

A check list of Pinnulariaceae (Class Bacillariophyceae) in the ecosystems of Iran

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Abstract

Introduction and aim: The current study is provided for floristic research of Pinnulariaceae for the first time in Iran from 1972 to July 2021. The pinnulariaceae family contains 6 genera Pinnularia, Oestrupia, Hygropetra, Envekadea, Diatomella, and Craspedopleura which are two genera Pinnularia and Diatomella have been recorded in Iran. The purpose of the present study was to provide a checklist of Pinnulariaceae in Iran ecosystems.

Methods: Different recourses were used to provide this paper, including the thesis of students' dissertations, books, and articles. The old taxonomic names of taxa were converted to new names based on algae-based websites.

Results: This taxonomic list contains 2 genera comprises Diatomella and Pinnularia. It includes 52 species with emphasis on the Pinnularia Ehrenberg genus from various ecosystems. The Pinnularia was the most frequent genus with 51 species and 98% of the species in the Pinnulariaceae. Diatomella Greville was stand in the second genus in the frequency of population (2%) with 1 species. There are only one species of Diatomella in the current checklist of Pinnulariaceae which has been reported from Kordan River in Alborz Province.

Conclusion: Some of the species' names have changed based on this update.

Keywords: Diatomella, Kordan River, Marine, Pinnularia, Phytogeography

Introduction

Diatoms are one of the main ancestries of photosynthetic organisms which live in various habitats such as soil, freshwater, marine, and even saltwater. They are unicellular creatures with two siliceous cell walls (valves) which calls frustules. The valves are attached by the girdle bands. The frustule is extremely variable due to the presence of special ornamentations which

are essential in the systematic and identification of taxa. They belong to heterokontophyta and chromist lineages as algae with golden brown chloroplast.

The radial centric diatoms are more ancient than the pennate ones which *Pinnularia* are categorized in the pennate group (Kooistra *et al.*, 2007).

Algae are constantly present in aquatic environments and increase rapidly due to changes in environmental conditions in a short

time (Antón-Garrido *et al.*, 2013). Based on the 30 years of research with light, scanning, and transmission electron microscopy on the diatoms, we can estimate 75,000 species (Kociolek, 2018). Diatoms account for 45% of the total number of algae species found in lakes based on research findings of algal percentage in Iran's ecosystems (Zarei-Darki, 2009).

The diatom taxa can be cosmopolitan or endemic. If the distribution of a genus or family is restricted to a continent, on the other hand, there be a disjunction of distribution, so that taxa will be endemic. The taxa which have been distributed across three continents are "widely distributed and the taxa which have been distributed in four or more continents will be cosmopolitan. According to Kociolek (2018), the *Pinnularia* is a cosmopolitan taxon that has been reported from five continents. He concluded that 56% of endemic diatoms have been reported from Asia and it is 4 times greater than continents.

Pinnularia is a type of Bacillariophyta diatoms that occurs in freshwater. It is usually found in damp and soil lagoons, springs, estuaries (sea tidal inlets), sediments, and oceans (Naseri *et al.*, 2020). This genus was used as a subgenus of *Navicula* by Ehrenberg (1840a, 1840b) however, due to lack of a description, the name didn't publish reliably. They have linear, lanceolate, or elliptic valves. They have external and internal fissures and alveolated coastal systems (Krammer, 2000). Based on the algae base website there are 1424 species which 810 species were flagged as accepted taxa.

P. bertrandii var. *angustefasciata* Krammer has been reported from Karaj River also it's a new record for Iran (Kheiri *et al.*, 2018a).

Da Silva *et al.* (2016) reported 20 taxa of *Pinnularia* for Brazil which all of them were rare species. The most frequent of *Pinnularia* were *P. meridiana* var. *meridiana* Metzeltin & Krammer and *P. rumrichiae* Krammer.

Zidarova *et al.* (2012) have reported Seventeen different *Pinnularia* taxa from Livingston Island (South Shetland Islands, Maritime Antarctic Region) which 12 of which

were new records. In the other study in Brazil, twenty-three species of *Pinnularia* were reported from periphytic habitats which *P. subanglica*, *P. angustivalva*, and *P. butantanum* were the most frequent species (França *et al.*, 2017). In a study in France 79 species of diatoms were identified which the *Pinnularia* was the dominant taxon with 63% total valve count (Beauger *et al.*, 2020).

Several morphological groups in the large genus *Pinnularia* need to break into smaller groups (Kociolek, 2018).

The other genus in pinnulariaceae is *Diatomella* Greville which 8 species and 5 intraspecific are present in the database. Six species names have been accepted for this genus in classification.

In some cases, opinions about the validity of the classification vary from author to author, encouraging users to comment (Guiry & Guiry, 2021)

In this study, we have evaluated the *Pinnulariaceae* in the ecosystems of Iran

Materials and Methods

This checklist of pinnulariaceae is provided from 1972 to July 2021 for the first time. Different recourses were used to provide this paper, include the thesis of students' dissertations, books, and articles. Base on the algae base website the old taxonomic names of taxa was converted to the new names (Table 1).

The following resources have been used in this study: Anzali Lagoon (Nejadsattari *et al.*, 2005; Ramezanpour, 2004); Karaj and Marbareh rivers (Kheiri *et al.*, 2018a & b); Tizab River (Kheiri, 2019); Lake Urmia: (Mohebbi, 2019); Guilan Province: (Noroozi *et al.*, 2019); Central and South-eastern Iran: (Compère, 1981); Zayandeh Rood Lake (Shams *et al.*, 2012); Neure (Neor) Lake: (Nejadsattari, 2005); Balikhli River (Panahy-Mirzahasanlou *et al.*, 2018, 2020); Golestan Province: (Ahmadi-Musaabad *et al.*, 2019), Goharbaran region: (Makhloogh *et al.*, 2017); Bushehr area: (Fatemi *et al.*, 2005); Kordan & Taleghan Rivers: (Mehrani-Adl *et al.*, 2020,

Nasari & Noorzi, 2021); Gavkhouni Wetland (Shams & Karimian- Shamsabadi, 2019); Bandar Abbas (Saeedi & Ashja-Aradalan, 2009); Phytoplankton Hormuz (Subba-Rao & Al-Yamani, 1998); South coastal waters of the Caspian Sea: (Omidmoazam *et al.*, 2020); Caspian Sea (Iranian coasts): (Nasrollahzadeh-Saravi *et al.*, 2015); Kashkan River (Safiallah *et al.*, 2020); Rivers in Turkey and Iran (Atici & Shams, 2017); streams in Ramsar: (Soltanpour-Gargari *et al.*, 2011); Boujagh National Park: (Noroozi *et al.*, 2009); Southern Caspian Sea: (Fallahi, 1993); Helleh River (Farhadian *et al.*, 2015), checklist of phytoplankton taxa in the Caspian (Bagheri & Fallahi, 2014); Gharasou River: (Atazadeh *et al.*, 2007), and Algae of aquatic ecosystems of Iran (Zarei-Darki, 2009, 2011). The taxa name are classified base on to Guiry & Guiry (2021).

Results

The proportion of the species of pinnulariaceae are depicted in Figure 1 which shows 98 percent of this family belongs to *Pinnularia* genus. Species in the Pinnulariaceae checklist are categorized according to Guiry & Guiry (2021) (Figure 1 and Table 1).

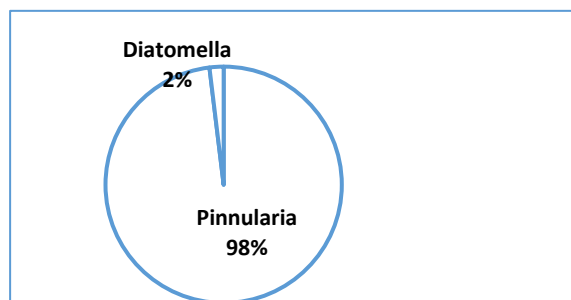


Figure 1. The percentage of the species in the checklist of pinnulariaceae of Iran

Discussion

The pinnulariaceae family contains 6 genera: *Pinnularia*, *Oestrupia*, *Hygropetra*, *Envekadea*, *Diatomella*, and *Craspedopleura* which are two genera (*Pinnularia* and *Diatomella*) have been recorded in Iran.

There are only one species of *Diatomella* (*D. balfouriana* Greville) in the current checklist of pinnulariaceae which has been reported from the Kordan River in Alborz Province, Iran (Mehrani-Adl *et al.*, 2020). It is a freshwater species.

Diatomella has been reported in the Arctic: Iceland (Foged, 1977); Europe: Britain (Hartley *et al.*, 1986); Ireland (Foged, 1977); North Macedonia (Levkov & Williams, 2012); North America: Alaska (Foged, 1981); California (Bahls, 2005); Idaho (Bahls, 2005); Montana (Bahls 2005); Oregon (Bahls, 2005); United States of America (Kociolek, 2018), Washington (Bahls, 2005), Western Canada (Bahls *et al.*, 2018); Africa: Ghana (Foged, 1966); Middle East: Turkey (Aysel, 2005); South-west Asia: India (Gupta & Das, 2020); Asia: Bering Island (Potapova, 2014); China (Li & Qi, 2010); Russia (Kulikovskiy *et al.*, 2016); Antarctic and Antarctic islands: Ile de la Possession (Van De Vijver *et al.*, 2005).

There are 1424 names of *Pinnularia* species in the database, also 1474 infraspecific names which 810 species have been flagged as accepted taxonomically (Guiry & Guiry, 2021). The *Pinnularia* genus is a complex taxonomic group with a high number of species and diverse morphological characters.

Therefore it is necessary to reconsider this genus with polyphasic identifications including molecular techniques, morphology, ultrastructure, and also biochemical characters. The *Pinnularia* is present in various habitats such as normal freshwater, Antarctic region (Pinseel *et al.*, 2017).

There is other publications on Checklists of Pinnulariaceae however, it includes phytoplankton taxa of the Caspian Sea (Bagheri & Fallahi, 2014), and algae of aquatic ecosystems of Iran (Zarei-Darki, 2011). Unlike them, the currently checklist is focused only on the Pinnulariaceae.

Thirty-three species of Pinnulariaceae are reported in checklist algae of aquatic ecosystems of Iran which all species is belong to *pinnularia* genus (Zarei-Darki, 2011). Only

P. nobilis Ehrenberg is reported in the checklist of phytoplankton taxa of the Caspian Sea (Bagheri & Fallahi, 2014).

Table 1. The checklist of pinnulariaceae (Bacillariophyta) in Iran's resources

Bacillariophyceae	<i>P. intermedia</i> (Lagerstedt) Cleve
Pinnulariaceae	<i>P. interrupta</i> W.Smith (<i>P. interrupta</i> f. <i>biceps</i> (W.Gregory) Cleve)
<i>Diatomella</i>	<i>P. interrupta</i> f. <i>typica</i> A.Cleve
<i>D. balfouriana</i> Greville	<i>P. issykkulensis</i> Kisselev
<i>Pinnularia</i>	<i>P. lata</i> (Brebisson) Rabenhorst
<i>P. abaujensis</i> (Pantocsek) R.Ross	<i>P. lundii</i> var. <i>linearis</i> Krammer
<i>P. acrosphaeria</i> W.Smith	<i>P. major</i> var. <i>paludosa</i> F.Meister
<i>P. acutobrebissonii</i> Kulikovskiy, Lange-Bertalot & Metzeltin	<i>P. major</i> var. <i>horrida</i> (M.Peragallo & Héribaud) F.W.Mills
<i>P. appendiculata</i> (C.Agardh) Schaarschmidt	<i>P. major</i> var. <i>major</i> (Kützing) W.Smith
<i>P. brebissonii</i> (Kützing) Rabenhorst (<i>P. microstauron</i> var. <i>brebissonii</i> (Kützing) Ant.Mayer	<i>P. microstauron</i> var. <i>biundulata</i> (O.Müller) Ant.Mayer
<i>P. bertrandii</i> var. <i>angustefasciata</i> Krammer	<i>P. microstauron</i> f. <i>lata</i> Hustedt
<i>P. bicapitata</i> (Lagerstedt) Cleve (<i>Navicula bicapitata</i> Lagerstedt)	<i>P. nobilis</i> Ehrenberg
<i>P. biceps</i> W.Gregory	<i>P. nodosa</i> (Ehrenberg) W.Smith
<i>P. borealis</i> var. <i>barodensis</i> H.P.Gandhi	<i>P. obscuriformis</i> Krammer (<i>P. brebissonii</i> var. <i>diminuta</i> (Grunow) Cleve
<i>P. bogosoensis</i> Foged	<i>P. obscura</i> Krasske (<i>P. brebissonii</i> var. <i>diminuta</i> (Grunow) Cleve)
<i>P. brauniana</i> (Grunow) Studnicka (<i>P. braunii</i> Cleve)	<i>P. oriunda</i> Krammer (<i>P. viridis</i> var. <i>leptogongyla</i> Cleve)
<i>P. brebissonii</i> (Kützing) krammer and Lange Bertalot (<i>P. microstauron</i> var. <i>brebissonii</i> (Kützing) Ant.Mayer)	<i>P. pectinalis</i> Skvortsov
<i>P. cocconeis</i> (Ehrenberg) Ehrenberg (<i>Navicula cocconeis</i> Ehrenberg)	<i>P. rabenhorstii</i> (Grunow) Krammer
<i>P. decurrens</i> Ehrenberg	<i>P. rangoonensis</i> Grunow ex Cleve
<i>P. dactylus</i> Ehrenberg	<i>P. rupestris</i> Hantzsch
<i>P. divergens</i> W. Smith	<i>P. saprophila</i> Lange-Bert., H. Kobayasi and Krammer
<i>P. divergens</i> var. <i>elliptica</i> (Gnmow) Cleve	<i>P. schroederi</i> (Hustedt) Cholnoky
<i>P. divergentissima</i> (Grunow) Cleve	<i>P. stomatophora</i> (Grunow) Cleve
<i>P. gentilis</i> (Donk. Cleve (<i>P. viridis</i> var. <i>clevei</i> Meister)	<i>P. subcapitata</i> W.Gregory
<i>P. globiceps</i> W.Gregory	<i>P. sudetica</i> Hilse
<i>P. graciloides</i> var. <i>triundulata</i> (Fontell) Krammer	<i>P. tabellaria</i> Ehrenberg
<i>P. hemiptera</i> (Kützing) Rabenhorst	<i>P. viridis</i> (Nitzsch) Ehrenberg
<i>P. ignobilis</i> A.Cleve	<i>P. viridis</i> var. <i>diminuta</i> Ant.Mayer

Note: The old taxon name is depicted in the bracket.

There are not any species of pinnulariaceae family in Thirteen of references including Anzali lagoon: (Nejadsattari *et al.*, 2005; Ramezani, 2004); Zayandeh-Rood Dam in Isfahan province: (Shams *et al.*, 2012); Golshahr coast, Bandar Abbas (Saeedi & Ashja-Aradalan, 2009); Phytoplankton Hormuz: (Subba-Rao & Al-Yamani, 1998); Kashkan River (Safiallah *et al.*, 2020); Goharbaran region: (Makhloogh *et al.*, 2017); South coastal waters of the Caspian Sea: (Omidmoazam *et al.*, 2020); Bushehr area: (Fatemi *et al.*, 2005); Caspian Sea -Iranian coasts: (Nasrollahzadeh-Saravi *et al.*, 2015); Tizab River (Kheiri, 2019); Marbareh rivers (Kheiri *et al.*, 2018 b), and Neure (Neor) Lake: (Nejadsattari, 2005).

There are seven species of *Diatomella* in the algae base site including *D. balfouriana* Greville: *D. colonialis* Van de Vijver & Le

Cohu; *D. lecohui* G.Moser, Lange-Bertalot & Metzeltin; *D. ouenkohana* R. Maillard, *D. parva* Manguin, and *D. salina* M. Voigt which are accepted in taxonomically.

Conclusion

Results of the study show that Pinnulariaceae has 2 genera and 52 species in Iranian water resources including Pinnularia (51 species) and Diatomella (1 species). Some species' names have changed based on this update.

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