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Occurrence of *Acartia tonsa* Dana in the Black Sea. Was it introduced from the Mediterranean?

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Abstract

It was reported for the first time that Acartia tonsa was present in the Black Sea as early as in 1976. A.tonsa was found in the Mediterranean Sea in 1985. So, this copepod was initially introduced to the Black Sea and did not invade here from the Mediterranean. Probably A.tonsa was transferred to the Black Sea with ship's ballast water from some other region of the World Ocean. Differences in seasonal dynamics and size structure of A.clausi and A.tonsa in the Bay of Sevastopol in 1976 are discussed.

Keywords: *Acartia tonsa*, Seasonal dynamic, Black Sea.

Introduction

Three species of the genus Acartia were reported from the Black Sea: *A. clausi* Giesbrecht, 1889, *A. latisetosa* (KRICHAGIN, 1873), *A. italica* Steuer, 1910 (Guidebook for marine fauna of the Black Sea, 1969). *A. clausi* small form for the Black Sea was described by POTEMKINA (1940). Nowadays it has been reported as *A. margalefi* (BELMONTE & MAZZOCCHI, 1997).

Acartia tonsa Dana, 1848 is an abundant neritic species common in coastal waters of the Western Atlantic, Indian and Pacific Oceans. The populations of *A. tonsa* can reach great abundance (RAYMONT, 1983). However, in both Mediterranean and the Black seas *A. tonsa* was discovered relatively recently.

For the Black Sea *A. tonsa* was reported as late as in 1994 (BELMONTE *et al.*, 1994). The copepod was found in plankton samples collected in September 1990 near Karadag, in the south-eastern part of Crimea. Later, relatively high abundance of *A. tonsa* was recorded in the southern part of the Black Sea (KOVALEV *et al.*, 1998) and in Sevastopol Bay (SHMELEVA & GUBANOVA, unpublished data). Thus, the question arose about the period when *A.tonsa* had appeared in the Black Sea for the first time.

The aims of this study are to determine:
- when *A. tonsa* appeared in the Black Sea for the first time;
- did this species invade to the Black Sea from the Mediterranean or not?

Material and methods

To clarify the species composition of the genus *Acartia*, we have examined samples from the collection stored at the Department of Plankton, of the Institute of Biology of the Southern Seas. The series of samples were collected in Sevastopol Bay year round in 1976, 1980, 1990 and in August, September, October 1968. Samples were taken by vertical hauls from bottom (10 m depth) to the surface using Juday net with 150 mkm mesh size and 0.36 m mouth (opening area $0.1m^2$). Samples were preserved in a 4% formalin seawater solution.

The *Acartia* species were analysed under stereomicroscope in entire samples or in subsamples (1/2; 1/4; 1/8) depend on numbers of *Acartia*. During the examination, mature female and male copepods *A.tonsa* and *A.clausi* were counted and measured.

Results and discussion

It follows from the inspection that along with *A. clausi A.tonsa* occurred in Sevastopol Bay as early as in 1976. In summer its abundance was even greater than the abundance of *A. clausi*. By 1994 *A. tonsa* was confused with *A. clausi* due to close dimensional and morphological similarity. In the samples dated 1968, *A. tonsa* was absent. Apparently, it appeared in the Black Sea in early 1970s.

Two morphotypes of *A. clausi* were described in Sevastopol Bay by Shadrin and Popova in 1994. However, after discussion about morphometric parameters and seasonal dynamics of morphotype "A", we agreed with the researchers that the object of debating was none other than *A. tonsa*.

A.tonsa is absent in the list of Mediterranean copepods given by KOVALEV & SHMELEVA (1982). It was found in the Mediterranean Sea recently (GAUDY & VINAS, 1985). A. FARABEGOLI with co-authors were the first who identified *A.tonsa* in the Adriatic lagoon in 1987. They noted that this species was not found in plankton samples taken there during the preceding decade (FARABEGOLI *et al.*, 1989).

So, all this data indicate that *A.tonsa* was initially introduced in the Black Sea and then in the Mediterranean. The hypothesis that *A. tonsa* was invaded to the Black Sea from the Mediterranean (BELMONTE *et al.*, 1994; KOVALEV *et al.*, 1998) seems disputable. Most probably, the copepod was transported with a ship's ballast water from some other region of the World Ocean where it is very common in coastal areas, *A.tonsa* is tolerant of salinity changes (JEFFRIES, 1962) and produces resting eggs (ZILLOUX & GONZALES, 1972) which are more resistant to adverse environmental conditions than the active stage may provide a proof.

Taking into account that during earlier studies the researchers did not distinguish between *A.tonsa* and *A.clausi*, we decided to repeat examination of the samples taken during 1976. This would clarify the population dynamics of *A.tonsa* in the Bay of Sevastopol as taken apart from *A.clausi*.

Figure 1 shows seasonal dynamics of the numbers of mature copepods *A.clausi* and *A.tonsa*. The adults of *A.clausi* were found in the plankton year round. From January to May and in November-December the abundance of *A.clausi* was very low (less than 25 adults/m^3). An increase began in early June, when the sea water was warmed up to 18°C, and high values of abundance persisted during summer and autumn with two peaks: the first one in June and the second one in September (177 and 227 ind/m^3 correspondingly). *A.tonsa* was not found in the bay from February to May. The adults appeared only in late May when the sea water had warmed to 16°C. Rapidly increasing, the abundance of *A.tonsa* exceeded the abundance of *A. clausi* from the end of June to August. In August the peak (1232 ind/m^3) was reported; the abundance was one order of magnitude greater than the average of the year. The sea water was warmest (21-22°C) during July-August. With cooling of the sea the abundance of *A.tonsa* was gradually decreasing. In December it was as low as 7 copepods per cub. meter. It is known that it produces resting eggs in response to cold temperature (ZILLOUX & GONZALES, 1972). The copepod maintain in the envi-

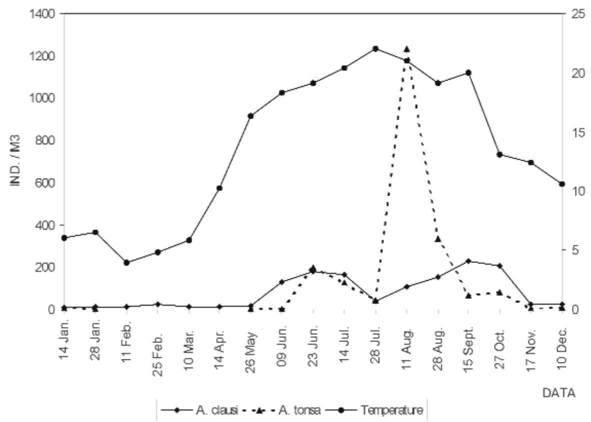

Fig. 1: Seasonal variation in the numbers of adult *Acartia clausi* and *A. tonsa.*

ronment through the dormancy stage. So in the Black Sea, *A. tonsa* has added up to the ecological group of the warm water organisms. Temperature is an important factor controlling seasonal distribution of *Acartia* species in the Bay of Sevastopol.

Seasonal fluctuations of both species were studied for the western coast of the North America (CONOVER, 1956; DEEVEY, 1960; JEFFRIES, 1962; LEE & MCALICE,1979), where *A. clausi* and *A. tonsa* co-exist and reach great abundance. All these investigations have indicated a well defined relationship between seasonal changes and the temperature. However, seasonal dynamics of these calanoid copepods depend upon their habitat. *Acartia tonsa* is present all year round only in warmer waters further south (SULLIVAN & MCMANUS, 1986) while *A. clausi* shows up in the cold season. Moving northward, *A. clausi* becomes a year-round species, while *A. tonsa* occurs in the warm season only. R.J.CONOVER has studied biology and ecology of these species off the Long-Island (CONOVER, 1956) and noted that *A. clausi* dominates in winter and spring, while *A. tonsa* dominates in summer and fall. The author assumes, that different optimum temperature of species development keeps the ecological niches separated, which coincide at intermediate temperatures only. However, to the north, in the Man Bay, where *A. clausi* is presented all year round, and *A. tonsa* appears since May till December, the abundance peaks of both species are pronounced simultaneously: in the summer and autumn (LEE & MCALICE, 1979). These data are in good agreement with ours and this confirms the Gonzales hypothesis that, having developed physiological adaptation to environment, *A. tonsa* can co-exist with congeneric forms without their displacement (GONZALES, 1974).

A.clausi and *A.tonsa* differ in size. It follows from Table 1 that *A.clausi* - both males and females are generally larger in compari-

Table 1
The body length of the both species.

Arial	Year	Species	Sex	Body length	
				Mean ± SD (mm)	Range (mm)
Black Sea	1976	*Acartia clausi*	Female	1,18 ± 0.077	1,09-1,30
			Male	1,13 ± 0.082	1,03-1,26
		Acartia tonsa	Female	1,09 ± 0.066	0,96-1,20
			Male	0,97 ± 0.065	0,86-1,10

son with *A.tonsa* ($p < 0.05$; *t*-test). On the average, females of *A.clausi* were 0.08 mm longer and males 0.16 mm longer than their counterparts in *A.tonsa* in 1976 .

Figure 2 illustrates the inverse correlation between the body sizes of both species and water temperature. The size of copepods largest in the cold season of a year and smallest during summer and early autumn. Coefficients of correlation were relatively high for both species. However, the abundance of food in the period of copepods individual development is an important factor as well. DEEVEY has suggested that the negative correlation between body length of copepods and temperature should be recorded in regions, where the range of the annual temperature should be 14°C or above that [9]. If seasonal changes of temperature are less than 14°C, copepod size should be correlated directly (linearly) with amount of phytoplankton. In the investigated period temperature in the Bay of Sevastopol changed from 3,9° to 22°C. High values of correlation coefficients (**r** *A.clausi* = -0,93,**r** *A.tonsa* = -0,80) have indicated that temperature is the most important factor affecting the *Acartia* body length in Sevastopol Bay.

Conclusions

- *Acartia tonsa* appeared in the Black Sea and Sevastopol Bay in the early 1970s; it was earlier than it appeared in the

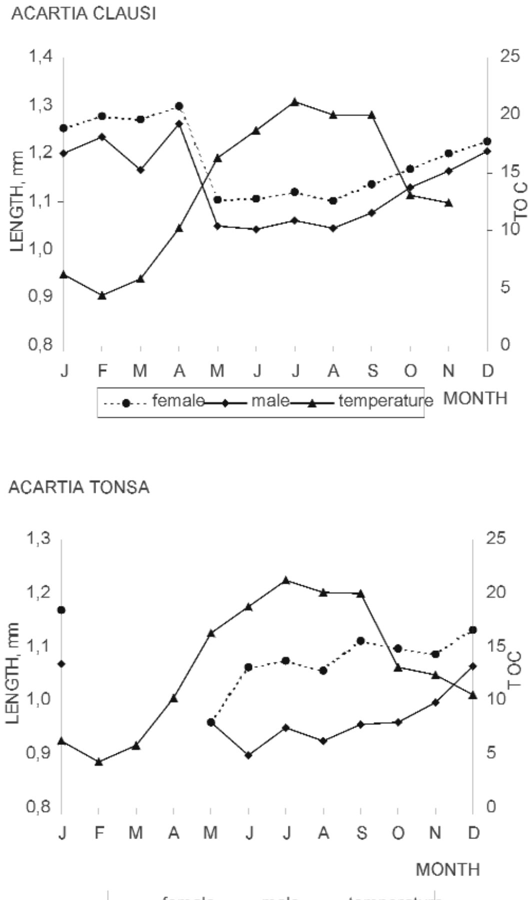

Fig. 2: Seasonal variation of average body length in females and males of the both species.

Mediterranean. It seems to be an accidental introduction with ballast water of a ship from the Atlantic, Indian or Pacific Oceans where this species is common in coastal waters.

- During the cold season of a year the population of *A.tonsa* is in the state of dormancy. Seasonal warming of the sea triggers the hatching of the resting eggs. As soon as the water temperature reaches 16°C the mature copepods appear in the plankton.
- The body size of *A.tonsa* is smaller than *A.clausi*.
- There is inverse relationship between the body size of both species and water temperature.

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