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Parasites (*Ellobiopsis chattoni* Caullery, 1910) on Copepoda with two new host records, from Sea of Marmara, Turkey

M. Levent Artüz

Abstract

Background: In the various sites in Sea of Marmara, copepoda *Acartia* (*Acartiura*) *clausi*, *Calanus euxinus*, *Centropages ponticus* were invaded by *Ellobiopsis chattoni*.

Results: This study provides the first evidence of *Centropages ponticus* and *Calanus euxinus* being a host to *Ellobiopsis chattoni* and the first record of *Ellobiopsis chattoni* in the Sea of Marmara, Turkey.

Conclusions: Also this study emphasizes the consequences of parasitic infection in the case of the special position of Sea of Marmara.

Keywords: Copepoda, *Ellobiopsis*, Parasites, Sea of Marmara, Zooplankton

Background

The Sea of Marmara, with 933.3 km coastline, is an inland sea within Turkey with a maximum depth of 1272 m. It has unique hydrodynamic features, due in large part to the structural characteristics of the Turkish straits (The Çanakkale Strait or Dardanelles, and the Boğaziçi or Bosphorus), which connect it to the Aegean and Black Seas, respectively. Collectively, the two Straits and the Sea of Marmara provide an important "acclimatization zone" for transiting species of pelagic fishes of Atlantic origin during their migration from the Black Sea to the Aegean and vice versa.

The Sea of Marmara has, in vertical section, three different water layers distinctly separated from each other. The top layer originates from low salinity Black sea water, in which salinity increases, but the thickness of the layer decreases considerably with the distance traveled from the Bosphorus to the Dardanelles by mixing and upwelling of the deeper layers originating from the Aegean and Mediterranean Seas.

The average depth of this top layer is about 25 m, in which salinity ranges from 19 to 26 ‰ according to the season and inflow from the Black Sea. This mixing of the top and the middle water masses has also a considerable effect on the temperature of both layers.

The middle layer of water has its greatest thickness near the Dardanelles, where the top layer tends to diminish to a thin film of water of some few meters, but becomes markedly thinner from this point to the entrance of the Bosphorus. This high salinity water fills all the deeper parts of the Bosphorus below 25–30 m and extends, under certain conditions, into the depths of the Black Sea. There is also considerable changes in sea level caused by the outflow from the Black Sea, which is also largely responsible for the surface and deep currents in both directions, as well as the position of the vertical and horizontal boundaries of both layers.

The third and unaffected mass of water, which occupies all depths bellow 200 m in Sea of Marmara, has a constant temperature of 14.2 °C and salinity of 38.5 ‰ and no seasonal variations occurred (Artüz et al., 2007).

Copepoda often serves as hosts for parasitic protozoa, monogenea or even isopoda (Smyth 1994). *Ellobiopsis* spp. are regarded as dangerous parasites of copepoda. They can adversely affect fertility in females (Albaina & Irigoien, 2006) and cause feminisation in males (Shields, 1994). There are also a number of studies reporting the lethal effects of *Ellobiopsis* spp. infection on copepoda (Timofeev, 2002). *Ellobiopsis* spp. are known to cause epizootics in its host populations, which may result

Correspondence: levent@artuz.com
Sevinç-Erdal İnönü Foundation, MAREM (Marmara Environmental Monitoring Project) Naval Researches Department, 34810 Anadoluhisarı, Istanbul, Turkey

in fundamental changes in ecological communities (Shields, 1994).

Representatives of the genus *Ellobiopsis* are common parasites of pelagic marine copepoda. Their taxonomic status remains vague, however, they have been classified as after Guiry (2015) as Infraphylum Protalveolata Cavalier-Smith, 1991; Order Ellobiopsida; Family Ellobiopsidae Coutière, 1911. The genus *Ellobiopsis* Caullery, 1910 consists of three species – *Ellobiopsis chattoni* Caullery, 1910; *Ellobiopsis elongata* Steuer, 1932 and *Ellobiopsis fagei* Hovasse, 1951.

Ellobiopsis spp. has been noted in many species of copepoda, including *Acartia (Acartiura) clausi* Giesbrecht, 1889. This study provides the first evidence of *Calanus euxinus* Hulsemann, 1991 and *Centropages ponticus* Karavaev, 1895 being a host to *Ellobiopsis chattonii* Caullery, 1910 and the first record of *E. chattoni* in the Sea of Marmara, Turkey.

Results

Ellobiopsis chattoni (Fig. 1a) were found in all research periods, and ranged from 4.6 % (2007) to 8.6 % (2012) total of all three copepoda species *Acartia (Acartiura) clausi, Calanus euxinus,* and *Centropages ponticus*; in two stations in 2007, in one station in 2008, in three station in 2009, in one station in 2010, in five stations in 2011 and in three stations in 2012 in the Sea of Marmara (Table 1).

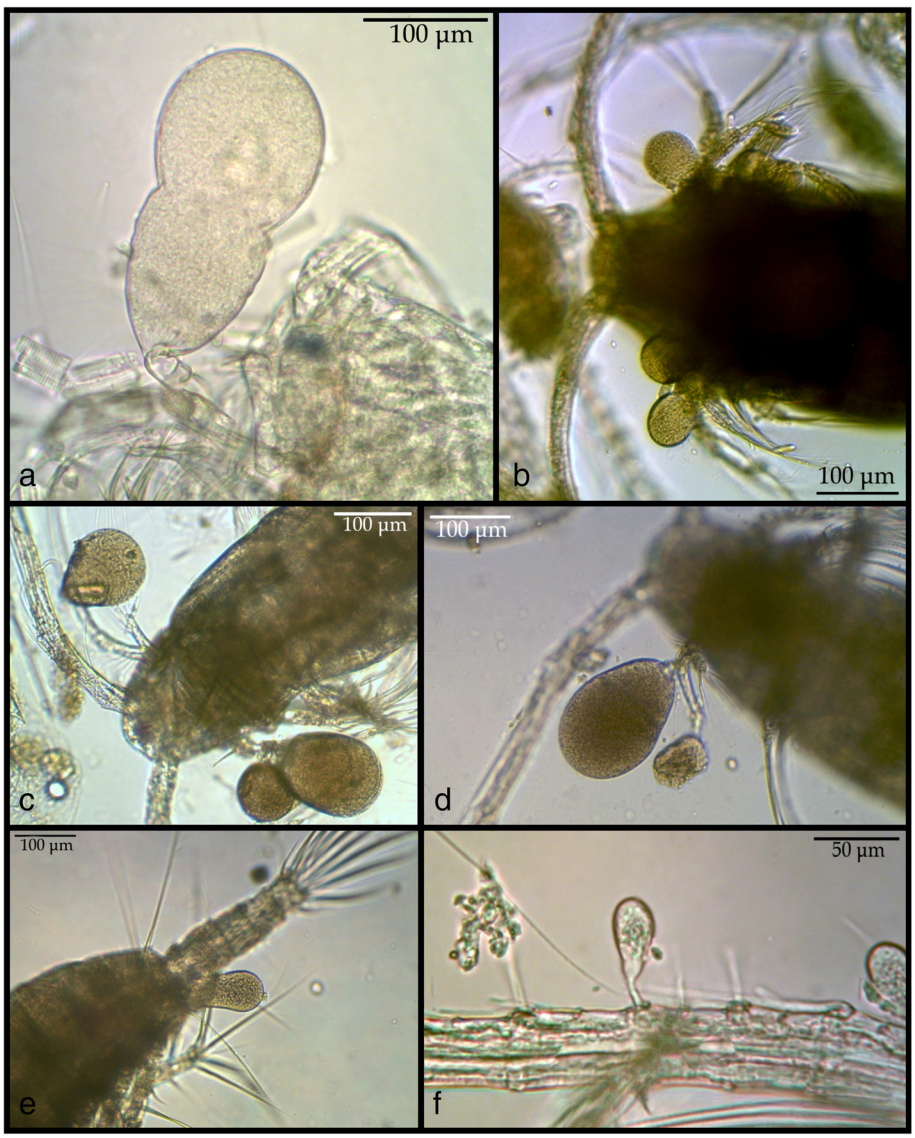

Fig. 1 (**a**) *Ellobiopsis chattoni* Caullery, 1910 (**b**) *E. chattoni* trophonts on *C. ponticus* dorsal view (**c**) *E. chattoni* trophonts on antenna and antennules of *C. euxinus* ventral view (**d**) Several *E. chattoni* trophonts on antennulla and maxilliped of *C. euxinus* ventral view (**e**) *E. chattoni* trophonts on 5. thoracic segment of *A. clausi* (**f**) *E. chattoni* trophonts on antenna of *A. clausi*

The dominant taxa of copepoda of the Sea of Marmara were the most commonly attacked (Table 1) *Acartia (Acartiura) clausi* (37.8 % of all infested individuals), *Calanus euxinus* (19.5 % of all infested individuals) and *Centropages ponticus* (42.7 % of all infested individuals).

Percentage of the infected to the uninfected individuals of the examined three copepoda species was in total **6.4 %** ± *3.34* with by *Acartia (Acartiura) clausi* **7.3** ± *3.32*, by *Calanus euxinus* **3.8** ± *1.86* and by *Centropages ponticus* **8.3** ± *2.94*.

The mean values of counts, for 1 cm^3 volume, of total examined species in annual basis were in 2007, 113; in 2008, 86; in 2009, 105; in 2010, 98; in 2011, 90; in 2012, 79 respectively.

The mean number of *E. chattoni* trophonts on each parasitized copepod individual was 3.64 ± 1.99, with a maximum of nine. The mean number of *E. chattoni* trophonts on each parasitized *A. clausi* individual was 3.97 ± 2.19, with a maximum of nine; on each parasitized *C. euxinus* individual was 3.66 ± 1.98 with a maximum of nine; and on each parasitized *C. ponticus* individual was 3.28 ± 1.74 with a maximum of eight (mean ± st.dev.). The sampling period and station based percentage of infected individuals are given in Table 1.

The points of attachment of *E. chattoni* trophonts, in decreasing order of prevalence on copepoda were: antenna, mandible, antennules, maxilla, 5. thoracic segment, genital segment, rostrum, first pair of swimming legs, maxilliped (Fig. 1b–f).

Table 1 Date and station based distribution of the percentages of infected individuals to the non-infected individuals. Mean values of ten replicates of 1 cm^3 from each station. (**%** ± *st. dev.*)

Date	Station nr	Percentage (%)			Total (%)
		A. clausi	*C. euxinus*	*C. ponticus*	
09/08/2007	36	**5.6** ± *1.63*	**4** ± *1.07*	**5.6** ± *2.87*	**5.1** ± *0.92*
07/08/2007	40	**4.5** ± *2.08*	**2.5** ± *0.44*	**5.3** ± *1.70*	**4.1** ± *1.44*
11/08/2008	40	**7.2** ± *1.39*	**5.3** ± *2.21*	**7.5** ± *1.77*	**6.7** ± *1.19*
05/08/2009	17	**10.9** ± *1.42*	**7.5** ± *3.21*	**10.2** ± *1.65*	**9.5** ± *1.79*
06/08/2009	24	**7.9** ± *1.29*	**2.7** ± *1.23*	**9.9** ± *3.46*	**6.8** ± *3.71*
11/08/2009	40	**4.5** ± *0.74*	**1.8** ± *1.08*	**5.5** ± *1.70*	**3.9** ± *1.91*
11/08/2010	17	**10.7** ± *3.94*	**7.3** ± *2.07*	**10.8** ± *2.01*	**9.6** ± *1.99*
06/08/2011	30	**2.1** ± *0.82*	**1.3** ± *5.35*	**2.5** ± *1.15*	**2.0** ± *0.61*
07/08/2011	40	**5.1** ± *2.75*	**2.8** ± *0.51*	**8.2** ± *1.93*	**5.4** ± *2.71*
07/08/2011	40	**5.6** ± *0.63*	**4.8** ± *2.86*	**10.4** ± *4.37*	**6.9** ± *3.03*
07/08/2011	34	**5.8** ± *1.82*	**3.5** ± *3.01*	**5.2** ± *3.44*	**4.8** ± *1.19*
08/08/2011	35	**5.9** ± *1.80*	**4.1** ± *2.44*	**8.1** ± *3.22*	**6.0** ± *2.00*
22/07/2012	19	**14.3** ± *2.59*	**2.1** ± *0.99*	**11.8** ± *1.77*	**9.4** ± *6.44*
26/07/2012	3	**12.1** ± *3.96*	**4.3** ± *2.37*	**12.9** ± *2.98*	**9.8** ± *4.73*
28/07/2012	26	**7.5** ± *3.54*	**2.5** ± *2.66*	**10** ± *2.49*	**6.7** ± *3.82*

Discussion

During plankton surveys in Sea of Marmara, specimens of the copepoda *Acartia (Acartiura) clausi*, *Calanus euxinus*, *Centropages ponticus* infected with *Ellobiopsis chattoni* were collected. This finding seems important, both of the tree copepod species, indicated here, are important for the fishery of the area directly and via food web, especially *C. ponticus* is very important for the immigrant fishes such as *Sarda sarda*, (Zaitsev 1992).

The enormous effects would arise by the spread of any kind of the Sea of Marmara sourced negativity, especially given that it merges the Black Sea originated upper layer water mass with the Mediterranean Sea through the Aegean Sea and also the Mediterranean Sea originated limited scale of water mass with the Black Sea, as a conveyor.

Meanwhile, the Sea of Marmara has been subjected to various human impacts that have led to changes in the ecology of this inland sea. The main problem in the Sea of Marmara since 1980 is the growing pollution. All the settled areas around the Sea of Marmara are discharging the wastes using 'deep sea discharges' directly under the pycnocline–thermocline layer in the Sea of Marmara, without any treatment (Artüz et al., 2007).

In my opinion, the long-term changing of the chemical environmental variables such as pH changes (see Additional file 1), increasing pesticide concentration (Aksu & Taşkın, 2012) and/or increasing amounts of chlorine in the Sea of Marmara, that originated in large quantities as a result of the cleaning fouling organisms on the inside of the direct discharge pipes of sewage and power plants, discharged directly to the water column, are effecting to the hosts immunity and making them more susceptible to the parasitic attack; but this hypothesis requires further study.

Conclusions

The occurrence of a possible attack of the parasite *Ellobiopsis chattoni* to some copepod species is significant because the subject has high social and economic importance. Besides the direct affect of growing pollution, the uniqueness of the Sea of Marmara from oceanographical and geological point of view plays an important role for the social and economic structure of the area.

In other words, parasitic attack to the copepod, position, pollution dilemma, and productivity of the Sea of Marmara should be considered as a block.

High probability of a fatal attack to the zooplankton communities will affect directly to the biodiversity via food web and finally to the fishery of the area. The effect may grow or/and spread exponentially to the adjacent seas, because of the oceanographical and biological specialities of the Sea of Marmara and its connections trough Turkish straits. It can be imagined the Sea of Marmara as a biological corridor between two totally

Table 2 Date, Station Number, (**BC**) Beginning and (**EC**) Ending Coordinates of haul, Station Depth and (**HM**) Hauling Method (V; vertical, O; Oblique, H; horizontal)

Date	Station	BC	EC	Depth (m)	HM
09/08/2007	36	40° 31.967' **N**/026° 59.983' **E**	40° 31.900' **N**/026° 59.850' **E**	41	H
07/08/2007	40	40° 34.083' **N**/027° 14.850' **E**	40° 34.083' **N**/027° 14.850' **E**	1050	V
11/08/2008	40	40° 34.067' **N**/027° 14.817' **E**	40° 34.283' **N**/027° 14.767' **E**	1000	O
05/08/2009	17	40° 40.617' **N**/028° 33.933' **E**	40° 40.450' **N**/028° 34.500' **E**	427	O
06/08/2009	24	40° 31.883' **N**/027° 59.917' **E**	40° 31.883' **N**/027° 59.917' **E**	45	V
11/08/2009	40	40° 48.233' **N**/027° 27.550' **E**	40° 48.167' **N**/027° 27.433' **E**	1100	O
11/08/2010	17	40° 40.417' **N**/028° 33.100' **E**	40° 40.167' **N**/028° 32.283' **E**	455	O
06/08/2011	30	40° 21.900' **N**/027° 42.983' **E**	40° 21.833' **N**/027° 43.017' **E**	38	H
07/08/2011	40	40° 48.167' **N**/027° 26.500' **E**	40° 48.200' **N**/027° 25.500' **E**	800	O
07/08/2011	40	40° 48.183' **N**/027° 27.600' **E**	40° 47.733' **N**/027° 26.667' **E**	1000	O
07/08/2011	34	40° 54.233' **N**/027° 33.633' **E**	40° 54.233' **N**/027° 33.633' **E**	187	V
08/08/2011	35	40° 28.750' **N**/026° 59.533' **E**	40° 28.683' **N**/026° 59.483' **E**	55	H
22/07/2012	19	40° 56.600' **N**/028° 33.583' **E**	40° 56.600' **N**/028° 33.583' **E**	59	V
26/07/2012	3	40° 42.400' **N**/029° 04.350' **E**	40° 42.450' **N**/029° 04.967' **E**	1200	O
28/07/2012	26	40° 25.083' **N**/028° 02.967' **E**	40° 25.083' **N**/028° 02.967' **E**	44	V

different basins with different characteristics such as the Black Sea and the Mediterranean Sea.

Methods

Collection of material

Plankton samples were collected between years 2007 and 2012 by annual surveys as part of the MAREM (Marmara Environmental Monitoring) project. The details of hauls are given in Table 2 and the station locations are given in Fig. 2.

Plankton net with a 650 mm net diameter and of 0.180 mm mesh size were used as sampling gear. Two replicates were taken at each station. For the vertical haul, the net lowered to the maximum depth and hauled all the water column, for oblique hauls used closed nets with same sizes from the depth of thermocline layer

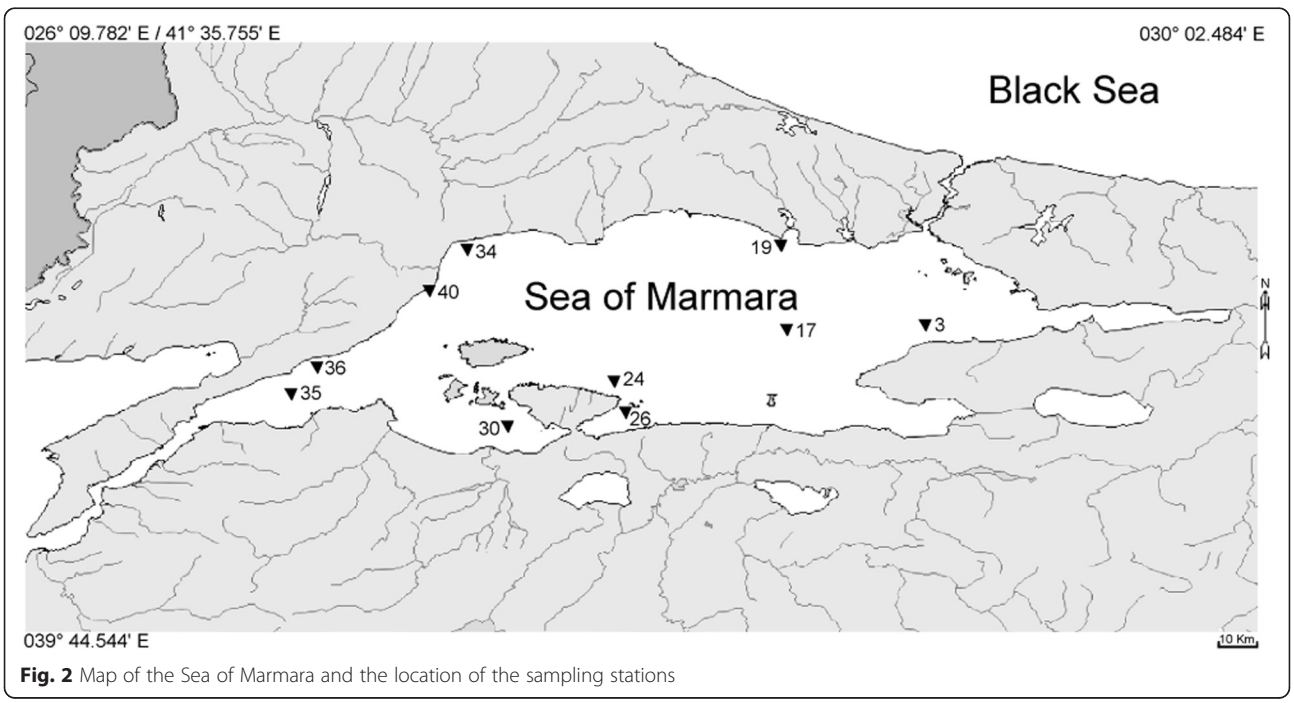

Fig. 2 Map of the Sea of Marmara and the location of the sampling stations

(average 25 m depth) and horizontal hauls were realized of 0.5 m depth, with 5 min duration.

Samples were preserved immediately after collection, in a 4 % solution of borax-buffered formaldehyde in seawater. After fixation, samples were precipitated by waiting; liquid level minimized material were rinsed and random sample replicas of ten pieces of each 1 cm^3 were picked up from each sample group. Infected and non-infected individuals for each 1 cm^3 replica were counted and the average percentages were calculated. Additionally 500 infected individuals of *A. clausi*; 500 infected individuals of *C. euxinus*; 500 infected individuals of *C. ponticus* were examined for the number of attached trophonts and for infesting point of *Ellobiopsis chattoni*. All samples are bar-coded and listed in MAREM database.

Species identification

Principal literature used for the identification of *Ellobiopsis chattoni* was from Caullery (1910) and Hovasse (1952). The biological characteristics of the copepoda were compared with the original descriptions. Subsequent, detailed descriptions of these species published by Boxshall & Halsey (2004) were also used for comparison.

Photographic documentation

Photographs of copepoda and parasites were captured using a DCM 500 digital camera mounted on an Olympus trinocular microscope, and prepared with HeliconFocus software.

Availability of supporting data

The data sets supporting the results of this article are available in the MAREM (Marmara Environmental Monitoring) database repository, http://prog.marem.org

Additional file

Additional file 1: Average long-term pH distribution/fluctuation of whole Sea of Marmara area incl. Turkish straits, during summer seasons, in depth basis between years 2005 and 2014. pH data sheet's between 2005 and 2014. (PDF 535 kb)

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