Research Article

ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., Suppl. 13, 2019: 75-80

Assessing the Status of Endangered Invertebrates from the Ancient Lake Ohrid: The Endemic Species *Gocea ohridana* Hadžišče, 1956 (Gastropoda: Hydrobiidae)

Biljana Budzakoska Gjoreska[1], Sasho Trajanovski[1], Sonja Trajanovska[2] & Konstantin Zdraveski[3]

[1] Department of Benthic Fauna, PSI Hydrobiological Institute Ohrid, 50 Naum Ohridski Street, 6000 Ohrid, Republic of Macedonia; E-mail: biljanab@hio.edu.mk
[2] Department of Hydrobotany, PSI Hydrobiological Institute Ohrid, 50 Naum Ohridski Street, 6000 Ohrid, Republic of Macedonia
[3] Association for Ecology ECOMENLOG Ohrid, ASNOM zg. 3/1/3, 6000 Ohrid, Republic of Macedonia

Abstract: One of the most important characteristics of Lake Ohrid is the benthic fauna and its richness and diversity, with endemic and relict taxa. Among all groups from the benthic fauna inhabiting Lake Ohrid, the fauna of gastropods has evolved in a faunal group with the highest level of diversity and endemism. In the present study, we assessed the status of the endemic gastropod *Gocea ohridana* based on its distribution and density in Lake Ohrid. The samples were collected from six depth points along transects at the localities Velidab and Sveti Zaum situated in the south-eastern littoral region of Lake Ohrid, the only region known as a habitat of this endemic snail. At Velidab locality, *G. ohridana* was recorded only at a depth of 0.5 m, while at Sveti Zaum locality, this species was present at a depth of 0.5 m with a low density, and at a depth of 2.0 m with a higher density. The species was recorded only on a sandy-stony bottom, with a population density in the range of 44–220 ind. m^{-2}. The species was not found in other types of habitats, which points out to the high 'selectiveness' or narrow ecological valence for settling in different habitats as one of the factors that limits the species only to this region in Lake Ohrid. The main threats are mentioned and measures for conservation of this endangered endemic gastropod species are discussed and recommended.

Key words: Gastropoda, *Gocea ohridana,* Lake Ohrid, status, distribution, density

Introduction

Ancient lakes represent key ecosystems for endemic freshwater species and this high endemic biodiversity has been shown to be mainly as a result of intra-lacustrine diversification (Föller et al. 2015). The species fauna of Lake Ohrid – similarly as that of, for example, Baikal or Tanganyika lakes – contains many endemic elements, especially of Gastropoda (Radoman 1955, Hadžišće 1956, Hubendick 1960, Stanković 1960). According to the literature data (Albrecht & Wilke 2008), there are 72 gastropod species, out of which 56 (78%) are endemic. Strong et al. (2008) noted 72 gastropod species, of which 55 are endemic. Budzakoska Gjoreska (2012) recorded 50 gastropod species, of which 8 cosmopolitan and 42 endemic for the Macedonian part of Lake Ohrid and its watershed.

Gocea ohridana Hadžišče, 1956 (Gastropoda: Hydrobiidae) (Fig. 1) is an endemic and rare species that inhabit Lake Ohrid and its surrounding springs. According to Radoman (1985), it has a valvatiform shell, with radial striations in the front view. The first whorls are slightly developed but the last one is strongly developed and stretched, i.e. separated from the other whorls, so that the aperture is considerably distant from the last but one whorl. Seen in front, the aperture is three-cornered, narrowed, nearly angular at the top, its lower lip being arched incised (concave), while the outer lip being convex. The umbilicus is opened, hole let-like. The operculum is reddish, prolonged in form of a wide screw with lamellose ‘highlight’ stretching from the animal foot, whose tissue, in form of a small outgrowth, fills a minute hole in the operculum.

This species inhabits the rocky areas of the shore in the south-eastern part of Lake Ohrid where it is found in the surroundings of sublacustrine springs on the underside of the stones (sublithic species). It is a sublacustrine interlithon species (Hadžišče 1956). Its limited distribution in the lake could be due to the environmental barriers and specific nature of spring biocenosis (Radoman 1985).

The aims of our study were to assess the current status of this endemic and endangered species based on population parameters, such as density changes and dynamics over time, and its habitat preferences for different bottom types, i.e. vertical and horizontal distribution.

Fig. 1. *Gocea ohridana* Hadžišče, 1956 from Lake Ohrid (Sveti Zaum locality, depth 0.5 m)

Materials and Methods

The survey was based on monthly sampling dynamics for one year, in the period August 2009 – August 2010. The samples of *G. ohridana* were taken along two transects from two localities: Velidab locality (N40°59’188”; E20°47’904”) and Sveti Zaum locality (N40°56’916”; E20°46’463”) (Fig. 2). The samples were collected using standard limnological methods for benthic material, according to Lind (1985), Wetzel (1975), Wetzel & Likens (1979), Rosenberg et al. (1997), Mandaville (2002), Perez et al. (2004), and Dillon (2006). For assessing both vertical and horizontal distribution of this species, a grab (type van Veen) of 225 cm² (15 x 15 cm) was used. At each locality, samples were collected from six different depth points in the littoral zone (0.5 m, 2 m, 5 m, 10 m, 15 m and 20 m). The samples were preserved in 96% ethyl alcohol and determined in the laboratory, using the key by Radoman (1985). The standard shell morphometric parameters were measured. The density was calculated as a number of individuals per m².

Results

The density variations of *G. ohridana* in the littoral zone of Lake Ohrid on a monthly level, in the period August 2009 – August 2010, are presented in Fig. 3. The maximum density was recorded in July 2010, with 1,100 ind. m^{-2}, while the minimum density was in November 2009 and February 2010 (176 ind. m^{-2}). Out of these months, the density varied from 367 to 733 ind. m^{-2} per month. In two of the months, we did not find samples of the investigated species (Fig. 3). The reason could be mechanical displacing of the specimens of *G. ohridana* by the waves into deeper water layers or on the surface of the sediment.

The vertical distribution of *G. ohridana* in the littoral zone of Lake Ohrid is shown in Fig. 4. The species occurred in both studied profiles, Velidab and Sveti Zaum. In Velidab it was found at a depth of 0.5 m, while in the profile Sveti Zaum – at depths of 0.5 and 2.0 m. A higher total density of *G. ohridana* was recorded at the depth of 2 m (264 ind. m^{-2}) on a sandy-stony bottom, with vegetation. A density of 176 ind. m^{-2} was recorded at a depth of 0.5 m and a stony bottom, with *Cladophora*. The annual average value of density of this species in Lake Ohrid was 220 ind. m^{-2}.

Gocea ohridana was recorded only on a sandy-stony bottom, with a population density in the range of 44–220 ind. m^{-2}. The maximum density was on sandy-stony bottom covered by *Chara tomentosa.* The minimum density of the population was recorded on stony bottom with *Cladophora*. The species was not found in other types of habitats, such as: sand, submerse vegetation, mud, mud with vegetation, shell zone, and belts of *Chara.*

The average values of shell morphometric parameters in specimens of *G. ohridana* at the depths of 0.5 m and 2.0 m in Lake Ohrid are presented in Table 1. The results show that shell length and diameter increase with the increase in depth.

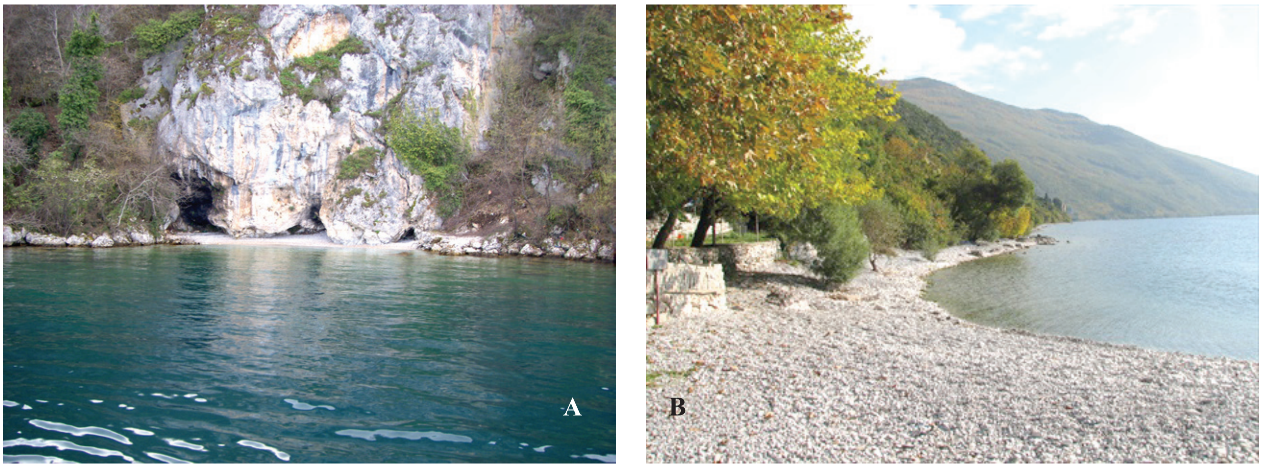

Fig. 2. Sampling localities: Velidab (A) and Sveti Zaum (B), in the south-eastern littoral region of Lake Ohrid

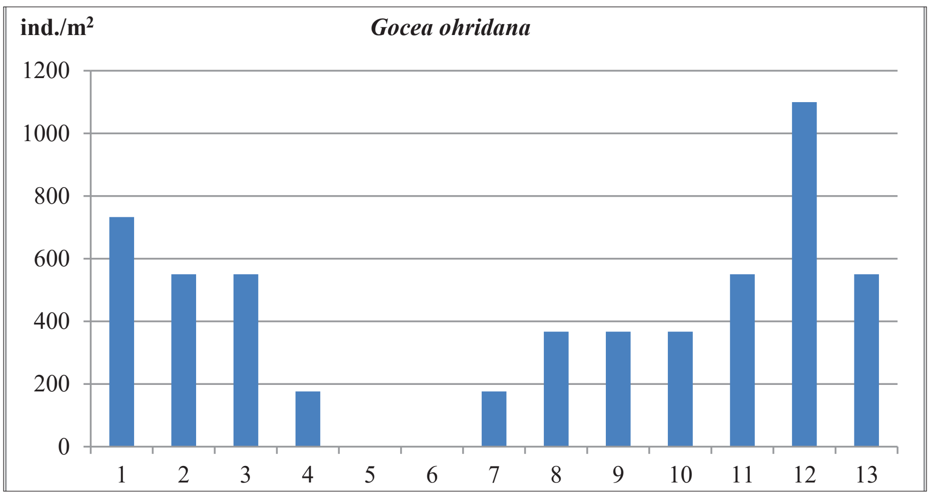

Fig. 3. Variations in the density of *Gocea ohridana* in the littoral zone of Lake Ohrid, on a monthly basis in the period August 2009 – August 2010

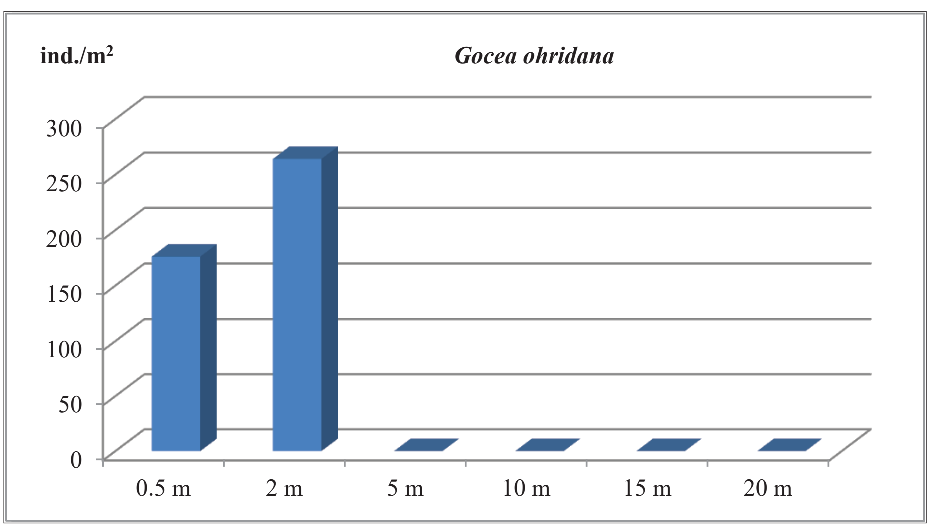

Fig. 4. Average density of *Gocea ohridana* at different depth points in the littoral zone of Lake Ohrid, in the period August 2009 – August 2010

Table 1. Shell morphometric parameters (average values) in specimens of *Gocea ohridana* at different depths in Lake Ohrid

Depth (m)	Shell (μm)		Apex (μm)		Whorls (μm)		Operculum (μm)	
	Length	Diameter	Length	Diameter	Length	Diameter	Length	Diameter
0.5	252.10–276.10	255.10–310.23	17.12–19.36	19.24–26.00	108.66–116.97	80.22–104.02	40.80–54.45	50.00–58.60
2.0	253.01–278.12	258.50–279.73	17.19–20.00	19.69–28.00	112.02–139.29	95.21–122.07	51.97–56.44	55.32–69.12

Discussion

As shown by our results, *G. ohridana* had a low population density in general, as well as limited distribution. This could be interpreted as a result of both water physicochemical conditions and general specific limnological conditions in the lake. The long history and evolution of the Lake Ohrid basin, enabled creating of diverse coastal areas in its littoral (Albrecht & Wilke 2008). These littoral areas are much more diverse and steep in the eastern part of the lake, with numerous karst springs and shallow sandy habitats in the north. Wilke & Albrecht (2007) identified several areas of particular importance in regards to the level of endemism of the invertebrate fauna of Lake Ohrid. Both Velidab and Sveti Zaum, the sampling localities in our research, are part of these areas. The arguably most important one is Velidab, which is the locality with the highest gastropod diversity: 24 species, out of which 22 are endemic (Budzakoska Gjoreska 2012). The eastern coast of the lake features a sandy bottom and large rocks with a number of scattered endemic species, often very small in size. Some of these taxa, such as *G. ohridana,* have very limited distribution with a total area of less than 1 km^2. The small sandy areas between the rocks could be considered as a migratory barrier for the dispersion of the small taxa, including *G. ohridana*, which results in limitation in the distribution of the species (Albrecht & Wilke 2008).

Other authors also reported about the limited distribution and low densities of *G. ohridana*. According to Radoman (1985), the species is limited to the eastern shore of Lake Ohrid. It has fragmented distribution, with a total area of less than 1 km^2 at Sveti Zaum locality. Hauffe et al. (2010) reported that *G. ohridana* is known from only one location, Lake Ohrid, where it is found in a small area (area of occupancy of less than 10 km^2) and has very specific hydrological requirements in the littoral zone.

In recent years, Lake Ohrid has suffered from increasing anthropogenic pressure and a 'creeping biodiversity crisis' (Wilke & Albrecht 2007). The comparatively small size of Lake Ohrid and the extremely small range of many endemic species, together with increasing human pressure, made its fauna particularly vulnerable, and some endemic species presumably have already gone extinct. Whereas anthropogenic effects are noticeable all around the lake, adverse human impact on key endemic areas could have grave consequences. For example, the destruction of the habitats around Velidab can cause loss of biodiversity of the lake for more than 10% (Wilke & Albrecht 2007). The analyses of recent ecology of the lake showed an increased level of eutrophication (Levkov et al. 2013), which has already been reflected in the change of the ratio between the cosmopolitan and endemic species in the watershed of the lake (Trajanovski et al. 2015). The concentration of nutrients has been increased two-fold during the last 60 years. On the other hand, it is expected that the climate change and global warming will have impact on lake ecology, with decreasing of the water level, and more important on mixing processes. It is known that most of the endemic animal species are connected with high oxygenated waters, and decreasing of the level of dissolved oxygen will be critical for their survival.

The main threats to the existence of *G. ohridana* are water pollution and habitat changes, which have an increasing trend, especially in the northern part of Lake Ohrid, as well as introduction of alien species and increased fire danger in the region (Trajanovski et al. 2015, 2019). Furthermore, deforestation of the neighbouring area leads to erosion and an increased sediment load, which impacts this small gastropod, diminishing its ability to filter water. Not only direct impacts threaten the species. Pollution from sewage from major adjacent towns contaminates the water of the lake. The agriculture areas near Lake Prespa contaminate the same lake waters, which feeds the aquifer of Lake Ohrid, resulting in an increased nutrient load (Matzinger et al. 2006).

According to the principles and criteria of the IUCN (2010) Red List of endangered species, *G. ohridana* is listed as Critically Endangered (CR) species B1ab(iii)+2ab(iii) (Hauffe et al. 2010). However, there are no conservation actions for this species, although Lake Ohrid is a World Heritage Site, and the Albanian side is protected under national jurisdiction since 1999. A Memorandum of Understanding has been signed between the Republic of Macedonia and the Republic of Albania for the management of the lake. Habitat monitoring of the water quality was recommended to assess potential changes in rates of decline in the water quality, and hence impact on this species.

According to Cuttelod et al. (2011), further sustaining of the populations of endangered mollusc species, including *G. ohridana*, within the boundaries of a stable density should include:

1) Site conservation: The main conservation action is to protect key habitats, such as the ancient lakes in the Balkans, underground systems and regions displaying either high diversity or high threat levels. Many species have very restricted distributions and threats, such as urbanisation, agriculture and tourism are encroaching on and destroying the habitat of these narrow-range species. Within these key habitats, maybe that only small micro-habitats need protection (rock crags, waterfalls, springs, caves). Some species would benefit from a landscape or catchment level approach with multi-taxon species conservation plans, for example, regarding the ancient forest faunas, marshlands, limestone pavement, ancient lakes and large rivers.

2) Monitoring of species or habitats: Except for the species monitoring requirements under the EU Habitats Directive, monitoring programmes for molluscs exist only in a small number of European countries. Programmes for threatened and Data Deficient species need to be established in all countries in order to determine their actual population size, distribution and trends. These programmes may be best implemented through regular habitat monitoring (as a proxy for species status) and occasional species surveys, in order to assist in the management plans for the threatened species. Such monitoring programmes will also help to evaluate the impact of conservation measures on this important indicator group of invertebrates and improve the accuracy of red listing in the future.

Conclusions

The results of our study on the population status of *G. ohridana* in Lake Ohrid showed a low population density and limited distribution of this species. At Velidab locality, *G. ohridana* was found at a depth of 0.5 m, while at Sveti Zaum locality, it was present at depths of 0.5 and 2.0 m, with a density in the range of 44–220 ind. m^{-2}. The highest population density was recorded on a sandy-stone bottom covered by *Chara tomentosa*, while the lowest density was on stony bottom with *Cladophora*. Specimens of *G. ohridana* were not found at other investigated depth points, where the bottom was covered by sand, submerse vegetation, mud, mud with vegetation, shell zone, and belts of *Chara*.

In the future, these key endemism and diversity littoral localities (areas or habitats) must be protected taking into account the specific ecological requirements of the endemic species, including *G. ohridana* as one of the most specific endemic species from the diverse class of Gastropoda in Lake Ohrid.

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