

# Small mammals as paleoenvironmental indicators: validation for species of central Chile

Micromamíferos como indicadores paleoambientales:  
validación para especies de Chile central

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## ABSTRACT

The validity of two approaches to infer past environments using archaeofaunal remains is tested based on the small mammals of central Chile. The first approach considers taxa as attributes of the sample, focusing on their pattern of presence/absence. This approach is shown to be invalid. Small mammals of central Chile thrive over a wide range of habitat types, and are relatively insensitive to varying conditions. The second approach considers taxa as variables of the sample, focusing on the temporal variation in the relative abundance of taxa. This approach was validated with some species which varied in abundance predictably relative to environmental variables. This approach is less parsimonious but more informative, and could be utilized to infer past environments when target species are generalists. In addition, the natural history of the target species should be considered in order to select the best approach for reconstructing paleoenvironments.

Key words: Archaeofaunal analysis, vegetational change

## RESUMEN

La validez de dos aproximaciones para inferir paleoambientes empleando restos arqueofaunísticos es contrastada en base a la fauna de micromamíferos de Chile central. Una primera aproximación considera los taxa como atributos de la muestra, centrándose en la variación temporal del patrón de presencias/ausencias. Se demuestra que esta aproximación es inválida. Los pequeños mamíferos de Chile central están presentes sobre un amplio rango de tipos de hábitats, siendo insensibles como indicadores de cambios ambientales. La segunda aproximación considera los taxa como variables de la muestra, centrándose en la variación temporal de la abundancia relativa de éstos. Esta aproximación es validada, en virtud que algunas especies varían de forma predecible en relación a la variable ambiental de interés. Este enfoque es menos parsimonioso pero más informativo que aquella aproximación que considera los taxa como atributos, y debería preferirse para inferir paleoambientes cuando las especies utilizadas son generalistas. Además, junto con las ventajas de una determinada aproximación metodológica, la historia natural de las especies indicadoras debería considerarse para seleccionar el método apropiado en la reconstrucción de paleoambientes.

Palabras claves: Análisis de arqueofauna, cambios vegetacionales.

## INTRODUCTION

Vertebrate species found in archaeological sites are commonly used as indicators of paleoenvironmental conditions. Vertebrates are sensitive to environmental conditions, and a given species may only be present, or be more abundant, in a specific situation (Findley 1964). Thus, temporal changes in the distribution and abundance of vertebrate taxa may reveal the nature of the environment during the time of deposition (e.g., Graham 1976, Grayson 1977).

Analyses of archaeological vertebrates are principally of two kinds. A first type of

analysis treats the presence/absence of vertebrate taxa as an attribute of the sample (Grayson 1981 for review). The bases for paleoenvironmental inferences are the characteristics of the species recorded in the archaeofaunal record. That is, if species *i* currently occurs in a habitat (climate, environment) type *x*, the environment at the time of deposition must have been of type *x*. This approach therefore, restricts the suite of useable taxa to habitat or environmental specialists only. Further, this analysis is asymmetrical. Presences are interpretable, but absences are not. The latter may imply that a given species was

not inhabiting the area at the time the other taxa deposited, or that such taxon was lost in the process of deposition or it was not recovered (Grayson 1981).

In the second type of analysis, variation in the abundance of vertebrates are incorporated as variables. Although this analysis provides more information, it is more difficult to carry out. The use of taxon abundance as a variable requires the same assumptions as the analysis of taxon presence/absence, and in addition problems associated with the quantification of the archaeofaunal remains. The abundance of recovered remains should be proportional or representative of the material deposited in the site, and in turn should be representative of the fauna inhabiting the area at the time the remains were deposited (Grayson 1981). Given these limitations, the approach using the presence/absence of taxa as an attribute has been proposed to be the most parsimonious procedure for reconstructing paleoenvironments (Grayson 1981).

Regardless of the approach, archaeological vertebrates can be considered as calculation tools (Loehle 1983). As such, there is a range of situations in which they may be utilized to reconstruct paleoenvironments. Thus, the use of vertebrates as indices of paleoenvironmental changes should be validated each time a different suite of species is used as indicators (cf. Grayson 1983). An attempt is presented here for small mammal species of central Chile. To do so, I briefly describe the ecological problems that the use of archaeological material of small mammals should address. In addition, I evaluate the heuristic value of using rodent species currently inhabiting central Chile for providing information regarding types of environments, both in terms of presence/absence and of frequency. Finally, I test the validity of these small mammal species to infer past environments based on archaeofaunal material from the Andean foothills of central Chile.

*The environmental problem: shrub cover changes in prehistoric-historic times in central Chile*

The predominant natural vegetation of central Chile is currently a shrubland, with a mosaic of evergreen shrubs arranged in multispecific clumps (Fuentes *et al.* 1984). It has been suggested that this vegetation

was originally a woodland (*sensu* Lincoln *et al.* 1982) rather than a shrubland, but no empirical evidence has been presented (Rundel 1981). Early accounts indicate that central Chile was covered by woodlands, which persisted as isolated patches up to the nineteenth century. Human exploitation may have reduced tree and shrub coverage for agricultural purposes, to the extent that the current configuration may be unrelated to the original vegetation (Rundel 1981; see Miller 1980 for a review). The case to be examined is whether there has been a historical reduction in vegetation cover in central Chile. If this is the case, small mammal species that currently prefer open vegetation should have been absent (utilizing the presence/absence criteria) or should have been less abundant in the past than presently (utilizing the criteria of species frequency).

*Habitat affinities of small mammals of central Chile*

The shrublands of central Chile are inhabited by several species of small mammals, of which eight will be considered here, using the available information on their habitat affinities. If the occurrences of small mammals are valid paleoenvironmental indicators, their presence should be restricted to specific portions of a vegetation continuum, ranging from high cover (around 100%, representing remnants of the presumed past woodland) to low shrub cover (30% or less). Information regarding presence/absence of species in shrubland areas of different shrub cover as well as their abundance was obtained from a perusal of the literature (indicated in Table 1). The small mammal species considered were four cricetids: *Akodon longipilis*, *A. olivaceus*, *Oryzomys longicaudatus*, and *Phyllotis darwini*, along with two octodontids: *Octodon degus* and *Octodon lunatus*, one abrocomid: *Abrocoma bennetti*, and a didelphid marsupial: *Marmosa elegans*.

The presence/absence pattern indicates that seven out of the eight species are present over the complete range of variation of shrub cover (expressed as the percentage of the ground surface covered by shrub canopies or their projections). Only *Octodon lunatus* is restricted to sites with high cover (Table 1). That is, small mammals tend to be generalists regarding

TABLE 1

Matrix of presence/absence of small mammal species from central Chile in areas of evergreen shrublands of different shrub cover (expressed as percentage). Codes for species are: Alo = *Akodon longipilis*, Aol = *Akodon olivaceus*, Olo = *Oryzomys longicaudatus*, Pda = *Phyllotis darwini*, Mel = *Marmosa elegans*, Abe = *Abrocoma bennetti*, Ode = *Octodon degus*, and Olu = *Octodon lunatus*.

Matriz de presencias/ausencias para micromamíferos centro chilenos en áreas de matorral siempreverde de diferente cobertura (expresada en porcentaje). El código para especies está descrito en el párrafo anterior.

| Shrub cover (%)  | Alo | Aol | Olo | Pda | Mel | Abe | Ode | Olu | Source |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|--------|
| 40 <sup>a*</sup> |     | +   | +   | +   | +   | +   | +   |     | 1      |
| 40 <sup>a</sup>  |     | +   | +   | +   | +   | +   | +   | 1   | 1      |
| 40 <sup>b</sup>  | +   | +   |     | +   | +   | +   | +   |     | 2      |
| 49               |     | +   | +   | +   | +   | +   | +   |     | 3      |
| 51               | +   | +   | +   | +   | +   |     | +   |     | 4      |
| 54               | +   | +   | +   | +   | +   |     | +   |     | 5      |
| 56               | +   | +   | +   | +   | +   | +   | +   |     | 6      |
| 59               | +   | +   | +   | +   | +   | +   |     |     | 4      |
| 60               | +   | +   | +   | +   | +   | +   | +   |     | 7      |
| 70 <sup>c</sup>  | +   | +   | +   | +   | +   |     | +   |     |        |
| 70 <sup>c</sup>  | +   | +   | +   | +   | +   |     |     | +   | 2      |
| 85 <sup>d</sup>  | +   | +   | +   | +   | +   | +   | +   | +   | 2      |
| 90 <sup>e</sup>  | +   |     | +   | +   | +   |     |     |     | 1      |
| 90               | +   |     | +   | +   | +   | +   | +   |     | 3      |

\* Range of covers reported from sampling area: <sup>a</sup> 20-60%; <sup>b</sup> 30-50%; <sup>c</sup> 60-80%; <sup>d</sup> 70-80%; <sup>e</sup> 80-100%.

Sources: 1. Jaksić *et al.* (1981); 2. Glanz (1977); 3. Simonetti & Fuentes (unpublished data); 4. Simonetti (1986); 5. Fulk (1975); 6. Iriarte *et al.* (1989) 7. Meserve (1981).

habitat (Glanz 1977). Therefore, if shrub cover has diminished through time in central Chile, a temporal analysis of their pattern of presence/absence will not detect such a change. Clearly, based on presence/absence, central Chilean small mammals are not valid indicators of past environments.

The second approach to paleoenvironmental reconstruction incorporates the abundance of rodents as variables, and assumes that it changes predictably with shrub cover. Here, I test whether the ratio of the abundance of four species changes with shrub cover.

The abundance of *Akodon longipilis* relative to that of *A. olivaceus*, and that of *Octodon degus* relative to *O. lunatus* is a function of shrub cover and provides a valid calculation tool for reconstructing paleoenvironments. *Akodon longipilis* is more common in dense shrublands, same as *Octodon lunatus*, while their congeners *A. olivaceus* and *O. degus* are more abundant in open shrublands (Glanz 1977, 1984). The relationship of the relative abundance of *Akodon* and *Octodon* species to shrub cover is expressed by the negative correlations between the relative abundance of these species and shrub cover. The ratio of the abundance of *A. olivaceus*/*A. olivaceus* + *A. longipilis* is inversely correlated to

shrub cover ( $r_s = -0.90$ ,  $n = 15$ ,  $P << 0.001$ ). Data were collected from Glanz (1977), Jaksić *et al.* (1981), Meserve (1981), Simonetti (1983, 1986), Iriarte *et al.* (1989). Similarly, the partial abundance of *Octodon degus*, that is, the ratio *O. degus*/*O. degus* + *O. lunatus* is also negatively correlated to shrub cover ( $r = -0.90$ ,  $n = 8$ ,  $P = 0.001$ ). Data are from Glanz (1977: fig. 25). A third species of *Octodon*, *O. bridgesi* resembles *O. lunatus* in habitat preferences, being restricted to dense woodlands (see Contreras *et al.* 1987 for review). Therefore, both *A. olivaceus* and *O. degus* should be expected to become progressively more abundant toward recent times if shrub cover has been reduced since the time of chroniclers.

In summary, while small mammals of central Chile are not valid indicators of paleoenvironments based on presence/absence data, they may be valid calculation tools if relative abundance is considered in the archaeozoological sample.

*Field test: historical changes in the abundance of Octodon*

If central Chile was covered by a woodland rather than a shrubland, the relative abundance of *A. olivaceus* and *O. degus* should

increase toward recent times. This hypothesis was empirically tested with faunal material from two archaeological sites at Cajón del Manzano, Maipo River, (i.e., El Manzano 1, and La Batea 1 rockshelters).

Details of the recovery process will be published elsewhere. Briefly, bulk samples taken from natural strata were sieved through 3 and 1.5 mm wide mesh screens. This technique allowed us to recover even isolated molars from cricetid species. Recovered material was determined to species based on molars and mandibles, following standard keys and reference materials (Reise 1973, Pearson 1986<sup>1</sup>). The absolute abundance of each taxon is expressed as the minimum number of individuals (MNI; Grayson 1984).

Remains from at least 117 individuals were recovered from La Batea 1 and 136 from El Manzano 1, comprising 13 different species. Of these, *Akodon* species represented only 5% of the individuals while *Octodon* species accounted for 25% of them. Therefore, the analysis was restricted to species of *Octodon*. Specimens belonging to *O. degus* were distinguished from those of *O. bridgesi* and *O. lunatus* but it was not possible to discriminate between latter two species. However, because both *O. bridgesi* and *O. lunatus* exhibit similar habitat preferences, this

methodological problem does not bias my analysis.

In terms of presence/absence, *O. degus* coexisted with *O. bridgesi-lunatus* for some time as represented in strata 1 to 5 from El Manzano 1, and 5 to 8 at La Batea 1. *Octodon bridgesi-lunatus* disappeared from the faunal record in the uppermost strata (Table 2). Radiocarbon ages for stratum 4 to 6 from La Batea 1 are 1,520 ± 280 B.P., 2,390 ± 130 B.P., and 4,460 ± 180 B.P., respectively. This change suggests a change in habitat conditions at the time of disappearance, when the vegetation may have become more sparse. During the time when both species coexisted, no vegetation change could be inferred.

At El Manzano 1 and La Batea 1 rockshelters, the relative abundance of *O. degus*, (i. e.,  $O. degus/O. bridgesi + O. lunatus$ ), is negatively correlated with time, as indicated in the different strata ( $r_s = -0.67$ ,  $n = 6$ ,  $0.05 < P < 0.10$  for El Manzano 1, and  $r_s = -0.93$ ,  $n = 6$ ,  $P = 0.001$  for La Batea 1). That is, *O. degus* becomes progressively more abundant in recent times, and is relatively rare in older strata. This pattern can not be attributed to sampling error (cf. Grayson 1981), because the absolute value of the coefficient  $O. degus/O. bridgesi + O. lunatus$  is not correlated with sample size (neither with total number of small mammals recovered per stratum nor with the number of *Octodon* specimens per stratum;  $P > 0.20$  in all cases). This approach indicates that the temporal

<sup>1</sup> PEARSON OP (1986) Annotated key for identifying small mammals living in or near Nahuel Huapi National Park and Lanin National Park, southern Argentina, Unpublished manuscript.

TABLA 2

Matrix of presence/absence and partial abundance of *Octodon* species in two rockshelters from Cajón del Manzano, central Chile. Strata with low numbers are more recent than strata with high number denominations. Codes for species are: Ode = *Octodon degus*, Obl = *O. bridgesi-lunatus*.

Matriz de presencia/ausencias y abundancia parcial de especies de *Octodon* en dos aleros rocosos del Cajón del Manzano, Chile central. Estratos denominados con números bajos son más recientes que aquellos con denominaciones más altas. Los códigos para especies son: Ode = *Octodon degus*, Obl. = *O. bridgesi-lunatus*.

| Strata | El Manzano rockshelter |     |               | La Batea rockshelter |     |     |               |
|--------|------------------------|-----|---------------|----------------------|-----|-----|---------------|
|        | Ode                    | Obl | Ode/Ode + Obl | Strata               | Ode | Obl | Ode/Ode + Obl |
| 0      | +                      |     | 1.00          | 3                    | +   |     | 1.00          |
| 1      | +                      | +   | 0.50          | 4                    | +   |     | 1.00          |
| 2      | +                      | +   | 0.82          | 5                    | +   | +   | 0.78          |
| 3      | +                      | +   | 0.69          | 6                    | +   | +   | 0.86          |
| 4      | +                      | +   | 0.25          | 7                    | +   | +   | 0.75          |
| 5      | +                      | +   | 0.67          | 8                    | +   | +   | 0.20          |

change of the relative abundance of *O. degus* is more gradual than that suggested by presence/absence data.

This example with *Octodon* species illustrates the value of small mammals as paleoenvironmental indicators in central Chile, particularly when relative abundance is considered. Further, the consistent change in the relative abundance of *O. degus* and the local extinction of *O. bridgesi-lunatus* suggests an increase in the amount of open shrublands (i. e., a reduction in vegetation cover) in central Chile. Therefore, the hypothesis that central Chile was covered by a woodland rather than a shrubland is supported by the archaeofaunal analysis. Interestingly, the disappearance of *O. bridgesi-lunatus* from La Batea 1 coincides with the development of pre-Columbian agriculture in central Chile (Falabella & Stehberg 1989). Radiocarbon dating (now in progress) of the remaining strata from La Batea 1 and all strata from El Manzano 1 along with the analysis of human cultural remains will allow the establishment of a chronology of the vegetational changes, and of whether this reduction resulted from human exploitation of the vegetation, as is currently assumed (e.g., Miller 1980, Simonetti, 1986), and suggested by the present preliminary analysis.

#### CONCLUSIONS

Small mammals from central Chile are valid indicators of habitat change if relative abundance is considered rather than presence/absence in archaeological samples. The latter method is insensitive to potential environmental changes because central Chilean small mammals are able to survive in most, if not all of the vegetation continuum. Further, recent studies on archaeofaunal samples from southern America suggest that local small mammals are resilient to environmental changes. That is, the abundance of a given species may vary through time associated with postglacial environmental changes, but no extinctions or invasions seem to have occurred (Pearson & Pearson 1982, Pearson 1987, Simonetti & Rau 1989).

The criterion of parsimony mandates that the method with fewer assumptions and less demanding upon the data set should be preferred. However, in this case, the use of presence/absence data is

less informative because the small mammals studied are not habitat specialists as assumed by the approach. Paradoxically then, the less parsimonious method should be preferred in order to reconstruct past environments using Chilean small mammals.

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