••• БОТАНІКА ТА ЕКОЛОГІЯ РОСЛИН ••• BOTANY AND PLANT ECOLOGY •••

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Ecological and biological characteristics of the green flagellates (Phytomonadina) of the continental waters of Ukraine

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The results of the analysis of original, literature, and archive data (1971–2010) on the ecology and geographical distribution of 91 taxa (88 species and 3 varieties) of Phytomonadina of the continental waters of Ukraine are presented. For each species (where data are available) there are indicated: the coefficient of occurrence and abundance in different type water bodies, the temperature, pH and saprobic index, in which the particular species was found, the degree of halophily, rheophily, the habitat, as well as the data on the geographical distribution. Autecologic evaluation is given.

Key words: *ecology, bioindication, saprobity, Phytomonadina, geography, continental waters, Ukraine.*

Эколого-биологические характеристики зеленых жгутиковых (Phytomonadina) континентальных водоемов Украины

О.С.Горбулин

Приводятся результаты анализа оригинальных, литературных и архивных данных (1971–2010) по экологии и географическому распространению 91 таксона (88 видов, 3 разновидности) Phytomonadina континентальных водоемов Украины. Для каждого вида (при наличии данных) указываются: коэффициент встречаемости и численность в разнотипных водоемах; значения температуры, pH и индекса сапробности, при которых обнаружен данный вид; степень галобности, реофильности, биотоп; а также данные о географическом распространении. Дается аутэкологическая оценка.

Ключевые слова: *экология, биоиндикация, сапробность, Phytomonadina, география, континентальные водоемы, Украина.*

Еколого-біологічні характеристики зелених джгутикових (Phytomonadina) континентальних водойм України

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Наводяться результати аналізу оригінальних, літературних і архівних даних (1971–2010) з екології і географічного поширення 91 таксона (88 видів, 3 різновиди) Phytomonadina континентальних водойм України. Для кожного виду (за наявності даних) зазначено: коефіцієнт трапляння і чисельність в різнотипних водоймах; значення температури, pH та індексу сапробності, при яких виявлений даний вид; ступінь галобності, реофільності, біотоп; а також дані про географічне поширення. Дана аутекологічна оцінка.

Ключові слова: *екологія, біоіндикація, сапробність, Phytomonadina, географія, континентальні водойми, Україна.*

Introduction

Phytomonads is the group of green flagellates, treated, until recently, in the rank of order *(*Volvocales*)* or class *(*Volvocophyceae*)* of volvocophycean algae. Extensive study of phytomonads was held in the first third of the XX century in Kharkov University by professor A.A.Korshikov. The result of his many years of work was the publication of the first issue of the native series of freshwater algae identification manuals

(Korshikov, 1938), in which for Ukraine there were cited 137 species (out of the total – 163), 82 of them being described by the author, including ones in the scope of 8 genera being new for the science. For his contribution into development of the science about algae and, in particular, «monographic studies of Volvocales in eastern Europe and the former USSR», the name of A.A.Korshikov was included into the list of outstanding phycologists of XX century (Matvienko, Dogadina, 1996).

Later, the knowledge on species composition of phytomonads in water bodies of Ukraine was supplemented in the appropriate identification manual (Dedusenko-Shchegoleva et al., 1959), which comprises data on 262 species, including 174 – in the waters of Ukraine. Continued work on the study of the green flagellates increased the number of taxa known in the flora of Ukraine to 369 species presented by 390 intraspecific taxa (Masyuk, 2003) including soil forms. Also there was conducted the taxonomic, ecological and geographical analysis of phytomonads of Ukraine (Masyuk, 2003).

Modern reclassification on molecular characteristics by the methods of cladistics not using polyphasic approach has led to the fragmentation of the group into five classes inside two divisions, to the establishment of new orders and families and to the provision of new genera, including monotype ones. However, in spite of the heterogeneity of a number of molecular features, members of the group have a significant similarity in morphological and physiological status, way of reproduction and ecology that can be seen clearly when studying natural populations. The specific characteristics of representatives of the group (especially single-celled), mainly due to the dwelling in ephemeral ponds, were pointed by A.A.Korshikov – the first monographer of the group. They are: the obligatory presence of the sexual process, which occurs even at small changes in the external environment, the ability of zygotes to dry quickly and germinate quickly, often well-developed ability to transit quickly to palmelloid state and just as quickly to return to the motile state (Korschikov, 1938, p.31).

Return to the use of the old protistology term – Phytomonadina (Ettl, 1983; Masyuk, 2003) for green flagellate algae presents, in our opinion, the evidence of commonality of members of the group and its unity. Ultrastructural detail and detail of the course of sexual process already identified and being identified under culture conditions in different strains of the same species, as well as in different species within genera and suprageneric taxa (Flora of algae of Ukraine, 2010) indicate, in our opinion, the lability and high adaptive capacity of the group.

As a result of many years of regular algofloristic study the scientists of Kharkiv University have accumulated a large amount of factual material, the treatment of which allows to complement and extend the ecological and biological characteristics of a large number of species of algae of all taxonomic groups and to assess the ecological valence of separate species.

This article is the continuation of work on the development and analysis of ecological and biological characteristics of algae of continental waters of Ukraine (Gorbulin, 2011) and is devoted to green flagellates in the modern interpretation (Ettl, 1983; Algae of Ukraine, 2011) of the group scope.

Materials and methods

As the material for the work there served both the original, including unpublished, data (1989–2010) of the study of algae of water bodies of Ukraine and published data, summarized in the latest report (Diversity of algae of Ukraine, 2000; Algae of Ukraine, 2011). In composing the specific characteristics archive data were used as well: the field expedition diaries of 1971–1988 and the protocols of treatment of living and fixed specimens done by the department professors A.M.Matvienko and T.V.Dogadina. From the above materials there were used measurements of temperature, pH and salinity, abundance counting data, as well there were taken into account the values of the occurrence of each species in different types of water bodies in all habitats (plankton, microphytobenthos, epiphyton). For a part of the archival materials we counted the rate of occurrence in cases where the material in this respect had not been processed by the authors, the coefficient was calculated by the empirical formula. The saprobic indices were calculated personally. Indicative value of Phytomonadina representatives was assessed by observing each species in the samples with known values of saprobic index, which had been calculated by the indicator forms (Algae, 1989).

Hydrochemical analyzes data were taken from laboratory journals, kindly provided to us by professor T.V.Dogadina from her personal archives. The part of the data was used in publications by other authors, most of the material never published, but was indicated by us as literature data.

In the case of coincidence of the original data with the known for water bodies of Ukraine values of abundance of certain species (Dogadina, Ilchenko, 1973; Ilchenko, Matvienko, 1969; Klochenko, 1995;

Masyuk, Lilitskaya, 1998; 2004a, b; Roll et al., 1947; Jónasson, Kristiansen, 1967) there were shown in the table the published data only.

The studies were conducted by standard methods (Algae, 1989), with the account of the special procedures, elaborated by the author of the first native identification manual for the group (Korshikov, 1938). In assessing the present geographical distribution of Phytomonadina in addition to the literature (Snitko, 2009; Temniskova-Topalova, 1975; Ettl, 1978; Dogadina et al., 2007; Jónasson, Kristiansen, 1967; Willen, 1980–1981) the international electronic database http://algaebase.org was used.

Ecological and biological characteristics of the species are written in the form proposed in the literature (Barinova et al., 2006) with some changes and additions: columns of affinity to habitat and the relationship to flow are replaced by the columns of occurrence and abundance of species in the reservoirs of various types. In assessing existing data there were used the environmental groups (Tavassi et al., 2005). The sources, in which the figures duplicate earlier publications or coincide with the original data, were not included in the reference list. In the table data from the literature are presented in boldface. For each species in the column for relevant factor, in addition to numeric data the autecology of species is given (see the note to the table). The paper does not take into account the information about findings Phytomonadina in soils.

Results and discussion

Of the total number of Phytomonadina taxa, known for the flora of Ukraine (390), 90 are permanent residents of soils (Masyuk, 2003). It suggests that the waters of Ukraine are inhabited by 300 species and varieties of green flagellates. Processing the literature shows the lack of data on the environmental and biological characteristics for approximately 100 species of phytomonads, even for more than 100 species there are available the results of single measurements of 1–2 indices only (pH or temperature), which were given by different authors, including for other countries and continents. Sufficient factual material is available for 91 taxa of phytomonads of continental waters of Ukraine (table).

In general, Phytomonadina are characterized by rather wide ecological amplitude. Being typical active plankton dwellers, phytomonads can also develop in other habitats. At the same time, the group contains typical inhabitants of benthos and the species that grow in the bottom layers of water. So, for microphytobenthos of fishponds there were indicated more than 20 species of phytomonads (Matvienko, 1956b). According to the original data, in the communities of microphytobenthos of flood waters there were common *Carteria globosa, Chlamydomonas snowiae, Gonium pectorale, Pandorina charkowiensis, P. morum, Phacotus coccifer, Pteromonas aculeata, P. angulosa.* There are known inhabitants of periphyton communities in the group – epiphytes and epizootes, information about the ecology and biology of which being very limited (Masyuk, 2003). One of the members of the group – *Chloromonas anuraeae* – was found on the shells of rotifers in a floodplain lake and in the upper portion of the reservoir Travyanskoe (Kharkiv region).

Phytomonadina are present in all types of water bodies, but they prefer small stagnant, often highly eutrophic water. It is these reservoirs that are characterized by considerable diversity and high abundance of phytomonads. Thus, at the analysis of the results of studies of phytoplankton of different types of reservoirs it was found that 14 species of phytomonads were part of the complex of dominant forms of phytoplankton of floodplain water bodies (lakes with direct human impact – organized beaches, recreational fishing water bodies with the introduction of organic matter in the form of lure fish fodder) and fish ponds; the complex of dominant phytoplankton forms in rivers Phytomonadina did not fall into. Only three species were common in the complexes of the dominant forms of phytoplankton in flood waters and fish ponds: *Carteria globosa, Pandorina morum, Phacotus coccifer* (Gorbulin, 2012).

In the literature, there are often references to the "bloom" of water, caused by various representatives of phytomonads. According to the original data and archive records cases of "bloom" (in the conventional abundance threshold of >50 million cells/L) were recorded only in ponds of various purposes (technical, biological, fish) and caused by: *Carteria klebsii, Chlamydomonas monadina, Hyalobrachion omphalotus, Pandorina morum, Pyrobotrys casinoënsis* (table).

The information on the frequency of occurrence is available for 84 taxa, including for 43 species only single measurements are available obtained during expedition surveys of reservoirs in specific region or during studies of a particular water body for a long period of time. In the literature the information on the frequency of occurrence of species of Phytomonadina is extremely rare and only the indication of class of occurrence value was given (Maystrova, 2002). Thus, with a few exceptions, the data on the frequency of occurrence are original and produced exclusively at the study of continental waters of Ukraine.

Table.

Values of ecological factors of habitats and autecology of green flagellates (Phytomonadina) of continental water bodies of Ukraine (by original and literature data)

Species	Temp., °C	Halophily	pH	Saprobity	Saprobity index	Geoelement	Coefficient of occurrence, %	Abundance, thousand cells/L
Carteria crucifera Korsch.	**11,2–23** 19,2–24,0 temp	**166–354** 279–600 hb	**5,4–7,8** 6,0–7,7 acb	**o-β**	1,33–2,33	**Ha**	1. 0,9–1,9 2. **<10**; 3,3 4. 2,3	22,2 – –
C. globosa Korsch.	**16–23** 9,0–31,0 eterm	224–1472 i	**5,6–6,0** 3,4–8,81 ind	**β** o-β	1,25–2,60	Ne	1. 1,0–39,1 2. 1,1–18,8 3. 1,0–46,0 4. 2,5–24,2	5–338 6–310 5–5918 7–1310
C. klebsii (Dang.) France	9,6–29,0 eterm	240–800 **i** 7,52–31,04 ‰	6,8–7,3 acb	**β** o-β	1,2–2,6	**k**	1. 0,9–15,5 2. 1,5–21,7 3. 1,0–25,0 4. 0,4–8,6	1,4–449 5–75 20–61715 5–79
C. multifilis (Fres.) Dill	**14,0–22,0** 18,0–26,0 temp	**238–1101** 8,17 ‰ i	**6,8–9,6** 6,0–7,9 acb	**p** **β-α**	**4** 1,33–3,3	Ha	1. 1,5–3,3 2. 1,1–16,9 4. 1,8–2,9	– – –
C. radiosa Korsch.	**16,0–23,0** temp	**166–172** 464–776 hl	**5,4–7,6** 5,5–8,5 ind	**β** **o-α**	1,25–2,33	**k**	1. 5,7–14,8 2. 0,7–2,8 4. 1,4–21,3	– – 35–1242
Chlamydomonas angulosa Dill	2,0–31,0 eterm	320–1400 i	5,6–8,81 ind	**o-α**	1,25–2,63	**Ha**	1. 1,0–17,5 2. 1,3–30,6 3. 1,5–3,0 4. 1,3–4,9	5–186 6–43 5–7995 15–648
Ch. asymmetrica Korsch.	**28,0** 14,5–20,5 temp	436–913 i	**6,9** 6,3–8,4 alb	o	0,7–1,13	Ne	1. 1,7	–
Ch. debaryana Gorosch. var. *debaryana*	**2,5–8,0** 12,0–14,5 cool	320	5,2–6,9 acb	β	1,76–2,27	Ha	1. 0,7 2. 1,3–21,7 4. 1,4	5 5–21 –
Ch. debaryana Gorosch. var. *atactogama* (Korsch.) Gerloff	**7,0–23,0** 12,0–24,2 eterm	**222–356** **i** 224–790	**5,6–8,4** 5,2–8,75 ind	o-β	1,2–2,6	**k**	1. 0,7–10,4 2. 3,0–8,7 3. 5,5 4. 2,0–10,0	11–185 6–1284 11–611 22–64
Ch. elliptica Korsch.	**4,0–26,0** 17,5–22,4 eterm	**600–900** 422 i	**6,0–8,0** 6,1–7,7 alb	o-α	0,9–3,1	k	1. 1,8–16,0 2. 3,7 3. 1,5–3,5 4. 0,8–8,8	– – – 6–113
Ch. gelatinosa Korsch.	**7,0–16,6** cool	**268–356** hb	**7,4–8,4** alb	**β-α**	**2,3**	Ne	–	–
Ch. globosa Snow	**28,0** 15,5–21,0	7,52–9,47 ‰ i?	**6,9** 5,6–7,0	**o-α**	1,25–3,3	**k**	1. 2,9–17,8 2. 1,0–39,3	– –

	temp		acb				3. 1,5–16,0 4. 1,0–20,6	– –
Ch. kuteinikowii Gorosch.	**18,0–20,0** 17,5–23,0 temp	**279–325** hb	**7,9–8,8** 5,8–6,3 ind	β	1,76–2,27	Ne	4. 2,6	–
Ch. matwienkoae Ettl	19,0–21,0 temp	436	6,2–6,3	o	0,9–1,26	Ne	1. 1,2–1,7	–
Ch. monadina Stein	**4,0–26,0** 9,6–36,0 eterm	**68–6838** **i** 162–1400	**6,0–9,6** 3,4–8,7 ind	**β** o-α	**1,83–2,13** 0,9–3,3	**k**	1. 0,9–32,1 2. 1,0–52,2 3. 1,3–33,0 4. 1,3–17,2	3–909 6–**300** 10–**263500** 5–363
Ch. nostigama Korsch.	**16,0–28,0** 18,8–21,2 temp	**68–89** 400–600 hb	**6,4–7,3** 5,8–6,2 acb	**β-α**	2,08	Ne	1. 5,0 3. 0,7 4. –	– – **400–16000**
Ch. pertyi Gorosch.	17,5–20,5 temp	224–464 hb	7,5–8,45 alb	**β-o**	1,2–2,6	Ne	1. 0,7–1,0 3. 1,3 4. 4,0	– 28–109 –
Ch. proboscigera Korsch. var. *proboscigera*	**11,2–22,0** 10,5–12,0 cool	**222–354** 400 hb	**6,8–7,8** 6,0–6,5 acb	β	1,68	Ne	1. 2,5	–
Ch. proboscigera Korsch. var. *charkowiensis* (Korsch.) Peterfi	12,0–21,5 temp	178–367 hb	5,2–7,5 acb	o-β	1,13–2,27	Ne	1. 0,7–6,0 2. 14,8	– –
Ch. proboscigera Korsch. var. *conferta* (Korsch.) Ettl	**7,0–22,0** 14,5–24,0 eterm	**222–356** 308–500 hb	**7,4–8,4** 6,3–8,81 alb	o-β	1,25–2,6	Ha	1. 1,4–28,2 2. 2,7–8,7 3. 2,0–40,6 4. 2,0–10,0	5–941 6–1284 7–1649 5–762
Ch. pseudopertusa Ettl	**11,8–22,0** 20,5–22,2 temp	**222–306** 240–512 hb	**6,0–7,8** 5,5–7,5 acb	–	–	Ne	1. 1,7 2. 4,4 3. 1,5	2–22 6 –
Ch. rattuli Korsch.	17,5–20,0 temp	216	5,5–5,8	–	–	Ne	4. 1,0	–
Ch. reinhardtii Dang.	**3,0–26,0** 2,0–31,0 eterm	**222–3960** 300–1200 i	**6,0–9,0** 3,4–8,81 ind	**β-α** **α-β** **α** o-α	**3,1** 1,25–3,3	k	1. 2,0–68,0 2. 2,0–57,0 3. 2,7–36,4 4. 5,0–28,6	4–333 5–305 12–15873 **2000–7000**; 5–1418
Ch. snowiae Printz	**5,0–27,0** 18,0–27,0 eterm	320–700 i	**7,3–8,4** 6,0–7,3 alb	**β** β-α	1,7–3,3	Ha	1. 1,0–17,8 2. 1,3–31,4 3. 1,0–5,0 4. 3,0–6,0	10–16 – – –
Ch. sphagnicola (Fritsch) Fritsch et Takeda	17,0–26,0 temp	–	5,3–6,9 acb	**o**	1,25–1,54	Ha	1. 1,0 4. 0,8–14,0	9 5–23
Chlorogonium elongatum (Dang.) Dang.	**7,0–25,4** 15,5–22,4 eterm	**222–4514** 422–900 i	**5,4–7,8** 6,0–7,2 acb	**β-α** **α** β	**2,9** 1,54–2,6	**k**	1. 0,7–27,5 2. 0,5–4,4 3. 4,7–5,4 4. –	6 5–54 11–414 **300**

Ch. euchlorum Ehrenb.	12,0–26,0 temp	240–1236 i	5,8–8,81 ind	**β-p** **α-p** o-β	**3,6** 1,25–2,44	k	1. 0,7–7,5 2. 9,3 3. 2,0–27,0 4. 10	5–31 11–21 5–2532 5–1601
Ch. fusiforme Matwienko	**11,8–23,0** 14,5–19,2 temp	**172–306** 320 hb	**5,6–7,8** 6,0–8,5 ind	**β** β-α	1,78–2,83	–	1. 0,9–25,8 2. 0,7 3. 3,0–12,2	– 10 –
Ch. maximum Skuja	18,0–21,5 temp	**68–582** i	**5,0–8,5** 3,4–6,7 ind	o	1,0–1,37	Ne	1. 1,9 4. 1,3	5–7 11–33
Ch. minimum Playfair	13,0–19,2 temp	**238–606** i	**7,4–9,6** 6,9–8,45 alb	β	1,33–1,51	Ne	1. 0,9–20 3. 2,3–4,0	– 12–386
Ch. peterhofiense Kisselew	14,0–18,3 temp	–	6,6–6,9 acb	o-β	1,25–1,63	Ha	2. 8,7 4. 0,4	22–32 –
Chloromonas anuraeae (Korsch.) Gerloff et Ettl	19,2–22,5 temp	240–256 hb	7,0–8,4 alb	–	–	Ne	2. 0,3 4. 0,8	– –
Ch. clathrata Korsch.	**16,0–23,0** 21,0 temp	600	**5,6–6,0** 5,5 acb	β	1,68	Ne	1. 0,7	15
Ch. infirma (Gerloff) Silva	14,5–21,9 temp	–	5,5–7,5 acb	o-α	0,9–3,1	Ha	1. 1,9–2,5 2. **<10**; 1,3–3,0 4. 2,0–2,5	– – 26
Ch. paradoxa Korsch.	**16,0–23,0** 14,5–21,8 temp	–	**5,6–6,0** 5,2–6,7 acb	**β-α** **α-p** β	1,7–2,6	Ne	1. 0,7–7,5 2. **<10**	– –
Ch. pseudoplatyphyncha (Pascher) Silva	**2,0–6,0** 9,6–14,5 cool	436 15,77 ‰ i	**7,2–9,0** 6,3–8,4 alb	o	0,7–1,2	Ha	1. 3,5 4. 5,9	– **1000–6300**
Ch. serbinowii Wille	**23,0–36,0** warm?	**280–386** hb	**6,4–8,4** alb	–	–	–	–	–
Ch. vulgaris (Anachin) Gerloff et Ettl	12,0–26,0 temp	436–913 i	6,8–8,4 alb	**o-β**	0,7–2,63	Ne	1. 1,4–3,5 2. 1,5–2,5 3. 2,7 4. 2,7–3,0	22 – – –
Coccomonas orbicularis Stein	**14,0**	**236–606** i	**7,0–9,6** **alb**	–	–	–	–	–
Dysmorphococcus variabilis Takeda	**11,2–28,0** 18,0–20,0 temp	**222–606** 320 i	**7,4–9,6** 6,3–6,6 alb	**β** o-β	1,1–2,15	Ha	1. – 2. 0,7 4. 0,8	**1–11** – –
Eudorina cylindrica Korsch.	**18,0–21,0** 19,0–29,0 temp	**i** 300–422	**6,8–6,9** 6,5–8,5 alb	o-α	1,25–3,3	k	1. 1,0–28,3 2. 1,3–18,0 3. 2,0–12,5 4. 1,7–4,0	90 – – 85–984
E. elegans Ehrenb.	**2,8–30,0**	**68–3960**	**5,3–9,6**	**β-α**	**1,9**	**k**	1. 0,7–28,3	**20–256**; 45–179

	8,5–29,0 eterm	**i** 30770	3,4–8,81 ind	**β** o-α	**1,85** 0,9–3,3		2. 1,0–28,6 3. 0,7–47,3 4. 1,4–30,8	91 13–2160 82–10301
E. illinoisensis (Kofoid) Pascher	**17,0–22,0** 10,25 temp	**880–980** **hl** 300–800	**6,5–6,9** 4,8–8,5 ind	**β-α** **β**	1,54–2,39	**k**	1. 0,9–8,5 3. 2,0–3,6 4. 0,8–7,1	86–679 **40300** **1000**–171
Gloeomonas mucosa (Korsch.) Ettl	**20,6–25,4** 26,5–39,0 eterm	**280–6838** i	**7,2–8,4** 7,0–8,7 alb	o-β	1,25–2,27	Ne	1. 0,7–33,9 2. 1,3–28,2 3. 10,7 4. 1,4–7,0	5 21 – –
G. ovalis Klebs	12,0–16,3 cool	–	6,6–7,0 acb	**β** o	0,7–1,1	Ne	1. 2,5–3,5 3. 2,0	12–32 –
Gonium pectorale O.F. Müller	**14,9–32,0** 10,0–25,0 eterm	**68–606** **i** 328–800	**5,4–9,6** 3,4–7,7 ind	**β-α** **α** **α-p** o-β	**3** **3,25** 1,25–2,63	**k**	1. 0,7–11,3 2. 1,1–30,4 3. 0,7–9,0 4. 1,4–10,3	**60–72**; 7–167 12–365 30–193 **170–4000**; 65–1934
G. sociale (Duj.) Warming	**2,8–23,0** 14,0–17,5 temp	**160–5200** 500 i	**5,6–9,6** 5,8–6,7 ind	**o-β** **β**	1,76–2,27	**k**	1. 1,0–1,4 2. 0,7 3. 1,0 4. 1,4	– – – –
Haematococcus pluviatilis Flotow em Wille	**28,0** 10,0–23,5 eterm	–	**6,8** 4,8–6,3 acb	**o** β	1,7–2,6	**Ha**	1. 0,7–1,0 2. 1,0 3. 1,6 4. 0,5–2,6	5 – 5–13 **200**–6
Hafniomonas reticulata (Korsch.) Ettl et Moestrup	**26,0** 19,0–23,0 temp	300	6,6–8,5 alb	o-β	1,2–2,33	Ne	1. 0,7 2. 0,5 4. –	– – **5200**
Hyalobrachion omphalotus Swindell	**22,0** 21,5–22,4 temp	**1600** 422–1200 i	**6,0** 6,0–7,7 acb	β	1,39–2,15	Ne	1. 0,7 3. 0,9	– **290900**
Lobomonas ampla Pascher	12,0–18,0 temp	–	4,8–6,6 acb	**o-α** β	1,99	Ne	1. 3,4 2. **11–50** 4. 2,6	6–447 – –
L. denticulata Korsch.	**24,5–28,0** 14,5–24,0 eterm	**264–289** 304–420 hb	5,2–7,5 acb	β	1,54–2,39	Ne	1. 1,4–7,5 2. 1,1 3. 16,1 4. 0,9	**1**–5 – – –
L. monstruosa Korsch.	16,5–26,5 temp	600–1000 i	6,0–8,55 alb	o-β	1,25–2,63	Ha	1. 0,9–6,1 2. 0,7–3,0 3. 7,8–43,3 4. 2,7–3,4	5–128 6 5–1061 5–2180
L. stellata Chodat	9,6–19,2 cool?	512	6,5–7,7 acb	**o-α** β	1,7–2,6	Ne	1. 0,7–0,9 2. 1,3–4,4	– 11
Mesostigma viride Lauterborn	19,2–22,5 temp	256	**8,0–9,0** 8,4–8,7	**o-β** **β-α**	**2,5**	Ha	2. 0,7	–

			alf	**β**				
Nephroselmis olivacea Stein	**7,0–25,0** eterm	**222–356** hb	**6,9–8,4** alb	**β-o**	–	Ne	4.–	**620**
Pandorina charkowiensis Korsch.	**4,0–26,0** 10,0–39,0 eterm	**558–900** 200–1236 i	**6,0–8,0** 3,4–8,81 ind	**β** o-α	0,9–3,1	**Ha** k	1. 1,0–52,2 2. 1,1–47,2 3. 3,0–18,7 4. 2,0–32,0	85–1743 82–1336 6–8467 90–11707
P. morum (O.F. Müll.) Bory	**2,0–48.0** 2,0–39,0 eterm	**68–3960** **i** 224–1400	**5,3–9,0** 3,4–8,81 ind	**β-o** **β** o-α	**1,83–2,64** **2,0** 0,9–3,3	**k**	1. 1,0–50,4 2. 1,5–50,0 3. 1,0–39,3 4. 2,0–47,9	**4**–1232 **1**–679 71–**175000** 47–20000
Pascherina tetras (Korsch.) Silva	**14,6–15,8** cool?	**2348–3960** i	**7,8–8,0** alb	**o-α**	–	–	–	–
Pedinomonas major Korsch.	13,0	760	6,7	β	1,68	Ne	3. 1,6	113–149
Pedinopera robusta Matwienko	15,5	900	6,0	–	–	–	2. 0,5	–
Pedinoperopsis gracilis Korsch.	20,5	324	8,45	–	–	–	2. 2,2	–
Phacotus angustus Pascher.	19,2	304	8,45	o	1,25	Ne	2. 1,1	9
Ph. coccifer Korsch.	**7,0–29,5** 9,0–39,0 eterm	**222–639** 200–1400 i	**7,0–8,6** 3,4–8,81 ind	**β-p** o-α	1,13–3,3	k	1. 0,6–49,0 2. 1,0–92,5 3. 2,5–36,0 4. 5,0–37,7	5–904 5–2808 6–25000 5–5256
Ph. lenticularis (Ehrenb.) Stein	**3,5–28,0** 19,2–24,0 eterm	**222–4514** 328 i	**7,4–9,6** 5,6–6,2 ind	**β**	**2,0** 1,37–1,99	**k**	1. 3,6 2. 1,1–7,4 3. 2,0 4. 0,8	**1–74** **1–100** – **2000–29000**
Polytoma uvella Ehrenb.	**11,2–23,0** temp	**300–354** hb	**5,6–7,6** acb	**p**	**4,0**	Ha	3. 2,7	–
Pseudocarteria peterhofiensis (Kisselew) Ettl	**12–23** 9,6–24,0 eterm	500–700 i	**6,7–7,2** 5,8–6,5 acb	**o-β** **α-β**	1,2–2,6	Ha	1. 1,7–18,3 2. 0,7 3. 0,7–11,0 4. 1,4–3,9	5–113 27 5–700 20–224
Pteromonas aculeata Lemmerm.	**7,0–26,0** 2,0–36,0 eterm	**222–356** 224–1236 i	**7,4–8,4** 5,3–8,81 ind	**β** o-α	1,25–3,3	**k**	1. 1,0–53,7 2. 1,0–27,8 3. 0,7–23,4 4. 1,0–30,8	**1–2**–113 9–204 5–1185 5–194
P. angulosa (Carter) Lemmerm.	**7,0–25,0** 9,6–26,5 eterm	**68–3344** 224–1000 i	**5,4–9,0** 4,5–8,75 ind	**β** o-α	1,20–3,3	**k**	1. 6,5–50,4 2. 1,1–26,1 3. 7,2–36,0 4. 1,4–29,5	**1**–151 **1**–154 5–737 5–1921
P. armata Skvortzow	**8,0–20,0** 19,2–22,5 temp	256–320 hb	**7,0** 8,0–8,45 alb	β	1,33–2,25	Ne	1. – 2. 1,5	**1–2** 8–11
P. chodatii Lemmerm.	14,5–20,0 temp	307–800 i	5,8–6,6 acb	β	2,01–2,27	Ne	1. 1,4–3,4 3. 2,3 4. 1,7	5–11 27–62 17–29

P. golenkiniana Pascher	**11,0–20,0** 24,0 temp	776	**6,7–6,9** 6,4 acb	–	–	–	4. 0,7	–
P. robusta Korsch.	9,6–24,0 eterm	320–1000 i	5,8–8,45 ind	o-β	1,2–2,64	k	1. 0,9–10,8 2. 1,3–17,4 3. 20,3 4. 0,9–25,2	6–178 5–42 6–180 15–594
P. sinuosa Chodat	**21,0–26,0** 18,0 temp	800 8,17 ‰ i	6,7	–	–	–	4. 2,9	–
P. torta Korsch.	**10,0–17,0** 9,6–24,0 temp	256–1400 i	**6,0–7,2** 5,6–8,81 ind	β-α	1,7–3,3	**k**	1. 2,1–50,4 2. 1,0–18,1 3. 10,0–17,2 4. 3,7–27,4	5–60 5–17 5–2057 5–2695
Pyrobotrys casinoënsis (Playfair) Silva	**9,0–22,0** 15,5–22,0 temp	**1600** 900–1400 i	**6,0** 5,8–6,5 acb	**α-p** β-α	1,67–3,3	Ha	1. 1,7–4,0 2. 7,6 3. –	– – 340–**78400**
P. incurva Arnoldi	**9,0–27,0** 19,2–20,5 eterm	300	7,7–8,45 alb	**β-o** β	1,72–2,37	Ne	2. 1,5 3. 1,5 4. 1,0	– – –
P. squarrosa (Korsch.) Korsch.	**16,0–23,0** 20,0–22,0 temp	**1600** 600 i	**5,6–6,0** 6,0–7,0 acb	β-α	2,27–3,1	Ne	1. 0,7 3. –	43 **39200**
Sphaerellopsis aulata (Pascher) Gerloff	**17,0** 18,8–20,6 temp	–	**5,4–7,2** 6,0–6,2 acb	**β** **o-α**	–	Ne	3. 2,0	–
S. fluviatilis (Stein) Pascher	19,0–23,0 temp	**238–606** i	**7,4–9,6** 6,0–8,05 alb	β	1,72–2,37	–	2. 1,5	6
S. gloeocystiformis (Dill) Gerloff	**32,0** 18,0–26,0 eterm	**68–1101** i	**6,4–9,6** 5,8–6,7 ind	β	1,76–2,27	–	3. 0,8 4. 4,3	– –
S. velata (Korsch.) Gerloff	14,5–22,2 temp	776	5,8–8,0 ind	o-β	1,25–2,27	Ne	1. 2,6–13,7 2. 0,7 3. 4,7 4. 1,4–17,0	5–196 – 5–264 15–10194
Scherffelia ovata Pascher	**11,0–22,0** 10,5–12,0 temp	**222–354** 400–670 i	**6,0–7,8** 6,0–6,5 acb	o	1,0	Ne	1. 1,7	–
Spermatozopsis exultans Korsch.	**20**	**–**	**7,0–9,0** alb	–	–	–	4. –	**420–500**
Spondylomorum quaternarium Ehrenb.	**22,0**	**1600**	**6,0**	**α** **β-α**	3,0	Ne	3. –	**15700**
Tetraselmis arnoldi (Proschk.-Lavr.) Norris et al.	**17,0–21,0** 12,0–26,0	**5584–6593** 7,52–18,84	**8,7–8,8** 5,3–8,55	β	1,7–2,6	Ne	1. 1,0–6,0 4. 0,8–4,7	5–109 5–17

	temp	‰ hl	ind					
T. cordiformis (Carter) Stein	**0,0–22,0** 17,5–23,0 eterm	**222–354** 240–464 hb	**7,4–9,0** 5,5–8,75 ind	**β-α** **β**	1,33–2,72	**Ha**	1. 0,5 2. 1,2 4. 0,8	– 14–353 **1500**
Thorakomonas irregularis Korsch.	**20,6–21,0** 23,0 temp	**558** 800 i	**7,8** 5,8 acb	o-β	1,42	Ne	3. 2,0	–
Volvox aureus Ehrenb.	**13,9–29,0** 18,0–24,0 temp	**168** **i** 320–800	**5,5–7,6** 5,6–6,9 acb	**β** **o-β**	**1,5** 1,64–2,27	**k**	1. 0,9–6,0 2. 2,2–2,9 3. 8,0–12,0 4. 1,0–7,1	– – 300 col./25 ml –
V. globator Linne	**27,0–29,0** 14,0–39,0 eterm	**162–200** 328–600 i	5,5–8,55 ind	**β** **o-β** **o-α**	**1,4** 1,76–2,54	k	1. 0,9–1,7 2. 1,0–27,8 3. 2,0–10,0 4. 1,0–2,8	– – 5 col./25 ml –
Volvulina steinii Playfair	13,0–25,5 temp	308–512 i	5,6–8,45 ind	**α-β** β	1,86–2,54	k	1. 7,5 2. 1,5 3. 5,4	– – –

Note. Literature data are shown in bold; mineralization indicated in mg/l, salinity in ‰; geoelements: a-a – arctic-alpine, b – boreal, Ha – holarctic, Ne – nemoral, k – cosmopolitan, types of water bodies: 1 – rivers, 2 – reservoirs, 3 – ponds, 4 – natural reservoirs with slow runoff; relation to temperature conditions: cool – cold-water, eterm – everytherm, temp – moderate; halobity category: hb – halophob, oh – undifferentiated oligohalob, i – oligohalob-indifferent, hl – halophil; pH-category: alf – alkaliphil, alb – alkalibiont, ind – indifferent, acb – acidobiont, acf – acidophil; "-" – not available.

Analysis of the distribution of phytomonads by classes of occurrence (Devyatkin, Mitropolskaya, 1994) was performed for 44 species with known occurrence at least in three typological groups of water bodies (see the table). In the analysis, the maximum values of the occurrence of species were taken into account, regardless of the type of water body. Almost all analyzed species were more or less evenly distributed among three classes: Class A (0–20 % incidence) – 17 species, Class B (21–40 %) – 14, Class C (41–60 %) – 11 species. Higher values of incidence were observed for two species only: Class D (61–80 %) – *Chlamydomonas reinhardtii* in rivers, Class E (81–100 %) – *Phacotus coccifer* in reservoirs.

The information about the intensity of development (abundance) of 23 species of phytomonads (table) with the reference to environmental factors (pH or temperature) is given in a number of literature sources both as groups of range (Klochenko, 1995) and specific figures for individual species (Gorbulin, 1999; Lilitskaya, 2004a; Masyuk, Lilitskaya, 1998; Roll et al., 1947; Jónasson, Kristiansen, 1967). The original data are available for 55 species, including for 18 species being the result of single observations. In the latter case, this may indicate the rarity of the species.

In general, the treatment of the data available for 87 species of phytomonads on the frequency and intensity of development in diverse reservoirs indicates the predominance of the group of limnophils (46), preferring standing water, but being also found in rivers, where, apparently, they are carried out from bayous, bays and backwaters, where phytomonads are a common component of the tychoplankton. Limnobionts (22), characteristic to the standing water only, and indifferents (19) are represented by nearly equal values among *Phytomonadina* of continental waters of Ukraine. Rheophils and reobionts are apparently absent from the group.

Of the total number of Phytomonadina identified in water bodies of Ukraine, the data sufficient to identify environmental groups with the respect to the factor of temperature, are available for 83 taxa. Most of the analyzed species are mesotherm (temp) forms (47), which prefer moderate temperatures and usually develop over a long period in open water. The group of everytherm (eterm) forms includes 28 species capable of growing in a wide temperature range from 0,0–8,0°C in winter, in pools under the ice and in the open water period in rivers and ponds, more rarely in floodplain lakes in depth (Dedusenko-Shchegoleva, 1956b; Lilitskaya, 2004a, b, c; Roll, 1938), in the lakes of tundra and forest-tundra (Dogadina, Gorbulin, 1994; Jónasson, Kristiansen, 1967; Kristiansen, Mathiesen, 1964; Willen, 1980–1981) at up to 27,0–48,0°C rarely in puddles and floodplain water bodies (Masyuk, Lilitskaya, 1998; Roll, 1926; Temniskova-Topalova, 1975; Milovanović, 1967; Woodson, Holoman, 1965), often in the cooling ponds of thermal power plants (TPP) and nuclear power plants (NPP) according to published (Vinogradskaya, 1978; Dogadina et al., 1993) and unpublished original data on Zaporizhzhya NPP.

In relation to salinity sufficient to identify the environmental group data are available for 64 species, for 17 of them – the results of single measurements only. Almost all of them are attributed to oligohalobs that coincides with the general characteristic of the group (Masyuk, 2003). The group of indifferent (i) forms includes 47 species that can live in a wide range of salinity, including brackish steppe rivers (Dedusenko-Shchegoleva, 1956a; Matvienko, 1956a), and occasionally in salty man-made lakes (Gorbulin et al., 2003). The group of halophobs (hb), preferring low-mineralized water, contains 13 species.

Sufficient amount of data to identify the environmental group in relation to pH value is available for 82 representatives of Phytomonadina*;* for 8 species – only the results of single measurements by the original data (table). The available pH values are given by different authors for different water bodies and are rarely accompanied by the data on occurrence and abundance of certain species, resulting in that at the definition of the environmental group for each species the preference was given to the original data. The most numerous group (32) were acidobionts (acb), often recorded at pH <7, but giving high values of occurrence and abundance at pH <5,5. Representative group as well (28) were indifferents (ind), species of low sensitivity, able to successfully vegetate in a wide range of pH: from 3,4–5,4 in dystrophic and oligotrophic lakes, marshes and ponds up to 8,2–9,6 in ponds, reservoirs, ephemeral ponds on different substrates (Vinogradskaya, 1978; Dedusenko-Shchegoleva, 1956b; Dogadina, Gorbulin, 1994; Matvienko, 1941; Temniskova-Topalova, 1975; Jónasson, Kristiansen, 1967; Kristiansen, 1959; Kristiansen, Mathiesen, 1964). The group of alkalibionts (alb), that prefer alkaline water (pH>7,5), included 21 species. Complete coincidence of literature and original data was noted for the species *Mesostigma viride* – the representative of alkaliphils (alf).

The data on the prevalence of Phytomonadina in small stagnant eutrophic water bodies formed the basis for the definition of the majority of the group as mesosaprobs (Korshikov, 1938). Later, the accumulation of the data on occurrence of phytomonads under highly eutrophic conditions, including sewage

(Ilchenko, Matvienko, 1969; Lenova, Stupina, 1990; Matvienko, Dogadina, 1973), allowed expanding the list of saprobic forms and clarifying their indicative value. However, the data of different authors (Barinova et al., 2006; Algae, 1989; Snitko, 2009; Ettl, 1978) contain significant variations in the assessment of the indicative value of the same species and often are not accompanied by specific numerical data. That data are generally very rarely presented in the literature (Klochenko et al., 1993), although as the indicative forms for the flora of Ukraine 85 species are indicated with their distribution by saprobic zones (Masyuk, 2003).

With the use of the available literature and original data there was carried out the comparative evaluation of the indicative value of 81 taxa of Phytomonadina occurring in Ukraine (see the table). Saprobic index data, at which the development of species was reported were obtained for 74 taxa, for 8 – from single findings, for 10 – data were not available. At that, the complete coincidence of the literature and original data on indicative values was reported for 23 species, with the account for the original data the indicative value of 23 species was adjusted and reported for the first time for 35 taxa.

Analysis of the available data on the incidence of certain species of phytomonads can allocate among Phytomonadina of the waters of Ukraine 3 geoelements: the majority were nemoral species – 37, cosmopolitan group included 25, 18 species were attributed to the holarctic geoelement. For species with a limited number of known localities the geoelement definition was provisional, for 11 species the data are not enough even for preliminary conclusions. Such species are not necessarily endemic. They can be either additors or possess ephemeral character of vegetative phase of ontogenesis that greatly complicates the discovery of such species even at targeted research of the group.

Conclusion

By processing and comparative analysis of the original, archival and published data there were compiled ecological and biological characteristics of 91 taxa of *Phytomonadina* of continental waters of Ukraine. Sufficient data for autecologic characteristics are available: for 87 species – on the typology of water bodies, for 83 – on the factor of temperature, 64 – on halobity, 82 – on the factor of pH, 81 – on saprobity, for 80 species – on geographical distribution.

Analysis of the distribution of habitats shows that the majority of Phytomonadina is plankton inhabitants, more than 20 species are typical for communities of microphytobenthos. By the typology of water bodies among 87 species limnophily predominates (46), limnobionts (22) and indifferents (19) being nearly equal, and rheophils or reobionts within the group apparently absent.

With the respect to the temperature conditions mesotherm (47) and everytherm (28) forms prevail among Phytomonadina; oligotherm group includes a small number (7) of cold-loving forms, one species is assigned to thermophils.

In relation to salinity the group is represented by oligohalobs with indifferents (47) predominated, halophobs (13) and halophiles (4) are also present.

Of the 82 species of *Phytomonadina* with sufficient information about the pH of water acidobionts are the most numerous (32), indifferents (28) and alkalibionts (21) are also present.

By the factor of saprobity it is refined the indicative value for 23, and given for the first time for 35 species of phytomonads of reservoirs of Ukraine.

In view of the recent data on the distribution in the Phytomonadina in water bodies of Ukraine there are allocated 3 geoelements: the majority is nemoral species – 37, cosmopolitan group includes 25, 18 species are referred to as the holarctic geoelement.

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