

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

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**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  $11.95 \pm 0.5\%$ . 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 congeners, occupies well drained, barren, rocky habitats in the foothills and mountains (MALIKOV *et al.* 1999, MORSHED, PATTON 2002) at elevations of 400-3500 m a.s.l. (NOWAK 1999, TOFTS 2003). Although some

morphological (ELLERMAN 1941, MUSSER, CARLETON 2005), molecular (MORSHED, 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).

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Live-trapping is commonly used to estimate abundance and diversity of small mammals (e.g. VON TREBRA *et 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, FELDHAMER *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, FELDHAMER *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, FELDHAMER *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  $25 \times 9 \times 9$  cm) modelled based on those reported by O'FARRELL *et al.* (1994). This single-capture live trap was constructed from galvanised steel mesh. Its metal trip 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  $36^{\circ}08' - 37^{\circ}03' N$  and  $59^{\circ}13' - 59^{\circ}42' E$  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  $+35^{\circ}C$  and  $-15^{\circ}C$  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  $25 \times 9 \times 9$  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

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

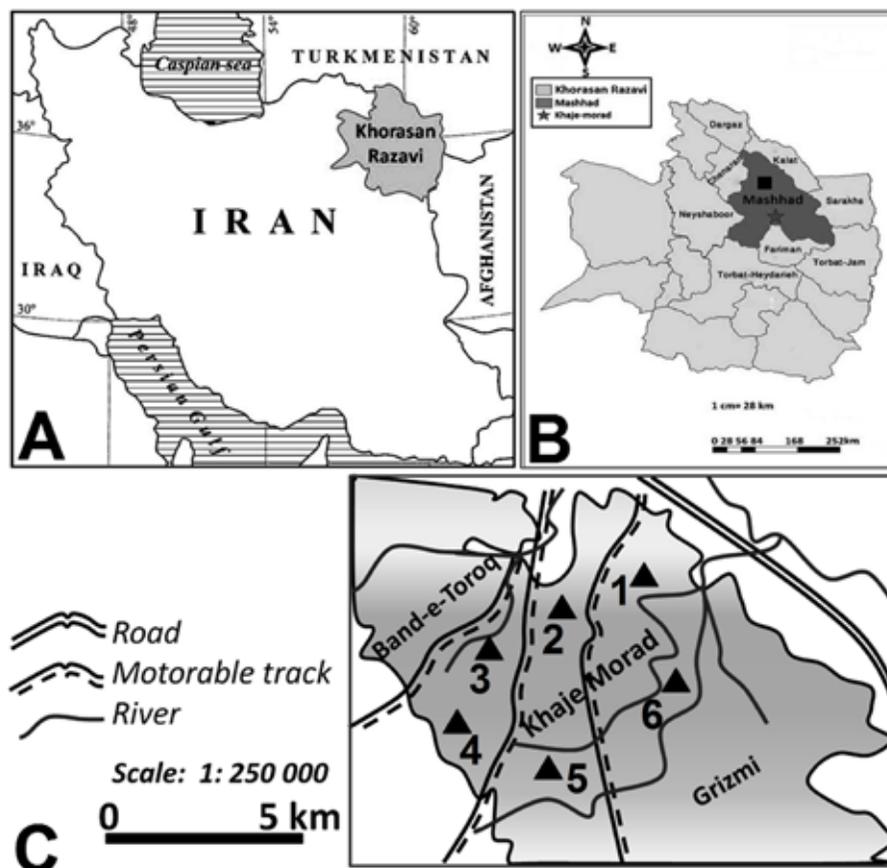
Since variances of different sub-samples were similar (Levene's test,  $p > 0.05$ ) and the data distributions did not generally depart from normality

(Kolmogorov – Smirnov test,  $p > 0.05$ ), variables variations in our study were evaluated by independent-sample t-tests, Chi-square test ( $\chi^2$ ) 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 ( $\chi^2$ ) 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.  $T = (Nm / Ntn) \times 100$ , where Nm is the number of individuals trapped and Ntn the number of trap-nights (NELSON, CLARK 1973).



**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 (MADIKIZA *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;  $p = 0.37$ ,  $p > 0.05$ ).

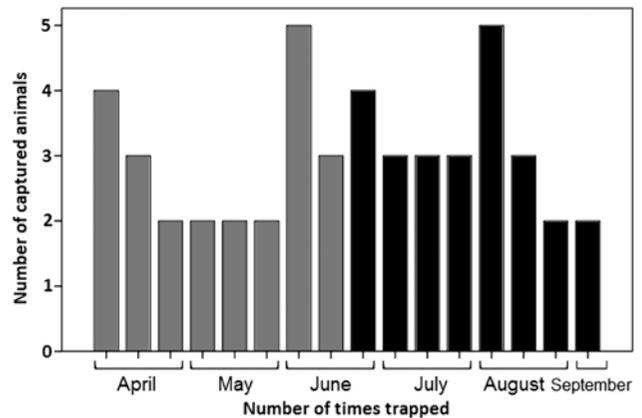
Chi-square test ( $\chi^2$ ) showed that traps captured less males than females in summer (3 adult males vs. 9 adult females) (d.f. = 1;  $p = 0.77$ ,  $p > 0.05$ ).

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;  $p = 0.77$ ,  $p > 0.05$ ).

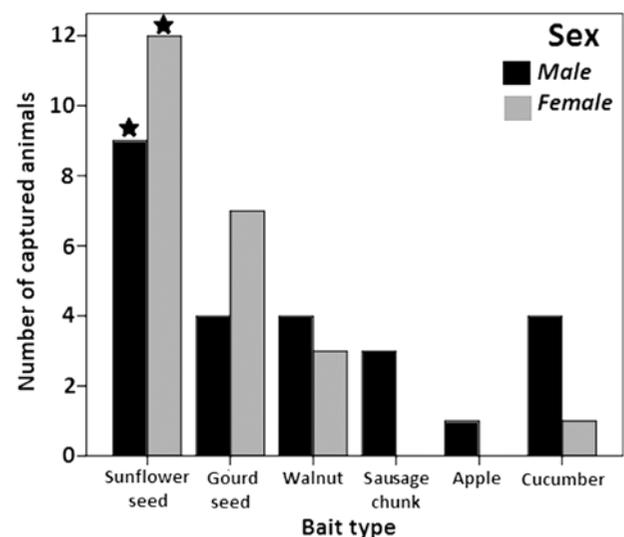
### Effects of Bait Types

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-



**Fig. 2.** Number of times (n = 16 trapping nights) that Goodwin's brush-tailed mice *Calomyscus elburzensis* (n = 48) were trapped between April and September 2014 in Khaje Morad, Mashhad, Iran. Grey and black bars refer to trapping nights in spring and summer, respectively



**Fig. 3.** Total number of male and female *C. elburzensis* captures using different baits.

\*Scorched sunflower seed was significantly more effective than any other bait (One way ANOVA analysis; d.f. = 5,  $p < 0.05$ )

fective at capturing males, whilst seeds were more effective in capturing females (Fig. 3).

### Trap Success

During trials, trapping success averaged  $11.95 \pm 0.5\%$  (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

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

Season	Number of nights operated	Number of trap nights	Number of captured males			Number of captured females			Total captures in each season
			Adult	Sub-adult	Juvenile	Adult	Sub-adult	Juvenile	
Spring	8	221	9	2	4	6	1	1	23
Summer	8	217	3	3	4	9	3	3	25
<b>Total</b>	16	438	12	5	8	15	4	4	48

**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  $\times 100$

Trapping success (%)	Sex class		Age class			Total trapping success in each season
	Male	Female	Adult	Sub-adult	Juvenile	
Spring	6.78	3.61	6.78	1.35	2.26	10.40
Summer	4.60	6.91	5.52	2.76	3.22	11.52
<b>Overall</b>	5.70	5.25	6.16	2.05	2.73	10.95

**Table 3.** Trapping success for single-capture mesh live trap in Khaje Morad region, calculated as the number of captures for each bait type/ number of trap- nights  $\times 100$

Bait type	Trapping success (%)
Scorched sunflower seed	4.79
Scorched gourd seed	2.51
Scorched walnut	1.59
Sausage chunk	1.14
Apple pieces	0.68
Cucumber pieces	0.22
<b>Overall</b>	10.95

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. elburzensis* 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).

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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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