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Reproductive biology of *Acomys cilicicus* Spitzenberger, 1978 (Rodentia: Muridae) in Turkey

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Abstract: The genus *Acomys* is represented by 19 species in a vast area in the African and eastern Mediterranean regions. *Acomys cilicicus*, belonging to the genus *Acomys*, is an endemic species in Turkey. In this study, by evaluating the reproductive data in laboratory conditions and the natural habitat of *A. cilicicus*, the reproductive biology of the species was researched in detail for the first time. The data concerning the reproduction of 1404 samples, reproduced from 1 male and 2 females in the laboratory and 34 samples obtained from 6 localities near Silifke, were recorded. For *A. cilicicus*, it was determined that the pregnancy period was 38–40 days, litter size was 1–3 (n = 321, mean = 2.05), and time to maturity was 2–4 months. The newborns' eyes were closed, their auricles were bonded to the head, they had short hair, their abdomens were hairless, and their backs were dark gray. Dentition was completed within 9–10 days and therefore the newborn could easily take food. Suckling was under control of the mother and carried on for approximately 2–3 months. Furthermore, the reproductive, infanticidal, and cannibalistic behaviors of this species were monitored periodically. These data were compared with *A. cahirinus*, *russatus*, *nesiotes*, *minous*, and *dimidiatus*, whose reproductive biologies are known and who are close to *A. cilicicus* geographically. Finally, it was determined that some reproductive findings of *A. cilicicus* were compatible with the findings of other species, and some findings were different from those of the species above.

Key words: Spiny mouse, *Acomys cilicicus*, reproductive biology, Silifke, Turkey

1. Introduction

The genus *Acomys* inhabits Crete, Cyprus, Anatolia, southern Iran, Palestine, the Arabian Peninsula, northwestern India, and Africa. Although this species is common in a wide area, the classification is represented as 2 species (*cahirinus* and *russatus*) according to Ellerman and Morrison-Scott (1951) and Corbet (1978), as 14 species according to Wilson and Reeder (1992), and as 19 species (*cahirinus*, *cilicicus*, *cinneraceus*, *ignitis*, *kempi*, *louisae*, *minous*, *mullah*, *nesiotes*, *percivali*, *russatus*, *spinossissimus*, *subspinosus*, *wilsoni*, *airensis*, *chudeaui*, *dimidiatus*, *johannis*, and *seurati*) with the same researchers' revision in 2005. In phylogenetic studies, the species *nesiotes*, *minous*, and *cilicicus* (Middle East, Cyprus, Crete) are included in the clade *cahirinus-dimidiatus* (Barome, 1998–2000; Frynta et al., 2010). The reproductive biology of the species in this clade was researched in detail, except for *A. cilicicus*. The remaining species, except the clade *cahirinus-dimidiatus*, are generally distributed in Africa (Morocco, Chad, Mali, Mauritania, Nigeria, Togo, Somali, Tanzania, Kenya, Ethiopia, Djibouti, and South Africa) and data about their reproductive biology are insufficient.

The reproductive biology of *A. cahirinus* (Bodenheimer, 1949; Dieterlen, 1961–1963; Strasser, 1968; Young, 1976; Peitz, 1981; Al Khalili and Delany, 1986; Delany and Farook, 1989; Krystufek and Vohralik, 2009; Nováková et al., 2010), *russatus* (Searight, 1987), *nesiotes* (Spitzenberger, 1978; Krystufek and Vohralik, 2009), *minous* (Zimmermann, 1953; Dieterlen, 1978), and *dimidiatus* (Dieterlen, 1961–1963) has been explained in detail.

In 1978, Spitzenberger compared the samples of *Acomys* taken from Silifke with the samples from Cyprus (*nesiotes*) and Crete (*minous*) and defined the *Acomys* population as a new species, *Acomys cilicicus*. Afterwards, Macholan et al. (1995) and Kıvanç et al. (1997) examined the karyotypic features of *Acomys* samples from Silifke and recorded the species of *A. cilicicus* as a validated species. However, current genetic studies make the taxonomy of the species questionable (Krystufek and Vohralik, 2009; Frynta et al., 2010). Although there are studies on this species' taxonomy, there are no studies in detail, except for some data about reproductive biology. In this study, the reproductive biology of *A. cilicicus* in the natural habitat and in laboratory conditions between 1995 and 2009 were evaluated in detail.

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2. Materials and methods

In this research, 34 *Acomys* specimens were acquired between 1995 and 2005 from 6 locations (36°23′12″N, 33°59′85″E; 36°25′65″N, 34°05′93″E; 36°27′26″N, 34°06′58″E; 36°27′20″N, 34°07′24″E; 36°27′26″N, 34°07′48″E; 36°28′18″N, 34°09′13″E; WGS 84 coordinating system) around Silifke (Mersin Province). Between 2003 and 2009, the reproductive characteristics of 1404 specimens, the offspring of 2 females and 1 male at the laboratory, were studied. In total, 1438 specimens were evaluated.

Nine wire cages connected to each other with collapsible runways (80 × 60 × 60 cm and 60 × 60 × 60 cm) were used in the laboratory during the research. On 13 February 2004 the cage of the adult female (D1) and on 20 March 2004 the cage of the young adult female (D2) were joined with the male's cage and their subsequent reproduction behaviors were monitored periodically. During the entire research period the populations in the cages increased. The runways that enabled the connection between the cages were open and shut as necessary in order to prevent adverse incidents between the males and to observe the behavior of the mice. Fresh food (apples, oranges, green leafy vegetables, seeds) was given to the mice every day, and once a week fresh tree (*Pyracantha coccinea*, *Quercus robur*, *Malus floribunda*) branches were put in their cages. The cages were cleaned every week. During the duration of the research, the laboratory temperature and humidity were routinely recorded. Except for testing periods to observe the effect of low temperature on reproduction, the temperature was kept between 18 °C and 32 °C, and the humidity rate was kept between 30% and 80%.

The following points were carefully taken into consideration so that the reproduction and natural behaviors of the mice would not be affected.

1) Apart from cleaning and unavoidable interventions, the mice were not disturbed or marked. Remote observations, taking photos and videos, were carried out.

2) After the birth of the offspring, they were not taken from their mother, and body sizes were taken from dead offspring and from situations that would not affect the mother–offspring relationship.

3) No intervention took place if incidents occurred in the cages, and mice were not captured unnecessarily so as not to introduce stress or habits related to frequent capture.

4) As periodic capture adversely affects mice, periodic measurements were not taken.

5) When a mouse was away from its cage for a long time, it was determined that this individual was not accepted back into the cage. For this reason, mice could not be taken away from their cages for long periods.

In 2006, 404 mice were released into their natural habitats, and then another 120 mice in 2007 and 88 mice in 2009, for a total of 612 mice. As the numbers of adults changed, the evaluation of the birth numbers of the mice were not carried out yearly and monthly (Table 1).

3. Results

3.1. Reproduction period

The reproduction period of *A. cilicicus* was determined by the findings in the laboratory and in the species' natural habitat. The pregnant females had been captured from nature on 24 September 1995 (Table 1) and, in accordance with their pregnancy period, the births happened in October and November. The juvenile mouse, captured in March, was born from the female that had been pregnant in February. According to these reproductive findings recorded in the natural habitat, it was considered that the reproduction period in nature was between February and November.

The parturitions were observed between February and October in laboratory conditions. However, a winterization period was determined between October and December. The winterization period took 1 or 1.5 months, but the beginning of this period changed depending on the individual. Reproductive behaviors could not be identified in mature mice during this period. The mature mice who got through this period exhibited reproductive behaviors from the second half of November and during the winter months. The parturitions in winter months were the results of these behaviors. The births indicated in October and November were mostly from the previous months (Table 2).

If the laboratory temperature did not fall below 18 °C, parturitions could be observed in winter (Tables 1 and 2). On the other hand, when the laboratory temperature was below 18 °C, the reproductive behavior slowed down and the activities of individuals decreased. Considering the laboratory findings, it could be said that some individuals in nature could engage in reproductive activity during the winter, if there were high temperatures (above 18 °C) for long periods at this time of year (Table 3).

As a result, according to the laboratory and natural findings, if the nutrition and weather conditions were suitable, this species could reproduce throughout the year. Its high reproductive potential seems to be a significant factor for *A. cilicicus* to be able to survive in its natural habitat, despite rapidly degenerating living conditions, environmental pressures, and insufficient protective measures.

3.2. Pregnancy period

The first mating between the male and D1 occurred on 22 March 2004, and the birth occurred on 30 April 2004 (39 days). The mating of D2 and a male occurred on 29 March and 3 offspring were born on 6 May 2004 (38 days) (Table 4). D1 experienced 6 births up until the beginning of 2005. Duration of pregnancy of the species under laboratory

Table 1. The reproductive findings of dead mice and dates observed.

Localities from which reproductive findings were determined (related literature)	Reproductive findings (emb. = with embryo, lac. = lactating, prem. = premature, juv. = juvenile)	Observation dates of reproductive findings and number of mice (n)
Laboratory	3 emb.	31 January 2009 (n = 1)
Laboratory Silifke (Lehmann, 1966)	2 emb. juv.	17 March 2009 (n = 1) March 1966 (n = 1)
Silifke	3 emb., 2 right-1 left 3 emb., 2 right-1 left	15–20 April 2005 (n = 2)
Laboratory	1 emb. (2.5 × 2 mm) 3 emb., 2 right-1 left (43–41 mm)	9–15 June 2006 (n = 2)
Laboratory	prem.	14 June 2007 (n = 1)
Laboratory	2 emb.	17 June 2008 (n = 1)
Laboratory	1 emb.	5 July 2006 (n = 1)
Silifke (Spitzenberger, 1978)	3 emb., 2 left, 1 right 2 emb., 1 left, 1 right (35.2 mm)	16–24 July 1978 (n = 2)
Silifke	lac.	31 August 2004 (n = 1)
Laboratory	2 emb. / prem.	19–26 August 2006 (n = 2)
Laboratory	1 emb.	24 August 2009 (n = 1)
Silifke	2 emb., 1 right-1 left (14 × 9 mm) 3 emb. (7 × 6 mm) 2 emb. (8 × 5 mm), 2 emb.	24 September 1995 (n = 4)
Silifke	juv.	25 November 2003 (n = 1)
Laboratory	2 emb. (19 × 13 mm)	28 December 2006 (n = 1)

Table 2. Number of parturitions in the laboratory and their distribution according to month between 2004 and 2009.

Year	Month												**Total**
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2004	-----	-----	-----	1	1	2	1	4	2	4	4	3	**22**
2005	10	6	5	9	8	17	19	12	6	-----	-----	4	**96**
2006	15	11	22	18	22	27	23	20	13	-----	-----	-----	**171**
2007	35	20	34	37	44	38	30	31	15	2	-----	3	**289**
2008	14	6	8	14	6	7	10	4	6	1	-----	-----	**76**
2009	3	3	3	2	3	10	6	5	-----	-----	-----	-----	**35**
Total	**77**	**46**	**72**	**81**	**84**	**101**	**89**	**76**	**42**	**7**	**4**	**10**	**689**

Table 3. The monthly average temperature of Mersin between 1975 and 2008; the lowest and the highest average temperature of the months; the lowest and the highest temperatures of the months (http://www.dmi.gov.tr).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean temp. (°C)	0.5	1.2	13.9	17.7	21.6	25.3	28.0	28.4	25.9	21.7	16.0	12.0
Mean highest temp. (°C)	4.8	5.4	18.1	21.5	24.8	28.0	30.7	31.4	30.0	26.9	21.2	16.4
Mean lowest temp. (°C)	6.8	7.3	9.8	13.7	17.4	21.5	24.6	24.8	21.7	17.3	12.0	8.4
Highest temp. (°C)	21.8	24.0	29.8	33.9	35.8	35.0	36.6	37.2	38.5	36.4	43.0	25.5
Lowest temp. (°C)	–2.5	–3.0	–1.5	3.8	9.8	5.3	18.1	18.0	13.9	8.0	1.8	–0.4

Table 4. The parturitions that occurred in 2004 (db = date of birth, n = number of offspring, A = first generation, B = second generation).

	db, n	db, n	db, n	db, n	db, n	db, n	db, n	db, n	db, n
D1	30.04.04 n = 2	08.06.04 n = 2	23.07.04 n = 2		13.09.04 n = 2	22.10.04 n = 2	29.11.04 n = 2		
D2	06.05.04 n = 3	14.06.04 n = 3		11.08.04 n = 3		18.10.04 n = 2			02.01.05 n = 2
A				11.08.04 n = 2			08.11.04 n = 2	27.12.04 n = 2	
A				08.08.04 n = 2			03.11.04 n = 3	20.12.04 n = 2	
A				04.08.04 n = 1	12.09.04 n = 2	22.10.04 n = 2		10.12.04 n = 2	
B						26.10.04 n = 2			06.01.05 n = 1
B							20.11.04 n = 2		

conditions varied between 38 and 40 days (n = 45). When the duration of pregnancy and birth dates were taken into account, it was determined that females giving birth were pregnant again soon after the parturition. Thus, it was determined that these species had postpartum estrus. In situations where postpartum estrus was not observed after the birth, the female was in heat after 6–8 days (Table 4). The mature male was observed to be ready for mating again 6 days after the previous copulation.

3.3. Pregnancy deaths and still births

Seven females that were born in the laboratory died for unknown reasons in the early stages of pregnancy. Although the cause of death of these females was unknown, it was observed that they were overweight (46–86 g, mean = 63.9 g n = 7). Out of the 5 mice that possessed embryos of 8–10 days old, 2 died from volvulus and the other 3 died from unknown causes. There were 4 mice that were about to give birth but passed their birth dates and lost their lives as they could not give birth. One mouse (no. 941), giving birth on 6 July 2006, died after the birth of the second offspring while the placenta remained in the mother's womb. The cause of death was assumed to be laceration of the womb and internal bleeding. In a delivery that occurred on 11 August 2004, one of the offspring was normal; however, the amniotic membrane of the second offspring ruptured and was stuck to the face and the shoulder area of the offspring while the placenta was stuck under the chin (Figure 1).

Afterwards, 3 more types of parturitions were observed on 23 March 2005 (no. 770), on 2 May 2005 (no. 786), and on 26 January 2007 (no. 1051). Premature parturitions were observed with unknown causes. One of the parturitions occurred after 33 days while the other occurred after 30 days. In the first parturition, one of the offspring was born dead, and the second died from hunger

due to lack of care by the mother; in the second birth, the offspring were found dead in the cage (Figure 2). A fetus born dead on 14 June 2007 was estimated to be 24–25 days old (Table 5).

3.4. Number of offspring and maturity

It was observed that the numbers of offspring varied between 1 and 3 (n = 321, mean = 2.05) for each parturition. Of the 689 parturitions identified during the research period, the numbers of offspring in 321 parturitions were definitely counted. Out of these 321 parturitions, 44 (13.7%) were single offspring and were observed generally in obese and primipara females. The most frequent parturition was observed as 2 offspring (218; 67.9%). In 59 parturitions, 3 offspring in a single delivery were observed (18.4%), and these were observed in much older mature females. According to the parturitions during 2004, the male/female ratio was 31/19, 62% in favor of males.

The first offspring of Dl and D2 experienced their first parturition between 94 and 97 days after their birth. As the duration of pregnancy was taken into account in these parturitions, the first mating of the first generation of female offspring was realized approximately after 55–58 days, and the first mating of the second-generation offspring of Dl and D2 was observed after 100–120 days (Table 4). It can be said that the offspring would mature in 2–4 months, and thus the offspring born in spring would start to participate in the reproduction process in summer. It was observed that the male offspring started to take an interest in females when they were 45–50 days old. However, it was further observed that in communities where there were fewer females than males, the young males were continually being chased by mature males in the cage and were not able to make contact with the females or participate in mating activity. However, in situations where the numbers of females in the cage were high, the males ready for mating activity tried to participate in copulation while the dominant males were mating, or tried to mate after the dominant males had completed their copulation. It was observed that they were chasing the females in heat together with the dominant males.

3.5. Birth and afterwards

Births in the cages started with the contractions of the pregnant adult either in the nest or outside the nest. It was observed that a female experiencing birth pains started cleaning itself, especially its nipples. The object of this action might be to stimulate the secretion of the contraction hormone oxytocin. In situations such as the intervals between contractions taking a long time, it was observed that the pregnant females drank water, had food, and performed backward rolls frequently. As the frequency



Figure 1. Picture of the amniotic membrane stuck to the face and shoulder area.



Figure 2. The 30-day-old premature birth.

Table 5. Premature births under laboratory conditions.

Premature birth	Date of birth	External measurements (Total length [mm], tail length [mm], hind food length [mm], ear length [mm], weight [g])
First birth (no. 868)	28.02.2006 (33 days)	77-33-14-6 ≡ 4 g
Second birth (no. 991)	26.08.2006 (30 days)	73-35-14-6 ≡ 2.5 g
Third birth (no. 1178)	14.06.2007 (24–25) days	62-24-12-0 ≡ 1.9 g

of contractions increased, it was observed that the fetuses were able to change their position in the abdominal area of the pregnant female and the birth process began. After giving birth, the mother cut off the umbilical cord; the placenta and fetal sac was eaten by the mother and nothing was left behind.

After the first offspring was born, the offspring was alone for a certain period and during this time it tried to get up and walk while swaying from side to side; it also tried to attract its mother's attention vocally. The mother started looking after the babies after the birth of the second and third (if any) offspring. The newborn offspring are first thoroughly cleaned by the mother, and then the mother cleans itself and starts suckling the offspring. If the mother had a birth outside of the nest, it carried the offspring by the nape of the neck to a safe location or into a nest, and sometimes acted aggressively if required to protect its offspring. In situations where the numbers of mice greatly increased in the cage, or if the delivery occurred in nature, it was observed that the tired female was not able to protect its offspring and the offspring were eaten by the mature males immediately after birth. For births in the nest, the newborn offspring are protected by the other females as well and, in particular, female newborns had a better chance of survival.

3.6. Development and growth of the newborn offspring

The newborn offspring had their eyes closed with short dark gray hair, and the auricles were observed as being bonded to their head. On the abdomen the hairs were short, thin, and a light color. The spiny part of the hairs toward the dorsal hind quarters were differentiated from other regions by its light color and short, hard hair structure. The eyes started to open in the first 24 h; on the second day, they opened more and the offspring were able to see somewhat. On the third day, the eyes were fully opened. In comparison to those of related species, the auricles were fully developed in the newborn, but they seemed to be stuck to the back by amniotic fluids. After the fluid dried, the auricles took their normal position. The oval-shaped face of the newborn offspring returned to a normal shape with the start of dentition (9–10 days), in parallel with the growth of the offspring (Figure 3).

In newborn offspring, the incisive teeth on the mandible were more distinct and up to 1 mm long. The incisive teeth on the maxilla were behind the lip and were up to 0.5 mm long, or a little longer. The molar teeth could not be seen at first. When the mucosa covering the molar teeth was removed, the tubercles in the first and second molars could be seen distinctly, while the third molars were not as distinctive (Figure 4). In the first week, rapid growth in the offspring was observed; the weight after birth was a mean of 5.03 g, and this growth reached 8.1 g after 1 week (Table 6; Figure 5).



Figure 3. Mother and newborn offspring after birth.

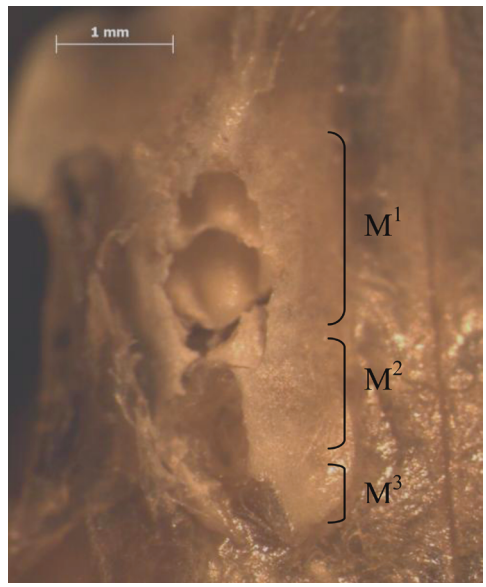


Figure 4. Molars on the mandible of a newborn offspring.

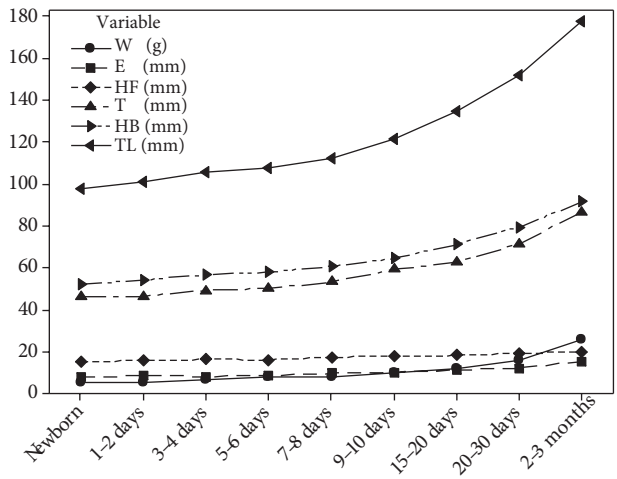


Figure 5. Growth rate of standard body measurements in captivity; W: weight, E: ear length, HF: hind foot length, T: tail length, HB: head and body length, TL: total length.

Table 6. The standard body measurements of the offspring with specific combinations: maximum–minimum, (mean), n = number of mice.

Groups of age	TL (mm)	HB (mm)	T (mm)	HF (mm)	E (mm)	W (g)
Newborn	108–91 (97.7) n = 21	60–48 (52.1) n = 21	52–40 (45.95) n = 23	18–11 (15.39) n = 23	11–5 (7.91) n = 23	7–4 (5.03) n = 22
1–2 days old	108–92 (101.2) n = 49	62–46 (54.2) n = 53	56–42 (46.5) n = 50	18–11 (15.64) n = 54	12–6 (8.41) n = 48	7–4.3 (5.43) n = 49
3–4 days old	115–92 (105.6) n = 65	66–48 (56.6) n = 69	55–40 (49.1) n = 66	19–13 (16.3) n = 69	13–6 (82) n = 65	10–5 (6.7) n = 64
5–6 days old	115–101 (107.9) n = 23	65–52 (58) n = 25	54–46 (50.2) n = 24	19–14 (16.1) n = 26	14–6 (8.4) n = 26	12–5 (8.1) n = 23
7–8 days old	117–108 (112.3) n = 12	68–54 (60.7) n = 16	58–49 (53.3) n = 12	19.5–16 (17.4) n = 16	13–7 (9.7) n = 14	11.7 (8.1) n = 15
9–10 days old	128–117 (121.3) n = 21	73–58 (64.6) n = 25	61–54 (59.2) n = 22	20–15 (17.8) n = 26	13–8 (10.1) n = 23	18–6.2 (9.7) n = 23
15–20 days old	145–123 (134.8) n = 8	78–65 (71.3) n = 10	67–58 (62.6) n = 8	20–16 (18.2) n = 10	14–8 (11.3) n = 10	17–8 (11.9) n = 9
20–30 days old	170–128 (151.9) n = 11	86–71 (79.6) n = 15	83–57 (71.6) n = 11	22–17 (19.3) n = 15	14–9 (12.1) n = 13	23–10.7 (15.9) n = 15
2–3 months old	196–153 (177.4) n = 20	104–75 (91.6) n = 23	99–68 (86.8) n = 20	22–17 (19.8) n = 22	18–11 (15.4) n = 17	34.2–14 (25.8) n = 23

TL: total length, HB: head and body length, T: tail length, HF: hind foot length, E: ear length, W: weight.

It was observed that the initial reaction of the newborn offspring to danger was to jump and during the day they would try to run away, slowly at first and faster in time. The newborn offspring left the nest 7–8 days after their birth. The larger male offspring were the first ones to leave the nest.

It was also observed that the mother continually looked after the offspring, watching for danger when they were out of the nest. By this time the offspring were able to move as fast as adults and were spending their time in play. At first they were carrying leaves, corn, and small wood pieces in their mouths, moving around on the branches, and when they sensed danger, they would rapidly run to their mother or to the nest to protect themselves. It was observed that the offspring were able to feed when they were 8–9 days old; they were gnawing at branches and were able to undertake cleaning activities. It was determined that at 9–10 days old the offspring were able to live without their mothers. After 10 days, the mother was less interested in the offspring and the other males did not disturb the offspring when they were alone.

3.7. Offspring care

The mothers practically never left the offspring alone for the first 3 days after birth. When the offspring were 1 week old, the mothers left them alone for a while to find food, and the amount of time they were left alone increased in parallel with the growth of the offspring. The others took an active role in the care of the offspring when the mother was away from the nest, and they protected the offspring by being around them or by hiding them amongst themselves and monitoring for potential external dangers. They also protected them against the effects of light.

The suckling offspring developed rapidly in 3 days due to the body heat of their mothers. It was seen that the body temperature of the mother played an important role in enabling the offspring to stay alive and grow. An offspring born on 6 July 2006, whose mother died, was dead in 40 h in spite of being fed with milk at laboratory temperature (26 °C). The reason for the death might be attributed to the inability to keep body temperature consistent. It was also seen that before each suckling the mother cleaned her body, especially the nipples, and she also cleaned the whole body of the offspring with her tongue. This behavior was considered as not only a cleaning of the offspring but also to encourage expulsion of swallowed gas. It was further observed that the offspring did not compete during suckling and they sucked the 6 teats of their mother respectively, spending 1–3 min on each teat (Figure 6).

It was seen that the suckling females in the nest did not differentiate between offspring and they suckled their own as well as other mothers' offspring. The termination of suckling was completely under the control of the mother. It was observed that a mother that did not leave the offspring

alone for the first week started to be away for longer periods from the second week onwards. The offspring were suckled until the end of the second week, but in the colder months, or when there were other sucklings present, the suckling continued until the third week. After the suckling period was over, the mother prevented suckling by staying away from the offspring. Female offspring not being suckled anymore were allowed to stay in the nest while the male offspring were pushed outside of the nest and carried on their lives on the branches in the cage, but they stayed away from dominant males.

3.8. Reproductive behavior

The testicles of males became apparent when they were ready for mating. Males ready for mating also became aggressive and dominant. It was observed that other males and females tried to stay away from them. The males ready for mating would go around the cage and smell the vulvas of the females to determine those in estrus. A male mounting the female from behind started the mating immediately as the female tried to move away. The active male ran until the female got tired and was caught. The male then immediately mounted the female, lifted one of its hind feet, and ejaculated. This event lasted for 2 s. Afterwards, it was observed that the female moved away again and tried to hide while the male cleaned its phallus region, and then the active male started to search for the female again. This chasing started again when the female was found and went on until a new mating. The mating was repeated many times and the mating activity ended when the parties got tired or the active male ejaculated all of its semen. If there were other males ready to mate, the dominant active male had to keep the other males away. When the dominant male had mated and had taken a break from mating, it was observed that the other males searched for the female in estrus. Both the males and females spent time cleaning their bodies after the end of each copulation. If the dominant male was not ready for mating, the other active males mated with the female in estrus. However, the offspring born in this manner were not accepted and were killed by the dominant male of the nest.



Figure 6. Suckling process.

3.9. Infanticide and cannibalistic behavior

The observations under laboratory conditions demonstrated the existence of infanticide and cannibalism in *A. cilicicus*. D1 had given birth (30 April 2004), and while D1 was out of the nest, a male rapidly entered the nest and bit the 1-week-old male offspring in several places and killed it, although the mother chased the male away several times. Between 2004 May and 2009 September over 100 similar incidents of the killing and eating of offspring were observed. Over 260 dead offspring were taken out of the cages and most of them were male.

The killing of the offspring may be attributed to the following reasons: to prevent the introduction of different genes; so that the dominant male can force the lactating female to mate; so that competition is hindered by preventing any increase in the number of males; that cannibalistic and infanticidal characteristics emerged due to the inability to provide enough protection to the offspring in the crowded cages; and for the killing off of disabled offspring due to gene flow in the family.

As a result of the laboratory observations, it was determined that this lifestyle was similar to the lifestyle of lions. In this type of lifestyle the family group, under the protection of the dominant male, was getting bigger by means of new offspring, the group members knew each other by their smells, and other individuals from the outside were not allowed into the group. The male offspring were always forcefully kept away from the group after they were grown.

4. Discussion

The results of the present study are based mainly on laboratory findings, although the data about the reproductive biology in the natural habitat, the laboratory data, and the literature data were evaluated together and this study demonstrated the compatibility of the research findings with those of the natural environment. This study was planned to create a lifestyle in the cage that was as close as possible to the lifestyle in a natural environment, by ensuring that the mice were observed from a distance as much as possible, that events were not interfered with unless it was necessary, and that the data used belonged to the early times, when the numbers of specimens under evaluation were few (Tables 1 and 4).

As the weather records for Silifke were not available for the reproduction period, reports from Mersin were utilized (http://www.dmi.gov.tr). Mersin is 60–70 km away from the habitat of the species and is located by the sea, and there are no climatic barriers between these 2 regions. It was determined that the weather conditions of certain years in Mersin were suitable for reproduction (Table 3). This situation supports the definition and the results for the reproduction period. Dieterlen (1978) recorded

that newborn offspring were not able to stabilize their body temperatures. This situation was also shown in our findings, in parallel with the literature, as the newborn whose mother died could not survive.

Bodenheimer (1949) found that *A. cahirinus* in captivity in Israel reproduced mostly between April and September, but also throughout the year. Al Khalili and Delany (1986) found that the reproduction period of *A. cahirinus* ranged from February to July, and in Asir (Saudi Arabia) it was found to be all year long. In a study conducted by Delany and Farook (1989), it was observed that in Oman's shore plateau the most reproduction was carried out between March and April. Krystufek and Vohralik (2009) recorded that pregnant *A. cahirinus* females were encountered between February and October. Searight (1987) revealed that reproduction of *A. russatus* continued all year in captivity. Dieterlen (1978) reported that the reproduction period of *A. minous* started in February and also observed that, in nature, the offspring born in spring could participate in the reproduction period in summer. Zimmermann (1953) stated that females with embryos were found in April and June and that mice in captivity could give birth not only from April to October but also to January. Krystufek and Vohralik (2009) recorded that in *A. nesiotes*, the reproduction period began in April and ended in October. In the present study it was discovered that the reproduction period of *A. cilicicus* was between February and November. On the other hand, if the temperature and food conditions were suitable, the reproduction period continued through the entire year.

Al Khalili and Delany (1986) found that for *A. cahirinus* in the Negev, the number of embryos of 6 pregnant females was between 2 and 5. Peitz (1981) reported that according to certain studies (Dieterlen, 1963; Strasser, 1968; Young, 1976), the number of offspring was between 1 and 4, but was mostly 2. Krystufek and Vohralik (2009) recorded that in *A. cahirinus*, the number of the offspring at birth was 1–6 (mean = 3). Searight (1987) revealed that for *A. russatus*, the number of offspring for young adults varied from 1 to 2, but for older adults it was up to 4, and so the number of offspring varied from 1 to 4. Zimmermann (1953) reported that for *A. minous*, matured offspring were able to obtain 1–4 female embryos and thus the number of offspring was between 1 and 4. Spitzenberger (1978) found 5 *A. nesiotes* females with 2–3 embryos and the mean was 2.8. Krystufek and Vohralik (2009) recorded that in *A. nesiotes*, the number of embryos was 1–4 and the mean was 2.1, n = 55. In the present study, it was observed that for *A. cilicicus*, the embryo and offspring numbers were between 1 and 3 (mean = 2.05, n = 321).

In relation to the pregnancy periods, Bodenheimer (1949) found that for *A. cahirinus* it lasted 42 days. Peitz (1981) reported that according to certain studies (Dieterlen, 1963; Young, 1976), the pregnancy period was 38–39 days for *A. cahirinus*. On the other hand, Searight (1987) found that the pregnancy period of *A. russatus* was 44 days. Dieterlen (1978) found that for *A. minous* the pregnancy period was 35–37 days. In this study, it was observed that the pregnancy period for *A. cilicicus* generally varied between 38 and 40 days.

Searight (1987) found that the females of *A. russatus* matured in 31 days. Dieterlen (1978) found that for *A. minous* the offspring matured in between 2 and 3 months and the most productive period of the females was observed between days 39 and 50 at the earliest. In this study of *A. cilicicus*, while the offspring matured in 2–4 months, the females were able to get pregnant at days 55–58 and the male offspring displayed reproductive behavior when they were 45–50 days old.

Searight (1987) found that the male/female ratio was equal for *A. russatus*. Dieterlen (1978) revealed that the male/female ratio was 179/96, in favor of males (65%), for *A. minous*. Krystufek and Vohralik (2009) recorded that in *A. nesiotes*, according to the literature, the male/female ratio was 52% in favor of males. Nováková et al. (2010) recorded that the male/female ratio was 50.2% in *A. cahirinus*, 49.5% in *A. dimidiatus*, and 50% in *A. cilicicus* in favor of males. In the present study, according to observations for the year 2004, the male/female ratio for *A. cilicicus* was 31/19 in favor of the males (62%).

Dieterlen (1961) observed postpartum estrus for *A. cahirinus* and determined that when postpartum estrus for *A. cahirinus* was not observed in a female, its estrous period was then observed after approximately 11 days (between 9–15 days). Dieterlen (1978) revealed for *A. minous* that postpartum estrus was observed in females, and if it was not observed, then estrus was observed after approximately 8–14 days. Krystufek and Vohralik (2009) recorded that in *A. nesiotes*, according to the literature, postpartum estrus was observed. In this study, postpartum estrus for *A. cilicicus* was observed, and where it was not seen, it was observed that the females would be in estrus after 6–8 days.

Dieterlen (1963) observed that for *A. cahirinus*, eyes opened in 0–1 days after birth. In another study conducted by Dieterlen (1978) on *A. minous*, the eyes in newborn offspring were shut and the auricles were bonded. Auricles separated from the head right after the birth and eyes opened after 2 days. Frynta et al. (2011) recorded that the *cahirinus-dimidiatus* group produces large precocial offspring after a long gestation and mentioned that this was exceptional for muroid rodent species. In our study, it was determined that the offspring of *A. cilicicus* were born with closed eyes and bonded auricles. Eyes were partially opened in the first 24 h and totally opened in 3 days. These findings demonstrate

that the newborns of *A. cilicicus* are precocial offspring, similar to reports in the literature.

Dieterlen (1978) revealed that the offspring of *A. minous* were suckled up to 20 days old, and from 6 days old onwards they were able to live without their mothers. In this study, it was determined that for *A. cilicicus* the offspring were suckled by the mother for approximately 2 or 3 weeks and the offspring were able to feed by themselves when they were 8–9 days old. They were able to live without their mothers from 10 days old.

Al Khalili and Delany (1986) for *A. cahirinus* and Searight (1987) for *A. russatus* observed that suckling females suckled other females' offspring, as well, and played a role in their protection. In this study of *A. cilicicus*, it was observed that the other suckling females had a role to play in the protection of offspring, that the offspring accepted other suckling mothers as their own mothers, and that these offspring were suckled.

Finally, in this study, the reproductive biology of *A. cilicicus* was detailed for the first time. As stated above, it was determined that some reproductive findings of *A. cilicicus* were similar to those of other species stated in the discussion, but some of them were different.

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