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Taking a ride! Phoretic association of the freshwater limpet *Gundlachia radiata* (Planorbidae: Ancylinae) and the apple snail *Pomacea lineata* (Caenogastropoda: Ampullariidae), with the description of a new record of this ancylinid in southeastern Brazil

LUCAS R. P. PASCHOAL[1*], LUIZ E. M. LACERDA[2] & IGOR C. MIYAHIRA[3]

[1] *Universidade Estadual Paulista (UNESP), 13506-900, Rio Claro, SP, Brazil.*
[2] *Universidade do Estado do Rio de Janeiro (UERJ), Instituto de Biologia Roberto Alcantara Gomes, 20550-900, Rio de Janeiro, RJ, Brazil.*
[3] *Universidade Federal do Estado do Rio de Janeiro (UNIRIO), Instituto de Biociências, Departamento de Zoologia, 22290-240, Rio de Janeiro, RJ, Brazil.*

*Corresponding author: lucasrezende20@gmail.com

Abstract. The occurrence of *Gundlachia radiata* is recorded for the first time in the Minas Gerais state, expanding its distribution in southeastern Brazil. We also report the phoresy between this ancylinid and *Pomacea lineata* and discuss the participation of this ampullariid in the transport and possible dispersion of *G. radiata*.

Keywords: New occurrence, phoresy, freshwater snails, Neotropical reservoir

Resumo. Dando uma volta! Associação forética de *Gundlachia radiata* (Planorbidae: Ancylinae) e *Pomacea lineata* (Caenogastropoda: Ampullariidae), com a descrição de um novo registro deste ancilinídeo no sudeste do Brasil. A ocorrência de *Gundlachia radiata* é registrada pela primeira vez no estado de Minas Gerais, ampliando sua distribuição no sudeste brasileiro. Relatamos também a foresia entre este ancilinídeo e *Pomacea lineata*, e discutimos a participação deste ampularídeo no transporte e possível dispersão de *G. radiata*.

Palavras-chave: Nova ocorrência, foresia, caramujos dulciaquícolas, reservatório Neotropical

The freshwater limpet *Gundlachia radiata* (Guilding, 1828) is a small-sized species (3-15 mm) with a wide distribution, inhabiting lotic and lentic aquatic environments in the Americas from southern USA to northern Argentina (Lanzer 1996, Santos 2003, Ovando *et al.* 2011, Lacerda *et al.* 2013). In Brazil, its occurrence is confirmed in the North Region in the states of Amazonas and Pará, in the Northeast in the states of Paraíba, Pernambuco, and Alagoas, in the Mid-West in the state of Goiás, and in the Southeast in the state of Rio de Janeiro (Santos 2003, Thiengo *et al.* 2005, Lacerda *et al.* 2013, Birckolz *et al.* 2016). This mollusk is a benthic organism and can be found adhered to aquatic macrophytes, decomposed organic matter, stones, or even artificial substrates (Santos 2003, Lacerda *et al.* 2013).

Recorded cases of phoresy involving mollusks usually consist of these animals taking a ride on other invertebrates (White *et al.* 1980, Zelaya & Marinone 2012, Kenderov 2017) or vertebrates (Santos 2003, Green & Figuerola 2005, Coughlan *et al.* 2017, Kolenda *et al.* 2017). The first can be regarded as local dispersal agents and the second as great-distance dispersal agents, including overland dispersal (Rees 1965, Mackie 1979). However, despite their usually slow pace, in some cases, mollusks can give a ride to others invertebrates (Darwich *et al.* 1989, De-Carli *et al.* 2014, Robinson *et al.* 2017).

The above-mentioned range of *Gundlachia radiata* in Brazil has several gaps, but whether it is really discontinuous or a result of insufficient sampling effort remains to be seen. In this note, we

report a new record for *G. radiata* from Southeast Brazil and reveal the phoretic association of this species with the apple snail *Pomacea lineata* (Spix in Wagner, 1827).

The studied area is located in the Paraná River catchment, on the left margin of the Grande River (20° 35' 3.4'' S; 46° 34' 54.5'' W), inserted in the Neotropical reservoir of the Marechal Mascarenhas de Morais Hydroelectric Power Station near the municipality of São João Batista do Glória, in the state of Minas Gerais (Fig. 1). This area is within the Cerrado Biome region and is characterized by high water level fluctuation (human-mediated), and the presence of clay-silt sediment, gravel, and pebbles on the river margins. During an analysis of the mating behavior of *P. lineata* (Fig. 2A) individuals obtained by scuba diving (up to 4 m), we observed small gastropods adhered to the body whorl (Fig. 2B) and/or other portions of the shell (Fig. 2C) and the operculum (Fig. 2D). The adhered specimens were separated and subsequently analyzed and identified according to Lanzer (1996), Santos (2003) and Lacerda *et al.* (2013). The animals were collected under legal authorization from MMA/ICMBio/SISBIO (permit number 36210-1), on January 1st, 2014. Shell length (SL) and operculum width (OW) of the apple snails were measured using a caliper (0.02 mm) according to Youens & Burks (2008).

The small limpets attached to *P. lineata* were identified as *Gundlachia radiata*. Of the five couples of apple snails captured, the presence of limpets was verified in seven individuals, with a single limpet adhered to each individual *P. lineata* (Figure 2B-C). Only two *P. lineata* individuals carried more than one specimen of *G. radiata* (two and five individuals, respectively, Figure 2D). The apple snails did not seem particularly affected by the presence of the hitchhikers since they were observed mating and moving around without difficulties. Twelve specimens of *G. radiata* were obtained and analyzed and had their shell length (SL) and height (SH) measured under a Leica® stereomicroscope (software Leica® IM50). These animals had an elliptical shell, a rounded apex bent to the right, and their protoconch showed a shallow apical depression occupying up to 2/3 of the structure. These characteristics fit well with the descriptions of *G. radiata* in Lanzer (1996), Santos (2003) and Lacerda *et al.* (2013). The mean (± standard deviation) SL of *G. radiata* shells was 5.18 ± 2.71 mm, while SH was 2.63 ± 1.35 mm. The smallest individual analyzed had 1.99 mm SL and 1.35 mm SH, while the largest individual had 9.14 mm SL and 4.49 mm SH. Moreover, *G. radiata* showed great phenotypic plasticity, with weak or heavy pigmentation of the mantle, as already described by Lacerda *et al.* (2013). The ampullariids presented a slight discrepancy in size, with females (SL: 46.48 ± 4.67 mm, OW: 36.70 ± 3.04 mm) larger than males (SL: 43.30 ± 11.60 mm, OW: 32.83 ± 7.76 mm). The smallest apple snail carrying limpets had 31.8 mm SL and 24.9 mm OW. Shells of *P. lineata* comprising four or five whorls, separated by deep suture. Specimens of *G. radiata* were found adhered to male and female ampullariids, showing no apparent preference for sex or size.

Voucher specimens fixed in 70% ethanol were deposited in the Museu de Zoologia da Universidade de São Paulo (MZSP), under the number 108051 (*P. lineata*) and 116259 (*G. radiata*).

The animals studied herein were found in areas with depths between 0.3 and 4 meters. In the sampling area, we verified the occurrence of other gastropod and bivalve species: *Melanoides tuberculata* (Müller, 1774) and *Corbicula fluminea* (Müller, 1774), respectively. However, the association of the ancylinid with any these species was not verified. Between the tree possible dispersal vectors, *G. radiata* hitchhiked in the fastest. Kappes & Haase (2012) stated that *Pomacea paludosa* (Say, 1829) is capable of moving for long distances with active dispersal at a rate of 2 to 6 meters/day/population. It is likely *P. lineata* disperses at the same rate as its congener, since this species is active throughout the day, moving inside or outside the water (Paschoal, personal observation). On the other hand, *M. tuberculata* had a slower rate of dispersion. Miyahira *et al*. (2009) observed an active movement of a population of *M. tuberculata* throught 90 meters over three years. It is noteworthy that the movement of *M. tuberculata* was counter-current and delayed them a little. Adult clams and mussels usually present few horizontal movements and are not good dispersers (Kappes & Haase 2012). Although, small specimens of *C. fluminea* can produce mucous threads and disperse downstream (Prezant & Chalermwat 1984). However, this pattern was observed only in small specimens (7 to 14 mm), making the ride difficult for the ancylinids.

The new record presented herein is the first record of *G. radiata* for the state of Minas Gerais, increasing the range of the species in southeastern Brazil. Until now, this species has not been recorded in a huge area between the states of Góias and Rio

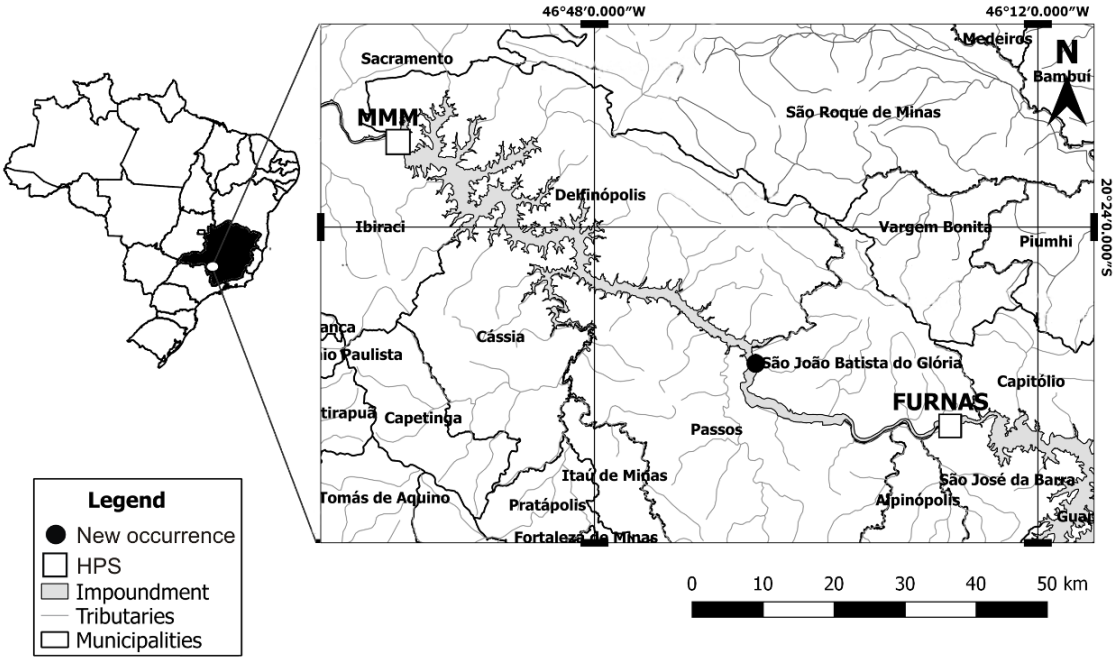

Figure 1. Map showing the new occurrence of *Gundlachia radiata* in the state of Minas Gerais. This new record was registered between the dam of the Marechal Mascarenhas de Morais (MMM) Hydroelectric Power Station (HPS) reservoir (downstream) and the dam of Furnas HPS reservoir (upstream), in the municipality of São João Batista do Glória.

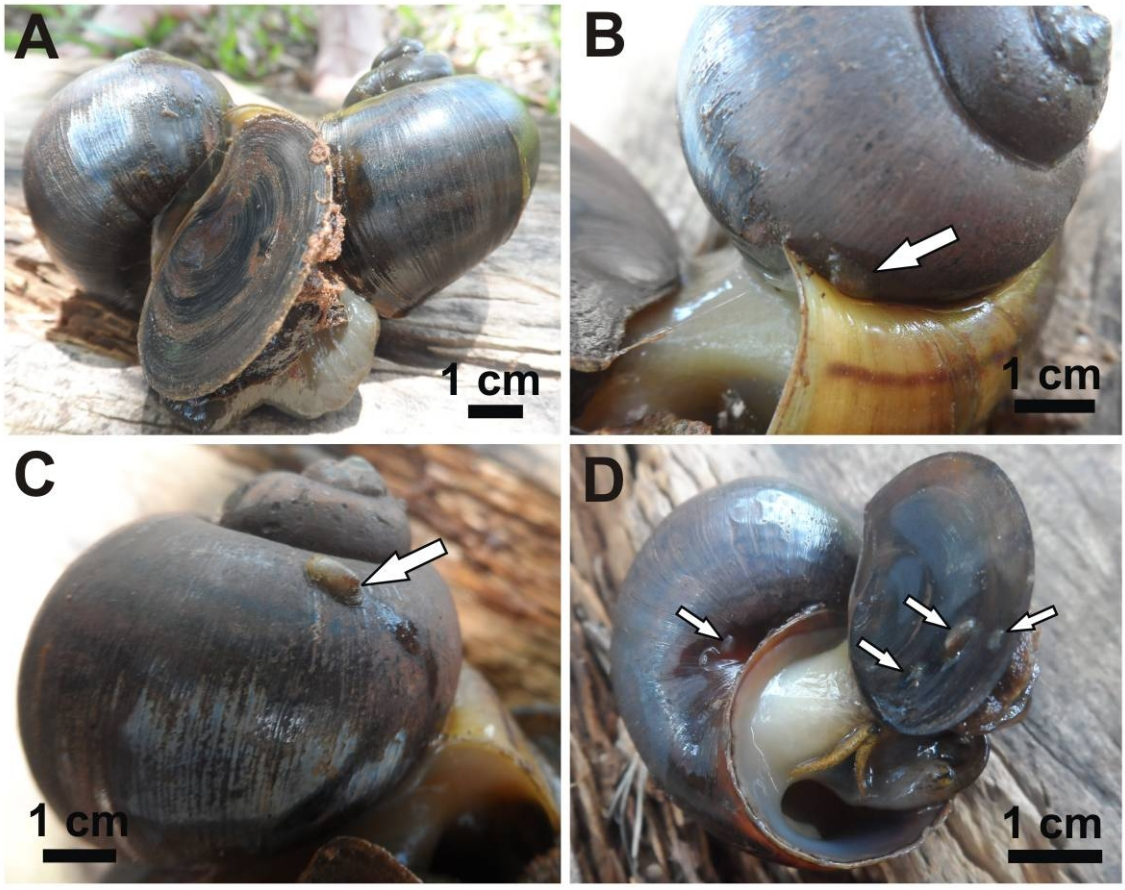

Figure 2. A. Apple snails *Pomacea lineata* during mating. **B.** *Gundlachia radiata* (white arrow) adhered to the suture of of *Pomacea lineata*. **C.** *Gundlachia radiata* (white arrow) adhered to the body whorl of *Pomacea lineata*. **D.** Four limpets adhered to the umbilicus and operculum (white arrows) of *Pomacea lineata*.

de Janeiro and northeastern Argentina. This new record is a first step towards filling these gaps. The Paraná River basin where the studied reservoir is located also encompasses all the areas mentioned above and *Gundlachia radiata* seems to be a species with a continuous and wide distribution in the Americas. Moreover, this new record in the state of Minas Gerais indicates that the local malacological fauna is still poorly known as already pointed by Paschoal *et al.* (2013a,b).

Here, we observed the participation of ampullariids in the transport and probable dispersion of *G. radiata* in aquatic environments of the studied area. Watanabe *et al.* (2015) verified that *Pomacea bridgesii* (Reeve, 1856) is a highly active species, moving day and night to explore and recognize the surrounding environment, being more active during the night. The authors regarded this movement pattern as a response to predation pressure and substrate selection. Such pattern is similar to that observed in *P. lineata* in the studied area (Paschoal, personal observation). It is probable that *G. radiata* benefits from the movement of *P. lineata*, which would aid in the transport and local dispersion, i.e. indirect or non-obligatory phoresy. Few phoretic associations have been documented for ancylinids. Rees (1965) presented some cases of phoresy between *Ancylus* spp. and insects, and related this to the successful dispersion of the former. The same can be probably said about the widely distributed *G. radiata*. Walther *et al.* (2008) demonstrated the dispersion of the freshwater limpet *Laevapex fuscus* (Adams, 1841) attached to the water bug *Belostoma flumineum* Say, 1832. These authors stated that this association maintains stable populations and that phoretic associations should not be overlooked. The case reported here seems to be the first between a freshwater limpet and another mollusk species, as opposed to an insect. Furthermore, this new record helps to elucidate the distribution gaps of *G. radiata*, and also brings new information on the ecology of the species.

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References

Birckolz, C. J., Salvador, R. B., Cavallari, D. C. & Simone, L. R. 2016. Illustrated checklist of newly described (2006-2016) land and freshwater Gastropoda from Brazil. **Archiv für Molluskenkunde: International Journal of Malacology**, 145(2): 133-150.

Coughlan, N. E., Stevens, A. L., Kelly, T. C., Dick, J. T. A. & Jansen, M. A. K. 2017. Zoochorous dispersal of freshwater bivalves: an overlooked vector in biological invasions? **Knowledge & Management of Aquatic Ecosystems**, 418(42): 1-8.

Darwich, S. M., Py-Daniel, V. & Mardini, L. B. L. F. 1989. Predação e foresia (ocasional?) entre imaturos de Simuliidae (Diptera: Culicomorpha) e *Asolene* (*Pomella*) *megastoma* (Sowerby, 1825) (Mollusca: Gastropoda: Ampularidae). **Memórias do Instituto Oswaldo Cruz**, 84(Suppl 4): 145-148.

De-Carli, B. P., Rotundo, M. M., Paschoal, L. R. P., Andrade, D. P., Cavallari, D. C., Oceguera-Figueroa, A. & Alonso, D. D. 2014. First record of the association between the leech *Helobdella triserialis* (Hirudinea, Glossiphoniidae) and two species of *Pomacea* (Gastropoda, Ampullariidae) in Brazil. **Pan-American Journal of Aquatic Sciences**, 9(2): 136-140.

Green, A. J. & Figuerola, J. 2005. Recent advances in the study of long-distance dispersal of aquatic invertebrates via birds. **Diversity and Distributions**, 11(2): 149-156.

Kappes, H. & Haase, P. 2012. Slow, but steady: dispersal of freshwater molluscs. **Aquatic Sciences**, 74(1): 1-14.

Kenderov, L. A. 2017. An invader along with an invader: an unusual record of a zebra mussel *Dreissena polymorpha* (Pallas, 1771) (Bivalvia) living phoretically on a killer shrimp *Dikerogammarus villosus* (Sowinsky, 1894) (Amphipoda). **Acta Zoologica Bulgarica**, Suppl. 9: 287-291

Kolenda, K., Najbar, A., Kuśmierek, N. & Maltz, T. K. 2017. A possible phoretic relationship between snails and amphibians. **Folia Malacologica**, 25(4): 281-285.

Lacerda, L. E. M, Miyahira, I. C. & Santos, S. B. 2013. First record and range extension of the freshwater limpet *Gundlachia radiata* (Guilding, 1828) (Mollusca: Gastropoda: Planorbidae) from southeast Brazil. **Check List**, 9(1): 125-128.

Lanzer, R. 1996. Ancylidae (Gastropoda, Basommatophora) na América do sul:

sistemática e distribuição. **Revista Brasileira de Zoologia = Zoologia**, 13(1): 175-210.

Mackie, G. L. 1979. Dispersal mechanisms in Sphaeriidae (Mollusca: Bivalvia). **Bulletin of the American Malacological Union**, 45: 17-21.

Miyahira, I. C., Lacerda, L. E. M. & Santos, S. B. 2009. Dispersão ativa de *Melanoides tuberculatus* (Müller, 1774) e sua influência no processo de invasão. **Informativo SBMa**, 167: 3-5.

Ovando, X. M. C., Lacerda, L. E. M. & Santos, S. B. 2011. Mollusca, Gastropoda, Heterobranchia, Ancylidae, *Gundlachia radiata* (Guilding, 1828): First record of occurrence for the Northwestern region of Argentina. **Check List**, 7(3): 263-266.

Paschoal, L. R. P., Andrade, D. P. & Darrigran, G. 2013a. Size comparison of quadrats in sample of non-native bivalve *Corbicula fluminea* (Müller, 1774) (Bivalvia: Corbiculidae). **Pan-American Journal of Aquatic Sciences**, 8(4): 369-374.

Paschoal, L. R. P., Andrade, D. P. & Cavallari, D. C. 2013b. First record of *Aylacostoma francana* (Ihering, 1909) (Gastropoda, Thiaridae) in Minas Gerais state, Brazil. **Biotemas**, 26 (2): 277-281.

Prezant, R. S. & Chalermwat, K. 1984. Flotation of the bivalve *Corbicula fluminea* as a means of dispersal. **Science**, 225: 1491-1493.

Rees, W. J. 1965. The aerial dispersal of Mollusca. **Journal of Molluscan Studies**, 36(5): 269-282.

Robinson, J. L., Wetzel, M. J. & Tiemann, J. S. 2017. Some phoretic associations of macroinvertebrates on transplanted federally endangered freshwater mussels. **Northeastern Naturalist Notes**, 24(4): 29-34.

Santos, S. B. 2003. Estado atual do conhecimento dos ancilídeos na América do Sul (Mollusca: Gastropoda: Pulmonata: Basommatophora). **Revista de Biología Tropical**, 51(3): 191-223.

Thiengo, S. C., Santos, S. B. & Fernandez, M. A. 2005. Malacofauna límnica da área de influência do lago da usina hidrelétrica de Serra da Mesa, Goiás, Brasil. I. Estudo qualitativo. **Revista Brasileira de Zoologia = Zoologia**, 22: 867-874.

Walther, A. C., Benard, M. F., Boris, L. P., Enstice, N., Tindauer-Thompson, A. & Wan, J. 2008. Attachment of the freshwater limpet *Laevapex fuscus* to the hemelytra of the water bug *Belostoma flumineum*. **Journal of Freshwater Ecology**, 23(2): 337-339.

Watanabe, T. T., Hattori, G. Y. & Sant'Anna, B. S. 2015. Activity, substrate selection, and effect of a simulated Amazon flood regime on the behaviour of the apple snail, *Pomacea bridgesii*. **Marine and Freshwater Research**, http://dx.doi.org/10.1071/MF14066

White, T. R., Weaver III, J. S. & Fox, R. C. 1980. Phoretic relationships between Chironomidae (Diptera) and benthic macroinvertebrates. **Entomological News**, 91(3): 69-74.

Youens, A. K. & Burks, R. L. 2008. Comparing apple snails with oranges: the need to standardize measuring techniques when studying *Pomacea*. **Aquatic Ecology**, 42: 679-684.

Zelaya, D. G. & Marinone, M. C. 2012. A case of phoresis of Sphaeriids by Corixids: first report for the Americas. **Malacologia**, 55(2): 363-367.

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