Association of Anagr us amazonensis Triapitsyn, Querino & Feitosa (Hymenoptera, Mymaridae) with aquatic insects in upland streams and floodplain lakes in central Amazonia, Brazil

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ABSTRACT

Anagrus amazonensis Triapitsyn, Querino & Feitosa (Hymenoptera, Mymaridae) is a parasitoid that uses aquatic insect eggs as a host for the development of its immature stages. The objectives of this study are to record the interaction between A. amazonensis and its hosts and the aquatic plants used by these hosts to lay their eggs. Field work was conducted in floodplain lakes and upland (terra firme) streams, in four municipalities in Amazonas State, Brazil, where aquatic plants were scanned for the presence of aquatic insect eggs. In the laboratory, eggs were maintained in plastic containers with water until the emergence of the parasitoid or of the first instar insect. A total of 1223 adults of A. amazonensis emerged from eggs of Hemiptera, Lepidoptera and Odonata; these eggs were collected on 12 species of aquatic plants.

Among parasitoid hymenopterans, a small group has one or more life stages associated with aquatic environments (Bennett, 2008) where they oviposit on the eggs, larvae or pupae of a large range of host insects (Williams and Felkate, 1992). Most are endoparasitoids of immature insects that are actually embedded partly or almost completely inside the host plant tissue or other submersed substrates or on floating substrates (Querino, 2012). In Brazil there are currently seven families (Braconidae, Diapriidae, Eulophidae, Figitidae, Mymaridae, Platygastridae, and Trichogrammatidae) and eight genera of Hymenoptera known to be associated with aquatic hosts (Querino and Hamada, 2014). In Central Amazonia, the riparian vegetation and aquatic macrophytes in streams and floodplain lakes are the preferred substrates for aquatic insects to oviposit (Bentes et al., 2014) but few records exist of the interaction between parasitoid, aquatic host, and plant used for oviposition by the insect host. Hydrophylita neusa (Querino and Pinto) (Hymenoptera: Trichogrammatidae) was found associated to Odonata eggs deposited on leaves of Thurnia sphaerocephala Hook. (Thurniaceae) (Querino and Pinto, 2007). Pseudoligosita longifrangiiata (Viggiani) (Hymenoptera, Trichogrammatidae) was recorded for the first time in Brazil parasitizing eggs of Argia insipida Hagen in Selys (Odonata, Coenagrionidae) deposited on Tonina fluvialitis Aublet (Eriocaulaceae) (Querino and Hamada, 2009). Anagrus amazonensis Triapitsyn, Querino and Feitosa (Hymenoptera, Mymaridae) was observed parasitizing Odonata (Zygoptera) eggs deposited on Rhynchospora pubera (Vahl) Bockeler (Cyperaceae) (Triapitsyn et al., 2008).

Knowledge of the parasitoid host fauna and their habitats is important for studies of population dynamics because these organisms act as a natural population control of their hosts. The aim of the present study is to document the aquatic insect hosts of A. amazonensis and the plants on which host eggs are laid in Central Amazonia. Eggs were randomly collected in 2004, 2005, and 2006 in three floodplain lakes (lentic environments) and eight upland (terra firme) forest streams (lotic environments) in four municipalities (Irânduba, Manaus, Presidente Figueiredo, and Rio Preto da Eva) in Amazonas State, Brazil (Fig. 1). Aquatic plants and vegetation trawling from stream banks were scanned for aquatic insect eggs, and, when present, eggs were collected and placed in plastic bags to be transported to the laboratory in Styrofoam boxes. In the laboratory, each aquatic insect egg batch was placed in a plastic container with water treated with fungicide in order to inhibit fungal growth, and was inspected daily until the emergence of parasitoids or immature insect hosts. Identification of aquatic insect egg was based on Bentes et al. (2014) and of A. amazonensis was based on the original description (Triapitsyn et al., 2008). Specimens obtained in this study are deposited in the Invertebrate Collection of the National Institute of Amazonian Research, Manaus, Brazil.
A total of 1223 individuals of *A. amazonensis* were obtained, of which 1128 were female and 95 were male. Many factors can be influencing the sex ratio and result in a higher prevalence of females in the samples, such as reproduction habits and host characteristics. These factors may be explored in future studies.

*A. amazonensis* emerged from eggs of Hemiptera, Lepidoptera, and Odonata. *A. amazonensis* parasitized eggs placed on the underside of the macrophyte’s leaves, the exception of lepidopteran eggs, which were placed on the upper surfaces of the leaves. The higher rate of parasitism in Odonata eggs is most likely due to the fact that they are more easily found in the sampled locations. The host range of *A. amazonensis* appears to be exceptionally wide (encompassing three insect orders) even for a taxon (Mymaridae) where there seems to be a tendency for species not to be host-species specific; many mymarid species present host specificity at the genus level, while others are known to parasitize hosts of a wide range of families in a single insect order (Huber, 1997). The habitat range also appeared to be exceptionally wide. Although most aquatic Hemiptera are recorded in lentic environments, at least 1/3 of the species are associated with lotic environments (Bennett, 2008). *A. amazonensis* did not show any preference, occurring in both lotic (upland streams) and lentic (floodplain lakes) environments (Fig. 1).

*A. amazonensis* emerged from aquatic insect eggs laid on 12 species of aquatic plants (Table 1). Of these, only *Eichhornia crassipes* (Mart.) Solms., *Salvinia sp.*, *Pistia stratiotes* L., *T. fluviatilis* Aublet, *Thurnia* sp., and Ciperaceae had been previously associated with oviposition of aquatic insect eggs in the Amazon region (Bentes et al., 2014).

Huber (1986) reported *Anagrus* as one of the three most-abundant genera of Mymaridae in faunal surveys. However, of the eight species of *Anagrus* recorded in Brazil, as far as it is known, only

### Table 1

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>Aquatic plants</th>
<th>Insect hosts</th>
<th>Anagrus amazonensis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thurniaceae</td>
<td><em>Thurnia sphaerocephala</em> (Rudge) Hook.</td>
<td></td>
<td>Odonata</td>
<td>93</td>
</tr>
<tr>
<td>Araceae</td>
<td><em>Philodendron</em> sp.</td>
<td></td>
<td>Odonata</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td><em>Urospatha sagittifolia</em> (Rudge) Schott</td>
<td></td>
<td>Lepidoptera</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td><em>Spathiphyllum maugeirei</em> Bunting</td>
<td></td>
<td>Odonata</td>
<td>16</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td><em>Rhynchospora pubera</em> (Vahl) Boeck.</td>
<td></td>
<td>Odonata</td>
<td>106</td>
</tr>
<tr>
<td>Eriocaulaceae</td>
<td><em>Tonia fluviatilis</em> Aublet</td>
<td></td>
<td>Odonata</td>
<td>25</td>
</tr>
<tr>
<td>Parkeriaceae</td>
<td><em>Ceratopteris pteroides</em> (Hook.) Hieron</td>
<td></td>
<td>Odonata</td>
<td>45</td>
</tr>
<tr>
<td>Poaceae</td>
<td><em>Panicum laxum</em> Sw.</td>
<td></td>
<td>Odonata</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><em>Poaceae</em> not identified</td>
<td></td>
<td>Odonata</td>
<td>4</td>
</tr>
<tr>
<td>Pontederiaceae</td>
<td><em>Eichhornia crassipes</em> (Mart.) Solms.</td>
<td></td>
<td>Hemiptera</td>
<td>52</td>
</tr>
<tr>
<td>Xyridaceae</td>
<td><em>Pondeleria rotundifolia</em> L.</td>
<td></td>
<td>Hemiptera</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td><em>Xyris caroliniana</em> Walt.</td>
<td></td>
<td>Odonata</td>
<td>25</td>
</tr>
</tbody>
</table>

Subtotal 1234

* Upland stream plants.
* Floodplain lake plants.
A. amazonensis is associated with aquatic environments (Triapitsyn et al., 2008). Host records are only known for 7 of these 8 species; only A. brasiliensis Triapitsyn does not have a confirmed host.

The results of this study therefore contribute to current understanding of this parasitoid, including its natural history, host interactions, and geographic distribution, especially for aquatic environments.

Conflicts of interest

The authors declare no conflicts of interest.

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We thank the staff of the Instituto Nacional de Pesquisas da Amazônia (INPA) Herbarium (Gleison Viana and José Ferreira Ramos) for identifying the plants and Vivian C. de Oliveira for generating the map. The INPA/PIBIC program provided a fellowship for Malu Feitosa and CNPq provided a research fellowship for N. Hamada. We also thank Natsumi H. Fearnside and Philip M. Fearnside for the English translation and we are grateful for valuable comments on the manuscript from anonymous reviewers.

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