

HIBERNATION AND POSTNATAL DEVELOPMENT OF THE MOUSE-TAILED DORMOUSE, *Myomimus roachi* REARED OUTDOOR'S IN A CAGE

Ebru BURULDAĞ & Cengiz KURTONUR

ABSTRACT. The first information on hibernation and postnatal development of mouse-tailed dormouse (*Myomimus roachi*), live-trapped in the field reared and caged outdoors, is reported herein. They go into hibernation in the second half of November and arouse in the first half of April. They hibernate underground in hibernacula without nesting materials. Parturitions occurred in May 19, 1998 and in June 01, 1998, and litter sizes were 6 (4 males and 2 females) and 5 (2males and 3females) respectively. For eleven pups, the average body weight was 2.1 g (range=1.9-2.4 g) at day 0. All pups walked at day 12, and their eyes and ears had opened at day 15-19 and at day 12-19 respectively. First solid food intake and movement from the breeding nest co-occurred at day 19-22 with an average body weight of 7.67 g. They were weaned at day 29-31 when they had reached an average body weight of 9.6 g. The average adult weight was attained at the age of ca. 120 days after birth.

Key words. *Myomimus roachi*, hibernation, postnatal development, litter size, parental behaviour, cannibalism.

DIŞORTAM KAFESİNDE YETİŞTİRİLEN *Myomimus rochi*' LERDE KIŞ UYKUSU VE POSTNATAL GELİŞİM

ÖZET. Bu çalışmada araziden canlı yakalanan ve dış ortam kafesinde yetiştirilen yer yeduiyuru (*Myomimus roachi*)'nun kış uykusu ve postnatal gelişimine ait ilk bilgiler verilmiştir. Kış uykusuna Ekim ayının ikinci yarısında girerler ve Nisan ayının ilk yarısında da uykudan kalkarlar. 19.Mays.1988 ve 1. Haziran.1988'de olan doğumlarda sırasıyla 6 (4 erkek ve 2 dişi) ve 5 (2 erkek ve 3 dişi) yavru meydana gelmiştir. 11 yavrunun doğum günündeki (0.gün) ortalama vücut ağırlığı 2,1 gramdır (dağılım =1,9-2,4). Tüm yavrular 12. günde yürüdüler, gözler 15.-19. günlerde, kulaklar ise 12.-19. günlerde açıldı. İlk katı besin almaları ve yuvadan dışarı çıkmaları aynı anda 19.-22. günlerde oldu. Ortalama vücut ağırlıkları 9,6 grama ulaştığında 29.-31. günlerde süttten kesildiler. Doğumdan yaklaşık 120 gün sonra ortalama ergin vücut ağırlığına eriştiler.

Anahtar sözcükler. *Myomimus roachi*, kış uykusu , doğumsonrası gelişim, yavru sayısı, ebeveyn davranışı, kannibalizm.

INTRODUCTION

The mouse-tailed dormouse, *Myomimus roachi* is one of the little-known species of Gliridae. Although Pleistocene and post-Pleistocene fossil remains are known from a wide area extended from Israel (Bate 1937, Haas 1951,1960) through S-Anatolia (Corbet & Morris 1967, Storch 1988) to the Aegean Islands and Greece (Storch 1975,1978, Kuss&Storch 1978), recent distribution of *M. roachi* is very patchy and restricted to Bulgaria (Peschev *et al.* 1960, 1964, Angerman 1966, Rossolimo 1976), Turkish Thrace (Kurtunur 1975, Kurtunur & Özkan 1991), and W-Anatolia (Mursaloğlu 1973, B. Özkan per. com.). Besides this taxonomic and distributional knowledge, there is no information available on the life history and breeding biology of this species. For instance no pregnant female was collected from its recent range. So information is lacking on litter size and even on hibernation (Wahlert *et al.* 1993).

The aim of this paper is to summarize the observations on two captive pairs of *M. roachi* and to describe the physical and behavioural development of the 11 pups from two litters born to these captive pairs.

MATERIALS AND METHOD

Observations were made on one female and two males live trapped in 19 May 1997, and one female and one male live trapped in 22 July 1997 in Enez, Edirne, Turkey, and they were housed in 6 June 1997 and 30 July 1997 respectively in two adjacent compartments (each 1.5x1x1 m) of an outdoor cage constructed with wire mesh. The cage was placed in a small orchard of the senior author's house in Havsa, Edirne. Two nest-boxes (17x12x12 cm, 15x15x24 cm) were hanged on the walls, and one nest-box (17x12x12 cm) and one aquarium (24x28x40 cm) filled with soil were placed on the floor of each compartment. Deep litter with a wide variety of materials was put on the floor. Fresh leafy branches and twig were also added.

Food (sunflower seeds, wheat, maize, acorn, fresh fruits and insects) and water were provided *ad libitum*.

When the animals emerged from hibernation, we immediately housed one female (designated F1) and one male (M2) captured 19 May 1997 in one compartment, and one male (M1) captured 19 May 1997 and one female (F2) captured 22 July 1997 in the other compartment for breeding pairs (Table 1).

Before and after hibernation, animals were observed 24 hours every 5 days. At night we used two 20W red lamps. Pregnant females were observed daily for parturition. The first 24 hours following parturition was considered to be day 0. After parturition litter size was determined and morphological and behavioural development of the 11 pups from two litters were monitored daily with the aid of a video camera (Panasonic VHS-C, A3) and still camera. Daily monitoring of the pups were made as quickly as possible by removing the nest-box with pups from the cage, but without mothers. So, the disturbance of the pups and mother were minimized. Apart from transferring the pups to another nest, this level of disturbance had no adverse effect such as mothers killing or abandoning their pups.

Table 1. Legend of breeding pairs. After arousal adult Female (F1) housed with adult male (M2), and young female (F2) housed with adult male (M1). Young male (M3) died during hibernation. Mass in gram.

Animals	M1	M2	F1	M3	F2
Sex / Age	Male/Adult	Male/Adult	Female/ Adult	Male/ Young	Female/Young
Locality	Enez	Enez	Enez	Enez	Enez
Capture date and mass	19 May 1997 ?	19 May 1997 ?	19 May 1997 ?	22 July 1997 16.5	22 July 1997 16.5
Captivity date and mass	06 June 1997 36	06 June 1997 ?	06 June 1997 33	30 July 1997 ?	30 July 1997 ?
Mass in autumn					
14 Sept. 1997	35	47.5	37	34	28
14 Oct. 1997	45	46	39.5	40.5	30.5
28 Oct. 1997	46.5	48	42	35	31
14 Nov. 1997	47	?	44	?	37
Onset of hibernation	17 Nov. 1997	20 Nov. 1997	20 Nov. 1997	20 Nov. 1997	20 Nov. 1997
arousal date and mass	08 Apr. 1998 31	08 Apr. 1998 41	05 Apr. 1998 31	11 Apr. 1998 12.5 !	11 Apr. 1998 19
Mass loss during hibernation %	%33	%18	%32.5	-	%50

RESULTS

Hibernation and arousal

At the introduction to the cage the animals used the empty nest-boxes as nests for daytime sleeping. They were not interested in the soil in the aquariums. But, three animals (M1, M2 and F1), kept together in one compartment, entered the soil for the first time on October 28.1997. There was one entrance-hole on the soil surface that had been covered with fine saw dusts to detect the animals’ movement through to the soil. They spent the daytime in the soil and went out at night on the same day. Following days they used the nest-boxes again for daytime sleeping. In this group M2 entered into the soil for hibernation on November 17th, and M1 and F1 on November 20th (Table 1, Fig. 1). F1 and M2 hibernated uninterrupted, they spent 136 and 142 days in the soil and went out on April 5th and on April 8th respectively. M1 showed three hibernation bouts lasting 12, 5 and 114 days, interrupting two arousal periods of 6 and 2 days. During arousal periods, he was active at night and used the nest box for daytime sleeping. He was aroused at April 8th. After arousal the males M1 and M2 reacted aggressively to each other with a serious attack which was never seen in the prehibernation period. On April 9th, we placed the M1 in a separate cage and three days later, on April 12th we housed it with young female F1.

The young animals, F2 and M3 that were kept together in the other compartment entered the soil on November 20th. After 142 days of uninterrupted hibernation, F2 went out on April 11th in a very bad condition. She lost 50% of her prehibernation body mass. This forced us to dig out the soil to learn what happened to M3, and we found him dead with 12.5g of body weight (Table 1, Fig. 1). In each aquarium there was one hibernaculum at about 12 cm below the soil surface. There was no nesting material present and no obvious way leading in. This finding showed that they hibernated together.

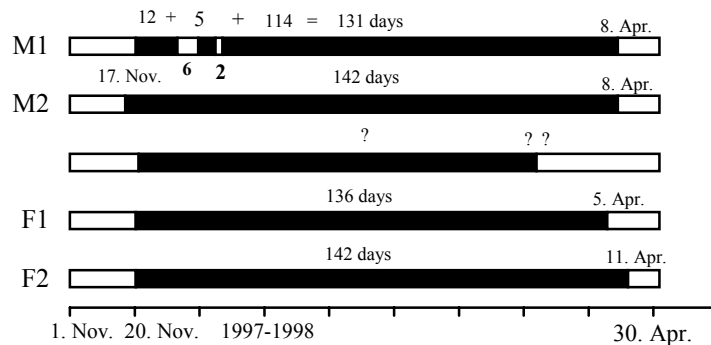


Fig. 1. Hibernation patterns of the males (M1,M2,M3) and females (F1,F2) *Myomimus roachi* in captivity. Black bars indicate the time (days) spent in the soil. M2, F1 and F2 showed uninterrupted hibernation lasting 142, 136 and 142 days respectively. M3 died during hibernation. Hibernation of M1 interrupted two arousal periods lasting 6 and 2 days.

Breeding nest.

As mentioned above the animals used the empty nest-boxes as nests. The soils in the aquarium were only used for hibernation purpose. They did not carry any materials into the nest-boxes, but a week before parturition, female F1 began to carry materials into the nest-box while female F2 started this activity one day before parturition. Both females preferred the smaller nest boxes hung on the wall of their compartment. Wood chips, dry leafs and straw were preferred as nesting materials. A few pieces of paper, almond shells and peach seeds, lichens and wood fragments were also carried. They did not construct a spherical nest woven fine grass, but just filled the material into the boxes. Although they used the nest and slept together with females, males took no part in the construction of the breeding nest.

Parturition and litter size.

The female, F1 gave birth on 19 May 1998 (22.30 p.m.) and the young female, F2 on 1 June 1998 (02.30 a.m.); litter sizes were 6 (4 males, 2 females) and 5 (2 males, 3 females) respectively.

Body weight.

Because of the mean body mass of F1 and F2 pups, did not vary significantly at day 0 ($P=0.24$), on day of first solid food intake ($P=0.10$) and on the day of weaning ($P=0.29$) we combined the body mass of two litters. Mean body weight of the eleven pups at day 0 was 2.10 g (range= 1.9-2.4 g); this was increased to 9.46 g (range= 8.6-10.4 g) at weaning, with an average weight gain of 0.245 g per day (Fig. 2A and B). After weaning, mean body weight of juveniles steadily increased until four months of ages. At this age, the mean adult mass was attained (Fig. 3, Table 2). By comparing the mean body masses of females and males littermates (F1 and F2) we found no significant correlation (Table 2).

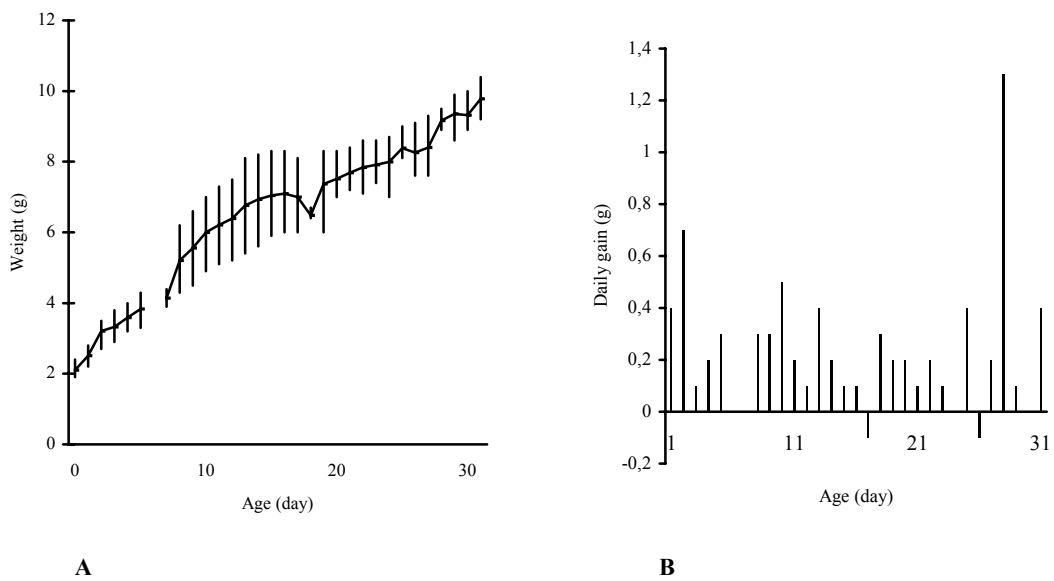


Fig. 2. A- Mean body weight changes (solid line) in the young *Myomimus roachi* (n=11) from day 0 to day 31. Vertical bars represent the ranges. B- Body weight gains per day from day 0 to day 31.

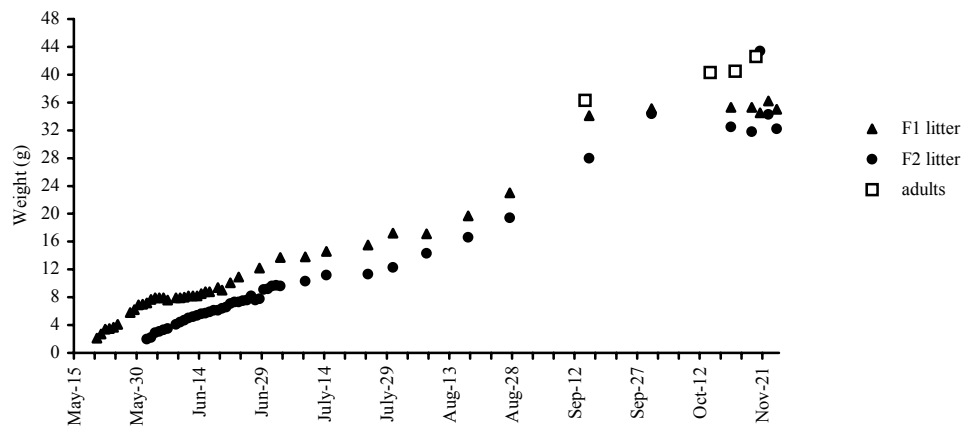


Fig. 3. Changes in the mean body weight of F1 litters (n=6), F2 litters (n=5) and parents (=adults) (n=4).

Table 2. Comparisons of the mean body masses of the females and males young at different ages, in the litters of the female F1 and F2.

F1 litter	Females (n=2)		Male (n=4)				
Age (day)	Mean±SD	Range	Mean±SD	Range	t	P	
19 solid food intake	7.55±0.63	(7.10-8.00)	8.20±0.08	(8.10-8.30)	2.30	0.083	ns
29 weaning	9.05±0.63	(8.60-9.50)	9.67±0.17	(9.50-9.90)	2.06	0.11	ns
60	15.48±1.81	(14.55-16.40)	14.91±0.81	(14.30-16.10)	0.68	0.54	ns
90	21.20±0.70	(20.70-21.70)	19.05±0.65	(18.50-20.00)	3.71	0.021	s
120	36.75±1.26	(34.50-39.00)	32.33±1.15	(31.00-33.00)	2.54	0.064	ns

F2 litter	Female (n=3)		Male (n=2)				
Age (day)	Mean±SD	Range	Mean±SD	Range	t	P	
22 solid food intake	7.30±0.11	(7.20-7.40)	7.55±0.21	(7.20-7.50)	0.59	0.60	ns
31 weaning	9.46±0.23	(9.20-9.60)	10.25±0.21	(10.10-10.40)	3.82	0.032	s
60	12.00±1.15	(10.70-12.90)	12.90±1.27	(12.00-13.80)	0.83	0.47	ns
90	17.83±2.08	(15.50-19.50)	20.50±0.70	(20.00-21.00)	1.67	0.19	ns
120	29.83±1.26	(28.50-31.00)	36.25±1.06	(35.50-37.00)	5.88	0.0098	s

Morphological development

Eyes and ears. The eyes were closed at day 0 and eyelids were blackish. The eyes opened at day 15-19. The pinnae were not fused with the skin at day 0. Ears opened at day 12-19.

Hand and foot digits. The digits of all limbs were attached to each other at day 0 and had tiny claws. The hind foot had sole-pads. Separations of the fore digits began at day 5-8 and were completed at day 10-15. Separations of the hind digits started at day 7-8 and were completed at day 13-15. The first separated digits of the hand were the first and fourth digits, and of the foot were the first and fifth digits.

Incisors. Lower incisors erupted at day 5-7, and upper incisors at day 9-12.

Fur. Dorsal skin was pink and had sparse grey and blackish tiny hairs at day 0, and was covered entirely with greyish hairs at day 11-13. Ventral skin was pink and translucent, and had very sparse, short white hairs at day 0, and was covered entirely with greyish white hairs at day 12-15.

Behavioural development

Righting. At day 0 and 1 none of the pups could right themselves. One pup could right itself at day 2 in 54 sec. All pups could right themselves at day 3 in 18-26 sec, at day 4 in 6-7 sec, at day 5 in 3 sec, at day 6 in 2 sec and at day 9 in 0.5-1 sec.

Pivoting. Pivoting movements of 180° and 360° on hind-legs, either clockwise or counter clockwise were seen at day 3 and disappeared at day 10 when the pups were able to walk.

Crawling and walking. At day 1, one pup crawled backwards. At day 2, all the pups crawled, mostly forwards. When crawling, they could bend the tail upward. At day 4, they could bend the tail towards the body. The pups walked on four legs at day 10. Walking was skilled at day 12.

Clinging. At day 2 one pup could cling to a stick in 2 sec. At day 4 two pups could cling in 5-6 sec. At day 9, all the pups could cling. At day 11 they could climb to a vertical stick.

Nocturnal activity, feeding. After the eyes opened (day15-19) the pups began to look out at the entrance of the nest boxes. On June 7, 1998 (day 18) one of the pups of F1 went out at 22.10 p.m, following this one, all the pups were outside at 02.20 a.m. (day 19). At these hours, with the guarding of the mother, the pups foraged for 10-15 minutes intervals and ate their first solid food (some sunflower seeds, wheat and apple). The next night (day 20) all pups foraged together with the parents in the cage.

Among the pups of F2, leaving the nest was first seen on June 22,1988 at 23.45 p.m. (day 21). The next night at 21.00 p.m. (day 22) all pups were outside, and they ate their first solid food.

The pups of both females used the wire mesh when climbing down to the ground and up to the nest, interestingly the pathway that they followed was the same as their parent's. They ate whatever they could find in the cage. At day 21-23, they started to eat a variety of insects.

Weaning. The litters of F1 were weaned at day 29, and those of F2 weaned at day 31, at about ten days after solid food intake. Mean body mass at weaning was 9.6 g.

Parental behaviour

One day before parturition, both females began to react aggressively towards their mates in the vicinity of the nest and feeding grounds, and kept them out of the breeding nest and feeding grounds. Fights were not seen. Aggressive display and acoustical signals by females caused male submission. These aggressions by females ceased and the fathers were permitted in the breeding nest at day 19 (F1) and at day 11 (F2). Thereafter, such aggressions were never observed. Males that were allowed back into the nest they did not show paternal behaviour such as feeding and transferring or grooming young, however they did sit and sleep in contact with the female and young. Moreover, outside the nest, males often stole the seeds with force from the mouth of the young while they were eating.

Table.3. Relative food preferences of *M. roachi*. (-: not consumed, +: low, ++:medium, +++: high preference).

Food	Preferences	Food	Preferences
Sunflower seeds	+++	Wild apple	+
Peanuts	+++	Plum	+
Fresh corn	+++	Blackberry	-
Wheat	+++	Strawberry	-
Unhusted rice	+++	Tomato	++
Acorn	++	Cucumber	++
Seeds of <i>Paliurus spina-christi</i>	++	Pumpkin	++
Almond seeds	-	Grasshoppers	+++
Grape	+++	Butterflies	+++
Apricot	+++	Moths	+++
Peach	+++	Nueropters	+++
Apple	+++	Dragonflies	+++
Pear	+++	Dermopters	+++
White mulberry	+++	Coleopters	+++
Black mulberry	++	Hemipters	+++
Watermelon	++	Mole-crickets	+++
Melon	++	Millipedes	++
Quince	+	Spiders	+++
Cherry	+	Slugs	+++
Morella-Cherry	+	Lizards	+++

Parental care was provided completely by the mother. Besides nursing, she took care of young by warming, grooming and guarding them. While nursing, the mother laid down on her back or stood above her offspring. Sometimes our monitoring of the pups disturbed the mothers. This resulted in building new breeding nests and transferring her pups into the new nest. While transferring, she gently picked up the pup by the flank with her mouth.

Food preferences

We fed the dormice mainly with sunflower seeds, wheat and apple. In addition to these food we gave them great variety of seasonal food items including fruits, vegetable, insects, spiders, slugs and lizards. All animals food items presented them alive expect lizards. Accidentally dead lizards were presented. They could detect and easily catch insect preys. Most preferred foods were mole-crickets, grasshoppers, butterflies and moths. Relative preferences of food items were given in Table.3.

Hibernation in 1998-1999 winter

In 14 September 1998, we opened a small passageway between two compartments, which were soon detected by dormice. Next day two family combined and 15 dormice slept together in one small nest-box hanging on the wall of the cage. No aggressive behaviour was seen among them. On November 20, they changed their daytime nest and began to sleep together on the soil surface of the one aquarium. They never entered into the soil. All of them were active during the nights even snowy night. Thus, they did not hibernate in 1998-1999 winter. On March 20th, we stopped the study and transferred the dormice to the laboratory in a separate cages for further study. In this winter one unusual event occurred on 25 January, 1999. We found four dead females including F2 in the cage. All of them were eaten by the other dormice. After this unfortunate event we immediately increased the amount of food in the cage and this cannibalistic act was never observed again.

CONCLUSION

In the presence of foods *M. roachi* showed two different patterns of hibernation. In their first winter in captivity, the parents went into long and uninterrupted hibernation, whereas in their second winter the parents and their young didn't hibernate. In his comparative study on hibernation of recently captured dormice species, Vogel (1997) points out that "*Freshly captured animals from nature probably show a behaviour more comparable to the normal than animals habituated for long period. On the other hand, the stress and the limited possibilities may alter behaviour because natural clues are no longer available. These possibilities must be kept in mind when discussing controversial observations on captive animals*". So we can suggest that hibernation patterns observed in their first winter are the most probable situation in the wild, lasting from second half of November to first half of April. They probably hibernate together underground in hibernacula without nest materials. Morris (1997) describes similar underground hibernacula for free living *Glis glis* in England. In the second winter in captivity complete inhibition of hibernation and cannibalistic behaviour may be a result from the stress of long periods of caged conditions, and inadequate and limited food supplies.

It is obvious that females are sexually mature after the first hibernation (F2 female) and have one litter per year. We were not able to observe copulation. Therefore we do not know exact gestation period. In the other dormice species, the range of recorded gestation periods is between 30-39 days in *Glirulus japonicus* (Minato, 1997) and 21-22 days in *Eliomys melanurus* (Eilam, 1997). From these knowledge we may suggest that gestation period of *M. roachi* can be about 30 days. Female F1 came out hibernation on April 5th and gave birth on May 19th, after 44 days of arousal. Female F2 aroused on April 11th and gave birth June 1st, after 51 days of arousal. Thus, it seems that copulation occurs at the end of April and in the first half of May. They give birth at the end of May and at the beginning of June. Litter size is 5-6. *M. roachi* has seven pairs of mammae. Hence older females may have more litter size than young females. In our collection, one female trapped on 19th of May 1997 in Enez had 14 embryos of 4mm. Thus more litter size is possible.

One remarkable feature in the postnatal development of the young is the first solid food intake which was started 10 days before weaning. In *Myomimus roachi* the mean body mass of weanling (9.6 g) is 4.5 times of its mean birth mass (2.1g), this value is in accordance with the other rodent species (range 4.3-5.1; Eliam, 1997) and other taxonomic groups (range 3.2-4.9; Lee et al., 1991). Their food preferences are also interesting. They are most likely omnivorous, feeding on a wide range of animal and vegetable food items (Table 3).

REFERENCES

- Angermann, R. Ein weiterer Fundort von *Myomimus personatus* Ogniew, 1924. – Z. Säugetierkde., 31: 411; Hamburg – Berlin, 1966.
- Bate, D. M. A. Systematic: With descriptions of new species, : 157-233. – In: Garrod, D. A. E., Bate, D. M. A.: The stone age of Mount Carmel, 1. – xii + 240 p.; Oxford (Clarendon Press), 1937.
- Corbet, G. B., Morris, P. A. A collection of recent and subfossil mammals from southern Turkey (Asia Minor), including the dormouse *Myomimus personatus*. – J. Nat. Hist., 4: 561-569; London, 1967.
- Haas, G. (In Neuville R., Le Paléolithique et le Mésolithique du Desert de Judée) Remarques sur la Microfaune de Mammifères de la Grotte d'Oumm Qatafa Archives Inst. Paleont. Hum. Mem. 24, 1951.
- Haas, G. Some Remarks on *Philistomys roachi* Bate. Ann. Mag. nat. Hist. [13] II, 688-690, 1960.
- Kurtonur, C. New records of Thracian mammals. – Säugetierkdl. Mitt., 23: 14-16; München, 1975.
- Kurtonur, C., Özkan, B. New records of *Myomimus roachi* (Bate 1937) from Turkish Thrace (Mammalia: Rodentia: Gliridae). – Senckenbergiana biol., 71: 239-244; Frankfurt am Main, 1991.
- Kuss, S. E., Storch, G. Eine Säugetierfauna (Mammalia: Artiodactyla, Rodentia) des älteren Pleistozäns von der Insel Kalymnos (Dodekanés; Griechenland). – N. Jb. Geol. Paläont., Mh., 1978: 206-227; Stuttgart, 1978.
- Lee, P. C., Majluf, P and Gordon, I. J. Growth, weaning and maternal investment from a comparative perspective. J. Zool., Lond. 225, 99-114, 1991.
- Minato, S. Physical and behavioral development of the Japanese Dormouse, *Glirulus japonicus* (Rodentia, Myoxidae). – Mammalia, t. 60, n° 1, 35-51, 1997.
- Mursaloglu, B. New records for Turkish rodents (Mammalia). Commun. Fac. Sci. Univ. Ankara, (C) 17: 213-219; Ankara, 1973.
- Pechev, T., Dinev, T. S., Anguelova, V. I. *Myomimus personatus* Ogn. (Mammalia Myoxidae) – a new rodent in the fauna of Bulgaria. – Zool. Zh., 39: 784-785; Moskva, 1960.
- Pechev, T., Anguelova, V., Dinev, T. Études sur la taxionomie du *Myomimus personatus* (Ogniew, 1924) (Rodentia) en Bulgaria. – Zool. Zh., 28: 419-428; Paris, 1964.
- Rossolimo, O. L. Taxonomic status of the mouse like dormouse *Myomimus* (Mammalia, Myoxidae) from Bulgaria. – Zool. Zh., 55: 1515-1525; Moskva, 1976.
- Storch, G. Eine mittelpleistozäne Nager-Fauna von der Insel Chios, Ägäis (Mammalia: Rodentia). – Senckenbergiana biol., 56: 165-189; Frankfurt a. M. 1975.
- Storch, G. *Myomimus roachi* (Bate, 1937) – Mausschläfer, : 238-242. – In: Niethammer, J., Krapp, F. (Hrg): Handbuch der Säugetiere Europas, 1. – 476 p.; Wiesbaden (Akademische Verlagsgesellschaft), 1978.
- Storch, G. Eine jungpleistozäne/altholozäne Kleinsäuger-Abfolge von Antalya, SW-Anatolien (Mammalia, Rodentia). – Z. Säugetierkde., 53: 76-82; Hamburg – Berlin, 1988.
- Vogel, P. Hibernation of recently captured *Muscardinus*, *Eliomys* and *Myoxus*: a comparative study. – Nat. Croat., Vol. 6 No: 2, 217-231, 1997.
- Wahlert, J. H., Sawitzke, S. L., Holden, M. E. Cranial anatomy and relationships of dormice (Rodentia, Myoxidae). – American Museum Novitates, 3061: 1-32, 1993.