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Methodological approaches in studying the diversity of algae in floodplain water bodies

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The results of algofloristic studies of reservoirs of various genesis and different stages of genesis series in the floodplains of small rivers of Kharkov and other regions of Ukraine are considered. Examples of common and rare species, representatives of different ecological–systematic groups of algae in floodplain water bodies are given. The data can be used by researchers of environmental institutions of different levels of the reserve. A brief characteristic of typological groups of reservoirs of a river floodplain is given. Methodical and methodological advices are provided for planning and conducting research on such water bodies. It is noted that it is important to select sites for collecting material in order to obtain representative data on the status of the studied water bodies, as well as to identify rare species of algae in need of protection. Habitats are listed, which should be noted during algal floristic works, as part of the general hydrobiological research. Examples are given of two types of floodplain habitat, promising from the point of view of finding rare species of algae, including new ones for the nature protection object, the region, and quite possible for science.

Key words: *floodplain water bodies, habitats, algae.*

Методологічні підходи у вивченні різноманітності водоростей заплавних водойм

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Розглядаються результати альгофлористичних досліджень водойм різного генезису і різного етапу генезисного ряду в заплавах малих річок Харківської та інших областей України. Наводяться приклади фонових і рідкісних видів, представників різних еколого-систематичних груп водоростей заплавних водойм. Дані можуть бути використані дослідниками – співробітниками природоохоронних установ різного рівня заповідання. Дана коротка характеристика типологічних груп водойм річкової заплави. Містяться методичні й методологічні поради з планування і проведення досліджень подібних водних об'єктів. Відзначається важливість вибору місць збору матеріалу з метою отримання репрезентативних даних про стан досліджуваних водойм, а також виявлення рідкісних видів водоростей, які потребують охорони. Перераховано місцезростання, на які слід звертати увагу під час альгофлористичних робіт, як складової частини загальних гідробіологічних досліджень. Як приклади наводяться описи двох типів середовища існування заплави, перспективних з точки зору пошуку раритетних видів водоростей, в тому числі нових для природоохоронного об'єкта, регіону, цілком можливо для науки.

Ключові слова: *заплавні водойми, місцезростання, водорості.*

Методологические подходы в изучении разнообразия водорослей пойменных водоемов

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Рассматриваются результаты альгофлористических исследований водоемов различного генезиса и разного этапа генезисного ряда в поймах малых рек Харьковской и других областей Украины. Приводятся примеры фоновых и редких видов, представителей разных эколого-систематических групп водорослей пойменных водоемов. Данные могут быть использованы исследователями – сотрудниками природоохранных учреждений разного уровня заповедания. Дана краткая характеристика типологических групп водоемов речной поймы. Содержатся методические и методологические советы по планированию и проведению исследований подобных водных объектов. Отмечается важность выбора мест сбора материала с целью получения репрезентативных данных о состоянии исследуемых водоемов, а также выявления редких видов водорослей, нуждающихся в охране. Перечислены местообитания, на которые следует обращать внимание в ходе альгофлористических работ, как составной части общих гидробиологических исследований. В качестве примеров приводятся описания двух типов местообитаний поймы, перспективных с точки зрения поиска раритетных видов водорослей, в том числе новых для природоохранного объекта, региона, вполне возможно для науки.

Ключевые слова: *пойменные водоемы, местообитания, водоросли.*

Introduction

Algae are an important component of the global biodiversity of the planet as the main source of organogenic oxygen necessary for life in water. This is the primary link of trophic chains in the hydrosphere, the basis of the productivity of aquatic ecosystems. Algae, in addition, are active agents of processes of self-purification of sewage, reliable indicators of the general state of water bodies.

Algae are truly aquatic plants and are not accidentally related either to the diversity of biotopes in water bodies, or to the features of water as habitat. Natural water – the habitat of algae – is a multicomponent system, active and very mobile, with numerous factors forming their chemical composition in time and space (Nikanorov, 2001). Algae have a corresponding complex of morpho–physiological adaptations that ensure existence in such a mobile environment. It is lability and adaptive plasticity that ensure the ability of representatives of various systematic groups of algae to withstand changes in hydrological regimes, eutrophication, pollution of reservoirs of all typological groups.

At the same time, algae, as an important component of biodiversity in the hydrosphere, require constant study in the system of environmental monitoring in order to:

- inventory the common species diversity of algal flora;
- study dominant forms in the composition of different groupings, the dynamics of their development by seasons and types of water bodies;
- identify rare species that require protection.

Results and discussion

The territories of the natural parks of the Kharkov region, in addition to the forest tracts as the main objects of protection, include aquatic complexes, which are parts of the valleys of small rivers of the region. The most interesting for conducting algofloristic studies in the general complex of hydrobiological works are floodplain water bodies, as a component of wetland complexes playing an exceptionally important ecological role (Directory…, 2006).

When carrying out such studies, it is necessary to take into account the peculiarities of working in the field, be familiar with methods of collecting primary material, to be able to assess the general status of a water body and to choose the algorithm of work at a particular moment in time, considering the real situation. In this paper, an attempt is made to highlight some methodological approaches to studying the diversity of algae in floodplain reservoirs.

General approaches and specific methods of collecting algological material in the field are fairly simple, do not require complex equipment, and are detailed in the literature (Algae, 1989; Dogadina et al., 2013). At the same time, several authors emphasize that often not the method, but the specific place of sampling determines the correctness of results and the validity of conclusions (Komulainen, 2001). It should also take into account the need to determine a number of abiotic indicators (temperature, pH, mineralization (or electrical conductivity) of water) directly at the time of sampling using express analyzers. To identify the most complete species and coenotic diversity of algae of the selected object (territory), all-the-year-round collections of material with sufficiently frequent repetitions are necessary depending on climatic changes (fluctuations), both seasonal and perennial.

River ecosystems are the most complex continental water bodies, and the river basin is currently defined as the main natural unit of the aquatic environment (EU Water Framework..., 2006). The most interesting for the algologist in the river system are the floodplain reservoirs, which are the result of a river erosion ravage and form a genetic series: the channel → the sleeve → the halt → the old → the lake → the swamp → the dry land. In addition, ephemeral reservoirs are characteristic of the floodplain, the number and size of which are determined by the features of the microrelief and the amount of precipitation.

Thus, the water bodies of the floodplain are extremely diverse in morphological (the size and shape of the basin, the underlying rocks, the presence and thickness of bottom sediments, the development of aquatic and coastal vegetation) and hydrological (the degree and duration of communication with the river during the flood period and low water).

In general, a complex mosaic system of biotopes is formed in the floodplain, united by a horizontal (coastline) and vertical (water column) ecotone network. The exclusive role of water-terrestrial ecotones in the formation and conservation of species and biological diversity is noted by many authors (Sharipova, 2006).

To date, there is already a certain amount of factual material, the use of which as a basis allows planning algal floristic studies of floodplain water bodies, analyzing the data obtained for a particular water body (territory), and evaluating the correctness of the results obtained.

In the late 70's – early 80's XX century algofloristic works were carried out to study the floodplain reservoirs of the valley of the middle reaches of the Seversky Donets River within the borders of Ukraine (Kharkiv, Lugansk, Donetsk regions). In the course of the survey of 267 reservoirs, the overall species composition of algal flora (668 species and intraspecific taxa) was revealed, and its distribution by systematic groups and types of waves was analyzed. It is noted that the distribution of the general species composition of algae, the intensity of phytoplankton development as a whole reflect the typological features of water bodies of one group, as well as the features of morphometry and the degree of anthropic loading of each particular water body (Dogadina, 1987).

Later, during the monitoring studies of the Gomolshansky Park, complexes of common algal species were identified. For floodplain water bodies, such a complex includes 42 taxons: *Merismopedia tenuissima* Lemm., *Characiopsis subulata* (A. Br.) Borzi, *Ophiocytium capitatum* Wolle, *Tribonema viride* Pasch., *Stephanodiscus astraea* (Ehr.) Grun., *Cyclotella meneghiniana* Kütz., *Fragilaria capucina* Desm., *Synedra acus* Kütz., *Navicula cryptocephala* Kütz. var. *veneta* (Kütz.) Grun., *N. hungarica* Grun. var. *capitata* Cl., *N. radiosa* Kütz., *Stauroneis phoenicenteron* Ehr., *Pinnularia microstauron* (Ehr.) Cl., *Cocconeis pediculus* Ehr., *Cymbella lanceolata* (Ehr.) V.H., *C. ventricosa* Kütz., *Gomphonema acuminatum* Ehr., *G. constrictum* Ehr. var. *capitatum* (Ehr.) Cl., *G. olivaceum* (Lyngb.) Kütz., *Nitzschia palea* (Kütz.) W. Sm., *N. paleacea* Grun., *N. tryblionella* Hantzsch var. *tryblionella*, *N. tryblionella* Hantzsch var. *levidensis* (W. Sm.) Grun., *Trachelomonas intermedia* Dang., *T. hispida* (Perty) Stein em. Defl., *T. volvocina* Ehr., *Euglena acus* Ehr., *E. pisciformis* Klebs, *E. proxima* Dang., *E. texta* (Duj.) Hübner, *Colacium vesiculosum* Ehr., *Chlorogonium euchlorum* Ehr., *Chlamydomonas reinhardii* Dang., *Phacotus coccifer* Korsch., *Pandorina morum* (Müll.) Bory, *Scenedesmus protuberans* Fritsch, *S. quadricauda* (Turp.) Bréb., *Cladophora glomerata* (L.) Kütz., *Oedogonium sp.*, *Spirogyra sp.*, *Mougeotia sp.* (Dogadina, Gorbulin, 1999).

In subsequent years, the geography of algal floristic research expanded and continued in the floodplains of small rivers of other regions of Ukraine (Poltava, Sumy, Chernigov, Nikolaev regions). Processing and comparative analysis of long-term data obtained in the study of water bodies in the floodplains of more than 20 rivers in 7 regions of Ukraine give reason to consider floodplain water bodies as algal diversity reserves. It is in these water bodies that the main species diversity of algae is concentrated within the region. A number of representatives of green flagellates (*Pedinomonas minor* Korsch., *Cardiomonas caeca* Korsch., *Phyllocardium complanatum* Korsch., *Spermatozopsis exultans* Korsch., *Pyramidomonas tetrarhynchus* Schmarda, *Raciborskiella uroglenoides* Swir., *Haematococcus* Buetschlii, *Chlorogonium acus* Matv., *Ch. gracile* Matv., *Ch. leiostracum* Str., *Ch. tetragamum* Bohl., *Phyllariomonas phacoides* (Korsch.) Pasch., *Ph striata* (Korsch.) Pasch., *Diplostauron angulosum* Korsch., *Furcilla quadriloba* Korsch., *Carteria dissecta* Korsch., *C. obtuse* Dill, *C. oleifera* Pasch., *C. pallida* Korsch., *C. stellate* Korsch., *Thorakomonas sabulosa* Korsch., *Dysmorphococcus coccifer* Korsch., *Pedinoperopsis gracilis* Korsch., *Pteromonas sinuosa* Chod., *Polytoma fusiforme* Korsch., *Hyalogonium acus* Pasch., *H. elongatum* Matv., *H. klebsii* Pasch. etc.), coccoid (*Actinochloris sphaerica* Korsch., *Palmellopsis gelatinosa* Korsch., *Characiochloris apiculata* Korsch., *Gloeodendron ramosa* Korsch., *Dicranochaete reniformis* Hieron., *Apiocystis brauniana* Näg. var. *linearis* (Näg) Rabenh., *A. caput-medusae*, (Bohl.) Korsch., *Tetraspora gelatinosa* (Vaucher) Desv., *T. lacustris* Lemm., *T. simplex* Korsch., *Gloeochaete wittrokiana* Lagerh. etc.), Conjugatophyceae (*Mesotaenium macrococcum* (Kütz.) Roy et Bism., *Roya anglica* G.S. West, *R. obtusa* (Bréb.) W. et G.S.West, *Spirotaenia condensata* Bréb., *Cylindrocystis brebissonii* Menegh. var. *jenneri* (Ralfs) Hansg., *Netrium interruptum* (Bréb.) Lütkem., *N. oblongum* (De Bary) Lütkem., *Gonatozygon brebissonii* De Bary, *Penium cylindrus* (Ehr.) Bréb., *P. exiquum* W. West, *P. margaritaceum* (Ehr.) Bréb., *P. spirostriolatum* Barker) algae were found in floodplain water bodies (Gorbulin, 2012).

Besides registering the general species diversity of algae and data on the out-ecology of mass and common species, the addition of the indicator of the intensity of development of species (phytoplankton abundance) can be a significant contribution to the research program. It is established that a significant part of the algal flora of different water bodies is composed of species that have low occurrence values and do not determine the “face” of the flora. At the same time, many of them are able to use optimal conditions as quickly as possible (the “outbreak” of numbers), which are formed at a particular moment in

a particular reservoir. The accumulation of such data may be of interest in two directions – the out-ecology of specific algal species and the assessment of possible outbreaks of "flowering" (Gorbulin, 2012).

The protection of algae, especially microscopic forms, has not been practically developed. Recently, scientists from different countries have come up with the idea of creating red lists or cadasters of rare algae species (Sieminska, 2006), principles and methods for protecting freshwater algae are discussed (Komulainen, 2009).

It is clear that the protection of both individual algae species and rare communities is possible only by preserving landscapes or aquatic complexes as part of nature conservation areas or objects.

Long-term experience of carrying out of algal floristic studies by the authors indicates that the search for new and rare species of algae should be carried out in biotopes, in which:

- the foci of conditions characteristic for the initial state and typological class of the reservoir are preserved;
- fundamentally new conditions are emerging;
- new buffer zones are formed with variable conditions, where one can find the types of different adaptation status.

In any case, the differentiation of biotopes of a specific study area should be carried out with an emphasis on indicators that are relevant for algae, and which can occur under certain conditions and have a different nature. As an example of the formation of such conditions, the following can be cited.

Despite the diversity of floodplain water bodies, they all depend on the hydrological characteristics of the river, especially its flood regime. Flooding, as a regular natural phenomenon, plays an important role in the formation of the regime of floodplain reservoirs and, as a consequence, in the composition of hydrobionts, including algae.

The study of the regime of some river ecosystems in a number of European countries made it possible to distinguish separate stages of the regime of flood waters (Technogenic..., 2002). From the standpoint of the hydrobiologist, the first (pre-flood) and the last (post-flood) stages are of the greatest interest in this respect. In the first, pre-flooding stage, melted waters with low electrical conductivity, weakly acid reaction (pH=4.9–5.6), low temperature, increased concentrations of nitrogen and phosphorus are formed in the floodplain. In small relief depressions, these waters form ephemeral reservoirs – spring puddles. It is in these reservoirs that rare cryophilic forms develop – representatives of golden, yellow-green, dinoflagellates and other algal divisions. Specificity of such biotopes is very short – before the flood water flow appears or, in the absence of high water (for various reasons), warming up of water and loss of its special physical condition "thawed". It was in a similar biotope in the spring of 1984 when a representative of the flagellate forms of Xanthophyta, *Chlorokardion pleurochloron* Pascher, was found in the floodplain of the Seversky Donets River in the spring of 1984. This discovery was the first after the author's description and remains the only one for the algal flora of Ukraine (Gorbulin, 2006).

Of particular interest for the researcher are also the tussock bogs, which occupy constant relief depressions. During the vegetation period (early spring – late autumn), these reservoirs pass through several stages (spring puddle → floodwater flow → semi-labor stage → transition to the marsh → typical marsh with cold acidic water), each of which is characterized by the development of both trivial and rare species specific for each stage.

Stationary algal floristic observations of such biotopes make it possible not only to reveal the composition and degree of development of trivial representatives of different ecological–systematic groups of hydrobionts, but also to make interesting finds of rare species that are new for the nature protection object, the region, perhaps for science.

Conclusions

Thus, the organization of algal floristic studies of floodplain water bodies can take place in two directions, important for the activities of environmental organizations.

1. Monitoring work on the study of composition, intensity of development, seasonal dynamics of common species. Such information is an indicator of the stability of the regime of the investigated reservoirs; it also provides a fairly representative estimate of the influence of a complex of factors, including anthropic nature.

2. Identification of rare and new species, description of biotopes, compilation of out-environmental characteristics, with the purpose of compiling red lists or inventories of rare algae species.

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