A Field Study on the Behaviour of Calomyscus elburzensis Goodwin, 1938 (Rodentia: Calomyscidae): Sexual and Seasonal Variations in the Trapping Success

Kordiyeh Hamidi1, Jamshid Darvish1,2,3*, Maryam M. Matin1,4, Vladimir Malikov5

1 Department of Biology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran
2 Research Group of Rodentology, Institute of Applied Zoology, Ferdowsi University of Mashhad, Mashhad, Iran
3 Research Department of Zoological Innovations, Institute of Applied Zoology, Ferdowsi University of Mashhad, Mashhad, Iran
4 Cell and Molecular Biotechnology Research Group, Institute of Biotechnology, Ferdowsi University of Mashhad, Mashhad, Iran
5 Laboratory of Theriology, Zoological Institute of the Russian Academy of Sciences 1, Universitetskaya emb., Saint-Petersburg, Russia

Abstract: Obtaining reliable data on rodent biology and behaviour requires comprehensive field studies. Herein, we compared six different baits on the capture rate of Calomyscus elburzensis (Rodentia: Calomyscidae) in North-eastern Iran during spring and summer of 2014. Our aim was to investigate the seasonal and sexual differences in trapping success of C. elburzensis and evaluate the efficiency of different bait types. Single-capture custom-made mesh live traps were set for 16 trials. We had 48 captures of C. elburzensis: 27 adults, nine subadults, and 12 juvenile males and females. Capture rates were 47.9% and 52.1% in spring and summer, respectively. Overall capture number was 25 (52.1%) individuals for males and 23 (47.9%) individuals for females. Sunflower seeds were more effective in capturing than any other bait. Trapping success averaged at 11.95±0.5%. More adult males were trapped during the mating season (in spring), whereas more adult females were caught during the lactating period (in summer). There was no overall difference between male and female captures. However, there was a significant difference in the number of captures between males and females when using different baits: seeds captured more females and fruits more males. Further studies are required to investigate the population dynamics and the success of trapping with different baits in varying habitats for Calomyscus species, for most of which limited scientific data are available.

Keywords: Calomyscus elburzensis; Live-Trapping; Trapping success; Bait type; Iran

Introduction

Goodwin’s brush-tailed mouse, Calomyscus elburzensis Goodwin, 1938, has been reported from mountains of north and northeast of Iran: southern foothills of Elburz Mountains in Semnan Province (Lebedev et al. 1998) and also eastern part of Yazd Province (Shahabi et al. 2010). This species lives in colonies (Ellerman, 1941) and, similarly to its congens, occupies well drained, barren, rocky habitats in the foothills and mountains (Morshead, Patton 2002) at elevations of 400-3500 m a.s.l. (Nowak 1999, Tofts 2003). Although some morphological (Ellerman 1941, Musser, Carleton 2005), molecular (Morshead, Patton 2002, Shahabi et al. 2011, 2013) and karyological (Graphodatsky et al. 2000, Shahabi et al. 2010) studies on this genus, behavioural data on brush-tailed mice in the wild are missing.

Obtaining reliable data on rodent biology and behaviour requires comprehensive and schematized field studies with using efficient traps for capturing all functional categories of the population (Mihok et al. 1982, Getz et al. 1986, Feldhamer et al. 2008).

*Corresponding author: Darvish_j2001@yahoo.com
Live-trapping is commonly used to estimate abundance and diversity of small mammals (e.g. von Trebret al. 1998; Carey, Wilson 2001, Janova et al. 2010, Theuerkauf et al. 2011) and usually allows the trapped animals to be identified, aged and sexed with more accuracy (Jones et al. 1996). Different types of live traps (single and multiple-capture) have been used in several studies of small mammals ecology and distribution (e.g. Getz et al. 1986, Bowman et al. 2001a, b, c, Feldhammer et al. 2008, Madikiza et al. 2010). Although there are many reports indicating that multiple captures of small mammals cannot be used to infer aspects of their social and reproductive behaviour, several studies have concluded that double captures are indicative of social interactions (Taulman et al. 1994, Drickamer et al. 2003, Christopher, Barrett 2007, Feldhammer et al. 2008).

Several experiments have already been conducted on trap efficiency and bait preference in small mammals (e.g. Astua et al. 2006, Belant et al. 2007, Feldhammer et al. 2008, Madikiza et al. 2010, Brooks, Trout 2012). Food habits within species may exhibit a considerable variation, particularly for species with wide geographical distribution and adapted to a variety of habitats (Getz 1989; Hahus, Smith 1990, Clark, Kaufman 1991). Food habits of small mammals also show considerable variation by season (Madikiza et al. 2010). Thus, many seemingly innocuous variables can affect trapping success, including trap type and bait preference (Dizney et al. 2008, Theuerkauf et al. 2011) and season (Madikiza et al. 2010). In addition, trap efficiency for a given species may differ in different localities (Astua et al. 2006, Nicolas, Colyn 2006, Dizney et al. 2008). Each trap has its own mechanical limitations that are likely to favour capture of some species over others. No single trap type will capture individual members of a local ecological community of all species, sexes and age classes with equal probability. Therefore, a combination of trap types should be used to capture a representative sample of the local small mammal fauna (Lee 1997, Anthony et al. 2005).

In our study, we used a custom-made mesh live trap (approximate 25 × 9 × 9 cm) modelled based on those reported by O'Farrell et al. (1994). This single-capture live trap was constructed from galvanized steel mesh. Its metal trap wire is so sensitive that with a little movement from the entered animal, the door will be closed automatically without any harming. This simple structure trap remains one of the most commonly used traps for studies on rodent diversity and has been widely used for capturing Calomyscus spp. throughout Iran (Darvish et al. 2006, Shahabi et al. 2010, 2011).

In this study, we compare the trapping success of the Goodwin’s brush-tailed mouse, Calomyscus elburzensis, between different classes of individuals and seasons as well as different bait types. We hypothesise that: 1) seasonal and sexual related differences in trapping success would respectively reflect variations in activity levels in different climatic conditions and reproductive strategies of Goodwin’s brush-tailed mouse, and 2) bait type would influence the number of individuals captured.

Materials and Methods

Study Area

This study was conducted in Khaje Morad, approximately 12 km southeast of Mashhad, Khorasan-Razavi Province, Iran, and located 36°08’-37°03’N and 59°13’-59°42’E at an altitude of av. 1,146 m a.s.l. (Fig. 1). This site is located in a generally cold and dry climatic condition. The maximum and minimum temperatures are between +35°C and -15°C in summer and winter, respectively. The topography is generally flat, with some mounds. The habitat is well drained, barren and rocky. The vegetation is mostly of Artemisia sp., Ephedra sp. and Euphorbia sp. (identified in Plant Biodiversity Research Lab, Ferdowsi University of Mashhad). Agriculture in this region is not intensive; however, some lands were under cultivation and considerable pastureland and livestock grazing could also be observed. Patches of trees remain on the steep of foothills. In the vicinity of sampling stations, lots of industrial and residential constructions are localized.

Six stations in the Khaje Morad region were selected for this study. These sites were selected for their rocky habitats and low levels of human disturbances. We had previously captured two species of rodents, i.e. brush-tailed mouse, C. elburzensis, and Persian Jird, Meriones persicus (Blanford, 1875), from this region (Darvish et al. 2006).

Field Work and Trapping Method

Custom-made mesh live traps (designed for single captures), measuring 25 × 9 × 9 cm, were soaked for 24 h in detergent and water, cleaned, and dried prior to placements. We carried out trapping for 24 weeks between April and September 2014. An average 29.6 traps were randomly placed on rocky clefts in each trial. The exact positioning of the traps was determined by the suitability of the site (“most likely runway” positions on rocky clefts of humid foothills). We marked each station with removable flags. Small pieces of rocks were placed around the traps to increase their attractiveness to rodents and to
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prevent hyperthermia in hot weather. A small piece of cotton cloth was inserted inside each trap to provide bedding and insulation for captured rodents and prevent them from dying of cold in early spring.

Six bait types were tested to determine which one is most preferred and hence most useful for capturing *C. elburzensis*. These included scorched sunflower seed, scorched gourd seed, scorched walnut, sausage chunk, apple and cucumber pieces. Order of trap placement (and thus baits) was randomly redistributed in order to have the same number of each bait type in the whole area. Traps were set in the late afternoons and checked initially in the following mornings and were recorded date, species, sex, body weight and approximate age of all captured individuals. All collected traps were emptied, soaked, thoroughly washed and made ready for the following trapping session. Species identification followed Corbet (1978). By finishing the project, all captured specimens were released in their home range.

**Data Analysis**

Since variances of different sub-samples were similar (Levene’s test, *p* > 0.05) and the data distributions did not generally depart from normality (Kolmogorov – Smirnov test, *p* > 0.05), variables variations in our study were evaluated by independent-sample t-tests, Chi-square test (χ²) and one-way Analysis of Variance (ANOVA) (Rice, 1989). Statistical analyses were performed with the SPSS 16.0 (SPSS Inc., 2007).

For each season (spring and summer), we tested if sex or maturity status of individuals had an effect on their capture by live trap. Chi-square test (χ²) was used for sex and maturity comparisons between different seasons, as well as to compare bait types used in different seasons or by different sexes. Since the data were normally distributed, Independent-sample t-test was used for analysis of trapping results in various conditions. The results were analyzed using one-way Analysis of Variance (ANOVA) to detect any preference for bait types.

**Trapping Success**

A trap in use for a 24-h-period is referred to as a trap-night (TN). Trap success (T) is defined as the number of individuals caught per 100 TNs, i.e. \( T = \frac{N_m}{N_{tn}} \times 100 \), where *Nₘ* is the number of individuals trapped and *Nₜₙ* the number of trap-nights (Nelson, Clark 1973).

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**Fig. 1.** Geographical location of the sampling region (Khaje Morad) in Southeast of Mashhad, Khorasan – Razavi Province, Iran
As the number of used traps was different between the 6 trapping stations, variation in trapping success were expressed as percentage rather than absolute numbers of traps containing a certain class of individuals (Madikiẓa et al. 2010). Trap success may have been influenced by inherent site-specific variation among the two seasons. Therefore, we used Analysis of Variance (ANOVA) to compare the mean number of individuals captured with each of the baits or in each maturity groups.

Results
Number of Individuals and Species Composition

The experiment was conducted over sixteen nights between early April 2014 and late September 2014. We captured 48 individuals of Calomyscus elburzensis in 438 trap nights in Khaje Morad region. These were 12 adult and 5 sub-adult males, 15 adult and 4 sub-adult females and 12 juveniles.

The distribution of trapping events for the Goodwin’s brush-tailed mouse under study is presented in Figure 2. The numbers of captured individuals with different age and sex classes of C. elburzensis as well as sexual composition with respect to bait types are shown in Table 1 and Figure 3, respectively.

On three occasions, two individuals of C. elburzensis were caught in one live trap. Moreover on several occasions, two non-target animals were caught: Persian Jird, Meriones persicus, and Grey Dwarf Hamster, Cricetulus migratorius (Pallas, 1773). We excluded these data from our analyses.

Sex and Season Related Differences

Overall capture number was 25 individuals (52.1%) for males and 23 individuals (47.9%) for females. We did not observe any significant differences in sexes of captured C. elburzensis based on independent-sample t-test results (d.f. = 46; p = 0.11, p > 0.05).

Overall capture numbers in spring and summer were 23 individuals (47.9%) and 25 individuals (52.1%), respectively (Table 1). Independent-sample t-test showed that there was no significant difference in the number of animals captured between the two different seasons (d.f. = 46; p = 0.37, p > 0.05).

Chi-square test ($\chi^2$) showed that traps captured less males than females in summer (3 adult males vs. 9 adult females) (d.f. = 1; p = 0.77, p > 0.05).

On average, trap captured more adults in spring and sub-adults and juveniles in summer (Table 1) but there was no significant difference in maturity status of individuals captured in different seasons (d.f. = 1; p = 0.77, p > 0.05).

Effects of Bait Types

All six bait types showed some feeding by C. elburzensis individuals. The descending order of preference was scorched sunflower seed, scorched gourd seed, scorched walnut, sausage chunk, apple and cucumber pieces (Fig. 3). One way ANOVA analysis revealed that scorched sunflower seed was significantly more effective than any other bait (d.f. = 5; p = 0.038, p < 0.05).

Also Chi-square tests ($\chi^2$) showed that there was no significant effects of bait types on the captures in different seasons (d.f. = 1; p = 0.77, p > 0.05) or different sexes (d.f. = 1; p = 0.77, p > 0.05). However, apple and sausage chunks appeared to be more ef-
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**Trapping Success**

During trials, trapping success averaged 11.95 ± 0.5% (range 6.90-17.24%). Trapping success increased in summer. However, the observed seasonal variations were not statistically significant (Independent samples t-test: d.f. = 46; \( p = 0.61, p > 0.05 \)).

Although the trapping success of individuals of *C. elburzensis* did not differ by sex (One way ANOVA analysis: d.f. = 1, \( p = 0.76, p > 0.05 \)) but a tendency was found for male trapping success to be higher in spring than summer. Female trapping success, on the contrary, was higher during summer in comparison to spring.

The trapping success of three groups of maturity status were not significantly varied (One way ANOVA analysis: d.f. = 2, \( p = 0.34, p > 0.05 \)). However, generally adult trapping success was higher in spring than in summer (Table 2).

Bait types showed some interesting relationships to trapping success. One way ANOVA analysis indicated that bait differences (d.f. = 5; \( p = 0.007, p < 0.05 \)) in mean numbers of individuals captured were highly significant (Table 3). Total captures of individuals per bait types ranged from 1 (2.08%) for the cucumber bait to 21 (43.75%) for scorched sunflower seed.

**Discussion**

We had captured *Calomyscus elburzensis* from different areas in our previous studies. However, this is the first time that we have considered the trapping success of custom-made mesh live traps in capturing this small rodent. Herein, we showed that this trap type worked successfully at capturing Goodwin’s brush-tailed mouse. We captured 27 adult individuals (out of 48) in the rocky region of Khaje Morad, representing 12 males and 15 females. We recorded a satisfactory trapping success (on average 11.95%). Use of mesh live traps with dimensions appropriate with our target animals, would decrease the risk of capturing non-target animals (e.g. in this study, *Meriones persicus* and *Cricetulus migratorius*).

**Sexual and seasonal variations in the trapping success**

There was a little gradual increase in the trapping success from spring to summer. This pattern can be explained by variations in *C. elburzensis* numbers during the year. As recorded for *C. bailwardi*, in *C. elburzensis* litters are born in spring and may become part of the trappable population in summer (Ellerman 1941).

Trapping success of male Goodwin’s brush-tailed mouse was a bit higher in spring, which may have resulted from increased mobility during the mating season in order to locate females in estrus. The pattern of female trapping success was very similar to that recorded for males but the peak had shifted towards summer. As Madikiza et al. (2010) have interpreted for Woodland Dormice, *Graphiurus murinus* (Desmarest, 1822), this result can probably be explained by an increase in their mobility, as females need to find favourable nesting areas and enough food for milk production during the reproductive season in April and June. It has been observed that some female rodents, especially breeding ones (Grunwald 1975, Madikiza et al. 2010), are more interested in entering live traps perhaps because traps remind the burrow and offer food. Furthermore, females may

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**Table 1.** Numbers of captured *Calomyscus elburzensis* in the study area, with respect to sex and age classes

<table>
<thead>
<tr>
<th>Season</th>
<th>Number of nights operated</th>
<th>Number of trap nights</th>
<th>Number of captured males</th>
<th>Number of captured females</th>
<th>Total captures in each season</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adult</td>
<td>Sub-adult</td>
<td>Juvenile</td>
</tr>
<tr>
<td>Spring</td>
<td>8</td>
<td>221</td>
<td>9</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Summer</td>
<td>8</td>
<td>217</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>438</td>
<td>12</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

**Table 2.** Trapping success for single-capture mesh live trap in Khaje Morad rocky region, calculated as the number of captures% for each group/number of trap-nights ×100

<table>
<thead>
<tr>
<th>Trapping success (%)</th>
<th>Sex class</th>
<th>Age class</th>
<th>Total trapping success in each season</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Adult</td>
</tr>
<tr>
<td>Spring</td>
<td>6.78</td>
<td>3.61</td>
<td>6.78</td>
</tr>
<tr>
<td>Summer</td>
<td>4.60</td>
<td>6.91</td>
<td>5.52</td>
</tr>
<tr>
<td>Overall</td>
<td>5.70</td>
<td>5.25</td>
<td>6.16</td>
</tr>
</tbody>
</table>
serve as an additional enticement for pups to enter traps during lactating period (Jensen 1998, Thomas et al. 1999). In all three double captures of C. el-burzensis in our study, one adult female with her litter were captured. However, the low number of multiple captures in our study (mostly because of the use of single-capture live trap instead of multiple-capture one) makes it difficult to draw robust conclusions about their social behaviour.

### Bait Preference

There are different reports on several bait effectiveness in capturing small mammals. Woodman et al. (1996) found no influence of different bait types on trapping success for small mammals in Neotropical lowlands. On the other hand, several bait experiments showed that the bait used might affect composition and abundance of small mammal species captured (e.g. Oswald, Flake 1994, Astua et al. 2006, Brooks, Trout 2012). Oswald, Flake (1994) showed that murids were best captured by grain, peanut butter, molasses and dried fruit, while short-tailed shrews were primarily attracted to grain, meat scraps and suet formulations, or grain, meat scraps, suet and dried fruit mixtures. Moreover, Janova et al. (2010) study demonstrated that young voles or post breeding females preferred baits rich in fat. Boonstra, Krebs (1976) and Drickamer (1976), suggested that use of olfaction is a primary cue in attracting small mammals. On the other hand, factors such as invertebrates attack (ants mainly), weather conditions, durability and local availability are determinants when choosing a specific bait (Voss, Emmons, 1996).

Consistent with previous studies, we found that using different baits sometimes resulted in differences in capture rates. The success of the smaller sized seeds such as scorched sunflower or gourd seeds may have been due, in part, to oils presents in these baits; such oils may have exerted an olfactory cue that enticed individuals to enter the trap. Furthermore, their smaller seed size and species familiarity with seed type (vs. sausage chunks) may have been factors in more attractiveness of these baits. It is common sense that animals should be more attracted to a bait resembling their preferred diet, which has also been confirmed by Laurance (1992). Thus, specific baits may have applications in sampling various habitats and species. Furthermore, sunflower seeds are hardly carried away by insects or washed by rain and would last longer than others. The natural longevity of each bait type should also be considered before use in capturing.

### Conclusion

This study was the first ecological trial of Goodwin’s brush-tailed mouse, which is one of the endemic species of Iranian plateau. Although trap and bait types, sampling location, season and many other factors, could influence small mammals capture rates but in our study, we showed no differences in capturing success in different seasons or between different sexes. We examined six commonly used baits and showed that scorched sunflower seeds are more effective in capturing this rodent but there are a large number of other baits that have been used as attractant in different trap types. A comparison of the efficiency of different types of baits and the potential for seasonal and sexual variations in the effectiveness of particular baits would be interesting. Additional studies are needed to estimate the diversity, abundance, population dynamics and other aspects of ecological and behavioural facts of Calomyscus spp.

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