

Female striped mice (*Rhabdomys pumilio*) change their home ranges in response to seasonal variation in food availability

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Animals may respond to seasonally changing environments with physiological and behavioral strategies. Whereas migration is a behavioral strategy used by many taxa, it may not be an option for small mammals. However, small mammals can seasonally vary the area of habitat in which they are active. The striped mouse *Rhabdomys pumilio* in the semiarid Succulent Karoo of South Africa lives in a seasonal environment, characterized by hot, dry summers with low food abundance and cold, wet winters, followed by high food abundance in spring. We radio tracked a total of 28 females during the 2004 dry season, the following breeding season in spring, and the following dry season in 2005 and tested the prediction that females shift their home ranges in relation to food availability. Females shifted their home ranges from an area characterized by evergreen succulent shrubs in the vicinity of a dry riverbed in the dry season to sandy areas that were characterized by new plant growth of annuals in spring. Home ranges during the breeding season in spring had a higher percentage of annuals than dry season home ranges measured in spring. Female home range size increased during the breeding season. We suggest that female striped mice shift their home ranges seasonally to gain access to protein-rich young plant material, which is important for breeding. *Key words*: annuals, habitat variation, migration, Succulent Karoo. [*Behav Ecol* 17:452–458 (2006)]

For animals inhabiting seasonally varying habitats, the availability, distribution, quantity, and quality of food, shelter, mates, and other resources vary according to climatic changes during the year (Forman, 1995). Food is often more abundant in summer than in winter or after the rainy season. Animals may possess physiological and/or behavioral strategies to cope with these seasonal challenges. One behavioral strategy is to migrate to avoid seasonal fluctuations and lack of resources (Alerstam et al., 2003; Forman, 1995).

Migration over large distances may be impractical for small mammals because of high energy costs and high predation pressure risk (Alerstam et al., 2003; Bowers and Dooley, 1993; Hanski et al., 2001; Soulé and Terborgh, 1999), and their low life expectancy would make such a long-term strategy unprofitable (Roff, 1992). Nevertheless, many rodents disperse from their natal home ranges in order to find mates (Gundersen and Andreassen, 1998; Krackow, 2003; Randall et al., 2002), to avoid competition with other group members (Gerlach, 1998), or to escape local climatic conditions such as floods and snowfall (McShea and Madison, 1992).

Dispersal differs from migration in the distance covered and in the functional direction. Migration is bidirectional, with directional movement occurring toward an area of better resource availability and ending at the point of departure (Alerstam et al., 2003). In contrast, dispersal is unidirectional and often leads to high mortality of dispersers (Anderson, 1989; Lidicker and Stenseth, 1992). Moreover, dispersal is a complex behavior (Lidicker, 1985), and the decision and motivation (forced or voluntary) to disperse may differ be-

tween individuals and circumstances (Lin and Batzli, 2004; Solomon, 2003).

Apart from dispersal away from an original (natal or non-natal) home range, one can also expect directed seasonal movements in small mammals. When small mammals live in a seasonal environment with different habitats that offer resources on a seasonal basis, one would predict that they would use the different areas in a seasonal pattern. For example, wood mice (*Apodemus sylvaticus*) display seasonal variation in habitat use in relation to changes in the availability of cover (Todd et al., 2000) and extend their home ranges into cultivated fields when food becomes available there (Wolton, 1985).

The striped mouse *Rhabdomys pumilio* in the Succulent Karoo of South Africa lives in a seasonal environment. The Succulent Karoo is a desert to semidesert environment with an annual rainfall of 160 mm at our field site (Rösch, 2001). Rainfall is seasonal and occurs mainly during winter, resulting in a seasonal pattern of plant growth (Cowling et al., 1999). At our field site, striped mice live along a dry riverbed, and the habitat is variable within a small area. Succulent shrubs are present all year round around a dry riverbed, and in spring, annuals are available less than 100 m away. Striped mice feed on both succulent shrubs and annuals (Schradin, in press). The results of other studies indicate that young plant growth provides striped mice with a high-protein source, which determines the onset of the breeding season (Nel, 2003; Perrin, 1980). The physiological mechanisms linking protein levels and onset of reproduction in *R. pumilio* are unknown, although dietary protein most likely influences endocrine pathways and gonad function (Schneider, 2004; Schoech and Bowman, 2003).

In the Succulent Karoo, *R. pumilio* is group living, with groups consisting of two to four breeding females, one breeding male, and adult philopatric offspring (Schradin and Pillay, 2004). However, single solitary females occur as well (Schradin and Pillay, 2004). While individuals of one group share one

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nest and one territory (Schradin and Pillay, 2005b), they forage and feed alone during the day (Schradin, in press). Territories are occupied by philopatric females while males are the dispersing sex. Replacement of breeding males occurs throughout the year, even outside the breeding season, as soon as breeding males disappear, for example, due to predation (C. Schradin, unpublished data). The mating system can be regarded as polygynous, with little evidence for extragroup copulations (Schradin, in press), although the percentage of extragroup paternity is unknown.

As *R. pumilio* inhabits a seasonally varying environment in the Succulent Karoo, we hypothesized that striped mice would shift their home ranges seasonally. Because the distribution of female mammals is often influenced by the distribution of food resources and the distribution of males is influenced by the distribution of females (Ostfeld, 1990), we restricted our observations to female striped mice. We expected that females would establish home ranges along the dry riverbed during the dry season, where succulent shrubs offer a year-round food source and cover and shift their home ranges away from the dry riverbed to areas where protein-rich annuals become abundant for a short period during the breeding season in spring. We predicted that the boundaries of female home ranges would be further away from the dry riverbed during the breeding season than during the dry season, and a higher proportion of annuals occur in the breeding season than in the dry season home ranges (both measured during the breeding season). Furthermore, as annuals provide less cover than shrubs, we tested whether there were differences in the availability of cover between the breeding and dry season home ranges.

MATERIALS AND METHODS

Study area and period

The study was conducted from May 2004 to February 2005 in Geogap Nature Reserve (Rösch, 2001) located near Springbok in the Northern Cape Province, South Africa. The vegetation type is Succulent Karoo (Cowling et al., 1999). Our 10-ha field site (Figure 1; for more pictures visit <http://www.strippedmouse.com>) was characterized by a dry riverbed, which contains water only about every 20 years. The vegetation around the dry riverbed was characterized by the evergreen succulent shrub *Zygophyllum retrofractum*. Sandy patches are frequent away from the riverbed, in which annuals (wildflowers and succulents) grow in spring. These plants are especially palatable for striped mice and are a major food source for them in spring (Schradin, in press; this study).

Rains usually fall from May to September, and the dry season is from November to April (Cowling et al., 1999). The rainfall pattern during this study was unusual; the rains arrived late, starting in July (Table 1). Thus, the dry season was extended until June. Surprisingly, heavy, unseasonal rain fell during the dry season in January (Table 1). Plant growth started approximately 4 weeks later, so that home range data during the dry season could still be collected in February, but the method of determining the availability of food plants had to be changed (for details see below).

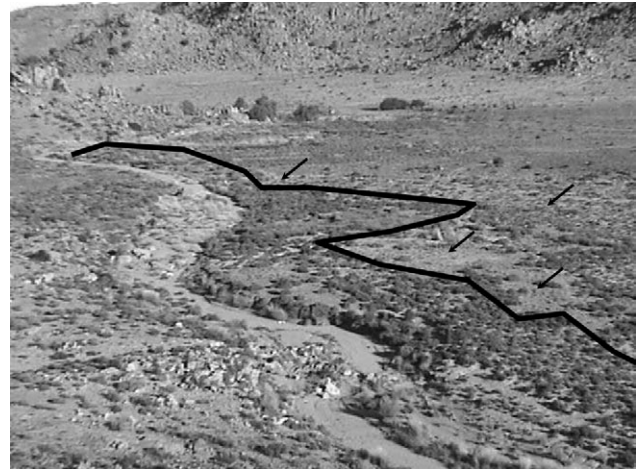


Figure 1

Our field site in the Succulent Karoo, South Africa during the dry season. The dry riverbed is in the middle. The line shows the approximate border of the shrub belt (left). To the right are the sandy areas (arrows) where annuals are abundant in spring. For more pictures of the field site, visit <http://www.strippedmouse.com>.

Trapping and marking of animals

Striped mice were trapped using metal live traps (26 × 9 × 9 cm), baited with a mixture of bran flakes, currants, sea salt, and sunflower oil. Traps were placed in the shade under bushes containing nesting sites. *R. pumilio* is diurnal, with peak activity in the morning and late afternoon (Schradin, in press). Trapping was conducted in the morning (starting at sunrise) and in the afternoon (ending with sundown), but not during the hottest times of the day, and each group was trapped at least once a month. Traps were checked at least every hour. Trapped mice were sexed, weighed, and their reproductive status determined. Females were regarded as being reproductively active when their vaginae were perforate, when they were lactating (red nipples), or when they gave birth (loss of more than 10% of body weight from one day to another). To permanently mark mice, we used ear tags (National Band and Tag Co., Newport, KY, USA). For individual recognition in the field, a number was written on the side of each mouse with black hair dye (Rapido, Pinetown, South Africa; see figure in Schradin and Pillay, 2004, or at <http://www.strippedmouse.com>). Group affiliation of individuals was determined by observing nests during mornings and afternoons, when all individuals present at each nest were recorded (Schradin and Pillay, 2004).

Radio tracking

We radio tracked a total of 11 adult females during the dry season in June 2004, 17 during the breeding season in September 2004, and 10 during the following dry season in February 2005. Seven females radio tracked during the June dry season survived until September and were radio tracked again. Only one of these females survived until February and was radio tracked for a third time; the mortality of breeding

Table 1

Monthly rainfall at the field site in Geogap Nature Reserve from June 2004 to February 2005

Month	June	July	August	September	October	November	December	January	February
Rainfall (mm)	1.2	6.0	3.5	16.0	22.5	0.2	0.0	60.1	2.7

females is usually high at the end of the breeding season (C. Schradin, unpublished data). Two more females were radio tracked in September and again in February. Radio tracking was performed using an AOR 8000 wide-range receiver and a Telonics RA-14K antenna. Individuals were equipped with MD-2C or PD-2C radio transmitters (Holohil, Canada), weighing 2.5 and 4 g respectively, and were less than 10% of body weight. A radio-tagged mouse was approached until it was either seen or the shrub in which it was hiding was located. Its position was recorded using a global positioning systems (GPS) (eTrex Venture, GARMIN International, Olathe, KS, USA) with an accuracy of 5 m. We took six fixes a day for 9 days approximately every 2 h from 0800 to 1700 h during the dry season and 0700 to 1800 h during the breeding season, when days were longer. The 2-h interval between fixes was long enough to enable mice to visit their entire territory (Schradin, 2005b), making fixes independent from each other (Kenward, 1987). The total of 54 fixes lead to a saturation curve of home range sizes (Kenward, 1987), that is, home ranges would not have increased significantly with more fixes (previously validated by us: Schradin and Pillay, 2005b).

Plant surveys

Plant surveys were conducted in the home ranges of 11 females during the June dry season and of 14 females during the September breeding season. For each home range, the edge points of the 100% minimum polygon were determined using the software MapSource. These points were then located in the field using the "Go To" function of the GPS and marked with an iron rod. The boundaries of home ranges were marked with barrier tape. Using a 20-m measuring tape, we placed a 3 × 3-m grid over each home range. At each 3-m point, we recorded whether a plant was present and noted whether it was green or dead. Additionally, we recorded whether the cover would have been sufficient for mice to hide in (scored "1") or not (scored "0"), which we judged from our experiences during several years of radio tracking. Plants were identified to genus level and, where possible, to species level. Plants that could not be identified were recorded as "unknown shrub, dead" (3.8% of all counts), "unknown shrub, green" (0.1% of all counts), and "unknown annual" (0.4% of all counts). If no plant grew directly under the 3-m point, a zero score was recorded.

Each plant species was categorized according to its seasonal appearance, growth form, relative abundance, and palatability to striped mice (Appendix). Plants were designated as annual if they were present at the field site for less than 12 months. Although shrubs of the genus *Lycium* are perennial, they lose their leaves during the dry season and are thus an annual resource for striped mice that feed on the leaves.

Food plants were identified from a total of 180 h of animal focal observations in the field from 2002 to 2003 (Schradin, 2005b; C. Schradin, unpublished data) and 640 h of focal nest observations (see above) of 12 groups in 2004 and 2005 (ad libitum sampling). We did not observe free-living striped mice feeding on *Psilicaulon* spp. and *Ericocephalus* spp., which were common in the home ranges of two females, but these were consumed by captive individuals. We did not know whether striped mice fed on a few species of rare annuals, but these plants represented less than 1% of all plant counts and were unlikely to have influenced our results.

No plant surveys were conducted after the February 2005 dry season. The field site received unexpectedly heavy rainfall at the end of January (Table 1: 60 mm compared to an average of 4.5 mm and a maximum of 49.5 mm because the Springbok weather station became operational in 1960). This resulted in new plant growth in our field site 4 weeks later, after we had

collected home range data in February. Thus, plant surveys in March would not have been representative of the conditions at the time when home range data were collected in February. Instead, we used data collected at our field site in February. The data were collected using standard protocols (Braun-Blanquet method; Werger, 1974) established at our field site since October 2004 and involved sampling ten 2 × 2-m plots in the home ranges of 10 different *R. pumilio* groups. All plant species, their abundance, and their vegetative status in each plot were recorded. Using these data, we compared abundance of food plants between October 2004 (breeding season) and February 2005 (dry season before onset of plant growth due to rain).

Statistics

Home range size and overlap were calculated using the software Ranges6. For better comparison with previous studies on the same population (Schradin and Pillay, 2004, 2005b), the same species (Schradin and Pillay, 2005b), and other species (Asher et al., 2004; Madison et al., 1984; Tew and Macdonald, 1994), home range size was determined using 100% minimum convex polygons (Kenward, 1987; Sterling et al., 2000). It was easy to mark 100% minimum convex polygon home ranges in the field, which was important for the plant surveys and which would have been impossible with kernel contours.

We used a paired data design throughout the analysis. Two data points, which were more dependent on each other than on other data points were regarded as one pair. This was obviously the case when a single female was followed during two seasons, for example, the June dry season and the September breeding season. However, because of relatively high mortality, which is typical for small mammals, often females radio tracked during one season disappeared before the next season and could not be radio tracked again. In this case, a female was replaced by another female of her own group. Females of one group are closely related because they are the philopatric sex (C. Schradin, unpublished data), and those belonging to one group share one nest and one territory (Schradin and Pillay, 2004, 2005b). Therefore, the data of two females of one group (during two different seasons) are more dependent on each other (and were thus paired) than data of other females from different groups. This is especially the case in a heterogeneous environment like our field site, characterized by significant differences in plant community within small areas (this study). Even home ranges of neighboring groups can differ significantly in availability of food and cover (this study). By choosing a paired data design, we controlled for such confounding effects, such as quality of the natal home range, which is not possible with unpaired data.

We excluded data for some females from the analyses because we had no complementary data to meet the requirements for a paired design. Two of 11 females were excluded in June, four of 17 females were excluded in September, and two of 10 females were excluded in February.

All data sets were tested for normality using the Kolmogorov-Smirnov test, and appropriate parametric tests were used. Data are presented as mean ± SD. Analyses were done using the software InStat and Statistica; all tests were two tailed.

For comparisons of presence of cover and availability of food plants and annuals in home ranges between seasons, we used a paired data design for $n = 9$ females. For seven females, we had home range data for both seasons. The remaining two disappeared after the dry season, and to compensate for these disappearances, we radio tracked two other females from the same groups as the two which disappeared. Because percentage data were collected, data sets were arcsine

transformed and analyzed using a repeated measures ANOVA followed by the Bonferroni-corrected paired *t* test to compare the availability of food plants, quantity of annuals, and cover in three conditions: dry season home range, dry season home range in the breeding season, and breeding season home range.

To calculate distances of home ranges from the dry riverbed, we marked the 100% minimum polygon home range in the software MapSource and included the dry riverbed into the file as a track recorded with the GPS. In MapSource, for every point marking the edge of the minimum polygon, we measured the minimum distance to the dry riverbed and took the average of all these measurements. We had paired data for nine groups for the comparison between June and September and for eight groups for the comparison between September and February. In the latter groups, two were newly established during the breeding season by founder females, and no data were available for these groups for the June period. For this reason, we used two paired *t* tests, instead of ANOVA.

RESULTS

Seasonal changes in female home ranges

Females significantly increased their home ranges from 0.35 ± 0.20 ha during the June dry season to 0.54 ± 0.21 ha during the breeding season in September ($t_8 = 3.554, p = .007, n = 9$, paired *t* test; Figure 2) and decreased from 0.46 ± 0.20 ha in September to 0.26 ± 0.07 ha during the February dry season ($t_7 = 2.933, p = .022, n = 8$, paired *t* test; two values are pro-

vided for September because different females were included into the analysis). Home ranges during the breeding season included $66.3 \pm 30.7\%$ of the home range area from the previous dry season, ranging from 17% to 100%.

Home range borders were 50.8 ± 47.2 m away from the dry riverbed during the June dry season, which increased to 68.3 ± 44.5 m during the September breeding season ($t_8 = 2.740, p = .025, n = 9$, paired *t* test; Figure 2). During the following dry season in February, the distance to the riverbed decreased again to 36.3 ± 22.1 m ($t_7 = 2.433, p = .045, n = 8$, paired *t* test).

Differences in food and cover availability between seasons and home ranges

Repeated measured ANOVA (all $n = 9$) revealed significant variation for food availability ($F_{2,8} = 17.348, p < .001$), abundance of annual plants ($F_{2,8} = 23.047, p < .001$), and cover ($F_{2,8} = 4.377, p = .031$) between the dry season home range (measured in the dry season) and the dry and breeding season home ranges, both measured in spring. To detect seasonal differences, we compared the dry season home range during the dry season in June and during the breeding season in September. Food availability and annuals increased significantly from June to September, but there were no differences in the amount of cover (Figure 3). Breeding season home ranges contained significantly more annuals than dry season home ranges sampled in spring, although both home range types contained similar amounts of food (Figure 3). There was no significant difference in the amount of cover (Figure 3). However, the breeding season home ranges had less cover than the dry breeding season home ranges measured during the dry season but contained significantly more food and annuals (Figure 3).

Comparisons between 10 plots for October 2004 and February 2005 revealed that fewer food plant species were available during the February dry season (3.1 ± 1.2) than during the October breeding season ($4.8 \pm 1.2; t_7 = 3.052, p = .019, n = 10$, paired *t* test).

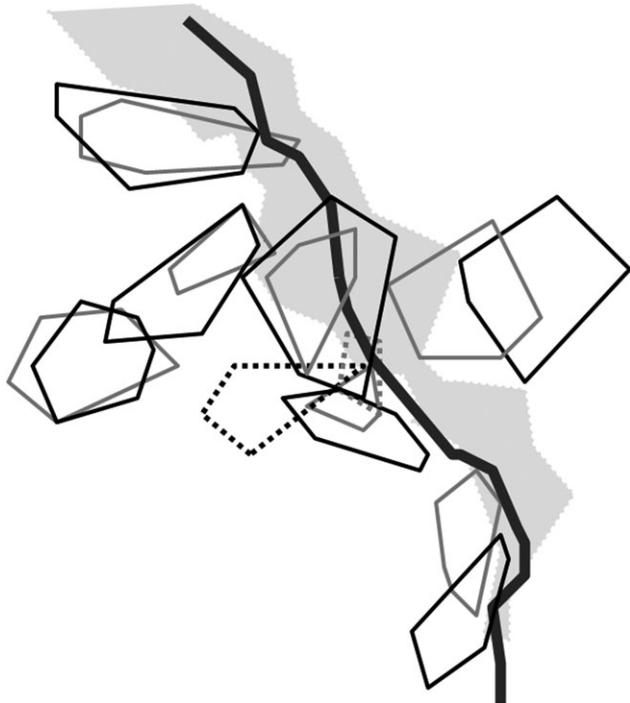


Figure 2
Female home ranges during the dry season in June (gray) and during the breeding season in September (black). The home ranges of one female are represented by dots to distinguish between home ranges. One female is excluded because its home ranges were in the middle of the figure, and its inclusion would have made the figure cluttered. The dry riverbed is indicated as a thick black line, and the shrub belt is shown in gray (measured as a track using the GPS function).

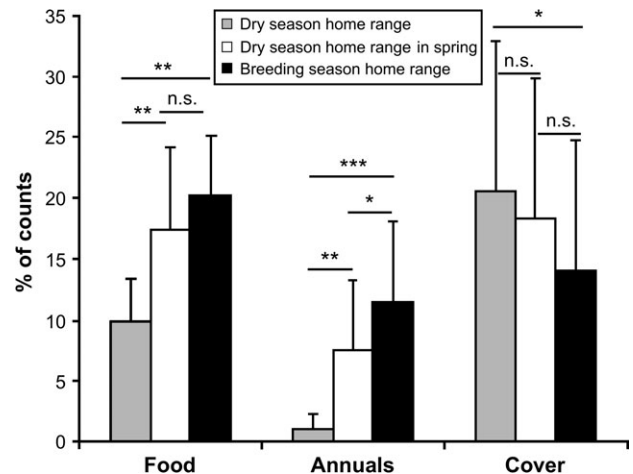


Figure 3
Comparison of the percentage counts (every 3 m) of food plants and annuals (protein-rich food source) and cover in the dry season home ranges during the dry season, the same home ranges during the breeding season, and the breeding season home ranges. $n = 9$ for each season. ns: not significantly different, * $p < .05$, ** $p < .01$, *** $p < .001$; Bonferroni-corrected paired *t* tests.

DISCUSSION

Whereas several studies have investigated dispersal (Gundersen and Andreassen, 1998; Knowles, 1985; McGuire et al., 1993; Ribble, 1992; Stenseth and Lidicker, 1992) and seasonal changes in home range sizes (Corp et al., 1997; Keesing, 1998; Tew and Macdonald, 1994; Webster and Brooks, 1981) in rodents, few studies have investigated seasonal changes of home range use (Todd et al., 2000). Moreover, the function of shifting home ranges is not understood and is either regarded as a random event (Wolton, 1985) or ignored (Salvioni and Lidicker, 1995).

The Succulent Karoo is a seasonal habitat, characterized by a long dry season (November–May), followed by rain (June–October) and accompanying plant growth in spring (August–October; Cowling et al., 1999; Rösch, 2001). Accordingly, we found that annuals were largely absent during the dry season but abundant during the spring after the winter rain. Because protein is the main limiting factor in striped mice reproduction (Nel, 2003; Perrin, 1980), the presence of protein-rich young plant growth, such as annuals, restricts the breeding season to 2–3 months in spring (Schradin, in press; Schradin and Pillay, 2005a).

During the dry season, home ranges were located in the shrub belt around the dry riverbed, and 90% of food plants comprised succulent shrubs, especially *Z. retrofractum*. These shrubs also provide safe refuge against predators and are used for nesting (Schradin, 2005a; Schradin and Pillay, 2004). In spring, females enlarged their home ranges from the shrub belt around the dry riverbed into sandy areas containing annuals.

The availability of annuals in the dry season home range around the dry riverbed increased from 1% during the dry season to 8% during spring. However, in the breeding season, home ranges included sandy patches away from the riverbed, and annuals were even more abundant (12% of counts). Our results suggest that the access to protein-rich food sources (i.e., annuals) was the driving force for home range shifting as the total availability of food plants (including succulent shrubs) was not better in the breeding season home ranges than in the former dry season home ranges.

While females responded to seasonal changes in food distribution, they did not simply migrate into areas with a higher percentage of protein-rich food. Instead, most females enlarged their home ranges, retaining all or large parts of their dry season home ranges. It might seem surprising that home ranges increased rather than decreased during the season of high food abundance. Experimental provisioning of extra food leads to a reduction in female home range sizes in several muroid rodents (Ims, 1987; Taitt, 1981). However, females in natural muroid populations often increase their home ranges during the breeding season, when food supply is maximal (Salvioni and Lidicker, 1995; Tew and Macdonald, 1994). This demonstrates that food supply per se does not determine home range sizes. There are two possible reasons for female striped mice increasing home range sizes. (1) The shrub belt around the dry riverbed provides the most suitable nesting sites. Thus, to gain access to these nesting sites, breeding season home ranges must include the shrub belt. (2) After

the breeding season, plant quality decreases rapidly from November onward because summer conditions are hot and dry. Thus, it may be necessary for striped mice to maintain access to the dry season home range, which offers a year-round stable food source (succulent shrubs). This is especially the case as population size increases sharply during the breeding season (Schradin and Pillay, 2005a), such that territories abandoned during the breeding season could be taken over by other *R. pumilio* groups, which are highly territorial (Schradin, 2004; Schradin and Pillay, 2004). Retaining the dry season territory during the breeding season would not only benefit the female herself but also her philopatric adult offspring (Schradin and Pillay, 2004).

By shifting their home ranges during the breeding season, females experienced a decrease in cover compared to the previous dry season home range. However, there was no statistical difference between cover in the breeding and dry season home ranges, when measured simultaneously in spring, although the mean value was lower for the breeding season home range (Figure 3). Therefore, we are uncertain about whether shifting of home ranges induced a cost due to reduced cover, but because foraging in annuals is likely to be more risky than in shrubs, we consider this a potential cost. Annuals are mainly low growing, single plants in our study site, which, in contrast to the shrubs closer to the dry riverbed, do not provide cover. The availability of cover is a critical resource for small mammals (e.g., Asher et al., 2004; for our study area, Keller, 2005), rodents typically prefer areas providing cover (Jensen et al., 2003), and the abundance of striped mice correlates with cover (Bond et al., 1980; Krug, 2002). Reduced cover in the breeding season home range would represent a cost due to increased predation risk (Peles and Barrett, 1996; Perrin and Johnson, 1999; Taitt and Krebs, 1983; Todd et al., 2000). However, it is difficult to estimate predation pressure for small mammals as the disappearance of marked striped mice in our study area may occur for many reasons apart from predation, such as dispersal, mortality due to old age, or thermal stress. However, mortality of mice due to predation by raptors (as indicated by transmitters recovered from buzzard pellets) is highest during the breeding season (C. Schradin and N. Pillay, unpublished data).

Animals cope with seasonal environments by using physiological and behavioral strategies. While migration into areas with favorable conditions is an option for animals that fly (Gwinner, 1977; Urquhart, 1960) or large animals that can move large distances (e.g., ungulates, elephants, and whales; Alerstam et al., 2003; Dingle, 1980), small mammals either endure the environmental conditions in the habitat they live in or bear the high costs of dispersal, often into unknown areas. Here, we showed that a small mammal seasonally varies the use of its habitat, even if at a small spatial scale. While *R. pumilio* has a reduced capacity to respond physiologically to changing environmental conditions (Christian, 1979), its behavioral flexibility must be regarded as the main reason why it can occur in very different habitats throughout southern Africa, such as deserts and moist grasslands (Schradin, in press; Schradin and Pillay, 2005b), and why it can exist in harsh habitats, such as the Succulent Karoo.

APPENDIX

Counts of plants for the nine home ranges of females that were surveyed both during the June dry season and the September breeding season

Species	Family	Palatability	Seasonal growth	Growth form	Dry season home range in June	Dry season home range in September	Breeding season home range	Total	%
Unknown	Poaceae	—	p	Grass	0	10	2	12	0.13
<i>Schismus inermis</i>	Poaceae	1	a	Grass	1	39	84	124	1.31
<i>Stipagrostis namaquensis</i>	Poaceae	0 ¹	p	Grass	91	94	81	266	2.82
<i>Juncus acutus</i>	Juncaceae	0 ¹	p	Grass	67	80	81	228	2.41
Reeds, unknown species		0	p	Grass	27	33	2	62	0.66
<i>Galenia africana</i>	Aizoaceae	0	p	Shrub	5	2	2	9	0.10
<i>Galenia sarcophylla</i>	Aizoaceae	1	a	Shrub	4	23	32	59	0.62
<i>Hypertelis salsoloides</i>	Aizoaceae	—	a	Dwarf succulent	0	0	6	6	0.06
<i>Drosanthemum</i> spp.	Mesembryanthemaceae	1	p	Dwarf succulent	22	10	35	67	0.71
<i>Mesembryanthemum guericchianum</i>	Mesembryanthemaceae	1	a	Succulent shrub	20	12	26	58	0.61
<i>Psilocaulon</i> spp.	Mesembryanthemaceae	1	p	Succulent shrub	72	33	35	140	1.48
<i>Heliophila variabilis</i>	Brassicaceae	1	a	Wildflower	0	10	19	29	0.31
<i>Lebeckia sericea</i>	Fabaceae	1	a	Shrub	32	5	13	50	0.53
<i>Lessertia diffusa</i>	Fabaceae	1	a	Herb	0	2	2	4	0.04
<i>Sutherlandia microphylla</i>	Fabaceae	—	a	Shrub	0	0	1	1	0.01
<i>Wiborgia monopectera</i>	Fabaceae	—	a	Shrub	0	2	5	7	0.07
<i>Pelargonium sericifolium</i>	Geraniaceae	—	a	Shrub	0	1	0	1	0.01
<i>Zygophyllum retrofractum</i>	Zygophyllaceae	1	p	Succulent shrub	321	379	469	1169	12.38
<i>Aptosimum spinescens</i>	Scrophulariaceae	1	p	Succulent shrub	3	6	9	18	0.19
<i>Atriplex lindleyi</i>	Polygonaceae	1	a	Herb	34	40	43	117	1.24
<i>Hermannia disermifolia</i>	Sterculiaceae	1	a	Shrub	0	1	0	1	0.01
<i>Lycium cinereum</i>	Solanaceae	1	a	Shrub	54	58	67	179	1.89
<i>Salsola zeyheri</i>	Chenopodiaceae	—	a	Herb	0	0	3	3	0.03
<i>Lycium afrum</i>	Solanaceae	1	a	Shrub	0	3	1	4	0.04
<i>Gnidia deserticola</i>	Thymelaceae	—	a	Shrub	1	2	2	5	0.05
<i>Asparagus retrofractus</i>	Asparagaceae	1	p	Shrub	0	1	0	1	0.01
<i>Amsinckia calycina</i>	Boraginaceae	—	a	Herb	0	0	1	1	0.01
<i>Arctotis fastuosa</i>	Asteraceae	1	a	Wildflower	0	0	1	1	0.01
<i>Cotula leptalea</i>	Asteraceae	1	a	Wildflower	0	19	44	63	0.67
<i>Dimorphotheca polyptera</i>	Asteraceae	—	a	Wildflower	0	2	3	5	0.05
<i>Felicia australis</i>	Asteraceae	1	a	Wildflower	0	2	0	2	0.02
<i>Eriocephalus erigoides</i>	Asteraceae	1	p	Shrub	14	16	23	53	0.56
<i>Gazania lichtensteinii</i>	Asteraceae	1	a	Wildflower	0	0	1	1	0.01
<i>Helichrysum hebelepis</i>	Asteraceae	0	a	Herb	0	1	2	3	0.03
<i>Leysera tenella</i>	Asteraceae	1	a	Shrub	0	7	8	15	0.16
<i>Oncosiphon grandiflorum</i>	Asteraceae	—	a	Wildflower	0	1	3	4	0.04
<i>Osteospermum pinnatum</i>	Asteraceae	1	a	Wildflower	0	3	6	9	0.10
<i>Othonna oleracea</i>	Asteraceae	1	a	Succulent shrub	0	1	0	1	0.01
<i>Pentzia incana</i>	Asteraceae	1	a	Wildflower	0	2	0	2	0.02
<i>Pentzia grandiflora</i>	Asteraceae	1	a	Wildflower	0	0	2	2	0.02
<i>Pentzia pilulifera</i>	Asteraceae	1	a	Wildflower	4	23	33	60	0.64
<i>Senecio cardaminifolius</i>	Asteraceae	1	a	Wildflower	0	1	0	1	0.01
<i>Senecio cinerascens</i>	Asteraceae	1	a	Wildflower	0	1	6	7	0.07
<i>Deverra aphylla</i>	Apiaceae	0 ¹	p	Shrub	28	19	27	74	0.78
Unknown shrub, dry		0			18	150	188	356	3.77
Unknown shrub, green		—			4	1	1	6	0.06
Unknown ephemeral		—			0	8	26	34	0.36
Zeros					2007	1759	2359	6125	64.84
Total					2829	2862	3754	9445	100.00

1, food plant; 0, not a food plant; 0¹, not a food plant during the study period but consumed in summer; —, status unknown; a, annual; p, perianth.

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