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Functional groups of algae in small shallow fishponds

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Abstract

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This study aims to analyze the seasonal changes of dominant algae in shallow fishponds by implementing for the first time in the country the concept of functional groups proposed by Reynolds et al., (2002). One hundred seventy-two taxa classified into 22 functional groups have been identified. With the largest number of species are the codons: J, X1, MP, F, Lo and W1. Results from the applied cluster analysis show that algae are grouped into four clusters. The first one consists of two homogeneous subclusters, one of which includes dominant green algae and the other – the most common cyanoprokaryotes. The second cluster consists of species with different taxonomic and functional attributes that occur throughout the whole period without strict seasonal preferences. Some taxa with large intergroup distances are differentiated into a third cluster. The fourth cluster is also heterogeneous and it consists of different functional groups. The obtained data show that this ecological approach completely tailored to the characteristics and specifics of artificial fishponds would be appropriate in the study of ecology and seasonal changes of dominant algae species.

Keywords: dominant algae; cluster analysis; shallow fishponds; functional groups

Introduction

The term ''functional groups'' adopted today is designed to group species with similar morphological and physiological features as well as those with similar ecological requirements (Reynolds et al., 2002). In the review of Padisak et al. (2009), more than 40 functional groups are described although not all of them are differentiated clear enough. Good knowledge of taxonomy and ecology of species is a must for inclusion of species among functional codons. This approach is well described in terms of habitats, environment, tolerance and trophic status compared to other systems (Reynolds, 2006; Padisak et al., 2009). In recent years, this concept is the classical and most widely used phytoplankton classification system (Salmaso et al., 2015). Groups are characterized by alpha-numeric codons distributed by blocks that show seasonal changes in algae development. The change from group A to D may be indicative of spring blooms while the change from B, E, L and N is typical of mesotrophic environment and the change from E to H is an indicator for the beginning of summer stratification. The change in direction C-G-M-P shows a process of eutrophication of ponds (Reynolds et al., 2002). An important feature of the shallow basins is that the entire surface of the bottom sediments is in constant contact with the open water phase (Padisak & Reynolds, 2003; Reynolds, 2006). According to Padisak & Reynolds (2003) some shallow water basins can be stratified similarly to the deep ones. Shallowness depends not only on the depth, but other factors such as the morphology of the ponds should be taken into account (Fonseca & Bicudo, 2008). Such water basins with organic matter resulting from agricultural activity have rich algae flora (Borics et al., 2003). The diversity of functional groups in these ecosystems is rarely a subject of research. Biodiversity in small ponds is greater than that in the large ones but this rarely attracts the attention of researchers (Borics et al., 2003). They are difficult to be examined due to the variable water balance, the smaller volume and the spatial heterogeneity due to which their knowledge and information is more limited compared to the knowledge of the large ones (Borics et al., 2003).

Research on algae in fishponds in Bulgaria has a long history and includes analysis of seasonal dynamics and structure. Detailed data on the algal flora in fishfarms is provided by Vodenicharov et al., (1974); Lüdskanova & Paskaleva (1975); Paskaleva (1975); Kiryakov et al., (1982); Paskaleva & Vodenicharov (1984), etc. The monograph published by Hadjinikolova et al., (2016) contains an extensive study of the species composition and the seasonal dynamics of algae in fishfarms in Bulgaria with different production systems. According to Michev & Stoyneva (2007), the species composition of algae found in fishponds consists of about 600 species. Stoyneva (2014) provides a critical analysis and discusses in detail the prospect of using the concept of functional groups in connection with its eventual application in the national monitoring program. Results concerning the same approach applied in large reservoirs used for aquaculture were published by Dochin (2019) and Dochin & Iliev (2019). Currently in Bulgaria there are no published data on the functional classification of algae in fishponds. This is the factor that motivates us to formulate the final aim, of this study, which, is to try to analyze the seasonal changes of dominant algae species in small shallow fishponds by using Reynolds et al., (2002) proposed environmental concept.

Materials and Methods

Sampling and analysis

The study was carried out in the experimental ponds of the Institute of fisheries and aquaculture, Plovdiv, Bulgaria. Each year cultivated species and the structure of polyculture was one and the same in all ponds. During the study in experimental ponds, common carp (*Cyprinus carpio* L.), bighead carp (*Hypophthalmichtys nobilis* Rich.) and grass carp (*Ctenopharyngodon idella* Val.) were grown.

Phytoplankton analysis

During a three-year study (2009-2011) a total of 189 phytoplankton samples were taken from 15 small and shallow (with a depth of 0.8 to 1.5 m) ponds with area (between 0.18 to 0.40 ha) with a total area of 4.39 ha (Figure 1). The sampling was conducted at the depth of 0.5 m twice a month from May to September. The water samples for analysis of phytoplankton were collected and processed by standard methods of fixation with formalin to final concentration 4% and further sedimentation (ISO 5667-1:2006/AC:2007; ISO 5667-3:2003/AC:2007). Microscope work has been done on

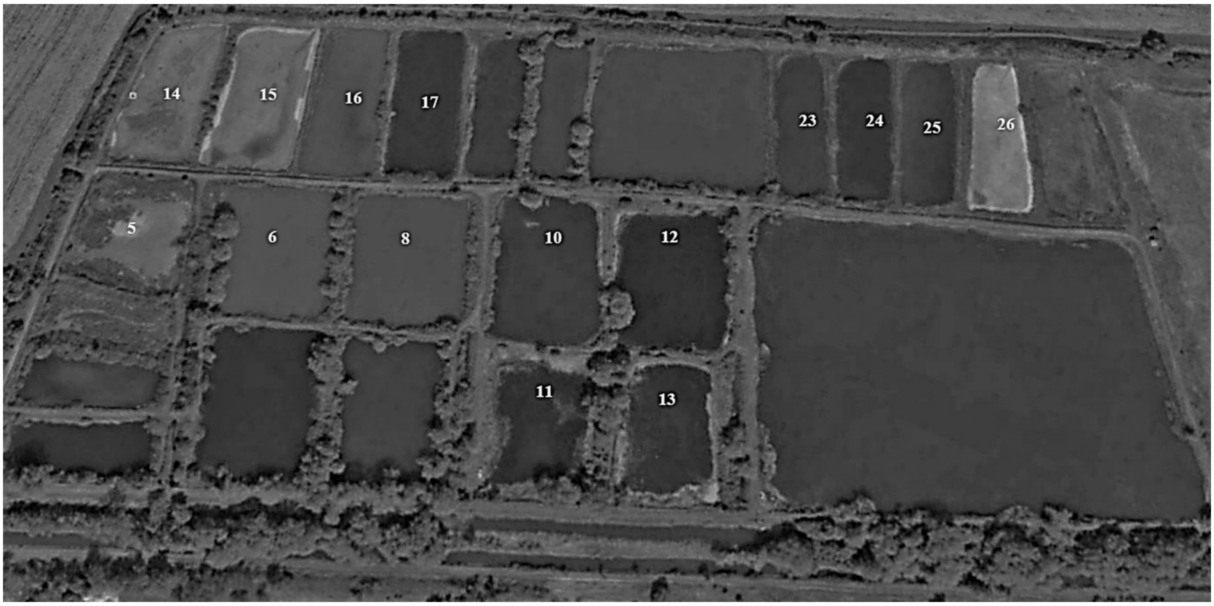

Fig. 1. Satellite map of the examined ponds

Bürker chamber (Laugaste, 1974). The species composition was determined by light microscope (Carl Zeiss, Axioscope 2 plus) with magnification 400x using standard taxonomic literature with critical use of AlgaeBase (Guiry & Guiry, 2019). Diatoms were identified after Cox (1996). The main counting unit was the cell and the biomass was estimated by the method of stereometrical approximations (Rott, 1981; Deisinger, 1984). Counting is carried out individually (cell, filament or colony). The total biomass of each sample was assessed and it was defined as the amount of biomass of all species summarized in separate taxonomic groups. Phytoplankton functional groups were identified according to Reynolds et al., (2002); Padisak et al., (2009) and Borics et al., (2016).

Statistical analysis

Statistical analysis was performed with SPSS 19 (IBM analytical). A hierarchical cluster analysis (Durant & Odelle, 1977; Ward, 1963) a multivariate technique was used to group phytoplankton dominant species and functional groups. The Euclidean distance was used as a measure of similarity. The clusterization results were plotted by a dendrogram showing the cluster formation and the distance between groups.

Results and Discussion

A total of 172 taxa of plankton algae from the following groups were found during the study: Cyanoprokaryota (27), Chlorophyta (71), Streptophyta (13), Euglenophyta (14), Pyrrhophyta (2) and 45 of Ochrophyta (Eustigmatophyceae 5; Synurophyceae 1; Bacillariophyceae 39, Table 1). The identified phytoplankton species are classified according to the concept proposed by Reynolds et al., (2002) in 22 functional groups: B, C, D, E, F, G, H1, J, S1, S2, TC, TD, W1, W2, X1 and X2 (Table 1). Six of the codons are represented by the largest species: J (25), X1 (25), MP (21), F (19), Lo (11) and W1 (11). Species belonging to the most massive functional groups are 112 which are 65% of all species found in experimental ponds during the study period.

Representatives of the following functional groups were found in May: D; F; J; Lo; MP; P; TC; W1; W2. Dominant species are *Oscillatoria limosa* C. Agardh ex Gomont (T_C), *Desmodesmus protuberans* (F. E. Fritsch & M. F. Rich) E. Hegewald (J) and *Ulnaria ulna* (Nitzsch) Compère of functional group D. In June the dominant phytoplankton species were classified in the functional codons: C; F; G; H1; J; Lo; MP; M; N; P; TB; TC; W1; W2 and X1. Among the most abundant species during the period are cyanoprokaryotes *Dolichospermum flos-aquae* (Brébisson ex Bornet & Flahault) Wacklin, Hoffmann and Komárek (H1) and *Microcystis aeruginosa* (Kützing) Kützing (M), green algae *Crucigenia quadrata* Morren (X1) *Coelastrum microporum* Nägeli (J) and *Dictyosphaerium simplex* (Korshikov) (F), diatoms *Caloneis amphisbaena* (Bory) Cleve (MP) and *Aulacoseira granulata* (P) and euglenoid *Phacus orbicularis* K. Hübner (W1). Representatives of the following functional groups were reported in July: C; D; G; H1; J; F; Lo; M; MP N; P; TC; W1; W2; X1. Among the dominant species are the blue-green *Merismopedia glauca* (Ehrenberg) Kützing (Lo), the green algae *Actinastrum hantzschii* Lagerheim (J) and *Pandorina morum* (O. F. Müller) Bory (G) as well as the euglenas *Lepocinclis acus* (O. F. Müller) B. Marin & Melkonian (W1) and *Trachelomonas* sp. (W2). Among the most abundant during the period are also the blue-green *Limnococcus limneticus* (Lemmermann) Komárková, Jezberová, O.Komárek &(Lo), *Anabaena* sp., (H1), *O. limosa* (TC) and the diatoms *Cyclotella meneghiniana* Kützing (C) and *Fragilaria acus* (Kützing) Lange-Bertalot (D). In August the most abundant species in the ponds are grouped into codons: B; D; E; H1; J; F; Lo; M; MP; N; P; TC; W1; W2; X1. Among the dominant species during the period are cyanoprokaryotes *Aphanizomenon flosaquae* Ralfs ex Bornet & Flahault (H1), green *Ankistrodesmus fusiformis* Corda (F) and diatom *Stephanodiscus hantzschii* Grunow of codon D, cyanoprokaryote *M. aeruginosa* (M), green *Ankistrodesmus bibraianus* (Reinsch) Korshikov (F) and *Pediastrum duplex* Meyen (J), *Lepocinclis oxyuris* (Schmarda) B. Marin & Melkonian (W1) and *U. ulna* (D). In September the dominant phytoplankton species were classified into the following functional groups: B; C; D; G; H1; J; F; Lo; M; MP; P; TC; W1; W2; X1. The most abundant during the same period are the blue-green *Anabaena sphaerica* Bornet & Flahault (H1), the green *Schroederia setigera* (Schröder) Lemmermann (X1), the representatives (from Euglenophyta) of the codons W1 and W2 *Euglena texta* (Dujardin) Hübner and *Trachelomonas planctonica* Svirenko as well as the diatom *A. granulata* from functional group P. Among the most massive ones are the cyanoprokaryotes *M. aeruginosa* (M), *A. flosaquae* (H1) and *O. limosa* (TC), pyrrhophyte *Ceratium hirundinella* (O. F. Müller) Dujardin (Lo), the green *Desmodesmus communis* (E. Hegewald) E. Hegewald (J) as well as the diatom *U. ulna* (D).

According to the performed cluster analysis, the dominant species are grouped into four main clusters. The first one consists of two subclusters (Figure 2). The first subcluster is more homogeneous and it includes predominantly dominant green algae classified in different functional groups such as *P. morum* (G), *S. setigera* (X3), *A. hantzschii* (J), *A. bibraianus* (F) and *H. contortum* (X1) most commonly observed in the summer. The second subcluster includes the most abundant

Table 1. List of identified taxa and their belonging to a functional group, according to (Reynolds et al., 2002; Padisák et al., 2009; Borics et al., 2016)

Taxa	2009	2010	2011	FGs
1	2	3	4	5
Cyanoprokaryota				
Anabaena sp.	*	**	**	H1
Anabaena sphaerica Bornet & Flahault	**	**	**	H1
Anabaenopsis arnoldii Aptekar	**	*	*	H1
Aphanizomenon flos-aquae Ralfs ex Bornet & Flahault	**	**	**	H1
Aphanizomenon sp.	*			H1
Aphanocapsa sp.			*	K
Chroococcus sp.	*		**	Lo
Coelosphaerium confertum West & G.S.West	**	*	*	Lo
Coelosphaerium dubium Grunow	*	*		Lo
Coelosphaerium sp.		*		Lo
Dolichospermum flos-aquae (Brébisson ex Bornet & Flahault) Wacklin, Hoffmann & Komárek	*	**	*	H1
Gomphospaeria sp.		*		Lo
Leptolyngbya foveolara (Gomont) Anagnostidis & Komárek	*			S1
Limnococcus limneticus (Lemmermann) Komárková, Jezberová, O.Komárek & Zapomelová		**		Lo
Merismopedia glauca (Ehrenberg) Kützing	**	**	*	Lo
Merismopedia tenuissima Lemmermann	*	*		Lo
Microcystis aeruginosa(Kützing) Kützing	**	**	*	M
Microcystis pulverea (H.C.Wood) Forti			*	M
Microcystis sp.	*		*	M
Oscilatoria sp.	*	*		T_C
Oscillatoria limosa C.Agardh ex Gomont	**	**	**	T_C
Phormidium sp.	*			T_C
Planktothrix agardhii (Gomont) Anagnostidis & Komárek			*	S1
Pseudanabaena sp.	*			S1
Snowella lacustris (Chodat) Komárek & Hindák			*	Lo
Spirulina major Kützing ex Gomont	*			S1
Spirulina sp.	*			S2
Chlorophyta				
Actinastrum hantzschii Lagerheim	**	**	*	J
Ankistrodesmus bibraianus (Reinsch) Korshikov	**	**	*	F
Ankistrodesmus fusiformis Corda	**	*	*	F
Ankistrodesmus longissimus (Lemmermann) Wille	*	**	*	F
Ankyra ocellata (Korshikov) Fott	*	*		X1
Chlamydomonas sp.	*	*		X2
Chlorolobion braunii (Nägeli) Komárek	*			X1
Coelastrum microporum Nägeli	*	*	**	J
Coelastrum sphaericum Nägeli	*	*	*	J
Colemanosphaera charkowiensis (Korsh.) Nozaki, Yamada,Takahashi, Matsuzaki & Nakada			*	G
Crucigenia fenestrata (Schmidle) Schmidle		*		X1
Crucigenia quadrata Morren	*	*	*	X1
Crucigenia tetrapedia (Kirchner) Kuntze	**	*	*	X1
Crucigeniella irregularis (Wille) P.M.Tsarenko & D.M.John	*	*	*	X1
Desmodesmus armatus var. *longispina* (Chodat) E.Hegewald		*		J
Desmodesmus brasiliensis (Bohlin) E.Hegewald		*		J

Table 1. Continued

1	2	3	4	5
Desmodesmus communis (E.Hegewald) E.Hegewald	**	**	**	J
Desmodesmus denticulatus var. *fenestratus* (Teiling) E.Hegewald	*			J
Desmodesmus opoliensis (P.G.Richter) E.Hegewald	*			J
Desmodesmus protuberans (F.E.Fritsch & M.F.Rich) E.Hegewald	**	*	**	J
Desmodesmus spinosus (Chodat) E.Hegewald	*			J
Dictyosphaerium ehrenbergianum Nägeli			*	F
Dictyosphaerium simplex Korshikov		*	**	F
Didymogenes anomala (G.M.Smith) Hindák	*			J
Eudorina elegans Ehrenberg		*		G
Golenkinia radiata Chodat	*			X1
Gonium pectorale O.F.Müller	**	*	*	W1
Hyaloraphidium contortum Pascher & Korshikov	**	*		X1
Kirchneriella lunaris (Kirchner) Möbius	*	*		F
Kirchneriella sp.	*			F
Lagerheimia genevensis (Chodat) Chodat			*	X1
Lagerheimia quadriseta (Lemmermann) G.M.Smith	*	*		X1
Lagerheimia sp.	*		*	X1
Lambertia sp.	*	*	*	X1
Micractinium belenophorum (Korshikov) T.Proschold, C.Block, W.Luo & L.Kreinitz			*	J
Micractinium bornhemiense (W.Conrad) Korshikov			*	F
Micractinium pusillum Fresenius	**	*	*	F
Micractinium quadrisetum (Lemmermann) G.M.Smith		*	*	F
Monoraphidium griffithii (Berkeley) Komárková-Legnerová		*	*	F
Mucidosphaerium pulchellum (H.C.Wood) C.Bock, Proschold & Krienitz	*		*	F
Mychonastes anomalus (Korshikov) Krienitz, C.Bock, Dadheech & Proschold	*			F
Oocystidium ovale Korshikov	*	*	*	F
Oocystis borgei J.W.Snow	**	*	*	F
Oocystis lacustris Chodat		*		F
Oocystis novae-semliae Wille	*	*	*	F
Oocystis sp.	*			F
Pandorina morum (O.F.Müller) Bory	**	**	**	G
Pandorina sp.		*		G
Pediastrum duplex Meyen	*	**	*	J
Pediastrum simplex Meyen	*	*	**	J
Pseudopediastrum boryanum (Turpin) E.Hegewald	*	*	*	J
Pseudoschroederia robusta (Korshikov) E.Hegewald & E.Schnepf	**	*	**	X1
Raphidocelis danubiana (Hindák) Marvan, Komárek & Comas			*	F
Scenedesmus acuminatus var.*elongatus* G.M.Smith	*	*	*	J
Scenedesmus arcuatus (Lemmermann) Lemmermann	*	*	*	J
Scenedesmus intermedius var. *acutispinus* (Y.V.Roll) E.Hegwald & An	*	*	*	J
Scenedesmus quadricauda var. *eualternans* Proshkina-Lavrenko			*	J
Scenedesmus sp.	*			J
Schroederia spiralis (Printz) Korshikov	*	*	*	X1
Schroederia setigera (Schröder) Lemmermann	**	*	**	X1
Selenastrum bibraianum Reinsch	*	*	*	J
Senedesmus acuminatus var.*biseriatus* Reinhard	*	*	*	J
Tetradesmus lagerheimii M.J.Wynne & Guiry	*	*		J

Table 1. Continued

1	2	3	4	5
Tetradesmus obliquus (Turpin) M.J.Wynne	*	*	*	J
Tetraëdron minimum (A.Braun) Hansgirg	*			X1
Tetraedron sp.		*		X1
Tetrastrum glabrum (Y.V.Roll) Ahlstrom & Tiffany	*	*	*	X1
Tetrastrum sp.	*			J
Treubaria schmidlei (Schröder) Fott & Kovácik	**		*	X1
Treubaria sp.	*			X1
Volvox aureus Ehrenberg			*	G
Streptophyta				
Closterium acutum Brébisson			*	P
Closterium pronum Brébisson	**	*	*	P
Closterium sp.	**	*		P
Closterium venus Kützing ex Ralfs	**	*		P
Cosmarium sp.	**	**	**	N
Elakatothrix gelatinosa Wille			*	F
Staurastrum gracile Ralfs ex Ralfs		*		N
Staurastrum pingue var. *planctonicum* (Teiling) Coesel & Meersters			*	N
Staurastrum sp.	*		*	N
Staurastrum tetracerum Ralfs ex Ralfs	**	*		N
Stauratrum hexacerum		*		N
Xanthidium sp.			*	N
Zygnema sp.	*			T_D
Euglenophyta				
Euglena polymorpha P.A.Dangeard	*	**	*	W1
Euglena sp.	*	**	*	W1
Euglena texta (Dujardin) Hübner	**			W1
Euglenaformis proxima (Dangeard) M.S.Bennett & Triemer	*	*	*	W1
Lepocinclis acus (O.F.Müller) B.Marin & Melkonian	**	**	*	W1
Lepocinclis oxyuris (Schmarda) B.Marin & Melkonian	*	**	*	W1
Phacus limnophilus (Lemmermann) E.W.Linton & A.Karnkowska-Ishikawa	*	*	*	W1
Phacus longicauda (Ehrenberg) Dujardin	*	*	*	W1
Phacus orbicularis K.Hübner	*	*	**	W1
Phacus sp.	*	*	*	W1
Strombomonas gibberosa (Playfair) Deflandre	*			W2
Strombomonas sp.	*	**	*	W2
Trachelomonas planctonica Svirenko	**			W2
Trachelomonas sp.	**	**	**	W2
Pyrrhophyta				
Ceratium hirundinella (O.F.Müller) Dujardin		**	*	Lo
Peridinium sp.	**	*	*	Lo
Ochrophyta				
Eustigmatophyceae				
Tetraedriella acuta	*		*	X1
Tetraedriella limbata Pascher		*		X1
Tetraëdriella regularis (Kützing) Fott	*			X1
Tetraëdriella sp.	*	*		X1
Tetraedriella spinigera Skuja	*	*		X1

Table 1. Continued

1	2	3	4	5
Synurophyceae				
Mallomonas sp.		**		E
Bacillariophyceae				
Asterionella formosa Hassall	**			C
Aulacoseira granulata (Ehrenberg) Simonsen	**	**	**	P
Aulacoseira islandica (Otto Müller) Simonsen		*	*	B
Aulacoseira italica (Ehrenberg) Simonsen			*	B
Aulacoseira sp.	**	**	*	B
Caloneis amphisbaena (Bory) Cleve	**	**	*	MP
Caloneis silicula (Ehrenberg) Cleve	*	*	*	MP
Caloneis sp.		*		MP
Cocconeis pediculus Ehrenberg		*		MP
Cocconeis placentula Ehrenberg	*			MP
Cyclotella meneghiniana Kützing			**	C
Cyclotella sp.	*			C
Cymatopleura solea (Brébisson) W.Smith	*	*	*	MP
Cymbella sp.	*	*	*	MP
Diatoma elongata (Lyngbye) C.Agardh			*	MP
Diatoma vulgaris Bory	**	**		MP
Encyonema leibleinii (C.Agardh) W.J.Silva, R.Jahn, T.A.Veiga Ludwig & M.Menezes	*			MP
Fragilaria acus (Kützing) Lange-Bertalot		*	**	D
Fragilaria capucina Desmazières			*	MP
Fragilaria crotonensis Kitton		*		P
Gomphonema acuminatum Ehrenberg	*	**	*	MP
Gomphonema acuminatum var.*coronatum* (Ehrenberg) Rabenhorst	*	*		MP
Gomphonema constrictum Ehrenberg		*		MP
Gomphonema gracile Ehrenberg			*	MP
Gomphonema sp.	*	*		MP
Gyrosigma acuminatum (Kützing) Rabenhorst	**	*		MP
Navicula radiosa Kützing	**			MP
Navicula sp.	*	*	**	MP
Navicula vulpina Kützing	*			MP
Nitzschia holsatica Hustedt	*	*		D
Pleurosigma elongatum W.Smith	*	*		D
Pleurosigma sp.	*			D
Rhopalodia gibba (Ehrenberg) Otto Müller			*	MP
Stephanodiscus astraea (Kützing) Grunow	*		*	C
Stephanodiscus hantzschii Grunow	**	**		D
Stephanodiscus neoastraea Håkansson & Hickel			*	B
Synedra sp.	*	*		D
Tabellaria flocculosa (Roth) Kützing	*			N
Ulnaria ulna (Nitzsch) Compère	**	**	**	D

**dominant taxa

in the same period Cyanoprokaryota representatives such as *M. aeruginosa* (M) and *O. limosa* (TC) as well as more rarely occur *A. arnoldii* (H1) and *M. glauca* (Lo). The second major cluster consists of representative species of different taxa and functional groups such as *C. amphisbaena* (MP), *D. vulgaris* (C), *Trachelomonas* sp. (W2), *Peridinium* sp. (Lo), *Closterium* sp. (P), *Cosmarium sp.* (N), *G. pectorale* (W1), *O. borgei* (F) which occur throughout the whole study period without strict seasonal preferences. In a third independent cluster there are grouped the blue-green *O. limosa* (TC) which was found everywhere throughout the whole study, as well as the green *C. quadrata* (X1), which was reported only in the early summer. The fourth major cluster includes species with different taxonomic and functional classification including the everywhere dominant *A. granulata* (P) and *U. ulna* (D) as well as *C. confertum* (Lo), *C. venus* (P), *Strombomonas* sp. (W2), *M. pusillum* (F), *D. protuberans* (J), *L. acus* (W1), *C. tetrapedia (X1).* According to Ward's method in *C. confertum* species (Lo) *O. limosa* (TC) and *Cosmarium* sp. (N) they reported the largest Euclidean distance between

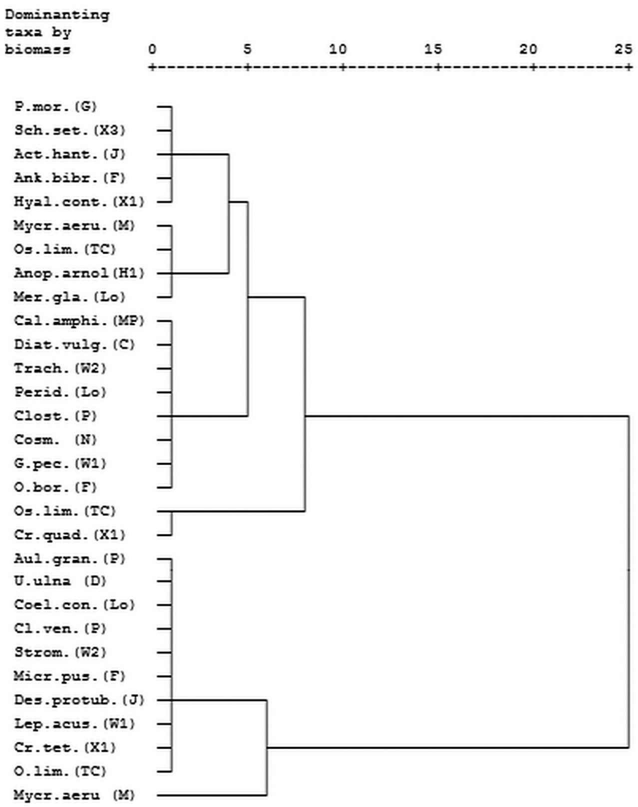

Fig. 2. Dendrogram of dominant species grouped in individual clusters by functional groups according to Reynolds et al., (2002) and Padisak et al., (2009)

them and the other taxa. This big distance is probably due mainly to the seasonal dynamics in the occurrence of the dominant species.

Shallow eutrophic lakes include ponds that are different in terms of hydrology, alkalinity and macrophytes. These differences are manifested by changes in the composition of phytoplankton (Borics et al., 2012). In these basins the temperature and the presence of light are the most important factors with impact on the algal development. The dominant blooms caused by cyanoprokaryotes leads to a decrease in their functional and species diversity (Borics et al., 2012). Their fine sediments can cause turbulence which disrupts the penetration of light. On the other hand, simultaneous water retention and biogenic detritus provide a mechanism for an accelerated turnover of resources back to the water layers (Reynolds, 2006). The external pressure on the fish farms from the agricultural sector and their poor management may additionally increase their eutrophication. Fertilizers are very often used in fish farming to stimulate the development of main production to increase yields due to which these ponds are eutrophic with frequent occurrences of algae blooms (Radojicic & Kopp, 2016). Because of their different hydrology and their small depth, they have no seasonal temperature stratification (Kopp et al., 2016). The use of high densities of farmed fish leads to an increase in the trophic status. The most frequent indicators of this are cyanobacteria bloom and oxygen fluctuations that destabilize their ecosystem (Komárková, 1998).

Frequently in fishponds, the blue-green algae represent the biggest part of the biomass in the summer. Sometimes they cause intense blooming on water followed by fish death caused by oxygen depletion. Their specific features make them more adaptive of certain conditions such as reduced light and nitrogen depletion in the upper layer. Cyanoprokaryotes, fixing atmospheric nitrogen have a selective advantage over competitors in case of depletion. Many species can migrate vertically by regulating buoyancy and this feature is a competitive advantage in stratified water basins (Sevrin-Reyssac & Pletikosic, 1990). According to Borics et al., (2016) in the small ponds despite the expected development of small nanoplankton, the conditions during the summer period promote the development of large euglenas. The same authors reported that colonial flagellates, filamentous cyanoprokaryotes and chlorophytes have high numbers in small and large basins where the pond size has a significant impact on the phytoplankton composition (Borics et al., 2016). In the shallow ponds, the presence of numerous nutrients favors the development of group representatives in the direction from Z, X and J through D to S (Kruk et al., 2002). In a long-term study of moderate shallow ponds, dominant algae include representatives that inhabit both high and low trophic level ponds characterized by changes during the study period where in the beginning cryptophytes (Y, X2, X1 and L_O) dominate followed by cyanoprokaryotes of K, dinoflagellates (L_O and Y), cryptophytes (L_O, F, X2) and diatom of D, K, P, A codons (Napiórkowska-Krzebietke, 2017).

Some phytoplankton representatives in shallow ponds often include green algae of group X1. According to Reynolds (2006), the species representing group J of eutrophic green are typical of a shallow eutrophic environment with poor light. Phytoplankton in hypertrophic basins often includes both functional group J species as well as nanoplanktons from X1. The most common dominants in our study colonial green algae of group J (cluster I) of the genus *Desmodesmus, Pediastrum, Coelastrum* and *Actinastrum* inhabit shallow, mixed and trophic rich waters during the summer (Reynolds et al., 2002; Sarmento & Descy 2008; Padisak et al., 2009; Becker et al., 2010). Representatives of F group *Ankistrodesmus* (cluster I), *Oocystis* (cluster II) and *Micractinium* (cluster IV) inhabit pure, deep, mixed meso- to eutrophic basins. According to the publications of Reynolds et al., (2002) and Padisak et al., (2009) *Schroederia setigera* (Cluster I) as well as representatives of the genus *Crucigenia* (cluster IV) and *Hyaloraphidium* (cluster I) of the X1 group inhabit shallow, eutrophic- to hypertrophic basins. In trophic rich ponds, monospecific blooming of *Microcystis* (M) can be observed which can regulate its buoyancy thus avoiding strong daylight near the surface (Reynolds, 2006). According to Padisak et al., (2009), *Oscillatoria* (TC) species which are among the most widespread in the current study (clusters I and III) are typical of eutrophic standing waters with the presence of macrophytes but at the same time they can be met in conditions of poor light (Reynolds, 1997). According to the concept of functional groups, the dominant at the end of summer *M. aeruginosa* (M) (cluster I) inhabits small to medium-sized eutrophic ponds. The species grouped in the second subcluster of cluster I such as *A. arnoldii* (H1) inhabits stratified shallow low-nitrogen eutrophic ponds while *M. glauca, L. limneticus* and *Peridinium* of the Lo codon inhabit deep or shallow oligo-eutrophic basins (Padisak et al., 2009).

Euglenophyte algae of the W2 functional group are also found in the bottom ecosystem of shallow water basins but sometimes they also occur in open waters (Reynolds et al., 2002). The same report states that the W2 functional group *Trachelomonas* sp. (Cluster II) often identified among the dominant species inhabits shallow meso- to etrophic ponds and *Strombomonas* (W2) grouped in cluster IV in habits meso- to eutrophic shallow ponds (Huszar et al., 2003). The massive members of the W1 group, *L. acus* (cluster IV) and *G. pectorale* (cluster II) inhabit basins rich in organic matter (Kruk et al., 2002; Sarmento & Descy, 2008). The member of G codon, *P. morum* (cluster I) inhabits small, eutrophic and nutrient-rich basins (Reynolds et al., 2002) and the representative of the functional D group, *U. ulna* (Cluster IV) inhabits muddy water (Reynolds et al., 2002; Padisak et al., 2009). *A. granulata* grouped in cluster IV and everywhere dominant in the current study as well as the streptophytic *Closterium* (P, Cluster II) are typical of high trophic status (Padisak et al., 2009). According to Sarmento & Descy (2008) *Cosmarium* spp. (N, cluster II) inhabits basins with constant or semiconstant mixed shallow waters while *Coelosphaerium* (Lo, cluster IV) is typical of both deep and shallow oligo- to eutrophic ponds (Kruk et al., 2002). The grouped in cluster II representatives of the functional MP group diatom *C. amphisbaena* and *Diatoma vulgaris* are often abundant in muddy and shallow water basins (Padisak et al., 2009).

Conclusions

In conclusion we can say that for the first time in the country this study presents of the functional classification of phytoplankton in small eutrophic fishponds. Their algae biodiversity is relatively rich with 172 identified taxa, grouped into 22 functional groups. The largest number of speciesis represented by the functional codes J, X1, MP, F, Lo and W1. By applying a cluster analysis (Ward's method), the identified dominant functional groups are grouped in four main clusters depending on the Euclidean distances between them. The obtained results confirm the usefulness of the functional classification approach in analyzing the seasonal changes that affect the most commonly occurring algae species in shallow fishponds. In our opinion, the study showed that the application of an ecological approach for functional groups, fully tailored to the characteristics and specifics of artificial fishponds is an appropriate tool in the study of ecology and seasonal changes of dominant algae.

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