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First record of *Luidia atlantidea* Madsen, 1950 (Echinodermata: Asteroidea: Paxillosida: Luidiidae) in the Sidi-Medjdoub area—Mostaganem (West Algerian coast, Mediterranean Sea)

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Abstract

The genus *Luidia* is currently represented in the Mediterranean Sea by three species, namely *Luidia ciliaris* (Philippi, 1837), *Luidia sarsii sarsii* (Düben & Koren in Düben, 1844) and *Luidia atlantidea* (Madsen, 1950) which is an Atlantic species recently reported from the Spanish and Tunisian coasts. Two individuals of *Luidia atlantidea* were collected as bycatch from small-scale fisheries in the region of Sidi-Medjdoub (Mostaganem, Algeria) at a depth of 53 m. The detailed study of the morphological and anatomical characters allowed us to formally identify the two individuals of *Luidia atlantidea* and therefore to report it for the first time in the Algerian West coast.

Key words: Asteroidea, new records, alien, Mediterranean Sea, Algerian Basin

Introduction

The Mediterranean Sea is a biodiversity hotspot with between 15,000 and 20,000 marine species, of which nearly a quarter are endemic (Bianchi *et al.* 2011). However, this biodiversity has been affected by several factors including global warming, human pressure, and changes in the physical and chemical characteristics of seawater (Lejeusne *et al.* 2010; UNEP-MAP RAC/SPA 2010).

As a result, the Mediterranean Sea has become more receptive to non-endemic animal and plant species of Atlantic (through the Strait of Gibraltar) and Pacific origin (through the Suez Canal) (Ben Rais Lasram *et al.* 2008; Raitsos *et al.* 2010; Zuljevic *et al.* 2011; Otero *et al.* 2013). Regular monitoring and reporting of species diversity are necessary because of contributions by these Herculean and Lessepsian immigrants, which can modify the composition of the Mediterranean biota (Bianchi *et al.* 2011) and can present a real threat not only for native species (competition then eradication), but also for human health and the economy (fishing, aquaculture, tourism) (Pomeroy *et al.* 2004; Ben Souissi 2015). Nevertheless, not all non-native species threaten native species, such is the case of the sea cucumber *Holothuria* (*Roweothuria*) *arguinensis* (Koehler & Vaney, 1906) which does not compete for food with other holothurian species present in the Algerian coast such as *Holothuria* (*Holothuria*) *tubulosa* Gmelin, 1791, *Holothuria* (*Roweothuria*) *poli* Delle Chiaje, 1824, *Holothuria* (*Panningothuria*) *forskali* Delle Chiaje, 1823 and *Holothuria* (*Platyperona*) *sanctori* Delle Chiaje, 1823 (Belbachir & Mezali 2021).

Several marine invertebrates originating from the Atlantic Ocean have entered the Mediterranean Sea (Gofas & Zenetos 2003). Among the echinoderms we find the sea cucumber *Holothuria* (*R.*) *arguinensis* reported in Spain and Algeria (González-Wangüemert & Borrero-Pérez 2012; Mezali & Thandar 2014), *Parastichopus tremulus*

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(Gunnerus, 1767) reported in Spain (Ordines *et al.* 2019), *Parastichopus regalis* recorded in the Algerian coast (Benzait *et al.* 2020; Khodja *et al.* 2021) and the starfish *Luidia atlantidea* reported in Spain and Tunisia (Gallardo-Roldán *et al.* 2015; Chammem *et al.* 2019). This study reports for the first time the presence of *Luidia atlantidea* in the West Algerian coastal waters.

Material and methods

Two individuals of *Luidia atlantidea* were caught in the net of a demersal gillnet as bycatch in the Sidi-Medjdoub (Mostaganem) region, west of the Algerian coast (36°0.032'N, 0°1.456'E) at a depth of 53 m in February 2019 (Figure 1). The individuals were photographed and transported to the PVCMRMS (Protection, Valorization of Coastal Marine Resources and Molecular Systematics laboratory, Mostaganem, Algeria), anesthetized and stored in formalin (10%) for subsequent identification based essentially on morphological criteria using the descriptions of Koehler (1911), Madsen (1950), Clark (1953, 1955), Nataf & Cherbonnier (1973), Clark (1982), Clark & Downey (1992). Each individual was weighed using a 0.01 g precision balance (wet body weight) and measured [minor radius "r" (from the center of the disc to the interradial edge) and major radius "R max" (from the center of the disc to tip of the longest arm) with a measuring tape and width of the arms at their base with a 0.01 cm precision caliper].

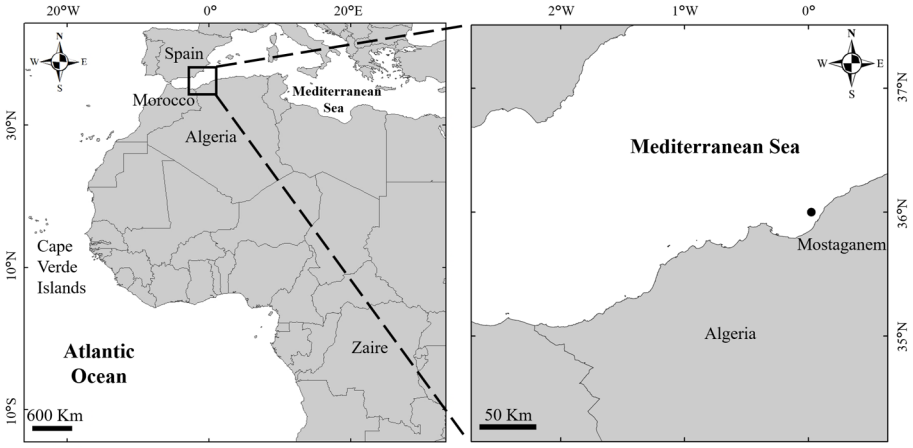

FIGURE 1. Sampling station of *Luidia atlantidea* (indicated by the black circle).

Starfish are not externally sexually dimorphic (Mariante *et al.* 2010). Sexes were distinguished after analysis of histological sections of the gonads of the two individuals of *L. atlantidea*. Histological analysis consists of the fixation of the gonads in formalin (10%), dehydration in an ascending series of alcohol baths, clarification in xylene, inclusion in paraffin, cutting into 5 µm thick sections, staining with haematoxylin eosin and observation under a light microscope (Leica DMLP) with an attached camera.

Acronym

Abbreviations used: LPVCMRMS—Laboratory of Protection, Valorization of Coastal Marine Resources and Molecular Systematics, Mostaganem, Algeria.

Results and discussion

Order Paxillosida Perrier, 1884

Family Ludiidae Sladen, 1889

Genus Luidia Forbes, 1839

***Luidia atlantidea* Madsen, 1950**
Figures 2–3, Table 1

Luidia sarsi Studer, 1884: 43.
Luidia africana Koehler, 1911:19; Doderlein, 1920: 288–289.
Luidia atlantidea Madsen, 1950: 192–198, fig. 5, pl. 16, figs 1, 2; Nataf & Cherbonnier, 1973: 76–80; pl. I, B, pl. II, A, B, pl. VII, 1–5, pl. IX, E, F; Clark & Downey, 1992: 10–11, figs 5b, 6b, 7p, pl. 2A; Clark, 1953: 393, 394; 1955: 22, 32; 1982: 168, fig. 3p.

Material examined. LPVCMRMS2019.401, LPVCMRMS2019.402, Mostaganem, Algeria, 36°0.032'N, 0°1.456'E, 53 m, February 2019, 2 specs.

Description. Two specimens, minor radius "r" 42.83 and 34.51 mm, wet weight 185.22 and 128.92 g respectively. Flat body, five slender arms from base to tip. Major radius "R max" 230.30 and 180.40 mm and average width 25.83 and 24.98 mm respectively. Abactinal side (Figure 2A) gray, paxillae white, marginal paxillae show white bands. Superomarginal paxillae squarish (Figure 2C1 & 2E1), larger with 4 rows of spinelets, abactinal paxillae small and rounded (Figure 2C2 & 2E2) with 3 rows of short and thick spinelets. Central paxillar spinelets larger and shorter than the peripheral ones. Actinal side beige (Figure 2B). Dorsolateral Inferomarginal plates with 3 rows of needle-like spines (Figure 2F1) black at the base and white at the tips, the central spines significantly larger than the peripheral ones. Ventrolateral inferomarginal plates with 3 alternating rows of white spines (Figure 2F2) that decrease in size from the abactinal surface to the actinal surface. Adambulacral plates (Figure 2G1) with 3–4 smaller spines arranged perpendicular to the ambulacral groove with the spine adjacent to the ambulacral groove longer than the peripheral spines. Two long spines at the mouth plate (Figure 2D) directed toward the mouth followed by pedicellariae and shorter spines. Pedicellariae with two valves, numerous especially on the inferomarginal and adambulacral plates. Two rows of large podia. Madreporite small.

Gonad description. The largest specimen male (LPVCMRMS2019.401) and the smallest one female (LPVCMRMS2019.402). The gonads extend into the coelomic cavity, forming two rows of tufts on each side of the arm (ten in total), above the caeca pyloric. Color beige to cream for both sexes. Microscopically, gonads enclosed in two sacs (inner and outer) separated by the genital coelom. Testes (Figure 3A) composed of spermatogenic columns, spermatids attached to the top of the columns and the lumen where the spermatozoa accumulate. Ovaries (Figure 3B) with an elongated tubular shape. Oocytes of the same size (synchronous growth). Centric circular nuclei.

Distribution, abundance and habitat. *Luidia atlantidea* was first recorded from the western and northwestern African Atlantic coast from Morocco to Zaire including the Cape Verde Islands (Clark 1953; Clark 1982; Clark & Downey 1992; Entrambasaguas 2008). It occurs between 10 and 80 m deep (Clark 1982) and frequents rocky bottoms with gray mud, sand and calcareous algae, muddy sand, fragments of gastropod shells, mud with stones, sand with stones, fine sand (Clark & Downey 1992). Recently, *L. atlantidea* has been reported in the Canary Islands (Osaer & Narváez 2017) and in the Mediterranean Sea [northern Alboran Sea (Gallardo-Roldán *et al.* 2015) and the Golf of Gabes (Chammem *et al.* 2019)].

In the Mediterranean, studies on the ecology and biology of *L. atlantidea* are practically very few, even anecdotal. In fact, only Gallardo *et al*. (2015) and Chammem *et al.* (2019) recorded it at the Spanish and Tunisian water respectively, these authors affirmed the very low abundance of this species (generally < 2 individuals per haul). Individuals of *L. atlantidea* were found at a greater depth range in the Mediterranean (0.9 – 95 m) (Gallardo *et al.* 2015; Chammem *et al.* 2019) than that reported by Clark (1982) in the Atlantic.

No conclusion can be taken on the invasive status of this species, in fact, according to Makhlouf & Shakman (2021), it is very difficult to identify invasive species in any country or region, because the species and their interactions with ecosystems are very complex.

Remarks. In the Mediterranean Sea, two species of the genus *Luidia* are documented, *Luidia sarsii sarsii* Düben & Koren in Düben, 1844 and *Luidia ciliaris* (Philippi, 1837). The differences that exist between the three species present in the Mediterranean Sea are summarized in the table 1.

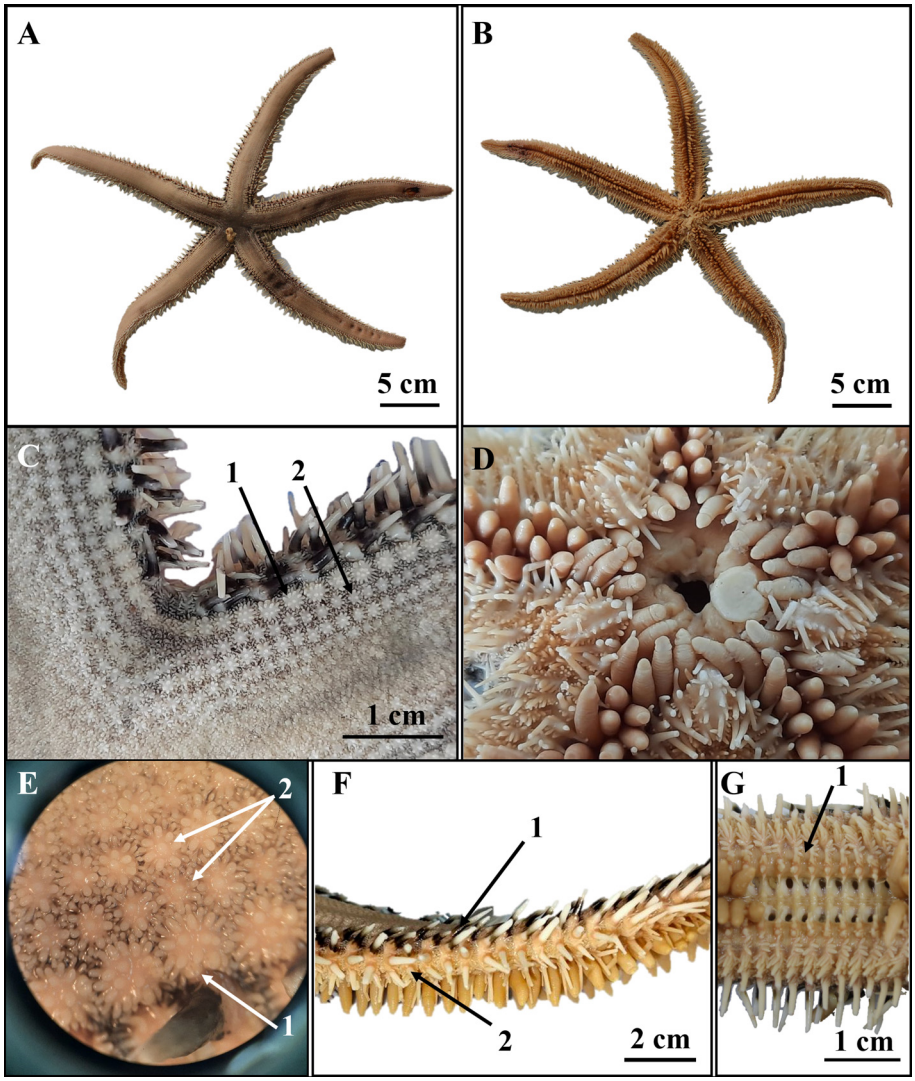

FIGURE 2. Morphological characters of *Luidia atlantidea* Madsen, 1950 (fixed individual: LPVCMRMS2019.402) sampled in the region of Sidi-Medjdoub (Mostaganem). **A.** Abactinal surface. **B.** Actinal surface. **C.** Paxillae of the abactinal surface. **1.** Large superomarginal paxillae. **2.** Small abactinal paxillae. **D.** Mouth. **E.** Detail of abactinal paxillae. **1.** Large superomarginal paxillae. **2.** Small abactinal paxillae. **F.** Detail of an arm, lateral view. **1.** Dorsolateral inferomarginal spines. **2.** Ventrolateral inferomarginal spine. **G. 1.** Adambulacral plate.

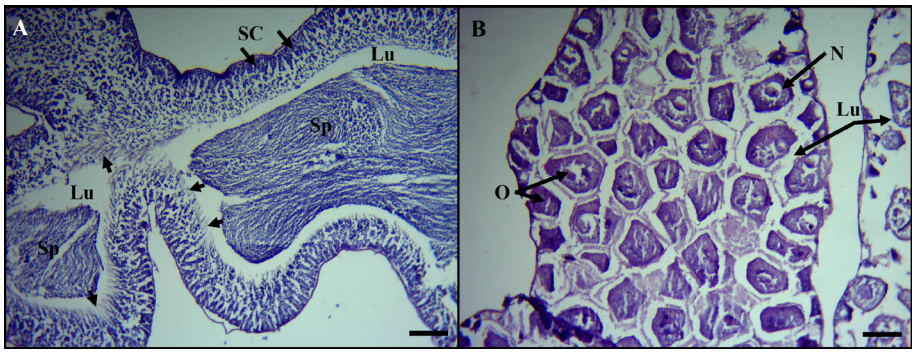

FIGURE 3. Histological sections of the gonads of *Luidia atlantidea*. **A.** Testes. **B.** Ovaries. **O.** Oocytes. **N.** Nuclei. **Sp.** Spermatozoa. **SC.** Spermatogenic columns. Small black arrows indicate spermatids. **Lu.** Lumen. Scale bar = 100 µm.

TABLE 1. Morphological comparison of species of the genus *Luidia* found in the Mediterranean Sea

	L. atlantidea	*L. sarsii sarsii*	*L. ciliaris*
Number of arms	5 (Clark & Downey 1992; Present study)	5 (Clark & Downey 1992)	7 (Koehler 1921)
Shape of abactinal paxillae	Small and rounded with 3 rows of short and thick spinelets. Central larger and shorter than the peripheral ones (Clark & Downey 1992; Present study)	Small and rounded (Clark & Downey 1992)	Small and rounded (Clark & Downey 1992)
Paxillar spinelets	Central markedly more coarse and squat than the slender peripheral ones (Clark & Downey 1992; Present study)	Fine spinelets of fairly uniform length, median paxillae mostly with only single central spinelet, sometimes distinctly coarser and the peripheral ones are also less attenuated (Clark & Downey 1992)	Variable in shape but fairly uniform in height, a large central spinelet and 10 or 12 smaller peripheral ones (Clark 1982; Clark & Downey 1992)
Superomarginal paxillae	Slightly longer than broad but many (often alternate ones) almost square (Clark 1953; Clark & Downey 1992; Present study)	Elongated (Clark & Downey 1992)	More or less elongated (Clark & Downey 1992)
Pedicellariae	Ventrolateral pedicellariae short and truncated (Nataf & Cherbonnier 1973; Present study)	Elongated, narrow, and not tumid, and have the outline of a somewhat produced isosceles triangle (Norman 1865)	Threevalved on some of the actinal plates but bivalved when on the inferomarginals (Clark & Downey 1992)
Inferomarginal spine	Uppermost inferomarginal spine usually of the same length or longer than the second one (Clark 1953; Present study)	Uppermost inferomarginal spine usually shorter than the second one (Clark 1953)	Uppermost inferomarginal spine usually of the same length or longer than the second one (Clark 1953)

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