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ORIGINAL ARTICLE

Echinoderms in an anchialine cave in Mexico

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Abstract

Five surveys in an anchialine cave from Cozumel Island, Mexico, were made in order to determine the diversity of invertebrates, especially of the phylum Echinodermata. Aerolito sinkhole (cenote), with an open coastal waters connection, was explored and the organisms were sampled by hand. The abiotic parameters (conductivity, salinity, oxygen, temperature, light and pH) were also measured. We identified three main classes of echinoderms from this cave. The first class is Asteroidea, located below the halocline in marine waters (37 ppt) at 256 m from the entrance and at 45 m from the entrance in marine waters. The second class is Ophiuroidea, located below the halocline in marine waters at 40 and 336 m from the entrance, and the third class, Echinoidea, is located in marine waters 60 m from the entrance. Only the asteroid species shows a depigmentated body; it is the unique species not found outside the cave. To date, only few species of Holothuridae have been reported from caves. We discuss the colonization and adaptations to cave life these animals show.

Problem

Anchialine caves or systems are environments with a high species diversity, mainly of crustaceans (Botosaneanu 1986; Iliffe 1993a). Relict animals have been reported here that are much older than the caves they inhabit (Iliffe 1986). Among the phyla occupying these environments around the world are: Porifera, Mollusca, Annelida, Arthropoda, Echinodermata and Pisces (Botosaneanu 1986; Marmonier *et al.* 1993; Sket 2005).

The characteristics of species adapted to subterranean environments are: (i) the differentiation level between these species is such that most are new taxa, (ii) some species are older than the caves in which they live, (iii) several anchialine cave organisms are primitive forms, (iv) the discontinuous distribution of phylogenetically closely related species raises the question about their mode of dispersal, (v) they have a close affinity with taxa from the deep sea and (vi) they show strong endemism (Iliffe *et al.* 1983).

Marine invertebrates are known to colonize such environments, so that the marine entrances of these caves commonly contain organisms such as snails, sponges, worms and fishes. Most of these animals colonize caves to escape predation. To date, among the echinoderms, only the holothuroids have been reported in sea or anchialine caves (Botosaneanu 1986). For this reason, we report for the first time the presence of other echinoderm classes penetrating beyond the marine entrance of caves, and discuss the colonization and adaptations to cave life these animals can show.

Material and Methods

The study area is the sinkhole (cenote) El Aerolito, also called Sistema Purificación, located in Cozumel Island, Quintana Roo, Mexico, at 20°27′58″ N and 86°58′41″ W (Reddell 1981). This system has a length of approximately 6100 m and a connection with the Caribbean Sea at 240 m from the main entrance. Its conduits are mainly formed by

rock dissolutions. Formations, such as stalactites and stalagmites, and columns are located in the deeper area. The sediment is clay and mud (Fig. 1). We measured the abiotic data from the water (temperature, conductivity, salinity, pH, depth, dissolved oxygen and light) using the Hydrolab Data Sonde 5, applying SCUBA techniques. The animals were collected by hand during the surveys, preserved in 70% alcohol and deposited in the Colección del Laboratorio de Bioespeleología y Carcinología de la Universidad de Quintana Roo – Cozumel (UQROO – Cozumel), and the Colección Nacional de Equinodermos Dra. Ma. Elena Caso M. from UNAM. The echinoderms were identified at the species and genus level.

Results

Two species of asteroids were found. *Asterinides folium* was located in marine waters at 256 m from the entrance. We counted 20 individuals of this species. These animals show depigmentation and were only located inside the sinkhole (Fig. 2a and b). They were frequent below the halocline.

The second group of asteroids, *Copidaster* sp., was located in marine waters at 45 m from the entrance. These animals had pigmented bodies and were seen above the halocline (Fig. 2c and d). We only sampled one individual.

Ophiuroids (*Ophionereis* sp.) were located in marine waters at 40 and 336 m from the entrance of the sinkhole (Fig. 2e and f). They were abundant above the halocline and in a deep area showing sulphur conditions. These ophiuroids were pigmented, and we counted five at the first site and 15 at the second. Echinoids were collected above the halocline at 60 m from the entrance of the cenote and are from the genus *Eucidiaris* (Fig. 2g and h); we collected only one organism.

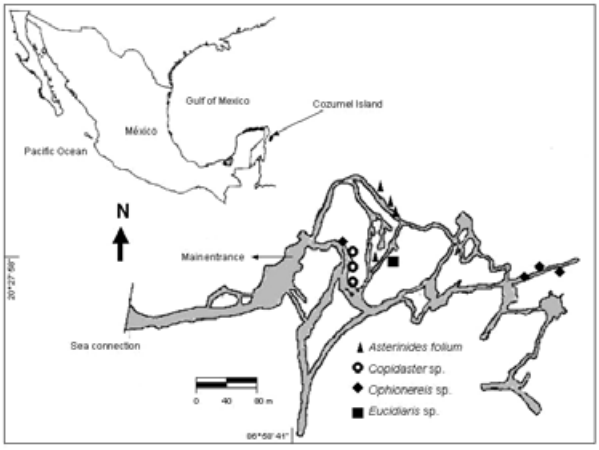

Fig. 1. Map of Cenote Aerolito and the distribution of echinoderms in the sinkhole.

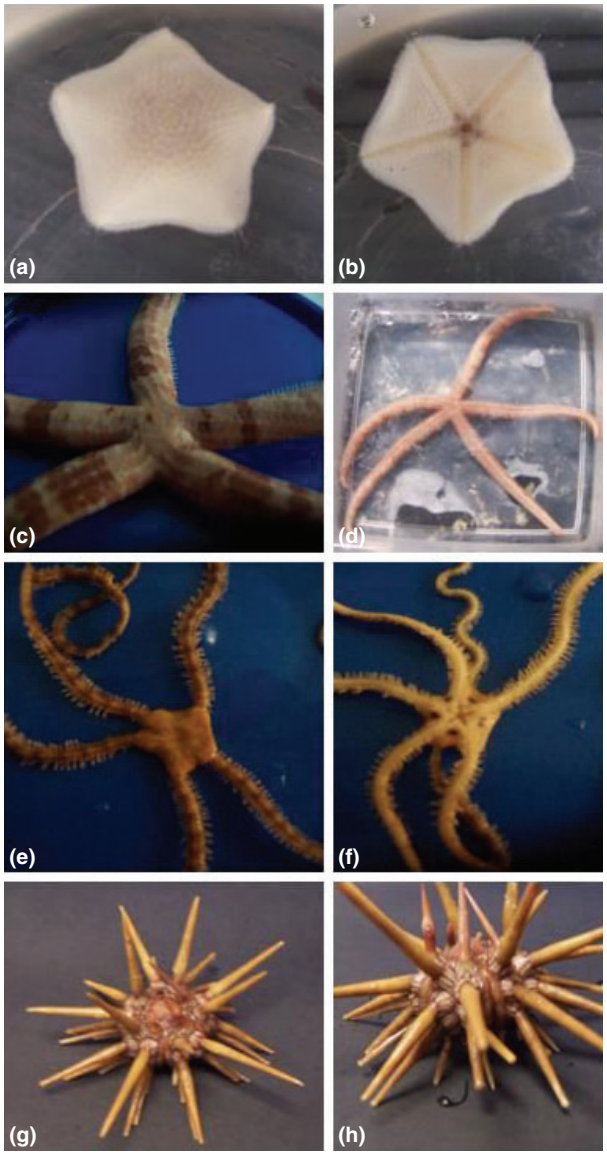

Fig. 2. (a) and (b): *Asterinides folium*; (c) and (d): *Copidaster* sp.; (e) and (f): *Ophionereis* sp.; (g) and (h): *Eucidiaris* sp.

The water values show a major halocline at 7-m depth. The salinity changed from 15 to 37, and the behaviour of this parameter paralleled that of temperature and pH. The dissolved oxygen concentration was low (5.5%, 0.28 $mg \cdot l^{-1}$). Note that all echinoderms were collected from the deeper, dark area (salinity 37), whereby light penetrated only close to the entrance (33 $\mu E \cdot s^{-1} \cdot m^{-2}$) (Fig. 3).

Discussion

To date, the echinoderms recorded from anchialine caves have been restricted to the order Holothuroidea, *i.e.* from

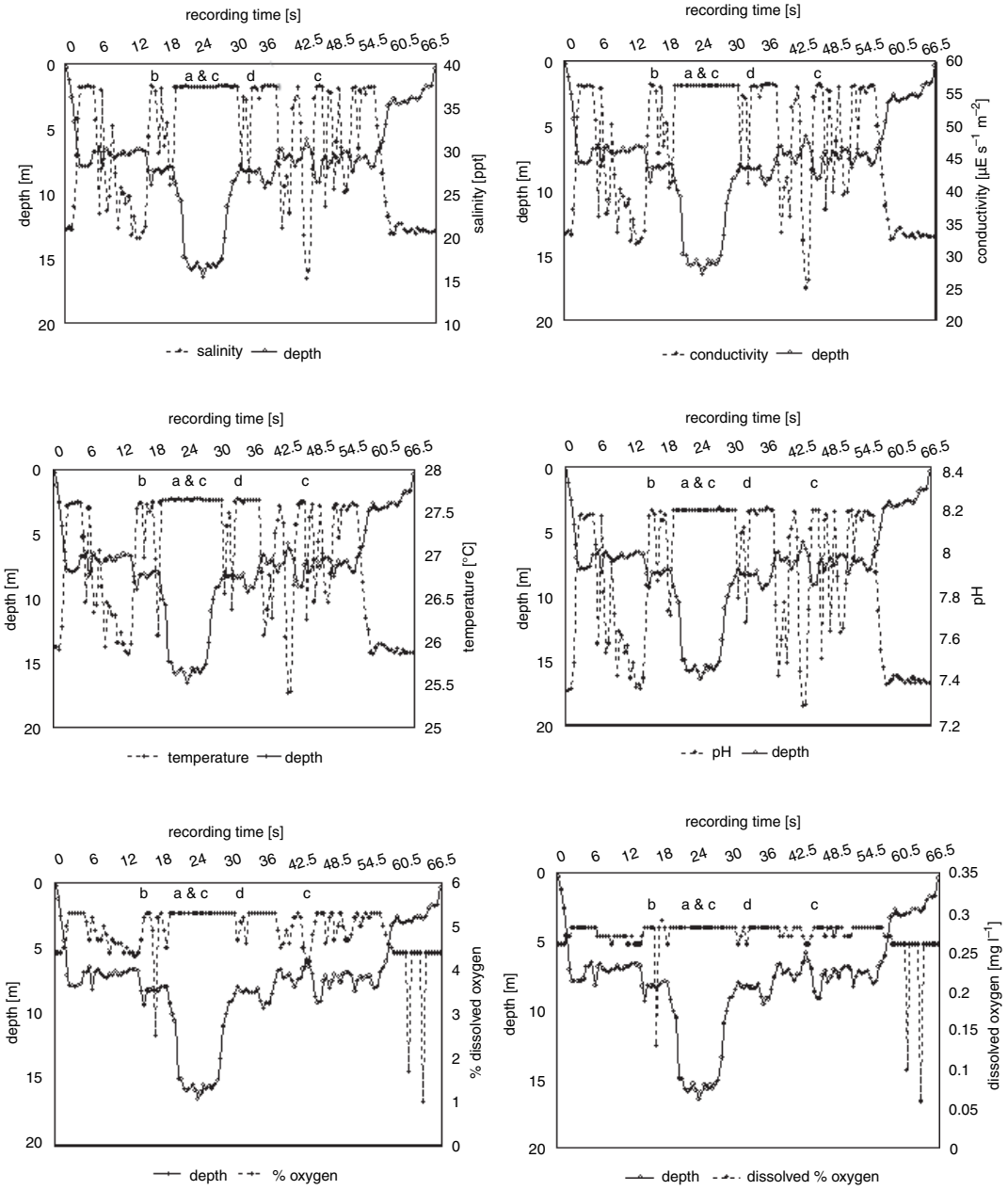

Fig. 3. The behaviour of abiotic parameters during recording in the Cenote Aerolito. The letters indicate the places where echinoderms were sampled; a: *Asterinides folium*; b: *Copidaster* sp; c: *Ophionereis* sp.; d: *Eucidiaris* sp.

the Mediterranean, North Sea and India (Salvini-Plawen & Rao 1986). However, the presence of other echinoderm classes in these areas shows they can successfully colonize anchialine caves with salinity conditions similar to marine waters.

The colour or level of depigmentation is an indicator of the adaptation level to cave life (Culver 1982). The presence of a species lacking pigmentation in an area where the mimetic coloration is very important suggests that this echinoderm is actually adapted to cave life; this is opposed to relatives that merely invaded cave environments to escape predators such as fishes. Regarding food availability inside the cave, we also sampled bivalves, which asteroids and ophiuroids might feed on. Moreover, we noted that the cave floor contained abundant organic matter, which animals such as echinoids feed on.

In Mexico, crustaceans are the main fauna reported from caves (Hobbs *et al.* 1977; Iliffe 1992, 1993b), with

the best-explored anchialine caves being those located along the Riviera Maya on the Yucatán Peninsula (Wilkens 1982; Gerrard 2000). Our results reveal other classes of Echinodermata occupying such systems. Ongoing scientific surveys will certainly expand our knowledge of the biodiversity in these environments.

Acknowledgements

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