Pan-American marine coastal distribution of the acanthocephalan *Profilicollis altmani* based on morphometric and phylogenetic analyses of cystacanths from the mole crab *Emerita brasiliensis*

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Abstract

Thorny-headed acanthocephalan worms of the genus *Profilicollis* are widely distributed in the oceans of the world and present complex life cycles with intermediate and definitive hosts. The genus is still poorly known, with an unstable taxonomy and, for most species, incompletely characterized geographical distributions. In this study, based on molecular and morphological evidence, we report that the species *Profilicollis altmani* is also distributed along the South American Atlantic coast, using the mole crab *Emerita brasiliensis* as an intermediate host. As such, our record shows that *P. altmani* has a Pan-American distribution where five species of *Emerita* are utilized as intermediate hosts.

Introduction

*Profilicollis* Meyer, 1931 encompasses polymorphid acanthocephalans with long necks, females and males with a fully ovoid proboscis, eggs with concentric membranes and decapods as intermediate hosts (Nickol et al., 1999). The species richness of the genus is still unclear due to the taxonomic status of some forms being unstable as well as the lack of revisionary studies. As currently understood (e.g. Brockerhoff & Smales, 2002; Tantaleán & Cárdenas, 2004; Amin, 2013; Goulding & Cohen, 2014), the genus encompasses nine species: *P. altmani* (Perry, 1942), which includes *P. bullocki* (Mateo, 1982), *P. kenti* (Van Cleave, 1947) and *P. texensis* (Webster, 1948) in its synonymy; *P. antarcticus* Zdzitowiecki, 1985; *P. arcticus* (Van Cleave, 1920); *P. formosus* (Schmidt & Kuntz, 1967); *P. major* (Lundström, 1942); *P. novaezelandensis* Brockerhoff & Smales, 2002; and *P. sphaerocephalus* (Bremer in Rudolphi, 1819).

Three species, *P. altmani*, *P. antarcticus* and *P. bullocki*, were traditionally recognized as inhabiting the coasts of the South American Pacific Ocean. *Profilicollis antarcticus* uses the estuarine crab *Hemigrapsus crenulatus* as intermediate host. Meanwhile, *P. altmani* and *P. bullocki* have the mole crab *Emerita analoga* as intermediate host and different species of sea birds as definitive hosts (Torres et al., 1993; Riquelme et al., 2006). A recent phylogeographic study (Goulding & Cohen, 2014) corroborates the morphology-based suggestion made by Tantaleán & Cárdenas (2004) that *P. bullocki* is a subjective junior synonym of *P. altmani*. This latter species has a large bi-oceanic distribution and has been recorded along the Pacific coast of North America (California) and South America (Chile) and along the Atlantic coast of North America (Rhode Island, North Carolina) and the Gulf of Mexico (Florida)
and Mississippi). Meanwhile, for the South American Atlantic coast the thorny-headed worm *P. chasmagnathi* has been cited with the crab species *Neohelice granulata* and *Cyrtograpsus angulatus* as intermediate hosts (Holcman-Spector et al., 1977; Alda et al., 2011; La Sala et al., 2012) and *Larus atlanticus* and *L. dominicanus* as definitive hosts (Diaz et al., 2011; La Sala et al., 2013). There is a mention of cystacanths of *P. altmani* infecting *Emerita brasiliensis* and *Calidris canutus* in Rio, southern Brazil (Buehler et al., 2010). However, this record is ambiguous because the parasite species was mentioned in the publication as either *Profilicollis* sp. or *P. altmani*, and no indication of the evidence used to identify the specimens was given.

Here, by means of morphological and molecular evidence, we analyse a sample of *Profilicollis* retrieved from specimens of the mole crab *E. brasiliensis* collected on the southern Atlantic coast of Uruguay. We assign these specimens to *P. altmani*, thereby extending the known geographical range of the acanthocephalan, previously shown to have a Pan-American distribution (Goulding & Cohen, 2014).

**Materials and methods**

Thirty-seven specimens of *E. brasiliensis* were collected by hand on two sandy beaches of Uruguay: Cabo Polonio, Rocha (34°24.200'S, 53°47.700'W; December 2014) and Arachania, Rocha (34°37.179'S, 54°8.800'W; January 2016). Mole crabs were stored in 95% ethanol, transported to the laboratory and dissected for the presence of cystacanths. These were placed on distilled water to force osmotic eversion of the proboscis, examined under a stereomicroscope and identified using Nickol et al. (2002).
Results and discussion

Of the 37 specimens of *E. brasiensis* examined, three were infected with *Profilicollis* (prevalence = 8.1%), with one, one and two parasites each (total = 4; mean intensity = 1.3). These four *Profilicollis* were sequenced and three distinct haplotypes were found. Observed average divergence of the Uruguayan sequences is 1.0%. In the genealogical analysis the haplotypes do not form a monophyletic group (fig. 1) and fall within the large clade of *P. altmani*, which is strongly supported (PP = 1). As such, the Bayesian analysis of DNA sequences suggests that cystacanths recovered from *E. brasiensis* on the southern Atlantic coast belong to the same species, *P. altmani*, that has already been recorded on the Californian and Chilean Pacific coasts, as well as on the Atlantic coast of North America. Observed $p$ distances among species of *Profilicollis* ranged from 22.2 to 25.1%.

A morphological assessment of the cystacanths collected in Uruguay points in the same direction, as it clearly differentiates them from *P. chasmagnathi* and *P. bullocki*, the other southern South American thorny-headed worms, in the number of hooks per head row as well as in the shape of the proboscis (table 1; Holcman-Spector *et al.*, 1977; Balboa *et al.*, 2009). Cystacanths collected in Uruguay have an elongated body and an ovoid proboscis, with 26–29 longitudinal rows of 14–15 hooks each. Similarly, cystacanths from the Pacific coast of Chile have between 14 and 16 hooks per row (Balboa *et al.*, 2010) and fall within the large clade of *P. altmani*.

Dirichlet prior. Runs were allowed to proceed for 20 million generations, with trees sampled every 1000 generations per chain. To check for convergence on a stable log-likelihood value, we plotted the log-likelihood values against generation time for each. The first 25% of the trees were discarded as burn-in and the remaining trees were used to compute a 50% majority rule consensus tree and to obtain posterior probability (PP) estimates for each clade.

Table 1. Morphometrics (measurements in $\mu$m and mean values given in brackets) of cystacanths of *Profilicollis altmani* from the USA, Chile and Uruguay.

<table>
<thead>
<tr>
<th>Study site</th>
<th>Host</th>
<th>USA (Nickol <em>et al.</em>, 2002)</th>
<th>Chile (Balboa <em>et al.</em>, 2009)</th>
<th>Uruguay (This study)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>1000–1740 (1512)</td>
<td>850–1690 (1232)</td>
<td>805–1100 (939)</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>336–470 (406)</td>
<td>350–580 (473)</td>
<td>379–595 (461)</td>
<td></td>
</tr>
<tr>
<td>Hooks/row</td>
<td>12</td>
<td>14–16</td>
<td>14–15</td>
<td></td>
</tr>
<tr>
<td>Length of apical hooks</td>
<td>34–43 (37)</td>
<td>56</td>
<td>41–48 (44)</td>
<td></td>
</tr>
<tr>
<td>Length of medial hooks</td>
<td>41–53 (45)</td>
<td>73</td>
<td>48–61 (54)</td>
<td></td>
</tr>
<tr>
<td>Length of end hooks</td>
<td>43–57 (52)</td>
<td>90</td>
<td>52–79 (64)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Morphometrics (measurements in $\mu$m and mean values given in brackets) of cystacanths of *Profilicollis altmani* from the USA, Chile and Uruguay.
2009; reported as *P. bullocki*). Interestingly, specimens of *P. altmani* from the Atlantic and Pacific coasts of the USA have 12 hooks in each longitudinal row (Nickol et al., 2002).

Taken as a whole, the evidence suggests that cystacanths recovered from *E. brasilensis* along the southern Atlantic coast belong to the same species, *P. altmani*, already recorded on the Californian and Chilean Pacific coast as well as on the Atlantic coast of North America. These results confirm that the acanthocephalan *P. altmani* has a Pan-American distribution with much variation (table 1), although the biological significance of this at the intermediate host stage remains unclear.

We also enlarge the list of intermediate hosts of *P. altmani*. Goulding & Cohen (2014) reported cystacanths of *P. altmani* parasitizing the mole crab species *E. analoga*, *E. rathbunae*, and *E. dominicanus* as definitive hosts (e.g. Díaz et al., 2012) and the gulls *L. atlanticus* and *L. dominicanus* as definitive hosts (e.g. Díaz et al., 2011; La Sala et al., 2013). *Profilicollis altmani* has the mole crab *E. brasilensis*, which inhabits sandy beaches, as intermediate host. Future studies should clarify the definitive host of *P. altmani* in this environment (but see Buehler et al., 2010, who reported a mortality event of the sandpiper *Calidris canutus* that may be linked to the presence of *P. altmani*). Finally, the recording of *P. altmani* on the South American Atlantic coast is of relevance, given that infection with this parasite has caused the mortality of marine mammals in North America (Kreuder et al., 2003; Mayer et al., 2003). Similarly, there are suggestions that *P. altmani* can infect humans and domestic animals that accidentally ingest cystacanths when eating mole crabs (Tantaleán et al., 2002; Rojas & Sebastián, 2011).

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### Conflict of interest

None.

### References


Brockerhoff, A. & Smales, L. (2002) *Profilicollis noveaelandensis* n. sp. (Polymorphidae) and two acanthocephalan parasites from shore birds (*Haematopodidae* and *Scolopacidae*) in New Zealand, with records of two species in intertidal crabs (*Decapoda: Grapsidae and Ocyopodidae*). *Systematic Parasitology 52*, 55–65.


