

Ecology and biology of *Allactaga elater*, *Allactaga euphratica* and *Allactaga williamsi* (Rodentia: Dipodidae) in Turkey

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Abstract: The young of *Allactaga williamsi* and *Allactaga euphratica* were born at an average weight of 2.51 and 2.74 g., respectively. Litter size ranged from 3 to 6 with an average of 4.8 in *A. williamsi*, and it changed from 4 to 8 with an average of 4.8 in *A. euphratica*. *A. williamsi* breeds during the period of March to August, *A. williamsi* and *A. euphratica* produced 2 and 2 or 3 litters per year, respectively. *Allactaga elater* has four types of burrows: winter, summer, reproduction and temporary. *A. williamsi* and *A. euphratica* have two types of burrows: reproduction and summer. *A. elater* was in behavior a more active animal, more eager to explore surrounding habitats than *A. euphratica* and *A. williamsi*. Every three species generally feed on plant material, but *A. williamsi* eats various insects and their larvae in the months April and May. The clear patterns of molting in *A. euphratica* were observed from July to September; in *A. williamsi*, molting occurred during the period of June to September. Findings revealed that *Allactaga* species are not agricultural pest.

Key Words: *Allactaga elater*, *Allactaga euphratica*, *Allactaga williamsi*, Reproduction, Burrow, Feeding, Behavior.

Türkiye'deki *Allactaga elater*, *Allactaga euphratica* ve *Allactaga williamsi* (Rodentia: Dipodidae)'nin biyolojisi ve ekolojisi

Özet: *Allactaga williamsi* ve *Allactaga euphratica* yavruları sırasıyla ortalama 2,51 ve 2,74 gram ağırlığında doğdular. Yavru sayısı *A. williamsi*'de 3-6, *A. euphratica*'da 4-8, ortalama yavru sayısı *A. williamsi*'de 4,8, *A. euphratica*'da ise 6 olarak saptandı. *A. williamsi*'nin Nisan-Temmuz, *A. euphratica*'nın ise Mart-Ağustos ayları arasında ürediği belirlendi. *A. williamsi*'nin yılda iki kez, *A. euphratica*'nın ise iki ya da üç doğum yapabileceği görüldü. *Allactaga elater*'in kış, yaz, üreme ve geçici olmak üzere dört yuva tipine, *A. williamsi* ve *A. euphratica* ise üreme ve yaz yuvalarına sahip oldukları tespit edildi. *A. elater*'in davranış bakımından *A. williamsi* ve *A. euphratica*'ya göre daha aktif bir hayvan olduğu, çevresini araştırmada daha istekli davrandığı gözlemlendi. Her üç türün genellikle bitkisel materyalle beslendiği ancak *A. williamsi*'nin Nisan ve Mayıs aylarında çeşitli böcek ve böcek larvalarıyla beslendiği saptandı. *A. euphratica*'nın Temmuz-Eylül ayları arasında, *A. williamsi*'nin ise Haziran-Eylül ayları arasında kürk değiştirdiği görüldü. Bulgular *Allactaga* türlerinin tarım zararlısı olmadığını gösterdi.

Anahtar Sözcükler: *Allactaga elater*, *Allactaga euphratica*, *Allactaga williamsi*, Üreme, Yuva, Beslenme, Davranış.

Introduction

Attallah and Harrison (1) demonstrated that *Allactaga euphratica* Thomas, 1881, and *A. williamsi* Thomas, 1897, are conspecific and form a perfect cline. They reduced *A. williamsi* to subspecific status under *A. euphratica*. Recent data have shown that *A. euphratica* and *A. williamsi* are two different species rather than subspecies of the same species (2). *A. elater* (Lichtenstein, 1825), *A. euphratica* and *A. williamsi* are the representatives of the genus *Allactaga* in Turkey. Fig.1 shows the distribution of *Allactaga* species and of males and females for which reproductive data in Turkey is available.

Kadhim and Wahid (3) examined the reproduction

of male *A. euphratica* individuals and stated that the period of February-May included higher level of breeding activity of males of *A. euphratica* without giving any information about its reproductive biology such as mating, birth, litter size and the number of litter per year. The burrows of *A. euphratica*, the reproductive biology and the burrows of *A. williamsi* are very poorly known in Turkey and other countries. Our aim in this work was to study the burrows of *A. elater*, *A. euphratica* and *A. williamsi* along with the reproductive biology of *A. euphratica* and *A. williamsi*.

Materials and Methods

Seventeen *A. elater*, 42 *A. euphratica*, 214 *A. wil-*

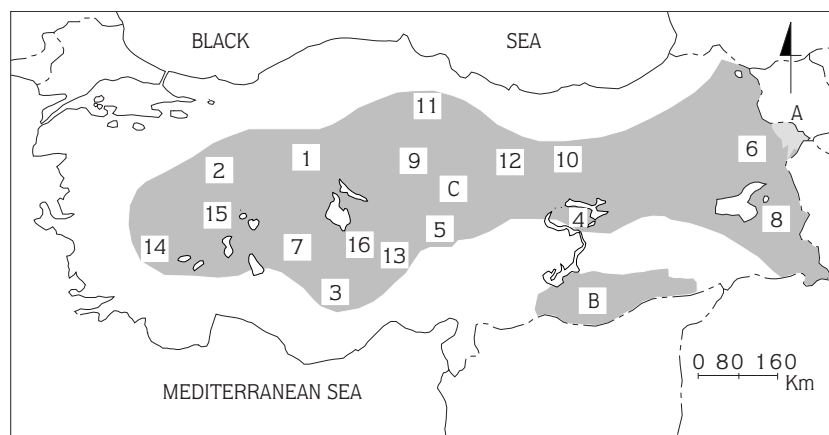


Figure 1. The Turkish map showing the distribution of *Allactaga* species and the localities of specimens having reproductive data of *A. williamsi*. Numbers are presented in Table 4. A: *A. elater*. B: *A. euphratica*. C: *A. williamsi*.

williamsi were collected in Turkey from April to December between the years 1991-1994. Collection was done with snap traps and by using small insect nets (35 cm in diameter) thrown from a slowing down car overnight. To determine the reproductive activity, the testis conditions (swollen testis) of the males were recorded. In the females, dimensions were taken of any embryo present, the presence of maculas in the uterus, lactating, the status of the genital tracts were recorded. The pregnant females were transferred alive into the laboratory to observe births in captivity, and here housed singly in a cage (60x60x60 cm). To observe the birth of offsprings, females were inspected daily and nightly. Since the females of both species did not suckle their young in captivity, their postnatal development could not be investigated.

The burrows belonging to three species were studied throughout Turkey during the years 1991-1994. To determine the structure of burrow and population density the plugged burrows were found and then these burrows were dug. After digging, the measurements of the whole length of the burrow were recorded as well as the depth. Lateral passage, the number of nest chambers and contents of nest chambers were documented, configurations of the burrows were drawn. The types of the burrows were determined by a comparison of all the excavated burrows. The stomach contents in the field were stored in the vials containing 10% formaldehyt and examined by lighth microscopy, separating contents into animal and planty material percent.

Results and Discussion

Allactaga elater (Lichtenstein, 1825)

Habitat: In the Aras basin, *A. elater* lives in areas with sparse and dense vegetation which consists of var-

ious kinds of halophytes, such as *Alhagi camelorum*, *Artemisetum*, *Halocmemum*, *Halostachys*, *Halidium*, and *Salsoletum verrucosae*. In Nakhichevan, Argyropulo (4) stated that *A. elater* inhabites on the foothill slopes of the narrow salty semiarid belt along the Aras without entering the region of mountainous xeo-phytic vegetation, where it is replaced by *A. williamsi*. In this study, we could not collect any specimens of *A. elater* on the lowhill of Ağrı mountain, with consistent with Argyropulo (4).

Reproduction: On 25 June, in an excavated burrow we found a female and its four young whose eyes and ears were opened and trapped two young which left from the maternal burrow. According to Kolesnikov (5), reproduction of *A. elater* includes three periods; spring, summer and autumn and the first birth occurs in April, being a litter size which varies from 2 to 6. Naumov and Lobachev (6) revealed that *A. elater* cares for 30-35 days. On the basis of data given by reasechers above, it can be said that the young obtained on 25 June was born in May, four young are consistent with the litter size given by Kolesnikov (5). Also, on 25 July, two males with reproductive signs (scortol testis) were captured. This shows that Turkish specimens of *A. elater* breeds during summer.

Burrows: *A. elater* lives on the salty semiarid belt along the River Aras in Turkey. In this study, 14 burrows belonging to *A. elater* were excavated. A single animal was found in each burrow, with the exception of the winter burrows. The excavated burrows were classified into four types.

Reproduction Burrow: The reproduction burrow located below bushes was determined for the first time. We dug only a single burrow and found a female and its four young in this burrow. The initial part of the burrow was plugged with a pile of soil. The entrance

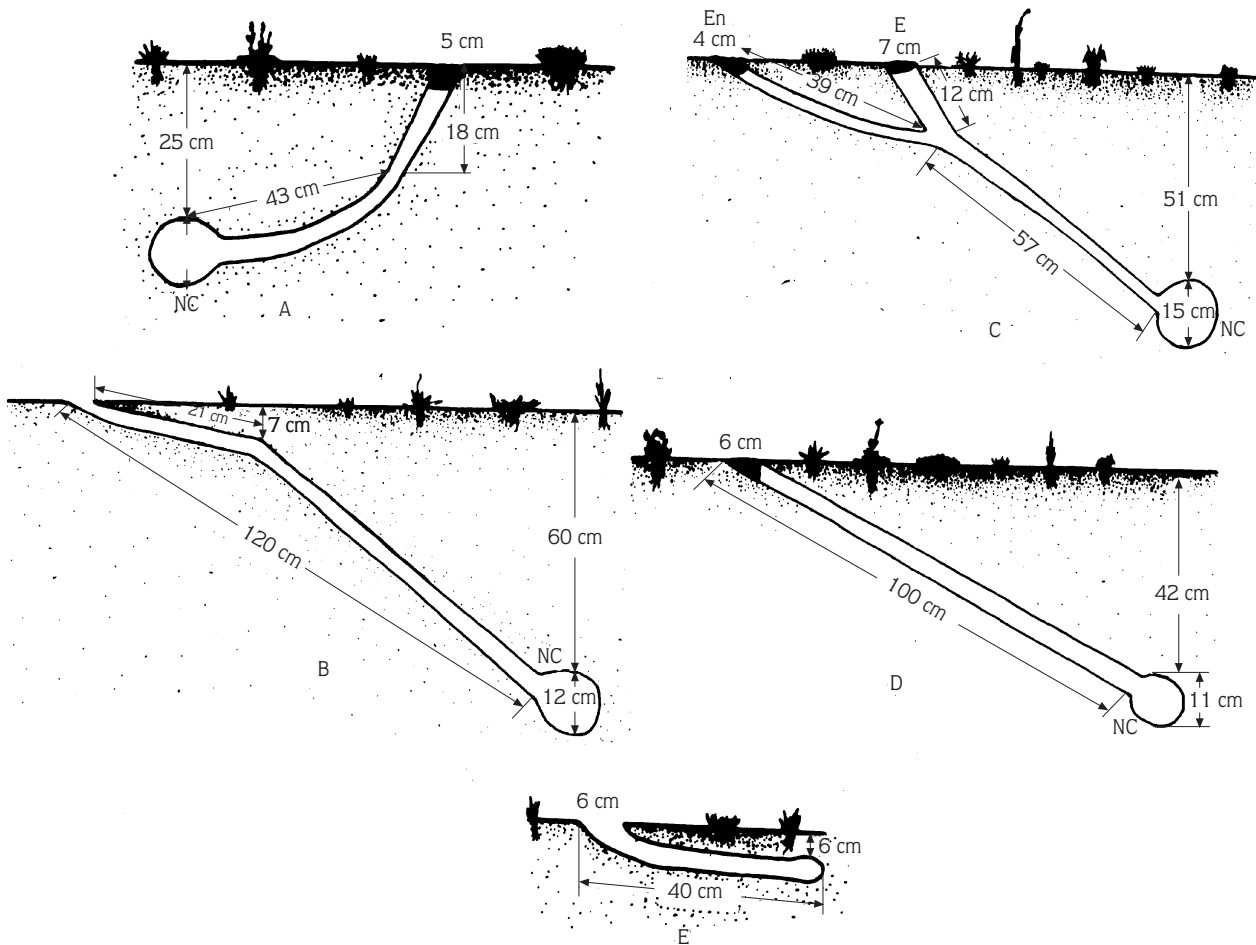


Figure 2. A, B, C, D and E: Burrow structures belonging to *A. elater* at the Aras basin. NC: Nest Chamber, LP: Lateral Passage, E: Exit, En: Entry.

to the burrow was oval, its size being about 5 cm. The passage descended from the entrance hole at an angle of 20° , at first linearly and then turning left at a distance of 18 cm from the entrance. The total length of the burrow to the nest chamber was 61 cm (Fig. 2.A). It was determined that the nest was lined with soft dry grass and sheep wool and there was no the stored food.

Winter Burrow: The burrow was located on the sandy area with sparse vegetation. We excavated two burrows which were only occupied by toads, several insects and lizards. There was fresh excavated soil just at the front of the hole. The entrance of the burrow was open. According to Kolesnikov (5), the winter burrows belonging to *A. elater* have a number of nesting chambers at various depths. In this study, it was determined that the winter burrows had a single nest chamber, the passage descended from the entrance at an angle of about 20° at first extending linearly to 21 cm, then swerving sharply to 7 cm from the surface

and dropping to the nest chamber. The burrow of 115-120 cm in length ended in a spherical nest chamber of 12-13 cm in diameter (Fig. 2.B). The nest chamber without the stored food consists of nesting material, along with a few insects and toads.

Summer Burrow: According to Kolesnikov (5), the summer burrows inhabited by adult male and female have two exits, one blocked with a plug and the other open, and the length of the burrow may reach 138 cm, ending in a spherical nest chamber of 10 cm in diameter, and descending gradually to as deep as 60 cm without branching. In this study, we dug and drew 8 burrows, and determined two types of summer burrows. One had a lateral passage leading to the surface other than the main gallery. The initial part of the main gallery was plugged, the lateral passage ended 3-4 cm down the surface of soil. It was determined that the jerboa broke through thin crust at the end of the lateral passage and escaped through the hole when its burrow was dug open. Then we prevented the animals

from escaping by putting an insect net over the hole while we were digging. The passage descended from the entrance at an angle of 15°, extending linearly to 36-42 cm (n=4), then sewerved sharply and dropped down to the nest chamber. The lateral passage was 12-14 cm (n=4) in length (Fig. 2.c). The length of the main passage was 90-120 cm (n=4), the depth of the nest chamber from surface was 40-55 cm, its diameter was 12-15 cm. The second was a burrow with a single exit. The passage descended from the entrance at an angle of 30°, linearly down to the nest chamber. The total length of the burrow was 94-100 cm, and it ended in a nest chamber of 13-15 cm in diameter, which located at a depth of 48-60 cm (Fig. 2.D). There was no stored food at the nest chamber lined poorly with dry grass.

Temporary Burrow: The temporary burrow (n=3) was determined in this study for the first time (Fig. 2.E). The initial part of the burrow occupied by young of *A. elater* was open. The total length of the burrow was 40 cm. There was no marked nest chamber.

Argyropulo (4) discovered small additional chambers in 4 of 100 burrows and a sharp corner described as "jerboa corner" and its associated drop in the burrows in Transcaucasia. He assumed that this sharp corner and its associated drop were highly characteristic for *A. elater*. In this study, we found the sharp corner and the drop in 6 of 14 burrows without any extra chamber. This shows that the specimens from Turkey are different from those from Transcaucasia with respect to the sharp corner and the extra chamber.

Feeding: The stomach contents of 12 animals were examined and it was determined that *A. elater* feeds on planty material in June and July. Also, we found minor insect parts in the stomach contents. Absence of the stored food in the excavated burrows (n=14) showed that animals eat heavily during the night. Additionally, we found a lot of holes near the burrows which were possibly dug by animals to eat bulbs and rhizomes, as in description of Argyropulo (4). In captivity, it was determined that *A. elater* fed on wheat and sunflower seeds, green parts of various plants (trifolium, gramineae), apple, carrot and drunk water.

Density and Co-occurring Rodent Species: It is most abundance in the plain with sparse or dense vegetation, selecting special areas with very sparse grassy which is available for escaping from enemies, because dense and long vegetation prevent animal from running and jumping. We found eighth burrows at an

areas of 300 m² by detecting the plugged part of burrow, being 5-6 m away one burrow from another. The ratio of trapping was determined to be one animal per 400 traps.

A. elater was recorded with three rodent species; *Meriones tristrami*, *M. vinogradovi*, *Mus musculus* and *Cricetulus migratorius*. *M. tristrami* is the most abundant species co-occurring with *A. elater*.

Behavior: In the field, the movement of *A. elater* is more rapid and it is a more active animal and less eager to explore surrounding parts than *A. williamsi* and *A. euphratica*. It was determined that *A. elater* rapidly run far from the emergency hole of the burrow as soon as excavation operation began in the exit of the burrow. Contrastly, according to Argyropulo (4), *A. elater* sits quietly when burrow is being excavated, only bound out when the nest chamber is uncovered. In this study, in order to capture animal which bound out during digging, we put a net (30 cm in diameter) over the excavated hole and then poured water into burrow after the burrow was excavated up to 10-15 cm from surface. Thus, the animal bound out was captured by holding net before bound out.

In captivity, seven animals were housed alive together in a cage (60 x 60 x 60 cm) with a nest box of 17 x 10 x 10 cm and observed for about five weeks. During inspecting, we did not hear any sounds and fighting did not occur, sleeping together at a corner of the cage without inhabiting the nest box. It was determined that *A. elater* was afraid of darkness areas; nest box, below cages in the laboratory.

Allactaga euphratica Thomas, 1881

Habitat: *A. euphratica* is an inhabitant of steppe areas, preferring low plains with sparse grassy and tigth ground. *A. euphratica* do not inhabite in sandy and the cultuvated areas. According to Harrison and Bates (7), *A. euphratica* lives in steppe desert terrain, with preferring low foothills, the periphery of wadi systems and the grassy part of the limestone, and the lack of specialised hair fringes on the functional toes probably prevents it from colonising sandy areas. Contrast to Harrison and Bates (7), in Harran, we trapped only one animal in foothills and the periphery of a small wadi during 10 days.

Reproduction: The reproductive males and females of *A. euphratica* appear in Table 1. Kadhim and Wahid (3) examined the reproduction of the male *A. euphratica* and stated that the period of February to May includes higher level of breeding activity of the male

Table 1. The reproductive males and females of *A. euphratica*.

Animal No	Reproductive Sign	Collecting Date	Locality
681♂	Swollen testis	6 May 1993	Urfa
682♀	7 young	14 May 1993	Urfa
683♀	5 young	14 May 1993	Urfa
684♀	8 young	14 May 1993	Urfa
690♂	Swollen testis	15 May 1993	Urfa
691♂	Swollen testis	15 May 1993	Urfa
266♀	Lactation	16 May 1992	Harran-Urfa
698♀	6 embriyos	17 May 1993	Urfa
711♀	7 embriyos	19 May 1993	Urfa
720♀	4 embriyos	23 May 1993	Urfa
721♀	6 embriyos-lactation	23 May 1993	Urfa
729♂	Swollen testis	28 May 1993	Urfa

A. euphratica with a second activity during October. We captured 8 young from an excavated burrow on 14 May. Their eyes were closed and suckled by their mother. According to Misonne (8), the young of *A. euphratica* open their eyes after about two weeks. The eyes of young obtained by us were opened on 19 May. Based on Misonne (8), we estimated that these young had been born on 4 or 5 May. Harrison (9) and Atallah (10) found lactating and pregnant females in April. This findings showed that the specimens from Turkey mates in April. We collected 25 specimens in May and 17 in September. All the specimens collected in May were adult. There are no pregnant and no lactating females among 9 subadults, 4 young and 4 adults of 17 specimens which were collected in September. These findings show that *A. euphratica* does not give birth in winter months and March, and does not mate in August. In contrast to Kadhim and Wahid (3), in this study, it was determined that the period of March to July is breeding season in Turkey, based on the reproductive activity of male and female *A. euphratica*, without reproductive activity after July.

Harrison (9) took a pregnant female bearing nine embryos and a lactating female contained five gestation sacs. Atallah (10) collected 2 females holding 6 and 9 embryos each. Litter size recorded in this study was four to eight ($n=7$, average: 6). Misonne (8) confirmed that *A. euphratica* has several pregnancies in the year and noted that the second pregnancy terminated in birth during the second week of June. A lactating female which died in captivity had 6 embryos (70 mg in average). This shows that the females *A. euphratica* mate even when they are lactating, giving at least two or three litters per year.

A pregnant female collected from Urfa province on 14 May produced 4 young in captivity on 3 June. The average weight of young was 2.74 g., total length 46.92 mm, tail 15.92 mm, hind foot 7 mm., ear 1 mm (Table 2). They were born blind and naked. The mother left its young and these young died after 2-3 days. Therefore, the postnatal development of *A. euphratica* could not be discovered. According to Misonne (8), eyes of *A. euphratica* do not open until the end of the second week, hair growth commences about the fifth or sixth day and the white hairs at the end of the tail appear later, about the tenth day. We collected 8 young from a burrow excavated on 14 May, the white hairs at the end of the tail were marked, the fur developed, and these young opened their eyes on 19 May. The average weight of young whose eyes were newly opened was 20.12 g., total

Table 2. Body measurements (mm) and weights (g) of four newborns of *A. euphratica*.

Newborns	Total length	Tail length	Hind foot	Ear	Weight
1	57	15	7	1	2.73
2	46	16	7	1	2.92
3	47	15	7	1	2.74
4	47	15	7	1	2.74
Average (mm)	46.92	15.92	7	1	2.74

length 174.12 mm., tail 105.5 mm., hind foot 51.25 mm., ear 25 mm (Table 3). According to Misonne (8), we estimated that these young had been born on 5 May. This showed that the eyes of *A. euphratica* are opened for about 15 days. They ate food (sunflower, wheat seeds) when suckled. Weaning took place on 31 May for 25 days when mother left its young. According to Misonne (8), adult females are excellent mothers, they adopt and care for the young of another fe-

Table 3. Body measurements (mm) and weight (g) of the young whose eyes were newly opened of *A. euphratica*.

Young	Total length	Tail length	Hind foot	Ear	Weight
1	174	105	52	25	19
2	173	107	51	26	21
3	175	106	50	26	20
4	174	107	52	25	21
5	173	106	51	24	20
6	174	104	53	25	21
7	175	105	51	24	19
8	175	104	50	25	20
Mean (mm)	174.12	105.5	51.25	25	20.12



Figure 3. The plugged initial part (arrow) of the burrow of *A. euphratica* in Urfa province.

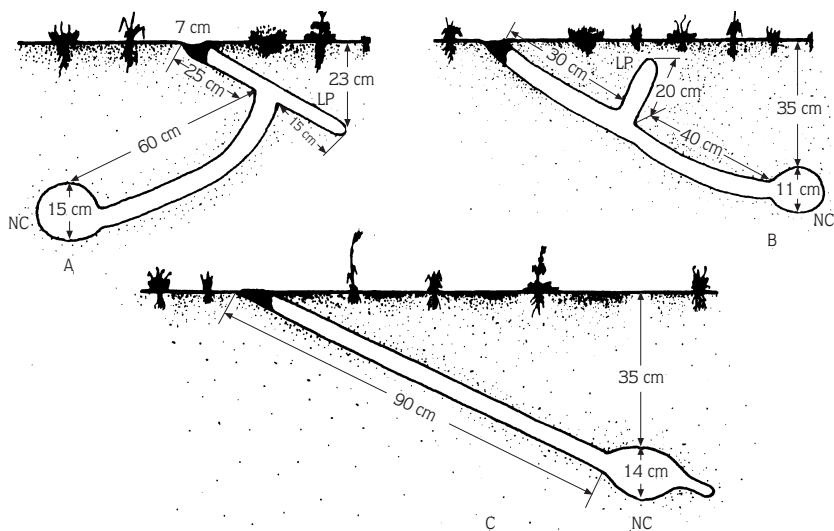


Figure 4. A, B, and C: Burrow structures belonging to *A. euphratica* in Urfa province.

male as if they were their own. In contrast to Missonne (8), the females did not care for their young in captivity. Males and females were kept in captivity for about three years and they did not mate during this period.

Burrows: The initial part of the passage of an inhabited *A. euphratica* burrow is always plugged with a pile soil (Fig. 3). We dug 14 burrows in May and October. According to Lewis et al. (11) the burrow of *A. euphratica* has a single entrance, it is vertically Z-shaped, and the entire system is approximately three feet long and eighteen inches deep. Two types of burrows belonging to *A. euphratica* were identified in this study. Contrast to Lewis et al. (11), no Z-shaped burrow was encountered. There was a lateral passage which ranged from 10 to 20 cm long other than the main passage in some burrows (n=8), with the excep-

tion of reproduction burrows (n=6). Three litters along with their mothers were found in the excavated burrows, and these burrows without lateral passage were evaluated as reproduction burrows (Fig. 4.C). The reproduction burrows (n=6) descended gradually to as deep as 35 cm deep without turning. The length of burrows (n=6) varied from 80 to 120 cm. The diameter of the central gallery was 5-11 cm. The burrow ended in a spherical nest chamber, which was 14 cm in diameter, which was lined with sheep hair, wool and plant materials. There was no stored food in the nest chamber. The others (n=8) were inhabited by adult male or female. These burrows were treated as summer burrow. Each burrow had a blind lateral passage of 15-20 cm long, branching from main gallery. Lateral passage extends down or up (Fig. 4.A, B). The length of burrows (n=8) varied from 45 to 70 cm.

The diameter of the central gallery ranged from 6 to 9 cm. The burrow ($n=8$) ended in a spherical nest chamber of 11-15 cm in diameter, lined with plant materials and no stored food. The burrows ($n=8$) descended gradually to as deep as 35-40 cm, with a gentle turn left or right (Fig. 4.A, B).

Feeding: Little is known about the diet of *A. euphratica*. Harrison (9) stated, based on data of Kırmız (12)'s, that *A. euphratica* consumed dry barley, wheat and noting that the stores of barley and other seeds found in the burrows of this species must be able it to survive prolonged periods of drought. In September, we examined stomach contents of 17 specimens and found out that the diet of *A. euphratica* was composed of plenty material such as green leaf, fresh roots, stem and seeds. Also, we had evidents that *A. euphratica* ate bulbs and rhizomes, with detecting a lot of holes around the burrows as weel as the leaves and the pieces of bulbs and rhizomes which were also found in nest chamber. Contrast to Harrison (9), there was no stored food in 18 burrows inhabited by *A. euphratica*. It was determined that *A. euphratica* heavy fed during the nighth, on the basis of the filled stomachs. This is also a proof that *A. euphratica* does not store food in the burrow. We kept animals in captivity to examine the feeding habit of *A. euphratica*. The observations showed that *A. euphratica* easily ate wheat and sunflower seeds, green leaves, stems, fresh and flowers of various plants and drunk free water.

Density and Co-occurring Rodent Species: We made the field work in May, July and September. *A. euphratica* was found to be the most abundance in May, when reproduction is in maximum, and in September When young leave from maternal nest. According to Harrison (9), on the basis of findings of Hoogstrall

(13), population density varies from 1 to 50 or more per half mile, depending on availability of food and nature of the soil. We obtained completely supportive findings to Harrison (9). In may we counted 25 burrows in an areas of about 800 m², being a distance of at least 25 m between two burrows, with the plugged initial parts of the burrows, captured in September, alive 17 specimens in same place in Urfa. The ratio of trapping was manitored to be one animal per 300 traps.

A. euphratica was recorded with the rodent species, *Meriones tristrami* and *M. crassus* and an insectivor species, *Hemiechinus auritus*. *M. crassus* was found to be the most abundant species co-occurring with *A. euphratica*.

Molting: The clear patterns of molting were observed during the period ranged from July to September. According to Kadhim et al (14), in Iraq, molting in *A. euphratica* occurs only in July once a year. This is not consistent with findings obtained in this study.

Behavior: Behavior observations were based on the works carried out in captivity and in the field, examining behaviors of both adults and young. On 14 May, we collected four lactating females and their young. On 28 May, females and young were transferred together into singly cages of 34 x 34 x 34 cm with a nest box. Contrastly, females did not care for their young in captivity and then young died. Whereas Misonne (8) stated that the females of *A. euphratica* will adopt and care for the young of another mother as if they were their own. In spite of this, in the fields, as digging operation was countining, a lactating female escaped from the nest chamber, leaving its young. Next day, we found the female in suckling its young.

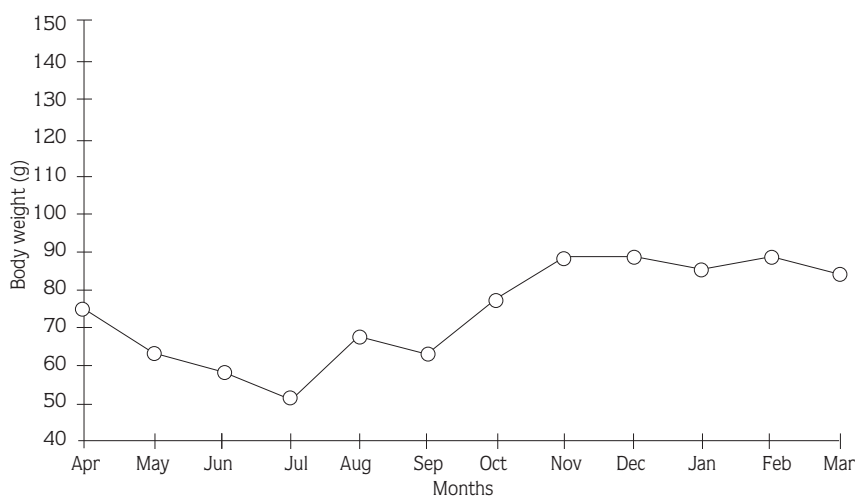


Figure 5. Changes in body weight of *A. euphratica*. Specimens in captivity were evaluated during the period of October to April.



Figure 6. A specimen of *A. euphratica* in torpor position.

This showed that female *A. euphratica* was a good mother in the field, not in captivity.

It was determined that new borns at an age of 2 days began to crawl, emitting interesting sounds, and being tendency to direct to mother.

A. euphratica was determined to be an active animal and eager to explore surrounding habitats in captivity. It is also very docile in the field. Alive collection of *A. euphratica* is easier than *A. williamsi*. In the night, we observed that *A. euphratica* entered into.

Changes in Body Weight and Hibernation: We weighed the specimens of *A. euphratica* during the period of September to March to reveal changes in body weight. In summer, the specimens collected in the field were evaluated. Fig. 5 indicates that *A. euphratica* exhibited fluctuations which changed from 51 g in July to 88 g in November. The increase in body

weight in September is a characteristic of hibernating rodents which folded their body weight in September, at the beginning of hibernation season (15, 16, 17, 18).

We found a specimen of *A. euphratica* in torpor condition extending from 27 November to 11 December. Also, three specimens were torpor in cages for two days in July, for four days in September. The animals were laying on the side of body, without characteristic body position of hibernating animals. The body was cold, with closed eyes, heartbeat was faint (Fig. 6).

***Allactaga williamsi* Thomas, 1897**

Habitat: *A. williamsi* lives in burrows with one entrance and occurs from plains at 500 m. altitude in middle Anatolia to steppe area at an altitude of about 2500 m. in western and eastern Anatolia. The favorable habitat of *A. williamsi* is steppe areas with sparse vegetation. In spite of this, in Gökçekısıık (Eskişehir) and Demirci (Manisa), we found animals running on the roads extending through the pine forest. This species avoids from entering the cultivated and dense grassy areas. Only, in Van, we encountered a few animals in agricultural plains.

Reproduction: The reproductive biology of *A. williamsi* is very poorly known. In this study, 214 specimens of *A. williamsi* as well as the observations in captivity were used. Males with swollen testes along with lactating and pregnant females were taken during a period extending from 25 April to 26 July (Table 4). We considered this period to be the breeding season of *A. williamsi*. We obtained a pregnant female with three embryos, (their body weight 2.38, 2.41 and 2.54 g) on 28 June, after this time any pregnant

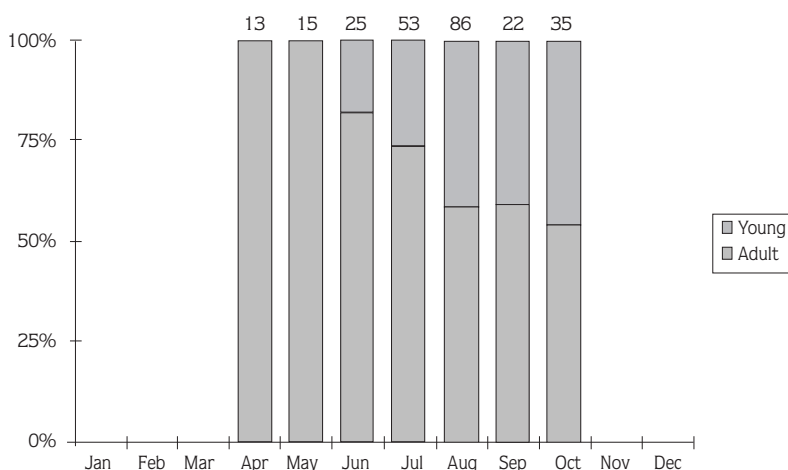


Figure 7. Seasonal changes in age composition of *A. williamsi*. Numbers on the top of figure are monthly sample sizes.

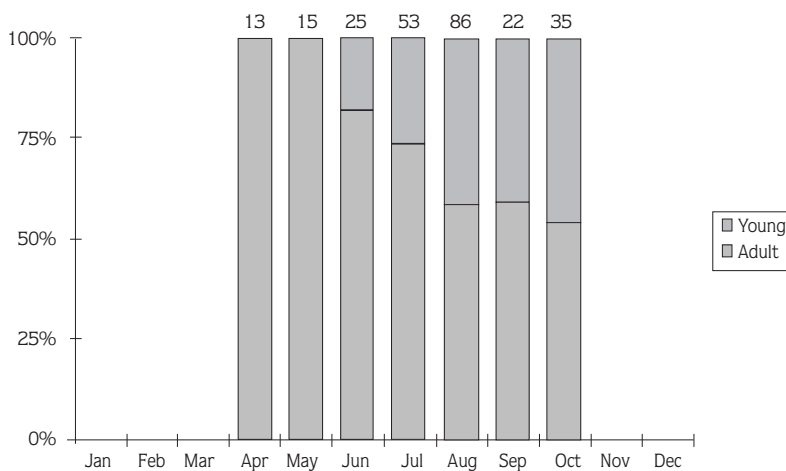


Figure 8. Seasonal changes in sex ratio of *A. williamsi*. Numbers on the top of the figures are monthly sample sizes.

female was not encountered. also, six pregnant females gave six litters in captivity on 31 May, 2, 3, 5 June. These findings showed that the first birth occurred on 31 May, the last birth at the beginning of July, being one or two births per year. We collected six specimens in April, 50 in May, 32 in June, 41 in July, 26 in August, 47 in September and 12 in October. All the specimens collected in April and May were adult (Fig. 7). There were young among specimens collected during the period 16 July-28 October. We also noted the lack of the pregnant females and the males with swollen testes among specimens collected after 16 July. These findings showed that the young *A. williamsi* which were born at the beginning of June left the nest by 40-45 days and attained sexual maturity by 10-11 months. Also, the ratio of females to males was determined to be 55%. In June, females were more abundant than males (65%) (Fig. 8).

Table 4. Specimens having reproductive data of *A. williamsi* collected during the years 1991-1994.

Animal No	Reproductive Data	Date	Locality	The Number on the Map
253 ♂	Swollen testes	25 April 1992	Ankara	1
255 ♂	Swollen testes	25 April 1992	Ankara	1
256 ♂	Swollen testes	25 April 1992	Ankara	1
647 ♂	Swollen testes	26 April 1993	Eskişehir	2
667 ♂	Swollen testes	30 April 1993	Eskişehir	2
672 ♀	4 Embryos	1 May 1993	Karaman	3
673 ♂	Swollen testes	1 May 1993	Karaman	3
684 ♀	5 Embryos	7 May 1993	Ankara	1
666 ♂	Swollen testes	8 May 1993	Ankara	1
263 ♀	5 Embryos	15 May 1993	Elazığ	4
710 ♂	Swollen testes	19 May 1993	Kayseri	5
714 ♂	Swollen testes	20 May 1993	Ankara	1
717 ♂	Swollen testes	21 May 1993	Ankara	1
725 ♂	Swollen testes	26 May 1993	Ankara	1

726 ♀	5 Embryos	26 May 1993	Ankara	1
727 ♀	6 Embryos	26 May 1993	Ankara	1
728 ♂	Swollen testes	26 May 1993	Ankara	1
776 ♀	5 Embryos	31 May 1993	Ankara	1
846 ♀	6 Embryos	31 May 1993	Ankara	1
781 ♀	5 Embryos	2 June 1993	Ankara	1
737 ♀	6 Embryos	3 June 1993	Ankara	1
738 ♀	4 Embryos	3 June 1993	Ankara	1
730 ♂	Swollen testes	4 June 1993	Ankara	1
732 ♂	Swollen testes	4 June 1993	Ankara	1
733 ♀	Lactating	5 June 1993	Ankara	1
734 ♀	5 Embryos	5 June 1993	Ankara	1
278 ♀	Lactating	7 June 1992	Eskişehir	2
18 ♀	4 Embryos	16 June 1991	Ankara	1
30 ♀	6 Embryos	22 June 1993	Eskişehir	2
753 ♀	Lactating	25 June 1993	İğdır	6
754 ♀	Lactating	25 June 1993	İğdır	6
755 ♀	Lactating	25 June 1993	İğdır	6
335 ♀	4 Embryos	26 June 1992	Konya	7
348 ♀	3 Embryos	28 June 1992	Konya	7
769 ♂	Swollen testes	1 July 1993	Van	8
777 ♀	Lactating	7 July 1993	İğdır	7
778 ♀	Lactating	8 July 1993	Ankara	1
350 ♀	Lactating	9 July 1992	Yozgat	9
785 ♀	Lactating	11 July 1993	Ankara	1
786 ♀	Lactating	12 July 1993	Ankara	1
376 ♀	Lactating	13 July 1992	Erzincan	10
788 ♀	Lactating	13 July 1992	Ankara	1
791 ♀	Lactating	14 July 1993	Van	8
854 ♀	Lactating	21 July 1993	Van	8
859 ♀	Lactating	21 July 1993	Van	8
831 ♀	Lactating	25 July 1993	Amasya	11
854 ♀	Lactating	25 July 1993	Van	8
874 ♀	Lactating	26 July 1993	Sivas	12
462 ♀	Lactating	12 August 1992	Niğde	13
903 ♀	Weaned	22 August 1993	Denizli	14
913 ♀	Weaned	28 August 1993	Konya	7
529 ♀	Weaned	4 September 1992	Afyon	15
530 ♀	Weaned	4 September 1992	Afyon	15
556 ♀	Weaned	22 September 1992	Aksaray	16

As the precise duration of the pregnancy of *A. williamsi* is unknown, it is impossible to determine exactly when the mating takes place. But, according to our findings, mating occurs at the end of April when the males with swollen testes appear. Based on the date of the mating and of the first birth, we estimated that the duration of the pregnancy of *A. williamsi* is about 25-30 days. Six litters were born in captivity. These litters were weighed and their body measurements were taken (Table 5). The young *A. williamsi* were born blind and naked, their ears were covered

Table 5. External and cranial measurements of newborns in *A. williamsi* (\pm SD: Standard Deviation).

Characters (mm)	n	Mean	Range	\pm SD
Weight (g.)	31	2.51	2.31 - 2.92	0.21
Total length	31	45.72	44 - 47	0.30
Tail	31	13.77	11 - 16	1.02
Hind foot	31	6.80	6 - 7	0.02
Ear	31	1.2	1 - 1.4	0.01

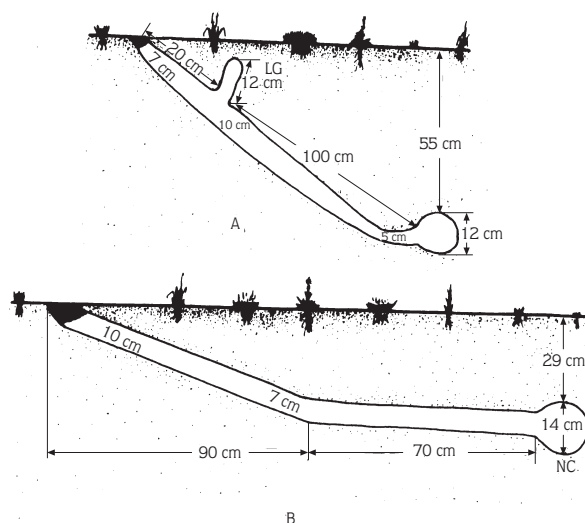


Figure 10. A and B: Burrow structures belonging to *A. williamsi* in Ankara (A) and Kastamonu (B).

with skin. As the females did not suckle their young in captivity, we could not discover the postnatal development of *A. williamsi*. On the basis of the number of embryos and of the young, we determined that the litter size in *A. williamsi* ranged from 3 to 6, with an average of 4.8 (Table 4). We observed the birth of two young in captivity. The birth commenced at 14.15 pm. At the first, the female timidly walked and jumped then slowed down when the birth got closer, laterally constricted its belly and kept quiet at the corner of the cage. The head of the young appeared (Fig. 9.A). Then, the female helped young to be birth by using its forefoot (Fig. 9.B). Then, the female helped young to be birth by using its forefoot (Fig. 9.B). The birth lasted for about 15 minutes.

Burrow: The initial part of the passage of an inhabited *A. williamsi* burrow, as in *A. euphratica*, was plugged with a pile soil. We dug 28 burrows during the period April-November. Two kinds of burrows were determined (Fig. 10.A, B). No lactating female was found in 28 burrows excavated other than adult males or females. Some burrows described as reproduction burrow (n=17) had a blind lateral passage, which is 12-16 cm long (Fig. 10.A). In Caucasia, according to Argyropulo (4) the burrows of *A. williamsi* are tunnelled in gentle sloped, terminating in a nest chamber without sharp turns. In this study, it was determined that some burrows (n=14) evaluated as summer burrow built on the foothill belts extended linearly from the initial part to the nest chamber (Fig. 10.B). In contrast to Argyropulo (4), the others (n=12) were tunnelled with gentle turns (left or right), ending to the nest chamber. According to Argy-

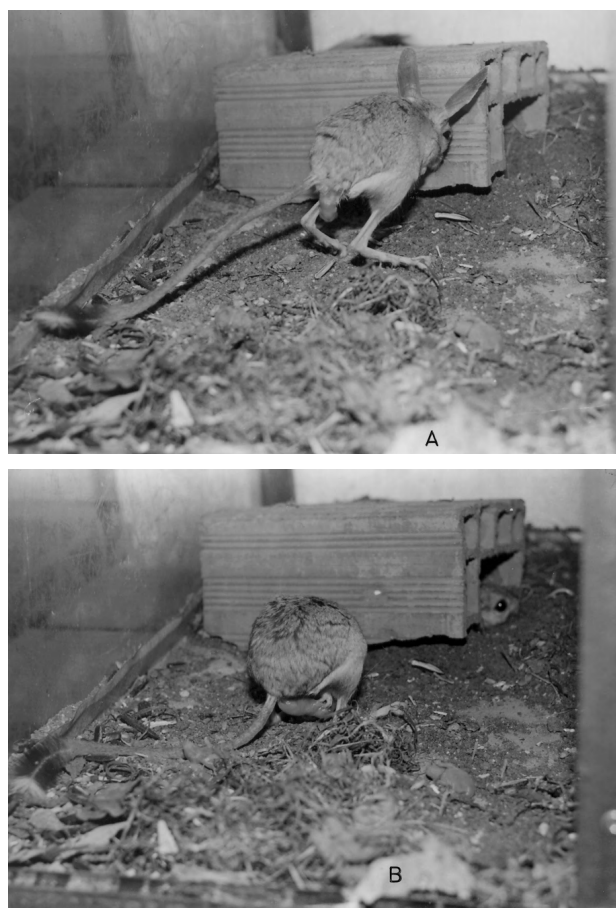


Figure 9. A and B: Showing the birth of a young in *A. williamsi* in captivity.

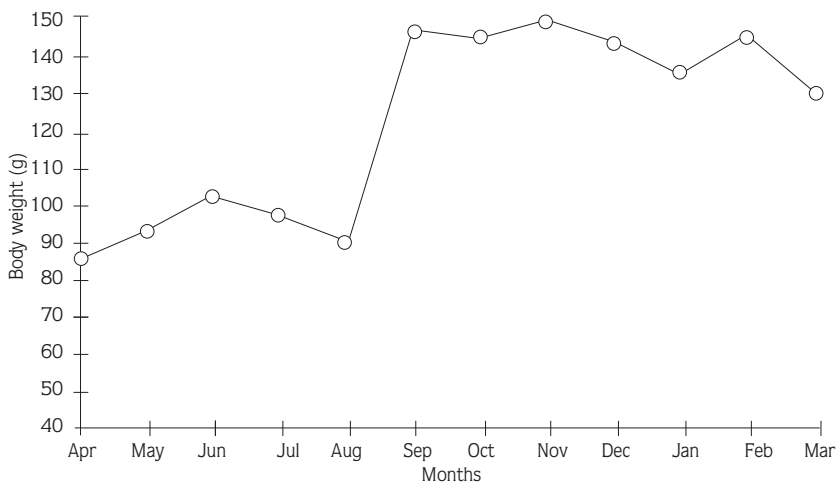


Figure 11. Changes in body weight of *A. williamsi*. Specimens in captivity were evaluated during the period of September to March.

ropulo (4), the burrow of *A. williamsi* is 170 cm down the surface of ground. In this study, the length of the burrows of *A. williamsi* in Turkey (n=28) ranged from 100 to 160 cm and the nest chambers (n=128) were 29-55 cm down the surface of the ground. The diameter of the central gallery ranged from 5 to 10 cm. The diameter of spherical nest chamber was 12-14 cm. The nest chamber was lined with generally the soft root of several plant and dry grass, no sheep wool.

Feeding: It was determined that the diet of *A. williamsi* varied seasonally. The stomach contents of the specimens (n=42) collected during the period of April to October was examined. The findings showed that *A. williamsi* mainly feed on various insects and their larvae from April to June, on planty material from June to September, on seeds from September to November. Animal food in the stomach consists of 50% kitine, 5% setae and 10% trachae, planty material 10% green parts, 5% stem, 2% root, 2% flower parts and undetermined material. Observations in captivity showed that *A. williamsi* easily ate green leaf, roots and flowers of various plants wheat and sunflower seeds, apple and drunk water.

Density and Co-occurring Rodent Species: The population density of *A. williamsi* varies in different habitat types and in relation to season. In April, density increased in narrow wadis in Ankara. In summer, density increased in plains. We determined two peaks in population, one in May and June, the other in September. In May, we counted 8 to 10 individual at an areas of 800 m² in Gölbaşı (Ankara) and trapped 11 specimens by 100 traps at a night in September.

The ratio of trapping was found to be one animal per 200 traps. The distance between two burrows in habitat which *williamsi* is the most abundance was determined to be 15 to 20 m.

A. williamsi was trapped with *Meriones tristrami*, *M. meridianus*, *Cricetulus migratorius*, *Mesocricetus brantdi*, *Mus musculus*, *Microtus guentheri*, *M. epiroticus*, *M. socialis*, *Apodemus sylvaticus*, *Citellus citellus*.

Molting: It is unknown about molting of *A. williamsi*. The molting observations are based on the specimens kept in captivity during winter and on the specimens collected during the period of April to November. Molting animals were trapped during the period of 20 June to 22 September (Table 6).

Active Period, Changes in Body Weight and Hibernation: *A. williamsi* is a nocturnal animal, it became active about 1-2 hours after sun sank, and active ends before dusk. Active period of *A. williamsi* includes the period of 12 April to 2 November. We could not find any specimens from December to March. This means that *A. williamsi* either stores food in the burrow or accumulates fat to survive during the winter. Findings showed that *A. williamsi* did not store food, but body weight attained 146 gm in September by overfeeding during active period in captivity (Fig. 11). This condition is a characteristic of hibernating animals. Satunin (19) stated that a specimen kept in captivity did not hibernate. Contrast to Satunin (19), in January, two of 15 specimens kept in captivity hibernated for periods of 2 and 6 days at an ambient temperature of 4-5°C. Hibernating animal had a characteristic body

Table 6. The specimens with the clear patterns of molting in *A. williamsi*.

Animal No	Date	Locality
968♀	22 January 1994	Manisa
970♂	10 March 1994	Manisa
27♀	20 June 1991	Eskişehir
777♀	7 July 1993	Iğdır
785♀	11 July 1993	Van
786♀	12 July 1993	Ankara
432♂	24 July 1992	Darende
831♀	25 July 1993	Amasya
439♂	4 August 1992	Aksaray
437♂	4 August 1992	Aksaray
863♀	5 August 1993	Iğdır
447♂	6 August 1992	Darende
150♂	7 August 1991	Ankara
462♀	12 August 1992	Niğde
197♂	22 August 1992	Niğde
904♂	25 August 1994	Denizli
488♂	25 August 1993	Tosya
504♂	31 August 1992	Eskişehir
528♂	5 September 1994	Afyon
529♀	5 September 1992	Afyon
931♂	20 September 1994	Amasya
557♂	22 September 1992	Aksaray
556♀	22 September 1992	Aksaray
943♂	10 October 1994	Manisa

position, which ensure temperature loss during hibernation, being a tigh ball, it was cold, with closed eyes, and heartbeat was faint.

Behavior: *A. williamsi* is very docile and less active animal, sleeping daytime in captivity. It is a timid animal, for the first time then it rapidly becomes tamed to approaching visitors without beating. It was determined that *A. williamsi* threated from free water when it encountered for the first time, and it inserted its arm into free water to drink and sucked the watered arm. After 10 days, it drunk water by moving the tongue backwards and forwards. *A. williamsi* continuously slept outside nest boxes.

Fighting and Aggression: In order to determine this aspect of behavior, animals were put into cages in 10 different combinations.

A. One female in the cage (30x40x30 cm)

B. One male in the cage (30x40x30 cm)

C. One male and one female in the cage (30x40x30 cm)

D. Two females in the cage (30x40x30 cm)

E. Two males in the cage (30x40x30 cm)

F. Seven animals in the cage (30x40x30 cm)

G. One female *A. williamsi* and one male *A. euphratica* in one cage (30x40x30 cm)

H. *A. williamsi* and *Mus musculus* in one cage (30x40x30 cm)

I. *A. williamsi* and *Mesocricetus brandti* in one cage (30x40x30 cm)

J. *A. williamsi* and *Meriones tristrami* in one cage (30x40x30 cm)

K. *A. williamsi* and *Cricetulus migratorius* in one cage (30x40x30 cm)

In the combinations A and B, the animals kept very timid for about 3-4 days then sleeping during all day. In the combination C, the female aggressed the male, by jumping for a sort time. Then, male and female became peaceful in the distinct corner of the cage. Afterwards, both slept together in the same place. In the combination D and E, a strongly fighting occurred for two hours. The next morning, the killed animal was not encountered, they were peaceful. We induced them to arousal, after arousing, fighting started again. In the combination F, fighting was observed and one wounded and two kiled animals were found the next day. Particularly, subadult and weak animals were killed. The wounds were on the thighs and abdomen. Also, we heard sounds during sleeping. In the combination G, as soon as *A. euphratica* introduced to the cage inhabited by *A. williamsi*, *williamsi* entered to its nest which was built below the stone and it prevented *euphratica* from approaching its nest by emitting sounds without fighting. This lasted during the experiment. In the combinations H, I and J, we transfered new rodent species into the cage inhabited by *williamsi*. As soon as new individuals introduced to the cage, *williamsi* moved peachfully from one place to another without fighting, except for *M. brandti* which attacked *williamsi* with a bit beat, we removed *brandti* from the cage in case the death occurred. *A. williamsi* was determined to be docile animal by these findings. Misonne (8) examined *A. williamsi* on the basis of its habit and behavior, noted that *williamsi* is a less active animal and less eager to explore sourrounding habitats, which was rejected by Atallah and Harrison (1).

Damage: *A. williamsi* lives in steppe areas surrounding or away from the cultivated areas. This reduces or minimizes the effect of *williamsi* to agricultural crops. Although Kral and Benli (20) suggested that *williamsi* damaged wheat, melon and watermelon crops, we could not obtain any proof that supports Kral and Benli (20), but, in Gölbaşı (Ankara) a farmer let us to see a few beated pumpkins that were damaged possibly by *williamsi* according to him. According to Satunin (19), *A. williamsi* brings down into its burrow armfulls of wheat. We found out that there was no stored food (wheat and other grains) in 28 burrows dug by us. Also, observations in captivity indicated that *williamsi* did not store food during four years. Besides, *A. williamsi* strongly consumes insect

and insect larvae during the period of April to May when seeds germinate. This shows that *A. williamsi* has an important role in biological competition against agricultural pests rather than damage to agricultural crops.

Extinction: *A. williamsi* is menaced due to decreasing in steppe areas in which this species is dominant, as well as *A. euphratica* and *A. elater*. Also, the heavy use of the pesticides increasingly results in the reduction of population.

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