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Original article

Taxonomy and distribution of fresh water Ostracoda from Socotra Island, Yemen

Taxonomie et la distribution de l'eau douce Ostracoda de l'Île de Socotra, Yemen

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Abstract

Eleven species belonging to ten genera of fresh water Ostracoda, have been identified from thirteen sediment samples collected from the bottom of permanent streams running along the N-NE part of Socotra Island. The fauna shows close affinity with the S-E African and S-E Asian assemblages, with interesting findings regarding the Palearctic *Limnocythere stationis* Vávra, 1891. The taxonomy and geographic distribution of the fauna are here discussed in detail.

Keywords: Fresh water ostracods; Streams; Socotra Island; Yemen

Résumé

Onze espèces appartenant à dix genres d'ostracodes d'eau douce ont été identifiés à partir de 13 échantillons de sédiments prélevés dans le fond des cours d'eau permanents qui courent le long de la partie septentrionale de l'Île de Socotra. La faune montre une affinité étroite avec des associations sud-est africaines et sud-est asiatiques, avec des résultats intéressants concernant l'espèce Paléarctique *Limnocythere stationis* Vávra, 1891. La taxonomie et distribution géographique de la faune sont ici discutées en détail.

Mots clés : Ostracodes d'eau douce ; Cours d'eau ; Îles de Socotra ; Yemen

1. Introduction

Ostracoda occupy a wide variety of aquatic habitats such as marine, brackish and fresh water and the calcified bivalve carapace of these tiny crustaceans are often well-preserved in sediments (Martens and Horne, 2009). Their specific ecological limitations, particularly in respect of salinity, temperature, nutrient levels, substrate and depth allow the establishment of paleonvironmental reconstructions (Namiotko et al., 2012; Zaïbi et al., 2012).

The study area is characterized by a diverse geomorphology and a monsoonal climate. This combination results in a diversity of microclimates characterized by marked changes in air temperature, and rainfall. These characteristics lead to the development of several permanent streams running mainly in the northern and southern parts of Socotra Island offering a habitat for a typical local fresh water fauna.

The knowledge on ostracods from Yemen is in general very poor, particularly for non-marine species. However, a few papers were published on ostracods of this region. Malz (1976) discussed the changes of carapace morphology and the taxonomic problem of the Recent genera, *Heterocypris* Sars, 1903 and *Cyprinotus* Brady, 1886 and its fossil relative *Cheikella* Sohn and Morris, 1963 described from Tertiary fresh water deposits in Saudi Arabia. His study also includes some specimens from

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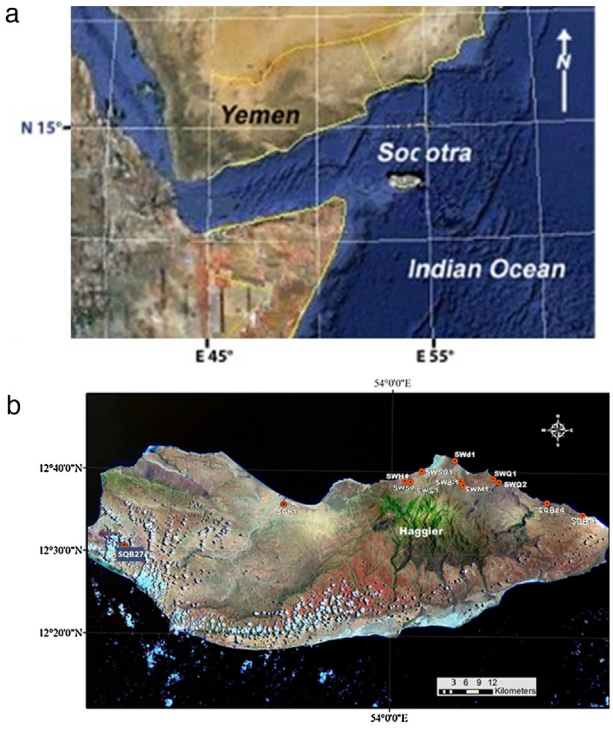

Fig. 1. a: geographic position of the Socotra Island in the Indian ocean; b: location of studied samples on an Landsat ATM + image of the Socotra island.

Yemen. The work by Dumont et al. (1986) focused on the taxonomy and distribution of Cladocera, Copepoda and Ostracoda from fresh waters of South Yemen. Three valves of *Cyprinotus rostrata* Lowndes, 1932 have been recorded by Mohammed (2004) from sub-recent dry mud from Aden City. Mazzini and Sardella (2004) found some fresh water ostracods during their quaternary study on Socotra Island. They emphasized the faunal connection of Socotra to Africa as well as to the Arabian Peninsula.

The present study aims to investigate the taxonomy and distribution of fresh water ostracods extracted from surface sediments of the northern valleys of Socotra Island. Besides the biodiversity, the biogeography is one of the main objectives of this work.

2. Geomorphological and climatic setting of the studied area

Socotra Island with an area of 3500 km^2, is the largest island of the Socotran Archipelago in the Indian Ocean near the mouth of the Gulf of Aden, and the largest Yemeni island (Fig. 1a).

It can be subdivided into three geomorphological zones: alluvial coastal and inland plains, limestone plateaus, and the Haghier Mountains (Scholte and Geest, 2010). The alluvial coastal and inland plains and the limestone plateaus are, to a great extent, arid regions. The highest mountain chain, Haghier, located in the centre of the island (Fig. 1b), is intersected by many valleys, covered with various tree species and displays an endemic fauna (Kingdon, 1989). This plant growth is based on the more intense rain in the higher mountains (Borth et al., 2011), which form the most important watershed of the island. Many periodical creeks and streams start in the mountains and run to the north and to the south of the island. Socotra's plateaus and mountains are considered as water towers of the island, providing fresh water that allows diverse life in a semi-arid environment. Permanent and sporadic springs can also be found there, especially on the northern side. Some seasonal fresh and brackish water lakes are formed by the result of natural damming up the mouths of streams and wadis by marine deposits, pebble banks, beaches and bars. Such environment is found in areas along the narrower northern coastal plain which are interrupted by wadi systems terminating in brackish pools separated from the sea by spits and bars (Scholte and Geest, 2010).

The coastal plains are divided into two parts, the northern, with a series of smaller fertile basins between headlands, and the southern, a 60-km-long by 6-km-wide dry strip backed by a 400 m escarpment (UNEP–WCMC, 2007–2008).

Seasonal reversals of currents are common in the Gulf of Aden when the NE and SW monsoons with their associated currents are fully developed. From October to April, the moist tropical northeast monsoon prevails; October and November are quite wet on the north coast and on north-facing mountain cliffs, often cloud-covered at that time. From June to September a hot, dry sub-equatorial southwest monsoon blows from Africa; tropical cyclones and strong winds up to 110 km/h create high waves and cause upwelling of cooler nutrient-rich water when the sea temperature falls 2–4 °C. Strong winds and high seas cut off the island during the time of the southwest monsoon from June to September and the rough seas make fishing and communication with the outside world very difficult for up to 4 or 5 months (UNEP–WCMC, 2007–2008) and (Borth et al., 2011).

The rainfalls and major wind systems in Socotra Island are dominated by the seasonal monsoons of the Indian Ocean. The diverse topography of the island creates various microclimates. These cause marked changes in Socotra's weather patterns. The average rainfall at sea level is 150 mm, but in the mountains may rise to 1000 mm. At sea level, dew, and in the highlands, condensation from clouds may double the measured precipitation. The annual average temperature in the capital Hadibuh attains 28.31 °C and the average annual humidity is approximately 65.76% (Cheung and DeVantier, 2006).

Because of its extremely long geographical isolation, Socotra Island possesses a lot of uniqueness in its relief, environment and natural life which make it a source for biogeography and evolution studies (Borth et al., 2011).

The Socotran Archipelago was acknowledged by being inscribed on the UNESCO World Heritage List in July 2008 for it "is globally important for biodiversity conservation because of its exceptionally rich and distinct flora and fauna" (http://whc.unesco.org/en/list/1263).

3. Methodology

During November 2007 and January 2008, twelve wet sediment samples were collected from several nearly perennial streams in the N-NE region of Socotra Island (Fig. 1b). The geographical co-ordinates of the sampled locations are given in