

Research note

First record of *Ophioderma ensiferum* (Echinodermata: Ophiuroidea) from the southeastern continental shelf of the Gulf of Mexico and from an anchialine cave

Primer registro de *Ophioderma ensiferum* (Echinodermata: Ophiuroidea) del sureste de la plataforma continental del golfo de México y de una cueva anquihalina

Yoalli Quetzalli Hernández-Díaz^{1✉}, Francisco A. Solís-Marín², Nuno Simões³ and Laura Sanvicente-Añorve⁴

¹Posgrado en Ciencias del Mar y Limnología, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México. Apartado postal 70-305, 04510 México, D. F., México.

²Colección Nacional de Equinodermos "Dra. Ma. Elena Caso Muñoz", Laboratorio de Sistemática y Ecología de Equinodermos, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México. Apartado postal 70-305, 04510 México, D. F., México.

³Unidad Multidisciplinaria de Docencia e Investigación-Sisal, Facultad de Ciencias, Universidad Nacional Autónoma de México, Puerto de Abrigo s/n, Sisal, 97356 Yucatán, México.

⁴Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México. Apartado postal 70-305, 04510 México, D. F., México.

✉ quetzalli.hernandez@gmail.com

Abstract. Two specimens of *Ophioderma ensiferum* Hendler and Miller, 1984 were collected at 2 different localities in the Yucatán Peninsula, Mexico. The first one collected at Alacranes Reef, Yucatán, a transition zone between the Gulf of Mexico and the Caribbean, and the second one in an anchialine cave located in Cozumel Island, Quintana Roo. These records expand the known distribution of the species to the southern part of the continental shelf of the Gulf of Mexico. This finding represents the first record of this ophiuroid on the continental shelf of Mexico, and also the first record of this species in an anchialine cave.

Key words: new record, Alacranes Reef, ophiuroid, anchialine cave, Yucatán, Quintana Roo.

Resumen. Dos especímenes de *Ophioderma ensiferum* Hendler y Miller, 1984 fueron recolectados en 2 localidades diferentes de la península de Yucatán, México. La primera fue en el arrecife Alacranes, Yucatán, la cual es un área de transición entre el golfo de México y el Caribe, y la segunda en una cueva anquihalina ubicada en la isla de Cozumel, Quintana Roo. Estos registros amplían la extensión de la distribución de la especie hacia el sureste de la plataforma continental del golfo de México. Se presenta el primer registro de dicho ofiuoideo en la plataforma continental de México y el primer reporte de dicha especie en una cueva anquihalina.

Palabras clave: nuevo registro, arrecife Alacranes, ofiuoideo, cueva anquihalina, Yucatán, Quintana Roo.

The genus *Ophioderma* Müller and Troschel, 1840 (Family Ophiodermatidae Ljungman, 1867) is distinguished by a disc covered with oval or flattened granules. Each jaw holds a group of oral papillae, wider than long, and 3 to 5 teeth. Four bursal slits are present in each interradius. Six to 13 arm spines per segment, and 2 tentacle scales per arm plate covering the tentacle pore (Müller and Troschel, 1840). Currently, 27 species are recognized in the genus *Ophioderma* according to the latest census of the Ophiuroidea (Stöhr and O'Hara, 2007).

In the Atlantic Ocean, at least 11 species of *Ophioderma* occur (Hendler et al., 1995), all but the east Atlantic. *O. longicauda* Bruzelius, 1805 and the South African *O. leonis* Döderlein, 1910 are restricted to the western parts (Stöhr et al., 2009). Some species of this genus (i.e., *O. brevispinum* and *O. longicauda*) have a short-lived vitellaria larva, which has duration of the pelagic life of 8 or 9 days (Fenaux, 1969; Webb, 1989). *Ophioderma ensiferum* Hendler and Miller, 1984 is a shallow water subtropical brittlestar (11 to 24 m depth) previously recorded only in 2 different places belonging to the marine ecoregions of the Western Caribbean and the Greater Antilles, which

are part of the Tropical Northwestern Atlantic province according to the bioregionalization of Spalding et al. (2007): its type locality, Carrie Bow Cay in Belize, Barrier Reef (Hendler and Miller, 1984; Hendler and Pawson,

2000) and Peninsula de Hicacos, Cuba (Abreu-Pérez, 2003; Abreu-Pérez et al., 2005).

Recently (August 2009 and July 2010), *O. ensiferum* was collected in 2 different localities in the Yucatán

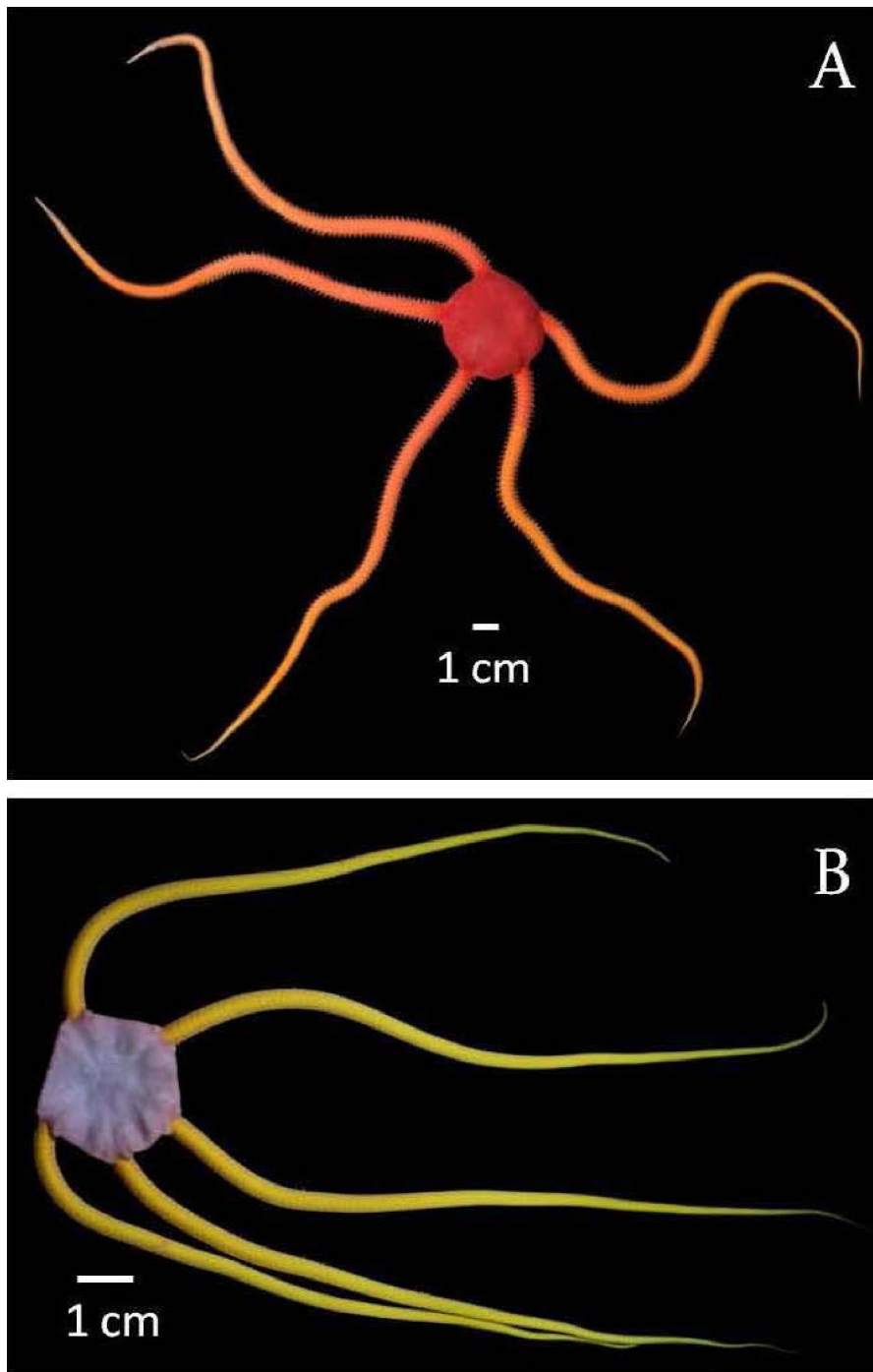


Figure 1. *Ophioderma ensiferum*: A, living specimen, dorsal view (Alacranes Reef); B, living specimen, dorsal view (Cenote Aerolito del Paraíso).

Peninsula in shallow water habitats (11 - 12 m), living on coral or muddy bottoms. These 2 records constitute the first time that *O. ensiferum* has been collected in the continental shelf of Mexico, as well as the first record of this species in an anchialine cave habitat. The first location was Alacranes Reef (according to Spalding et al. [2007] is located in the marine ecoregion of the Southern Gulf of Mexico), which is a transition zone between the Gulf of Mexico and the Caribbean containing echinoderm species considered exclusive to both biogeographical subprovinces (Hernández-Díaz, 2011). The second specimen was collected in an anchialine cave (cenote Aerolito de Paraíso, Cozumel Island, Quintana Roo, in the Western Caribbean marine ecoregion [Spalding et al., 2007]). Cenote Aerolito, is located close in the western coast of Cozumel, 240 m from the shore. This system has a length of approximately 6 100 m, and it is connected to the sea through an

underwater cave system (Mejía-Ortiz et al., 2007). At its northwestern end, a relict of mangrove vegetation is present (*Rhizophora mangle* Linnaeus, 1753), and large aggregations of algae are found all around its edges (Frontana-Uribe and Solís-Weiss, 2011). *Ophioderma ensiferum* is the fifth confirmed record of an echinoderm from Mexican Caribbean anchialine caves (Mejía-Ortiz et al., 2007; Solís-Marín and Laguarda-Figueras, 2010).

Collected specimens were compared with the holotype material held at the National Museum of Natural History, Smithsonian Institution, Washington D.C., USA (USNM E30579) and with the diagnosis by Hendler and Miller (1984). The specimens collected were deposited in the Colección Nacional de Equinodermos de México, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México (ICML-UNAM).

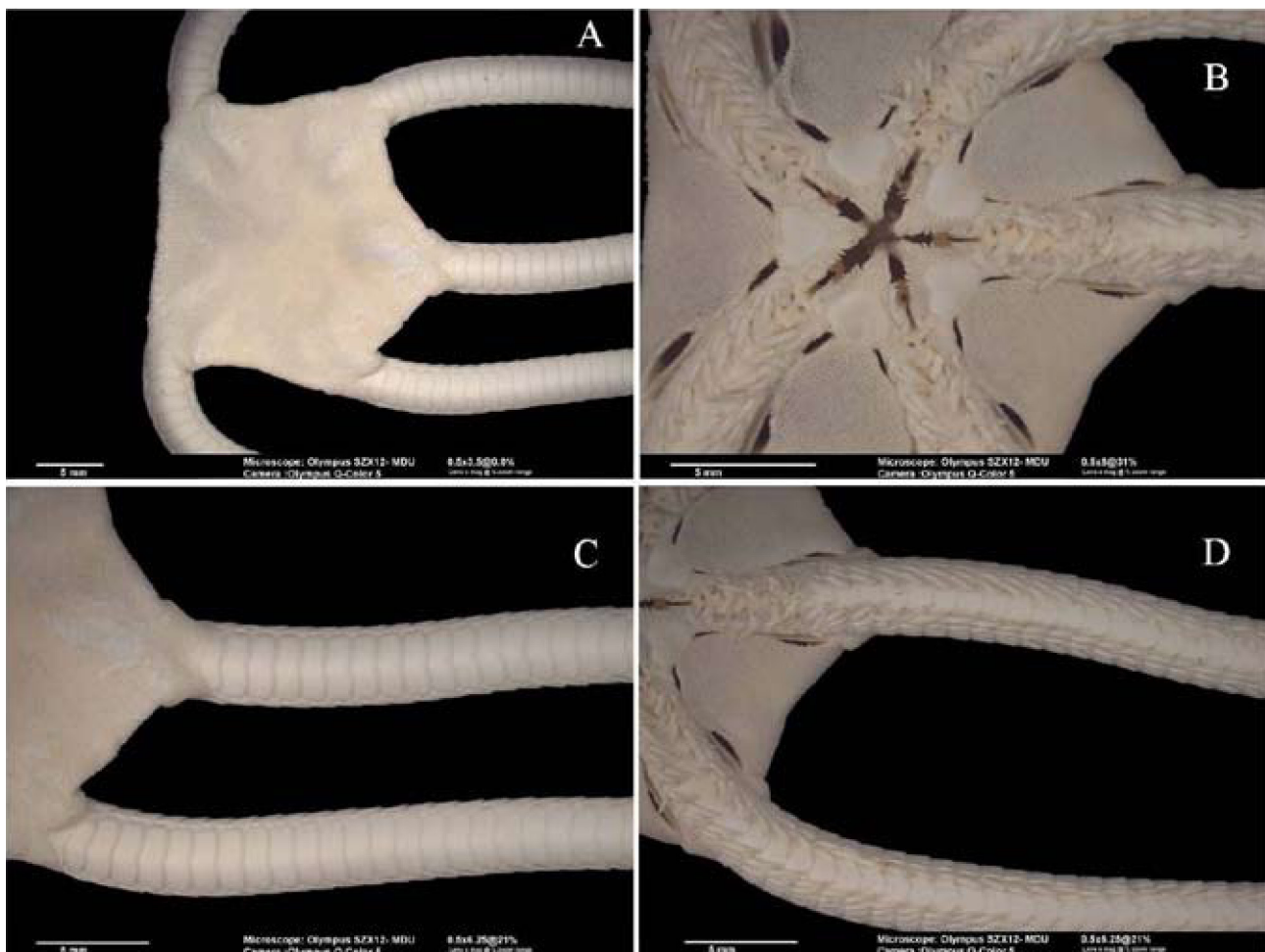


Figure 2. *Ophioderma ensiferum*: A, disc, dorsal view; B, disc with madreporite, ventral view; C, portion of arms, dorsal view; D, portion of arms, ventral view.

Systematics

Order OPHIURIDAE Müller and Troschel, 1840

Family OPHIODERMATIDAE Ljungman, 1867

Genus *Ophioderma* Müller and Troschel, 1840

Ophioderma ensiferum Hendler and Miller, 1984

Ophioderma ensiferum Hendler and Miller, 1984: 455-460, figs. 1, 4, table 1 (diagnosis); Hendler, 1988: 265, 270 (mention); Hendler and Pawson, 2000: 279 (mention); Abreu-Pérez, 2003: 6; Abreu-Pérez et al., 2005: 41 (mention); Pomory, 2007: 11, 18 (mention); Alvarado et al., 2008: 42 (mention); Hernández-Herrejón, 2010: 14, 16, 20, 116, 120, 121, 122, 124, 129, 130, 156, 157, plates 3, 4 (description).

Geographical distribution: Carrie Bow Cay in Belize, Barrier Reef, Belize (24 m depth) (Hendler and Miller, 1984); at kilometer 14 of the Peninsula de Hicacos, Cuba (15 m depth) (Abreu-Pérez, 2003; Abreu-Pérez et al., 2005); Alacranes Reef, Gulf of Mexico, Yucatán, Mexico (12 m depth); Cenote Aerolito de Paraíso, Cozumel Island, Quintana Roo, Mexico (11 m depth) (Fig. 3).

Material examined: USNM E30579, holotype, 1 specimen

(disc diameter 14 mm, longest arm 66 mm), on the reef slope of the Belize Barrier Reef, off Carrie Bow Cay, Belize (24 m depth); ICML-UNAM-3.219.0, 1 specimen (disc diameter 28.4 mm, longest arm 136 mm), Alacranes Reef, Gulf of Mexico, Yucatán, Mexico (22°23'07.8" N, 89°40'02.4" W), on coral, 12 m, coll. Axcan Moreno, 4 August 2009, night dive (SCUBA diving); ICML-UNAM-3.219.1, 1 specimen (disc diameter 20 mm, longest arm 122.4 mm), Cenote Aerolito del Paraíso, Cozumel, Quintana Roo, Mexico (20°27'58" N, 86°58'41" W), on muddy bottom, 11 m, coll. Germán Yáñez, 26 July 2010 (SCUBA diving).

Diagnosis (modified Hendler and Miller, 1984): disc subpentagonal, covered with rounded granules. Radial shields small and with very few attached granules (diameter $61 \pm 4 \mu\text{m}$). Oral shields pentagonal, slightly wider than long (length : width = 1 : 1.26). Most of surface of adoral shields free of granules. Jaws bearing 16 to 19 oral papillae. Dorsal arm plates not fragmented. Arm spines thin, slightly flattened laterally, bearing a maximum of 7 arm spines and 2 tentacle scales. Ventralmost arm spine thicker and longer than the dorsal, and reaches the

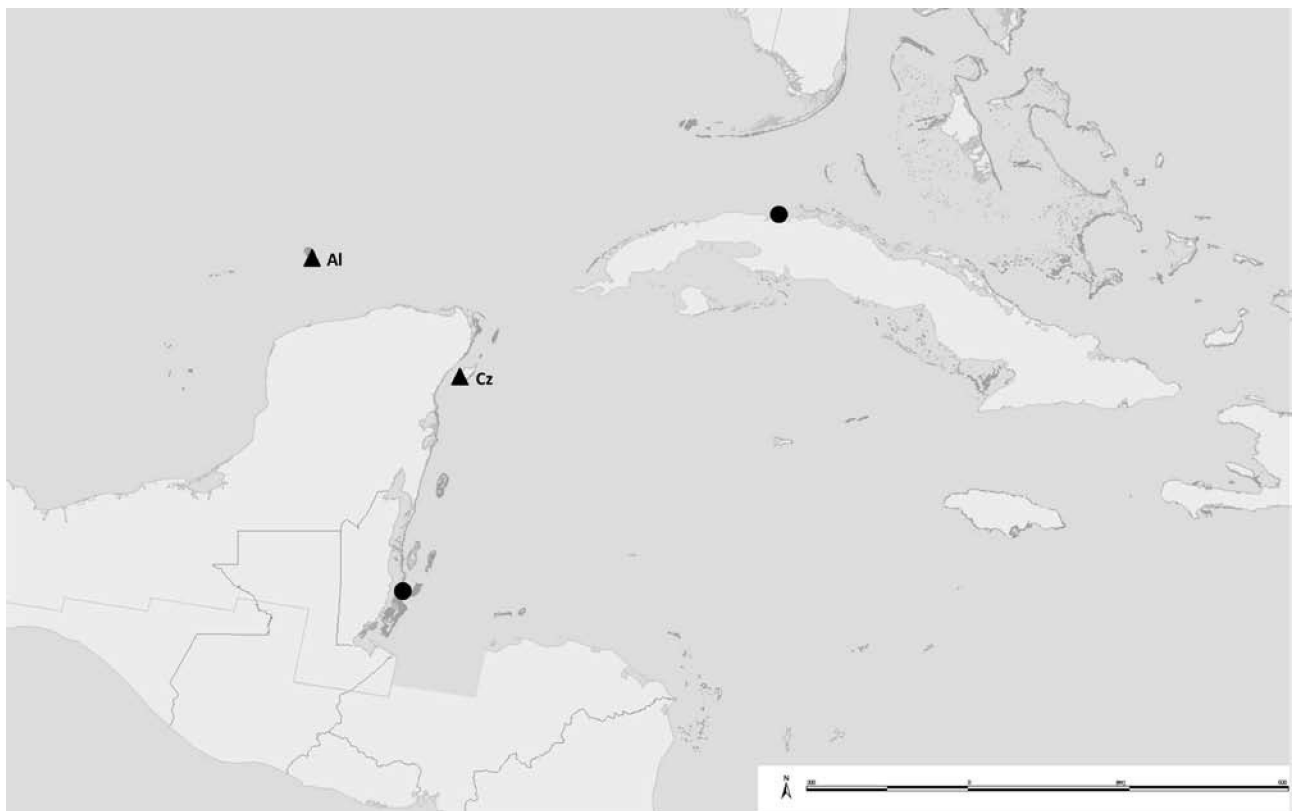


Figure 3. Distribution map of *Ophioderma ensiferum*. (●) Previous records. (▲) New records in Mexican waters: Al, Alacranes Reef; Cz, Cozumel Island.

base of the ventral spine on the adjacent arm segment. Lacks bare scales at the base of the arms and lacks scales between the arm and distal genital slit. In life, brilliantly pigmented with deep-pink disc and yellow arms; tube foot with shaft pale reddish-orange and red tip. Holotype preserved in alcohol and dried: granulose portion of disc very pale tawny off-white color, arms and oral frame and radial shields white.

Ophioderma ensiferum Hendler and Miller, 1984 (Figs. 1, 2)

Disc covered with granules slightly separated each other. Radial shields oval, longer than wide, covered by the same granules that cover the disc (Fig. 2A). Oral shields triangular with rounded angles, as wide as long. Adoral shields are not covered by granules. The oral shields are pentagonal shaped. Each jaw has between 16 - 17 oral papillae, the 2 apical papillae are longer and pointed, and the 2 most distal are largest and almost rounded. Madreporite large, circular and distal within one oral shield. Two genital slits on each side of the arms. Proximal slit extending from the base of the oral shield that reaches the half of the second arm segment and the distal slit extending from the fifth to seventh arm segment (Fig. 2B). Longest arms 136 mm and 122.4 mm long, 4.5 mm and 3.0 mm wide at the base, respectively. Dorsal arm plates wider than long, not fragmented (Fig. 2C). Lateral arm plates shaped like a half circle, there are 6-7 flattened arm spines, separated and long, the ventral ones longer than the dorsal ones, and reach the tentacle scale on the adjacent segment. Two tentacle scales covering a tentacular pore. Ventral arm plates are longer than wide (Fig. 2D).

Ecological observations: Other echinoderms collected in Alacranes Reef were: *Ophiactis quinqueredia* Ljungman, 1872, *O. savignyi* (Müller and Troschel, 1842), *Ophiocoma echinata* (Lamarck, 1816), *O. pumila* Lütken, 1859, *O. wendtii* Müller and Troschel, 1842, *Diadema antillarum* Philippi, 1845 and *Isostichopus badionotus* (Selenka, 1867) (Hernández-Díaz, 2011). The habitat of these species was a section of the reef about 12 m depth, characterized by a patch reef located northeast of Isla Pérez; it is composed mainly by *Diploria*, *Montastrea*, *Siderastrea* and large branching gorgonians like *Pseudoplexaura*. *Ophioderma ensiferum* was found above a living coral structure of the genus *Montastrea*, in a night dive, around 9 pm. The habitat inside the anchialine cave where we found *O. ensiferum* was a region where no light penetrates, approximately 60 m from the principal cave entrance, below the halocline. The specimen was moving on the muddy bottom.

The pigmentation of the arms of *O. ensiferum* from Alacranes Reef was reddish-orange, which differs from the yellow color of the arms of the holotype specimens (Fig.

1A). The specimen from Cenote Aerolito showed the same coloration pattern as the holotype (Fig. 1B). A review of the existing literature indicates that *Ophioderma* is exclusively gonochoric, with each species exhibiting a single annual reproductive cycle that may result in a single or multiple spawning events (Hendler, 1991; Hagman and Vize, 2003). We propose that the dispersion of the larvae was favored by the movement of currents from the Caribbean Sea. Before entering the Gulf of Mexico and becoming the loop current, the Yucatán current flows northward along the Cozumel and the Yucatán channels (Abascal et al., 2003). A fraction of the water turns westward over the Campeche Bank reaching the Alacranes reef, constituting the main water mass in the region (Capurro, 1969). In accordance with a numerical simulation of the larvae transport, based on a HYCOM hindcast (<http://hycom.org>) and a particle dispersion model based on a Runge-Kutta scheme, larvae living 9 days in the pelagic environment can travel about 1 - 10 kilometers along the Yucatán current and the Campeche Bank, and then be recruited to the benthic adult population, following the dispersal stepping stone model suggested by Selkoe and Toonen (2011).

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Literature cited

- Abascal, A. J., J. Sheinbaum, J. Candela, J. Ochoa and A. Badan. 2003. Analysis of flow variability in the Yucatan Channel. *Journal of Geophysical Research* 108(C12), 3381, doi:10.1029/2003JC001922.
- Abreu-Pérez, M. 2003. Cinco registros nuevos de ofiuroides (Echinodermata: Ophiuroidea) para el Archipiélago Cubano. *Cocuyo* 13:5-6.
- Abreu-Pérez, M., F. A. Solís-Marín y A. Laguarda-Figueroa. 2005. Catálogo de los equinodermos (Echinodermata: Asteroidea y Ophiuroidea) nerítico-bentónicos del Archipiélago Cubano. *Revista de Biología Tropical* 53:29-52.
- Alvarado, J. J., F. A. Solís-Marín y C. Ahearn. 2008. Equinodermos (Echinodermata) del Caribe Centroamericano. *Revista de Biología Tropical* 56:37-55.
- Capurro, A. L. 1972. La circulación oceánica en el Golfo de México. *Memorias IV Congreso Nacional de Oceanografía*, Cd. de México, UNAM. México, D. F. p. 3-12.

- Fenaux, L. 1969. Le développement larvaire chez *Ophioderma longicauda* (Retzius). Cahier de Biologie Marine 10:59-62.
- Frontana-Uribe, S. C. and V. Solis-Weiss. 2011. First records of polychaetous annelids from Cenote Aerolito (sinkhole and anchialine cave) in Cozumel Island, Mexico. Journal of Cave and Karst Studies 73:1-10.
- Hagman, D. K. and P. D. Vize. 2003. Mass spawning by two brittle star species, *Ophioderma rubicundum* and *O. squamosissimum* (Echinodermata: Ophiuroidea), at the Flower Garden Banks, Gulf of Mexico. Bulletin of Marine Science 72:871-876.
- Hendler, G. 1988. Western Atlantic *Ophiolepis* (Echinodermata: Ophiuroidea): a description of *O. pawsoni* new species, and a key to the species. Bulletin of Marine Science 42:265-272.
- Hendler, G. 1991. Echinodermata: Ophiuroidea. In Reproduction of marine invertebrates, volume VI, A. C. Giese, J. S. Pearse and V. B. Pearse (eds.). The Boxwood Press, California. p. 355-511.
- Hendler, G. and J. E. Miller. 1984. *Ophioderma devaneyi* and *Ophioderma ensiferum*, new brittlestar species from the western Atlantic (Echinodermata: Ophiuroidea). Proceedings of the Biological Society of Washington 97:442-461.
- Hendler, G. and D. L. Pawson. 2000. Echinoderms of the Rhomboidal Cays, Belize: biodiversity, distribution, and ecology. Atoll Research Bulletin 479:275-299.
- Hernández-Díaz, Y. Q. 2011. Zoogeografía de equinodermos (Echinodermata) de los Bajos de Sisal y Arrecife Alacranes, Yucatán, México. Tesis maestría, Posgrado en Ciencias del Mar y Limnología, ICMYL, Universidad Nacional Autónoma de México. México, D. F. 131 p.
- Hernández-Herrejón, L. A. 2010. Filogenia del género *Ophioderma* Müller and Troschel, 1840 (Ophiuroidea: Echinodermata). Tesis maestría. Posgrado en Ciencias del Mar y Limnología, ICMYL, Universidad Nacional Autónoma de México. México, D.F. 196 p.
- Hybrid Coordinate Ocean Model (HYCOM), Center for Ocean-Atmospheric Prediction Studies (COAPS). <http://hycom.org>; last access: 11.X.2012.
- Mejía-Ortíz, L. M., G. Yañez and M. López-Mejía. 2007. Echinoderms in an anchialine cave in Mexico. Marine Ecology 28:31-34.
- Pomory, C. M. 2007. Key to the common shallow-water brittle stars (Echinodermata: Ophiuroidea) of the Gulf of Mexico and Caribbean Sea. Caribbean Journal of Science 10:1-42.
- Selkoe, K. A. and R. J. Toonen. 2011. Marine connectivity: a new look at pelagic larval duration and genetic metric dispersal. Marine Ecology Progress Series 436:291-305.
- Spalding, M. D., H. E. Fox, G. R. Allen, N. Davidson, Z. A. Ferdaña, M. Finlayson, B. S. Halpern, M. A. Jorge, A. Lombana, S. A. Lourie, K. D. Martin, E. Mcmanus, J. Molnar, C. A. Recchia and J. Robertson. 2007. Marine ecoregions of the world: a bioregionalization of coastal and shelf areas. Bioscience 57:573-583.
- Stöhr, S. and T. D. O'Hara. 2007. World Ophiuroidea database. Vlaams Instituut voor de Zee. Available from: <http://www.marinespecies.org/ophiuroidea>; last access: 01.X.2012.
- Stöhr, S., E. Boissin and A. Chenuil. 2009. Potential cryptic speciation in Mediterranean populations of *Ophioderma* (Echinodermata: Ophiuroidea). Zootaxa 2071:1-20.
- Webb, C. M. 1989. Larval swimming and substrate selection in the brittle star *Ophioderma brevispinum*. In Reproduction, genetics and distributions of marine organisms: 23rd European Marine Biology Symposium University of Wales, Swansea, J. S. Ryland and P. A. Tyler (ed.). Olsen and Olsen, Fredensborg, Denmark. p. 217-224.