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ORIGINAL PAPERS

DISTRIBUTION AND ABUNDANCE OF THE MACROZOOPLANKTON COMUNITY IN THE BLACK SEA IN 2021

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Abstract. *This paper focuses on the dynamics of four jellyfish species, Aurelia aurita, Beroe ovata, Mnemiopsis leidyi and Pleurobrachia pileus, from the Black Sea. The samples were taken in time of two expeditions in 2021 (May-June and August-September). Aurelia aurita species was dominant in terms of biomass due to its large size, The density of the species Pleurobrachia pileus recorded high values, in the north, but also between the isobaths of 40-80 m. The density of the species Mnemiopsis leidyi was higher in the southern and central area of the Romanian Black Sea. Because jellyfish feed on zooplankton organisms, the eggs and larvae of commercially important fish, high densities of jellyfish can produce direct decreases in the trophic chain by reducing the biomass of zooplankton, and fish eggs and larvae.*

Keywords: Macrozooplankton, Romanian Black Sea, ctenophores, biomass, distribution.

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1.Introduction

The Black Sea has been exposed to a series of stress factors, thus characterizing it as an ecosystem that responds quickly to environmental changes [1]. Among these stressors, overexploitation of marine resources, nutrient input and the impact of eutrophication have been studied to see their impact on the marine environment [1]. A classic example of adverse effects on the ecosystem is the invasion of the ctenophore *Mnemiopsis leidyi* (A. Agassiz, 1865), in the Azov and Black seas in the early 1980s [2]. Introduced by ballast water from the North Atlantic coast, *M. leidyi* became a species whose impact on the Black Sea in the early 1990s was superimposed on the effects of eutrophication, overfishing, environmental damage, the destructive effect of the marine environment appearing quickly [3]. The high abundances of the species *M. leidyi* contributed to the decrease of zooplankton biomass and fish stocks [3, 4, 5].

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The evolution of the Black Sea ecosystem has been divided into several stages, depending on the critical anthropogenic impact (e.g., eutrophication, biological invasions, overfishing).

- clean period, in which *Rhizostoma pulmo* (Macri, 1778), predominated (1960s-70s) [3];
- period of *Aurelia aurita* (Linnaeus, 1758), expansion (1970-1980) [3];
- period recognized as the "*Mnemiopsis* era" (late 1980s-90s) [3];
- the period after 1997, when a new ctenophore for the Black Sea ecosystem, *Beroe ovata* (Bruguière, 1789), was reported for the first time [3].

The reduction of the nutrient supply and the introduction of the *B. ovata* species contributed to the control of the *M. leidyi* species' impact on the marine environment, being considered a recovery period for the Black Sea ecosystem [6, 7, 8]. The evolution of the Black Sea ecosystem is evident from the 1960s to present, with increased nutrient loads from northern waters, especially from the Danube [1]. In the 2000s, signs of a restoration of the Black Sea ecosystem [6, 7, 8] by increasing the abundant diversity and dynamics of the Black Sea zooplankton was reported, which can be interpreted as result of the consumption of the ctenophore *M. leidyi* by *B. ovata*, [6, 7, 8].

Mutlu and Bingel (1999) studied the dynamics of *A. aurita, M. leidyi and Pleurobrachia pileus* (O. F. Müller, 1776) species and their zooplankton food source in the southern Black Sea during 1991–1995 [1, 9]. Following these studies, *P. pileus* biomass doubled from 1990 to 1993 [1]. Kideys and Romanova (2001) studied the spatial and temporal distributions of *A. aurita, M. leidyi and P. pileus* during 1996-1999 and noted for the first time the presence of *B. ovata* with a biomass of 12g m^2 in the southern region during September 1999 [1].

In order to determine the state of macrozooplanktonic populations, two expeditions were made in 2021. The first expedition was carried out with the research vessel "Steaua de Mare 1" between May and June. The maximum depth of the sampling areas on the Romanian Black Sea continental shelf was up to 60 m bathymetric line. The second expedition was carried out between August and September with the research vessel "Mare Nigrum", having a more extensive distribution for the sampling stations, up to the bathymetric line of 1580 m. The species identified in the two expeditions were: scyphozoan *A. aurita*, ctenophores *P. pileus, M. leidyi* and *B. ovata.*

The purpose of this work was to describe the quantitative structure of the species *A. aurita, P. pileus, M. leidyi* and *B. ovata* from the western Black Sea in the months of May-June and August-September 2021.

2.Materials and method

A simple definition of hyerarchy would be that it refers to a series of phenomena At the Romanian seaside, macrozooplankton samples are collected with Hansen net with a diameter of 70 cm and a sieve eye of 300 μm (Fig. 1).

The biological material is obtained by vertically towing the net in the water mass (from 2 m above the seabed to the surface), at low speed (0.5-1 m/s), to prevent damage to gelatinous organisms or clogging of the sieve. After collection, the net is gently washed with sea water to remove organisms or mucus from them.

The organisms in the cod end are carefully moved to a bucket and immediately identified, measured, and counted. The big specimens are washed with sea water, above the container in which the sample was extracted from the fillet. All organisms in the sample are measured (depending on the species: width, aboral length, respectively total length). In the case of large-sized organisms (*A. aurita* species), the measurements are carried out by means of a ruler, positioning the individuals directly on the laboratory table or on a plastic plate. In the case of small-sized specimens, a water-filled petri dish, in which the organisms stay suspended, to allow the measurement without the appearance of deformation of the body was used.

The density and wet biomass of gelatinous organisms was expressed in ind./m^3 respectively g/m^3.

The calculation of these parameters was carried out in accordance with the recommendations of the Macrozooplankton Monitoring Guide (or gelatinous plankton) [10] (Table 1).

Fig. 1. Hansen net for the sampling of macrozooplankton

Table 1. Formulas used to calculate the wet weight of organisms [10]

Species	**WW (mg)**	**References**
Aurelia aurita	**WW =0.053 D $^{2.98}$**	-
Pleurobrachia pileus	**WW =0.682 L $^{2.52}$**	Mutlu, 1994; Anninsky, 1994
Mnemiopsis leidyi	**WW** (L<45mm) (total length) = **3.100 x L$^{2.22}$** **WW** (L≥45mm) (total length) = **3.800 x L$^{2.22}$**	Vinogradov et al., 2000
Beroe ovata	**WW =0.85 L $^{2.47}$**	Finenko et al., 2003; Anninsky et al., 2005
*WW - wet weight		

3. Results and discussions

The analyzed results were obtained following the average values resulted from the expeditions from May – June and August – September 2021.

In all the analyzed areas (coastal, with variable salinity, marine and offshore waters), the *A. aurita* species was dominant in terms of biomass values, due to its larger size, compared to the other organisms (Fig. 2, 3, 4, Table 2).

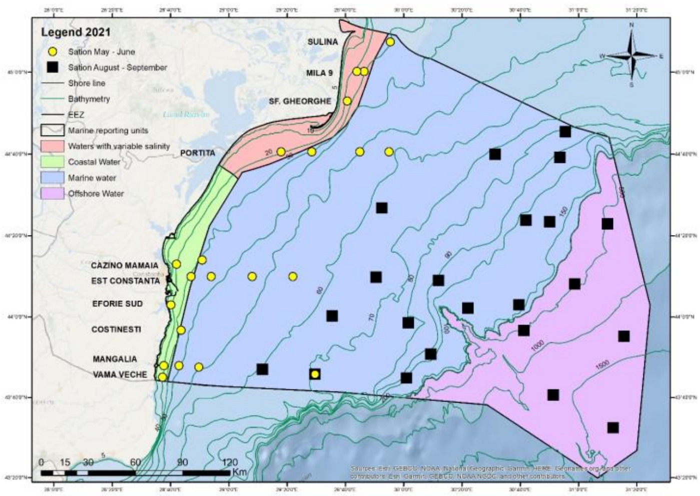

Fig. 2. Network of macrozooplankton sampling stations, 2021

With a spread throughout the Romanian continental shelf of the Black Sea, *A. aurita* species was reported in coastal waters, with the highest biomass value of 2.26 g/m^3, followed by the species *P. pileus* with a biomass of 0.03 g/m^3. The species *M. leidyi* and *B. ovata* were not identified in the analyzed samples, because the period of occurrence of these species begins from August - September and the samples from the coastal zone were collected in the expedition from May – June (Table 2, Fig. 3, 4).

In waters with variable salinity, the highest biomass value was recorded by *A. aurita* species 16.40 g/m^3, followed by species *P. pileus* with 0.62 g/m^3, and the lowest biomass value of 0.26 g/m^3 for *M. leidyi*. *B. ovata* species was not identified in the analyzed samples, the period of appearance for these species beginning from August - September, the samples from waters with variable salinity being 0collected in the expedition from May – June (Table 2, Fig. 3, 4).

In marine waters, *A. aurita* species recorded the maximum biomass value of 4.55 g/m^3, *M. leidyi* species recorded the biomass value of 1.46 g/m^3, followed by *B. ovata* with 0.31 g/m^3, and the lowest value was recorded by *P. pileus* 0.25 g/m^3 (Table 2, Fig. 3, 4).

In the offshore waters, the *A. aurita* species reached the maximum biomass value of 0.82 g/m^3, *P. pileus* species registered the biomass value of 0.11 g/m^3, followed by *B. ovata* with 0.09 g/m^3, the lowest value being recorded by *M. leidyi* 0.02 g/m^3 (Table 2, Fig. 3, 4).

Table 2. Biomass (g/m^3) average of gelatinous zooplankton in the analyzed areas

Water reporting unit	Coastal	Variable salinity	Marine	Offshore
Aurelia aurita	2.26	16.40	4.55	0.82
Pleurobrachia pileus	0.03	0.62	0.25	0.11
Mnemiopsis leidyi	0.00	0.26	1.46	0.02
Beroe ovata	0.00	0.00	0.31	0.09

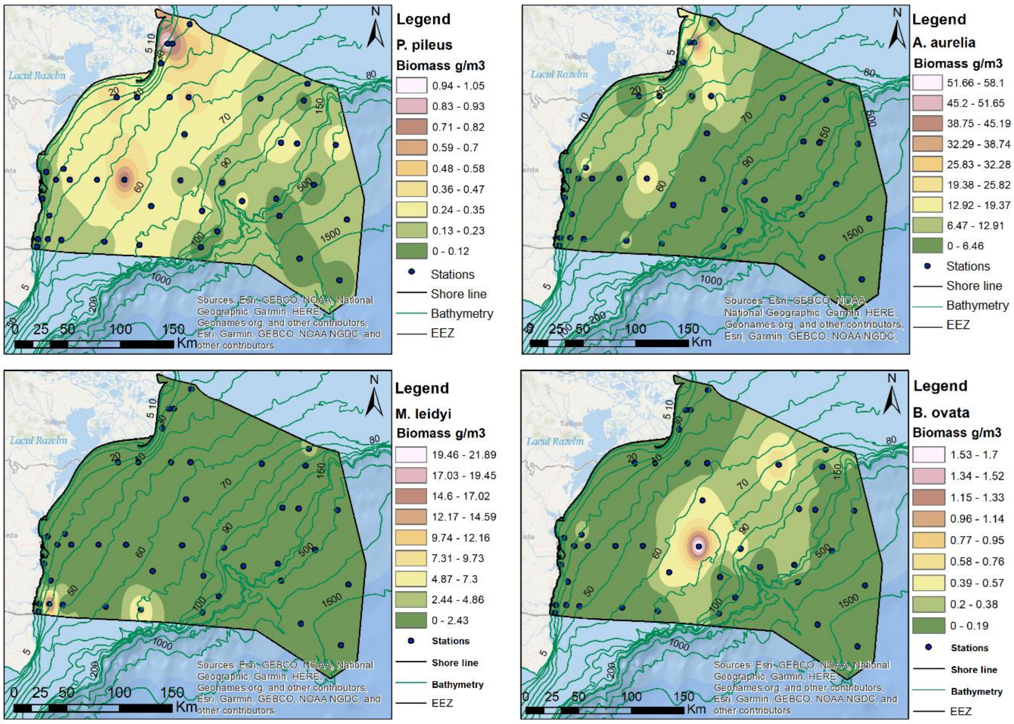

Fig. 3. Distribution of biomass values for gelatinous zooplankton, by species

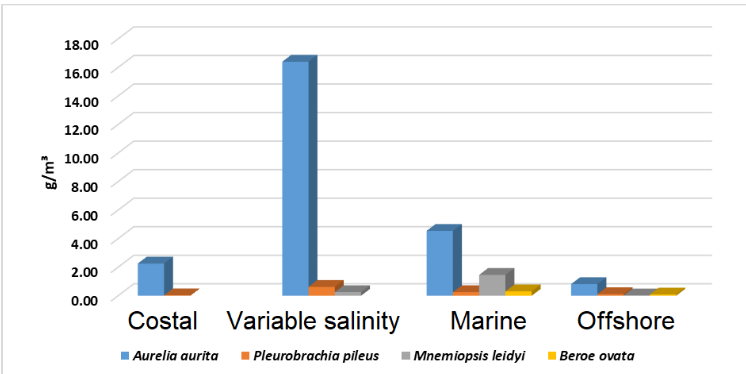

Fig. 4. Biomass (g/m^3) of gelatinous zooplankton on each body of water

Regarding the density of macrozooplanktonic organisms, the dominant species was *P. pileus* with the highest density values in all the analyzed areas, excepting coastal waters where the dominant species was *A. aurita* (Table 3, Fig. 5, 6).

In the coastal zone, the species *A. aurita*, reached the maximum density value of 3.51 ind/m^3, followed by *P. pileus* with a value of 0,19 ind/m^3. The species *M. leidyi* and *B. ovata* were not identified in the analyzed samples (Table 3, Fig. 5, 6).

In waters with variable salinity, *P. pileus* reached the maximum density value of 8.28 ind/m^3, *A. aurita* species recorded a lower density of 1.98 ind/m^3, followed by *M. leidyi* with a density value of 0.04 ind/m^3, the species *B. ovata* was not identified in the analyzed samples (Table 3, Fig. 5, 6).

In marine waters, the species *P. pileus* reached the maximum density value of 3.77 ind/m^3, followed by the species *A. aurita* with a density value of 1.46 ind/m^3, the lower density values being recorded by the species *M. leidyi* 0.06 ind/m^3 and *B. ovata* 0.04 ind/m^3 (Table 3, Fig. 5, 6).

In offshore waters, *P. pileus* reached the maximum density value of 1.54 ind/m^3, followed by the species *A. aurita* with the density value of 0.06 ind/m^3, species *B. ovata* recorded a density of 0.04 ind/m^3 and *M. leidyi* a value of 0.01 ind/m^3 (Table 3, Fig. 5, 6).

Table 3. Average density (ind/m^3) of gelatinous zooplankton

Marine reporting unit	Coastal	Variable salinity	Marine	Offshore
Aurelia aurita	3.51	1.98	1.46	0.06
Pleurobrachia pileus	0.19	8.29	3.77	1.54
Mnemiopsis leidyi	0.00	0.04	0.06	0.01
Beroe ovata	0.00	0.00	0.04	0.04

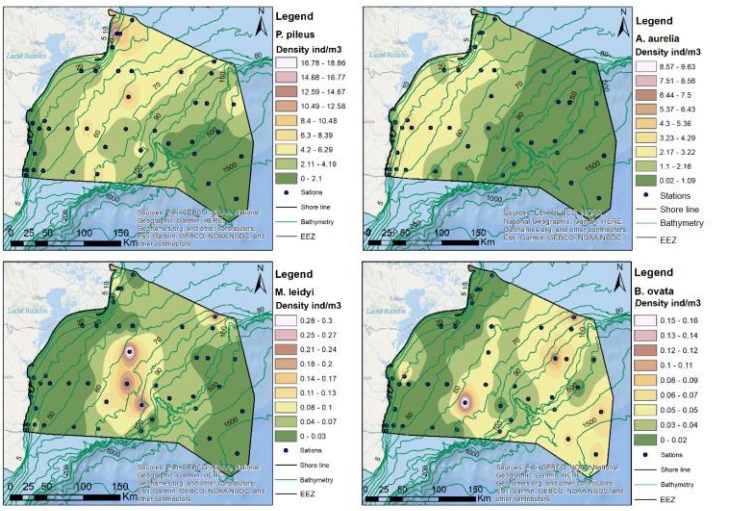

Fig. 5. Distribution of density values of the species of gelatinous zooplankton

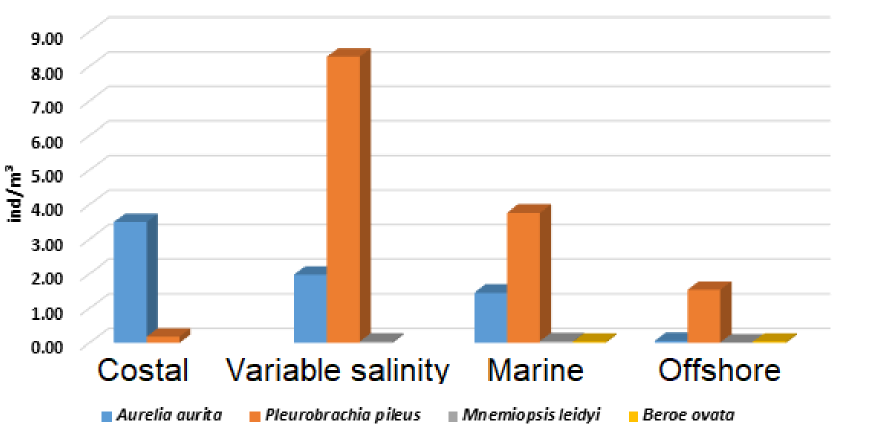

Fig. 6. Density (ind/m^3) of gelatinous zooplankton on each body of water

Regarding the distribution of the identified species, maps were made in the ArcGis program, data analysis showing that the species *P. pileus* had a significant spread in waters with variable salinity, coastal and marine waters, recording low values of biomass and density in the offshore waters. The highest species abundance was in waters with variable salinity, at Danube mouths, where fresh water and nutrients input is higher compared to the rest of the analyzed areas, with lower depths and a higher food intake (Fig 3, 5).

From the biomass point of view, *A. aurita* species was the most representative in the entire analyzed area, with high biomass values in the northern part, at Danube mouths. In terms of density, the highest value was recorded in the coastal zone followed by waters with variable salinity, marine and offshore area (Fig 3, 5). According to Mutlu and Bingel (1999) research, the species *M. leidyi* and *A. aurita* are encountered above CIL at depth stations and compete for food [6, 9].

M. leidyi species had a low distribution of biomass values, high values being identified in only two stations located in the southern part, belonging to marine waters. As for the density values, the species was identified in the south and center of the Romanian continental shelf of the Black Sea, at isobaths between 60-100 m (Fig 3, 5), During the warm season, it is found above the thermocline, in the range of 0-25 m and in winter season, it is found up to a depth of 50 m [6, 11].

B. ovata was concentrated in the central area, between 60-100 m isobaths, both for the biomass values and density values, the species was identified in marine and offshore waters from 60 m up to 1580 m deep (Fig 3, 5).

It is seen on the distribution maps how *B. ovata* concentrates its populations to areas where there are high densities of the species *M. leidyi*, because *B. ovata* is the natural predator of the invasive species *M. leidyi*, feeding on it, thus maintaining a balance in the marine ecosystem (Fig 3, 5) [6, 7, 8].

Also, in the maps for *A. aurita* and *P. pileus* densities, it is observed that in areas where *A. aurita* species is identified, *P. pileus* is in low quantities or is absent, and in the areas where *P. pileus* has high densities, *A. aurita* species recorded low values or absence. Bibliographic sources claim that there are no significant correlations between these two species (Fig 3, 5) [9]. The research of Mutlu and Bingel (1999) affirmed that *P. pileus* in response to light conditions, is found below the thermocline to the anoxic layer, with temperatures of <8 °C. Following visual observations, in the range of 70 – 110 m there are high abundances of *P. pileus* with extended tentacles, and below 110 – 140 m, *P. pileus* was found very rarely [9].

Conclusions

In 2021, four species were identified in gelatinous zooplankton samples: the sciphozoar *A. aurita* and the ctenophores *P. pileus*, *M. leidyi* and *B. ovata.*

In all the analyzed samples, *A. aurita* species was dominant in terms of biomass due to its large size, being concentrated in the southern and central part of the Romanian Black Sea.

The spatial distribution of *P. pileus* was dominant along the Romanian continental shelf of the Black Sea, the largest values being identified in the north, but also between 40-80 m isobaths.

The Ctenophore *M. leidyi* was more abundant in the southern and central area, between 60-100 m isobaths, in the rest of the analyzed areas being identified in very low quantities or even missing.

Between August and September, *B. ovata* ctenophore had a widespread distribution in terms of density, starting with the isobath of 60 m to the depth of 1580 m.

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REFERENCES

[1]E. Mutlu, "Recent distribution and size structure of gelatinous organisms in the southern Black Sea and their interactions with fish catches," Mar Biol, vol. 156, no. 5, pp. 935–957, Apr. 2009, doi:10.1007/s00227-009-1139-8.

[2]M. E. Vinogradov, E. A. Shushkina, P. Yu. Sorokin, and E. I. Musaeva, "Ctenophore Mnemiopsis leidyi (A. Agassiz) (Ctenophora: Lobata) – new settlers in the Black Sea," Oceanology (Wash D C), vol. 29, no. 2, pp. 293–298, 1989.

[3]L. Kamburska, "Effects of Beroe cf ovata on gelatinous and other zooplankton along the Bulgarian Black Sea Coast," in Aquatic Invasions in the Black, Caspian, and Mediterranean Seas, Dordrecht: Kluwer Academic Publishers, 2004, pp. 137–154. doi: 10.1007/1-4020-2152-6_5.

[4]G. Daskalov, "Overfishing drives a trophic cascade in the Black Sea," Mar Ecol Prog Ser, vol. 225, pp. 53–63, 2002, doi: 10.3354/meps225053.

[5]A. C. Gucu, "Can Overfishing be Responsible for the Successful Establishment of Mnemiopsis leidyi in the Black Sea?" Estuar Coast Shelf Sci, vol. 54, no. 3, pp. 439–451, Mar. 2002, doi: 10.1006/ecss.2000.0657.

[6]T. Shiganova et al., "Population development of the invader ctenophore Mnemiopsis leidyi, in the Black Sea and in other seas of the Mediterranean basin," Mar Biol, vol. 139, no. 3, pp. 431–445, 2001, doi: 10.1007/s002270100554.

[7]A. E. Kideys, "Fall and Rise of the Black Sea Ecosystem," Science (1979), vol. 297, no. 5586, pp. 1482–1484, Aug. 2002, doi: 10.1126/science.1073002.

[8]G. A. Finenko, "Population dynamics, ingestion, growth and reproduction rates of the invader Beroe ovata and its impact on plankton community in Sevastopol Bay, the Black Sea," J Plankton Res, vol. 25, no. 5, pp. 539–549, May 2003, doi: 10.1093/plankt/25.5.539.

[9]E. Mutlu and F. Bingel, "Distribution and abundance of ctenophores, and their zooplankton food in the Black Sea. I. Pleurobrachia pileus," Mar Biol, vol. 135, no. 4, pp. 589–601, Dec. 1999, doi: 10.1007/s002270050660.

[10]T. A. Shiganova et al., "Black Sea Monitoring Guidelines Macroplankton (Gelatinous plankton)," 2015.

[11]E. Mutlu, "Distribution and abundance of ctenophores and their zooplankton food in the Black Sea. II. Mnemiopsis leidyi," Mar Biol, vol. 135, no. 4, pp. 603–613, Dec. 1999, doi: 10.1007/s002270050661.