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THE SYSTEM OF AQUATIC HABITATS FROM TEPLIȚA, A VITAL ELEMENT FOR CONSERVATION OF THE BIODIVERSITY OF THE UPPER CORRIDOR OF TISA RIVER

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Abstract: Protected areas are a critical aspect towards safeguarding biodiversity with impacts on climate change and carbon sequestration. This study presents the results of the analysis on the living conditions offered to aquatic birds by the aquatic habitats of ROSPA0143 Upper Tisa protected area and highlights the importance of the aquatic habitats from Teplița for the conservation of biodiversity. Teplița aquatic system registers the largest number of aquatic species (66 out of a total of 68 for the entire protected area), of species that occur only here (22), of those nesting exclusively at Teplița (36.84% of the total nesting aquatic species) as well as the largest populations of aquatic species that are important for conservation. The vegetal carpet that supports the fauna has a simplified structure due to anthropic pressures, being comprised of three types of hygrophilous habitats, but with a high degree of ruderalization. Water quality analysis reveals a slightly more basic pH value for Tisa than for the 3 lakes in the area. Also, high values of dissolved oxygen and oxygen saturation determined for Tisa and the three lakes reflect a good level of oxygenation, above the minimum of 6.5-8 mg·L^{-1} required for healthy water. In accordance to water legislation, all measured parameters (i.e., alkalinity, Na, NH_4^+, NO_2^-, NO_3^-, Cl, iron) fall within the very good, good, and moderate quality classes. Dissolved copper, however, reveals a degraded water quality for lake 3 with a concentration slightly higher than the legal limit (0.123 mg·L^{-1}).

Keywords: aquatic habitats, aquatic birds, conservation, biodiversity, protected area

1. INTRODUCTION

In recent years, the human footprint on the environment has become much more apparent, with anthropogenic activities leading to a severe deterioration of habitats and a heavy impact on biodiversity. It is clear that protected areas have an essential role in mitigating the human impact on the environment and the conservation of biodiversity (Cieplok et al., 2022, Jojić Glavonjić et al., 2019). However, they are also imperative for withstanding climate change through carbon sequestration (Anderson & Mammides, 2020, Watson et al., 2016). Nonetheless, the loss of biodiversity does not affect just one small area, it can have a bigger environmental impact especially considering the current issues regarding climate change.

The Upper Tisa Corridor follows the course of the Tisa River, for a length of about 65 km, on the northern-northwestern border of the country. The portion of approximately 55 km between the localities of Piatra and Lunca la Tisa is included in the ROSPA 0143 Upper Tisa protected area, which includes the Romanian side of the river and a large part of its meadow. The protected area was established to preserve 49 species of birds along with the habitats that ensure their survival. The majority (69.38 %) of the species included in the site sheet are totally or partially dependent on aquatic habitats, preferring still waters and their associated territories. Although they support the largest number of species in the protected area, stagnant waters of various types, lakes, ponds or dead arms, are rather poorly represented.

Water quality in lakes largely depends on the physical, chemical and biological parameters and their interaction with each other (Akhtar et al., 2021). There is a close interdependence between water quality in aquatic habitats and biodiversity (Irfan & Alatawi, 2019). When wetland habitats are healthy (filled with a variety of fauna and flora), they can function as filtering systems, removing different pollutants from water, thus creating an ecological balance (Kochi et al., 2020, Geng et al., 2021). There is a range of physical or chemical elements as well as biological processes that self-purify and restore lake waters even if a certain level of pollution has been detected (Loucif et al, 2020).

This balance can be disrupted however by the introduction of severe chemical factors such as toxic pesticides or even an oversupply of nutrients, leading to a rapid overgrowth of algae (Njagi et al., 2022) and eutrophication of freshwater ecosystems (Cvijanović et al., 2023). Wetlands are considered one of the richest ecosystems in terms of biodiversity, alongside rain forests and coral reefs (Balwan & Kour, 2022), sheltering various forms of life (i.e., fish, reptile, birds) which do influence one another. This can lead to a causal sequence with environmental impacts. Planktonic organisms are dependent on the physico-chemical conditions and, in turn, influence some of them (El-Serehi & Sleigh, 1992). While phytoplankton is an integral part of the ecosystem food web and plays a healthy part in carbon cycling, algal bloom and an overabundance of cyanobacteria can lead to severe drawbacks, such as the lack of oxygen or poor access of local fish to food (Bhateria & Jain, 2016, Stauffer et al., 2019). This, in turn, impacts local birds. Such bird species are an important parameter for the quality of the entire ecosystem. As waterfowl are easy to monitor, they have been used as a standard for the physical characteristics of water bodies (i.e. nutrient abundance or lack thereof, quantity of fish and aquatic plants) (Özgencil et al., 2020, Guevara et al., 2021, Boros et al., 2023). Nitrogen inorganic compounds, especially the non-ionized forms, NH_3, are among the major pollutants in fresh water, being physiologically harmful for aquatic animals and negatively affecting the functioning of the ecosystem (Leoni et al., 2018). Also, water quality is vital for the assessment of waterfowl habitats as some of the physico-chemical properties of water influence the primary productivity of the aquatic environment and thus affect the global biomass along the aquatic food web and, implicitly, the availability and abundance of food for these birds (Akram & Ilya, 2021, Cheng et al., 2022).

Local soil types have to also be taken into account as they are the foundation of the local ecosystem. Soil erosion surpasses the loss of fertile land, as salts and minerals from land adjacent to water bodies can influence water quality with effects on flora and fauna (Issaka & Ashraf 2017, Szpakowska et al., 2022). A continuously growing population paired with urbanization and modernization also poses severe problems in terms of wastewater discharge and other contamination of surface waters (i.e., weathering of rocks and soil processing) (Yuan et al., 2019, Karadavut et al., 2011).

In view of these, the main objective of the present work is to highlight the importance of the aquatic habitats in Teplița, within the conservation of biodiversity of the protected area and, implicitly, of the entire corridor of the Upper Tisa.

The novelty of the paper consists in a complex approach of the Teplița area considering the inventory of birds, their nesting status and also in showing the charcteristics of their habitats: vegetation and abiotic factors: soils and water quality. Until now, such an extended study in the area has not been published.

2. MATERIALS AND METHODS

2.1. Inventory of aquatic habitats and monitoring of bird species

All data was collected montly, in the February 2020 – November 2021 time period. All aquatic habitats in ROSPA0143 and its vicinity were inventoried, the conservation potential of these habitats for aquatic species was analyzed and a monitoring protocol to cover all habitats throughout the year was established.

For the monitoring of the avifauna, the recommendations formulated in "*The standard guide for monitoring bird species of community interest*" (Societatea Ornitologică Română et al., 2014) were followed and the methodology indicated for the targeted aquatic species was used. The presence and activity of aquatic species was monitored by traversing transects and by observation at points that ensured a total coverage of aquatic habitats, during weekly visits.

The following were utilized for the collection of groundwork data:

- Nikon Monarch 10x42 binoculars;
- Nikon P1000 digital camera;
- GPS Garmin Etrex Legend;
-” *Guide to bird identification”* terrain determiner (Svensson et al., 2017)
- mobile applications (WiewRanger, ObsMapp)

2.2. Water quality analysis

The analysis of water quality consisted in measurements, within the field, of some water indicators in the largest bodies of water in Teplița with the help of portable devices. The water samples were taken from the water bodies in clean polyethylene bottles. pH, electrical conductivity, and dissolved oxygen were measured directly in the water bodies using a portable Hach multiparameter instrument. Water turbidity was measured using the Hach Lange 2100 Q/DR portable turbidimeter. Hardness, alkalinity, free and total ammonia, free and total chlorine and orthophosphates were measured with the SL 1000 Hach Lange portable multiparameter. For the analysis of water indicators: hardness, alkalinity, free chlorine, total chlorine, free ammonia, total ammonia, orthophosphates standardized methods or rapid tests using Hach Lange's Chemkey tests, specific for the indicators, were used. The water analysis was carried out in September 2021. The descriptive statistics of water parameters was performed using Microsoft Excel. To identify the water bodies with the most similar composition, cluster analysis (CA) was conducted with Statgraphic program in Q-mode. CA was formulated based on the Nearest Neighbor algorithmic method. The Euclidean distances were used for measuring the distance between the water samples in the multidimensional space of parameters of water quality.

2.3. Identification of soil types

The soil types in the studied area were identified by soil profiles that were placed on parallel directions arranged transversely across the width of the protected area. The small differences in level materialize by separating the meadow area from the terrace areas of the river. At the level of the soil profiles, the pedogenetic horizons and the relationships between the parent material and the basic properties of the soil were identified (De Deyn & Kooistra 2021, Damian et al., 2010).

3. RESULTS AND DISCUSSION

3.1. Aquatic bird habitats

Following the inventory of suitable habitats, the ecosystems and habitats of interest for aquatic birdlife were identified:

- **The lotic component –** running water – is represented by the Tisa River together with the discharge segment of the main tributaries, Vișeu, Iza, Săpânța. Tisa River forms the natural border of the country along a length of about 65 km, of which a segment of about 55 km is included in the ROSPA 0143 Upper Tisa protected area. To these, small streams and, in some places, active arms with variable flow, depending on the season, are added.
- **The lentic component –** standing waters – is represented by a series of elements of natural or artificial origin, unevenly distributed within the Tisa meadow, grouped in several aquatic systems: *Aquatic habitats from Teceu, Excavation lakes from Câmpulung la Tisa, Aquatic habitats from Sarasău, Aquatic habitats from Teplița.*

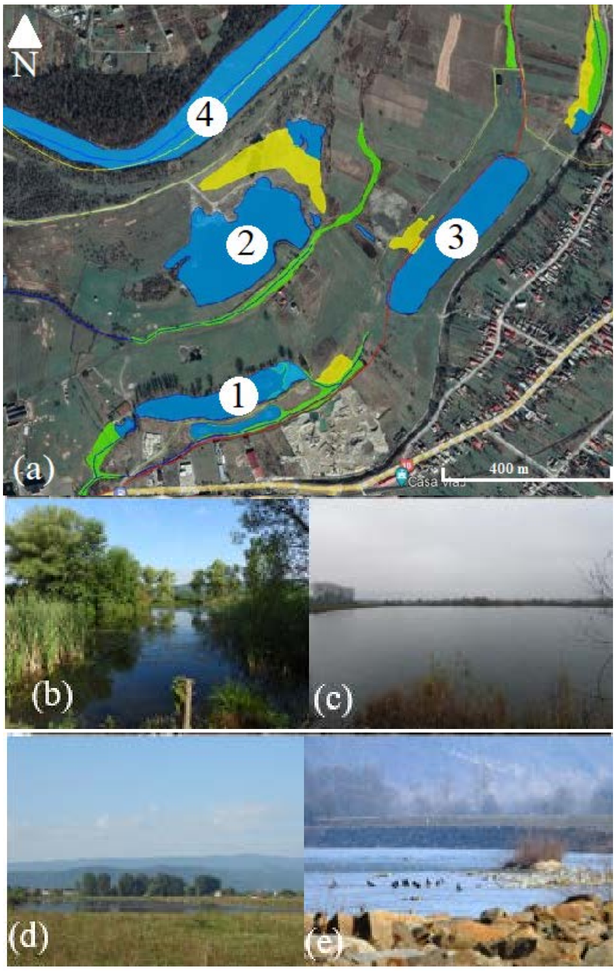

Figure 1. Location of aquatic habitats from Teplița (a), leisure lake 1 (b), excavation lake 2 (c), excavation lake 3 (d) and Tisa river (4, e) open waters, reed areas, floodable areas, blue line – streams, red line – ROSPA 0143 limit

The aquatic habitats from Teplița represent a heterogeneous mixture of aquatic habitats that includes: the Tisa River; standing water bodies, lakes and ponds; reeds, dolls; streams, ditches, canals; wet meadows; distributed over a fairly small area in the Tisa Meadow, located within the perimeter of Sighetu-Marmației and Tisa localities. In this material, the generic name Teplița (the name of the recreational lake and the stream that feeds it) is used for the entire nearby aquatic system. The aquatic system from Teplița is composed of several categories of aquatic habitats:

- **open standing waters -** a group of seven standing water bodies, lakes, ponds, naturalized or in the process of being naturalized, with a total area of approx. 16 ha, of which three larger lakes, 1 - 2.85 ha (Figure 1b); 2 - 6.58 ha (Figure 1c); 3 - 4.92 ha (Figure 1d), with the rest being smaller in size.
- **areas covered with swamp vegetation -** reeds and cattail, having a total area of approx. 4.74 ha, the largest covering areas being of 1.35 ha, and 1.29 ha respectively, the only compact reeds in the protected area.
- **low-lying land, prone to flooding -** with areas totaling approx. 4.2 ha. The existence of these lands favors the temporary appearance of swampy areas, habitats with shallow water and abundant vegetation, during periods of high rainfall.
- **Tisa River -** located nearby, with shallow water and several islands suitable for sheltering aquatic species. The location of these elements is shown in the map in Figure 1.

3.2. Vegetation in aquatic habitats

The Teplița area is heavily anthropized with most of the habitats being strongly influenced or even created by man as a secondary result of his activities. There was no concern for the development of the territory, for the conservation of vegetation and habitats. Relative to the total area, the vegetal carpet is damaged in a proportion of about 90%, while the floristic composition and the structure of the habitats are simplified from a qualitative point of view. In the Teplița analyzed territory, the following types of habitats were identified:

- **Habitat R5305,** built up by species of cattail: *Typha angustifolia*, *T. latifolia*. It is a semi-natural, isolated habitat, present on the edge of the old lake from Teplița. The floristic composition is characteristic, although the surface is restricted by systematic anthropic intervention.
- **Habitat R3709**, Danube communities with Juncus effusus, J. inflexus and Agrostis canina, having the following characteristic species: Juncus inflexus, J. effusus, Agrostis canina, Alopecurus pratensis, Rumex crispus, Festuca arundinacea, Carex hirta, Lolium perenne. This habitat, which was dominant on the surfaces between the lakes from Teplița, is currently comprised of only a few square meters, being replaced by rubble deposits.
- **Habitat 92A0**, Danubian forests of white willow (*Salix alba*) with *Rubus caesius* constitute the potential vegetation of the site and the Teplița point. Currently, it is identified only by the mini structures presented as narrow strips of no more than 1m along the canals and the river. They are shoots of willow, the vegetation being systematically removed, and currently, although the roots are old, the aerial organs of the component individuals do not exceed 2-3 years.

The qualitative analysis of the phytocenoses highlights a pauperization of the floristic composition, with only approximately 40-60% of the species that normally make up these communities being present, a strong infiltration of anthropophilic allogeneic species being observed. In these conditions, although at present, ensuring the support of the avifauna species, the maintenance of the current anthropic pressures will generate the deterioration of the phytocenoses and their replacement with ruderal plant formations, which will no longer be able to support the faunal diversity.

3.3. Water quality in Teplita area

Water quality in wetlands is an important factor for the health of aquatic habitats. Some of the physicochemical properties of water influence the aquatic primary productivity and global biomass along the aquatic food web with effects on the availability and abundance of food for birds in such habitats. (Lagos et al., 2008, Calizza et al., 2022). Polluted water due to the action of anthropogenic factors (intensive agriculture, grazing, the discharge of waste) affects aquatic habitats including the health of avian fauna. In addition, an excess of nutrients in the water leads to lake eutrophication. Lake blooms can occur where cyanobacteria that produce toxins dangerous to aquatic life can thrive (Chislock et al., 2013, Liu et al., 2021). The main indicators of the quality of standing water bodies 1-3 in the Teplița area and Tisa river, 4, are presented in Table 1. The mean values, standard deviation and coefficient of variation for water parameters were calculated. High values for the coefficient of variation were found for turbidity, nitrites, NH_3 total, free chlorine and dissolved copper. The turbidity of the 4th body water (Tisa River) was significantly higher than the turbidity values of the water bodies 1-3 due to the nature of Tisa, running water, while the water bodies 1-3 are lakes with standing waters. The other high coefficient of variation for free chlorine and dissolved Cu (high content in water body 3), nitrites and total NH_3 (water body 1) could be attributed to anthropic influences. An important water quality parameter is electrical conductivity, being employed to describe the level of salinity and is the measure of the content of minerals dissolved in water (Ustaoğlu et al., 2020). It is given by the inorganic and organic salts which ensure the mobility of the specific ions in the water by dissociation. While having a strong association with sediment, it is difficult to identify due to the transformations by evaporation (105°C) of carbonate/bicarbonate species. In the present case, low values were measured in all sampling points. The pH decreases with increasing temperature which leads to a negative effect on aquatic flora and fauna (Cyronak et al., 2020). The pH value is slightly more basic in the Tisa River than in the 3 lakes.

Turbid water, especially in the case of Tisa River, (29.61 NTU) can be a cause of concern as it can shelter a variety of pathogens and interfere with the proper disinfection of water, potentially leading to waterborne diseases (Jain et al, 2022, Latif et al., 2022). Turbidity results from the entrainment of solid particles (i.e., clay, silt, organic matter, dissolved mineral salt ions) within water (Vasistha & Ganguly, 2020). Erosion is more pronounced in regions where there are built-up zones, for agricultural land after harvesting, and less intense in areas rich in forests (Mapulanga & Naito, 2019). Turbidity can suffer variations over time within different areas with a maximum usually at the beginning of spring (Tedford et al., 2019). In the case of ROSPA0143 water bodies, water is weakly basic, well oxygenated and clear for lakes 1-3 and the Tisa River, 4.

The high values of dissolved oxygen and oxygen saturation determined in Teplița lakes 1-3 and Tisa River (sample 4) reflect a good oxygenation, necessary for the development of aquatic organisms. The concentration of dissolved oxygen in water depends on water temperature, air pressure, content in oxidizable substances and microorganisms.

Ecological stoichiometry and ionomics describe that not just the amount of a single element but a balance between elements can influence the performance of an organism (Kaspari, 2020). This is especially important in the case of the presently discussed protected area that holds such a range of biodiversity. Ammonia serves as a nutrient for plants, accelerating eutrophication in water, but chloramines are toxic to other aquatic life and are converted to nitrites and nitrates by *Nitrosomonas* and *Nitrobacter* organisms (Nemerow et al, 2009). Ammonia is the first product of the decomposition of organic matter, thus, appreciable concentrations of ammonia usually indicate fresh pollution of sanitary importance (Liu et al., 2019) the exception here would be the involvement of ammonium sulfate of mineral origin which can be removed by superchlorination (Nemerow et al, 2009).

The concentration of nitrates and nitrites in the lakes is due to the organic matter in the soil through which the water passes, coming from fertilizers, the degradation of organic waste, industrial discharges, the discharge from waste deposits and following the mineralization of nitrogenous organic substances from plants and animals (Nemerow et al, 2009).

Based on the concentrations of ammonium ions, the studied water bodies fall into the very good quality class for water body 4 (Tisa River) or good quality (lakes 1-3). Based on the concentration of nitrates, the water of lake 1 is classified as moderate quality (class III), while the water bodies 2-4 (lakes 2, 3 and Tisa River) fall into class II (good quality). Considering the concentration of nitrites, only the water body 1 was of good quality, while water bodies 2-4 fall into very good quality due to their very low nitrites content.

Salinity is another parameter that may cause concern. If salinity increases over time, wetland ecosystems may become prone to degradation, endangering local species and thus, decreasing biodiversity. Not only does excess salt within an area make water unconducive to life, it also leads to errosion of soil and the leaching of different other problematic substances within water. Availability of low salinity wetlands is especially important during the breeding seasons of waterfowl as it can affect the mortality of progenies (Schacter et al., 2021, Sibilia, et al., 2022). The analysis of water from the three lakes, 1-3, and Tisa, 4, show that sodium is within the range of 11.9-28.3 $mg \cdot L^{-1}$, way below the legal limit of 200 $mg \cdot L^{-1}$.

Iron is another variable in need of monitoring as high concentrations of iron are detrimental towards the local ecosystems. Iron can form stable complexes with dissolved organic matter, complexes that can be difficult to process by aquatic organisms (Blanchet et al., 2022). An overabundance of dissolved iron may lead to toxicity and the storage of iron within the liver (as hemosiderin) in the case of many species (Cork, 2000). For the water bodies in the ROSPA0143 Upper Tisa protected area iron levels are below the admissible limit, positioning both the three lakes and Tisa River within the very-good quality class. Copper levels were also quite low under the legal limit for Lakes 1-2 and Tisa River (sample 4), the water falling within the very good quality class. However a level of 0.123 $mg \cdot L^{-1}$ (above the 0.10 $mg \cdot L^{-1}$ admissible value) was registered for lake 3. While it is an essential element for all living organisms, copper toxicosis has been identified as a potential source of illness in waterfowl (Osofsky et al., 2001).

Table 1. Quality parameters of the main water bodies in the Teplița area

Parameters	**1**	**2**	**3**	**4**	**Mean**	**Standard deviation**	**Coeff. of variation, %**	**Legal limits L311/2004**
Electric conductivity, μS·cm^{-1}	356	331	376	223	321.5	68.2	21.2	≤ 2500
pH	7.70	7.92	8.03	8.15	7.95	0.19	2.41	6.5 ÷ 9.5
Turbidity, NTU	2.38	4.87	8.46	29.61	11.33	12.44	109.79	≤ 5
Dissolved oxygen, mg·L^{-1}	11.10	9.96	9.07	10.54	10.17	0.87	8.53	
Total Hardness, German degrees	22.6	21.2	13.6	6.01	15.85	7.66	48.33	≥ 5
Alkalinity, mg·L^{-1} $CaCO_3$	154.3	138.2	160.7	122.7	143.98	17.05	11.84	
Concentration of $NH4^+$, mg·L^{-1}	0.611	0.585	0.718	0.333	0.56	0.16	29.02	0.5
Concentration of NO_3^-, mg·L^{-1}	3.49	1.23	2.64	1.22	2.15	1.12	52.10	50
Concentration of NO_2^-, mg·L^{-1}	0.021	0	0.003	0.005	0.007	0.009	129.58	0.5
Concentration of $NH_{3\ free}$, mg·L^{-1}	0.032	0.02	0.050	0.055	0.035	0.024	68.96	
Concentration of $NH_{3\ total}$, mg·L^{-1}	2.125	0.75	0.070	0.075	0.755	0.968	128.15	0.50
Concentration of Cl^-, mg·L^{-1}	30.2	26.6	16.3	14.3	21.85	7.75	35.46	250
Concentration of Cl_{free}, mg·L^{-1}	0.01	0.04	0.37	0.022	0.11	0.17	156.96	0.10
Concentration of Cl_{total}, mg·L^{-1}	2.18	1.27	0.43	0.026	0.98	0.95	97.81	0.50
Orthophosphates, mg·L^{-1}	0.062	0.02	0.223	0.172	0.12	0.09	79.07	0.40
Dissolved iron, mg·L^{-1}	0	0.02	0.027	0.032	0.020	0.014	71.17	0.20
Dissolved copper, mg·L^{-1}	0.016	0.01	0.123	0.010	0.040	0.056	139.8	0.10
Sodium, mg·L^{-1}	11.9	27.8	28.3	17.8	21.45	7.99	37.27	200

In accordance to Water legislation no. 107/1996; where colors are assigned to the 5 classes of water quality: blue-very good quality (I); green-good quality (II); yellow-moderate quality (III); orange-satisfactory quality (IV); red-degraded quality (V)

However, the limits are relatively low in the area as to not be an immediate cause of concern. Cu content in water was relatively high for lake 3, falling into degraded quality (class V) while lakes 1-2 and Tisa River, 4, fall into very good quality with a low content of Cu. Lake 3 is surrounded by cultivated land. Thus, the Cu determined in its water has the use of fungicides or pesticides for plant protection as a possible source. Copper in water comes from natural sources such as an interaction with rocks or from pollution sources such as agricultural practice with the use of copper-based fungicides (Leonzio et al., 2009). Copper pollution of water (and generally of the environment) affects mainly the insectivorous birds (Leonzio et al., 2009).

The hardness in areas with floating vegetation is lower than in areas with clear water. Hydrology and water quality are influenced by erosion processes, land management around the water body, land changes around the water, application of chemical fertilizers or pesticides on cultivated land near the water body, discharge into the lake water of untreated domestic waters, especially when these waters contain N and P. The alkalinity of natural water originates from the soil and bedrock through which it passes especially rocks that contain carbonates, bicarbonates and hydroxide compounds (Park et al., 2018). Chlorine can come from the soil or as a result of animal or human pollution and can serve as a source of information about water pollution with industrial, communal and household waste (Javadinejad et al., 2019). Dissolution of chloride-bearing minerals from igneous rocks increases the concentration of chloride ions in lake waters in the study area (Ramachandran et al, 2020).

Phosphorus in the form of orthophosphates was present in the lake waters in concentrations of 0.08-1.13 mg·L^{-1}, not exceeding the legal limit for Teplița water bodies 1-3 and Tisa (sample 4). Considering the ortophosphate concentration, lakes 1 and 2 fall into the very good quality class while lake 3 showed a moderate quality and Tisa River (sample 4) showed a good quality of water. Above a certain level (0.5 mg·L^{-1} P) phosphates lead to the multiplication and increased development of algae (so-called water bloom) which has the effect of eutrophication of lakes. High concentrations of phosphorus, as phosphates, along with nitrates and organic carbon are often associated with heavy growth of aquatic plants, which often result in the reduction in dissolved oxygen quantities (Moloantoa et al., 2022). Even at a slight increase, phosphorous can trigger a whole chain of undesirable events, including accelerated plant growth, algal blooms, low dissolved oxygen, and the death of certain fish (Bhateria & Jain, 2016).

Free and total ammonia in surface water comes from pollution with nitrogen-based fertilizers as well as from the decomposition of organic matter (Khan et al., 2018). In the impounding water body, free and total ammonia concentrations were much higher than in Teplița Lakes 1-3 and Tisa River, 4.

Cluster analysis (Figure 2) was performed to show the similarities or differences among the water bodies based on their quality parameters. Clusters are groups of observations (in this case water bodies) with similar characteristics (quality parameters of water). The greatest similarity was found between lakes 2 and 3 which are both excavation lakes.The standing water (lakes 1-3) are linked at about the same linking distance, while Tisa River (4), a running water, is linked to the water bodies 1-3 to a higher distance showing its different nature.

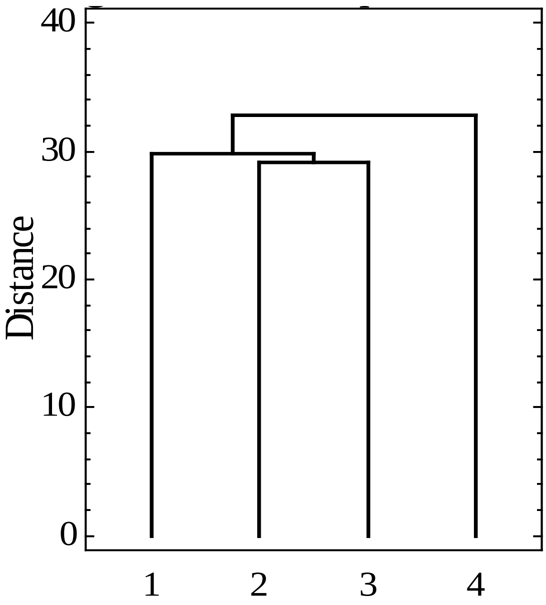

Figure 2. Cluster analysis of water bodies in Teplita area based on water quality parameters by Nearest Neighbor Method, Squared Euclidean Distance; 1, 2, 3 represent lakes 1-3 and 4 corresponds to Tisa River

3.4. Soils

3.4.1 Alluvisols

In the meadow area of the Tisa River, the lithological substrate is represented by alluvium with different grain sizes. To this, the sediment input from the flood periods that influenced the different degree of individualization of the pedogenetic horizons was added. These conditions were favorable for the formation of typical alluvial soils, which have an alternation of 2-3 lithological substrates as a C horizon. Alluvial soils in the meadow area of the Tisa River are well-drained, being moist in all seasons. The alluvial soils are present in the meadow area adjacent to the Tisa River, along the entire length from Teceu to the Tisa meadow. These soils occupy the area with natural vegetation and partially also develop in the lower terrace region with agricultural use, being specific to flat surfaces with a low slope. According to the characteristics of the horizons in the soil profiles in terms of differentiation, the degree of structuring and stability of the soil aggregates, they correspond to an early stage towards a solification environment. According to the pH values, the alluvisols fall within a wide range of values corresponding to the moderately acidic to weakly alkaline reaction classes. Meadow soils, with natural vegetation, are poor in the N, P, K main macronutrients. The low nitrogen and phosphorus supply of alluvial soils in the natural environment is due to the tendency to leach nutrients from the sand-rich soil composition.

3.4.2 Regosols

Regosols have a reduced presence, being clearly developed on coarse deposits of gravel-boulders from an area that corresponds to an old terrace along the Săpânța River, in the area of the Săpânța Peri Monastery. The low pH value places the soil in the slightly acidic reaction class.

3.4.3 Gleysols

The presence of hydric soils of the gleysol type is due to the influence of water in the water table for a long period of time. The humus is of poor quality. This type of soil develops in the meadow area between Teceu and Remeți and in the area between Săpânța and Câmpulung la Tisa, in a depressed portion of land in the lower terrace in an area covered with reed vegetation, restrictive for agriculture. According to the pH value, the soil belongs to the slightly acidic reaction class.

3.4.4. Luvisols

Luvisols were identified starting from the area located between Remeți and Săpânța, up to the area of Lunca la Tisa town. Luvisols can be found in the lower or middle terraces and in the areas of the upper terraces. Between Remeți and Săpânța. It develops on land areas representative of the upper terrace, in the region of operation of the ballast station from Câmpulung la Tisa, being represented by gelic luvosols. Starting from Săpânța area after the crossing of the Saroş River, between Săpânța and Câmpulung la Tisa, at the exit from Câmpulung la Tisa towards Sighetu Marmației in the Crăciunești area, and in the area of the town of Lunca la Tisa locality, representative of the luvisols class are the stagno-gleic luvisols. The pH value of the soil samples from the luvisol type varies from 4.47 to 5.92, which places the soil samples in the strongly acidic to moderately acidic reaction classes.

3.5. Species inventory and importance of Teplița Lake for aquatic birds

Following the analysis of all data obtained by monitoring the bird fauna in ROSPA 0143 Upper Tisa, the aquatic system from Teplița stands out as the most valuable one for the conservation of the aquatic bird fauna in the protected area. The special ornithological role of Teplița Lake is mentioned in specialized works, with many observations of rare species for this part of the country (Béres, 1990, 1997, Ardelean, 2000, Ardelean & Béres, 2000). The monitoring of aquatic birds resulted in the identification of 68 aquatic or wetland-dependent species present in suitable habitats within ROSPA 0143. The list of species, along with the location of observations and their nesting status, is presented in Table 2. As can be observed from the presented data (Table 2), the number of aquatic species recorded in Teplița far exceeds the number of species reported in the other monitored habitats. Among the 68 aquatic species identified in the ROSPA0143 perimeter, 66 species (97.05%) were recorded in Teplița. A number of 22 aquatic species were observed only within the aquatic habitats of Teplița (Figure 3), without any other signals in the protected area or in its vicinity. Of the aquatic and wetland-dependent species, most visit the protected area outside the breeding season, during passage or winter. Among the 19 species that breed in the protected area, the nesting of seven species (36.84%) was reported only in Teplița (Figure 4).

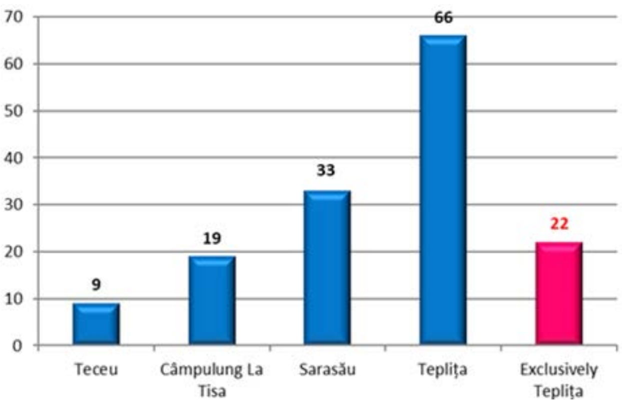

Figure 3. Number of aquatic species reported in the monitored habitats

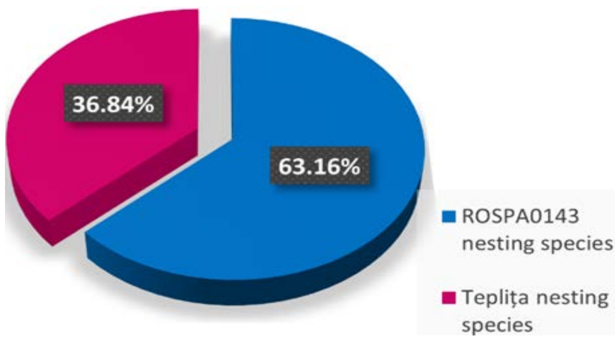

Figure 4. Ratio of the number of species nesting exclusively at Teplița compared to the total number of nesting species in the ROSPA0143 perimeter

The numbers for the common species recorded in Teplița are disproportionately high when compared to those reported outside of this perimeter. In the case of the *Fulica atra* species, out of the total of 3690 registered individuals, only three were observed in other habitats, so practically the entire population lives in Teplița.

For *Aythya ferina*, out of 994 recorded specimens, only seven were observed outside of the Teplița habitats (Sarasău, Câmpulung la Tisa). The situation is similar for most aquatic species. The overwhelming preference of aquatic species for Teplița habitats is caused by the specific characteristics of this aquatic system:

- **the presence of unique nesting habitats -** some nesting habitats sought by aquatic species that include: clumps of compact marshy vegetation bordering open water surfaces, extensive compact reed beds, can only be found within this aquatic system. The recreational lake 1 from Teplița (Figure 1) is the most populated water body in the protected area. Here, on a very small area covered with vegetation, the following species nest: *Aythya ferina, Anas platyrhynchos, Fulica atra, Gallinula chloropus, Tachybaptus ruficollis, Acrocephalus arundinaceus, Acrocephalus schoenobaenus, Rallus aquticus.* On the other water bodies, of more recent date, the nesting habitats are less than prevalent.

The location of the main categories of habitats used for reproduction in the Teplița aquatic system is shown in the map in Figure 5. The quality of the nesting habitats leaves much to be desired, but being the only ones of their kind, they are used by birds as such.

Figure 5. The main breeding habitats of aquatic species in the Teplița aquatic system. Where:

Aythya farina, Fulica atra, Anas platyrhynchos, Gallinula chloropus, Ixobrychus minutus, Rallus aquaticus

Anas platyrhynchos, Gallinula chloropus, Ixobrychus minutus, Rallus aquaticus, Acrocephalus spp.

Anas platyrhynchos, Fulica atra, Tachybaptus ruficollis, Podiceps cristatus, Acrocephalus spp.

Sterna hirundo

Table 2. Aquatic and wetland-dependent species identified in ROSPA 0143 Upper Tisa (1-Tisa River, 2-Teceu, 3-Câmpulung la Tisa, 4-Sarasău, 5 Teplița, 6,8-Exclusively Teplița, 7 – Nesting ROSPA0143)

Nr.	Species	Presence						Nesting status	
		Teplița 1-3	**Teplița 1-3 Exclusively**	**Tisa 4**	**Teceu**	**Câmpulung la Tisa**	**Sarasău**	**ROSPA0143**	**Teplița 1-3 Exclusively**
1	*Tachybaptus ruficollis,* Pallas,1764	x				x	x	x	x
2	*Podiceps cristatus,* Linnaeus,1758	x					x	x	
3	*Podiceps nigricollis,* Brehm,1831	x	x						
4	*Phalacrocorax carbo,* Linnaeus,1758	x		x		x	x		
5	*Botaurus stellaris,* Linnaeus,1758	x	x						
6	*Ixobrychus minutus,* Linnaeus,1766	x			x		x	x	
7	*Nycticorax nycticorax,* Linnaeus,1758	x					x		
8	*Ardeola ralloides,* Scopoli,1769	x	x						
9	*Egretta alba,* Linnaeus,1758	x		x		x	x		
10	*Ardea cinerea,* Linnaeus,1758	x		x	x	x	x		
11	*Ardea purpurea,* Linnaeus,1766	x					x		
12	*Ciconia nigra,* Linnaeus,1758	x		x					
13	*Ciconia ciconia,* Linnaeus,1758	x		x		x			
14	*Cygnus olor,* Gmelin,1789	x				x	x		
15	*Anser albifrons,* Scopoli,1769	x				x			
16	*Anser anser,* Linnaeus,1758	x	x						
17	*Anser fabalis,* Latham,1787	x	x						
18	*Tadorna tadorna,* Linnaeus,1758						x		
19	*Anas penelope,* Linnaeus,1758	x					x		
20	*Anas strepera,* Linnaeus,1758	x	x						
21	*Anas crecca,* Linnaeus,1758	x				x	x		
22	*Anas platyrhynchos,* Linnaeus,1758	x		x	x	x	x	x	
23	*Anas acuta,* Linnaeus,1758	x					x		
24	*Anas querquedula,* Linnaeus,1758	x					x		
25	*Anas clypeata,* Linnaeus,1758	x					x		
26	*Netta rufina* , Pallas,1773	x	x						
27	*Aythya ferina,* Linnaeus,1758	x				x	x	x	x
28	*Aythya nyroca,* Guldenstadt,1770	x	x						
29	*Aythya fuligula,* Linnaeus,1758	x	x						
30	*Bucephala clangula,* Linnaeus,1758	x	x						
31	*Mergellus albellus,* Linnaeus,1758	x	x						
32	*Mergus serrator,* Linnaeus,1758	x	x						
33	*Mergus merganser,* Linnaeus,1758	x		x		x	x	x	
34	*Circus aeruginosus,* Linnaeus,1758	x					x		
35	*Rallus aquaticus,* Linnaeus,1758	x			x		x	x	
36	*Porzana porzana,* Linnaeus,1766	x	x						
37	*Gallinula chloropus,* Linnaeus,1758	x			x		x	x	
38	*Fulica atra,* Linnaeus,1758	x					x	x	x
39	*Himantopus h.,* Linnaeus,1758	x	x						
40	*Charadrius dubius,* Scopoli,1786	x		x		x	x	x	
41	*Vanellus vanellus,* Linnaeus,1758	x				x	x		
42	*Philomachus pugnax,* Linnaeus,1758	x							
43	*Gallinago gallinago,* Linnaeus,1758	x	x						
44	*Gallinago media,* Latham,1787						x		
45	*Numenius phaeopus,* Linnaeus,1758	x	x						
46	*Tringa erythropus,* Pallas,1764	x		x					
47	*Tringa totanus,* Linnaeus,1758	x		x					
48	*Tringa nebularia,* Gunnerus,1767	x		x					
49	*Tringa ochropus,* Linnaeus,1758	x							
50	*Tringa glareola,* Linnaeus,1758	x							
51	*Actitis hypoleucos,* Linnaeus,1758	x		x		x	x	x	
52	*Larus cacchinnans,* Pallas,1811	x							
53	*Larus canus,* Linnaeus,1758	x	x						
54	*Larus minutus,* Pallas, 1776	x	x						
55	*Larus ridibundus,* Linnaeus,1766	x				x	x		
56	*Sterna hirundo,* Linnaeus,1758	x	x	x	x	x	x	x	x
57	*Sterna albifrons,* Pallas,1764	x							
58	*Chlidonias hybridus,* Pallas,1811	x		x					
59	*Chlidonias niger,* Linnaeus,1758	x							
60	*Alcedo atthis,* Linnaeus,1758	x		x	x	x	x	x	
61	*Riparia riparia,* Linnaeus,1758	x		x		x	x	x	
62	*Locustella luscinoides,* Savi,1824	x	x						
63	*Acrocephalus schoenobaenus,* Linnaeus,1758	x	x					x	x
64	*Acrocephalus palustris,* Bechstein,1798	x		x	x		x	x	
65	*Acrocephalus scirpaceus,* Hermann,1804	x	x					x	x
66	*Acrocephalus arundinaceus,* Linnaeus,1758	x					x	x	
67	*Remiz pendulinus,* Linnaeus,1758	x		x	x		x		
68	*Emberiza schoeniclus,* Linnaeus,1758	x				x		x	x
	Total	**66**	**22**	**18**	**9**	**19**	**33**	**19**	**7**

- **the heterogeneity of habitats -** represents a positive factor for supporting biodiversity. The fact that the main categories of aquatic habitats, lakes, reed beds, swamps, can be found on a fairly small area of land, favors a wider range of aquatic species with the most diverse requirements for habitat conditions.
- **the surface of the lakes -** is large enough so that birds seeking refuge on the surface of the water feel safe. This condition is not met by the other water bodies in the protected area. Added to this is the fact that on the lake 3 (Figure 1) fishing is prohibited causing much less disturbance for the birds.
- **the functioning as a „system" -** allows nearby aquatic habitats to replenish their resources. The small area and fragmentation is somewhat compensated by the small distance that separates them. The birds move from one lake to another, or sometimes to the Tisa River, depending on the season or the needs of the moment, which allowsthe efficient exploitation of the resources offered by these aquatic habitats

During the breeding season, waterfowl prefer areas near nesting habitats, on lakes 1 and 2, as well as on land near them (Figure 6). Outside this period, the birds move to the lakes 2 and 3 and to the agricultural land upstream (Figure 7). In very cold winters, the lakes freeze in turn: firstly, lake 1, along with the smaller pools, then 2, and finally 3. During the two cold seasons, within the data collection period, lake 3 remained thawed, providing shelter and food for the birds even during the coldest time of the year.

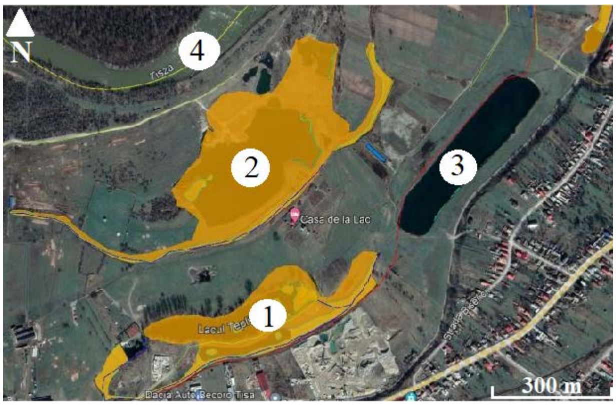

Figure 6. Area of aquatic species during the reproduction period

- **the existence of abundant food resources in the immediate vicinity -** the existence of food resources near nesting places or refuges during the passage and winter period is a condition of survival. The location of the aquatic habitats at Teplița, in close proximity to pastures and agricultural crops, is an advantage, especially for *Anas spp.*, *Anser spp.*, *Fulica atra,* which do not have to travel long distances between shelter and feeding sites.

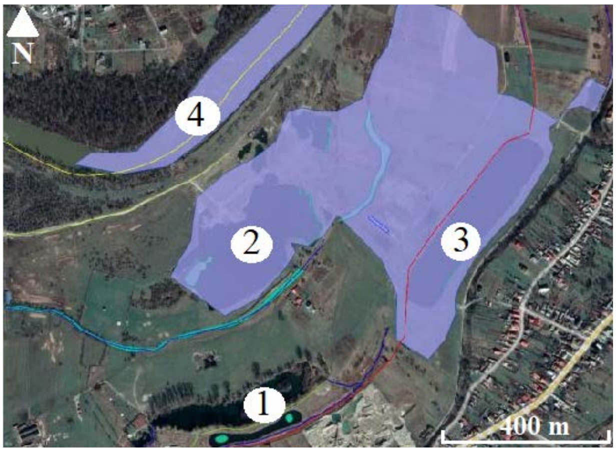

Figure 7. Area preferred by aquatic species outside of the nesting period.

3.6. Vulnerabilities

The quality of habitats leaves much to be desired throughout the upper corridor of the Tisa, a statement from which the aquatic habitats in Teplița are no exception, which leads to the existence of vulnerabilities that affect both species and habitats.

***3.6.1. The small area of habitats and their fragmentation* -** even if these habitats are large, compared to similar ones in the protected territory, their area is insufficient to provide optimal conditions of existence for most aquatic species, especially for anthropophobic ones, or those that have need for large territories. The species that thrive in these habitats are those that accept human proximity and have low demands on habitat quality: *Anas platyrhynchos, Fulica atra, Galinulla chloropus.*

***3.6.2. Populations are generally small or very small* -** from a few pairs or specimens to a few dozen, a situation valid both for nesting species and for those that pass through or winter in the area. Small and fragmented habitats cannot provide the necessary resources for large numbers of waterfowl for a long period of time and act as limiting factors for population sizes. These small populations are very vulnerable to environmental changes and are constantly threatened with extinction. The only exception is *Anas platyrhynchos* which forms, for short periods of time, aggregations of hundreds of specimens, usually in the cold season.

***3.6.3. Location* -** in a populated area, on the outskirts of the Sighetu-Marmației municipality, industrial, agricultural and tourist activity, with intense traffic, almost non-stop human presence, contribute to the increase of human pressure and lead to a decrease in the quality of habitats.

3.6.4. Anthropogenic pressures **-** the aquatic habitats in Teplița are effectively suffocated by anthropogenic pressures of the most diverse types, which endanger their very existence. Listed below are just a few, considered the most important:

- **the disappearance of habitats by filling water basins with waste and earth.** From the beginning of the data collection period until the date of writing this material, three smaller basins, with an area of about 0.7 ha near the Tisa have disappeared in this way. Given that the remaining aquatic habitats are greatly reduced compared to the minimum requirement, every loss of this kind is a catastrophe for the area's biodiversity.
- **burning vegetation.** It is a practice as widespread as it is harmful, which leads to the destruction of significant portions of the forest every year. In the case of reeds, an important resource of food and shelter for species dependent on this habitat is destroyed.
- **intensive grazing.** The permanent presence of livestock, shepherds and dogs is a constant disturbance to the area's wildlife, as well as a drastic reduction in available food resources.
- **the constructions built in the immediate vicinity of the lakes.** In addition to the obvious disturbance, they reduce the area, already far too small, of the remaining natural habitats.
- **the recreational activities on the shores of lakes**, the presence of sports fishermen, the illegal storage of waste on the shores, the clearing of riparian vegetation, the use of pesticides are just some of the elements that complete the gloomy picture of the threats to the habitats in Teplița.

4. CONCLUSIONS

The number of aquatic bird species and those dependent on wet habitats reported in the Teplița aquatic system is the highest in the protected area (66), but they are generally represented by small populations or isolated specimens, presenting a high degree of vulnerability. Among the aquatic species, a third (22) were reported only in Teplița. The aquatic habitats here house the largest part of the population for the common aquatic species, and, of the nesting species in the protected area, more than a third (36.84%) nest only in Teplița.

At this moment, the integrity of the Teplița habitats is very seriously threatened by a whole series of destabilizing anthropogenic factors, which lead to their continuous degradation. The loss of these habitats would lead to the disappearance of an important percentage of species of conservation interest and would represent an irreplaceable loss for the biodiversity of the Upper Tisa corridor.

The water quality, in terms of the monitored indicators, is good, all measured parameters falling within the very good, good and moderate water quality classes. Biodiversity in a wetland is an indicator of water quality. In waters with good quality, a greater number of bird species survive, and in polluted ones, the number of species is reduced, with only those resistant to pollution surviving.

Maintaining the aquatic system in Teplița, at least at the current level, is an absolute priority in the efforts to preserve the area's biodiversity. Efforts made to conserve the aquatic system at Telpița will bring important benefits to the community in the area by attracting tourists who can observe the birds and visit the aquatic habitats for educational purposes.

The paper is an alarm signal to public management, to local authorities and residents as well as to the scientific world in order to take urgent measures of conservation and remediation of the area until the high bird biodiversity in Teplița is not irreversibly affected.

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