TRANSYLVANIAN REVIEW OF SYSTEMATICAL AND ECOLOGICAL RESEARCH

24.3

The Wetlands Diversity

Editors

Angela Curtean-Bănăduc, Teodora Trichkova & Doru Bănăduc

Sibiu – Romania
2022

TRANSYLVANIAN REVIEW OF SYSTEMATICAL AND ECOLOGICAL RESEARCH

24.3

The Wetlands Diversity

Editors

Doru Bănăduc, Teodora Trichkova &Angela Curtean-Bănăduc

Applied Ecology Research Center,
"*Lucian Blaga*" University of Sibiu

Ecotur Sibiu N.G.O., Romania	"*Lucian Blaga*" University of Sibiu, Romania	International Association for Danube Research	Applied Ecology Research Center of *LB*US, Romania	Broward College, Fort Lauderdale, USA	Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences

Sibiu – Romania
2022

Scientifical Reviewers

Sergey AFANASYEV
Institute of Hydrobiology of the National Academy of Sciences of Ukraine,
Kyiv – Ukraine.

John Robert AKEROYD
Sherkin Island Marine Station,
Sherkin Island – Ireland.

Sophia BARINOVA
Institute of Evolution, University of Haifa,
Haifa – Israel.

Doru BĂNĂDUC
"Lucian Blaga" University of Sibiu,
Sibiu – Romania.

Ioana BOERAŞ
"Lucian Blaga" University of Sibiu,
Sibiu – Romania.

Alexandru BURCEA
"Lucian Blaga" University of Sibiu,
Sibiu – Romania.

Kevin CIANFAGLIONE
Université de Lorraine,
Vandoeuvre-lés-Nancy – France.

Angela CURTEAN-BĂNĂDUC
"Lucian Blaga" University of Sibiu,
Sibiu – Romania.

Constantin DRĂGULESCU
"Lucian Blaga" University of Sibiu,
Sibiu – Romania.

Emily ELSNER
Elsner Research and Consulting,
Zürich – Switzerland.

Nicolae GĂLDEAN
Ecological University of Bucharest,
Bucharest – Romania.

Sanda MAICAN
Romanian Academy Institute of Biology,
Bucharest – Romania.

Grant S. MCCALL
Center for Human-Environmental Research,
New Orleans, Louisiana – USA.

Alexander PROTASOV
Institute of Hydrobiology of National Academy of Sciences,
Kyiv – Ukraine.

Geta RÎŞNOVEANU
University of Bucharest,
Bucharest – Romania.

David SERRANO
Broward College,
Fort Lauderdale, Florida – United States of America.

Erika SCHNEIDER-BINDER
Karlsruhe University, Institute for Waters and River Basin Management,
Rastatt – Germay.

Editorial Assistants

IN MEMORIAM

Oleksiy DZYZIUK

(1975 – 2022)

Mr. ***Oleksiy Dzyziuk*** was a Ukrainian zoologist, nature conservationist, and researcher of the vertebrate fauna. He was born on October 13, 1975, into a large family in the nice Cossack village of Novoprokopivka, Tokmatsky district, Zaporizhia region of Ukraine. As a kid, he was excited by nature and interested in his country nature. This determined his life. While studying at school, he was the winner of many competitions in natural sciences.

In the autumn of 1992, *Oleksiy Dzyziuk* studied in the Faculty of Biology at Zaporizhia University. During this period, he conducted active public and environmental work and led a group of young ornithologists for the education of schoolchildren. Oleksiy was able to gather like-minded people around him and was a man of principle and a patriot of his country. In the first year, the University officials wanted to expel him from the university for refusing to take one of the exams in Russian, insisting on his right to Ukrainian. Then his entire course in support also refused to take this subject in Russian. Together with like-minded people, he took an active part in many nature protection and anti-poaching raids. In 1996, Oleksiy was able to turn this activity into an official one, and with his active participation, the Nature Protection Group was founded at Zaporizhzhya State University, which he headed. In addition to community service, he also worked as a biology teacher at school, and published nature articles in a student newspaper. He was married and had two daughters.

After graduating from the university in 1997, *Oleksiy Dzyziuk* began working in the Lviv region, in the Society of Military Hunters and Fishermen of the Western Region of Ukraine. In 2000 he became the director of the Maidan Hunting and Fishing Farm (Vereshchytsia village, Yavoriv district, Lviv region) located within the International Biosphere Reserve “Roztochchya”. With his arrival at this job, the nature-based economy began to grow rapidly. For this and other zoological and environmental projects, he successfully involved teachers and young environmentalists and ecologists from the Lviv City Children’s Ecological and Naturalistic Center for several years. During this time, he also conducted active scientific work and wrote more than 15 scientific publications on the vertebrate fauna of the International Biosphere Reserve “Roztochchya”, in particular in co-authorship with the famous Ukrainian ornithologist Dr. *Ihor HORBAN*. He also actively collaborated with scientists from the Yavorivskyi National Nature Park, the Roztocze Nature Reserve, and the Western Ukrainian Ornithological Society. In 2004 he was elected a deputy of the local self-government body. He held this public office service for three terms.

Oleksiy Dzyziuk was a hard-working, versatile, and erudite scientist, who actively studied and protected the nature of the International Biosphere Reserve "Roztochchya", and successfully helped to educate young zoologists and ecologists, who sought to be useful to the local community. He was a true patriot of Ukraine.

In 2014 he was an active participant in the Russian influenced terrorist events on the Maidan in Kyiv and the Revolution of Dignity in Ukraine. After the armed invasion and annexation of Crimea by the army of Russia’s President Putin in the east of Ukraine, Oleksiy voluntered to join the Armed Forces of Ukraine. He served during several rotations in the zone of operations of the Joint Forces of Ukraine in the Donetsk and Luhansk regions, in the newly-started Russian-Ukrainian armed confrontation on Ukrainian territory.

On March 22, 2022, ***Oleksiy Dzyziuk*** died as a hero, defending Ukrainean civilian lives, his country’s freedom, and the corner-stone beliefs of democracy and liberty of the free world. He was killed by Russians near the town of Popasna in the Donetsk region of Ukraine. He is buried in the cemetery of the village of Vereshchytsia in the Lviv region.

Bohdan PROTS and *Andriy KYIKO*

CONTENTS

Preface

In a global environment in which the climate changes are observed from few decades no more only through scientific studies but also through day by day life experiences of average people which feel and understand allready the presence of the medium and long-term significant change in the "average weather" all over the world, the most comon key words which reflect the general concern are: heating, desertification, rationalisation and surviwing.

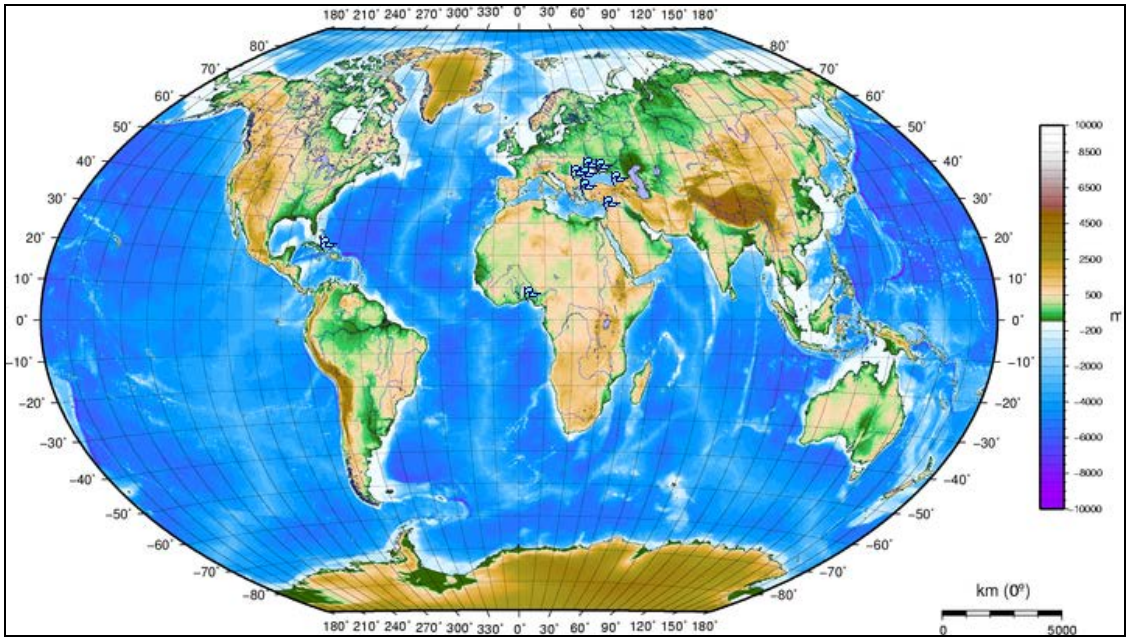
The causes, effects, trends and possibilities of human society to positively intervene to slow down this process or to adapt to it involve a huge variety of aproacess and efforts.

With the fact in mind that these aproaces and efforts shuld be based on genuine scientific understanding, the editors of the *Transylvanian Review of Systematical and Ecological Research* series launch three annual volumes dedicated to the wetlands, volumes resulted mainly as a results of the *Aquatic Biodiversity International Conference*, Sibiu/Romania, 2007-2017.

The therm wetland is used here in the acceptance of the Convention on Wetlands, signed in Ramsar, in 1971, for the conservation and wise use of wetlands and their resources. **Marine/Coastal Wetlands** – Permanent shallow marine waters in most cases less than six metres deep at low tide, includes sea bays and straits; Marine subtidal aquatic beds, includes kelp beds, sea-grass beds, tropical marine meadows; Coral reefs; Rocky marine shores, includes rocky offshore islands, sea cliffs; Sand, shingle or pebble shores, includes sand bars, spits and sandy islets, includes dune systems and humid dune slacks; Estuarine waters, permanent water of estuaries and estuarine systems of deltas; Intertidal mud, sand or salt flats; Intertidal marshes, includes salt marshes, salt meadows, saltings, raised salt marshes, includes tidal brackish and freshwater marshes; Intertidal forested wetlands, includes mangrove swamps, nipah swamps and tidal freshwater swamp forests; Coastal brackish/saline lagoons, brackish to saline lagoons with at least one relatively narrow connection to the sea; Coastal freshwater lagoons, includes freshwater delta lagoons; Karst and other subterranean hydrological systems, marine/coastal. **Inland Wetlands** – Permanent inland deltas; Permanent rivers/streams/creeks, includes waterfalls; Seasonal/intermittent/irregular rivers/streams/creeks; Permanent freshwater lakes (over eight ha), includes large oxbow lakes; Seasonal/intermittent freshwater lakes (over eight ha), includes floodplain lakes; Permanent saline/brackish/alkaline lakes; Seasonal/intermittent saline/brackish/alkaline lakes and flats; Permanent saline/brackish/alkaline marshes/pools; Seasonal/intermittent saline/brackish/alkaline marshes/pools; Permanent freshwater marshes/pools, ponds (below eight ha), marshes and swamps on inorganic soils, with emergent vegetation water-logged for at least most of the growing season; Seasonal/intermittent freshwater marshes/pools on inorganic soils, includes sloughs, potholes, seasonally flooded meadows, sedge marshes; Non-forested peatlands, includes shrub or open bogs, swamps, fens; Alpine wetlands, includes alpine meadows, temporary waters from snowmelt; Tundra wetlands, includes tundra pools, temporary waters from snowmelt; Shrub-dominated wetlands, shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils; Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils; Forested peatlands; peatswamp forests; Freshwater springs, oases; Geothermal wetlands; Karst and other subterranean hydrological systems, inland. **Human-made wetlands –** Aquaculture (e. g., fish/shrimp) ponds; Ponds; includes farm ponds, stock ponds, small tanks; (generally below eight ha); Irrigated land, includes irrigation channels and rice fields; Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture); Salt exploitation sites, salt pans, salines, etc.; Water storage areas, reservoirs/barrages/dams/impoundments (generally over eight ha); Excavations; gravel/brick/clay pits; borrow pits, mining pools; Wastewater treatment areas, sewage farms, settling ponds, oxidation basins, etc.; Canals and drainage channels, ditches; Karst and other subterranean hydrological systems, human-made.

The editors of the *Transylvanian Review of Systematical and Ecological Research* started and continue the annual sub-series (*Wetlands Diversity*) as an international scientific debate platform for the wetlands conservation, and not to take in the last moment, some last heavenly "images" of a perishing world …

This volume included variated original researches from diverse wetlands around the world.



The subject areas (▻) for the published studies in this volume.

No doubt that this new data will develop knowledge and understanding of the ecological status of the wetlands and will continue to evolve.

Acknowledgements

The editors would like to express their sincere gratitude to the authors and the scientific reviewers whose work made the appearance of this volume possible.

The Editors

Editorial Office:

"Lucian Blaga" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection, Dr. Ion Rațiu Street 5-7, Sibiu, Sibiu County, Romania, RO-550012, Angela Curtean-Bănăduc (ad.banaduc@yahoo.com, angela.banaduc@ulbsibiu.ro)

(ISSN-L 1841 – 7051; online ISSN 2344 – 3219)

INTENSIVE INFILLING PROCESSES OF A CUTOFF MEANDER IN THE DANUBE DELTA

Laura DUŢU *, *Florin DUŢU* *
and *Gabriel IORDACHE* *

* National Institute for Research and Development on Marine Geology and Geo-Ecology – GEOECOMAR, 23-25 Dimitrie Onciul Street, Romania, laura.dutu@geoecomar.ro, ORCID: 0000-0003-3482-6938, florin.dutu@geoecomar.ro, ORCID: 0000-0002-5393-3125, gabriel.iordache@geoecomar.ro, ORCID: 0000-0002-8335-5995.

DOI: 10.2478/trser-2022-0015

KEYWORDS: cutoff meander, sedimentation, GIS, aDcp.

ABSTRACT

This paper documents the structure of flow and bed morphology of a cutoff meander of the Danube River in relationship with a GIS approach. The cutoffs effect produce changes in the repartition of the water and sediment fluxes between the natural channel and the man-made canal, with direct implications on the environmental evolution of the delta. The Dranov de Jos meander (Lower Dranov meander – LDM) belt seems to be one of the most affected by the rectification works performed on Sfântu Gheorghe branch between 1981 and 1992. The upstream and downstream parts of the cutoff are characterized by the decrease of the channel width by banks sedimentation (with the rate of –6.2 m/year) and at the apex zone, the bank's sedimentation is associated with intense sediment infilling of the central part of the channel, where a large deposit of 950 m in length and 190 m in width is formed.

RÉSUMÉ: Processus de colmatage d'un méandre recoupé du Delta du Danube.

Cet article s'occupe de la structure du flux liquide et la morphologie d'un méandre du delta du Danube selon l'approche SIG. Les rectifications des méandres produisent des changements dans la répartition des flux d'eau entre le chenal naturel et le chenal artificiel, avec des implications directes sur l'évolution environnementale du delta. Le méandre Dranov de Jos semble être l'un des plus affectés par les travaux de rectification réalisés sur le bras de Saint-Georges entre 1981 et 1992. Les parties amont et aval du méandre sont caractérisées par la diminution de la largeur du chenal et par la sédimentation des berges tandis que dans son apex, la sédimentation de la berge est associée à un remplissage sédimentaire intense de la partie centrale du chenal.

REZUMAT: Procese de sedimentare accentuată într-un meandru rectificat din Delta Dunării.

Acest articol analizează procese hidrologice şi morfologice care au loc de-a lungul unui meandru rectificat din delta Dunării. În general, rectificările meandrelor produc modificări ale repartiţiei fluxurilor de apă între canalul natural şi cel de rectificare, cu efecte asupra mediului înconjurător. Meandrul Dranov de Jos pare să fie unul dintre cele mai afectate meandre ale braţului Sfântu Gheorghe, în urma lucrărilor de rectificare care au avut loc în perioada dintre anii 1981 şi 1992. Părţile situate în amonte şi aval sunt caracterizate prin reducerea lăţimii în timp ce în zona de apex se observă colmatarea părţii centrale a albiei.

INTRODUCTION

The hydrotechnical works have complex environmental impacts and produce pressures and alterations of hydro-sedimentary flows downstream (Zaharia et al., 2011; Zhang et al., 2016; Li et al., 2018; Duţu Tiron et al., 2019; Nistor et al., 2021). Many studies on the meandering systems showed that the change of sinuosity rates, the reduction of the widths or changes of the meanders mobilities are the response of the channel to the construction of a reservoir upstream (Gaeuman et al., 2005; Phillips et al., 2005). Thus, dams are responsible for the morphology changes of the rivers. They produce interruptions of the river system continuity and decrease the transport of the sediments to the littoral zones (Batalla, 2003).

The Danube River is one of the most important European waterways, flowing over 2,860 km across the continent from the Black Forest Massif down to the Black Sea. The Danube drainage basin extends over 817,000 km^2 and more than 15 countries share the Danube catchment area. The average annual water discharge of the Danube River at the delta apex (Ceatal Izmail) is 6,550 $m^3.s^{-1}$. The present sediment discharge was modified by the building of the Iron Gates I and II dams and reservoirs systems (in 1972 and 1984 respectively) which induced a critical decrease in the sediment discharge from ≈ 67 million $t.yr^{-1}$ to ≈ 30-40 million $t.yr^{-1}$ (Stănică and Panin, 2009; Nistor et al., 2021).

In its delta, the Danube has built a particular area affected by multiple and complex constraints. At the scale of the drainage basin area, the river has undergone major transformations with effects on the functioning of the downstream part of its course (Tiron Duţu et al., 2019; Pacioglu et al., 2022).

GIS studies (maps analyse, aerial photographs, satellite images) were frequently used to understand the mobility and the evolution of the large fluvial channels such as the Mississippi Delta (Hooke, 1980), Rhone Delta (Antonelli et al, 2004), Rhine Delta (Berendsen et al., 2007), Danube Delta (Ungureanu and Stănică, 2000; Tiron Duţu et al., 2014), etc. Therefore, the GIS results must be correlated with *in situ* measurements (bathymetrical, hydrological, topographical and sedimentological data).

The natural chute cutoffs have been largely studied (Zinger et al., 2013; Li and Gao, 2019; Li et al., 2021; Qiao et al, 2022) than the artificial ones (Eekhout and Hoitink, 2015; Schwenk and Foufoula-Georgiou, 2016). The artificial corrections of the meanders produce fast and dramatic responses (Tiron Duţu et al., 2019; Duţu et al., 2022; Qiao et al., 2022). The scope of this study is to expand the existing knowledge of artificial cutoff and may serve as a reference to scientists interested in this topic and for the authorities involvement in the management and protection of the Danube Delta.

MATERIAL AND METHODS

Background. The St. George distributary starts from the hydrographic knot at Ceatal Sfântu Gheorghe at 108.8 km until the sea (Fig. 1). The course of the St.George branch can be subdivided into three sections (Panin, 2003, Tiron, 2010): the Dobrogean section of limited meandering (between km 104 and km 90), the free meandering segment of the St. George arm (between km 90 and km 22) and the straight downstream section between km 22 and km 0). The St. George meander loops have been rectified in 1981-1992 period; these cut-offs lead to a shortening of the distributary by about 32 km. Consequently, the free water surface slope increased and water flow velocity determined higher water and sediment discharges and important changes in the local distribution of flows (Tiron Duţu et al., 2014, 2019). A rupture of the natural bend evolution occurred – strong clogging processes are more and more active, expressed in the aggradation of the channel bed, narrowing of channels and development of bars and islands along the natural meander bends sections (Tiron Duţu et al., 2014).

The study area is represented by a former meander of the middle part of the Sfântu Gheorghe branch (Fig. 1), Dranov de Jos/Lower Dranov meander – LDM. LDM was formed at the end of the Phanagorian regression when the Black Sea level lowered by a few meters (–2/–4 m) and the relief energy increased (Panin, 2003). LDM is very elongated being the most sinuous meander loop of the Sfântu Gheorghe branch. Its length is 8.8 km, the wavelength is 1.4 km, the amplitude is 3,852 m and the sinuosity index is 6.59. During the period between 1880 and 1970, the natural channel of the LDM exhibited a continuously accentuated narrowing of 1.4 m/year between 1880 and 1910 and 1.2 m/year between 1910 and 1970 (Tiron, 2010). The water discharge transported by the artificial canal has progressively increased, from 14% in 1993, just after the rectification, to 28% in 1996 and 95% in 2020.

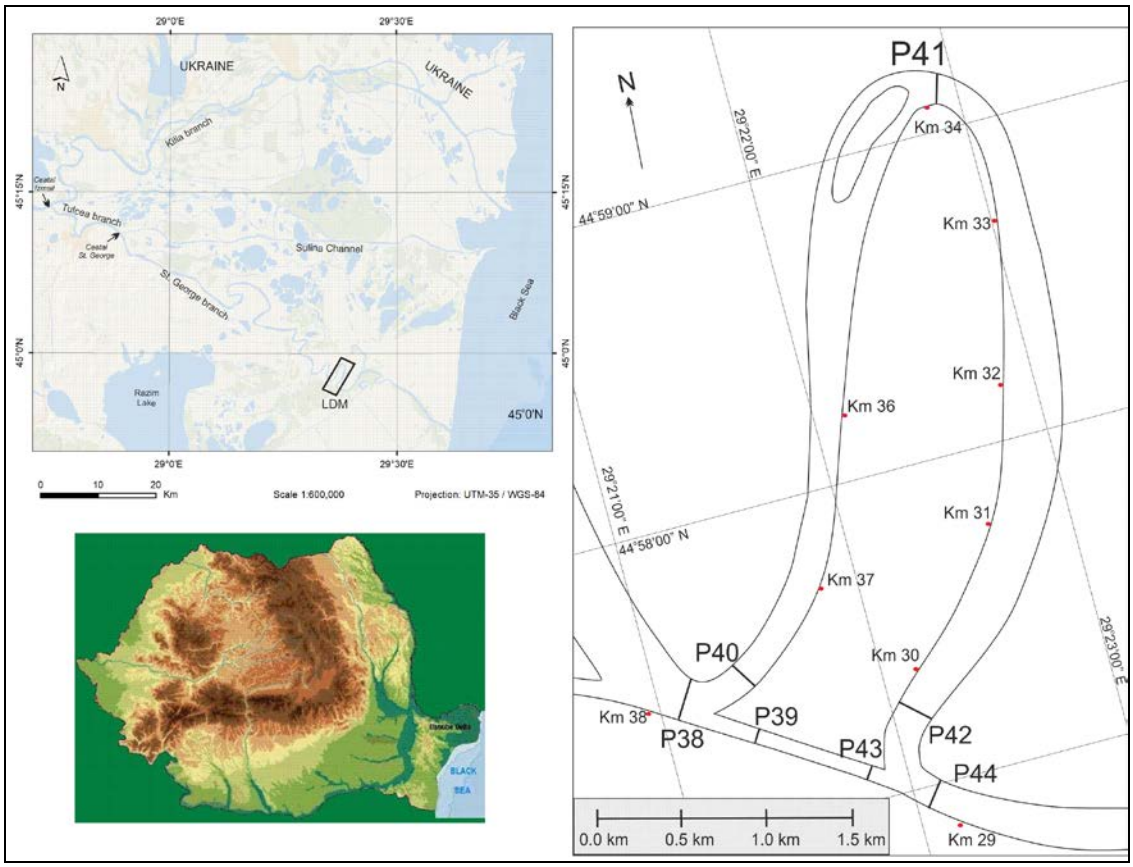


Figure 1: The Danube Delta location and the investigated cross-sections.

The hydrological measurements were made in September 2020, during the average autumn waters. An ADCP River Ray 600 kHz mounted on a power boat was used for the data acquisition. During the measurements (on 9 September 2020) the flow discharge entering in LDM was 1,237 $m^3.s^{-1}$. Seven transversal profiles were completed at relevant sections such as around the upstream bifurcation (P38, P39 and P40), around the downstream confluence (P42, P43, and P44) and along the cutoff meander in the apex zone (P41) (Fig. 1). Multiple transects of each cross-section were performed (four to six transects on each cross-section) to reduce the errors (Qiao et al., 2022).

The hydrodynamic processes were analyzed by two parameters, the stream power and the boundary shear stress using the formulas described and applied previously in the deltaic environment by many authors (Duțu et al., 2022; Qiao et al., 2022) (Tab. 1):

For the stream power the following equation was used:

$$\omega = \Omega/B \ (W \cdot m^{-2})$$

where B is the bankful channel width and Ω is the stream power, calculated as:

$$\Omega = \rho \ g \ Q \ S \ (W \cdot m^{-1})$$

where the representative discharge Q ($m^3 \cdot s^{-1}$) is usually taken as the bankful discharge Qbf.

The bed mean shear stress (τ_0) corresponds to the unit tractive force exerted on the bed following the equation:

$$\tau_0 = \rho \ g \ R \ S \ (N \cdot m^{-2})$$

ρ is the fluid density (1,000 $kg \cdot m^{-3}$ for sediment-free water), g is the gravitational acceleration (9.81 $m \cdot s^{-2}$), R is the hydraulic radius (m), and S is the water energy slope ($m \cdot m^{-1}$).

The topographical measurements were measured with an RTK global positioning system (TRIMBLE R4). The measurements consisted of the topographic points acquired at the water/land interface in the bank's area and the major bed at each change of the terrain slope.

For each topographic point, three sessions of measurements of five seconds were performed using the kinematic method. Thus, the coordinates and elevations were obtained in real-time through RTK technology, being instantly available in the field without requiring corrections. The National planimetric System STEREO ’70 and absolute depths (Z) in National Altimetrically System Black Sea ’75 Constanța were obtained for each measured point using the standard EN 14614:2004 (Directive 2014/101/CE).

Geographic information system (GIS) tools (Global Mapper 18) was used to compare two sets of data of Landsat 7 ETM+2000 and Lansat 2020. The error sources (RMSE) include inaccuracies from the manual delineation of banklines, water level differences, effects of vegetation, etc. To estimate the changes in the planform of LDM were determined from the two sets of remote sensing data and combined with information on average channel depth.

RESULTS AND DISCUSSION

Present time flow and morphological processes

With a sinuosity index of 6.59 and an amplitude of 3,852 m, LDM is one of the most sinuous meanders of the Sfântu George branch. The meandriforme shape has an important impact on his morphological behaviour in general and on the distribution of the flows between the former meander and the artificial canal in particular.

The water fluxes at the nodal point of bifurcation (P38 = 1,237 $m^3.s^{-1}$) are distributed unequally between the former meander (P40 = 62 $m^3.s^{-1}$) and the artificial canal (P39 = 1,156 $m^3.s^{-1}$), with a dominated discharge carried out by the artificial canal (~93.5%) (Tab. 1).

The bifurcation point (P40) corresponds to an important reduction of the depth (Tab. 1). The thalweg is decreasing from 23.1 m to 5.88 m, with a counterslope of –6.9 m/km. Here, on P40, the cross-section has an asymmetrical shape and the left bank correspond to a stagnation zone, for a distance of approximately 50-70 m from the left bank (Fig. 2).

Going downstream, the water discharge is almost constant, with a flux of 66.4 $m^3.s^{-1}$ in the apex zone and 63.2 $m^3.s^{-1}$ near the confluence (on P42). Along the former meander (P40, P41, and P42), the depths and the channel slope are lower, and the velocities decrease and are homogeneously distributed on the cross-sections (Figs. 3 and 4) and facilitate the sediment deposition (mean velocities between 0.26 $m.s^{-1}$ and 0.06 $m.s^{-1}$) (Tab. 1). Close to the confluence point, the profile P42 is asymmetrical, with a deepening toward the left bank (until 12.2 m) and a large zone of water stagnation situated on the right bank (Figs. 2 and 3).

Table 1: Hydrometrical and hydro-dynamical parameters on investigated cross-sections.

Profile	**Width (m)**	**Maximum depth (m)**	**Water discharge ($m^3.s^{-1}$)**	**Mean velocity ($m.s^{-1}$)**	**ω $W.m^{-2}$**	**τ_0 $N.m^{-2}$**
P38	171	23.1	1237	0.48	0.56	1.27
P39	137.7	21.2	1156	0.57	1.05	1.84
P40	134.2	5.88	62	0.26	0.42	0.59
P41	104.9	9.9	66.4	0.11	0.05	0.09
P42	181.4	12.2	63.2	0.06	0.01	0.02
P43	125.7	21.7	1194	0.61	1.30	2.09
P44	180.0	24.5	1272	0.44	0.42	1.05

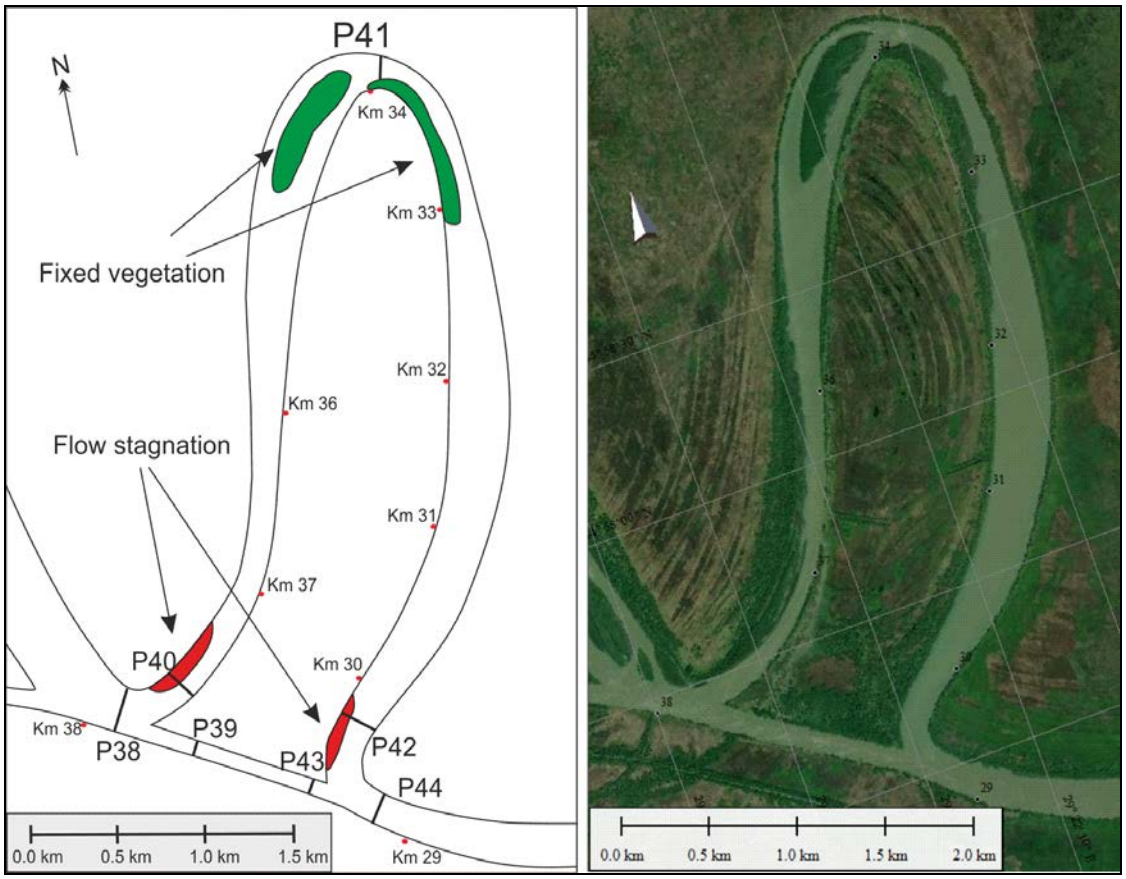


Figure 2: The flow stagnation areas (in red) and fixed vegetation area (in green) along the LDM.

The entrance in the artificial canal (P38-P39) corresponds to an increase of the velocities (from 0.48 $m.s^{-1}$ to 0.57 $m.s^{-1}$) and even higher downstream (0.61 $m.s^{-1}$ on P43) due to the reduced width of the artificial canal (max 140 m) and to the higher slope (4.1 m/km). On the artificial canal, the profiles are symmetrical in shape and many large nuclei of higher velocity (between 0.85 and 1.1 $m.s^{-1}$) are located in the central part of the cross-sections (Fig. 3).

From the hydraulic point of view, cross-sections with high stream power are found on the main channel (P38 and P44) and on the artificial canal (P39 and P43) in relationship with the reduced widths and steep slope. Along the former meander, the energy is lower and decreases with the distance, from 0.42 $W.m^{-2}$ downstream of the bifurcation (on P40) to 0.01 $W.m^{-2}$ close to the confluence (P42). The bed shear stress values follow the same distribution, with lower values located on the former meander (between 0.59 and 0.02 $N.m^{-2}$) and higher values located in the artificial canal on P39 and P43, indicating the increased erosion capacity of the channel (Tab. 1).

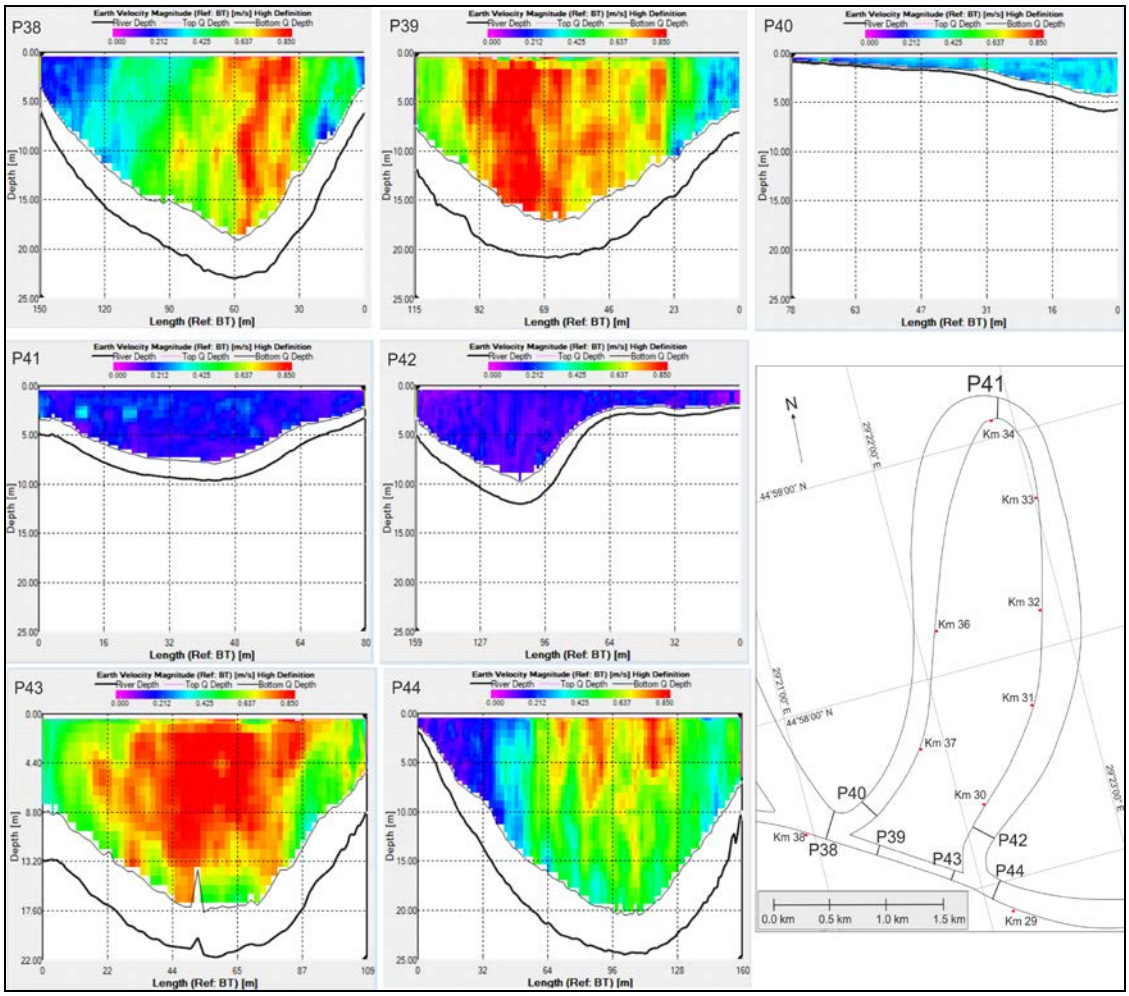


Figure 3: Distribution of the flow velocities on each investigated cross-section.

The concept of stagnation zone was developed by Zinger et al. (2013) to examine the flow hydrodynamic characteristics and channel morphology during the evolution of chute cutoff. The authors showed that at the bifurcation and the confluence zones, the hydrodynamic processes are similar. For our case, the LDM, the hydrodynamic and morphological features are in good agreement with those obtained by Zinger et al. (2013) and later applied to an artificial cutoff in the upper Yellow River by Qiao et al. (2022).

Based on the previous research studies (Edmonds and Slingerland, 2008; Letter et al., 2008; Tiron Duţu et al., 2014) the behaviour of the meander systems is in relationship with a series of factors, such as the water flow, the channel bed slope ratio, the sinuosity, the bed grain size, water surface elevation at the bifurcation areas, the diversion angle, etc. On LDM, there is an evident inequality in the repartition of the liquid fluxes between the natural and artificial channels that obviously explain the infilling processes along the former meander. However, the water flow acceleration in the artificial canal maintains higher dynamics and enhances erosion processes, therefore, the disparity of operation of both channels that we consider the most important factor determining the sedimentation of the former meander.

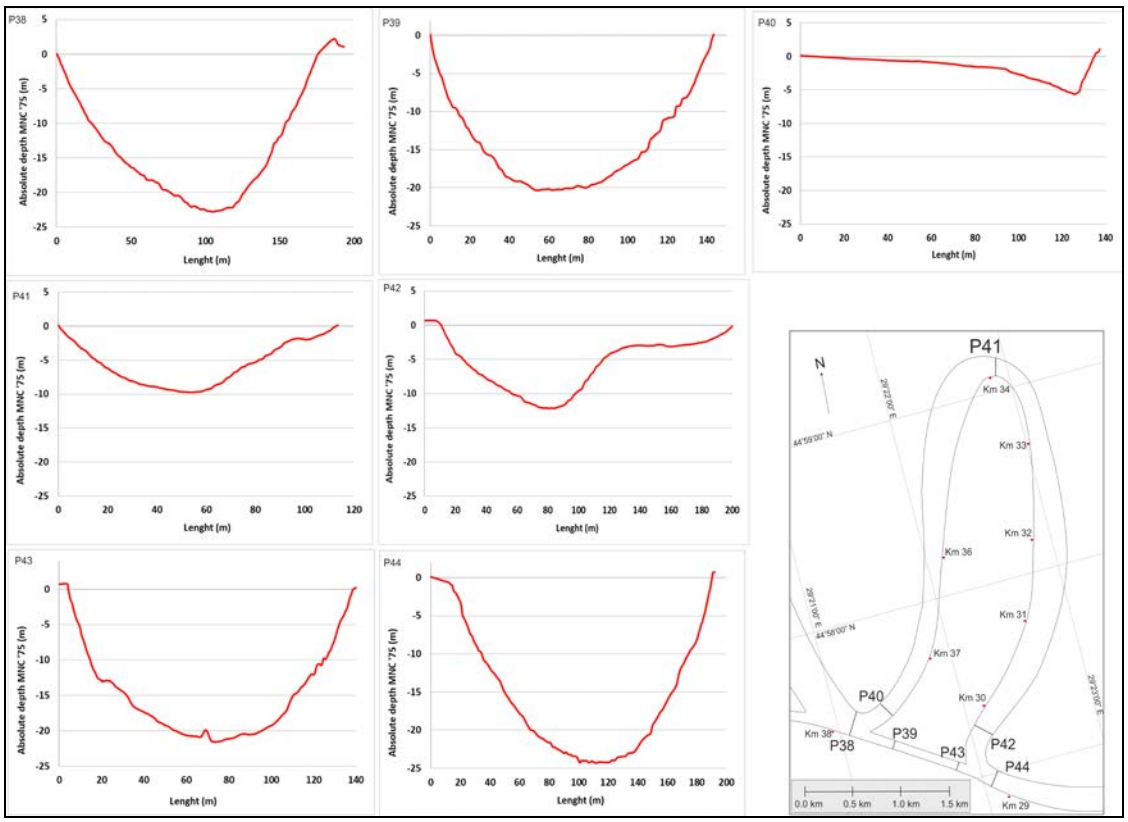


Figure 4: Topo-bathymetrical profiles
of the investigated cross-sections.

Overview of GIS imagery analyses

Channel widths are the distance measured perpendicular from a bank edge to the opposite bank edge. The LDM channel widths were measured every 300 m streamwise. By superimposition of satellite images, the evolution diagram of the channel width between 2000 and 2020 has been drawn (Fig. 5). In the last twenty years, the former meander of LDM narrowed substantially, especially in the upstream first part (between km 37.5 and km 36), with a retraction of the channel width until 124 m (approximately –6.2 m/year) (Fig. 5). Downstream, in the proximity of the apex zone (between km 34.5 and km 34), the channel is relatively stable in width, but the sedimentation remains also the dominant process. Here, sediment infilling is revealed by the formation and development of a large internal island of 950 m in length and 190 m in width shown in figure 1. The sedimentation of the convex bank is dominated downstream of the apex (between km 33.5 and km 32) with rates of –4.4 to –2.75 m/year). Close to the confluence, the channel width remains relatively stable along the analysed period, with low retraction rates (between –1.5 and 0.65 m/year).

The retraction rates are higher than those calculated by Jugaru et al. (2006) for the period 1970-2000, with a maximum of –1.5 m/year. Our data indicate that the infilling processes along the former meander are faster in the last 20 years.

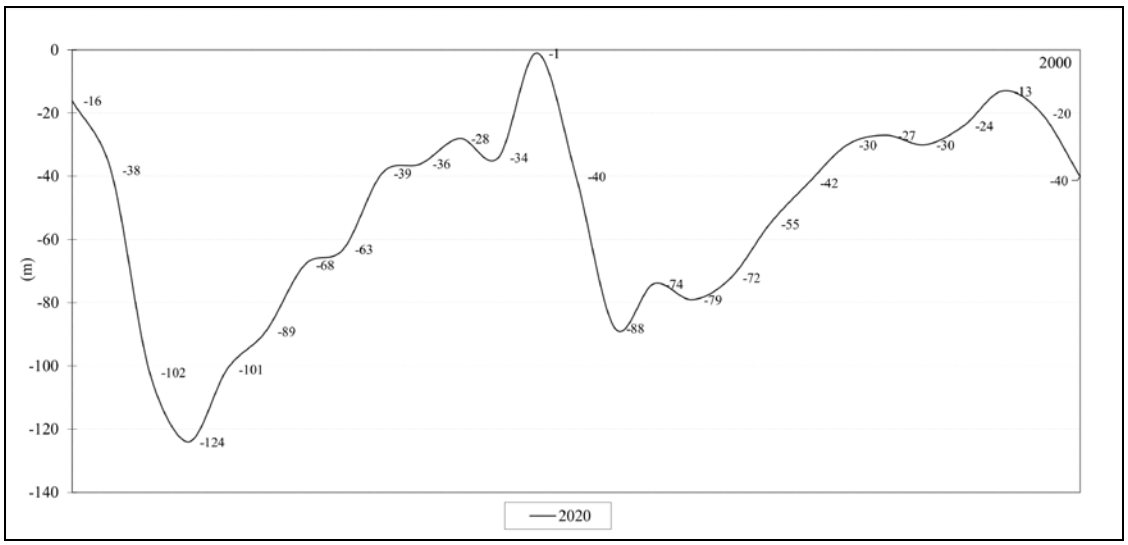


Figure 5: Evolution of the channel width between 2000 and 2020
(the x-axes represent the values from 2000).

CONCLUSIONS

According to the studies performed, the LDM is very sensitive to the meanders cut-off programme, with fast response in decreasing of its water discharges and in the changes of hydro-morphological and sedimentological processes. The study of the Lower Dranov meander reveals the need to understand the critical processes that generally affect the cutoff works. The effects of the hydrotechnical works are fast and intensive. During a period of around thirty years, the channel has undergone significant changes and important transformations. The results show that the intervention on the water transfer in a meandering system by cutoff diminishes the energy of the former meander and thus interrupts the sedimentary transit and important morphological changes. The GIS results are in good

agreement with the hydrological and morphological data and interpretations. The effects of the meander cutoff, together with some other factors such as climate changes and other human interventions (i.e. reservoirs and dams, etc.) are to be found in studies related to the environmental state and biodiversity of the entire delta, which represent a current concern of the society.

ACKNOWLEDGEMENTS

The research was supported by the Ministry of Research, Innovation and Digitization Core Program, Project PN16450503 (contract no. 37N/2016) and PN19200401 (contract no. 13N/08.02.2019) and Project AMBIACVA (Contract 23PFE/30.12.2021).

REFERENCES

1. Antonelli C., Provansal M. and Vella C., 2004 – Recent morphological channel changes in a deltaic environment. The case of the Rhone River, France, *Geomorphology*, 57, 3-4, 385-402.
2. Batalla R. J., 2003 – Sediment deficit in rivers caused by dams and instream gravel mining. A review with examples from NE Spain, *Revista C & G*, 17, 3-4, 79-91.
3. Berendsen H. J. A., Cohen K. A. and Stouthamer E., 2007 – The use of GIS in reconstructing the Holocene palaeogeography of the Rhine-Meuse delta, The Netherlands, *International Journal of Geographical Information Science*, 21, 5, 589-602.
4. Duţu F., Duţu L., Catianis I. and Ispas B.-A. 2022 – Sediment dynamics and hydrodynamical processes in the Danube Delta (Romania): A response to hydrotechnical works, *Zeitschrift fur Geomorphologie*, 64, 4, 365-378.
5. Edmonds D. A. and Slingerland R. L., 2008 – Stability of delta distributary networks and their bifurcations, *Water Resources Research*, 44, W09426.
6. Eekhout J. P. C. and Hoitink A. J. F., 2015 – Chute cutof as a morphological response to stream reconstruction: the possible role of backwater, *Water Resources Research*, 51, 3339-3352.
7. Gaeuman D., Schmidt J. and Wilcock P. R., 2005 – Complex channel responses to changes in stream flow and sediment supply on the lower Duchesne River, Utah, *Geomorphology*, 64, 185-206.
8. Jugaru L., Provansal M., Panin N. and Dussouillez P., 2006 – Apports des Systèmes d'Information Géographiques à la perception des changements morphodynamiques (1970-2000) dans le delta du Danube. Le cas du bras de Saint-George, *Geo-Eco-Marina*, 12, 29-42.
9. Letter Jr. J. V., Pinkard Jr. C. F. and Raphelt N. K., 2008 – River diversions and shoaling. Coastal and Hydraulics Engineering Technical Note ERDC/CHL CHETN-VII-9.U.S. Army Engineering Research and Development Center, Vicksburg, MS.
10. Li S., Li Y., Yuan J., Zhang W., Chai Y. and Ren J. 2018 – The impacts of the Three Gorges Dam upon dynamic adjustment mode alterations in the Jingjiang reach of the Yangtze River, China, *Geomorphology*, 318, DOI: 10.1016/j.geomorph.2018.06.020.
11. Li Z. W. and Gao P., 2019 – Channel adjustment after artificial neck cutofs in a meandering river of the Zoige basin within the Qinghai-Tibet Plateau, China, *Catena*, 172, 255-265.
12. Li Z. W., Yang H. Y., Xia J. Q, Zhou M. R., Deng S. S. and Wang Y. Z., 2021 – Channel morphologic processes of a highly sinuous bend approaching neck cutof by bank erosion in the middle Yangtze River, *International Journal of Sediment Research*, 36, 457-467.
13. Nistor C., Săvulescu I., Mihai B.-A., Zaharia L., Virghileanu M. and Cacablaisa S., 2021 – The impact of the large dams on fluvial sedimentation; the Iron Gates reservoir on the Danube River, *Acta Geographica Slovenia*, 61, 1, 41-55.
14. Pacioglu O., Duţu F., Pavel A. B. and Tiron Duţu L., 2022 – The influence of hydrology and sediment grain-size on the spatial distribution of macroinvertebrate communities in two submerged dunes from the Danube Delta (Romania), *Limnetica*, 41, 1, 85-100.

15. Panin N., 2003 – The Danube Delta. Geomorphology and Holocene evolution: a Synthesis, *Geomorphologie: Relief, Processus, Environnement*, 4, 247-262.
16. Phillips J. D., Slaterry M. C. and Musselman Z. A., 2005 – Channel adjustments of the the lower Trinity River, Texas, downstream of Livingston dam, *Earth Surface Processes and Landforms*, 30, 1419-1439.
17. Qiao Q., Li C., Jing H. and Huang L., 2022 – Flow structure and channel morphology after artificial chute cutoff at the meandering river in the upper Yellow River, *Arabian Journal of Geosciences*, 15, 147.
18. Schwenk J. and Foufoula-Georgiou E., 2016 – Meander cutofs nonlocally accelerate upstream and downstream migration and channel widening, *Geophysical Research Letters*, 43, 1-10.
19. Ungureanu V. G. and Stănică A., 2000 – Impact of human activities on the evolution of the Romanian Black Sea beaches, *Lakes & Reservoirs Research and Management*, 5, 2, 111-115.
20. Stănică A. and Panin N., 2009 – Present evolution and future predictions for the deltaic coastal zone between the Sulina and Sf. Gheorghe Danube River mouths (Romania), *Geomorphology*, 107, 1, 2.
21. Tiron L., 2010 – Delta du Danube – Bras de St. George. Mobilité morphologique et dynamique hydro-sédimentaire depuis 150 ans, *Geo-Eco-Marina*, 4, 280.
22. Tiron Duţu L., Provansal M., Le Coz J. and Duţu F., 2014 – Contrasted sediment processes and morphological adjustments in three successive cutoff meanders of the Danube Delta, *Geomorphology*, 204, 154-164.
23. Tiron Duţu L., Duţu F., Secrieru D. and Opreanu G., 2019 – Sediments grain size and geo-chemical interpretation of three successive cutoff meanders of the Danube Delta, Romania, *Geochemistry*, 79, 399-407.
24. Zaharia L., Grecu F., Toroimac I. G. and Neculau G., 2011 – Sediment transport and river channel dynamics in Romania – variability and control factors, in Manning A. J. (ed.), *Sediment Transport in Aquatic Environments*, London, IntechOpen, DOI: 10.5772/21416.
25. Zinger J. A., Rhoads B. L., Best J. L. and Johnson K. K., 2013 – Flow structure and channel morphodynamics of meander bend chute cutofs: A case study of the Wabash River, USA, *Journal of Geophysical Research Earth Surface*, 118, 4, 2468-2487, https://doi.org/10.1002/jgrf.20155.
26. Zhang W., Yuan J., Han J., Huang C. and Li M., 2016 – Impact of the Three Gorges Dam on sediment deposition and erosion in the middle Yangtze River: A case study of the Shashi Reach, *Hydrology Research*, 47-S1, DOI:10.2166/nh.2016.092.

MICROBIAL SPECTRUM AND ANTIBIOTIC SENSITIVITY PATTERN OF BACTERIA ISOLATED FROM THE SPINY LOBSTER, *PANULIRUS REGIUS* (DE BRITO CAPELLO, 1864)

Aderonke Omolara LAWAL-ARE *,
Rasheed Olatunji MORUF ** and *Israel Adebowale OMOYELE* *

* University of Lagos, Department of Marine Sciences, Akoka, Lagos, Nigeria, alawalare@gmail.com, ORCID: 0000-0001-7656-6930, awarushs@yahoo.com, ORCID: 0000-0001-5860-2256.
** Bayero University, Department of Fisheries and Aquaculture, Gwarzo Street, Kano, Nigeria, tunjimoruf@gmail.com, ORCID: 0000-0002-0459-0621.

DOI: 10.2478/trser-2022-0016

KEYWORDS: lobster, microbes, pathogen, seafood, Lagos, Nigeria.

ABSTRACT

Microbial spectrum and antibiogram of bacteria isolated from *Panulirus regius* of the coast of Lagos were analysed using standard techniques. The lobster head had higher total bacteria and total coliform counts with respective significant ($P < 0.05$) values of $4.17 \times 10^6 \pm 1.46$ CFU g^{-1} and $3.06 \times 10^3 \pm 1.56$ CFU g^{-1}. A higher total fungi count ($2.99 \times 102 \pm 1.63$) was recorded in the lobster tail. In the bacterial group, *Bacilus megaterium* had the highest frequency of occurrence (22.6%) while in the fungal group, *Aspergillus niger* had the highest frequency of occurrence (20.0%). All isolates were sensitive to ciprofloxacin and showed resistance to rocephin and zinnacef except *Micrococcus* sp. and *Salmonella* sp. The presence of antibiotic-resistant bacteria from the lobsters is a serious concern.

RÉSUMÉ: Le spectre microbien et l'antibiogramme des bactéries isolées sur la langouste verte *Panulirus regius* (De Brito Capello, 1864).

Le spectre microbien et l'antibiogramme des bactéries isolées à partir de *Panulirus regius* au large de Lagos ont été analysés par les techniques standards. La tête de homard présentait un nombre plus élevé de bactéries totales et de coliformes totaux avec des valeurs respectives significatives ($P < 0,05$) de $4,17 \times 10^6 \pm 1,46$ UFC g^{-1} et $3,06 \times 10^3 \pm 1,56$ UFC g^{-1}. Un nombre total de champignons plus élevé ($2,99 \times 10^2 \pm 1,63$) a été enregistré dans la queue du homard. Dans le groupe bactérien, *Bacilus megaterium* avait la fréquence d'occurrence la plus élevée (22,6%) tandis que dans le groupe fongique, *Aspergillus niger* avait la fréquence d'occurrence la plus élevée (20,0%). Tous les isolats étaient sensibles à la ciprofloxacine et montraient une résistance à la rocéphine et au zinnacef, à l'exception de *Micrococcus* sp. et *Salmonella* sp. La présence de bactéries résistantes aux antibiotiques dans les homards est une grave préoccupation.

REZUMAT: Spectrul microbian și antibiograma bacteriilor izolate de pe *Panulirus regius* (De Brito Capello, 1864).

Spectrul microbian și antibiograma bacteriilor izolate de pe *Panulirus regius* din largul portului Lagos au fost analizate prin metode standardizate. Regiunea cefalică a homarului a înregistrat valori mai mari pentru numărul total de bacterii și totalul coliformelor, cu valori semnificative ($P < 0,05$) de $4,17 \times 10^6 \pm 1,46$ CFU g^{-1} și $3,06 \times 10^3 \pm 1,56$ CFU g^{-1}. Numărul total de fungi a atins valori mai mari în zona caudală ($2,99 \times 10^2 \pm 1,63$). Dintre bacterii, *Bacilus megaterium* a avut frecvența cea mai ridicată (22,6%) iar dintre fungi frecvența cea mai ridicată a avut-o *Aspergillus niger* (20,0%). Toate izolatele au prezentat sensibilitate la ciprofloxacină și au fost rezistente la rocephin și zinacef, cu excepția *Micrococcus* sp. și *Salmonella* sp. Prezența bacteriilor rezistente la antibiotice la homari prezintă motive serioase de îngrijorare.

INTRODUCTION

Aquatic foods are an important resource that contribute directly and indirectly considerable protein value in sustainable healthy human diets (Khoshnood and Khoshnood 2013; Milstein et al., 2013; Saikia, 2015; Troell et al. 2019; Ahern, 2021). It is a large component with several major groups, including finfish and shellfish, aquatic foods, particularly marine foods, which are nutritionally significant in the delivery of protein, particularly the nine essential amino acids (Elegbede and Fashina-Bombata, 2013). One of the main sources of healthy food for human nutrition is edible crustaceans, including shrimp, prawns, crayfish, lobster, and crab, which in many nations provide a significant quantity of nutritional protein and lipids (Moruf and Lawal-Are, 2019).

Lobster is regarded as a nutritious and highly desirable food due to its contribution of high-quality protein that can easily and completely digest. It is a proteinase crustacean which has become one of the most favourite seafoods that commands a high price in the restaurants (Moruf et al., 2021). It is typically prepared by boiling or steaming. It can be eaten as a main course, enjoyed as a sandwich filler, or added to rich dishes like pasta, mashed potatoes, and eggs. The potential use of lobsters is encouraged by the fact that it can be used for different purposes. Lobster species, can be used to prepare dietary supplements, to obtain chitin, and as a source of astaxanthin for aquaculture (García-López et. al., 2016; Varisco et. al., 2020).

The major deteriorative processes that affect the texture, colour, and flavour of seafood are microbial spoilage, autolysis, polymerization, deamination, decarboxylation, and biochemical reactions (Tavares et al., 2021; Lawal-Are et al., 2022a). Different forms of shell condition disease have been reported to affect lobsters. This condition involves the blackening and erosion of the tail fans, and in extreme cases, parts of the abdomen (Feinman et al., 2017; Zha et al., 2019). Bacterial diseases are the second major cause of mortality in both wild and cultured seafoods, with the major cause being viral infections (Moruf, 2022). Bacterial contamination is either due to direct contamination of the lobster by polluted water or due to secondary contamination during handling, processing, storage, preparation or distribution. According to Obiakara-Amaechi et al. (2022), sewage effluent entering coastal waters contains amongst others, diverse pollutants including viral and bacterial pathogens, noxious substances, as well as organic and inorganic wastes.

Previous works on lobster in Nigeria focused on their growth coefficient (Lawal-Are et al., 2018), proximate composition (Ayanda et al., 2018) and trace metal contamination (Afolayan et al., 2020). The significance of pathogenic bacteria in lobsters from the coastal waters of Nigeria has not been investigated. Meanwhile, the microbiological quality is of importance to public health since it directly relates to seafood spoilage and may cause food poisoning (Lawal-Are et al., 2022b). It is therefore important to monitor the quality of harvested lobsters to ensure that the products do not pose health risks to end users. Hence, this research seeks to determine the antibiogram of bacteria associated with head and tail of the Royal Spiny Lobster, *Panulirus regius* (De Brito Capello, 1864) found off Lagos Harbour, Nigeria.

MATERIAL AND METHODS

The study area. The study area lies between 6°20'N-6°34'N and 2°45E'-3°60'E and falls within the barrier lagoon complex (200 km) (Fig. 1). It is a marine environment extending from the Badagry to the Ibeju-Lekki Local Government Areas of Lagos State, Nigeria. The sampling station lies along the eastern parts of the Lagos Harbour, the commodore channel, which is at the mouth to the Atlantic Ocean, having a semidiurnal tidal rhythm.

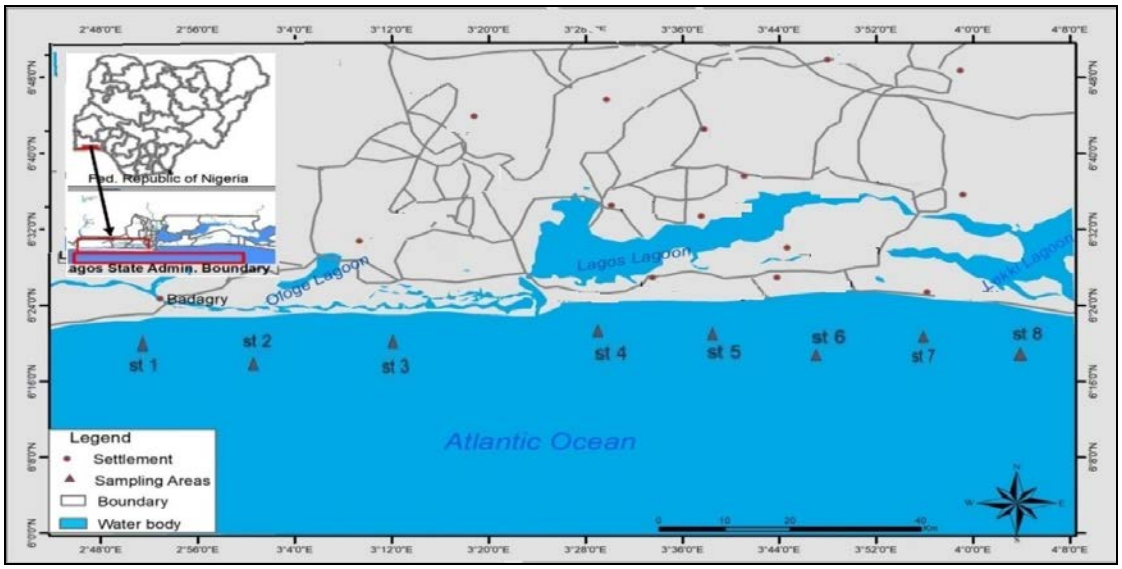


Figure 1: Map of Lagos coast showing sampling locations (Oluboba et al., 2021).

Collection of samples. Samples were obtained from commercial trawl catches at the study site on a monthly basis for six months (January to June 2022) and between 8.00 hrs and 12.00 hrs on each sampling day. A total of 90 Royal Spiny Lobsters were collected during the sample period. The specimens were identified using taxonomic keys of Schneider (1990) and aseptically transported in ice chest boxes to the Ecotoxicological Laboratory located at the Department of Marine Sciences, University of Lagos for further processing and analysis.

Sample preparation. Samples of *P. regius* were measured with the aid of Sartorius top loading balance (Model 1106) to the nearest tenth of a gram. Specimens weighing 53.1 to 195.6g were used for the study. The specimens were sacrificed and the incidental materials adhering to the shells were removed by washing the lobsters aseptically with sterile distilled water before opening the ventral surface with sterile scissors to expose the head and tail. Five grams of each specimen were mixed with 225 mL of sterile 0.1% peptone water in a sterile beaker and thoroughly homogenized under aseptic conditions. Thereafter, the homogenized samples were serially diluted to 10^6 as described by APHA (2005).

Enumeration of bacteria and fungi. Standard pour plate technique described by Dubey and Maheshwari (2014) was employed for the analysis of total bacteria, coliforms, and fungi in colony forming unit per gram (CFU g^{-1}). The prepared samples were analyzed immediately. One gram of each of the sample was taken and diluted serially in nine ml of sterile distilled water into five folds (10^{-1} to 10^{-5}). One hundred microliters (100 µl) of two different dilutions were inoculated into sterile petri dishes in duplicates with the aid of micropipette fitted with sterile tips. Sterile molten nutrient agar, eosine methylene blue agar and potato dextrose agar were poured into the inoculated plates. They were swirled to ensure even distribution of the inoculum and left to solidify. The inoculated plates were then incubated aerobically at 37°C for 24 hours – two days (bacteria) and 28°C for five days (fungi). The developed colonies were counted in duplicates using a colony counter. Average colonies of the dilutions that met up with the standard pour plate technique of 30-300 colonies were taken and multiplied by the corresponding dilution factor to give the total number of bacteria, coliforms, and fungi population per gram of the samples.

Characterization of isolates. Gram's staining and motility test were done following the method of Harrigan and McCance (1976) while biochemical tests were carried out as described in Collins et al. (2004). Further identification of isolates into species was done according to the methods described in Bergey's Manual of Systemic Bacteriology (Krieg and Holt, 1984).

Antimicrobial sensitivity test. The Kirby-Bauer susceptibility testing technique (Bauer et al., 1966) was carried out. Isolates were cultured on Nutrient agar overnight at 37°C. The inoculum was adjusted to McFarland 0.5. The isolates were tested with 12 antibiotics which include: Amoxacillin (5 µg), Augmentin (30 µg), Rocephin (10 µg), Gentamycin (10 µg), Pefloxacin (5 µg), Tarivid (30 µg), Streptomycin (5 µg), Septrin (10 µg), Ciprofloxacin (5 µg), Erythromycin (5 µg), Ampiclox (10 µg), and Zinnacef (30 µg) on Mueller Hinton agar plates. Incubation was performed at 37°C for 24 hours and results were also interpreted using EUCAST criteria (2019).

Statistical analysis. Data was analyzed using Microsoft Excel (2010). Significant difference was set at $p < 0.05$. Results are presented as means ± standard error (SE). Duncan Multiple Range Test (DMRT) was used to sort out the differences in the means.

RESULTS AND DISCUSSION

Microbial load in the head and tail of *P. regius* is shown in table 1. The lobster head had higher total bacteria counts (TBC) and total coliform counts with respective significant ($P < 0.05$) values of $4.17 \times 10^6 \pm 1.46$ CFU g^{-1} and $3.06 \times 10^3 \pm 1.56$ CFU g^{-1}. However, higher total fungi counts (TFC) ($2.99 \times 10^2 \pm 1.63$) were recorded in the lobster tail. The values of TFC were not significantly different ($P > 0.05$) across the lobster parts. This finding suggests that the lobster head is colonized by its own intestinal bacterial community. Bekaert et al. (2015) reported that the effect of tailing (which removes the internal bacteria of the stomach) did not result in any reduction on the formation of bacteria. It is known, however, that removal of the internal organs of fishery products can result in longer shelf life for some species. A prolongation of the shelf life was noticed for haddock, saithe, plaice (Karl and Meyer, 2007) and aquaculture sea bass (Paleologos et al., 2004). Shell disease in lobsters is associated with a range of bacteria. Different bacteria may also cause the same apparent disease in marine organisms via traditional infection models (Kumar et al., 2016).

In the present study, the level of mean TFC reported was lower than the $9.36 \pm 2.20 \times 10^3$ CFU g^{-1} reported for *Galatea paradoxa* from Cross River (Udoh et al., 2017). Furthermore, the total plate counts for both bacteria and fungi did not exceed the range of specified microbiological limits recommended for fish and fishery products by International Commission on Microbiological Specification for Foods (ICMSF). According to ICMSF (1986), microbial counts of seafood below 10^5 CFU g^{-1} are considered good quality and counts between 10^5 and 10^6 CFU g^{-1} are considered marginally acceptable quality.

Table 1: Microbial counts (CFU g^{-1}) in *Panulirus regius* off the coast of Lagos, Nigeria.

Cfu/g	Head	Tail	*P* value
Total Bacteria Counts	$4.17 \times 10^6 \pm 1.46$	$2.67 \times 10^6 \pm 1.07$	0.04*
Total Coliform Counts	$3.06 \times 10^3 \pm 1.56$	$2.26 \times 10^2 \pm 1.96$	0.02*
Total Fungi Counts	$2.63 \times 10^3 \pm 0.52$	$2.99 \times 10^2 \pm 1.63$	0.55

Collection of wetland water and sediment samples

Eleven bacteria species consisting both gram-positive and gram-negative bacteria were isolated from the head and tail of *P. regius* (Tab. 2). Using their morphological and cultural characteristics (shape, catalase, oxidase, indole, citrate, spore, and motility), the isolates were identified as *Bacillus* sp., *B. subtilis*, *B. megaterium*, *Citrobacter* sp., *Clostridium* sp., *Coccobacillus* sp., *Escherichia coli*, *Enterobacter* sp., *Micrococcus* sp., *Pneumococcus* sp., *Salmonella* sp., and *Staphylococcus aureus*. *Bacillus* spp. occurred across the lobster parts. These bacteria species have been implicated in causing a wide range of infectious diseases including abscesses, food borne infections, ear infections, respiratory and urinary infections (Afolabi et al., 2020) while other isolates are potential spoilage organisms of unprocessed lobsters. The detection of coliforms of faecal origin and *E. coli* gives relevant information regarding the food safety and sanitary conditions of the lobsters. Therefore, the presence of *E. coli* may be due to the presence of faecal pollution caused by human and other environmental wastes in the water bodies from which the lobsters were affected. Similar observations were made by Porter et al. (2001), where *E. coli* was predominant among the normal bacterial flora of the spiny lobster *P. argus* from the Florida Keys and Dry Tortugas in America.

Table 2: Morphological and cultural characterization of bacteria isolated from *Panulirus regius* off the coast of Lagos, Nigeria.

Sample	Gram reaction	Shape	Catalase	Oxidase	Indole	Citrate	Spore	Motility	Probable organisms
Head	+	Micrococci	+	–	–	+	–	–	*Micrococcus* sp.
	+	Coccorod	+	–	–	–	–	–	*Coccobacillus* sp.
	+	Cocci	+	–	–	–	–	–	*Staphylococcus aureus*
	+	Rod	+	–	–	+	–	+	*B. megaterium*
	–	Rod	+	–	+	+	–	+	*Escherichia coli*
	+	Rod	+	–	–	+	+	+	*Bacillus subtilis*
	-	Rod	+	–	–	–	–	+	*Salmonella* sp.
	+	Rod	+	–	–	–	+	+	*Clostridium* sp.
	–	Rod	+	–	–	+	–	+	*Citrobacter* sp.
	–	Rod	+	–	–	+	–	+	*Enterobacter* sp.
	–	Rod	+	–	–	–	–	–	*Pneumococcus*
Tail	–	Rod	+	–	–	–	–	–	*Citrobacter* sp.
	–	Rod	+	–	+	+	–	+	*E. coli*
	+	Rod	+	+	–	+	+	+	*B. subtilis*
	+	Cocci	+	–	–	–	–	–	*S. aureus*
	+	Rod	+	–	–	+	+	–	*B. megaterium*
	–	Rod	+	–	–	–	-	+	*Salmonella* sp.
	–	Rod	+	–	–	+		–	*Enterobacter* sp.
	+	Micrococci	+	+	–	+	-	–	*Micrococcus*

The cultural and morphological characterization of fungi isolated from the head and tail of *P. regius* is shown in table 3. The predominant fungi species isolated were *Aspergillus flavus, A. niger, A. wentii, Fusarium* sp., *Penicillium* sp., and *Saccharomyces* sp. The lobster head had higher diverse fungi isolates with *Aspergillus flavus, A. fumigatus, A. niger, A. wentii, Flavobacterium* sp., *Fusarium* sp., *Penicillium* sp., *Sacchromyces* sp., and *Trichoderma* sp. identified. These fungi were similar to the genera reported for the marine organisms, *Xenograpsus testudinatus, Aspergillus penicillioides, Aspergillus versicolor, Penicillium citrinum*, and *Penicillium paxili* (Shaumi et al., 2021). The majority of these fungi belong to the Phylum: Ascomycota, with *Aspergillus* and *Penicillium* being the most speciose genera, and these are also two of the most speciose genera in the marine environment (Jones et al., 2015). *Aspergillus* spp. appears to be predominant across the lobster parts. This corroborates the work of Xu et al. (2021) on the detection of *Aspergillus* spp. in Chinese mitten crab.

Table 3: Cultural and morphological characterization of fungi isolated from *Panulirus regius* off the coast of Lagos, Nigeria.

Sample	Cultural character	Cellular morphology	Probable identity
Head	Filamentous black-mold	Septate hyphae with sporangium filled spores	*Asperigillus niger*
	Filamentous mold with whitish mold	Fusiform, sickle-shaped and elongated	*Fusarium* sp.
	Pure yellowish mold	Septate hyphae, conidiophore is enlarged at the tip forming vesicle and spores enclosed	*Aspergillus wentii*
	Cream, raised, soft colonies with alcohol	Oval shaped with some budded	*Saccharomyces* sp.
	Orange mold-like, blue green and filamentous, whitish mold	Hyphae, conidiophores with conidia at the end; Fusiform to sickle-shaped	*Flavobacterium* sp., *Penicillium* sp. and *Fusarium* sp.
	Yellowish-green mold, bluish-grey mold	Conidia spore and sclerotia, hyphae, conidiophores with conidia	*Aspergillus flavus, A. fumigatus, Penicillium* sp.
	Dirty-brown, yellowish, pure-green molds and mucoid cream colonies	Oval shaped with some budded, hyphal conidia and conidiophores, conidiophores branched, irregularly verticillate, bearing clusters of divergent, often bent, flask-shaped phialides	*Aspergillus fumigatus, A. wentii, Trichoderma* sp., *Sacchromyces* sp.
	Yellowish-green mold	Conidia spore and sclerotia	*Aspergillus flavus*
	Black, yellowish-green and bluish-grey molds	The conidiophores are protrusions from a septate and hyaline hyphae bearing conidia; Conidia spore and sclerotia; Fusiform to sickle-shaped	*Aspergillus niger, A. flavus, Penicillium* sp., *Fusarium* sp.

Table 3 (continued): Cultural and morphological characterization of fungi isolated from *Panulirus regius* off the coast of Lagos, Nigeria.

Sample	Cultural character	Cellular morphology	Probable identity
Tail	Whitish fluppy, wool-like	Non-septate hyphae	*Muccor* sp.
	Black mold and yellow mold	Septate hyphae, conidiophore is enlarged at the tip forming vesicle and spores enclosed	*Aspergillus niger*, *A. wentii*
	Filamentous mold with whitish colony	Fusiform, sickle-shaped and elongated	*Fusarium* sp.
	Pure green and blue-green molds	Conidiophores branched, irregularly verticillate, bearing clusters of divergent, often irregularly bent, flask-shaped phialides. Hyphae, conidiophores with conidia at the end.	*Trichoderma* sp., *Penicillium* sp.
	Cream raised, soft colonies with alcohol odour, bluish-grey	Oval shaped with some budded	*Saccharomyces* sp., *Penicillium* sp., *Fusarium* sp.
	Pure-greenish mold, black mold, bluish-grey and yellowish-green	Conidiophores branched, irregularly verticillate, bearing clusters of divergent, often irregularly bent, flask-shaped phialides, conidia spore and sclerotia, and hyphae, conidiophores with conidia at the end	*Trichoderma* sp., *Aspergillus niger*, *A. flavus*, *Penicillium* sp.
	Mucoid cream-like colonies, black and yellowish molds	Oval shaped with some budded; The conidiophores are protrusions from a septate and hyaline hyphae bearing conidia	*Sacchromyces* sp., *A. niger*, *A. wentii*
	Black, yellowish-green molds and mucoid colonies	Oval shaped with some budded, conidia spore and sclerotia, and oval-shaped with some budded	*Aspergillus niger*, *A. flavus*, *Fusarium* sp., *Sacchromyces* sp.
	Bluish-grey mold	Hyphae, conidiophores with conidia at the end	*Penicillium* sp.

The percentage occurrence of isolates from the head and tail of *P. regius* is presented in table 4. In the bacterial group, *Bacilus megaterium* had the highest frequency of occurrence (22.6%) while *Clostridium* sp., *Coccobacillus* sp., and *Pneumococcus* sp. occurred the least (3.2%). The lobster head had higher number of bacterial isolates (17). In the fungal group, *Aspergillus niger* had the highest frequency of occurrence (20.0%) while *Flavobacterium* sp. and *Muccor* sp. occurred the least (4.0%). Higher fungi occurrence was observed in the lobster tail. With the exception of *A. fumigatus, Flavobacterium* sp., and *Muccor* sp., all identified fungi occurred in both parts of the lobster. Previous studies have demonstrated that *Aspergillus* species are essential components of seafood fungal communities. For instance, *Aspergillus* has been described as the dominant genus retrieved from the crushed dilutions of the vent crab *X. testudinatus* (Pang et al., 2019).

Table 4: Percentage occurrence of isolates in *Panulirus regius* of the coast of Lagos, Nigeria.

Isolates	Lobster part		Total (%)
Bacteria	Head	Tail	
Bacillus subtilis	3	3	6 (19.4)
B. megaterium	4	3	7 (22.6)
Citrobacter sp.	2	2	4 (12.9)
Clostridium sp.	1	0	1 (3.2)
Coccobacillus sp.	1	0	1 (3.2)
Escherichia coli	1	2	3 (9.7)
Enterobacter sp.	1	2	2 (6.5)
Micrococcus sp.	1	1	2 (6.5)
Pneumococcus sp.	1	0	1 (3.2)
Salmonella sp.	1	1	2 (6.5)
Staphylococcus aureus	1	1	2 (6.5)
Total	17	14	31 (100.0)
Fungi			
Aspergillus flavus	2	1	3 (12.0)
Aspergillus fumigatus	2	0	2 (8.0)
Aspergillus wentii	1	1	2 (8.0)
Aspergillus niger	2	3	5 (20.0)
Flavobacterium sp.	1	0	1 (4.0)
Fusarium sp.	1	1	2 (8.0)
Muccor sp.	0	1	1 (4.0)
Penicillium sp.	1	2	3 (12.0)
Saccharomyces sp.	1	2	3 (12.0)
Trichoderma sp.	1	2	3 (12.0)
Total	12	13	25 (100.0)

Table 5 shows *in vitro* antibiotic sensitivity test of 11 different types of bacterial isolates to 11 different antibiotics. *B. subtilis*, *B. megaterium*, and *S. aureus* were not resistant to any of the antibiotics. All isolates were sensitive to ciprofloxacin and showed resistance to rocephin and zinnacef except *Micrococcus* sp. and *Salmonella* sp. All the gram positive bacteria were sensitive to amoxacillin and pefloxacin. Among the gram negative bacteria, *Enterobacter* sp., *E. coli* and C*itrobacter* sp. were sensitive to septrin. Similar to the report of Marijani (2022), *Salmonella* spp. isolates recovered from marine fish showed resistance to six antimicrobial agents comprising gentamicin, tetracycline, penicillin, erythromycin, azithromycin, and ciprofloxacin. Rose et al. (2009) concluded that the presence of antibiotic-resistant bacteria from marine animals indicates not only the widespread presence of the microbes but often a significant percentage of the bacteria demonstrating resistance to multiple antibiotics. Bacterial groups co-habiting a common environment may express a similar antibiotics pattern if they share a common pool of R-factor plasmids (Imarhiagbe et al., 2016).

Table 5: Antibacterial activity against the bacterial isolated from *Panulirus regius* of the coast of Lagos, Nigeria – (Not applicable), R (Resistant), I (Intermediate).

Antibiotics	*Coccobacillus* sp.	*Micrococcus* sp.	*Bacillus subtilis*	*Clostridium* sp.	*Staphylococcus aureus*	*Bacillus megaterium*	*Pneumo coccus* sp.	*Enterobacter* sp.	*Escherichia coli*	*Citrobacter* sp.	*Salmonella* sp.
Amoxacillin	S	S	S	S	S	S	S	S	R	I	R
Ampiclox	I	R	I	–	–	S	R	–	R	S	–
Augmentin	–	–	–	R	S	–	–	I	–	–	R
Ciprofloxacin	R	R	S	I	S	S	R	S	I	S	R
Erythromycin	I	I	S	–	–	S	–	–	S	I	–
Gentamycin	R	R	I	S	I	S	R	S	R	S	R
Pefloxacin	S	S	S	S	S	S	R	I	I	I	S
Rocephin	R	S	R	R	R	R	R	R	R	R	S
Septrin	I	I	I	S	I	S	I	S	S	S	R
Streptomycin	R	I	S	R	S	S	I	S	I	S	R
Zinnacef	R	S	R	R	R	R	R	R	R	R	S

CONCLUSIONS

The Spiny Lobster, *Panulirus regius* off the coast of Lagos harbours microorganisms including those that are pathogenic. The isolates varied in their antibacterial sensitivity to antibiotics. The results of the antimicrobial sensitivity test revealed that every sample contains food-borne bacteria that are multidrug resistant and could be dangerous to the public's health if they spread to people. In order to prevent any further pathogen outbreaks, it is advised that such seafood types be subjected to stricter surveillance by the appropriate authorities.

REFERENCES

1. Afolabi O. J., Oladele O. O. and Olususi F. C., 2020 – Assessment of bacterial loads of *Clarias gariepinus* (Burchell, 1822) obtained from cultured and natural habitats, *The Journal of Basic and Applied Zoology*, 81, 1, 1-7.
2. Afolayan O. A., Moruf R. O. and Lawal-Are A. O., 2020 – Bacterial contamination and heavy metal residues in frozen shellfish retailed within Lagos Metropolis, Nigeria, *Science World Journal*, 15, 1, 11-14.
3. Ahern M., 2021 – The role of aquatic foods in sustainable healthy diets, UN Nutrition, 1-58.
4. APHA, 2005 – Standard methods for the examination of water and wastewater, American Public Health Association (APHA), Washington DC, USA.
5. Ayanda I. O., Dedeke G. A., Ekhator U. I. and Etiebet M. K., 2018 – Proximate composition and heavy metal analysis of three aquatic foods in Makoko river, Lagos, Nigeria, *Journal of Food Quality*, 1-6, DOI: 10.1155/2018/2362843.
6. Bauer A. W., Kirby W. M. M., Sherirs J. C. and Turck M., 1966 – Antibiotic susceptibility testing by standard single disk method, *American Journal of Clinical Pathology*, 45, 4, 433-96.
7. Bekaert K., Devriese L., Maes S. and Robbens J., 2015 – Characterization of the dominant bacterial communities during storage of Norway lobster and Norway lobster tails (Nephrops norvegicus) based on 16S rDNA analysis by PCR-DGGE, *Food Microbiology*, 46, 132e138.
8. Collins C. H., Lyne P. M., Grange J. M. and Falkinham J. O., 2004 – Collins and Lyne's Microbiological Methods, 8th Edition, Arnold, Hodder Headline Group, 338 Euston Road, London, 465.
9. Dubey R. C. and Maheshwari D. K. 2014 – Practical microbiology, Revised Edition, Chand S. and Company Private Limited, Ram Nagar, New Delhi, 1034.
10. Elegbede I. O. and Fashina-Bombata H. A., 2013 – Proximate and mineral compositions of common crab species (Callinectes pallidus and Cardisoma armatum) of Badagry Creek, Nigeria, *Poultry, Fisheries and Wildlife Sciences*, 2, 1, 110-115, DOI: 10.4172/pfw.1000110.
11. EUCAST, 2019 – Breakpoint tables for interpretation of MICs and zone diameters, European Committee on Antimicrobial Susceptibility Testing Version 9.0, http://www.eucast.org.
12. Feinman S. G., Martınez A. U. and Bowen J. L., 2017 – Fine-scale transition to lower bacterial diversity and altered community composition precedes shell disease in laboratory-reared juvenile American lobster, *Disease of Aquatic Organisms*, 124, 41-54.
13. García-López M, Pérez-Martín R. and Sotelo C., 2016 – Carotenoid pigments composition of two commonly discarded decapod crustaceans in Grand Sole and the Galician-Northern Portugal coast fisheries, *Journal of Aquatic Food Product Technology*, 25, 114-121, DOI: 10.1080/10498850.2013.830279.
14. Harrigan W. F. and Mccance M. E. (eds), 1976 – Laboratory methods in food and dairy microbiology, Academic Press, London, 401-430.
15. ICMSF., 1986 – Microorganisms in foods, sampling for microbiological analysis: Principles and specific applications, Second Edition, International Commission on Microbiological Specification for Foods (ICMSF), Blackwell Scientific Publications, Oxford.
16. Imarhiagbe E. E., Ofuya M. E., Osarenotor O. and Ekhaise F., 2016 – Antibiotic sensitivity pattern of microorganisms isolated from smoked and frozen fishes sold in Benin and Warri metropolis, *Nigerian Journal of Biotechnology*, 31, 40-45.
17. Jones E. B. G., Suetrong S., Sakayaroj J., Bahkali A. H., Abdel-Wahab M. A., Boekhout T. and Pang K. L., 2015 – Classification of marine Ascomycota, Basidiomycota, Blastocladiomycota and Chytridiomycota, *Fungal Diversity*, 73, 1-72.
18. Karl H. and Meyer C. 2007 – Effect of early gutting on shelf life of saithe (Pollachius virens), haddock (Melanogrammus aeglefinus) and plaice (Pleuronectes platessa) stored in ice, *Food Safety*, 2, 2, 130e137.
19. Khoshnood Z. and Khoshnood R., 2013 –.Health risks evaluation of heavy metals in sea food, *Transylvanian Review of Systematical and Ecological Research*, 15.1, 137-144.

20. Krieg N. R. and Holt J. G., 1984 – Bergey's Manual of Systematic Bacteriology, Williams and Wilkins, Baltimore, 2648.
21. Kumar V., Zozaya-Valdes E. and Kjelleberg S., 2016 – Multiple opportunistic pathogens can cause a bleaching disease in the red seaweed Delisea pulchra, *Environmental Microbiology*, 18, 62-75.
22. Lawal-Are A. O., Moruf R. O. and Idumebor-Okorie J. O., 2018 – Growth coefficient and assessment of species-specific primers for amplification of mtDNA of the Royal Spiny Lobster, Panulirus regius (De Brito Capello, 1864), *FUTA Journal of Research in Sciences*, 14, 1, 75-83.
23. Lawal-Are A. O., Moruf R. O., Ibrahim, O. O. and Ogunbambo M. M., 2022a – Microbial characteristics of Lagoon Crab (Callinectes amnicola) as influenced by processing steps, *FUW Trends in Science & Technology Journal*, 7, 1, 328-332.
24. Lawal-Are A. O., Moruf R. O., Ojetola I. J., Obiakara-Amaechi A. I. and Usman B. I. 2022b – Microbial assemblage of the anatomical parts of gercacinid crab from a tropical mangrove swamp, *Animal Research International*, 19, 1, 4333-4342.
25. Marijani E., 2022 – Prevalence and antimicrobial resistance of bacteria isolated from marine and freshwater fish in Tanzania, *International Journal of Microbiology*, 1-8.
26. Milstein A., Naor A., Barki A. and Harpaz S., 2013 – Utilization of periphytic natural food as partial replacement of commercial food in organic Tilapia culture – an overview, *Transylvanian Review of Systematical and Ecological Research*, 15.1, 49-60.
27. Moruf R. O. and Lawal-Are A. O., 2019 – Protein, amino acid and fatty acid profiles of two edible crabs of Lagos coast, Nigeria, *Journal of Bangladesh Agricultural University*, 17, 3, 396-401, DOI: 10.3329/jbau.v17i3.43222.
28. Moruf R. O., 2022 – Isolation of gut associated bacteria from Callinectes amnicola (Crustacea: Portunidae) collected from two interconnecting tropical lagoons in Nigeria, *Sri Lankan Journal of Biology*, 7, 1, 12-17, DOI: 10.4038/sljb.v7i1.79.
29. Moruf R. O., Afolayan O. A., Taiwo M. A. and Ogunbambo M. M., 2021 – Estimation of nutritional energy values, mineral ratio and mineral safety index in the Royal Spiny Lobster, Panulirus regius (De Brito Capello, 1864), *Croatian Journal of Food Science and Technology*, 13, 1, 105-110, DOI: 10.17508/CJFST.2021.13.1.13.
30. Obiakara-Amaechi A. I., Iyiola D. O., Oyem I. M., Moruf R. O. and Chukwu L. O., 2022 – Bacterial indicators of contamination in highly impacted segment of tropical lagoon, Southwest Nigeria, *Journal of Applied Sciences and Environmental Management*, 26, 4, 705-710, DOI: 10.4314/jasem.v26i4.21.
31. Oluboba T. F., Lawal-Are A. O., Ogunkanmi A. L. and Moruf R. O. 2021 – Estimation of biometric characters, relative growth and sex ratio of cuttlefish, Sepia officinalis Linneus, 1758 (Cephalopoda: Sepioidea) off the coast of Lagos, Southwest, Nigeria, *Agriculture and Natural Resources*, 55, 3, 440-447, DOI: 10.34044/j.anres.2021.55.3.14.
32. Paleologos E. K., Savvaidis I. N. and Kontominas M. G., 2004 – Biogenic amines formation and its relation to microbiological and sensory attributes in ice-stored whole, gutted and filleted Mediterranean Sea bass (Dicentrarchus labrax), *Food Microbiology*, 21, 5, 549e557.
33. Pang K. L., Guo S. Y., Chen I. A., Burgaud G., Luo Z. H., Dahms H. U., Hwang J. S., Lin Y. L., Huang J. S., Ho T. W. and Tsang L. M., 2019 – Insights into fungal diversity of a shallow-water hydrothermal vent field at Kueishan Island, Taiwan by culture-based and metabarcoding analyses, *PLoS One*, 14, 12, e0226616, DOI: 10.13, 71/journal. pone.0226616.
34. Porter L., Butler M. and Reeves R. H., 2001 – Normal bacterial flora of the spiny lobster Panulirus argus and its possible role in shell disease, *Marine and Freshwater Research*, 52, 1401-1405.
35. Rose J. M., Gast R. J. and Bogomolni A., 2009 – Occurrence and patterns of antibiotic resistance in vertebrates off the northeastern United States coast, *FEMS Microbiology Ecology*, 67, 3, 421-431.

36. Saikia S. K., 2015 – Food and feeding of fishes. What do we need to know? *Transylvanian Review of Systematical and Ecological Review*, 17.1, 71-84.
37. Shaumi A., Cheang U. C., Yang C. Y., Chang C. W., Guo S. Y., Yang C. H and Pang K. L., 2021 – Culturable fungi associated with the marine shallow water hydrothermal vent crab Xenograpsus testudinatus at Kueishan Island, Taiwan, *Botanica Marina*, 64, 4, 289-300.
38. Tavares J., Martins A., Fidalgo L. G., Lima V., Amaral R. A., Pinto C. A. and Saraiva J. A., 2021 – Fresh fish degradation and advances in preservation using physical emerging technologies, *Foods*, 10, 4, 780-786.
39. Troell M., Jonell M. and Crona B., 2019 – The role of seafood in sustainable and healthy diets, Scoping Report, The EAT-Lancet Commission report through a blue lens, Stockholm Resilience Centre, 1-24.
40. Udoh D. I., Udo I. U. and Udoh E. I., 2017 – Microbiological analysis of the freshwater clam (Galatea paradoxa, Born 1778) caught from Cross River, Nigeria, *Nigerian Journal of Agriculture, Food and Environment*, 13, 3, 59-64.
41. Varisco M., Crovetto C., Colombo J., Vinuesa J. and Risso S., 2020 – Proximate composition and nutritional quality of the meat of the Squat Lobster Munida gregaria (Fabricius 1973), *Journal of Aquatic Food Product Technology*, 29, 3, 229-237. DOI: 10.1080/10498850.2020.1719256.
42. Xu S., Wang X., Nageen Y. and Pecoraro L., 2021 – Analysis of gut-associated fungi from Chinese mitten crab Eriocheir sinensis, *All Life*, 14, 1, 610-621.
43. Zha H., Lewis G., Waite D. W., Wu J., Chang K., Dong K. and Jeffs A., 2019 – Bacterial communities associated with tail fan necrosis in spiny lobster, Jasus edwardsii, *FEMS Microbiology Ecology*, 95, 1-9.

PHYTOPLANKTON COMMUNITY OF THE PELAGIC AND THE MACROPHYTE-RICH LITTORAL ZONE IN SOME BULGARIAN INLAND WATERS

*Mihaela BOGOMILOVA BESHKOVA *, Roumen KIRILOV KALCHEV *, Borislava PETROVA GYOSHEVA *, Detelina STOJANOVA BELKINOVA *,* and *Stefania LASLO KLAYN **

* Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Gagarin Street 2, Sofia, Bulgaria, BG-1113, beshkova_m@yahoo.com, ORCID: 0000-0001-8259-5260; rkalchev@zoology.bas.bg, ORCID: 0000-0002-1879-8589; borislavagyosheva@gmail.com, ORCID: 0000-0001-7129-4083; detbel18@gmail.com, ORCID: 0000-0003-0738-4871; stefaniaklayn@yahoo.com, ORCID: 0000-0003-3610-8155.

DOI: 10.2478/trser-2022-0017

KEYWORDS: phytoplankton, macrophytes, littoral zone, pelagic zone, Bulgaria.

ABSTRACT

Statistically significant differences between phytoplankton of the pelagic area and littoral zone, overgrown with macrophytes, were observed in seven reservoirs and three natural lakes. Both total biomass and species diversity of the phytoplankton were higher in the macrophyte settlements than in the pelagic zone. Regarding biomass, the divisions of Pyrrhophyta and Cryptophyta were the main contributors to the similarity of the pelagic areas while the pennate Bacillariophyta were the main contributors to the similarity of macrophyte zones. The phytoplankton structure in the littoral zone differed also within the same water body but in sites with different macrophyte dominant species, as the differences concerned mainly the ratio between pennate diatoms and conjugatophyceans.

RÉSUMÉ: Communauté phytoplanctonique de la zone pélagique et de la zone littorale riche en macrophytes dans certaines eaux intérieures bulgares.

Des différences statistiquement du phytoplancton de la zone pélagique et des zones littorales recouvertes de macrophytes ont été observées dans sept réservoirs et trois lacs naturels. La biomasse de phytoplancton et la diversité des espèces étaient plus élevées dans les colonies de macrophytes que dans la zone pélagique. En ce qui concerne la biomasse, les divisions de Pyrrhophyta et Cryptophyta étaient les principaux contributeurs des zones pélagiques, tandis que les Bacillariophyta pennés étaient les principaux contributeurs des zones de macrophytes. La structure du phytoplancton dans la zone littorale différait également au sein du même corps d'eau, mais dans des sites avec différentes espèces dominantes de macrophytes, les différences concernant principalement le rapport entre les groupes de diatomées pennées et les conjugatophytes.

REZUMAT: Comunitatea fitoplanctonului din zona pelagică și zona litorală bogată în macrofite din unele ape interioare bulgare.

Diferenţele statistice ale fitoplanctonului din zona pelagică şi zonele litorale cu macrofite au fost observate în şapte rezervoare şi trei lacuri naturale. Atât biomasa fitoplanctonului, cât şi diversitatea speciilor au fost mai mari în zonele cu macrofite decât în zona pelagică. În ceea ce priveşte biomasa, Pyrrhophyta şi Cryptophyta sunt principalii contribuitori la similitudinea zonelor pelagice, în timp ce Bacillariophyta au fost principalii contribuitori la similitudinea zonelor cu macrofite. Structura fitoplanctonului în zona litorală se deosebea, de asemenea, în cadrul aceluiaşi corp de apă, dar în situri cu specii dominante de macrofite diferite, deoarece diferenţele se refereau la raportul dintre grupurile de diatomee penate şi conjugatophyceae.

INTRODUCTION

The primary producers in aquatic ecosystems – phytoplankton and macrophytes are the basis of the aquatic food chain and play a leading role affecting the overall metabolism of freshwater systems (Jeppesen at al., 1998). They are also good indicators of the ecological state of environment (Sender 2012, Muntean, 2013; Sender and Maślanko, 2013; Muntean and Alexoaie 2013; Bilous et al., 2013; Kalchev et al., 2016; Barinova et al., 2017; Schneider-Binder, 2018; Krupa et al., 2018; Novoselova et al., 2021).

Most of the studies concerning the phytoplankton – macrophytes relations refer mainly to the shallow waters which alternate between macrophyte dominated clear water state and the phytoplankton dominated turbid water state (Scheffer, 1998, Scheffer et al., 1993). This interaction is a complex and multifaceted process which includes different mechanisms, some of them associated with the plants themselves, including creation of a still water environment, poor light climate, and secretion of allelopathic substances, as well as, mechanisms indirectly linked with the plants, such as provision of refuges or habitat for grazers on algae, and modification of the ambient nutrient regime by the metabolic activity of the plants (Søndergaard and Moss, 1998).

Although the influence of macrophytes on the aquatic ecosystem decrease with the increase of lakes size and depth (Gasith and Hoyer, 1998), it is also present in stratified reservoirs (Hilt et al., 2010), where it is pronounced in the littoral zone. This ecotone zone acts as a buffer between the terrestrial and aquatic ecosystems and it has variable hydrological processes induced by changes in water level, and wind phenomena, leading in turn to the release of nutrients from the bottom sediments into the water column.

Except mechanisms responsible for sustaining the clear macrophyte dominated state and factors that may cause the shift in the two stable states, the phytoplankton dynamics should be explored in relation to the presence or absence of aquatic macrophytes, because controlling phytoplankton biomass and species composition is a major interest in water management (Takamura et al., 2003).

The structuring role of macrophyte vegetation for the composition and quantities of the phytoplankton assemblage of different stagnant water bodies has been evidenced in a number of works (Asaeda et al., 2001; Takamura et al., 2003; Mulderij et al., 2007; Ferreira et al., 2018; They and Marques, 2019; Pełechata et al., 2020).

The present work aims to compare the phytoplankton community structure, biomass and species diversity of the macrophytes free pelagic area and macrophyte rich littoral zone of stagnant water bodies with different morphometric and trophic characteristics as well as to compare the phytoplankton of sites with macrophyte communities dominated by different species.

MATERIAL AND METHODS

Study area

Seven reservoirs and three natural lakes from the Danube River and Black Sea drainage basins in Bulgaria, characterized by the presence of macrophyte vegetation in their littoral zone were studied (Fig. 1, Tab. 1). According the ecological state assessment system (MoEW, 2020) the studied water bodies refered to groups with oligotrophic or mesotrophic conditions (Tab. 1).

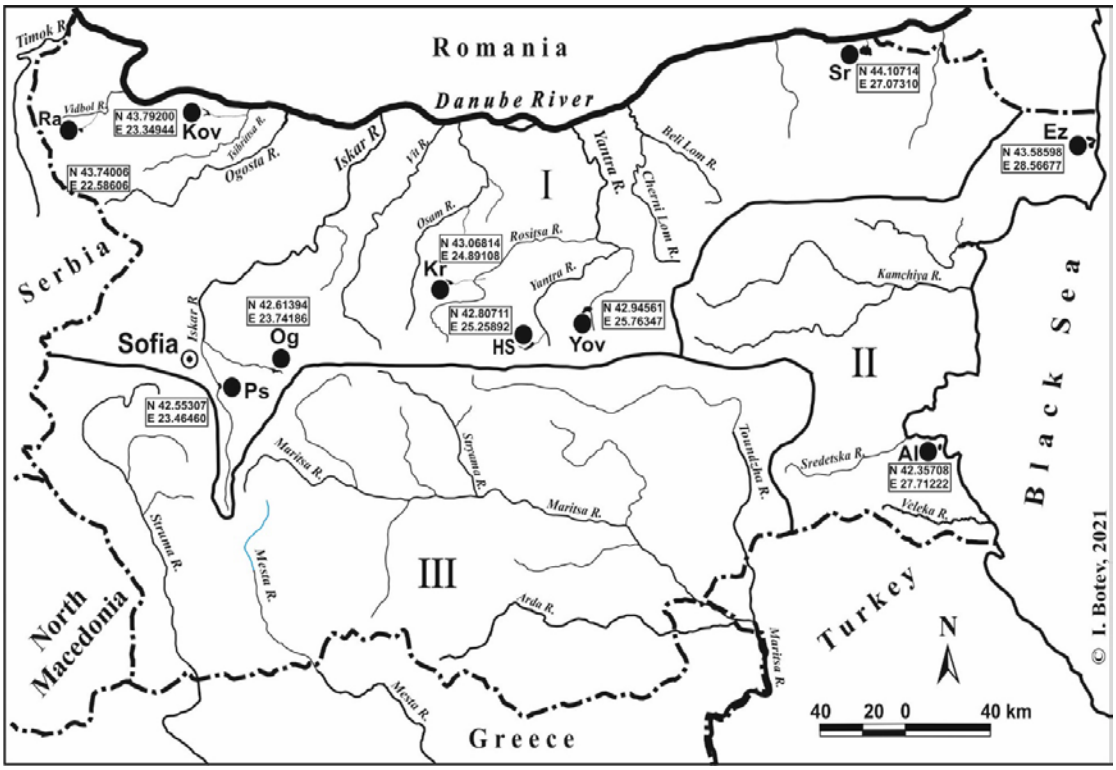


Figure 1: Map of the studied sites. I – Danube River drainage basin;
II – Black Sea River drainage basin; III – Aegean Sea River drainage basin.

Sampling and data analysis

The water bodies were sampled once in the summer of 2019 (Kovachitsa, Hristo Smirnenski, Yovkovtsi) and of 2020 (the others). Phytoplankton samples were taken from one station in the deepest open area in pelagial and from one or two stations with different dominant macrophytes in the littoral zone. In the pelagic area a 0.5 l mixed samples were taken with a plastic water sampler from several depths of the euphotic zone. At the shallow littoral places the samples were taken directly inside macrophyte beds. The samples were fixed with Lugol's solution.

The numerical abundance (ind.ml^{-1}) and biomass (mg. l^{-1}) of the phytoplankton were determined by counting in haemocytometer chamber on an upright light microscope at 200x and 400x magnifications and estimating the individual algal biovolume using standard stereometric method (Rott, 1981; Hillebrand et al., 1999). The structure of the phytoplankton assemblages was evaluated as relative biomass of the major divisions and subdivisional groups: Cyanobacteria, Chlorophyta, Cryptophyta, Chrysophyta, Pyrrhophyta, Euglenophyta, Xantophyta, pennate Bacillariophyta, centric Bacillariophyta, and Conjugatophyceae. The relative biomass of groups of flagellated (FL) and nonflagellated (NF) species was also calculated.

The phytoplankton species diversity was calculated by the Shannon-Weaver formula (Shannon and Weaver, 1964).

The relative abundance of macrophytes was estimated after Kohler (1978). Macrophyte species with the highest relative abundance were considered dominant (Tab. 1).

Statistical data analyses

Linear regression was applied to determine the influence of habitat type (pelagial and among macrophytes), lake type (natural or reservoir), and lake trophic status (oligo- or mesotrophic), as well as possible interactions between them, on the phytoplankton biomass and species diversity (Shannon index). In the total phytoplankton biomass model, Srebarna was excluded from the analysis, because its values there were 10x higher than in the rest of the lakes, and often showed the opposite trend between habitats, obscuring any possible habitat effects. The dependent variable (phytoplankton biomass) was log-transformed because of unequal variances between groups. In the model of species diversity, the dependent variable (Shannon index values) was not transformed, since the variances were deemed constant, and Srebarna was not excluded, because it was not an influential outlier in that case. The linear regressions and subsequent analyses were done in R v. 4.1.0 (R Core Team, 2021).

A global ANOSIM (analysis of similarities) and SIMPER (similarity percentages) analyses (Clarke and Gorley, 2006) were used to evaluate the similarities and differences between phytoplankton communities of the pelagic and the overgrown with macrophytes zones. The tests were performed separately based on both the relative biomass of different phytoplankton groups and on the FL/NF ratio.

Table 1: Characteristics of the studied water bodies; abbreviations: Alt. – altitude, S – water surface area, V – water volume, MD – maximum depth, st. 1, st. 2 – sampling stations with different macrophyte communities.

Water body	Code	Lake type	Dominant macrophyte species	Alt. m.a.s.l.	S. $км^2$	V. m^3	MD. m
Rabisha	Ra	Reservoir (mesotrophic)	st. 1: *Chara connivens* P. Salzmann ex A. Braun st. 2: *Myriophyllum spicatum* L.	286	3.25	42.64	22
Kovachitsa	Kov	Reservoir (mesotrophic	*Myriophyllum spicatum* L.	107	1.12	8.02	25
Pasarel	Ps	Reservoir (oligotrophic)	*Elodea canadensis* Michx.	700	0.30	2.70	20
Ognyanovo	Og	Reservoir (oligotrophic)	st. 1: *Zannichellia palustris* L. st. 2: *Elodea nuttallii* (Planch.) H. St. John	621	1.79	31.60	47
Krapetz	Kr	Reservoir (oligotrophic)	*Myriophyllum spicatum* L.	405	1.80	17.80	17
Hristo Smirnenski	HS	Reservoir (oligotrophic)	*Myriophyllum spicatum* L.	520	0.97	28.30	55
Yovkovtsi	Yov	Reservoir (oligotrophic)	*Myriophyllum spicatum* L.	333	5.74	92.20	50
Srebarna	Sr	Lake (eutrtrophic)	*Ceratophyllum demersum*	10	2.50	1.50	2
Ezerets	Ez	Lake (mesotrophic)	*Nuphar lutea* (L.) Sibth. and Sm.	0	0.72	2.50	9
Alepu	Al	Lake (mesotrophic)	st. 1: *Trapa natans* L. st. 2: *Ceratophyllum demersum* L.	2	0.14	–	1

RESULTS

Total phytoplankton biomass

The variances in phytoplankton biomass (Fig. 2) between the pelagic part and that overgrown with macrophytes are slightly significant ($F(1.19) = 5.44$, $p = 0.03$, adjusted $R_2 = 0.18$).

The model suggests that there is a significant effect of habitat on average phytoplankton biomass (Fig. 3).

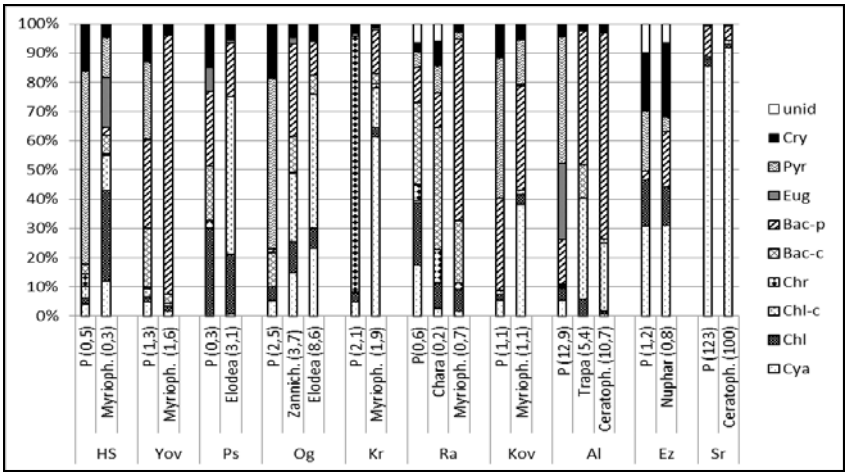


Figure 2: Relative biomass of different phytoplankton groups (%) and total phytoplankton biomass, $mg.l^{-1}$ (in parentheses) in the pelagic zone (P) and among macrophyte vegetation (dominant macrophytes mentioned). Abbreviations: unid – unidentified; Cry – Cryptophyta; Pyr – Pyrrhophyta; Eug – Euglenophyta; Bac-p – pennate Bacillariophyta; Bac-c – centric Bacillariophyta; Chr – Chrysophyta; Chl-c – Conjugatophyceae; Chl – Chlorophyta; Cya – Cyanobacteria.

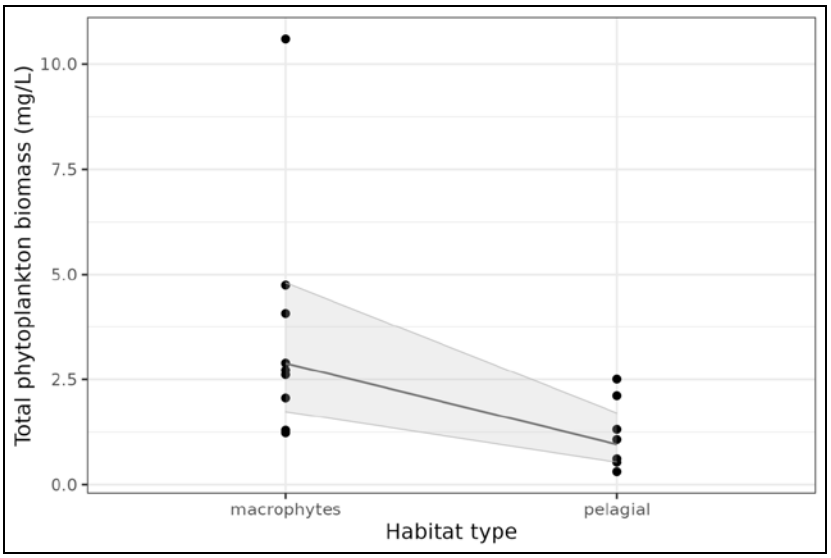


Figure 3: Differences in Shannon diversity index of phytoplankton communities between pelagic and littoral (among macrophytes) habitats and fitted linear regression model with 95% confidence intervals.

Taking into account the type of water body (reservoir or natural lake), we found that the differences between pelagic and littoral zones are more pronounced in the reservoirs than in the lakes. When the analysis was performed only for the reservoirs, taking into account the influence of depth as a factor, the same trends were maintained and no significant influence of reservoir depth was found. Lake trophic status did not contribute to explaining the observed differences in phytoplankton biomass and species diversity between habitats, either.

Phytoplankton community structure

The one-way ANOSIM test showed statistically significant differences between phytoplankton community structure among macrophytes and in the pelagic zone of the lake/reservoir (Fig. 5A). They referred either to different proportions between the same phytoplankton groups (in Rabisha reservoir, lakes Ezerets and Srebarna) or to the participation of different groups of algae in the phytoplankton community (Fig. 4).

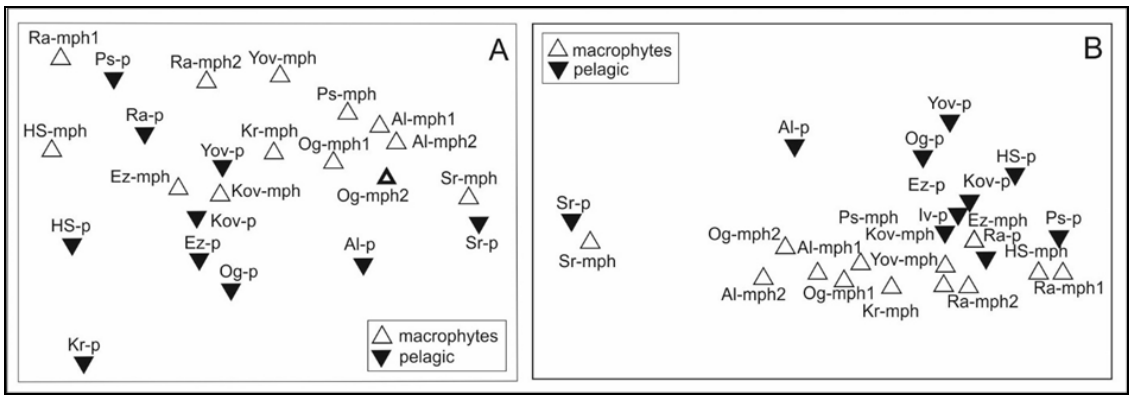


Figure 4: Non metric multidimensional scaling (one-way ANOSIM) of reservoir/lake pelagic area (-p) and within macrophyte crops (-mph1, -mph2). A./based on the relative biomass (%) of algal groups (global R = 0.166, significance level 2.0%); B./based on the FL/NF ratio (log-transformation, global R = 0.155, significance level 1.9%).

The similarity between pelagic phytoplankton communities was due mainly to Pyrrhophyta and Cryptophyta divisions (Tab. 2). The percentage of average dissimilarity between the group of pelagic and the group of littoral zones was significantly higher than the within groups similarities (Tabs. 2 and 3). The pennate Bacillariophyta were the main contributors to the dissimilarity between both zones, followed by Cyanobacteria, Pyrrhophyta, and Conjugatophyceae (Tab. 2).

Table 2: Contribution of different phytoplankton groups to the similarity of samples in “pelagic” and “among macrophytes” zones and to the dissimilarity between them.

Pelagic Av. similarity 28,03 %			Among macrophytes Av. similarity 33.13 %			Among macrophyte/Pelagic Average dissimilarity: 74.08 %.				
	Contr %	Cum %		Contr %	Cum %		Av. Abund	Av. Abund	Contr %	Cum %
Pyr	27.75	27.8	Bac-p	40.63	40.6	Bac-p	0.70	0.46	22.73	22.73
Cry	20.12	47.9	Chl-c	15.51	56.1	Cya	0.58	0.60	18.72	41.45
Bac-p	13.52	61.4	Cya	12.50	68.6	Pyr	0.02	0.41	14.32	55.77

Table 2 (continued): Contribution of different phytoplankton groups to the similarity of samples in "pelagic" and "among macrophytes" zones and to the dissimilarity between them.

Chl	13.14	74.5	Chl	12.09	80.7	Chl-c	0.50	0.02	13.65	69.42
Cya	12.91	87.4	Cry	8.95	89.7	Chl	0.22	0.24	7.34	76.76
Bac-c	9.23	96.0	Bac-c	7.09	96.8	Cry	0.16	0.22	6.50	83.26
–	–	–	–	–	–	Bac-c	0.14	0.14	6.44	89.71
–	–	–	–	–	–	Chr	0.01	0.12	5.83	95.54

Conjugatophyceae clearly predominated in the zone of macrophytes, especially in the cases when *Elodea* dominated the macrophyte community. The higher proportion of conjugates was mainly at the expense of pennate diatoms in Pasarel and Ognyanovo reservoirs (Fig. 4). Moreover, in these cases it contributed to the significantly higher total phytoplankton biomass in comparison to all others studied sites.

The Cyanobacteria division was the second largest contributor to the dissimilarity between pelagic and macrophyte zones (Tab. 2). In four of the studied reservoirs the Cyanobacteria relative biomass was higher in the macrophyte zone, and the differences were the most significant in Krapetz and Kovachitsa reservoirs in communities dominated by *M. spicatum* (Fig. 4). These differences were only quantitative and did not affect the species composition. Thus, in Hristo Smirnenski reservoir *Woronichinia naegeliana* (Unger) Elenkin was the most abundant blue-green alga in both zones, *Dolichospermum* sp. in Ognyanovo reservoir, and *Planktolyngbya subtilis* (W. West) Anagnostidis and Komárek and *Glaucospira* sp. – in Kovachitsa reservoir. In Krapetz reservoir *W. naegelian*a prevailed in the open area, while in the macrophyte zone *Dolichospermum* sp. and *Komvophoron constrictum* (Szafer) Anagnostidis and Komárek dominated. In the other water bodies, the relative share of Cyanobacteria did not differ substantially between pelagic and littoral zones, especially in the Ezerets and Srebarna Lake, where they made up a very large proportion of the total biomass (Fig. 4). No relation was observed with respect to the dominant macrophyte species in these cases.

Significant separation on the plot (Fig. 5B) between pelagic and macrophyte zones was found concerning FL/NF ratio, and it was confirmed by the SIMPER analysis, which clearly shows the prevalence of flagellates in the pelagic areas (Tab. 3).

Table 3: Contribution of groups of flagellate (FL) and non flagellate (NF) species to the similarity within "pelagic" and "among macrophytes" zones and to the dissimilarity between them.

Pelagic Av. similarity 53.47%			Among macrophytes Av. similarity 33.13%			Pelagic/Among macrophytes Average dissimilarity: 74.08%.				
	Contr %	Cum %		Contr %	Cum %		Av. Abund. macroph.	Av. Abund. pelagic	Contr %	Cum %
NF	40.42	100.00	NF	81.77	100.00	NF	2.82	1.41	64.91	64.91
FL	59.58	81.77	FL	18.23	81.77	FL	0.23	1.10	35.09	100.0

The phytoplankton composition differed also between the stations with different macrophyte vegetation in the same water body. Thus, in Ognyanovo and Alepu the most significant differences were registered between the relative biomass of pennate diatoms and conjugatophyceans (Fig. 4). In Ognyanovo the diatoms had higher relative biomass in *Z. palustris* crops, while in the community dominated by *E. nuttallii*, the conjugatophyceans were more abundant and the total phytoplankton biomass was higher. In Alepu Lake the relative biomass of pennate diatoms and the total phytoplankton biomass were higher in the area with *C. demersum* abundance, while in the *T. natans* dominated community, the conjugatophyceans and centric diatoms prevailed over pennate diatoms (Fig. 4). In Rabisha reservoir, we observed no differences in the total phytoplankton biomass between communities dominated by *Ch. connivens* and *M. spicatum*, but the phytoplankton assemblages' structure was quite different. The phytoplankton in *Chara* dominated site consisted of more groups than the one dominated by *M. spicatum*, and it was more similar to the pelagic phytoplankton assemblage (Fig. 4). It was characterized by higher relative biomass of flagellated algae from Cryptophyta (*Plagioselmis nannoplanctica* (H. Skuja) G. Novarino, I. A. N. Lucas and S. Morrall), Pyrrhophyta (Peridinium spp.) and Chrysophyta (*Mallomonas* sp., *Spiniferomonas* sp.), and with prevalence of centric (*Cyclotella* sp.) over pennate diatoms. The most abundant in *M. spicatum* stands were pennate diatoms (*Roppalodia gibba* (Ehr.) O. Muller, *Fragilaria* sp., *Acanthoceras zachariasii* Brun. Simonsen).

DISCUSSION

We observed statistically significant differences between total biomass, species diversity, and community structure of the phytoplankton of the pelagic zone and the zone of macrophyte vegetation. The differences were more expressed in the reservoirs than in the lakes. However, since Srebarna was excluded from the analyses as an outlier, the remaining dataset only included two natural lakes, leading to lower-confidence estimates. We therefore consider that the models accounting for habitat only probably better represent the observed data. The stratification in the deep part of the reservoirs creates different hydrological conditions, unlike in the shallow littoral zone. The presence of macrophytes in the littoral is a main factor affecting the phytoplankton. The influence of macrophytes on phytoplankton is considered to be negative with respect to its biomass, thanks to the complex action of various mechanisms like nutrients competition (Søndegaard and Moss, 1998; Scheffer et al., 2001), shading effect or allelopathy (Gross et al., 2007). However, it is positive regarding the phytoplankton species diversity, as far as, the biomass and the species diversity are generally inversely related. Higher species diversity of phytoplankton in the littoral zone was observed by other authors too. Cuncha et al. (2012) observed that the free-floating and emerged plants induced qualitative shifts in the phytoplankton, raising the diversity of species. Mukhortova et al. (2015) demonstrated that the plankton of the macrophyte zone (incl. phytoplankton) is characterized by a high species diversity and peculiarity of all groups as compared with the pelagic zone in a stratified lake. Sakharova and Korneva (2018) found the highest species richness in the zone overgrown with higher vegetation in the Rybinsk Reservoir. Our data show that both total biomass and species diversity of phytoplankton were higher in the macrovegetation zone. Despite the disturbed light and higher zooplankton grazing pressure, in the higher aquatic plants thickets, the number of species increase was conditioned by the epiphytic algae influx into the water column, as was found also by Klochenko et al. (2015).

We observed significantly higher proportion of phytoflagellates in the pelagic area at the expense of conjugatophyceans and pennate diatoms that predominated in the macrovegetated littoral zones.

The presence or absence of flagellum (ability of active movements) is one of the main adaptive morpho-functional traits of the phytoplankters. While most authors find that in shallower water bodies macrophytes favor the development of phytoflagellates (Søndegaard and Moss, 1998; Fonseca and Bicudo, 2010; Sakharova and Korneva, 2018), it was suggested, that in thermally stratified systems being flagellated could be an advantage because the organism could remain suspended in the water column by itself, regardless of water turbulence (Lopes et al., 2005 after Fonseca and Bicudo, 2010). Furthermore most of the flagellated species, especially cryptophytes, have ability for mixotrophic nutrition and thus are more adapted to nutrient deficiency in the oligotrophic conditions of stratified systems. Thus the motility and mixotrophy could give competitive advantages to flagellates in the stratified area of the reservoirs. The prevalence of pennate diatoms and conjugates we found in the littoral of the water bodies is expectable, taking into account that these groups generally consist of tychoplanktonic species detached from different substrates, including macrophytes, and that their quantity in the water column relates to the extent to which macrophytes are colonized by the epiphyton. We found, however, that the ratio between these tychoplanktonic groups was different in the habitats dominated by different macrophyte species in the same water body. For example higher relative biomass of conjugatophyceans over pennate diatoms was observed in sites with *E. nuttallii* (in Ognyanovo) and *T. natans* (in Alepu) dominance (Fig. 4). One reason could be the selective allelopathic activity of different macrophytes over some epiphytes. Erhard and Gross (2006) showed that extracts from *E. canadensis* and *E. nuttallii*, and exudates of *E. nuttallii* reduce the growth of several aquatic primary producers, among them epiphytic algae and cyanobacteria isolated from different submerged macrophytes. However, the different morphological structure of macrophyte species could also affect the phytoplankton structure (Declerck et al., 2007). The same authors experimentally proved that the mere structure of macrophytes can affect the phytoplankton and other organisms' diversity. The physical structure of macrophytes is believed to contribute to aquatic diversity because it supplies substrate to a wide variety of organisms and because it creates multiple microgradients in the water column and enhances sedimentation rates of phytoplankton cells. Compared to floating-leaf species such as *Trapa*, submerged macrophytes with many segmented and compound leaves such as *Ceratophyllum* create a larger surface area for colonization by epiphytic pennate diatoms. The differences in the structure of the phytoplankton between the open and the overgrown zones were expressed in different degrees. Mukhortova et al. (2015) found that differences in components of the planktonic community (including phytoplankton) developing in the pelagic part of the lake and in individual macrophyte species are more significant than differences between macrovegetation plankton communities. We observed the same in Ognyanovo and Alepu, where the pelagic phytoplankton contained a significantly higher percentage of groups of flagellates. However, we found the opposite in Rabisha reservoir where the phytoplankton community structure among *Chara* thickets was similar to the pelagic one, but differed significantly from that in *M. spicatum* crops (Fig. 4). The phytoplankton assemblage in the *Chara* dominated macrophyte community was characterized by higher relative biomass of phytoflagellate groups as a whole and prevalence of centric over pennate diatoms. Some authors also found a significant proportion of phytoflagellates in both the qualitative and quantitative structure of the phytoplankton assemblages of *Chara* dominated lakes, moreover, no relation between physicochemical water characteristics and the biomass and diversity of phytoflagellates were found, which was probably due to the complex interplay between charophytes and phytoplankton (Pełechata et al., 2020). The differences in phytoplankton structure in *Chara* in

comparison with *Myriophyllum* vegetation could be a result of possible allelopathic activity of *Chara* preventing their colonization. Mulderij et al. (2003) established that differential sensitivity of the species to *Chara* might influence the composition and biomass of phytoplankton communities in the field. However, in comparison with other, floating on the surface species, *Chara* probably affects phytoplankton through the reduction of resuspension rather than by allelopathic or shading effects (Mulderij et al., 2007). On the other hand, Forsberg et al. (1990) find no evidence for such an effect. Bakker et al. (2010) studied the effects of the different macrophyte communities (dominated by different species) on the phytoplankton, and found that the blooms were rarer in the pools dominated by *Chara* than in those, dominated by *Potamogeton.* However, it was unclear whether these differences were the result of higher biomass formation by *Chara*, or of its allelopathy activity. Thus, although *Chara* has been experimentally shown to secrete allelopathic substances that inhibit phytoplankton, the question of whether this can occur *in situ* is still unclear.

CONCLUSIONS

The results of the present work show qualitative and quantitative differences in the phytoplankton assemblages in the macrophyte-free pelagic zone and the macrophyte-rich littoral zone in both shallow and deep stratified water basins. Higher phytoplankton biomass and species diversity of the phytoplankton in the littoral zone was due mainly to the higher numbers of pennate diatoms and conjugatophycean species, while the pelagic areas characterized by a higher relative share of phytoflagellates from Pyrrhophyta and Cryptophyta divisions. The phytoplankton structure differed also between sites dominated by different macrophyte species within the same water basin which is in line with the understanding of the structuring role of macrophytes in the phytoplankton community.

ACKNOWLEDGEMENTS

This work has been carried out in the framework of the National Science Program "Environmental Protection and Reduction of Risks of Adverse Events and Natural Disasters", approved by the Resolution of the Council of Ministers No. 577/17.08.2018 and supported by the Ministry of Education and Science (MES) of Bulgaria (Agreement №ДО-230/06-12-2018).

REFERENCES

1. Asaeda T., Trung V. K., Manatunge J. and Van Bon T., 2001 – Modelling macrophyte-nutrient-phytoplankton interactions in shallow eutrophic lakes and the evaluation of environmental impacts, *Ecology Engineering*, 16, 3, 341-357.
2. Bakker E., Van Donk E., Declerck S., Helmsing N., Hidding B. and Nolet B., 2010 – Effect of macrophyte community composition and nutrient enrichment on plant biomass and algal blooms, *Basic and Applied Ecology*, 11, 5, 432-439.
3. Barinova S., Krupa E. and Kadyrova U., 2017 – Spatial dynamics of species richness of phytoplankton of lake Balkhash in the gradient of abiotic factors, *Transylvanian Review of Systematical and Ecological Research*, 19.2, 1-18.
4. Bilous O., Barinova S. and Klochenko P., 2013 – Climatic influence on the phytoplankton communities of the upper reaches of the Southern Bug River (Ukraine), *Transylvanian Review of Systematical and Ecological Research*, 15.2, 61-86.
5. Clarke R. and Gorley R., 2006 – PRIMER v6: User Manual/Tutorial. PRIMER – E, Plymouth, UK: Plymouth Marine Laboratory, 190.

6 Cunha D., Bottino F. and do Carmo Calijuri. M., 2012 – Can free-floating and emerged macrophytes influence the density and diversity of phytoplankton in subtropical reservoirs? *Lake and Reservoir Management*, 28, 4, 255-264.
7. Declerck S., Vanderstukken M., Pals A., Muylaert K. and De Meester L., 2007 – Plankton biodiversity along a gradient of productivity and its mediation by macrophytes, *Ecology*, 88, 9, 2199-2210.
8. Erhard D. and Gross E., 2006 – Allelopathic activity of Elodea canadensis and Elodea nuttallii against epiphytes and phytoplankton, *Aquatic Botany*, 85, 3, 203-211.
9. Ferreira T., Crossetti L., Motta Marques D., Cardoso L., Fragoso C. and van Nes E., 2018 – The structuring role of submerged macrophytes in a large subtropical shallow lake: Clear effects on water chemistry and phytoplankton structure community along a vegetated-pelagic gradient, *Limnologica*, 69, 142-154.
10. Fonseca B. and Bicudo C., 2010 – How important can the presence/absence of macrophytes be in determining phytoplankton strategies in two tropical shallow reservoirs with different trophic status? *Journal of Plankton Research*, 32, 1, 31-46.
11. Forsberg C., Kleiven S. and Willén T., 1990 – Absence of allelopathic effects of Chara on phytoplankton *in situ*, *Aquatic Botany*, 38, 2-3, 289-294.
12. Gasith A. and Hoyer M., 1998 – Structuring role of macrophytes in lakes: changing influence along lake size and depth gradients, in: The structuring role of submerged macrophytes in lakes, Jeppesen E., Søndergaard M., Søndergaard M. and Christoffersen K., (eds), *Ecological Studies*, New York: Springer, 131, 381-392.
13. Gross E., Hilt S. (nee Körner), Lombardo P. and Mulderij G., 2007 – Searching for allelopathic effects of submerged macrophytes on phytoplankton – state of the art and open questions, *Hydrobiologia*, 584, 1, 77-88.
14. Hillebrand H., Dürselen C. D., Kirschtel D., Pollingher U. and Zohary T., 1999 – Biovolume calculation for pelagic and benthic microalgae, *Journal of Phycology*, 35, 2, 403-424.
15. Hilt S., Henschke I., Rücker J. and Nixdorf B., 2010 – Can submerged macrophytes influence turbidity and trophic state in deep lakes? Suggestions from a case study, *Journal of Environment Quality*, 39, 2, 725.
16. Jeppesen E., Søndergaard M., Søndergaard M. and Christoffersen K., 1998 – The Structuring Role of Submerged Macrophytes in Lakes, New York, Springer, 1-281.
17. Kalchev R., Berczik Á., Beshkova M., Dinka M., Kalcheva H., Kiss A. and Ágoston-Szabo E., 2016 – Trophic status and phytoplankton limitation conditions in a few Bulgarian and Hungarian Danube River wetlands, *Transylvanian Review of Systematical and Ecological Research* 18.2, 19-28.
18. Kohler A. 1978 – Methoden der Kartierung von Flora und Vegetation von Süßwasserbiotopen, *Landschaft und Stadt*, 10, 2, 73-85. (in German)
19. Klochenko P., Shevchenko T. and Kharchenko G., 2015 – Structural and functional organization of phytoplankton in the thickets and in the sections free of vegetation in the lakes of Kiev, *Hydrobiological Journal*, 51, 3, 45-60.
20. Krupa E., Barinova S., Ponamareva L. and Tsoy V., 2018 – Statistical mapping and 3-D surface plots in phytoplankton analysis of the Balkhash Lake (Kazakhstan), *Transylvanian Review of Systematical and Ecological Research*, 20.1, 1-16.
21. Lopes M., Marques R., Bicudo C. and Ferragut C., 2005 – Short term spatial and temporal variation of phytoplankton in a shallow tropical oligotrophic reservoir, southeast Brazil, *Hydrobiologia*, 542, 1, 235-247.
22. MoEW, 2020 – Ordinance No. H-4 of 14.09.2012 for characterization of surface waters. Issued by the Minister of Environment and Water, promulgated, SG, no. 22 of 05.03.2013, in force from March 5, 2013, amended and add., no. 79 of 23.09.2014, in force since 23.09.2014, amended and ext. DV, 85, October 2, 2020. Sofia.

23. Mukhortova O., Bykova S., Tarasova N., Unkovskaya E. and Bolotov S., 2015 – Plankton community in the pelagic and littoral zones of the overgrown lake Beloe (Volzhsko-Kamskiy Biosphere Natural State Reserve, Republic of Tatarstan, Russian Federation), *Journal of Siberian Federal University Biology*, 1, 8, 66-84.
24. Mulderij G., Van Donk E. and Roelofs J. G. M., 2003 – Differential sensitivity of green algae to allelopathic substances from Chara, *Hydrobiologia*, 491, 1-3, 261-271.
25. Mulderij G., Van Nes E. and Van Donk E., 2007 – Macrophyte–phytoplankton interactions: The importance of allelopathy versus other factors, *Ecological Modelling*, 204, 1-2, 85-92.
26. Muntean H., 2013 – Relations between river chemistry and its phytoplankton. Case study – Timiş River, *Transylvanian Review of Systematical and Ecological Research*, 15, 43-50.
27. Muntean H. and Alexoaie L., 2013 – Flood effects on the phytoplankton diversity of Bega River (Romania), *Transylvanian Review of Systematical and Ecological Research*, 15, 207-214.
28. Novoselova T., Barinova S. and Protasov A., 2021 – Long-term dynamics of trophic state indicators in phytoplankton of the cooling reservoir of a nuclear plant, *Transylvanian Review of Systematical and Ecological Research*, 23.1, 1-14.
29. Pełechata A., Pukacz A., Kaczmarek L. and Pełechaty M., 2020 – Do charophytes influence biomass and species composition of phytoflagellates?, *Aquatic Botany*, 103240.
30. Rott E., 1981 – Some results from phytoplankton counting intercalibrations, *Schweizerische Zeitschrift für Hydrologie*, 43, 1, 34-62.
31. Sakharova E. and Korneva L., 2018 – Phytoplankton in the littoral and pelagial zones of the Rybinsk reservoir in years with different temperature and water-level regimes, *Inland Water Biology*, 11, 1, 6-12.
32. Scheffer M., 1998 – Ecology of Shallow Lakes, Chapman & Hall, London, Kluwer, 358.
33. Scheffer M., Hosper H., Meijer M. L., Moss B. and Jeppesen E., 1993 – Alternative equilibria in shallow lakes, *Trends in Ecology & Evolution*, 8, 8, 275-279.
34. Schneider-Binder E., 2018 – Aquatic macrophyte communities of the Gorgova-Isac-Uzlina area (Danube Delta, Romania), *Transylvanian Review of Systematical and Ecological Research*, 20.3, 39-57.
35. Sender J., 2012 – Possibilities of macrophyte indicators, application for assessment of ecological status of lakes, *Transylvanian Review of Systematical and Ecological Research*, 14, 115-128.
36. Sender J. and Maslanko W., 2013 – Long- and short-term changes of the structure of macrophytes in lake Piaseczno in relation to land use in the Łęczna-Włodawa Lakeland (Poland), *Transylvanian Review of Systematical and Ecological Research*, 15.2, 101-110.
37. Shannon C. and Weaver W., 1964 – The mathematical theory of communication, University of Illinois Press, Urbana, U.SA., 125.
38. Søndergaard M. and Moss B., 1998 – Impact of submerged macrophytes on phytoplankton in shallow freshwater lakes, in The structuring role of submerged macrophytes in lakes, Jeppesen E., Søndergaard M., Søndergaard M. and Christoffersen K., (eds), *Ecological Studies*, New York, Springer, 131, 115-132.
39. Takamura N., Kadono Y., Fukushima M., Nakagawa M. and Baik-H. Kim O., 2003 – Effects of aquatic macrophytes on water quality and phytoplankton communities in shallow lakes, *Ecological Research*, 18, 381-395.
40. They N. H. and da Motta Marques D., 2019 – The structuring role of macrophytes on plankton community composition and bacterial metabolism in a large subtropical shallow lake, *Acta Limnologica Brasiliensia*, 31, e19.

NEW RECORDS OF DESMIDS FROM BLANKET BOGS IN TURKEY

Bülent AKAR * and *Utku AVCI* **

* Gümüşhane University, Faculty of Engineering and Natural Sciences, Department of Food Engineering, Gümüşhane, Turkey, TR-29000, akarblnt@gmail.com, ORCID: 0000-0002-1421-374X.
** Eskişehir Osmangazi University, Faculty of Agriculture, Department of Agricultural Biotechnology, Eskişehir, Turkey, TR-26160, utkuavci@gmail.com, ORCID: 0000-0001-5355-9906.

DOI: 10.2478/trser-2022-0018

KEYWORDS: algae, desmids, new records, peatland, Turkey.

ABSTRACT

Peatlands are one of the globally important ecosystems. Blanket bogs are a type of peatlands where water is generally supplied by meteorological events (rain, snow). We have been conducting the first detailed algal flora study of blanket bogs of Turkey and found new records of algae genera ever given for Turkey. Here, we report a total of four desmids genera identified as new records for freshwater algal flora of Turkey: *Spirotaenia* (*Spirotaenia condensata*, *Spirotaenia erythrocephala*), *Mesotaenium* (*Mesotaenium macrococcum*), *Hyalotheca* (*Hyalotheca dissiliens*), and *Bambusina* (*Bambusina borreri*). Their ecological habitat is also discussed to highlight the importance of protection and sustainability of these unique areas.

RÉSUMÉ: Des nouvelles mentions des desmidiales des tourbières ombrotrophes en Turquie.

Les tourbières sont des écosystèmes importants au niveau global. Les tourbières ombrotrophes sont un type de tourbière dont l'eau est fournie généralement par les phénomènes météorologiques comme la pluie ou la neige. Nous avons mené la première étude détaillée de la flore algale des tourbières ombrotrophes de Turquie et nous avons trouvé des genres d'algues mentionnées pour la première fois en Turquie. Le présent article fait mention de quatre genres de desmidiales identifiées comme nouvelles mentions pour la flore algale d'eau douce en Turquie: *Spirotaenia* (*Spirotaenia condensata*, *Spirotaenia erythrocephala*), *Mesotaenium* (*Mesotaenium macrococcum*), *Hyalotheca* (*Hyalotheca dissiliens*), and *Bambusina* (*Bambusina borreri*). Leur habitat écologique en est aussi discuté afin de souligner l'importance de la protection et de la soutenabilité de ces uniques zones.

REZUMAT: Noi semnalări de desmide din mlaştinile de tip stratificat din Turcia.

Turbăriile sunt unul dintre ecosistemele importante la nivel global. Mlaştinile de tip stratificat sunt un tip de turbării în care apa este, în general, furnizată de evenimente meteorologice (ploaie, zăpadă). Am efectuat primul studiu detaliat al florei algelor din mlaştinile de tip stratificat din Turcia şi am realizat înregistrări de genuri de alge noi pentru Turcia. Aici, semnalăm un total de patru genuri de desmide identificate ca noi semnalări pentru flora de apă dulce a Turciei: *Spirotaenia* (*Spirotaenia condensata*, *Spirotaenia erythrocephala*), *Mesotaenium* (*Mesotaenium macrococcum*), *Hyalotheca* (*Hyalotheca dissiliens*), and *Bambusina* (*Bambusina borreri*). Habitatul lor ecologic este, de asemenea discutat pentru a evidenţia importanţa protecţiei sustenabilităţii acestor zone unice.

INTRODUCTION

Wetlands are one of the most valuable, diverse and complex realms of our planet (Schneider-Binder, 2008; Kalchev et al., 2010; Straškrábová et al., 2011; Barinova and Nevo, 2012; Klymiuk et al., 2015; Sipaúba-Tavares et al., 2017; Kar, 2019) among them peatlands are one of the globally important ecosystems for the conservation of biological diversity at the genetic, species and ecosystem levels (Beadle, 2015; Harenda et al., 2018).

Peatlands in the world cover an area of approximately 3.985.000 km^2 and have about 5.000 to 6.000 gross tonnage (Lappalainen, 1996). Peatlands, which have the highest carbon storage capacity per unit area (Frolking et al., 2011), are the most important carbon storage of terrestrial ecosystems. Therefore, they play an important role in terms of climate change and biodiversity richness (Harenda et al., 2018). Algae are one of the organism groups that contribute to this high biodiversity of peatlands. Acidophilic and sphagnophilous alga taxa are more common in these areas (Cambra, 2015). Particularly, desmids prefer a widely low nutrient environment and are distributed in acidic areas such as blanket bogs (Brook, 1981). Therefore, protection and conservation of these areas are essential. However, approximately 85% of the total area of peatlands in Turkey has been degraded because of human intervention (Hoş-Çebi and Korkmaz, 2015). Blanket bogs are a type of peatlands where water is generally supplied by meteorological events (rain, snow), making them mostly ombrotrophic. *Sphagnum* moss forms the bog peat and accumulates about one mm per year and some of these areas are thousands of years old. In Turkey, blanket bogs are rare habitats and are all located in the Eastern Black Sea region except the one located in Çanakkale province (Kırmacı et al., 2019). These unique areas are generally located in high altitudes. EU Habitats Directive listed blanket bogs as prioritized protection areas and the Eleventh Development Plan of Republic of Turkey emphasizes the recognition, protection, and sustainability of Turkish biodiversity. Consequently, proper identification of flora in blanket bogs is very important before their possible degradation and even disappearance in the future.

Although floristic research on freshwater algae in Turkey was firstly carried out by Geldiay (1949) numerous studies have been conducted as both floristically and ecologically perspectives on fresh water algae since the late 1970s (Taşkın, 2019). Most of these studies have been carried out to determine the diversity and ecology of all taxonomic groups of benthic and planktonic algae of aquatic ecosystems such as lakes, wetlands, streams, ponds, and dam lakes. To our knowledge, there has been no study and report of algae from blanket bogs of Turkey; thus, this is the first report of new algae genera from these special areas. Although diatoms and green algae are more common in algal flora of peatlands (Štěpánková et al., 2008) desmids are typical and dominant organisms of high acidity areas such as *Sphagnum* peat (Coesel and Meesters, 2007; Štástný, 2010). In addition, desmids which found only in freshwater environments prefer in ecologically oligo-mesotrophic, slightly acidic (pH 5) (Coesel and Meesters, 2007; Kouwets, 2008) and slightly alkaline (pH 8) environments (Coesel and Meesters, 2007).

There has been a significant interest in the ecology of desmids since they are present in almost all freshwater environments and certain characteristics drive accumulation of certain species in distinctive habitats (Brook, 1981). Studies have been conducted to find and determine the algal flora of alpine and subalpine lakes having oligo-mesotrophic slightly acidic and slightly alkaline in the Eastern Black Sea Region of Turkey and new record of desmid species has been identified for the algal flora of the Turkey (Şahin 1998, 2005, 2021; Şahin and Akar 2007, 2019; Akar and Şahin 2014; Şahin et al., 2020). The main objective of this study was to determine new records of desmids in blanket bogs for the first time studied in Turkey.

MATERIAL AND METHODS

Study area

The algal samples were collected from blanket bogs of Ağaçbaşı (40°41ʾ44.79ʾʾN, 40°04ʾ59.31ʾʾE), Barma (40°42ʾ09.46ʾʾN, 40°08ʾ53.03ʾʾE), Yılanlıtaş (40°41ʾ44.25ʾʾN, 39°59ʾ32.69ʾʾE), Sazak (41°13ʾ50.05ʾʾN, 41°19ʾ37.04ʾʾE), Kabaca-Petek (41°09ʾ50.03ʾʾN, 41°30ʾ58.12ʾʾE) located in Eastern Black Sea of Turkey (Fig. 1). Among them, Ağaçbaşı is the Turkey's largest blanket bog (Payne et al., 2008; Hoş-Çebi and Korkmaz, 2015).

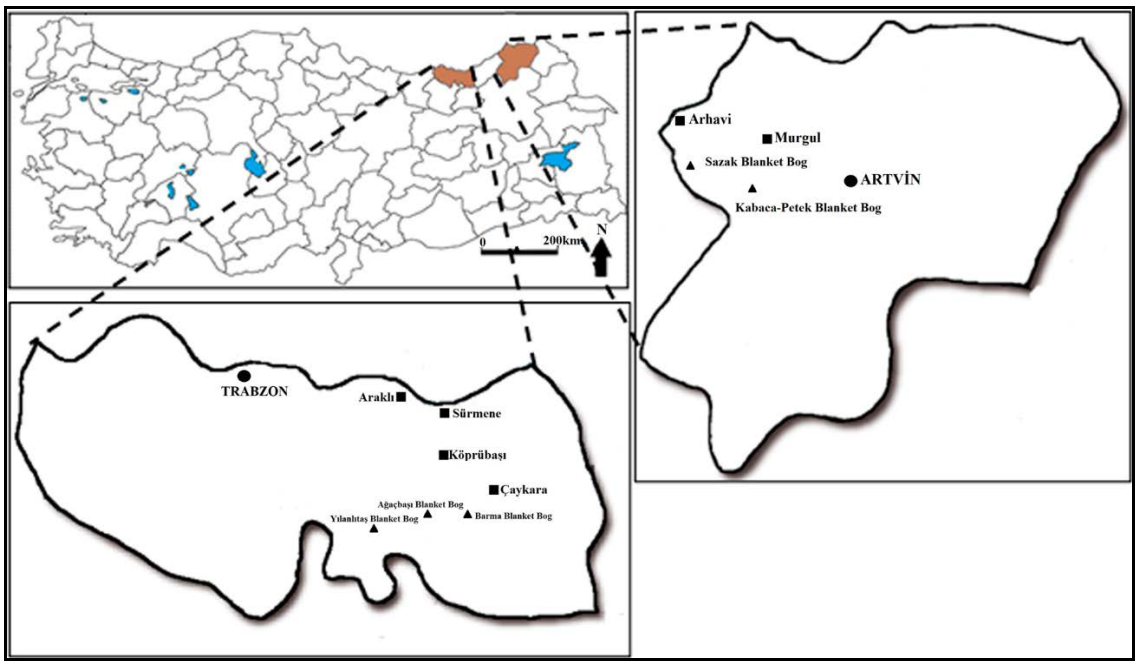


Figure 1: Map of the study areas.

Sampling

Samplings were conducted in May, July, and September of 2021. In each sampling month, 44 sampling stations for Ağaçbaşı, 10 sampling stations for Barma, five sampling stations for Yılanlıtaş, five sampling stations for Sazak, and nine sampling stations for Kabaca-Petek were selected. Epipelic algal samples were collected from the surface of the sediments of the blanket bog pool with a plastic pipe in one cm diameter, while epiphytic samples were collected by squeezing the submerged plants and mosses (*Sphagnum* out of the water) in 370 ml glass bottles. Conductivity, pH, dissolved oxygen and temperature of water were measured with Hach Lange HQ40D Portable Multi Meter. All of the algal samples were stored at +4°C. The samples were examined in fresh condition in microscopic studies. In addition, a certain amount of each sample was fixed with formaldehyde for long-term storage. A light microscope (ZEISS Axioimager) was used for taxonomic identification of desmids.

Desmids were ascertained from West and West (1904), West et al. (1923), Förster (1982), John et al. (2002), Coesel and Meesters (2007), Brook and Williamson (2010) and Kim (2012). The taxa were controlled by checking algal flora of Turkey (Taşkın, 2019; Guiry and Guiry, 2022). The taxonomy of the species was determined by the rules of the International Code of Nomenclature (Turland et al., 2018).

RESULTS AND DISCUSSION

Division Charophyta; Class Zygnematophyceae; Order Desmidiales; Family Mesotaeniaceae; Genus *Spirotaenia* Brébisson ex Ralfs 1848. (Guiry and Guiry, 2022)

Lectotype species: *Spirotaenia condensata* Brébisson

Saccoderm genus *Spirotaenia* contains taxonomically accepted 22 species, two varieties and fur forms (Guiry and Guiry, 2022). Cells in different shapes cylindrical, ellipsoid or narrowly fusiform. Apices of the cell acute or broadly rounded. Chloroplast single or two (only in *Spirotaenia diplohelica* Coesel) ribbon like twisted (spiraling) parietal and lengthens continuously from end to other end of the cell without interruption. Chloroplasts have reddish cap in some species. Cells in two, four or more are usually surrounded with mucilaginous sheath. The wall is smooth and colourless without pores.

***Spirotaenia* genus** of desmids, are mostly rare except for common and cosmopolitan species *Spirotaenia condensata* and generally distributed in North America and Europe (Guiry and Guiry, 2022). Generally rare, these interesting saccoderms mostly found in acidic waters and are most commonly found in peat ponds and *Sphagnum* bogs (Förster, 1982; Brook and Williamson, 2010), but also live in oligotrophic and mesotrophic water accumulations up to an altitude of 2.500 m, more rarely also atmophytic between mosses and moist rocks. Only two species occur in plankton (Förster, 1982). In addition, some members of *Spirotaenia* inhabit small rocky shallow pools and it is even resistant (Brook and Williamson, 2010). For example, *Spirotaenia* species (*Spirotaenia clostridia* (Kützing) Rabenhorst, *Spirotaenia condensate* Brébisson, *Spirotaenia endospira* W. Archer, *Spirotaenia filiformis* G. J. P. Ramos, C. E. M., Bicudo and C. W. N. Moura) collected from bromeliad tanks of *Alcantarea nahoumii* (Leme) J. R. Grant grown in the rocky outcrops in northeastern Brazil which is located in the southern hemisphere (Ramos et al., 2017). Cells of *Spirotaenia* and mucilaginous colonies were also identified on the trees' bark (*Arbutus unedo* L. (Ericaceae), *Tilia cordata* Mill. (Tiliaceae)) as corticolous microalgae in Europe (Neustupa and Štifterová, 2013).

Spirotaenia condensata Brébisson 1848: 179, pl. XXXIV (34).

West and West, 1904, p. 38, Pl. 2: Figs 7-10; Förster, 1982, p. 39, Pl. 1: Figs 15-17; Coesel and Meesters, 2007, p. 25, Pl. 1: Figs 1-2; Brook and Williamson, 2010, p. 70, Pl. 24: Figs 1-5; Kim, 2011, p. 16, Pl. 12: Figs A-K. Homotypic synonym: *Entospira condensata* (Brébisson) Kuntze.

Cells cylindrical with parallel or slightly convex sides, about 6.4 times longer than broad, could even be up to 13 times longer. Cell straight, sometimes slightly curved, rounded apices in a thick, stratified mucilage envelope covering. Cell wall smooth, without pores and without segmentation. Chloroplasts parietal from a wide, spirally coiled band. Cells with 122-149 µm lengths and 19-23 µm breadths (Fig. 2A).

Habitat – Epiphytic (on submerged plants) and epipelic in Ağaçbaşı, Barma. Measured maximum and minimum values of physicochemical parameters at the stations where the species was detected: temperature: 7.3-18.6°C, pH 5.76-7.25, conductivity: 19.4-103.3 µS/cm, dissolved oxygen 4.5-6.31 mg/L. Ecology – It is cosmopolitan and has a worldwide distribution extending to the arctic and tropical regions (Förster, 1982) and inhabits *Sphagnum* bog and bog pools particularly at high altitudes (Brook and Williamson, 2010), which is at 2,150 m above sea level on Alps, in British Columbia about 2.500 m above sea level, in swampy areas all over the world, specially predominant in the littorals of boggy ponds (Förster, 1982). In addition to benthic, they also exist as atmophytic (inhabit a thin film of water, periodically on drying substrates) (Štástný, 2010). However, it is not common in oligo-mesotrophic European lowlands (Coesel and Meesters, 2007), acidophilous (Štástný, 2010),

and circumneutral and alkaliphilous. Common ininhabited the plankton of oligo- and mesotrophic lakes and larger bog waters (Förster, 1982). The species is present in bromeliad tanks (*Alcantarea nahoumii)* in the southern hemisphere (Ramos et al., 2017). Geographical distribution – Europe, North America, Caribbean Islands, South America, Africa, South-West Asia, South-East Asia, Asia, Australia, and New Zealand (Guiry and Guiry, 2022).

Spirotaenia erythrocephala Itzigsohn in Braun 1856: 46, no figure.

Coesel and Meesters, 2007, p. 25, Pl. 1: Figs 3-4; Brook and Williamson, 2010, p. 70, Pl. 26: Figs 1-7. Synonym: No synonym.

The cell is six times as long as broad, cell fusiform apices rounded. The cells are enclosed in a couple in a mucilage envelope. They have a chloroplast consisting of a single tape and a broad, closely spiralled, making 2.5 turns of the cell. As it is understood from its specific epithet, chloroplasts have reddish caps on each pole, which is its characteristic feature. However, Brook and Williamson (2010) stated that these reddish caps of chloroplast are seen in mature cells, and may not be seen in quickly dividing populations. Cells are 40 µm lengths and seven µm breadths (Fig. 2B).

Habitat – Epiphytic (on submerged plants) in Ağaçbaşı. The species was present at one station in May 2021. Temperature: 18.4°C, pH 6.17, conductivity: 23.9 µS/cm, dissolved oxygen 4.55 mg/L. Ecology – Preferr oligo-mesotrophic habitats and rare occurrence (Coesel and Meesters, 2007; Štástný, 2010). It is benthic and atmophytic (Štástný, 2010). Brook and Williamson (2010) reported that the species is distributed in acidic environments especially in shallow ponds. In addition, it has been observed in temporary pools and sediments of marshes and acidic peaty pools. Geographical distribution – Europe (Britain, Bulgaria, Czech Republic, Germany, Netherlands, Romania, Slovakia), Asia (Guiry and Guiry, 2022).

***Mesotaenium* genus Nägeli, 1849**

Holotype species: *Mesotaenium endlicherianum* Nägeli

The taxonomic history of the genus *Mesotaenium* Nägeli in Zygnematophyceae begins with Nägeli (1849) paper. Taxonomically, the genus has all accepted 18 species, 14 varieties, three forms in the algal database at present (Guiry and Guiry, 2022). Cell cylindrical or ellipsoidal with mostly rounded apices or subtruncate. Usually straight or slightly curved, not constricted. The cell has one or two chloroplast (rarely two chloroplast) ribbons or plate-like. Cells are often singular or in small groups. Members of *Mesotaenium* found usually in subaerial habitats mostly as mucilaginous stacks particularly through mosses such as *Sphagnum*, on wet rock and soil. However, rarely, oligotrophic aquatic environments or in acid bog pools (Guiry and Guiry, 2022). Ling and Seppelt (1990) reported that *Mesotaenium berggrenii* (Wittrock) Lagerheim is a common member of the algal flora of snow in Windmill Islands of Continental Antarctica. In addition, the species were reported on snow in Himalayas (Yoshimura et al., 1997), in Alaska (Takeuchi, 2001), in the South America (Takeuchi and Kohshima, 2004), in the Russian Altai Mountains (Takeuchi et al., 2006), and in European Alps (Remias et al. 2009). Likewise *Spirotaenia*, an individual of *Mesotaenium* genus, were also present on the bark of trees (*Juniperus oxycedrus* L.) in Europe (Neustupa and Štifterová, 2013).

Mesotaenium macrococcum (Kützing) J. Roy and Bisset 1894: 61.

West and West, 1904, p. 38, Pl. 3: Figs 34-36; John et al., 2002, p. 513, Pl. 128: Fig C; Coesel and Meesters 2007, p. 21, Pl. 2: Figs 24-26; Brook and Williamson 2010, p. 86, Pl. 37: Figs 1-7: Pl. 38: Figs 1-8. Homotypic synonym: *Palmogloea macrococca* Kützing.

Cells cylindrical, mostly two times longer than broad, rarely 2.5 times. The apices varied form broadly rounded to truncate rounded sometime slightly attenuated. Chloroplast in the shape of a strong axile plate is single in each cell and can have distinctly toothed and almost lengthens to the inner side of the cell wall in some populations. It contains one central pyrenoid. Especially in sub-aerial habitats, cells enclosed by a wide, firm, often layered mucilaginous masses. Cells are 23 µm lengths and 12 µm breadths (Fig. 2C).

Habitat – Sub-aerial (on *Sphagnum*), epipelic, epiphytic in Ağaçbaşı. Measured maximum and minimum values of physicochemical parameters at stations where the species was detected. Temperature: 10.8-20.2°C, pH: 5.59-6.87, conductivity: 27.7-47.8 µS/cm, dissolved oxygen: 4.28-6.31mg/L. Ecology – *Mesotaenium macrococcum* are commonly found in gelatinous masses on sub-aerial materials. However, it is present in bog pools and on *Sphagnum* (Brook and Williamson, 2010). It is oligotrophic and common on wet acidic substrates (Coesel and Meesters, 2007). Geographical distribution – As *Palmogloea macrococca* Kützing: Europe, Australia and New Zealand; as *Mesotaenium braunii*: Europe, North America, South America, Australia and New Zealand; as *Mesotaenium macrococcum*: Europe, North America, South America, Africa, South West Asia, South-East Asia, Asia, Australia and New Zealand (Guiry and Guiry, 2022).

Family: Desmidiaceae

Genus: *Hyalotheca* Ehrenberg ex Ralfs, 1848

Lectotype species: *Hyalotheca mucosa* Ralfs

Currently, the genus contains taxonomically accepted 12 species names, eight varieties, and two forms in the database (Guiry and Guiry, 2022). Cells are very shallow constricted, shaped sub-cylindrical. Apices of the cell truncate united into long filaments, which are sometimes bent and almost always surrounded by a mucilage sheath of a certain thickness. Chloroplast one in each semicell and axile with radiating ridges from central core and each chloroplast have one central pyrenoid. Members of the genera (especially, *Hyalotheca dissiliens* Brébisson ex Ralfs and *Hyalotheca mucosa*) are cosmopolitan usually in habitats non-flowing waters such as acidic, oligotrophic lakes, ponds, and swamps (John et al., 2002; Guiry and Guiry, 2022).

Hyalotheca dissiliens Brébisson ex Ralfs 1848: 51, pl. 1: figure 1 a-I.

West et al., 1923, p. 229, Pl. 161: Figs 16, 18-27; John et al., 2002, p. 589, Pl. 143: Fig I; Coesel and Meesters, 2007, p. 208, Pl. 121: Figs 1-4. Heterotypic synonyms: *Desmidium mucosum* (Dillwyn) Brébisson, *Hyalotheca dissili*ens f. *tridentula* Nordstedt, *Hyalotheca dissiliens* var. *quadridentula* Nordstedt, *Hyalotheca dissiliens* var. *bidentula* (Nordstedt) Boldt, *Hyalotheca dissiliens* f. *bidentula* Nordstedt.

Cells broader than length almost 1¼ to two times, median constriction rather shallow, rectangular semicells with rounded angles in the outline. Apices of semicells broadly truncate. United apices of each cell form long filaments. It could not be observed in apical view. Each semicell has one axile chloroplasts containing a central pyrenoid with several radiating ridges. Thick (10.5 µm), colourless mucilaginous envelope surrounded with filaments. The length of the cell 12-14 µm, breadth 19-21 µm (Fig. 2D).

Habitat – Epiphytic, epipelic, and subaerial in Ağaçbaşı, Barma, Yılanlıtaş Sazak, Kabaca-Petek. Measured maximum and minimum values of physicochemical parameters at the stations where the species was detected. Temperature: 6.3-36.8°C, pH: 4.88-7.65, conductivity: 14.50-341.80 µS/cm, dissolved oxygen: 4.00-7.45 mg/L. Ecology – It is a cosmopolitan species and one of the most common of all desmids. It is often found in large quantities in acid bogs and ditches (West and West, 1923; John et al., 2002) and common in nutrient poor to

moderately nutrient rich lakes as plankton (John et al., 2002), It occurs in mesotrophic waters such as peat pits, quivering fen hollows, moorland pools and dune pools (Coesel and Meesters, 2007). Geographical distribution – As *Desmidium mucosum*: Europe; as *Hyalotheca dissiliens*: Arctic, Europe, North America, Caribbean Islands, Africa, Middle East, South-West Asia, South-East Asia, Asia, Australia, New Zealand, Pacific Islands/Pacific Ocean; as *Hyalotheca dissiliens* f. *tridentula*: Europe, North America, Asia, Australia and New Zealand; as *Hyalotheca dissiliens* var. *bidentula*: Europe, North America, Asia; *Hyalotheca dissiliens* f. *bidentula*: Europe, Caribbean Islands, South America: Brazil, Asia, Australia, and New Zealand (Guiry and Guiry 2022).

Genus *Bambusina* Kützing ex Kützing, 1849

Holotype species: *Bambusina brebissonii* Kützing ex Kützing

Currently accepted name for the type species: *Bambusina borreri* (Ralfs) Cleve

Genus *Bambusina* first described Kützing F. T. in 1849. There are six species, six varieties and one form of the genus taxonomically accepted in the database (Guiry and Guiry, 2022). Members of genus have the cylindrical or barrel-shaped cells (like two flower pots with the upper edges placed side by side) having a very shallow median constriction, V-shaped sinus. Cell wall smooth. Chloroplast one in each semicell axial with radiating widges. In addition, *Bambusina* has a distinctive type of cell division and differed form "*Cosmarium*-type" cell division in many constricted species in Desmidiaceae and it was called *Bambusina* type (Hall et al., 2008). *Bambusina* is found in acidic, oligotrophic, aquatic habitats with other filamentous algae. Species of *Bambusina* are rare in Africa, Asia, Europe, Indonesia, North America, and South America except *Bambusina borreri* (Guiry and Guiry, 2022).

Bambusina borreri (Ralfs) Cleve 1864: 496.

West et al., 1923, p. 255, Pl. 165: Figs 8, 9; John et al., 2002, p. 587, Pl. 143: Fig. M; Coesel and Meesters, 2007, p. 210, Pl. 123: Figs 7-9.

Basionym: *Desmidium borreri* Ralfs

Homotypic synonym: *Desmidium borreri* Ralfs

Heterotypic synonyms: *Bambusina moniliformis* Teiling, *Gymnozyga brebissonii* (Kützing) Wille, *Bambusina brebissonii* Kützing, and *Gymnozyga moniliformis* Ehrenberg.

Barrel shaped cell, forms filaments by attaching end to end like a flower pot. Very slight median constriction, V-shaped. Lateral margins straight, apices broad and truncate. Cell walls are smooth but some have delicate vertical striations. Each semicell has one axile chloroplast including a central pyrenoid. Cell length 28-32 µm, breadth 17-20 µm (Fig. 2E).

Habitat – Epiphytic, epipelic and subaerial in Sazak and Kabaca-Petek. Measured maximum and minimum values of physicochemical parameters at stations where the species was detected. Temperature: 8.24-28.9°C, pH: 5.17-6.79, conductivity: 8.70-55.80 µS/cm, dissolved oxygen: 5.81-6.85 mg/L. Ecology – It is cosmopolite and very common in acid habitats. The species is widespread in the littoral zone of lakes and ponds (nutrient-poor) (John et al., 2002). It occurs in oligotrophic and more or less acid environments (Kouwets, 1987). Geographical distribution – As *Gymnozyga brebissonii*: Europe; as *Desmidium borreri*: Europe; as *Bambusina brebissonii*: Europe, North America, South America, Africa, South-West Asia, South-East Asia, Asia, Australia, and New Zealand; as *Gymnozyga moniliformis*: Europe, North America, South America, Africa, South-West Asia, South-East Asia, Asia, Australia, and New Zealand; as *Bambusina borreri*: Europe, North America, South America, Pacific Islands/Pacific Ocean, Africa, South-West Asia, South-East Asia, Asia, Australia, and New Zealand (Guiry and Guiry, 2022).

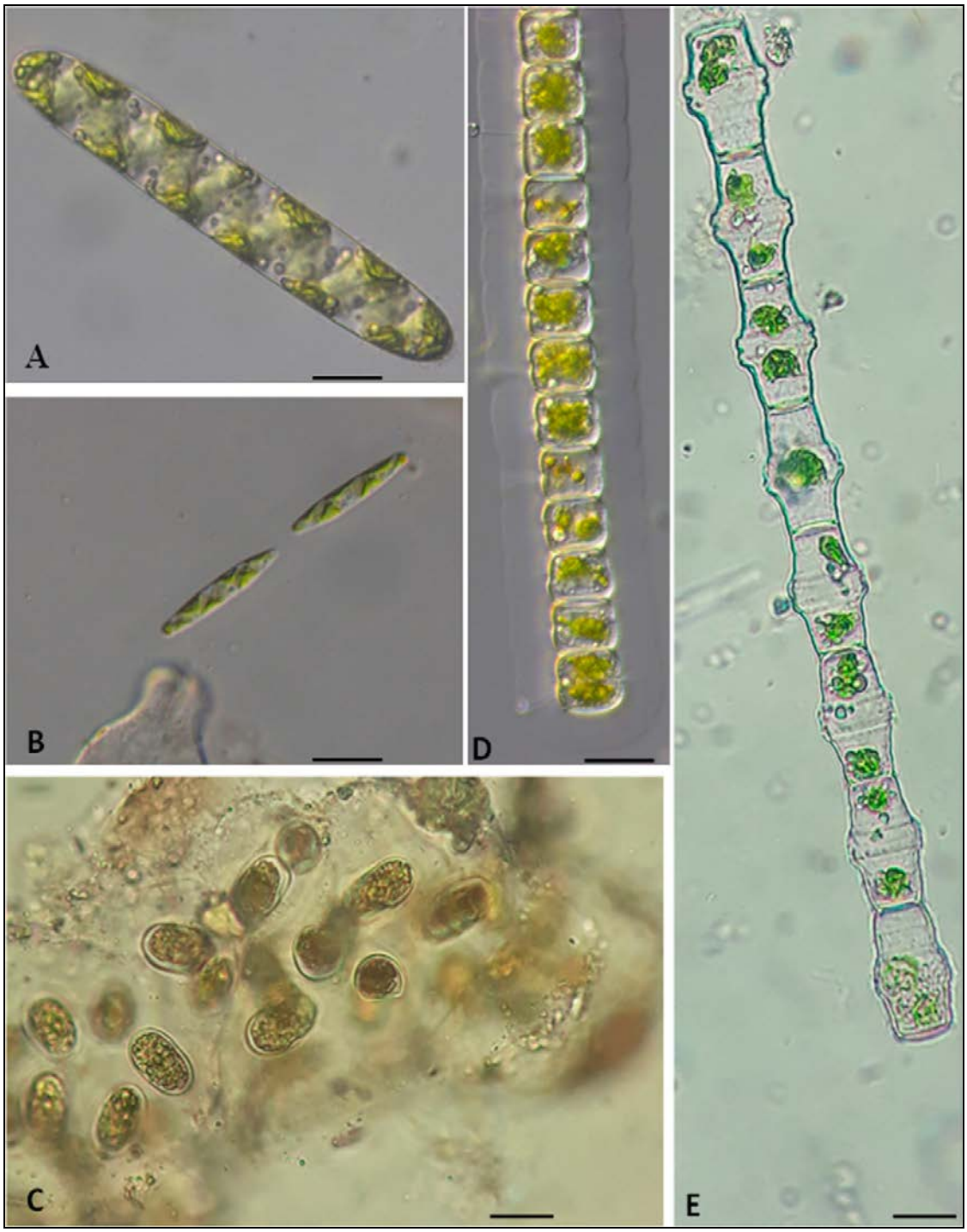


Figure 2: A. *Spirotaenia condensata*, B. *Spirotaenia erythrocephal*a, C. *Mesotaenium macrococcum*, D. *Hyalotheca dissiliens*, E. *Bambusina borreri*; scale bars are equal to 20 µm.

CONCLUSIONS

The new record of desmids for Turkey identified in the blanket bogs are *Spirotaenia condensata, Spirotaenia erythrocephala, Mesotaenium macrococcum, Hyalotheca dissiliens,* and *Bambusina borreri*. This determination of algal flora of blanket bogs in Turkey make significant contributions to the algal biodiversity knowledge.

ACKNOWLEDGEMENTS

This work was supported by the TÜBİTAK (The Scientific and Technological Research Council of Turkey) with project number 120Z575. We would like to thank Dr. Frans Kouwets for critically reading the manuscript.

REFERENCES

1. Akar B. and Şahin B., 2014 – New desmid records of Karagol Lake in Karagol-Sahara National Park (Şavşat-Artvin/Turkey), *Turkish Journal of Fisheries and Aquatic Sciences*, 14, 269-274.
2. Barinova S. and Nevo E., 2012 – Algal diversity of the Akko Park wetlands in the Bahai Gardens (Haifa, Israel), *Transylvanian Review of Systematical and Ecological Research*, 14, 55-80.
3. Beadle J. M., Brown L. E. and Holden J., 2015 – Biodiversity and ecosystem functioning in natural bog pools and those created by rewetting schemes, *Wiley Interdisciplinary Reviews: Water*, 2, 65-84.
4. Brook A. J., 1981 – The biology of desmids. University of California Press Berkeley USA, 276, ISBN: 9780632002535.
5. Brook A. J. and Williamson D. B., 2010 – A monograph on some British desmids. The Ray Society London UK, 364, ISBN: 9780903874427.
6. Cambra J., 2015 – Micro-scale distribution of algae in a Pyrenean peat-bog, Spain, *Hidrobiológica*, 25, 213-222.
7. Coesel P. F. M. and Meesters K. J., 2007 – Desmids of the lowlands: Mesotaeniaceae and Desmidiaceae of the European lowlands, KNNV Publishing Netherlands, 351, ISBN: 978-90-5011-265-9.
8. Förster K., 1982 – Conjugatophyceae Zygnematales und Desmidiales (excl. Zygnemataceae), in Huber-Pestalozzi G (ed.), Das Phytoplankton Des Süßwassers Systematik Und Biologie, Schweizerbart'sche Verlangbuchhandlung (Nägele U. Obermiller) Stuttgart Germany, 543, ISBN: 3510400240. (in German)
9. Frolking S., Talbot J., Jones M. C., Treat C. C., Kauffman J. B., Tuittila E. S. and Roulet N., 2011 – Peatlands in the earth's 21st century climate system, *Environmental Reviews*, 19, 371-396.
10. Geldiay R., 1949 – Comparative analysis of macro and micro fauna between Çubuk Dam and Eymir Lake, *Journal of Ankara University Science Faculty*, 2, 146-252.
11. Guiry M. D. and Guiry G. M., 2022 – AlgaeBase, World-wide electronic publication, National University of Ireland, Galway, http://www.algaebase.org.
12. Hall J. D., Mccourt R. M. and Delwiche C. F., 2008 – Patterns of cell division in the filamentous Desmidiaceae, close green algal relatives of land plants, *American Journal of Botany*, 95, 643-654.
13. Harenda K. M., Lamentowicz M., Samson M. and Chojnicki B. H., 2018 – The role of peatlands and their carbon storage function in the context of climate change, in Zielinski T., Sagan I. and Surosz W. (eds), Interdisciplinary Approaches for Sustainable Development Goals, GeoPlanet: Earth and Planetary Sciences, Springer, Cham, 169-187.
14. Hoş-Çebi F. and Korkmaz S., 2015 – Organic geochemistry of Ağaçbaşı Yayla Peat deposits, Köprübaşı/Trabzon, NE Turkey, *International Journal of Coal Geology*, 146, 155-165.
15. John D. M., Whitton B. A. and Brook A. J., 2002 – The freshwater algal flora of the British Isles: an identification guide to freshwater and terrestrial algae, Cambridge University Press London England, 702, ISBN: 978-1108478007.
16. Kalchev R., Beshkov V., Bogdanović T., Coman A., Edinger M., Hein T., Ivanov B., Krasic D., Mihaljevic M., Nikolov V., Pehlivanov L., Puzovic S., Sandu C., Stojnic N., Vasilev M. and Vujic A., 2010 – Vertebrate species distribution in selected wetlands of the Danube River basin, *Transylvanian Review of Systematical and Ecological Research*, 10, 151-168.
17. Kar D., 2019 – Wetlands and their fish diversity in Assam (India), *Transylvanian Review of Systematical and Ecological Research*, 21.3, 47-94.
18. Klymiuk V., Barinova S. and Fatiuka A., Algal bio-indication in assessment of hydrological impact on ecosystem in wetlands of Slavyansky Resort, *Transylvanian Review of Systematical and Ecological Research*, 63-70, 17.1.

19. Kim H. S., 2012 – Algal Flora of Korea: Charophyta: Conjugatophyceae (Desmids I): Zygnematales: Mesotaeniaceae, Desmidiales: Gonatozygaceae, Peniaceae, Closteriaceae, Desmidiaceae, Freshwater Green Algae, National Institute of Biological Resources (Inch'on) Korea, 94, ISBN: 9788997462605.
20. Kırmacı M., Semiz A., Filiz F. and Çatak, U., 2019 – Turkish blanket bogs and Sphagnum (Bryophyta) diversity of these blanket bogs, *Acta Biologica Turcica*, 32, 211-219.
21. Kouwets F., 1987 – Desmids from the Auvergne (France), *Hydrobiologia*, 146, 193-263.
22. Kouwets F., 2008 – The species concept in desmids: the problem of variability, infraspecific taxa and the monothetic species definition, *Biologia*, 63, 881-887.
23. Lappalainen E., 1996 – General review on world peatland and peat resources, Technical Report NEI-FI-326, International Peat Society Finland, 53-56, ISBN: 9529074875.
24. Ling H. U. and Seppelt R. D., 1990 – Snow algae of the Windmill Islands, continental Antarctica. Mesotaenium berggrenii (Zygnematales, Chlorophyta) the alga of grey snow, *Antarctic Science*, 2, 143-148.
25. Nägeli C. 1849 – Gattungen einzelliger Algen: physiologisch und systematisch bearbeitet. Friedrich Schulthess Zürich, 138, ISBN: 9780270817355. (in German)
26. Neustupa J. and Štifterová A., 2013 – Distribution patterns of subaerial corticolous microalgae in two European regions, *Plant Ecology and Evolution*, 146, 279-289.
27. Payne R. J., Charman D. J., Matthews S. and Eastwood W. J., 2008 – Testate amoebae as palaeohydrological proxies in Sürmene Ağaçbaşi Yaylası Peatland (northeast Turkey), *Wetlands*, 28, 311-323.
28. Remias D., Holzinger A. and Lütz C., 2009 – Physiology, ultrastructure and habitat of the ice alga Mesotaenium berggrenii (Zygnemaphyceae, Chlorophyta) from glaciers in the European Alps, *Phycologia*, 48, 302-312.
29. Ramos G. J. P., Bicudo C. E. D. M. and Moura C. W. D. N., 2017 – Taxonomic notes on Spirotaenia (Mesotaeniaceae, Zygnematophyceae) from a Brazilian phytotelm habitat: new species and new records, *Phytotaxa*, 309, 265-270.
30. Schneider-Binder E., 2008 – Importance of floodplains and floodplain wetlands along the lower Danube with special regard to phytodiversity, *Transylvanian Review of Systematical and Ecological Research*, 6, 59-70.
31. Straškrábová V., Lakatos G. and Kereszturi P., 2011 – Bacterial community structure in the wetlands of Hortobágyi Nemzety Park (Hungary), *Transylvanian Review of Systematical and Ecological Research*, 12, 127-136.
32. Štástný J., 2010 – Desmids (Conjugatophyceae, Viridiplantae) from the Czech Republic; new and rare taxa, distribution, ecology, *Fottea*, 10, 1-74.
33. Štěpánková J., Vavrušková J., Hašler P., Mazalová P. and Poulíčková A., 2008 – Diversity and ecology of desmids of peat bogs, in The Jizerské Hory Mts., *Biologia*, 63, 895-900.
34. Şahin B., 1998 – Some new records of desmids from Turkey, *Pakistan Journal of Botany*, 30, 7-13.
35. Şahin B., 2005 – A preliminary checklist of desmids of Turkey, *Cryptogamie, Algologie*, 26, 399-415.
36. Şahin B., 2021 – New desmid records from two high mountain lakes in Camlıhemşin/Rize (Turkey), *Botanica Serbica*, 45, 273-284.
37. Şahin B. and Akar B., 2007 – The desmid flora of some high mountain lakes of the Turkish Eastern Black Sea Region, *Pakistan Journal of Botany*, 39, 1817-1832.
38. Şahin B. and Akar B., 2019 – New desmid records from high mountain lakes in Artabel Lakes Nature Park, Gümüşhane, Turkey, *Turkish Journal of Botany*, 43, 570-583.
39. Şahin B., Akar B. and Barinova S., 2020 – Cohabitant charophyte algal flora and its ecology in high-mountain lakes of the Artabel Lakes Nature Park (Gümüşhane, Turkey), *Botanica Serbica*, 44, 11-25.

40. Sipaúba-Tavares L. H., Scardoelli Truzzi B., Milstein A. and Marcari Marques A., 2017 – Associated fauna to Eichhornia crassipes in a constructed wetland for aquaculture effluent treatment, *Transylvanian Review of Systematical and Ecological Research*, 29-42, 19.1.
41. Takeuchi N., 2001 – The altitudinal distribution of snow algae on an Alaska glacier (Gulkana Glacier in the Alaska Range), *Hydrological Processes*, 15, 3447-3459.
42. Takeuchi N. and Kohshima S., 2004 – A snow algal community on Tyndall Glacier in the Southern Patagonia Icefield, Chile, *Arctic, Antarctic, and Alpine Research*, 36, 92-99.
43. Takeuchi N., Uetake J., Fujita K, Aizen V. B. and Nikitin S. D., 2006 – A snow algal community on Akkem Glacier in the Russian Altai Mountains, *Annals of Glaciology*, 43, 378-384.
44. Taşkin E., 2019 – A checklist of the flora of Turkey (Algae), Ali Nihat Gökyiğit Vakfı İstanbul, Turkey, 804, ISBN: 9786056717291.
45. Turland N. J., Wiersema J. H., Barrie F. R., Greuter W., Hawksworth D. L., Herendeen P. S., Knapp S., Kusber W. H., Li D. Z., Marhold K., May T. W., Mcneill J., Munro A. M., Prado J., Price M. J. and Smith G., 2018 – International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Koeltz Botanical Books, 254, ISBN: 9783946583165.
46. West W. and West G. S., 1904 – A monograph of the British Desmidiaceae, Ray Society London UK, 224, ISBN: 9781179240374.
47. West W., West G. S. and Carter N. 1923 – A monograph of the British Desmidiaceae, Ray Society London UK, 300, ISBN: 9781152423817.
48. Yoshimura Y., Kohshima S. and Ohtani S., 1997 – A community of snow algae on a Himalayan glacier: change of algal biomass and community structure with altitude, *Arctic and Alpine Research*, 29, 126-137.

STATUS OF CONSERVATION OF THE MANGROVE OF PLAYA BLANCA, HOLGUIN (CUBA)

*Jonathan Pozo-Serrano**, (c.a.), Enrique Reynaldo de la Cruz *, David F. Hernández-Marrero** and *Lisbet Guzmán-Alberteris***

* Centro de Investigación y Servicios Ambientales de Holguín. Departamento de Gestión Costera y Recursos Naturales, Cuba, Street 18 s/n e/ 1st and Maceo, Delivery, El Llano, Holguín, Cuba, CU-80100, jpozo920@gmail.com (c.a.), ORCID: 0000-0001-8391-7380, ereynaldodelacruz@gmail.com, ORCID: 0000-0003-3790-9843; david@cisat.cu, ORCID: 0000-0001-6963-3875.
** University of Holguín Oscar Lucero Moya. Facultad Ciencias Empresariales y Administración. Departamento Economía. Ave. XX aniversario Delivery Piedra Blanca, Holguín, Cuba, CU-80100, guzmanlisbet60@gmail.com, ORCID: 0000-0002-3274-8932.

DOI: 10.2478/trser-2022-0019

KEYWORDS: abiotic variables, contamination, density, mangrove forest species, regeneration.

ABSTRACT

This study determined the state of conservation and association of abiotic variables in the mangrove forest of Playa Blanca, Holguin, Cuba. Three randomly located transects were made, each of 100 m^2 (10 x 10 m). A stress level (0.06) was obtained, allowing to establish a good level of adjustment in the distribution of the ecological distances of both species in relation to the previously established chemical-physical parameters. A poor state of conservation of the Playa Blanca mangrove forest is confirmed, and a strong association between temperature and the total height of the trunk of both mangrove species present.

RESUMEN: Estado de conservación del manglar de Playa Blanca, Holguín (Cuba).

Se buscó determinar el estado de conservación y asociación de las variables abióticas en el manglar de Playa Blanca, Holguín, Cuba. Se realizaron tres transectos ubicados de forma aleatorios. La dimensión fue de 100 m^2 (10 x 10 m). Se obtuvo un nivel de stress (0,06), permitiendo establecer un buen nivel de ajuste en la distribución de las distancias ecológicas de ambas especies, en relación a los parámetros químicos-físicos del agua. Se detectó un pobre estado de conservación del manglar de Playa Blanca y asociación entre la temperatura y la altura del tronco.

REZUMAT: Starea de conservare a mangrovelor de la Playa Blanca, Holguín (Cuba).

S-a determinat starea de conservare și asocierea variabilelor abiotice în mangrovele de la Playa Blanca, Holguin, Cuba. Au fost realizate trei transecte localizate aleatoriu. Dimensiunea fiecăruia a fost de 100 m^2 (10 x 10 m). S-a obţinut un nivel de stres (0,06), permiţând stabilirea unui bun nivel de ajustare în distribuţia distanţelor ecologice ale ambelor specii în raport cu parametrii chimico-fizici stabiliţi anterior. Se stabilește o stare proastă de conservare a mangrovelor de la Playa Blanca și o asociere puternică între temperatură și înălțimea totală a trunchiului ambelor specii prezente.

INTRODUCTION

Mangroves are evergreen forests of wide tropical distribution; in Cuba this vegetation formation has an extent that represents approximately 5% of the national territory (Linares et al., 2016). They constitute coastal marine ecosystems that develop characteristics of tolerance to anoxia, so they are generally established in protected and muddy areas near coasts or riverbanks (Geomar, 2017). Mangroves provide a series of ecological services, among which stand out the protection they provide to the coastline against storms and hurricanes, stabilize sediments, function as biological filters, constitute areas of high landscape value, due to the fact that they are home to a great biological diversity, and also function as breeding and spawning grounds for fish and invertebrates of commercial interest (Alang et al., 2010; López et al., 2011).

A fundamental characteristic of mangroves is their very high primary productivity and the contribution of carbon to coastal areas (Acosta et al., 2019). These plants play a critical role in the removal and degradation of pollutants such as heavy metals, pesticides, and nitrogenous and phosphate compounds (Aziz and Hashim, 2010; Moroyoqui-Rojo et al., 2015). As they are highly specialized ecosystems, they can die suddenly when one of the parameters of their environment is modified, which is why on tropical coasts they are the first to detect variations in the water regime, however small these may be (Guzmán and Ménedez, 2013).

The temperature of the water where the mangroves live should not exceed 40°C, because it can have negative effects on the establishment of the seedlings. Favourable temperatures should be less than 35°C. Salinity should not be high or exceed the minimum tolerance levels that the different species can withstand. The appropriate pH concentration range to ensure the survival of species should be maintained in a range of 6.5 to 8.0; outside this range, diversity is reduced due to stress problems (Buchili, 2020). The health of any ecosystem is given by the behavioral functioning and dynamics of all its components under stress conditions (Mitra et al., 2017).

The coastal zone of the province of Holguín, Rafael Freyre municipality, has fragments of mangrove forests which are highly human-disturbed, so that knowing their conservation status and the association of the physical-chemical variables of water constitutes valuable information for its management and administration. Therefore, this study objective was to determine the mangrove forest conservation status and related association of abiotic variables of water of Playa Blanca.

MATERIAL AND METHODS

Description of the study area

The studied Playa Blanca mangrove forest (Fig. 1) is located in Rafael Freyre municipality on the north coast of Cuba, northwest of Holguín Province. Between 21º05'06.53'' north latitude and 76º00'16.14'' west longitude, it has a territorial extent of 0.95 km². It is six kilometers from the town of Rafael Freyre, with a coastal strip extent of 250 m wide, located at the entrance to Bariay Bay. It is bordered on the north by the Atlantic Ocean, on the south by Miramar, on the east by Don Lino and on the west by Bariay Bay. Three geo-referenced transects were selected for this study (Tab. 1). The study was conducted in November 2019.

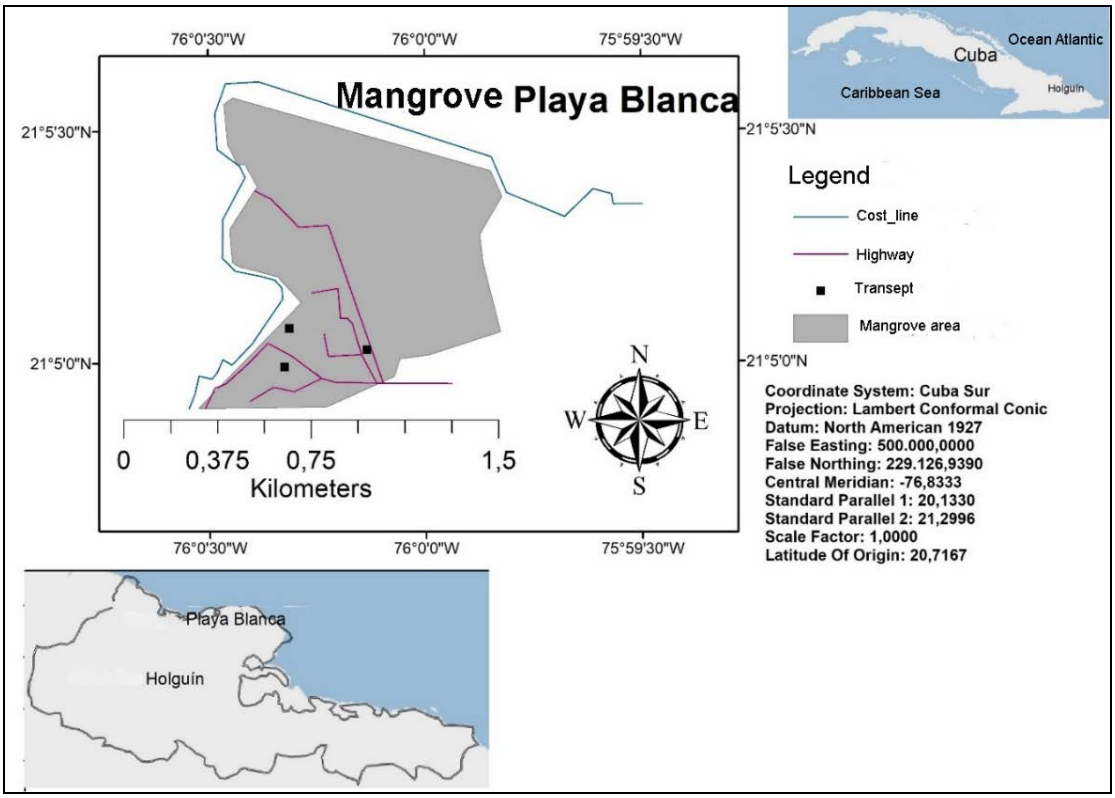


Figure 1: Location of the area of study.

Table 1: The transects' coordinates.

Area of study	Plane coordinates South Cuba	
Transect 1	586 026.4 629	269 920.2 821
Transect 2	586 356.8 924	269 989.5 878
Transect 3	586 045.8 815	270 074.1 461

Sampling design

Three transects were randomly located. The dimension of each transect was 100 m^2 (10 x 10 m), the separation between each transect was 50 m across. The methodology of Guzmán and Menéndez (2013) was used. Point samples of the mangrove water were taken and O_2, BOD_5^{20}, COD, pH, temperature, ammonium, and salinity were determined at the Empresa Nacional de Análisis y Servicios Técnicos (ENAST).

Statistical analysis

A multiple correspondence analysis (CA) was performed to establish the association between species and abiotic variables. Spearman's rs correlation was also used for a $p < 0.05$, with 9,999 permutations, taking the variables of greatest association established in the previous analysis. An n-MDS analysis was used to represent the ecological distance between mangrove species based on the variables of greatest similarity. Data processing was performed using the statistical software PAST 4.10 (Hammer et al., 2001).

RESULTS

A total of 57 mangrove individuals were observed, including one family, two genera, and two species. There was a predominance of *Laguncularia racemosa* with 47 individuals/100 m^2 over *Conocarpus erectus* with 10 individuals/100 m^2. A predominance of the species *L. racemosa* over *C. erectus* was observed in the three transects, and a low level of regeneration associated with the high rate of contamination. Of a total of 57 individuals recorded, 47 were of the species *L. racemosa* and 10 of *C. erectus*. In the first work sector, with a canopy cover of 35%, *L. racemosa* had a basal area of 2.74 m^2/ha, an average height of 5.85 m, density of 1,500 trees/ha and 79% presence in the plot. *C. erectus* had a basal area of 0.0907 m^2/ha, mean height of 4.38 m, density of 400 number of trees/ha and 21% presence in the plot.

The second transect presented a canopy cover of 85%, *L. racemosa* with a basal area of 25.1607 m^2/ha, a mean height of 6.49 m, density of 2,100 number of trees/ha and 100% presence in the plot. In the third transect a canopy cover of 95% was obtained, *L. racemosa* presented a basal area of 9.18 m^2/ha, a mean height of 5.13 m, a density of 1,100 number of trees/ha and 65 % of presence in the plot. The basal area for *C. erectus* was 1.67 m^2/ha, mean height of 4.10 m, density of 600 number of trees/ha and 35 % of presence in the plot (Tabs. 2 and 3).

Table 2: Observations of the sectors of work: *Laguncularia racemosa* (L. r.), *Conocarpus erectus* (C. e.).

Sectors of work	No. individuals	Coverage canopy	Average height pneumatophores	Contamination level	Type of flood	Regeneration
1.	19 (15 L. r y, 4 C. e)	35%	None	High	stream	Low
2.	21 (21 L. r)	85%	None	High	stream	Low
3.	17 (6 C. e y, 11 L. r)	95%	None	Medium	stream	Not abundant

Table 3: Structure of the mangrove forest: *Laguncularia racemosa* (L. r.), *Conocarpus erectus* (C. e.).

Sectors of work	Basal area (m^2/ha):		Average height (m):		Tree density (number of trees /ha)		Percentage of presence of each species by parcels	
	Species		Species		Species		Species	
	L. r	C. e	L. r	C. e	L. r	C. e	L. r	C. e
1.	2.74	0.09	5.85	4.38	1 500	400	79	21
2.	25.16	0	6.49	0	2 100	0	100	0
3.	9.18	1.67	5.13	4.10	1 100	600	65	35

When performing the multiple correspondence analysis (CA), a strong association was determined between the total height of the trees, trunk height, temperature, salinity, pH, NH_4 and dissolved oxygen, obtaining a percentage of the weight of the variables in axis 1 (58.05%) and in axis 2 (25.10%) for a total accumulated association of 83.15%. This allowed describing the existing relationship between these variables and showing that they have a correlation level (Fig. 2).

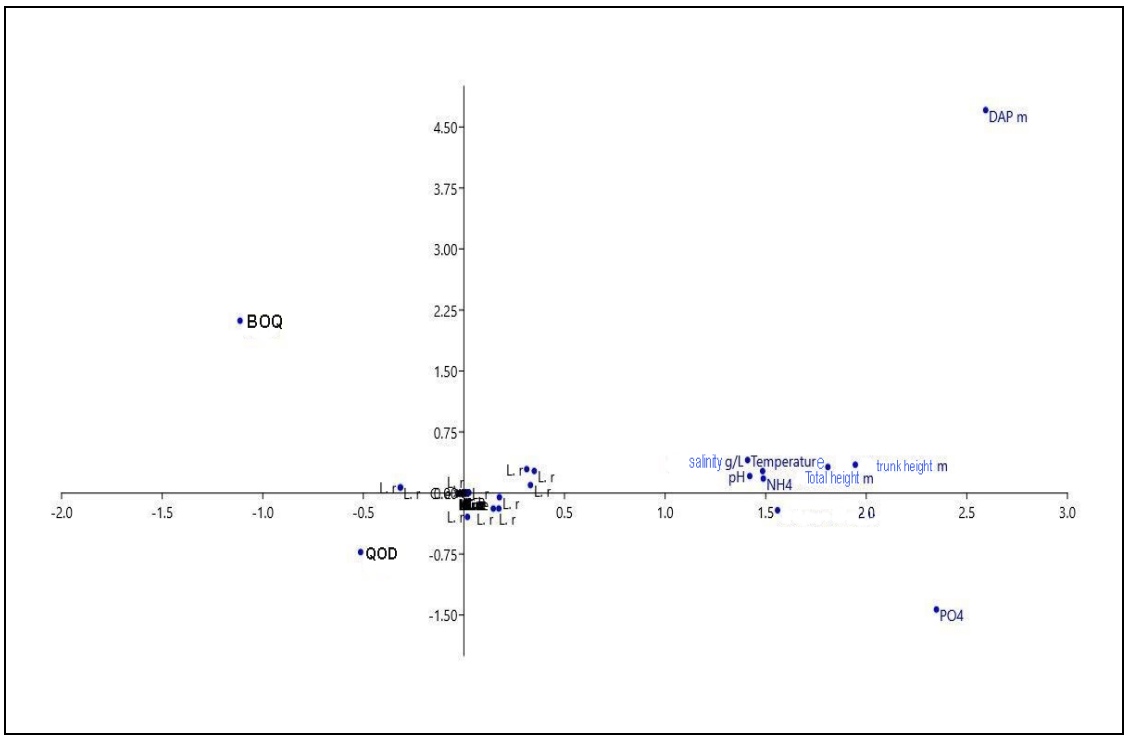


Figure 2: Multiple Correspondence analysis (CA)
for the abundance of different types of mangrove in dependence
of eight variables, environmental means with n = 57.

After performing the Spearman correlation between the previously associated variables, a positive correlation was obtained, but not consistently, between trunk height and total height ($r_s = 0.78$; $p < 0.05$; $n = 57$); between dissolved oxygen with total height and trunk height respectively ($r_s = 0.71$; $p < 0.05$; $n = 57$); between NH_4 and pH ($r_s = 0.66$; $p < 0.05$; $n = 57$); finally of the positive correlations of significance is NH_4 with trunk height and total height ($r_s = 0.66$ respectively; $p < 0.05$; $n = 57$).

The other positive relationships because they are close to 0 are considered to be random or non-existent. Significant negative correlations were also observed, the salinity variable with temperature, pH, trunk height, total height and dissolved oxygen ($r_s = –0.83$; $r_s = –0.74$; $r_s = –0.63$; $r_s = –0.63$ and $r_s = –0.50$ respectively; $p < 0.05$; $n = 57$) showing that increase in the salinity variable causes the decrease of the other variables, thus having a negative impact on the ecosystem.

The other negative relationships, since they are close to 0, are considered to be random or non-existent (Fig. 3).

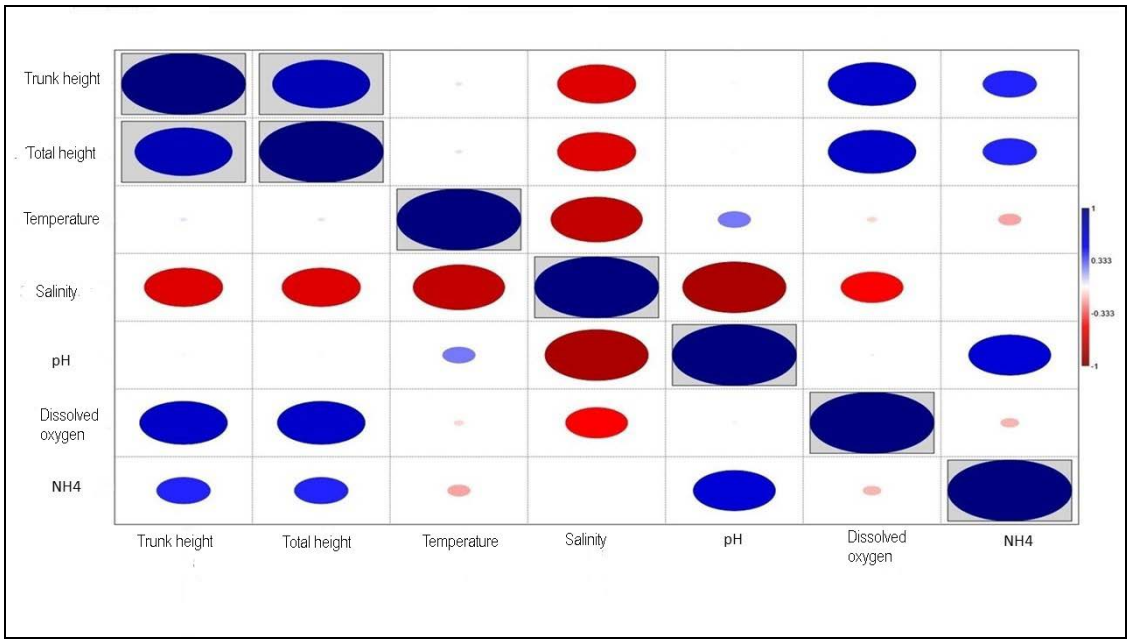


Figure 3: Spearman correlation rs to a $p < 0.05$ with 9 999 permutations.

The chemical-physical parameters previously determined, the analysis of the non-metric multidimensional scaling (n-MDS) was used, reaching a stress level of (0.06) allowing to establish a goodness of fit of the spatial similarity between *L. racemosa* and *C. erectus*, showing that despite the variation of the chemical-physical parameters, there is no difference between the two mangrove species (Fig. 4).

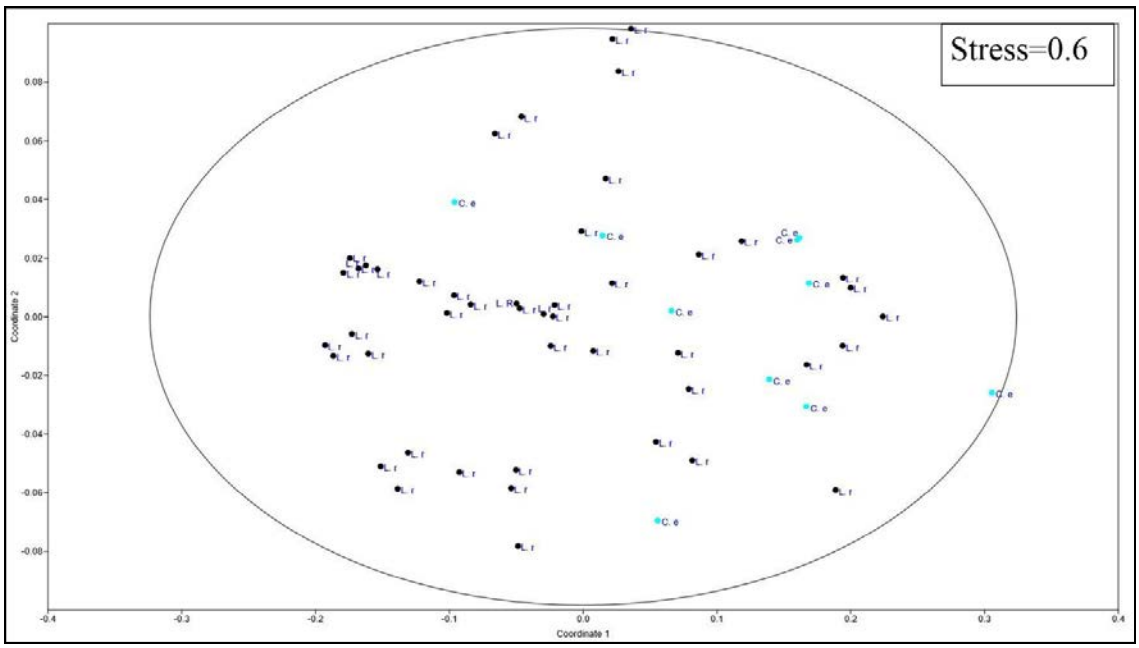


Figure 4: N-MDS to a 95% of reliability, L. r (*L. racemosa*) y C. e (*C. erectus*).

DISCUSSION

Cruz-Portorreal and Pérez-Montero (2017) measured the average heights of mangrove species in nine mangrove forest transects in the municipality of Guamá, obtaining the following average heights for *C. erectus*: 3.2 m, 4.4 m, 6.75 m, and 7.1 m respectively. While for *L. racemosa* they obtained heights of 3.3 m and 8.9 m; these measurements showed similarity with the present work although with greater variability.

Torán-Figueroa (2020) studied *L. racemosa* mangroves with 18.3-5.71 m average heights, and a density of 0.28 number of trees/ha compared to three other species, *Risophora mangle*, *Avecennia germinans*, and *Pelliciera rhizophorae*. In a total of eight stations, only a few individuals were observed in two stations, in the second with 15 individuals and in the seventh with 16 individuals. In the second station, average heights were similar to those obtained in the present study. Moreno-Martínez et al. (2021) determined a basal area of 1.34 m^2/ha of *L. racemosa*, although they obtained lower densities than those obtained in this study.

A study carried out in Isla del Carmen, Campeche, south of the Gulf of Mexico, within the Laguna de Términos natural protected area the species *L. racemosa* showed a height of 4.49 m, a density of 850 number of trees/ha and a basal area of 1.80 m^2/ha (Echeverría et al., 2019).

Acosta et al. (2019), demonstrated how the conditions of temperature, salinity, humidity, and pH of the environment have a significant impact on the rate of decomposition of mangrove leaf litter, this degradation being a way of nutritional sustenance in the trophic network of the surrounding ecosystem and the contribution of the mangrove in relation to the organic matter that can be released to the environment.

Alterations in salinity levels have been shown to have a high impact on the growth of coastal vegetation such as mangroves. The impact of salinity on biomass has been established; when salinity decreases, mangrove biomass, and live cover decreases. Spearman's rho correlation coefficient between mangrove height and salinity in the central sector of the Indian Sundarbans was (rs = 0.85) (Banerjee et al., 2017).

The Spearman correlation determined by Méndez-Ortiz (2014), reflects that there was no positive association between total height and salinity (rs = –0.65; p = 0.334), pH (rs = –0. 573; p = 0.107), temperature (rs = –0.646; p = 0.066), and dissolved oxygen (rs = –0.209; p = 0.558) in the mangroves of La Graciosa Bay, Guatemala, *Rhizophora mangle* and *L. racemosa* species. Results different from those obtained in the present work.

Rossalino-Jiménez (2015), established the relationship between water temperature and height in the mangrove forest of Tumilco, Tuxpan, in the species *R. mangle*, *Avicennia germinans*, and *L. racemosa*. There is a slight relationship between both variables in the different mangrove species (rs = 0.101; p = 0.318). The relationship between pH of the water and total mangrove height expressed a relationship, where the highest mangrove heights of the species are found in areas with high pH concentrations (rs = 0.199; p = 0.048). Surface water salinity in relation to mangrove height shows that the higher the salinity, the higher the vegetation height increases; although the range of both parameters is not very constant (rs = 0.054; p = 0.594).

CONCLUSIONS

In the three work areas there was a predominance of the species *L. racemosa* with an average density of 1.567 number of trees/ha over *C. erectus* 333 number of trees/ha. In addition to poor mangrove regeneration and a poor state of conservation, temperature showed the highest positive correlation with total and trunk height of both species respectively. In contrast, dissolved oxygen showed the lowest correlation.

REFERENCES

1. Acosta B. G., La Manna R., Velásquez J., Imery A., Santana P. and Cruz Y., 2019 – Descomposición de la hojarasca del mangle rojo (Rhizophora mangle) en un sector del Caribe Venezolano, Martha Molina Moreira (Comp.), Primer Congreso Manglares de América, Guayaquil, Ecuador, 1-9. (in Spanish)
2. Alang R. N. N. R., Jusoh W. F. A, W., Nur-Zati A. M. and Hashim N. R., 2010 – Ant diversity of Sonneratia caseolaris trees in Rembau-Linggi mangrove forest, Peninsular Malaysia, *Transylvanian Review of Systematical and Ecological Research*, 10, 77-82.
3. Aziz T. N. A., Hashim N. R., 2010 – Heavy metal concentrations in an important mangrove palm (Nypa fruticans), in Rembau-Linggi Mangrove Forest (Peninsular Malaysia), Peninsular Malaysia, *Transylvanian Review of Systematical and Ecological Research*, 10, 1111-116.
4. Banerjee K., Cazzolla G. R. and Abhijit M., 2017 – Climate change-induced salinity variation impacts on a stenoecious mangrove species in the Indian Sundarbans, *Ambio*, 46,492-499.
5. Buchili E. E. K., 2020 – Comportamiento del Mangle Rojo (Rhizophora mangle) en vivero y plantación en la Parroquia Salima – Canton Muisne, Esmeraldas – Ecuador, Diploma Thesis, University of Pontificia Católica del Ecuador, Ecuador, 160. (in Spanish)
6. Cruz-Portorreal Y. and Pérez-Montero O., 2017 – Evaluación de la salud del manglar en Guamá, Cuba, *Madera y Bosques*, 23, 1, 23-37, DOI10.21829/myb.2017.2311517. (in Spanish)
7. Echeverría Á. S., Pérez C., R., Zaldívar J. A., Canales D. J., Brito P. R., Merino I. M. and Vovides A., 2019 – Regeneración natural de sitios de manglar degradado en respuesta a la restauración hidrológica, *Revista Madera y Bosques*, 25, 1,1-8. (in Spanish)
8. Geomar M. B. 2017 – Malacofauna y Carcinofauna asociada a Rhizophora mangle (L, 1753) en un estuario: río Ranchería, La Guajira, Colombia, *Posgrado y Sociedad*, 15, 1,1-15. (in Spanish)
9. Guzmán M. J. M. and Menéndez C. L. 2013 – Protocolo Para El monitoreo del Ecosistema de manglar, Memorias de Primer Simposio del Centro Nacional de Áreas Protegidas, La Habana, Cuba, 1-6, ISBN: 978-959-287-042-0. (in Spanish)
10. Hammer Ø., Harper D. A. T. and Ryan P. D. 2001 – Paleontological statistics software package for education and data analysis, PAST, Version 4.10, *Palaeontologia Electronica*, 4, 1,1-9.
11. Linares R. J. L., Cáceres R. A. M., Alonso T. Y., Hernández M. F. R., Berovides Á. V., Camejo L. J. A., Varela M. R., Márquez Ll. L., Fernández M. I. and Márquez G. L. 2016 – Densidad de jutía conga (C*apromys pilorides*) en tres localidades del manglar de la Reserva de la Biósfera Península de Guanahacabibes, Cuba, *Ecovida*, 6.1, 1-77. (in Spanish)
12. López B., Barreto M. and Conde J. 2011 – Caracterización de los manglares de zonas semiáridas en el noroccidente de Venezuela, *Interciencia*, 36, 12,888-893. (in Spanish)
13. Méndez-Ortiz C. L. 2014 – Asociación de los parámetros físico-químicos del agua con la estructura y composición de los ensambles de manglar en la Bahía La Graciosa, Refugio de Vida Silvestre Punta de Manabique, Izabal, Guatemala, Diploma Thesis, Facultad de Ciencias Químicas y Farmacia, University of San Carlos, Guatemala, 68. (in Spanish)
14. Mitra A., Pal N., Saha A., Tanmay, R. C., Fazli P. and Zaman, S. 2017 – Survival rate of mangroves, *Indian Journal of Geo Marine Sciences*, 46, 10, 2046-2053.
15. Moreno-Martínez A., Álvarez A. G. and Orozco H. M. E. 2021 – Heterogeneidad ambiental y alteraciones antrópicas en comunidades de manglar en el pacífico sur de México, *Revista de Ciencias Ambientales*, 55, 1, 70-85, https://doi.org/10.15359/rca.55-1.4. (in Spanish)
16. Moroyoqui-Rojo L., Flores V. F., Urias E. C. D., Santiago F. F. and Farías G. F. 2015 – Uso potencial de dos especies de mangle subtropical la remoción de nutrientes en sistemas de recirculación cerrados, *Ciencias Marinas*, 41, 4, 1-12. (in Spanish)
17. Rossalino-Jiménez M. B. 2015 – Estructura del mangle y la asociación con características fisicoquímicas de agua y suelo en Tumilco, Municipio de Tuxpan, Master Thesis, Facultad de Ciencias Biológicas y Agropecuarias, University of Veracruz, México, 87. (in Spanish)
18. Torán-Figueroa R. G. 2020 – Estructura y composición florística en relación con los parámetros físicos y bióticos del bosque de manglar del refugio de vida silvestre manglares estuario río Muisne, Diploma Thesis, University Católica of the Ecuador, Ecuador, 68. (in Spanish)

UNWANTED GUEST CONTINUES ITS NORTHERN JOURNEY IN THE AEGEAN SEA: *PTEROIS MILES* (BENNETT, 1828)

İlker AYDIN *, *Sevan AĞDAMAR* ** and *Sercan YAPICI* ***

* Ege University, Faculty of Fisheries, İzmir, Turkey, TR-35000, ilker.aydin@ege.edu.tr, ORCID: 0000-0003-1752-2780.
** Çanakkale Onsekiz Mart University, Gökçeada School of Applied Sciences and Bayramiç Vocational School, Çanakkale, Turkey, TR-17760, agdamars@gmail.com, ORCID: 0000-0002-1268-0379.
*** Muğla Sıtkı Koçman University, Faculty of Fisheries, Muğla, Türkiye, TR-48000, sercanyapici@mu.edu.tr, ORCID: 0000-0003-2288-5084.

DOI: 10.2478/trser-2022-0020

KEYWORDS: lionfish, cytochrome oxidase I, indo-pacific sp., marine bioinvasion.

ABSTRACT

Pterois miles (Bennett, 1828), one of the most destructive marine invaders, was reported from the Mediterranean in 1991. It has invaded most parts of the Mediterranean from 2013, when it was reported for the second time, until today. On 7th October 2020, a single specimen of *P. miles* was collected by the bottom trawl from the Edremit Bay (Northern Aegean Sea). COI barcode region was used for the molecular identification of the specimen. DNA barcode data suggest that the specimen used in the present study is *P. miles* with a 99.69% probability. The current study is presented by providing the northernmost occurrence of the *P. miles* from the Aegean Sea with molecular confirmation.

ZUSAMMENFASSUNG: Unerwünschte Gäste setzen ihre Ausbreitung im Ägäischen Meer fort: *Pterois miles* (Bennett, 1828).

Pterois miles (Bennett, 1828), eine der destruktivsten Meeres-Eindringlinge, wurde aus dem Mittelmeer 1991 angegeben. Ab 2013, als sie zum zweitenmal gemeldet wurde, hat sie sich bis heute im größten Teil des Mittelmeeres invasiv ausgebreitet. Am 7 Oktober 2020 wurde ein einziges Exemplar von *Pterois miles* aus dem Bodenschleppnetz im Bereich der Endremit Bucht (Nördliches Ägäisches Meer) gesammelt. Der COI Strichcode der Region wurde zur molekularen Identifikation der Art verwendet. Die Daten des DNA Strichcodes belegen, dass es sich bei der in vorliegender Studie untersuchten Art mit einer Wahrscheinlichkeit von 99,69% um *Pterois miles* handelt. Die vorliegende Studie soll das durch molekulare Untersuchung bestätigte, nördlichste Vorkommen von *Pterois miles* aus dem Ägäischen Meer unterstützen.

REZUMAT: Oaspetele nedorit îşi continuă călătoria în nordul Mării Egee: *Pterois miles* (Bennett, 1828).

Pterois miles (Bennett, 1828), unul dintre cei mai distructivi invadatori marini, a fost raportat în Marea Mediterană în 1991. A invadat cele mai multe părţi al Mediteranei până astăzi, din 2013, când a fost raportat pentru a doua oară. În 7 Octombrie 2020, un singur specimen de *P. miles* a fost colectat cu un traul de fund din Golful Edremit (nordul Mării Egee). Codul de bare COI a fost utilizat pentru identificarea moleculară a specimenului respectiv. Datele codului de bare ADN sugerează faptul că specimenul utilizat în studiul de faţă este *P. miles* cu o probabilitate de 99.69%. Studiul actual este prezentat ca oferind date despre ocurenţa cea mai nordică din Marea Egee a lui *P. miles*, cu confirmare moleculară.

INTRODUCTION

Endemic and endangered taxa of the Mediterranean Sea have faced the invasion of the Indo-Pacific species since the opening of the Suez Canal in 1869. This invasion called Lessepsian migration is ever-growing due to climate change, constructional changes in the Suez Canal, and other anthropogenic activities. Lessepsian migration is effective throughout the Mediterranean, however, non-native species diversity still displays sharp differences between western and eastern basins of the Mediterranean Sea except for several fish species. (Coll et al., 2010) The marine ichthyofauna of the Turkish coasts currently consists of 530 species, including four classes: Actinopterygii (463 species), Elasmobranchii (65 species), Cephalaspidomorphi (one species), and Holocephali (one species). Turkish Mediterranean (Levantine coast) has 453 spp. and the Aegean Sea 453 spp., with the highest diversity, followed by Sea of Marmara (257 spp.) and Black Sea (151 spp.). Turkish coasts are hotspots of marine bio-invasion due to mainly its proximity to the Suez Canal, Mediterranean currents, and intensive maritime shipping. Considering the origin of the distributed fishes along the Turkish coasts, a total of 90 (16.9% of total) species are non-native (35 alien, 29 established, and 26 invasive), originating from Indo-Pacific (79 spp.), Atlantic (seven spp.), and cosmopolitan (four spp.) species. (Karataş et al., 2021)

The genus *Pterois* Oken, 1817, belonging to Scorpaenidae, is mainly called lionfish or firefish. It is characterized by venomous dorsal, anal and pelvic fin spines (Allen and Erdmann, 2008). *P. volitans* and *P. miles* are a recent, significant, and dangerous invasive species in the Mediterranean Sea as well as in the west Atlantic and the Caribbean Sea. *P. miles* (Bennett, 1828), reported by Golani and Sonin (1992) as first *Pterois* species in the Mediterranean area, has been expanded along Israel, Lebanon, Cyprus, Türkiye, and Greece (Dailianis et al., 2016).

We aim to present the current status, northernmost occurrence, and genetic information of the worst invader fish, *Pterois miles*, in the Aegean Sea.

MATERIAL AND METHODS

Sampling and morphological identification

On October 7th 2020, a specimen of *P. miles* (Fig. 1) was caught by commercial trawler, from Edremit Bay (39.4730°N', 26.6230°E') at a depth of approximately 70 m.

Figure 1: A view of fresh specimen of the *Pterois miles*.

The morphometric characters of this specimen were measured with a digital caliper (to the nearest 0.1 mm), while meristic details and counts were examined using a stereo zoom microscope. Morphological and taxonomic descriptions of the collected specimen were followed according to Golani and Sonin (1992).

DNA extraction, PCR and sequencing

Genomic DNA was isolated from a muscle tissue of the specimen using EurX GeneMATRIX Tissue and Bacterial DNA Kit according to manufacturer's protocol. DNA barcode region of cytochrome c oxidase subunit I (COI) was amplified using the primers of FishF1 (5'-TCAACCAACCACAAAGACATTGGCAC) and FishR1 (5'-TAGACTTCTGGGTGGCCAAAGAATCA) (Ward et al., 2005). DNA amplifications were performed in 50 µl volumes, each containing: 5 µl of 10X Taq Buffer with KCl (100 mM Tris-HCl, 500 mM KCl, pH 8.8), 5 µl of MgCl2 (25 mM), 1 µl of dNTPs (10 mM), 1 µl of each primer (10 pM/µl), 2 U of Taq polymerase (5 U/µl), and 3 µl of DNA (50 ng/µl). PCR amplifications were performed in Eppendorf Mastercycler® with the following cycling conditions (Keskin and Atar, 2013): preliminary denaturation at 95°C for five minutes followed by 40 cycles consisting of denaturation at 95°C for 45 seconds, primer annealing at 57°C for 45 sec., primer extension at 72°C for one minute and final extension step at 72°C for five minutes. Sanger sequencing was performed by BM Labosis (Ankara, Türkiye) using ABI 3730XL DNA Analyzer (Applied Biosystems, USA).

Data analyses

Reference sequences of the species gathered from GenBank were reported in the below table 1.

Table 1: List of GenBank COI sequences of the species used in the molecular analysis of *Pterois miles.*

Species	Country	Location	GenBank Acc. No.	Reference
Pterois miles	India	Lakshadweep	OK602740	Unpublished
Pterois miles	Yemen	Unspecified	MH331851	Unpublished
Pterois miles	Israel	Eilat	MF124020	Kimmerling et al., 2018
Pterois miles	South Africa	Vetch's Pier	GU805078	Unpublished
Pterois miles	Unspecified	Unspecified	FJ584026	Steinke et al., 2009
Pterois volitans	Unspecified	Unspecified	FJ584044	Steinke et al., 2009
Dendrochirus brachypterus	South Africa	Indian Ocean	JN312280	Unpublished
Scorpaena scrofa	Malta	Mediterranean Sea	KJ709885	Landi et al., 2014
Scorpaena porcus	Türkiye	Antalya Bay	KC501412	Keskin and Atar, 2013

Molecular data analyses of COI gene region were conducted from a specimen of *P. miles*. Nucleotide sequences were aligned using the ClustalW algorithm in MEGA X (Kumar et al., 2018). DNA sequence data were submitted to GenBank and the accession number OM128427 was assigned. *Pterois volitans* (FJ584044), *Dendrochirus brachypterus* (JN312289), *Scorpaena porcus* (KC501412), and *Scorpaena scrofa* (KJ709885) haplotypes were used as outgroup taxa in phylogenetic analysis. A phylogenetic tree was generated in MEGA X (Kumar et al., 2018) using neighbor-joining (NJ) algorithm (Saitou and Nei, 1987) of genetic p-distances with 1,000 bootstrap replications in pair wise deletion mode. Genetic p-distances have been remarked to perform better for species identification than the corrected substitution models (e.g., Kimura 2-parameter, Tamura-Nei model) (Srivathsan and Meier, 2012). Genetic distances between species were calculated in MEGA X (Kumar et al., 2018) using the p-distance model with 1,000 bootstrap replications.

RESULTS AND DISCUSSION

The examined specimen (family Scorpaenidae Risso, 1827, *Pterois* Oken, 1817, *Pterois miles* (Bennett, 1828) (Fig. 1)) has a 224 mm TL (174 mm SL) and 177.42 g in weight. Moderately compressed body with alternating wide dark brown and narrow white and reddish dorsal bands, pectoral and pelvic fins covered with black, red, and white bands. Dark spots on soft rays of dorsal, anal, and caudal fins. Several prominent white spots on pelvic fins. The morphometric measurements and meristic counts of the specimen (Fig. 1) are described as follows: body depth, 2.7 in SL. head length (HL), 3.4 in SL; snout length, 2.5 in HL, eye diameter, 3.8 in HL, and the interorbital width, 4.2 in HL; dorsal fin XIII + 10, anal fin III + 6, pectoral fin 14, pelvic fin I, 5.

Figure 2 shows phylogenetic relationships based on the COI barcode region of a specimen of *P. miles*, and its closest congeneric and same species, showing the monophyly of all of them, with good statistical support.

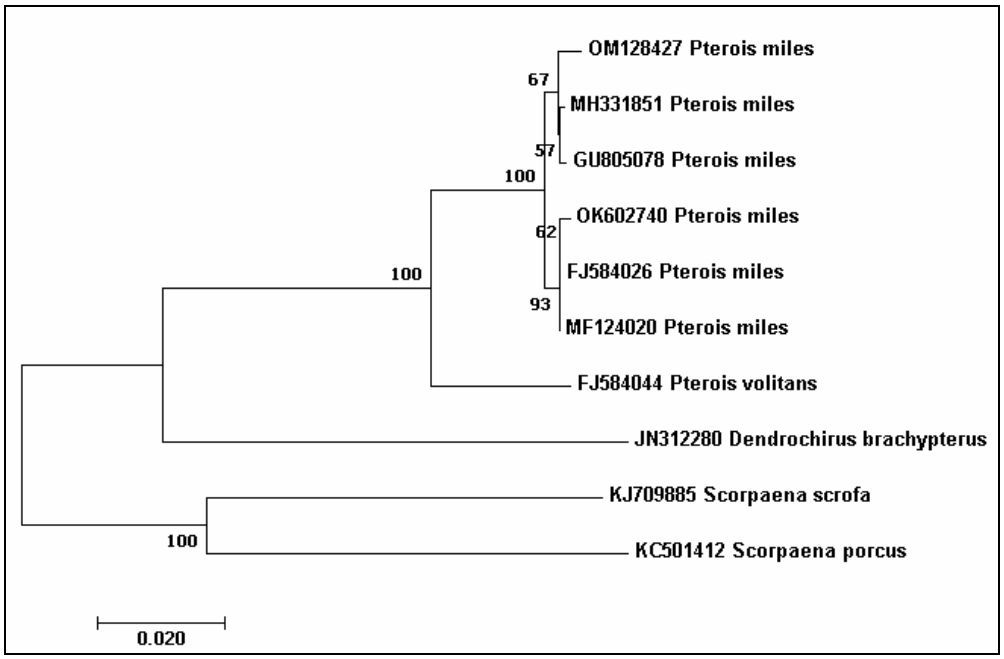


Figure 2: Tree based on the neighbor-joining (NJ) analysis of pairwise genetic p-distances. Bootstrap values for 1,000 replicates are shown above branches on the tree; scale: 2% p-distance.

COI barcode of the specimen exhibit an identical nucleotide sequence and form a cluster that is similar from its closest sequences, *P. miles* (GU805078 and MH331851), by 0.5% and 0.6%, respectively (Tab. 2). On the other hand, *P. miles* and *P. volitans* were determined as genetically distinct from each other (4.6%; Tab. 2). Additionally, according to the nucleotide data, the specimen belongs to the family Scorpaenidae, with a 100% probability of placement after a BLAST search in the GenBank database, which also matches *P. miles*, with a 99.69% probability.

Table 2: Genetic distances (p-distances) based on mitochondrial COI barcode regions of the species used in this study.

	GenBank Acc. No.	Species	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	OM128427	*Pterois miles*	***									
2.	MH331851	*Pterois miles*	0.006	***								
3.	GU805078	*Pterois miles*	0.005	0.008	***							
4.	OK602740	*Pterois miles*	0.008	0.002	0.005	***						
5.	MF124020	*Pterois miles*	0.009	0.008	0.002	0.006	***					
6.	FJ584026	*Pterois miles*	0.008	0.002	0.005	0.000	0.006	***				
7.	FJ584044	*Pterois volitans*	0.046	0.043	0.043	0.042	0.042	0.042	***			
8.	JN312289	*Dendrochirus brachypterus*	0.138	0.137	0.135	0.135	0.133	0.135	0.138	***		
9.	KJ709885	*Scorpaena scrofa*	0.179	0.175	0.176	0.176	0.174	0.176	0.177	0.182	***	
10.	KC501412	*Scorpaena porcus*	0.180	0.179	0.180	0.179	0.181	0.179	0.176	0.192	0.127	***

Pterois miles, is one of the worst known marine invaders, is distributed naturally in the Indian Ocean and the Red Sea. It prefers coastal waters in muddy habitats (Froese and Pauly, 2022).

The first Mediterranean-based record of *P. miles* was given from Israeli coast in 1991 (Golani and Sonin, 1992). Azzurro et al. (2016) considered its first record in the Mediterranean as a failed introduction and declared: “Considering the conspicuous appearance of *P. miles*, and its relative ease in recognition, the lack of observations until 2012 is unlikely “a detection lag” and the 1991 record (Golani and Sonin, 1992) can be considered as evidence of a failed introduction”. Even if its first introduction was considered to fail, *P. miles* has invaded throughout the Mediterranean and its adjacent seas today. The chronology of the lionfish journey, which includes the period of all observation, showed a continuous progressive expansion of the lionfish westward and northward from the coast of the Levant (Fig. 1 and Tab. 3).

Table 3: Confirmed Mediterranean records of *Pterois miles* (Oruç et al. 2022).

No	Location	Coordinates	Length Range (TL, mm)	Habitat	Depth (m)	Observation Method	Reference
1.	Herzliya, Israel	–	328	–	35	Trawl	Golani and Sonin (1992)
2.	Al Minie, Lebanon	34.29N, 35.54E	209	Coralligenous	30	Trammel net	Bariche et al. (2013)
3.	İskenderun, Türkiye	36.17N, 35.46E	276	Rocky bottom	25	–	Turan et al. (2014)
4.	Rhodes, Greece	36.38N, 28.24E	–	Rocky bottom	7	Diving	Crocetta et al. (2015)
5.	Rhodes, Greece	35.91N, 27.85E	–	Shipwreck	–	Diving	Crocetta et al. (2015)
6.	Rhodes, Greece	36.45N, 28.21E	–	Rocky bottom	2	Diving	Crocetta et al. (2015)
7.	Ormidia, Cyprus	–	170	–	10	Gill net	Iglésias and Frotte (2015)
8.	Karpas, Cyprus	–	373	Rocky bottom	40	Gill net	Oray et al. (2015)
9.	Dalyan, Türkiye	–	–	Sandy bottom	11	Diving	Turan and Öztürk (2015)
10.	Datça, Türkiye	36.69N, 27.68E	–	–	10	Gill net	Bilge et al. (2016)
11.	NE Crete, Greece	35.20N, 26.30E	250	Rocky bottom	33	Gill net	Dailianis et al. (2016)
12.	SE Crete, Greece	35.01N, 25.96E	100	Rocky bottom	12-37	–	Dailianis et al. (2016)
13.	Karpathos Island, Greece	35.55N, 27.20E	100	Rocky bottom	17	Diving	Mytilineou et al. (2016)
14.	Karpathos Island, Greece	35.50N, 27.22E	200	Rocky bottom	16	Diving	Mytilineou et al. (2016)
15.	Mersin, Türkiye	36.08N, 33.40E	250	–	100-110	Trawl	Yağlıoğlu and Ayas (2016)
16.	Vendicari coast, Italy	36.49N, 15.06E	250	Sandy bottom	100-110	Diving	Azzurro et al. (2017)
17.	Kemer, Türkiye	–	85-293	Rocky bottom	10-15	Spearfishing	Özgür Özbek et al. (2017)
18.	Didim-Aydın, Türkiye	37.20N, 27.14E	–	Rocky bottom	18	Diving	Yapıcı (2018)
19.	Bodrum and Teos, Türkiye	–	100	Rocky bottom	10	Diving	Ulman et al. (2020)
20.	Kokar Bay, Türkiye	38.13N, 26.61E	144	Rocky bottom	15	Spearfishing	Özgül (2020)
21.	Kefalonia, Greece	38.16N, 20.40E	225	–	12-15	Gillnets-trammel nets	Vavasis et al. (2020)
22.	Vis Island, Croatia	48.00N, 16.00E	–	Rocky bottom	15	Diving	Dragičević et al. (2021)
23.	İzmir Bay, Türkiye	38.65N, 26.52E	309	Sandy bottom	36	Diving	Oruç et al. (2022)
24.	Edremit Bay, Türkiye	39.47N, 26.62E	224	Sandy bottom	70	Trawl	This study

Therefore are for both the Atlantic and the Mediterranean invasion processes of *P. miles* have clear evidence of how to be a successful globally marine invader. However, Kimball et al. (2004) claimed that the invasion of the lionfish in the Atlantic Ocean is dependent on temperature since their experimental studies have suggested the lionfish stops feeding below 16.1°C. In contrast, Özgür Özbek et al. (2017) noted that the *P. miles* continued feeding in low winter temperature (14.9°C) in the eastern Mediterranean. As well as in the present study, reported existences of *P. miles* from the northern Aegean sectors that has low winter inshore temperature are clearly evidence that widespread colonisation of the Mediterranean and Aegean region realized by *P. miles* seems not to be temperature dependent. Poursanidis et al. (2020) modeled the potential spread of *P. miles* in the Mediterranean Sea and declared that local adaptation and propagule spread are the main vectors to accelerate its future invasion. Nevertheless, they stated possibilities of a further expansion of the climatic niche of *P. miles* in the Mediterranean Sea seem to be likely. The occurrence of *P. miles* in the recent study may be evidence of its accelerating northern expansion in the Mediterranean and an indication of an attempt of a possible settlement in northern sectors of the Aegean Sea.

CONCLUSIONS

Inter-specific nucleotide divergences and molecular cladograms are powerful tools to determine the species (Hillis et al., 1997). The NJ analysis of the DNA barcode data concluded in congruent tree constructed with high bootstrap values. In the molecular identification of *P. miles* using COI barcode, this have proven to characterize the same species as such in traditional taxonomy. According to the NJ approach and genetic p-distances values, the specimen used in this study was *P. miles* and it was found as genetically distinct from *P. volitans*. Previous studies also found a clear distinction between these species in the phylogenetic analyses (Kochzius et al., 2003; Freshwater et al., 2009; Turan et al., 2020). Future studies performed by using other molecular markers might be enhanced to define adjunct species-specific determination between *P. miles* and *P. volitans* to simplify taxonomic identifications.

ACKNOWLEDGEMENTS

This study was supported by the project numbered 2017/SÜF/005, Ege University, Scientific Research Projects Coordination Unit. The authors would like to thank to captains Hasan Biran and Uğur Ali Biran from the F/V “Dülger”.

REFERENCES

1. Allen G. R. and Erdmann M. V., 2008 – Pterois andover, a new species of scorpionfish (Pisces: Scorpaenidae) from Indonesia and Papua New Guinea, *Aqua International Journal of Ichthyology*, 13, 127-138.
2. Azzurro E., Maynou F., Belmaker J., Golani D. and Crooks, J. A., 2016 – Lag times in Lessepsian fish invasion, *Biological Invasions*, 18, 2761-2772.
3. Azzurro E., Stancanelli B., Di Martino, V. and Bariche M., 2017 – Range expansion of the common lionfish Pterois miles (Bennett, 1828) in the Mediterranean Sea: an unwanted new guest for Italian waters, *BioInvasions Records*, 6, 95-98.
4. Bariche M., Torres M. and Azzurro, E., 2013 – The presence of the invasive Lionfish Pterois miles in the Mediterranean Sea, *Mediterranean Marine Science*, 14, 292-294.
5. Bilge G., Filiz H., Yapıcı S. and Gülşahin A., 2016 – On the occurrence of the devil firefish Pterois miles (Scorpaenidae), from the southern Aegean Sea with an elaborate occurrence in the Mediterranean coast of Turkey, 2nd International Congress on Applied Ichthyology and Aquatic Environment, Messolonghi, Greece.
6. Coll M., Piroddi C., Steenbeek J., Kaschner K., Ben Rais Lasram F., Aguzzi J., Ballesteros E., Bianchi C. N., Corbera J., Dailianis T., Danovaro R., Estrada M., Froglia C., Galil B. S., Gasol J. M., Gertwagen R., Gil J., Guilhaumon F., Kesner-Reyes K., Kitsos M. S., Koukouras A., Lampadariou N., Laxamana E., López-Fé de la Cuadra C. M., Lotze H. K., Martin D., Mouillot D., Oro D., Raicevich S., Rius-Barile J., Saiz-Salinas J. I., San Vicente C., Somot S., Templado J., Turon X., Vafidis D., Villanueva R. and Voultsiadou, E., 2010 – The biodiversity of the Mediterranean Sea: estimates, patterns, and threats, *PLoS One*, 5, e11842.
7. Crocetta F., Agius D., Balistreri P., Bariche M., Bayhan Y., Çakir M., Ciriaco S., Corsini-Foka M., Deidun A., El Zrelli R., Ergüden D., Evans J., Ghelia M., Giavasi M., Kleitou P., Kondylatos G., Lipej L., Mifsud C., Özvarol Y., Pagano A., Portelli P., Poursanidis D., Rabaoui L., Schembri P., Taşkin E., Tiralongo F. and Zenetos A., 2015 – New Mediterranean Biodiversity Records (October 2015), *Mediterranean Marine Science*, 16, 682-702.
8. Dailianis T., Akyol O., Babali N., Bariche M., Crocetta F., Gerovasileiou V., Chanem R., Gökoğlu M., Hasiotis T., Izquierdo-Muñoz A., Julian D., Katsanevakis S., Lipez L., Mancini E., Mytilineou C., Ounifi Ben Amor K., Özgül A., Ragkousis M., Rubio-Portillo E. and Trkov D., 2016 – New Mediterranean Biodiversity Records (July 2016), *Mediterranean Marine Science*, 17, 608-626.
9. Dragičević B., Ugarković P., Krželj M., Zurub D. and Dulčić J., 2021 – New record of Pterois cf. miles (Actinopterygii: Scorpaeniformes: Scorpaenidae) from the eastern middle Adriatic Sea (Croatian waters): Northward expansion, *Acta Ichthyologica et Piscatoria*, 51, 379-383.
10. Freshwater D. W., Hamner R. M., Parham S. E. T. H. and Wilbur A. E., 2009 – Molecular evidence that the lionfishes Pterois miles and Pterois volitans are distinct species, *Journal of the North Carolina Academy of Science*, 125, 39-46.
11. Froese R. and Pauly D., 2022 – FishBase, available from: www.fishbase.org (date of access: 20/02/2022).
12. Golani D. and Sonin O., 1992 – New records of the red sea fishes, Pterois miles (Scorpaenidae) and Pteragogus pelycus (Labridae) from the Eastern Mediterranean Sea, *Japanese Journal of Ichthyology*, 39, 167-169.
13. Hillis D. M., 1997 – Phylogenetic analysis, *Current Biology*, 7, 129-131.
14. Iglésias S. and Frotté L., 2015 – Alien marine fishes in Cyprus: update and new records, *Aquatic Invasions*, 10, 425-438.
15. Karataş A., Filiz H., Erciyas-Yavuz K., Özeren S. C. and Tok C. V., 2021 – Biodiversity, conservation and sustainability in Asia, in Öztürk M., Altay V. and Efe R. (eds), The Vertebrate Biodiversity of Turkey, Springer, Germany, 175-274.
16. Keskin E. and Atar H. H., 2013 – DNA barcoding commercially important fish species of Turkey, *Molecular Ecology Resources*, 13, 788-797.

17. Kimball M., Miller J., Whitfield P. and Hare J., 2004 – Thermal tolerance and potential distribution of invasive lionfish (Pterois volitans/miles complex) on the East Coast of the United States, *Marine Ecology Progress Series*, 283, 269-278.
18. Kimmerling N., Zuqert O., Amitai G., Gurevich T., Armoza-Zvuloni R., Kolesnikov I., Berenshtein I., Melamed S., Gilad S., Benjamin S., Rivlin A., Ohavia M., Paris C. B., Holzman R., Kiflawi M. and Sorek, R., 2018 – Quantitative species-level ecology of reef fish larvae via metabarcoding, *Nature Ecology & Evolution*, 2, 306-316.
19. Kochzius M., Söller R., Khalaf M. A. and Blohm D., 2003 – Molecular phylogeny of the lionfish genera Dendrochirus and Pterois (Scorpaenidae, Pteroinae) based on mitochondrial DNA sequences, *Molecular Phylogenetics and Evolution*, 28, 396-403.
20. Kumar S., Steche G., Li M., Knyaz C. and Tamura K., 2018 – MEGA X: Molecular evolutionary genetics analysis across computing platforms, *Molecular Biology and Evolution*, 35, 1547-1549.
21. Landi M., Dimech M., Arculeo M., Biondo G., Martins R., Carneiro M., Carvalho G. R., Lo Brutto S. and Costa F. O., 2014 – DNA barcoding for species assignment: the case of Mediterranean marine fishes, *PLoS One*, 9, e106135.
22. Mytilineou C., Akel E., Babali N., Balistreri P., Bariche M., Boyaci Y., Cilenti L., Constantinou C., Crocetta F., Çelik M., Derel, H., Dounas C., Durucan F., Garrido A., Gerovasileiou V., Kapiris K., Kebapcioglu T., Kleitou P., Krystalas A., Lipej L., Maina I., Marakis P., Mavrič B., Moussa R., Peña-Rivas L., Poursanidis D., Renda W., Rizkalla S., Rosso A., Scirocco T., Sciuto F., Servello G., Tiralongo F., Yapici S. and Zenetos A., 2016 – New Mediterranean biodiversity records (November, 2016), *Mediterranean Marine Science*, 17, 794-821.
23. Oray I. K., Sınay E., Karakulak F. S. and Yıldız, T., 2015 – An expected marine alien fish caught at the coast of Northern Cyprus: Pterois miles (Bennett, 1828), *Journal of Applied Ichthyology*, 31, 733-735.
24. Oruç A. Ç., Şensurat Genç T., Özgül A. and Lök A., 2022 – The northernmost dispersal record of the lionfish, Pterois miles (Bennett, 1828) for the Aegean Sea, *Ege Journal of Fisheries and Aquatic Sciences*, 39, 84-87.
25. Özgül A., 2020 – Occurrence of lionfish, Pterois miles (Bennett, 1828) in the coast of Aegean Sea (Turkey): The northernmost dispersal record, *Ege Journal of Fisheries and Aquatic Sciences*, 37, 313-317.
26. Özgür Özbek E., Mavruk S., Saygu İ. and Öztürk B., 2017 – Lionfish distribution in the eastern Mediterranean coast of Turkey, *Journal of the Black Sea/Mediterranean Environment*, 23, 1-16.
27. Poursanidis D., Kalogirou S., Azzurro E., Parravicini V., Bariche M. and Zu Dohna H., 2020 – Habitat suitability, niche unfilling and the potential spread of Pterois miles in the Mediterranean Sea, *Marine Pollution Bulletin*, 154, 111054.
28. Saitou N. and Nei M., 1987 – The neighbor-joining method: A new method for reconstructing phylogenetic trees, *Molecular Biology and Evolution*, 4, 406-425.
29. Srivathsan A. and Meier R., 2012 – On the inappropriate use of Kimura-2-parameter (K2P) divergences in the DNA-barcoding literature, *Cladistics*, 28, 190-194.
30. Steinke D., Zemlak T. S. and Hebert, P. D., 2009 – Barcoding nemo: DNA-based identifications for the ornamental fish trade, *PLoS One*, 4, e6300.
31. Turan C., Ergüden D., Gürlek M., Yağlıoğlu D., Uyan, A. and Uygur N., 2014 – First record of the Indo-Pacific lionfish Pterois miles (Bennett, 1828) (Osteichthyes: Scorpaenidae) for the Turkish marine waters, *Journal of the Black Sea/Mediterranean Environment*, 20, 158-163.
32. Turan C. and Öztürk B., 2015 – First record of the lionfish Pterois miles from the Aegean Sea, *Journal of the Black Sea/Mediterranean Environment*, 21, 334-338.
33. Turan C., Uyan A., Gürlek M. and Doğdu S. A., 2020 – DNA barcodes for identifications of two lionfish species Pterois miles (Bennett, 1828) and Pterois volitans (Linnaeus, 1758) in the Mediterranean, *FishTaxa*, 16, 29-36.

34. Ulman A., Tunçer S., Kizilkaya I. T., Zilifli A., Alford P. and Giovos I., 2020 – The lionfish expansion in the Aegean Sea in Turkey: a looming potential ecological disaster, *Regional Studies in Marine Science*, 36, 101271.
35. Vavasis C., Simotas G., Spinos E., Konstantinidis E., Minoudi S., Triantafyllidis A. and Perdikaris C. 2020 – Occurrence of Pterois miles in the island of Kefalonia (Greece): the northernmost dispersal record in the Mediterranean Sea, *Thalassas: An International Journal of Marine Sciences*, 36, 171-175.
36. Ward R. D., Zemlak T. S., Innes B. H., Last P. R. and Hebert P. D. N., 2005 – DNA barcoding Australia's fish species, *Philosophical Transactions of the Royal Society*, B, 360, 1847-1857.
37. Yağlıoğlu D. and Ayas D., 2016 – New occurrence data of four alien fishes (Pisodonophis semicinctus, Pterois miles, Scarus ghobban and Parupeneus forsskali) from the North Eastern Mediterranean (Yeşilovacık Bay, Turkey), *Biharean Biologist*, 10, 2, 150-152.
38. Yapıcı S., 2018 – Piscis non grata in the Mediterranean Sea: Pterois miles (Bennett, 1828), *Ege Journal of Fisheries and Aquatic Sciences*, 35, 467-474.

ZOOLOGICAL WATER QUALITY INDICATORS FOR ASSESSMENT OF ORGANIC POLLUTION AND TROPHIC STATUS OF CONTINENTAL WATER BODIES

Sophia BARINOVA * and *Vasiliy DYADICHKO* **

* Institute of Evolution, University of Haifa, Mount Carmel, 199 Abba Khoushi Avenue, Haifa, Israel, IL-3498838, sophia@evo.haifa.ac.il, ORCID: 0000-0001-9915-2503.
** Institute of marine biology NAS of Ukraine, Odessa, 37 Pushkinska Street, Odessa, Ukraine, UA-65011, wasilij_d@mail.ru, ORCID: 0000-0003-1417-4442.

DOI: 10.2478/trser-2022-0021

KEYWORDS: aquatic invertebrates, non-photosynthetic protists, ecological preferences, water quality, trophic state, organic pollution, bioindicators.

ABSTRACT

This paper presents data compilation for invertebrates and protists indicator taxa of organic pollution and trophic state of continental waters. Information was collected from research papers, monographs, electronic resources, and our own research. Altogether 1732 indicator taxa of Kingdoms Protista, Protozoa, Chromista, and Animalia from 19 taxonomical Phyla are represented with ecological preferences for saprobity with saprobity index (S) and trophic state. This comprehensive data can be used for the purpose of aquatic ecosystem assessment and monitoring of water quality based on bioindication methods.

ZUSAMMENFASSUNG: Zoologische Indikatoren für Wasserqualität zur Bewertung der organischen Verschmutzung und des trophischen Zustands kontinentaler Gewässer.

Dieser Beitrag stellt eine Datensammlung von Zeigerarten wirbelloser Tiere und Einzeller organischer Verschmutzung und des trophischen Zustands kontinentaler Gewässer. Die Informationen wurden aus Forschungsarbeiten, Monographien, elektronischen Quellen und unserer eigenen Forschung gesammelt. Insgesamt sind 1732 Indikatorarten aus den Reichen der Einzeller der Protozoa, der Chromista und Animalia 19 taxonomischer Stämmen mit ihren ökologischen Präferenzen für Saprobität, Saprobitätsindex (S) und trophischem Zustand vertreten. Diese umfassenden Daten können für die Bewertung aquatischer Ökosysteme und die Überwachung der Wasserqualität auf der Grundlage von Bioindikationsmethoden verwendet werden.

REZUMAT: Indicatori zoologici de calitate a apei pentru evaluarea poluării organice și a stării trofice a corpurilor de apă continentale.

Această lucrare prezintă compilarea datelor pentru taxoni indicatori de nevertebrate şi protiste ai poluarii organice şi a stării trofice a apelor continentale. Informațiile au fost colectate din lucrări de cercetare, monografii, surse electronice și cercetări proprii. În total, 1732 de taxoni indicatori ale regnurilor Protista, Protozoa, Chromista și Animalia din 19 încrengături taxonomice sunt reprezentate cu preferințe ecologice pentru saprobitate cu indice de saprobitate (S) și stare trofică. Aceste date cuprinzătoare pot fi utilizate în scopul evaluării ecosistemului acvatic și al monitorizării calității apei pe baza metodelor de bioindicație.

INTRODUCTION

The European Framework Directive (FWD) (European Parliament, 2000) proposed biological variables for the sorting of ecological status of aquatic organisms (Ponti et al., 2009). Bioindicators are organisms or a group of organisms whose presence or state give data on ecosystem's characteristics. According Burger (2006) "Monitoring ecosystem health requires the use of a suite of bioindicators that are biologically, methodologically, and societally relevant, and can be used over time to assess trends and provide early warning". Bioindicators can be used for assessing: 1. health status of aquatic ecosystems for spatio-temporal trends (Guidance, 2022; Burger, 2006); 2. the effects of natural or anthropogenic stressors (Bănăduc et al., 2022, 2023; Burger, 2006); and 3. evaluating the efficacy of deliberate anthropogenic measures such as remediation and restoration (Burger, 2006; Poikane, et al., 2016). With the help of bioindicators can be assessed two different types of properties of aquatic ecosystem: physico-chemical (organic pollution) or functional (trophic state) under impact of natural or anthropogenically induced environmental changes (Zaghloul et al., 2020).

Aquatic invertebrates relate to trophic states of water bodies (Pedi et al., 2020). Biological assessment based on the invertebrates is widely applied for indications of environmental quality, and more specifically water quality (Lenat, 1993; White and Brigham, 1996; Cummins and Merritt 2001; Frey et al., 2011; Cuffney et al., 2014). Invertebrates participate in basic ecological processes including in changes in trophic state and pollution by wastewater (Cairns and Pratt, 1993; Marvan et al., 2005; Shevchenko et al., 2007; Water quality, 2021). The bioindication, based on analyzing the response of biota to environmental conditions changes, is significant in estimating the effect of pollution on aquatic ecosystems (Friedrich et al., 1996; Oliveira and Callisto, 2010; Petrakis et al., 2018; Abdel Gawad, 2019). Saprobity index S can be calculated for the invertebrates' community and then incorporated to the system of the water quality assessment mainly for organic pollution (Uzunov et al., 1988; Sládeček, 1983; Chertoprud, 2007; Schmidt-Kloiber and Hering, 2015; Yermolaeva and Dvurechenskaya, 2016; Abukenova et al., 2016; Hegab and Khalifa, 2021). Assessment of human impact by invertebrates is more used for the lakes and wetlands (Alyabina and Sorokin, 1983; Fennessy et al., 2001; USEPA 2003; Lasukov, 2018). The systems with combined assessment methods for the invertebrates, diatoms, and other aquatic inhabitants are also developed (Friedrich et al., 1996; Hering et al., 2006; Beyene et al., 2009; Tachet et al., 2010).

We collected the environmental preferences of aquatic species during many years. First of all, we paid attention to the ecological characteristics of algae and cyanobacteria (Barinova et al., 2006, 2019), then collecting information about aquatic plants and mosses (Barinova, 2021), and in current time about macroinvertebrates from solid published works of reliable authors and combining information into a database. The work was carried out for more than three years and data was compiled for two groups of indicators in different indicator systems. The part of this array of data on the ecological preferences of algae and cyanobacteria includes 9,450 species (Barinova and Fahima, 2017) the indicator value tables are in English and are available via electronic link in references (Barinova et al., 2006, 2019). In this work, we have set the task to collect indicative data on other organisms inhabiting the aquatic environment such as invertebrates and some not photosynthetic protists. The material turned out to be so large that we considered it logical to divide it into two parts, each of which can be combined to different publication. Currently, the first part about plants and mosses was published (Barinova, 2021). The ecological preferences of aquatic invertebrates are presented in current paper. We summarized the material with descriptions and calculation that combine reference data on indicator species from different Phyla of aquatic invertebrates, but can serve as indicators of water quality to assess the impact of pollution on aquatic ecosystems.

We aimed to compile the list of inhabitants in continental water bodies from aquatic species of invertebrates, some protozoan, and non-photosynthetic protists with each species preferences for different level of organic pollution and trophic state.

MATERIAL AND METHODS

Data on ecological preferences of aquatic species of invertebrates and non-photosynthetic protists were taken from nine monographs, published papers and electronic resources (Marvan et al., 2005 [1]; Alyabina and Sorokin, 1983 [2]; Yermolaeva and Dvurechenskaya, 2016 [3]; Derevenskaya, 2015 [4]; Shevchenko et al., 2007 [5]; Golubkov et al., 2017 [6]; Lasukov, 2018 [7]; Ermolaeva and Dvurechenskaya, 2013 [8]; Abukenova et al., 2016 [9]; Bezmaternykh, 2007 [10]; Oleksiv, 1992 [11]; Unified methods, 1977 [12]; Uzunov et al., 1988 [13]; Schmidt-Kloiber and Hering, 2015 [14]; Chertoprud, 2007 [15]; Water quality, 2021 [16]; Naberezhny, 2007 [17]; Sládeček, 1983 [18]). The number in square brackets corresponds to the reference number in the environmental preferences table. The collected data about each of the species was inserted into a table, and then the data was classified according to categories of bioindication (Barinova, 2017a). The species' ecological characteristics were grouped according to the variables trophic state and water saprobity with self-purification zones according to Sládeček (1973), and species-specific Index saprobity S.

The ecological preferences of each taxon are described in different sources, from which we took all the available information and then summarized it for each indicator. In the process of data integration, we provided the indicator values mentioned in the reference and if there were several data, then the highest of them. For example, if there were different values of the species-specific index of saprobity, then the highest was given. On the other hand, if different values of the trophic category were indicated for the same species, then the highest was tacked, for example, from the mesotrophic and eutrophic, the eutrophic was chosen.

Integrated data about saprobity and self-purification can be defined in a scale of water quality with the relationship between saprobity index S and water quality category (Romanenko et al., 1990; Barinova, 2017a) (Tab. 1). We given EU Color code include five classes as common used colors and class 6 as black according SEQ (SEQ-water quality) because the invertebrates and protists are mostly heterotrophs, that often indicated class 6 of water quality and extremely polluted waters (Barinova, 2017b).

Table 1: Classification relations of Water Quality Class, Rank, Index of Saprobity S, and self-purification zones according to Romanenko et al. (1990) and Barinova (2017a).

Water quality	Water Quality Class	Self-purification zone	Rank	EU Color code	Saprobic zone	Index Saprobity S
Very clear	1	1	1	Blue	xenosaprobity	0-0.5
Clear	2	2a	2	Green	oligo-saprobity	0.5-1.0
	2	2b	3	Green		1.1-1.5
Moderate polluted	3	3a	4	Yellow	beta-meso-saprobity	1.6-2.0
	3	3b	5	Yellow		2.1-2.5
Polluted	4	4a	6	Orange	alpha-meso-saprobity	2.6-3.0
	4	4b	7	Orange		3.1-3.5
Very polluted	5	5a	8	Red	polysaprobity	3.6-4.0
	5	5b	9	Red		> 4.0
Extremally polluted	6	6	9	Black	transsaprobity	> 4.0

Index S community tolerance to the organic matter enrichments can be calculated on the base of collected data about species-specific index S with the following equation, where S is the index of saprobity for community; s_i is the species-specific saprobity index; a_i is the species frequency values (Eq. 1):

$$S = \sum_{i=1}^{n}(s_i.a_i) \Big/ \sum_{i=1}^{n}(a_i)$$

Equation 1

Data about trophic state preferences can be compared to the bioindicators category of this parameter (Barinova, 2017a) in the system started by Herman Van Dam in 1994 (Van Dam et al., 1994). Species-indicators names were adapted to modern taxonomic system with help of available electronic sources (GBIF; WoRMS).

RESULTS AND DISCUSSION

As a result of collecting and integrating of data about ecological preferences of aquatic invertebrates and non-photosynthetic protists were analyzed data from 18 sources of the references for 1732 species (Tab. 2). In Table 2 were used the abbreviations: Saprobity groups: x – xenosaprob, x–o – xeno–oligosaprob, o–x – oligo–xenosaprob, x–b – xeno–betamesosaprob, o – oligosaprob, o–b – oligo–beta–msosaprob, b–o – beta–oligosaprob, o–a – oligo–alpha–mesosaprob, b – beta–mesosaprob, b–a – beta–alpha–mesosaprob, a–o – alpha–oligosaprob, a – alpha-mesosaprob, i – i–eusaprob. Trophic state groups: ot – oligotraphentic; om – oligo–mesotraphentic; m – mesotraphentic; me – meso–eutraphentic; e – eutraphentic; o–e – oligo–eutraphentic; he – hypereutraphentic. "–" property is unknown. Their reference number is in square brackets and is the same in the reference list by bold.

Table 2: Index saprobity S, saprobic zone groups, and group of trophic state for taxa of aquatic invertebrate and non-photosynthetic protist indicators with numbered of source data.

No.	Indicator taxa	Index S	Saprobity zone	Trophic state	Reference
	Sarcomastigophora (Kingdom: Protista)				
1.	*Amphimonas fusiformis* Mereschkoysky, 1879	2.50	b-a	–	[1]
2.	*Amphimonas globosus* W. S. Kent 1881	2.50	b-a	–	[1]
	Amoebozoa (Kingdom Protozoa)				
3.	*Breviata anathema* Walker, Dacks, Embley, 2006	4.50	i	–	[1]
4.	*Mastigamoeba gigantea* Klug 1936	4.00	p	–	[1]
5.	*Mastigamoeba limax* Moroff, 1903	4.70	i	–	[1]
6.	*Mastigamoeba reptans* Stokes, 1890	3.90	b-p	–	[1]
7.	*Mastigamoeba trichophora* Lauterborn, 1901	4.70	i	–	[1]
8.	*Mastigella penardii* Lemmermann, 1913	4.00	p	–	[1]
9.	*Mastigella radicula* (Moroff) Goldschmidt, 1907	3.40	a	–	[1]
10.	*Multicilia lacustris* Lauterborn 1895	4.60	i	–	[1]
	Cercozoa (Kingdom Protozoa)				
11.	*Cercobodo agilis* (Moroff) Lemmermann, 1914	4.60	i	-	[1]
12.	*Cercobodo bodo* (H. Meyer) Lemmermann, 1910	2.50	b-a	-	[1]
13.	*Cercobodo crassicauda* Lemmermann 1913	4.00	p	-	[1]
14.	*Cercobodo digitalis* (H. Meyer) Lemmermann, 1910	2.50	b-a	-	[1]
15.	*Cercobodo grandis* Skvortsov, 1977	5.70	m	-	[1]
16.	*Cercobodo longicauda* (Dujardin) Senn 1900	4.70	i	–	[1]

17.	*Cercobodo ovatus* (Klebs) Lemmermann, 1908	2.50	b-a	–	[1]
18.	*Cercobodo radiatus* (Klebs) Lemmermann, 1908	3.50	p-a	–	[1]
19.	*Cercobodo simplex* (T. Moroff) Lemmermann, 1908	5.70	m	–	[1]
20.	*Cercobodo varians* Skuja, 1948	5.70	m	–	[1]
21.	*Spongomonas uvella* F. Stein 1878	1.50	o-b	–	[1]
	Choanozoa (Kingdom Protozoa)				
22.	*Astrosiga radiata* Zacharias, 1914	1.40	o-b	–	[1]
23.	*Codonosigopsis robinii* Senn 1900	2.00	b	–	[1]
24.	*Codosiga botrytis* (Ehrenberg) Bütschli, 1878	2.60	a-o	–	[1]
25.	*Codosiga furcata* W. S. Kent, 1881	2.00	b	–	[1]
26.	*Codosiga umbellata* (Tatem) W. S. Kent, 1881	2.10	b	–	[1]
27.	*Desmarella moniliformis* Kent, 1878	2.60	a-o	–	[1]
28.	*Diploeca flava* (Korshikov, 1926) Bourrelly, 1957	2.00	b	–	[1]
29.	*Diplosiga socialis* Frenzel, 1891	1.20	o	–	[1]
30.	*Diplosigopsis entzii* Francé, 1897	1.75	b-o	–	[1]
31.	*Lagenoeca globulosa* Francé, 1897	2.00	b	–	[1]
32.	*Lagenoeca obovata* Lemmermann, 1913	2.00	b	–	[1]
33.	*Monosiga ovata* W. S. Kent 1881	1.50	o-b	–	[1]
34.	*Pachysoeca ruttneri* (Bourrelly) Fott	2.00	b	–	[1]
35.	*Protospongia haeckelii* W. S. Kent, 1881	1.00	o	–	[1]
36.	*Salpingoeca amphoridium* H. J. Clark 1867	2.20	b	–	[1]
37.	*Salpingoeca brunnea* Stokes	2.00	b	–	[1]
38.	*Salpingoeca buetschlii* Lemmermann 1913	2.00	b	–	[1]
39.	*Salpingoeca frequentissima* (Zacharias) Lemmermann 1913	1.80	o-a	–	[1]
40.	*Salpingoeca fusiformis* W. S. Kent 1878	2.00	b	–	[1]
41.	*Salpingoeca globulosa* Zhukov 1993	2.00	b	–	[1]
42.	*Salpingoeca gracilis* H. J. Clark 1867	2.00	b	–	[1]
43.	*Salpingoeca macrostoma* Korshikov 1926	2.00	b	–	[1]
44.	*Salpingoeca massartii* De Saedeleer, 1927	2.50	b-a	–	[1]
45.	*Salpingoeca obliqua* (B. Fott) H. Heynig 1992	2.00	b	–	[1]
46.	*Salpingoeca oblonga* F. Stein 1878	2.40	b-a	–	[1]
47.	*Salpingoeca obovata* (Lemmermann) Bourelly	2.00	b	–	[1]
48.	*Salpingoeca riethii* Fott 1960	2.00	b	–	[1]
49.	*Salpingoeca ringens* W. S. Kent 1878	2.00	b	–	[2]
50.	*Salpingoeca ruttneri* Bourelly	2.00	b	–	[1]
51.	*Salpingoeca vaginicola* F. Stein 1878	2.00	b	–	[1]
52.	*Salpingoeca volvox* Lauterborn 1894	3.20	a	–	[1]
53.	*Stelexomonas dichotoma* Lackey 1942	1.50	o-b	–	[1]
	Metamonada (Kingdom Protozoa)				
54.	*Gyromonas* sp.	3.90	b-p	–	[1]
55.	*Thylacomonas compressa* Schewiakoff	2.30	b	–	[1]
56.	*Trepomonas agilis* Dujardin 1841	5.00	m	–	[1]
57.	*Trepomonas steinii* Klebs, 1892	4.00	p	–	[1]
58.	*Trigonomonas compressa* G. A. Klebs	5.00	m	–	[1]
59.	Trigonomonas cyrusii Cyrus et Sládeček	5.00	m	–	[1]
60.	*Trigonomonas inflata* Skuja	5.00	m	–	[1]
61.	*Trigonomonas tortuosa* Skuja	5.00	m	–	[1]
62.	*Urophagus caudatus* Skuja 1939	5.00	m	–	[1]
63.	*Urophagus rostratus* (F. Stein) Klebs 1892	5.00	m	–	[1]
	Percolozoa (Kingdom: Protozoa)				
64.	*Tetramitus descissus* Perty 1852	5.00	m	–	[1]
65.	*Tetramitus pyriformis* Klebs 1892	5.00	m	–	[1]
66.	*Tetramitus rostratus* Perty, 1852	4.00	p	–	[1]
67.	*Tetramitus sulcatus* Stein, 1878	4.00	p	–	[1]

	Ciliophora (Kingdom: Chromista)				
68.	*Campanella umbellaria* (Linnaeus, 1758) Goldfuss, 1820	3.00	a-b	–	[9]
69.	*Carchesium polypinum* (Linnaeus, 1758)	2.90	b-p	–	[9]
70.	*Litonotus fasciola* (Wresniowski, 1870)	3.00	a	–	[9]
71.	*Litonotus lamella* Schewiakoff, 1896	2.20	b-a	–	[9]
72.	*Paramecium aurelia* Ehrenberg, 1838	2.50	a-p	–	[9]
73.	*Paramecium caudatum* Ehrenberg, 1834	3.30	a-p	–	[9]
74.	*Spirostomum ambiguum* (Müller, 1786) Ehrenberg, 1835	3.00	a	–	[9]
75.	*Spirostomum minus* Roux, 1901	2.60	a	–	[9]
76.	*Stentor roeseli* Ehrenberg, 1835	2.45	a-b	–	[9]
77.	*Stylonychia pustulata* (Müller, 1786) Ehrenberg, 1835	2.00	o	–	[9]
78.	*Vorticella campanula* Ehrenberg, 1831	2.20	b-a	–	[9]
79.	*Vorticella convallaria* Linnaeus, 1758	2.90	a	–	[9]
	Annelida (Kingdom: Animalia)				
80.	*Aelosoma tenebrarum* Vejdovský, 1880	–	b	–	[5],[10]
81.	*Aeolosoma hemprichi* Ehrenberg, 1828	–	o	–	[10],[5]
82.	*Aeolosoma* sp.	2.50	–	–	[13]
83.	*Aeolosoma hemprichi* Ehrenberg 1828	2.20	–	–	[13]
84.	*Alexandrovia onegensis* Hrabe, 1962	-	o	–	[5],[10]
85.	*Amphichaeta leydigi* Tauber, 1879	2.10	–	–	[13]
86.	*Amphichaeta* sp.	–	–	me	[14]
87.	*Aulodrilus limnobius* Bretscher, 1899	–	b	–	[5],[10]
88.	*Aulodrilus pluriseta* (Piguet, 1906)	2.20	b	–	[5],[10],[13]
89.	*Aulodrilus pigueti* Kowalewski, 1914	1.90	–	–	[13]
90.	*Aulophorus* sp.	-	–	e	[14]
91.	*Branchiobdella* sp.	–	–	ot	[14]
92.	*Branchiura sowerbyi* Beddard, 1892	2.40	–	e	[13],[14]
93.	*Chaetogaster diaphanus* (Gruithuisen, 1828)	2.30	b	–	[5],[10],[13]
94.	*Chaetogaster diastrophus* (Gruithuisen, 1828)	2.20	–	–	[13]
95.	*Chaetogaster limnaei* von Baer, 1827	1.45	b	–	[5],[10],[13]
96.	*Chaetogaster* sp.	2.30	–	me	[13],[14]
97.	*Dendrodrilus rubidus* subsp. *subrubicundus* (Eisen, 1874)	–	–	e	[14]
98.	*Dero digitata* Müller, 1773	2.80	b	–	[5],[10],[13]
99.	*Dero dorsalis* Ferronnière, 1899	1.20	–	–	[13]
100.	*Dero obtusa* d'Udekem, 1855	2.70	–	–	[13]
101.	*Dero* sp.	2.90	–	e	[13],[14]
102.	*Dina lineata* (O.F.Müller, 1774)	3.10	–	me	[14]
103.	*Dorydrilus michaelseni* Piquet, 1913	–	–	me	[14]
104.	*Eiseniella tetraedra* (Savigny, 1826)	2.10	–	ot	[13],[14]
105.	Enchytraeidae gen. sp.	2.90	–	e	[13],[14]
106.	*Erpobdella octoculata* (Linnaeus, 1758)	–	a	–	[5],[10]
107.	*Erpobdella* sp.	2.65	a	me	[14],[16]
108.	Erpobdellidae gen. sp.	3.00	–	–	[7],[15]
109.	*Glossiphonia paludosa* (Carena, 1824)	2.40	–	me	[14]
110.	*Glossiphonia* sp.	2.70	–	me	[14]
111.	*Glossiphonia verrucata* (Müller, 1844)	2.30	–	me	[14]
112.	Glossiphoniidae gen. sp.	2.50	b	–	[7],[15],[16]
113.	*Glossosiphonia complanata* (Linnaeus, 1758)	–	b-a	–	[5],[10]
114.	*Haemopis sanguisuga* (Linnaeus, 1758)	2.60	b	me	[6],[10],[14],[16]
115.	*Haplotaxis gordioides* (Hartmann, 1821)	2.20	–	ot	[14]
116.	*Helobdella stagnalis* (Linnaeus, 1758)	2.90	–	e	[14]
117.	*Hemiclepsis marginata* (O. F. Müller, 1774)	2.20	–	me	[14]
118.	Hirudinidae gen. sp.	3.00	–	–	[15]
119.	*Hirudo medicinalis* Linnaeus, 1758	2.10	–	me	[14]
120.	*Hypania invalida* (Grube, 1860)	2.50	–	e	[13],[14]

121.	*Isochaetides michaelseni* (Lastočkin, 1937)	2.80	–	–	[13]
122.	*Isochaetides newaensis* (Michaelsen, 1903)	–	o	–	[5]
123.	*Lamprodrilus achaetus* Izosimov, 1962	–	o	–	[5],[10]
124.	*Lamprodrilus isoporus* Michaelsen, 1901	–	b	–	[5],[10]
125.	*Limnodrilus claparedeianus* Ratzel, 1868	2.90	b	–	[5],[10],[13]
126.	*Limnodrilus hoffmeisteri* Claparède, 1862	3.60	p-a	–	[4],[5],[10],[13]
127.	*Limnodrilus profundicola* (Verrill, 1871)	3.00	b	–	[5],[10],[13]
128.	*Limnodrilus udekemianus* Claparède, 1862	3.80	b	–	[5],[10], [13]
129.	Lumbricidae gen. sp.	2.50	–	–	[13]
130.	Lumbriculidae gen. sp.	2.20	b	–	[16]
131.	*Lumbriculus variegatus* (Müller, 1774)	2.30	b	–	[5],[10],[13]
132.	Naididae gen. sp.	3.70	b	–	[13],[15],[16]
133.	*Nais alpina* Sperber, 1948	–	o	–	[5],[10]
134.	*Nais barbata* Müller, 1773	2.80	b	–	[5],[10],[13]
135.	*Nais behningi* Michaelsen, 1923	1.00	o	–	[5],[10],[13]
136.	*Nais bretscheri* Michaelsen, 1898	2.50	o	–	[5],[10],[13]
137.	*Nais communis* Piguet, 1906	2.90	b	–	[5],[10],[13]
138.	*Nais elinguis* Müller, 1774	2.90	o	–	[5],[10],[11]
139.	*Nais pardalis* Piguet, 1906	2.40	-	–	[13]
140.	*Nais pseudobtusa* Piguet, 1906	1.70	o	–	[10],[13]
141.	Nais pseudoobtusa Piguet, 1906	–	o	–	[5]
142.	*Nais simplex* Piguet, 1906	2.70	o	–	[5],[10],[13]
143.	*Nais* sp.	2.90	–	me	[13],[14]
144.	*Nais variabilis* Piguet, 1906	2.90	–	–	[13]
145.	*Ophidonais serpentina* Müller, 1773	3.00	–	e	[13],[14]
146.	*Paranais frici* Hrabe, 1941	2.30	–	–	[13]
147.	*Paranais* sp.	–	–	e	[14]
148.	*Piguetiella blanci* (Piguet, 1906)	–	b	me	[5],[10],[14]
149.	*Piscicola geometra* (Linneaus, 1758)	2.20	b	me	[5],[10],[14],[16]
150.	Piscicolidae gen. sp.	2.50	–	–	[15]
151.	*Placobdella costata* (Müller, 1846)	1.60	–	me	[14]
152.	*Potamothrix hammoniensis* (Michaelsen, 1901)	2.70	b	–	[5],[10],[13]
153.	Potamothrix moldaviensis (Vejdovský et Mrázek, 1903)	2.50	–	–	[13],[14]
154.	*Pristina aequiseta* Bourne, 1891	2.40	–	–	[13]
155.	*Pristina bilobata* (Bretscher, 1903)	2.80	–	–	[13]
156.	*Pristina longiseta* Ehrenberg, 1828	2.50	–	–	[13]
157.	*Pristina rosea* Piguet, 1906	2.60	–	–	[13]
158.	*Pristina* sp.	2.60	–	e	[13],[14]
159.	*Pristinella* sp.	–	–	e	[14]
160.	*Propappus volki* Michaelsen, 1916	1.90	b	m	[5],[10],[13],[14]
161.	*Psammoryctides albicola* (Michaelsen, 1901)	2.70	b	–	[5],[10],[13]
162.	*Psammoryctides barbatus* (Grube, 1891)	2.00	b	–	[5],[10],[13]
163.	*Rhyacodrilus coccineus* (Vejdovský, 1875)	1.80	–	–	[13]
164.	*Rhynchelmis limosella* Hoffmeister, 1843	–	b	–	[5],[10]
165.	*Rhynchelmus vagensis*	0.40	x-o	–	[4]
166.	*Ripistes parasita* (Schmidt, 1847)	1.60	–	me	[13],[14]
167.	*Slavina appendiculata* d'Udekem, 1855	2.20	–	e	[13],[14]
168.	*Sparganophilus tamesis* Benham, 1892	-	–	e	[14]
169.	*Specaria josinae* (Vejdovksy, 1883)	2.50	–	e	[14]
170.	*Spirosperma ferox* Eisen, 1879	2.30	–	–	[13]
171.	*Stylaria lacustris* Linnaeus, 1767	2.40	o-b	e	[5],[10],[13],[14]
172.	*Stylodrilus heringianus* Claparède, 1862	1.90	o	ot	[4],[5],[10],[13],[14]
173.	Stylodrilus parvus (Hrabe et Cernosvitov, 1927)	–	o	–	[5],[10]
174.	*Tatriella slovenica* Hrabě, 1939	–	o	–	[5],[10]

175.	*Theromyzon tessulatum* (O. F. Müller, 1774)	2.40	–	me	[14]
176.	*Trocheta* sp.	–	–	e	[14]
177.	*Tubifex newaensis* (Michaelsen, 1903)	1.60	–	–	[10],[13]
178.	*Tubifex* sp.	3.70	–	–	[13]
179.	*Tubifex tubifex* (Müller, 1774)	3.70	p	–	[4],[5],[10],[13]
180.	Tubificidae gen. sp.	4.00	a	–	[15],[16]
181.	*Uncinais uncinata* Ørsted, 1842	2.00	b	me	[5],[10],[13],[14]
182.	*Vejdovskyella* sp.	-	–	ot	[14]
183.	*Vejdovskyella comata* (Vejdovský, 1884)	1.70	b	–	[5],[10],[13]
	Arthropoda (Kingdom: Animalia)				
184.	*Ablabesmyia* sp.	–	b-a	–	[5],[10]
185.	*Acanthocyclops vernalis* (Fischer, 1853)	1.85	b	–	[4]
186.	*Acanthocyclops viridis* (Jurine, 1820)	1.50	o-b	–	[6]
187.	*Acanthodiaptomus denticornis* (Wierzejski, 1887)	2.33	–	–	[3],[8]
188.	*Acentrella sinaica* Bogoescu, 1931	–	–	ot	[14]
189.	*Acentria ephemerella* Olivier, 1791	2.00	–	me	[14]
190.	*Acentropus niveus* (Olivier, 1791)	–	o	–	[5],[10]
191.	*Acilius* sp.	2.00	–	e	[14]
192.	*Acroperus harpae* (Baird, 1834)	1.17	–	–	[3],[8]
193.	*Adicella* sp.	–	–	ot	[14]
194.	Aeschnidae gen sp.	3.00	–	–	[7],[15]
195.	*Aeshna isosceles* Muller, 1767	–	–	me	[14]
196.	*Aeshna* sp.	2.00	–	me	[14]
197.	*Agabus* sp.	2.00	–	e	[14]
198.	*Agapetus* sp.	1.50	x-o	ot	[5],[10],[14],[16]
199.	*Agraylea* sp.	1.70	o-b	ot	[5],[10],[14]
200.	*Agrion* sp.	1.30	o	–	[16]
201.	*Agriotypus* sp.	–	–	me	[14]
202.	*Agrypnia* sp.	–	–	me	[14]
203.	*Allogamus* sp.	0.30	–	ot	[14]
204.	*Allotrichia pallicornis* (Eaton, 1873)	–	–	e	[14]
205.	*Alona affinis* Leydig, 1860	1.44	–	–	[3],[8]
206.	*Alona guttata* G. O. Sars, 1862	1.60	–	–	[3],[8]
207.	*Alona quadrangularis* (O. F. Müller, 1776)	1.25	–	–	[3],[8]
208.	*Alona rectangula* Sars, 1861	1.00	–	–	[3],[8]
209.	*Alonella excisa* (Fischer, 1854)	1.00	–	–	[3],[8]
210.	*Alonella nana* (Baird, 1850)	1.50	o-b	–	[3],[6],[8]
211.	*Alonopsis elongata* Sars, 1862	0.80	o	-	[4]
212.	Ameletidae gen. sp.	0.50	–	–	[15]
213.	*Ameletus inopinatus* Eaton, 1887	0.50	–	ot	[14]
214.	*Amphinemura* sp.	1.50	–	ot	[14]
215.	*Amphinemura sulcicollis* (Stephens, 1836)	–	o	–	[5],[10]
216.	*Anabolia brevipennis* (Curtis, 1834)	–	–	ot	[14]
217.	*Anabolia laevis* Zetterstedt, 1840	–	b-a	–	[5],[10]
218.	*Anabolia nervosa* (Curtis, 1834)	–	o-b	–	[5],[10]
219.	*Anabolia* sp.	2.30	b	me	[14],[16]
220.	*Anacaena* sp.	–	–	e	[14]
221.	*Anax* sp.	2.00	–	ot	[14]
222.	Anisops sardeus subsp. sardeus Herrich-Schaeffer, 18[1]	–	–	e	[14]
223.	*Anomalopterygella chauviniana* (Stein, 1874)	1.50	–	ot	[14]
224.	*Anopheles* sp.	2.50	–	me	[14]
225.	*Anostraca* gen. sp.	–	–	e	[14]
226.	*Apatania* sp.	1.00	o	ot	[5],[10], [14]
227.	Apataniidae gen. sp.	0.50	–	–	[15]
228.	Aphelocheiridae gen. sp.	2.00	–	–	[15]

229.	*Aphelocheirus aestivalis* (Fabricius, 1794)	2.00	o-b	ot	[5],[14],[16]
230.	*Apsectrotanypus trifascipennis* (Zetterstedt, 1838)	–	o-b	–	[5],[10]
231.	*Arctocorisa* sp.	–	–	ot	[14]
232.	Arctopsychidae gen. sp.	1.00	–	–	[15]
233.	*Arcynopteryx compacta* (McLachlan, 1872)	0.10	–	ot	[14]
234.	*Argulus* sp.	–	–	e	[14]
235.	*Arthroplea congener* Bengtsson, 1908	1.80	–	–	[14]
236.	Asellidae gen. sp.	3.00	o-b	–	[6],[7],[15]
237.	*Asellus aquaticus* (Linnaeus, 1758)	3.00	a	me	[5],[10],[14],[16]
238.	Astacidae gen. sp.	2.00	-	–	[15]
239.	*Astacus astacus* (Linnaeus, 1758)	2.00	–	ot	[14]
240.	*Astacus fluviatilis* Fabricius, 1775	–	o	–	[5],[10]
241.	*Astacus leptodactylus* (Eschscholz, 1823)	–	x-b	–	[5],[10]
242.	Athericidae gen. sp.	2.00	–	–	[15]
243.	*Atherix ibis* (Fabricius, 1798)	1.15	o	–	[4],[5],[10]
244.	*Atherix* sp.	1.10	o	ot	[14],[16]
245.	*Athripsodes* sp.	2.10	–	me	[14]
246.	*Atrichops crassipes* (Meigen, 1820)	–	–	ot	[14]
247.	*Atyaephyra desmaresti* (Millet, 1831)	2.30	–	e	[14]
248.	*Aulonogyrus* sp.	–	–	e	[14]
249.	*Austropotamobius* sp.	–	–	ot	[14]
250.	*Baetidac* sp.	2.10	b	–	[16]
251.	Baetidae gen. sp.	2.00	–	–	[7],[15]
252.	*Baetis bacillus* (Klu P.O., 1983)	–	b	–	[5],[10]
253.	*Baetis fuscatus* (Linnaeus, 1761)	–	b	–	[5],[10]
254.	*Baetis gemellus* Eaton, 1885	0.30	x	–	[4]
255.	*Baetis rhodani* (Pictet, 1843)	1.15	o-b	–	[5],[10],[16]
256.	*Baetis* sp.	1.70	–	e	[14]
257.	*Baetis tricolor* Tshernova, 1928	–	b	–	[5],[10]
258.	*Baetis ursinus* Kazlauskas, 1963	–	b	–	[5],[10]
259.	*Baetis vernus* Curtis, 1834	–	b	–	[5],[10]
260.	*Baetopus tenellus* (Albarda, 1878)	2.00	–	me	[14]
261.	*Beraea* sp.	0.50	–	–	[14]
262.	*Beraeamyia squamosa* Mosely, 1930	–	–	–	[14]
263.	Beraeidae gen. sp.	2.00	–	–	[15]
264.	*Beraeodes minutus* (Linnaeus, 1761)	2.00	–	e	[14]
265.	*Beraeodina palpalis* Mosely, 1931	–	–	–	[14]
266.	*Berosus* sp.	–	–	e	[14]
267.	*Besdolus* sp.	–	–	ot	[14]
268.	*Bezzia* sp.	2.20	b	–	[16]
269.	*Bidessus* sp.	–	–	me	[14]
270.	*Blepharicera fasciata* subsp. *fasciata* (Westwood 1842)	1.50	–	ot	[14]
271.	*Bosmina coregoni* Baird, 1857	1.50	o-b	–	[6]
272.	*Bosmina longirostris* (O. F. Müller, 1776)	1.53	o-b	–	[3],[8]
273.	*Bosmina thersites* Poppe, 1887	1.00	o	–	[6]
274.	*Boyeria irene* (Fonscolombe, 1838)	–	–	ot	[14]
275.	Brachycentridae gen. sp.	2.00	–	–	[15]
276.	*Brachycentrus maculatus* (Fourcroy, 1785)	1.90	o	ot	[10],[14]
277.	*Brachycentrus* sp.	–	–	ot	[14]
278.	*Brachycentrus subnubilus* Curtis, 1834	0.80	o	–	[16]
279.	*Brachycercus harrisella* Curtis, 1834	2.00	b	me	[5],[10], [14]
280.	*Brachyptera risi* (Morton, 1896)	–	x-o	–	[5],[10]
281.	*Brachyptera* sp.	1.20	–	ot	[14]
282.	*Brachytron pratense* Muller, 1764	–	–	e	[14]

283.	*Branchipus schaeferi* Fischer, 1934	–	o-b	–	[5],[10]
284.	*Brillia longifurca* Kieffer, 1921	–	o-b	–	[5],[10]
285.	*Brillia modesta* (Meigen, 1830)	–	o-b	–	[5],[10]
286.	*Brychius elevatus* (Panzer, 1794)	2.00	–	me	[14]
287.	*Bythotrephes cederströmii* Schödler, 1877	1.88	–	–	[3],[8]
288.	*Bythotrephes longimanus* Leydig, 1860	1.10	o	–	[3],[8]
289.	Caenidae gen. sp.	2.50	–	–	[7],[15]
290.	*Caenis horaria* (Linnaeus, 1758)	–	b-o	–	[5],[10]
291.	*Caenis miliaria* (Tshernova 1952)	–	b	–	[5],[10]
292.	*Caenis pseudorivulorum* Keffermüller, 1960	–	b	–	[5],[10]
293.	*Caenis robusta* Eaton, 1884	–	b	–	[5],[10]
294.	*Caenis* sp.	2.00	–	me	[14]
295.	*Calamoceras marsupus* Brauer, 1865	-	–	ot	[14]
296.	*Callicorixa praeusta praeusta* (Fieber, 1848)	2.30	–	e	[14]
297.	Calopterygidae gen. sp.	2.50	–	–	[7],[15]
298.	*Calopteryx* sp.	2.20	–	me	[14]
299.	*Candona eremita* (Vejdovsky, 1880)	–	x	–	[5]
300.	*Capnia bifrons* (Newman, 1838)	–	o	–	[5],[10]
301.	*Capnia* sp.	1.40	–	me	[14]
302.	Capniidae gen. sp.	1.00	–	–	[15]
303.	*Capnioneura* sp.	-	–	me	[14]
304.	*Capnopsis schilleri* subsp. *schilleri* (Rostock, 1892)	1.50	–	e	[14]
305.	*Carinogammarus roeselii* (Gervais, 1835)	–	x-b	–	[5],[10]
306.	*Cataclysta lemnata* (Linnaeus, 1758)	2.20	b	e	[5],[10], [14]
307.	*Catagapetus nigrans* McLachlan, 1884	–	–	ot	[14]
308.	*Centroptilum luteolum* (O. F. Müller, 1776)	2.10	b	me	[5],[10],[14]
309.	*Centroptilum pennulatum* Eaton, 1870	–	o-b	–	[5],[10]
310.	*Ceraclea* sp.	2.10	–	e	[14]
311.	Ceratopogoninae gen. sp.	–	–	e	[14]
312.	*Ceriagrion tenellum* (De Villers, 1789)	–	–	ot	[14]
313.	*Ceriodaphnia affinis* Lilljeborg, 1900	1.68	o-b	–	[3],[4],[8]
314.	*Ceriodaphnia pulchella* G. O. Sars, 1862	1.50	o-b	–	[6]
315.	*Ceriodaphnia quadrangula* (O. F. Müller, 1785)	2.00	b	–	[3],[6],[8]
316.	*Ceriodaphnia reticulata* (Jurine, 1820)	1.69	–	–	[3],[8]
317.	*Chaetarthria seminulum* (Herbst, 1797)	2.60	–	e	[14]
318.	*Chaetopteryx* sp.	–	o	–	[5],[10]
319.	*Chalcolestes viridis* (Van der Linden, 1825)	2.20	–	me	[14]
320.	*Chaoborus crystallinus* (De Geer, 1776)	2.25	b-a	–	[4],[5],[10]
321.	*Chaoborus* sp.	2.40	–	e	[14]
322.	*Cheumatopsyche lepida* (Pictet, 1834)	2.20	–	me	[14]
323.	*Chimarra marginata* (Linnaeus, 1767)	–	–	ot	[14]
324.	Chironomidae gen. sp.	2.00	b	–	[16]
325.	*Chironomiis plumosus*	3.70	p	–	[16]
326.	Chironomini gen. sp.	2.50	–	e	[14]
327.	Chironomus acutiventris Wulker et Ryser, 1983	–	a	–	[5],[10]
328.	*Chironomus cingulatus* Meigen, 1830	–	p-a	–	[5],[10]
329.	*Chironomus piger* Strenzke, 1959	–	p	–	[5],[10]
330.	*Chironomus plumosus* (Linnaeus, 1758)	–	p	–	[5],[10]
331.	*Chironomus semireductus* (Lenz, 1924)	–	b-a	–	[5],[10]
332.	*Chironomus thummi* (Kieffer, 1911)	3.65	p	–	[4],[5],[10]
333.	*Chitonophora krieghoffi* Ulmer, 1920	0.40	x-o	–	[4]
334.	*Chloroperla* sp.	1.50	–	ot	[14]
335.	*Chloroperla torrentium* (F. J. Pictet, 1841)	–	x-o	–	[5],[10]
336.	Chloroperlidae gen. sp.	1.00	–	–	[15]
337.	*Choroterpes picteti* (Eaton, 1871)	2.10	–	e	[14]

338.	*Choroterpes* sp.	–	b	–	[5],[10]
339.	Chrysomelidae gen. sp.	3.00	-	–	[15]
340.	*Chrysopilus* sp.	–	–	e	[14]
341.	*Chydorus ovalis* Kurz, 1874	1.63	–	–	[3],[8]
342.	*Chydorus sphaericus* (O. F. Mueller, 1785)	1.28	b-o	–	[3],[4],[6],[8]
343.	*Cladotanytarsus mancus* (Walker, 1856)	–	o-b	–	[5],[10]
344.	Clinocerinae gen. sp.	–	–	me	[14]
345.	*Cloeon bifidum* Bengtsson, 1912	–	b	–	[5],[10]
346.	*Cloeon dipterum* (Linnaeus, 1761)	–	b	–	[5],[10]
347.	Cloeon macronyx Kluge et Novikova, 1992	–	b	–	[5],[10]
348.	*Cloeon simile* Eaton, 1870	–	b	–	[5],[10]
349.	*Cloeon* sp.	2.30	–	e	[14]
350.	*Coenagrion* sp.	2.00	–	me	[14]
351.	Coenagrionidae gen. sp.	3.50	–	–	[7],[15]
352.	*Colymbetes* sp.	–	–	e	[14]
353.	*Conchapelopia melanops* (Meigen, 1818)	–	o-b	–	[5],[10]
354.	Conchostraca gen. sp.	–	–	e	[14]
355.	*Copelatus* sp.	–	–	e	[14]
356.	*Cordulegaster* sp.	1.50	–	ot	[14]
357.	Cordulegasteridae gen. sp.	1.50	–	–	[15]
358.	*Cordulia aenea* Linnaeus, 1758	1.60	–	me	[14]
359.	Corduliidae gen. sp.	2.00	–	–	[15]
360.	*Corixa* sp.	2.00	o-b	m	[5],[10],[14]
361.	Corixidae gen. sp.	2.50	–	–	[15]
362.	*Corophium* sp.	–	–	me	[14]
363.	*Crangonyx* sp.	–	–	me	[14]
364.	*Crenitis punctatostriata* (Letzner, 1840)	2.30	–	e	[14]
365.	*Cricotopus bicinctus* (Meigen, 1818)	–	b-o	–	[5],[10]
366.	*Cricotopus biformis* Edwards, 1929	–	x	–	[5],[10]
367.	*Cricotopus* gr. *algarum*	–	b-o	–	[5],[10]
368.	*Cricotopus* gr. *silvestris*	–	o-b	–	[5],[10]
369.	Cricotopus latidentatus Chernovskij, 19[1]	–	b-o	–	[5],[10]
370.	*Crocothemis erythraea* (Brullé, 1832)	–	–	me	[14]
371.	*Crunoecia* sp.	1.00	–	ot	[14]
372.	*Cryptochironomus defectus* (Kieffer, 1913)	–	b	–	[5],[10]
373.	*Cryptothrix* sp.	–	–	–	[14]
374.	*Culex* sp.	–	b-a	–	[5],[10]
375.	Culicinae gen. sp.	–	–	e	[14]
376.	*Cybister lateralimarginalis* (De Geer, 1774)	2.80	–	e	[14]
377.	*Cyclops furcifer* Claus, 1857	1.50	o	–	[3],[4],[8]
378.	*Cyclops serrulatus* Fischer, 1851	1.65	b	–	[4],[8]
379.	*Cyclops strenuus* Fischer, 1851	1.14	b-a	–	[3],[4],[8]
380.	*Cyclops vicinus* Ulyanin, 1875	1.38	b	–	[3],[8]
381.	*Cymatia* sp.	–	–	me	[14]
382.	*Cymbiodyta marginella* (Fabricius, 1792)	2.50	–	e	[14]
383.	*Cyphon* sp.	–	–	e	[14]
384.	*Cypria ophthalmica* (Jurine, 1820)	–	o-b	–	[5],[10]
385.	*Cypridopsis vidua* (Müller, 1776)	–	o-b	–	[5],[10]
386.	*Cyrnus* sp.	1.80	-	e	[14]
387.	*Cyzicus tetracerus* (Krynicki, 1830)	–	o-b	–	[5],[10]
388.	*Daphnia cristata cristata* G.O. Sars, 1862	1.00	o	–	[6]
389.	*Daphnia cucullata* G. O. Sars, 1862	1.88	b	–	[3],[6],[8]
390.	*Daphnia longispina* (Mueller, 1785)	1.58	b	–	[3],[4],[8]
391.	*Daphnia magna* Straus, 1820	1.58	a-p	–	[3],[4],[8]

392.	*Daphnia pulex* Leydig, 1860	1.72	a	–	[3],[4],[8]
393.	*Daphnia similis* Claus, 1876	1.88	–	–	[3],[8]
394.	Dasyheleinae gen. sp.	–	–	me	[14]
395.	*Deronectes* sp.	–	–	me	[14]
396.	*Diamesa insignipes* Kieffer, 1908	–	x-b	–	[5],[10]
397.	*Diamesa thienemanni* Kieffer, 1909	–	o-b	–	[5],[10]
398.	*Diaphanosoma brachyurum* (Liévin, 1848)	1.52	o-b	–	[3],[6],[8]
399.	*Diaptomus gracilis* Sars GO, 1863	1.00	o	–	[6]
400.	*Dictyogenus* sp.	1.00	–	ot	[14]
401.	*Dikerogammarus* sp.	2.20	–	e	[14]
402.	*Dinocras cephalotes* (Curtis, 1827)	–	x	–	[5],[10]
403.	*Dinocras* sp.	1.40	–	ot	[14]
404.	*Diplectrona felix* McLachlan, 1878	–	–	ot	[14]
405.	*Disparalona rostrata* (Koch, 1841)	1.13	–	–	[3],[8]
406.	*Diura bicaudata* (Linnaeus, 1758)	1.00	x	ot	[5],[10],[14]
407.	*Dixa* sp.	1.70	-	ot	[14]
408.	*Dixella* sp.	–	–	me	[14]
409.	*Dolerocypris fasciata* (O.F.Müller, 1776)	–	o	–	[5],[10]
410.	Dolichopodidae gen. sp.	–	–	e	[14]
411.	*Donacia* sp.	1.90	–	e	[14]
412.	*Drusus* sp.	1.00	x-o	ot	[5],[10],[14]
413.	Dryopidae gen. sp.	2.50	–	–	[15]
414.	*Dryops* sp.	–	–	e	[14]
415.	*Dupophilus brevis* Mulsant et Rey, 1873	–	–	ot	[14]
416.	Dytiscidae gen. sp.	2.50	–	–	[7],[15]
417.	*Dytiscus* sp.	2.10	–	e	[14]
418.	*Ecclisopteryx* sp.	1.10	–	ot	[14]
419.	*Ecdyonurus abracadabras* Kluge, 1983	–	b	–	[5]
420.	*Ecdyonurus russevi* Braasch et Soldán, 1985	–	b	–	[10]
421.	*Ecdyonurus* sp.	2.30	b	me	[14],[16]
422.	*Ecdyonurus vicinus* (Demoulin, 1964)	–	b	–	[5],[10]
423.	*Echinogammarus* sp.	1.50	–	me	[14]
424.	*Ecnomus* sp.	–	–	me	[14]
425.	*Electrogena* sp.	–	–	me	[14]
426.	Elmidae gen. sp.	1.50	–	–	[15]
427.	*Elmis* sp.	2.00	–	ot	[14]
428.	*Elodes* sp.	1.50	–	me	[14]
429.	Elodidae gen. sp.	2.00	–	–	[15]
430.	*Elophila nymphaeata* (Linnaeus, 1758)	2.00	–	me	[14]
431.	*Enallagma cyathigerum* Charpentier, 1840	2.10	–	me	[14]
432.	*Enchytraeus albidus* Henle, 1837	–	b	–	[5],[10]
433.	*Enochrus* sp.	1.50	–	e	[14]
434.	*Eoperla ochracea* (Kolbe, 1885)	–	–	ot	[14]
435.	*Epeorus assimilis* Eaton, 1865	–	x-o	–	[5],[10]
436.	*Epeorus pellucidus* (Brodsky, 1930)	–	b	–	[5],[10]
437.	*Epeorus* sp.	1.30	–	ot	[14]
438.	*Ephemera orientalis* McLachlan, 1875	–	b	–	[5],[10]
439.	*Ephemera* sp.	2.00	b	me	[14],[16]
440.	*Ephemera vulgata* Linnaeus, 1758	–	b	–	[5],[10]
441.	*Ephemerella ignita* Poda, 1761	–	b	–	[5],[10]
442.	*Ephemerella krieghoffi* (Ulmer, 1920)	–	x-o	–	[5],[10]
443.	*Ephemerella lenoki* Tshernova, 1952	–	b	–	[5],[10]
444.	Ephemerella lepnevae Tshernova, 19[1]	–	b	–	[5],[10]
445.	*Ephemerella major* Klapalek, 1905	–	o-b	–	[5],[10]
446.	*Ephemerella* sp.	1.80	–	me	[14]

447.	Ephemerella triacantha Tschernova, 19[1]	–	o	–	[5],[10]
448.	Ephemerellidae gen. sp.	2.00	–	–	[15]
449.	Ephemeridae gen. sp.	1.50	–	–	[15]
450.	*Ephoron virgo* (Olivier, 1791)	2.50	b	e	[5],[10],[14]
451.	Ephydridae gen. sp.	–	–	me	[14]
452.	*Epitheca bimaculata* Charpentier, 1825	–	–	me	[14]
453.	*Eretes sticticus* (Linnaeus, 1767)	–	–	e	[14]
454.	*Eriocheir sinensis* (Milne-Edwards, 1853)	1.50	o-b	e	[5],[10],[14]
455.	*Eristalis* sp.	4.00	p	–	[16]
456.	*Eristalis tenax* (Linnaeus, 1758)	–	p	–	[5],[10]
457.	*Ernodes* sp.	1.00	–	ot	[14]
458.	*Erotesis baltica* McLachlan, 1877	–	–	me	[14]
459.	*Erythromma* sp.	2.00	–	e	[14]
460.	*Esolus* sp.	–	–	ot	[14]
461.	*Eubosmina coregoni* (Baird, 1857)	1.54	o	-	[3],[8]
462.	*Eubosmina longispina* (Leydig, 1860)	1.50	–	–	[3],[8]
463.	*Eubria palustris* (Germar, 1818)	0.60	–	ot	[14]
464.	*Eucypris lutaria* (Koch, 1838)	–	o-b	–	[5],[10]
465.	*Eudiaptomus gracilis* (G. O. Sars, 1862)	1.50	o	–	[3],[8]
466.	*Eudiaptomus graciloides* (Lilljeborg, 1888)	1.50	–	–	[3],[8]
467.	*Eudiaptomus vulgaris* (Schmeil, 1896)	1.66	–	–	[3],[8]
468.	*Eukiefferiella bavarica* Goetghebuer, 1934	–	b-o	–	[5],[10]
469.	*Eukiefferiella brevicalcar* (Kieffer, 1911)	–	b-o	–	[5],[10]
470.	*Eukiefferiella clypeata* (Kieffer, 1923)	–	x	–	[5],[10]
471.	*Eukiefferiella coerulescens* (Kieffer in Zavřel, 1926)	–	b-o	–	[10]
472.	*Eukiefferiella hospita* (Edwards, 1929)	–	x	–	[5],[10]
473.	*Eukiefferiella longicalcar* Thienemann, 1926	–	b-o	–	[5],[10]
474.	Eukiefferiella longipes Chernovskij, 19[1]	–	b-o	–	[5],[10]
475.	*Eukiefferiella similis* Goetghebuer, 1939	–	b	–	[5],[10]
476.	*Eukiefferiella coerulescens* (Kieffer in Zavřel, 1926)	–	b-o	–	[5]
477.	*Eukiefferilla alpestris*	–	o	–	[5],[10]
478.	*Eurycercus lamellatus* (O. F. Mueller, 1776)	1.62	–	–	[3],[8]
479.	*Eylais infundibulifera* subsp. *meridionalis* (Thon 1899)	–	o-b	–	[10]
480.	*Eylais meridionalis* Thon, 1899	–	o-b	–	[5]
481.	*Feltria minuta* Koenike, 1892	0.20	x	–	[4]
482.	Gammaridae gen. sp.	2.50	-	–	[7],[15]
483.	*Gammarus pulex* (Linnaeus, 1758)	–	o-b	–	[5],[10],[16]
484.	*Gammarus pulex* subsp. *fossarum* Margalef, 1951	–	x-b	–	[5],[10]
485.	*Gammarus* sp.	–	–	me	[14]
486.	*Gerris* sp.	1.60	o-b	e	[5],[14]
487.	*Glaenocorisa propinqua* (Fieber, 1860)	0.70	–	ot	[14]
488.	*Glossosoma* sp.	1.50	–	ot	[14]
489.	Glossosomatidae gen. sp.	0.50	–	–	[15]
490.	*Glyphotaelius pellucidus* (Retzius, 1783)	2.20	–	me	[14]
491.	*Glyphotaelius* sp.	–	o-b	–	[5],[10]
492.	*Glyptotendipes barbipes* (Staeger, 1839)	–	p	–	[5],[10]
493.	*Glyptotendipes glaucus* (Meigen, 1818)	–	b	–	[5],[10]
494.	*Glyptotendipes gripekoveni* (Kieffer, 1913)	–	b	–	[5],[10]
495.	*Goera pilosa* (Fabricius, 1775)	2.10	o-b	me	[5],[10],[14]
496.	*Goera* sp.	1.50	o	–	[16]
497.	Goeridae gen. sp.	1.00	–	–	[15]
498.	Gomphidae gen. sp.	2.00	–	–	[15]
499.	*Gomphus* sp.	2.50	b	ot	[14],[16]
500.	*Grammotaulius* sp.	–	o	–	[5],[10]

501.	*Graphoderus* sp.	–	–	e	[14]
502.	*Graptodytes* sp.	–	–	e	[14]
503.	*Graptoleberis testudinaria* (Fischer, 1851)	1.21	o-b	–	[3],[6],[8]
504.	Gyrinidae gen. sp.	2.50	–	–	[15]
505.	*Gyrinus* sp.	2.00	–	e	[14]
506.	*Habroleptoides* sp.	–	–	ot	[14]
507.	*Habrophlebia* sp.	1.50	o-b	me	[5],[10],[14],[16]
508.	*Hagenella clathrata* (Kolenati, 1848)	1.10	–	e	[14]
509.	*Halesus* sp.	1.90	o	ot	[5],[10],[14]
510.	Haliplidae gen. sp.	2.50	–	–	[15]
511.	*Haliplus* sp.	1.80	–	e	[14]
512.	*Hapalothrix* sp.	–	–	ot	[14]
513.	*Helicopsyche* sp.	–	–	ot	[14]
514.	*Helochares* sp.	–	–	e	[14]
515.	Helophoridae gen. sp.	3.00	–	–	[15]
516.	*Helophorus* sp.	–	–	e	[14]
517.	Hemerodromiinae gen. sp.	–	–	me	[14]
518.	*Hemianax ephippiger* (Burmeister, 1839)	–	–	me	[14]
519.	*Hemimysis anomala* Sars, 1907	–	–	e	[14]
520.	*Hemisphaera guignoti* Schaefer, 1976	–	–	e	[14]
521.	*Heplagenia* sp.	2.00	b	–	[16]
522.	*Heptagenia flava* Rostock, 1878	–	b	–	[5],[10]
523.	*Heptagenia fuscogrisea* (Retzius, 1783)	–	b	–	[5],[10]
524.	*Heptagenia* sp.	2.00	-	me	[14]
525.	*Heptagenia sulphurea* (Müller, 1776)	–	b	-	[5],[10]
526.	Heptageniidae gen. sp.	2.00	–	–	[15]
527.	*Hesperocorixa* sp.	–	–	e	[14]
528.	*Heterocope appendiculata* Sars G. O., 1902	1.55	–	–	[3],[8]
529.	*Holocentropus* sp.	2.00	o	me	[5],[10],[14]
530.	*Hydaticus* sp.	1.90	-	e	[14]
531.	*Hydatophylax* sp.	–	–	–	[14]
532.	*Hydraena* sp.	2.00	–	me	[14]
533.	Hydraenidae gen. sp.	2.00	–	–	[15]
534.	*Hydrobius* sp.	–	–	e	[14]
535.	*Hydrochara* sp.	–	–	e	[14]
536.	Hydrochidae gen. sp.	3.00	–	-	[15]
537.	*Hydrochus* sp.	1.70	–	e	[14]
538.	*Hydrocyphon* sp.	–	–	me	[14]
539.	*Hydroglyphus* sp.	–	–	e	[14]
540.	*Hydrometra* sp.	–	–	me	[14]
541.	*Hydrometra stagnorum* (Linnaeus, 1758)	–	o-b	–	[5],[10]
542.	Hydrophilidae gen. sp.	3.00	–	–	[15]
543.	*Hydrophilus* sp.	1.50	–	e	[14]
544.	*Hydroporus* sp.	1.50	–	e	[14]
545.	*Hydropsyche instabilis* (Curtis, 1834)	–	x-o	–	[5],[10]
546.	*Hydropsyche* sp.	2.00	b	me	[5],[10],[14],[16]
547.	Hydropsychidae gen. sp.	2.00	–	–	[15]
548.	*Hydroptila* sp.	2.00	b	me	[5],[10],[14]
549.	Hydroptilidae gen. sp.	2.00	b	–	[15],[16]
550.	*Hydroscapha granulum* (Motschulsky, 1855)	–	–	me	[14]
551.	*Hydrovatus* sp.	1.80	–	e	[14]
552.	*Hygrobia hermanni* (Fabricius, 1775)	–	–	e	[14]
553.	*Hygrotus confluens* (Fabricius, 1787)	–	–	e	[14]
554.	*Hygrotus* sp.	1.70	–	e	[14]
555.	*Hyphydrus* sp.	–	–	e	[14]

556.	*Iliocryptus aequalis* Romijn, 1919	1.89	–	–	[3],[8]
557.	*Ilybius* sp.	2.00	–	e	[14]
558.	*Ilyocoris cimicoides* subsp. *cimicoides* (Linnaeus, 1758)	2.10	b	e	[5],[10],[14]
559.	*Ironoquia dubia* (Stephens, 1837)	2.00	–	e	[14]
560.	*Ischnura* sp.	2.00	–	me	[14]
561.	*Isogenus nubecula* Newman, 1833	2.00	–	me	[14]
562.	*Isonychia ussurica* Bajkova, 1970	–	b	–	[5],[10]
563.	*Isoperla grammatica* (Poda, 1761)	–	b	–	[5],[10]
564.	*Isoperla* sp.	1.60	–	ot	[14]
565.	*Isoptena serricornis* (Pictet, 1841)	1.70	–	–	[14]
566.	*Ithytrichia* sp.	–	–	ot	[14]
567.	*Jaera istri* Veuille, 1979	2.20	–	–	[14]
568.	*Laccobius* sp.	–	–	e	[14]
569.	*Laccophilus* sp.	–	–	e	[14]
570.	*Laccornis oblongus* (Stephens, 1835)	–	–	e	[14]
571.	*Lepidostoma basale* (Kolenati, 1848)	2.00	–	ot	[14]
572.	*Lepidostoma hirtum* (Fabricius, 1775)	2.00	–	ot	[14]
573.	Lepidostomatidae gen. sp.	1.50	–	-	[15]
574.	*Lepidurus apus* Linnaeus, 1758	1.50	–	e	[14]
575.	Leptoceridae gen. sp.	2.50	–	–	[15]
576.	*Leptocerus* sp.	2.50	–	me	[14]
577.	Leptoconopinae gen. sp.	–	–	me	[14]
578.	*Leptodora kindtii* (Focke, 1844)	1.75	b-o	–	[3],[6],[8]
579.	*Leptophlebia marginata* (Linnaeus, 1767)	–	b	–	[10]
580.	*Leptophlebia* sp.	1.80	–	me	[14]
581.	*Leptophlebia submarginata* (Stephens, 1835)	–	b	–	[5]
582.	Leptophlebiidae gen. sp.	1.50	–	–	[15]
583.	*Lestes* sp.	2.10	–	me	[14]
584.	Lestidae gen. sp.	3.00	–	–	[15]
585.	*Leucorrhinia dubia* Vander Linden, 1825	–	–	ot	[14]
586.	*Leuctra geniculata* Stephens, 1836	2.00	o	me	[5],[10],[14]
587.	*Leuctra hippopus* Kempny, 1899	–	x	–	[5],[10]
588.	*Leuctra nigra* (Olivier, 1811)	–	o-b	–	[5],[10]
589.	*Leuctra* sp.	1.50	–	ot	[14]
590.	Leuctridae gen. sp.	1.00	–	–	[15]
591.	*Libellula* sp.	2.20	–	e	[14]
592.	Libellulidae gen. sp.	3.00	–	–	[7],[15]
593.	*Limnebius* sp.	1.20	–	m	[14]
594.	Limnephilidae gen. sp.	2.00	–	–	[15]
595.	*Limnephilus decipiens* (Kolenati, 1848)	–	o-b	–	[5],[10]
596.	*Limnephilus extricatus* McLachlan, 1865	–	o-b	–	[5],[10]
597.	*Limnephilus flavicornis* (Fabricius, 1787)	–	o-b	–	[5],[10]
598.	*Limnephilus marmoratus* Curtis, 1834	–	o	–	[5],[10]
599.	*Limnephilus rhombicus* (Linnaeus, 1758)	–	o-b	–	[5],[10]
600.	*Limnephilus* sp.	1.75	b	–	[16]
601.	*Limnephilus stigma* Curtis, 1834	–	o-b	–	[5],[10]
602.	*Limnephilus vittatus* (Fabricius, 1798)	–	o-b	–	[5],[10]
603.	*Limnius* sp.	1.60	–	ot	[14]
604.	*Limnocythere inopinata* (Baird, 1843)	–	o-b	–	[5],[10]
605.	*Limnomysis benedeni* Czerniavsky, 1882	2.10	o	e	[5],[10], [14]
606.	*Limnosida frontosa* Sars 1862	1.00	o	–	[6]
607.	*Limnoxenus niger* (Gmelin, 1790)	2.70	–	e	[14]
608.	*Liponeura* sp.	1.00	–	ot	[14]
609.	*Lithax* sp.	0.60	–	ot	[14]

610.	*Lype* sp.	–	–	e	[14]
611.	*Macrocyclops albidus* (Jurine, 1820)	1.65	b	–	[3],[4],[6],[8]
612.	*Macrocyclops fuscus* (Jurine, 1820)	1.93	–	–	[3],[8]
613.	*Macromia splendens* (Pictet, 1843)	–	–	me	[14]
614.	*Macronychus quadrituberculatus* (Muller, 1806)	2.00	–	me	[14]
615.	*Macropelopia nebulosa* (Meigen, 1804)	–	b	–	[5],[10]
616.	*Macroplea appendiculata* (Panzer, 1794)	–	–	e	[14]
617.	Macrothrix hirsuticornis Norman et Brady, 1867	1.64	–	–	[3],[8]
618.	*Marthamea* sp.	–	–	ot	[14]
619.	*Megacyclops gigas* (Claus, 1857)	2.00	–	–	[3],[8]
620.	*Megacyclops viridis* (Jurine, 1820)	1.88	b-o	–	[3],[4],[8]
621.	*Melademа coriacea* Laporte, 1836	–	–	me	[14]
622.	*Melampophylax* sp.	–	–	–	[14]
623.	*Mesocyclops leukarti* (Claus, 1857)	1.69	o	–	[3],[4],[6],[8]
624.	*Mesophylax* sp.	2.00	–	–	[14]
625.	*Mesovelia* sp.	–	–	me	[14]
626.	*Metanoea* sp.	–	–	ot	[14]
627.	*Metaporus meridionalis* (Aube, 1838)	–	–	e	[14]
628.	*Metreletus balcanicus* (Ulmer, 1920)	0.90	–	e	[14]
629.	Metretopodidae gen. sp.	1.00	–	–	[15]
630.	*Metriocnemus* sp.	–	x-o	–	[5],[10]
631.	*Micrasema* sp.	1.50	–	ot	[14]
632.	*Microcara* sp.	–	–	e	[14]
633.	*Microchironomus tener* (Kieffer, 1918)	–	b	–	[5],[10]
634.	*Micronecta* sp.	–	–	ot	[14]
635.	*Microvelia* sp.	–	–	e	[14]
636.	*Mixodiaptomus theeli* (Lilljeborg in Guerne et Richard, 1889)	1.94	–	–	[3],[8]
637.	*Mochlonyx* sp.	–	–	me	[14]
638.	*Moina brachiata* (Jurine, 1820)	2.28	a-p	–	[3],[8]
639.	*Moina macrocopa* (Straus, 1820)	2.15	–	–	[3],[8]
640.	*Molanna albicans* (Zetterstedt, 1840)	–	o	–	[10]
641.	*Molanna angustata* Curtis, 1834	–	o	–	[5]
642.	*Molanna* sp.	1.00	o	e	[14],[16]
643.	Molannidae gen. sp.	2.00	–	–	[15]
644.	*Molannodes tinctus* (Zetterstedt, 1840)	–	–	ot	[14]
645.	Muscidae gen. sp.	3.00	–	e	[14],[15]
646.	*Mystacides* sp.	2.10	b	e	[5],[10],[14],[16]
647.	Naucoridae gen. sp.	3.00	–	–	[15]
648.	*Naucoris maculatus* subsp. *maculatus* Fabricius, 1798	–	–	ot	[14]
649.	*Nebrioporus* sp.	–	–	me	[14]
650.	*Nehalennia speciosa* Charpentier, 1840	–	–	me	[14]
651.	*Nemotaulius punctatolineatus* (Retzius, 1783)	–	–	ot	[14]
652.	*Nemoura erratica* Claassen, 1936	–	o	–	[5],[10]
653.	*Nemoura* sp.	1.50	–	me	[14]
654.	Nemouridae gen. sp.	2.00	–	–	[15]
655.	*Nemurella pictetii* (Klapálek, 1900)	1.00	x	ot	[5],[10],[14]
656.	*Nepa cinerea* Linnaeus, 1758	–	o-b	–	[5],[10]
657.	*Nepa* sp.	–	–	me	[14]
658.	Nepidae gen. sp.	2.50	–	–	[15]
659.	*Neureclipsis bimaculata* (Linnaeus, 1758)	2.10	o-b	e	[5],[10],[14]
660.	*Neurorthus fallax* (Rambur, 1842)	–	–	ot	[14]
661.	*Neutrodiaptomus incongruens* (Poppe, 1888)	1.94	–	–	[3],[8]
662.	*Niphargus aquilex* Schiödte, 1855	–	x	–	[5],[10]
663.	*Niphargus* sp.	0.10	–	ot	[14]
664.	*Nixe joernensis* (Bengtsson, 1909)	–	b	–	[5],[10]

665.	*Normandia* sp.	–	–	ot	[14]
666.	Noteridae gen. sp.	2.50	–	–	[15]
667.	*Noterus* sp.	–	–	e	[14]
668.	*Notidobia* sp.	–	–	ot	[14]
669.	*Notodromas monacha* (O. F. Müller, 1776)	–	o	–	[5],[10]
670.	*Notonecta* sp.	2.20	b	m	[5],[10],[14]
671.	Notonectidae gen. sp.	3.00	–	–	[7],[15]
672.	*Ochthebius* sp.	1.80	–	e	[14]
673.	*Odontocerum albicorne* (Scopoli, 1763)	1.30	–	ot	[14]
674.	*Oecetis* sp.	2.40	–	me	[14]
675.	*Oecismus monedula* (Hagen 1859)	1.50	–	ot	[14]
676.	*Oligoneuriella rhenana* (Imhoff, 1852)	2.00	b	me	[5],[10],[14]
677.	*Oligoplectrum maculatum* (Fourcroy, 1785)	–	o	–	[5]
678.	*Oligostomis reticulata* (Linnaeus, 1761)	2.10	–	–	[14]
679.	*Oligotricha striata* (Linnaeus, 1758)	1.80	o-b	me	[5],[14]
680.	*Onychogomphus* sp.	–	–	me	[14]
681.	*Ophiogomphus cecilia* (Fourcroy, 1785)	2.00	–	e	[14]
682.	*Orchestia* sp.	–	–	e	[14]
683.	*Orconectes limosus* (Rafinesque, 1817)	2.40	–	me	[14]
684.	*Orectochilus villosus* (O. F. Müller, 1776)	2.00	–	me	[14]
685.	*Oreodytes* sp.	1.60	–	ot	[14]
686.	*Orthetrum* sp.	–	–	e	[14]
687.	*Orthocladius rivulorum* Kieffer, 1909	–	x-o	–	[5],[10]
688.	*Orthocladius thienemanni* Kieffer et Thienemann, 1906	–	b	–	[5],[10]
689.	*Orthotrichia* sp.	2.10	–	e	[14]
690.	*Osmylus* sp.	–	–	ot	[14]
691.	*Oulimnius* sp.	–	–	ot	[14]
692.	*Oxyethira* sp.	1.80	o	ot	[5],[10],[14]
693.	*Oxygastra curtisii* (Dale, 1834)	–	–	me	[14]
694.	*Oxyurella tenuicaudis* (Sars, 1862)	1.50	–	–	[3],[8]
695.	*Pachyleuctra* sp.	–	–	ot	[14]
696.	*Pacifastacus* sp.	–	–	ot	[14]
697.	*Paduniella vandeli* Décamps 1965	–	–	–	[14]
698.	*Palingenia longicauda* (Olivier, 1791)	–	o	–	[5],[10]
699.	*Parachiona* sp.	–	–	ot	[14]
700.	*Paracorixa concinna* subsp. *concinna* (Fieber, 1848)	1.60	–	e	[14]
701.	*Paracyclops fimbriatus* (Fischer, 1853)	1.74	–	–	[3],[8]
702.	*Paracymus* sp.	–	–	e	[14]
703.	*Paragomphus genei* (Selys, 1841)	–	–	ot	[14]
704.	*Paraleptophlebia* sp.	1.80	–	me	[14]
705.	*Paraleptophlebia submarginata* (Stephens, 1835)	–	o-b	–	[5],[10]
706.	*Paraleptophlehia* sp.	1.50	o	–	[16]
707.	*Parapoynx stratiotata* (Linnaeus, 1758)	1.50	–	me	[14]
708.	*Parasigara* sp.	–	–	me	[14]
709.	*Paratrichocladius inaequalis* Kieffer, 1926	–	o-b	–	[5],[10]
710.	*Peltodytes* sp.	–	–	e	[14]
711.	*Peracantha truncata* (O. F. Müller, 1785)	1.54	o-b	–	[3],[6],[8]
712.	*Perla bipunctata* F. J. Pictet, 1833	–	o	–	[5],[10]
713.	*Perla burmeisteriana* Claassen, 1936	–	o-b	–	[5],[10]
714.	*Perla marginata* (Panzer, 1799)	–	x	–	[10]
715.	*Perla maxima* (Scopoli, 1763)	–	x	–	[5]
716.	*Perla* sp.	1.50	–	ot	[14]
717.	*Perlodes microcephalus* (F. J. Pictet, 1833)	–	o	–	[5],[10]
718.	*Perlodes* sp.	1.50	–	ot	[14]

719.	Perlodidae gen. sp.	1.00	–	–	[15]
720.	*Phalacrocera* sp.	–	–	e	[14]
721.	*Philopotamus* sp.	1.20	–	ot	[14]
722.	*Phryganea grandis* Linnaeus, 1758	–	o	–	[5],[10]
723.	*Phryganea* sp.	1.50	–	me	[14]
724.	Phryganeidae gen. sp.	2.50	–	–	[15]
725.	*Picripleuroxus striatus* (Schödler, 1862)	1.64	–	–	[3],[8]
726.	*Platambus maculatus* (Linnaeus, 1758)	2.30	–	me	[14]
727.	*Plateumaris* sp.	–	–	e	[14]
728.	Plathycnemididae gen. sp.	3.00	–	–	[15]
729.	*Platycnemis* sp.	–	–	me	[14]
730.	*Plea minutissima minutissima* Leach, 1817	2.00	–	me	[14]
731.	*Plecoptera* sp.	1.20	o	–	[16]
732.	*Plectrocnemia conspersa* (Curtis, 1834)	–	x-o	–	[5],[10]
733.	*Plectrocnemia* sp.	1.70	o	ot	[14],[16]
734.	Pleidae gen. sp.	2.50	–	–	[15]
735.	*Pleuroxus aduncus* (Jurine, 1820)	1.52	–	–	[3],[8]
736.	Podonominae gen. sp.	–	–	–	[14]
737.	*Podura aquatica* Linnæus, 1758	–	o-b	–	[5],[10]
738.	Polycentropodidae gen. sp.	1.50	–	–	[15]
739.	*Polycentropus* sp.	2.00	b	me	[5],[10],[14]
740.	Polymitarcyidae gen. sp.	2.00	–	–	[15]
741.	*Polypedilum bicrenatum* Kieffer, 1921	–	b	–	[5],[10]
742.	*Polypedilum nubeculosum* (Meigen, 1804)	–	b	–	[5],[10]
743.	*Polypedilum scalaenum* (Schrank, 1803)	–	b	–	[5],[10]
744.	*Polyphemus pediculus* (Linnaeus, 1761)	1.63	o	–	[3],[6],[8]
745.	*Pomatinus substriatus* (Müller, 1806)	2.20	–	me	[14]
746.	*Porhydrus lineatus* (Fabricius, 1775)	2.20	–	e	[14]
747.	Potamanthidae gen. sp.	2.00	–	–	[15]
748.	*Potamanthus luteus* (Linnaeus, 1767)	2.25	b	e	[5],[10],[14],[16]
749.	*Potamon* sp.	–	–	ot	[14]
750.	*Potamophilus acuminatus* (Fabricius, 1792)	2.00	–	me	[14]
751.	*Potamophylax latipennis* (Curtis, 1834)	–	o	–	[10]
752.	*Pottasia gaedei*	–	x	–	[5],[10]
753.	*Proasellus* sp.	–	–	me	[14]
754.	*Procambarus clarkii* (Girard, 1852)	–	–	e	[14]
755.	*Procladius choreus* (Meigen, 1804)	–	b-a	–	[5],[10]
756.	*Procladius ferrugineus* (Kieffer, 1918)	–	b-a	–	[5],[10]
757.	*Procloeon bifidum* (Bengtsson, 1912)	2.20	–	me	[14]
758.	*Procloeon pennulatum* (Eaton, 1870)	2.30	–	me	[14]
759.	*Prodiamesa olivacea* (Meigen, 1818)	–	b-a	–	[5],[10]
760.	*Prodiamesa* Kieffer, 1906	2.25	b-a	–	[4]
761.	*Prosopistoma pennigerum* (Müller, 1785)	–	o	me	[5],[10],[14]
762.	*Protonemura meyeri* (F. J. Pictet, 1841)	–	x	–	[10],[5]
763.	*Protonemura* sp.	1.50	–	ot	[14]
764.	*Psectrotanypus varius* (Fabricius, 1787)	–	b-a	–	[5],[10]
765.	*Pseudochydorus globosus* (Baird, 1843)	1.77	–	–	[3],[8]
766.	*Pseudoneureclipsis lusitanicus* Malicky, 1980	–	–	me	[14]
767.	*Psychoda* sp.	–	p	–	[5],[10]
768.	Psychodidae gen. sp.	–	–	e	[14]
769.	*Psychomyia fragilis* (Pictet, 1834)	–	–	e	[14]
770.	Psychomyia pusilla (Fabricius, 1781)	2.10	–	me	[14]
771.	Psychomyidae gen. sp.	2.00	–	–	[15]
772.	*Ptilocolepus granulatus* (Pictet, 1834)	1.00	–	ot	[14]
773.	Ptychopteridae gen. sp.	–	–	e	[14]

774.	*Pyrrhosoma nymphula* (Sulzer, 1776)	2.10	–	me	[14]
775.	*Ranatra linearis* (Linnaeus, 1758)	2.00	b	m	[5],[10],[14]
776.	*Rhabdiopteryx* sp.	1.40	–	me	[14]
777.	*Rhantus grapii* (Gyllenhal, 1808)	2.50	–	e	[14]
778.	*Rhantus* sp.	–	–	e	[14]
779.	*Rheocricotopus bruensis* Goetghebuer, 1937	–	b	–	[12],[10]
780.	*Rheotanytarsus exiguus* (Johannsen, 1905)	–	o-b	–	[5],[10]
781.	*Rhithrogena bajkovae* Sowa, 1973	–	o-b	–	[5],[10]
782.	*Rhithrogena semicolorata* (Curtis, 1834)	–	x	–	[5],[10]
783.	*Rhithrogena* sp.	0.50	–	ot	[14]
784.	*Rhyacophila (Pararhyacophila)* sp.	1.10	–	ot	[14]
785.	*Rhyacophila dorsalis* (Curtis, 1834)	–	o	–	[5],[10]
786.	*Rhyacophila laevis* Pictet, 1834	1.00	–	ot	[14]
787.	*Rhyacophila* sp.	1.40	o-b	ot	[5],[10],[14],[16]
788.	Rhyacophilidae gen. sp.	1.00	–	–	[15]
789.	*Riolus* sp.	1.70	–	ot	[14]
790.	*Scapholeberis microcephala* Sars, 1890	1.00	o	–	[4]
791.	*Scapholeberis mucronata* (O. F. Müller, 1776)	1.79	–	–	[3],[8]
792.	*Scarodytes halensis* (Fabricius, 1787)	1.90	–	e	[14]
793.	*Schizopelex furcifera* McLachlan, 1880	–	–	ot	[14]
794.	Sciomyzidae gen. sp.	–	–	e	[14]
795.	*Scirtes* sp.	–	–	e	[14]
796.	*Sericostoma personatum* (Kirby et Spence, 1826)	–	o	–	[5],[10]
797.	*Sericostoma* sp.	1.50	o	ot	[14],[16]
798.	Sericostomatidae gen. sp.	1.50	–	–	[15]
799.	*Serratella* sp.	–	–	me	[14]
800.	*Setodes* sp.	–	–	e	[14]
801.	Sialidae gen. sp.	2.00	–	–	[7],[15]
802.	*Sialis lutaria* (Linnaeus, 1758)	–	b-a	–	[5],[10]
803.	*Sialis* sp.	2.35	b	me	[14],[16]
804.	*Sida crystallina* (O. F. Müller, 1776	1.50	o	–	[3],[8]
805.	*Siettitia* sp.	–	–	ot	[14]
806.	*Sigara* sp.	2.00	–	me	[14]
807.	Silo pallipes (Fabricius, 1781)	–	o	-	[5],[10]
808.	*Silo* sp.	1.50	o	ot	[14],[16]
809.	*Silonella aurata* (Hagen, 1864)	–	–	ot	[14]
810.	*Simocephalus vetulus* (O. F. Müller, 1776)	1.80	o-b	–	[3],[8]
811.	Simuliidae gen. sp.	1.15	o-b	–	[4],[15],[16]
812.	*Simulium* sp.	–	o-b	–	[5],[10]
813.	Siphlonuridae gen. sp.	2.50	–	–	[15]
814.	*Siphlonurus alternatus* (Say, 1824)	–	b	–	[5],[10]
815.	*Siphlonurus* sp.	2.00	–	e	[14]
816.	*Siphonoperla* sp.	1.40	–	ot	[14]
817.	*Sisyra* sp.	–	–	e	[14]
818.	*Sminthurides aquaticus* (Bourlet, 1842)	–	o-b	-	[5],[10]
819.	*Somatochlora* sp.	–	–	ot	[14]
820.	*Spercheus emarginatus* (Schaller, 1783)	2.10	–	e	[14]
821.	*Stactobia* sp.	–	–	e	[14]
822.	Stactobiella risi (Felber 1908)	–	–	ot	[14]
823.	*Stenelmis* sp.	1.80	–	me	[14]
824.	*Stenophylax* sp.	–	o-b	–	[5],[10]
825.	*Stenophylax stellatus* Curtis, 1834	–	o	–	[5]
826.	*Stictonectes* sp.	–	–	me	[14]
827.	*Stictotarsus duodecimpustulatus* (Fabricius, 1792)	2.00	–	me	[14]

828.	Stratiomyidae gen. sp.	–	–	ot	[14]
829.	*Stratiomys chamaeleon* (Linnaeus, 1758)	–	a	–	[5],[10]
830.	*Sympecma* sp.	–	–	ot	[14]
831.	*Sympetrum* sp.	2.10	–	me	[14]
832.	*Synagapetus* sp.	1.00	–	ot	[14]
833.	Syrphidae gen. sp.	–	–	e	[14]
834.	Tabanidae gen. sp.	–	–	e	[14]
835.	*Tabanus* sp.	2.35	b-a	-	[5],[10],[16]
836.	Taeniopterigidae gen. sp.	1.50	–	–	[15]
837.	*Taeniopteryx nebulosa* (Linnaeus, 1758)	–	o-b	–	[5],[10]
838.	*Taeniopteryx* sp.	1.50	–	me	[14]
839.	Tanypodinae gen. sp.	–	–	e	[14]
840.	*Tanypus punctipennis* Meigen, 1818	–	b-a	-	[5],[10]
841.	Tanytarsini gen. sp.	–	–	me	[14]
842.	*Tanytarsus gregarius* Kieffer, 1909	–	o	–	[5],[10]
843.	Thaumaleidae gen. sp.	–	–	ot	[14]
844.	*Thermocyclops oithonoides* (Sars G. O., 1863)	1.65	o	–	[3],[6],[8]
845.	*Thienemanniella clavicornis* (Kieffer, 1911)	–	o	–	[5],[10]
846.	*Thraulus bellus* Eaton, 1881	–	–	ot	[14]
847.	*Thremma gallicum* McLachlan, 1880	–	x-o	–	[5],[10]
848.	*Thremma* sp.	–	–	ot	[14]
849.	*Tinodes* sp.	1.20	–	e	[14]
850.	*Tipula* sp.	–	o-p	–	[5],[10]
851.	Tipulidae gen. sp.	–	–	ot	[14]
852.	*Torleya major* (Klapálek, 1905)	2.00	–	ot	[14]
853.	*Triaenodes bicolor* (Curtis, 1834)	–	o	–	[5],[10]
854.	*Triaenodes* sp.	1.70	–	e	[14]
855.	*Tricholeiochiton fagesii* (Guinard, 1879)	–	–	me	[14]
856.	*Trichostegia minor* (Curtis, 1834)	1.50	–	ot	[14]
857.	*Triogma* sp.	–	–	me	[14]
858.	*Triops cancriformis* (Bosc, 1801)	1.50	o-b	e	[5],[10],[14]
859.	*Typhlocypris eremita* (Vejdovský, 1882)	–	x	–	[10]
860.	*Velia* sp.	1.00	–	ot	[14]
861.	*Wormaldia* sp.	1.40	–	ot	[14]
862.	*Xanthoperla apicalis* (Newman, 1836)	0.30	–	ot	[14]
863.	*Ylodes simulans* (Tjeder, 1929)	–	–	e	[14]
864.	*Yola bicarinata* (Latreille, 1804)	–	–	me	[14]
	Bryozoa (Kingdom: Animalia)				
865.	*Cristatella mucedo* Cuvier, 1798	2.10	o	me	[5],[10], [14]
866.	*Fredericella sultana* (Blumenbach, 1779)	2.00	–	me	[14]
867.	*Hyalinella punctata* (Hancock, 1850)	2.20	–	e	[14]
868.	*Lophopus crystallinus* (Pallas, 1768)	1.00	–	ot	[14]
869.	*Paludicella articulata* (Ehrenberg, 1831)	2.20	o-b	me	[5],[10],[14]
870.	*Pectinatella magnifica* (Leidy 1851)	1.60	–	ot	[14]
871.	*Plumatella fungosa* (Pallas, 1768)	–	b	–	[5],[10]
872.	*Plumatella repens* (Linnaeus, 1758)	–	b	–	[5],[10]
873.	*Plumatella* sp.	2.30	–	e	[14]
	Cnidaria (Kingdom: Animalia)				
874.	*Chlorohydra viridissima* (Pallas, 1766)	–	o	–	[5],[10]
875.	*Cordylophora caspia* (Pallas, 1771)	2.20	o-b	me	[11],[14]
876.	*Craspedacusta sowerbyi* Lankester, 1880	–	–	me	[14]
877.	*Hydra attenuata* Pallas, 1766	–	o-b	–	[5],[10]
878.	*Hydra oligactis* Pallas, 1766	–	b	–	[10]
879.	*Hydra* sp.	1.80	o-b	ot	[12],[14]
880.	*Hydra vulgaris* Pallas, 1766	–	o-b	–	[5],[10]

881.	*Pelmatohydra oligactis* (Pallas, 1766)	–	b	–	[5]
	Ecdysozoa (Kingdom: Animalia)				
882.	*Gordiidae* gen. sp.	–	–	ot	[14]
883.	Nematoda gen. sp.	1.55	o-b	–	[12]
	Gastrotricha (Kingdom: Animalia)				
884.	*Aspidiophorus paradoxus* (Voigt, 1902)	–	b	–	[5],[10]
885.	*Chaetonotus arquatus* Voigt, 1903	–	b-a	–	[5],[10]
886.	*Chaetonotus brevispinosus* Zelinka, 1889	–	o-b	–	[5],[10]
887.	*Chaetonotus chuni* Voigt, 1901	–	o	–	[5],[10]
888.	*Chaetonotus heideri* Brehm, 1917	–	o	–	[5],[10]
889.	*Chaetonotus hystrix* Metschnikoff, 1865	–	o-b	–	[5],[10]
890.	*Chaetonotus linguaeformis* Voigt, 1902	–	b	–	[5],[10]
891.	*Chaetonotus macrochaetus* Zelinka, 1889	–	o	–	[5],[10]
892.	*Chaetonotus maximus* Ehrenberg, 1838	–	o	–	[5],[10]
893.	*Chaetonotus multispinosus* Grünspan, 1908	–	o	–	[5],[10]
894.	*Chaetonotus octonarius* Stokes, 1887	–	o-b	–	[5],[10]
895.	*Chaetonotus ploenensis* Voigt, 1909	–	o	–	[5],[10]
896.	*Chaetonotus schultzei* Metschnikoff, 1865	–	o	–	[5],[10]
897.	*Chaetonotus simrothi* Voigt, 1909	–	a	–	[5],[10]
898.	*Dasydytes dubius* Voigt, 1909	–	b	–	[5],[10]
899.	*Dasydytes festinans* Voigt, 1909	–	a	–	[5],[10]
900.	*Dasydytes longisetosus* Metschnikoff, 1865	–	b-a	–	[5],[10]
901.	*Dasydytes ornatus* Voigt, 1909	–	a	–	[5],[10]
902.	*Dasydytes saltitans* Stokes, 1887	–	a	–	[5],[10]
903.	*Heterolepidoderma ocellatum* (Metschnikoff, 1865)	–	b	–	[5],[10]
904.	*Ichthydium forcipatum* Voigt, 1901	–	o	–	[5],[10]
905.	*Ichthydium podura* (Müller, 1773)	–	b	–	[5],[10]
906.	*Lepidodermella squamata* (Dujardin, 1841)	–	o	–	[10]
907.	*Neogossea antennigera* (Gosse, 1851)	–	a	–	[5],[10]
908.	*Polymerurus nodicaudus* (Voigt, 1901)	–	a	–	[5],[10]
909.	*Stylochaeta fusiformis* (Spencer, 1890)	–	o	–	[5],[10]
910.	*Stylochaeta stylifera* (Voigt, 1901)	–	o	–	[5],[10]
	Mollusca (Kingdom: Animalia)				
911.	Acroloxidae gen. sp.	2.50	–	–	[15]
912.	*Acroloxus lacustris* (Linnaeus, 1758)	2.20	o-b	me	[5],[10],[14]
913.	*Ampullaceana balthica* (Linnaeus, 1758)	–	b	–	[10]
914.	*Ampullaceana intermedia* (Lamarck, 1822)	–	b	–	[10],[5]
915.	*Ampullaceana lagotis* (Schrank, 1803)	–	b	–	[5],[10]
916.	Ancylidae gen. sp.	1.50	–	–	[15]
917.	*Ancylus fluviatilis* O. F. Müller, 1774	2.00	o-b	ot	[4],[5],[10],[14],[16]
918.	*Anisus septemgyratus* (Rossmässler, 1835)	–	o	–	[5],[10]
919.	*Anisus* sp.	2.20	–	ot	[14]
920.	*Anisus vortex* (Linnaeus, 1758)	–	o-b	–	[5],[10]
921.	*Anodonta cygnea* (Linnaeus, 1758)	–	b	–	[5],[10]
922.	*Anodonta* sp.	2.20	–	me	[14]
923.	*Aplexa hypnorum* (Linnaeus, 1758)	1.60	o-b	me	[10],[14]
924.	*Armiger crista* (Linnaeus, 1758)	–	o	–	[5],[10]
925.	*Bathyomphalus contortus* (Linnaeus, 1758)	2.20	–	ot	[14]
926.	*Belgrandia* sp.	–	–	ot	[14]
927.	*Bithynia leachi* (Sheppard, 1823)	–	o-b	–	[5],[10]
928.	*Bithynia* sp.	–	–	me	[14]
929.	*Bithynia tentaculata* (Linnaeus, 1758)	2.20	b	–	[5],[10],[16]
930.	Bithyniidae gen. sp.	2.50	–	–	[7],[15]
931.	Bulinidae gen. sp.	2.50	–	–	[15]

932.	*Bythinella austriaca* (Frauenfeld, 1857)	–	x	–	[5],[10]
933.	*Bythinella* sp.	1.00	–	ot	[14]
934.	*Bythiospeum* sp.	1.00	–	ot	[14]
935.	*Congeria* sp.	–	–	me	[14]
936.	*Corbicula* sp.	2.20	–	e	[14]
937.	*Dreissena polymorpha* (Pallas, 1771)	2.10	o-b	me	[4],[5],[10],[14],[16]
938.	Dreissenidae gen. sp.	2.50	–	–	[15]
939.	*Euglesa casertana* (Poli, 1791)	–	o	–	[10]
940.	*Euglesa* sp.	2.10	b	–	[16]
941.	Euglesidae gen. sp.	2.50	–	–	[15]
942.	*Ferrissia* sp.	–	–	ot	[14]
943.	*Galba truncatula* (O. F. Müller, 1774)	2.10	o-b	e	[10],[14]
944.	*Gyraulus acronicus* (Férussac, 1807)	2.20	b	e	[5],[10],[14]
945.	*Gyraulus albus* (O. F. Müller, 1774)	–	b	–	[5],[10]
946.	*Gyraulus crista* (Linnaeus, 1758)	2.20	–	e	[14]
947.	*Gyraulus* sp.	2.00	–	me	[14]
948.	*Hippeutis complanatus* Linnaeus, 1758	1.80	–	e	[14]
949.	Lithoglyphidae gen. sp.	2.50	–	–	[15]
950.	*Lithoglyphus naticoides* (C. Pfeiffer, 1828)	2.20	–	e	[14]
951.	*Lymnaea auricularia* (Linnaeus, 1758)	–	b	–	[5],[10]
952.	*Lymnaea ovata* (Draparnaud, 1805)	–	b	–	[5]
953.	*Lymnaea palustris* (O. F. Müller, 1774)	–	b	–	[5]
954.	*Lymnaea peregra* (O. F. Müller, 1774)	–	o-a	–	[5]
955.	*Lymnaea stagnalis* (Linnaeus, 1758)	2.00	b	me	[5],[10],[14],[16]
956.	*Lymnaea truncatula* (O. F. Müller, 1774)	–	o-b	–	[5]
957.	Lymnaeidae gen. sp.	2.50	b	–	[7],[15],[16]
958.	*Margaritifera margaritifera* (Linnaeus, 1758)	1.50	o	ot	[5],[10],[14]
959.	*Menetus* sp.	–	–	e	[14]
960.	*Musculium* sp.	–	–	me	[14]
961.	*Myxas glutinosa* (O. F. Mueller, 1774)	1.90	o	me	[5],[10],[14]
962.	Neritidae gen. sp.	2.50	–	–	[7],[15]
963.	*Peregriana peregra* (O. F. Müller, 1774)	2.00	b	–	[4],[10]
964.	*Physa fontinalis* (Linnaeus, 1758)	2.00	o-b	e	[5],[10],[14]
965.	*Physella acuta* (Draparnaud, 1805)	–	b	–	[5],[10]
966.	*Physella* sp.	–	–	me	[14]
967.	Physidae gen. sp.	3.00	–	–	[7],[15]
968.	*Pisidium obtusale* (Lamarck, 1818)	–	o	–	[5],[10]
969.	*Pisidium* sp.	2.40	–	ot	[14]
970.	*Planorbarius corneus* (Linnaeus, 1758)	2.35	b	–	[16]
971.	Planorbidae gen. sp.	3.00	–	–	[7],[15]
972.	*Planorbis planorbis* (Linnaeus, 1758)	–	b	–	[5],[10]
973.	*Planorbis* sp.	–	–	me	[14]
974.	*Potamopyrgus antipodarum* (Gray, 1843)	3.00	–	e	[14]
975.	*Potomida littoralis* (Cuvier, 1798)	–	–	ot	[14]
976.	*Pseudanodonta* sp.	–	–	ot	[14]
977.	*Radix* sp.	2.30	–	me	[14]
978.	*Segmentina nitida* (O. F. Muller, 1774)	1.50	–	me	[14]
979.	Sphaeriidae gen. sp.	2.50	–	–	[7],[15]
980.	*Sphaerium corneum* (Linnaeus, 1758)	–	b-a	–	[5],[10]
981.	*Sphaerium* sp.	2.60	b	me	[14],[16]
982.	*Stagnicola palustris* (O. F. Müller, 1774)	–	b	–	[10]
983.	*Stagnicola* sp.	2.00	–	me	[14]
984.	*Theodoxus fluviatilis* (Linnaeus, 1758)	2.00	o	me	[5],[10],[14],[16]
985.	*Unio pictorum* (Linnaeus, 1758)	–	b	–	[5],[10]
986.	*Unio* sp.	1.80	–	me	[14]

987.	Unionidae gen. sp.	2.50	b	–	[15],[16]
988.	*Valvata piscinalis* (O. F. Müller, 1774)	–	b	–	[5],[10]
989.	*Valvata* sp.	2.20	b	me	[14],[16]
990.	Valvatidae gen. sp.	3.00	–	–	[15]
991.	Viviparidae gen. sp.	2.50	–	–	[7],[15]
992.	*Viviparus* sp.	–	–	me	[14]
993.	*Viviparus viviparus* (Linnaeus, 1758)	1.65	b	–	[5],[10],[16]
	Nemertea (Kingdom: Animalia)				
994.	*Gordius aquaticus* Linnaeus, 1758	0.80	o	–	[5],[10],[16]
995.	*Prostoma graecense* (Böhmig, 1892)	1.50	–	e	[14]
	Platyhelminthes (Kingdom: Animalia)				
996.	*Bdellocephala punctata* (Pallas, 1774)	–	–	e	[14]
997.	*Crenobia alpina* (Dana, 1766)	1.10	x	ot	[5],[10],[14]
998.	*Cura foremanii* (Girard, 1852)	–	o-b	–	[10]
999.	*Dendrocoelum lacteum* (Müller, 1774)	2.70	b	e	[5],[10],[14],[16]
1000.	*Dugesia* sp.	–	–	e	[14]
1001.	*Euplanaria lugubris* (Schmidt, 1861)	1.60	b	–	[16]
1002.	*Phagocata vitta* (Duges, 1830)	–	–	ot	[14]
1003.	*Planaria gonocephala* Duges, 1830	–	x-o	–	[5],[10]
1004.	*Planaria lugubris* Schmidt, 1861	–	o-b	–	[5]
1005.	*Planaria polychroa* Schmidt, 1861	–	b-a	–	[5]
1006.	*Planaria* sp.	–	–	me	[14]
1007.	*Planaria torva* (O. F. Müller, 1774)	2.40	b-a	–	[5],[10],[12],[16]
1008.	*Polycelis felina* (Dalyell, 1814)	0.80	o	–	[5],[10],[16]
1009.	*Polycelis nigra* (Müller, 1774)	2.15	b	–	[5],[10],[16]
1010.	*Polycelis* sp.	–	–	me	[14]
1011.	*Schmidtea polychroa* (Schmidt, 1861)	–	b-a	–	[10]
	Porifera (Kingdom: Animalia)				
1012.	*Ephydatia fluviatilis* (Linnaeus, 1759)	–	b	–	[5],[10]
1013.	*Heteromeyenia baileyi* (Bowerbank, 1863)	–	–	ot	[14]
1014.	*Spongia* sp.	1.80	b	–	[16]
1015.	*Spongilla lacustris* (Linnaeus, 1758)	2.20	b	me	[5],[10],[12],[14]
1016.	*Trochospongilla horrida* Weltner, 1893	2.00	–	ot	[14]
	Protozoa *incertae sedis* (Kingdom: Animalia)				
1017.	*Phyllomitus amylophagus* G. A. Klebs 1892	3.00	a	–	[1]
	Rotifera (Kingdom: Animalia)				
1018.	*Acyclus trilobus* (Lucks, 1911)	1.00	o	–	[18]
1019.	*Adineta barbata* Janson, 1893	1.00	o	–	[17],[18]
1020.	*Adineta elongata* Rodewald, 1935	1.00	o	–	[18]
1021.	*Adineta glauca* Wulfert, 1942	0.20	o	–	[18]
1022.	*Adineta gracilis* Janson, 1893	1.50	o-b	–	[18]
1023.	*Adineta oculata* (Milne, 1886)	2.30	b	–	[18]
1024.	*Adineta vaga* subsp. *minor* Bryce, 1873	1.00	o	–	[18]
1025.	*Adineta vaga* subsp. *vaga* (Davis, 1873)	1.90	o-b	–	[18]
1026.	*Albertia typhlina* Harring et Myers, 1928	1.00	o	–	[18]
1027.	*Anuraeopsis fissa* (Gosse,1851)	1.20	o	–	[17],[18]
1028.	*Anuraeopsis fissa* subsp. *fissa* Gosse, 1851	1.20	o	–	[17],[18]
1029.	*Ascomorpha ecaudis* Perty, 1850	1.30	o	–	[17],[18]
1030.	*Ascomorpha minima* von Hofsten, 1909	1.70	b	–	[18]
1031.	*Ascomorpha ovalis* (Bergendal, 1892)	1.20	o	–	[17],[18]
1032.	*Ascomorpha saltans* Bartsch, 1870	1.00	o	–	[18]
1033.	*Ascomorphella volvocicola* (Plate, 1886)	1.50	o-b	–	[18]
1034.	*Aspelta circinator* (Gosse, 1886)	1.00	o	–	[17],[18]
1035.	*Aspelta lestes* Harring et Myers, 1928	1.00	o	–	[18]

1036.	*Asplanchna brightwelli* Gosse, 1850	2.50	a	–	[17],[18]
1037.	*Asplanchna girodi* de Guerne, 1888	1.50	b	–	[17],[18]
1038.	*Asplanchna herrickii* De Guerne, 1888	1.61	o	–	[3],[8],[17],[18]
1039.	*Asplanchna intermedia* Hudson, 1886	1.50	o-b	–	[18]
1040.	*Asplanchna priodonta* Gosse, 1850	1.50	b	–	[3],[6],[8],[17],[18]
1041.	*Asplanchna sieboldii* (Leydig, 1854)	1.50	b	–	[17],[18]
1042.	*Asplanchnopus multiceps* (Schrank, 1793)	1.50	b	–	[17],[18]
1043.	*Atrochus tentaculatus* Wierzejski, 1893	1.50	b	–	[17]
1044.	Bdelloidea Donner, 1951	2.20	b	–	[18]
1045.	*Beauchampia crucigera* (Dutrochet, 1812)	1.90	b	–	[17],[18]
1046.	*Beauchampiella eudactylota* (Gosse, 1886)	1.50	b	–	[17]
1047.	*Beauchampiella eudactylota* (Gosse, 1886)	1.20	o	–	[18]
1048.	*Brachionus angularis* f. *aestivus* Skorikov, 1914	1.90	b	–	[17]
1049.	*Brachionus angularis* subsp. *angularis* Gosse, 1851	2.50	a	–	[6],[17],[18]
1050.	*Brachionus angularis* subsp. *bidens* Plate, 1886	1.74	b-a	–	[3],[8],[18]
1051.	*Brachionus angularis* Gosse, 1851	2.50	a	–	[6],[17],[18]
1052.	*Brachionus bennini* Leissling, 1924	2.20	b	–	[17],[18]
1053.	*Brachionus bidentatus* Anderson, 1889	2.00	b	–	[17],[18]
1054.	*Brachionus bidentatus* subsp. *bidentatus* Anderson, 1889	2.00	b	–	[17],[18]
1055.	*Brachionus budapestinensis* Daday, 1885	2.00	b	–	[17],[18]
1056.	*Brachionus calyciflorus* subsp. *calyciflorus* Pallas, 1766	2.50	a	–	[3],[4],[8],[17],[18]
1057.	*Brachionus calyciflorus* Pallas, 1766	2.50	a	–	[3],[4],[8],[17],[18]
1058.	*Brachionus diversicornis* (Daday, 1883)	2.00	b	–	[3],[8],[17],[18]
1059.	*Brachionus diversicornis* subsp. *diversicornis* (Daday, 1883)	2.00	b	–	[3],[8],[17],[18]
1060.	*Brachionus falcatus* Zacharias, 1898	2.00	b	–	[17],[18]
1061.	*Brachionus forficula* Wierzejski, 1891	2.00	b	–	[17],[18]
1062.	*Brachionus leydigii* subsp. *rotundus* Rousselet, 1862	2.20	b	–	[17]
1063.	*Brachionus leydigii* Cohn, 1862	2.20	b	–	[3],[8],[17],[18]
1064.	*Brachionus nilsoni* Ahlstrom, 1940	3.00	a	–	[17]
1065.	*Brachionus plicatilis* (Müller, 1786)	2.00	b	–	[3],[8],[17]
1066.	*Brachionus plicatilis* subsp. *longicornis* Fadeev, 1925	2.00	b	–	[17]
1067.	*Brachionus plicatilis* subsp. *plicatilis* Müller, 1786	2.00	b	–	[3],[8],[17]
1068.	*Brachionus quadridentatus* Hermann, 1783	2.00	b	–	[3],[8],[17],[18]
1069.	*Brachionus quadridentatus* subsp. *ancylognathus* Schmarda, 1859	2.00	b	–	[17]
1070.	*Brachionus quadridentatus* subsp. *cluniorbicularis* Skorikov, 1894	1.83	–	–	[8]
1071.	*Brachionus quadridentatus* subsp. *melheni* Barrois et Daday, 1894	2.00	b	–	[3],[8],[17]
1072.	*Brachionus quadridentatus* subsp. *quadridentatus* Hermann, 1783	2.00	b	–	[3],[8],[17],[18]
1073.	*Brachionus quadridentatus* subsp. *rhenanus* Lauterborn, 1893	2.00	b	–	[17]
1074.	*Brachionus quadridentatus* subsp. *zernovi* Voronkov, 1907	2.00	b	–	[17]
1075.	*Brachionus rubens* Ehrenberg, 1838	3.25	a	–	[4],[17],[18]
1076.	*Brachionus sericus* Rousselet, 1907	1.00	o	–	[4],[18]
1077.	*Brachionus sessilis* Varga, 1951	1.30	b	–	[18]
1078.	*Brachionus urceolaris* subsp. *urceolaris* Müller, 1773	2.20	b	–	[17],[18]
1079.	*Brachionus urceus* (Linnaeus, 1758)	2.00	b	–	[3],[8]
1080.	*Brachionus variabilis* Hempel, 1896	2.00	b	–	[3],[8],[17]
1081.	*Bryceella stylata* (Milne, 1886)	1.00	o	–	[18]
1082.	*Bryceella tenella* (Bryce, 1897)	1.00	o	–	[18]
1083.	*Cephalodella apocolea* Myers, 1924	1.00	o	–	[18]
1084.	*Cephalodella auriculata* (Müller, 1773)	1.50	b	–	[17],[18]
1085.	*Cephalodella biungulata* Wulfert, 1937	1.50	o-b	–	[18]
1086.	*Cephalodella catellina* (Müller, 1786)	1.70	b-o	–	[17],[18]
1087.	*Cephalodella crassipes* (Lord, 1903)	1.50	b	–	[17]
1088.	*Cephalodella delicata* Wulfert, 1937	1.00	o	–	[17],[18]
1089.	*Cephalodella derbyi* (Dixon-Nuttall et Freeman, 1903)	1.00	o	–	[18]
1090.	*Cephalodella eva* (Gosse, 1887)	1.50	b	–	[17],[18]

1091.	*Cephalodella exigua* (Gosse, 1886)	1.50	b	–	[17],[18]
1092.	*Cephalodella fluviatilis* (Zawadowsky, 1926)	1.50	b	–	[17]
1093.	*Cephalodella forceps* Donner, 1949	2.00	b	–	[18]
1094.	*Cephalodella forficata* (Ehrenberg, 1832)	1.80	b	–	[17],[18]
1095.	*Cephalodella forficula* (Ehrenberg, 1831)	1.50	b	–	[17]
1096.	*Cephalodella gibba* (Ehrenberg, 1832)	2.10	b	–	[3],[8],[17],[18]
1097.	*Cephalodella gibboides* Wulfert, 1950	0.50	x-o	–	[18]
1098.	*Cephalodella globata* (Gosse, 1887)	2.00	b	–	[17],[18]
1099.	*Cephalodella glypha* Wulfert, 1950	1.50	o-b	–	[18]
1100.	*Cephalodella gracilis* (Ehrenberg, 1832)	1.80	b	–	[17],[18]
1101.	*Cephalodella gusuleaci* Rodewald, 1935	1.50	b	–	[17]
1102.	*Cephalodella hoodii* (Gosse, 1886)	2.00	o	–	[17],[18]
1103.	*Cephalodella hyalina* Myers, 1924	1.00	o	–	[18]
1104.	*Cephalodella incila* Wulfert, 1937	2.00	b	–	[18]
1105.	*Cephalodella intuta* Myers, 1924	1.00	o	–	[18]
1106.	*Cephalodella jakubskii* Wiszniewski, 1953	1.50	b	–	[17],[18]
1107.	*Cephalodella limosa* Wulfert, 1937	1.60	b-o	–	[18]
1108.	*Cephalodella megalochephala* (Glasscott, 1893)	1.90	b	–	[17],[18]
1109.	*Cephalodella misgurnus* Wulfert, 1937	2.00	b	–	[17],[18]
1110.	*Cephalodella nana* Myers, 1924	1.00	o	–	[17],[18]
1111.	*Cephalodella obvia* Donner, 1951	2.00	b	–	[18]
1112.	*Cephalodella pachydactyla* Wulfert, 1937	1.50	b	–	[17]
1113.	*Cephalodella panarista* Myers, 1924	1.50	b	–	[17]
1114.	*Cephalodella plicata* Myers, 1924	1.00	o	–	[18]
1115.	*Cephalodella reimanni* Donner, 1949	2.00	b	–	[18]
1116.	*Cephalodella rigida* Donner, 1949	1.50	o-b	–	[18]
1117.	*Cephalodella stenroosi* Wulfert, 1937	2.00	b	–	[17],[18]
1118.	*Cephalodella sterea* (Gosse, 1887)	2.00	b	–	[17],[18]
1119.	*Cephalodella tantilla* Myers, 1924	1.00	o	–	[18]
1120.	*Cephalodella tecta* Donner, 1950	2.00	b	–	[18]
1121.	*Cephalodella tenuior* (Gosse, 1886)	2.00	o	–	[17],[18]
1122.	*Cephalodella tenuiseta* subsp. *americana* Donner, 1949	2.00	b	–	[18]
1123.	*Cephalodella tinca* Wulfert, 1937	2.00	b	–	[18]
1124.	*Cephalodella trigona* (Rousselet, 1895)	1.00	o	–	[17]
1125.	*Cephalodella trigona* (Rousselet, 1895)	1.00	o	–	[18]
1126.	*Cephalodella ventripes* (Dixon-Nuttall, 1901)	1.50	o-b	–	[18]
1127.	*Cephalodella volvocicola* (Zavadovsky, 1916)	1.80	b	–	[18]
1128.	*Cephalodella tenuiseta* (Burn, 1890)	2.00	b	–	[17]
1129.	*Ceratotrocha cornigera* (Bryce, 1893)	1.00	O	–	[18]
1130.	*Collotheca ambigua* (Hudson, 1883)	1.50	o-b	–	[18]
1131.	*Collotheca atrochoides* (Wierzejski, 1893)	1.80	b	–	[17],[18]
1132.	*Collotheca balatonica* Varga, 1936	1.50	o	–	[18]
1133.	*Collotheca calva* (Hudson, 1885)	1.00	o	–	[18]
1134.	*Collotheca campanulata* (Dobie, 1849)	1.50	o-b	–	[18]
1135.	*Collotheca coronetta* (Cubitt, 1869)	1.00	o	–	[18]
1136.	*Collotheca edentata* (Collins, 1872)	1.00	o	–	[18]
1137.	*Collotheca heptabrachiata* (Schoch, 1869)	1.00	o	–	[18]
1138.	*Collotheca libera* (Zacharias, 1894)	1.00	o	–	[18]
1139.	*Collotheca mutabilis* (Hudson, 1885)	1.00	o	–	[17],[18]
1140.	*Collotheca ornata* (Ehrenberg, 1832)	2.30	b-a	–	[18]
1141.	*Collotheca pelagica* (Rousselet, 1893)	1.00	o	–	[17],[18]
1142.	*Collotheca trifidlobata* (Pittock, 1895)	1.00	o	–	[18]
1143.	*Collotheca undulata* Sládecek, 1969	1.50	o-b	–	[18]
1144.	*Colurella adriatica* Ehrenberg, 1931	1.80	b-o	–	[17],[18]

1145.	*Colurella colurus* (Ehrenberg, 1830)	1.30	o	–	[17],[18]
1146.	*Colurella colurus* subsp. *colurus* (Ehrenberg, 1830)	1.30	o	–	[17],[18]
1147.	*Colurella colurus* subsp. *compressa* (Lucks, 1830)	1.15	o	–	[17]
1148.	*Colurella dicentra* (Gosse, 1887)	2.50	b-a	–	[18]
1149.	*Colurella geophila* Donner, 1951	2.00	b	–	[18]
1150.	*Colurella hindenburgi* Steinecke, 1916	1.50	b	–	[17],[18]
1151.	*Colurella oblonga* Donner, 1943	1.50	o-b	–	[18]
1152.	*Colurella obtusa* subsp. *obtusa* (Gosse, 1886)	1.65	o	–	[3],[8],[17],[18]
1153.	*Colurella paludosa* Carlin, 1939	1.50	o-b	–	[18]
1154.	*Colurella tesselata* (Glascott, 1893)	1.10	o	–	[18]
1155.	*Colurella uncinata* (Müller, 1773)	1.30	o	–	[17],[18]
1156.	*Colurella uncinata* subsp. *bicuspidata* (Ehrenberg, 1832)	1.70	b	–	[17],[18]
1157.	*Colurella uncinata* subsp. *deflexa* (Ehrenberg, 1773)	1.70	b	–	[17],[18]
1158.	*Colurella uncinata* subsp. *uncinata* (Müller, 1773)	1.30	o	–	[17],[18]
1159.	*Conochilus coenobasis* (Skorikov, 1914)	1.30	o	–	[17]
1160.	*Conochilus deltaicus* (Rodewald-Rudescu, 1960)	1.30	o	–	[17]
1161.	*Conochilus dossuarius* Hudson, 1885	1.30	o	–	[17],[18]
1162.	*Conochilus hippocrepis* (Schrank, 1803)	1.15	o	–	[17],[18]
1163.	*Conochilus natans* (Seligo, 1900)	1.30	o	–	[17],[18]
1164.	*Conochilus unicornis* Rousselet, 1892	1.30	o	–	[6],[17],[18]
1165.	*Cupelopagis vorax* (Leidy, 1857)	1.40	o-b	–	[18]
1166.	*Cyrtonia tuba* (Ehrenberg, 1834)	1.50	o-b	–	[18]
1167.	*Dicranophorus artamus* Harring et Myers, 1928	2.00	b	–	[17]
1168.	*Dicranophorus caudatus* (Ehrenberg, 1834)	2.30	b	–	[17],[18]
1169.	*Dicranophorus epicharis* Harring et Myers, 1928	1.50	b	–	[17]
1170.	*Dicranophorus forcipatus* (Müller, 1786)	1.50	b	–	[17],[18]
1171.	*Dicranophorus grandis* (Ehrenberg, 1832)	1.50	b	–	[17],[18]
1172.	*Dicranophorus hauerianus* subsp. *brachygnatus* Wiszniewski, 1939	1.50	b	–	[17],[18]
1173.	*Dicranophorus hauerianus* Wiszniewski, 1939	1.50	b	–	[17],[18]
1174.	*Dicranophorus hercules* Wiszniewski, 1932	1.20	o	–	[18]
1175.	*Dicranophorus luetkeni* (Bergendal, 1892)	1.10	o	–	[18]
1176.	*Dicranophorus prionacis* Harring et Myers, 1928	2.00	b	–	[17]
1177.	*Dicranophorus proclestes* Harring et Myers, 1928	1.50	b	–	[17]
1178.	*Dicranophorus rosa* (Gosse, 1887)	1.50	b	–	[17]
1179.	*Dicranophorus rostratus* (Dixon-Nuttall et Freeman, 1902)	1.10	o	–	[18]
1180.	*Dicranophorus siedleckii* Wiszniewski, 1953	1.00	o	–	[18]
1181.	*Dicranophorus sigmoides* Wulfert, 1950	1.00	o	–	[18]
1182.	*Dicranophorus uncinatus* (Milne, 1886)	1.00	o	–	[18]
1183.	*Dipleuchlanis propatula* (Gosse, 1886)	2.00	b	–	[17],[18]
1184.	*Diplois daviesiae* Gosse, 1886	2.70	a	–	[17],[18]
1185.	*Dissotrocha aculeata* subsp. *aculeata* (Ehrenberg, 1832)	1.60	b	–	[17],[18]
1186.	*Dissotrocha aculeata* subsp. *crystallina* (Murray, 1832)	1.10	o	–	[18]
1187.	*Dissotrocha macrostyla* subsp. *macrostyla* (Ehrenberg, 1838)	1.20	o	–	[17],[18]
1188.	*Dissotrocha macrostyla* subsp. *tuberculata* (Gosse, 1838)	0.50	x-o	–	[18]
1189.	*Dorystoma caudata* (Bilfinger, 1894)	1.00	o	–	[18]
1190.	*Drilophaga judayi* Harring et Myers, 1922	1.00	o	–	[18]
1191.	*Elosa worrallii* Lord, 1891	1.50	b	–	[17],[18]
1192.	*Embata commensalis* (Western, 1893)	2.40	b-a	–	[18]
1193.	*Embata laticeps* (Murray, 1905)	1.00	o	–	[18]
1194.	*Embata parasitica* (Giglioli, 1863)	1.00	o	–	[18]
1195.	*Encentrum armatum* Donner, 1943	2.00	b	–	[18]
1196.	*Encentrum arvicola* Wulfert, 1936	1.30	o	–	[18]
1197.	*Encentrum asellicola* Bartoš, 1959	2.80	a	–	[17],[18]
1198.	*Encentrum belluinum* Harring et Myers, 1928	1.50	b	–	[17]
1199.	*Encentrum diglandula* (Zavadovsky, 1926)	1.50	o-b	–	[18]

1200.	*Encentrum fluviatile* Wulfert, 1939	1.50	b	–	[17]
1201.	*Encentrum gulo* Wulfert, 1936	1.50	b	–	[17]
1202.	*Encentrum kulmatyckii* Wiszniewski, 1953	2.50	b-a	–	[18]
1203.	*Encentrum longidens* Donner, 1943	1.50	o-b	–	[18]
1204.	*Encentrum lupus* Wulfert, 1936	2.40	a-b	–	[18]
1205.	*Encentrum lutra* Wulfert, 1936	1.10	o	–	[18]
1206.	*Encentrum mariae* Koniar, 1957	1.00	o	–	[18]
1207.	*Encentrum marinum* (Dujardin, 1841)	2.00	b	–	[18]
1208.	*Encentrum martes* Wulfert, 1939	1.50	o-b	–	[18]
1209.	*Encentrum martoides* Fott, 1960	1.50	b	–	[17],[18]
1210.	*Encentrum minax* Donner, 1943	1.50	o-b	–	[18]
1211.	*Encentrum moldavicum* Sládecek, 1961	1.90	b	–	[18]
1212.	*Encentrum mucronatum* Wulfert, 1936	0.80	o	–	[18]
1213.	*Encentrum mustela* (Milne, 1885)	1.90	b	–	[18]
1214.	*Encentrum parvum* Donner, 1952	2.00	b	–	[18]
1215.	*Encentrum putorius* Wulfert, 1936	2.00	b	–	[18]
1216.	*Encentrum rapax* Donner, 1943	1.50	o-b	–	[18]
1217.	*Encentrum saundersiae* (Hudson, 1885)	2.50	b-a	–	[18]
1218.	*Encentrum semiplicatum* Wulfert, 1936	1.60	o-b	–	[18]
1219.	*Encentrum sorex* Wulfert, 1950	1.50	o-b	–	[18]
1220.	*Encentrum sutor* Wiszniewski, 1936	1.00	o	–	[18]
1221.	*Encentrum sutoroides* Wulfert, 1940	1.10	o	–	[18]
1222.	*Encentrum uncinatum* (Milne, 1886)	0.40	x-o	–	[18]
1223.	*Enteroplea lacustris* Ehrenberg, 1830	1.30	o	–	[18]
1224.	*Eosphora ehrenbergi* Weber, 1918	1.50	b	–	[17],[18]
1225.	*Eosphora najas* Ehrenberg, 1830	1.70	b	–	[17],[18]
1226.	*Eothinia elongata* (Ehrenberg, 1832)	1.00	o	–	[18]
1227.	*Epiphanes brachionus* (Ehrenberg, 1837)	1.50	b	–	[17],[18]
1228.	*Epiphanes brachionus* subsp. *spinosa* (Rousselet, 1837)	2.00	b	–	[17],[18]
1229.	*Epiphanes clavulata* (Ehrenberg, 1832)	1.50	b	–	[17],[18]
1230.	*Epiphanes macroura* (Barrois et Daday, 1894)	1.50	b	–	[17]
1231.	*Epiphanes senta* (Müller, 1773)	3.50	a	–	[17],[18]
1232.	*Erignatha clastopis* (Gosse, 1886)	1.40	o-b	–	[18]
1233.	*Euchlanis alata* Voronkov, 1912	1.50	b	–	[18]
1234.	*Euchlanis arenosa* Myers, 1936	1.50	b	–	[17]
1235.	*Euchlanis calpidia* (Myers, 1930)	1.50	b	–	[17]
1236.	*Euchlanis contorta* (Wulfert, 1939)	1.00	o	–	[17]
1237.	*Euchlanis deflexa* Gosse	1.65	b	–	[3],[8],[17],[18]
1238.	*Euchlanis dilatata* Ehrenberg, 1832	1.90	b	–	[3],[8],[17],[18]
1239.	*Euchlanis dilatata* subsp. *dilatata* Ehrenberg,1832	1.90	b	–	[3],[8],[17],[18]
1240.	*Euchlanis dilatata* subsp. *lucksiana* Hauer, 1832	1.50	b	–	[17],[18]
1241.	*Euchlanis dilatata* subsp. *macrura* Ehremberg,1832	1.50	b	–	[17]
1242.	*Euchlanis dilatata* subsp. *unisetata* Leydig, 1854	1.50	b	–	[17]
1243.	*Euchlanis incisa* Carlin, 1939	1.50	b	–	[6],[17],[18]
1244.	*Euchlanis lyra* Hudson, 1886	1.50	b	–	[3],[8],[17]
1245.	*Euchlanis lyra* subsp. *larga* Kutikova, 1959	1.50	-	–	[3],[8]
1246.	*Euchlanis meneta* Myers, 1930	1.00	o	–	[17],[18]
1247.	*Euchlanis oropha* Gosse, 1887	1.90	b	–	[18]
1248.	*Euchlanis parva* Rousselet, 1892	1.90	b	–	[17],[18]
1249.	*Euchlanis phryne* Myers, 1930	1.50	b	–	[17]
1250.	*Euchlanis pyriformis* Gosse, 1851	1.50	b	–	[17],[18]
1251.	*Euchlanis triquetra* Ehrenberg, 1838	1.50	o	–	[17],[18]
1252.	*Filinia brachiata* (Rousselet, 1901)	1.00	o	–	[17],[18]
1253.	*Filinia cornuta* (Weisse, 1848)	1.00	o	–	[17],[18]

1254.	*Filinia longiseta* (Ehrenberg, 1834)	2.50	a	–	[3],[4],[8],[17],[18]
1255.	*Filinia maior* Carlin, 1943	2.00	b	–	[3],[8],[18]
1256.	*Filinia minuta* (Smirnov, 1928)	1.50	b	–	[17]
1257.	*Filinia opoliensis* (Zacharias, 1898)	1.60	b	–	[17],[18]
1258.	*Filinia passa* (Müller, 1786)	1.80	b	–	[17],[18]
1259.	*Filinia terminalis* (Plate, 1886)	2.00	b	–	[3],[6],[8],[17],[18]
1260.	*Floscularia conifera* (Hudson, 1886)	1.00	o	–	[18]
1261.	*Floscularia janus* (Hudson, 1881)	1.10	o	–	[18]
1262.	*Floscularia melicerta* (Ehrenberg, 1832)	1.90	b	–	[17],[18]
1263.	*Floscularia ringens* (Linnaeus, 1758)	1.90	b	–	[17],[18]
1264.	*Gastropus stylifer* Imhof, 1891	1.00	o	–	[17],[18]
1265.	*Habrotrocha angusticollis* subsp. *angusticollis* (Murray, 1905)	1.20	o	–	[17],[18]
1266.	*Habrotrocha angusticollis* subsp. *attenuata* (Murray, 1905)	1.20	o	–	[18]
1267.	*Habrotrocha annulata* (Murray, 1905)	1.00	o	–	[18]
1268.	*Habrotrocha bidens* (Gosse, 1851)	2.10	b	–	[17],[18]
1269.	*Habrotrocha collaris* (Ehrenberg,1832)	1.90	b	–	[17],[18]
1270.	*Habrotrocha constricta* (Dujardin, 1841)	1.90	b	–	[17],[18]
1271.	*Habrotrocha crenata* subsp. *sphagnicola* Pawlowski, 1905	1.00	o	–	[18]
1272.	*Habrotrocha elegans* (Milne, 1886)	1.00	o	–	[18]
1273.	*Habrotrocha flava* Bryce, 1915	2.00	b	–	[18]
1274.	*Habrotrocha gracilis* Montet, 1915	1.50	o-b	–	[18]
1275.	*Habrotrocha lata* (Bryce, 1892)	1.20	o	–	[17],[18]
1276.	*Habrotrocha longula* Bryce, 1915	1.00	o	–	[18]
1277.	*Habrotrocha microcephala* (Murray, 1906)	1.50	o-b	–	[18]
1278.	*Habrotrocha munda* Bryce, 1913	1.50	o-b	–	[18]
1279.	*Habrotrocha pulchra* (Murray, 1905)	1.50	o-b	–	[18]
1280.	*Habrotrocha reclusa* (Milne, 1889)	1.00	o	–	[18]
1281.	*Habrotrocha roeperi* (Milne, 1889)	1.00	o	–	[18]
1282.	*Habrotrocha rosa* Donner, 1949	2.10	b	–	[18]
1283.	*Habrotrocha sylvestris* Bryce, 1915	1.00	o	–	[18]
1284.	*Habrotrocha thermalis* Pax et Wulfert, 1942	0.00	X	–	[18]
1285.	*Habrotrocha thienemanni* Hauer, 1924	1.80	b	–	[18]
1286.	*Habrotrocha tridens* subsp. *globigera* Donner, 1886	1.50	o-b	–	[18]
1287.	*Habrotrocha tridens* subsp. *tridens* (Milne, 1886)	1.20	o	–	[18]
1288.	*Habrotrocha tripus* (Murray, 1907)	1.90	b	–	[18]
1289.	*Hexarthra fennica* (Levander, 1892)	1.70	b	–	[17],[18]
1290.	*Hexarthra intermedia* (Wiszniewski, 1929)	1.20	o	–	[17],[18]
1291.	*Hexarthra mira* (Hudson, 1871)	2.00	b	–	[3],[8],[17],[18]
1292.	*Hexarthra mollis* (Bartoš, 1947)	1.50	o-b	–	[18]
1293.	*Hexarthra oxyuris* (Zernov, 1903)	1.00	o	–	[17],[18]
1294.	*Hexarthra propinqua* (Bartoš, 1947)	1.50	o-b	–	[18]
1295.	*Hexarthra reducens* (Bartoš, 1947)	1.50	o-b	–	[18]
1296.	*Itura aurita* (Ehrenberg, 1830)	1.50	b	–	[17],[18]
1297.	*Itura myersi* Wulfert, 1935	2.00	b	–	[18]
1298.	*Kellicottia longispina* (Kellicott, 1879)	1.25	o	–	[17],[18]
1299.	*Keratella cochlearis* (Gosse, 1851)	1.70	b	–	[3],[4],[6],[8],[17],[18]
1300.	*Keratella cochlearis* subsp. *cochlearis* (Gosse, 1851)	1.70	b	–	[3],[4],[6],[8],[17],[18]
1301.	*Keratella cochlearis* subsp. *hispida* (Lauterborn, 1898)	1.15	o	–	[17],[18]
1302.	*Keratella cochlearis* subsp. *robusta* (Lauterborn, 1900)	1.10	o	–	[18]
1303.	*Keratella hiemalis* Carlin, 1943	1.92	o	–	[3],[8],[17],[18]
1304.	*Keratella irregularis* (Lauterborn, 1898)	1.15	o	–	[17],[18]
1305.	*Keratella paludosa* (Lucks, 1912)	1.00	o	–	[17],[18]
1306.	*Keratella quadrata* subsp. *dispersa* Carlin, 1943	1.50	b	–	[17]
1307.	*Keratella quadrata* subsp. *quadrata* (Müller, 1786)	1.65	b-o	–	[3],[8],[17],[18]
1308.	*Keratella quadrata* (Müller, 1786)	1.65	b-o	–	[3],[8],[17],[18]

1309.	*Keratella quadrata* var. *longispina* (Thiébaud, 1912)	1.77	–	–	[3],[8]
1310.	*Keratella serrulata* (Ehrenberg,1838)	1.15	o	–	[17],[18]
1311.	*Keratella serrulata* subsp. *serrulata* (Ehrenberg,1838)	1.15	o	–	[17],[18]
1312.	*Keratella tecta* (Gosse, 1851)	1.50	–	–	[3],[8]
1313.	*Keratella testudo* (Ehrenberg,1832)	1.15	o	–	[17],[18]
1314.	*Keratella ticinensis* (Callerio, 1920)	1.50	b	–	[17],[18]
1315.	*Keratella tropica* (Apstein, 1907)	1.80	b	–	[17]
1316.	*Keratella tropica* subsp. *aspina* Kutikova, 1970	1.50	b	–	[17]
1317.	*Keratella valga* (Ehrenberg, 1834)	1.40	o	–	[17],[18]
1318.	*Keratella valga* f. *heterospina* Klausener, 1908	1.40	o	–	[17]
1319.	*Keratella valga* subsp. *tropica* (Apstein, 1907)	1.80	b	–	[18]
1320.	*Lacinularia flosculosa* (Müller, 1777)	2.00	b	–	[17],[18]
1321.	*Lecane aculeata* (Jakubski, 1912)	1.50	b	–	[17]
1322.	*Lecane acus* (Harring, 1913)	1.00	o	–	[18]
1323.	*Lecane affinis* (Levander, 1894)	1.00	o	–	[18]
1324.	*Lecane agilis* (Bryce, 1892)	1.00	o	–	[18]
1325.	*Lecane arcuata* (Bryce, 1891)	1.80	o-b	–	[17],[18]
1326.	*Lecane arcula* Harring, 1914	1.50	b	–	[17],[18]
1327.	*Lecane bifurca* (Bryce, 1892)	1.00	o	–	[18]
1328.	*Lecane bryophila* Koniar, 1957	1.00	o	–	[18]
1329.	*Lecane bulla* subsp. *bulla* (Gosse, 1851)	1.90	b	–	[17],[18]
1330.	*Lecane bulla* subsp. *diabolica* (Hauer, 1851)	2.50	a	–	[17]
1331.	*Lecane clara* (Bryce, 1892)	1.80	o-b	–	[18]
1332.	*Lecane closterocerca* (Schmarda, 1859)	2.10	b	–	[17],[18]
1333.	*Lecane copeis* (Harring et Myers, 1926)	1.00	o	–	[17]
1334.	*Lecane cornuta* (Müller, 1786)	1.80	b	–	[17],[18]
1335.	*Lecane crepida* Harring, 1914	1.50	b	–	[17]
1336.	*Lecane curvicornis* (Murray, 1913)	1.50	b	–	[17]
1337.	*Lecane decipiens* (Murray, 1913)	2.00	b	–	[18]
1338.	*Lecane depressa* (Bryce, 1891)	1.00	o	–	[18]
1339.	*Lecane elasma* Harring et Myers, 1926	1.50	b	–	[17],[18]
1340.	*Lecane elongata* Harring et Myers, 1926	0.10	o	–	[18]
1341.	*Lecane elsa* Hauer, 1931	1.50	b	–	[17],[18]
1342.	*Lecane flexilis* (Gosse, 1889)	1.10	o	–	[17],[18]
1343.	*Lecane furcata* (Murray, 1913)	1.50	b	–	[17],[18]
1344.	*Lecane galeata* (Bryce, 1892)	1.90	b	–	[17],[18]
1345.	*Lecane gissensis* Eckstein, 1883	1.00	o	–	[17],[18]
1346.	*Lecane goniata* (Harring et Myers, 1926)	1.00	o	–	[17]
1347.	*Lecane hamata* (Stokes, 1896)	1.40	o	–	[17],[18]
1348.	*Lecane hastata* (Murray, 1913)	1.50	b	–	[17]
1349.	*Lecane hornemanni* (Ehrenberg, 1834)	1.50	b	–	[17],[18]
1350.	*Lecane hospes* Donner, 1951	1.00	o	–	[18]
1351.	*Lecane inermis* (Bryce, 1892)	1.90	b	–	[18]
1352.	*Lecane intrasinuata* (Olofsson, 1917)	1.00	o	–	[18]
1353.	*Lecane jessupi* Harring, 1921	1.00	o	–	[18]
1354.	*Lecane lamellata* (Daday, 1893)	1.50	b	–	[17]
1355.	*Lecane lauterborni* Hauer, 1924	1.00	o	–	[18]
1356.	*Lecane ligona* (Dunlop, 1901)	1.00	o	–	[18]
1357.	*Lecane ludwigii* (Eckstein, 1882)	1.50	b	–	[17],[18]
1358.	*Lecane luna* (Müller, 1776)	1.50	b	–	[3],[8],[17],[18]
1359.	*Lecane lunaris* (Ehrenberg, 1832)	2.00	b	–	[17],[18]
1360.	*Lecane mira* (Murray, 1913)	1.50	b	–	[17],[18]
1361.	*Lecane nana* (Murray, 1913)	1.00	o	–	[18]
1362.	*Lecane obtusa* (Myrray, 1913)	1.50	b	–	[17]

1363.	*Lecane ohioensis* (Herrick, 1885)	1.50	b	–	[17]
1364.	*Lecane papuana* (Murray, 1913)	1.50	b	–	[17]
1365.	*Lecane paxiana* Hauer, 1940	1.00	o	–	[18]
1366.	*Lecane pideis* (Harring et Myers, 1926)	2.10	b	–	[18]
1367.	*Lecane plesia* Myers, 1936	1.50	b	–	[17]
1368.	*Lecane pumila* (Rousselet, 1906)	1.00	o	–	[18]
1369.	*Lecane punctata* (Murray, 1913)	1.50	b	–	[17]
1370.	*Lecane pyriformis* (Daday, 1905)	2.00	b	–	[17],[18]
1371.	*Lecane quadridentata* (Ehrenberg, 1832)	1.50	b	–	[17],[18]
1372.	*Lecane rugosa* (Harring, 1914)	1.50	b	–	[17]
1373.	*Lecane scutata* (Harring et Myers, 1926)	1.00	o	–	[18]
1374.	*Lecane signifera* subsp. *ploenensis* (Voigt, 1896)	1.10	o	–	[18]
1375.	*Lecane stenroosi* (Meissner, 1908)	1.50	b	–	[17],[18]
1376.	*Lecane stichaea* Harring, 1913	1.70	b-o	–	[18]
1377.	*Lecane subtilis* Harring et Myers, 1926	1.00	o	–	[18]
1378.	*Lecane subulata* (Harring et Myers, 1926)	1.00	o	–	[17],[18]
1379.	*Lecane sulcata* (Gosse, 1886)	1.00	o	–	[18]
1380.	*Lecane tenuiseta* Harring, 1914	1.90	b	–	[17],[18]
1381.	*Lecane tryphema* Harring et Myers, 1926	1.00	o	–	[18]
1382.	*Lecane undulata* Hauer, 1938	1.50	b	–	[17],[18]
1383.	*Lecane ungulata* (Gosse, 1887)	1.50	b	–	[3],[8],[17],[18]
1384.	*Lecane verecunda* Harring et Myers, 1926	1.50	b	–	[17]
1385.	*Lepadella acuminata* (Ehrenberg, 1834)	1.50	o-b	–	[18]
1386.	*Lepadella adjuncta* Donner, 1943	2.00	b	–	[18]
1387.	*Lepadella amphitropis* Harring, 1916	1.50	b	–	[17]
1388.	*Lepadella astacicola* Hauer, 1926	1.50	b	–	[17]
1389.	*Lepadella borealis* Harring, 1916	1.50	b	–	[17],[18]
1390.	*Lepadella branchicola* Hauer, 1926	1.50	b	–	[17],[18]
1391.	*Lepadella costata* Wulfert, 1940	1.00	o	–	[17],[18]
1392.	*Lepadella cristata* (Rousselet, 1893)	1.50	o-b	–	[18]
1393.	*Lepadella dactyliseta* (Stenroos, 1898)	1.50	o-b	–	[18]
1394.	*Lepadella ehrenbergii* (Perty, 1850)	1.50	o-b	–	[18]
1395.	*Lepadella elliptica* Wulfert, 1939	1.00	o	–	[18]
1396.	*Lepadella glossa* Wulfert, 1960	1.50	b	–	[17]
1397.	*Lepadella haueri* Rodewald, 1935	1.50	b	–	[17]
1398.	*Lepadella heterodactyla* Fadeev, 1925	1.00	o	–	[17]
1399.	*Lepadella koniari* Bartoš, 1955	1.00	o	–	[18]
1400.	*Lepadella lata* subsp. *ovata* Bochko, 1980	1.50	b	–	[17]
1401.	*Lepadella lata* subsp. *sinuata* Wiszniewski, 1939	1.50	b	–	[17]
1402.	*Lepadella lata* Wiszniewski, 1939	1.50	b	–	[17]
1403.	*Lepadella minuta* (Weber et Montet, 1918)	1.50	o-b	–	[18]
1404.	*Lepadella nana* Bochko, 1980	1.50	b	–	[17]
1405.	*Lepadella nympha* Donner, 1943	1.50	o-b	–	[18]
1406.	*Lepadella obtusa* Wang, 1961	1.67	-	–	[3],[8]
1407.	*Lepadella ovalis* (Müller 1786)	1.70	b	–	[3],[8],[17],[18]
1408.	*Lepadella parasitica* Hauer, 1926	1.00	o	–	[18]
1409.	*Lepadella parvula* (Bryce, 1893)	1.50	o-b	–	[18]
1410.	*Lepadella patella* (Müller, 1773)	1.50	b	–	[17],[18]
1411.	*Lepadella patella* subsp. *oblonga* (Ehrenberg, 1773)	2.20	b-a	–	[17],[18]
1412.	*Lepadella patella* subsp. *patella* (Müller, 1773)	1.50	b	–	[17],[18]
1413.	*Lepadella patella* subsp. *persimilis* De Ridder, 1773	1.50	b	–	[17],[18]
1414.	*Lepadella prolongata* Naberejni, 1984	1.50	b	–	[17]
1415.	*Lepadella quadricarinata* (Stenroos, 1898)	1.50	b	–	[17],[18]
1416.	*Lepadella quinquecostata* (Lucks, 1912)	1.50	b	–	[17],[18]
1417.	*Lepadella rhomboides* (Gosse, 1886)	1.20	o	–	[17],[18]

1418.	*Lepadella rhomboides* subsp. *rhomboides* (Gosse, 1886)	1.20	o	–	[17],[18]
1419.	*Lepadella rottenburgi* (Lucks, 1912)	1.00	o	–	[18]
1420.	*Lepadella triptera* Ehrenberg, 1830	1.30	o	–	[17],[18]
1421.	*Limnias ceratophylli* Schrank, 1803	1.50	b	–	[17],[18]
1422.	*Limnias ceratophylli* subsp. *ceratophylli* Schrank, 1803	1.50	b	–	[17],[18]
1423.	*Limnias melicerta* subsp. *melicerta* Weisse, 1848	1.00	o	–	[17],[18]
1424.	*Limnias melicerta* Weisse, 1848	1.00	o	–	[17],[18]
1425.	*Lindia janickii* Wiszniewski, 1934	1.50	b	–	[17]
1426.	Lindia torulosa Dujardin, 1841	1.00	o	–	[17],[18]
1427.	*Lindia truncata* (Jennings, 1894)	1.50	b	–	[17]
1428.	*Lophocharis naias* Wulfert, 1942	1.50	o-b	–	[18]
1429.	*Lophocharis oxysternon* (Gosse, 1851)	1.71	o	–	[3],[8],[17],[18]
1430.	*Lophocharis rubens* Wulfert, 1939	1.50	o-b	–	[18]
1431.	*Lophocharis salpina* (Ehrenberg, 1834)	1.50	b	–	[17],[18]
1432.	*Macrochaetus subquadratus* Perty, 1850	0.10	o	–	[18]
1433.	*Macrotrachela concinna* (Bryce, 1912)	1.40	o-b	–	[18]
1434.	*Macrotrachela ehrenbergi* (Janson, 1893)	1.00	o	–	[17]
1435.	*Macrotrachela habita* (Bryce, 1894)	1.00	o	–	[18]
1436.	*Macrotrachela multispinosa* subsp. *brevispinosa* (Murray, 1892)	1.00	o	–	[17]
1437.	*Macrotrachela multispinosa* subsp. *multispinosa* Thompson, 1892	1.00	o	–	[17],[18]
1438.	*Macrotrachela musculosa* Milne, 1886	1.00	o	–	[18]
1439.	*Macrotrachela quadricornifera* Milne, 1886	0.90	o	–	[18]
1440.	*Microcodides robustus* (Glascott, 1892)	1.20	o	–	[18]
1441.	*Microcodon clavus* Ehrenberg, 1830	0.50	x-o	–	[17],[18]
1442.	*Mikrocodides chlaena* (Gosse, 1886)	1.50	b	–	[17],[18]
1443.	*Mniobia armata* (Murray, 1905)	1.20	o	–	[18]
1444.	*Mniobia frankenbergeri* Bartoš, 1944	1.00	o	–	[18]
1445.	*Monommata actices* Myers, 1930	1.00	o	–	[18]
1446.	*Monommata aequalis* (Ehrenberg, 1832)	1.50	b	–	[17],[18]
1447.	*Monommata astia* Myers, 1930	1.00	o	–	[18]
1448.	*Monommata dentata* Wulfert, 1940	1.00	o	–	[18]
1449.	*Monommata dissimilis* Berzinš, 1949	1.00	o	–	[18]
1450.	*Monommata grandis* Tessin, 1890	1.50	b	–	[17],[18]
1451.	*Monommata longiseta* (Müller, 1786)	1.50	b	–	[17],[18]
1452.	*Monommata phoxa* Myers, 1930	1.00	o	–	[18]
1453.	*Myersinella tetraglena* (Wiszniewski, 1934)	1.00	o	–	[18]
1454.	*Mytilina bicarinata* (Perty, 1850)	1.60	b	–	[17],[18]
1455.	*Mytilina bicarinata* (Perty, 1850)	1.00	o	–	[18]
1456.	*Mytilina bisulcata* (Lucks, 1912)	1.30	b-o	–	[18]
1457.	*Mytilina compressa* (Gosse, 1851)	2.50	b-a	–	[18]
1458.	*Mytilina crassipes* (Lucks, 1912)	1.50	o-b	–	[18]
1459.	*Mytilina mucronata* subsp. *mucronata* (Müller, 1773)	1.80	b	–	[3],[8],[17],[18]
1460.	*Mytilina mucronata* subsp. *spinigera* (Ehrenberg, 1773)	1.90	b	–	[3],[8],[17],[18]
1461.	*Mytilina mucronata* (Müller, 1773)	1.80	b	–	[3],[8],[17],[18]
1462.	*Mytilina mutica* (Perty, 1850)	1.50	b	–	[17],[18]
1463.	*Mytilina trigona* (Gosse, 1851)	2.30	a-b	–	[18]
1464.	*Mytilina ventralis* (Ehrenberg, 1832)	1.81	o	–	[3],[8],[17],[18]
1465.	*Mytilina ventralis* subsp. *brevispina* (Ehrenberg, 1832)	1.50	b	–	[17],[18]
1466.	*Mytilina ventralis* subsp. *macracantha* (GOSSE)	1.80	b	–	[18]
1467.	*Mytilina ventralis* subsp. *reduncа* (Ehrenberg, 1832)	1.00	o	–	[17]
1468.	*Mytilina ventralis* subsp. *ventralis* (Ehrenberg, 1832)	1.81	b	–	[3],[8],[17],[18]
1469.	*Mytilina videns* (Levander, 1894)	1.50	b	–	[3],[8],[17]
1470.	*Notholca acuminata* (Ehrenberg, 1832)	1.42	o	–	[3],[8],[17],[18]
1471.	*Notholca acuminata* subsp. *acuminata* (Ehrenberg,1832)	1.42	o	–	[3],[8],[17],[18]

1472.	*Notholca acuminata* subsp. *extensa* Olofsson, 1918	1.20	o	–	[17]
1473.	*Notholca foliacea* (Ehrenberg, 1832)	1.20	o	–	[17],[18]
1474.	*Notholca labis* subsp. *labis* Gosse, 1887	1.30	o	–	[17],[18]
1475.	*Notholca lyrata* Tikhomirov, 1927	1.00	o	–	[17]
1476.	*Notholca squamula* (Müller, 1786)	1.50	b	–	[17],[18]
1477.	*Notholca squamula* subsp. *limnetica* Naberezhnyj, 1984	1.50	b	–	[17]
1478.	*Notommata allantois* Wulfert, 1935	1.00	o	–	[18]
1479.	*Notommata aurita* (Müller, 1786)	2.20	b-a	–	[17],[18]
1480.	*Notommata brachyota* Ehrenberg, 1832	1.50	o-b	–	[18]
1481.	*Notommata cerberus* (Gosse, 1886)	1.00	o	–	[18]
1482.	*Notommata collaris* (Ehrenberg, 1832)	1.50	b	–	[17]
1483.	*Notommata copeus* Ehrenberg, 1834	1.20	o	–	[17],[18]
1484.	*Notommata cyrtopus* Gosse, 1886	2.00	b	–	[18]
1485.	*Notommata diasema* Myers, 1936	1.00	o	–	[17],[18]
1486.	*Notommata doneta* Harring et Myers, 1922	1.50	b	–	[17]
1487.	*Notommata falcinella* Harring et Myers, 1922	1.50	o-b	–	[18]
1488.	*Notommata glyphura* Wulfert, 1935	1.40	o	–	[18]
1489.	*Notommata groenlandica* Bergendal, 1892	1.00	o	–	[17],[18]
1490.	*Notommata lucens* Glascott, 1893	1.50	o-b	–	[18]
1491.	*Notommata pachyura* (Gosse, 1886)	1.50	b	–	[17],[18]
1492.	*Notommata paracyrtopus* Beauchamp, 1932	1.80	b	–	[17]
1493.	*Notommata pseudocerberus* de Beauchamp, 1908	1.00	o	–	[18]
1494.	*Notommata saccigera* Ehrenberg, 1830	1.00	o	–	[18]
1495.	*Notommata silpha* Gosse, 1886	1.50	b	–	[17]
1496.	*Notommata tripus* Ehrenberg, 1838	1.00	o	–	[18]
1497.	*Notommata voigti* Donner, 1949	1.00	o	–	[18]
1498.	*Otostephanos annulatus* Koniar, 1955	0.40	x-o	–	[18]
1499.	*Otostephanos auriculatus* subsp. *bilobatus* Hauer, 1911	1.50	o-b	–	[18]
1500.	*Otostephanos donneri* Bartoš, 1959	2.00	b	–	[18]
1501.	*Otostephanos monteti* Milne, 1916	2.00	b	–	[18]
1502.	*Paradicranophorus aculeatus* (Neisvestnova-Shadina, 1935)	1.50	b	–	[17]
1503.	*Paradicranophorus hudsoni* (Glascott, 1893)	2.00	b	–	[17],[18]
1504.	*Parencentrum lutetiae* (Harring et Myers, 1928)	1.00	o	–	[18]
1505.	*Parencentrum plicatum* (Eyferth, 1878)	1.00	o	–	[18]
1506.	*Philodina acuticornis* subsp. *acuticornis* Murray, 1902	0.40	x-o	–	[18]
1507.	*Philodina acuticornis* subsp. *minor* Pax et Wulfert, 1902	0.00	x	–	[18]
1508.	*Philodina acuticornis* subsp. *odiosa* Milne, 1902	2.00	b	–	[18]
1509.	*Philodina brevipes* Murray, 1902	1.50	b	–	[17],[18]
1510.	*Philodina citrina* Ehrenberg, 1832	1.30	b	–	[17],[18]
1511.	*Philodina convergens* Murray, 1908	1.00	o	–	[18]
1512.	*Philodina erytrophtalma* Ehrenberg, 1830	2.30	b	–	[17],[18]
1513.	*Philodina flaviceps* Bryce, 1906	1.70	o-b	–	[17],[18]
1514.	*Philodina lepta* Wulfert, 1950	0.10	x	–	[18]
1515.	*Philodina megalotrocha* Ehrenberg, 1832	1.70	b	–	[17],[18]
1516.	*Philodina nitida* Milne, 1916	1.80	b	–	[18]
1517.	*Philodina plena* (Bryce, 1894)	2.90	a	–	[18]
1518.	*Philodina roseola* Ehrenberg, 1832	2.00	b	–	[17],[18]
1519.	*Philodina rugosa* subsp. *coriacea* Bryce, 1903	1.10	o	–	[18]
1520.	*Philodina rugosa* subsp. *rugosa* Bryce, 1903	1.00	o	–	[18]
1521.	*Philodina striata* Rodewald, 1937	1.10	o	–	[18]
1522.	*Philodina tranquilla* Wulfert, 1942	0.20	x	–	[18]
1523.	*Philodina tridentata* Rodewald, 1935	1.20	o	–	[18]
1524.	*Philodinavus paradoxus* (Murray, 1905)	0.30	x-o	–	[18]
1525.	*Plationus patulus* (Müller, 1786)	1.80	b	–	[17],[18]
1526.	*Plationus polyacanthus* (Ehrenberg, 1834)	1.80	b	–	[3],[8],[18]

1527.	*Platyias quadricornis* (Ehrenberg, 1832)	1.90	b	–	[3],[8],[17],[18]
1528.	*Platyias quadricornis* subsp. *quadricornis* (Ehrenberg, 1832)	1.80	b	–	[3],[8],[17],[18]
1529.	*Pleurata uroglenae* (Beauchamp, 1948)	1.40	o-b	–	[18]
1530.	*Pleuretra brycei* (Weber, 1898)	0.60	o-x	–	[17],[18]
1531.	*Pleuretra intermedia* (Bartoš, 1938)	1.20	o	–	[18]
1532.	*Pleurotrocha constricta* Ehrenberg, 1832	1.50	b	–	[17]
1533.	*Pleurotrocha petromyzon* Ehrenberg, 1830	1.90	b	–	[17],[18]
1534.	*Pleurotrocha robusta* (Glascott, 1893)	1.20	o	–	[18]
1535.	*Pleurotrocha sigmoidea* Skorikov, 1896	1.50	b	–	[17]
1536.	*Ploesoma hudsoni* (Imhof, 1891)	1.20	o	–	[17],[18]
1537.	*Ploesoma lenticulare* Herrick, 1885	1.00	o	–	[17],[18]
1538.	*Ploesoma triacanthum* (Bergendal, 1892)	1.00	o	–	[17],[18]
1539.	*Ploesoma truncatum* (Levander, 1894)	1.30	o	–	[17],[18]
1540.	*Polyarthra dissimulans* Nipkow, 1952	1.50	b	–	[17],[18]
1541.	*Polyarthra dolichoptera* f. *brachyptera* Idelson, 1925	1.30	o-b	–	[18]
1542.	*Polyarthra dolichoptera* Idelson, 1925	1.63	b	–	[3],[8],[17],[18]
1543.	*Polyarthra euryptera* Wierzejski, 1891	1.67	o	–	[3],[8],[17],[18]
1544.	*Polyarthra longiremis* Carlin, 1943	1.00	o	–	[17],[18]
1545.	*Polyarthra luminosa* Kutikova, 1962	1.50	b	–	[17]
1546.	*Polyarthra major* Burckhardt, 1900	1.20	o	–	[3],[6],[8],[17],[18]
1547.	*Polyarthra minor* Voigt, 1904	1.50	o	–	[3],[8],[17],[18]
1548.	*Polyarthra proloba* Wulfert, 1941	1.50	o-b	–	[18]
1549.	*Polyarthra pseudoproloba* Albertová, 1960	1.50	o-b	–	[18]
1550.	*Polyarthra remata* Skorikov, 1896	1.64	o	–	[3],[6],[8],[17],[18]
1551.	*Polyarthra vulgaris* Carlin, 1943	2.10	b	–	[3],[8],[17],[18]
1552.	*Pompholyx complanata* Gosse, 1851	1.50	b	–	[17],[18]
1553.	*Pompholyx sulcata* Hudson, 1885	1.80	b	–	[17],[18]
1554.	*Postclausa hyptopus* (Ehrenberg, 1838)	1.10	o	–	[17],[18]
1555.	*Postolausa minor* (Rousselet, 1892)	1.50	b	–	[17],[18]
1556.	*Proales alba* Wulfert, 1939	1.40	o-b	–	[18]
1557.	*Proales daphnicola* (Thompson, 1892)	2.10	b	–	[17],[18]
1558.	*Proales decipiens* (Ehrenberg, 1830)	1.80	o-b	–	[18]
1559.	*Proales doliaris* (Rousselet, 1895)	1.00	o	–	[18]
1560.	*Proales fallaciosa* Wulfert, 1937	1.90	b	–	[18]
1561.	*Proales latrunculus* Penard, 1909	1.20	o	–	[18]
1562.	*Proales micropus* (Gosse, 1886)	1.50	b	–	[17],[18]
1563.	*Proales minima* (Montet, 1915)	1.00	o	–	[18]
1564.	*Proales parasita* (Ehrenberg, 1838)	1.50	o-b	–	[18]
1565.	*Proales provida* Wulfert, 1938	0.10	X	–	[18]
1566.	*Proales reinhardti* (Ehrenberg, 1834)	2.20	b	–	[18]
1567.	*Proales similis* de Beauchamp, 1907	3.00	a	–	[3],[8],[18]
1568.	*Proales sordida* Gosse, 1886	1.50	o-b	–	[18]
1569.	*Proales theodora* (Gosse, 1887)	0.90	x-b	–	[18]
1570.	*Proales werneckii* (Ehrenberg, 1834)	1.50	o-b	–	[18]
1571.	*Proalides subtilis* Rodewald, 1940	1.50	b	–	[17]
1572.	*Proalides tentaculatus* Beauchamp, 1907	1.50	b	–	[17],[18]
1573.	*Proalinopsis caudatus* (Collins, 1872)	1.50	b	–	[17],[18]
1574.	*Proalinopsis lobatus* Rodewald, 1935	1.00	o	–	[18]
1575.	*Pseudoharringia similis* Fadeev, 1925	1.60	b	–	[17]
1576.	*Ptygura beauchampi* Edmondson, 1940	1.50	o-b	–	[18]
1577.	*Ptygura brachiata* (Hudson, 1886)	3.00	a	–	[17],[18]
1578.	*Ptygura crystallina* (Ehrenberg, 1834)	2.10	b	–	[17],[18]
1579.	*Ptygura longicornis* (Davis, 1867)	1.90	b	–	[18]
1580.	*Ptygura melicerta* Ehrenberg, 1832	2.00	b	–	[17],[18]

1581.	*Ptygura mucicola* (Kellicott, 1888)	1.00	o	–	[18]
1582.	*Ptygura pilula* (Cubitt, 1872)	1.50	o-b	–	[18]
1583.	*Ptygura socialis* (Weber, 1888)	2.00	b	–	[17]
1584.	*Ptygura stygis* (Gosse, 1886)	1.50	o-b	–	[18]
1585.	*Ptygura velata* (Gosse, 1851)	1.00	o	–	[18]
1586.	*Resticula gelida* (Harring et Myers, 1922)	1.50	o-b	–	[18]
1587.	*Resticula melandocus* (Gosse, 1887)	1.00	o	–	[18]
1588.	*Resticula plicata* Wulfert, 1935	1.00	o	–	[18]
1589.	*Rhinoglena fertoeensis* (Varga, 1929)	1.10	o	–	[18]
1590.	*Rhinoglena frontalis* Ehrenberg, 1853	2.00	b	–	[18]
1591.	*Rotaria citrina* (Ehrenberg, 1838)	1.40	o-b	–	[18]
1592.	*Rotaria elongata* (Weber, 1888)	1.50	b	–	[17],[18]
1593.	*Rotaria gracilicauda* Bory de St. Vincent, 1959	1.00	o	–	[18]
1594.	*Rotaria haptica* (Gosse, 1886)	2.00	b	–	[18]
1595.	*Rotaria macroceros* (Gosse, 1851)	1.50	b	–	[17],[18]
1596.	*Rotaria macrura* (Ehrenberg, 1832)	1.90	b	–	[17],[18]
1597.	*Rotaria magnacalcarata* (Parsons, 1892)	2.00	b	–	[18]
1598.	*Rotaria neptunia* Ehrenberg, 1832)	3.80	a-p	–	[17],[18]
1599.	*Rotaria neptunoida* Harring, 1913	2.55	a	–	[17],[18]
1600.	*Rotaria quadrioculata* (Murray, 1902)	1.50	o-b	–	[18]
1601.	*Rotaria rotatoria* (Pallas, 1766)	3.25	a	–	[17],[18]
1602.	*Rotaria socialis* (Kellicott, 1888)	2.00	b	–	[18]
1603.	*Rotaria sordida* subsp. *sordida* (Western, 1893)	1.20	o	–	[17],[18]
1604.	*Rotaria tardigrada* (Ehrenberg, 1830)	2.40	p	–	[17],[18]
1605.	*Rotaria tridens* (Montet, 1915)	1.70	b-o	–	[18]
1606.	*Rotaria trisecata* (Weber, 1888)	1.90	o-b	–	[17],[18]
1607.	*Rotaria citrina* (Ehrenberg,1838)	0.90	o	–	[17]
1608.	*Scaridium longicauda* (Müller, 1786)	1.30	o	–	[17]
1609.	*Scaridium longicaudum* (Müller, 1786)	1.30	o	–	[18]
1610.	*Scepanotrocha corniculata* Bryce, 1910	1.20	o	–	[18]
1611.	*Scepanotrocha rubra* Bryce, 1910	1.10	o	–	[18]
1612.	*Sinantherina semibullata* (Thorpe, 1893)	1.20	o	–	[18]
1613.	*Sinantherina socialis* (Linnaeus, 1758)	2.00	b	–	[17],[18]
1614.	*Squatinella bifurca* (Bolton, 1884)	1.00	o	–	[18]
1615.	*Squatinella lamellaris* (Müller, 1786)	1.30	o	–	[17],[18]
1616.	*Squatinella leydigii* (Zacharias, 1886)	1.00	o	–	[18]
1617.	*Squatinella longispinata* (Tatem, 1867)	1.60	b-o	–	[18]
1618.	*Squatinella rostrum* (Schmarda, 1846)	1.00	o	–	[17],[18]
1619.	*Squatinella rostrum* subsp. *rostrum* (Schmarda, 1846)	1.00	o	–	[17],[18]
1620.	*Stephanoceros fimbriatus* (Goldfusz, 1820)	2.10	b	–	[18]
1621.	*Synchaeta grandis* Zacharias, 1893	1.40	o	–	[17],[18]
1622.	*Synchaeta kitina* Rousselet, 1902	1.40	o	–	[17],[18]
1623.	*Synchaeta longipes* Gosse, 1887	1.00	o	–	[18]
1624.	*Synchaeta oblonga* Ehrenberg, 1832	1.83	b	–	[3],[4],[8],[17],[18]
1625.	*Synchaeta pectinata* Ehrenberg, 1832	1.70	b	–	[4],[17],[18]
1626.	*Synchaeta stylata* Wierzejski, 1893	1.50	o-b	–	[3],[6],[8],[17],[18]
1627.	*Synchaeta tremula* (Müller, 1786)	1.30	o	–	[17],[18]
1628.	*Taphrocampa annulosa* Gosse, 1851	1.40	o-b	–	[18]
1629.	*Taphrocampa selenura* Gosse, 1887	1.60	b-o	–	[18]
1630.	*Testudinella aspis* Carlin, 1939	1.50	o-b	–	[18]
1631.	*Testudinella caeca* (Parsons, 1892)	2.40	b-a	–	[18]
1632.	*Testudinella clypeata* (Müller, 1786)	2.80	a	–	[18]
1633.	*Testudinella elliptica* (Ehrenberg, 1834)	2.00	b	–	[17],[18]
1634.	*Testudinella emarginula* (Stenroos, 1898)	1.40	o-b	–	[18]
1635.	*Testudinella incisa* (Ternetz, 1892)	1.30	o	–	[18]

1636.	*Testudinella mucronata* (Gosse, 1886)	1.20	o	–	[17],[18]
1637.	*Testudinella parva* (Ternetz, 1892)	1.50	o-b	–	[18]
1638.	*Testudinella parva* subsp. *bidentata* (Ternitz, 1892)	1.20	o	–	[18]
1639.	*Testudinella patina* (Hermann, 1783)	1.90	b	–	[3],[8],[17],[18]
1640.	*Testudinella patina* subsp. *patina* (Hermann, 1783)	1.90	b	–	[3],[8],[17],[18]
1641.	*Testudinella reflexa* (Gosse, 1887)	2.00	b	–	[18]
1642.	*Testudinella sphagnicola* Rudescu, 1960	1.00	o	–	[17]
1643.	*Testudinella truncata* (Gosse, 1886)	2.00	b	–	[17],[18]
1644.	*Trichocerca antilopaea* (Petr, 1891)	1.30	o	–	[18]
1645.	*Trichocerca barsica* (Varga et Dudich, 1939)	1.00	o	–	[18]
1646.	*Trichocerca bicristata* (Gosse, 1887)	1.50	b	–	[17],[18]
1647.	*Trichocerca bidens* (Lucks, 1912)	1.30	o-b	–	[18]
1648.	*Trichocerca brachyura* (Gosse, 1851)	1.00	o	–	[17],[18]
1649.	Trichocerca capucina (Wierzejski et Zacharias 1893)	1.50	o-b	–	[3],[6],[8],[17],[18]
1650.	*Trichocerca cavia* (Gosse, 1886)	1.30	o-b	–	[18]
1651.	*Trichocerca collaris* (Rousselet, 1896)	1.50	b	–	[17],[18]
1652.	*Trichocerca cylindrica* (Imhof, 1891)	1.20	o	–	[3],[6],[8],[17],[18]
1653.	*Trichocerca dixonnuttalli* (Jennings, 1903)	1.00	o	–	[17],[18]
1654.	*Trichocerca elongata* (Gosse 1886)	1.60	b	–	[3],[8],[17],[18]
1655.	*Trichocerca iernis* (Gosse, 1887)	1.50	b	–	[17],[18]
1656.	*Trichocerca inermis* (Linder, 1904)	1.30	o	–	[18]
1657.	*Trichocerca intermedia* (Stenroos, 1898)	1.40	o-b	–	[18]
1658.	*Trichocerca longiseta* (Schrank, 1802)	1.20	o	–	[17],[18]
1659.	*Trichocerca longistyla* (Olofsson, 1918)	1.00	o	–	[18]
1660.	*Trichocerca lophoessa* (Gosse, 1886)	1.50	b	–	[17],[18]
1661.	*Trichocerca macera* (Gosse, 1886)	1.00	o	–	[18]
1662.	*Trichocerca musculus* (Hauer, 1936)	1.30	o	–	[18]
1663.	*Trichocerca myersi* (Hauer, 1931)	1.00	o	–	[18]
1664.	*Trichocerca obtusidens* (Olofsson, 1918)	1.30	o	–	[18]
1665.	*Trichocerca porcellus* (Gosse, 1886)	1.20	o	–	[17],[18]
1666.	*Trichocerca pusilla* (Jennings, 1903)	1.50	b	–	[17],[18]
1667.	*Trichocerca rattus* (Müller, 1776)	1.50	b	–	[17],[18]
1668.	*Trichocerca rattus* subsp. *carinata* (Ehrenberg, 1830)	1.10	o	–	[18]
1669.	*Trichocerca rosea* (Stenroos, 1898)	1.10	o	–	[17],[18]
1670.	*Trichocerca rousseleti* (Voigt, 1902)	1.00	o	–	[17],[18]
1671.	*Trichocerca ruttneri* Donner, 1953	1.20	o	–	[18]
1672.	*Trichocerca scipio* (Gosse, 1886)	1.00	o	–	[18]
1673.	*Trichocerca sejunctipes* (Gosse, 1886)	1.10	o	–	[18]
1674.	*Trichocerca similis* (Wierzejski, 1893)	1.50	b	–	[17],[18]
1675.	*Trichocerca similis* subsp. *similis* (Wierzejski, 1893)	1.50	b	–	[17],[18]
1676.	*Trichocerca stylata* (Gosse 1851)	1.50	o-b	–	[6],[17],[18]
1677.	*Trichocerca sulcata* (Jennings, 1894)	1.10	o	–	[18]
1678.	*Trichocerca taurocephala* (Hauer, 1931)	1.00	o	–	[18]
1679.	*Trichocerca tenuior* (Gosse, 1886)	1.40	o	–	[17],[18]
1680.	*Trichocerca tigris* (Müller,1786)	1.20	o	–	[17],[18]
1681.	*Trichocerca uncinata* (Voigt, 1902)	1.00	o	–	[17],[18]
1682.	*Trichocerca vernalis* (Hauer, 1936)	1.00	o	–	[17],[18]
1683.	*Trichocerca weberi* (Jennings, 1903)	1.00	o	–	[17],[18]
1684.	*Trichotria curta* (Skorikov,1914)	1.10	o	–	[17]
1685.	*Trichotria pocillum* (Mller 1776)	1.60	b-o	–	[4],[17],[18]
1686.	*Trichotria tetractis* (Ehrenberg, 1830)	1.60	b-o	–	[17],[18]
1687.	*Trichotria tetractis* subsp. *similis* (Stenroos, 1830)	1.10	o	–	[18]
1688.	*Trichotria tetractis* subsp. *tetractis* (Ehrenberg, 1830)	1.60	o	–	[17],[18]
1689.	*Trichotria tetractus* subsp. *paupera* (Ehrenberg, 1830)	1.10	o	–	[17],[18]

1690.	*Trichotria truncata* (Whitelegge, 1889)	1.58	o	–	[3],[8],[17],[18]
1691.	*Trichotria truncata* var. *aspinosa* Rodewald, 1934	1.20	o	–	[17]
1692.	*Tripleuchlanis plicata* (Levander, 1894)	1.50	b	–	[17]
1693.	*Wierzejskiella sabulosa* (Wiszniewski, 1932)	1.00	o	–	[18]
1694.	*Wierzejskiella vagneri* Koniar, 1955	1.10	o	–	[18]
1695.	*Wierzejskiella velox* (Wiszniewski, 1932)	1.20	o	–	[18]
1696.	*Wigrella depressa* Wiszniewski, 1932	1.00	o	–	[18]
1697.	*Wolga spinifera* (Western, 1894)	1.50	b	–	[17],[18]
1698.	*Wulfertia ornata* Donner, 1943	1.00	o	–	[18]
	Tardigrada (Kingdom: Animalia)				
1699.	*Dactylobiotus ambiguus* (Murray, 1907)	-	o	–	[10]
1700.	*Dactylobiotus ampullaceus* (Thulin, 1911)	-	x-o	–	[10]
1701.	*Dactylobiotus dispar* (Murray, 1907)	-	o	–	[10]
1702.	*Dactylobiotus macronyx* (Dujardin, 1851)	-	o	–	[10]
1703.	*Diphascon scoticum* Murray, 1905	-	o	–	[10]
1704.	*Diphascon trachydorsatum* (Bartos, 1937)	-	o	–	[10]
1705.	*Hypsibius annulatus* (Murray, 1905)	-	o	–	[5]
1706.	*Hypsibius augusti* (Murray, 1907)	-	o	–	[5]
1707.	*Hypsibius convergens* (Urbanowicz, 1925)	-	o	–	[5],[10]
1708.	*Hypsibius dujardini* (Doyère, 1840)	-	o	–	[5],[10]
1709.	*Hypsibius gibbus* Marcus, 1928	-	o	–	[5]
1710.	*Hypsibius granulifer* (Thulin, 1928)	-	o	–	[5]
1711.	*Hypsibius oculatus* (Murray, 1906)	-	o	–	[5],[10]
1712.	*Hypsibius prosostomus* (Thulin, 1928)	-	o	–	[5]
1713.	*Hypsibius scoticus* (Murray, 1905)	-	o	–	[5]
1714.	*Hypsibius tetradactyloides* Richters, 1907	-	o	–	[5]
1715.	*Hypsibius trachydorsatum* Bartos, 1937	-	o	–	[5]
1716.	*Isohypsibius annulatus* (Murray, 1905)	-	o	–	[10]
1717.	*Isohypsibius gibbus* (Marcus, 1928)	-	o	–	[10]
1718.	*Isohypsibius granulifer* Thulin, 1928	-	o	–	[10]
1719.	*Isohypsibius papillifer bulbosus* (Marcus, 1928)	-	o	–	[5],[10]
1720.	*Isohypsibius prosostomus* Thulin, 1928	-	o	–	[10]
1721.	*Isohypsibius tetradactyloides* (Richters, 1907)	-	o	–	[10]
1722.	*Macrobiotus ambiguus* Murray, 1907	-	o	–	[5]
1723.	*Macrobiotus ampullaceus* Thulin, 1911	-	x-o	–	[5]
1724.	*Macrobiotus dispar* Murray, 1907	-	o	–	[5]
1725.	*Macrobiotus furciger* Murray, 1907	-	o	–	[5],[10]
1726.	*Macrobiotus hufelandi* C.A.S.Schultze, 1834	-	o	–	[5],[10]
1727.	*Macrobiotus macronyx* Dujardin, 1851	-	o	–	[5]
1728.	*Macrobiotus richtersi* Murray, 1911	-	o	–	[5],[10]
1729.	*Murrayon pullari* (Murray, 1907)	-	o	–	[5],[10]
1730.	*Pseudechiniscus tridentifer* Bartos, 1935	-	x-o	–	[5]
1731.	*Pseudechiniscus victor* (Ehrenberg, 1853)	-	x-o	–	[10]
1732.	*Thulinius augusti* (Murray, 1907)	-	o	–	[10]

It can be seen that most species-rich were Rotifera with 681 indicators (34%) and Arthropoda with 681 (34%) indicators of trophic state and organic pollution (Tab. 2, Fig. 1). These groups included more than 1362 indicator taxa of total indicators represented in table 3, which altogether is 78% of the revealed 1732 taxa-indicators. Since macroinvertebrates are widely studied and represented in water bodies, they may be sufficient to bioindicational assessment of organic pollution and trophic state of water bodies.

As a visualization example of bioindicational assessment of some water bodies' state and level of organic pollution were constructed two histograms based on table 2. Figure 2 shows species number distribution in ecological groups that placed on the x-axes in order to increasing of organic pollution or trophic state. Histogram for Class of Water Quality indicators distribution showed prevailing of two indicators groups that reflected clear and low organically polluted waters. The Class 2 indicators are of richest and followed indicators of Class 3 but both groups indicators number were between 589 and 539 taxa (Fig. 2a).

In Van Dam et al. (1994) mentioned seven indicators categories. The author noted that its category is rather qualitative (page 120). The trophic state indicators of invertebrates are representing four categories only (Fig. 2b). Table 2 represent data for each indicator taxon in category of trophic state as given in cited resources and mean that the trophic optimum of this species-indicator is in mentioned trophic state of water body. Distributions of trophic state indicators demonstrate two groups: first of which with prevailing of oligotraphentic species of invertebrates, and second one that included middle- to high-trophicity indicators of meso-eutrophic and eutrophic conditions (Fig. 2b).

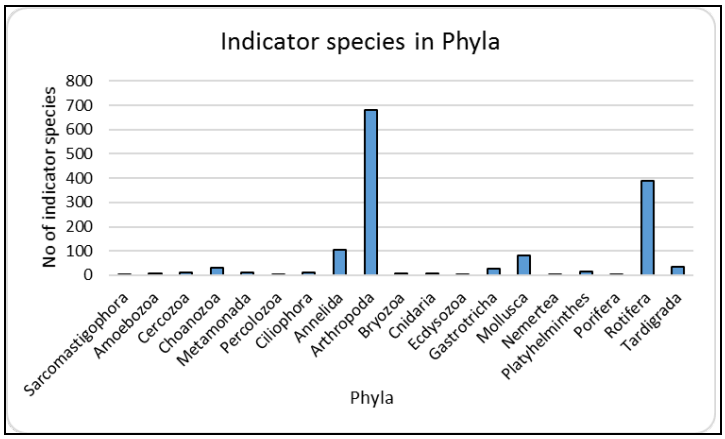


Figure 1: Distribution of number of macroinvertebrate and non-photosynthetic protists species-indicators of organic pollution and trophic state over taxonomic Phyla.

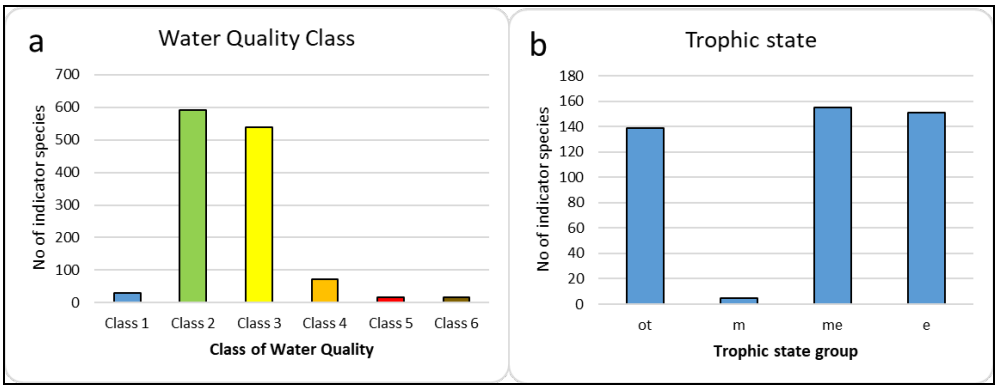


Figure 2: Distribution of number of macroinvertebrate and non-photosynthetic protists species-indicators of organic pollution over Water Quality Classes (a) and over groups of trophic state conditions (b). Ecological groups are located on the x-axis in accordance with the increase of the indicated parameter. Classes of Water Quality are toned in EU color code.

Table 3: Distribution of species-indicators of saprobity and trophic state over taxonomic Phyla of aquatic inhabitants.

Kingdom	Phylum	No. of indicator taxa
Kingdom: Protista	Sarcomastigophora	2
Kingdom: Protozoa	Amoebozoa	8
	Cercozoa	11
	Choanozoa	32
	Metamonada	10
	Percolozoa	4
Kingdom: Chromista	Ciliophora	12
Kingdom: Animalia	Annelida	104
	Arthropoda	681
	Bryozoa	9
	Cnidaria	8
	Ecdysozoa	2
	Gastrotricha	27
	Mollusca	83
	Nemertea	2
	Platyhelminthes	16
	Porifera	5
	Rotifera	681
	Tardigrada	34
Total	19	1732

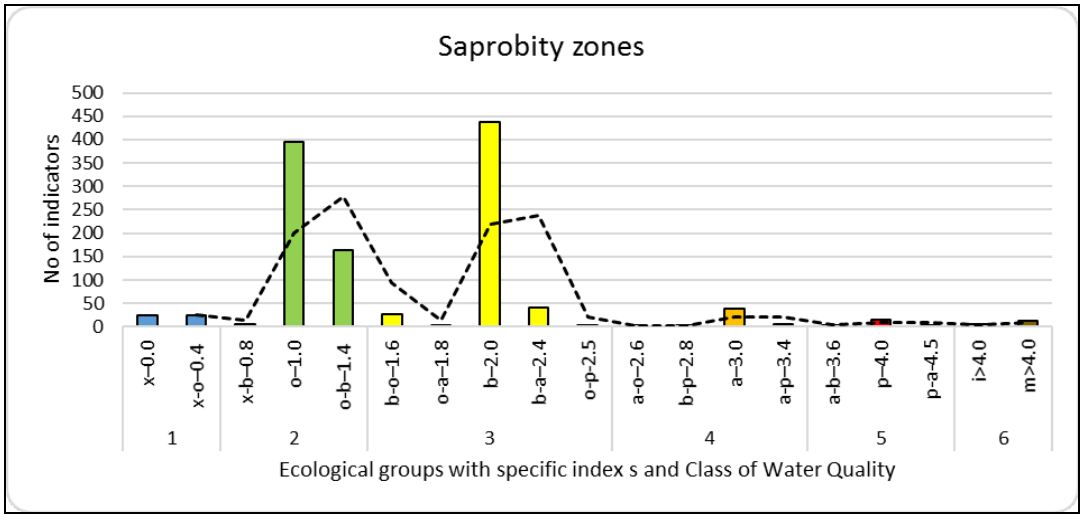


Figure 3: Distribution of number of macroinvertebrate and non-photosynthetic protists species-indicators of organic pollution over Water Quality Classes and over groups of self-purification zones. Ecological groups are located on the x-axis in accordance with the increase of the indicated parameter. Classes of Water Quality are toned in EU color code.

Collected data about macroinvertebrate and non-photosynthetic protists species-indicators of organic pollution that has species-specific index saprobity S were affiliated to six Classes of Water Quality and 19 groups of self-purification. Distribution of groups in order to increasing organic pollution is represented on figure 3. It can be seen that prevailed oligosaprobiontes and beta-mesosaprobiontes with 395 and 438 indicator-species respectively according the trend line. The large number of indicator taxa between macroinvertebrats and non-photosynthetic protists with species-specific index S can improve the assessment of organic pollution results because Index S is related to about of hundred chemical and biological variables of aquatic ecosystems (Romanenko et al., 1990; Barinova, 2017b).

CONCLUSIONS

In order to be able to determine the water quality by organic pollution, as well as assess the aquatic ecosystem trophic state we have collected the relevant ecological data from 18 references published as book, papers or electronic resource for each of the aquatic species of macroinvertebrates and non-photosynthetic protists. The list of indicators therefore includes 1732 taxa belonging to 19 Phyla. Whereas macroinvertebrates of Arthropoda and Rotifera groups prevail and demonstrated preferences of low to middle organically polluted waters Class 2 and 3 and oligo- to mesotrophic environment, the other indicator-species in invertebrates and protists preferred organically polluted waters Class of 5-6 and high trophic conditions. Collected data about organic pollution indicators with species-specific index S can be used for improvement of the system of water quality and trophic state assessment for monitoring of organic pollution in diverse continental water bodies.

ACKNOWLEDGEMENTS

We are thankful to Elena Cherniavsky for help in compilation of the database. This work was partly supported by the Israeli Ministry of Aliya and Integration.

REFERENCES

1. Abukenova V. S., Blyalova J. Z. and Shaibek A. Z., 2016 – Determination of the degree of saprobity of the Bukpa river section by indicator species of ciliates, *Bulletin of Karaganda University, Biology, Medicine, Geography*, KarSU, 3, 83, 49-57. (in Russian) [9]
2. Alyabina G. A. and Sorokin I. N., 1983 – The stock of substances in the watershed, the conditions for their implementation and entry into lakes. Changes in the "catchment-lake" system under the influence of the anthropogenic factor, L.: Nauka, 62-68. (in Russian) [2]
3. Barinova S., 2017a – Essential and practical bioindication methods and systems for the water quality assessment, *International Journal of Environmental Sciences & Natural Resources*, 2, 3, 555588, DOI: 10.19080/IJESNR.2017.02.555588.
4. Barinova S., 2017b – On the classification of water quality from an ecological point of view, *International Journal of Environmental Sciences & Natural Resources*, 2, 2, 1-8, DOI: 10.19080/IJESNR.2017.02.555581.
5. Barinova S., 2021 – Plants, mosses, charophytes, protozoan, and bacteria water quality indicators for assessment of organic pollution and trophic status of continental water bodies, *Transylvanian Review of Systematical and Ecological Research, "The Wetlands Diversity"*, 10, 17-36, DOI: 10.2478/trser-2021-0018.
6. Barinova S. and Fahima T., 2017 – The development of the World Database of Freshwater Algae-Indicators, *Journal of Environment and Ecology*, 8, 1, 1-7, http://www.macrothink.org/journal/index.php/jee/article/view/11228/8981.
7. Barinova S. S., Bilous O. P. and Tsarenko P. M., 2019 – Algal indication of water bodies in Ukraine: methods and prospects, Haifa, Kyiv, Publishing House of Haifa University, Israel, 367, https://www.academia.edu/38842519/Algal_indication_of_water_bodies_in_Ukraine_ methods and perspectives. (in Russian)

8. Barinova S. S., Medvedeva L. A. and Anissimova O. V., 2006 – Diversity of algal indicators in environmental assessment, Tel Aviv, Pilies Studio Publisher, Israel, 498, https://www.researchgate.net/publication/265251122_Diversity_of_Algal_Indicators_in_Environmental_Assessment. (in Russian)
9. Bănăduc D., Simić V., Cianfaglione K., Barinova S., Afanasyev S., Öktener A., McCall G., Simić S. and Curtean-Bănăduc A., 2022 – Freshwater as a sustainable resource and generator of secondary resources in the 21st century: stressors, threats, risks, management and protection strategies, and conservation approaches, *International Journal of Environmental Research and Public Health*, 19, 16570, 1-30, 10.3390/ijerph192416570.
10. Bănăduc D., Barinova S., Cianfaglione K. and Curtean-Bănăduc A., 2023 – Editorial: Multiple freshwater stressors – key drivers for the future of freshwater environments, *Frontiers in Environmental Science, Freshwater Science,* 11, Multiple Freshwater Stressors – Key Drivers for the Future of Freshwater Environments, DOI: 10.3389/fenvs.2023.1143706.
11. Beyene A., Addis T., Kifle D., Legesse W., Kloos H. and Triest L., 2009 – Comparative study of diatoms and macroinvertebrates as indicators of severe water pollution: Case study of the Kebena and Akaki rivers in Addis Ababa, Ethiopia, *Ecological Indicators*, 9, 2, 381-392, DOI: 10.1016/j.ecolind.2008.05.001.
12. Bezmaternykh D. M., 2007 – Zoobenthos as an indicator of the ecological state of aquatic ecosystems in Western Siberia, *Ecology*, *A series of analytical reviews of world literature*, 85, 1-86. (in Russian) [10]
13. Burger J., 2006 – Bioindicators: types, development, and use in ecological assessment and research, *Environmental Bioindicators*, 1, 1, 22-39, DOI: 10.1080/15555270590966483.
14. Cairns J. and Pratt J. R., 1993 – A history of biological monitoring using benthic macroinvertebrates, in Rosenberg D. M. and Resh V. H. (eds), Freshwater biomonitoring and benthic macroinvertebrates, New York, Chapman and Hall, New York, U.S.A., 10-27.
15. Chertoprud M. V., 2007 – Modification of the Pantle-Buck saprobity index for water bodies of European Russia, Proceedings of the International conference "Bioindication in the monitoring of freshwater ecosystems", SPb.: Lema, 298-302, DOI: 10.13140/2.1.4638.2086. (in Russian)
16. Cuffney T. F., Kennen J. G. and Waite I. R., 2014 – Aquatic ecosystems as indicators of status and trends in water quality, in Ahuja S. (ed.), Comprehensive water quality and purification, Elsevier, U.S.A., 1, 122-156.
17. Cummins K. W. and Merritt R. W., 2001 – Application of invertebrate functional groups to wetland ecosystem function and biomonitoring, in Rader R. B., Batzer D. P. and Wissinger S. A., (eds.), Bioassessment and management of North American freshwater wetlands, John Wiley and Sons, Inc., New York, U.S.A., 85-111.
18. Derevenskaya O. Y. (ed.), 2015 – Methods for assessing water quality by hydrobiological indicators: educational and methodological development for the course "Hydrobiology", Kazan, KFU, 44. (in Russian) [4]
19. Ermolaeva N. I. and Dvurechenskaya S. Y., 2013 – Regional indices of the indicator significance of zooplankton organisms in water bodies in the south of Western Siberia, *Ecology*, 6, 476-480. (in Russian) [8]
20. European Parliament, 2000 – Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for community action in the field of water policy, *Official Journal of the European Communities*, L, 327, 1-72.
21. Fennessy S., Gernes M., Mack J. and Waldrop D. H., 2001 – Methods for evaluating wetland condition: using vegetation to assess environmental conditions in wetlands, EPA 822-R-01-007j, U.S. Environmental Protection Agency, Office of Water, Washington, D.C., U.S.A.
22. Frey J. W., Bell A. H., Hambrook Berkman J. A. and Lorenz D. L., 2011 – Assessment of nutrient enrichment by use of algal-, invertebrate-, and fish-community attributes in wadeable streams in ecoregions surrounding the Great Lakes: U.S. Geological Survey Scientific Investigations Report 2011-5009, 49.

23. Friedrich G., Chapman D. and Beim A. 1996 – Chapter 5, The use of biological material, in Chapman D. (ed.), Water Quality Assessments – A guide to use of biota, sediments and water in environmental monitoring, 2_{nd} Edition, UNESCO/WHO/UNEP, London E. and Spon F. N., 626, https://apps.who.int/iris/handle/10665/41850 (assessed on 15 July 2021).
24. GBIF, 2021 –, Global Biodiversity Information Facility, https://www.gbif.org/ (assessed on 15 July 2021).
25. Golubkov S. M., Litvinchuk L. F., Golubkov M. S., Petukhov V. A. and Belyakov V. P., 2017 – Invertebrate animals and self-cleaning processes in the reservoir Sestroretsky Spill., *St. Petersburg Environment*, 28.08.2017. (in Russian) [6]
26. Guidance for the analysis of pressures and impacts in accordance with the Water Framework Directive, http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/framework_directive &vm=detailed&sb=Title&cookie=1.
27. Hegab M. H. and Khalifa N., 2021 – Applicability of using biological indices to assess water quality of the Nile branches, Egypt, *Pakistan Journal of Biological Sciences*, 24, 383-393, DOI: 10.3923/pjbs.2021.383.393.
28. Hering D., Johnson R. K., Kramm S., Schmutz S., Szoszkiewicz K. and Verdonscot P. F. M., 2006 – Assessment of European streams with diatoms, macrophytes, macroinvertebrates and fish: a comparative metric-based analysis of organism response to stress, *Freshwater Biology*, 51, 1757-1785, DOI: 10.1111/j.1365-2427.2006.01610.x.
29. Jersabek C. D. and Leitner M. F., 2013 – The Rotifer World Catalog, World Wide Web electronic publication, http://www.rotifera.hausdernatur.at/, (assessed on 24 June 2022).
30. Lasukov R. Y. 2018 – Inhabitants of reservoirs, Pocket field guide-identifier, Moscow: Ecosystem, 5th Ed., modified, 128, ISBN 978-5-4246-0268-9, Series Field guides-determinants, The middle zone of the European part of Russia, Scientific editor of the series Ph.D. Bogolyubov A. S. (in Russian) [7]
31. Lenat D. R. 1993 – A biotic index for the southeastern United States: derivations and list of tolerance values, with criteria for assigning water-quality ratings, *Journal of the North American Benthological Society*, 12, 3, 279-290.
32. Marvan P., Maršálek B., Heteša J., Sukačova K., Maršálková E., Geriš R. and Kozáková M., 2005 – Comments on the revised tables of algal (and other botanical) water quality indicators listed in CSN 75 7716 – discussion material for assessment of trophic status of water bodies, Association Flos Aquae, www.cyanobacteria.net assessed on 6th May 2005. [1]
33. Mohamad Saad Abdelkarim, 2020 – Biomonitoring and bioassessment of running water quality in developing countries: A case study from Egypt, *The Egyptian Journal of Aquatic Research*, 46, 4, 313-324.
34. Naberezhny A. I., 2007 – Species composition and distribution of rotifers in water bodies of Moldova, *Herald Hydrobiology*. (in Russian) [17]
35. Oleksiv I. T., 1992 – Indicators of the quality of natural waters from an ecological point of view, Lvov, Light, 234. (in Russian) [11]
36. Oliveira A. and Callisto M., 2010 – Benthic macroinvertebrates as bioindicators of water quality in an Atlantic forest fragment, *Iheringia Série Zoologia*, 100, 4, 291-300, DOI: 10.1590/S0073-47212010000400003.
37. Pešić V., Paunović M. and Kostianoy A. G. (eds), 2020 – The rivers of Montenegro, The handbook of environmental chemistry, Springer, Cham., 300, DOI: 10.1007/978-3-030-55712-6.
38. Petrakis P. V., Patang F., Soegianto A. and Hariyanto S. 2018 – Benthic macroinvertebrates diversity as bioindicator of water quality of some rivers in East Kalimantan, Indonesia, *International Journal of Ecology*, 5129421, DOI: 10.1155/2018/5129421.
39. Poikane S., Kelly M. and Cantonati M., 2016 – Benthic algal assessment of ecological status in European lakes and rivers: Challenges and opportunities, *Science of the Total Environment*, 568, 603-613, https://doi.org/10.1016/j.scitotenv.2016.02.027.

40. Ponti M., Vadrucci M. R., Orfanidis S. and Pinna M., 2009 – Biotic indices for ecological status of transitional water ecosystems, *Transitional Waters Bulletin*, 3, 3, 32-90, DOI: 10.1285/i1825229Xv3n3p32.
41. Romanenko V. D., Oksijuk O. P., Zhukinsky V. N., Stolberg F. V. and Lavrik V. I. 1990 – Ecological impact assessment of hydrotechnical constructions on water bodies, Kijev, Naukova Dumka, 291. (in Russian)
42. Schmidt-Kloiber A. and Hering D., 2015 – www.freshwaterecology.info – an online tool that unifies, standardises and codifies more than 20,000 European freshwater organisms and their ecological preferences, *Ecological Indicators*, DOI: 10.1016/j.ecolind.2015.02.007, freshwaterecology.info (assessed on 15 July 2021) [14].
43. Segers H., 2007 – Annotated checklist of the rotifers (Phylum Rotifera), with notes on nomenclature, taxonomy and distribution. Auckland, New Zealand, Magnolia Press, 104.
44. SEQ-water quality, 2022 – https://hmf.enseeiht.fr/travaux/CD0506/bei/bei_ere/5/html/b2/avt_proj/seq.htm (assessed on 25 June 2022).
45. Shevchenko L. B., Zelenskaya M. B. and Bezmaternykh D. M. 2007 – Zoobenthos as an indicator of the ecological state of aquatic ecosystems in Western Siberia: an analytical review, State public scientific and technical library of Siberian Branch of Russian Academy of Sciences, Institute of Water Resources and Ecological Problems, Novosibirsk, Ecology, 85, 87, ISBN 978-5-94560-142-0. (in Russian) [5]
46. Sládeček V., 1973 – System of water quality from the biological point of view, *Archiv für Hydrobiologie*, 7, 1-218.
47. Sládeček V., 1983 – Rotifers as indicators of water quality, *Hydrobiologia*, 100, 169-201. [18]
48. Abdel Gawad S. S., 2019 – Using benthic macroinvertebrates as indicators for assessment the water quality in River Nile, Egypt, *Egyptian Journal of Basic and Applied Sciences*, 6, 1, 206-219, DOI: 10.1080/2314808X.2019.1700340.
49. Tachet H., Bournaud M., Richoux P. and Usseglio-Polatera P., 2010 – Invertébrés d'eau douce – systématique, biologie, écologie, Paris, CNRS Editions, 600.
50. Unified methods for the study of water quality: part 3, 1977 – Methods of biological analysis of waters, Moscow: SEV, 1976, 168, Appendix 1, Indicators of saprobity, Moscow: Union for Mutual Economic Assistance, CMEA, 124, Appendix 2, Atlas of saprobic organisms, Moscow: Union for Mutual Economic Assistance, CMEA, 1977, 228. (in Russian) [12]
51. USEPA, United States Environmental Protection Agency, 2003 – Biological Indicators of Watershed Health, http://www.epa.gov/bioindicators (assessed on 2003-2004).
52. Uzunov I., Kosel V. and Sládeček V., 1988 – Indicator value of freshwater Oligochaeta, *Acta hydrochimica et hydrobiologica*, 16, 2, 173-186. [13]
53. Van Dam H., Mertens A. and Sinkeldam J., 1994 – A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands, *Netherlands Journal of Aquatic Ecology*, 28, 1, 117-133, DOI: 10.1007/BF02334251.
54. Water quality, 2021 – Operative evaluation of small streams biological quality by saprobity index of macroinvertebrates, http://www.eu-star.at (assessed on 15 July 2021). [16]
55. White D. S. and Brigham W. U. 1996 – Aquatic Coleoptera, in Merritt R. W. and Cummins K. W., (eds), An introduction to the aquatic insects of North America, 3rd edition. Kendall/Hunt Publishing Company, Dubuque, Iowa, U.S.A., 399-473.
56. WoRMS, World Register of Marine Species, http://www.marinespecies.org/about.php (assessed on 15 July 2021).
57. Yermolaeva N. and Dvurechenskaya S., 2016 – Developing the Regional Indicator Indexes of Zooplankton for Water Quality Class Determination of Water Bodies in Siberia, in Novel Methods for Monitoring and Managing Land and Water Resources in Siberia, 157-183, Springer, Cham. (in Russian). [3]
58. Zaghloul A., Saber M., Gadow S. and Awad F., 2020 – Biological indicators for pollution detection in terrestrial and aquatic ecosystems, *Bulletin of the National Research Centre*, 44, 127, DOI: 10.1186/s42269-020-00385-x.