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Burrow structure in the subterranean rodent *Ctenomys talarum*

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Abstract

Analysed the structure of completely excavated burrow systems of Tuco-tuco (*Ctenomys talarum*). Burrow systems of males and females show the same basic design. The main tunnel occupies 48 % of a burrow in total length and is formed by basic units (interfork distances) of 0.9 ± 0.4 m. Subterranean plant biomass was correlated with burrow length and with the number of branches. Soil granulometry affected the diameter and depth of tunnels and soil humidity was correlated with the main tunnel length.

Introduction

South-American caviomorph rodents of the genus *Ctenomys,* called Tuco-tucos are the most numerous in species number of all fossorial rodents (Reig et al. 1990). Tuco-tucos spend most of their lives within plugged burrows, evident by the mounds that result from pushing loosened soil out of the tunnels.

Burrow structure is of main importance in terms of energy costs or burrowing. As a consequence, foraging efficiency and escape from predators are the ultimate factors shaping burrowing behavior (Andersen 1988). Thus, burrows of different mammalian taxa have evolved into broadly convergent structures.

Studies on burrow architecture of North American geomyd rodents suggest that subterranean rodents maximize the energy expended per meter of burrow (Vleck 1981) and that architecture of burrow systems is not adaptive to resource availability (Cameron et al. 1988). Reichman et al. (1982) reported that total length of the burrow and the average number of branches are inversely related to plant productivity. Furthermore, these authors suggest that any spacing rule involves basic building units of the burrow system. This unit can be combined in such a way as to increase overall burrow length in response to resource availability.

The literature contains little information concerning the structure of Tuco-tuco burrow systems, although numerous studies have centered on those of the northern pocket-gopher. For a review on subterranean burrow structures, see Hickman (1990).

The present report offers information based on field observations on the structure of completely excavated burrow systems of the Tuco-tuco, *Ctenomys talarum,* and relates the major features of the burrow with characteristics of the surrounding habitat.

Material and methods

This study was conducted from January to December 1989 at the sandy dune belt from Mar del Cobo (Pdo. Mar Chiquita, Prov. Buenos Aires). Plastic live traps were set at fresh surface mounds. Weight and sex of the Tuco-tuco trapped were recorded. Burrow systems were excavated with a shovel. Tunnels, chambers and mounds were mapped on graph paper. The length of all tunnels in the entire burrow system of each individual Tuco-tuco was measured from the maps and the total above area covered by each individual was also measured from the maps using the minimum convex polygon

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method. The degree of convolution of each burrow system was quantified by dividing the total length of tunnels in the burrow system by its total above-ground area (Cameron et al. 1988).

We arbitrarily designated the longest continuous segment of a burrow as the main tunnel. Any tunnel comming off this segment was considered a branch. Tunnels ending at the surface were named feeding tunnels. Branch angle was measured as the smallest angle between two intersecting segments.

Plant biomass and soil characteristics were measured from samples taken near burrows. Vegetation was collected from a circle around the burrow in five 0.24 m^2 and 30 cm depth samples. Biomass was estimated by separation on aerial and subterranean portions of vegetation that were dried at 80 °C for 24 h. Soil samples were collected at the depth of burrow tunnels. Moisture was determined by differential readings before and after drying soil samples at 80 °C to constant weight. Silt-loam fractions were separated using a sieve set.

Numerical results are given as mean ± S.D. Student's t and χ^2 tests were used to test for significant differences between mean values and proportions, respectively. Discriminant analysis was performed between male and female burrows. Correlations among burrow variables as well as between these variables and soil and vegetation variables were established.

Results

Major features of a male and a female excavated burrow system are shown in Figure 1. Data for 12 female- and 10 male-excavated burrow systems are presented in Table 1.

Table 1. **Body mass and burrow system characteristics of *Ctenomys talarum* from Mar del Cobo, Buenos Aires, Argentina**

Values are given as x ± SD. Numbers in parentheses are sample sizes

Characteristic	Male (n=10)	Female (n=12)	Total (n=22)
Body mass (g)	133 ± 15	104 ± 13	117 ± 20
Burrow length (m)	17 ± 7	11 ± 7	14 ± 8
Burrow area (m^2)	10 ± 8	5 ± 4	8 ± 6
Degree of convolution	2 ± 0.7	2 ± 0.7	2 ± 0.7
Main tunnel length (m)	8 ± 4	5 ± 3	6 ± 4
Branch length (m)	9 ± 4	6 ± 4	7 ± 4
Number of branches	8 ± 6	8 ± 6	8 ± 6
Interfork distance (m)	1 ± 0.4	0.8 ± 0.3	0.9 ± 0.4

Table 2. **Soil humidity and granulometry in mass percent at the excavated burrow location**

Data are given as x ± SD

Soil characteristic	Male (n=10)	Female (n=12)	Total (n=22)
Humidity	5 ± 1	4 ± 2	5 ± 2
Silt (>2 mm)	0.2 ± 0.3	0.7 ± 0.9	0.5 ± 0.8
Very coarse sand (<2 mm >1 mm)	1.3 ± 1.5	2 ± 3	1.6 ± 2
Coarse sand (<1 mm >0.5 mm)	30 ± 6	13 ± 10	21 ± 12
Medium sand (<0.5 mm >0.25 mm)	18 ± 2	39 ± 12	30 ± 14
Fine sand (<0.25 mm >0.125 mm)	44 ± 8	39 ± 9	41 ± 9
Very fine sand (<0.125 mm >0.058 mm)	5 ± 2	5 ± 2	5 ± 2
Loam-clay (<0.058 mm)	1.4 ± 0.7	1 ± 0.5	1.2 ± 0.7

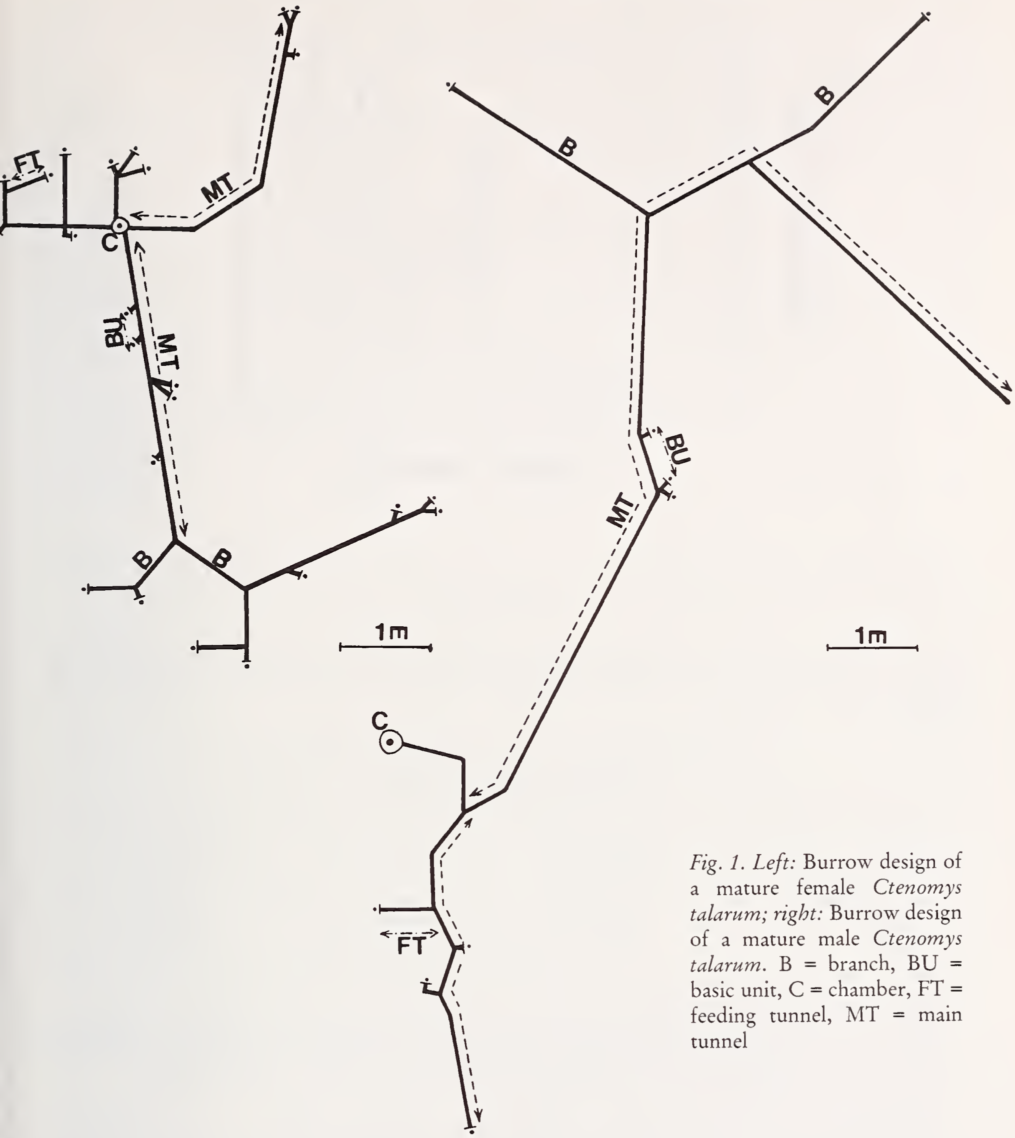

Fig. 1. Left: Burrow design of a mature female *Ctenomys talarum; right:* Burrow design of a mature male *Ctenomys talarum*. B = branch, BU = basic unit, C = chamber, FT = feeding tunnel, MT = main tunnel

The burrow system of *Ctenomys talarum* has a branching structure, consisting primarily of a main axial tunnel that occupies 48 % of the total length and a variable number of lateral branches and feeding tunnels. All tunnels to the surface are plugged and systems never interconnected.

Male and female burrow systems have the same basic design ($0.10 > P > 0.05$). The main tunnel is formed by basic unit buildings (interfork distances) of 0.9 ± 0.4 m. About 48 % of the branching angles were $> 40°$ and clustered around 75° and 90° (Fig. 2). The construction of left- and right-directed segments is statistically different ($P < 0.05$).

Average body weight was significantly different between sexes ($P < 0.001$). Male burrows occupied greater above-ground areas than female burrows ($0.1 < P < 0.05$). We

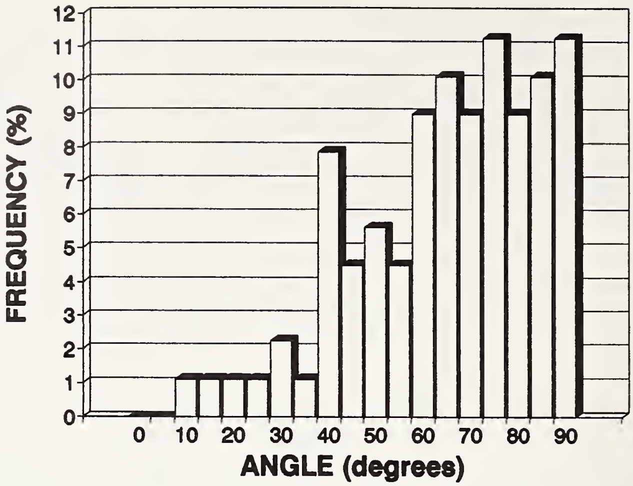

Fig. 2. Frequency distribution of burrow branch angles

did not detect a significant difference in the total length of tunnels, degree of convolution or diameter between burrow systems of male and female Tuco-tuco ($P > 0.1$).

A single nest chamber, packed with dry grasses, was found at the main tunnel in females, and in a blind lateral branch (0.5 ± 0.4 m) in males. Chamber mean diameter was 21 ± 7 cm and was built in deeper tunnels ($P < 0.02$) in males (45.62 ± 6.07 cm) than in females (35.5 ± 8.32 cm).

Table 3. **Plant biomass in g at excavated burrow location**

Data are given as x ± SD

Biomass	Male (n=10)	Female (n=12)	Total (n=22)
Subterranean	313 ± 63	249 ± 148	278 ± 120
Aerial	212 ± 198	350 ± 191	287 ± 202
Total	527 ± 189	647 ± 255	592 ± 231

Soil characteristics and plant biomass at the excavated burrow location are shown in Tables 2 and 3, respectively. Statistically significant correlations exist between a number of burrow parameters and between burrow parameters and habitat characteristics:

Burrow total length is correlated with: number of branches, number of feeding tunnels, animal weight and subterranean plant biomass ($P < 0.05$, $n = 22$).

Main tunnel length is correlated with: number of feeding tunnels, soil humidity and subterranean plant biomass ($P < 0.05$, $n = 22$).

Main tunnel depth is correlated with: number of branches, coarse grain sand, medium grain sand and subterranean plant biomass ($P < 0.05$, $n = 22$).

Tunnel diameter is correlated with: coarse grain sand and medium grain sand ($P < 0.05$, $n = 22$).

The number of branches of the system is correlated with the subterranean plant biomass ($P < 0.05$, $n = 22$).

Features of *Ctenomys talarum* compared to those of other subterranean rodents are reported in Table 4.

Table 4. **Burrow system characteristics of *Ctenomys talarum, Cryptomys hottentotus* and *Pappogeomys castanops***

Species Characteristic	*Ctenomys talarum*	*Cryptomys hottentotus*	*Pappogeomys castanops*
Surface (m^2) mounds	14.4 ± 6.7	–	74.0 ± 49.7
Total Length (m)	13.8 ± 7.5	181.0 ± 118.0	75.8 ± 27.0
Tunnel Depth (cm)	13.7 ± 4.1 39.9 ± 9.2	2.2 ± 0.5 49.5 ± 17.1	13.8 ± 4.0 81.8 ± 32.8
Tunnel mean diameter (cm)	8.1 ± 0.9	4.5 ± 0.6	10.2 ± 1.5
Nest chamber deep (cm)	39.9 ± 9.3	18.1 ± 8.9	34.5 ± 7.4
Occupants (n)	1.0 ± 0.0	2.2 ± 0.5	2.0 ± 1.0
Reference	this study	Hickman (1978)	Hickman (1977)

Discussion

As reported for other species of *Ctenomys* (Hickman 1990; Reig et al. 1990) our study shows that burrows of Tuco-tuco are convergent in their main features to those of other unrelated subterranean rodents. Andersen (1988) found that burrow systems of *Geomys* are linked segments of tunnels, and Reichman et al. (1982) suggested that burrow length of *Thomomys* are attained by incorporating burrow segments (one interfork distance and its associated branch). Furthermore, Vleck (1981), examining the energetics of foraging of geomyds, estimated a minimum-cost segment length between 0.6 and 2.4 m. The mean segment length (interfork distance) for Tuco-tuco lies within this interval and was 0.91 ± 0.31 m. Optimal foraging theory predicts the tendency for burrow branches to be orthogonal to the originating tunnel (Andersen 1988). We found that Tuco-tuco branch angles were variable, and greater than 60° (Fig. 2).

Moreover, in concurrence with studies in the family Geomyidae (Hickman 1990), gender did not affect architecture of burrow systems of *Ctenomys*. Although there are only statistically significant differences between male and female burrow areas, there is a tendency for males to occupy more elongated, branched burrow systems.

Position of the nest was reported to be adaptive, multiple entrances increased air circulation and less traffic congestion near the nest when occupied by young, while a central position allows equal foraging and territorial defense (Hickman 1990). Tuco-tuco males placed their nests on a central blind branch, while females have them in the main tunnel. Nest position was more central in heavier females, probably reflecting the burrowing pattern.

Soil type may influence burrow architecture as a mechanism to compensate for differences in the cost of excavating and rate of diffusion of gases. In our study, soil granulometry affected the diameter and depth of the tunnels. Similarly, soil humidity was correlated with main tunnel length of burrow.

Reichman et al. (1982) suggested that elongated, branched burrow systems may be required for resource acquisition in less productive areas. Although we did not find a correlation of burrow parameters to total above-ground biomass, both the length of the burrow and the number of branches were negatively correlated with subterranean biomass.

Field research throughout the year is needed to assess seasonal and reproductive influence on burrow parameters, as well as laboratory studies to estimate the cost of construction.

Acknowledgement

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Zusammenfassung

Die Struktur der Baue von Ctenomys talarum, einer unterirdisch lebenden Nagerart

Untersucht wurden 22 vollständig ausgegrabene Baue von Tuko Tukos (*Ctenomys talarum*). Die Gangsysteme der Männchen sind im Durchschintt größer und haben die Nestkammer am Ende eines Seitentunnels, wogegen die Weibchen ihr Nest im Hauptgang anlegen. Sonst sind die Baue bei Männchen und Weibchen ähnlich. Sie bestehen aus einem Hauptgang von durchschnittlich 48 % des Gesamtsystems, von dem im Abstand von im Mittel 0,9 ± 0,4 m Seitengänge abzweigen. Die unterirdische Pflanzenmasse pro Volumeneinheit war mit der Baulänge und der Anzahl von Abzweigungen negativ korreliert. Die Korngröße des Bodens beeinflußte den Durchmesser und die Tiefe der Gänge, und die Bodenfeuchtigkeit war mit der mittleren Tunnellänge korreliert.

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