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First recording of the non-native species *Beroe ovata* Mayer 1912 in the Aegean Sea

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Abstract

A new alien species Beroe ovata Mayer 1912 was recorded in the Aegean Sea. It is most likely that this species spread on the currents from the Black Sea. Beroe ovata is also alien to the Black Sea, where it was introduced in ballast waters from the Atlantic coastal area of the northern America. The species is established in the Black Sea and has decreased the population of another invader Mnemiopsis leidyi, which has favoured the recovery of the Black Sea ecosystem.

We compare a new 1 species with the native species fam. Beroidae from the Mediterranean and predict its role in the ecosystem of the Aegean Sea using the Black Sea experience.

Keywords: *Beroe ovata;* Non-native species; Aegean Sea; Black Sea; Ecosystem.

Introduction

During second part of 20th century the Mediterranean Sea became a recipient area for a great number of alien species, which comprised more than 46% of the total number of non-native species in all European seas (GOLLASH, 2004). The Black Sea is one of the sources of alien species for the Mediterranean Sea. Some the most euryhaline invasive species, which arrived and established themselves in the Black Sea, spread on the currents into the Aegean Sea via the Bosphorus strait, the Sea of Marmara and the Dardanelles strait. Most of them occur regularly in the Aegean Sea areas influenced by Black Sea waters (SHIGANOVA, 2006).

One such species of the genus *Beroe* was introduced into the Black Sea in 1997, spread around the entire Black Sea and created its own reproductive population in 1999 (KONSULOV & KAMBURSKAYA, 1998; SHIGANOVA *et al.,* 2000a;

VINOGRADOV *et al.,* 2000, FINENKO *et al.,* 2000). Later on this species was identified as *Beroe ovata* Mayer, 1912 (SERAVIN *et al.,* 2002).

Here we discuss the identification of the individuals of the genus *Beroe* collected in the Aegean Sea, as well as the origin of individuals and their possible role in the Aegean ecosystem.

Material and Methods

Sampling of ctenophores has been conducted in several gulfs and the offshore waters of the Aegean Sea since 1990. Samples were collected with WP3 (500 mm) and WP2 (200 mm) nets as well as by diving (SHIGANOVA *et al.,* 2001). In November 2004, ctenophores were collected by scuba diving by one of the authors (E.Christou) in the northern Evvoikos Gulf of the Aegean Sea (Fig.1), for experimental studies.

In the Black Sea, ctenophore samples have been collected since 1988 with a Bogorov-Rass net (square net opening of 1 m^2, mesh size 500 mm) by vertical hauls from thermocline to surface and from the boundary of anoxic layer to the surface in the offshore areas, and from the bottom to the surface in the shallow areas (SHIGANOVA, 1997).

Results and Discussion

The ctenophore specimens collected in the northern Evvoikos Gulf during November 2004 belonged to *Mnemiopsis*

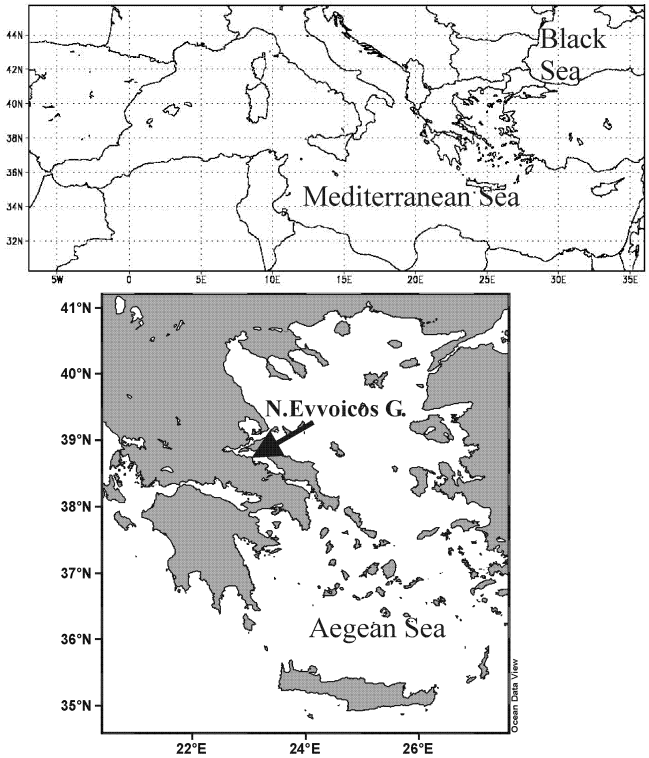

Fig. 1: Location of finding individuals of *Beroe ovata* in the Evvoikos Gulf of the Aegean Sea.

leidyi, except for two individuals, identified as *Beroe* sp. A detailed study of these specimens' morphology and their comparison with native Beroidae species from the Mediterranean and Black Sea has been performed in order to validate identification of species.

The body of *Beroe* species is miter-shaped, egg-shaped or conical. The mouth opening is wide and the ectodermal portion of the stomach (stomodeum) is voluminous. The polar-plate surrounding the sense organ at the aboral pole is fringed with a row of branched papillae. There are ciliated areas upon the walls of the stomodeum near the mouth to bite off piecesof their prey, and a wide-flaring mouth, which enables the animal to catch entire prey (Chun, 1880). There are 8 meridional canals and 2 paragastral canals (MAYER, 1912; MIANZAN, 1999) (Fig. 2). These ctenophores are generally pink in color; the largest adults are colored more strongly with a brown tinge.

Two native species of fam.Beroidae inhabit the Mediterranean Sea, according to identification by C. Chun: *Beroe ovata* Brown 1756 and *Beroe forskalii* Chun (CHUN, 1880; TREGOUBOFF & ROSE, 1957) (Fig. 3). Both species are widely distributed in the Mediterranean, in the eastern and western areas and in the Adriatic Sea (TREGOUBOFF & ROSE, 1957). *Beroe ovata* was also recorded in the Sea of Marmara near the Dardanelles strait in 1992 (SHIGANOVA *et al.,* 1994). Given that the fauna of the Aegean Sea is of Mediterranean origin (FURNESTIN, 1979), one would expect that the individuals of Beroe collected in the Evvoikos Gulf (Aegean Sea) should be attributed to the species inhabiting the Mediterranean Sea, *Beroe ovata* and *Beroe forskalii.* Nevertheless an introduction of *Beroe ovata* into the

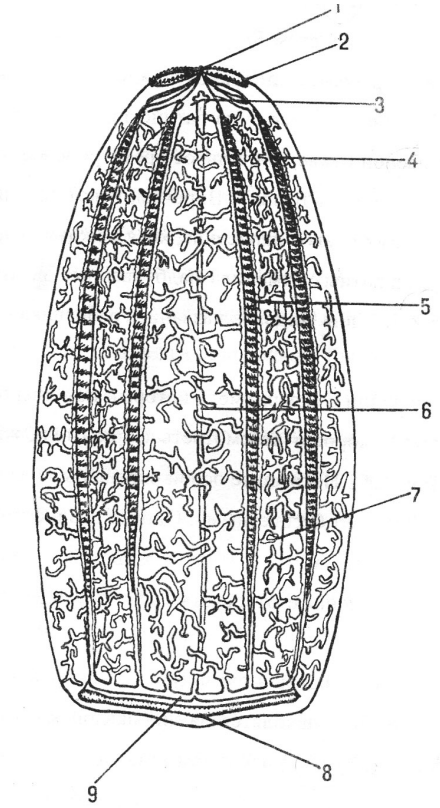

Fig. 2: Morphology of *Beroe cucumis* (after Mayer,1912) 1- aboral organ; 2- polar plate; 3-ifundibulum; 4-subsagital comb row; 5- subtentacular comb row; 6- paragastric canal;7-diverticul; 8-mouth; 9-labial canal.

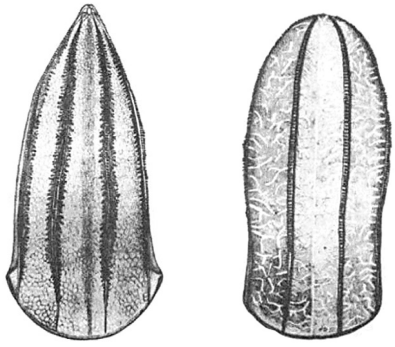

Fig. 3: Representatives of Beroidae in the Mediterranean (After Chun (1880) and Tregouboff & Rose, 1957) *Beroe ovata* Brown 1756 (right) and - *Beroe forskalii* (left) Chun.

Table 1
Length / width ratio (mm) of *Beroe ovata* from the Black Sea.

Length (mm)	Width (mm)	Numbers	Ratio L/W
18-20	16,5-18	2	1,09 ± 0,02
30-40	28-32	2	1,1 ± 0,009
42-50	32-45	5	1,00 ± 0,4
51-60	48-51	9	1,15 ± 0,09
61-70	46-65	12	1,10 ± 0,1
71-78	52-68	8	1,17 ± 0,09
82-90	70-79	10	1,28 ± 0,15
99-100	72-85	3	1,28 ± 0,08
102-110	81-94	5	1,29 ± 0,1
120-121	90-103	2	1,25 ± 0,11
Total average			1,18 ± 0,1

Table 2
Ratio length and width (mm) of *Beroe ovata* from the Aegean Sea.

Length (mm)	Width (mm)	Numbers	Ratio L/W
83	75	1	1,04
89	80	2	1,17
Total average			1,1 ± 0,01

Table 3
Ratio length and width (mm) of *Beroe ovata* from the Mediterranean.

Length (mm)	Width (mm)	Numbers	Ratio L/W
92	43	1	2,14
32	15	1	2,13
93	42	1	2,21
Total average			2,16 ± 0,045

Aegean Sea from the Black Sea cannot be excluded, as happened with *M.leidyi* (SHIGANOVA *et al.,* 2001).

Beroe forskalii Chun 1880 has a very distinct difference from *B. ovata* and *Beroe cucumis* – its aboral end is pointed, when viewed in the stomodaeal plane the body has aconical shape (Fig. 3). Therefore the collected individuals were compared only with the native individuals of *B. ovata* collected in the Mediterranean Sea before 2000 and with those collected in the Black Sea. Measurements of their length, width and ratio made from the pictures of different authors and from living specimens from the Black and Mediterranean Seas (Tables 1-3) allowed us to conclude that there are two groups of *Beroe* sp., according to their ratio of length to width.

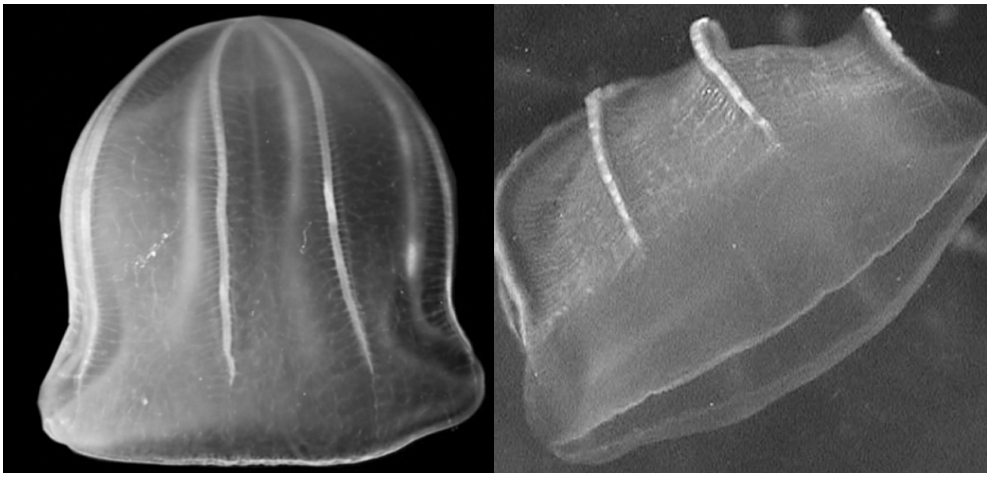

Fig. 4: *Beroe ovata* from the Black Sea (Photo: T.A. SHIGANOVA).

Individuals of a new non-native species *B. ovata* from the Black Sea have a ratio of length to width *(l/w)* 1.18 ± 0.1 (Table 1). In addition it was found while studying living Black Sea *Beroe ovata* that both sides of the lateral tubes (devirticuluses) of the meridional canals anostomose (connect) with each other and with paragastral canals. Paragastral canals do not have their own devirticuluses. The body was extremely flattened in the paragastral plane (the large diameter of the ellipse is 3-4 fold greater than the small diameter) (Fig. 4). All these features are characteristic of *Beroe ovata* (MAYER, 1912; MIANZAN, 1999). The size of large specimens in the Black Sea is from 81 to a maximum of 162 mm with mean 60-80 mm (SHIGANOVA *et al.,* 2000a). Young specimens are wider at the oral and aboral ends of the body (Table 1).

Native individuals of *Beroe ovata* from Mediterranean Sea (Fig. 5), described by Chun, have a distinct difference from *B.ovata* found in the Black Sea. This ctenophore has ratio of length to width *(l/w)* 2.16 ± 0.045 (Table 3) and an egg-shaped body; its lateral tubes of meridional canals do not anostomose with each other and do not connect with paragastral canals. The body is less flattened in the paragastral plane (the large diameter of the ellipse is twice greater than the small diameter). These features are not characteristic of *Beroe ovata* but of *Beroe cucumis* (MAYER,1912). Therefore we can hypothesize that the Mediterranean *Beroe ovata* is not a valid species, but that it is *Beroe cf. cucumis*. This hypothesis was mentioned by L. SERAVIN *et al.,* (2002) and R. HARBINSON (pers. communication).

The specimens collected in the Evvoikos Gulf had a ratio $l/w = 1.1 \pm 0.01$ (Fig. 6; Table 2), their meridional canals were interconnected by numerous diverticulae and with anostomoses form a wide network; their body was very flattened in the paragastral plane. Therefore, this species displays similar characteristics to the individuals of *Beroe ovata* found in the Black Sea and should be identified as *Beroe ovata* Mayer 1912. In addition these individuals were found in November, at the end of the seasonal development of

Beroe ovata in the Black Sea (SHIGANOVA *et al.,* 2003) and therefore they could penetrate into the Aegean Sea from the Black Sea on the currents.

Though the morphology of the two species is quite distinct, a genetic analysis of the species found in the Mediterranean and Black Sea regions could clarify any uncertainties.

Role of a new invader *Beroe ovata* in the Black and Aegean Sea ecosystems.

Species of Beroidae are specialized predators on zooplanktivorous ctenophores and occasionally on salps (L. AGASSIZ, 1860). Based on the studies performed from 1999-2006 on the distribution pattern of *Beroe ovata* in the Black Sea, we may consider that this species is established in the Black Sea, has created reproductive populations and has a specific seasonal pattern to its development in the Black Sea. The first specimens appear in mid- or late August or early September; reproduction takes place during late August, September and October and rapidly inflates the population; later in November, reproduction decreases. The rate of reproduction decrease depends on the availability of prey (*M.leidyi*). Large mature specimens die after reproduction, while a small fraction of the population, composed of specimens of a new generation, is believed to descend to near-bottom horizons in late November – December and spend time in torpor until the next burst of *M. leidyi* (SHIGANOVA *et al.,* 2003, 2004). Such behavior is specific to representatives of Beroe from other regions (SIFERD & CONOVER, 1992; FALKENHAUG, 1996). Within seven years, *B. ovata* was not found in the pelagic Black Sea in winter, spring, or summer before August, although single specimens were sporadically seen in the shelf zone in spring (SHIGANOVA *et al.,* 2004a).

Fig. 5: "*Beroe ovata*" from Mediterranean Sea (Photo: FABIEN NOMBA).

The appearance of *Beroe ovata* in the Black Sea was a positive event because it is a specialized predator on another invader *Mnemiopsis leidyi,* which had had dramatic effect on the Black Sea ecosystem as a predator on zooplankton, fish eggs and larvae. One of the factors that provoked the enormous bloom of *M. leidyi* in the Black Sea, never observed in its natural estuarial waters of North America, was the absence of a predator controlling its population

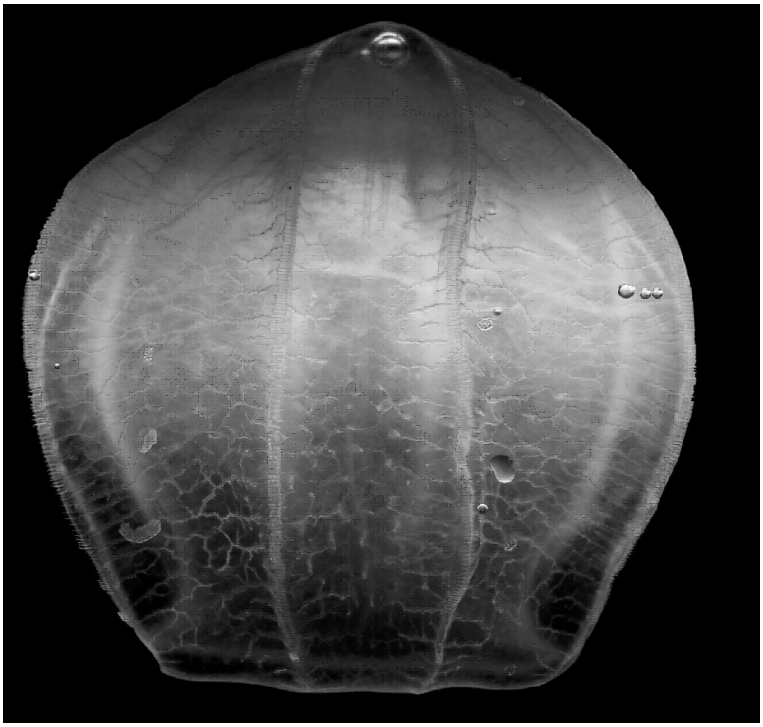

Fig. 6: *Beroe ovata* from the Aegean Sea (Photo: E. CHRISTOU).

size, since in their native area they occur as a feedback of prey and predator (PURCELL *et al.,* 2001).

After the development of *B.ovata* the Black Sea ecosystem has begun to recover, relieved from the pressure of *M.leidyi* for most of the year. But in some warm years during the seasonal absence of *B. ovata, M. leidyi* could still reconstitute high biomass, considerably affecting the pelagic ecosystem. Even in this case, however, the duration of its influence remained limited to 1-2 months when compared to 8-9 months before the appearance of B. ovata (SHIGANOVA *et al.,* 2003, 2004). Regarding its presence in the Sea of Marmara, up to 0, 3 ind.m^{-3} were found in 2001, resulting in a decrease of the *M.leidyi* population there (ISINIBILIR *et al.,* 2004). Since then, *B.ovata* has been observed regularly in this area (ISINIBILIR PERS. COM.).

In future *Beroe ovata* will probably continue its penetration into the Aegean Sea through the Black Sea current from August to November, the period of its seasonal development in the Black Sea. It can live and reproduce in conditions of prey *(M.leidyi)* availability; one of the *B.ovata* specimens collected in the Evvoikos Gulf had *M.leidyi* in its gastrovascular cavity (Fig. 7). *M.leidyi* does not create large populations in the Aegean Sea, and does not spread around the entire Aegean Sea due to low concentrations of zooplankton in these oligothropic conditions (SHIGANOVA *et al.,* 2001). Therefore Beroe ovata will probably follow the same distribution pat-

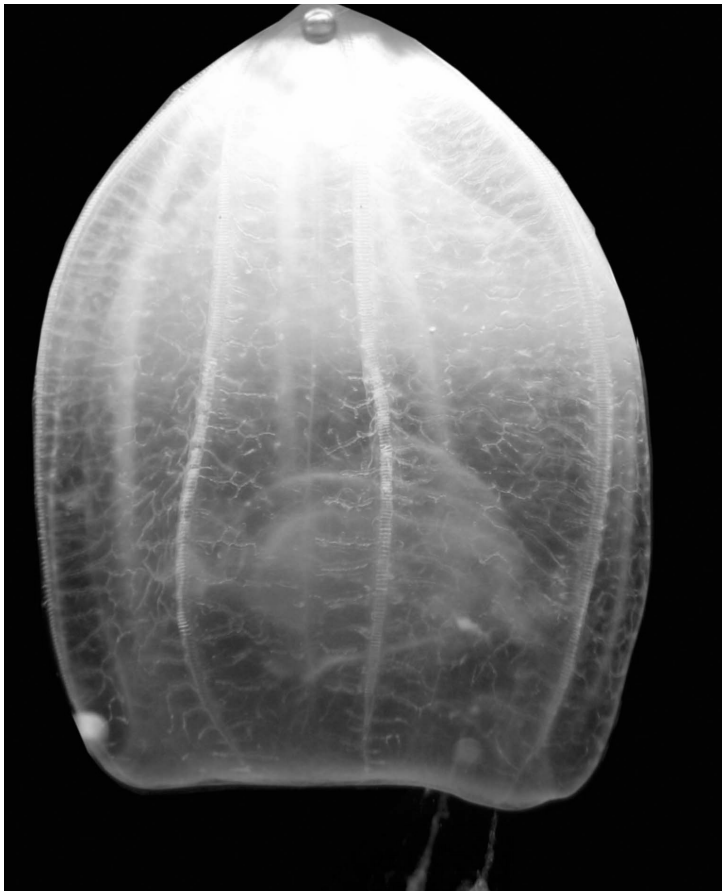

Fig. 7: *Beroe ovata* with *Mnemiopsis leidyi* in gastrovascular cavinity in the Aegean Sea water (Photo: E. CHRISTOU).

tern in the Aegean Sea as *M.leidyi.* More information is needed based on regular surveys in the area.

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