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Short Communication: First record of the non-native species *Beroe ovata* Mayer 1912 (Ctenophora: Nuda) in the Caspian Sea

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Introduction

During the late 1980s, carnivorous ctenophore *Mnemiopsis leidyi*, along with the other invaders, had been transported to the Black Sea from the coasts of eastern Atlantic, which resulted in ecosystem damage for the region (Vinogradov *et al*., 1989; Kideys, 2002a; Ghabooli *et al*., 2011). One of the major factors, resulted in the rapid expansion of the *M. leidyi* population during its initial invasion into the Black Sea, was the absence of a specialised predator (Kideys and Shiganova, 2001; Kideys *et al*., 2004a, 2004b, 2005, 2008; Roohi *et al*., 2008). The Black Sea, besides being a recipient area, also serves as a donor area for some invasive species that then spread further to the Sea of Azov, the Sea of Marmara, and the eastern Mediterranean Sea and, in some cases, to the Caspian Sea (Shiganova, 2010).

To evaluate the suitability of *Beroe ovata* as a solution to stop aggressive action of the *Mnemiopsi*s in the Caspian Sea (Ivanov *et al*., 2000), an international research team had performed extensive laboratory experiments, transporting *Beroe ovata* from the Black Sea in Caspian water salinity conditions and utilising Caspian sourced *M. leidyi* as a food (Kideys *et*

al., 2004b; Finenko *et al*., 2006; Finenko *et al*., 2011). Following obtained positive results and in response to concurring ecosystem disaster in the Caspian Sea, a group of experts were supported by the International Commission of Caspian Sea Environmental Programme (CEP), proposed the introduction of *Beroe ovata* as the potential predator for *Mnemiopsis leidyi* (Kideys, 2002a, 2004b). This document was submitted to autorities of the Caspian countries through CEP, however, this proposal could not formally implemented. However, this species appeared in the southern Caspian Sea for the first time in November 2019. Upon observation of a "comb jelly differing from *Mnemiopsis leidyi*" by one of the authors of this paper (Dr Seyed Mohammadvahid Farabi) on 12th November 2019, a research cruise was organized to the same sampling area the following day. For *Beroe ovata* study, the ctenophores were grouped according to 5 mm length intervals up to 35 mm maximum length to determine the abundance of different size groups according to (Kideys and Shiganova, 2001). The purpose of this study was to report primarily the first apperance of *Beroe ovata* in the Caspian Sea and to evaluate the importance and possible consequences of this new introduction.

Materials and methods

Ctenophore specimens (only *Beroe ovata* since *Mnemiopsis leidyi* was absent) were collected at one station in the southern Caspian Sea off Royan town, Mazandaran, Iran on 13th November 2019. The sampling area was located near an aquaculture site containing fish cages for producing rainbow trout (*Oncorhynchus mykiss*) production. Sampling station depth was 30 m. Sea surface temperature at the sampling station was 20-22^{o}C with salinity of 12.2‰ denoting normal seasonal Caspian Sea water characteristics for the area.

A plankton net (net diameter of 50 cm, mesh size of 500 µm) was used for vertical hauls from three water column layers (15-30 m, 5-15 m and 5 m up to the surface). Individual body lengths of *B. ovata* specimens were determined using a ruler under a transparent petri dish aboard the vessel. Additionally, one horizontal tow was performed from the sampling area to obtain further *B. ovata* specimens for behavioral observations and photographic purposes.

Results and Discusion

Ctenophores were collected at the different depths, included only *B.ovata* specimens without any specimen of *Mnemiopsis leidyi* (Fig. 1).

Vertical tows sampling found 58 *B. ovata* specimens in three water layers. Given that the surface area of the plankton net is about 0.2 m^2, the calculated density of ctenophores per unit area amounts to 290 ind./m^2.

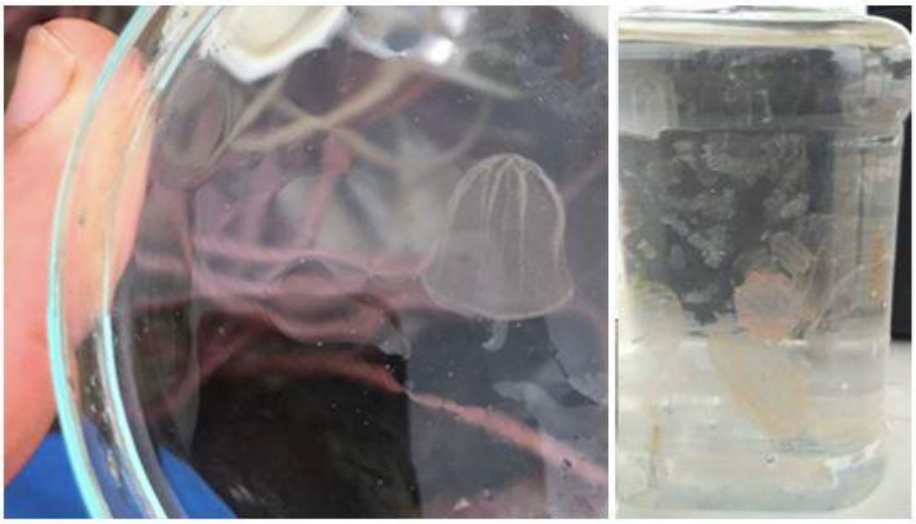

Figure 1: The ctenophore *B. ovata* from a horizontal tow in the southern Caspian Sea on 13th November 2019. Left: 15 mm long specimen in a petridish, Right: Aggregation of different sized *B.ovata* from 5 mm up to 35 mm in a glass jar (Photographs by Aboulghasem Roohi, taken aboard vessel).

Overall density per unit volume equals approximately 9.7 ind./m^3 for 30 m layer. Distribution of length frequency for five size groups of *B. ovata* is shown in Table 1. It is apparent that smaller-sized specimens (larvae and juvenile stages) dominated the population: 60% of specimens were <5 mm and 26% were between 6-10 mm. An average individual length of *B. ovata* from this subsample calculated as approximately 8 mm. The maximum length of the *B. ovata* was 35 mm (Table 1).

In the Caspian Sea, prior to the arrival of *Mnemiopsis leidyi* in the late 1990s, no other ctenophore species was reported (Kosarev and Yablonskaya, 1994). Impact of *M. leidyi* on mesozooplankton in the Caspian Sea was very pronounced. After explosion of *M. leidyi* population in early the 2000s, the number of species and abundance of mesozooplankton sharply decreased.

Table 1: Abundances (individuals per towing) and percentages of different size groups of *B. ovata* found in the vertical sampling at the station off Royan, Mazandaran (Iran) on the southern Caspian Sea coast on 13th November 2019 (All three vertical tows from the same station were combined).

Length of inidividuals (mm)	Ind./tow	%
<5	35	60
6-10	15	26
11-15	4	7
20-25	1	5
30-35	3	2
Total	58	100

Number of copepods species decreased from 7 to 3 and that of cladocerans from 24 to 1-2 in the period of 1996-2006 and in 2013 (Roohi *et al*., 2008, 2016). Mesozooplankton abundances in the southern Caspian decreased by an order of magnitude in the 2001-2002, after the *M. leidyi* invasion, compared to 1994-1996 (Kideys *et al*., 2008). Iranian catches of kilka, the most abundant and widespreaded zooplanktivorous fish species in the region, decreased

significantly in the Southern Caspian Sea after 1999. Iranian landings of kilka dropped by 70% from an average of 69.070±20.270 tonnes during 1995–2000 to 23.430±12.240 tonnes during 2001–2006, resulting in a loss of at least 125 million US dollars of income (Kideys *et al*., 2005; Fazli *et al*., 2017; Roohi *et al*., 2008, 2010, 2013).

Several studies have been shown that *B. ovata* feeds almost exclusively on *M. leidyi* and to a lesser extent on the other ctenophore *P. pileus* in the Black Sea (Kideys *et al*., 2004b). Kideys *et al.* (2004b) calculated the mean daily ration on *M. leidyi* as 45 % of *B. ovata* wet weight. Because of the positive impact of *B. ovata* in the Black Sea, some riparian countries of the Caspian Sea started to support further studies to examine feasibility as well as possible risks of the intentional introduction of the predatory ctenophore *B.ovata* as a control agent against the invasive ctenophore *M. leidyi* (Kideys, 2004b).

To assess the possibility of *B. ovata* establishment in the Caspian Sea, the survival and some physiological characteristics (feeding, respiration, reproduction and growth) of this predatory ctenophore were studied in Caspian Sea (salinity 12.6‰) conditions using animals, transported from the Black Sea (salinity 18‰) and Marmara Sea (salinity 22‰) to a laboratory, located on the Iranian Caspian coast in 2002 (Kideys *et al*., 2004a, 2004b; Finenko *et al*., 2006; Rowshantabari *et al*., 2012). The results of these studies demonstrated that the low salinity in the Caspian Sea is a major obstacle, which could be overcomed by gradual adaptation. *Beroe ovata* from Marmara and the Black Seas swam actively and feed on Caspian *M. leidyi* specimens, following each step of acclimation. The daily feeding rate of *B. ovata,* preying on Caspian *M. leidyi*, ranged between 26% and 43% of its body wet weight and was higher for smaller individuals (Kideys *et al*., 2004a). The conclusion from the adaptation experiments was that *B. ovata* individuals would be able to adapt well to survive and reproduce in Caspian Sea water. However, rearing of larvae was problematic in laboratory conditions and hence further experiments are needed to identify favorable conditions for egg development and larval growth. Based on the physiological experiments, published by Kideys *et al*. (2004a), it was suggested that once established in the Caspian Sea, *Beroe ovata* would be able to supress *Mnemiopsis leidyi* abundance sharply, with positive cascading effects all along ecosystem components.

The meachanism and route of introduction of *B. ovata* to the Caspian Sea is not known, but it could be either shipping through the Volga-Don channel between the Black Sea and the Caspian (as in the case of *M. leidyi*) or intentional. Because of the severe impact, especially on fishery, it cannot be excluded that some concerned parties deliberately transported *Beroe ovata* from the Black Sea to the Caspian Sea.

Sampling, performed in this study on November 13th 2019, demonstrated that an average (8 mm) and maximum (35 mm) sizes of *Beroe ovata* from the

southern Caspian were in general lower than those of individuals, caught in the Black Sea. Finenko *et al*. (2006) observed that in three consecutive years from 1999 to 2001, *B. ovata* was found only during the summer season, with body lengths ranging from <10 mm to 120 mm in Sevastopol Bay, in the northern Black Sea. In late September 1999, when *B. ovata* was first observed in Sevastopol Bay, the population consisted of animals measuring from <10 mm to 110 mm in length, whilst specimens of 10–50 mm size dominated (54%). In September 2000 *Beroe* juveniles of <10 mm prevailed, whilst in October–November specimens of 10–50 mm dominated the population (97% and 70%, respectively). In August 2001, 90% of the population consisted of individuals of <10 mm, most of which reached sizes as large as 10–30 mm by September of that year. It is worth to note that the average and maximum sizes of *M. leidyi* from the Caspian Sea were much less than observed in the Black Sea populations. Monthly sampling in 2001-2006, indicates that 88% of *M. leidyi* specimens belonged to the 2-5 mm group, with a maximum length of single individuals up to 70 mm (Roohi *et al*., 2008). However, Mutlu (1999) found that in 1992-1995 in the southern Black Sea average lengths of *Mnemiopsis leidyi* varied between 26 mm and 45 mm, with a maximum of 115 mm.

Beroe ovata was found to be present in the plankton of the northern Black Sea, generally during 3-4 months (Finenko *et al*., 2003; Shiganova *et al*., 2014), when its main prey *Mnemiopsis leidyi* is most abundant. The abundance of *Beroe* were consistent with maximum values, occurring one or two weeks after its prey (i.e. *Mnemiopsis leidyi*) attained highest levels to sustain population development). In Sevastopol Bay, *B. ovata* reached a maximum concentration of 140 ind./m^2 during 4 years of monitoring, which is lower than the 290 ind./m^2 value found in this study. A more regular sampling periodicity would better indicate the maximum and minimum levels of *B. ovata* abundance in the southern Caspian Sea, in order to evaluate an impact of this predatory ctenophore on its prey, *M. leidyi*. However, an absence of any *Mnemiopsis leidyi* specimens in our study looks very remarkable, though not unexpected in presence of high amount of its predator *B. ovata*. This observation, received for the first time, is a good indicator, that demonstrate the presumed effectiveness of *B. ovata* in control of *M. leidyi* population in the Caspian Sea.

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References

Fazli, H., Ghanghermeh, A.A. and Shahifar, R., 2017. Analysis of landings and environmental variables time series from the Caspian Sea. *Environmental Resources Research*

5, 1-11. 10.22069/IJERR.2017.12124.1180

Finenko, G.A., Romanova, Z.A., Abolmasova, G.I., Anninsky, B.E., Svetlichny, L.S., Hubareva, E.S., Bat, L. and Kideys, A.E., 2003. Population dynamics, Ingestion, growth and reproduction rates of the alien Beroe ovata and its iInpact on the plankton community in Sevastopol Bay (the Black Sea). J *Plankton Research,* 25, 539-549. DOI: 10.3354/meps314171

Finenko, G., Kideys, A.E., Anninsky, B.E., Shiganova, T.A., Roohi, A., Rowshantabari, M. and Rostami, H., 2006. Invasive ctenophore *Mnemiopsis leidyi* in the Caspian Sea: feeding, respiration, reproduction and the predatory impact on zooplankton community. *Marine Ecology Progress Series* 314,171-185. DOI: 10.3354/meps314171

Finenko, G., Arashkevitch, E. G., Kideys, A. E., Roohi, A., Mirzajani, A., Bagheri , S., Birinci, Z., Ustun, F., Satilmis, H., Sahin, F. and Bat, L., 2011. Reproduction characteristics and growth rate of ctenophore *Beroe ovata* larvae in the Caspian and Black sea waters. *Marine Ecological Journal* 10, 77-85. https://d1wqtxts1xzle7.cloudfront.net/83732434

Ghabooli, S., Shiganova, T. A., Zhan, G., Cristescu, M.E., Eghtesadi-Araghi, P. and MacIsaac, H.J., 2011. "Multiple introductions and invasion pathways for the invasive ctenophore Mnemiopsis leidyi in Eurasia." *Biological Invasions*, 13(**3**), 679-690. DOI:10.1007/s10530-010-9859-8

Ivanov, P.I., Kamakim, A.M., Ushivtzev, V.B., Shiganova, T., Zhukova, O., Aladin, N., Wilson, S.I., Harbison, G.R. and Dumont, H.J., 2000. Invasion of Caspian Sea by the comb jellyfish *Mnemiopsis leidyi* (Ctenophora). *Biological Invasions* 2, 255–258. DOI:10.1023/A:1010098624728

Kideys, A.E. and Shiganova, A.T., 2001. Methodology for the *Mnemiopsis* in the Caspian Sea, A Report Prepared for the Caspian Environment Program, Baku, Azerbaijan inDecember-2001. https://www.caspianenvironment.org/mnemiopsis/mnemmenu5.htm.

Kideys, A.E., 2002a. Fall and rise of the Black Sea ecosystem. *Science* 297, 1482–1484.

Kideys, A.E., Finenko, G.A., Anninsky, B., Shiganova, T.A., Roohi, A., Rowshantabari, M., Yousefyan, M. and Rostemian, M.T., 2004a. Feeding, respiration and growth of ctenophore *Beroe* cf *ovata* in the low salinity conditions of the Caspian Sea. In: Aquatic invasions in the Black, Caspian and Mediterranean Seas, H. Dumont, T. Shiganova and U. Niermann (Eds), Kluwer Academic Publishers, Dordrecht, The Netherlands, 193-199.

Kideys, A.E., Finenko, G., Anninsky, B., Shiganova, T., Roohi, A., Rowshantabari, M., Yousefyan, M., Rostamian, M.T. and

Negarestan, H., 2004b. Physiological characteristics of the ctenophore *Beroe ovata* in the Caspian Sea water. *Marine Ecology Progress Series* 266, 111-121. DOI:10.3354/MEPS266111

Kideys, A.E., Roohi, A., Bagheri, S., Finenko, G. and Kamburska, L., 2005. Impacts of invasive ctenophores on the fisheries of the Black Sea and Caspian Sea. *Oceanography-Black Sea Special Issue* 18, 76-85. DOI:10.5670/oceanog.2005.43

Kideys, A.E, Roohi, A., Eker Develi, E, Melin, F. and Beare, D., 2008. Increased chlorophyll levels in the southern Caspian Sea following an invasion of jellyfish. International Journal of Ecology, Article ID 185642, 4 P. DOI:10.1155/2008/185642.

Kosarev, A.N. and Yablonskaya, E.A., 1994. The Caspian Sea. SPB Academic, Amsterdam, the Netherlands.

Mutlu, E., 1999. Distribution and abundance of ctenophores, and their zooplankton food in the Black Sea. II. *Mnemiopsis leidyi*. *Marine Biology,* 135, 603–613.

Roohi, A., Zulfigar, Y., Kideys, A., Aileen, T., Eker-Develi, E. and Ganjian, A., 2008. Impact of a new invasive ctenophore (*Mnemiopsis leidyi*) on the zooplankton community of the southern Caspian sea. *Marine Ecol*ogy, 29, 421–434. DOI:10.1111/j.1439-0485.2008.00254.x

Roohi, A., Kideys, A.E., Sajjadi, A., Hashemian, A., Pourgholam, R., Fazli, H., Ganjian Khanari, A. and EkerDeveli, E., 2010. Changes in biodiversity of phytoplankton, zooplankton, fishes and macrobenthos in the southern Caspian Sea after the invasion of the ctenophore *Mnemiopsis leidyi*. *Biological Invasions,* 12, 2343–2361. DOI:10.1007/s10530-009-9648-4

Roohi, A., Pourgholam, R., Ganjian Khenari, A., Kideys, A.E., Sajjadi, A. and Kalantari, R.A., 2013. Factors influencing the invasion of the alien ctenophore *Mnemiopsis leidyi* development in the southern Caspian Sea. *ECOPERSIA (International Journal of Natural Resources and Marine Sciences, IJNRMS)* 1, 299-313. http://ecopersia.modares.ac.ir/article-24-3968-en.html

Roohi, A., Rowshantabari, M., Naderi Jolodar, M. and Sajjadi, A., 2016. The effect of the ctenophore *Mnemiopsis leidyi* (Ctenophora: Lobata) on the population density and species composition of mesoplankton in inshore waters of the Caspian Sea. *Ecology and Evolutionary Biology* 1, 29-34. DOI: 10.11648/j.eeb.20160102.14

Rowshantabari, M., Finenko, G.A., Kideys, A.E. and Kiabi, B., 2012. Effect of temperature on clearance rate, daily ration and digestion time of *Mnemiopsis leidyi* from the southern Caspian Sea. *Caspian Journal of Environmental Sciences*,

10, 157-167. http://research.guilan.ac.ir/cjes

Shiganova, T., 2010. Biotic Homogenization of Inland Seas of the Ponto-Caspian. *Annual Review of Ecology, Evolution and Systematic*, 41, 103-126. DOI:10.1146/annurev.ecolsys.110308.120148

Shiganova, T.A., Legendre, L., Kazmin, A.S. and Nival, P., 2014. Interactions between invasive ctenophores in the Black Sea: assessment of control mechanisms based on long-term observations. *Marine Ecology Progress Series*, 507, 111–123 2014. DOI: 10.3354/meps10806

Vinogradov, M.E., Shushkina, E.A., Musaeva, I.A. and Sorokin, P.Y., 1989. Ctenophore *Mnemiopsis leidyi* (*A. agassiz*) (ctenophora: lobata) – new settlers in the Black Sea. *Oceanology*, 29, 293–298.