Some new observations on the freshwater oyster *Acostaea rivolii* (Deshayes, 1827) (Bivalvia: Etheriidae)

Nuevas observaciones sobre la ostra de agua dulce *Acostaea rivolii* (Deshayes, 1827) (Bivalvia: Etheriidae)

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North South America has a great abundance of freshwater resources composed by some of the greatest river systems in the world, such as Amazonas, Orinoco and Magdalena. These rivers systems support a very large diversity of freshwater bivalves (82 species) (Pereira *et al.,* 2014). One of these river systems is the Magdalena river system the most important river in Colombia which drains the northern end of the Andes to the Caribbean Sea. The Magdalena system it's known for its diverse aquatic fauna that includes many endemic species. Unfortunately, for some groups there still exist a great gap of knowledge, this is especially true for the freshwater bivalves, according to Linares & Vera (2012) there is 21 species of bivalves in the Magdalena river basin, the majority of them poorly studied. One of these bivalves is *Acostaea rivolii* (Deshayes, 1827) an endemic species as well as an endemic genus of Colombia (Pain & Woodward, 1961; Arteaga-Sogamoso, 1994), native of the upper and middle basin of the Magdalena River, this species used to be found in small tributaries and rivers of the Magdalena in altitudes that vary between 195 to 1806 meters. The species has been assessed by the IUCN as critically endangered due to the continuous decrease of its populations caused by pollution, channelization of rivers, and water extraction for agriculture (Villa-Navarro *et al.,* 2016). *Acostaea rivolii* is also interesting for its complicated and debated systematics, it has been traditionally placed in the Etheriidae family alongside with the other two known species of freshwater oysters, *Etheria elliptica* Lamarck, 1807 from Africa and *Pseudomulleria dalyi* (E.A. Smith, 1898) from India (Graf 2000, Bogan & Hoeh, 2000; Graf & Cummings, 2007). However, the position of *A. rivolii* in the Etheriidae is widely discussed today and some studies place it near other families instead, doubting the existence of the Etheriidae family (Bogan & Hoeh, 2000; Bonetto, 1997). This has major implications in the biogeography of these three species and in the origin of cementation in freshwater bivalves, rather having a Gondwanan common ancestor (Yonge, 1977) or being the product of convergent evolution (Prashad, 1931).

The aim of this work it's to show some new observations regarding the morphology, ecology and distribution of the species based on the literature available and data obtained from fieldwork.

The fieldwork was conducted in the river Opia, Tolima, Middle Magdalena basin (04°32′36″N - 74°52′40″ W), a small tributary of the Magdalena River (Fig. 1). A total of 58 individuals were collected per hand, all the individuals were measured and weighed; and then transported to the laboratory in Bogotá, 12 were dissected using a stereomicroscope MoticK400 for morphological analysis, 15 were held for a filtration rate experiment and 10 were sacrificed for collection. The photos for the morphological analysis were taken using a Canon Powershot SD1300 IS and a Sony alpha nex 5.

The filtration rate was measured using the standard method from Coughlan (1969), with a known concentration of *Chlorella vulgaris* (Kryger & Riisgrad, 1988). Groups of five oyster were kept in an aquarium with the known concentration of the algae, an air pump was used to keep the *Chlorella* in suspension. Two replicas were made, the first one with a concentration of algae of $2.92x10^8$ cell/liter with periodical observations every 15 minutes during 120 minutes and the second one with a concentration of 1,33128x10^8 cells/liter with three observations every 30 minutes. The concentration of algae was measured using a hemocytometer Arthur Thomas 1/400 SQMM- 1/10 mm. Finally, the filtration rates were calculated using the equations of Quayle and Fox (Coughlan, 1969).

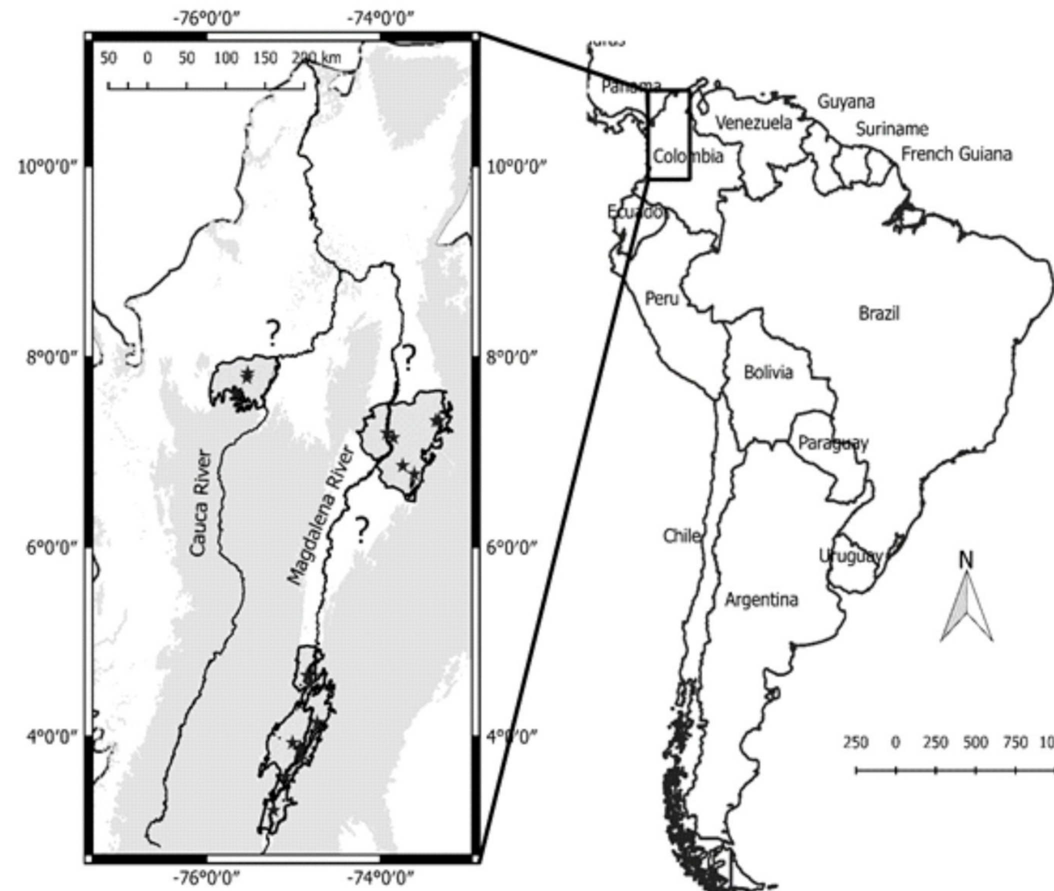

Figure 1. Rio Magdalena. Distribution of *Acostaea rivolii*. Questions marks: areas with no records. Stars areas: with confirmed presence.

Figura 1. *Río Magdalena. Distribución de* Acostaea rivolii*. Símbolos de interrogante son áreas sin registros. Estrellas son áreas con presencia confirmada*.

Morphology

The shell morphology of *A. rivolii* has been described previously in great detail (Ferussac, 1823; D'Orbigny, 1951; Anthony, 1907; Granados, 1973; Yonge, 1962), the principal features of it are the highly variable form due to the influence of the substrate, its medium to large size, the asymmetric valves with the fixed valve being thicker than the free one, and finally the spur like projection that connects the young shell with the adult shell and that is hollow in younger oysters and filled in older ones. Additionally, we observe that the articulation between the valves is made by a fracture line in the upper shell or free valve near the anterior outer layer and is filled with a corny substance in part of the ligament (Fig. 2). This secondary articulation may be a product of the bending of the shell to grow on the substrate, making it impossible to keep the ligament functioning.

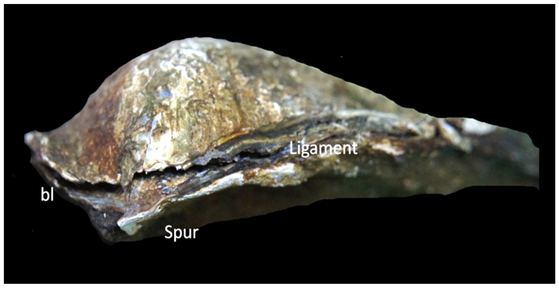

Figure 2. *Acostaea rivolii*, shell secondary articulation. Upper shell with clear breaking line for secondary articulation. Bl breaking line.

Figura 2. Acostaea rivolii*, concha articulación secundaria. Concha superior con línea de ruptura clara para articulación secundaria. Bl línea de ruptura.*

As to the soft parts, there had been much less work (Yonge, 1977; Guerrero-Kommritz & Escobar-Calderón, 2017). In general, the internal structure resembles *Unio*, but differs on the monomyarian condition of *A. rivolii*, the gut is similar to the one in *Anodonta* with three very well defined regions and a very large rectum that does not cross the pericardium. The labial palps has an external smooth face and an internal face that bears parallel lines covered with cilia, the mouth is wide and has a very distinctive set of protuberances inside and the anus is surrounded by two leaf-shaped palps. Finally, we were able to observe in younger individuals the extension of the mantle inside the hollow spur a character never observed before (Fig. 3), this observation confirms the pattern of growth of the species and the process of formation of the spur.

Distribution

Acostaea rivoii was abundant and had a range that spanned from the upper to the middle Magdalena basin around 6° 30' 43.57" N, 73° 37' 58.89" W to 3° 5' 32.63" N, 75° 19' 56.3" W (Granados, 1973). Other studies supports a larger probable range for the species that spans further north in the Cordoba Department, on the low Magdalena Basin (see Fig. 1) that will give the species a range from the 3.13° North through the 7.50° North and a longitudinal range from the 73.33° West through 75.40° West. Currently it is believed that the oyster only remains in the Opia River, in the department of Tolima (Villa- Navarro *et al.,* 2016). However, there are some reports of the species in the Aipe and Pata Rivers in the department of Huila (Repizo-Salazar *et al.,* 2009a; Mendez & Repizo-Salazar, 2011) and in the San Jorge river system in the department of Cordoba (Dueñas-Ramirez, 2001). These two departments represent the best chance of finding populations outside the Opia river.

Figure 3. *Acostaea rivolii*, spur in young animal.

Figura 3. Acostaea rivolii*, talón en animal joven*.

Ecology and conservation

The ecology of *A. rivolii* has been poorly studied with only few works presenting information about the habitat and diet of the species (Granados, 1973; Laverde, 1974; Martinez-Silva, 1971). Here the first measure of the filtration rate is presented. Suspension feeding bivalves play an important role in freshwater ecosystems and reliable data on filtration rates in freshwater bivalves are needed in order to assess their ecological role (Kryger & Riisgard, 1988) and also to determinate metabolism and growth rates (Gossling, 2004). For the first experiment, a filtration rate of 3.40 ml/min using the equation of Quayle and 2.45 ml/min for the equation of Fox was found. As to the second experiment, the filtration rate was 7.58 ml/min using Quayle and 3.57 ml/min using Fox (Table 1). The first experiment used an initial concentration of $2{,}9295 \times 10^{8}$ cell / liter while the second used a concentration of $1{,}33125 \times 10^{8}$ cells / liter. The filtration rate obtained was very low compared with other bivalves of similar size (Kryger & Riisgard, 1988), which did not pass 0.3l/h; suggesting a low metabolic rate. However this result could also be caused by external factors like the stress generated in the oysters due to the captive conditions. A new measurement using more natural conditions is recommended. Also a comparison with *Etheria* Lamarck, 1807 and *Pseudomulleria* Anthony, 1907 would give some information about this.

Table 1. Results from the filtration rate experiment on *Acostaea rivolii* using both methods; Quayle and Fox.

Tabla 1. *Resultados del experimento de tasas de filtración para* Acostaea rivolii *usando ambos métodos el de Quayle y Fox.*

Method/Experiment	1	2
Quayle (ml/min)	3.4037	7.5782
Fox (ml/min)	2.495	3.587
Average	2.94935	5.5826
Deviation	0.64254793	2.82220459

Regarding the reproduction it is known that *A. rivolii* bears a “lascidium” type larvae like the one in Mycetopodidae (Arteaga-Sogamoso, 1994) and that it has no preference for an specific species of host, with more than 11 species found to be infected with larvae (Gutierrez *et al.,* 2010).

Despite the existence of management plans (Lopez-Delgado *et al.,* 2009) and attempts to reproduce the oyster in captivity (Repizo-Salazar *et al.,* 2009a; Repizo-Salazar *et al.,* 2009b) right know there is no active program or plan for the conservation or restoration of *A. rivolii* in Colombia.

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