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Hibernation and body weight in Dormice, *Glis glis orientalis* (Nehring, 1903) (Rodentia: Gliridae), maintained under uncontrolled conditions

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Abstract: Hibernation pattern and changes in the body weight of juvenile and adult dormice, *Glis glis orientalis*, kept in uncontrolled conditions were investigated. It was determined that *G.g.orientalis* entered hibernation on October 28 when its body weight was 180 g and the ambient temperature was below 18 ºC, which seems to be the critical temperature for entering hibernation. Although body weight has an important role in entering hibernation at the beginning of the hibernation season, dormice hibernated as the hibernation season progressed regardless of their body weight. Adult dormice arose from hibernation during the period of May 13 to June 6. The maximum uninterrupted period of hibernation was 31 days in adult dormice and 36 days in juveniles. An adult dormouse spent 181 days in hibernation during the hibernation season. There were periodic cycles, varying from 1 to 6 weeks, in the body weight of *G.g.orientalis.*

Key Words: *Glis glis orientalis,* hibernation, body weight.

Değişen şartlarda tutulan *Glis glis orientalis* (Nehring, 1903) (Rodentia: Gliridae)'in hibernasyonu ve vücut ağırlığı

Özet: Değişen şartlarda tutulan *Glis glis orientalis*'in vücut ağırlığındaki değişiklikler ve hibernasyonu araştırıldı. *G.g.orientalis*'in 18 ºC'nin altındaki ortam sıcaklığında ve 180 g. vücut ağırlığında hibernasyona girdiği ve 18 ºC'lik çevre sıcaklığının hibernasyona giriş için kritik sıcaklık olduğu saptandı. Vücut ağırlığının hibernasyon sezonunun başlangıcında hibernasyona girmede önemli bir role sahip olmasına rağmen, hibernasyon sezonu ilerledikçe *G.g.orientalis*'in vücut ağırlığı ne olursa olsun hibernasyona girdiği görüldü. Ergin yediuyurlar 13 Mayıs ile 6 Haziran tarihleri arasında hibernasyondan uyandılar. Maksimum kesintisiz hibernasyon periyodu erginlerde 31 gün gençlerde ise 36 gün olarak saptandı. Ergin bir yediuyur bir hibernasyon sesonu boyunca 181 gün hibernasyonda kaldı. *G.g.orientalis*'in vücut ağırlığında 1-6 hafta arasında değişen periyodik sikluslar tespit edildi.

Anahtar Sözcükler: *Glis glis orientalis,* hibernasyon, vücut ağırlığı.

Introduction

Hibernation is a strategy that permits some mammals to survive seasons of low food availability (1). The dormouse, *Glis glis,* is a small arboreal nocturnal rodent and an excellent hibernator of the family Gliridae. If the ambient temperature is cold and dormice hibernate, the periodicity of he cycle is circannual (2). When kept in constant conditions, dormice display endogenous cycles of body weight, food intake and other variables (2). Food intake and body weight are controlled by endogenous rhythms (3). When the edible dormouse (*G. glis*) is kept in a warm room, it undergoes cycles of food intake and body weight of about two months (4). Scott and Fisher (5) reported that the maximum uninterrupted period of hibernation in *G. glis* was 40 days.

The studies mentioned above were carried out on adult dormice from different geographic regions kept in constant conditions (temperature and photoperiod). However, *G. glis* has 10 subspecies (6), and of these supspecies, *G. glis pindicus* Ondrias, 1966, and *G. glis orientalis* (Nehring, 1903) are distributed in Turkey, where deciduous woods are prevalent (7, 8).

The aim of this study is to examine hibernation patterns along with changes in the body weight of juvenile and adult dormice belonging to a distinct subspecies, *G. glis orientalis*, in order to discover if there are cyclical fluctuations in the body weight of juvenile and adult dormice maintained in uncontrolled conditions.

Materials and Methods

Dormice used in this study were taken from Çayeli (RİZE) in the year 1990. We conducted an experiment lasting 11 months, from August 1990 to June 1991, in order to study juvenile dormice, as they attain sexual maturity by 11 months (6). Five adults and eight juveniles were used for determining hibernating patterns and body weights.

Five adult females were weighed weekly until the beginning of hibernation, even during suckling and at periodic arousals during the hibernation season. After the 2-month postnatal development, 8 juvenile and 5 adult dormice were housed individually in a cage (30x40x30 cm) floored with soil of 10 cm, and juveniles were weighed (g) weekly. Animals were provided with food (hazelnuts, sunflower seeds, apple) and water. Hibernation was recorded according to Scott and Fisher (9). Animals were visited daily and a note made of whether they were active or hibernating. If hibernating, a small pile of sawdust was placed on the back of the animal. The sawdust remained in place until the animal became active. By this tecnique, periodic arousals and the duration of individual bouts of hibernation were detected. In order to observe behavior of dormice during hibernation season, 10 juvenile dormice were transfered into a cage (40x120x30 cm) filled with 10 cm of soil with two nesting boxes. Changes in ambient temperature were monitored by maximum and minimum (ºC) (Figure 1).

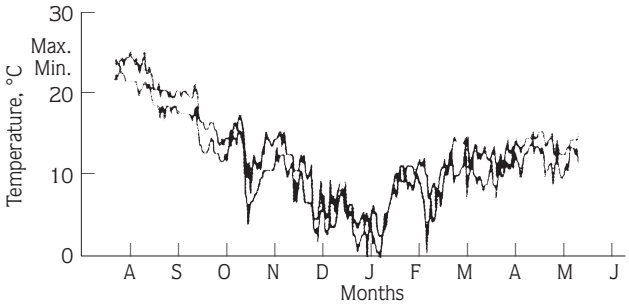

Figure 1. The ambient temperature of the laboratory where the animals were housed.

Results

Entering hibernation

Changes in the body weight of adult dormice during the 8-month hibernation preparation period are given in Table 1. The average body weight of adult dormice (n=5) was 110.4 g on August 14, and 178.6 g on October 13. After this time, dormouse numbers 8 and 11 lost weight; however, numbers 5 and 7 gained. *G.g.orientalis* entered hibernation on October 28 when its body weight was 180 g and the ambient temperature fell below 18 ºC, which seems to be the critical temperature for entering hibernation in *G.g.orientalis.* It is worth noting that dormice hibernated as the hibernation season progressed regardless of their body weights. This showed that body weight's main role is in entering hibernation.

Hibernation in Juvenile Dormice

The hibernation of juvenile dormice was different from that of adults with respect to entering hibernation and awaking from hibernation. Dormouse number 1 entered hibernation at the beginning of June when the adults awoke Hibernation was scanty in number 4, number 12 did not hibernate. Number 13 hibernated the same as the adults did (Figure 2).

Hibernation in Adult Dormice

Dormice numbers 5, 7, 8, 9 and 11 entered hibernation on October 27, November 10, December 9, October 27 and December 19, and awoke from hiberration on June 6, May 31, June 4, May 13, and January 31, respectively (Table 3).

Table 1. Changes in body weight (g) of 5 adult dormice during hibernation preparation.

Date/An.No	14 August 1990	29 September 1990	7 October 1990	13 October 1990	27 October 1990	10 November 1990
5 ♀	112	158	148	175	185	175
7 ♀	106	141	139	146	170	180
8 ♀	114	138	133	140	130	125
9 ♀	124	178	202	200	195	180
11 ♀	94	181	211	232	210	180
Average	110.4	159.2	166.6	178.6	178	168

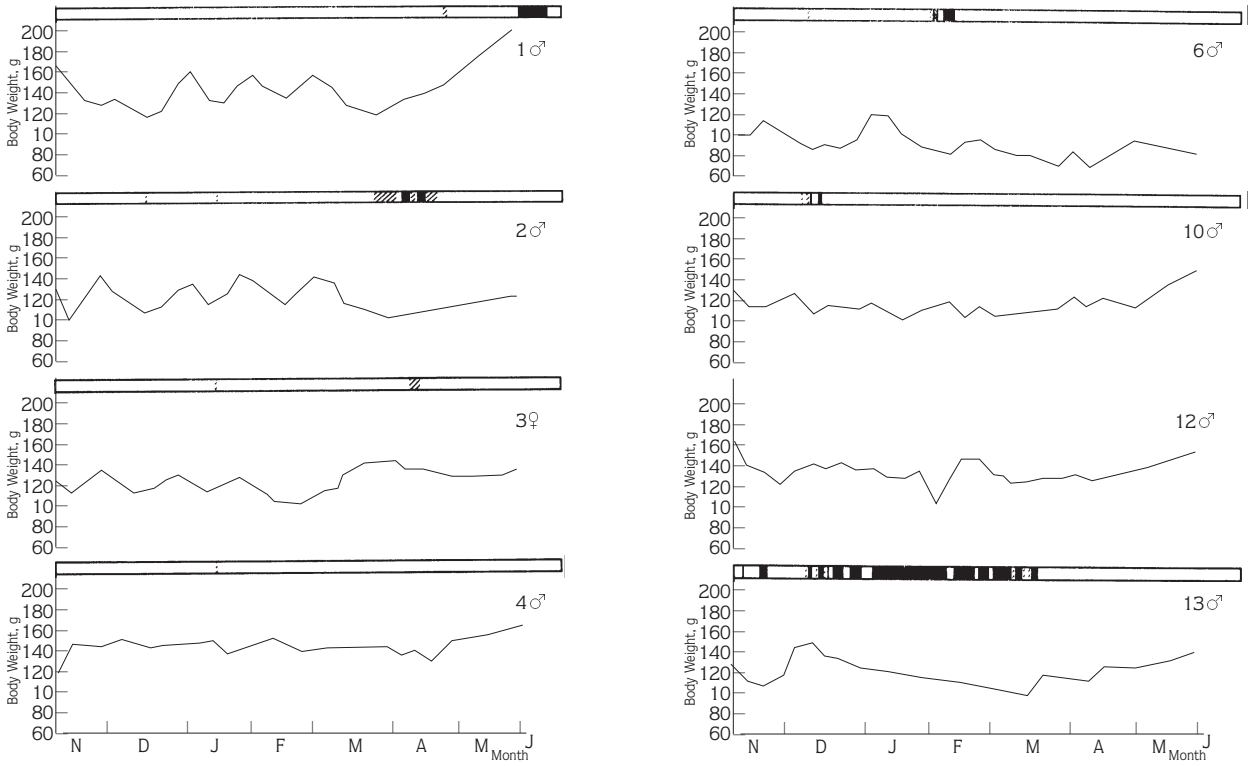

Figure 2. Body weight in grams (solid line) and periods of continuous hibernation (solid vertical bars) of 8 juvenile dormice. White spaces show that the animal was active. Hatched areas indicated the animal was without sawdust on the previous day.

Periodic Arousals

The duration of individual bouts of hibernation varied from 1 to 31 days (Table 2). There was tendency for bouts to grow longer as the hibernation season progressed and shorter in the terminal period. The number of days spent in hibernation fluctuated from 5 to 181 (Table 3).

Changes in Body Weight

Figures 2 and 3 depict changes in the body weight of juvenile and adult dormice. Fluctuations in body weight were very marked in juvenile dormice, but imperceptible in adults because they were hibernating. Fluctuations in body weight ranged from 72 to 202 g in 8 juvenile dormice and from 110 to 232 g in 5 adults (Table 4). The magnitude of the fluctuations varied among the animals and over the hibernation season. For example, in dormouse number 1, the body weight varied from 115 to 202 g, while in dormouse number 13, it varied from 100 to 147 g. The cycles of body weight were nearly synchronized in dormice numbers 1, 2 and 3. In adults, body weight ranged from 133 to 180 g in dormouse number 5, and from 133 to 185 g in dormouse number 7. The maximum and the minimum body weights of some juvenile and adult dormice were very close to each other (Figure 2 and 3, Table 4). In juvenile dormice, it ranged between 100 and 145 g in dormouse number 2, 100-141 g in number 3 and 100-147 g in number 13. Differences between the maximum and the minimum body weights of 5 juvenile dormice were nearly equal to each other. This range was 45 g in dormouse number 2, 41 g in number 3, 41 g in number 4 and 43 g in number 6 (Table 4). Although periodic cycles occurred in some juveniles (numbers 1, 2 and 3), there were no such cycles in adults because they hibernated. The cycles were more marked in the winter months, but broken in the spring (March, April, May) and June. The periodicity of body-weight cycles in body weight were about 3-5 weeks in dormice No. 1, 2 and 3, 3-6 weeks in No. 6, 2-5 weeks in dormouse No. 12 and imperceptible in numbers 4, 10 and 13 (Figure 2).

Table 2. Duration of bouts of hibernation of 5 adult dormice, days.

5 ♀	2 2 2 4 1 7 12 1 4 7 28 22 17 16 6 12 1 1 1 3 3 2 2 2 3
7 ♀	1 8 6 7 19 31 13 6 10 10 13 2 5 6 6 6 2 1 2 2 4 5 1 2 3 8
8 ♀	2 4 4 6 22 25 18 6 10 2 11 8 7 4 1 3 5
9 ♀	1 1 2 1 2 2 6 1 3 2 4 3 9 24 5 6 6 7 8 10 4 4 3 2 2 2 2 2 13
11 ♀	1 2 3 12 3 2 2 3 x died

Table 3. Data of a hibernating season for each of 13 d ormice.

Animal No	First Hibernation Entrance	Body Weight (g) in First Hibernation Entrance	Last Hibernation Arousal	Body Weight (g) in Last Hibernation Arousal	Time (day) spent in Hibernation
1 ♂	1 April 1991	117	2 April 1991	100	19
2 ♂	24 December 1990	105	23 April 1991	134	24
3 ♀	19 January 1991	111	20 April 1991	146	5
4 ♂	19 January 1991	147	20 January 1991	169	-
5 ♀	27 October 1990	185	6 June 1991	169	174
6 ♂	12 December 1990	87	14 February 1991	83	8
7 ♀	10 November 1990	180	31 May 1991	144	181
8 ♀	9 December 1990	164	4 June 1991	110	139
9 ♀	27 October 1990	185	13 May 1991	145	128
10 ♂	9 December 1990	125	18 December 1990	161	28
11 ♀	19 December 1990	190	31 January 1991	161	28
12 ♂	-	-	-	-	-
13 ♂	22 November 1990	105	23 March 1991	100	89

Table 4. Maximum and minimum body weight (g) in the hibernating season of 5 adult and 8 juvenile dormice.

	Minimum	Maximum	Range
1 ♂	115	202	87
2 ♂	100	145	45
3 ♂	100	141	41
4 ♂	120	161	41
6 ♂	72	115	43
10 ♂	103	152	49
12 ♂	104	168	64
13 ♂	100	147	47
5 ♀	133	180	52
7 ♀	133	185	47
8 ♀	110	178	68
9 ♀	143	200	57
11 ♀	155	232	77

From these results, it was determined that the periodicity of body-weight cycles in juvenile dormice, *G.g.orientalis,* kept under various conditions varies from 2 to 6 weeks.

Behavior During Hibernation Period

Both adults and juveniles had a tendency to hibernte underground, but some dormice hibernated in nest boxes insulated with soil and nesting material.

It was determined that the hibernating dormice had a characteristic body position that reduced loss in body temperature. Dormice curled into a tight ball with the nose tucked beneath the tail (Figure 4). When ambient temperature increased, dormice uncurled slightly. It took dormice about 50 minutes to awake from hibernation at an ambient temperature of 3 ºC. An awaking dormouse was observed to shiver until arousal was complete, squeaking and moving its body. After it had opened its eyes, it kept still for a time.

Discussion

The hibernation pattern of juvenile dormice was different from that of adults. However, one juvenile dormouse (number 13) hibernated in the same manner as adults, while the others hibernated irregularly. This showed that young born in captivity in August hibernated over their first hibernation season but that their hibernation was very disordered. The timing pattern of hibernation in juveniles was also different from that in adults. One reason for this may be that juveniles were not able to increase their weight sufficiently for hibernation.

Mrosovsky and Sherry (1) stated that food storage is not a necessary precondition even when food is

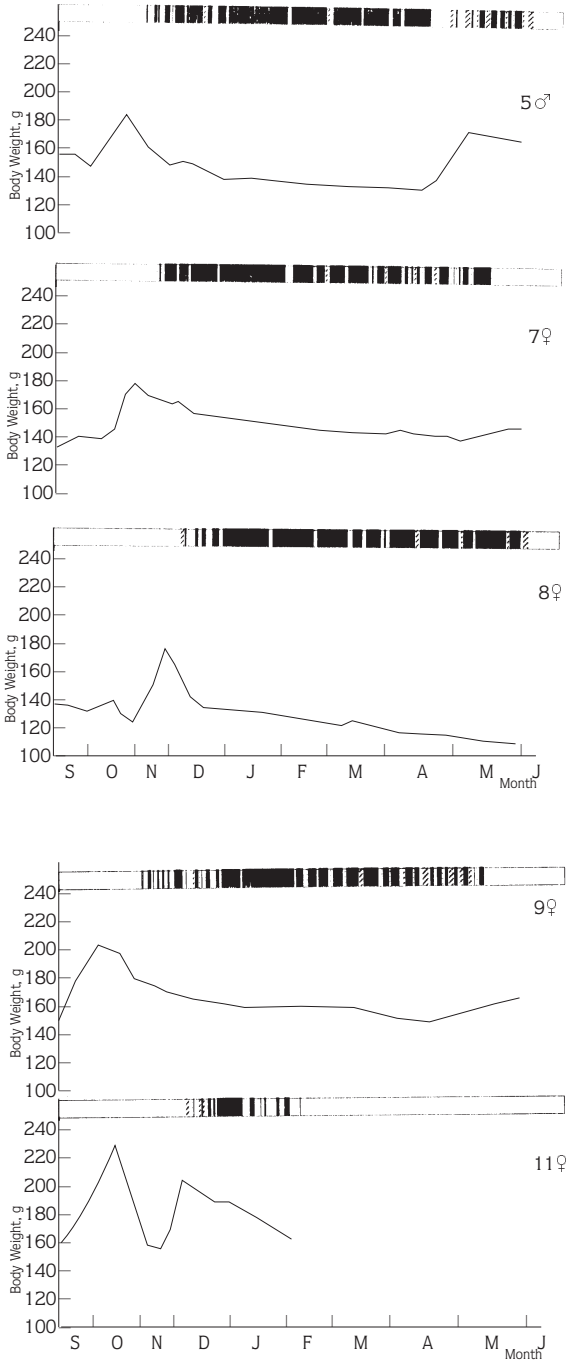

Figure 3. Body weight in grams (solid line) and periods of continuous hibernation (solid vertical bars) of 5 adult dormice. Other conventions as Figure 2.

available. In this study, dormice had access to food and water while preparing for hibernaton, and they ate during their periodic arousals. Food availability had no effect on the hibernation of dormice in captivity.

Figure 4. Characteristic body position (arrow) of G.g. orientalis *in* hibernation.

This is consistent with Mrosovsky and Sherry (1). In Caucasia, Ognev (6) suggested that *G. glis* begins to hibernate in October and awakes from hibernation on June 10. *G. g. orientalis* entered hibernation on October 28 and awoke between May 13 and June 6. This is consistent with Ognev (6).

Fisher and Manery (10) determined that *G. glis* eats during its periodic arousals, as in the present study. In contrast to Fisher and Manery (10), we revealed that it eats after long uninterrupted bouts of hibernation rather than short ones in order to compensate for lost weight.

Lyman (11) reported that the maximum uninterrupted period of hibernation was 7 days in *Cricetus cricetus,* Herter (12) 16 days in *Muscardinus avellanarius,* Pajunen (13 and 14) 15 days in *Eliomys quercinus* in Finland, and Crawford (15) 30.5 days in *Zapus princeps*. In *G. glis,* Wyss (16) and Scott and Fisher (5) recorded 33 and 40 days, respectively. Our findings of 31 days in adults and 34 days in juveniles (No. 13) in *G. g. orientalis* are consistent with Wyss (16) and Scott and Fisher (5). Scott and Fisher (5) reported that while the bouts of the hibernation became longer as the hibernation season progressed, they became shorter in the terminal period. In *G. g. orientalis,* periodic arousals took place, so the hibernation season was divided according to the bouts of hibernation. As given in Table 2, our findings are consistent with those of Scott and Fisher (5). The hibernation of juvenile dormice was inadequate over 7 months, with the exception of number 13. Cyclical fluctuations in body weight in some juvenile dormice were determined. The periodicity of the cycles is comparable to those reported by Mrosovsky and colleagues (4, 17, 18).

Mrosovsky (17) reported that cycles of a few weeks in body weight occur in dormice, *G. glis,* kept in the laboratory in relatively constant conditions of temperature (about 25 ºC) and with a photoperiod of about 12:12 L.D. Furthermore, these fluctuations appear to be marked in the winter months. Mrosovsky (17) revealed that periodicity in adult dormice kept in a warm room (about 20 ºC) is only about two months, while Mrosovsky and Boshes (2) determined the same periodicity for adult dormice kept at 25 ºC. Schaefer et al. (19) revealed that the cycles in the body weight of dormice, *G. glis,* kept in various conditions to be about 6 weeks. Following postnatal development of 3 months, we kept 8 juvenile dormice in an ambient temperature varying from 0 ºC to 27 ºC (Figure 1) with an uncontrolled photoperiod. We determined that the periodicity of the cycles in the body weight varies from 2 to 6 weeks. Since some juvenile dormice had cycles of 6 weeks, this is somewhat consistent with the findings of Schaefer et al. (19). That the cycles in juvenile dormice are more marked in the winter months in consistent with Mrosovsky (17).

Rathwell and Stock (20) stated that captive dormice, *G. glis,* show spontaneous cyclical fluctuations in body weight that are not synchronized among animals. They seem to be cyclical fluctuations in the body weight of dormice numbers 1, 2 and 3, which occur together at the same programmed time of the year, suggesting a synchronicity among these dormice (Figure 1). The maximum and the minimum body weights of juvenile dormice numbers 2, 3, 10 and 13 are very close to each other (Table 4). This condition indicates that changes in the body weight of juvenile dormice are controlled by an internal programme set up in a given gap.

There are several possible reasons for discrepancies in our data, in which periodicity varies from 2 to 6 weeks in juvenile dormice, as opposed to the two months determined by Mrosovsky (21). Firstly, we kept dormice in an uncontrolled environment; therefore, the internal programs underlying periodic cycles were changed by environmental factors (mainly temperature and photoperiod). Secondly, these dormice were juveniles and juveniles are more sensitive to environmental disturbances than adults. Finally, the dormice used belong to a different subspecies, *G. g. orientalis,* living in a different geographical region.

In contrast to Mrosovsky and other researchers who kept dormice in a controlled environment, we determined the cycles to vary from 2 to 6 weeks in juvenilen dormice maintained in an uncontrolled environment. This also shows that internal mechanisms controlling periodicity in body weight are related to environmental factors. According to the obtained findings, it can be said that body weight is controlled by internal rythms, and that these rythms along with environmental factors regulate how the animals eat and gain weight at any time of the year. It follows that internal factors trigger periodic cycles in hibernation and body weight, while environmental factors regulate the duration of these cycles.

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