



ORIGINAL RESEARCH PAPER

## SPECIES COMPOSITION AND ECOLOGY OF TARDIGRADES OF THE BLACK SEA

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### SYNOPSIS

The work presents information about species richness, some environmental characteristics and habitats of the found tardigrades of the Black Sea. At present, fauna of Tardigrades of the Black Sea includes 19 species of 12 genera, 5 families of two orders Arthrotardigrada and Echiniscoidea, class Heterotardigrada and 1 species of the class Eutardigrada that was found in the coastal waters of the northwestern part of the Black Sea. Most of the found Black Sea tardigrades species show a worldwide distribution, one of them can be considered as cosmopolitan species.

### INTRODUCTION

Marine tardigrades, or water bears, are small invertebrates that average 100 – 300 µm in length and can inhabit sublittoral, littoral and abyssal zones of the seas. They are widely distributed throughout the world and are capable to enter in a latent state to survive under unfavorable environmental conditions (e.g. salinity variations, and low oxygen tensions) (Nelson, 2002).

Fauna of marine tardigrades of the Black Sea is still poorly studied. For the first time tardigrades were found in the coastal area of Bulgaria and Romania in the middle of the last century (Rudescu, 1969). Since that, there was no information about Black Sea tardigrades. Only in 2004, near the Crimean coast (cape Tarkhankut and Sevastopol Bays) were found four species of tardigrades (Sergeeva et al., 2006). Later, the investigations of tardigrades were carried out in different areas and depths in the Black sea.

The purpose of this study is to provide additional information concerning the species diversity and ecology of Tardigrada from the different areas of the Black Sea.

## MATERIAL AND METHODS

Meiobenthic samples were taken from the shelf (0-300 m) in the different area of the Black Sea: coastal area of the Crimea, the north-western part of the Ukrainian shelf and the Bosphorus area (fig. 1).



Figure 1: The map-scheme of meiobenthic sampling in different study areas of the Black Sea.

From the coastal area of Crimea sediment samples were obtained by direct hand coring (18,1 cm<sup>2</sup>, and 12,56 cm<sup>2</sup>) at depth ranging from 1 to 30 m, *via* SCUBA diving from the sublittoral and littoral collections, and by bottom dredge, sampling the sediment from it by the use of meiobenthic tubes (18,1 cm<sup>2</sup>).

During the investigation of the deep-sea tardigrades in the Bosphorus area and in the Crimean shelf at cruise of R/V “*Maria S. Merian*” (April, 2010) samples for biological studies were collected using a multi-corer (diameter of tubes 9,5 cm), in the cruise of the R/V “*Arar*” (November, 2009) was used a gravity corer (diameter 7 cm), and near the methane seeps next to the submarine Dnieper Canyon in cruise R/V “*Meteor*” (February-March, 2007) by using a modified version of the Barnett multiple corer (MUC) (diameter of tubes 9,2 cm and 6,2 cm) (Barnett et al., 1984; Boetius, 2007).

All sediments were preserved in 75% alcohol, which is known to preserve morphological structures of fauna without distortion, or in 4% formalin. Each sample was washed through two sieves, the upper one with a mesh size of 1 mm, the lower one with a mesh size of 63 µm, and stained with Rose Bengal solution. All of the isolated organisms were counted and identified to higher taxa. Tardigrades were picked out using a glass pipette and placed in cavity slides with a mixture of glycerol (50%) and water (50%). Tardigrades specimens were observed and identified for

species with using of the microscope Nikon Eclipse E200. Micro photos were made by camera Nikon DS-Fi1.

## RESULTS AND DISCUSSION

During our investigations of tardigrades of the Black Sea, we have collected 4 already known species for this area (Sergeeva et al., 2006), as well as 16 species established at the first time for the area of the Black Sea.

We adhere to the classification of (Guidetti & Bertolani, 2005; Degma & Guidetti, 2007; Degma et al., 2013) that the tardigrades form separate phylum Tardigrada, which is divided into 3 classes: Eutardigrada, Mesotardigrada and Heterotardigrada. Phylum is divided into classes basing on morphological characters.

Tardigrades, which we have found in bottom sediments, belonged to two classes Eutardigrada and Heterotardigrada. Class, Mesotardigrada based on a single species *Thermozodium esakii* Rahm 1937, that no longer exist and the locality, where it was found, a hot spring in Japan, was destroyed in an earthquake (Nelson, 2002).

Taxonomical information, some essential ecological features, and data on distribution of each recorded species in the Black sea (our findings) and another localities (based on literature data) are noted below.

## TAXONOMICAL PART

Class: **HETEROTARDIGRADA** Marcus, 1927

Order: ARTHROTARDIGRADA Marcus, 1927

Family: BATILLIPEDIDAE Ramazzotti, 1963

Genus: *Batillipes* Richters, 1909

**BATILLIPES MIRUS** Richters, 1909 (fig.2)

Distribution in the Black Sea: we find tardigrades in the Sevastopol bays, cape Tarkhankut, Zernov Phyllophora Field, coastal area of Karadag Nature Reserve of NASU, Dvuyakornaya Bay (Sergeeva et al., 2006; Kharkevych, 2013a; Kharkevych, in press).

Ecology: interstitial; in the Black Sea species was found in the biotope of medium sand with fragments of shells and algae between depths of 0 and 24 m with other meiobenthic organisms.

Worldwide distribution (literature data): this species with its broad ecological requirements are considered as cosmopolitan, distributed in the seas and oceans throughout the world (Richters, 1909; Kristensen & Mackness, 2000).

**BATILLIPES GILMARTINI** McGinty, 1969

Distribution in the Black Sea: Dvuyakornaya Bay in the southwestern part of the Crimean coastal area of the Black Sea (Kharkevych, 2013a). This is the first finding of the species in the Black Sea.

Ecology: interstitial, within 2 m depth, biotope of medium sand.

Worldwide distribution (literature data): Pacific coast of North America (McGinty, 1969).

**BATILLIPES SPINICAUDA** Gallo D'addabbo, Sandulli, De Zio Grimaldi, 2005 (fig. 3)

Distribution in the Black Sea: Dvuyakornaya Bay (Kharkevych, 2013a). First finding of the species in the Black Sea.

Ecology: interstitial, within 2 m depth in medium sand.

Worldwide distribution (literature data): Mediterranean Sea (Orosei Gulf, Sardinia), Tyrrhenian Sea (D'Addabbo Gallo et al., 2005)

Family: CORONARCTIDAE Renaud-Mornant, 1974

Genus: *Coronarctus* Renaud-Mornant, 1974

**CORONARCTUS sp. A**

Distribution in the Black Sea: Ukrainian shelf of the Black Sea.

Ecology: within 100 m deep, in the biotope of detritus.

Family: HALECHINISCIDAE Thulin, 1928

Genus: *Dipodarctus* Pollock, 1995

**DIPODARCTUS SUBTERRANEUS** Renaud-Debyser, 1959 (fig. 4)

Distribution in the Black Sea: Bosphorus area of the Black Sea, coastal waters of Kerch Peninsula and north-western part of the Black Sea (Kharkevych & Sergeeva, 2013).

Ecological features: *D. subterraneus* was found in deep water detritus sediment at the depth of 88 - 122 m.

Worldwide distribution (literature data): at various sites in the Mediterranean Sea, Faroe Islands, Malta, Bahamas in Indian Ocean near Seychelles and Maldivian Island (Grimaldi de Zio et al., 2003; Gallo et al., 2007).

Genus: *Florarctus* Delamare Debutteville & Renaud-Mornant, 1965

**FLORARCTUS HULINGSI** Renaud-Mornant, 1976 (fig.5)

Distribution in the Black Sea: Karkinitzky Bay, Black Sea (Kharkevych, 2012).

Ecology: in the Black Sea this species was found in the biotope of medium sand at the depth of 10 - 25 m.

Worldwide distribution (literature data): species was found in the Mediterranean Basin (near the coast of Sardinia, France, Malta, Algeria, and Tunisia) and in Indian Ocean (Madagascar) (Grimaldi de Zio et al., 2003; D'Addabbo et al., 2007).

Genus: *Wingstrandarctus* Kristensen, 1984

**WINGSTRANDARCTUS CORALLINUS** Kristensen, 1984 (fig. 6)

Distribution in the Black Sea: northwestern part of the Black Sea in Zernov Phyllophora Field and Karkinitzky Bay.

Ecology: within 35 m in the biotope of medium sand; it is the first finding of the species in the Black Sea.

Worldwide distribution (literature data): Mediterranean Sea, Coral Sea, Great Barrier Reef (Australia) (Kristensen, 1984; Grimaldi de Zio et al., 2003).

Genus: *Halechiniscus* Richters, 1908

**HALECHINISCUS GUITELI** Richters, 1908

Distribution in the Black Sea: Sevastopol bays, cape Tarkhankut.

Ecology: species was found in the biotope of fine sand and detritus with fragments of algae at depths 3 – 20 m (Sergeeva et al., 2006).

Worldwide distribution (literature data): was collected in France, on the Atlantic and Mediterranean coasts (Ramazzotti, 1962).

**HALECHINISCUS sp. A**

Distribution in the Black Sea: Crimean shelf of the Black sea.

Ecology: species was found in the biotope of detritus within 150 m.

**HALECHINISCUS sp. B**

Distribution in the Black Sea: Crimean shelf of the Black sea.

Ecology: within 150 m in the biotope of detritus.

Genus: *Angursa* Pollock, 1979

**ANGURSA sp. A**

Distribution in the Black Sea: Crimean shelf of the Black sea.

Ecology: species found in the biotope of detritus within 150 m.

Genus: *Styraconyx* Thulin, 1942

**STYRACONYX QIVITOQ** Kristensen & Higgins, 1984 (fig. 7)

Distribution in the Black Sea: the north-west of the Black Sea in Karkinitsky Bay and Zernov Phyllophora Field.

Ecology: in the Black Sea species were found in the biotope of medium sand with fragments of algae and seashells at the depth of 12 - 34 m (Kharkevych, 2012).

Worldwide distribution (literature data): both in the coastal area of Greenland and in subtropical and tropical marine environments (Kristensen & Higgins, 1984).

**STYRACONYX NANOQSUNGUAK** Kristensen & Higgins, 1984 (fig. 8)

Distribution in the Black Sea: north-western part of the Black Sea, Karkinitsky Bay, Zernov Phyllophora Field.

Ecology: inhabit the biotope of medium sand with detritus and fragments of algae within 32 m (Kharkevych, 2012).

Worldwide distribution (literature data): Greenland, Mediterranean Sea (Grimaldi de Zio et al., 2003; Kristensen & Higgins, 1984).

Genus: *Tanarctus* Renaud-Debyser, 1959

**TANARCTUS RAMAZZOTTII** Renaud-Mornant, 1975 (fig. 9)

Distribution in the Black Sea: the Istanbul strait's (Bosporus) outlet area of the Black Sea, near Kerch Peninsula, on the open slope north-west of the Crimea Peninsula (Kharkevych & Sergeeva, 2013).

Ecology: subtidal, within 122 m depth. Some of the individuals were found in the biotope of detritus in specific hypoxic conditions (Kharkevych & Sergeeva, 2013).

Worldwide distribution (literature data): Mediterranean Sea (Grimaldi de Zio et al., 2003).

Family: STYGARCTIDAE Schulz, 1951

Genus: *Megastygarcides* McKirdy, Schmidt & McGinty-Bayly, 1976

**MEGASTYGARCTIDES ISOUNGUIS** Renaud-Mornant, 1981 (fig. 10)

Distribution in the Black Sea: Sevastopol bays of the Black Sea.

Ecology: interstitial; in the biotope of medium and fine sand with fragments of algae at the depths of 2 – 17 m.

Worldwide distribution (literature data): in the coastal waters of France (Renaud-Mornant, 1981).

**MEGASTYGARCTIDES conf. SETOLOSO** Morgan & O'Reilly, 1988 (fig. 11)

Distribution in the Black Sea: Sevastopol bays, Black Sea.

Ecology: interstitial; species was found in the biotope of medium sand with fragments of the seashells at the depths 2 - 15 m.

Worldwide distribution (literature data): Scottish waters (O'Reilly, 1999).

**MEGASTYGARCTIDES sp. n.**

Distribution in the Black Sea: NW of the Black Sea in Karkinitsky Bay.

Ecology: interstitial; in the biotope of medium sand with the fragments of seashells at the depth 11 m (Kharkevych, 2012).

Genus: *Stygarctus* Schulz, 1951

**STYGARCTUS BRADYPUS** Schulz, 1951

Distribution in the Black Sea: near the Bulgarian and Romanian coast of the Black Sea (Rudescu, 1969).

Ecology: interstitial, sublittoral and littoral zones; within 10 m depth.

Worldwide distribution (literature data): Mediterranean Sea, Atlantic and Indian Ocean (Grimaldi de Zio et al., 2003).

Order: ECHINISCOIDEA Richters, 1926

Family: ECHINISCOIDIDAE Kristensen & Hallas, 1980

Genus: *Echiniscoides* Plate, 1888

**ECHINISCOIDES SIGISMUNDI** (M. Schultze, 1865)

Distribution in the Black Sea: Kruglaya Bay, Sevastopol, Black Sea (Sergeeva et al., 2006).

Ecology: species was found in the biotope of medium sand at the depth of 6 m; sublittoral.

Worldwide distribution (literature data): near the coast of England, France, Germany, Norway, Brazil; Caribbean Sea, Mediterranean Sea (Grimaldi de Zio et al., 2003).

Class: **EUTARDIGRADA** Richters 1926

Order: PARACHELA Schuster, Nelson Grigarick & Christenberry, 1980

Family: HYPYSIBIIDAE Pilato, 1969

Genus: *Halobiotus* Kristensen, 1982

**HALOBIOTUS conf. STENOSTOMUS** (Richters, 1908) [*Macrobiotus appelloefi* Richters, 1908; *Hypsibius (Isohypsibius) geddesi* Hallas, 1971] (fig. 12)

Distribution in the Black Sea: 1 adult (female) individual in the third larval stage with eggs in the cuticle was collected in the littoral zone near Odessa (Tyras) in the northwestern part of the Black Sea.

Ecology: species was found in the coastal zone at a depth of 0,5 m in the biotope of medium-grained sand with fragments of filamentous algae. This work is the first record of the species in the Black Sea.

Worldwide distribution (literature data): in the littoral zone of the White Sea (Biserova & Kuznetsova, 2012).



Figure 2: General view of *Batillipes mirus*;

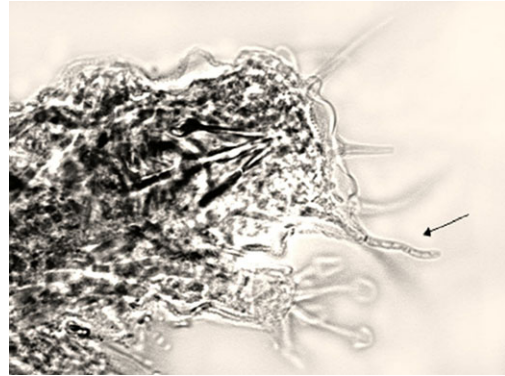


Figure 3: Head appendages of *Batillipes spinicauda*;



Figure 4: General view of *Dipodarctus subterraneus*;



Figure 5: *Florarctus hulingsi*;

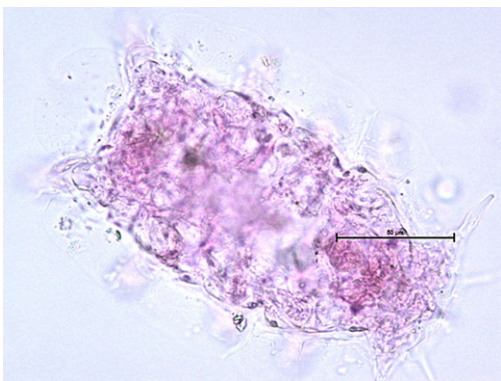


Figure 6: *Wingstrandarctus corallinus*;



Figure 7: *Styraconyx qivitoq*;





Figure 8: *Styraconyx nanoqsunguak*;



Figure 9: *Tanarctus ramazzottii*;



Figure 10: *Megastygarcoides isounguis*;



Figure 11: *Megastygarcoides conf. setoloso*;



Figure 12:  
*Halobiotus conf. stenostomus* with eggs.

## CONCLUSION

At present, the Black Sea tardigrades fauna is represented by two classes Heterotardigrada (2 orders – Arthrotardigrada and Echiniscoidea) and Eutardigrada (order Parachela). Arthrotardigrada are the most abundant with 4 families, 11 genera and 18 species, while Echiniscoidea only include the family Echiniscoididae with 1 genera and 1 species.

The family Halechiniscidae shows the highest diversity, with 7 genera and 10 species in subfamilies: Florarctinae and Styraconixinae each with 2 genera, 2 and 3 species respectively; Dipodarctinae, Halechiniscinae, and Tanarctinae include 1 genus each, with 1, 3, and 1 species respectively. The family Stygarctidae is present with 4 species arranged in 2 genera.

The family Batillipedidae is one of the most common families along the Crimean coast, particularly in the sublittoral zone with 3 species.

The most frequent species along the investigated Crimean coast area is *B. mirus*, collected in 65% of the sampling sites. It is followed by species of genus *Megastygartides* - 55%. The most of the remaining species were found in the deep zone of the Black Sea, where the species *T. ramazzottii* had the highest abundance and was found in 75% of the investigated sites.

This is nearly 12% of known marine Tardigrada fauna of the world (nearly 180 marine species).

Most of the encountered species found in the Black Sea have a wide range of the world distribution and were also found along Pacific American coast, European coast, African and Asian coasts. One of them is cosmopolitan species - *B. mirus*.

However, future investigation is needed to expand and add information about this unique group of invertebrates.

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