Shallow water Asteroidea and Ophiuroidea of Uruguay: composition and biogeography

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Abstract: Asteroidea (five species) and Ophiuroidea (18 species) recorded along the Uruguayan littoral (up to 50 m depth) are summarized and their distributional pattern are discussed. Species are gathered into four groups: 1) A. taxa distributed from North/South Carolina, or from the Caribbean Sea, to Southern Buenos Aires Province (Argentina), B. species ranging from North/South Carolina, Florida, São Paulo, to the mouth of Rio de la Plata, 2) species ranging from Rio de Janeiro south to the San Matias Gulf, 3) taxa recorded from Chile or from Antarctic/Subantarctic waters north to Uruguay, 4) a single cosmopolitan species. While ophiuroids are represented in each one of the mentioned groups, asteroids are restricted to the first one. As it happens with other elements of the Uruguayan fauna, this complex pattern is a consequence of the confluence of the warm Brazilian and the cold Malvinas (Falkland) currents, and of the discharge of fresh, muddy waters of the Rio de la Plata. Rev. Biol. Trop. 56 (Suppl. 3): 205-214. Epub 2009 January 05.

Key words: Asteroidea, Ophiuroidea, Uruguay, Rio de la Plata, biogeography, distribution.

The geographic distribution of many species along the Uruguayan littoral is mainly controlled by the fluctuation of salinity caused by the discharge of fresh, muddy waters of the Rio de la Plata into the Atlantic Ocean, and by the confluence of the warm coastal N-S Brazilian and the cold S-N Malvinas (Falkland) currents (Boltovskoy 1966, Podestá *et al.* 1991, Lentini *et al.* 2000, Piola *et al.* 2000, among others). Other factors such as wind, topography, seasonality, and El Niño Southern Oscillation (ENSO) phenomena also contribute to affect the littoral environmental conditions (Olson *et al.* 1988, Podestá *et al.* 1991, Lentini *et al.* 2000, Ortega & Martínez 2007), making this continuously changing area an interesting coastal sector of the south Atlantic Ocean to carry out biogeographic and macroecologic approaches (e.g. Martínez & Mooi 2005).

The main goal of this paper is to update and discuss the available data concerning asteroids and ophiuroids, two groups scarcely studied in Uruguay from the aforementioned viewpoints. Bernasconi (1964) focused on the biogeography of asteroids (and echinoids) of Southern South America, but the Uruguayan area is only briefly considered.

Littoral environmental changes affecting geographic distribution of faunas throughout geological time are not considered herein because, with the exception of a Devonian ophiuroid (Encrinaster pontis (Clarke, 1913), see Méndez-Alzola 1938), other ophiuroid or asteroid fossils are unknown from Uruguay.

MATERIALS AND METHODS

Taxonomy, distribution and substrates of species used in this paper (i.e. found in Uruguayan waters up to 50 m depth) were taken from the bibliographic information (see

references in the text). Geographic ranges have been registered from the specifically mentioned references, and for Uruguay and surrounding areas were checked against the primary bibliographic sources. The substrate indicated is the one recorded strictly in Uruguayan samples. Genera mentioned in bibliographic sources with undetermined species were only added when the genus was not otherwise recorded, but they were not taken into account for the biogeographic considerations.

RESULTS

Suprageneric classification of Ophiuroidea follows Smith *et al.* (1995) and of Asteroidea it follows Blake (1987) and Clark and Downey (1992).

Class Ophiuroidea Gray, 1840
Subclass Ophiuridea Gray, 1840
Order Euryalida Lamarck, 1816
Family Gorgonocephalidae Ljungman, 1867
Genus *Gorgonocephalus* Leach, 1815

Gorgonocephalus chilensis (Philippi, 1858)

References: Lucchi (1985), Scarabino (2006).
Distribution: Southwestern Atlantic Ocean from 35º S (off Rio de la Plata) to 33º S at the Pacific Ocean (Juan Fernández island), Southern Ocean, New Zealand (Lucchi 1985).
Substrate: not registered.

Order Ophiurida Müller & Troschel, 1840
Infraorder Gnathophiurina Matsumoto, 1915
Superfamily Gnathophiuridea Matsumoto, 1915
Family Ophiactidae Matsumoto, 1915
Genus *Ophiactis* Lütken, 1856

Ophiactis asperula (Philippi, 1858)

References: Bernasconi and D'Agostino (1977), Lucchi (1985), Scarabino (2006).
Distribution: Southern South America, from Chiloé (Pacific Ocean), to 34º S (Uruguay) in the Atlantic Ocean (Lucchi 1985).
Substrate: not registered.

Genus *Hemipholis* Lyman, 1865

Hemipholis elongata (Say, 1825)

References: Milstein *et al.* (1976, as *Amphilepis* sp.), Lucchi (1985), Scarabino (2006).
Distribution: South Carolina to Uruguay (Lucchi 1985, Borges 2006); South Carolina to Brazil (Hendler *et al.* 1995).
Substrate: Mud, shells (Scarabino 2006).

Family Amphiuridae Ljungman, 1867
Genus *Amphiura* Forbes, 1842

Amphiura complanata Ljungman, 1867

References: Tommasi *et al.* (1988b), Scarabino (2006).
Distribution: South and Southeastern Brazil to Northern Argentina (Borges *et al.* 2002, Borges 2006).
Substrate: shells (Scarabino 2006).

Amphiura crassipes Ljungman, 1867

References: Bernasconi & D'Agostino (1977), Lucchi (1985), Puig (1986), Tommasi *et al.* (1988b), Scarabino (2006).
Distribution: Southern Brazil (22º30' S- 24º S and 40º55' W-46º W) to San Matías Gulf (Lucchi 1985).
Substrate: Medium and fine sand, mud, shells (Lucchi 1985, Scarabino 2006).

Amphiura eugeniae Ljungman, 1867

References: Lucchi (1985), Scarabino (2006).
Distribution: from 20º15' S in the Pacific Ocean to 35º S in the Atlantic (off Rio de la Plata) (Lucchi 1985).
Substrate: mud (Lucchi 1985, Scarabino 2006).

Amphiura flexuosa Ljungman, 1867

References: Tommasi *et al.* (1988b), Scarabino (2006).

Distribution: "north region", Florida to Northern Argentina (Borges *et al.* 2002, Borges 2006).
Substrate: shells (Scarabino 2006).

Amphiura joubini Koehler, 1912

References: Bernasconi & D'Agostino (1977), Tommasi *et al.* (1988a, b), Scarabino (2006).
Distribution: New Zealand, Antarctic and Subantarctic regions, Argentina, Uruguay, South and Southeastern Brazil. (Borges *et al.* 2002, Borges 2006).
Substrate: shells (Scarabino 2006).

Amphiura princeps Koehler, 1907

References: Lucchi (1985), Scarabino (2006).
Distribution: around southern South America from 39º S in the Pacific Ocean to Uruguay (Lucchi 1985).
Substrate: Medium and fine sand, mud (Lucchi 1985, Scarabino 2006).

Genus *Amphiodia* Verrill, 1899

Amphiodia planispina (von Martens, 1867)

References: Milstein *et al.* (1976, as *Amphiodia* sp.), Lucchi (1985), Scarabino (2006, as *Diamphiodia planispina*).
Distribution: Florida to Mar del Plata (Lucchi 1985), Florida to Uruguay (Borges 2006).
Substrate: fine sand, mud, shells (Lucchi 1985, Scarabino 2006).

Amphiodia pulchella (Lyman, 1869)

References: Tommasi (1970b), Lucchi (1985), Scarabino (2006).
Distribution: Bermudas, Florida to Uruguay (Lucchi 1985, Borges 2006); Bermudas, Caribbean Sea to Argentina (Hendler *et al.* 1995).
Substrate: fine sand (Lucchi, 1985, Scarabino 2006).

Amphiodia sp. A

References: Carranza *et al.* (2007).
Substrate: sand (Carranza *et al.* 2007).

Genus *Amphioplus* Ljungman, 1867

Amphioplus albidus Verrill, 1899

References: Milstein *et al.* (1976, as *Amphioplus* sp. -*partim* – and *Amphiodia* sp. -*partim*), Bernasconi & D'Agostino (1977), Lucchi (1985), Demicheli & Scarabino (2006), Scarabino (2006).
Distribution: Rio de Janeiro to San Matías Gulf (Lucchi 1985); Southeastern Brazil to Uruguay (Borges *et al.* 2002).
Substrate: Fine sand, mud, shells, rocks (Lucchi, 1985, Scarabino 2006).

Amphioplus lucyae Tommasi, 1971

References: Carranza *et al.* (2007)
Distribution: São Paulo to Uruguay (Borges 2006, Carranza *et al.* 2007).
Substrate: Sand (Carranza *et al.* 2007).

Genus *Amphipholis* Ljungman, 1867

Amphipholis squamata (Delle Chiaje, 1828)

References: Tommasi (1970b), Scarabino (2006), Carranza *et al.* (2007).
Distribution: Cosmopolitan, except Polar Regions (Hendler *et al.*1995, Borges *et al.* 2002, Borges 2006).
Substrate: rock (Carranza *et al.* 2007).

Family Ophiothricidae Ljungman, 1867
Genus *Ophiothrix* Müller & Troschel, 1840

Ophiothrix angulata (Say, 1825)

References: Milstein *et al.* (1976), Lucchi (1985), Obenat *et al.* (2001), Scarabino (2006), López *et al.* (2007, as *Ophiogymna* sp.).

Distribution: North Carolina to Uruguay (Lucchi 1985, Hendler *et al.* 1995, Borges *et al.* 2002, Borges 2006).
Substrate: shells, polychaete colonies (Scarabino 2006).

Genus *Ophiothela* Verrill, 1867

Ophiothela sp.

References: Milstein *et al.* (1976), Scarabino (2006, as *Ophiothele* sp.).
Substrate: shells, rock (Milstein *et al.* 1976).

Infraorder Ophiolepidina Ljungman, 1867
Family Ophiolepididae Ljungman, 1867
Genus *Ophioplocus* Lyman, 1861

Ophioplocus januarii (Lütken, 1856)

References: Barattini (1938, as *Ophioceramis januarii*), Barattini & Ureta (1961, as *Ophioceramis januarii)*, Bernasconi & D'Agostino (1977), Bremec & Giberto (2004), Scarabino (2006).
Distribution: Antilles to Golfo Nuevo (Argentina) (Bernasconi & D'Agostino 1977, Borges 2006).
Substrate: coarse sand (Scarabino 2006).

Class Asteroidea de Blainville, 1830
Order Paxillosida Perrier, 1884
Family Luidiidae Verrill, 1899
Genus *Luidia* Forbes, 1839

Luidia alternata alternata (Say, 1825)

References: Juanicó & Rodríguez-Moyano (1976, as *Luidia quequensis*), Scarabino (2006).
Distribution: Discontinuous from Cape Hatteras (North Carolina) to Buenos Aires (Argentina) (Hendler *et al.* 1995); North Carolina (ca. 34.5ºN to Northern Argentina (ca. 38ºS) (Clark & Downey 1992).
Substrate: *Mytilus* sp. aggregations (Juanicó & Rodríguez-Moyano 1976, Scarabino 2006).

Family Astropectinidae Gray, 1840
Genus *Astropecten* Gray, 1840

Astropecten brasiliensis
Müller & Troschel, 1842

References: Barattini (1938), Juanicó & Rodríguez-Moyano (1976), Roux & Bremec (1996), Scarabino (2006).
Distribution: Antilles, Northeastern Brazil to Buenos Aires Province (Argentina) (Tomassi 1970a, Clark & Downey 1992).
Substrate: *Mytilus* sp. aggregations, middle sand (Juanicó & Rodríguez-Moyano 1976, Scarabino 2006).

Astropecten cingulatus Sladen, 1883

References: Bernasconi (1966), Juanicó & Rodríguez-Moyano (1976), Tomassi *et al.* (1988a), Scarabino (2006).
Distribution: Southern Pernambuco (Brazil) to Buenos Aires Province (Argentina) (Bernasconi 1966); North Carolina to Northern Brazil, West Africa (Clark & Downey 1992).
Substrate: *Mytilus* sp. aggregations (Juanicó & Rodríguez-Moyano 1976, Scarabino 2006).

Order Valvatida Perrier, 1884
Family Asterinidae Gray, 1840
Asterina Nardo, 1834

Asterina stellifera (Möbius, 1859)

References: Barattini (1938, as *Asterina marginata*); Bernasconi (1955), Barattini & Ureta (1961), Amaro (1967, as *Enoplopatiria marginata*), Bernasconi (1966), Milstein *et al.*(1976), Bremec & Giberto (2004, as *Patiria stellifer*), Riestra *et al.* (1992, 1998, as *Asterina stellifer*), Demichelli & Scarabino (2006), Scarabino (2006).
Distribution: Cabo Frio (Brazil) to Mar del Plata (Argentina); Senegal to Namibia (Clark & Downey 1992).
Substrate: sand, shells, mud, rocks (Scarabino 2006).

Order Spinusolida Perrier, 1884
Family Echinasteridae Verrill, 1870
Echinaster Müller & Troschel, 1840

Echinaster sp.

References: Juanicó & Rodríguez-Moyano (1976), Scarabino (2006).
Substrate: *Mytilus* sp. aggregations. (Juanicó & Rodríguez-Moyano 1976, Scarabino 2006).
Comments: The original material could not be checked, but it is very probable that the species is *Echinaster brasiliensis* Müller & Troschel, 1840, according to its distribution (Tomassi 1970a, Carrera-Rodríguez & Tommasi 1977, Clark & Downey 1992).

DISCUSSION

Although the knowledge of the Uruguayan species collected from shallow waters (up to 50 m depth) is fairly good (Scarabino 2006), detailed oceanographic and abundance data, as well as reproductive modes, are not fully known. Therefore, conclusions provided herein are based only on the presence-absence of species, and must be considered as preliminary and global approaches to this subject.

There are no endemic species, and the Ophiuroidea and Asteroidea taken into account in this analysis are gathered into four groups according to their geographic distribution.

1) **A.** Species distributed from North/South Carolina, or from the Caribbean Sea, to Southern Buenos Aires Province (Argentina). This group comprises all the asteroids and two species of ophiuroids: *Ophioplocus januarii* and *Amphiodia planispina* (Fig.1a).
   B. Species ranging from North/South Carolina, Florida, São Paulo, to the mouth of the Rio de la Plata: *Hemipholis elongata*, *Amphiodia pulchella*, *Amphioplus lucyae*, *Amphiura flexuosa*, and *Ophiothrix angulata* (Fig. 1b).
2) Species found from Rio de Janeiro to approximately the San Matias Gulf: *Amphioplus albidus*, *Amphiura crassipes*, and *Amphiura complanata* (Fig. 1c).
3) Species recorded from Chile or from Antarctic/Subantarctic waters north to Uruguay (occasionally Southern Brazil): *Gorgonocephalus chilensis*, *Ophiactis asperula*, *Amphiura joubini*, *Amphiura princeps*, and *Amphiura eugeniae* (Fig. 1d).
4) The cosmopolitan species *Amphipholis squamata*.

Group 1 is related to the development of tropical and subtropical waters in Uruguay caused by the presence of the Brazilian current in the region. Species of sub-group 1B do not extend their distribution across the Rio de la Plata, probably because of the temperature variation of the Subtropical Confluence Zone (ca. 30 to 45ºS, see Boltovskoy 1966 for example), where the cold Malvinas (Falkland) and the warm Brazilian currents meet, and/or due to the strong variation in salinity and the increase of turbidity of waters caused by the Rio de la Plata fresh water discharge (Piola *et al.* 2000, González-Silvera *et al.* 2004). The "salinity barrier" of the Rio de La Plata has previously been considered an explanation for the truncation of the distribution of other organisms at the Rio de la Plata area, such as molluscs (Scarabino 1977) or sand dollars (Martínez & Mooi 2005); the situation of other organisms is still in need of more detailed studies (see for example Genzano & Zamponi 1997 and López Gappa & Landoni 2005, concerning Hydrozoa and Porifera respectively). Martínez & Mooi (2005) also considered the turbidity factor as important, since turbidity favors fine-grained substrates not apt for the feeding mechanism of these echinoids. In reference to sub-group 1B, only one species (*Hemipholis elongata*) is found in muddy substrates, indicating that this factor may be of importance for the other species along with salinity. *Hemipholis elongata* is often found in "soft, poorly oxygenated, unvegetated sediments" (Hendler *et al.* 1995), and tolerates a reduced salinity (Ferguson 1948, Binyon 1966,

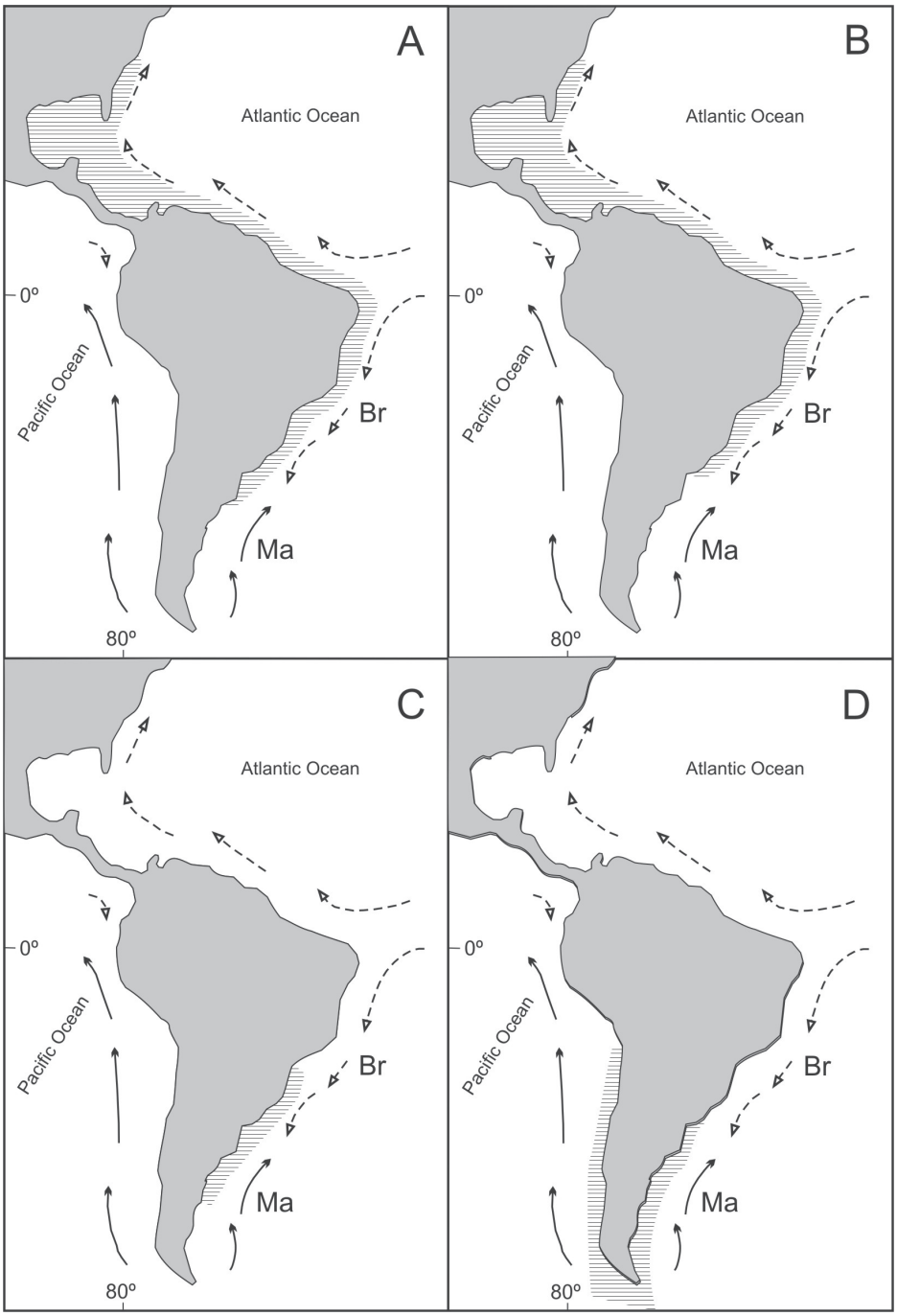

Fig. 1. Sketches of the American latitudinal geographic range of Uruguayan species of Asteroidea and Ophiuroidea (except the cosmopolite Amphipholis squamata). Longitudinal limits are arbitrary. A) Group 1a (all Asteroidea, *Ophioplocus januarii* and *Amphiodia planispina*). B) Group 1b (*Hemipholis elongata*, *Amphiodia pulchella*, *Amphiura flexuosa*, *Amphioplus lucyae* and *Ophiothrix angulata*). C) Group 2 (*Amphioplus albidus*, *Amphiura crassipes* and *Amphiura complanata*). D) Group 3 (*Gorgonocephalus chilensis*, *Ophiactis asperula*, *Amphiura joubini*, *Amphiura princeps*, and *Amphiura eugeniae*). Br: Brazilian Current , Ma: Malvinas (Falkland) Current.

Sheridan & Badger 1981). Thus, the Southern range boundary of H. elongata can be clearly explained by the temperature factor.

The distribution of the second group coincides with the area comprised by the Argentinean or Patagonian Province (ca. 43º S and ca. 28º S, Scarabino 1977, Boschi 2000), a unit characterized by a complex faunal composition. Moreover, Tommasi (1970b, ophiuroids), Scarabino (1977, molluscs) and Martínez & del Rio (2002a, molluscs) suggested that this zone may be a true transition zone or "Provinciatone" between the Magellanic and Brazilian Provinces. According to Martínez & del Rio (2002a, b), the Argentinean Province developed in post-Miocene times, when the Malvinas (Falkland) Current began to fully operate as far as at least Northern Patagonia, and consequently the warm or warm-temperate organisms retracted their geographic range or became extinct.

The third group is constituted of species that reach northern Uruguay due to the cold Malvinas Current. This range limit can be attributed again to the confluence between the warm and cold currents; in this case the species would not adapt to higher temperatures. Two of them, *Amphiura princeps* and *A. eugeniae*, have been found in muddy substrates; consequently the substrate factor may only be valid for the other species. On the other hand, evidently being more tolerant, *Amphiura joubini* reaches Southern Brazil.

Finally, we found a cosmopolitan species, which is not informative (but it is most likely a species-complex; not (yet) identifiable morphologically).

The fossil record of asteroids and ophiuroids in the Southwestern Atlantic Ocean is very poor and only three Tertiary ophiuroids from Argentina have been described: *Ophiura elegantoides* Furque & Camacho, 1949 (late Middle Eocene), *Ophiocrossota kollenbergorum* Caviglia, Martínez & del Río, 2007 (Early Miocene) and *Ophioderma bonaudoae* Martínez & del Río, 2008 (Late Miocene). Consequently, until new findings are made, the fossil record does not contribute to clarify present distribution patterns.

In contrast to ophiuroids, asteroids show a homogeneous distribution. The asteroids present in Uruguay, although not diverse, have a wide distribution from North Carolina or the Caribbean Sea to Southern Buenos Aires Province (Argentina) and apparently are not affected by the Rio de la Plata discharge. This distribution is related to the warm Brazilian Current, and according to the proposal of del Rio (1990, see also del Rio & Martínez 1998, Martínez & del Rio 2002a, b), dealing with the northern retraction of the Miocene molluscan faunas, it should also be considered that the Miocene relatives of the Recent asteroids may have lived at least as far south as northern Patagonia, where the proto-Brazilian current was already fully operating (Camacho 1967).

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RESUMEN

Se brinda una lista de los Asteroidea (5 especies) y Ophiuroidea (18 especies) de aguas someras (hasta 50 m) de Uruguay, y se discute su distribución, agrupándose las especies de acuerdo a su ámbito latitudinal en: 1) A. aquellas distribuidas desde Carolina del Norte o Sur o el mar Caribe hasta el sur de la Provincia de Buenos Aires (Argentina), 1) B. especies que se encuentran al norte de Uruguay pero que no pasan del Rio de la Plata hacia el sur, 2) las distribuidas desde Río de Janeiro hasta aproximadamente el Golfo San Matías, 3) desde Chile o aguas antárticas o subantárticas hasta Uruguay o sur de Brasil, y 4) cosmopolita. Todos los asteroideos pertenecen exclusivamente al primer grupo, distribuyéndose los ofiuroideos en los cinco. Como sucede con otros elementos de la fauna uruguaya, este patrón complejo es consecuencia de una situación oceanográfica compleja, producida fundamentalmente por la confluencia de la corriente cálida de Brasil y la fría de Malvinas (Falkland), y la descarga de agua dulce y turbia del Rio de la Plata.

Palabras clave: Asteroidea, Ophiuroidea, Uruguay, Rio de la Plata, biogeografía, distribución.

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