Eimeriid Oocysts From Archaeological Samples in Patagonia, Argentina

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Eimeriid Oocysts From Archaeological Samples in Patagonia, Argentina

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ABSTRACT: Oocysts attributable to Eimeria macusaniensis Guerrero et al. 1971, were found in coprolites and in archaeological sediments dating to the Holocene of Patagonia, Argentina. By means of a nonparametric regression using a generalized additive model, a significant relationship was found between the size of the oocysts and their antiquity. Specifically, a reduction in oocyst size over time was discovered, probably due to a parasite response to host replacement, to an extinct eimeriid species common during the Pliocene–Holocene transition, or to environmental changes known for the Holocene. Explanations regarding coevolution between parasites, hosts, and paleoenvironmental conditions are discussed herein.

Paleoparasitological studies focus on parasite remains such as cysts, eggs, and larvae in organic deposits derived from archaeological or palaeontological contexts (Bouchet et al., 2003). Interpretations of this evidence are based on knowledge of cultural, ecological, and biogeographical aspects of the human populations and their accompanying fauna (Reinhardt, 1990, 1992). In meridional Patagonia, there is evidence of human occupation extending to at least 11,000 yr ago (Miotti and Salemme, 2004). Archaeological reconstruction indicates that camelids were a main resource for Patagonian hunter–gatherer populations. Several extinct camelid species, i.e., Lama guanicoe and Paleolama sp., have been identified in fossil faunal remains at the Pleistocene transition (Borrero, 2001). Later, and up to the present, only L. guanicoe is reported in the zooarchaeological literature. At present, Eimeria macusaniensis Guerrero et al., 1971 (Protozoa, Coccidia) and E. ivitaensis Leguía and Casas 1998 are the coccidians with the largest oocyst size parasitizing South American camelids. In the Peruvian Andes, Leguía et al. (1999) found E. macusaniensis in feces of L. alpaca, L. guanicoe, and Vicugna vicugna. In Patagonia, Beldomenico et al. (2003) reported only E. macusaniensis in L. guanicoe feces from Chubut, Argentina (Patagonia).

Host specificity of these coccidians is a useful indicator for the presence of camelids in archaeological deposits and coprolites (Fugassa and Barberena, 2006; Fugassa, 2007; Fugassa et al., 2007). Recently, a large morphometric variability was observed in oocyst sizes in E. macusaniensis examined from different time periods in Patagonia. The aim of the present study was to determine if a temporal trend could be established for E. macusaniensis oocyst dimensions recovered from coprolites and archaeological sediments of the region.

Sixty-two oocysts, each with a thick wall, brown-reddish coloration, and prominent micropyle, and all compatible with E. macusaniensis (Fig. 1), were measured in length and width using a microscope equipped with an ocular micrometer. Oocysts were recovered from coprolites in the archaeological sites of Cerro Casa de Piedra 5 and 7 (CCP5 and CCP7), located in Perito Moreno National Park, Santa Cruz Province, Argentina, in strata dated from 10,000 yr BP (before present). Oocysts found in noncoprolite sediments of the archaeological sites Nombre de Jesús (500 yr BP) and Orejas de Burro I (3,500 yr BP), situated in the province of Santa Cruz, Argentina, and La Arcillosa II located in Tierra del Fuego, Argentina (4,000 yr BP), were also examined. Eimeriid oocyst measurements, arranged by date–time period and mean length and width, are presented in Table I. Because of the difference in sources, i.e., coprolites versus sediments, it could be argued that the oldest cysts might be larger because of better preservation conditions. However, alterations in oocyst structure between coprolites and sediments were not observed. Therefore, the preservation conditions of the coprolites versus sediments did not alter the morphology of the oocysts. For this analysis, the oocysts from coprolites and sediments were comparable.

For the statistical analysis, a nonparametric regression based on a generalized additive model (Hastie and Tibshirani, 1990) was used for length and width. The smooth function was computed using cubic splines, and the link with the variable response was calculated by the identity function.

Results obtained suggest that both of the nonparametric regressions (for length and width) have fit well. The R² was 0.83 for length and 0.81 for width, and the incorporation of the independent variable to both additive models was highly significant (P < 0.001). The plots show the final fitted cubic spline function for length (Fig. 2a) and width (Fig. 2b), along with the observed predictor values, plotted against the partial residuals (this figure permitted an evaluation of the nature of the relationship between the respective predictor [age] and the response variables length [Fig. 2a] and width [Fig. 2b] in the final model). In both plots, there was a general decay tendency in each dependent variable with respect to oocyst age. This tendency was greater between 10,000–8,000 yr BP decreasing until 3,000 yr BP for length and increasing to 5,000 yr BP for width.

The oocysts from coprolites and sediments measured in the present study were attributable to E. macusaniensis, according to descriptions provided by Leguía (1999) in Peru and by Beldomenico et al. (2003) and C. Beldomenico in Patagonia. Eimeria macusaniensis has been reported from different species of Lama (Jarvinen, 1999), Le...
The oldest fossil representatives of American camels belonged to the Lamini tribe, including species of *Pliauchenia* et al., 2007). During the Pleistocene, a descendant of *Hemiauchenia* migrated to South America during the Pleistocene–Holocene transition (Wheeler, 1995). Paleoparasitological studies carried out on mummified Peruvian camelids, i.e., *Lama guanicoe*, *L. guanicoe*, *L. vicugna*, and *L. alpaca*, only *L. guanicoe* is found in Patagonia.

Paleoparasitological results for the Pleistocene transition to middle Holocene can be reasonably interpreted as a parasite response to host replacement. It is also plausible that the “large-size” oocysts are those of an extinct erimeriid-like species common to camels during the Pleistocene–Holocene transition. Changing environmental conditions may have selected against the survival of these species, and it was succeeded by *E. macusaniensis*. Likewise, the major size of the oocysts during the pleistocene transition and their minimal size during the middle-Holocene can be related to environmental changes known for the area in these periods (Miotti and Salemme, 2004). These hypotheses will guide future research.

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### Table I. Age and measurement of eimeriid oocysts examined in the present study.

<table>
<thead>
<tr>
<th>Age (years before present)</th>
<th>Calibrated Mean (μm)</th>
<th>Noncalibrated Mean (μm)</th>
<th>Width (μm)</th>
<th>Length (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>507</td>
<td>515*</td>
<td>45.0</td>
<td>–</td>
<td>60.0–80.0</td>
</tr>
<tr>
<td>3,775</td>
<td>3,490†</td>
<td>61.0</td>
<td>2.4</td>
<td>57.5–63.75</td>
</tr>
<tr>
<td>3,978</td>
<td>3,565†</td>
<td>50.0</td>
<td>3.53</td>
<td>47.5–52.5</td>
</tr>
<tr>
<td>6,007</td>
<td>5,205‡</td>
<td>65.0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>7,434</td>
<td>6,540§</td>
<td>67.39</td>
<td>6.42</td>
<td>60.0–80.0</td>
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<tr>
<td>8,742</td>
<td>7,880</td>
<td>80.0</td>
<td>–</td>
<td>–</td>
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<tr>
<td>8,988</td>
<td>8,110</td>
<td>68.26</td>
<td>4.35</td>
<td>62.5–80.0</td>
</tr>
<tr>
<td>9,990</td>
<td>8,920</td>
<td></td>
<td>95.0</td>
<td>–</td>
</tr>
<tr>
<td>10,635</td>
<td>9,370</td>
<td>97.51</td>
<td>4.9</td>
<td>87.5–108.75</td>
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<td>11,032</td>
<td>9,730</td>
<td>73.75</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Modern sample (C. Beldomenico, pers. comm.)*#</td>
<td>67.0</td>
<td>2.7</td>
<td>53.3–70.5</td>
<td>85.1</td>
</tr>
<tr>
<td>Modern sample (Leguá 1999)¶</td>
<td>67.4</td>
<td>–</td>
<td>61.0–80.0</td>
<td>93.6</td>
</tr>
</tbody>
</table>

* Archaeological sites Nombre de Jesús, Santa Cruz Province.
† Orejas de Burro I, Santa Cruz Province.
‡ La Arcillosa II, Tierra del Fuego Province.
§ CCP5.
¶ Peru.
# Santa Cruz Province. Modern samples from Patagonia.

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**LITERATURE CITED**


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