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Harpacticoida (Copepoda) of the Caspian Sea: Faunistics, ecology and biogeography

Elena S. Chertoprud [a,b,*], Agniya M. Sokolova [b], Lesya A. Garlitska [c]

[a] Biological Faculty, Moscow State University, Leninskie Gory, Moscow 119991, Russia
[b] Severtsov Institute of Ecology & Evolution, Leninsky Pr., 33, Moscow 119071, Russia
[c] Shirshov Institute of Oceanology, Nakhimovski Prospect, 36, Moscow 117997, Russia

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ABSTRACT

Based on original material collected in the Caspian Sea, the harpacticoid fauna and its taxocene structure were described. The complied list of the Caspian harpacticoids includes 28 species of 16 genera and 10 families. Three species are new to science. Endemics make up 21% of the total species number, while cosmopolitans compose 36%. Four types of taxocenes in the soft littoral sediments of the Caspian Sea were described. High interannual variability in the structure of the harpacticoid taxocenes was observed in the Caspian littoral zone in February–March. This may be caused by strong climatic variations in the maritime area, with sporadic alternation of warm and cold winters.

A comparative analysis of the faunas of the Caspian, Aral, Azov, Black and Mediterranean Seas was performed. The faunas clearly diverge into two groups: the Mediterranean and the Sarmatian, which indicates the relationships among the faunas of the fragments of the common relict Sarmatian Sea Basin. The harpacticoid fauna also differs considerably within the Sarmatian cluster. The faunas of the Azov, Caspian and Aral Seas are mainly represented by brackish-water species, while marine species dominate in the Black Sea. However, these faunas share numerous brackish species that likely formed earlier the major part of the harpacticoid fauna of the Sarmatian Basin.

1. Introduction

The Sarmatian Basin existed 10.5–14 Ma and included modern areas of the Black, Azov, Caspian and Aral Seas (Rögl, 1999). It fell apart 5–7 Ma; the newly formed seas/lakes have almost completely different histories of hydrology and ecosystem development (Popov et al., 1993). However, interchanges of fauna between the seas of the Ponto-Caspian Basin repeatedly became possible due to emergence of the Manych Strait connecting the Caspian Sea and the Sea of Azov (Popov, 1983). This is confirmed by the comparative analysis of bivalve fauna in Neopleistocene and Holocene deposits, which shows significant correlation in the development of benthic assemblages in the Black, Azov and Caspian Seas (Janina, 2012).

The Caspian Sea became completely isolated in the late Khvalynsk period (20,000–10,000 BCE) (Popov, 1983). The isolated position of the Caspian Sea, along with its peculiar geological and hydrological history, has led to the formation of a unique fauna. This fauna includes some remnants of the Tethyan fauna and recent introductions from the Black Sea. The Caspian Sea, with its salinity of 12 per mille, is quite poorly inhabited, which is common for brackish waters (Khlebovich, 1974). According to Kasymov (1987), the fauna of Caspian invertebrates and fishes includes fewer than 800 species. Of these animals, 46% are endemic at the species level and, in some cases, at the genus level (Zenkevich, 1963).

The Caspian Sea is characterized by considerable long-term fluctuations in water level, occurring mainly due to climatic factors (Popov, 1983). In the 20th century alone, the total range of water level change was approximately three metres (Yaitskaya, 2012). Readjustment of the hydrological regime affects benthic communities, sometimes causing a change in the dominant species of macrobenthos (Janina, 2012). The influence of long-term changes in water level on meiobenthic and microbenthic communities has not been described up to today.

The copepod fauna of the Caspian Sea has been unevenly studied; representatives of the order Harpacticoida are the least described of all (Alekseev, 2015). Most of the surveys have primarily focused on fauna of the northern, desalinated part of the Caspian Sea, while the studies conducted in the southern part are scanty (Borutsky, 1952; Griga, 1969; Alekseev, 2015). There are only few taxonomic surveys devoted to describing the endemic Caspian species (Akatova, 1935; Sterba, 1973; Chertoprud and Kornev, 2005). In a paper by Sars (1927), findings of 14 new species are mentioned, but unfortunately they have never been described. Thus, the fauna of the Caspian Sea still remains largely

* Corresponding author at: Biological Faculty, Moscow State University, Leninskie Gory, Moscow 119991, Russia.
E-mail address: horsax@yandex.ru (E.S. Chertoprud).

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uninvestigated. It is likely that even families of Harpacticoida are not currently entirely recorded (Alekseev, 2015). The structure of harpacticoid assemblages in different biotopes of the Caspian is poorly studied. To date, there has only been one study characterizing the littoral taxocenes of this group (Chertoprud and Kornev, 2005).

Integrated studies of Harpacticoida in the Caspian will help to analyse the biodiversity and biogeographical reconstructions of the sea and to reveal how coastal ecosystems react to hydrological regime alterations. Some fundamental problems remain unsolved. First, what is the real species richness of benthic copepods in the Caspian Sea? What changes or successions in meiobenthic communities can be observed on an inter-annual basis? How similar is the Caspian harpacticoid fauna to those of the other seas of the Sarmatian Basin?

The aim of the present study was to conduct an inventory of the harpacticoid fauna and to describe its taxocenes and inter-annual dynamics. In addition, a comparative analysis of the Caspian fauna and other seas of the Sarmatian Basin is performed. This study broadens the modern knowledge on Caspian biodiversity and might provide useful information for future monitoring activities.

2. Materials and methods

2.1. Study area

Samples were collected in the Caspian Sea (Azerbaijan territory) on the Absheron Peninsula's coast (August 2014) and in Kyzylagach Bay (February 2003, March 2011, February and August 2014) (Fig. 1).

Kyzylagach Bay is a small, desalted bay on the south-east coast of the Caspian Sea. It is separated from the major waters by the Kurinskaya Spit (Kurinskaya Kosa) from the west. To the east, the Sara Peninsula divides the bay from a brackish lake. Littoral sediments of the bay are heterogeneous: fine sands alternate with mud and shell sands. The water salinity in the examined part of the bay is near 10 per mille; it is slightly below that in the eastern waters of the Caspian Sea (12 per mille). The bay serves as wintering and nesting grounds for waterfowl.

The Absheron Peninsula is located on the southwestern coast of the Caspian Sea. It extends 60 km eastward into the sea. The peninsula suffers from considerable anthropogenic influence due to activities of large cities (Baku, Sumgait) and the oil industry. Littoral sediments are mainly muddy or sandy. The salinity coincides with that of the rest of the water in the sea (11–12 per mille).

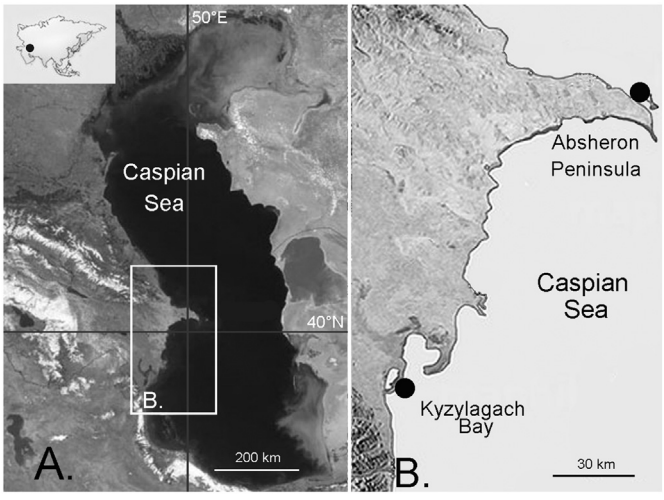

Fig. 1. Map of the sampling areas in the Caspian Sea. A. General map of the Caspian Sea; B. Map of the examined parts of coast. ● – Sampling areas.

2.2. Sampling

Brief characteristics of the series of samples are presented in Table 1.

2.2.1. Kyzylagach Bay

We collected 24 quantitative samples from six stations located 500 m apart in the littoral zone in February 2003. The studied area covered a slightly sloping sandflat without large stones or seaweeds. Twenty-four samples were taken from the same locations in February 2014. Thirty-three qualitative samples were collected from 11 stations in March 2013. Six of these stations are identical to the sites studied in 2003 and 2014, and three more samples were taken near the Liman Village at the entrance to Kyzylagach Bay. One sample was also collected here in August 2014. In total, approximately 10 km of the coastal littoral zone of the bay was explored.

Samples for quantitative analysis were collected from the bottom sediments using a 1.5 cm diameter corer (surface area 1.77 cm^2). Three replicate sediment samples were taken from each station. Only the upper 5 cm of sediment was retrieved. Granulometric analyses were performed on sediments collected from all stations. Mean grain size, silt (<0.3 mm), and large-sized shelly ground (≥2 mm) content were determined.

2.2.2. Absheron Peninsula

We collected samples from the north coast of the Absheron Peninsula in August 2014. Six qualitative samples were taken from the northern coast of Pirallahi Island (Artyom Island) at a depth of 1–8 m. Two qualitative samples (0.5 and 1.5 m depth) were collected from the waters approximately 6 km north-east of Shuvelan Town.

Each sample contained all types of sediment presented at the station. In the littoral zone, samples for qualitative analyses were collected using a 1.5 cm diameter corer. In the sublittoral zone, the materials were collected by SCUBA diving using plastic boxes.

In total, >84 quantitative and 6 qualitative samples from the littoral and sublittoral zones of 34 marine stations were analysed.

2.3. Taxonomy and life forms

The taxonomy followed the European Register of Marine Species (Costello et al., 2001). Adult harpacticoids were identified using Boxshall and Halsey (2004), Wells (2007), Lang (1948), Borutsky (1952), Griga (1969), Apostolov and Marinov (1988), Alekseev and Tsalolikhin (2010) and Alekseev (2015). Nomenclature within families and genera and recognition of synonymous species followed Bodin (1997) and Huys (2009). Species not present in the aforementioned lists were assigned to genera following Lang (1948) and Pesce (2007).

Harpacticoid species were allocated to life forms following Chertoprud et al. (2006), with phytal, planktonic, epibenthic, facultative interstitial (represented by small non-specialized species), and obligate interstitial (with vermiform and lanceolate habitus) forms recognized.

2.4. Literature data

Published data on harpacticoids from throughout the Caspian Sea were used to prepare an inventory of taxa from the region. The main part of the faunal data were obtained from Russian waters (the northern Caspian); moreover, some studies involved the territories of Azerbaijan and Kazakhstan (Sars, 1927; Akatova, 1935; Borutsky, 1952; Griga, 1969; Alekseev, 2015). A single paper focused on Iranian species (Sterba, 1973). Generally, most of the works related to the Caspian Sea Harpacticoida are behind the times or just combine data on single findings over the years. The only study fully describing the harpacticoid fauna of a particular section of the Caspian is the work of Chertoprud and Kornev (2005).

The worldwide database on shallow-water harpacticoids (Chertoprud et al., 2010; Azovsky et al., 2012) was used to compare

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