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RECOGNITION OF CONTINENTAL DINOFLAGELLATES OF IRAN

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Thirty seven species represented by 44 infra-specific taxa of dinoflagellates were identified by the author during 2000-2012, belonging to 1 class, 4 orders, 9 families, and 13 genera from different inland aquatic habitats of Iran, of which 25 species (31 infra-specific taxa) were found in the rivers. Brief ecological and geographical analysis of the algal flora was carried out. The geographical analysis showed the presence of 5 geoelements in Iranian algal flora of dinoflagellates (multiregional, holarctic, nemoral, boreal, arctic-alpine). Seven rare species which were unknown before for water bodies of Asia were identified along with widespread cosmopolitan dinokaryotes in investigated water bodies of Iran. According to the literary analysis and investigations carried out by the author, totally 42 species (50 inf. taxa) of freshwater dinoflagellates were known in the different water bodies of Iran.

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Key words: Dinoflagellates; water bodies of different types; salinity indicator; geographical elements; Iran

شناختی بر داینوفلاژله‌های آب‌های داخلی ایران

بهروز زارعی دارکی: استادیار دانشکده منابع طبیعي و علوم دریایي دانشگاه تربیت مدرس، تهران

طی این مطالعه ۳۷ گونه شامل ٤٤ آرایه درون گونه‌ای داینوفلاژله‌ها شناسائی شد. نمونه‌برداری‌ها طی سال های ۱۳۷۹ تا ۱۳۹۱ انجام گرفته است. داینوفلاژله‌های مورد مطالعه متعلق به ۱ رده، ٤ راسته، ۹ خانواده و ۱۳ جنس هستند و از اکوسیستم‌های آبی مختلف داخلی جمع آوری شده‌اند. بیشترین تعداد یعنی ۲۵ گونه (۳۱ آرایه درون گونه‌ای) متعلق به رودخانه هاست. در این مطالعه تجزیه و تحلیل مختصری نیز از نظر اکولوژیک و جغرافیای آلگافلور انجام گرفته است. تجزیه و تحلیل جغرافیایی آلگافلور داینوفلاژله‌های ایران نشان از وجود پنج منطقه (چندناحیه‌ای، هولارکتیک، جنگلی، شمالی و قطب-آلپی) دارد. همراه با گسترش گونه‌های جهان‌زی دینوکاریوت‌ها، ۷ گونه نادر که قبلا برای اکوسیستم‌های آبی آسیا بیگانه بودند از اکوسیستم‌های آبی ایران گزارش شد. در نتیجه تجزیه و تحلیل مطالعات قبلی و نتایج مطالعه حاضر، جمعاً ٤۲ گونه (۵۰ آرایه درون گونه ای) داینوفلاژله آب شیرین از اکوسیستم‌های آبی مختلف کشور معرفی می‌شود.

INTRODUCTION

Dinoflagellates (Dinophyta, Dinokaryota) make an important part of algal biocoenosis of the many water bodies especially in the relatively ditch-water and they are an important source of food for zooplanktons particularly in the springs. In last report of dinoflagellates, 2377 species of the algal group were known for the science (Gómez, 2012a). Majority of dinoflagellates are marine species. It has been ascertained relatively not long ago that freshwater and marine species are different from each other genetically to a much greater extent than it was considered previously. The natural barrier between marine and freshwater dinoflagellates became apparently border between these two groups in the course of evolution of these algae (Logares et al., 2007). According to F. Gomez (2012b), 420 species were recognized from continental waters (17% of 2377 species) among which heterotrophic species constituted only 48 taxa. In some other reports, 350 species of freshwater dinoflagellates were described and resting cysts for 84 species were described while newly described species that lacked depictions or contained inconsistencies are still discussed (Mertens et. al, 2012).

Dinoflagellates have adapted to the freshwater environment as free-floating in the water column and to the benthic habitat as attached and associated with the bottom. Most freshwater and marine dinoflagellates are planktonic forms. A few freshwater species are benthic, mainly composed of a group of insufficiently known

taxa representing the genera, *Cystodinium*, *Stylodinium* and *Tetradinium*. In contrast to the marine species, the continental species are highly dominated by plastid-containing species. The percentage of parasitic species in continental waters is slightly lower than in marine waters. Several genera of continental parasites contained plastids (*Cystodinium*, *Crepidoodinium*) and others are devoid of plastids (*Cystodinedria*, *Oodinioides* and *Stylodinium*) (Gomez, 2012b).

Common freshwater photosynthetic genera such as *Peridinium* or *Gymnodinium* contain the most typical chloroplast of dinoflagellates which is bounded by three membranes and possess chlorophylls a and c2 as well as peridinin as a major accessory pigment. Moreover, a few freshwater dinoflagellates have a blue pigment, phycobilin, obtained from a cryptophyte endosymbiont (Yamaguchi et al., 2011).

In the spring, growth of diatoms are able to exhaust warm water layer of nutrients quite strongly but dinoflagellates can thrive and outcompete other phytoplanktons as they are well adapted to utilizing organic nutrients (Oh et al. 2002, Lee and Kim 2007), migrating (usually at night) to deeper nutrient rich waters when the base of the surface mixed layer is shallow enough to reach (Ji and Franks 2007) and they can also consume a wide variety of the other protists and bacteria (Jeong et al. 2005a, Jeong et al. 2005b). Differences in freshwater bodies including chemistry, such as acidic or alkaline, or nutrient status, can strongly influence which species should be present. In general dinoflagellates are alkalinophile (Taylor et al., 2007).

Knowledge on the freshwater dynophytes of different water bodies of Iran are limited and presented by small number of publications such as (Löffler 1961; Wasylik 1975; Afsharzadeh et al. 2003; Noroozi et al. 2009, Mohsenpour Azari et al 2011; Rahmati et al 2011; Shams et al., 2012). Only two species were known in the beginning of our investigations (up to 2000), namely Durinskia occulata and Ceratium hirundinella (Zarei Darki, 2009a).

The aim of the present research was to identify and describe species of freshwater dinoflagellates in Iran and to summarize our knowledge on them.

MATERIALS AND METHODS

Materials for present work were collected during 2000-2012 from 138 water bodies of Iran among which dinoflagellates were found from 35 water bodies (Table 1). A total of 657 samples of plankton, benthos and periphyton (epiphytic, epipelic, epipelitic) from various substrata were examined. Methods of sampling, processing and storage of the algological material are those generally accepted in algology (Wasser et al., 1989). Net and bottle samples were preserved with Lugol's solution immediately in the field and fixed with 4% final concentration of formaldehyde after a few weeks. Cell concentration and ablution were realized by the centrifugation method. For detailed laboratory study of dinoflagellates, frustules were used methods of antireflection and splitting methods of theca by Javel water (Krakhmalny 2011).

In this paper, the taxonomy system followed after Fensome et al. (1993) and Adl et al. (2005) with some modifications (Krakhmalny, 2011). Identification of the species composition of algae was carried out using basic systematic reports (Starmach 1974, Matvienko and Lytvynenko, 1977; Popovský, 1990; Krakhmalny, 2011). They provide a clear description of species and so it is not necessary to give their complete description.

The bioindication of salinity is based on the classification system by Kolbe (1927) modified by Hustedt (1957). Distribution of species sensitive to pH and prospective bioindicators for this variable was analyzed according to the classification developed by Hustedt (1938, 1939) and further supplemented by Pork (1967).

Geographical analysis is based on the works of Oksner cited in the report by Wasser (1985). It involves allocation of geoelements according to the zonal distribution of species and ascribing them to plant-climate zones and altitudinal zones. Arctic-alpine geoelements combine mainly cryophilic species that have centers of mass in the Arctic and the upper treeless zones of mountains of more southern latitudes. Boreal elements are species that reach maximum number in a zone of coniferous forests of the Holarctic and regions of the Southern Hemisphere which are close to it by conditions. Holarctic elements include species not confined to a particular plant-climate zone and goes through all the zones of the Holarctic from North to South. Nemoral geoelements include species confined to the zone of deciduous forests and mountain deciduous forests. Cosmopolitans and species which were found minimum in the three Continents were attributed to multiregional geoelements.

For clarification of the species general distribution and ecological description, reports were used such as (Starmach. 1974; Matvienko and Lytvynenko.1977; Popovsky and Pfiester, 1990; Gorbulin. 2011; Krakhmalny, 2011; Guiry and Guiry, 2012).

The abbreviations and symbols used in the text are represented in the Table 2.

RESULTS

Thirty seven species representing 44 infra-specific taxa of Dinokaryota belonging to 1 class, 4 orders, 9 families and 13 genera were recognized from Iran.

Table 1. Investigated water bodies and their sites, which were visited for dinoflagellates collections.

Code	Name of water bodies	Sites	Locations	Date of sampling
1	Amirkabir Reservoir	1	35° 59' 46.08"N–51° 06' 31.67"E	16.05.2002
2	Anzali Swamp	1 2 3 4 5	37° 27' 44.73"N–49° 20' 10.62"E 37° 30' 44.01"N–49° 18' 09.79"E 37° 29' 53.97"N–49° 19' 55.76"E 37° 27' 55.19"N–49° 23' 29.95"E 37° 28' 36.92"N–49° 22' 09.98"E	27.05.2001 15.06.2002
3	Arvandrud River	1	30° 19' 49.55"N–48° 16' 53.20"E	11.05.2002
4	Cheghakhor Reservoir	1 2 3 4 5	31° 55' 20.39"N–50° 56' 04.99"E 31° 55' 40.17"N–50° 53' 09.24"E 31° 54' 58.39"N–50° 55' 39.69"E 31° 55' 20.39"N–50° 56' 04.99"E 31° 55' 40.17"N–50° 53' 09.24"E	12.06.2001 13.05.2002
5	Dez River	1	32° 24' 30.12"N–48° 24' 48.74"E	12.05.2002
6	Dizine Pond	1	37° 12' 02.84"N–50° 04' 05.75"E	17.05.2002
7	Gavkhuni Swamp	1 2	32° 17' 54.50"N–52° 53' 10.79"E 32° 17' 53.77"N–52° 53' 11.73"E	23.05.2002 07.05.2010
8	Golestan Reservoir	1 2	37° 19' 35.09"N–55° 17' 2.38"E 37° 19' 02.06"N–55° 17' 6.21"E	13.06.2002
9	Golpayegan Reservoir	1 2	33° 24' 20.69"N–50° 4' 48.48"E 33° 23' 54.33"N–50° 5' 9.34"E	01.06.2001
10	Hasanlu Reservoir	1 2	37° 2' 28.39"N–45° 30' 5.36"E 37° 2' 17.61"N–45° 30' 12.75"E	20.05.2002
11	Karkheh River	1	32° 11'41.88"N–48° 12' 36.97"E	12.05.2002
12	Karkheh Reservoir	1 2	32° 29' 32.38"N–48° 7' 58.04"E 32° 29' 11.82"N–48° 6' 26.28"E	12.05.2002
13	Karun Reservoir	1 2	32° 3' 1.92"N–49° 36' 27.24"E 32° 3' 11.35"N–49° 36' 20.67"E	13.05.2002
14	Karun River	1 2	30° 25' 59.27"N – 48° 12' 36.55"E 31° 21' 7.64"N–48° 42' 11.95"E	11.05.2002
15	Kashaf rud	1	28° 47' 34.46"N–57° 31' 37.18"E	13.06.2002
16	Kharghab river	1	33° 28' 25.78"N–50° 17' 4.81"E	30.05.2001
17	Lake Parishan	1 2	29° 32' 5.76"N–51° 46' 47.40"E 29° 32' 9.01"N–51° 47' 35.78"E	04.06.2002
18	Lake Shatt-e Mangar	1 2	31° 52' 27.28"N–49° 50' 43.85"E 31° 52' 18.39"N–49° 52' 3.66"E	12.05.2002
19	Mahabad Reservoir	1 2	36° 45' 41.44"N–45° 42' 9.17"E 36° 45' 24.45"N–45° 41' 29.25"E	20.05.2002
20	Morghab River	1	31° 58' 00.64"N–49° 46' 21.44"E	13.05.2002
21	Mill-pond (Vachek)	1	36° 51' 07.48"N–50° 48' 27.93"E	01.06.2001
22	Mill-pond (Mooteh)	1	33° 36' 29.00"N–50° 39' 54.27"E	09.05.2010
23	Panzdah-e Khordad Reservoir	1 2	34° 04' 12.81"N–50° 37' 26.82"E 34° 04' 35.07"N–50° 37' 18.85"E	18.06.2002
24	Qeshlagh Reservoir	1 2	35° 26' 20.31"N–46° 58' 37.66"E 35° 26' 34.73"N–46° 58' 25.37"E	21.05.2002
25	Qeshlagh River	1 2	35° 18' 35.14"N–47° 02' 09.58"E 35° 19' 52.27"N–47° 03' 04.47"E	21.05.2002
26	Robat-e khan Pond	1	33° 05' 25.39"N–55° 34' 36.80"E	11.06.2002
27	Shadegan Pond	1 2 3	30° 26' 44.61"N–48° 27' 23.68"E 30° 27' 03.61"N–48° 23' 31.10"E 30° 25' 14.48"N–48° 23' 25.99"E	21.05.2002
28	Fadak Reservoir	1	33° 54' 00.43"N–48° 43' 28.08"E	21.05.2002
29	Suleghan Pond	1 2	31° 57' 57.47"N–50° 46' 09.85"E 31° 58' 21.06"N–50° 46' 46.95"E	14.05.2002
30	Torogh Reservoir	1 2	36° 10' 24.22"N–59° 33' 05.00"E 36° 10' 13.62"N–59° 33' 06.17"E	13.06.2002

Table 1. Continued

Code	Name of water bodies	Sites	Locations	Date of sampling
31	Torogh River	1	36° 10' 50.46"N–59° 36' 07.20"E	13.06.2002
32	Voshmgir Reservoir	1 2	37° 12' 49.55"N–54° 43' 39.56"E 37° 12' 17.71"N–54° 42' 55.98"E	14.06.2002
33	Zayandehrud Reservoir	1 2 3 4	32° 42' 59.04"N–50° 32' 06.63"E 32° 43' 05.72"N–50° 36' 39.86"E 32° 44' 08.99"N–50° 39' 54.02"E 32° 44' 01.63"N–50° 44' 01.05"E	10.02.2000 22.05.2002 09.05.2010 20.10.2012
34	Zayandehrud River	1 2 3 4 5 6 7	32° 43' 05.57"N–50° 46' 58.28"E 32° 29' 15.05"N–50° 53' 54.48"E 32° 22' 17.35"N–51° 12' 19.76"E 32° 33' 15.65"N–51° 30' 59.30"E 32° 37' 57.09"N–51° 42' 20.77"E 32° 35' 06.25"N–51° 46' 13.28"E 32° 25' 28.39"N–52° 39' 11.31"E	11.02.2000 12.06.2001 23.05.2002 08.05.2010
35	Zoshk River	1	36° 23' 26.54"N–59° 17' 42.54"E	12.06.2002

Table 2. Abbreviations and symbols used in the text.

Halobity degree		pH degree		Geographical elements	
Abbreviations	Comments	Abbreviations	Comments	Abbreviations	Comments
hb	halophobous species	alb	alkalibiont	a-a	Arctic-alpine
ind	indifferents	acb	acidobiont	b	Boreal
hl	halophilous species	acf	acidophil	Ha	Holarctic
mh	mesohalobes	ind	indifferents	Ne	Nemoral
				M	Multiregional

Representatives of order Peridiniales (56.8%) were found more frequently than the others and species of Phytodiniales (1%) were the rarest. Species diversity of the genus *Peridinium* contained 29.5 % of the total of identified dinoflagellates and it is the highest value among the identified genera. Seven genera such as *Lingulodinium*, *Glenodiniopsis*, *Durinskia*, *Diplopsalis*, *Protoperidinium*, *Cystodinedria*, *Dinococcus* were represented by only one species of each.

The species Ceratium hirundinella**,** Gymnodinium fuscum, G. uberrimum, Glenodinium lemmermannii, Peridiniopsis penardiforme were the most often met taxa. The other interesting findigs were infrequently met are as fowllows: Woloszynskia pseudopalustris, Glenodinium pseudostigmosum, Peridinium subsalsum, Peridiniopsis borgei, Peridiniopsis charkowiensis, Peridiniopsis lubieniensiforma, Cystodinedria inermis. Among idntified species, Gymnodinium discoidale, Gymnodinium latum, Lingulodinium polyedrum, Peridinium umbonatum var. lubieniense, and Cystodinedria inermis were rare species and previously unknown for water bodies of Asia.

It was interesting to analyze the distribution of species of dinoflagellates in the water bodies of different types and reveal the type of water body where their abundance is higher and in contrast lower. A maximum number of 25 species (31 infr. taxa) were found in the rivers. Moreover 24 species (29 inf. tax.) were found in reservoirs, 7 species (8 inf. tax.) in lakes, 11 species in swamps, 17 species (22 inf. tax.) in ponds. Rivers were characterized with the highest species richness and lakes were represented by the least number of dinoflagellates. Among investigated rivers the Qeshlagh and Zayandehrud Rivers were represented by the most species diversity of dinoflagellates. Taxa such as *Peridinium bipes* (from Dez), *P. lomnickii* var. *lomnickii* (from Zayandehrud), *P. lomnickii* Wolosz. var. *wierzejskii,* and *Cystodinedria inermis* (from Dez) were also present exceptionally in rivers. Species such as *Peridinium achromaticum* (from Golestan), *P. pseudolaeve* (from Qeshlagh) and *Diplopsalis acuta* (from Golestan) were found only in reservoirs. It is necessary to note that Qeshlagh Reservoir had the most species diversity of this group of algae both among reservoirs and all types of water bodies that made 25.0% of the total of revealed dinoflagellates. Representatives such as *Gymnodinium discoidale*, *Peridinium subsalsum*, *P. umbonatum* var. *lubieniense* were determined only in Shadegan Pond, which was quite rich in dinoflagellates, including 22.7% of species. Specific taxa for lakes and swamps have not been marked but Anzali Swamp showed a great richness of dynophyte species because of the specificity of this water body and its specific conditions (direct contact with the sea, migration routes of migratory and anadromous fishes, reduced salinity, wintering grounds

of migrant birds, recreation zone, inflow of wastewater and polluted water) (Zarei Darki, 2009b). Rivers and reservoirs had the highest similarity according to species composition of dinophytes.

It is known that dinokaryotas inhabited in freshwater are typical representatives of plankton but they were observed very often both planktonic and benthic specimens. Phytoplankton is distributed evenly enough by current both in horizontal and in vertical directions in rivers. This is one of the reasons for the presence of typically planktonic forms in the collected samples of benthos. Species such as *Gymnodinium aeruginosum, Gymnodinium discoidale, Gymnodinium latum, Peridiniopsis elpatiewskyi* and the other species which were forming group of plankton-benthos, were repeatedly marked in the bottom layer of water. Among revealed species only *Dinococcus oedogonii* is periphytic form or more exactly epiphytic on the filiform algae.

With respect to salinity, dinoflagellates can be divided into 4 groups comprising 30 indicator species (68.2%). The "halophilous species" such as *Ceratium hirundinella* f. *furcoides*, *Ceratium hirundinella* f. *robustum*, *Peridiniopsis quadridens*, *Peridinium aciculiferum* and others constitute the dominant group. Halophobes and indifferents are represented by about the same number of species 8 and 7 correspondingly. Among them, *Gymnodinium palustre, Glenodiniopsis steinii, Glenodinium lemmermannii, Peridinium lomnickii, Peridinium willei* and others are noticed. Mesohalobous group is in the minority and it includes only two species including *Peridiniopsis elpatiewskyi* and *Protoperidinium achromaticum*. In the other words, it can be considered that continental dinoflagellates are more oligohalobous than mesohalobes.

Analysis of recent data on the geographical distribution of dinoflagellates allows classifying the received data in the following geographical elements: arctic-alpine, boreal, holarctic, nemoral and multiregional.

Group of multiregional geoelements includes 17 species and it is the largest group. Species of *Ceratium hirundinella* makes exception since it is the most widespread species among freshwater dinokaryotes and this species is ubiquist in opinion of some authors (Bohr, 1967). Nemoral elements are presented by 10 species in this algal flora. Holarctic elements are a little smaler than the nemoral elements and it is represented by 8 infra-specific taxa. Boreal elements are presented quite poorly in the flora of dinoflagellates of Iran, only three species of these elements including *Gymnodinium latum, Protoperidinium achromaticum* and *Cystodinedria inermis* were found. Arctic-alpine geoelements is submitted by one species of *Palatinus apiculatus***.** The geographical distribution has remained unknown for seven species.

Seven rare species, which were unknown before for water bodies of Asia were revealed along with widespread cosmopolitan dinokaryotes of Iran, are as follows: *Gymnodinium discoidale*, *Gymnodinium latum*, *Ceratium hirundinella* f. *furcoides*, *Ceratium hirundinella* f. *robustum*, *Peridiniopsis charkowiensis*, *Peridinium umbonatum* var. *lubieniense*, and *Cystodinedria inermis*.

Systematic and ecological enumeratio

Order **Gymnodiniales** Apstein 1909**;** Family **Gymnodiniaceae** (Bergh.) Lankester 1885**;**

Genus ***Gymnodinium*** F. Stein 1878

Gymnodinium aeruginosum F. Stein 1883. Organ. Infus. 3 (2): pl. 2, figs 19-22.

Vegetative cells 12.8-44 µm, long, 8.7-35 µm broad; cysts 35-60 µm in diameter.

Ecology: in plankton and benthos at water temperature of 11-22 °C and pH 6.5-8.5; (hl, acb, M).

Local distribution: Zayandehrud River (1-4, 8) and Gavkhuni Swamp (1).

General distribution: Europe, Asia, Africa, South America, Australia and New Zealand (probably cosmopolitan).

Gymnodinium discoidale T. M. Harris 1940. Proc. of the Linnean Soc. of London 152: 1-33.

Cells 8-18 µm long and 7-15.5 µm broad.

Ecology: in plankton and benthos at water temperature of 22-27 °C and pH 6.5-7.1; (acb, Ne).

Local distribution: Shadegan Pond (2).

General distribution: Europe, Australia.

Gymnodinium fuscum (Ehrenberg) F. Stein 1878. Organ. Infus. 3 (1): 95, 97.

Identified as *Gymnodinium purpureum* Skuja 1956.

Monad cells 80-118 µm long, 55-70 µm broad; cysts 60-65 µm in diameter.

Ecology: in plankton and benthos at water temperature of 14-28 °C and pH 6.3-8.5; (hb, acb, M).

Local distribution: Panzdah-e Khordad (1, 2), Torogh (1, 2) and Voshmgir Reservoirs (1, 2), Zayandehrud (1-3) and Zoshk Rivers, Lake Parishan (1, 2), Shadegan Pond (2, 3) and Anzali Swamp (2).

General distribution: Europe, Asia, North America.

Gymnodinium latum Skuja 1948. Symb. Botan. Upsalienses 9 (3): 1-399.

Cells 25-45 µm long and 20-34 µm broad.

Ecology: in plankton and benthos at water temperature of 22-27 °C and pH 6.5-7.5; (hb, acb, b).

Local distribution: Shadegan Pond (1. 2, 3) and Parishan Lake (1).

General distribution: Europe, South America.

Gymnodinium palustre A. J. Schilling 1891. Flora

Alg. Bot. Zhurn. 74: 248, 277, 278, pl. 9. figs. 11-12.
Vegetative cells 35-60 µm long and 22-37 µm broad.
Nutrition: autotrophic, holophytic and holozoic.
Ecology: in plankton and benthos at water temperature of 18-24 °C and pH 7; (hb, acb, M).
Local distribution: Golestan (1, 2) and Qeshlagh (1) Rivers, Qeshlagh (2) and Panzdah-e Khordad (1, 2) Reservoirs.
General distribution: Europe, Asia, America.

Gymnodinium paradoxum A. J. Schilling 1891. Flora Alg. Bot. Zhurn. 74: 278, 279 pl. 10. fig. 13.
Vegetative cells 60-75 µm long 61-67 µm broad; zoospores 40 µm long 35 µm broad. Nutrition: autotrophic and holozoic.
Ecology: in plankton and benthos at water temperature of 18-28 °C and pH 6.3-7.5; (ind, ind, M).
Local distribution: Golestan (2), Mahabad (1), Qeshlagh (1, 2) and Voshmgir (2) Reservoirs, Dizine Pond (1) and Anzali Swamp (1, 4, 5).
General distribution: Europe, Asia, Australia and New Zealand.

Gymnodinium uberrimum (G.J.Allman) Kofoid & Swezy 1921. Mem. Univ. Calif. 5: 264, fig 10(9).
Identified as Gymnodinium poculiferum Skuja 1956.
Vegetative cells 24-90 µm long and 19-75 µm broad.
Ecology: in plankton and benthos at water temperature of 11-28 °C and pH 6.4-8.5; (ind, ind, M).
Local distribution: Qeshlagh (1, 2), Torogh (1), Voshmgir Reservoirs (1, 2), Kashaf rud, Qeshlagh (1, 2), Torogh and Zayandehrud (2, 3) Rivers, Lake Parishan (1, 2), Shadegan Pond (1) as well as Anzali (2) and Gavkhuni Swamps (1, 2).
General distribution: Europe, South-east Asia, North and South America, New Zealand.

Gymnodinium sp.
Notes: cells were ellipsoidal, ring-shaped, and broad, with prominent ends and transapical groove, 30 µm long, 22 µm broad.
Ecology: in plankton at water temperature of 14 °C and pH 7.5.
Local distribution: Zayandehrud River (1).

Woloszynskia R.H. Tomps 1951

Woloszynskia pascheri (Suchlandt) Stosch 1973. Br. Phycol. J. 8: 105-134.
Vegetative cells 18-50 µm.
Indentified as Glenodinium polonicum Woloszynska 1916.
Ecology: in plankton at water temperature of 14-20 °C and pH 6.6-7.5; (hl, acf, Ha).
Local distribution: Parishan Lake (1, 2), Shadegan Pond (1, 3) and Anzali Swamp (5).
General distribution: Europe, South-west Asia, North America, New Zealand.

Woloszynskia pseudopalustris (Woloszynska) Kisselev 1954. Opredel. presnov. vodor. SSSR 6: 126, fig. 56, 1.
Cells 50 µm long and 40 µm broad.
Ecology: in plankton at water temperature of 9-15 °C and pH 7.2-8.1; (Ne).
Local distribution: Zayandehrud River (1, 2) and Reservoir (1).
General distribution: Europe, Asia.

Gonyaulacales Taylor 1980; **Gonyaulacaceae** Lindemann 1928;

Lingulodinium Dodge 1989

Lingulodinium polyedrum (F. Stein) J. D. Dodge 1989. Bot. Mar. 32: 289, pl. 29, figs 1-6.
Revealed as *Gonyaulax polyedra* Stein
Cells 29-39 µm long and 26-67 µm broad.
Ecology: in plankton and benthos at water temperature of 18-28 °C and pH 6.5-8.4; (hl, ind, Ha).
Local distribution: Qeshlagh River (1) and Reservoir (1) as well as Shadegan Pond (3) and Lake Parishan (1).
General distribution: Europe, Asia.

Ceratiaceae Wiley et Hickson 1909; ***Ceratium*** F. von P. Schrank, 1793

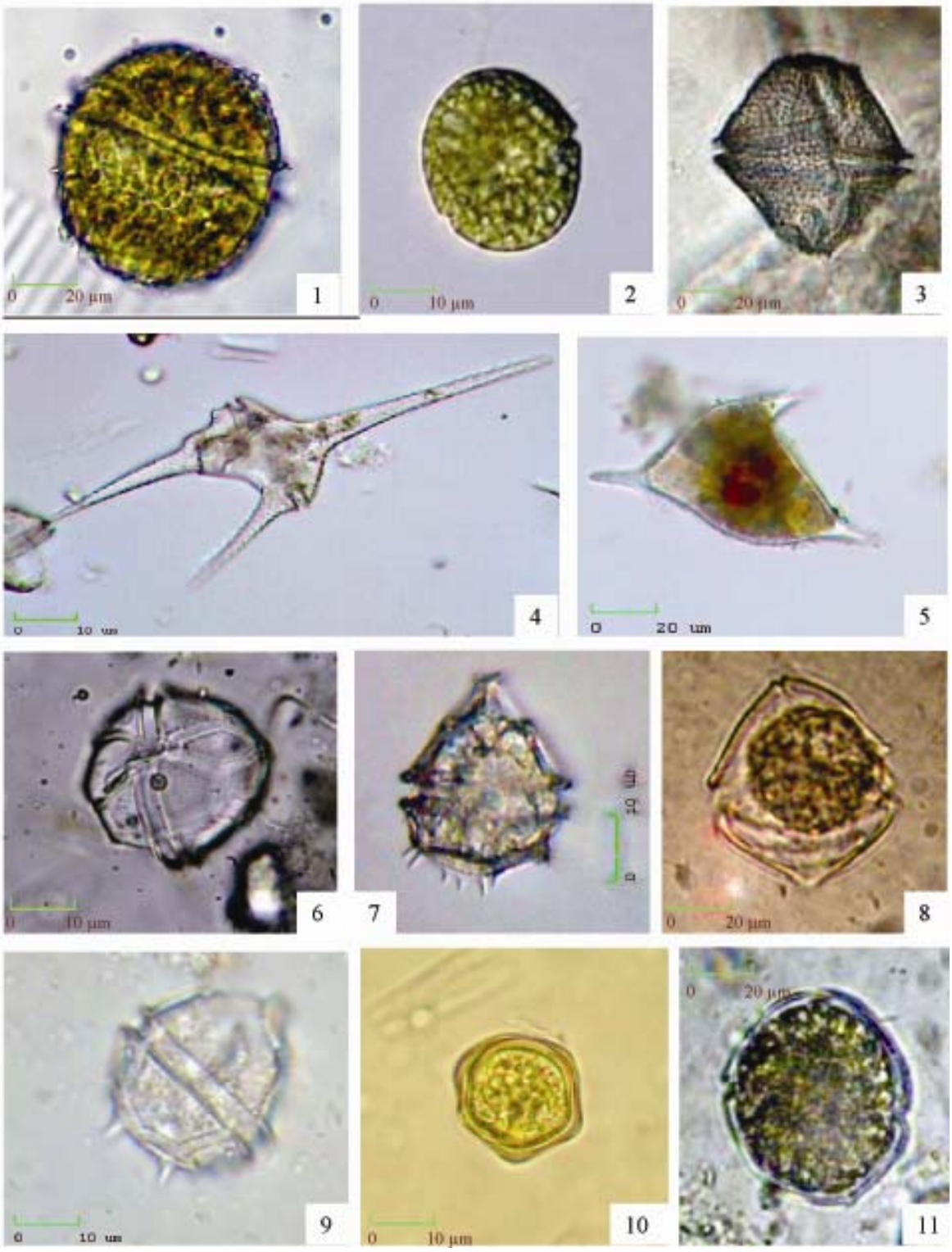
Ceratium hirundinella (O. F. Müller) Bergh 1881. Morph. Jahrb. 7 (2): 215, pl. 13, fig. 12.
Cells 40-45 µm long and 16-55 µm broad.
Ecology: in plankton and benthos at water temperature of 6-27 °C and pH 5-8.6; (hl, ind, M).
Local distribution: many water bodies.
General distribution: Cosmopolitan.

Ceratium hirundinella* f. *furcoides (Levander) Schröder 1918. Arch. Naturg. 84, Abt. A. **11** (8): 225.
Cells 130-300 µm long and 30-45 µm broad.
Ecology: in plankton at water temperature of 12-27 °C and pH 5-7.6; (hl, alb).
Local distribution: Cheghakhor (3) and Karun (1) Reservoirs, Karun (1), Kharghab and Morghab Rivers, Suleghan Pond (2) as well.
General distribution: Europe.

Ceratium hirundinella* f. *gracile H. Bachmann 1911. Phytoplankt. Süsswasser: 73, fig. 53.
Cells 140-302 µm long and 60-72 µm broad.
Ecology: in plankton at water temperature of 12-22 °C and pH 5.3-7.6; (hl, acf, M).
Local distribution: Dez and Kharghab Rivers, Cheghakhor Reservoir (1, 5) and Suleghan Pond (1).
General distribution: Europe, Asia, New Zealand (probably cosmopolitan).

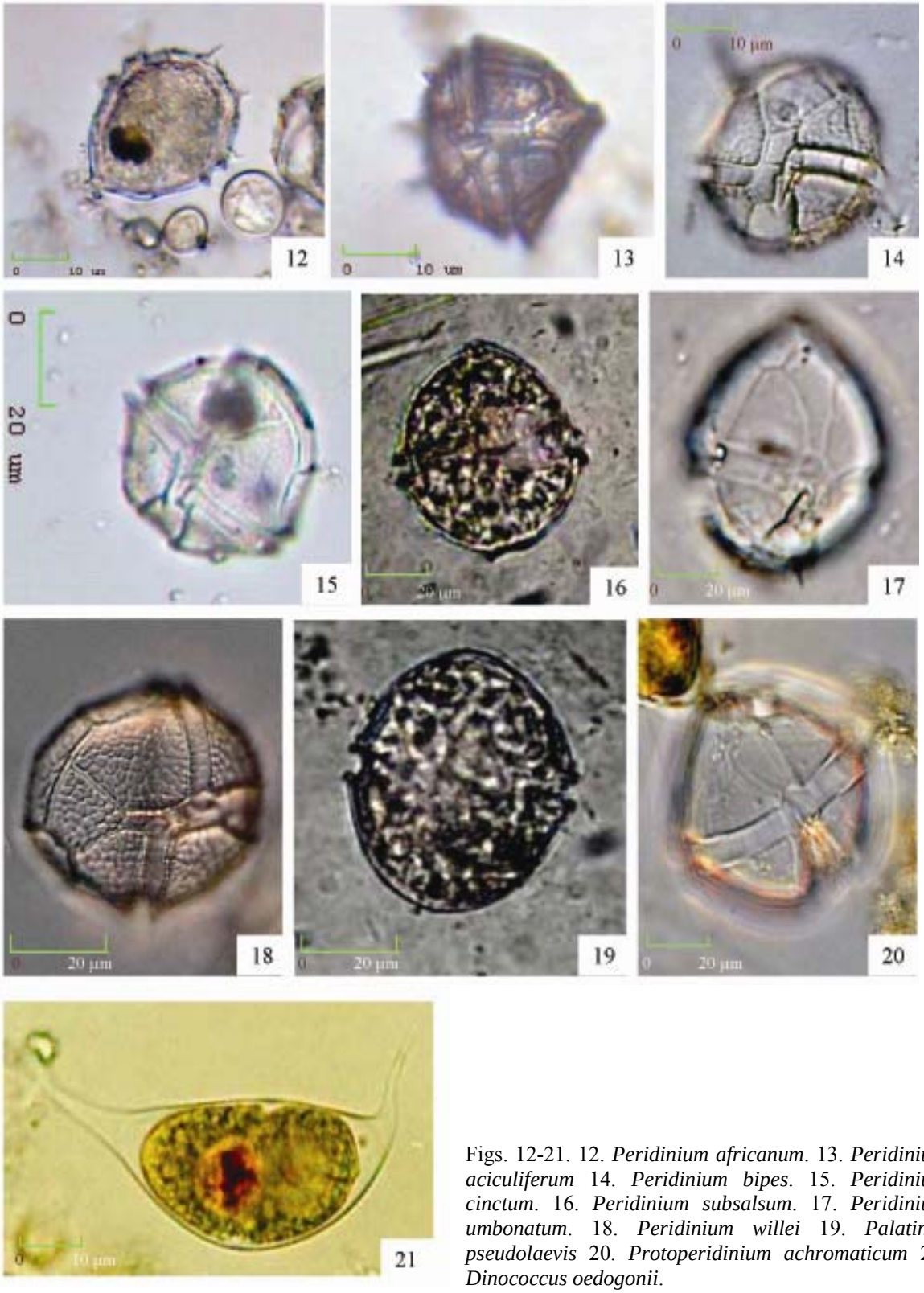
Ceratium hirundinella* f. *robustum (Amberg) H. Bachmann 1911. Phytoplankt. Süsswasser: 75, fig. 56.
Cells 270-310 µm long and 45-55 µm broad.
Ecology: in plankton and benthos at water temperature of 12-20 °C and pH 5.4-7.7; (hl, acf).
Local distribution: Dez and Kharghab Rivers, Cheghakhor Reservoir (1) and Suleghan Pond (1).

General distribution: Europe.
Order **Peridiniales** Haeck. 1894; Family **Glenodiniaceae** Wiley et. Hickson 1909**;** Genus ***Glenodiniopsis*** Wolosz 1916
Glenodiniopsis steinii (Lemmermann) Woloszynska 1916 Bull. Intern. Acad. Sci. Cracovie Cl. Sci. Math. Nat., Ser. B. Sci Nat.: 16.
Indentified as Sphaerodinium cinctum (Ehrenberg) Woloszynska 1917
Vegetative cells 25-50 µm long and 25-48 µm broad.
Ecology: in plankton at water temperature of 18-28 °C and pH 6.5-7.6; (hb, acb, Ha).
Local distribution: Dez River, Shadegan Pond (1, 2), Anzali Swamp (2, 3, 5).
General distribution: Europe, Asia, New Zealand.
Genus ***Glenodinium*** Ehrenb 1916
Glenodinium lemmermannii Zacharius 1901. Zool. Anz. 24: 308.
Vegetative cells 50 µm long and 40 µm broad.
Ecology: in plankton and benthos at temperature of water 18-28 °C and pH 5.5-8.2; (hb, acf, Ne).
Local distribution: Qeshlagh (1, 2) and Kashaf rud Rivers as well as Qeshlagh (1, 2), Panzdah-e Khordad (1) and Torogh Reservoirs (1), Dizine Pond (1,2), Anzali Swamp (1) and mill-pond near the Shahsavar, Vachek.
General distribution: Europe, Asia, Africa.
Glenodinium pseudostigmosum Skuja 1956. J. Popovsky & L.Pfeister 1986. Dynophyceae (Dinoflagellida). 6. Jena/Stuttgart: Fischer. 1990: 163, fig. 166.
Cells 30-38 µm long and 25-33 µm broad.
Ecology: in plankton and benthos at water temperature of 18-20 °C and pH 7-7.5; (unknown).
Local distribution: Qeshlagh River (1, 2) and Reservoir (1, 2).
General distribution: Europe, Asia.
Peridiniaceae Ehrenb. 1828**;** ***Peridiniopsis*** Lemmermann 1904
Peridiniopsis borgei Lemmermann 1904: 134, pl. 1; figs 1-5
Cells 40-55 µm long and 35-41 µm broad.
Ecology: in plankton and benthos at water temperature of 12-28 °C and pH 6.4-8.3; (hl, Ha).
Local distribution: Voshmgir (1) and Golestan Reservoirs, Lake Parishan (1), small ponds of Mooteh area (Abbarik pond) as well.
General distribution: Europe, Asia, New Zealand.
Peridiniopsis charkowiensis (Matvienko) Bourrelly 1968. Protistol. 4 (1): 5-14.
Cells 18-33 µm long and 15-30 µm broad.
Ecology: in plankton at water temperature of 18-20 °C and pH 7; (acb, Ne).
Local distribution: Qeshlagh River (1, 2) and Reservoir (2).
General distribution: Europe.
Peridiniopsis elpatiewskyi (Ostenfeld) Bourrelly 1968. Protistol. 4 (1): 5-14.
Cells 22-45 µm long and 22-35 µm broad.
Revealed as *Glenodinium pygmaeum* (Lindemann) Schiller 1937 in the some water bodies.
Ecology: in plankton and benthos at water temperature of 18-27 °C and pH 6.5-7.5; (mh, ind, M).
Local distribution: Voshmgir (2) and Golestan (1, 2) Reservoirs, Shadegan Pond (1, 3), and Anzali Swamp (2, 3, 5).
General distribution: Cosmopolitan.
Peridiniopsis lubieniensiforma (Diwald) Bourrelly 1968. Protistol. 4 (1): 5-14.
Vegetative cells 50-76 µm long and 47-72 µm broad.
Ecology: in plankton and benthos at water temperature of 22-24 °C and pH 7.4-7.6; (unknown).
Local distribution: Torogh River and Reservoir (1, 2).
General distribution: Europe, Asia.
Peridiniopsis penardiforme (Lindemann) Bourrelly 1968. Protistol. 4 (1): 5-14.
Cells 16-35 µm long, 9-30 µm broad.
Revealed as *Glenodinium penardiforme* (Lindemann) Schiller 1937
Ecology: in plankton and benthos at water temperature of 6-32 °C and pH 5.5-8.5; (hl, ind, Ha).
Local distribution: Karun (1, 2), Karkheh (1, 2), Voshmgir (1, 2), Mahabad (2), Cheghakhor (1, 5), Golpayegan (1, 2), Zayandehrud (2, 3) and Panzdah-e Khordad (1) Reservoirs as well as Karun (1 ,2), Karkheh, Zayandehrud (3), Kharghab and Morghab Rivers, Suleghan (1) and Robat-e khan Ponds, Lake Parishan (2), Lake Shatt-e Mangar (1) and Anzali Swamp (1).
General distribution: Europe, Asia, America.
Peridiniopsis quadridens (Stein) Bourrelly 1968. Protistol. 4 (1): 5-14.
Cells 23-39 µm long and 20-33 µm broad.
Ecology: in plankton and benthos at water temperature of 12-20 °C and pH 5.4-7.6; (hl, ind, Ha).
Local distribution: Cheghakhor (5), Golpayegan (1) and Zayandehrud (1-4) Reservoirs, and Zayandehrud (1, 4) and Kharghab Rivers, Suleghan Pond as well.
General distribution: Europe, Asia, New Zealand.
Durinskia Carty et Cox 1986
Durinskia occulata (F. Stein) G. Hansen et Flaim 2007. J. Limnol. 66 (2): P. 134. Figs 31A-G.
Indentified as *Glenodinium occulatum* Stein 1883.
Cells 19-36 µm long, 15-36 µm broad.
Ecology: in plankton and benthos at water temperature of 18-22 °C and pH 7.2-7.5; (hl, ind, M).
Local distribution: Mahabad (1, 2), Qeshlagh (1, 2) and Hasanlu (1, 2) Reservoirs, and Arvandrud River,



Figs. 1-11. 1. *Gymnodinium aeruginosum.* 2. *Gymnodinium paradoxum*. 3. *Lingulodinium polyedrum*. 4-5. *Ceratium hirundinella* and its cyst. 6. *Peridiniopsis borgei.* 7. *Peridiniopsis elpatiewskyi.* 8. *Peridiniopsis penardiforme*. 9. *Peridiniopsis quadridens.* 10. Cyst of *Peridiniopsis* 11. *Durinskia occulata*.

Suleghan Pond (1), Gavkhuni Swamp (1) as well.
General distribution: Europe, Asia, Africa, America, Australia and New Zealand.
Peridinium Ehrenb. 1832
Peridinium aciculiferum Lemmermann 1900. Ber. Deutsch. Bot. Gesell. 18: 28.
Vegetative cells 30-51 µm long and 20-42 µm broad.
Ecology: in plankton and benthos at water temperature of 18-20 °C and pH 7.2-7.5; (hl, ind, M).
Local distribution: Mahabad (1), Qeshlagh (1, 2) and Hasanlu (1) Reservoirs, Zayandehrud (1, 3-5) and Qeshlagh Rivers (1, 2).
General distribution: Europe, Asia, North America, Australia and New Zealand.
Peridinium aciculiferum* f. *inerme J.Woloszynska 1911. Kosmos 36: 303.
Cells 33-51 µm long and 24-42 µm broad.
Ecology: in plankton and benthos at water temperature of 18-28 °C and pH 6.5-8.5; (acb).
Local distribution: Qeshlagh (1, 2) Reservoir, Kashaf rud River, Lake Parishan (2) and Shadegan Pond (1, 2).
General distribution: Europe, Asia, North America.
Peridinium africanum Lemmermann 1907. J. Linn. Soc. Bot. 38: 81-197.
Cells 20-43 µm long and 20-35 µm broad.
Ecology: in plankton at water temperature of 23-24 °C and pH 7.4-7.6; (acb, M).
Local distribution: Torogh Reservoir (2) and Kashaf rud River.
General distribution: Europe, Asia, Africa, South America, Australia and New Zealand.
Peridinium bipes F. Stein 1883. Organ. Infus. 3(2): pl. 11. figs. 7-8.
Cells 40-95 µm long and 35-90 µm broad.
Ecology: in plankton at water temperature of 18-19 °C and pH 6.5-7.7; (ind, ind, M).
Local distribution: Dez River.
General distribution: Europe, Asia, North America, Australia and New Zealand.
Peridinium cinctum (O. F. Müller) Ehrenberg 1832. Infus. Vollkom. Organ. 18: 257, pl. 22, fig. 22.
Cells 36-78 µm long and 35-73 µm broad.
Ecology: in plankton and benthos at water temperature of 6-27 °C and pH 6.5-8.6; (ind, ind, M).
Local distribution: Amirkabir, Zayandehrud (1-4) and Karun (1) Reservoirs, Karun (1, 2) and Morghab Rivers.
General distribution: Europe, Asia, North and South America, Australia, and New Zealand.
Peridinium lomnickii Woloszynska 1916. Bull. Int. L'acad. Sci. Cracovie, Ser B. ., 8, 10 b: 267, pl. 10, figs. 25-29.
Cells 20-50 µm long and 22-50 µm broad.
Ecology: in plankton at water temperature of 14-20 °C and pH 6.5-7.6; (hb, acb, Ne).
Local distribution: Zayandehrud River (3, 5, 6).
General distribution: Europe, Asia.
Peridinium lomnickii* var. *splendidum J. Woloszynska 1916. Bull. Int. L'acad. Sci. Cracovie, Ser B. ., 8, 10 b: 268, pl. 10, figs. 30-40.
Cells 20-50 µm long and 22-50 µm broad.
Ecology: in benthos at water temperature of 22-24 °C and pH 7.4-7.6; (acb, Ne).
Local distribution: Torogh River and Reservoir (1, 2).
General distribution: Europe, Asia, Central America.
Peridinium lomnickii* var. *wierzejskii (Woloszynska) Lindemann 1928. Hedwigia 68: 291.
Cells 28-35 µm long and 28-32,5 µm broad.
Ecology: in plankton and benthos at water temperature of 19 °C and pH 7.7; (acb, Ne).
Local distribution: Dez River.
General distribution: Europe, Asia.
Peridinium subsalsum Ostenfeld 1908. Wiss. Ergebn. Aralse Exp. 8: 166, pl. 5, figs. 50-53.
Cells 22-60 µm long, 20-56 µm broad.
Ecology: in plankton at water temperature of 27 °C and pH 6.5; (hl, alb, M).
Local distribution: Shadegan Pond (3).
General distribution: Europe, Asia, Central, North and South America.
Peridinium umbonatum F. Stein 1883. Organ. Infus. 3(2): pl. 12. figs. 1-8.
Cells 15-45 µm long and 12-32 µm broad.
Ecology: in plankton at water temperature of 12-27 °C and pH 7.5-8.3; (ind, ind, M).
Local distribution: small ponds of Mooteh area (Abbarik pond).
General distribution: Cosmopolitan
Peridinium umbonatum* var. *lubieniense (Wolszynska) J. Popovsky & L. Pfeister 1986. Dynophyceae (Dinoflagellida). 6. Jena/Stuttgart:Fischer. 1990: 185, fig. 199.
Cells 35-45 µm long and 30-32 µm broad.
Ecology: in plankton at water temperature of 12-27 °C and pH 6.4-8.3; (acb, Ne).
Local distribution: Shadegan Pond (1, 2).
General distribution: Europe.
Peridinium willei Huitfeldt-Kaas 1900. Vidensk, Skrift, I Math.-Nat. Kl. 2: 5, figs. 6-9.
Cells 38-83 µm long and 36-80 µm broad.
Ecology: in plankton and benthos at water temperature of 19-27 °C and pH 6.5-7.7; (ind, ind, M).
Local distribution: Karun (2) Reservoir, Karun (1) and Morghab Rivers.
General distribution: Europe, Asia, North and South America, Australia and New Zealand (Probably cosmopolitan).
***Peridinium* sp.**



Figs. 12-21. 12. *Peridinium africanum*. 13. *Peridinium aciculiferum* 14. *Peridinium bipes*. 15. *Peridinium cinctum*. 16. *Peridinium subsalsum*. 17. *Peridinium umbonatum*. 18. *Peridinium willei* 19. *Palatinus pseudolaevis* 20. *Protoperidinium achromaticum* 21. *Dinococcus oedogonii*.

Notes: cells were ovoid almost globular, 16.2 µm long and 13.5 µm broad and 18 µm thick.
Ecology: in plankton at water temperature of 20 °C and pH 7.6.
Local distribution: Qeshlagh River (2).
Palatinus S.C.Craveiro, A.J.Calado, N.Daugbjerg & Ø.Moestrup 2009
Palatinus apiculatus (Ehrenberg) S. C. Craveiro, A. J. Calado, N. Daugbjerg & Ø. Moestrup 2009. J. Phycol. 45: 1178, figs. 2 a-e.
Indentified as *Peridinium palatinum* Laut.
Cells 30-55 µm long and 25-48 µm broad.
Ecology: in benthos at water temperature of 11-20 °C and pH 6.5-8.5; (hb, ind, a-a).
Local distribution: Zayandehrud River (1, 3) and Gavkhuni Swamp (1).
General distribution: Europe, Asia, North America.
Palatinus pseudolaevis (M. Lefèvre) S. C. Craveiro, A. J. Calado, N. Daugbjerg & Ø. Moestrup 2009. J. Phycol. 45: 1178, figs. 13 d-i.
Revealed as *Peridinium pseudolaeve* Lefèvre 1926
Cells 33-48 µm long and 28-42 µm broad.
Ecology: in plankton and benthos at water temperature of 18 °C and pH 7.6; (acf, Ha).
Local distribution: Qeshlagh Reservoir (1, 2).
General distribution: Europe, Asia.
Congruentidiaceae Schiller**; *Diplopsalis*** Bergh, 1881
Diplopsalis acuta (Apstein) Entz 1904. Res. D. Wiss. Erforsch. Balatonsee 2(1): 12, figs. 5 a-g.
Cells 29-39 µm long and 26-67 µm broad.
Ecology: in plankton at water temperature of 18°C and pH 7.6; (hl, ind, Ha).
Local distribution: Golestan Reservoir (2).
General distribution: Europe, Asia.
Protoperidinium Bergh. 1881
Protoperidinium achromaticum (Levander) Balech 1974. Revta Mus. Argent. Cienc. Nat. "B. Rivadavia", Hidrobiol. 7: 56.
Indentified as *Peridinium achromaticum* Lev.
Cells 28-48 µm long and 24-40 µm broad.
Ecology: in plankton at water temperature of 18°C and pH 7.6; (mh, acf, Ne).
Local distribution: Golestan Reservoir (1).
General distribution: Europe, Asia, South America, New Zealand.
Phytodiniales Christensen 1962 ex Loeblich III 1970;
Phytodiniaceae G. A. Klebs 1912; ***Cystodinedria*** Pascher, 1944
Cystodinedria inermis (Geitler) Pascher 1944. Beih. Bot. Centrabl. 62, A. 3: 381, Abb. 5.
Cells 8-88 µm long and 6-62 µm broad.
Ecology: in plankton and benthos at water temperature of 18-19 °C and pH 6.5-7.6; (hb, acb, b).
Local distribution: Dez River.
General distribution: Europe, New Zealand.
Dinococcus Fott, 1960
Dinococcus oedogonii (P. Richter) Fott 1960. Preslia 32: 142-154.
Cells 20-35 µm long and 12-20 µm broad. Nutrition partially unknown.
Ecology: in periphyton (epiphytic) at water temperature of 6-32 °C and pH 5-8.5; (unknown).
Local distribution: Shahnaz Reservoir, Lake Shatt-e Mangar (2) and Suleghan Pond (1).
General distribution: Europe, Asia, Africa, New Zealand.

DISCUSSION AND CONCLUSION

Dinokaryota do not belong to well-defined typology of water bodies and they can meet in rivers, reservoirs, ponds, lakes, swamps, and even in pools on the mineral substratum (Gorbulin, 2011). On the whole, overwhelming majority species of Dinophyta prefer shallow littoral section of bays and backwaters with intensive development of littoral hydrophilic flora that is conditions typical for representatives of tychoplankton. For example, species such as *Ceratium hirundinella*, *Diplopsalis acuta*, *Gonyaulax apiculata*, *Peridiniopsis polonicum*, *Peridinium umbonatum* are pointed as representatives of tychoplankton in the literature (Tamás, 1965).

A presented list of dinoflagellates with their regions of distribution and ecological and geographical features is the first list of continental dinoflagellates of Iran. However, six species such as *Glenodinium quadridens* (Stein) Schiller, *Glenodinium inconspicum* Lemm., *Peridinium cinctum* var. *tuberosum* (Meun.) Lind., *Woloszynskia neglecta* (Schilling) R. H. Thompson, *Peridinium wisconsinense* Eddy and *Glenodinium pulvisculus* (Ehre.) Schil. were not include here. They were found by other researchers (Afsharzadeh et al., 2003; Noroozi et al., 2009, Mohsenpour Azari et al 2011; Rahmati et al, 2011; Shams et al., 2012). Totally these authors revealed twelve taxa of freshwater dinoflagellates.

Taking into account this, it can say that a total of 42 species (50 inf. taxa) of freshwater dinoflagellates became known from continental water bodies of Iran at present time.

It is necessary to note that this taxonomic list of dinoflagellates allows picturing the nature of their distribution in the country and can be the basis for the study of this interesting and valuable group of organisms which are important nutrients for many planktivorous fishes and invertebrates due to fatty acid content of them. On the other hand, they can be toxic for them. Thus, knowledge on this group of algae is the most important especially on the water bodies, which

are used for drinking.

Freshwater dinoflagellates are generally considered nontoxic and harmless algae despite the fact that their marine counterparts may be extremely toxic. It is necessary to note that among revealed species some species can be potentially dangerous for water bodies in which they were found.

Peridinium aciculiferum can produce a toxic substance and that this substance could allow it to outcompete small flagellated phytoplankton that are better at nutrient uptake and have lower nutrient requirements (Rengefors and Lagrand, 2001).

Peridinium willei is known for its taste and odor producing metabolites. *Gymnodinium uberrimum* also is a nuisance for water supplies because it accelerates clogging of filter systems in drinking-water treatment but may also break through these filters with the consequence of elevating the dissolved organic carbon (DOC) concentrations of the purified water and thus enhancing microbial growth. (Niesel *et al*., 2007).

Lingulodinium polyedrum is the most dangerous among the described species. It has been related to production of Yessotoxins (YTXs), a group of structurally related polyether toxins, which can accumulate in shellfish and can produce symptoms similar to those produced by Paralytic Shellfish Poisoning (PSP) toxins (Paz et. al, 2008).

Freshwater dinoflagellates are less investigated with respect to toxins. May be, other presented species could pose hazard to life of invertebrate, fishes and human as well.

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