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Research Article

Distribution and Quantitative Characteristics of Four Invasive Alien Species off the Black Sea Coast of Georgia

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Abstract: The invasion of alien species in the Black Sea began about 200 years ago and is ongoing. Although the invasive alien species have caused significant changes in the Black Sea ecosystem, the knowledge about their distribution, population status and impact along the Black Sea coast of Georgia is still scarce. The aim of the present study was to assess the distribution and quantitative composition of four of the most common alien marine species in Georgia: the ctenophores *Mnemiopsis leidyi* and *Beroe ovata*, the crustacean *Amphibalanus improvisus* and the bivalve *Anadara kagoshimensis*. In May 2018, the two ctenophore species were recorded at the same depths, being most abundant and with the highest biomass at 40–50 m. *Mnemiopsis leidyi* occurred more frequently than *B. ovata. Amphibalanus improvisus* was present at all stations sampled in 2018, with the highest abundance registered in autumn and the lowest in spring. *Anadara kagoshimensis* was also recorded at all studied stations. Its quantitative parameters had the highest values at stations with higher salinity. Our results confirm that the four invasive alien species studied have established stable populations off the Black Sea coast of Georgia and may play a key role as factors which influence the native biodiversity.

Key words: Invasive alien marine species, *Mnemiopsis leidyi, Beroe ovata, Amphibalanus improvisus, Anadara kagoshimensis*, Black Sea, Georgia.

Introduction

From bioecological point of view the term "invasion" is considered as introduction and spread of alien species in new areas. Invasive species are part of the global natural changes. The successive changes of biocenoses and the destruction of ecosystems are directly related to the invasion process (Zaika et al. 2010). The globalisation, the increase of the commercial flows and the climate changes determine the invasive species as a general threat to all kinds of terrestrial, freshwater and marine ecosystems (Mooney 2005). The invasive species are believed to accelerate the decline of the native populations, which are already under environmental stress, leading to population losses and extinctions (Ricciardi 2004). The extent of the impact has been so severe that the invasive species are considered to be the second biggest cause for the biodiversity loss after the habitat destruction (Breithaupt 2003).

Invasion of the marine habitats has been the main ecological challenge worldwide. The integrated global effect, the ocean eutrophication and, in addition, the navigation development have assisted the invasive species to establish and dominate (Zaika et al. 2010). During the last 200 years, considerable

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numbers of invasive species have been recorded in some places of the World Ocean, well adapted to the new environmental conditions. The general number of the invasive species corresponds to the size of surveyed areas, as well as to the number of ports and trade routes (Alexandrov 2004).

The invasive species are spread all over the taxon and ecological groups, whereas the benthic alien species prevail in the European seas (Streftaris et al. 2005). In the Black Sea ecosystem, two invasive alien species, the comb jelly *Mnemiopsis leidyi* A. Agassiz, 1865 (Ctenophora: Tentaculata) and the veined rapa whelk *Rapana venosa* (Valenciennes, 1846) (Mollusca: Gastropoda) have been considered to cause the highest negative impact on the native populations (Yankova et al. 2013).

Because the data about the invasive alien species in the Black Sea coast of Georgia have been scarce, the aim of the present study was to assess the distribution and quantitative composition of four of the most common alien species of different ecological groups: two macro-zooplankton species, the ctenophores *M. leidyi* and *Beroe ovata* Bruguière, 1789 (Ctenophora: Nuda), and two benthic macroinvertebrates, the crustacean *Amphibalanus improvisus* (Darwin, 1854) (Crustacea: Cirripedia) and the bivalve *Anadara kagoshimensis* (Tokunaga, 1906) (Mollusca: Bivalvia).

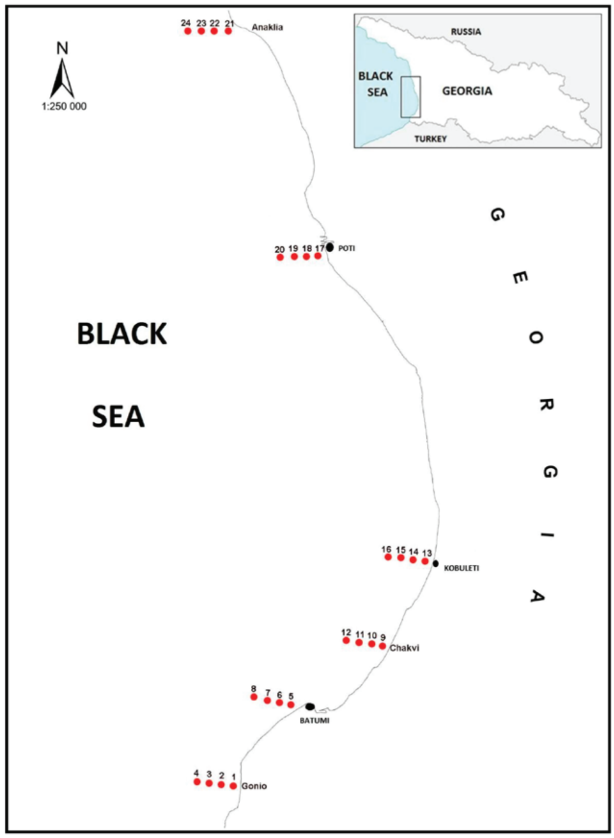

Fig. 1. Map of the sampling area in the Black Sea coast of Georgia and the stations and depth points (from 1 to 24) for zooplankton sampling.

Materials and Methods

The sampling was conducted at the Black Sea coast of Georgia, in the area from Batumi to Anaklia in 2018.

Zooplankton sampling and analysis of data

The zooplankton sampling was conducted in May 2018. The samples were taken from six stations (Gonio, Batumi, Chakvi, Kobuleti, Poti and Anaklia), at four depths (5, 15, 35 and 50 m) at each station; a total of 24 samples were collected (Fig. 1).

The ctenophores *M. leidyi* and *B. ovata* obtained by hauling at each station were separated immediately from the other organisms with a 2 mm mesh sieve. The total number of individuals and the total wet weight of the ctenophore species were determined in order to estimate their abundance and biomass (Mutlu 1999, Shiganova et al. 2000, 2015a,b, Finenko et al. 2001). The total number of species was calculated for a sample, or in the case of very high number of individuals, for a sub-sample. Then the abundance and biomass were estimated per cubic meter (m^3) of filtrated water.

The wet weight (W) or biomass of *M. leidyi* was calculated following the equation: W=0.043 L 1.896 (R2=0.944, n=300, p<0.01) (Shiganova et al. 2000, 2001a, 2004), while the W or biomass of *B. ovata* was calculated after the equation: W=0.0036·L 2.02 (R2=0.9353, n=40, p<0.01) (Shiganova et al. 2001b).

Benthic macroinvertebrate sampling and analysis of data

The samples of *A. improvisus* were collected during the spring, summer and autumn of 2018 at four stations (Sarpi, Green cape, Tsikhisdziri and Kobuleti) (Fig. 2). The samples of *A. kagoshimensis* were collected in spring (May), at seven stations of the Black Sea coast of Georgia: Anaklia, Batumi, Gonio, Poti, Chakvi, Kobuleti and Green Cape.

The macrozoobenthos samples were collected and treated according to the standard methods (Todorova & Konsulova 2005). The samples were taken with a Van Veen grab with a surface of 0.135 m^2, washed through a 0.5 mm mesh size sieve and fixed with 4% formaldehyde. In the laboratory, the organisms were identified to the lowest possible taxonomic level with the help of a binocular microscope. The abundance and biomass were estimated per square meter.

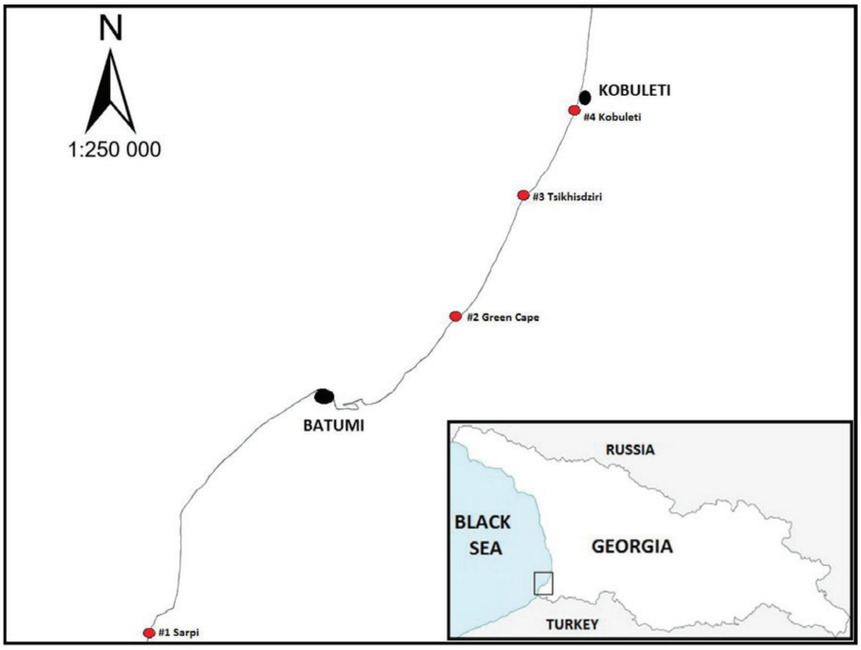

Fig. 2. Map of the sampling area in the Black Sea coast of Georgia and the sampling stations for *Amphibalanus improvisus*.

Results

The alien ctenophore species *M. leidyi* was recorded at three of the sampling stations (Gonio, Poti and Anaklia), while *B. ovata* occurred only at one station (Kobuleti) (Figs. 3 and 4). *Mnemiopsis leidyi* was found at the depths of 40 and 50 m at Gonio, at 50 m at Poti, and at 20, 40 and 50 m at Anaklia. The highest abundance of *M. leidyi* was detected at Anaklia at the depths of 20 and 50 m ($\geq$0.2 ind./m^3) (Fig. 3), while the highest biomass – at the same station at 50 m (31.5 mg/m^3) (Fig. 4). *Mnemiopsis leidyi* showed the lowest biomass at Poti at the depth of 50 m (12.1 mg/m^3) (Fig. 4). *Beroe ovata* was found at 40 m at Kobuleti with an abundance of 0.1 ind./m^3 and biomass of 0.2 mg/m^3 (Figs. 3 and 4).

Amphibalanus improvisus was present at the four sampled stations in the Black Sea of Georgia: Sarpi, Green cape, Tsikhisdziri and Kobule (Fig. 5). The highest abundance was registered in autumn, with the highest value (5,467 ind./m^2) being estimated at Tsikhisdziri. The lowest abundance was recorded in spring, with the lowest value (32 ind./m^2) at the Sarpi station. The highest average abundance for the whole study period (5,872 ind./m^2) was also recorded at Tsikhisdziri, while the lowest (160 ind./m^2) at Sarpi (Fig. 5).

Anadara kagoshimensis was recorded at all seven sampling stations: Anaklia, Batumi, Gonio, Poti, Chakvi, Kobuleti and Green Cape. The results on the abundance and biomass of this species are shown on Fig. 6. The distribution of *A. kagoshimensis* mainly depended on water salinity. At places where the river impact is less and the salinity equals to 18‰ the abundance of *A. kagoshimensis* was higher. The highest value of abundance was recorded at Gonio (346 ind./m^2), followed by Poti (241 ind/m^2). The highest values of biomass were registered at Kobuleti and Gonio (Fig. 6). On the other hand, the abundance of *A. kagoshimensis* at locations being impacted by the rivers Chorokhi and Chakvistskali, with stable low salinity (8–14‰ at Chakvi and Green Cape), was low (Fig. 6).

Discussion

The abundance, distribution range and the magnitude of alien species can vary over time. The alien species produce measurable effects on local community and ecosystem only after attaining a particular level of abundance and when occupying a sufficiently large area (Olenin et al. 2007).

Gelatinous plankton plays an important role in the functioning of the marine ecosystems, however in case of excessive proliferation its role is negative. Since the 1980s the two invasive alien ctenophore species have invaded the Black Sea. *Mnemiopsis leidyi*, which originates from the Atlantic coast of North and South America, was introduced in 1982 and since then has greatly affected the Black Sea ecosystem (Vinogradov et al. 1989). Ten years later, the second ctenophore species originating

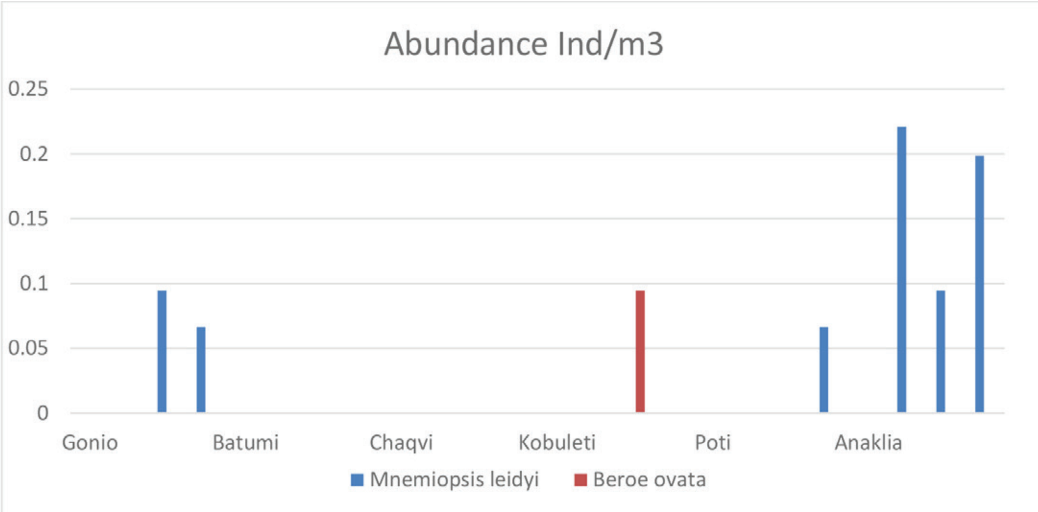

Fig. 3. Abundance of *Mnemiopsis leidyi* and *Beroe ovata* at the studied stations in the Black Sea coast of Georgia (May 2018).

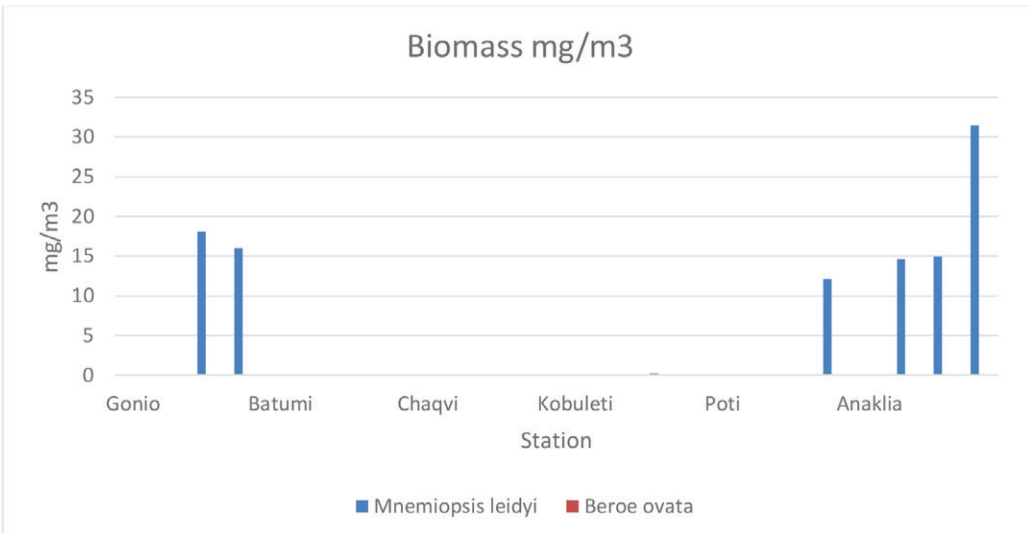

Fig. 4. Biomass of *Mnemiopsis leidyi* and *Beroe ovata* at the studied stations in the Black Sea coast of Georgia (May 2018).

from the South Atlantic Ocean *B. ovata* was reported (Konsulov & Kamburska 1998). Both species have been released with ballast waters into the Black Sea (Ghabooli et al. 2011). In general, *M. leidyi* and *B. ovata* share vertically the same depths – the water column from the surface down to the upper border of the thermocline and *M. leidyi* population is generally being controlled by the predator *B. ovata* (Kideys & Romanova 2001, Finenko et al. 2003, Shiganova et al. 2003, Mutlu et al. 2009). Our results on the distribution of the two Ctenophora species showed that *M. leidyi* was more frequently found, with maximum abundance and biomass at Anaklia station at isobaths of 20 m and 50 m, respectively. *Beroe ovata* was found only at one station, Kobuleti, at 40 m izobath.

The bay barnacle *A. improvisus* has been considered to originate from the Western Atlantic. Its white lime 'house' covers rocks and ship bottoms, installed nets, living lobsters and shells of molluscs. The species inhabits the sublittoral of the Black Sea, attached to stones, rocks, ship bottoms and hydrotechnical facilities, and being able to tolerate highly contaminated or fresh waters (Zaitsev 1998). Our results showed high abundance of this species at some stations (Tsikhisdziri), with a peak in the autumn and the minimal values in the spring. More specifically, the seasonal distribution of the abundance of *A. improvises* in the Black Sea coast shelf waters of Georgia in 2018 was as follows: the total abundance for the whole study period at all four sampled areas was 7,197 ind./m^2, about 82% of

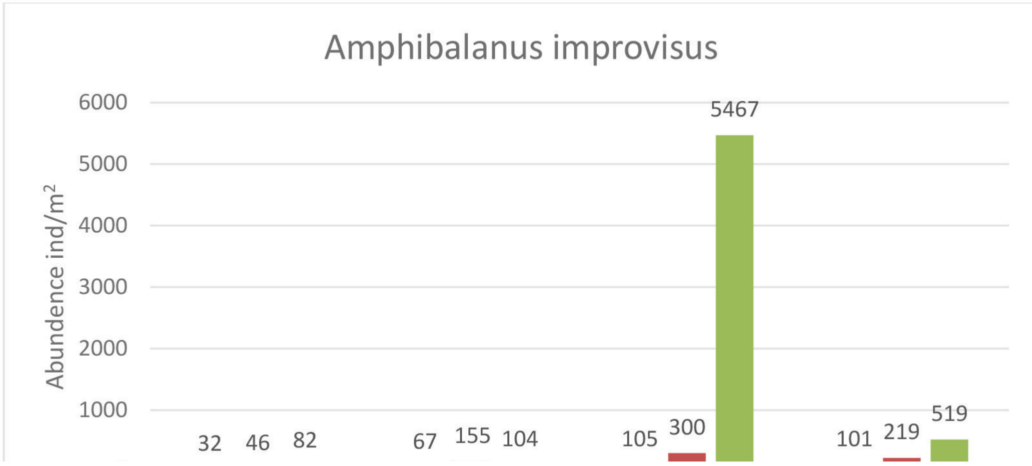

Fig. 5. Abundance of *Amphibalanus improvisus* in the Black Sea coast of Georgia in the different seasons of 2018.

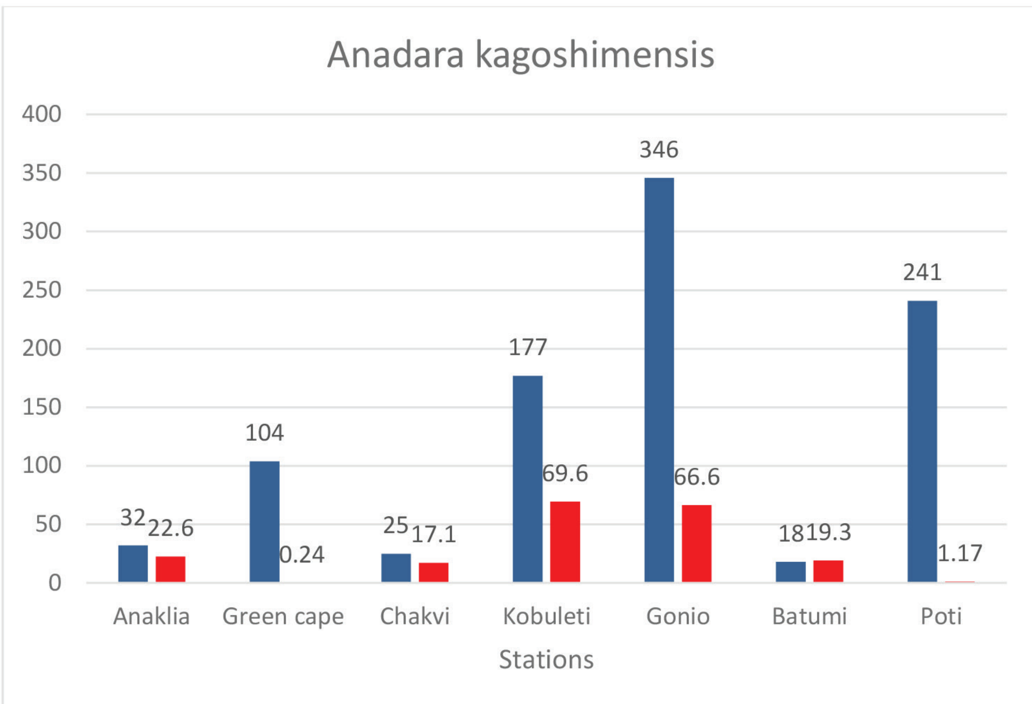

Fig. 6. Abundence and biomass of *Anadara kagoshimensis* at the studied stations in the Black Sea coast of Georgia in 2018.

which was registered at Tsikhisdziri and only 2,2% at Sarfi. The average abundance was 1,799 ind./m^2, with a maximal peak in autumn (1,543 ind./m^2) and minimal in spring (76 ind./m^2).

In 1978–1979, the bivalve mollusc *A. kagoshimensis*, which is native to the West Pacific Ocean, was recorded for the first time in Georgia in the benthos of the Chorokhi River mouth, at depths from 5 to 20 m (Gogmachadze & Mikashavidze 2005). At first, some individuals with sizes of 1–2.5 cm were detected, while afterwards, the bigger sized ones (6–8 cm) were found. These bivalves were especially abundant at Anaklia, where the mussel collectors were installed (Gogmachadze & Mikashavidze 2005). Currently, this mussel has been widely distributed in the benthos of the Black Sea of Georgia. According to some authors, the reason of its high proliferation is connected to its massive shell and hermetic hooking, which helps the mussel to survive during oxygen deficiency in water (Gogmachadze & Mikashavidze 2005). During our study, *A. kagoshimensis* was found at all sampling stations. Its biomass ranged between 1.17 and 69.6 g/m^2, with higher values at the stations with higher salinity. The highest biomass was observed at Kobuleti, while the lowest at Poti station. The abundence of *A. kagoshimensis* was the highest at Poti and the lowest at Batumi station.

Our results confirm that the four invasive alien species studied have established stable populations in the Black Sea coast of Georgia and may play a key role as factors which influence the native biodiversity.

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