THE DIVERSITY OF AQUATIC MACROPHYTES IN THE TRANSBOUNDARY LAKES OF SHKODRA, OHRID AND PRESPA - ALBANIAN PART

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Abstract

The present study is based chiefly on personal long term investigations and field data, collected in summer season 2009 (in Lake Ohrid) and 2013 (in Lake Shkodra and Lake Macro Prespa), (only in Albanian part of them), using the transect method. Supplementary data from the National Herbarium in Tirana and the existing literature were used for the compilation of the complete list of macrophytes. A total of 96 aquatic macrophyte species with moisture indicator 10 and up, belonging to three ecological groups, were recorded. The highest macrophytic diversity resulted in Shkodra with 80 species, followed by Prespa, with 64 species and Ohrid with 49 species only. Comparing historical and recent data on species distributions in Albanian part of these lakes, some changes in species composition were reported.

Përmbledhje

Ky studim mbështetet kryesisht në kërkimet tona afatgjata dhe në të dhënat e mbledhura në terren në stinën e verës 2009 (në Liqenin e Ohrit) dhe 2013 (në Liqenin e Shkodrës dhe Liqenin e Prespës së Madhe), (vetëm në pjesën shqiptare të tyre), duke përdorur metodën e transektit. Për të përpiluar listën e plotë të makrofiteve janë përdorur të dhëna shtesë nga Herbari Kombëtar në Tiranë dhe nga literatura në dispozicion. Në punim jepen gjithsej 96 specie makrofitesh ujore me tregues lagështie 10 e lart, që i përkasin tre grupeve ekologjike. Me diversitet më të lartë rezulton Liqeni i Shkodrës me 80 specie, i ndjekur nga Liqenet e Prespës me 64 specie dhe Liqeni i Ohrit me 49 specie. Duke krahasuar të dhënat historike me ato të kohëve të fundit, në lidhje me përhapjen e specieve në pjesën shqiptare të këtyre liqeneve, raportohen disa ndryshime që kanë ndodhur në përbërjen e specieve.

Key words: Albania, Lake Shkodra, Lake Ohrid, Prespa Lakes, macrophyte diversity.

Introduction

Lake Shkodra, Lake Ohrid and Prespa lakes are the largest lakes on Balkans and represent ecosystems of particular interest in terms of biodiversity. Lake Shkodra is situated at 6 m a.s.l., on the border between Albania and Montenegro, with an average surface of 475 km^2 and less than 10 meters deep. The water is moderately clear with transparency (Secchi depth) from 2 to 3 meters (Skarbøvik

et al., 2008); the lake was classified as oligo-mesotrophic (UNECE, 2011). Lake Ohrid is the deepest of Balkan, and one of the European deepest and oldest lakes, situated at 695m a.s.l, situated on the border between FYR of Macedonia and Albania. The water is exceptionally clear with transparency from 10 to 20.5 meters and lake was classified as oligotrophic (UNECE, 2011). Prespa lakes, Micro and Macro Prespa, are among the oldest and highest tectonic lakes in Europe. Macro Prespa is large (about 254 km^2), relatively shallow lake, with an average depth of about 14 m and a maximum depth of 48 m, lying at a high altitude of about 850 m a.s.l. The water is moderately clear with transparency from 2 to 3 meters (Skarbøvik et *al.*, 2008); the lake was classified as oligo-mesotrophic (UNECE, 2011).

All three lakes were managed for fishing and waterfowl and have served as a major feeding and resting area for migrating birds due to its diverse population of aquatic macrophytes. Due to their integrate values, the Albanian parts of Shkodra and Orid lakes hold the protection state of a Managed Natural Reserve (IUCN Category IV). Shkodra and Prespa lakes are included in the Ramsar list of protected areas. The Montenegrin part of Shkodra is also protected as National Park; while the whole Prespa is actually protected as International Park. Recently (in 2014), the Albanian-Macedonian part of the Ohrid-Prespa is designated as Transboundary Biosphere Reserve.

Macrophytes are one of the essential components for ecosystem functioning and aquatic biodiversity conservation. The communities of submerged and floating hydrophytes are important for storing nutrients, as an important food source for herbivorous fish and waterfowl, as spawning habitats for different aquatic organisms, such as fish, invertebrates, etc. The reedbed serve as a key habitat for the wildlife, especially for birds but also for amphibians and invertebrates.

The earliest sources about the presence of aquatic plants are referred to the late 19th century (Grimburg, 1871; Ascherson & Kanitz, 1877). During WW I, some floristic studies in the area of Lake Shkodra were carried on, from which Janchen (1920) and Schütt (1945) provided more complete data.

Later publications provide reports of new species for all three lakes and data on the distribution of rare and endangered plants (Paparisto & Qosja, 1976; 1981; Ruci, 1983; Mersinllari, 1997; Kashta & Rakaj, 1999; 2001; 2003; 2013; Kashta, 2007; 2009; Rakaj & Kashta, 1999; 2009; 2011; Perçini, 2010; Barina *et al.*, 2011; Rakaj & Hyseni, 2012; Kashta *et al.*, 2013; etc.)

In the present study we aim to summarize knowledge about the diversity and to reveal the differences and similarities of the macrophyte vegetation in Albanian part of these important aquatic ecosystems.

Material and methods

The present study is based chiefly on personal long term investigations and field data collected in summer 2009 (in lake Ohrid) and 2013 (in Lake Shkodra and Lake Macro Prespa) (in Albanian part of lakes), using the transect method. The collection of submerged and floating-leaved plants is done by boat, dropping a double-headed rake with an attached measured rope, at different depths, from the shoreline to the maximum depth of plant growth. In total 13 transects were carried out, six in Lake Shkodra, five in Lake Ohrid and two in Macro Prespa.

All plants observed were collected and identified at the species level using appropriate keys (Casper & Krausch, 1980/1981; Krause, 1997; Bazzichelli & Abdelahad, 2009). Voucher specimens are housed at National Herbarium in Tirana. Supplementary data from National Herbarium and literature were used for the compilation of the complete list of macrophytes of all three lakes.

The main historical and new literature sources were: Grimburg (1871); Janchen (1920); Bertram (1930); Schütt (1945); Hőpflinger (1964); Markgraf (1927); Paparisto & Qosja (1976; 1981); Ruci (1983); Mersinllari (1997); Mullaj & Ruci (2000); Kashta & Rakaj (1999; 2001; 2003; 2013); Kashta (2007; 2009); Rakaj & Kashta (2009); Perçini (2010); Barina *et al.* (2011); Rakaj & Hyseni (2012); Rakaj *et al.* (2013); Kashta *et al.* (2013); Zeneli & Kashta (2014); Trajanovska *et al.* (2014).

The present list of macrophytes was compiled taking in consideration only species with moisture indicator values of 10 and up (Ellenberg, 1991) as follows: 10 - Indicator of shallow-water sites that may lack standing water for extensive periods; 11 - Plant rooting under water, but at least for a time exposed above or plant floating on the surface; 12 - Submerged plant, permanently or almost constantly under water.

Sørensen's similarity coefficient (QS) was used to determine the degree of similarity of macrophyte species collected.

Results and discussions

According to floristic analysis in all three lakes 96 species were recorded. In decreasing order, the lakes with more species were Shkodra, Prespa and Ohrid, with 80, 64, and 49 species, respectively. Appendix 1 shows the list of species recorded at each lake.

All species belong to three different groups: 22 stoneworts (Charophyta), 3 ferns (Pteridophyta) and 71 angiosperms (Magnoliophyta); hence, 22 species were algae (Charophyta) and 74 vascular plants. The higher number of Charophyta species was found in Ohrid (Tab. 1).

The most represented families were Characeae, with 22 species (23%), and Potamogetonaceae, with 13 species (13.5%). In total there were 24 families and 49 genera, with a different distribution: 23 families and 47 genera in Shkodra, 17 families and 27 genera in Ohrid, and 22 families and 42 genera in Prespa (Appendix 1). The highest diversity was in Shkodra with about 80 species, then in Prespa, with 64 species and lowest in Ohrid with 49 species (Tab. 1).

Table 1. Number of species and proportion according to taxonomic groups at each lake (in Albanian part).

Taxonomic groups	Lake Shkodra	Lake Ohrid	Prespa lakes	Total
Charophyta	10 (12.5%)	13 (26.5%)	10 (15.6%)	22 (22.9%)
Pteridophyta	2 (2.5%)	-	1 (1.56%)	3 (3.12%)
Angiospermae	68 (85%)	36 (73.4%)	53 (82.8%)	71 (73.95%)
Total	80	49	64	96

The relatively high species richness of Shkodra and Prespa can be explained by the high ecological diversity or different wetland habitats types and nutrient rich waters, compared to oligotrophic waters of Ohrid.

Due to its shallowness and diversity of littoral micro-habitats, Lake Shkodra potentially can support more diverse and healthy population of aquatic macrophytes (Rakaj & Kashta, 2010). A large surface is covered by permanent/freshwaters marshes/pools habitat in Shkodra, and the same, but with a smaller surface extended in Prespa, quite favorable for the life.

In general, the macrophyte vegetation of these lakes is distributed in vertical belts. In littoral habitats of all three lakes, it is dominated by emerged plants, represented mainly by *Phragmites australis*, and lesser by *Schoenoplectus lacustris* and *Typha latifolia,* covering a large surface in Shkodra and Micro Prespa lakes.

Floating leaf plants are found mainly in wind-sheltered and marshy habitats, dominated by *Nuphar lutea* and *Nymphaea alba* in Shkodra, *Persicaria amphibia* in Ohrid, *Nymphoides peltata* and *Persicaria amphibia* in Macro Prespa, *Nuphar lutea, Nymphaea alba* and *Hydrocharis morsus-ranae* in Micro Prespa.

Submerged macrophytes were present in lacustrin habitats. *Ceratophyllum demersum*, *Potamogeton perfoliatus, Potamogeton lucens*, *Vallisneria spiralis* and *Najas marina* were the most frequent in Shkodra (Kashta & Rakaj, 2013; Zeneli & Kashta, 2014). *Ceratophyllum demersum, Myriophyllum spicatum* and *Nitellopsis obtusa* were the most commonly encountered in Prespa, showing also higher abundance (Kashta & Rakaj, 2013). The submersed vegetation of Ohrid is

characterized by large meadows of charophytes, dominated by *Chara tomentosa*. Other frequent macrophytes were: *Potamogeton perfoliatus, Myriophyllum spicatum* and *Elodea canadensis* (Perçini, 2009; Kashta *et al*., 2013).

Table 2. Number of species according to ecological groups at each lake (in Albanian part).

Ecological groups	Lake Shkodra	Lake Ohrid	Prespa lakes	Total
Submersed	29	27	26	41
Floating (and floating-leaves)	23	10	17	24
Emergent	28	12	21	31
Total	80	49	64	96

There were some differences in spatial aspect: growth form, depth and zonation in particular parts of the lakes, like marshes and inundation areas. Shkodra and Prespa lakes were characterized by almost the same proportion of submersed and emerged species, while Ohrid was dominated by submersed species, especially by charophytes (Fig. 1, Tab. 2).

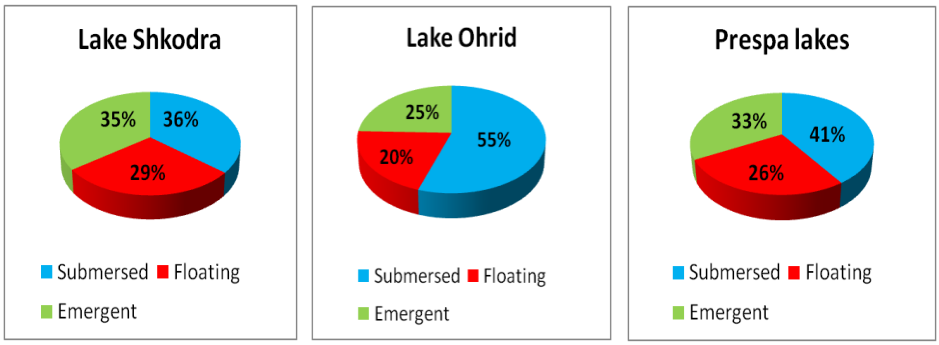

Figure 1. The percentage of species composition according to ecological groups

The maximum growth depth of submerged vascular macrophytes, along all transects, was 6.7 m, 8 m and 5.8 m, recorded respectively in Shkodra, Ohrid and Prespa (Kashta & Rakaj, 2013; Zeneli & Kashta, 2014; Perçini, 2009). It is important to highlight that the maximum depth growth of Charophyta, recorded in Ohrid, was 20 m (Kashta *et al*., 2013). As it is known from several studies the depth limit of submerged plants appears to be well correlated with water transparency (Canfield *et al.*, 1985; Caffrey *et al.*, 2007). The high value of

maximum depth growth of macrophytes in Ohrid can be explained with high transparency of the lake compared to lower transparency of Shkoder and Prespa.

Sørensen's similarity coefficient (QS) among different lakes was shown in table 3. The highest similarity was between Shkodra and Prespa up to 75 %.

Table 3. Number of common species and similarity (Sorensen index) among lakes (Albanian part).

Lakes	Number of common species	% Similarity (Ss)
Lake Shkodra & Lake Ohrid	40	62
Lake Shkodra & Prespa lakes	54	75
Lake Ohrid & Prespa lakes	41	72.5

All three lakes are under human pressure, especially during the last decades. The human impact include alteration of the hydrological regime and water abstraction, agricultural as well as industrial pollution and pollution from municipal wastewater, expansion of tourism areas and related infrastructure, introduction of alien species, etc. (UNECE, 2011), with consequences for ecosystems and their biota.

Comparing historical and recent data on aquatic macrophytes distributions in Albanian part of the lakes, some changes in species composition have occurred over time. Significant changes, with a drastic increase of the floating/emergent vegetation, especially reedbed, were observed in Micro Prespa (Shuka *et al.*, 2008). *Trapa natans* is currently widespread on the lake; it was referred non-frequent, even somewhere as rare fruits along the shore of Shkodra by Grimburg (1871) and Janchen (1920). Some species were present in Shkodra, like *Hydrocharis morsus-ranae, Hydrocotyle vulgaris, Spirodela polyrhiza* and *Caldesia parnassifolia*; they have not been recorded in previous studies, despite numerous surveys (Kashta & Rakaj, 1999; 2003). The water fern, *Marsilea quadrifolia*, can be considered almost extinct in Shkodra, since it was not found after its first collection in 1927 by Schütt (exsiccate at the Herbarium in Bremen, Germany). It should be noted the introduction of invasive alien species, like *Elodea canadensis*; expanded from Ohrid to Prespa lakes, and to Shkodra the last years; moreover *Azolla filiculoides* was found in Macro Prespa in 2012 (Bárina *et al.*, 2013).

Conclusions

The obtained results from our study and long-term research on macrophyte vegetation, suggest that there are favorable ecological conditions for intense growth and development of macrophyte vegetation in Albanian part of the three

transboundary lakes of Shkodra, Ohrid and Prespa. Their diversity of macrophytes is relatively rich. Lakes Shkodra and Prespa shelter more species, most of them with conservation interests. Ohrid is the richest in charophytes, including endemic, rare and threatened species. Differences in the number and species composition, among the three lakes, appear to be the result of differences in ecological conditions in their littoral areas.

All three lakes have been subject of increasing human pressure, especially during the last decades, which is expressed in some changes in species composition, including the introduction of alien species. Uncontrolled expansion of invasive alien species can potentially impact the native macrophyte vegetation in the future.

The results presented in this paper can be used as a basis for further studies and monitoring of aquatic flora of these lakes.

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Appendix 1. List of macrophytes recorded in three transboundary lakes (only Albanian part).

No.	Scientific name	Family	Shkodra	Ohrid	Prespa
I.	**AQUATIC BED VEGETATION**				
	Charophyta				
1.	*Chara aspera* Willd.	Characeae		+	
2.	*Chara contraria* A. Br. ex Kütz.	Characeae			+
3.	*Chara denudata* A.Br.	Characeae			+
4.	*Chara fragifera* Durieu de Mais.	Characeae	+		
5.	*Chara globularis* Thuill.	Characeae	+	+	+
6.	*Chara gymnophylla* A.Br.	Characeae		+	+
7.	*Chara hispida* L.	Characeae		+	
8.	*Chara imperfecta* A.Br.	Characeae		+	
9.	*Chara kokeillii* A.Br.	Characeae	+	+	+
10.	*Chara ohridana* Kostic	Characeae		+	+
11.	*Chara tenuispina* A.Br.	Characeae			+
12.	*Chara tomentosa* L.	Characeae		+	
13.	*Chara vulgaris* L.	Characeae	+		
14.	*Nitella confervacea* (Bréb). A. Br.	Characeae	+		
15.	*Nitella flexilis* (L.) C.Ag.	Characeae		+	
16.	*Nitella hyalina* (DC) C.Ag.	Characeae		+	
17.	*Nitella mucronata* (A.Br.) Miq.	Characeae		+	+
18.	*Nitella opaca* (C.Ag.) C. Ag.	Characeae	+		
19.	*Nitella syncarpa* (Thuill.) Kütz.	Characeae	+	+	+
20.	*Nitella tenuissima* (Desv.) Kütz.	Characeae	+		
21.	*Nitellopsis obtusa* (Desv.) J. Grov.	Characeae	+	+	+
22	*Tolypella glomerata* (Desv.) Leonh.	Characeae	+		
	Pteridophyta - Polypodiopsida				
23.	*Azolla filiculoides* Lam.	Azollaceae			+
24.	*Marsilea quadrifolia* L.	Marsileaceae	+		
	Angiospermae				
25.	*Caldesia parnassifolia* (L.) Parl.	Alismataceae	+		
26.	*Callitriche cophocarpa* Sendt.	Plantaginaceae	+		
27.	*Callitriche lenisulca* Clavaud	Plantaginaceae	+		
28.	*Callitriche palustris* L.	Plantaginaceae	+	+	+
29.	*Callitriche stagnalis* Scop.	Plantaginaceae	+		+
30.	*Ceratophyllum demersum* L.	Ceratophyllaceae	+	+	+
31.	*Ceratophyllum submersum* L.	Ceratophyllaceae	+	+	+

No.	Scientific name	Family	Shkodra	Ohrid	Prespa
32.	*Hydrocharis morsus-ranae* L.	Hydrocharitaceae	+		+
33.	*Elodea canadensis* Michx.	Hydrocharitaceae	+	+	+
34.	*Groenlandia densa* (L.) Fourr.	Potamogetoniaceae	+		+
35.	*Lemna gibba* L.	Araceae	+	+	+
36.	*Lemna minor* L.	Araceae	+	+	+
37.	*Lemna trisulca* L.	Araceae	+	+	
38.	*Myriophyllum spicatum* L.	Halorrhagidaceae	+	+	+
39.	*Myriophyllum verticillatum* L.	Halorrhagidaceae	+	+	+
40.	*Najas marina* L.	Hydrocharitaceae	+		+
41.	*Najas minor* Allioni	Hydrocharitaceae	+	+	+
42.	*Nuphar lutea* (L.) Smith	Nymphaeaceae	+		+
43.	*Nymphaea alba* L.	Nymphaeaceae	+		+
44.	*Nymphoides peltata* (S.Gmel.) O.Kuntze	Menyanthaceae	+		+
45.	*Persicaria amphibia* (L.) Delarbre	Polygonaceae	+	+	+
46.	*Potamogeton coloratus* Hornem.	Potamogetonaceae	+		
47.	*Potamogeton crispus* L.	Potamogetonaceae	+	+	+
48.	*Potamogeton gramineus* L.	Potamogetonaceae	+		
49.	*Potamogeton lucens* L.	Potamogetonaceae	+	+	+
50.	*Potamogeton natans* L.	Potamogetonaceae	+	+	+
51.	*Potamogeton nodosus* Poiret	Potamogetonaceae	+	+	+
52.	*Potamogeton perfoliatus* L.	Potamogetonaceae	+	+	+
53.	*Potamogeton praelongus* Wulfen	Potamogetonaceae	+		
54.	*Potamogeton pusillus* L.	Potamogetonaceae	+	+	+
55.	*Potamogeton trichoides* Cham. & Schleht.	Potamogetonaceae	+		
56.	*Ranunculus aquatilis* L.	Ranunculaceae	+		
57.	*Ranunculus tricophyllus* Chaix	Ranunculaceae	+	+	+
58.	*Spirodela polyrhiza* (L.) Schleid	Araceae	+		+
59.	*Stukenia pectinatus* (L.) Börner	Potamogetonaceae	+	+	+
60.	*Trapa natans* L.	Lythraceae	+		+
61.	*Utricularia australis* R. BR.	Lentibulariaceae	+	+	+
62.	*Utricularia minor* L.	Lentibulariaceae	+	+	+
63.	*Utricularia vulgaris* L.	Lentibulariaceae	+	+	+
64.	*Vallisneria spiralis* L.	Hydrocharitaceae	+	+	+
65.	*Zannichellia palustris* L.	Potamogetonaceae	+	+	+
II.	**EMERGENT VEGETATION**				
	Pteridophyta (Equisetopsida)				
66.	*Equisetum fluviatile* L.	Equisetaceae	+		

No.	Scientific name	Family	Shkodra	Ohrid	Prespa
	Angiospermae				
67.	*Alisma gramineum* Lej.	Alismataceae			+
68.	*Alisma lanceolatum* With.	Alismataceae	+		+
69.	*Alisma plantago-aquatica* L.	Alismataceae	+	+	+
70	*Baldellia ranunculoides* (L.) Parl.	Alismataceae			+
71.	*Berula erecta* (Huds.) Coville	Apiaceae	+	+	+
72.	*Butomus umbellatus* L.	Butomaceae	+		+
73.	*Carex rostrata* Stokes	Cyperaceae	+		
74.	*Cladium mariscus* (L.) Pohl	Cyperaceae	+		
75.	*Eleocharis acicularis* (L.) Roem. & Schult.	Cyperaceae	+		
76.	*Eleocharis palustris* (L.) Roem. & Schult.	Cyperaceae	+	+	+
77.	*Eleocharis uniglumis* (Link) Schult.	Cyperaceae	+		
78.	*Glyceria notata* Chevall.	Poaceae	+		
79.	*Hippuris vulgaris* L.	Plantaginaceae	+		+
80.	*Nasturtium officinale* (L.) R. Br.	Brassicaceae	+	+	+
81.	*Oenanthe aquatica* (L.) Poiret		+	+	+
82.	*Phragmites australis* (Cavan) Trin	Poaceae	+	+	+
83.	*Ranunculus lingua* L.	Ranunculaceae	+		
84.	*Ranunculus sceleratus* L.	Ranunculaceae			+
85.	*Rorippa amphibia* (L.) Besser	Brassicaceae	+		+
86.	*Rumex hydrolapathum* Huds.	Polygonaceae	+	+	+
87.	*Sagittaria sagittifolia* L.	Alismataceae	+		+
88.	*Scirpoides holoschoenus* (L.) Soják	Cyperaceae	+		+
89.	*Sium latifolium* L.	Apiaceae	+		
90.	*Schoenoplectus lacustris* (L.) Palla susbp. *lacustris*	Cyperaceae	+	+	+
91.	*Schoenoplectus lacustris* (L.) Palla susbp. *glaucus* (Sm.) Bech.	Cyperaceae	+		
92.	*Sparganium emersum* Rehmann	Typhaceae	+		
93.	*Sparganium erectum* gr. L.	Typhaceae	+	+	+
94.	*Typha angustifolia* L.	Typhaceae	+	+	+
95.	*Typha latifolia* L.	Typhaceae	+	+	+
96.	*Veronica beccabunga* L.	Scrophulariaceae	+	+	+
	Total		**80**	**49**	**64**