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.

INTRODUCTION

Dinoflagellates (Dinophyta, Dinokaryota) make an important part of algal bioenocesis 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
Continental dinoflagellates of Iran

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, Crepidodinium) and others are devoid of plastids (Cystodinedria, Oodinioides and Stylo dinium) (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 on 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 alcalinophile (Taylor et al., 2007).

Knowledge on the freshwater dinophytes of different water bodies of Iran are limited and presented by small number of publications such as (Löffler 1961; Wasylik 1975; Afsżarzadeh 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 Durinska 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, epipellic, epipelic) from various substrata were examined. Methods of sampling, processing and storage of the algalogical 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 ablation 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; Popovský and Přešter, 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.

<table>
<thead>
<tr>
<th>Code</th>
<th>Name of water bodies</th>
<th>Sites</th>
<th>Locations</th>
<th>Date of sampling</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>Amirkibir Reservoir</td>
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<td></td>
<td></td>
<td>2</td>
<td>37° 27’ 44.73”N–49° 20’ 10.62”E</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>3</td>
<td>37° 30’ 44.01”N–49° 18’ 09.79”E</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>37° 29’ 53.97”N–49° 19’ 55.76”E</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>37° 27’ 55.19”N–49° 23’ 29.95”E</td>
<td>15.06.2002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>37° 28’ 36.92”N–49° 22’ 09.98”E</td>
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</tr>
<tr>
<td>2</td>
<td>Anzali Swamp</td>
<td>30</td>
<td>30° 19’ 49.55”N–48° 16’ 53.20”E</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>48° 12’ 36.97”E</td>
<td>12.05.2002</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Arvandrud River</td>
<td>5</td>
<td>36° 10’ 24.22”N–59° 33’ 05.00”E</td>
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<td></td>
<td>36° 10’ 13.62”N–59° 33’ 06.17”E</td>
<td></td>
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<td>4</td>
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<td></td>
<td>2</td>
<td>31° 55’ 40.17”N–50° 53’ 09.24”E</td>
<td></td>
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<td></td>
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<td>3</td>
<td>31° 54’ 58.39”N–50° 55’ 39.69”E</td>
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<tr>
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<td>4</td>
<td>31° 55’ 20.39”N–50° 56’ 04.99”E</td>
<td></td>
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<td></td>
<td></td>
<td>5</td>
<td>31° 55’ 40.17”N–50° 53’ 09.24”E</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Dez River</td>
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<td>32° 24’ 30.12”N–48° 24’ 48.74”E</td>
<td>12.05.2002</td>
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<td>Dizine Pond</td>
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<td>37° 12’ 02.84”N–50° 04’ 05.75”E</td>
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<td></td>
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<td>Golestan Reservoir</td>
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<td></td>
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<td>2</td>
<td>33° 23’ 54.33”N–50° 5’ 9.34”E</td>
<td>20.05.2002</td>
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<td>Golpayegan Reservoir</td>
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<td></td>
<td>2</td>
<td>37° 2’ 17.61”N–45° 30’ 12.75”E</td>
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<td>10</td>
<td>Hasanlu Reservoir</td>
<td>1</td>
<td>37° 25’ 59.27”N–48° 12’ 36.55”E</td>
<td>11.05.2002</td>
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<td></td>
<td></td>
<td>2</td>
<td>31° 21’ 7.64”N–48° 42’ 11.95”E</td>
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<td>11</td>
<td>Karkheh River</td>
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<td>28° 47’ 34.46”N–57° 31’ 37.18”E</td>
<td>13.06.2002</td>
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<tr>
<td>12</td>
<td>Karkheh Reservoir</td>
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<td>30.05.2001</td>
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<td>2</td>
<td>29° 32’ 5.76”N–51° 46° 47.40”E</td>
<td>04.06.2002</td>
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<td>13</td>
<td>Karun Reservoir</td>
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<td>31° 52’ 27.28”N–49° 50’ 43.35”E</td>
<td>12.05.2002</td>
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<td></td>
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<td>31° 52’ 18.39”N–49° 52’ 3.66”E</td>
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<td>14</td>
<td>Karun River</td>
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<td>36° 45’ 41.44”N–45° 42’ 9.17”E</td>
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<td>15</td>
<td>Kashaf rud</td>
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<td>16</td>
<td>Kharghab river</td>
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<td>17</td>
<td>Lake Parishan</td>
<td>1</td>
<td>35° 18’ 35.14”N–47° 02’ 09.58”E</td>
<td>21.05.2002</td>
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<td>35° 19’ 52.27”N–47° 03’ 04.47”E</td>
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<td>Lake Shatt-e Mangar</td>
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<td>33° 05’ 25.39”N–55° 34’ 36.80”E</td>
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<td>20</td>
<td>Morghab River</td>
<td>1</td>
<td>33° 54’ 00.43”N–48° 43’ 28.08”E</td>
<td>21.05.2002</td>
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<td>21</td>
<td>Mill-pond (Vachek)</td>
<td>1</td>
<td>31° 57’ 57.47”N–50° 46’ 09.65”E</td>
<td>14.05.2002</td>
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<td>22</td>
<td>Mill-pond (Mooteh)</td>
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<td>31° 58’ 21.06”N–50° 46’ 46.95”E</td>
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<td>23</td>
<td>Panzdah-e Khordad Reservoir</td>
<td>1</td>
<td>36° 10’ 24.22”N–59° 33’ 05.00”E</td>
<td>13.06.2002</td>
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<td></td>
<td></td>
<td>2</td>
<td>36° 10’ 13.62”N–59° 33’ 06.17”E</td>
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</tr>
</tbody>
</table>
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 lemmernanni, Peridiniopsis penardiforme were the most often met taxa. The other interesting findings were infrequently met are as fowlows: Woloszynskia pseudopalustris, Glenodinium pseudostigmosum, Peridinium subsalsum, Peridiniopsis borgei, Peridiniopsis charkowiensis, Peridiniopsis lubieniensiforma, Cystodinedria inermis. Among identified species, Gymnodinium discoideae, 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 infr. 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 P. lomnickii var. lubieniense, and Cystodinedria inermis 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 dinothypye 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 dinoflagellates.

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 indifferenters 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 Prototheca acromactum. 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 smaller 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, Peridiniopsis acromactum 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 charkoviensis, Peridinium umbonatum var. lubienense, 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).

General distribution: Europe, Australia.
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 Zoshik Rivers, Lake Parishan (1, 2), Shadegan Pond (2, 3) and Anzali Swamp (2).

General distribution: Europe, Asia, North America.

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

General distribution: Europe, South America.
Gymnodinium palustre A. J. Schilling 1891. Flora
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; (hl, acf, M).
Local distribution: Qeshlagh (1, 2) and Reservoirs, Dizine Pond (1) and Karun (1, 2), Kashaf rud, Qeshlagh (1, 2), Torogh and Zayandehrud (2, 3) Rivers, Lake Parishan (1, 2), Shadegan Pond (1) as well. General distribution: East Asia, North and South America, New Zealand.

Identified as Gymnodinium pocoliferum Skuja 1956.
Vegetative cells 24-90 µm long and 19-75 µm broad.
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: Cheghakhor (3) and Karun (1) Reservoirs, Karun (1), Kharghab and Morghab Rivers, Lake Parishan (1, 2), Shadegan Pond (1) as well as Anzali Swamp (2, 1, 2).
General distribution: Europe, Asia, New Zealand.

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.

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) 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).

Gonyaulacales Taylor 1980; Gonyaulaceae Lindemann 1928; Lingulodinium Dodge 1989
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
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.

Lingulodinium Dodge 1989
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
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.

Lingulodinium Dodge 1989
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
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. gracile (H. Bachmann) 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 **Glenodinium** Wolosz 1916


Indenstified as *Sphaerodinium minuta* (Ehrenberg) Woloszynska 1917

Vegetative cells 25-50 μm long and 25-48 μm broad.

Ecology: in plankton and benthos at temperature of 18-20 °C and pH 6.5-7.6; (hb, acf, Ha).

Local distribution: Dez River, Shadegan Pond (1, 2), Anzali Swamp (2, 3, 5).

General distribution: Europe, Asia, New Zealand.

Genus **Glenodinium** Ehrenb. 1916


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.


Cells 30-38 μm long and 25-33 μm broad.

Ecology: in plankton and benthos at 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, America.

**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 temperature of 12-20 °C and pH 4.6-8.3; (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.


Cells 18-33 μm long and 15-30 μm broad.

Ecology: in plankton at water temperature of 18-20 °C and pH 7; (ac, Ne).

Local distribution: Qeshlagh River (1, 2) and Reservoir (2). General distribution: Europe.


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.


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.


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 quadridentis** (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


Identified 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,
Suleghan Pond (1), Gavkhuni Swamp (1) as well. General distribution: Europe, Asia, Africa, America, Australia and New Zealand.

**Peridinium Ehrenb. 1832**

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.

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.

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; (ind, ind, M).
Local distribution: Torogh Reservoir (2) and Kashaf rud River.
General distribution: Europe, 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.

Cells 36-78 µm long and 35-73 µm broad.
Ecology: in plankton at water temperature of 18-19 °C and pH 6.5-7.7; (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.

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.

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.

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.

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

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.

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.**
Notes: cells were ovoid almost globular, 16.2 µm long and 13.5 µm broad and 18 µm thick.
Local distribution: Qeshlagh River (2).


Cells 33-48 µm long and 28-42 µm broad.
Ecology: in plankton at water temperature of 18 °C and pH 7.6; (a-cf, Ha).
Local distribution: Qeshlagh Reservoir (1, 2).


Revealed as *Peridinium pseudolaevum* 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; (a-cf, Ha).
Local distribution: Qeshlagh Reservoir (1, 2).


Identified as *Peridinium palatinius* 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 Gavkhuoni Swamp (1).

General distribution: Europe, Asia, North America.

*Congruentidiaceae* Schiller; *Diplopsalis* Bergh, 1881

Cells 29-39 µm long and 26-67 µm broad.
Ecology: in plankton and benthos at water temperature of 18°C and pH 7.6; (a-cf, Ha).
Local distribution: Golestan Reservoir (2).
General distribution: Europe, Asia.

*Protoperidinium* Bergh. 1881


Identified as *Peridinium acromaticum* Lev.
Cells 28-48 µm long and 24-40 µm broad.
Ecology: in plankton at water temperature of 18°C and pH 7.6; (a-cf, Ha).
Local distribution: Golestan Reservoir (1).

General distribution: Europe, Asia, South America, New Zealand.

*Phytodiniolae* Christensen 1962 ex Loeblich III 1970;

*Phytodiniaceae* G. A. Klebs 1912; *Cystodinedria* Pascher, 1944

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

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 inconspicuum* Lemm., *Peridinium cinctum* var. *tuberosum* (Meun.) Lind., *Woloszynskia neglecta* (Schilling) R. H. Thompson, *Peridinium wisconsinense* Eddy and *Glenodinium pulvulcus* (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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