VERSITA

Biologia **69**/8: 1023—1029, 2014
Section Zoology
DOI: 10.2478/s11756-014-0403-7

Comparative biocenological analysis of Gastropoda on the Macedonian part of Lake Ohrid and its watershed

Biljana Budzakoska-Gjoreska[1], Sasho Trajanovski[1] & Sonja Trajanovska[2]

[1]*Department of benthic fauna, Hydrobiological Institute, Naum Ohridski 50, 6000 Ohrid, Macedonia; e-mail: biljanab@hio.edu.mk*
[2]*Department of Hydrobotany, Hydrobiological Institute, Ohrid, Macedonia*

Abstract: Lake Ohrid represents a refugial ecosystem which harbors a great number of endemic and relics living forms. Though the whole Lake's fauna characterizes high biodiversity and endemism, this is most obvious in the class of Gastropoda. Unlike the Lake, the fauna of the adjacent waters fairly differs from the Lake's fauna, i.e., it is poorer both in term of diversity and endemism. The main goal of our study was to perform comparative biocenological researches on the gastropod fauna from Lake Ohrid and the adjacent waters in the watershed of the Lake. Based on the results we have obtained, it could be clearly noted that different habitats are characterized with different qualitative composition of the gastropod fauna not only when compared the gastropod settlement between the Lake and its surrounding waters, but also in the Lake for itself. Total of 50 species of gastropods have been recorded in the littoral regions of the lake and its coastal waters during 2009/2010. They belong to subclass Orthogastropoda (50 taxa). 21 species out of 50 are recorded in the adjacent waters: 13 of them settle both the adjacent waters and the Lake, while 8 strictly inhabit the adjacent waters. In terms of endemism, 17 are endemic and 4 cosmopolitan. The remainig 29 (out of 50 recorded) settle up only the littoral zone of the Lake: 25 are endemic and 4 are cosmopolitan. The percentage of endemism based on the recorded species for the class Gastropoda is 84%.

Key words: Gastropoda fauna; composition; biodiversity; endemism

Introduction

An assessment of the fauna and flora of Lake Ohrid confirms that the lake harbors an incredible endemic biodiversity. Furthermore, Lake Ohrid is with 212 known endemic species probably by far the most diverse lake in the world, taking surface area into account (Albrecht & Wilke 2008).

The main subject in our investigations was to make integral biocenological researches in the composition of gastropod fauna (endemic: is one that is only found in that region and nowhere else in the world; and non-endemic species: species with large distribution in many, or all, parts of the world and ecosystems) on different habitats and in different localities of the littoral part of Lake Ohrid and its adjacent waters.

There are some similarities but differences as well if the gastropod fauna is being compared between the Lake and its adjacent waters. General characteristic of the registered Lake's gastropods is its higher diversity and endemism. This could be explained by the geological stability (geological isolation) and longtime existence of the Lake in almost its original form. The Lake and the coastal waters differ among themselves by many environmental factors which in combination create variety of biotopes. The endemic lake fauna during the long-term existence in unchanged conditions have managed to accommodate to the particular complex of environmental conditions present in the lake. Simultaneously, fauna became able to resist the invasion of external faunal elements. By accommodating to the lake condition, the endemic have become unable to live outside the lake biotope and to withstand the competition with no endemic residents of coastal waters, and therefore not definitively settle up in those waters.

Table 1. Geographical and hydrological characteristics of Lake Ohrid (Matzinger et al. 2006b)

Lake Ohrid, GIS data	
Location	40°54′–41°10′ N, 20°38′–20°48′ E
Altitude, m a.s.l.	693
Area lake, km^2	358
Length (max), km	30.0
Width (max), km	15.6
Depth (average), m	155
Depth (maximum), m	288.7
Volume, km^3	55
Watershed, km^2	1.002
Residence time, a (year)	70
Surface temperature of water (max), ℃	27

Hydrographic characteristics of Lake Ohrid and its surroundings

Lake Ohrid (40°54′–41°10′ N, 20°38′–20°48′ E) (Table 1) is situated in an attitude of 693 m a.s.l., shared between Macedonia and Albania. The lake has a length of coastline of 30 km, width of 15 km and an area of 358 km^2. The temperature of the lake waters in pelagic ranges from 6 °C at 240 m depth to about 24–27 °C (in July on the surface) (Naumovski et al. 2007; Matzinger et al. 2006b).

Lake Ohrid belongs among the cold oligomictic lakes (Wagner et al. 2008) with complete mixing every six to seven years – in years with very cold winters accompanied by strong winds. Its depth temperature throughout the year is 6 °C, and surface water in summer can reach up to 24 °C, i.e., above 26 °C near the coast.

Lake Ohrid belongs to the group of flow lakes. Lake feed is mostly with spring water from numerous surface and underwater (sublacustric) sources. With the exception of sources, surface tributaries flowing into the lake are small amounts slightly and bring water to the lake (Stankovic 1960). Major tributaries that are flowing into the lake rivers Koselska (Daljan) and Velgoshka (Grashnica) west of Ohrid and Cherava River east of St. Naum. Data of Matzinger et al. (2006b) confirm the fact that it is a lake flow or lake water comes from springs (53%), from direct precipitation (23%) and the flow of rivers (23%). Thus, the lake has a high flow of water from karst springs with underwater (49%) and surface sources (51%). While two thirds of the water leaves the lake through the river Crn Drim and the third is lost through evaporation (Stankovic 1960; Matzinger et al. 2006a).

In terms of the bottom heterogeneity and even more specific life conditions, the lake has been divided in three main depth zones: littoral (0–20 m), sublitoral (20–50 m) and profundal (50–289 m), (Radoman 1985). In general, the survival the density and the distribution of gastropod communities in Lake Ohrid have been strongly influenced by the conditions existing in these three zones. The littoral region comprises the highest biodiversity which is in close relation with the bottom heterogeneity and the presence of the macrophytic vegetation which had played huge role as one of the leading forces in the processes of sympatric speciation (Trajanovska 2009).

Material and methods

Investigated localities

The surveys were based on monthly sampling dynamic during one year researching period: August 2009 – August 2010. The subject of surveys were 26 localities from Lake Ohrid (Radozda, Livadishte, Kalista, Struga, Sateska, Podmolje, St. Erazmo, Daljan, Grashnica, Kaneo, Pristaniste, Mazija, Park, Gorica, St. Stefan, Konjsko, Metropol, Eleshec, Pestani, Gradiste, Velidab, Veljapesh, Trpejca, Zaum, Ljubanista, and St. Naum) along the entire littoral coastline of the Macedonian part of the Lake. Also, 13 coastal waters bodies around Lake Ohrid have been investigated: Kalista spring, Vevcani springs, Crn Drim River (D1-D7 from Moroishki most, Dobovjane, Tashmarunishta) Koselska River, Openichka River, Cherava River, Biljana springs, Spring Bej Bunar, spring Shum, springs Sini Viroj and St. Naum springs (Fig. 2).

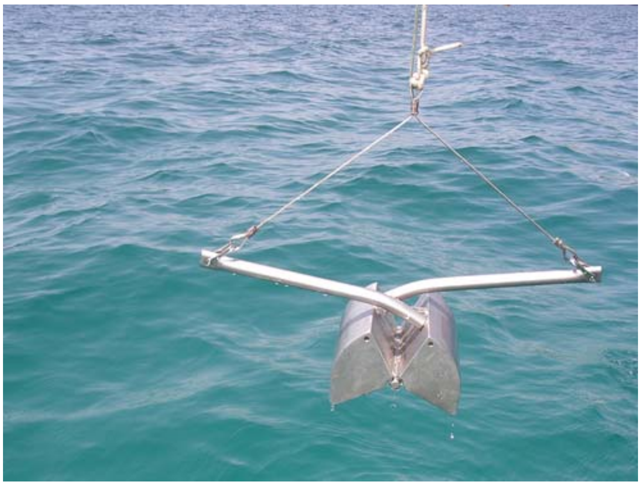


Fig. 1. Van Veen grab.

Collection and identification of gastropods

The surveys have been performed using standard limnological methods according to following authors: Lind (1985), Wetzel (1975), Wetzel & Likens (1979), Rosenberg et al. (1997), Mandaville (2002), Perez et al. (2004), Dillon (2006).

The samples from the littoral localities had been taken from 6 depth points (0.5, 2, 5, 10, 15, 20 m, while only one depth point (0.5 m) was considered during the sampling from the adjacent waters. A van Veen grab of 225 cm^2 was used for sampling (Fig. 1). Two samples have been taken from each depth point. The results are being shown as an average number of two consecutive samples and represent the density of the gastropods per square meter (ind. m^2).

The gastropods have been identified up to level of species using stereo microscope with use of the keys for identification of class Gastropoda: Polinski (1929), Hubendick (1960, 1970), Hadzisce (1974), Radoman (1983), Bodon et al. (2001); Glöer & Meier-Brook (2003) and Albrecht et al. (2006, 2008). The sampled material have been preserved in 4% formaldehyde and stored.

Results

Fifty gastropod species have been recorded in the littoral regions of the lake (species with "■") and its coastal waters (species with "•") (area of Ohrid and Struga and its valley) (Table 2). The results in our research for the qualitative composition of gastropod fauna in coastal waters (Studencista, pond St. Naum, springs Sini Viroj) are similar with the published ones by Radoman (1983), Stanković & Radoman (1955) and Budzakoska-Gjoreska (2012).

The species registered in our researches belong to subclass Orthogastropoda (50 taxa). Even 42 of the recorded species are endemic while the remaining 8 are cosmopolitan (species with "∗"). The percent of endemism reaches 84%.

Twenty-nine out of the total of 50 registered species have been found only in the littoral part of the Lake. Even 25 belong to the endemic species, i.e., the

Fig. 2. Investigated localities on Lake Ohrid and its watershads.

level of endemism is 86%. On third of the number of gastropod species recorded in the lake has been found in adjacent waters. Hereafter, 21 out of the recorded 50 species inhabit the coastal waters. 17 species are endemic while 8 only inhabit the coastal waters. The level of endemism reaches 81%.

Thirteen gastropod species (20%) were found in both Lake Ohrid and its coastal waters, which obviously illustrates the very low level of faunal exchange between the lake and coastal waters, the absence of interpenetration of both fauna (Stanković & Radoman 1955). Populations of some species are not present in the lake because of environmental barriers and specific nature of the bioconosis as well as the nature of the bottom (Radoman 1985).

Data in Table 3 show the different qualitative and quantitative composition of gastropods from the littoral localities on Lake Ohrid and its watershed, and quantitatively dominant species. Actually, the maximum number of species (24 and number of endemic species 22) of the gastropoda fauna was recorded on the localities Velidab. In the locality Openicka River, the qualitative composition was poorer compared with other localities (only one species present).

The highest diversity (8 taxa) in the coastal waters have been recorded in St. Naum springs, 7 taxa in Biljana Springs, Sateska River (estuary) and Dobovjane (along the Crn Drim River), 3 taxa have been recorded in Sini Viroj springs and Koselska River. In Vevcani springs and Cherava River no gastropods have been registered.

Regarding the quantitative composition (Table 3) it is obvious that Velidab with 47,061 ind. m^{-2}, represent the most populated locality. The locality Park is on

Table 2. List of recorded species of class Gastropoda in littoral region of Lake Ohrid and its watershed.

Subclass ORTHOGASTROPODA
■●∗*Theodoxus fluviatilis* (L., 1758)
■∗*Viviparus viviparus* (L., 1758)
■●*Valvata stenotrema* Polinski, 1929
■*Valvata hirsutecostata* Polinski, 1929
■*Valvata rhabdota* Sturanyi, 1894
■*Valvata relicta* (Polinski, 1929)
●*Horatia novoselensis* Radoman, 1966
■*Ohridohoratia sturanyi* (Westerlund, 1902)
■●*Ohridohoratia polinskii* (Radoman, 1960)
■●*Ohridohoratia pygmaea* (Westerlund, 1902)
■*Lyhnidia hadzii* Hadžišče, 1959
■*Lyhnidia stankovici* Hadžišče, 1959
■●*Pseudohoratia ochridana* (Polinski, 1929)
●*Orientalina curta kicavica* (Radoman, 1973)
●*Strugia ohridana* Radoman, 1973
■*Gocea ohridana* Hadžišče, 1956
■*Ohridohauffenia rotonda* (Radoman, 1964)
■*Ohridohauffenia sanctinaumi* (Radoman, 1964)
■*Zaumia sanctizaumi* (Radoman, 1964)
■●∗*Amphimelania holandrii* (C. Pfeiffer, 1828)
■●*Radix relicta* Polinski, 1929
●∗*Radix labiata* (Rossmässler, 1835)
■●*Gyraulus albidus* Radoman, 1953
■●*Gyraulus (Carinogyraulus) paradoxus* Stur.
■*Gyraulus lychnidicus* Hesse, 1928
■*Gyraulus trapezoides* Polinski, 1929
●*Gyraulus crenophilus* Hubendick & Radoman, 1959
●*Gyraulus fontinalis* Hubendick & Radoman, 1959
■*Acroloxus improvisus* Polinski, 1929
■●∗*Ancylus fluviatilis* O.F. Müller, 1774
■*Ancylus lapicidus* Hubendick, 1960
■*Ancylus scalariformis* Stankovic & Radoman, 1953
■●*Acroloxus macedonicus* Hadžišce, 1959
■*Ancylus tapirulus* Polinski, 1929
■*Planorbis macedonicus* Sturanyi, 1894
■∗*Planorbarius corneus* (L., 1758)
■∗*Lymnaea stagnalis* (L., 1758)
■∗*Galba truncatula* (O.F. Müller, 1774)
■●*Chilopyrgula sturanyi* (Brusina, 1896)
■●*Ochridopyrgula macedonica macedonica* (Brusina, 1896)
■*Ochridopyrgula macedonica charensis* Radoman, 1978
■*Xestopyrgula dybowskii* (Polinski, 1929)
■*Ginaia munda sublitoralis* Radoman, 1978
■*Ginaia munda munda* (Sturany, 1894)
■*Neofossarulus stankovici* Polinski, 1929
■*Stankovicia pavlovici* (Polinski, 1929)
■*Stankovicia wagneri* (Polinski, 1929)
■*Pyrgohydrobia grochmalickii* (Polinski, 1929)
●*Pyrgohydrobia jablanicensis* Radoman, 1955
●*Pyrgohydrobia sanctinaumi* Radoman, 1955

Explanations: ■ – species found in the lake littoral; ● – species found in the lake coastal waters; ∗ – cosmopolitan species.

the second place with 43,535 ind. m^{-2}, and the poorest density is registered in the locality Kalista spring (150 ind. m^{-2}).

The species *Chilopyrgula sturanyi* and *Radix relicta* qualitatively predominate in the samples from the littoral region of the Macedonian part of Lake Ohrid. The quantitative analyses (according to their presence on m^{-2}) have shown that the following species predominated: *Valvata hirsutecostata* (13375 ind. m^{-2}), *Chilopyrgula sturanyi* (10246 ind. m^{-2}), *Pyrgohydrobia grochmalickii* (8800 ind. m^{-2}) and *Ochridopyrgula macedonica charensis* (8175 ind. m^{-2}). Data on some of endemic gastropoda species from Lake Ohrid and its watershed are given of Fig. 3.

Discussion

Lake Ohrid has not been exposed to sensitive geological changes which enabled preserving of the original conditions during its continuous existence. As a result, the whole Lake's living world has had "optimal" conditions for undisturbed evolving throughout the processes of intralaciustrine speciation and creating new species (Hadžišče 1956). Many authors (Hadžišče 1956; Hubendick & Radoman 1959; Radoman 1960) underline the process of intralucistrine speciation as a major force which has driven creating not only new species but new genus's as well. The genus *Carinogyraulus* is well illustrative example both for the intralacustric speciation and the similarity of the Lake gastropod fauna with the fauna from the adjacent water. There are four very close species of this genus inhabiting the Lake (and the adjacent waters): *Carinogyraulus lychnidicus* is limited to the middle dense belt of Charophyta, mainly in the lower-coastal littoral region of the Lake. *Carinogyraulus trapezoides* inhabits the deeper zone of 5 to 30 m depth. *Carinogyraulus crenophilus* lives in the springs around Hydrobiological Institute (adjacent waters) and *Carinogyraulus fontinalis* also inhabits the adjacent waters i.e. St. Naum springs on the southern part of the Lake. These four species belonging to the same genus have very similar morphological features, but each has its own range of distribution in different zones in the Lake and the coastal waters. According to Radoman & Marinković (1959), the spring populations could occur at a time when the lake level was higher and all the present adjacent waters were a part of the Lake.

On the other hand, dissimilarity of the gastropod fauna in the Lake and the adjacent waters could be due to the fact that after the new species have been created and the spatial isolation have happened, the faunistic exchanges between the lake and adjacent waters (ponds, current leads and sources) with which it communicates are very limited. The other fact is that the coastal waters of Ohrid valley are inhabited by widespread European faunal elements that contain very small number of endemic taxa lake. The competition factor among the lake's fauna and the fauna of the coastal waters could also prevent their interference and their intense exchanges, which perform maintenance on the large number of remnants of the former gastropods fauna. Anyway, the great spatial separation from the Lake strongly protects its fauna from the invasion of new faunistic elements. According to Stankovic (1960) 17% of the total number of endemic species of snails were able to penetrate the coastal waters of Ohrid valley.

The high diversity of the gastropod fauna in the Lake and one of the leading factors responsible for it, could be observe on the example of the three species from the genus *Pseudamnicola: Pseudamnicola sturanyi* (recorded from 0.5–20) and *Pseudamnicola pyg-*

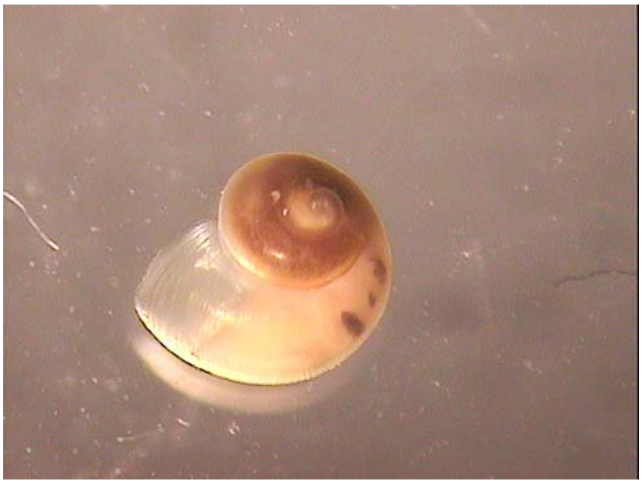
Table 3. Qualitative and quantitative composition of gastropods on the Macedonian part of Lake Ohrid and its watershed

Localities	No. of species	No. of endemic species	Total ind./m^2	Quantitative dominant species (ind./m^2)
Radozda	13	11	37299	*Radix relicta* (7850)
Livadiste	7	6	15950	*Chilopyrgula sturanyi* (6725)
Kalista	10	8	22673	*Valvata stenotrema* (8050)
Struga	12	10	35706	*Chilopyrgula sturanyi* (6922)
Sateska	7	5	9660	*Chilopyrgula sturanyi* (4011)
Podmolje	6	4	6899	*Radix relicta* (3825)
St. Erazmo	10	8	10046	*Valvata stenotrema* (3775)
Daljan	5	3	5474	*Pyrgohydrobia grochmalickii* (2500)
Grasnica	9	6	7735	*Chilopyrgula sturanyi* (2411)
Kaneo	15	12	32561	*Valvata hirsutecostata* (9000)
Pristaniste	16	13	36278	*Valvata hirsutecostata* (7175)
Mazija	10	9	15919	*Chilopyrgula sturanyi* (5325)
Park	16	14	43535	*Valvata hirsutecostata* (13375)
Gorica	10	9	14162	*Chilopyrgula sturanyi* (6350)
St. Stefan	10	8	20524	*Radix relicta* (6875)
Konsko	7	5	12025	*Ochridopyrgula m. macedonica* (6400)
Metropol	20	17	40568	*Valvata rhabdota* (7099)
Elesec	10	9	26334	*Ochridopyrgula m. charensis* (7500)
Pestani	18	16	31623	*Ochridopyrgula m. charensis* (8175)
Gradiste	10	8	11261	*Ochridopyrgula m. charensis* (3325)
Velidab	24	22	47061	*Polinskiola sturanyi* (6312)
Veljapes	10	8	5935	*Valvata relicta* (1461)
Trpejca	17	16	20548	*Polinskiola sturanyi* (4375)
Zaum	10	9	6774	*Radix relicta* (1850)
Ljubanista	9	8	14936	*Pyrgohydrobia grochmalickii* (8800)
St. Naum	15	14	29872	*Chilopyrgula sturanyi* (10246)
Kalista spring	2	1	150	*Radix relicta* (100)
Vevcani springs	0	0	0	*0*
River Crn Drim	7	3	650	*Valvata stenotrema* (525)
Koselska River	3	2	500	*Ancylus fluviatilis* (275)
Openicka River	1	0	275	*Ancylus fluviatilis* (100)
Cherava River	0	0	0	*0*
Biljana springs	7	3	725	*Gyraulus crenofilus* (500)
Bej Bunar spring	3	1	1375	*Ancylus fluviatilis* (500)
Sum spring	5	4	19958	*Pyrgohydrobia jablanicensis* (600)
SiniViroj spring	3	2	4412	*Ancylus fluviatilis* (2562)
St. Naum springs	8	6	1275	*Gyraulus fontinalis* (67)

maea (recorded from 0.5–20) and *Pseudamnicola polinskii* (0.5–2) had separated in different species as a result of the differences in the environmental conditions, i.e., existence of isolated habitats (especially in the zone of Chara) and springs (Radoman 1960). The belt of Chara as well as the local microhabitats have contributed in establishing of different settling valences. So, *Pseudamnicola sturanyi* "share" the same depth zone but have different preferential habitats. *P. sturany* reaches it maximum densities on the dense and tall Chara meadows, while *P. pygmaea* which is mostly attracted to the low dense and medium tall Chara meadow. Unlike the other two, *P. polinskii* is limited to the lower littoral on sandy-stony bottom. *P. polinskii* and *P. pygmaea* are beside in the Lake distributed in the adjacent waters (St. Naum springs, and species are also present in the adjacent waters, which is not a case with *P. polinskii.* According to Radoman (1960) the Lake's *Pseudamnicola* species have originally been spring inhabitants which secondary invaded the Lake's waters.

Different qualitative composition and density of Gastropoda (Table 3) can be explained with the different combination in the complex water conditions that happens in investigated localities, especially in habitate where they live, were different gastropod species have special affinity, like taxa *Radix relicta* on sandy bottom to 5 meters depth. Radozda locality, represents area where dominate rocky bottom facies. In locality Kalista has muddy community with well developed macrophytic vegetation. St. Naum is watershed point in southeastern littoral area which is found on beach near monastery St. Naum, where dominate sandy bottom. Habitat is important for quantitative and qualitative density of the fauna of Gastropoda.

The lowest faunal similarity among the adjacent waters has been noted between the localities along the Crn Drim River and Sini Viroj springs, as well as Sateska River and Sini Viroj springs. Sateska River performs most of the phosphorus load to the lake (Matzinger et al. 2006a) and represents a major source of organic and inorganic pollutants in the Lake Ohrid (Jordanoski et al. 2006). This river which was diverted into Lake Ohrid in 1962, runs through agricultural and urban environments and carry a big load of phosphates and sediments that are deposited in shallow waters of the lake at the mouth of the river. Therefore the three taxa of gastropods recorded in this locality are typical for this type of waters (*Viviparus viviparus, Valvata stenotrema, Radix relicta*).



Valvata stenotrema

Chilopyrgula sturanyi

Radix relicta

Ochridopyrgula macedonica charensis

Fig. 3. Endemic species of the Gastropoda fauna from Lake Ohrid.

In Lake Ohrid and its coastal waters, as it is the case with Lake Baikal, almost completely absence of exchange between Lake's endemic flora and fauna and no endemic Siberian inhabits of coastal waters is present (Stanković & Radoman, 1955).

Populations of some species are not present in the lake because of the environmental barriers and specific nature of biocenosis and nature of the bottom (Radoman 1985). The same author has an explanation for the low level of faunal exchange (immigration and emigration) between the lake and coastal waters. He underlines that the structures of biocenosis – high adjusted fauna of Lake Ohrid are adapted for survival, but was probably inferior to external species of Lake Ohrid – a scheme called eco-isolation (Boss 1978). Unfortunately, the lake is not excluded from anthropogenic pressure, "the crisis of biodiversity" (Albrecht & Wilke 2008). With the increase of anthropogenic pressure its fauna becomes easily vulnerable, and some species will disappear, which would have negative consequences for biodiversity.

References

Albrecht C., Trajanovski S., Kuhn K., Streit B. & Wilke T. 2006. Rapid evolution of an ancient lake species flock: Freshwater limpets (Gastropoda: Ancylidae) in the Balkan Lake Ohrid. Organisms, Diversity and Evolution **6 (4):** 294–307. DOI: 10.1016/j.ode.2005.12.003

Albrecht C. & Wilke T. 2008. Ancient Lake Ohrid biodiversity and evolution. Hydrobiologia **615:** 103–140. DOI: 10.1007/s10750-008-9558-y

Albrecht C., Wolf C., Glöer P. & Wilke T. 2008. Concurrent evolution of ancient sister lakes and sister species: The freshwater gastropod genus *Radix* in lakes Ohrid and Prespa. Hydrobiologia **615:** 141–156. DOI: 10.1007/s10750-008-9555-1

Bodon M., Manganelli G. & Giusti F. 2001. A survey of the European valvatiform hydrobiid genera with special reference to *Hauffenia* Pollonera, 1898 (Gastropoda: Hydrobiidae). Malacologia **43 (1-2):** 103–215.

Boss K.J. 1978. On the evolution of gastropods in ancient lakes, pp. 385–428. In: Fretter V. & Peake J. (eds), Pulmonates, Vol. 2a: Systematics, Evolution and Ecology, Academic Press, London, New York, San Francisco, 540 pp. ISBN: 0122675029, 9780122675027

Budzakoska-Gjoreska B. 2012. Gastropoda from Lake Ohrid and its watershed as a object of developing GIS monitoring according to EU Water Framework Directive. Doctoral dissertation. Sts. Cyril and Methodius University, Faculty of Nat-

ural Sciences and Mathematics, Institut of biology, Skopje, Macedonia.
Dillon R.T. Jr. 2006. Freshwater Gastropoda. Chapter 21, pp. 251–260. In: Sturm C.F., Pierce T.A. & Valdes A. (eds), The Mollusks: A Guide to Their Study, Collection and Preservation, American Malacological Society, Pittsburgh, PA, 445 pp. ISBN: 1581129300, 9781581129304
Glöer P. & Meier-Brook C. 2003. Süßwassermollusken. Ein Bestimmungsschlüssel für die Bundesrepublik Deutschland. 13. Neubearbeitete Auflage. Deutscher Jugendbund für Naturbeobachtung, Hamburg, 134 pp.
Hadžišče S. 1956. III Beitrag zur Kenntnis der Gastropodenfauna des Ohridsees. Beschreibungen der bis jetzt unbekannten Schnecken und Beispiele der Speciation bei den Gastropoden des Ohridseee. Zbornik na Rabotite, Chidrobioloshki Zavod Ochrid [Recueil des Traveaux, Station Hydrobiologique Ohrid] **4 (1 (14)):** 57–107.
Hadžišče S. 1974. The fauna of snails (gastropods) on the lake as a group rich in animal endemic forms and its distribution in individual zones of bentic region, pp. 259–271. In: Symposium on issues of regulation of Lake Ohrid, MANU, Skopje.
Hubendick B. 1960. Faunistic review of the Ancylidae of Lake Ohrid. Arhiv Biol. Nauka **13 (3–4):** 89–97.
Hubendick B. 1970. Studies on Ancylidae. The Palearctic and Oriental species and formgroups. Acta Regiae Societatis Scientiarum et Litterarum, Gothoburgensis, Zoologica **5**, 52 pp.
Hubendick B. & Radoman P. 1959. Studies on the *Gyraulus* species of Lake Ohrid. Morphology. Arkiv för Zoologi (Stockholm) **12 (16):** 223–243.
Jordanoski M., Lokoska L. & Veljanoska S.E. 2006. The river Sateska and consequences of its divers in to Lake Ohrid. BALWOIS, Conference on Water Observation and Information Systems for Decision Support. http://balwois.com/balwois/administration/full paper/ffp-584.
Lind O.T. 1985. Handbook of Common Methods in Limnology. The C.V. Mosby Company, St. Luis-Toronto-London, 199 pp. ISBN-10: 0840337531, ISBN-13:978-0840337535
Mandaville S.M. 2002. Benthic Macroinvertebrates in Freshwaters – Taxa Tolerance Values, Metric, and Protocols. (Project H-1) Soil & Water Conservation Society of Metro Halifax, 48 pp. & Appendix **A**: 58 pp, Appendix **B**: 4 pp. http://lakes.chebucto.org/H-1/tolerance.pdf (accessed 15.09.2013)
Matzinger A., Jordanoski M., Veljanovska-Sarafiloska E., Sturm M., Müller B. & Wüest A. 2006a. Is Lake Prespa jeopardizing the ecosystem of ancient Lake Ohrid? Hydrobiologia **553 (1):** 89–109. DOI: 10.1007/s10750-005-6427-9
Matzinger A., Spirkovski Z., Patceva S. & Wüest A. 2006b. Sensitivity of ancient Lake Ohrid to local anthropogenic impacts and global warming. J. Great Lakes Res. **32 (1):** 158–179. DOI: 10.3394/0380-1330(2006)32[158:SOALOT]2.0.CO;2
Naumoski T., Jordanoski M. & Veljanoska-Sarafiloska E. 2007. Physical and chemical characteristics of Lake Ohrid, pp. 42–43. In: 1st International Symposium for Protection of Natural Lakes in Republic of Macedonia, Proceedings, Hydrobiological Institute, Ohrid.
Perez K.E., Clark S. & Lydeard A. 2004. Freshwater Gastropod Identification Workshop. "Showing your Shells". A primer to Freshwater Gastropod Identification. Freshwater Mollusk Conservation Society, University of Alabama, Tuscaloosa, Alabama, 61 pp.
Polinski V. 1929. Limnological investigations of Balkan Peninsula. Relict gastropod fauna of Lake Ohrid. Monographs Serb. Acad. Sci. Belgrade **173 (65):** 131–178.
Radoman P. 1960. Two sibiling species of *Pseudamnicola* in Lake Ohrid. Basteria **24 (1-2):** 1–9.
Radoman P. 1983. Hydrobioidea, a superfamily of Prosobranchia (Gastropoda). I. Systematics. Monographs Serb. Acad. Sci. Belgrade, 256 pp.
Radoman P. 1985. Hydrobioidea, a superfamily of Prosobranchia (Gastropoda). II. Origin, Zoogeography, Evolution in the Balkans and Asia Minor. Posebna izdanja Srpska akademija nauka i umetnosti – Kniha 547, Serbian Academy of Sciences and Arts, Monographs Institute of Zoology 1, Belgrade, 173 pp.
Radoman P. & Marinkovič D. 1959. One such foundation species in the Ohrid basin. Arch. Biol. Sci. Belgrade **9 (1-4):** 73–75.
Rosenberg D.M., Davies D., Cobb G. & Wiens A.P. 1997. Protocols for Measuring Biodiversity: Benthic Macroinvertebrates in Fresh Waters. Department of Fisheries and Oceans, Freshwater Institute, 501 University Crescent, Winnipeg, Manitoba, R3T 2N6, 43 pp.
Stanković S. 1960. The Balkan Lake Ohrid and its Living World. Monographie Biol., Den Haag, W. Yunk, 357 pp.
Stanković S. & Radoman P. 1955. Le peuplement des eaux littorales adjacentes du Bassin d' Ohrid. Arch. Sci. Biol. Beograd **7 (1-2):** 1–19.
Trajanovska S. 2009. Taxonomy, ecology and status of charophytes flora (Charophyta) in Lake Ohrid. Doctoral thesis. Sts. Cyril and Methodius University, Faculty of Natural Sciences and Mathematics, Institut of Biology, Skopje, Macedonia.
Wagner B., Lotter F.A., Nowaczyk N., Reed M.J.L., Schwalb A., Sulpizio R., Valsecchi V., Wessels M. & Zanchetta G. 2008. A 40,000-year record of environmental change from ancient Lake Ohrid (Albania and Macedonia). J. Paleolimnol. **41:** 407–430. DOI: 10.1007/s10933-008-9234-2
Wetzel R.G. 1975. Limnology. W.B. Saunders College Publishing, Philadelphia, 743 pp. ISBN: 0721692400, 9780721692401
Wetzel R.G. & Likens G. 1979. Limnological Analyses. W. B. Saunders comp. Philadelphia, London, Toronto, 357 pp.

Received March 22, 2013
Accepted May 2, 2014