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SHORT COMMUNICATION

Larvae of *Lutrochus germari* (Lutrochidae: Coleoptera) and *Stegoelmis* sp. (Elmidae: Coleoptera) bore submerged woody debris in Neotropical streams

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ABSTRACT. We report boring activity of larval *Lutrochus germari* Grouvelle, 1889 and *Stegoelmis* sp. in submerged woody debris and describe the resulting grooves and faecal pellet production. This ability of the larvae was shown by three types of evidence: 1) examination of collected woody debris, 2) rearing of larvae and 3) gut content analysis. The larvae excavated galleries deep into the submerged woody debris. This is the first record of gallery-forming behaviour in submerged woody debris by aquatic beetles, adding larval *Lutrochus germari* and *Stegoelmis* sp. to the list of borers in Neotropical aquatic systems.

KEY WORDS. Faecal pellets; galleries; grooves; mining; xylophages.

The feeding behaviour of aquatic insects, such as gouging, shredding and boring, aids the breakdown of plant debris. In submerged woody debris, this behaviour is responsible for increasing its surface area, favouring colonization by fungi and microorganisms (McKie & Cranston 1998), promoting decomposition, and providing habitats for increasing numbers of macroinvertebrates (O'Connor 1991).

Some aquatic insects are known for gouging the surface of submerged wood, such as xylophagous species of Elmidae: *Lara avara* LeConte, 1852 (Steedman & Anderson 1985), *Ancyronyx variegata* (Germar, 1824) (Phillips 1997a) and *Macronychus glabratus* Say, 1825 (Phillips 1997b) from North America, and *Notriolus* spp. from Australia (McKie & Cranston 1998). These insects play an important role in the food chain of streams because they repackage nutrients, providing new microhabitats for other organisms (Steedman & Anderson 1985, McKie & Cranston 1998, 2001).

Gallery-forming aquatic insects tunnel inside submerged woody debris, opening new surfaces for other organisms to colonize (Dudley & Anderson 1982). However, only a few of these insect borers have been recorded inside the submerged wood (Dudley & Anderson 1982, Harmon *et al.*1986, Spänhoff *et al*. 2000).

In a study of aquatic beetles associated with submerged woody debris, *Lutrochus germari* Grouvelle, 1889 and *Stegoelmis* sp. larvae were encountered and their wood-boring behaviour is described here.

The criteria used to select submerged wood debris were the presence of hollows, which indicates the action of borers, and biofilm, which shows permanence in the water. Wood was collected manually in 12 low (first to third) order streams located in São Paulo State from March 2009 to August 2010. All streams had dense riparian vegetation, and showed no signs of environmental degradation.

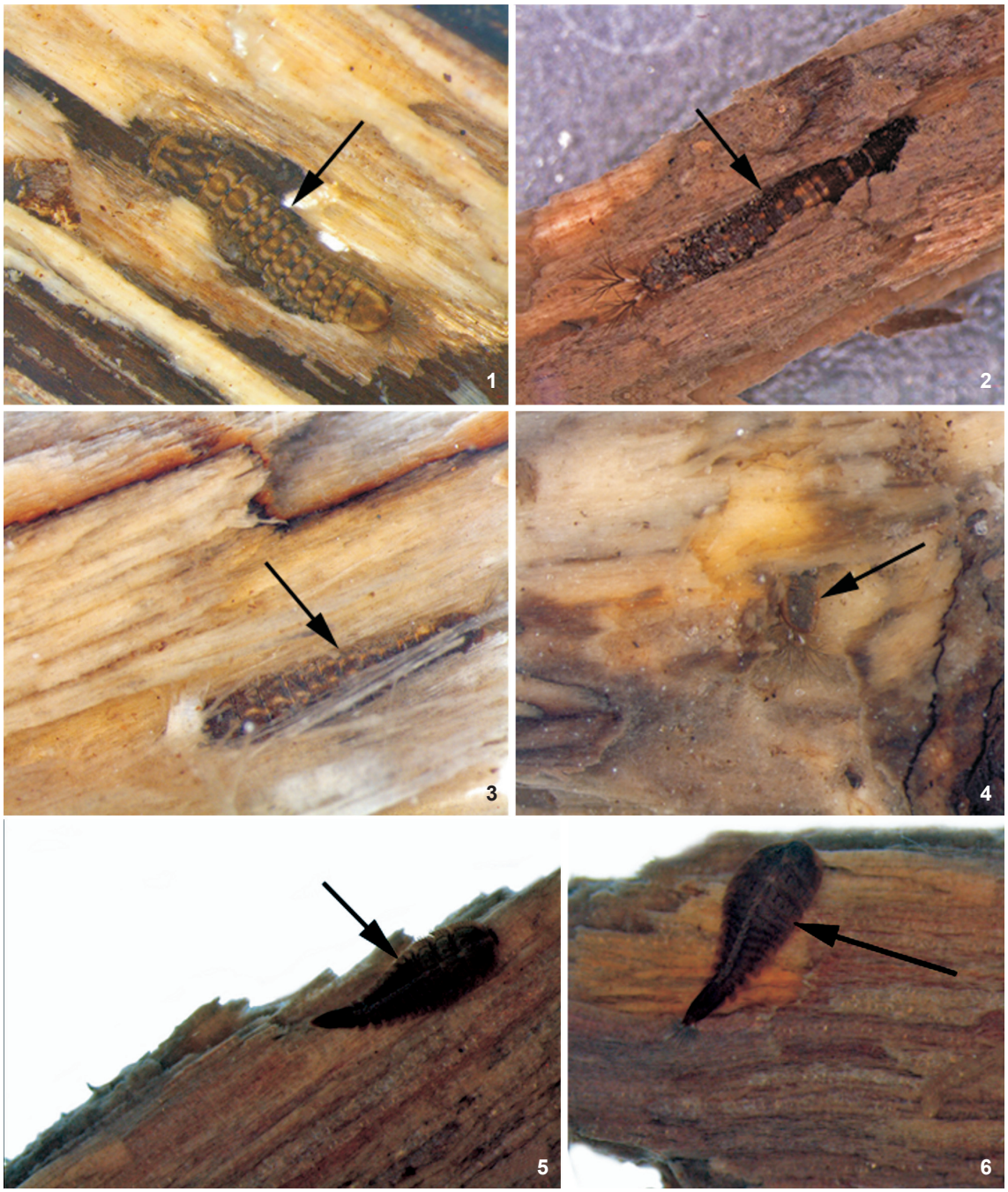
Lutrochus germari larvae were found in submerged woody debris from nine streams: four in the Campos do Jordão State Park (22°39'-22°41'S, 45°26'-45°28'W); three in the Atlantic Rainforest State Park (Santa Virginia Unit) (23°19'-23°22'S, 45°05'-45°08'W); one in a rural district on the outskirts of São Carlos city (21°57'S, 47°50'W) and one in a rural area of Matão city (21°37'S, 48°32'W). In general, these streams are characterized by acid to neutral waters (pH 5.0-7.2), low electrical conductivity (6-16 $\mu S.s^{-1}$), well-oxygenated water (D.O. 6.5-9.9 $mg.L^{-1}$), and low temperatures (9.4-14°C). *Stegoelmis* sp. larvae were collected in submerged woody debris from three streams, all in a rural area of São Carlos city (21°58'-21°54'S, 47°52'-47°49'W). These streams have acid waters (pH values between 5.4-5.9), low electrical conductivity (6-10 $\mu S.s^{-1}$), and high temperatures (18.0-23.0°C).

The *L. germari* and *Stegoelmis* sp. larvae were identified by association with adults found on the submerged wood surface, and by comparison with original descriptions (Costa *et al*. 1996, Spangler 1990). The *Stegoelmis* sp. was different from any of the 11 species currently described in *Stegoelmis* (Spangler 1990, Manzo & Archangelsky 2008), probably an undescribed species.

To establish the ability of larval *L. germari* and *Stegoelmis* sp. to bore submerged woody debris, three criteria were used. First, all the collected material was fragmented, from the bark to the heart wood, enabling the observation of galleries and of the presence of larvae inside the wood. Second, the larvae from the

wood were reared inside plastic containers of stream water in the laboratory, for periods ranging from two months to one year. This enabled direct observation of insect behaviour. Thirdly, some larvae were fixed and preserved in 70% ethanol, and their gut contents were analysed, to confirm the ingestion of wood.

Larvae of *L. germari* (Figs 1-4) and *Stegoelmis* sp. (Figs 5-6) were able to excavate deep galleries in submerged woody debris, reaching the heart wood. This is the first record of these species displaying gallery-forming behaviour in submerged woody debris. Other studies have only reported an association



Figures 1-6. Larvae of (1-4) *Lutrochus germari* (Lutrochidae) and (5-6) *Stegoelmis* sp. (Elmidae) associated with submerged woody debris.

between this substrate and *L. germari* larvae (Costa *et al*. 1996), *Stegoelmis ica* Spangler, 1990 adults and *Stegoelmis geayi* Spangler, 1990 larvae and adults (Spangler 1990). In fact, wood-boring behaviour has not previously been described for aquatic beetles, but only for terrestrial (see review by Grove 2002) and semi-aquatic species (Dudley & Anderson 1982).

Our results differ from those obtained by Spänhoff *et al*. (2000) for temperate streams in Europe, where there are no wood-boring aquatic insect species. It is argued that there are few insects that bore into submerged wood because the wood matrix has limited oxygen levels and biofilm growth. Furthermore, some authors report that galleries are restricted to the surface of the wood (Dudley & Anderson 1982), such as those produced by larval *Stenochironomus* Kieffer, 1919 (Diptera: Chironomidae) and *Lipsothrix* Loew, 1873 (Diptera: Limoniidae), which reach a maximum depth of 15 mm (Borkent 1984, Dudley & Anderson 1987).

Lutrochus and *Stegoelmis* larvae have tracheal gills that probably optimize oxygen absorption even within deep galleries, which may have low oxygen levels. Moreover, the increased porosity of the substrate may facilitate higher oxygen levels in the wood. Thus, there are likely to be enough nutrients and oxygen available for wood-boring insects (Dudley & Anderson 1982).

The ability of *L. germari* and *Stegoelmis* sp. larvae to produce grooves in the surface of wood could be the beginning of gallery formation. This is comparable to Australian *Notriolus* Carter & Zeck, 1929 (Coleoptera: Dryopidae) larvae, which produce 1-3 mm deep grooves (Mckie & Cranston 1998, 2001).

Larvae of both *L. germari* and *Stegoelmis* sp. were reared for 12 months, during which we observed only one moult, suggesting a long life cycle. Aquatic beetles feeding on submerged woody debris have life cycles that can last from four to six years or more (*L. avara* – Steedman & Anderson 1985), or one year (*A. variegata* – Phillips 1997a; *M. glabratus* – Phillips 1997b). These long life cycles are attributed to the low nitrogen concentration (0.2% dry weight) of wood (Mattson 1980).

A large number of faecal pellets were also observed during rearing, although the quantity produced was not measured. A high production of faecal pellets also occurs in *Lara avara* larvae, which produce 1.6 $g.m^{-2}.y^{-1}$ of faeces (Steedman & Anderson 1985). It should be noted that *L. germari*, *Stegoelmis* sp. and *L. avara* larvae have a straight gut, limiting the residence time of ingested wood and favouring the high production of faecal pellets. This production of faecal pellets is important to aquatic systems because it repackages nutrients for the food chain.

In summary, this study adds *L. germari* and *Stegoelmis* sp. larvae to the list of submerged wood debris borers in the Neotropical region, indicating that borer richness may not be as poor as previously hypothesized (Wantzen & Wagner 2006).

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