Bushclumps as refugia for small mammals in two Eastern Cape conservation areas

G.M. Whittington-Jones[1], R.T.F. Bernard[1] & D.M. Parker[1*]

Wildlife and Reserve Management Research Group, Department of Zoology and Entomology, Rhodes University, P.O. Box 94, Grahamstown, 6140 South Africa

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Bushclumps are scattered islands of thicket-like vegetation within a matrix of more open vegetation. We investigated the role of bushclumps as refugia for small mammals, and examined the effect of a limited number of abiotic and biotic factors on their richness, diversity and abundance. Small mammals were surveyed using Sherman small mammal traps at two sites in the Eastern Cape Province, South Africa (Mountain Zebra National Park and Kwandwe Private Game Reserve). Soil hardness and seed abundance, inside and outside bushclumps, were determined. Trap success was significantly higher inside bushclumps than in areas outside, and species diversity and the abundance of small mammals were greater within bushclumps compared to outside. Bushclumps also had significantly softer soil and a higher concentration of seeds. We conclude that bushclumps provide a concentrated source of food and protection from predators for small mammals, and are thus used significantly more than adjacent open areas. The conservation of bushclumps is therefore important for the overall maintenance of ecosystem functioning.

Key words: conservation, microhabitats, rodents.

Bushclumps are characteristically rounded clusters of dense, woody vegetation surrounded by a matrix of grass, forbs, small shrubs and bare soil (Fabricius *et al.* 1996) and are typical of several different vegetation types in the Eastern Cape Province of South Africa (Low & Rebelo 1996). It has been suggested that bushclumps originate (amongst other possible mechanisms) on termite mounds, which provide a concentrated source of moisture, minerals and nutrients in comparison with the surrounding environment (Fleming & Loveridge 2003). Thicket species benefit from the conditions provided by termitaria and their colonization of these mounds is thought to promote the foundation of thicket vegetation in predominantly grassland and shrubland habitat (Tinley 1977). Although the exact process driving the formation of bushclumps is open to conjecture, it is reasonable to assume that the presence of islands of structurally complex vegetation, and associated resources, will affect the abundance and local distributions of small mammals, and thus influence community structure (Rosenzweig & Winakur 1969; Abramsky 1978; Bond *et al.* 1980; Kotler 1984; Abramsky *et al.* 1985; Perrin & Johnson 1999; Avenant 2000). Certainly, the concept that habitat patches may function as islands to particular groups of organisms (Brown 1978), especially larger islands, which exhibit higher diversity and species richness than smaller islands, is consistent with the theory of island biogeography (see Quinn & Harrison 1988 for review).

Microhabitats may offer concentrated foraging resources for small mammals while at the same time reducing the risk of predation (Price 1978; Longland & Price 1991). It has been demonstrated that owls have a lower capture success of rodent prey when hunting in bush habitat compared to open areas and are more cautious when hunting in complex habitats (Kotler 1984; Longland & Price 1991).

Small mammals connect multiple levels in complex food webs in their capacity as prey, primary consumers and predators (Mendelsohn 1982; Avenant 2000; Ginsburg 2002). Some are also efficient seed dispersers and pollinators and may be used as indicators of environmental disturbance (Avenant 2000). The aim of this study was to investigate the role of bushclumps as refugia for small mammals, and to determine the relationship between a limited number of abiotic and biotic factors and small mammal diversity, richness and abundance.

Research was conducted at two sites in the Eastern Cape Province, South Africa, with bushclumps present; the Mountain Zebra National Park (MZNP; 32°11′S, 25°37′E) and Kwandwe Private Game Reserve (Kwandwe; 33°09′S, 26°37′E). MZNP occupies approximately 21 000 ha and is located 24 km west of Cradock. The vegetation is classified as eastern mixed Nama Karoo and central

*Author for correspondence. E-mail: d.parker@ru.ac.za

Table 1. The numbers of unique individuals (i.e. excluding recaptures) and species of small mammals trapped, the number of trap nights, trap success, total number of small mammal recaptures, Shannon-Wiener Diversity indices, evenness scores, seed abundance and soil hardness for areas inside (bushclumps) and outside (open areas) bushclumps at two sites in the Eastern Cape Province. Data are means ± 1S.D. For each species, numbers in brackets are total numbers of unique individuals.

	Bushclumps	Open areas
Species		
Mastomys natalensis sensu lato	3.4 ± 2.9 (26)	1.2 ± 1.1 (9)
Michaelamys namaquensis	2.7 ± 2.3 (19)	0.4 ± 0.6 (3)
Rhabdomys pumilio	3.3 ± 3.8 (23)	0.6 ± 0.8 (4)
Mus minutoides	0.7 ± 0.8 (5)	0.5 ± 0.8 (3)
Saccostomus campestris	0.4 ± 0.6 (2)	(0)
Total	10.5 ± 2.6 (75)	2.7 ± 2.4 (19)
Trap nights	340.5	459
Trap success	0.25 ± 0.15	0.07 ± 0.09
Total number of recaptures	57	12
Shannon-Wiener Diversity Index	1.26	1.06
Evenness	0.54	0.46
Seed abundance (mg/kg)	2225 ± 610	321 ± 106
Soil hardness (kg/cm^2)	1.96 ± 1.02	6.93 ± 8.64

lower Nama Karoo, both part of the Nama Karoo Biome (Low & Rebelo 1996). Kwandwe is a 20 000 ha reserve in the Great Fish River Valley and forms part of the Thicket Biome, with valley thicket and xeric succulent thicket being the dominant vegetation types (Low & Rebelo 1996). Although both are classed as semi-arid, the climate at MZNP is more extreme (Jackson & Bernard 2005), with greater seasonal and less inter-annual variation.

Small mammals were trapped over four consecutive nights at three separate trapping locations at MZNP and at four trapping locations at Kwandwe during April and July 2003 and in March 2004. Trapping locations were positioned on north and northwest facing slopes within bushclump savanna at both reserves and were at least 1 km apart. For each trapping session, 10 bushclumps at each trapping location were randomly sampled with two Sherman small mammal traps. In addition, two lines of between 30 and 40 traps were placed in the open areas between bushclumps as quasi-controls at each trapping location. Traps were 10 m apart in the trap lines and the distance between trap lines and bushclumps varied between 10 and 50 m. The same trapping locations but different bushclumps were used in the different trapping sessions. The traps were baited with a mixture of rolled oats and peanut butter (Perrin & Johnson 1999) and set on the afternoon of day one. Traps were checked early each morning, and shut until the afternoon (Perrin & Johnson 1999). Trapping was terminated on the morning of day five. Captured rodents were identified to species (Skinner & Chimimba 2005), weighed, sexed and given a unique mark by clipping a small amount of body hair. In order to assess trap success, the data were adjusted to a standard 100 trap nights (Rowe-Rowe & Meester 1982). Traps that were disturbed, or otherwise accidentally triggered were excluded from the calculation of trap success (Varty 1990). Species diversity was calculated using the Shannon-Wiener species diversity index.

Three soil hardness measurements (kg/cm^2) were taken randomly inside each bushclump and adjacent areas (>10 m away from the bushclump) using an S-170B pocket penetrometer (Brainard-Kilman, Stone Mountain, GA, USA). Seed abundance was assessed by collecting three soil samples from each bushclump and an equal number from the open areas. A hand trowel and cylindrical container (500 cm^3) were used to collect samples from the top 2 cm of the soil (Nelson & Chew 1977; Price & Joyner 1997). Each soil sample was weighed and then passed through three sieves (5 mm, 1.25 mm and 0.5 mm mesh size) to separate the seeds from the soil. Seeds were counted and weighed but not identified to species. Seed concentration was expressed as milligrams of seed per kilogram of soil.

Despite having more trap nights in the open areas, trap success was significantly greater inside bushclumps than in the open areas (Table 1; *t*-test, $t_{(12)} = 2.60$, $P < 0.05$). Position (inside or outside bushclumps) also had a significant effect (*t*-test, $t_{(12)} = 3.77$, $P < 0.01$) on the number of individual rodents (abundance) that were captured (Table 1). Significantly more animals were captured in the bushclumps than in the open areas (Table 1). In addition, significantly more recaptures were recorded inside bushclumps than outside (Table 1; *t*-test, $t_{(12)} = 3.50$, $P < 0.01$). Only two rodents that were captured in bushclumps were subsequently recaptured inside different bushclumps and no rodents that had been marked in bushclumps were recaptured in the open areas and *vice versa*. *Mastomys natalensis sensu lato* Smith (Rodentia: Muridae) and *Rhabdomys pumilio* Spearman (Rodentia: Muridae) were the two dominant species in the bushclumps, while *M. natalensis* dominated the open areas (Table 1). Shannon-Wiener indices were generally lower in the open area compared to the bushclumps ($Z = 0.29$, $P > 0.05$), but species richness and evenness was similar in both habitats (Table 1). Only one species (*Saccostomus campestris*) Peters (Rodentia: Cricetomyinae) was unique to the bushclumps, where it was rare (Table 1). Seed abundance in the soil samples was almost seven times higher within bushclumps than outside (Table 1; *t*-test, $t_{(198)} = 30.79$, $P < 0.001$) and the soil outside the bushclumps was significantly harder than the soil inside the bushclumps (Table 1; *t*-test, $t_{(198)} = -16.07$, $P < 0.001$).

The relative proximity of the trap lines (open areas) to the bushclumps, and the mobility of rodents (Keesing 1998; Shraden 2006), suggests that sampling would have been of a single rodent community at each trapping location. However, the cover provided by the bushclumps afforded benefits to the rodents, resulting in a concentration of their activity and this is reflected in the significantly greater number of recaptures and trap success in the bushclumps. The relatively low trapping success in the open areas and reduced species diversity, along with the lack of recaptures, suggests that little movement takes place between bushclumps and that they may act as habitat islands within a homogenous landscape. Although none of the rodent species sampled in this study were strictly granivorous, bushclumps provided a greater concentration of food for other granivores than the surrounding open areas where foraging is likely to increase susceptibility to predation (Price 1978; Kotler 1984; Longland & Price 1991; Perrin & Johnson 1999; Avenant 2000). Furthermore, bushclumps may also provide a favourable substrate for burrowing vertebrates to exploit, as the soil beneath the canopy is significantly softer compared to the open areas. Importantly, all small mammals captured in this study are known to excavate their own burrows (Skinner & Chimimba 2005).

We recognize that our current results may be influenced (limited) by the differential response of small mammals to traps (i.e. 'trap-happy' or 'trap-shy' species) and by effectively only sampling during one season. In addition, no attempt was made to survey the more specialized (e.g. arboreal) small mammal fauna in our study. Thus, future studies should incorporate more intensive and extended seasonal sampling and examine the potential for bushclumps to act as thermal refugia. Notwithstanding this, we believe that bushclumps possess the necessary characteristics to make them suitable refugia for small mammals, particularly in areas where alternate vegetative cover is limited. We contend that the loss of bushclumps either through natural processes (e.g. mega-herbivore browsing) or anthropogenic intervention (e.g. bush clearing) can be expected to negatively influence small mammal communities and therefore disrupt food webs.

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