasons than the females.

Table 3. The effect of ageing on the mean length of the hibernation periods.

$\bar{x}$	*SD*	*N*	Hibern. season
1		15	1
0.92	0.35	5	2
0.72	0.14	13	3
0.66	0.15	11	4
0.78	0.27	12	5
0.51	0.17	6	6
0.67	0.25	7	7
0.96	0.13	2	8
0.92		1	9

But in the males the mean duration of the hibernation periods shortened as much during the first 5 years as during the last 5 years, while in the females there was only a slight shortening during the first half of the study (Fig. 1). As a result, the original difference in the mean durations of the hibernation periods disappeared. During the latter half of the present study the hibernation periods in both sexes seemed to shorten evenly year after year; only the light-dark rhythm in 1975—76 stopped the shortening for that particular winter.

Towards the end of the seasons there was a shortening of the mean length of the hibernation periods in the males only (Fig. 1), while the females continued to display the midwinter hibernation pattern. This spring change in the hibernation pattern of the males became less evident during the latest winters studied.

Table 4 shows the relative weight loss during the different hibernation seasons. The more frequent arousals did not significantly increase the total loss of weight, which means that the rate of energy expenditure between hypothermic periods must have decreased. This could even be inferred from the behaviour of the animals during the normothermic periods in the cold. In the first few years the animals were more mobile and inclined to jump and make rapid rotating movements in the cage when normo-

Table 4. Relative weight loss during hibernation.

	Weight loss %	Days in the cold	Arousals/ 100 days
1969—71	43.4	167—194	7.6
1974—75	41.6	176—181	9.7
1975—76	36.3	156—157	11.4
1976—77	34.6	164—168	11.6
1977—78	33.5	111	13.6
1978—79	40.4	136	14.4

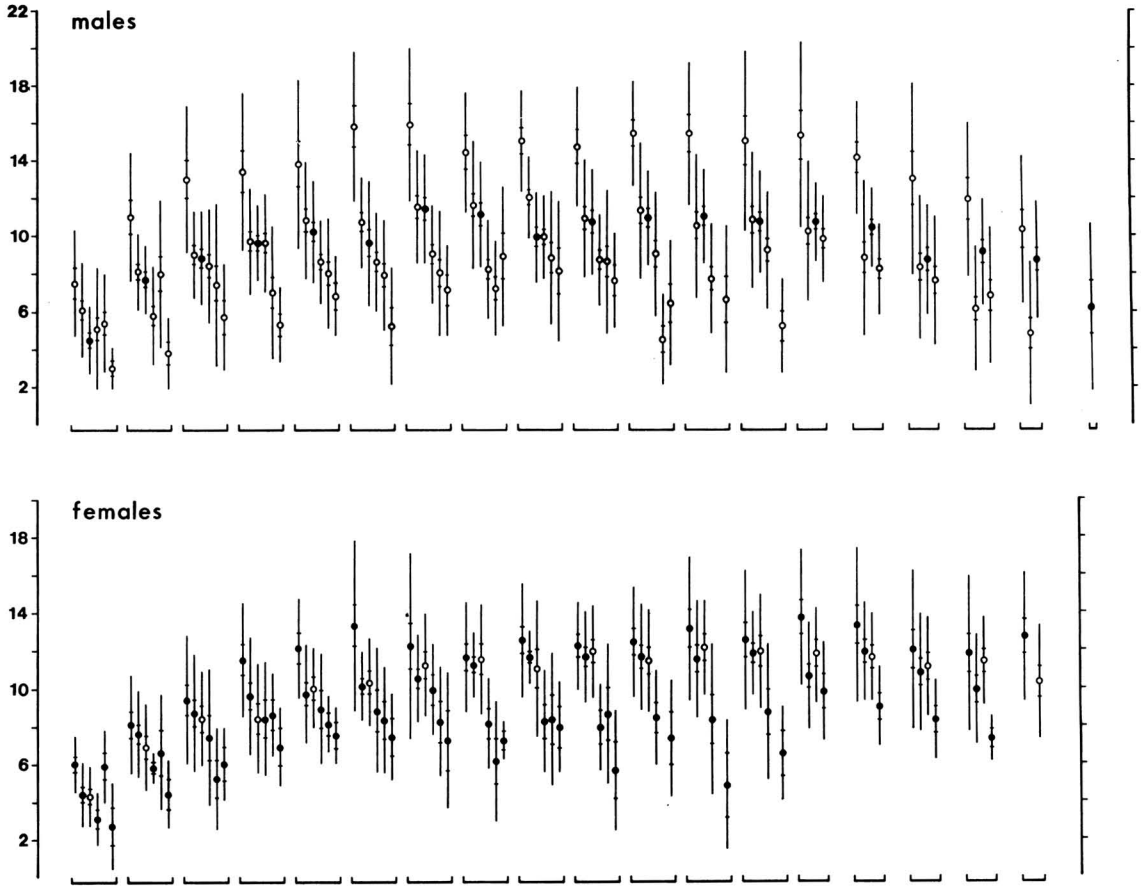

Fig. 1. Mean values for lengths of the hibernation periods in the garden dormice at 10-day intervals throughout the different seasons. Values for different years are grouped in chronological order, with equal spacing between successive means of a given year. The means for the winter when the light-dark rhythm was used are indicated by filled circles in the males and by open circles in the females. The standard errors of the means are marked off with short horizontal lines on the vertical lines denoting standard deviations.

thermic in the cold. During the last few years they moved very little.

In spite of these changes, garden dormice can be considered good hibernators in laboratory conditions, the periods of hypothermia lasting for several days even during the last winter studied, and averaging maximally (in midwinter) 6—7 days.

4. Discussion

The T_A of 4 °C used in the present study is believed to be near the optimal T_A for hibernation in the garden dormouse (Pajunen 1976b, 1978). At this T_A the hibernation periods can be expected to be of maximal length. The present results show that very careful attention has to be paid to how long the animals have been reared in the laboratory. During 10 years the mean duration of the hibernation periods of the females shortened by about half and that of the males still more. Analysis showed that the periods shortened with increasing age, but that the long rearing of the whole stock in the laboratory was a further contributory factor. It was impossible to evaluate which factor contributes more to the change in the hibernation pattern during the laboratory rearing, the constant conditions during the study winters or the monotonous environment in general. The physiology of rodents is known to be influenced by environmental complexity (e.g. Rosenzweig et al. 1968). The change in the summer food did not influence the continuous shortening of the mean duration of the hibernation periods.

In the beginning of the present study there was a sex difference in the mean durations of the hibernation periods. Pengelley et al. (1978) have also detected differences between the sexes in *Citellus lateralis* at a T_A of 5 ± 1 °C. Their results differed in some respects from my data for garden dormice, as do many parameters in different hibernating species. For example, within the whole hibernation season female *Citellus lateralis* spent more days in deep hibernation than males, but males had longer periods of continuous deep hibernation than females. In the beginning of the present study with the same technique the male garden dormice also had longer hibernation periods throughout the season, but there were no differences in the duration of the normothermic periods. Thus, during the first winters the males spent more time within the whole season in deep hibernation than the females. However, during the first half of the present study this difference disappeared.

Another difference between the sexes in the present study was detected towards the end of each hibernation season. At that time only the males showed a shortening of the mean duration of the hibernation periods, whilst the females continued to follow the midwinter hibernation pattern. This shortening may be interpreted as a sign of readiness to terminate the hibernation season. This may be due to the difference in genital reactivation between the sexes towards the end of the season (Pajunen 1976b), an idea which is consistent with the observation that only males had shorter hibernation periods in the spring. However, the shortening of the hibernation periods became less evident during the latest winters of the present study.

From the results of Pajunen (1976a) in Finnish garden dormice it can be calculated that one arousal lasting about 12 h (including spontaneous arousal, the period of normothermia and entrance into deep hibernation) consumes as much energy as about 60 days in deep hibernation. During the present study the duration of the normothermic periods remained about the same throughout the different seasons and the number of arousals increased about twofold. As regards the economy of energy expenditure during the whole season the number of arousals did not play such an important role after long rearing in the laboratory, for the total loss of weight remained about the same year after year, evidently owing to the change in the general behaviour of the animals during the normothermic periods in the cold. Thus, hibernation in the present environmental conditions seems to be a stable phenomenon. Energy expenditure remains about the same during the different seasons; if the hibernation pattern changes in some respect, this is balanced by a change in some other respect.

The great changes in the hibernation pattern suggest that results obtained from animals reared for long periods in the laboratory may not be applicable to field conditions.

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