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Spatial behaviour of Townsend's chipmunks and habitat structure

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Habitat structure affected location of activity and choice of travel routes of captive Townsend's chipmunks (*Tamias townsendii* Bachman, 1839). When traveling between nesting and feeding sites, chipmunks used indirect routes with cover (boards elevated above the ground) more often than direct routes with only a grass substrate or indirect routes with boards lying flush with the ground. They did not exhibit a preference between overhanging or vertical cover. Use of travel routes with cover increased with increasing continuity of cover. Although proportion of time chipmunks were active remained constant, proportion of time spent away from nest boxes and proportion of time spent at feeding dishes increased with increasing continuity of cover. Cover has quantifiable characteristics that determine its quality and affect spatial behaviour of chipmunks.

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Introduction

When small mammals leave their nest sites to forage or engage in other activities, they are exposed to predators. While away from their nest site, animals should behave so as to reduce risk of predation (Holmes 1984, Anderson 1986, Lima and Valone 1986, Brown 1988). Prey can avoid predators by moving about under and near cover (Clark and Kaufman 1991, Merkens and Harestad 1991). Cover is the structural components of habitat that can isolate prey from their predators (Elton 1939). Habitat structure, measured qualitatively as vegetation characteristics, woody debris, rocks, or other substrate features, is an important factor in movements and habitat selection of chipmunks (*Tamias* spp.) (Meredith 1972, 1976; Parmenter and MacMahon 1983). Habitat structure has been implicated in outcomes of agonistic interactions and competitive exclusion between chipmunk species (Brown 1971, Meredith 1977). Habitat structure is related to type, abundance, and dispersion of cover and is used to describe cover in general terms. In many studies, cover is described by general type (States 1976) or as either of two states: dense or sparse (covered or open) (Rosenzweig and Winakur 1969, Taitt *et al.* 1981, Kotler 1984, Kaufman *et al.* 1985, Brown *et al.* 1988, Travers *et al.* 1988).

Cover has attributes that may determine its use and value to animals. One attribute of cover is its shape or structure that determines places in which animals can hide or scan for predators (Heller 1971, Meredith 1976). Another attribute of cover that may determine its utility is continuity, which is a function of size and dispersion of cover patches.

My objectives were to determine the effect of cover on movement patterns and examine the importance of habitat structure to activity and use of space by Townsend's chipmunks (*Tamias townsendii* Bachman, 1839). I hypothesized: that chipmunks would use travel routes with cover more than travel routes without cover; that chipmunks would prefer overhanging cover rather than vertical cover; and that use of travel routes would increase with increasing continuity of cover.

Methods

Four wild adult Townsend's chipmunks were caught and held separately in 40 by 60 by 40 cm wire cages. A container filled with cotton and grass provided a nest in each cage. Laboratory rat chow and water were provided *ad libitum*. The chipmunks' diet was supplemented with fruit, vegetables, and seeds.

Experiments were conducted in a 10 by 18 m outdoor arena enclosed by a sheet metal fence 90 cm high (Fig. 1). The ground in the arena was covered by short grass, which was mowed twice a week. A nest box was placed at one end of the arena and a food dish placed 9.5 m away at the other end. Habitat structure was manipulated by placing boards in an arc to the sides of a direct route between the nest box and food dish. The lengths of these indirect routes with boards were 33 percent longer than the direct route without boards. Two boards, 50 by 20 by 2 cm, were joined along the long side to form a section of cover (Fig. 1). A supporting leg, 18 cm long by 2 cm diameter, was attached to each cover section to prevent it from tipping over. Overhanging cover was formed when a section was placed with one board on its edge and the other board elevated above the ground. Vertical cover was formed when a section was placed with one board upright on its edge and the other board flat on the ground.

For each experimental trial, a chipmunk was placed in the arena and left for 24 h before data were collected. During the experiments, location (to the nearest metre) of the chipmunk was recorded every 5 s for three hours in the morning and three hours in the late afternoon.

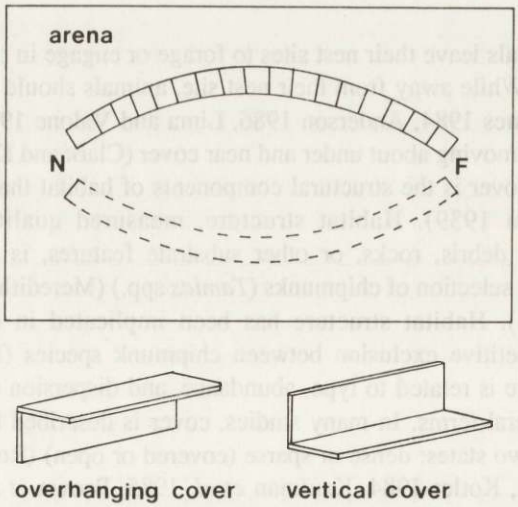

Fig. 1. In an outdoor arena, cover was placed in arcs between a nest box (N) and food dish (F). Overhanging cover was provided by elevated boards and vertical cover was provided by boards place upright on their sides. Positions of the different types of cover were alternated between trials to ensure there was no bias due to location in the arena.

Experiment 1. Choice of Travel Route: To determine the effect of cover on choice of travel route, I provided the chipmunks with three possible routes. A continuous strip of boards, flush with the ground, was placed on one side of the arena and a strip of overhanging cover on the other side. With this configuration, the chipmunks had a choice of traveling over the grass in a direct route, taking a long route via the boards flush with the ground, or a long route via the overhanging cover (Fig. 1). Between trials, positions of the flush boards and overhanging cover were switched to ensure there was no bias due to location in the arena. Trials were also conducted when there were no boards in the arena.

Experiment 2. Vertical and Overhanging Cover: To determine if chipmunks preferred different types of cover, I provided vertical cover on one side of the arena and overhanging cover on the other side of the arena. Along the route with vertical cover, edges of the upright boards were 2 cm wide, providing a narrow elevated surface along which chipmunks could travel.

Experiment 3. Continuity of Cover: To test for the effect of continuity of cover, I presented chipmunks with a choice of routes (with cover or without cover). On the route with cover, manipulations of gaps formed

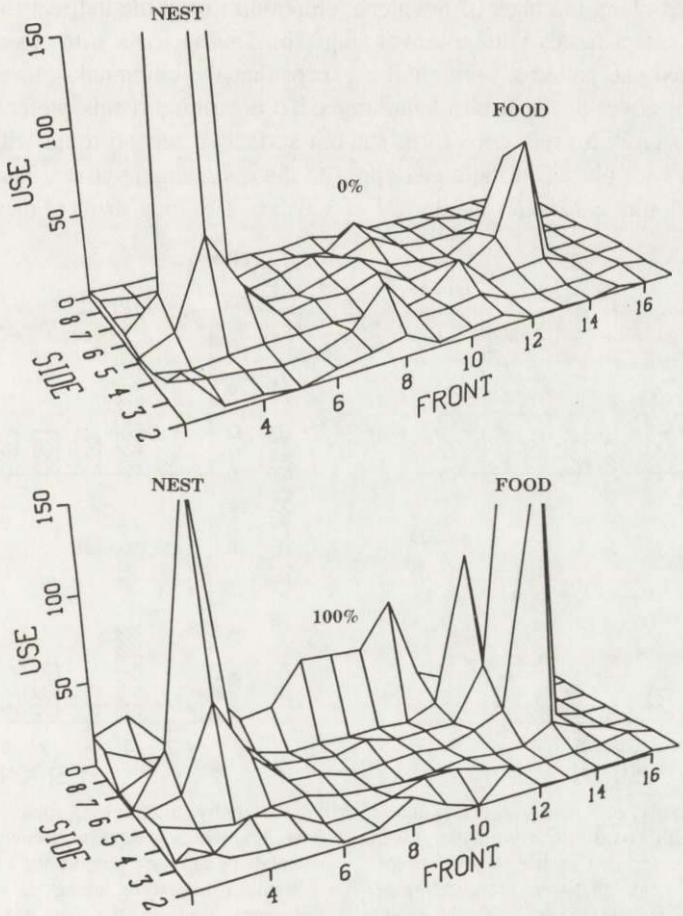

Fig. 2. Numbers of observations per 6 hours of chipmunks in different quadrats of the arena: 0 percent cover – short grass was between the nest box and feeding site; 100 percent cover – a strip of overhanging cover sections was present along the back of the arena (at position 8 on the side axis and between positions 5 an 13 along the length of the arena).

treatments with 0, 25, 50, 75 or 100 percent cover. Overhanging cover sections were placed to one side of a direct route between the nest box and food dish. A continuous strip of sections was used to create 100 percent cover. I removed one out of four sections to create 75 percent cover, two of four sections to create 50 percent cover, three of four sections to create 25 percent cover, or all of the sections to create 0 percent cover. The sections that remained were repositioned so the spaces between them were equidistant along the strip. Trials were conducted for each of 0, 25, 50, 75, and 100 percent cover. Repetitions of trials for each of these levels of continuity were separated by trials with other cover configurations.

Results

Chipmunk activity centered around the nest box and feeding site when there were no cover sections in the arena (Fig. 2a). When a continuous strip of cover (100 percent overhanging cover) was placed along the back of the arena, chipmunks used the indirect route with cover more often than direct routes without cover (Fig. 2b). During trials with cover placed at the front of the arena, use patterns were similar except that the chipmunks' travel routes were along the strip of cover at the front of the arena. To determine if this preference for routes with cover was merely a preference for a smooth surface, a second route with boards flush with the ground were placed in the arena opposite the overhanging cover. The proportion of observations of chipmunks occurring along 1 m wide and 6 m long strips of the arena between

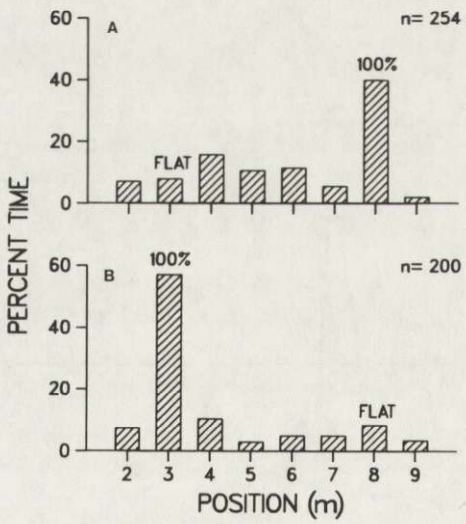

Fig. 3. Use by chipmunks of routes with overhanging cover and routes with boards flush with the grass. Percent time is calculated as the proportions of observations of chipmunks that were along different sections of the arena between the nest box and feeding site. A – A continuous strip of overhanging cover was along side position 8 and a flat strip of boards flush with the grass was along side position 3. B – Overhanging cover along side position 3 and flat boards along side position 8.

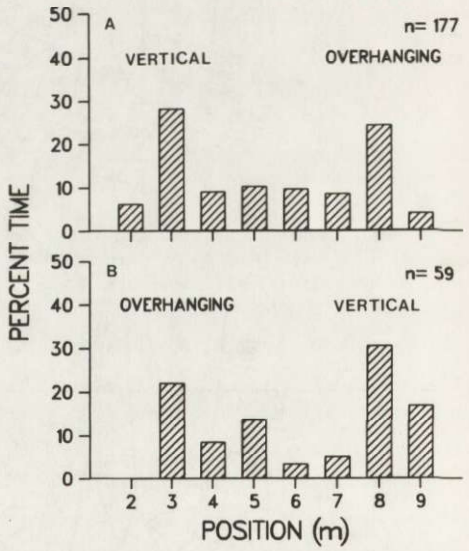

Fig. 4. Use by chipmunks of routes with overhanging cover and routes with vertical cover. Percent time is calculated as the proportions of observations of chipmunks that were along different sections of the arena between the nest box and feeding site. A – A continuous strip of overhanging cover was along side position 8 and a continuous strip of vertical cover was along side position 3. B – Overhanging cover along side position 3 and vertical cover along side position 8.

the nest box and feeding site were calculated and indicate the relative use of strips with different cover conditions. Chipmunks used strips with cover more often than they used strips without cover (Fig 3a, $\chi^2 = 196.9$, $p < 0.01$; Fig. 3b, $\chi^2 = 369.4$, $p < 0.01$). Chipmunks used strips with overhanging cover more frequently than strips without cover irrespective of the orientation of the cover within the arena (cover near front, side position 3; cover near back, side position 8).

When given the choice of vertical and overhanging cover, there was no difference between the frequency of use of the two cover types (Fig 4a, $\chi^2 = 0.6$, $p = 0.44$; Fig 4b, $\chi^2 = 0.6$, $p = 0.44$). Although chipmunks did not exhibit a preference for cover type, they did use strips of the arena with cover more frequently than strips without cover (Fig. 4a, $\chi^2 = 76.7$, $p < 0.01$; Fig. 4b, $\chi^2 = 23.4$, $p < 0.01$).

Relative use by chipmunks, along strips of the arena with overhanging cover, was calculated as a proportion of the total number of observations of chipmunks between the nest box and feeding site. Relative use of travel routes with cover increased with increasing continuity of cover (Fig. 5, Spearman's rank correlation coefficient, $r_s = 0.90$, $p = 0.02$). The proportion of time chipmunks were active (outside of their nest box) did not change with increasing

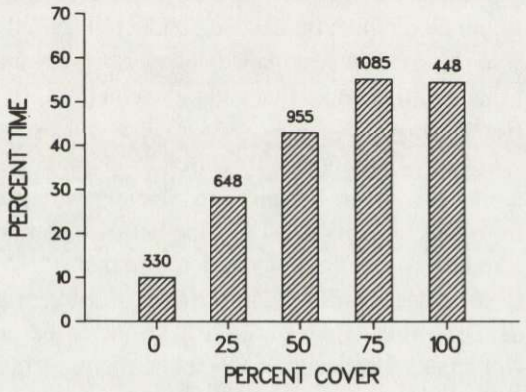

Fig. 5. Continuity of cover and use of travel routes by chipmunks. Sections of a continuous strip of overhanging cover were removed to form 0, 25, 50 and 75 percent cover. Percent time was calculated as the proportion of chipmunk observations between the nest box and feeding site that occurred along the overhanging cover.

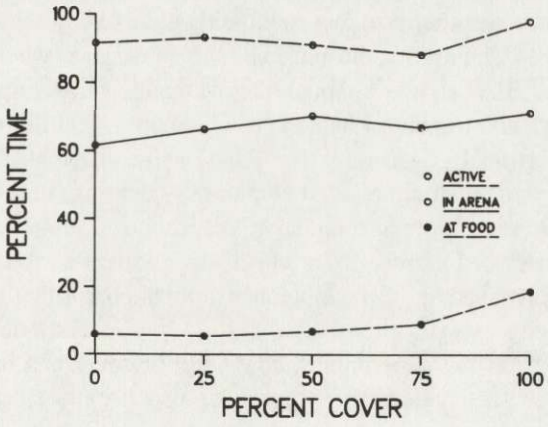

Fig. 6. Continuity of cover and activity of chipmunks in different regions of the arena. Sections of a continuous strip of overhanging cover were removed to form 0, 25, 50 and 75 percent cover. Percent time active is the proportion of time chipmunks were outside of their nest box. Percent time in arena is the proportion of active time chipmunks were not on or near the nest box and not at the feeding site. Percent time at food is the proportion of active time chipmunks were at the feeding dish.

continuity of cover (Fig. 6, $r_s = 0.10$, $p = 0.44$). Proportion of active time spent in the arena (away from the nest box and feeding site) (Fig. 6, $r_s = 0.90$, $p = 0.02$) and proportion of active time spent at the feeding dish (Fig. 6, $r_s = 0.90$, $p = 0.02$) increased with increasing continuity of cover.

Discussion

Foraging theories incorporate both energy (or nutrient) availability and risk of predation to examine tradeoffs between these two factors (Milinski and Heller 1978, Lima and Valone 1986, Brown 1988). Animals can use cover to avoid predators and reduce their risk of predation (Travers *et al.* 1988, Clark and Kaufman 1991). Cover is an important factor in habitat use by chipmunks (Meredith 1976, Parmenter and MacMahon 1983) and other small mammals (Anderson 1986, Harmon *et al.* 1986). In these studies, cover was described as either dense or sparse (covered or open). However, cover has attributes that determine its quality and these attributes affect affinities to cover. Cover, in the form of trees, shrubs, logs, and rocks, is a habitat component which can influence habitat use and other behaviour of chipmunks. Movements of chipmunks tend to be associated with cover, and, thus, cover can influence where chipmunks forage and conduct other activities (Sheppard 1971, Getty 1981, Henderson *et al.* 1985). The importance of cover to birds and mammals has been examined largely through behavioural changes that coincide with distance from cover (Caraco *et al.* 1980, Holmes 1984, Huntly *et al.* 1986).

In my experiments, Townsend's chipmunks preferred to travel along routes that were on or close to cover. Because use of routes with boards lying flat on the ground was not different from that of grass substrate, the use of routes with cover was not the result of preference for a solid flat surface along which to move.

Because routes with cover were 33 percent longer than the direct route over the grass, use of the indirect routes would have increased energy expended for traveling, indicating that chipmunks were willing to expend more energy to use a travel route with cover than a route without cover. I expect that the preference for the longer route with cover would occur up to some length beyond which the travel costs would be too great, and the chipmunks would then use the shorter direct route without cover.

Chipmunks did not exhibit a preference when given a choice between overhanging and vertical cover. Although the overhanging cover appeared more similar in structure to logs and debris in natural habitats of chipmunks than did the vertical cover, perhaps the two types of artifical cover were not functionally different. Overhanging cover provided overhead and vertical structures that chipmunks could use to hide, and a wide elevated surface from which to view their surroundings. Vertical cover provided vertical structures for hiding and a narrow elevated surface from which to view their surroundings. A better experimental design would have been to give chipmunks vertical boards that were too narrow for them to use the elevated edge.

In my experiments, continuity of cover is a linear measure, but in natural habitats it is a characteristic that expresses the dispersion of patches of cover and the distances among them.

Preferences exhibited by chipmunks for travel routes with high continuity of cover suggest that habitats with dense vegetation or debris would be preferred habitats. These preferences are exhibited by white-footed mice (*Peromyscus leucopus*) which used dense bushes for traveling more than they used sparse bushes (Kaufman *et al.* 1985). Chipmunks also exhibit habitat preferences related to cover, although there are interspecific differences which contribute to spatial segregation of species (Brown 1971, Meredith 1977).

My results indicate that chipmunks respond to quantitative attributes of cover by altering their movements and locations of activities. Although chipmunk habitats can be assigned to broad classes of cover, these differences, must be quantified if the role of cover in habitat selection is to be understood. Although other studies have shown that distance from cover is important for foraging, my study indicates that characteristics of cover are factors which must also be considered when assessing behaviour and habitat use.

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