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Habitat relations in *Ctenomys talarum* (Caviomorpha, Octodontidae) in a natural grassland

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Abstract

Tested the hypothesis that the spatial distribution of *Ctenomys talarum* ("tuco-tuco") in a natural grassland on a coastal cliff at Mar de Cobo, Argentina, is determined by topographic, soil and vegetation characteristics of the habitat.

In summer, there was no correlation between the number of "tuco-tucos" and any of the vegetation, soil or topography variables. In contrast, in autumn and winter, the number of animals was positively correlated with the density of grasses with small reserve organs (definite rhizomes). In spring, the number of animals was positively correlated with soil humidity, density and height of the vegetation, and density of grasses without reserve organs and with small reserve organs, and was negatively correlated with the sand percentage in the soil.

The results indicate that the spatial distribution of *Ctenomys talarum* is associated with the studied variables, although their relative importance varies seasonally.

Introduction

Rodents of the genus *Ctenomys* ("tuco-tucos") are subterranean and herbivorous. Populations are distributed throughout Argentina, southern Brazil, and parts of Paraguay, Bolivia, Uruguay, Perú and Chile (Woods 1984). The "tuco-tucos" dig sinuous burrows with several openings that are plugged with vegetation and/or sand during the greatest part of the day and night. These burrows consist of a main gallery connected with shorter ones that end on or below the surface (Contreras 1973; Altuna 1983).

Because movement underneath the earth is energetically very expensive, characteristics related to energetic balance and foraging costs are presumably under high selection pressure (Vleck 1981). Since the habitat productivity determines the foraging benefits and the soil hardness determines the costs, foraging economies should favor a maximum body size for each type of habitat such that benefits and costs are equal (Vleck 1981). The larger animals should occupy zones with high productivity and/or lighter soils. The subadults should occupy less favorable habitats, migrating to favorable zones when these are vacated because of the death of their previous occupants (Pearson et al. 1968). Other habitats should be unsuitable because of excessive hardnesss of the soil or low food availability. Soil texture is also important in determining burrow temperature and ventilation, with sandy soils favoring gaseous exchange (McNab 1966; Wilson and Kilgore 1978). Consequently, factors such as topography and exposure of the occupied zones relative to dominant winds, and vegetation structure, should also affect *Ctenomys* habitat selection.

Because of the high energetic cost of digging, soil hardness could be the most limiting factor affecting the dispersion of subterranean rodents (Best 1973; Abraham 1980). Species with larger body size would be the most affected (Best 1973; Vleck 1981). Along the Atlantic coast of Buenos Aires Province, Argentina, there is a clear halt of *Ctenomys* distribution between Santa Clara del Mar and Necochea (Contreras and Reig 1965).

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Contreras (1973) found a positive correlation between the textural type "sandy-clay-loam" of the second horizon and the presence of *Ctenomys.*

Tuco-tucos at Mar de Cobo (Partido de Mar Chiquita), where the habitat is heterogeneous, have a clumped distribution (Busch et al. 1989). The present study tests whether *Ctenomys* spatial distribution is associated with topography, soil and vegetation characteristics of the habitat; and evaluates their relative importance.

Study site

The experimental area covered a surface of 100 by 70 m divided in 10 by 10 m squares in Mar de Cobo (Partido Mar Chiquita, Buenos Aires Province, Argentina) on a coastal cliff where the vegetation was a natural grassland with predominance of species with rhizomes. To characterize the vegetation of the site, the frequency of occurrence of each species was calculated seasonally as the number of touches of green parts over the number of total touches. The dominant species in summer were *Panicum racemosum* (32 %), *Ambrosia tenuifolia* (17 %), and *Distichlis scoparia* (16 %). In autumn, *Panicum racemosum* (19 %), *Distichlis scoparia* (12 %), *Bromus unioloides* (8 %) and *Stipa neesiana* (7 %). In winter, *Bromus unioloides* (17 %), and *Stipa neesiana* (8 %); in this season, 61 % of the vegetation was dry, and warm season species such as *Panicum racemosum* and *Distichlis scoparia* dropped to 2 % and 4 % of green material, respectively. In spring, there were 19 % *Panicum racemosum*, 10 % *Bromus unioloides*, 10 % *Ambrosia tenuifolia*, 10 % *Distichlis scoparia*, and 8 % *Stipa neesiana*.

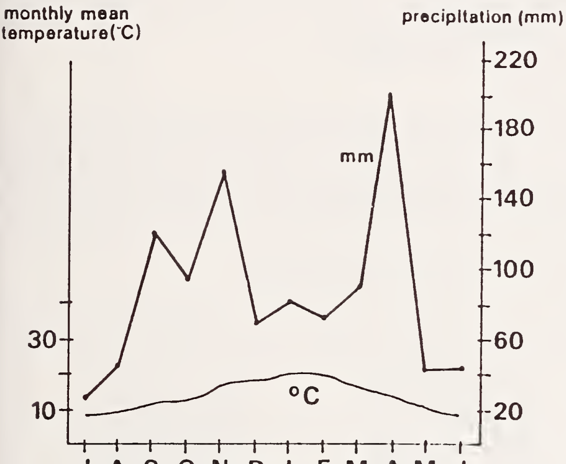

Fig. 1. Cilmatic data (1986). Source: Estación Aérea Mar del Plata. Data are plotted according to Walter (1977)

In sixteen measurements, the sand percentage in the soil varied from 88 % to 99 %, winter soil moisture varied from 4 % to 19 %, spring soil moisture varied from 4 % to 15 %, and soil hardness varied from 7 to 52 $\overrightarrow{\mathrm{kg}}/\mathrm{cm}^2$. The topographic map showed that the difference in altitude between the lowest and the highest point of the study area was 2.4 m.

Fig. 1 shows climatic data for the year when the studies were conducted (1986). Data are plotted according to Walter (1977).

Material and methods

The vegetation of the experimental area was sampled in March, May, August, and December 1986 by means of a non-destructive method which consisted of positioning a vertical needle and recording the canopy contacts (Levy and Madden 1933; Greig-Smith 1964; Heslehurst 1971; Jong et al. 1983). The needle was lowered systematically, each 20 cm, along four 70 m transects perpendicular to the coast. For each touch we recorded: the plant species, its height above the surface, and whether it was living. This method of sampling vegetation underestimates forbs and overestimates grass cover (Greig-Smith 1964), and may explain the low percentages of *Hydrocotyle bonariensis,* which never exceeded 5 % in the plots.

Samples of soil were collected at a depth of 20 cm in August and December along the same transects used to study vegetation. Four 500 g samples were obtained systematically in each transect. Organic matter from soil samples was removed using hydrogen peroxide. Sand percentages were determined by leaching the silt and clay fractions. These latter percentages were determined only in the winter samples, because they do not vary throughout the year. Soil moisture was determined by differential weight readings before and after drying the soil samples at 105 °C. Soil hardness was measured along the transects with a soil penetrometer.

The contours of the topographic map were traced with respect to the highest point that was set at the arbitrary value of zero. The greater values are the lower points of the study site.

Density and spatial distribution of *Ctenomys* were obtained in a simultaneous study in the same grid (Busch et al. 1989) by capture-recapture methods. Population size on the grid was estimated as the minimum number known alive between trapping intervals (Petrusewicz 1983). The Jolly-Seber method (Caughley 1977) was also used to estimate population size, but in the present study we used the former situation (Fig. 2), and data on their spatial distribution to estimate the number of animals in each square of the grid. Poisson distribution analysis indicated that the distribution of animals on the study area was clumped (df. = 69; P = 0.01).

The following variables were measured for each square in each season:

a. Vegetation: Total cover (total number of touches); Green cover (number of touces of green parts); Mean maximum height (cm); Cover of grasses with large reserve organs (indefinite rhizomes); Cover of grasses with small reserve organs (definite rhizomes); Cover of grasses without reserve organs; Cover of forbs with reserve organs (rhizomes); Cover of forbs without reserve organs (Table). We grouped the vegetation this way because we considered that the presence of rhizomes is an important character in *Ctenomys* nourishment.
b. Soil: Percentage sand; Relative humidity; Soil hardness ($\overrightarrow{kg}/cm^2$).
c. Relief: Distance from the coast (m); Relative elevation (m).
d. *Ctenomys talarum:* Number of individuals.

Vegetation, soil and relief data were analyzed complementing ordination and classification techniques. Principal Components Analysis (PCA) (Harris 1975) and Cluster Analysis (CA) by the nearest neighbor with simple linkage (Orlóci 1978) using 1-Pearson correlation coefficient for sample distances, were performed. Simple correlations were established between sample positions along the first seven axes and sample animal numbers. SYSTAT statistical program was used.

Vegetation groups and their principal species

Grasses with large reserve organs	Grasses with small reserve organs	Grasses without reserve organs
Panicum racemosum	*Festuca arundinacea*	*Bromus unioloides*
Distichlis scoparia	*Poa bonariensis*	*Stipa neesiana*
Paspalum vaginatum	*Poa lanigera*	*Dactylis glomerata*
Stenotaphrum sp.	*Paspalum dilatatum*	*Phalaris platensis*
Cynodon dactylon	*Setaria geniculata*	*Lolium multiflorum*
		Lolium perenne
		Hordeum leporinum
		Sporobolus indicus
Forbs with reserve organs	**Forbs without reserve organs**	
Ambrosia tenuifolia	*Medicago lupulina*	
Hydrocotyle bonariensis	*Melilotus officinalis*	
Solidago chilensis	*Phylla cannescens*	
Oxalis cordobensis	*Stellaria media*	
	Anagallis arvensis	
	Sonchus oleraceus	
	Geranium dissectum	
	Rapistrum rugosum	
	Brassica campestris	
	Dichondra repens	
	Gamochaeta spicata	

Results

Fig. 3 shows data ordination, grouped according to CA. The figure is a bidimensional representation of the first two spring axes. Although analysis of all the seasons were performed and plotted, spring results are the most interesting since animal spatial distribu-

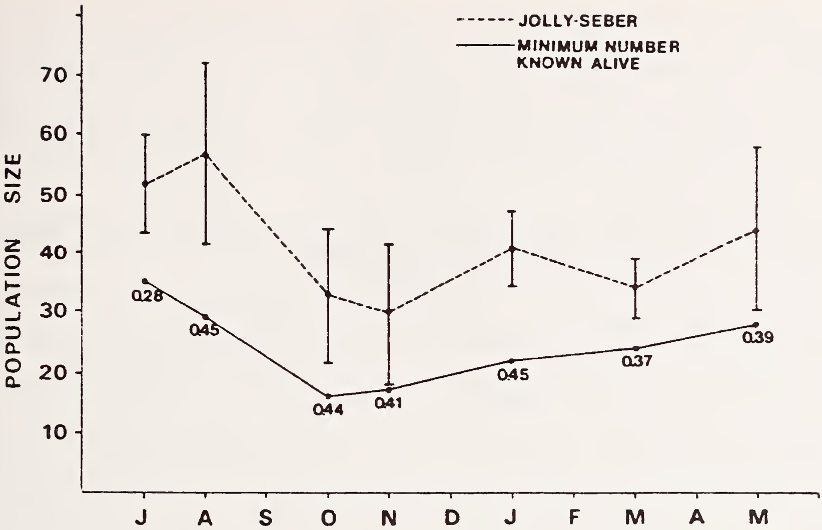

Fig. 2. Estimates of number of *Ctenomys talarum* on a 100 by 70 m grid in Mar de Cobo, Argentina, July 1985–May 1986. Vertical lines indicate 2 SE above and below the Jolly Seber estimate. Numbers indicate proportion of males in the sample. (Taken from Busch et al. 1989)

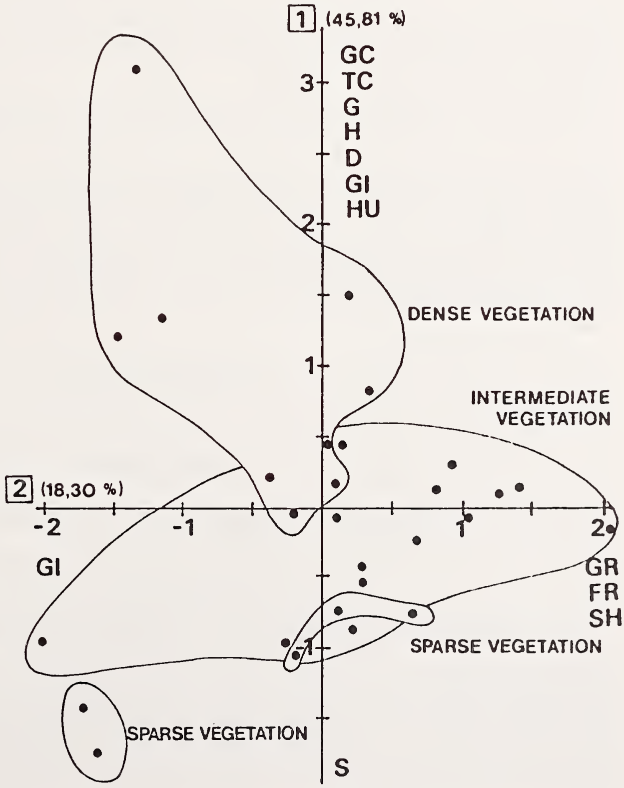

Fig. 3. Scatter diagrams of spring samples along axes 1 and 2 of the Principal Components Analysis. Grouping according to Cluster Analysis. Values between brackets show the percentage of the variance explained by each axis. GC = green cover; TC = total cover; G = cover of grasses without reserve organs; H = vegetation mean maximum height; D = distance from the coast; Gl = cover of grasses with small reserve organs; HU = humidity percentage in the soil; S = sand percentage in the soil; GR = cover of grasses with large reserve organs; FR = cover of forbs with reserve organs; SH = soil hardness

tion is closely related to vegetation heterogeneity at the community level. In the other seasons, animal distribution is associated with intracommunity heterogeneity (fine grain), and thus, scatter diagrams are poorly informative. A common aspect of the analyzed seasons is that the principal tendency of data variability (ax 1 of the PCA) shows a contrast between samples with sparse vegetation and sandy soil, and samples with dense and high vegetation and humid soil, more distant from the sea. Such contrast always explains over 38 % of the total variance.

In March (summer) no correlation was found between the number of "tuco-tucos" and the position of the samples along the first seven axes. In this season, no soil samples were collected; as a consequence, there were no moisture data.

In May (autumn), the number of animals was significantly correlated ($P < 0.05$) with the position of the samples along ax 3 of the PCA, and significantly correlated ($P < 0.055$) with the position of samples along ax 4. No correlation was found with any of the other first seven axes. Ax 3 opposes forbs without reserve organs and grasses that have small reserve organs, with grasses and forbs that have large reserve organs. The loading of these variables in ax 3 is 0.730, 0.474, 0.679 and 0.439 respectively, being animal distribution positively correlated with the first two variables. Ax 3 explains 13.45 % of the total variance. Ax 4 shows a gradient of samples with and without grasses that have small reserve organs. The loading of this variable in ax 4 is 0.601, being the number of animals positively correlated with the presence of grasses that have small reserve organs. Ax 4 explains 8.07 % of the total variance. In this season, no soil samples were collected.

In August (winter), the number of "tuco-tucos" was significantly correlated ($P < 0.05$) with the position of samples along ax 4. No correlation was found with any of the other first seven axes. Ax 4 shows a gradient of samples with and without grasses that have small reserve organs. The loading of this variable in ax 4 is 0.793, being the number of animals positively correlated with the presence of grasses that have short reserve organs. Ax 4 explains 9.80 % of the total variance.

In December (spring), the number of animals was significantly correlated ($P < 0.05$) with the position of the samples along axes 1 and 6. No correlation was found with any of the other first seven axes. Ax 1 opposes samples of sandy soils (loading 0.826) and low vegetation cover, with samples of high vegetation cover (total cover, green cover, cover of grasses with small reserve organs and without reserve organs, height of the vegetation, whose loadings lie between 0.768 and 0.949), humid soils (loading 0.675), more distant from the sea (loading 0.794). The number of animals is positively correlated with high vegetation cover and humid soils. Ax 1 explains 45.81 % of the total variance (Fig. 3). Ax 6, which only explains 3.53 % of the total variance, shows a gradient of samples with and without forbs that have reserve organs (loading 0.418), being the number of animals positively correlated with the samples without forbs that have reserve organs.

Discussion

Soil texture and humidity are important factors in the distribution of subterranean rodents. Abraham (1980) found that *Ctenomys talarum* does not build its burrows in soils containing 25 % or more of clay; Hansen and Beck (1968) found that when the soil moisture exceeds 50 %, pocket gophers *(Thomomys talpoides)* move to dryer sites.

The percentage of sand in the soil of our experimental area is high, never below 87 %, therefore, texture and hardness should not be limiting factors in the dispersion and occupation of new zones of the area. As sand percentage is very high, soil humidity is low, even in the colder seasons. Soil humidity and probably soil temperature, conditioned by the vegetation cover, can be very important when climatic factors are extreme. The fact that the number of animals in late spring (Fig. 3) was positively correlated with humidity, suggests that low soil humidity and high soil temperature can affect the occupation of certain areas during the hot season. Therefore, in warm months, favorable zones should be those of higher humidity, and consequently less sandy and with greater density and height of the vegetation (Fig. 3). Also, in spring, most of the vegetation is green, so that the positive correlation of the "tuco-tucos" with the density of the vegetation can have a dietary explanation. Results of this kind would be expected in summer. In this season, on the contrary, no correlation was found between animal density and any of the variables examined. During this season, green vegetation (warm season species) is ubiquitous. Also, this period coincides with the end of the breeding season and the dispersion of the subadults who will occupy the less favorable areas (Pearson et al. 1968). In this situation, the animal distribution could be mainly determined by social factors.

When the aerial productivity of the vegetation is low in autumn and winter, the animals' energetic requirements are higher because of the regulation of body temperature and the lactation of the young. The breeding season lasts nine months, from the end of May to the end of February with a peak in August (Busch et al. 1989). The autumn (ax 3 and 4 of the principal components analysis) and winter (ax 4) association of animal density with grasses that have small reserve organs, suggests a relationship between energetic requirements and animal spatial distribution. Most of this vegetation is composed of cool season species, and is therefore green when most of the other vegetation is dry. Further, Reig (1970) and Lohfeldt et al. (1989), suggest that *Ctenomys* eats much more aerial than underground vegetation.

Also, in autumn, the positive correlation of animals with the presence of forbs without reserve organs (ax 3 of the PCA), can be explained by animal continuous earth movements that favor the implantation of annual forbs.

Although the tendency of the variable along the axes is subtle, the negative correlation of animal spatial distribution with the presence of forbs that have reserve organs in autumn (ax 3 of the PCA) and spring (ax 6), suggests a rejection of these species, which are principally *Ambrosia tenuifolia* and *Hydrocotyle bonariensis*. This rejection can have a dietary explanation, since Lohfeldt et al. (1989) suggest that *Ctenomys talarum* prefers grasses in autumn and spring.

In conclusion, the clumped distribution of *Ctenomys talarum* in the area, can be correlated with environmental factors, the presence of grasses with small reserve organs being the most important determinant in autumn and in winter, and soil humidity, density and height of the vegetation in spring. Also, data suggest that other factors, like animal behavior, may be important determinants of animal spatial distribution during certain seasons.

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Zusammenfassung

Habitat-Beziehungen von Ctenomys talarum (Caviomorpha, Octodontidae) auf natürlichem Grasland

Auf einer bestimmten Fläche von natürlichem Grasland an der Küste von Argentinien nahe Mar de Cobo, Provinz Buenos Aires, wurde untersucht, in welcher Weise die räumliche Verteilung von Individuen der Art *Ctenomys talarum* (Tukotuko) durch Topographie, Bodenbeschaffenheit und Vegetation bestimmt ist. Für den Sommer ergab sich keine Korrelation von Individuenanzahl zu irgendeinem der untersuchten Faktoren. Im Herbst und Winter war demgegenüber die Anzahl der

Tiere positiv korreliert mit der Dichte von Gräsern, die mit kleinen Speicherorganen ausgestattet sind. Auch für den Frühling ergab sich eine positive Korrelation, diesmal jedoch mit der Bodenfeuchtigkeit, mit Dichte und Höhe der Vegetation, sowie mit der Dichte von Gräsern sowohl ohne besondere, als auch mit kleinen Speicherorganen. Andererseits wurde eine negative Korrelation zum prozentualen Sandanteil des Bodens festgestellt. Die Ergebnisse deuten an, daß die räumliche Verteilung von Tukotukos zu den untersuchten Faktoren in Beziehung steht, im Laufe des Jahres jedoch in unterschiedlicher Weise.

Literature

Abraham, M. A. (1980): Factores edáficos limitantes de la distribución del "tuco-tuco" de Magdalena *(Ctenomys talarum)*. Ecología Argentina **4**, 1–4.

Altuna, C. A. (1983): Sobre la estructura de las construcciones de *Ctenomys pearsoni* Lessa y Langguth, 1983 (Rodentia, Octodontidae). Resúmenes y comunicaciones de las Jornadas de Ciencias Naturales, Uruguay.

Best, T. L. (1973): Ecological separation of three genera of pocket gophers (Geomyidae). Ecology **54**, 1311–1319.

Busch, C.; Malizia, A. I.; Scaglia, O. A.; Reig, O. A. (1989): Spatial distribution and attributes of a population of *Ctenomys talarum* (Rodentia, Octodontidae). J. Mammalogy **70**, 204–208.

Caughley, G. (1977): Analysis of vertebrate populations. New York: John Wiley.

Contreras, J. R. (1973): El tuco-tuco y sus relaciones con los problemas del suelo en la Argentina. Idia **29**, 14–36.

Greig-Smith, P. (1964): Quantitative plant ecology. 2nd ed. London: Butterworths.

Hansen, R. M.; Beck, R. F. (1968): Habitat of pocket gophers in Cochetopa Creek Drainage, Colorado. Am. Midl. Natural. **79**, 103–117.

Harris, R. J. (1975): A primer of multivariate statistics. London: Academic Press.

Heslehurst, M. R. (1971): The point quadrat method of vegetation analysis: a review. Reading: Univ.

Jong, P. de; Aarsen, L. W.; Turkington, R. (1983): The use of contact sampling in studies of association in vegetation. J. Ecol. **71**, 545–559.

Levy, E. B.; Madden, E. A. (1933): The point method of pasture analysis. New Zealand J. Agriculture **46**, 267–279.

Lohfeldt, M.; Comparatore, V.; Busch, C. (1989): Preferencias alimentarias de *Ctenomys talarum*. Resúmenes de la 14° Reunión Argentina de Ecología, abril de 1989, San Salvador de Jujuy, Argentina.

McNab, B. K. (1966): The metabolism of fossorial rodents: a study of convergence. Ecology **47**, 712–733.

Orlóci, L. (1978): Multivariate analysis in vegetation research. The Hague: Dr. W. Junk Publ.

Pearson, O. P.; Binsztein, H.; Boiry, L.; Busch, C.; DiPace, M.; Gallopin, G.; Penchaszadeh, P.; Piantanida, M. (1968): Estructura social, distribución especial y composición por edades de una población de tuco-tucos *(Ctenomys talarum)*. Invest. Zool. Chilenas **13**, 47–80.

Petrusewicz, K. (1983): Numbers: the concept and definitions. Acta Theriol. **28**, 89–101.

Reig, O. A. (1970): Ecological notes on the fossorial octodont rodent *Spalacopus cyanus* (Molina). J. Mammalogy **51**, 592–601.

Vleck, D. (1981): Burrow structure and foraging costs in the fossorial rodent, *Thomomys bottae* Oecologia **49**, 391–396.

Walter, H. (1977): Zonas de vegetación y clima. Barcelona: Ed. Omega, S. A.

Wilson, K. J.; Kilgore Jr, D. L. (1978): The effects of location and design on the diffusion of respiratory gases in mammal burrows. J. Theor. Biol. 71, 73–101.

Woods, Ch. A. (1984): 14. Histricognath rodents. In: Orders and families of recent mammals of the world. Ed. by S. Anderson and J. K. Jones. New York: John Wiley. pp. 389–446.

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