Reproduction, postnatal development, and social behavior of *Ellobius lutescens* Thomas, 1897 (Mammalia: Rodentia) in captivity

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**Abstract:** The reproduction, postnatal development, and social behaviors of the Transcaucasian mole vole (*Ellobius lutescens*) were studied in the laboratory in 2012/2013. The collected voles were kept in glass cages in captivity conditions and observations were made throughout the year. The litter size, gestation period, neonate weight, eye-opening, weaning, and earliest sexual maturity age were observed. Pups were born with ‘nipple-seizing incisors’. These incisors were different from those of adults. The molars and normal incisor eruption appeared after 19–21 days. Females have three pairs of nipples. The adult females were bigger in size than the males, yet the males consumed more food than the females. Isolated individuals consumed more food than did the paired animals.

**Key words:** Mammals, *Ellobius lutescens*, mole vole, reproduction, Turkey

1. **Introduction**

Mole voles (genus *Ellobius*) are adapted to underground life and are distributed from East Anatolia to Mongolia in the Palearctic Region (Ognev, 1963; Corbet, 1978; Corbet and Hill, 1991). Five species of the genus, *E. fuscocapillus*, *E. lutescens*, *E. talpinus*, *E. tancrei*, and *E. alaicus*, exist at present. These species exhibit allopatric distribution (Ellerman and Morrison-Scott, 1951; Walker, 1964; Panteleyev, 1998).

*E. lutescens* (Transcaucasian mole vole) was described by Thomas (1897) based on six specimens that were collected from Van-Erçek and is distributed in Iran, Armenia, Azerbaijan, and East Anatolia (Lay, 1967; Hassinger, 1973; Roberts, 1977). There is only one species (*E. lutescens* Thomas, 1897) of the genus *Ellobius* in Turkey (Coşkun, 1997, 2001; Moradi Gharkhello and Kivaç, 2003).

On reproduction of *E. lutescens*, Lederberg (1999) and Just et al. (2002) reported that *E. lutescens* produces litters inadequately in captivity, but Stefan and Steimer (1978) stated that *E. lutescens* has a relatively regular reproduction rate in the laboratory. Ognev (1963) found that *E. lutescens* gave birth to four litters annually, each with 2–4 young; Coşkun and Ulutürk (2003) reported that they gave birth to at least two litters throughout the year having 2–4 pups; Nowak (1995) stated that they produce 6–7 litters annually, each with 3–5 young; Walker (1964) found that *E. lutescens* can bear 1–7 pups twice a year; and Stefan and Steimer (1978) stated that they produce litters regularly each with 1–4 pups throughout the year. The gestation period of *E. lutescens* is 26 days and the young reach sexual maturity by 96 days. The pups stay with parents for 2 months (Nowak, 1995). According to Ognev (1963) and Coşkun and Ulutürk (2003), *E. lutescens* breeds from April to the end of October and in March–April and October–November, respectively.

Evdokimov (2013) concluded that the northern mole vole (*E. talpinus*) has a low reproductive potential. Smorkatcheva and Kumaitova (2014) mentioned that while Zaisan mole voles (*E. tancrei*) readily breed in captivity, the birth rate is generally low and quite unpredictable, with intervals between litters ranging from 32 days to about 6 months. Evdokimov (2013) reported that sexual maturation in *E. talpinus* depends on the time of the animal’s birth, but most of them matured after the first wintering. The young opened their eyes on days 21–28 and independent feeding was observed on days 20–25. Younglings reach the size of adult animals at an age of 2–3 months. Smorkatcheva and Kumaitova (2014) stated that pups of *E. tancrei* opened their eyes around days 22–26. Weaning gradually occurred over the next several days. *E. talpinus* offspring stay in the natal burrow until at least 2–3 months of age. During this period, reproductive females can deliver one or several litters. Female offspring most likely will not breed unless their mother dies. Litter size ranges from 1 to 4 pups. Smorkatcheva and Kumaitova
(2014) stated that *E. tancrei* was fed vegetables and mashed meat twice a week in their study. Evdokimov (2002) stated that *E. talpinus* individuals each consume 59–67 g of food per day and experience periods of hibernation.

Coşkun and Ulutürk (2003) reported that *E. lutescens* eats all kinds of vegetation. An individual consumes 79.66 g of food a day. There is a linear relationship between the weight of the animal and the food consumed. The animals that were kept together in a cage consumed less food than the ones kept separately. The animals primarily preferred carrots to potatoes, beets, radishes, and onions based on the amounts consumed, with females consuming more food overall than males. Individuals did not hibernate or aestivate. Ognev (1963) reported that dry earthworms were found among the vegetable food in the mole vole’s summer store and that these are part of the diet as well.

According to Neuhauser (1936), females of the genus *Ellobius* have eight nipples. Hinton (1926), Harrison (1972), and Çağlar (1967) further specified that *E. lutescens* females have four pairs of nipples, two of them pectoral and the others inguinal. Ognev (1963) identified that a family consists of an adult female and 4 young, while the number of inhabitants varies widely from 1 to 11 in a burrow. However, Coşkun and Ulutürk (2003) noted that *E. lutescens* individuals live as a family society, not in groups, and each burrow system contains one male, one female, and at least one pup. Ognev (1963) stated that *E. lutescens* digs most vigorously from morning to noon and then also during dusk in the spring. Specifically, most activity occurs between 1000 and 1100 hours and between 1600 and 1700 hours. *E. lutescens* digs its tunnels by scratching with its incisors and pushing the loosened dirt behind its body with its fore and hind limbs. It then turns and transports the dirt with its head and breast (Coşkun, 2001).

Data on the biology of *E. lutescens* are limited and there were previously no data on reproduction and postnatal development of this species. The aim of this study is to reveal the reproduction and postnatal development of *E. lutescens* in captivity in Turkey.

### 2. Material and methods

Three (1♀, 2♂) individuals were collected 23 km south of Iğdır (39°47′7″N, 44°8′10″E on 20.04.2012) and 2♂ from Ağrı-Doğubeyazıt-Çetenli (39°26′76″N, 44°0′74″E on 28.04.2012). Three glass cages were used to hold the animals. The dimensions of two of the containers were 40 × 35 × 80 cm; those of the other were 40 × 35 × 125 cm (width-height-length, respectively). Soil, sawdust, wood, and stone were put in each cage. The sexes of the adult animals were determined and the Iğdır samples were put together in the same small cage and the Doğubeyazıt samples in the other small cage. After the Iğdır pair produced its third litter, the parents and all pups were transferred to the larger enclosure. A female pup from the second litter of the Iğdır pair and a male from Doğubeyazıt were brought together to form a new second pair and were put together in a small cage that was vacant. Voles were observed throughout the year. The pups were measured weekly up to the age of 1 month. Afterwards, measuring continued at 2-week intervals up to 98 days of age. The animals were fed with mostly vegetables, fresh grass, corn, and sunflower seeds. On the starting day, all animals were weighed and housed conventionally in individual stainless steel cages in standard room conditions. The food consumption record of the animals was maintained daily. On arrival, animals were placed into their cages and allowed access to a preweighed amount of food. The food was reweighed the next day and the amount consumed was calculated by the difference. The foods were offered completely for minimum water loss. Measuring of food consumption was calculated on a monthly basis per individual (eight samples) and at 15 days for the paired specimens (two pairs). Animals were visited daily to note observations. The skins and skulls of the specimens were ultimately deposited in the Department of Biology of the Faculty of Science of Dicle University.

### 3. Results

#### 3.1. Reproduction

One pair gave three litters and the other pair gave two litters in a year. In total, two pairs produced five litters with 13 pups in a year. The mean litter size was 2.6, and the gestation period was 21 days. The lowest interval between two births was 28 days. The births took place in July, October, February, and March. The birth periods were not consistent (Table 1).

#### 3.2. Postnatal development

Immediately after birth, the pups were altricial, and the average body mass was 3.4 g. They were born pink with

<table>
<thead>
<tr>
<th>Pairs</th>
<th>Date</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st pair</td>
<td>06.07.2012</td>
<td>2</td>
</tr>
<tr>
<td>2nd litter</td>
<td>01.10.2012</td>
<td>3</td>
</tr>
<tr>
<td>3rd litter</td>
<td>29.10.2012</td>
<td>3</td>
</tr>
<tr>
<td>2nd pair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st litter</td>
<td>12.02.2013</td>
<td>2</td>
</tr>
<tr>
<td>2nd litter</td>
<td>11.03.2013</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>13</td>
</tr>
</tbody>
</table>
scarce hairs and no vibrissae on the snout, and the claws of the fore and hind feet were not complete. The dorsal surface of the body was darker than the ventral. Genital, anus, and ear openings as well as navel cord scarring and signs of nipples could be seen. Eyes were closed (Figure 1A). The locomotion and voices of the pups were still quite weak.

After the first week, the dorsal surface of the body was darker than previously but the ventral was still pink. Locomotion and balance were better than the week before. Because the arms and legs of the pups were quite weak, they could not stand on their limbs and usually moved by crawling (Figure 1B).

By day 14, hair had grown longer and denser. The ventral surface of the body was still lighter than the dorsal side. The vibrissae were prominent and the nails of the fore and hind claws were visible. The pups could stand on their belly when they rolled upside down. They were looking for each other and their mother. Their body movements were slow and unevenly balanced, but pups were capable of following their mother (Figure 1C).

At the third week, the claws of the fore and hind limbs were complete with distinct nails. Pups could move by steps and were able to turn upside-down quickly. The molars and normal incisors reached eruption in 19–21 days. The lower incisor was longer than the upper. The pups were roaming freely in the cage and they could find their mother easily. After 23–24 days they were able to gnaw soft vegetables independently, but the mother was still breast-feeding the young (Figure 1D).

Eyes opened at 26–28 days. Body movement and balance seemed to be regular. The fur was complete, but was brighter and darker than adult fur. The pups could stand on their hind legs and were trying to climb, and they gnawed all vegetables and sunflower seeds. In addition, they still continued to suckle. Aggressive behavior was seen occasionally; the pups were sometimes fighting each other and bit each other, but not dangerously. They could also bite when someone tried to catch them (Figure 1E).

The pups were weaned on days 33–35. The duration of the pups to both suckle and feed on vegetables was about 8–10 days. At this age, they tried to dig, but only for a short time.
time. The nipples of the mother disappeared after 38–40 days (Figure 1F).

The pups began to hoard food by days 56–60 (Figure 1G). Body mass and other outer measurements increased up to 21 days and declined between 21 and 28 days, after which the measurements increased again. By day 70, only weight changed; all other measurements were nearly stable (Figure 1H; Table 2). The total, hind foot, and tail lengths reached nearly the adult size by age of 80–90 days and the weight increase was less (Figure 1I). The young resembled the adults in terms of manner and appearance by days 96–98 (Figure 2).

The most interesting observation was that the pups had incisors at birth; however, these incisors appeared different from the normal incisors of adults. These incisors were yellowish and bent sideways at the tips (Figure 3A). They could be used to seize nipples that were too small. Therefore, we called these incisors ‘nipple-seizing incisors’. The normal incisors grew in white and the tips of the teeth were adjacent (Figure 3B). The nipple-seizing incisors disappeared after 19–21 days and the normal incisors replaced them.

It was difficult to distinguish the young from the adults after 3 months. However, the fur of the young appeared more brilliant and their incisors were shorter. The tips of dorsal hairs were light brown in the adults. The earliest age of sexual maturity of females was 16–17 weeks. A female in the colony gave her first birth at 20 weeks of age. Assuming a gestation of 21 days, she had mated at 17 weeks of age. The females had three pairs of nipples: two pectoral pairs and one inguinal pair. The tips of the nipples were very slight and were visible only between the births and weaning; as previously stated, they disappeared after 38–40 days. There was no sign of nipples outside of this interval. Male sexual maturity could not be observed in this study.

Adult females and males can be differentiated by their overall size and the structure of their anal openings. The females were bigger than the males. In the female, the anal opening is platy or concave if the female has given birth, but the male’s is protrusive or convex. The activity and aggression of the male was also a distinctive characteristic. Young males and females could not be distinguished easily.

**Table 2.** The mean weight and linear measurements of the pups from birth to 98 days of age and the adult sizes (N: number of individuals; SE: standard error; W: weight; ToL: total length; HFL: hind foot length; TL: tail length; *: collected from the field).

<table>
<thead>
<tr>
<th>Day</th>
<th>N</th>
<th>Mean W ± SE (g)</th>
<th>Mean ToL ± SE (mm)</th>
<th>Mean HFL ± SE (mm)</th>
<th>Mean TL ± SE (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12</td>
<td>3.42 ± 0.14</td>
<td>36.08 ± 1.28</td>
<td>5.67 ± 0.13</td>
<td>4.50 ± 0.14</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>8.73 ± 0.44</td>
<td>51.45 ± 1.31</td>
<td>8.18 ± 0.25</td>
<td>5.55 ± 0.19</td>
</tr>
<tr>
<td>14</td>
<td>9</td>
<td>15.67 ± 0.75</td>
<td>68.11 ± 1.76</td>
<td>11.67 ± 0.35</td>
<td>7.22 ± 0.54</td>
</tr>
<tr>
<td>21</td>
<td>9</td>
<td>21.22 ± 1.02</td>
<td>79.56 ± 1.30</td>
<td>15.44 ± 0.39</td>
<td>10.22 ± 0.64</td>
</tr>
<tr>
<td>28</td>
<td>7</td>
<td>25.71 ± 1.60</td>
<td>84.29 ± 1.14</td>
<td>16.86 ± 0.47</td>
<td>11.14 ± 0.47</td>
</tr>
<tr>
<td>42</td>
<td>7</td>
<td>39.14 ± 3.80</td>
<td>100.86 ± 4.50</td>
<td>20.29 ± 0.82</td>
<td>12.14 ± 0.42</td>
</tr>
<tr>
<td>56</td>
<td>6</td>
<td>48.33 ± 7.66</td>
<td>108.00 ± 6.17</td>
<td>22.00 ± 1.11</td>
<td>13.00 ± 0.47</td>
</tr>
<tr>
<td>70</td>
<td>6</td>
<td>61.67 ± 7.42</td>
<td>120.17 ± 4.13</td>
<td>23.50 ± 0.56</td>
<td>13.67 ± 0.31</td>
</tr>
<tr>
<td>84</td>
<td>6</td>
<td>73.17 ± 6.50</td>
<td>125.00 ± 3.34</td>
<td>24.33 ± 0.35</td>
<td>13.83 ± 0.36</td>
</tr>
<tr>
<td>98</td>
<td>5</td>
<td>77.00 ± 5.95</td>
<td>126.40 ± 4.14</td>
<td>24.60 ± 0.36</td>
<td>14.20 ± 0.33</td>
</tr>
</tbody>
</table>

*Adults 5 65.6 ± 8.60 127.2 ± 4.15 24.2 ± 0.33 14 ± 0.28

Figure 2. The graphics of mean mass and linear measurements of *E. lutescens* from birth to 98 days of age (ToL: total length, HFL: hind foot length, TL: tail length).
3.3. Feeding
The animals ate a variety of food but primarily fed on vegetables, especially red radishes, carrots, and potatoes. They consumed red radishes (66.7%) more than carrots (63%) and potato (47.4%) when offered food. Although the male (on average 60.8 g) was smaller than the female (on average 90.8 g), males consumed more than females according to the ratio of body weight. Male and female consumption was 101.3% and 71.2% of body weight, respectively. Isolated animals kept in a cage alone consumed more (81.1% of body weight) than animals kept in pairs (66.1% of body weight). The animals got fat easily in the cage exclusively with females. Cannibalism was seen in the cage occupied by adults and older pups.

3.4. Digging modality and daily activity
In our direct observations, the animals used their incisors to scratch the soil and their forelimbs to dig, but they used only forelimbs when the soil was loose. They started by scratching the soil with their incisors and then dug with forelimbs (5–6 times). Afterwards, they pushed the dirt underneath them with their forelimbs and pushed it behind them with their hind limbs (5–6 times). They turned back and pushed the dirt with their head and chest. They were active (feeding, digging, grooming) almost all day and night, but mostly during morning and evening. They usually fed in the morning. They did not hibernate or aestivate in captivity.

3.5. Behavior
Some male-male and female-male conflict occurred initially when two individuals were kept together in the same cage; the quarrels rarely resulted in serious injury or death. Male-male fighting was more typical than female-male. The conflict was over in 1–3 days. They could live as both a family society and in groups. The parents and the pups of three litters could live in the same cage peacefully. Additionally, unfamiliar individuals could live in the same cage after the first meeting and after the initial conflict was ended. The males and young individuals oversaw the care of babies. They cleaned, groomed, and guarded the babies. The males were more active, aggressive, and fearful than females, especially when a male was caged alone.

The mothers nursed the pups of two litters when the interval between births was short, but the mothers gave priority to the younger pups. The female could also give birth after the previous litter’s pups were weaned. The female nursed the babies approximately 30 min each time. This duration shortened gradually as the pups grew up. There were three sucking modalities: face down sucking, where the pups lay under the female; the mother on her back, with the pups on the female’s abdomen and thorax; and the mother lying on her side. The position of how the animals rested also had three types: curving, especially at cold times; lying on their back with outstretched limbs when they got too warm; and face-down resting.

4. Discussion
This paper represents the first record of this species (E. lutescens) collected from Ağrı and Iğdır) from the north of Van and the record of new localities extends the known range of the species in the region.

Contrary to the results of Lederberg (1999), Just et al. (2002), Stefan and Steimer (1978), Evdokimov (2013), and Smorkatcheva and Kumaitova (2014) on E. talpinus and E. tancrei, the reproduction potential of E. lutescens was sufficient and the intervals were unsteady. The annual reproductive activity period of E. lutescens was longer than the findings of Coşkun and Ulutürk (2003), Nowak (1995), Evdokimov (2002, 2013), and Smorkatcheva and Kumaitova (2014) on E. talpinus and E. tancrei.
E. tancrei. Additionally, it appears that E. lutescens is able to reproduce throughout the year when considering the results of the annual period of reproductive activity of E. lutescens in this study and in that of Coşkun and Ulutürk (2003). The litters throughout the year and their sizes (Table 1) were similar to those reported by Ognev (1963), Coşkun and Ulutürk (2003), Walker (1964), and Stefan and Steimer (1978), but smaller than those of Nowak (1995) as reported for E. lutescens. Annual litters and sizes were smaller than those of E. tancrei (Smorkatcheva and Kumaitova, 2014) and E. talpinus (Evdokimov, 2002). The gestation period was shorter than in E. lutescens as reported by Nowak (1995), as well as E. talpinus (Evdokimov, 2002). The age of sexual maturity was younger than in E. talpinus (Evdokimov, 2002, 2013), but older than in another study of E. lutescens (Nowak, 1995). The ages at eye-opening and weaning were older than in E. tancrei (Smorkatcheva and Kumaitova, 2014) and E. talpinus (Evdokimov, 2013), but age of independent feeding was similar (Table 3). The age at which the animals reached adult size was similar to that found by Evdokimov (2013) (Table 2). The neonatal body mass was similar; however, the age of the eruption of incisors was later than in E. talpinus as reported by Evdokimov (2013).

According to Smorkatcheva and Kumaitova (2014), the mothers produce litters even if there are older offspring in the cage, yet the female offspring do not breed unless their mother dies or they become separated from the mother. They also stated that the females are bigger than the males and the males are more active (bringing food and burrowing) than the females. The results of this study are similar to Smorkatcheva and Kumaitova’s (2014) findings.

The number and position of nipples were different from those reported by Neuhäuser (1936), Hinton (1926), Harrison (1972), and Çağlar (1967). On the other hand, the difference in sizes of males and females was similar to the findings of Matthey (1958).

The diet and consumption of E. lutescens was similar to the results of Evdokimov (2002) and Coşkun and Ulutürk (2003). The animals preferred radish to other vegetables, and the males consumed more than females in terms of the ratio of consumption to weight, contrary to the findings Coşkun and Ulutürk (2003). We saw that E. lutescens will consume meat, as had also been reported by Ognev (1963) and Smorkatcheva and Kumaitova (2014).

Petrovski et al. (2010) reported that loss of circadian body temperature rhythms in mole voles (E. talpinus) does not require the low body temperature of deep torpor or hibernation even though their body temperature remains high in wintertime. This suggests that they hibernate, but hibernation and aestivation were not observed here in E. lutescens, which coincides with the findings of Coşkun and Ulutürk (2003) and contrasts with Evdokimov’s (2002) findings that E. talpinus hibernates.

We recorded that the parents and the pups of three litters could co-inhabit a cage, which conflicts with the results of Coşkun and Ulutürk (2003) but is similar to those of Ognev (1963). They could live both as a family society and in separate groups, differing from the findings of Coşkun and Ulutürk (2003).

Table 3. The comparison of various aspects of reproduction and postnatal development of Ellobius lutescens, E. talpinus, and E. tancrei.

<table>
<thead>
<tr>
<th>Species</th>
<th>Litter annually</th>
<th>Litter size</th>
<th>Gestation (days)</th>
<th>Eye-opening (days)</th>
<th>Self-feeding (days)</th>
<th>Weaning (days)</th>
<th>Sexual maturity</th>
<th>Breeding season</th>
<th>References</th>
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<tr>
<td>E. lutescens</td>
<td>4</td>
<td>2–4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Ognev (1963)</td>
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<tr>
<td>At least 2</td>
<td>2–4</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>Mar–Apr, Oct–Nov</td>
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<td>2</td>
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<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>Walker (1964)</td>
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<tr>
<td>Regular</td>
<td>1–4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Stefan and Steimer (1978)</td>
</tr>
<tr>
<td>3</td>
<td>2–3</td>
<td>21</td>
<td>26–28</td>
<td>23–30</td>
<td>33–35</td>
<td>16 weeks</td>
<td>All year</td>
<td>This study</td>
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<tr>
<td>1–2</td>
<td>1–7</td>
<td>30</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>One year</td>
<td>Feb–Mar</td>
<td>Evdokimov (2002)</td>
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</table>
E. lutescens was active during the day and night, but was most active in the morning and evening. These observations were compatible with those of Ognev (1963). The digging modality was the same as that reported by Coşkun (2001) and Lay (1967).

Providing such data on the reproductive biology of Anatolian populations of E. lutescens will be of value in laboratory and field studies, but we suggest that the further studies should compare other populations and more samples using similar methods and new techniques.

References


