Journal of Arid Environments (1999) 42: 129–135
Article No. jare.1999.0512
Available online at http://www.idealibrary.com on IDEAL®

Small mammals of the Atacama Desert (Chile)

Fabian M. Jaksic*, Juan Carlos Torres-Mura†, Cintia Cornelius* & Pablo A. Marquet*

**Departamento de Ecología, P. Universidad Católica de Chile, Casilla 114-D, Santiago, Chile*
†Sección Zoología, Museo Nacional de Historia Natural, Casilla 787, Santiago, Chile

(Received 16 September, accepted 15 March 1999)

The little-known mammalian fauna of the Atacama Desert and adjacent Puna in northern Chile is analysed by means of live-trapping, and examination of fox scats and owl pellets. On the basis of physiognomy, climate, altitude and vegetation, four biomes were recognized: coastal lowland Lomas, mid-altitude Riparian and Oasis biomes, and highland Puna. A total of 188 individuals in six small mammal species was caught with 2736 trap-nights chiefly during the summer months of 1997 and 1998. Representatives of another four small mammal species were detected among 123 fox scats (*Pseudalopex* spp.). A total of 346 pellets cast by Barn owls (*Tyto alba*) showed that they caught species not found in the fox diet, but captured in Sherman traps. The mammal sampling effected by live-traps, foxes and owls was rarely coincident, with some species collected only by traps or by foxes (owls coincided nicely with traps in presence–absence records). Even when captured by the three, the proportional representation of small mammals in live-traps, fox scats and owl pellets differed markedly. It is recommend that all these means of data collection (and perhaps snap-traps) are used to assess the mammalian biodiversity of any little-known site, lest surveying results be seriously flawed.

Keywords: rodents; marsupials; foxes; owls; surveys; biodiversity; predation

Introduction

The warm Atacama Desert (roughly 17° to 27°S) constitutes the Chilean part of the great Pacific Coastal Desert that stretches from the south of Ecuador to the northern part of Chile, strapped between the Pacific Ocean on the west and the Andean Ranges on the east (Marquet, 1994). Considered to be the most barren desert in the world, it contains some dispersed but replicated habitats which are more benign for the existence of flora and fauna: the coastal shores, the surroundings of lakes, lagoons, rivers, streams, and a few isolated oasis-like wetlands. Toward the east of the Atacama, and embraced by two major branches of the Andean Ranges, a highland area (>3000 m elevation) known locally as Puna develops between *c.* the same latitudes and is a cold desert. Apart from wetlands associated with water courses and bodies, the Puna is characterized by a singular habitat type: the bogs, known locally as either vegas or bofedales. In addition, because

0140–1963/99/060129 + 07 $30.00/0

of the more generous supply of water, a number of vegetation formations from tussock grasslands to scrublands and even to an endangered forest type (*Polylepis* sp.; see nomenclature source for plants below) develop in this high-altitude area.

The mammalian fauna of Chile's Atacama Desert is among the least-known in the country (Jaksic, 1997), specifically in comparison to the southern cone of South America (Marquet, 1994), and surely the least-known of the deserts in four continents (Kelt *et al.*, 1996). By taxon, foxes (*Pseudalopex culpaeus* and *P. griseus*; see nomenclature source for vertebrates below) have received scant attention, aside from focussing on their diet (Simonetti *et al.*, 1984; Marquet *et al.*, 1993*a*), and a single cricetid mouse (*Phyllotis* sp.) has been analysed from the viewpoint of its energetics and torpor (Bozinovic and Marquet, 1991). Thus far, most of what is known about the Atacama Desert mammalian fauna consists of fragmented notes in four general works (Osgood, 1943; Mann, 1978; Pine *et al.*, 1979; Jaksic, 1997), and the treatment by Marquet (1994).

The mammalian fauna of the Chilean high Andean plateau or Puna is better known simply because more expeditions have been made to that area. The authors were already mentioned (see Jaksic, 1997, for a general overview), an exception being the report by Marquet *et al.* (1993*b*) on the natural history of the cavy *Microcavia niata*.

In this paper the authors expand the knowledge of the mammalian fauna of the Atacama Desert and adjacent Puna areas, based on trapping and analysis of fox scats and owl pellets collected in several localities with different physiognomy. This work was largely performed during 1997 and 1998.

Study area and methods

Scientific nomenclature

Marticorena & Quezada (1985) are followed for plants and Jaksic (1997) for vertebrates.

Study area

On the basis of physiognomy, climate, altitude and vegetation, four biomes were recognized within the region: coastal lowland Lomas, mid-altitude Riparian and Oasis biomes, and highland Puna (see Marquet *et al.*, 1998). Between one and five sites per biome were surveyed for small mammals, fox scats and owl pellets (Fig. 1).

Lomas biome: (a) *Paposo (25°00′27″S, 70°26′43″W, 550 m elev.)*: This coastal site is dominated by cacti (*Eulychnia* sp. and *Trichocereus* sp.) and *Euphorbia lactiflua*, a large shrub. Yearly precipitation averages 15·5 mm, evenly distributed throughout the year.

Riparian biome: (b) *Chiu-Chiu (22°18′01″S, 68°38′26″W, 2534 m elev.)*: This interior site is 10 km W of the Chiu-Chiu town, along the Loa River. A large portion of the land bordering the river is cultivated with alfalfa (*Medicago sativa*) and vegetables (carrot, lettuce, celery, garlic, etc.). A common practice is to set fire to the grass *Distichlis spicata* and the reed *Cortaderia atacamensis* to open land for agriculture. Very few shrubs are found. Yearly precipitation averages 5·4 mm, falling mostly during summer.

(c) *Quitor (22°53′S, 68°12′W, 2500 m elev.):* This interior site is 2 km south of the oasis of San Pedro de Atacama, along the San Pedro River. There is some agricultural activity in this area, but it still is dominated by shrubs (*Pluchea absinthioides* and *Atriplex* sp.) and reeds such as *Cortaderia atacamensis*. Yearly precipitation averages 33 mm, concentrated in summer months.

Oasis biome: (d) *Beter (22°58′S, 68°13′W, 2380 m elev.)*: This interior site is 8 km S of the oasis of San Pedro de Atacama. Area with abandoned agricultural fields, and dominated by shrubs (*Atriplex* sp. and *Pluchea absinthioides*). A few scattered trees

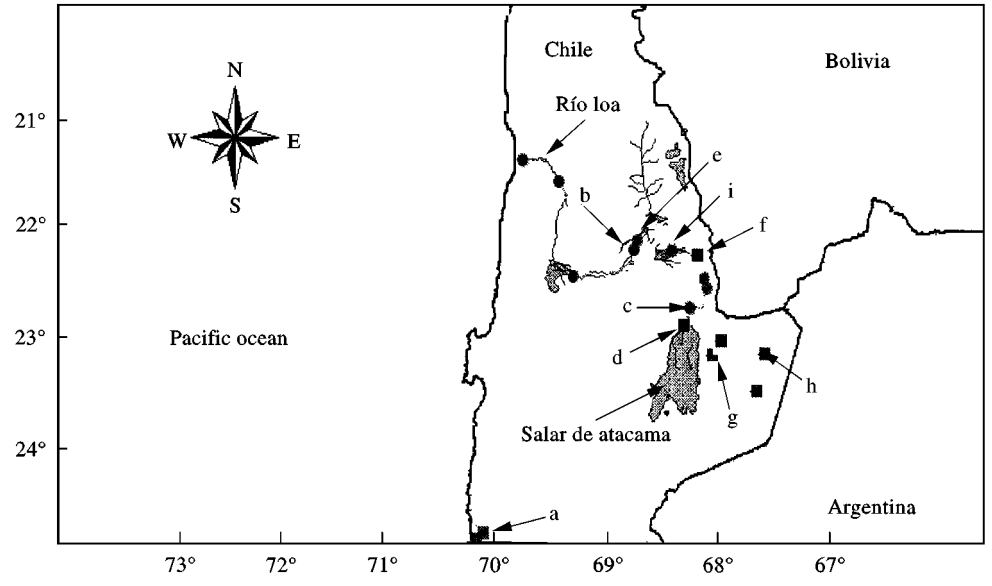

Figure 1. Study sites in the Atacama Desert. (a) Paposo, (b) Chiu-Chiu, (c) Quitor, (d) Beter, (e) Río Salado, (f) Coya, (g) Salar de Aguas Calientes, (h) Salar de Quisquiro, (I) Toconce. See details under Study area.

(*Prosopis* sp.) are still found here. Yearly precipitation averages 33 mm, mostly during summer.

Puna biome: (e) *Río Salado (22°16′37″S, 68°12′59″W, 3108 m elev.)*: This interior site is in the Puna belt of the Andean Ranges (Villagrán *et al.*, 1981). The dominant vegetation is a sparse scrub of small thorny shrubs such as *Chuquiraga atacamensis* and *Fabiana densa*. Yearly precipitation averages 62·3 mm, concentrated in summer.

(f) *Coya (22°25′58″S, 68°08′32″W, 3782 m elev.)*: This site is also in the Puna belt, but the dominant species are the shrubs *Parastrephia lucida* and *Parastrephia quadrangularis* Yearly precipitation averages 141·6 mm and occurs in summer.

(g) *Salar de Aguas Calientes (23°10′07″S, 67°23′57″W, 4550 m elev.)*: The dominant vegetation is typical of the Puna belt, chiefly *Parastrephia quadrangularis*, and tussock grasses such as *Festuca* sp. No measurements of yearly precipitation are available.

(h) *Salar de Quisquiro (23°11′40″S, 67°18′59″W, 4100 m elev.)*: Area dominated by Puna vegetation, mostly by the shrubs *Parastrephia* and *Baccharis*. No measurements of yearly precipitation are available.

(i) *Toconce (22°14′24″S, 68°08′20″W, 3412 m elev.)*: Area with Puna vegetation, dominated by the shrubs *Parastrephia lucida* and *P. quadrangularis*. Yearly precipitation averages 79 mm.

Trapping procedures

Small mammals were trapped using grids of six columns by eight rows, with each trapping station separated 15 m and equipped with one medium Sherman trap, baited with rolled oats. Each grid of 48 traps/0·79-ha was operated during three consecutive nights. In each site two grids were set, except for Salar de Quisquiro were there was one grid and Quitor were there was no grid. Captured small mammals were marked with a numbered ear tag, weighed, sexed and then released. Total trapping effort was 2736 trap-nights chiefly during summer months (November 1996, January 1997, and January 1998), with a negligible effort effected during July 1997.

Fox scat and owl pellet collections and analyses

In parenthesis is the number of *Pseudalopex* fox feces collected by site and date: Paposo (four in January 1997), Chiu-Chiu (seven in November 1996 and eight in July 1997), Quitor (16 in January 1997), Beter (34 in January 1998), Río Salado (two in November 1996), Coya (10 in November 1996 and 18 in July 1997), Salar de Aguas Calientes (nine in January 1997), Salar de Quisquiro (nine in January 1997), Toconce (six in January 1998). Total was 123 fox scats, 79% collected during two summer months (November or January), and 21% during winter (July). Barn owl (*Tyto alba*) pellets in, around, and under nests and roosts were found only in Chiu-Chiu (145 in November 1996 and 183 in July 1997) and in Quitor (18 in January 1997). Total was 346 pellets plus uncounted fragments and prey remains, 47% collected during two summer months (November or January), and 53% during winter (July). The distribution of fox scats and owl pellets by biomes is shown in Table 1.

Most vertebrates in the pellets were identified on the basis of skulls, beaks or dentary pairs (Reise, 1973), whichever gave the highest count. For remains such as hair and feathers, reference collections were used and these prey quantified assuming the smallest possible number of individuals (e.g. hair or feathers of a given species were deemed as representing only one individual). For insect identification, Peña (1986) was favoured and these prey quantified by counting head capsules and mandibles. Scorpions were easily counted by noting the presence of pincers or stings. Prey items were identified to the finest possible taxonomic category in all cases, as recommended by Marti (1987).

Results and discussion

A total of 188 different individuals comprising six small mammal species was caught in Sherman traps positioned in the four major biomes recognized in the Atacama Desert and adjacent high-altitude Puna. Not a single small mammal was trapped in the Lomas (gently-rolling sparse scrubland along the coastal fringe of the Desert). Most of them were trapped in the Puna, but this result is meaningless without consideration of trapping effort (Table 2). Indeed, on a per capita trap effort, it appears that small mammals were more abundant (or easy to trap) in the two mid-altitude, riparian-like biomes (Riparian proper and Oasis), than in the high-altitude Puna biome (Table 1). This happened despite a 3*x* trapping effort invested in five Puna sites combined.

Table 1. *Percentage overall prey identified in fox scats/owl pellets collected in four biomes of the Atacama Desert and adjacent highland Puna of northern Chile. Notice that owl pellets were found only in the Riparian biome*

Prey	Lomas biome	Riparian biome Fox/Owl	Oasis biome	Puna biome
Mammals	5.3	40.6/99.3	69.2	85.1
Birds	0.0	5.8/0.6	9.6	14.9
Reptiles	0.0	5.8/0.0	0.0	0.0
Amphibians	0.0	0.0/0.1	0.0	0.0
Gastropods	2.6	0.0/0.0	0.0	0.0
Insects	86.8	47.8/0.0	21.2	0.0
Arachnids	5.3	0.0/0.0	0.0	0.0
Total prey by number	38	69/692	52	67
Total scats/pellets by no.	4	31/346	34	54

Table 2. *Small mammals live-trapped versus those identified in fox scats and owl pellets collected in four biomes of the Atacama Desert and adjacent highland Puna of northern Chile. Except for the marsupial* Thylamys, *all other small mammals are rodents. Notice that owl pellets were found only in the Riparian biome*

Small mammals	Lomas biome Traps/Scats	Riparian biome Traps/Scats/Pellets	Oasis biome Traps/Scats	Puna biome Traps/Scats
Didelphidae: *Thylamys elegans*	0/0	3/0/8	0/0	0/0
Muridade: *Mus musculus*	0/0	12/0/23	0/0	0/0
Cricetidae: *Akodon olivaceus*	0/1	0/0/0	0/0	0/0
Cricetidae: *Akodon andinus*	0/0	19/4/50	2/0	9/2
Cricetidae: *Akodon sp.*	0/0	0/0/0	0/0	13/0
Cricetidae: *Phyllotis xanthopygus*	0/0	18/9/200	22/16	32/5
Cricetidae: *Phyllotis magister*	0/0	3/0/51	0/0	0/0
Cricetidae: *Phyllotis sp.*	0/0	0/0/5	0/0	0/0
Cricetidae: *Eligmodontia puerulus*	0/0	0/1/0	13/3	42/8
Abrocomidae: *Abrocoma cinerea**	0/0	0/1/0	0/0	0/7
Chinchillidae: *Lagidium viscacia**	0/0	0/1/0	0/0	0/11
Ctenomyidae: *Ctenomys* sp.*	0/0	0/0/0	0/9	0/3
Unidentified rodent	0.1	0/9/9	0/7	0/20
Total in traps/scats/pellets (No.)	0/2	55/25/346**	37/35	96/56
Trap effort (No. trap-nights)	288	576	288	1584
Mammals/100 trap-hights	0.0	9.5	12.8	6.1

*Medium Sherman trap inadequate for capturing this rodent, which nonetheless was sighted (pers. obs.)
**Plus fragments picked up from under nests and roosts.

In all biomes with small-mammal captures, the cricetid rodent *Phyllotis xanthopygus* was either the most—or second most—abundant species, pointing out its high ubiquitousness, versatility in biome distribution, or generalized habitat preferences (Table 2). Despite its name, *Akodon andinus* was the second most abundant rodent at mid-elevations and not in the high-altitude Puna sites. *Phyllotis xanthopygus* was the most abundant rodent in the only oasis site sampled, and *Eligmodontia puerulus* was the most common rodent in the high-altitude Puna. No species appeared to be exclusively distributed in high altitudes, but some species were trapped only in low to mid-altitudes (the native marsupial *Thylamys elegans*, the introduced murid *Mus musculus*, and the native cricetid *Phyllotis magister*).

Overall, mammalian prey identified in fox scats constituted from as little as 5% of total items in the coastal Lomas to a peak of 85% in the highland Puna (Table 1). Bird predation showed the same trend (0% in Lomas, 15% in Puna). Reptiles (both lizards and snakes) were detected only in the diet of Riparian foxes, and gastropods (clams) only in that of Lomas foxes. Insects followed the opposite trend of mammal consumption, from a high 87% in the diet of coastal Lomas foxes to a low 0% in that of highland Puna foxes. Arachnids (indeed, scorpions) were detected only in the diet of Lomas foxes. These results are not surprising (Marquet *et al.* 1993*a*): there is very little to eat along the coastal fringe of the Atacama Desert, and only the smaller *Pseudalopex griseus* is found here. The larger *Pseudalopex culpaeus* is found in the higher-productivity Riparian, Oasis, and Puna biomes. Barn owls were detected only in the Riparian biome, and were almost exclusively mammal eaters ($>99\%$ of their diet by number).

Fox predation on small mammals was rather idiosyncratic (Table 2). Disregarding unidentified rodents, foxes did not appear to take *Thylamys elegans*, *Mus musculus* or *Phyllotis magister* in any biome, and preyed less than expected on *Akodon andinus* and about as expected on *Phyllotis xanthopygus* in the Riparian biome. Of course, it would be naive to attach any statistical significance to these trends because of the known timing of small-mammal trapping *vs.* the unknown age of the scats collected (recent as they seemed to be). In the Oasis biome, predation on *Phyllotis xanthopygus* also seemed in line with its measured availability in the field (or in the traps), whereas *Eligmodontia puerulus* appeared as underconsumed. The overconsumption of *Ctenomys* sp. is of course an artefact, because Sherman traps are ineffective for this fossorial rodent. At the Puna sites, the underconsumption of *Phyllotis xanthopygus* and of *Eligmodontia puerulus* by foxes may rest on some solid—if still unknown—ground, while the overconsumption of *Abrocoma cinerea*, *Lagidium viscacia* and *Ctenomys* sp. is surely an underestimate of their actual abundance in the field because of inadequate traps for them. The first two rodents are obviously too big for the size of the medium-sized Sherman traps used, and the third one is not known to fall in such traps ever.

Barn owls at the Riparian biome differed strongly in diet from foxes. The former did consume *Thylamys elegans*, *Mus musculus* and *Phyllotis magister*, whereas the latter did not. Barn owls appeared to overconsume *Phyllotis xanthopygus* and to underconsume *Akodon andinus*.

As has been demonstrated time and again, live-traps and predators sample local or regional mammalian faunas differently. In this case, Sherman traps did not reveal the presence of the rodents *Akodon olivaceus*, *Abrocoma cinerea*, *Lagidium viscacia* or *Ctenomys* sp., whereas foxes did take them as prey. On the other hand, foxes were inadequate samplers of *Thylamys elegans*, *Mus musculus*, and of *Phyllotis magister* at any site, while the Barn owl *Tyto alba* did take them all to a relevant extent.

Live-traps (and perhaps snap-traps), scats and pellets of predators of all types should be used to assess the mammalian species richness of any little-known site, LEST SURVEY RESULTS BE SERIOUSLY FLAWED. This study in the Atacama Desert and surrounding areas supports this conclusion.

This research was funded by grant FONDECYT 596-0011 to P.A.Marquet. E. Silva identified prey contents in scats, pellets, and remains.

References

Bozinovic, F. & Marquet, P.A. (1991). Energetics and torpor in the Atacama desert-dwelling rodent *Phyllotis darwini rupestris*. *Journal of Mammalogy*, 72: 734–738.

Jaksic, F.M. (1997). *Ecología de los vertebrados de Chile*. Santiago: Ediciones Universidad Católica de Chile. 262 pp.

Kelt, D.A., Brown, J.H., Heske, E.J., Marquet, P.A., Morton, S.R., Reid, J.R.W., Rogovin, K.A. & Shenbrot, G. (1996). Community structure of desert small mammals: comparisons across four continents. *Ecology*, 77: 746–761.

Mann, G. (1978). Los pequeños mamíferos de Chile (marsupiales, quirópteros, edentados y roedores). *Gayana Zoología (Chile)*, 40: 1–342.

Marquet, P.A. (1994). Diversity of small mammals in the Pacific Coastal Desert of Peru and Chile and in the adjacent Andean area: biogeography and community structure. *Australian Journal of Zoology*, 42: 527–542.

Marquet, P.A., Contreras, L.C., Torres-Mura, J.C., Silva, S.I. & Jaksic, F.M. (1993*a*). Food habits of *Pseudalopex* foxes in the Atacama desert, pre-Andean ranges, and the high Andean plateau of northernmost Chile. *Mammalia*, 57: 130–135.

Marquet, P.A., Contreras, L.C, Silva, S.I., Torres-Mura, J.C. & Bozinovic, F. (1993*b*). Natural history of *Microcavia niata* in the high Andean zone of northern Chile. *Journal of Mammalogy*, 74: 136–140.

Marquet, P.A., Bozinovic, F., Bradshaw, G.A., Cornelius, C., González, H., Gutiérrez, J.R., Hajek, E.R., Lagos, J.A., Lopez-Cortés, F., Núñez, L., Rosello, E.F., Santoro, C., Samaniego, H., Standen, V.G., Torres-Mura, J.C. & Jaksic, F.M. (1998). Los ecosistemas del desierto de Atacama y área andina adyacente en el norte de Chile. *Revista Chilena de Historia Natural*, 71: 593–617.

Marti, C.D. (1987). Raptor food habits studies. In: Giron Pendleton, B.A., Millsap, B.A., Kline, K.W. & Bird, D.M. (Eds.), *Raptor Management Techniques Manual*, pp. 67–80. Washington, DC: National Wildlife Federation.

Marticorena, C. & Quezada, M. (1985). *Catálogo de la flora vascular de Chile. Gayana (Botánica)*, 42: 1–157.

Osgood, W.H. (1943). The mammals of Chile. *Field Museum of Natural History, Zoological Series*, 30: 1–268.

Peña, L.E. (1986). *Introducción a los insectos de Chile*. Santiago: Editorial Universitaria. 253 pp.

Pine, R.H., Miller, S.D. & Schamberger, M.L. (1979). Contributions to the mammalogy of Chile. Mammalia, 43: 339–376.

Reise, D. (1973). Clave para la determinación de los cráneos de marsupiales y roedores chilenos. *Gayana Zoología (Chile)*, 27: 1–20.

Simonetti, J.A., Poiani, A. & Raedeke, K.J. (1984). Food habits of *Dusicyon griseus* in northern Chile. *Journal of Mammalogy*, 65: 515–517.

Villagrán C., Armesto, J.J. & Kalin Arroyo, M.T. (1981). Vegetation in a high Andean transect between Turi and Cerro León in northern Chile. *Vegetatio*, 48: 3–16.