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Redescription of *Acartia (Acanthacartia*) *tonsa* Dana, 1849 (Copepoda: Calanoida) from the Caspian Sea

Elena Krupa[1], Sophia Barinova[2] and Maksim Alyimov[3]

[1] Republican State Enterprise "Institute of Zoology", Ministry of Education and Science, Science Committee, Al-Farabi 93, Almaty, 050060, Kazakhstan

[2] Institute of Evolution, University of Haifa, Mount Carmel, 199 Abba Khoushi Ave., Haifa, 3498838, Israel
Corresponding author

[3] Limited Liability «Kazakh environmental project», Republic of Kazakhstan

Abstract

Acartia (Acanthacartia) tonsa from Northeastern and Middle Caspian Sea, male and female, is re-described. The difference in the morphological structure of the fifth pair of legs of males *A. (Acanthacartia) tonsa* from the North-East of the Caspian Sea from the available descriptions is outlined. Based on an analysis of the published data and our Index saprobity S calculation, the conclusion is drawn that biological characteristics of *A. (Acanthacartia) tonsa* determine the ecological preferences of brackish, but not saline waters, middle oxygenated, low alkaline, and low-to middle organically enriched that confirm by bio-indication results.

Keywords: Copepoda, Calanioda, *Acartia*, Caspian Sea

1 Introduction

Acartia (Acanthacartia) *tonsa* Dana inhabits the Indian, Atlantic and Pacific Oceans, the Malay Archipelago, the Baltic Sea, the Sea of Azov [3; 12; 22]. In the Black Sea, acartia is known since 1976 [10], in the Mediterranean – since 1986

[12]. In the Caspian Sea, this species has been long defined as *A. (Acartiura) clausi* Giesbrecht, 1889, which is obviously due to the lack of the detailed descriptions of both species. Study of hydrobiological samples from the Caspian Sea [17; 21] evidenced that the Caspian Sea was not inhabited by *A. (Acartiura) clausi*, but by *A. (Acanthacartia*) *tonsa*. The analysis of the published data, carried out by the authors, suggested that this species appeared in the South Caspian in 1981, in the Middle Caspian - in 1982, in the North Caspian - in 1983.

The paper presents the redescription of females and males of *A. (Acanthacartia) tonsa* from the Northeastern and Middle Caspian. The difference in the morphological structure of the fifth pair of legs of males from the Northeastern Caspian Sea from the available descriptions of *A. (Acanthacartia) tonsa* is outlined.

2 Materials and methods

Zooplankton samples were collected in the Kazakhstan sector of the Northeast and Middle Caspian within different seasons of the 2010-2014. Samples were taken using Juday net with 12 cm diameter and were fixed in 4% neutral formaldehyde solution. The further processing was performed by standard methods [15]. Adult males and females were selected from zooplankton samples for further preparation. 25 males and 25 females from the Northeast Caspian Sea and 20 males and 20 females from the Middle Caspian were studied in total. Mature males and females were selected from zooplankton samples for further preparation. 25 males and the same number of females from the Northeast Caspian Sea and 20 males and 20 females from the Middle Caspian Sea were studied on the whole. For descriptions and photographs of the male and female species, Cannon 1000D camera and microscope Axiolab.A1 were used. The object was located in different planes, so it was impossible to achieve the same image clarity for all the details when captured at high magnification. Therefore, series of pictures were made with alternate focusing on individual components (spines, setae, rami, segment as a whole, etc.). Image processing (cleaning background, juxtaposition) was performed using the program Adobe Photoshop and Corel Draw.

For ecological characteristics of studied species habitat we involved bio-indication results of phytoplankton collected in parallel with zooplankton samples. Phytoplankton samples were collected and processed by standard methods [16]. Algal species-specific ecology comes from database [1]. Indices of saprobity were calculated with using species-specific indices of algae and abundance of each species in phytoplankton samples.

3 Results

Redescription of Acartia (Acanthacartia) tonsa Dana, 1849

Body is elongated, oval, slender. Both females and males have cephalothorax approximately 4 times longer than abdomen. Cephalothorax has somewhat angular profile at the front. Both sexes have a thin, threadlike biramous rostrum.

Female (Fig. 1). The abdomen is very short, slightly shorter than a quarter of the length of cephalothorax. According to our data, the ratio between the length of cephalothorax and the abdomen without caudal rami is 4.8:1. The rear edges of cephalothorax are rounded. Sides of urosomite (genital somite) are with setae. Antennules reach the middle of the urosomite. Genital somite is of trapezoidal shape, with an extension in the proximal part; its width in the lateral projection slightly exceeds the length. Caudal rami are short; their length is 1.3-1.4 times bigger than the width. The fifth pair of legs is small; on the front surface of basis there is a swelling, well-marked in the lateral projection of the female body with unseparated legs (Fig. 1, indicated by the arrow); apical setae is largely serrated at the distal end.

Male (Fig. 2). The first segment of the right antennule is with long setae. The lateral parts of the genital somite are with tufts of short setae; shorter setae are on the sides of somites following the genital. Last abdominal somite is with short spines. The width of the third abdominal segment in the dorsal projection is twice as large as its height. Caudal rami are almost round and have the tufts of setae on the inner edge. The fifth pair of legs is asymmetrical and uniramous. According to the descriptions [3; 9; 21; 23], there are no processes on the inner surface of the 2nd segment of the right leg of the fifth pair (Fig. 2). Species from Northeast Caspian Sea have, on the inner surface of the 2nd segment of the right leg of the fifth pair, in the proximal part, a small rounded process, armed with spine (Fig. 3: *6-7; 9*, marked by an arrow). Species from the Middle Caspian have no processes; there are only small spines (Fig. 3: *8*). On the third segment of the right leg of the fifth pair there is very large internal process; fourth segment is elongated, curved, armed with spines and thin long setae; the distal end is with setae and two spines, of which the apical is larger; a spine about 2 times smaller than apical located more proximal. Basis of the left leg is with a large process bearing spine; distal segment is armed with small setae and has apical spine, and another spine in the middle of the inner edge.

Body size: females 0.72-0.94; males 0.71-0.82 mm.

Systematic notes

A. (Acanthacartia) tonsa is regarded as cryptic species, with two forms distinguished - lineages F and lineages S [6]. The greatest variability is observed within antennule's length, the sizes of proximal rami of the fifth pair of legs, and for the females additionally - all the parameters of the fifth pair of legs [7]. Analysis of available data showed that in addition to the variability of the above-mentioned characteristics, *A. (Acanthacartia) tonsa* has a changeable shape of the proximal process of the third segment on the right leg of the fifth pair of a male: a

regular or irregular semicircle (Northeastern and Middle Caspian, our data), semi-oval (Atlantic coasts) [12] or the process has relatively sharp edges [21].

A. (Acanthacartia) tonsa from our collection exhibits some morphological differences from the specimens described earlier [3; 9; 21; 23]. Males from the Northeastern Caspian Sea are different compared to specimens from other habitats; they have a small round process, armed with spine, on the proximal part of the 2nd segment of the right leg of the fifth pair. The specimens from the Middle Caspian have no process or there is a small spine instead. Females from our collection are characterized by a long caudal rami (length/width ratio of 1.3-1.4:1) and cephalothorax being slightly longer than abdomen (cephalothorax/abdomen length ratio is 4.8:1).

Abundance and biology

According to averaged long-term data (2005-2014, up to [18] with amendments), the number of *A. (Acanthacartia) tonsa* in the Northeast Caspian Sea ranged within 2767-26380 ind/m^3 (Fig. 3). The maximum abundance of acartia was noted in July, September and October. The proportion of acartia increased linearly from 12-15% of the total number of zooplankton in the spring to 84% in October and November, and declined December.

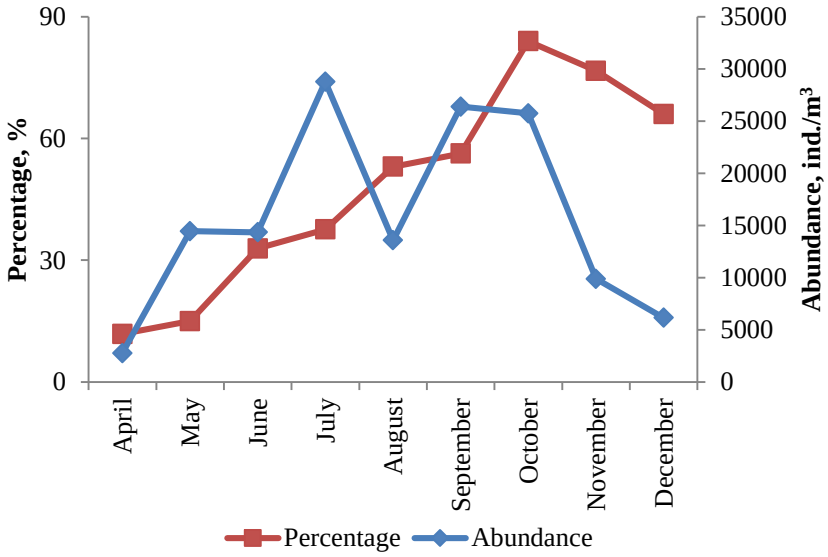

Fig. 3. Seasonal dynamics of *A. (Acanthacartia) tonsa* in the Northeast Caspian Sea (the abundance and proportion within the total number of zooplankton, on average during 2005-2014)

In the Middle Caspian Sea, the abundance of acartia was within the range of 577-9177 ind/m^3. The proportion of acartia within the total number of zooplankton ranged from 30.9-45.5% in May and July to 81.5-91.7% in September and October.

Ecological data for studied species are minimal that because we try to characterize their environment by algal bio-indication methods which give an integral characteristic of habitat.

Bio-indication of Caspian population ecological preferences show that waters inhabit by studied species are medium oxygenated (with 30 algal indicators), temperate in temperature (with 16 indicators), brackish (with 41 indicators), low alkaline (with 31 indicators), low to middle organically polluted (with 40 indicators), and have oligotrophic to eutrophic ecological state. Calculated Indices of saprobity were fluctuated between 1.50 and 2.62 in spring, and 1.53-2.0 in autumn. Remarkable that indices were higher in surface waters up to 10 m in spring, whereas in autumn it were lower and varied in small range with increasing tendency to the bottom. In the 20 m level where acartia is abundant, Index S was lower than in surface and in bottom and fluctuated in small range (1.60-2.13), that show low-to-middle organic pollution, Class of water quality II-III.

4 Discussion

Individual variability of Acartiidae family remains essentially unexplored. We have described the morphological features of *A. (Acanthacarti) tonsa* from the North-East of the Caspian Sea, and they may be associated with the individual variability of the species in different parts of its area.

In some parts of its area range, *A. (Acanthacartia) tonsa* is often found alongside with *A. (Acartiura) clausi*, but there is a spatial or temporal separation of habitats due to the biological characteristics of these two species. In the Atlantic region, the first species dominates in the summer, the second - in the winter [8]. In the Gulf of Fos in Mediterranean, *A. (Acartiura) clausi* dominates the habitat, and in the lagoon Etang de Berre, zooplankton is represented primarily by *A. (Acanthacartia) tonsa*, despite the fact that these two habitats are connected by channels, allowing marine fauna to permeate through both. This sort of distribution of species is attributed to salinity gradient, as nauplii and copepodites of *A. (Acanthacartia) tonsa* have bad chances of survival when salinity increases over 25 ‰. That confirm by bio-indication the result of which shows species preferences of brackish, but not saline waters, middle oxygenated low alkaline and low-to middle organically enriched. *A. (Acartiura) clausi* produces only subitaneous summer eggs with bare shell [5]. Eggs of *A. (Acartiura) clausi* have a lower density than that of *A. (Acanthacartia) tonsa* and, at all temperatures regimes of the Black Sea, may develop in the upper layers, spreading across the water by currents [11]. *A. (Acartiura) clausi* feeds on smaller objects (0.006-7.0 um) [19; 20], compared with *A. (Acanthacartia)tonsa*, which can consume small food (5-30 um) as well as large (30-100 um) [14].

The Caspian Sea has favorable hydrochemical conditions for *A. (Acanthacartia) tonsa*. Water salinity across aquatory varies on the average from 1.8 ‰ near the river flow to 12.94 ‰ in the southern, most saline part of the

Caspian [13]. Despite the decrease in oxygen content with depth, the favorable gas condition remains even in the deep sea, and this does not prevent the development of acartia eggs, sinking to the bottom. The ascent of nauplii hatched from eggs is enabled, apparently, by the intense convective mixing of waters of the Caspian Sea, due to the peculiarities of its hydrochemical regime [4]. Favorable environmental conditions and biological features of *A. (Acanthacartia) tonsa* resulted in successful settlement and consequent domination of the species within zooplankton in the Caspian Sea.

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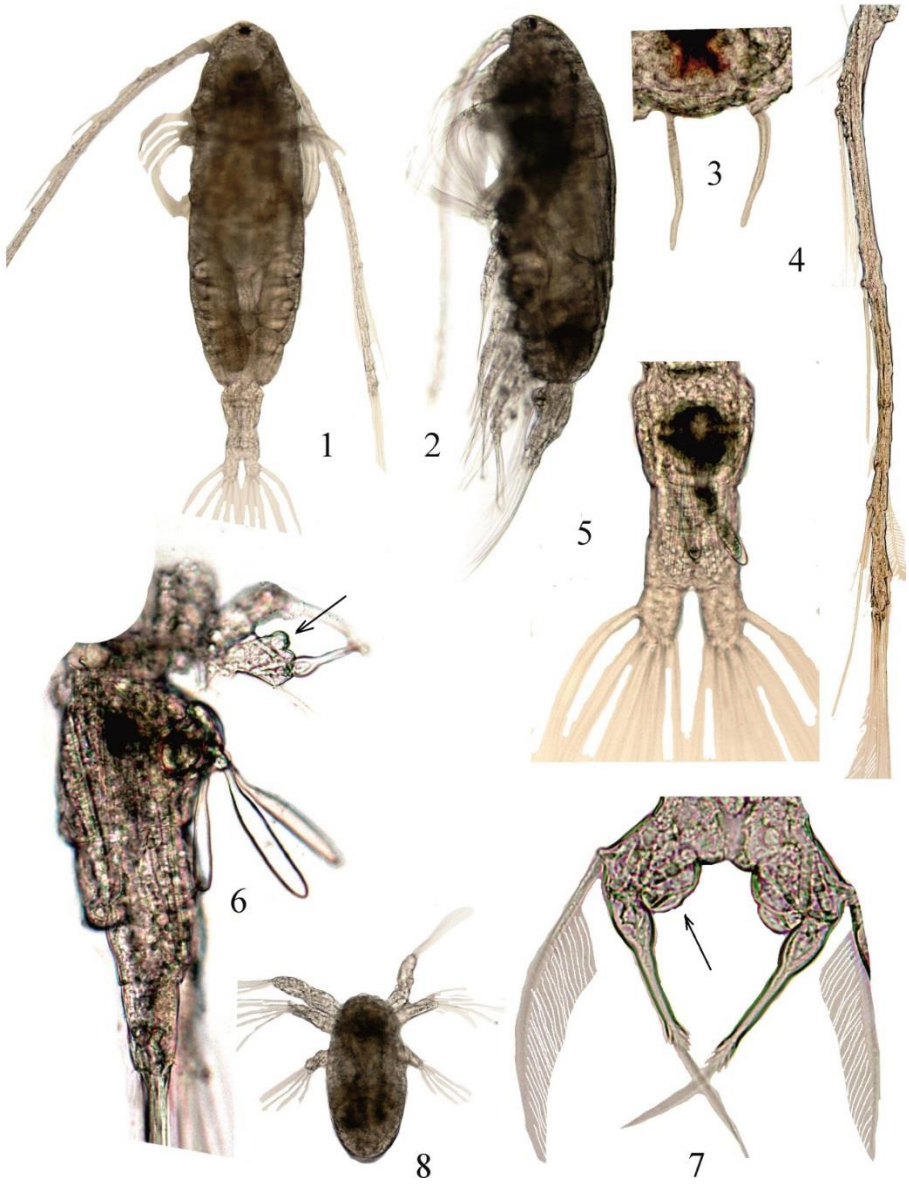

Fig. 1. *Acartia (Acanthacartia) tonsa* Dana, female, the Caspian Sea. 1-2. Habitus; 3. Rostrum; 4. Antennule; 5. Abdomen with caudal rami; 6. The abdomen, lateral view, and the fifth pair of legs; 7. The fifth pair of legs; 8. Nauplii.

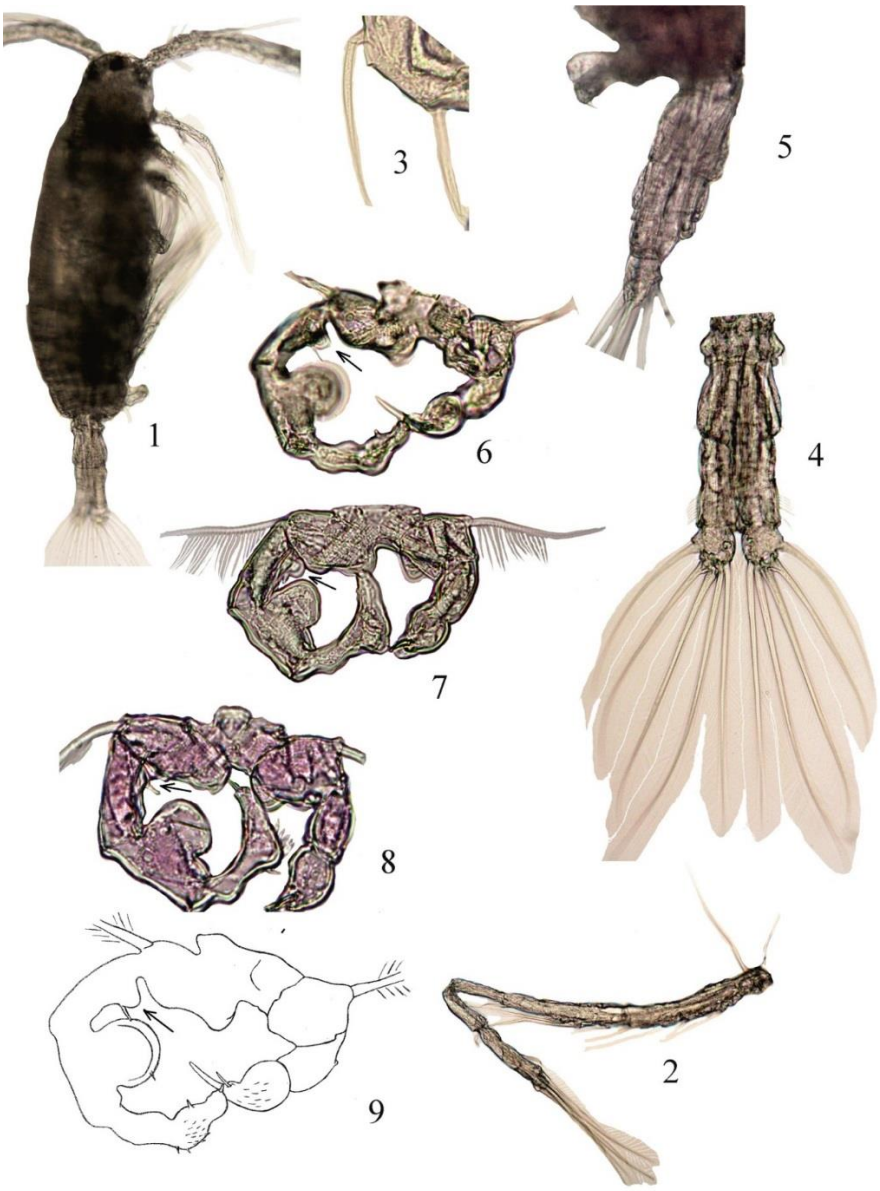

Fig. 2. *Acartia (Acanthacartia) tonsa* Dana, male, Caspian Sea. 1. Habitus; 2. Right antennule; 3. Rostrum; 4. Abdomen with caudal rami; 5. Abdomen, lateral view, and the fifth pair of legs; 6-7; 9. The fifth pair of legs, Northeastern Caspian; 8. The fifth pair of legs, Middle Caspian.

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