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REPORT OF ARMORED DINOFLAGELLATES FROM WATERS SURROUNDING HORMUZ ISLAND (THE STRAIT OF HORMUZ)

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Despite the scientific and strategic importance of the Persian Gulf and Gulf of Oman as well as a significant number of articles, there are still gaps in knowledge about their ecosystems. The knowledge on species composition and morphology of armored dinoflagellates in the vicinity of Hormuz Island (the Strait of Hormuz) are presented. Totally, 99 species (109 infra-specific taxa), belonging to 1 class. 6 orders, 13 families and 24 genera are reported. Seven species and 11 infra-specific taxa were found for the first time. Some new taxa are provided with the original descriptions and photographs. Moreover, based on a critical review of the literature on dinoflagellates discovered in the Persian Gulf and Gulf of Oman up to the present investigation, a pilot checklist of dinoflagellates numbered 363 infra-specific taxa belonging to 81 genera was composed. By summing up previous and present knowledge, it turns out that the number of dinoflagellates recorded in these water bodies makes up 374 infra-specific taxa until now. The multispecies genera *Ceratium* and *Protoperidinium* made the greatest contribution to phytoplankton populations.

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Key words: Dinophyta; biodiversity; the Ropme Sea Area; Iranian waters

گزارش داینوفلاژله‌های زره‌دار از آبهای حوالی جزیره هرمز (تنگه هرمز)

بهروز زارعی دارکی: استادیار گروه زیست‌شناسی دریا، دانشکده علوم دریایی دانشگاه تربیت مدرس
الکساندر کراخمالنی: استاد انستیتو اکولوژی تکاملی، آکادمی ملی علوم اوکراین، کی‌یف، اوکراین

علیرغم اهمیت علمی و استراتژیک خلیج فارس و خلیج عمان، حتی با وجود تعداد قابل توجهی از منابع، هنوز نواقصی در دانش اکوسیستم‌های آنها مشاهده می‌شود. در این پژوهش اطلاعاتی مربوط به ترکیب گونه‌ای و ریخت‌شناسی داینوفلاژله‌های زره‌دار در حوالی جزیره هرمز ارائه شده است. به طور کلی ۹۹ گونه (۱۰۹ آرایه درون گونه) معرفی شدند که به یک کلاس، ۶ راسته، ۱۳ تیره و ۲۴ جنس متعلقند و برای اولین بار ۷ گونه و ۱۱ آرایه درون گونه از این منطقه گزارش می‌شود. برخی از تاکسون‌های جدید با توصیف و تصویر اصلی ارائه شده‌اند، علاوه بر این براساس بررسی و مقایسه منابع مربوط به داینوفلاژله‌های یافت شده در خلیج فارس و خلیج عمان تا این تحقیق، یک چک لیست از داینوفلاژله‌ها به تعداد ۳۶۳ آرایه درون گونه که متعلق به ۸۱ جنس هستند، ارایه می‌شود. با تجزیه وتحلیل نتایج مطالعات قبلی و نتایج مطالعه کنونی، تعداد داینوفلاژله‌های ثبت شده در این آبها تقریباً ۳۷۴ آرایه درون گونه را شامل می‌شود. بیشترین تأثیر را در جامعه فیتوپلانکتون‌های این منطقه جنس‌های چند گونه‌ای Ceratium و Protoperidinium داشتند.

INTRODUCTION

The marine ecosystem of the Persian Gulf and Gulf of Oman hereinafter the ROPME Sea Area (RSA) is endowed with valuable natural resources and a peculiar biodiversity of plant and animal species due to extreme physical conditions such as high temperatures and salinity (Sheppard & al. 2010; John 2012). Salinity can exceed 43 in some parts of the RSA because of high evaporation (a typical oceanic salinity is 37) and may reach 70-80 in tidal pools and lagoons (Reynolds 1993; Swift & Bower 2003). Furthermore, the shallow character and limited freshwater inflow, especially if it is considered in the context of climate change impacts, make it one of the most fragile ecosystems in the world (Pachauri & Meyer 2014).

Despite to the scientific and strategic importance of the RSA as well as a significant number of articles, there are still gaps in knowledge about its ecosystem health, food web dynamics, biodiversity and sustainability, especially in Iranian waters (Dorgham 2013). A Japanese panel made the first attempt to study a complex pattern of biological and physical processes taking place in the Persian Gulf and the Gulf of Oman (Otsuki & al. 1998). To understand the state of the marine environment in the RSA, the ROPME scientific Cruises were also conducted in winter 2006 (ROPME, 2012).

Moreover, plenty of localized algological researches from the different parts of the RSA, which can be divided into two groups, were also carried out during the past fifty years. The first one occupies all investigation conducted in Iranian waters and its coastline (Grice and Gibson 1978; Hulburt & al.1981; Rouhani Ghadikolaei 2001; Fallahi & al.2005; Abhijit & al. 2007; Attaran-Fariman & al. 2011). A number of investigations were conducted on marine coastal waters in Iraq (Al-Saboonchi and Al-Shawi 2016). The second group combines surveys of Arabian countries marine water environment (Jacob & Al-Muzaini 1995; Chandy & al. 1991; Dorgham 1991; Al-Muzaini & Jacob 1996; Husain & Ibrahim 1998; Morton & al. 2002; Abdul & al. 2003; Al-Harbi 2005; El-Din & Al-Khayat 2005; Al-Hashmi & al. 2012; Piontkovski & al. 2012; Quigg & al. 2013). Both in the past and present, the highest number of researches among Arabian countries were conducted in Qatari and Kuwaiti waters and along their coastline (Jacob 1979; Dorgham & Moftah 1989; Dorgham 1991; Ismail & al. 1999; Al-Yamani & al. 2006; Al-Kandari & al. 2009; Polikarpov & al. 2009; Al-Yamani & Saburova 2010; Piontkovski & al. 2011; Dorgham 2013; Saburova & al. 2012a, b, 2013a, b).

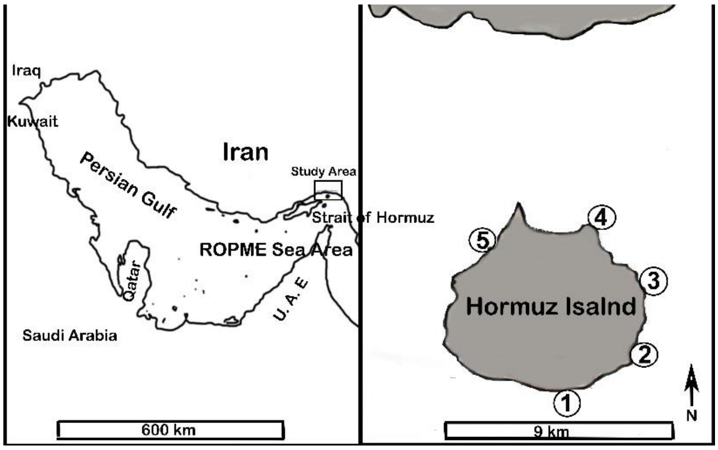
The phytoplankton species diversity in contrast to biomass and production tends to increase from north to south and to Arabian Sea (Subba-Rao & Al-Yamani 1998). In the Gulf of Oman and Strait of Hormuz, where the gulf opens to the ocean, the phytoplankton species diversity is the greatest at 527 and biomass the lowest (Subba Rao & Al-Yamani 1998; Quigg & al. 2013). Furthermore, there is a subtropical seasonal chlorophyll concentration cycle being at maximum in winter and minimum in spring-summer (Nezlin & al. 2010). In increasing frequency, exotic algae are also encountered in this water area. Their introduction into the area may be related to ballast water associated with the thousands of cargo ships and oil tankers moving in and out of the region and making pollution as the prerequisites for their spreading and growth (Shapoori & Gholami 2014). There are also serious concerns that these introductions could trigger ecological changes in the phytoplankton community structure, leading to potential economic loss to commercial fisheries (Quigg & al. 2013). The intensive industrial effluents discharging wastewater containing a variety of chemicals, including heavy metals, hydrocarbon compounds, and nutrients along the coastline of the Persian Gulf and the Gulf of Oman could also be critical for the marine ecosystems (Humood 2014).

However, an insignificant number of papers were published about dinoflagellates of Iranian waters of the RSA, and moreover, some of them were only limited to genera identification (Jalilli & Rezai 2010; Rabbaniha & al. 2012; Jamshid & al. 2014; Shapoori & Gholami 2014). Grice and Gibson (1978) collected samples in the vicinity of Hormuz Island in spring 1977, but no species have been pointed out in this area. Other investigations were focused on revelation of reasons of harmful algal blooms in Iranian coastal waters in which dinoflagellates were frequent pathogenic microorganisms (Rezai 1995; Attaran-Fariman & al. 2011; Fatemi & al. 2012; Hamzehei & al. 2012). Meanwhile, it can be admitted that species diversity of Iranian waters may be significantly higher than reported because of the low saline and warm oceanic waters from Arabian Sea which flow into the Gulf of Oman, move close to the coast of Iran through the Strait of Hormuz and form high productive water (Hirawaka & al. 1998; Subba Rao & Al-Yamani 1998).

Therefore, the aim of the present paper is to enhance the knowledge about armored dinoflagellates in the vicinity of Hormuz Island including the Persian Gulf and Gulf of Oman and providing comments on species composition, morphology and distribution.

MATERIALS AND METHODS

Materials were collected in waters surrounding Hormuz Island (42 km^2, 8 km long and 7 km wide) located 8 km off the Iranian coast in the Strait of Hormuz in January and July 2015 (map1). Sampling was carried out from five sites. One-time samples were taken with a plankton net with a mesh size of 55 μm filtering the sea water. In total, 10 samples were collected. Water temperature, salinity, electrical conductance, dissolved oxygen level, and pH were measured at all sites, (table 1). At first, the material was studied in vivo at the laboratory of the Department of Marine Biology of Tarbiat Modares University (Iran) and then it was preserved with 4% formalin. At the Institute for Evolutionary Ecology, National Academy of Sciences of Ukraine, Kiev, the further examination of the samples was carried out with a light microscope «Olympus-52X» in transmitted light by phase contrast, relief-phase contrast (DIC), dark-field modes, and fluorescence emission at magnification levels up to 800x, staining dinoflagellates preliminary with Calcofluor White Stain (Fritz & Triemer 1985). The dinoflagellate photomicrographs were taken with a digital camera «Olympus-420".



Map 1. Schematic map of the study area with the sampling sites around the Hormuz Island

Table 1. Locations and ranges of environmental factors of the sampling sites in the vicinity of Hormuz Island for the investigated time.

Sites	Geographic coordinates	T, °C	pH	DO ppm	EC mS/cm	Salinity
1	27°2'10.45"N–56°27'48.23"E	20.1-34.1	8.1-8.3	4.6-7.6	67.4-69.9	38.5-40.7
2	27°2'38.17"N–56°29'45.97"E	20.0-34.3	8.1-8.3	4.5-7.4	67.4-69.7	38.5-40.5
3	27°4'27.29"N–56°29'54.55"E	20.2-34.6	7.8-8.0	3.4-6.7	66.3-68.8	37.8-39.6
4	27°5'38.14"N–56°28'47.67"E	20.3-34.4	8.2-8.4	4.8-7.9	68.2-70.2	38.8-40.9
5	27°5'35.27"N–56°26'45.80"E	20.5-34.7	8.1-8.2	4.4-7.3	67.1-69.6	38.3-40.4

The taxonomy of occurring species was presented according to the system of extant and extinct dinoflagellates by Fensome & al. (1993) with the exception of family Congruentidiaceae J.Schiller which was replaced by Protoperidiniaceae (Fensome & al.1998). Identification of the species composition of Dinoflagellate was carried out using the basic reports and identification keys, as well as the keys for the genera *Ceratium* and *Protoperidinium* by Okolodkov Y.B. (2008, 2010). The old name of the genus *Ceratium* is going on to remain because the new name has not yet caught on and there was already an unsuccessful attempt to rename this genus in *Neoceratium* Gomez.

The new taxa of the RSA are given in the same way: name; data of nomenclature with reference to primary description; information about its basionym, if it exists; the most well-known synonyms; description and photographs; the local and world distribution.

RESULTS

In the plankton of the Iranian coastal waters surrounding Hormuz Island, 99 species represented by 109 infra-specific taxa (infra taxa) of armored dinoflagellates, belonging to 6 orders, 13 families and 24 genera were identified. According to a review of the previous reports, 7 species and 11 infraspecific taxa were found for the first time in the Persian Gulf and the Gulf of Oman. The representatives of the orders Gonyaulacales (46 species/52 taxa) and Peridiniales (45 species) represent higher diversity; at the same time, there were little numbers of species from orders Dinophysiales (6 species), Prorocentrales (3 species), Phytodiniales (3 species), and Noctilucales (1 species).

Among families, the largest species number was identified in *Protoperidiniaceae* (40 species) and *Ceratiaceae* (28 species, 38 taxa). The other families included few species, are as follows: *Gonyaulacaceae* (5 species), *Dinophysiaceae* (5 species), *Pyrocystaceae* (5 species), *Prorocentraceae* (3 species), *Phytodiniaceae* (3 species), *Ceratocoryaceae* (2 species), *Goniodomaceae* (2 species), *Peridiniaceae* (2 species), *Podolampaceae* (2 species), *Amphisoleniaceae* (1 species) and *Noctilucaceae* (1 species). At the generic level, *Protoperidinium* (33 genera) and *Ceratium* (28 species, 38 taxa) were also the most species rich genera. A few number of species were related to genera *Pyrocystis* (5 species), *Gonyaulax* (4 species); *Ornithocercus* and *Prorocentrum* (on 3 species); *Ceratocorys, Diplopelta, Podolampas, Dinophysis* and *Pyrophacus* (on 2 species); and *Alexandrium, Goniodoma, Peridinium, Scrippsiella, Lingulodinium, Diplopsalis, Diplopsalopsis, Oblea, Preperidinium, Amphisolenia, Pyrodinium, Noctiluca* (on 1 species).

Systematics of Occurring Species

Division **DINOFLAGELLATA** (Butschli 1885) Fensome & al.1993
Class Dinophyceae Pascher 1914

Order Gonyaulacales Taylor 1980

Family Gonyaulacaceae Lindemann 1928

Gonyaulax Diesing 1866
G. digitale (Pouchet) Kofoid 1911*
G. polygramma F.Stein 1883
G. scrippsae Kofoid 1911
G. spinifera (Claparède & Lachmann) Diesing 1866
Lingulodinium Wall 1967
L. polyedra (F.Stein) J. D. Dodge 1989

Family Ceratocoryaceae Lindemann 1928

Ceratocorys F. Stein 1883
C. horrida F. Stein 1883*
C. magna Kofoid 1910***

Family Ceratiaceae Willey and Hickson 1909

Ceratium Schrank 1793
C. belone Cleve 1900*
C. breve var. *parallelum* (Schmidt) Jörgensen 1911*
C. candelabrum (Ehrenberg) F. Stein 1883
C. candelabrum f. *depressum* (Pouchet) J. Schiller 1937
C. carriense Gourret 1883
C. contortum var. *karstenii* (Pavill.) Sournia 1966
C. contrarium (Gourret) Pavillard 1905
C. declinatum G. Karsten 1907
C. dens Ostenfeld & J. Schmidt 1901*
C. extensum (Gourret) A. Cleve 1900
C. furca (Ehrenberg) Claparède & Lachmann 1859*
C. furca var. *eugrammum* (Ehrenberg) Jörgensen *
C. fusus var. *seta* (Ehrenberg) Jörgensen 1911*
C. gibberum Gourret 1883*
C. gibberum var. *dispar* (Pouchet) Sournia 1966***
C. gravidum Gourret 1883***
C. hexacanthum Gourret 1883
C. horridum (Cleve) Gran 1902
C. horridum var. *buceros* (Zacharias) Sournia 1966**
C. incisum (G.Karsten) Jörgensen 1911***
C. karstenii Pavillard 1907
C. kofoidii Jörgensen 1911
C. lineatum (Ehrenberg) Cleve 1899
C. longipes (J. W. Bailey) Gran 1902
C. longirostrum Gourret 1883*
C. lunula Schimper ex G. Karsten 1906
C. macroceros (Ehrenberg) Cleve 1899
C. massiliense (Gourret) G. Karsten 1906
C. minutum Jörgensen in Schmidt 1920
C. pavillardii Jörgensen 1911**
C. pentagonum Gourret 1883
C. pentagonum var. *subrobustum* Jörgensen 1920**
C. pentagonum var. *tenerum* Jörgensen 1920**
C. praeolongum (Lemmermann) Kofoid 1907*
C. ranipes Cleve 1900*
C. trichoceros (Ehrenberg) Kofoid 1881
C. tripos (Müller) Nitzsch 1917
C. vultur var. *summatranum* (G. Karsten) Nielsen 1934

Family Goniodomaceae Lindemann 1928

Alexandrium Halim 1960
A. sp.
Goniodoma F. Stein1883
G. polyedricum (Pouchet) Jörgensen 1899

Family Pyrocystaceae Apstein 1909

Pyrocystis Murray 1885 ex Haeckel 1820
P. fusiformis C.W.Thomson in J.Murray 1876
P. lunula (Schütt) Schütt in Engler & Prantl 1896
P. noctiluca Murray ex Haeckel 1890
P. obtusa Pavillard 1931
P. robusta Kofoid 1907

Order Peridiniales Haeckel 1894

Family Peridiniaceae Ehrenberg 1831

Peridinium Ehrenberg 1830
P. quinquecorne T. H. Abé 1927
Scrippsiella Balech 1959 ex Loeblich III 1965
S. acuminata (Ehrenberg) Kretschmann & al.2015

Family Protoperidiniaceae Fensome & al. 1998 (=Congruentidiaceae J. Schiller 1935)

Archaeperidinium Jørgensen 1912

A. minutum (Kofoid) Jörgensen 1912
Diplopelta F. Stein 1883
D. bomba Stein ex Jörgensen 1912
D. parva (T. H. Abé) K. Matsuoka 1988
Diplopsalis Bergh 1881
D. lenticula Bergh 1881
Diplopsalopsis Meunier 1910
D. orbicularis (Paulsen) Meunier 1910
Oblea Balech 1964 ex Loeblich Jr. and Loeblich III 1966
O. rotunda (Lebour) Balech ex Sournia 1973
Preperidinium Mangin 1913
P. meunieri (Pavillard) Elbrächter 1993
Protoperidinium Berh 1881
P. abei (Paulsen) Balech 1974
P. cerasus (Paulsen) Balech 1973
P. biconicum (P. -A. Dangeard) Balech 1974
P. claudicans (Paulsen) Balech 1974
P. conicum (Gran) Balech 1974
P. cf. *curtipes* (Jörgensen) Balech 1974*
P. depressum (Bailey) Balech 1974
P. divergens (Ehrenberg) Balech 1974
P. elegans (Cleve) Balech 1974
P. exiquipes (Mangin) J. D. Dodge***
P. cf. *inclinatum* (Balech) Balech 1974**
P. latissimum (Kofoid) Balech 1974
P. leonis (Pavillard) Balech 1974
P. cf. *marielebourae* (Paulsen) Balech 1974*
P. mite (Pavillard) Balech 1974
P. murrayi (Kofoid) Hernández-Becerril 1991
P. oblongum (Aurivillius) Parke & Dodge1976
P. oceanicum (Vanhöffen) Balech 1974
P. ovatum Pouchet 1883
P. pallidum (Ostenfeld) Balech 1973
P. pellucidum Bergh 1881
P. pentagonum (Gran) Balech 1974
P. punctulatum (Paulsen) Balech 1974
P. pyriforme (Paulsen) Balech 1974
P. quarnerense (B. Schröder) Balech 1974
P. sphaericum (Murray & Whitting) Balech 1974
P. solidicorne (Mangin) Balech 1974
P. spiniferum (J. Schiller) Balech 1974
P. steinii (Jörgensen) Balech 1974*
P. subpyriforme (P. -A. Dangeard) Balech 1974
P. thorianum (Paulsen) Balech 1974
P. ventricum (T. H. Abé) Balech 1974
P. venustum (Matzenauer) Balech 1974
Family Podolampaceae Lindemann 1928
Podolampas F. Stein 1883
P. bipes F. Stein 1883
P. spinifera Okamura 1912
Order Dinophysiales kofoid 1926
Family Dinophysiaceae F. Stein 1883
Dinophysis Ehrenberg 1839
D. caudata Saville-Kent 1881
D. miles Cleve 1900
Ornithocercus F.Stein 1883
O. magnificus F. Stein 1883
O. steinii Schütt 1900
O. thumii (Schmidt) Kofoid & Skogsberg 1928
Family Amphisoleniaceae Lindemann 1928
Amphisolenia F. Stein 1883
A. bidentata Schröder 1900
Order Prorocentrales Lemmermann 1910
Family Prorocentraceae F. Stein 1883
Prorocentrum Ehrenberg 1834
P. cf. *arabianum* Morton & Faust 2002**
P. gracile Schütt 1895
P. cf. *norrisianum* M. A. Faust & S. L. Morton 1997
Order Phytodiniales Christensen 1962 ex Loeblich III 1970
Family Phytodiniaceae Klebs 1912
Pyrodinium Plate 1906
P. bahamense Plate 1906
Pyrophacus F. Stein 1883
P. horologium F. Stein 1883
P. steinii (J. Schiller) Wall & Dale 1971
Order Noctilucales Haeckel 1894
Family Noctilucaceae Saville-Kent 1881
Noctiluca Suriray in Lamarck 1816
N. scintillans (Macartney) Kofoid & Swezy 1921

Note in «Systematics of Occurring Species»: '*' the species which have been illustrated with the microphotographs; '**' and '***' the species have not been found before in the RSA; '***' the species which have been illustrated with the microphotographs and the original descriptions.

New recorded Dinoflagellates

The following are the ammended descriptions of some new taxa which differed from descriptions in the identification keys.

Ceratocorys F. Stein, 1883

1- C. magna Kofoid, 1910: 182.

Cells solid, pentagonal or rhombic. Theca dotted with small spines and pores. Epitheca cone-shaped with apical pore complex. Hypotheca inversely trapezoidal. Large spines on the apical tip and in the sulcus broad. Cingulum descending with well-developed membranes. Sulcus is straight, wide and does not reach the antapex.

Dimension: Cell length 131.8–142.6 µm, breadth 153.1–160.4 µm. It is comparatively rare species which bears close resemblance to *C. armata* but larger than it. Size of *C. armata* is not more than 93.0 µm (Taylor, 1976).

General Distribution: Oceanic, tropical species; worldwide distribution.
Distribution in Iran: The Strait of Hormuz. Fig. 1, e-l.

Ceratium Schrank, 1793
2- C. gibberum var. ***dispar*** (Pouchet) Jörgensen, 1920: fig. 67.
Basionym: ***Ceratium tripos*** var**.** ***dispar*** Pouchet 1883: 423, fig. D.
Solid, pentagonal cells with convex dorsal side, Epitheca short, slightly convex. Apical horn moderately long, straight, deflected to the left. The widest part of cell is in the cingulum board. Antapical horns large, directed forward and almost perpendicular to the apical horn.
Dimension: Common length 147.2–148.7 µm, width 102.7–218.7 µm, length of epitheca (not including height of horn) 25.0 µm, length of hypotheca 70.8 µm; length of antapical horns 138.8–146.6 µm.
General Distribution: Atlantic, Pacific, and Indian Oceans; tropical species, worldwide distribution
Distribution in Iran: The Strait of Hormuz. Fig. 3, i.

3- C. gravidum Gourret, 1883: 58, T. 1, fig. 15.
Description: Cells large, strongly dorsoventrally flattened. Epitheca also large, circular or oval-shaped without apical horn. Apical pore is present. The widest cell part is at the center of epitheca. Cingulum narrow, ring-shaped. Hypotheca extending into two short antapical horns (left larger than right). Sulcus slightly laid on epitheca. Theca soft, sometimes wrinkled.
Dimension: 224.7–450.5 µm long, 102.7–210.7 µm wide; cell width in the cingulum board 60.5 µm.
Distribution: Oceans and seas; tropical, oceanic species.
Distribution in Iran: The Strait of Hormuz. Fig. 4, a-b.

4- C. incisum (G.Karsten) Jörgensen, 1911: 19, figs. 29-30.
Basionym: C. furca incisum G.Karsten, 1906: t. 23, figs. 6 a, b.
Cells strongly elongated. Epitheca larger than hypotheca. Cingulum mesial. *C. incisum* differs clearly from similar species the genus *Ceratium* in large left antapical horn inclined towards the ventral side. Right antapical horn straight and twice as small as left one.
Dimension: Common length 362.3 µm, width 32.4 µm, length of epitheca 197.9 µm.
General Distribution: Tropical and subtropical species. It is comparatively rare species.
Distribution in Iran: The Strait of Hormuz. Fig. 2, g-h.
5- ***C. pentagonum*** var**.** ***subrobustum*** Jörgensen, 1920: 26, fig. 15.
Synonym: Ceratium subrobustum (Jörgensen) Steemann Nielsen, *Tripos subrobustus* (Jörgesen) F.Gómez.
Description: Cells medium size, dorsoventrally flattened. Central body pentagonal with straight sides. Epicone triangular. Hypocone inversely trapezoidal. Apical horn strongly elongated, straight, thin. Antapical horns short, spine-shaped, and slightly divergent. Cingulum ring-shaped. It differs from another type varieties by smaller sizes and longer, thinner apical horn.
Dimension: Length of cells 240.0–310.0 µm, width 60.0–80.0 µm.
General Distribution: Oceanic species; cosmopolitan.
Distribution in Iran: The Strait of Hormuz. Fig. 2, o.

Protoperidinium Bergh, 1881
6- P. exiquipes (Mangin) J.D.Dodge, 1985: 47.
Basionym: Peridinium exiquipes Mangin 1930, 377, fig. 3.
Description: Cells pentagonal, strongly dorsoventrally flattened. Epitheca with large 1' apical plate which has diamond shape, with slit-like apical pore. Hypotheca inversely trapezoidal, with two antapical spines. Cingulum mesial, slightly descending (*P. exiquipes* distinguishes from *P. latissimum* by this). Sulcus laid on epitheca and widen to bottom of hypotheca. Species also resembles *P. conicum* and *P. pentagonum* but 1' apical plate of *P. exiquipes* much larger and wider.
Dimension: Length 68.2–72.0 µm, width 60.0–68.0 µm.
Distribution: Atlantic Oceans.
Distribution in Iran: The Strait of Hormuz. Fig. 5, d-e.

DISCUSSION

In spite of the large number of studies conducted in the RSA, there is not a common checklist of algae including dinoflagellates from the area making difficulties for comparison and reports on new species for the water ecosystem. On the other hand, taxonomic identity of the species with citation of the original author was not given in most of these publications (Subba Rao & Al-Yamani 1998). It is only known that the number of dinoflagellates steadily increased from 34 species that have been first listed by Bohm (1931) to 211 in 1995 (Jacob & Al-Muzaini 1995). The extension in species number was a result of sustained efforts of many scientists in identification of dinoflagellates. Moreover, the species number may have increased due to their migration from the Gulf of Oman and Indian Ocean to the Persian Gulf (Dorgham & al. 1987). It is also possible that plankton organisms immigrate in two opposite directions between Gulfs through the Strait of Hormuz which is a pathway for epipelagic species and a barrier for others (Dorgham & Moftah 1989).

Nevertheless, the pilot checklist of dinoflagellates numbered 363 taxa belonging to 81 genera were composed by authors based on the literature sources mentioned in the introduction (Table 2). The contribution of leading genera are slightly more than 69% of the species diversity of dinoflagellates in the RSA. The first two range places are occupied by *Protoperidinium* and *Ceratium* that are the leading genera along the coast of Indian Ocean (Alkawri & Ramaiah 2010).

Among other genera, Amphidiniopsis, Heterocapsa, Karenia, Sinophysis (on 4 taxa); Amphisolenia, Coolia, Diplopelta, Diplopsalopsis, Gambierdiscus, Katodinium, Podolampas, Pronoctiluca, Pyrophacus (on 3 taxa); Ceratocorys (C. armata and C. horrida), Cochlodinium, Corythodinium, Dictyocha, Dissodinium, Goniodoma, Histioneis, Oblea, Ostreopsis, Peridiniella, Pyrodinium, Testudodinium, Thecadinium, Togula, Torodinium (on 2 taxa); Abedinium, Achradina, Actiniscus, Adenoides, Akashiwo, Amylax, Apicoporus, Archaeperidinium, Blepharocysta, Brachidinium, Bysmatrum, Centrodinium, Ceratoperidinium, Cucumeridinium, Dicroerisma, Diplopsalis, Durinskia, Herdmania, Heterodinium, Kryptoperidinium, Levanderina, Lingulodinium, Mesoporos, Micracanthodinium, Noctiluca, Nusuttodinium, Oxyrrhis, Peridinium, Polykrikos, Preperidinium, Protoceratium, Roscoffia, Sabulodinium, Scaphodinium, Scrippsiella, Spiraulax, Triposolenia, Tryblionella, Warnowia (on 1 taxa) were recorded in the previous papers making 30.9 % of total dinoflagellate flora in the RSA.

According to this, 7 new species (11 infraspecific taxa) of dinoflagellates such as Ceratocorys magna, Ceratium gibberum var. dispar, C. gravidum, C.horridum var. buceros, C. incisum, C. pavillardii, C. pentagonum var. subrobustum, C. pentagonum var. tenerum, Prorocentrum cf. arabianum, Protoperidinium exiquipes and Protoperidinium cf. inclinatum are newly identified for the RSA by the present investigation. Of these, only two dinoflagellates such as Protoperidinium exiquipes were not reported from the Indian Ocean (Taylor 1976). Based on the present research the number of dinoflagellates, recorded in the RSA, is increased to 375 taxa. Moreover, the checklist of dinoflagellates, identified in the vicinity of Hormuz Island, was enhanced by this study from 72 that has been reported by ROPME (2012) to 146 taxa.

In many previous studies, the multispecies genus *Ceratium* made the greatest contribution to phytoplankton populations. For instance, *C. furca* (up to 80%) was dominated in Qatari waters in 1986 (Dorgham and Moftah 1989). In the inner part of ROPME Sea Area in 1993-1994, the most abundant *Ceratium* species were *C. trichoceros*, *C. massiliense, C. carrienses, C. tripos, C. furca* and *C. fusus* (Husain and Ibrahim 1998). *C. massiliense* was significantly widespread during study of Al-Harbi (2005) and Quigg & al. (2013). The dinoflagellates of the genus *Ceratium* were also recorded in %91 and 98% of samples along the Qatari coast (El-Din & Al-Khayat 2005). The dominant dinoflagellate species included *C. furca* and *C. breve* along coastal waters of Bandar Khyran Bay, the Gulf of Oman (Al-Hashmi & al. 2012). Although, overall, *Ceratium* was noticed as the frequently found, but could not be recognized as an abundant genus. Howeve it does not include more than 12% of the total phytoplankton within the RSA (ROPME 2012). In the present study, *Ceratium candelabrum*, *C. macroceros*, *C. breve*, *C. gibberum*, *C. vultur* var. *summatranum*, *C. karstenii*, and *C. massiliense* were dominated by the cell number in plankton among species of the genus *Ceratium*

The genera, *Protoperidinium* (*P. depressum*, *P. divergens*, *P. murrayi*, *and P. venustum*) and *Dinophysis* (*D. miles*) were frequent in the current investigation whereas the previous researchers found a significant number of species i.e. *Oxytoxum variabile* (Grice & Gibson 1978; ROPME 2012), *Pyrodinium bahamense* (Dorgham and Moftah 1989), *Protoperidinium depressum* (Al-Harbi 2005) as well as *Mesoporos perforates*, *Scrippsiella trochoidea*, *Torodinium robustum* and *Protoperidinium* sp. (ROPME, 2012). Some dinoflagellates that cause harmful blooms, are as follows: *Cochlodinium polykrikoides* (Fatemi & al. 2012; Hamzehei & al. 2012), *Noctiluca scintillans* and *Gonyaulax polygramma* (Piontkovski & al. 2012), as well as *Lingulodinium polyedra, Prorocentrum gracile,* and *P. micans* (Al-Muftah 2008).

Table 2. The spectrum of leading genera of dinoflagellates recorded in the RSA based on the literature sources*.

Rank	Genus	Num taxa	%	Species
1	*Protoperidinium*	67	18.5	*P. abei, P. acutipes, P. biconicum, P. bipes, P. bispinum, P. breve, P. brevipes, P. brochii, P. cerasus, P. diabolus, P. subpyriforme, P. cerasus, P. claudicans, P. conicoides, P. conicum, P. conicum* f. *asamushii, P. conicum* var. *concavum, P. conicum* var. *quardafuianum, P. crassipes, P. curtipes, P. curvipes, P. denticulatum, P. depressum, P. divergens, P. elegans, P. grande, P. globulus, P. granii, P. hamatum, P. heteracanthum, P. islandicum, P. latidorsale, P. latissimum, P. leonis, P. mariebourae, P. mediterraneum, P. mite, P. oblongum, P. obtusum, P. oceanicum, P. orbiculare, P. orientale, P. ovatum, P. ovum, P. oviforme, P. pallidum, P. parviventer, P. pedunculatum, P. pentagonum, P. pellucidum, P. punctulatum, P. pyriforme, P. quarnerense, P. quinquecorne, P. retiferum,* ***P. sceabrve**,*** *P. solidicorne, P. sourniae, P. spiniferum, P. steinii, P. subinerme, P. subpyriforme, P. tenuissimum, P. thorianum, P. tuba, P. ventricum, P. venustum*
2	*Ceratium*	60	16.5	*C. arietinum, C. azoricum, C. belone, C. biceps, C. bigelowii, C. breve, C. breve* var. *parallelum, C. candelabrum, C. carriense, C. contortum, C. contrarium, C. declinatum, C. deflexum, C. dens, C. digitatum, C. ehrenbergii, C. extensum, C. falcatum, C. furca, C. furca* var. *eugrammum, C. fusus, C. fusus* var. *seta, C. geniculatum, C. gibberum, C. gravidum* var. *praeolongum, C. hexacanthum, C. horridum, C. humile, C. karstenii, C. kofoidii, C. limulus, C. lineatum, C. longipes, C. longirostrum, C. lunula, C. macroceros, C. macroceros* var. *gallicum, C. massiliense, C. massiliense* var. *armatum, C. massiliense* var. *protuberans, C. minutum, C. pelagica, C. pennatum, C. pentagonum, C. pulchellum, C. ranipes, C. reflexum, C. schrankii, C. schmidtii, C. strictum, C. symmetricum, C. tenue* var. *buceros, C. teres, C. trichoceros, C. tripos, C. tripos* var. *atlanticum, C. tripos* f. *balticum, C. tripos* var. *indicum, C. vultur, C. vultur* var. *summatranum*
3	*Prorocentrum*	22	5.0	*P. arabianum, P. balticum, P. bimaculatum, P. cordatum, P. concavum, P. consutum, P. dactylus, P. dentatum, P. emarginatum, P. fukuyoi, P. gracile, P. lenticulatum, P. lima, P. magnum, P. maximum, P. micans, P. norrisianum, P. pyriforme, P. rhathymum, P. rostratum, P. triestinum, P. vaginula*
4	*Gonyaulax*	17	4.7	*G. birostris, G. brevisulcata, G. diegensis, G. digitale, G. fragilis, G. hyalinium, G. kofoidii, G. minuta, G. monacantha, G. monospina, G. orientalis, G. polygramma, G. subulata, G. scrippsae, G. spinifera, G. turbynei, G. verior,*
5	*Dinophysis*	15	4.1	*D. acuminata, D. acuta, D. argus, D. caudate, D. caudate* var. *abbreviate, D. hastate, D. dens, D. irregularis, D. miles, D. nasuta, D. norvegica, D. ovum, D. pulchella, D. schuettii, D. tripos*
6	*Amphidinium*	13	3.6	*A. bidentatum, A. carterae, A. corpulentum, A. gibbosum, A. herdmanii, A. incoloratum, A. mootonorum, A. operculatum, A. ovum, A. psittacus, A. scissum, A. semilunatum, A. steinii*
7	*Oxytoxum*	13	3.6	*O. brunellii, O. caudatum, O. laticeps, O. longiceps, O. constrictum,* ***O. cucumis**,*** *O. curvatum, O. gracile, O. milneri, O. sceptrum, O. scolopax, O. tesselatum, O. variabile*
8	*Phalacroma*	8	2.2	*Ph. cuneus, Ph. doryphorum, Ph. favus, Ph. minutum, Ph. mitra, Ph. operculatum, Ph. rapa, Ph. rotundatum*
9	*Alexandrium*	7	1.9	*A. cohorticula, A. fraterculus, A. insuetum, A. leei, A. minutum, A. tamarense, A. tamiyavanichii*
10	*Gymnodinium*	7	1.9	*G. catenatum, G. allophron, G. gracile, G. gracilentum, G. punctatum, G. pygmaeum, G. venator*
11	*Pyrocystis*	7	1.9	*P. elegans, P. fusiformis, P. hamulus, P. lunula, P. pseudonoctiluca, P. obtuse, P. robusta*
12	*Gyrodinium*	6	1.7	*G. estuariale, G. fusiforme, G. glaucum, G. nasutum, G. prunus, G. spirale,*
13	*Ornithocercus*	5	1.4	*O. magnificus, O. quadratus, O. splendidus, O. steinii, O. thurnii*
14	*Cladopyxis*	4	1.1	*C. brachiolata, C. hemibranchiata, C. setifera, C. spinosa*
	Others	112	30.9	
	Total	363	100	

* Grice & Gibson 1978; Dorgham & Moftah 1989; Husain & Ibrahim 1998; Subba Rao & Al-Yamani 1998; Morton & al. 2002; Al-Harbi 2005; Fallahi & al. 2005; El-Din & Al-Khayat 2005; Al-Kandari & al., 2009; Al-Yamani & Saburova 2010; Attaran-Fariman & al. 2011; Al-Hashmi & al. 2012; Saburova & al. 2012a, b, 2013a, b; ROPME, 2012; Quigg & al. 2013; Al-Saboonchi & Al-Shawi 2016. ** Species names which contained mistakes just as in the primary sources Al-Harbi (2005) and Grice and Gibson (1978).

This is a contributtion to studies on species diversity of dinoflagellates across the RSA. Obviously, the future seasonal algofloristic investigations of Iranian waters in the vicinity of Hormuz Island may increase the species number in the checklist of dinoflagellates not only for this water area, but also for the RSA as a whole.

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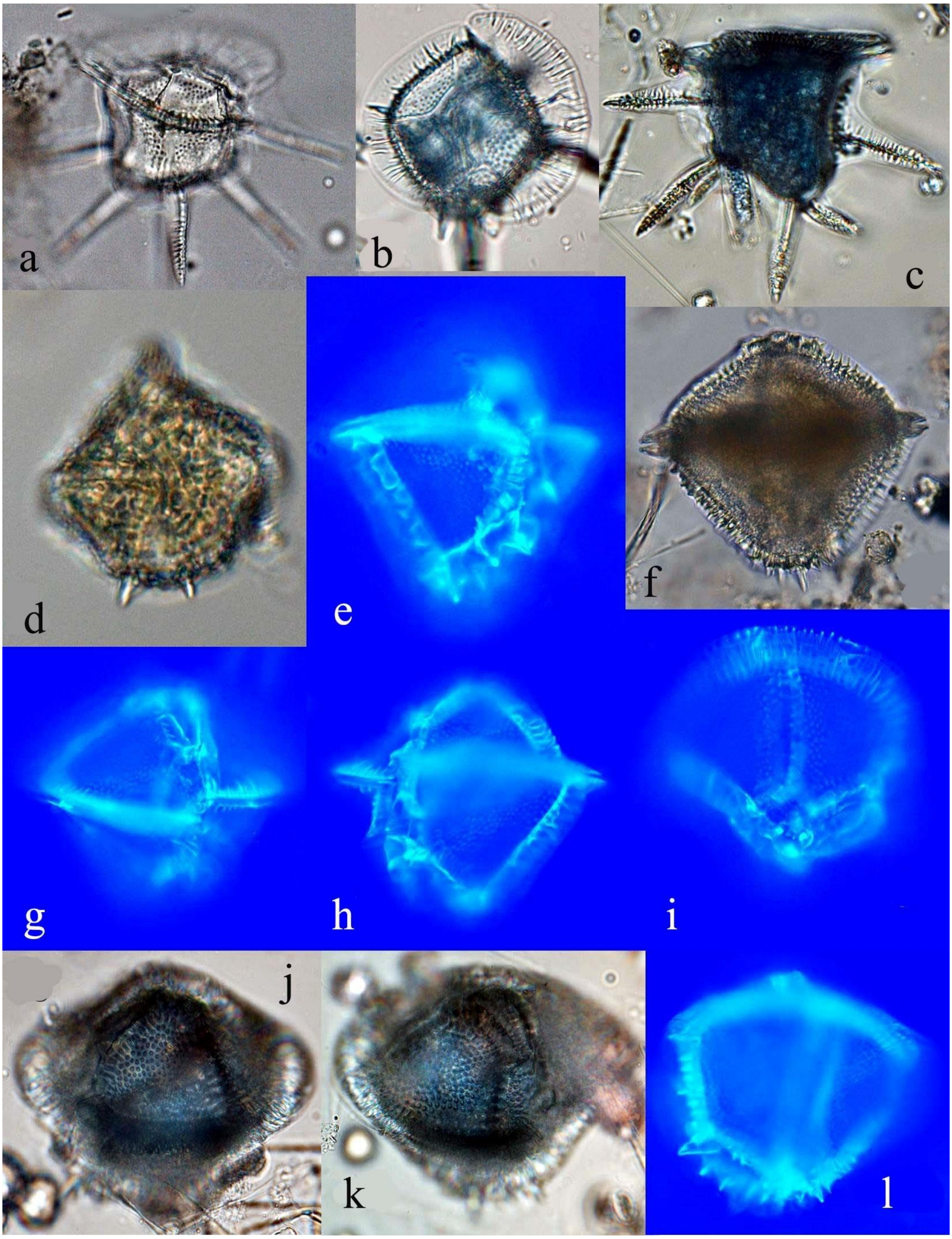

Fig. 1. The Dinoflagellates from the Iranian waters surrounding Hormuz Island. a-c- *Ceratocorys horrida* F.Stein; d- *Gonyaulax digitale* (Pouchet) Kofoid; e-l- *Ceratocorys magna* Kofoid. e, g-i, l- fluorescence mode with Calcofluor White. Microscope Olympus BX51.

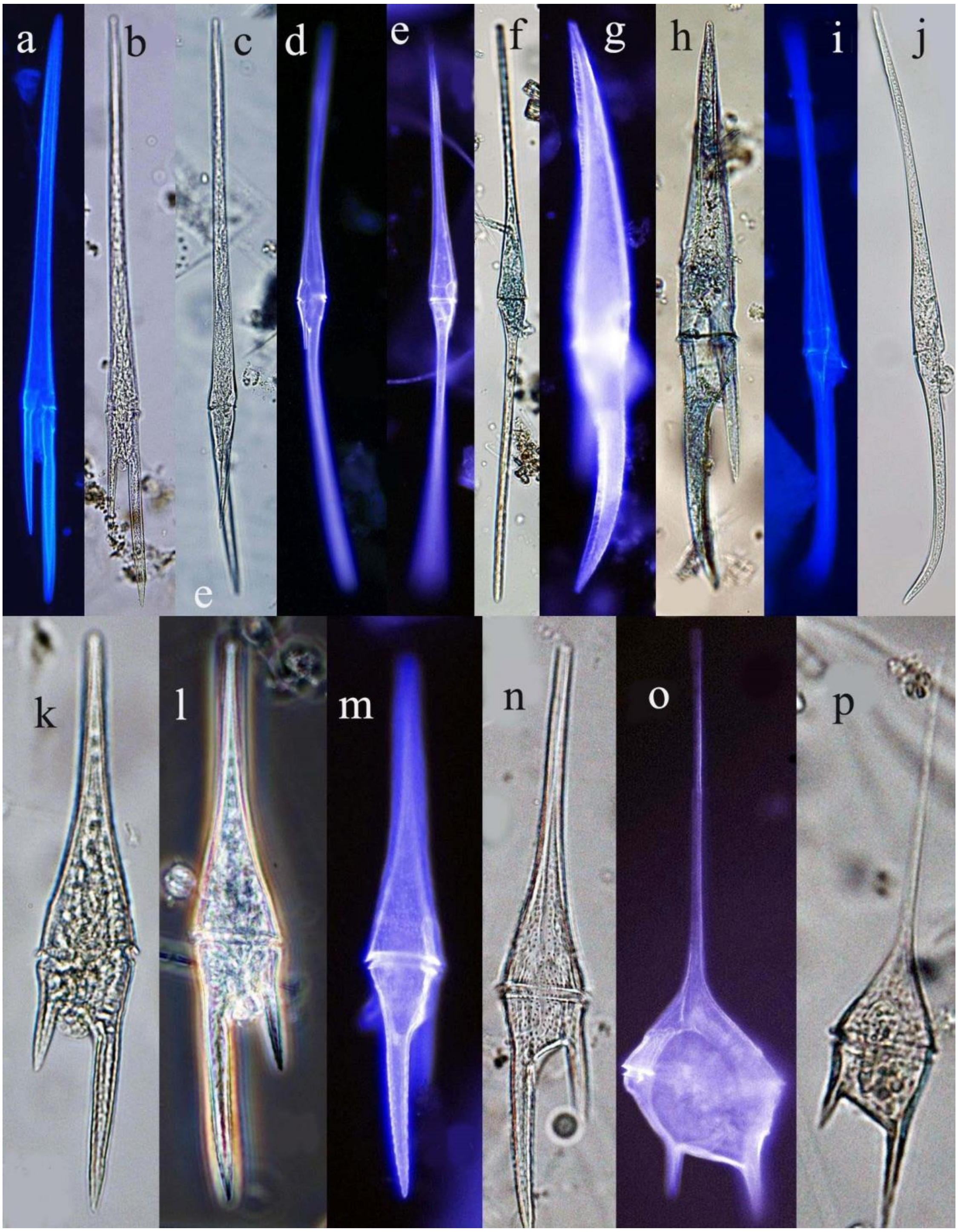

Fig. 2. The Dinoflagellates from the Iranian waters surrounding Hormuz Island. a-c- *Ceratium belone* Cleve; d-f- *Ceratium fusus* var. *seta* (Ehrenberg) E.J.F.Wood; g-h- *Ceratium incisum* (G.Karsten) Jörgensen; i-j- *Ceratium longirostrum* Gourret; k-m- *Ceratium furca* (Ehrenberg) Claparède & Lachmann; n- *Ceratium furca* var. *eugrammum* (Ehrenberg) Jörgensen, o- *Ceratium pentagonum* var. *subrobustum* Jörgensen; p- *Ceratium kofoidii* Jörgensen; k- Phase contrast. a, d-e, g, i, m, o- fluorescence mode with Calcofluor White. Microscope Olympus BX51.

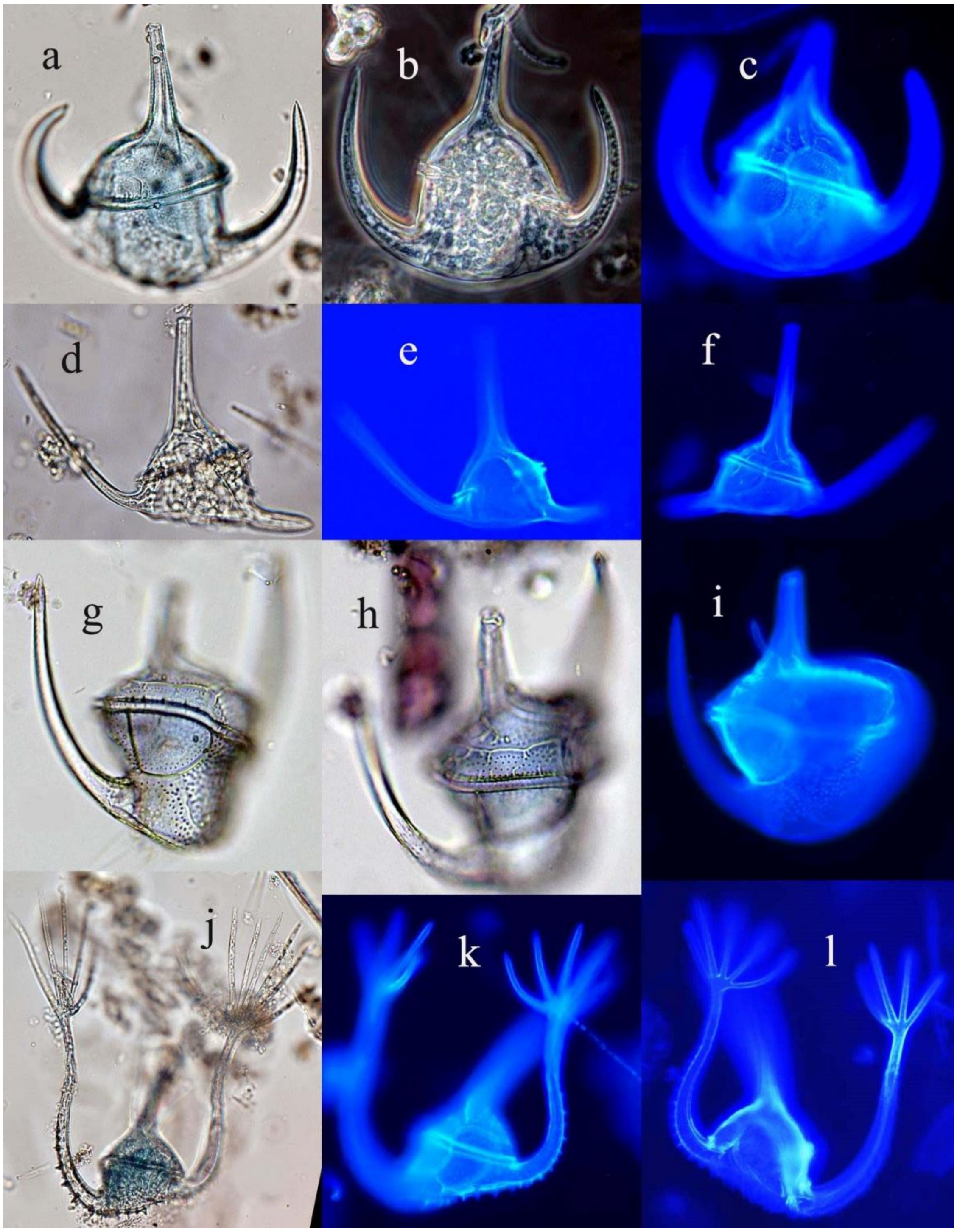

Fig. 3. The Dinoflagellates from the Iranian waters surrounding Hormuz Island. a-c- *Ceratium breve* var. *parallelum* (Schmidt) Jörgensen; d-f- *Ceratium dens* Ostenfeld & J.Schmidt; g-h- *Ceratium gibberum* Gourret; i- *Ceratium gibberum* var. *dispar* (Pouchet) Sournia; j-l- *Ceratium ranipes* Cleve. b- Phase contrast. c, e-f, i, k-l- fluorescence mode with Calcofluor White. Microscope Olympus BX51.

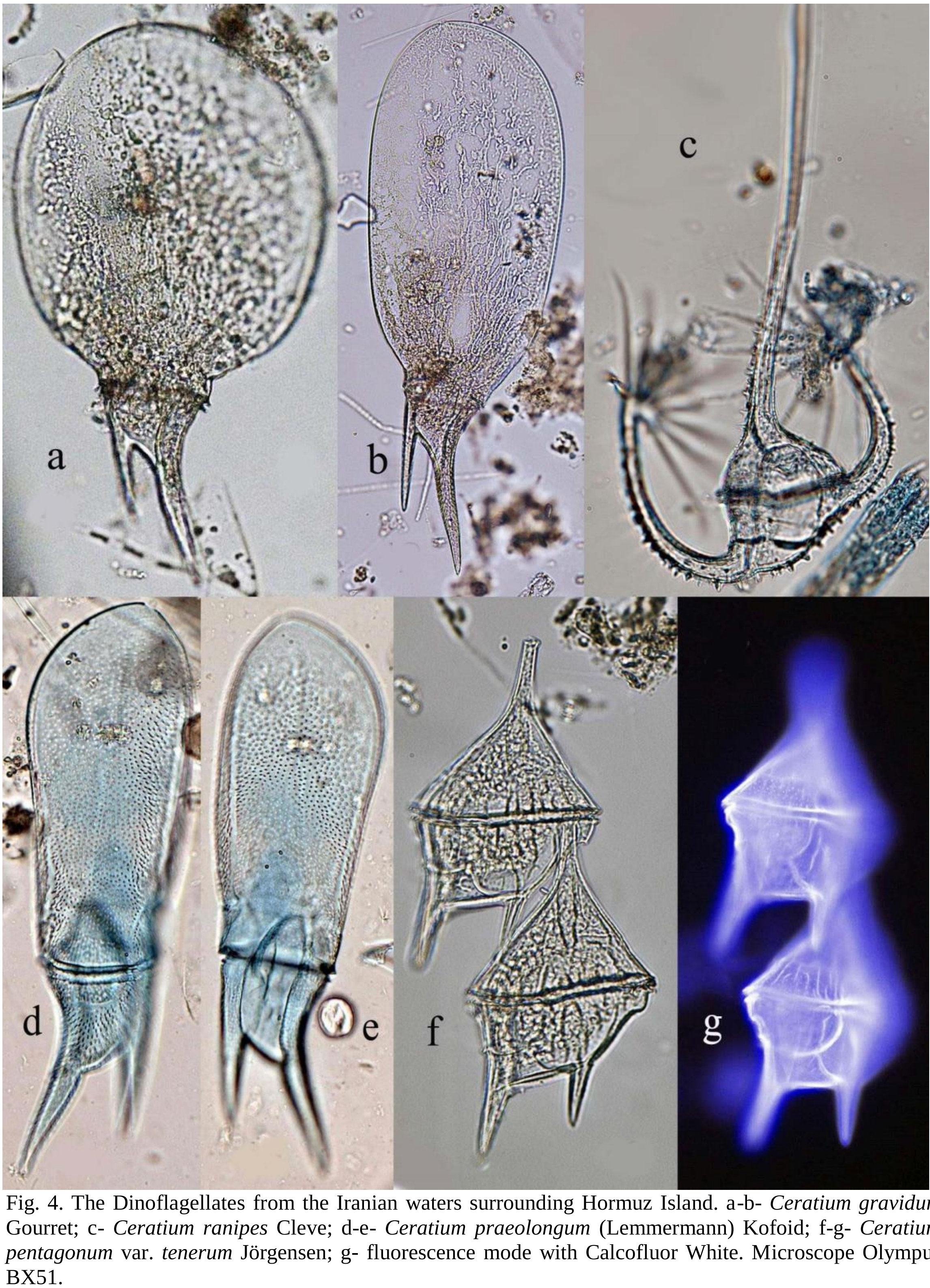

Fig. 4. The Dinoflagellates from the Iranian waters surrounding Hormuz Island. a-b- *Ceratium gravidum* Gourret; c- *Ceratium ranipes* Cleve; d-e- *Ceratium praeolongum* (Lemmermann) Kofoid; f-g- *Ceratium pentagonum* var. *tenerum* Jörgensen; g- fluorescence mode with Calcofluor White. Microscope Olympus BX51.

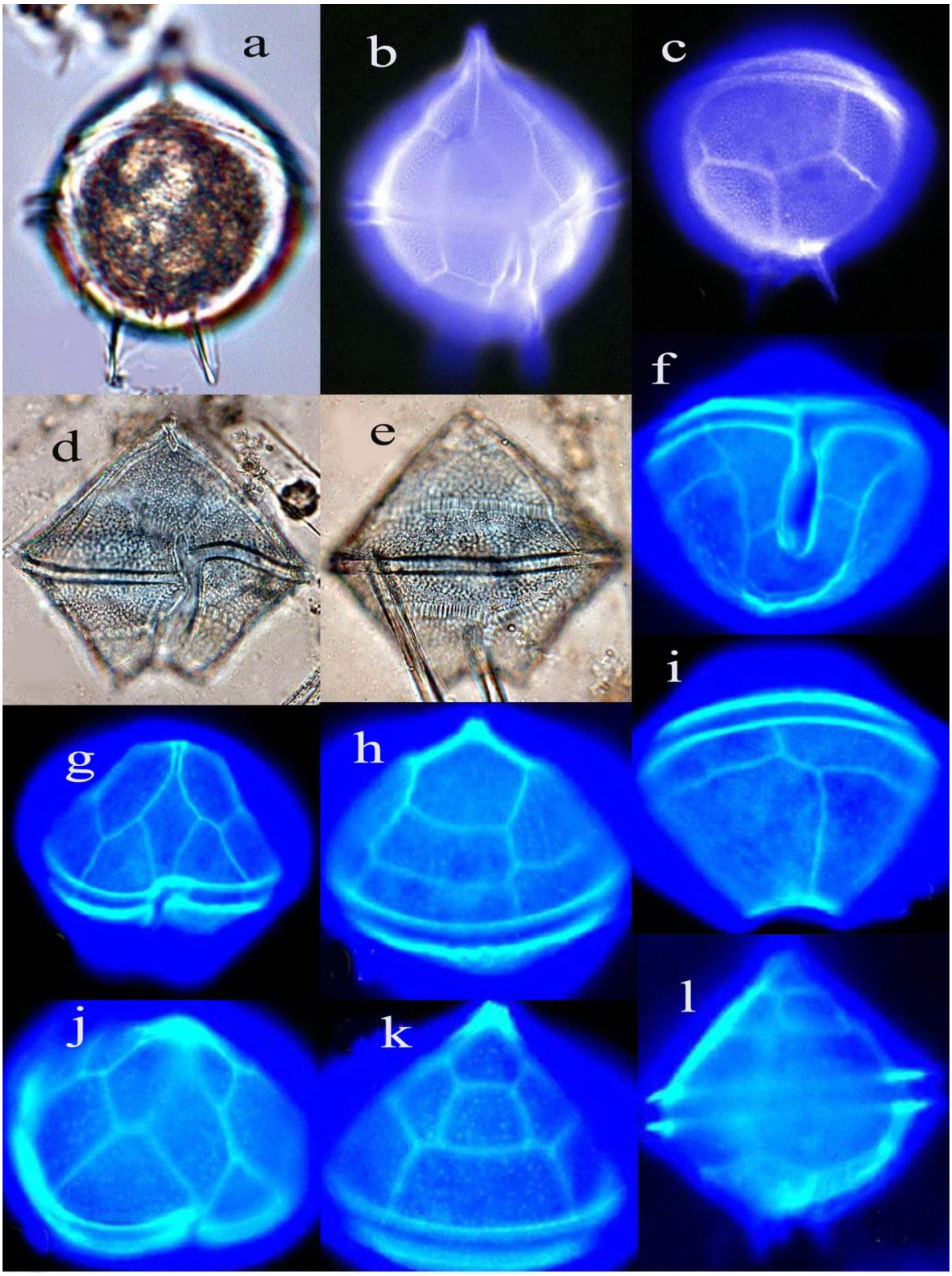

Fig.5. The Dinoflagellates from the Iranian waters surrounding Hormuz Island. a-c- *Protoperidinium steinii* (Jörgensen) Balech; d-e- *Protoperidinium exiquipes* (Mangin) J.D.Dodge; f-i- *Protoperidinium* cf. *mariele bouriae* (Paulsen) Balech; j-l- *Protoperidinium* cf. *curtipes* (Jørgensen) Balech. b-c, f-l- fluorescence mode with Calcofluor White. Microscope Olympus BX51.