Mamm. biol. **67** (2002) 167–175

http://www.urbanfischer.de/journals/mammbiol

Mammalian Biology
Zeitschrift für Säugetierkunde

Original investigation

Seasonal food habits of the endangered long-tailed chinchilla (*Chinchilla lanigera*): the effect of precipitation

By A. CORTÉS, E. MIRANDA, and J. E. JIMÉNEZ

Departamento de Biología, Universidad de La Serena, La Serena and Departamento de Ciencias Básicas, Universidad de Los Lagos, Osorno, Chile

Receipt of Ms. 19. 04. 2001
Acceptance of Ms. 19.09. 2001

Abstract

Based on the content of feces, we studied the food habits of the endangered rodent *Chinchilla lanigera*. On a seasonal basis, during two years of contrasting rain levels (1992 = 242 mm; 1993 = 123 mm), we collected chinchilla feces from El Cuyano ravine, adjacent to the Chinchilla National Reserve in north central Chile (31° 29′ 10.8″ S, 71°03′ 43.9″ W). The main plant species eaten was the perennial graminoid *Nassella chilensis*. Chinchillas showed a broader trophic niche during the rainy year, than during the dry year, consuming 55.5 and 40.7% of the 38 and 27 plants available, respectively. Within the wet year the diet differed less between winter and summer (Horn similarity index $R_0 = 0.58$) than within the dry year ($R_0 = 0.83$). Between years, the diet differed more during winters ($R_0 = 0.20$) than during summers ($R_0 = 0.52$). Chinchillas are folivorous, using a feeding pattern of a generalist species. The opportunistic feeding behavior of chinchillas may be an adaptation to the harsh conditions and high variability in food availability triggered by fluctuations in rainfall among years in the arid north central Chile.

Key words: *Chinchilla lanigera*, food habits, Chile, rainfall

Introduction

The long-tailed chinchilla (*Chinchilla lanigera* Molina, 1782) is a medium-sized hystricognath rodent endemic to north central Chile. These chinchillas had a relatively wide distribution in the past, ranging in the rugged coastal mountains from the Choapa River (32° S) north to Potrerillos (26° S; JIMÉNEZ 1996). Because of over-exploitation for its valuable fur, it was almost extirpated by the end of the 19th century and was considered extinct until the 1970's (JIMÉNEZ 1994). This chinchilla is currently considered endangered and known only from the locality of Aucó (31° 38′ S, 71° 06′ W), in the Chinchilla National Reserve and its surroundings, and from a colony north of Coquimbo (29° 33′ S, 71°04′ W; JIMÉNEZ 1995). However, despite protection in the reserve, chinchilla abundance is still declining (JIMÉNEZ 1990).
Information on the ecology and natural history of these chinchillas is scant. They are herbivorous, live in discrete colonies, and are nocturnal (JIMÉNEZ 1995). Ecological densities (within colonies) vary widely in

1616-5047/02/67/03-167 $ 15.00/0.

time and space, ranging between 0.9 to 10.7 individuals/ha (Jiménez 1990). Most of the scattered colonies are located on steep and dry equatorial-facing slopes, where the chinchillas use the succulent bromeliad, *Puya berteroniana*, rock crevices, and boulder piles as refugia (Jiménez 1995).

Food habits of chinchillas are poorly known. Accounts on their diet have been qualitative and non-rigorous (Mohlis 1983). Based on the analysis of feces collected in the Chinchilla National Reserve in north central Chile, Serra (1979) first reported chinchilla diet quantitatively. Combining information from 3 years, she found that chinchillas had a diverse diet, fed mostly on shrub leaves, and that species composition in the diet varied considerably among seasons. More recently, Jiménez (1990) estimated the diet of the same population using cafeteria tests and fecal analysis. Interestingly, he found that when offered fresh and dead leaves of several plant species, chinchillas preferred the dead and dried leaves, mainly from herb species. Chinchillas showed no interest in seeds and pods of native plants. According to Jiménez (1990), wild chinchillas feed an up to 24 plant species, mainly herbs, and their diet changes substantially between sites and during the year.

To know the dietary requirements and its dependence on the availability of food items in the field, especially when the availabilities change in space and time, is crucial for understanding the trophic ecology and behavior of a wild species. This is especially important for implementing conservation plans for endangered species, such as the chinchilla that lives in a food-poor and harsh environment in which resources fluctuate enormously in space and time (Jiménez et al. 1992). To bridge this gap, we studied the chinchilla diet throughout two years of contrasting rainfall.

Material and methods

Study area: We sampled fresh chinchilla feces at El Cuyano Bajo ravine (31° 29′ 10.8″ S, 71° 03′ 43.9″ W), close to the Chinchilla National Reserve, in Aucó, north central Chile. The climate is mediterranean-arid (Hajek and Di Castri 1976), with sparse rainfall concentrated during the cold austral winter (88% between May and August). Mean annual precipitation for 10 years is about 200 mm (range 86–513 mm), but exhibits high interannual variability (Fuentes et al. 1988). Mean annual temperature is between 15 and 16 °C, reaching freezing temperatures during winter nights and over 40 °C during summer days.

The rugged topography shapes the landscape forming interspersed slopes, ravines, and flatlands. Elevations range from 400 to 1,700 m. The vegetation is dominated by thorn-scrub species. Species composition and density af plants depend on slope, aspect, substrate, water availabitity, and anthropogenic disturbance (Gajardo 1978). Slopes that face north (equatorial) receive higher solar radiation, and have sandy soils with scattered gravel patches and frequent rock outcrops. Because of the xeric character of these slopes grasses are scarce (mainly *Nassella chilensis* and *Stipa plumosa*), but cacti (*Echinopsis chilensis*, *Opuntia ovata*), bromeliads (*Puya berteroniana*), and sclerophyllous shrubs including *Bahia ambrosioides*, *Cordia decandra*, *Bridgesia incisaefolia*, and *Flourensia thurifera* are abundant. In contrast, slopes that face south (polar) receive less radiation and are thus more mesic. Grasses here are more abundant, cacti and bromeliads are absent, and a different assemblage of shrubs prevails (*Adesmia* spp., *Porlieria chilensis*, *Colliguaja odorifera*, and *Proustia* spp.; Jiménez et al. 1992).

Collection of feces and reference plant samples: Fresh fecal pellets were sampled in the field for three days in each of the four seasons during two years of cantrasting precipitation regimes: in 1992, when it rained 242 mm (a "wet" year) and in 1993 when it rained 123 mm (a "dry" year). Then, samples were taken to the laboratory and dried at 60 °C for 48 to 72 h.

On a seasonal basis we sampled leaves, stems, and flowers of all plant species present at the study site. Herbs, shrubs, and succulents were determined by comparisons with the plant collection deposited at Universidad de La Serena. A microhistological slide collection was prepared following Sparks and Malechek (1968). Black and white pictures were obtained from all slides samples.

From the more than 100 fecal pellets collected during each season, we randomly selected 40 for dietary analysis. From each group we obtained 10 slide preparations (Baumgartner and Martin 1939). In turn, 10 fields from each slide were studied under a Leitz microscope with 36-x magnification, which was equipped with a 7 × 7-grid quadrant. Fields with less than 50% of the area covered by plant material were disregarded. Plant fragments were compared to the samples in the voucher slide collection. Diet composition was estimated by using the relative surface covered by each food item in the fields. Then, we computed the frequency of occurrence of each item in the fields examined (Meserve 1976).

Trophic niche breadth: We used the Shannon-Weaver index (Shannon and Weaver 1949) to estimate the diet diversity as: $H' = -\Sigma p_i \log p_i$, where p_i is the proportion of items of species i in the sample (estimated as $p_i = n_i/N$; where n_i is the number of items af species i out of all items across species, which is N). Diet diversity increases as the index increases.

Diet similarity: To compare the similarity of diets between seasons (within years) and between years (for the same seasons) we used the Horn (1966) overlap index as: $R_0 = H_{4'} - H_{3'}/H_{4'} - H_{5'}$, where $H_{3'}$, H_4, and $H_{5'}$ are computed based on the Shannon-Weaver index (as in Brower and Zar 1984). The index ranges from 0 (complete dissimilitude) to 1 (highest diet similarity).

Results and discussion

The dietary analysis of chinchilla based an the contents of feces indicates that the different plant life forms eaten varied markedly among seasons and between years (Tab. 1). Overall, fibers made up most (> 66%) of the diet in both years and in all seasons. These fibrous items are extremely difficult to identify and may correspond to highly lignified plant parts such as bark and woody stems of shrubs and of the succulent agave-like bromeliad *Puya berteroniana*. Herbs and shrubs followed in importance in the chinchilla diet (Tab. 1). Identified succulents made up only a small fraction af the chinchilla diet, and were eaten in a non-predictable way throughout the two years. The same was true for seeds, the least represented food category in the diet.

Yearly variation of the chinchilla diet: The proportion of plants eaten by chinchillas differed between the two years. Herbs and shrubs were incorporated into the diet throughout both years. Not accounting for the unidentified material and fibers, during the wet year herbs made up the bulk of the diet, followed in importance by shrubs (Tab. 1). The reverse occurred during the dry year. The amount of fiber and undetermined material ingested was remarkably similar between years. The seed component in the chinchilla diet was minor and almost absent from the diet during the wet year, but their importance increased during the dry year (Tab. 1).

The same yearly pattern detected for the abundance of plant groups and parts was found for the species composition in the chinchilla diet (Tab. 1). The diet included more species during the wet year than during the dry year, incorporating a total of 21 and 11 species, respectively. More shrub species than herbs were consumed during both years, with the exception of the winter and spring of the wet year (Tab. 1).

By species, as well as by percent of occurrence, herbs were consumed more during the wet than during the dry year (Tab. 1). The reverse was true for shrubby species. During the dry year there were 3 plant species that made up most of the recognized food items: the succulent *P. berteroniana* the herb *N. chilensis*, and the shrub *Bridgesia incisifolia*. These species showed up in the diet consistently throughout the seasons and may be used by chinchillas when other plants are less available.

It appeared that chinchillas are capable of using a wide range of plants when these are available in the environment. Out of the 38 plant species detected in the field during the wet year, chinchillas consumed at least 55.3% of these plant species (Tab. 1). When fewer plants (27 species) were available due to a lack of rain, the rodents showed a much narrower diet (11 species), ingesting only 40.7% of the plants available. This same trend was observed in the niche breadth index. On average, an H′ of 0.78 was found during the wet year, whereas H′ was 0.65 during the dry year.

Seasonal changes in the chinchilla diet: The abundance of different plant life forms varied highly across seasons in the chinchilla

Table 1. Food items consumed seasonally (%) by *Chinchilla lanigera* and plant species availablities (AV) in north central Chile during a wet (1992) and a dry year (1993). Totals by category are shown in parentheses. The H′ Shannon-Wiever index of food diversity is shown at the bottom of the table.[1]: FA = fall, WI = winter, SP = spring, SU = summer, AV = availability. [[2]: – = not detected. [3]: + = present, - = not found, na = not assessed.]

	Wet year					Dry year				
	FA[1]	WI	SP	SU	AV	FA	WI	SP	SU	AV
SHRUBS	**(17.5)**	**(5.2)**	**(2.1)**	**(4.0)**		**(8.8)**	**(7.3)**	**(12.2)**	**(7.7)**	
Asclepiadacea										
Astephanus geminiflorus	0.8	–[2]	–	–	+[3]	–	–	–	–	+
Boraginaceae										
Cordia decandra	–	–	–	0.1	+	–	–	–	–	+
Heliotropium stenophyllum	3.1	1.9	–	1.8	+	2.9	0.3	–	–	+
Campanulaceae										
Lobelia polyphylla	1.0	1.3	0.3	0.3	+	–	0.8	–	–	+
Compositae										
Baccharis linearis	–	–	–	–	+	–	–	–	–	+
Flourensia thurifera	–	–	–	–	+	–	–	–	–	+
Gutierresia resinosa	–	–	–	–	+	–	–	–	–	+
Proustia cuneifolia	3.3	1.1	–	–	+	1.2	0.3	1.7	–	+
Ephedraceae										
Ephedra andina	–	–	–	1.6	+	–	–	–	1.3	+
Euphorbiaceae										
Colliguaja odorifera	–	0.9	1.3	–	+	–	0.1	1.5	–	+
Krameriaceae										
Krameria cistoidea	–	–	–	–	+	–	–	–	–	+
Papilionaceae										
Adesmia microphylla	1.5	–	–	0.2	+	–	–	–	–	+
Phytolaccaeae										
Anisomeria litoralis	–	–	–	–	+	–	–	–	–	+
Sapindaceae										
Bridgesia incisifolia	2.7	–	–	–	+	4.7	5.5	6.4	6.0	+
Solanaceae										
Cestrum parqui	–	–	–	–	+	–	–	–	–	+
Lycium chilense	–	–	0.2	–	+	–	0.2	2.2	–	+
Zygophyllaceae										
Porlieria chilensis	5.1	–	0.3	–	+	–	0.1	0.4	0.4	+

Table 1. (Continued)

	Wet year					Dry year				
	FA[1]	WI	SP	SU	AV	FA	WI	SP	SU	AV
HERBS	**(9.7)**	**(3.7)**	**(23.5)**	**(4.2)**		**(2.1)**	**(5.0)**	**(8.2)**	**(3.5)**	
Adiantaceae										
Adiantum chilense	7.0	–	1.4	–	+	–	–	–	–	–[3]
Notholaena molis	–	–	–	–	+	–	–	–	–	–
Amaryllidaceae										
Rhodophiala phycelloides	–	0.4	0.3	–	+	–	–	–	–	–
Caesalpineaceae										
Caesalpinia angulicaulis	–	–	–	–	+	–	–	–	–	–
Compositae										
Moscharia pinnatifida	–	–	2.1	–	+	–	–	–	–	–
Geraniaceae										
Erodium sp.	–	0.4	1.6	–	+	–	–	–	–	–
Gramineae										
Hordeum murinum	–	–	–	–	+	–	–	–	–	–
Nassella chilensis	1.2	1.4	16.0	4.2	+	2.1	4.9	8.2	3.5	+
Stipa plumosa	–	–	–	–	+	–	–	–	–	+
Liliaceae										
Pasithaea coerulea	–	–	–	–	+	–	–	–	–	+
Lythraceae										
Pleurophora pucilla	–	–	0.6	–	+	–	–	–	–	+
Oxalidaceae										
Oxalis carnosa	1.5	1.5	0.8	–	+	–	0.1	–	–	–
Plantaginaceae										
Plantago hispidula	–	–	–	–	+	–	–	–	–	+
Rubiaceae										
Galium aparine	–	–	–	–	+	–	–	–	–	–
Sapindaceae										
Llagunoa glandulosa	–	–	–	–	+	–	–	–	–	+
Umbelliferae										
Apium laciniatum	–	–	0.3	–	+	–	–	–	–	–
Verbenaceae										
Glandularia sulphurea	–	–	0.4	–	+	–	–	–	–	–

Table 1. (Continued)

	Wet year					Dry year				
	FA[1]	WI	SP	SU	AV	FA	WI	SP	SU	AV
SUCCULENTS	**(4.2)**	**(1.0)**	**(0.0)**	**(3.2)**		**(4.6)**	**(2.7)**	**(4.3)**	**(0.4)**	
Bromeliaceae										
Puya berteroniana	4.2	1.0	–	3.2	+	4.6	2.7	4.3	0.4	+
Cactaceae										
Echinopsis chilensis	–	–	–	–	+	–	–	–	–	+
Eulychnia acida	–	–	–	–	+	–	–	–	–	+
Opuntia ovata	–	–	–	–	+	–	–	–	–	+
OTHERS	**(68.2)**	**(90.1)**	**(74.4)**	**(88.6)**		**(84.5)**	**(85.0)**	**(75.3)**	**(88.4)**	
Seeds	–	1.0	–	–	na	–	0.2	4.1	1.0	na
Unrecognized material	2.4	10.3	6.4	8.4	na	12.9	9.1	3.6	10.8	na
Fibers	66.2	78.8	68.0	80.2	na	71.6	75.7	67.6	76.6	na
TOTAL NUMBER OF SPECIES	11	9	13	7		5	10	7	5	
Shannon-Wiever Index	0.91	0.91	0.64	0.65	na	0.68	0.69	0.72	0.51	na

diet (Tab. 1). This variability produced no recognizable patterns when comparing the two years sampled. No patterns were detected in the numbers of species eaten across the seasons when comparing years either (Tab. 1). However, the diet breadth during the spring of both years showed interesting opposite trends. Although the diet during the spring of the wet year included the largest number of plant species, the niche breadth index was the narrowest (Tab. 1). Conversely, the relatively few species consumed during the dry year rendered the broadest niche breadth during that year. This is most likely reflected by the less-even diet during the spring of the wet year, which resulted from the disproportionate high consumption of *N. chilensis* (16%) by chinchillas. In contrast, during the dry year most food items were eaten in a more proportional way. In fact, when herbs were scarce in the environment (only 6 of the 17 species detected) during the dry year, most of the diet was made up of perennial shrubs (Tab. 1).

The food items eaten that had the largest variability in amount and diversity within the years were the herbs and shrubs, whereas the succulent *P. berteroniana* and the graminoid *N. chilensis* were eaten on a more regular basis. Given its 70 to 80% water composition, it is likely that *P. berteroniana* represents a predictable water source for chinchillas throughout the year (CORTÉS, unpubl. data). It is unfortunate that cacti tissue do not show up in diet analysis. There were at least 3 cactus species present at the site and it is well known that chinchillas eat cacti fruits, which are also mostly made up of water (JIMÉNEZ 1990; see also SERRA 1979).

Herb species are most affected by the amount of rain over the short term (GUTIÉRREZ et al. 1997). Thus, during the wet year, it was likely that, compared to the dry year, herbaceous plants were plentiful and therefore available to chinchillas. This response was also shown by the amount and the diversity of herbs consumed by chinchillas during the spring of the wet year (Tab. 1). Indeed, *N. chilensis*, which appeared as the most consumed plant species by chinchillas during the spring of 1992, is a graminoid, the growth of which is dependent upon the amount of rainfall (GUTIÉRREZ et al. 1997). By comprising the bulk of the herbs consumed by chinchilla during the spring of the wet year, when availability of plant species and amount of green biomass are high, *N. chilensis* appears to be a preferred diet component. Even when plants were scarcer, as in 1993, *N. chilensis* was still an important component of the chinchilla diet. During the springs, when the ingestion of more fleshy species with a higher water content increased, fibrous plants with low digestibility and lower energetic and nutritious value (VELOSO and BOZINOVIC 1993) decreased (Tab. 1). Thus, *N. chilensis* may be an item of high energetic and nutritious value, perhaps necessary when gestation and lactation take place (JIMÉNEZ 1990).

To our knowledge, the only other diet study of this chinchilla species in the wild was conducted by SERRA (1979) in the nearby Chinchilla National Reserve. She also found high variation in the plant species composition and amounts eaten during the different seasons. Her differing results may have been due to local plant availabilities or rainfall. However, the data are hardly comparable, given that her samples were collected in three different years, with rainfall amounts unreported. The technique that SERRA (1979) used was not sufficiently lucid.

Preliminary analysis on the chinchilla diet from the Chinchilla National Reserve (JIMÉNEZ 1990) using a method similar to this study, showed that during 1987 and 1988 the chinchilla diet was highly variable among seasons and also between sites. The diet was diverse, including between 6 and 12 plant species, well in line with the 5 to 13 plant species detected in this study. JIMÉNEZ (1990) also conducted several cafeteria tests on 3 wild chinchillas kept in captivity for a short time period. He offered seeds of 8 shrubby species native to the area, but unlike findings in this study and that of SERRA (1979), he found no consumption by chinchillas. From the other 23 native species' leaves offered to the chinchillas, JIMÉNEZ (1990) detected consumption of 56.5% of them. The most frequently eaten items were leaves of the herbs *Pasithaea coerulea* and *N. chilensis.* We did not detect *P. coerulea* in the diet, although it was present in the field in the two years of the study. In accordance with our findings, JIMÉNEZ (1990) also found high consumption of *N. chilensis.* He noted that when he offered dead and fresh leaves of the same plant, chinchillas often preferred the dead leaves.

It is important to note here that we did not distinguish different structures or parts for the same plant species eaten by chinchillas. Chinchillas may have consumed selectively different plant structures in different seasons or for different plant availabilities in the field as reported by SERRA (1979). Our study could not evaluate any of these potential scenarios.

Diet similarity: Because of the lack of quantitative plant availabilities during the years sampled, we could not infer food preference by chinchillas. We did, however, calculate the degree of diet similarity within years and between years. Comparing contrasting seasons (i. e., summer vs. winter), similarity was lower during the wet year ($R_0 = 0.58$) than during the dry year ($R_0 = 0.83$). This is consistent with the lower number of plant species available during the dry year (Tab. 1).

In contrast, higher number of plant species during the summer of the wet year compared with that of the winter, could render a consumption of different plant species by chinchillas, and thus results in a lower diet similitude. On the other hand, the low similitude found between the two winters ($R_0 = 0.20$) compared to that of the two summers ($R_0 = 0.52$), points in the same direction as above: rainfall appears to trigger plant production that is detected in the chinchilla diet during the summer.

Based on the above analysis, we conclude that chinchilla is a generalist and opportunist herbivorous rodent, incorporating herbaceous plants into its diets when available. This is seen as a dietary adaptation to an ecosystem that is highly variable in rainfall and thus primary production, a characteristic of the arid shrublands of north central Chile.

Acknowledgements

We are grateful to the Chilean Forest Service (IV Region, Chile) for logistical support, and to ranger BALDOMERO PEÑA for his knowledge and help in the field. We thank RONALD GETTINGER and three other reviewers for their constructive comments. The help of GINA ARANCIO for providing access to the herbarium of Universidad de La Serena, and for identifying the plant species is appreciated. KATJA KUNZ kindly translated the abstract into German. This research was funded by grants FONDECYT 1981122 and DIULS 120-2-81.

Zusammenfassung

Saisonale Ernährungsgewohnheiten des gefährdeten Chinchilla (*Chinchilla lanigera*): Der Effekt von Niederschlag

Anhand der Zusammensetzung von Kotproben studierten wir die Ernährungsgewohnheiten des gefährdeten Nagers *Chinchilla lanigera*. In zwei Jahren unterschiedlicher Niederschlagshäufigkeit (1992: 242 mm; 1993: 123 mm) sammelten wir in verschiedenen Jahreszeiten Chinchilla-Kotproben in der El Cuyano-Schlucht, die an das Chinchilla-National-Reservat im nördlichen Zentral-Chile (31° 29′ 10.8″ S, 71° 03′ 43,9″ W) angrenzt. Die wesentliche Futterpflanze ist die mehrjährige Gramineen-Art *Nassella chilensis*. Chinchillas zeigten während des niederschlagsreicheren Jahres eine weitere trophische Nische als während des Trockenjahres. Beobachtet wurden die Nutzung von 55,5% bzw. 40,7% von jeweils 38 bzw. 27 verfügbaren Pflanzen. Während des niederschlagsreicheren Jahres variierte die Nahrungszusammensetzung zwischen Winter und Sommer weniger (Horn-Index $R_0 = 0{,}58$) als während des Trockenjahres ($R_0 = 0{,}83$). Im mehrjährigen Vergleich sind größere Unterschiede im Winter ($R_0 = 0{,}20$) als im Sommer ($R_0 = 0{,}52$) zu beobachten. Chinchillas sind herbivore Generalisten, deren opportunistische Ernährungsgewohnheiten als Anpassung an die Aridität und die niederschlagsbedingten Änderungen im Nahrungsangebot im nördlichen Zentral-Chile zu deuten sind.

References

BAUMGARTNER, L. L.; MARTIN, A. C. (1939): Plant histology as an aid in squirrel food-habit studies. J. Wildlife Manage. **3**, 266–268.

BROWER, J. E.; ZAR, J. H. (1984): Field and Laboratory Methods for General Ecology. Dubuque, Iowa: W. C. Brown Publishers.

FUENTES, E. R.; HAJEK, E. R.; ESPINOZA, G. (1988): Same consequences of rainfall variability for mediterranean-type ecosystems in Chile. In: Proceedings of the 5th International Conference on Mediterranean Ecosystems: time scales and water stress. Ed. by F. DI CASTRI, C. FLORET, S. RAMBAL, and J. ROY. Paris: Internat. Union Biol. Sci. Pp. 342–360.

GAJARDO, R. (1978): Antecedentes preliminares para la determinación de la comunidades vegetales presentes en Aucó. (Ilapel, IV Región). Ciencias Forestales (Chile) **1**, 19–27.

GUTIÉRREZ, J. R.; MESERVE, P. L.; HERRERA, S.; CONTRERAS, L. C.; JAKSIC, F. (1997): Effects of small mammals and vertebrate predators on vegetation in the Chilean semiarid zone. Oecologia **109**, 398–406.

HAJEK, E. R.; DI CASTRI, F. (1976): Bioclimatografía de Chile. Santiago, Chile: Dirección de investigación de la vice-rectoría académica, Universidad Católica de Chile.

HORN, H. S. (1966): Measurement of “overlap” in comparative ecological studies. Am. Nat. **100**, 419–424.

JIMÉNEZ, J. (1990): Bases biológicas para la conservación y el manejo de la chinchilla chilena silvestre. Proyecto conservacicón de la chinchilla chilena (*Chinchilla lanigera*). CONAF-WWF 1297. Final report, March 1987–February 1990. CONAF IV Región, Chile.

Jiménez, J. E. (1994): Overuse and endangerment of wildlife: the case of Chilean mammals. Medio Ambiente (Chile) **12**, 102–110.

Jiménez, J. E. (1995): Conservation of the last wild chinchilla (*Chinchilla lanigera*) archipelago: a metapopulation approach. Vida Silvestre Neotropical **4**, 89–97.

Jiménez, J. E. (1996): The extirpation and current status of wild chinchillas *Chinchilla lanigera* and *C. brevicaudata*. Biol. Conserv. **77**, 1–6.

Jiménez, J. E.; Feinsinger, P.; Jaksic, F. M. (1992): Spatiotemporal patterns of an irruption and decline of small mammals in northcentral Chile. J. Mammalogy **73**, 356–364.

Meserve, P. L. (1976): Food relationships of rodent fauna in a California coastal sage scrub community. J. Mammalogy **57**, 300–319.

Mohlis, C. (1983): Información preliminar sobre la conservación y manejo de la chinchilla silvestre en Chile. Boletín Técnico No. 3, Corporación Nacional Forestal, Santiago, Chile.

Serra, M. T. (1979): Composición botánica y variación estacional de la alimentación de *Chinchilla lanigera* en condiciones naturales. Ciencias Forestales (Chile) **1**, 11–18.

Shannon, C. E.; Weaver, W. (1949): The Mathematical Theory of Communication. Urbana, Illinois: University of Illinois Press.

Sparks, D. R.; Malechek, J. C. (1968): Estimating percentage dry weight in diets using a microscopic technique. J. Range Manage. **21**, 264–265.

Veloso, C.; Bozinovic, F. (1993): Dietary and digestive canstraints on basal energy metabolism in a small herbivorous rodent. Ecology **74**, 2003–2010.

Authors' addresses: Artuto Cortés and Eduardo Miranda, Departamento de Biología, Facultad de Ciencias, Universidad de La Serena, Casilla 599, La Serena, Chile; Jaime E. Jiménez, Laboratorio de Ecología, Departamento de Ciencias Básicas, Universidad de Los Lagos, Casilla 933, Osorno, Chile. (e-mail: jjimenez@ulagos.cl).