NOTA

FIRST RECORD OF AN AZOOXANTHELLATE REEF-BUILDING CORAL (SCLERACTINIA) AT SINALOA, MEXICO (EASTERN GULF OF CALIFORNIA)

Primer registro de un coral azooxantelado (Scleractinia) constructor de arrecifes, en Sinaloa, México (oriente del Golfo de California)

RESUMEN. Se presenta el primer registro de un coral azooxantelado constructor de arrecifes (*Dendrophyllia oldroydae* Oldroyd, 1924), encontrado frente a la costa del estado de Sinaloa, México, en el margen suroriental del Golfo de California. El hallazgo se complementó con un análisis de distribución de la especie que incluye el rango geográfico estimado según la Base de Datos para Invertebrados del Golfo, así como un modelo de nicho ecológico y de distribución potencial construido con un algoritmo de máxima entropía, basado en 11 variables oceanográficas: temperatura, salinidad, concentración de oxígeno, nitratos, fosfatos y silicatos, productividad primaria, omega de aragonita, profundidad, profundidad de la zona eufótica y tipo de sustrato en la zona costera (fondo blando o duro). Los resultados de ambos análisis denotan la alta probabilidad de ocurrencia de *D. oldroydae* en la costa de Sinaloa; el ejemplar recolectado extiende el rango geográfico conocido para esta especie hacia la región sureste del Golfo de California.

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The data on the distribution, biology and ecology of scleractinian corals of the eastern Pacific was fragmentary until the 1950s (Durham & Barnard, 1952), but it has increased remarkably ever since; over 200 papers have been written on the subject by the beginning of last decade (Cortés, 2003). In México, both shallow-water (zooxanthellate) and deep-water (azooxanthellate) corals have been studied, although information about the latter is mostly restricted to taxonomic and biogeographic aspects of the fauna (Reyes-Bonilla & Cruz-Piñón, 2000).

One of the most conspicuous azooxanthellate corals of western Mexico is *Dendrophyllia oldroydae* Oldroyd, 1921. This species has been reported under two synonyms: *D. oldroydi* Oldroyd, 1924, and *D. cortezi* Durham and Barnard, 1952 (Cairns, 1994), and has a geographic range from the southwestern United States of America (33°N) to the Galápagos Islands, Ecuador (0°S), at depths of 40 to 576 m (Cairns, 1994). According to Durham and Barnard (1952) and Cairns (1994), the diagnostic characters of this species include large, ramose colonies (up to 1 m in height), with wide robust bases (reaching 5 cm in diameter) and branches of 2 to 3 cm diameter. Its corallites project 4 to 7 mm in a perpendicular direction from the coenosteum, reach 10 to 15 mm in diameter, and usually have 4 cycles of septa (48 to 72 in total). Primary and secondary septa are exsert and reach the columella. The fossa is very shallow and presents a fascicular or papillar columella that covers 12% to 37% of the calicular surface (Fig. 1). In life, the tissues are bright yellow in color, and by personal observation and information from other researchers (Canet *et al*., 2010; Carles Canet. Instituto de Geofísica, Universidad Nacional Autónoma de México, pers. comm. May 2013), the colonies usually appear aggregated in clumps that build up deep-water “reefs” similar to those erected by other ramose species of the genera *Enallopsammia* and *Lophelia* (Howell *et al*., 2011).

In the Gulf of California, *D. oldroydae* was first reported by Durham and Barnard (1952) between 126 and 150 m deep at Partida Island (La Paz Bay; 24° 32’ N, -110° 23’ W) and colonies were also collected at Puerto Refugio, northern Angel de la Guarda Island (29° 16’ N, -113° 23’ W), at -150 m. Squires (1959) extended the records to Tiburón Island in the eastern gulf (28° 56’ N, -112° 21’ W, no depth given), and Parker (1964) recovered dead and probably allochtonous colonies west of San Lorenzo Island (28° 37’ N, -113° 02’ W, -460 m). Horta-Puga and Carricart-Ganivet (1993) and Cairns (1994) confirmed these findings, and Reyes-Bonilla *et al.* (2005, 2008) recorded other specimens of *D. oldroydae* collected at Carmen Island (26° 00’ N, -111° 08’ W, 20 m deep), Guaymas (27° 55’N, -110° 53’ W) and Los Angeles Bay (28° 55’ N, -113° 32’ W), which are housed in different scientific collections in the United States. Finally, Cairns (1994) and Reyes-Bonilla *et al*. (2008) point out the fact that fishermen along the Gulf of California Midriff Islands and in California usually find colonies entangled in lines or nets placed at depths of 50 m or more.

The southeastern portion of the Gulf of California belongs to the Mexican state of Sinaloa, an area that chiefly presents soft bottoms and large mangro-

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ve stands along the coast, and for that reason corals are rare. There are only two publications referring to the local coral fauna (Cupul-Magaña, 2003; Medina-Rosas, 2006), and they include no azooxanthellate corals. Because of the dearth of information it is important to document all findings, and here we record the collection of a specimen of *Dendrophyllia oldroydae*, which corresponds to the first report of a deep-water coral from Sinaloa.

The specimen represents the lower portion of a larger colony and was collected by a shrimp trawler; although no specific coordinates were taken, the coral was most probably found at about 24° 10' N, -107° 48' W. The fragment presents all diagnostic traits mentioned by Cairns (1994), and is 230 mm in height and 330 mm wide (Fig. 1). The base has 66 mm in maximum diameter, and calices have a larger diameter of 11.90 + 0.17 mm, and minor diameter of 10.80 + 0.24 mm, present 45.90 + 1.76 septa and they protrude 8.00 + 0.39 mm from the coenosteum (in all cases, 10 randomly selected calices were analyzed).

In order to improve on the knowledge of the geographic distribution of *D. oldroydae* in the gulf, we took the information from the Gulf of California Invertebrate Database (http://www.desertmuseum.org/center/seaofcortez/searchdb.php) and of the General Bathymetric Chart of the Oceans (http://www.gebco.net/), and used a geographic information system (ArcView ver. 10) to denote the possible distribution of the coral along the gulf on the basis of its distribution polygon and the depth range of the species in the area (extended to depths from 100 to 200 m, to allow margin of error). Finally, for comparative purposes we developed a model of the geographic distribution of the species based on its ecological niche. For this, we gathered a total of 42 geo-referenced records, including those from the literature and referred to areas in México, Panamá, and the oceanic islands Cocos (Costa Rica), Malpelo (Colombia) and the Galápagos (Ecuador; Durham & Barnard, 1952; Squires, 1959; Cairns, 1991, 1994; Reyes-Bonilla **et al**., 2005, 2008; Reyes **et al**., 2010; Canet **et al**., 2013). They were complemented with information from specimens gathered along the Pacific coast of the Americas, that are deposited in scientific collections and enlisted in the Global Biodiversity Information Facility (GBIF; http://data.gbif.org/species/2259686/), the Ocean Biogeographic Information System (OBIS; www.iobis.org/mapper/), and the database Hexacorallians of the World (http://hercules.kgs.ku.edu/hexacoral/anemone2/index.cfm). The correct identification of all these corals was personally confirmed by the authors in the museums (Smithsonian Institution, Washington; Museum of Paleontology of the University of California, Berkeley; Invertebrate Zoology Collection of the California Academy of Sciences, San Francisco; Invertebrate Collection of the Los Angeles County Museum of Natural History, Los Angeles; Museo de Historia Natural de la Universidad Autónoma de Baja California Sur, La Paz), or by direct information from collection managers.

Supported by these records, we used the software MaxEnt ver. 3.3.3k to produce an ecological niche model of the species based on average surface values of the following oceanographic factors

Figure 1. Picture of a specimen of *Dendrophyllia oldroydae* collected off the Sinaloa coast (MHNUABCS 1953). Bar: 15 cm. Photograph: Israel Sánchez.

(pixel scale of 9 km by side): temperature (C), salinity (PSU), oxygen (mg/L), concentration of nitrate, phosphate, and silicate (micromol/L), primary productivity (mg/m^3), omega aragonite (indicative of calcium carbonate saturation; no units), bathymetry (m), depth of euphotic zone (m) and coastal type (soft or hard bottom). The information was gathered from the World Ocean Atlas 2009 (oxygen, nutrients and salinity; http://www.nodc.noaa.gov/OC5/SELECT/woaselect/woaselect.html), the Ocean Color Radiometry Online Visualization and Analysis Tool (GIOVANNI) of the National Aeronautics and Space Administration of the United States (NASA; temperature, depth of euphotic zone: http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=ocean_month), the Ocean Color webpage of NOAA (primary productivity; http://oceancolor.gsfc.nasa.gov/cgi/l3?per=DAY), the Global Bathymetric Chart of the Oceans (www.gebco.net), and Google Earth (coast type). Omega aragonite was estimated using the program CO2SYS (http://carboocean.iopan.gda.pl/co2sys.htm), and from data on temperature, salinity, silicate, nitrate and atmospheric concentration of carbon dioxide (obtained from the Scripps Institution of Oceanography CO_2 Program; http://scrippsco2.ucsd.edu/). For modeling, in Maxent we used a maximum iteration value of 1,000 and the logistic output to evaluate probability of occurrence of the species in each pixel in a scale of 0 to 1; by consensus, values of 0.5 and higher represent presence of the species at that pixel (Peterson *et al*., 2011). The efficiency of the model was determined with the area under the curve (AUC) of the threshold independent receiver operating characteristic analysis (ROC), using 75% of the occurrences for training and 25% for testing (Franklin, 2009).

The results are as follows. The map of potential distribution constructed from data of the Gulf Invertebrate Database and only considering the depths where *D. oldroydae* can occur (Fig. 2), indicates that this coral may occupy an area in the deep continental shelf of the northwestern and central gulf (where in fact the coral presents important populations, Reyes-Bonilla *et al*., 2008; Canet *et al*., 2013), and also appears in Los Angeles Bay, and south of the Midriff Islands down to La Paz (24°N) and Banderas Bay (20°N); as the entire coast of Sinaloa is included in the polygon, this opens the possibility of the presence of local populations. Furthermore, the maximum entropy niche model confirms some of the previous observations as the probability of occurrence of the species is very high in the northern gulf and along the peninsular coast, a region here considered as having adequate environmental conditions for the presence of this coral (Fig. 3a**)**. The map also indicates a series of pixels off the central coast of Sinaloa

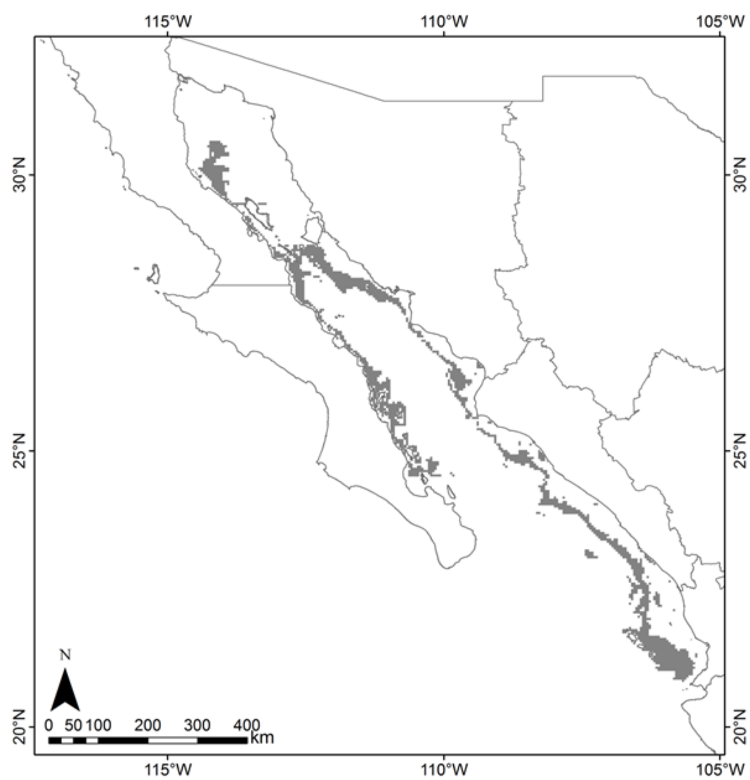

Figure 2. Distribution area of *Dendrophyllia oldroydae* in the Gulf of California, according to information of the Gulf of California Invertebrate Database and adjusted on the basis of the regional depth range of the species.

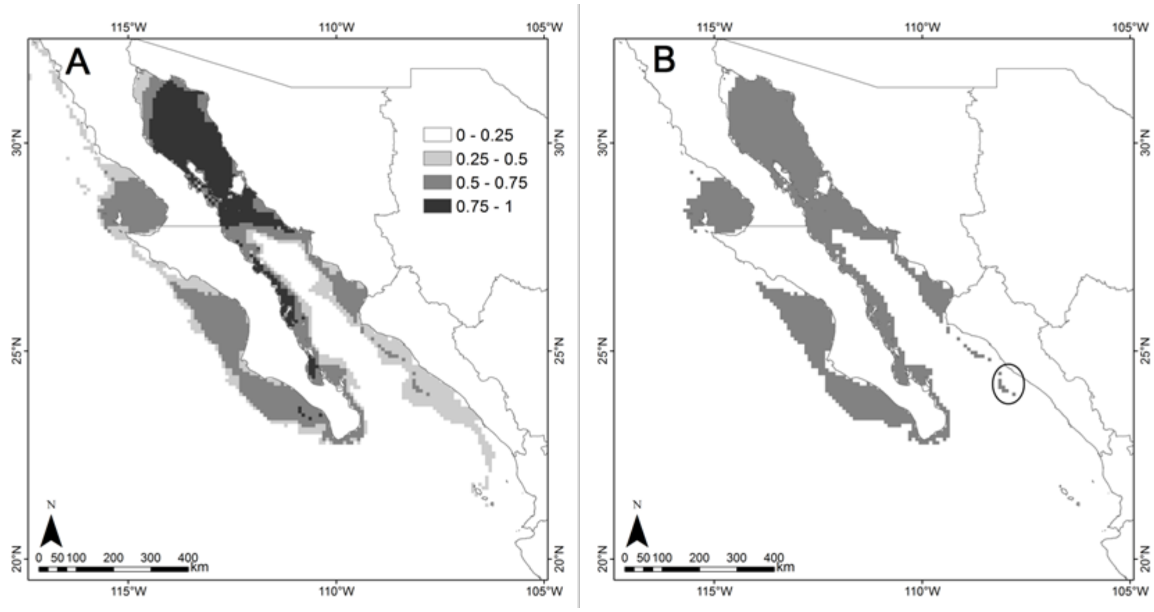

Figure 3. Potential distribution of *Dendrophyllia oldroydae* in the Gulf of California, according to the MaxEnt model. a) Probability of occurrence; b) Presence-absence based on probability of occurrence values of 0.5 or higher. Points encircled in black indicate the possible collection area of the specimen illustrated in Figure 1.

which include the general area where the specimen was collected (Fig. 3b), thus providing a good prediction. Finally, it is interesting to note that the model depicts the possible occurrence of this species in large areas of the west side of Baja California, as several reports included in the analysis came from Asunción Bay and Natividad Island (27°N; Reyes-Bonilla *et al*., 2005), and from the southwest coast of the United States (Cairns, 1994). A recent finding of specimens of *D. oldroydae* at the Gulf of Ulloa (Eduardo Balart, Centro de Investigaciones Biológicas del Noroeste, pers comm. July 2013), is also correctly predicted by our model, highlighting its precision.

In conclusion, in this paper we extended the known range of a reef builder, azooxanthellate coral (*D. oldroydae*) to the southeastern Gulf of California, and presented maps of its possible occurrence sites in that region and nearby based on two different methodologies. The maximum entropy model applied here, correctly predicted both the new record from Sinaloa and another from the southwest coast of Baja California, demonstrating its efficiency.

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REFERENCES

Cairns, S. D. 1991. A revision of the ahermatypic Scleractinia of the Galápagos and Cocos Islands. *Smiths. Contr. Zool.*, 504: 1–30.

Cairns, S. D. 1994. Scleractinia of the temperate North Pacific. *Smiths. Contrib. Zool*., 557: 1–150.

Canet, C., P. Anadón, P. Alfonso, R. M. Ledesma-Prol, R. E. Villanueva-Estrada & M. García-Valles. 2013. Gas-seep related carbonate and barite authigenic mineralization in the northern Gulf of California. *Mar. Petr. Geol*., 43: 147-165.

Canet, C., R. M. Ledesma-Prol, P. R. Dando, V. Vázquez-Figueroa, E. Shumilin, E. Birostra, A. Sánchez, C. J. Robinson, A. Camprubí & E. Tauler. 2010. Discovery of massive seafloor gas seepage along the Wagner Fault, northern Gulf of California. *Sed. Geol*., 228: 292-303.

Cortés, J. 2003. *Latin American coral reefs*. Elsevier, Amsterdam.

Cupul-Magaña, A. L. 2003. Comunidades coralinas de Sinaloa, 91-97, In: Cifuentes-Lemus, J. L. & J. Gaxiola (Eds.), *Atlas de los ecosistemas de Sinaloa*, El Colegio de Sinaloa, Culiacán. 481 p.

Durham, J. W, & J. L. Barnard. 1952. Stony corals of the eastern Pacific collected by the Velero III and Velero IV. *Allan Hancock Pac. Exped*., 16: 1–110.

Franklin, J. 2009. *Mapping species distributions: spatial inference and prediction.* Cambridge University Press, Cambridge.

Horta-Puga, G. & J. P. Carricart-Ganivet J. P. 1993. Corales pétreos recientes (Milleporina, Stylasterina y Scleractinia) de México, 66-80, In: Salazar-Vallejo, S. I. & N. E. González (Eds.), *Biodiversidad marina y costera de México*, CONABIO/CIQRO, Chetumal. 865 p.

Howell, K. L., R. Holt, I. P Endrino & H. Stewart. 2011. When the species is also a habitat: Comparing the predictively modelled distributions of *Lophelia pertusa* and the reef habitat it forms. *Biol. Conserv*., 144: 2656-2665.

Medina-Rosas, P. 2006. Los corales hermatípicos de Mazatlán, Sinaloa, México. *Cienc. y Mar*, 10: 13-17.

Peterson, A. T., J. Soberón, R. G. Pearson, R. Anderson, E. Martínez-Meyer, M. Nakamura & M. Araújo. 2011. *Ecological niches and geographic distributions*. Princeton University Press, Princeton.

Reyes, J., N. Santodomingo & P. Flórez. 2010. Corales escleractinios de Colombia. *INVEMAR Ser. Publ. Esp*., 14: 1-246.

Reyes-Bonilla, H. 2003. Coral reefs of the Pacific coast of México. 331-349, In: Cortés, J. (Ed.), *Coral reefs of Latin America*, Elsevier, Amsterdam. 497 p.

Reyes-Bonilla, H. & G. Cruz-Piñón. 2000. Biogeografía de los corales ahermatípicos (Scleractinia) del Pacífico de México. *Cienc. Mar*., 26: 511–531.

Reyes-Bonilla, H., L. E. Calderón-Aguilera, G. Cruz-Piñón, P. Medina-Rosas, R. A. Lopéz-Pérez, M. D. Herrero-Pérezrul, G. E. Leyte-Morales, A. L. Cupul-Magaña & J. D. Carriquiry-Beltrán. 2005. *Atlas de corales pétreos (Anthozoa: Scleractinia) del Pacífico mexicano*. CONABIO-CICESE-UMar-UdG-UABCS, Guadalajara. 124 p.

Squires D. F. 1959. Corals and coral reefs in the Gulf of California. *Bull. Amer. Mus. Nat. Hist.*, 118: 367–432.