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〈Original article〉

New Records of Genus *Dinophysis*, *Gonyaulax*, *Amphidinium*, *Heterocapsa* (Dinophyceae) from Korean Waters

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Abstract - A study describing unrecorded and taxonomically undescribed indigenous species is in progress since 2006. Samples were collected from many sites in coastal waters and offshore of Korea as well as from Jeju Island. Since 2008, we have found ten unrecorded species of four genera belonging to family Dinophysaceae, Gonyaulacaceae, Gymnodiniaceae, and Heterocapsaceae. The species are as follows, *Dinophysis elongata* (2016 winter), *D. nasuta* (2016 winter), *Gonyaulax alaskensis* (2016 winter), *G. diegensis* (2017), *G. monospina* (2008), *Amphidinium flagellans* (2017), *Heterocapsa circularisquama* (2017), *H. horiguchii* (2017), *H. lanceolata* (2017), and *H. pygmaea* (2017) (note; The numbers in the parenthesis refer to the year in which the species was reported as unrecorded indigenous species by National Institute of Biological Resources, NIBR hereafter). Among them, seven species were described as newly recorded species in Korean waters, and three have been re-described in this study.

Keywords : *Amphidinium*, *Dinophysis*, *Gonyaulax*, *Heterocapsa*, new record species

INTRODUCTION

Jeju Island has experienced a peculiar change of marine ecosystem due to climate changes by global warming over last two decades, which include increasing seawater temperature and expansion of the high salinity and high temperature Kuroshio Current (Yeh and Kim 2010; Kang *et al*. 2012). Dinoflagellates are a major group of phytoplankton community and are composed of various species in terms of habitat and nutrition type. They also contribute to primary production in oceans and distribute from tropical to artic sea in many waters world-wide (Dodge 1982). A total of 153 planktonic dinoflagellates from Korean waters have been described by Shim *et al*. (1981), Han and Yoo (1983a, b), Yoo and Lee (1986), Lee *et al*. (1993), and Shim (1994). During the last decade, more than 170 planktonic and benthic dinoflagellates have been added to a checklist of dinoflagellates by several researchers in Korea (Kim *et al*. 2013; Shah *et al*. 2013; Lee *et al*. 2014). Since 394 dinoflagellates were listed as recorded species in Korean waters (Lee and Kim 2015), Lee *et al*. (2015) reported newly 19 species belonging to genera *Dinophysis*, *Histoneis*, and *Parahistioneis* in Korean waters. Lee and Kim (2017a) added 4 unrecorded Prorocentroid dinoflagellates, and Lee and Kim (2017b) 16 unrecorded species including of five unarmored genera. Lee and Kang (2017) reported 5 unrecorded species and re-described 8 species belonging to family Diplopsaliaceae, Heterocapsaceae, Kolkwitziellaceae, Protoperidiniaceae and Thoracosphaeraceae. However, there were few recent taxonomic studies on planktonic dinoflagellates except Shin (2016). The objectives of this study were to check the list and to describe some newly recorded species, focusing on the genera of family Dinophysaceae, Gonyaulacaceae, Gymnodiniaceae and Heterocapsaceae.

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MATERIALS AND METHODS

Samplings were done at coastal waters and offshore in Korea as well as around Jeju Island from September 2008 to August 2017. Plankton samples were obtained by using a 20 μm mesh size plankton net and fixed with formaldehyde (final concentration of 1%). Planktonic dinoflagellates were identified by using LM (Axioplan, Carl Zeiss, Oberkochen, Germany). To make slide specimens for one species, the dinoflagellate samples were washed with distilled water and then the method described in Kim *et al*. (2013) was followed. To allow for more detailed observations, dinoflagellate cells were isolated with a micropipette, placed on a cover slip, air-dried and gold-coated, and finally observed with a field emission scanning electron microscope (JSM-6700F, JEOL, Tokyo, Japan).

For the species identification, several monographs that were reported from different oceans such as the British and Atlantic Ocean (Dodge 1982), Korean waters (Shim 1994) and Western Pacific (Omura 2012) were used. A dinoflagellate classification for the new combinations of the family Dinophysaceae, Gonyaulacaceae, Gymnodiniaceae, and Heterocapsaceae was cited from AlgaeBase (http://www.algaebase.org) (Guiry and Guiry 2018).

RESULTS AND DISCUSSION

A total of 77 species of four genera (*Dinophysis*, *Gonyaulax*, *Amphidinium* and *Heterocapsa*) belonging to the family Dinophysaceae, Gonyaulacaceae, Gymnodiniaceae and Heterocapsaceae were identified from Korean waters and classified in the checklist based on valid name as below. Among them seven species were described as newly recorded species in Korean waters and three were re-described. The newly recorded and the re-described species are marked with asterisks (*) and sharps (#), respectively. 'C' indicates a currently accepted name, 'S' a synonym, 'U' uncertain taxonomic name, 'P' preliminary based on the species database of AlgaeBase (Guiry and Guiry 2018), respectively.

Checklist of the genus *Dinophysis*, *Gonyaulax*, *Amphidinium* and *Heterocapsa* occurred in Korea Waters

Class Dinophyceae West et Fritsch
Order Dinophysiales Kofoid
Family Dinophysaceae Bütschli
Genus *Dinophysis* Ehrenberg
Dinophysis acuminata Claparéde et Lachmann C
Dinophysis acuta Ehrenberg C
=*Dinophysis dens* Pavillard S
Dinophysis argus (Stein) Abé C
Dinophysis caudata Kent C
Dinophysis contracta (Kofoid et Skogsberg) Balech C
**Dinophysis elongata* (Jörgensen) Abé C
Dinophysis exigua Kofoid et Skogsberg C
Dinophysis fortii Pavillard C
=*Dinophysis lapidistrigiliformis* Abé S
Dinophysis hastata Stein C
Dinophysis infundibulum Schiller C
Dinophysis irregularis (Lebour) Balech C
Dinophysis joergensenii Kofoid et Skogsberg C
Dinophysis laevis Claparéde et Lachmann C
Dinophysis micropterygia Dangeard C
Dinophysis miles Cleve C
**Dinophysis nasuta* (Stein) Parke et Dixon C
Dinophysis norvegica Claparéde et Lachmann C
Dinophysis ovum Schütt C
Dinophysis parvula (Schütt) Balech C
Dinophysis punctata Jörgensen C
Dinophysis recurva Kofoid et Skogsberg C
Dinophysis rudgei Murray et Whitting C
Dinophysis schroederi Pavillard C
Dinophysis schuettii Murray et Whitting C
Dinophysis similis Kofoid et Skogsberg C
Dinophysis tripos Gourret C

Order Gonyaulacales F.J.R.Taylor
Family Gonyaulacaceae Lindemann
Genus *Gonyaulax* Diesing
#Gonyaulax alaskensis Kofoid C
Gonyaulax brevisulcatum Dangeard C
Gonyaulax bruunii Taylor C
#Gonyaulax diegensis Kofoid C
Gonyaulax digitale (Pouchet) Kofoid C
Gonyaulax fragilis (Schütt) Kofoid C
Gonyaulax hyalina Ostenfeld et Schmidt C
Gonyaulax lebouriae Balech C

Gonyaulax macroporus Mangin C
Gonyaulax monacantha Pavillard C
#*Gonyaulax monospina* Rampi C
Gonyaulax orientalis Lindemann C
Gonyaulax pavillardii Kofoid et Michener C
Gonyaulax polygramma Stein C
Gonyaulax scrippsae Kofoid C
Gonyaulax spinifera (Claparéde et Lachmann) Diesing C
= *Gonyaulax apiculata* Entz S
= *Gonyaulax buxus* Balech S
= *Gonyaulax levanderi* (Lemmermann) Paulsen S
Gonyaulax striata Mangin C
Gonyaulax turbynei Murray et Whitting C
Gonyaulax verior Sournia C

Order Gymnodiniales Apstein
Family Gymnodiniaceae Lankester
Genus *Amphidinium* Claparéde et Lachmann
Amphidinium acutissimum Schiller C
Amphidinium carterae Hulburt C
Amphidinium corpulentum Kofoid et Swezy C
Amphidinium crassum Lohmann C
Amphidinium flagellans Schiller C
Amphidinium flexum Herdman C
Amphidinium fusiforme Martin P
Amphidinium gibbosum (Maranda et Shimizu) Jørgensen et Murray C
Amphidinium globosum Schröder C
Amphidinium herdmanii Kofoid et Swezy C
Amphidinium incoloratum Campbell C
Amphidinium inflatum Kofoid C
Amphidinium kesslitzii Schiller C
Amphidinium longum Lohmann C
Amphidinium massartii Biecheler C
Amphidinium mootonorum Murray et Patterson C
Amphidinium operculatum Claparéde et Lachmann C
Amphidinium ovum Herdman C
Amphidinium scissum Kofoid et Swezy C
Amphidinium steinii (Lemmermann) Kofoid et Swezy C
Amphidinium stigmatum Schiller C
Amphidinium thermaeum Dolapsakies et Economou-Amilli U
Amphidinium trulla Murray, Rhodes et Jørgensen C

Order Peridiniales Haeckel
Family Heterocapsaceae Fensome, Taylor, Norris, Sarjeant, Wharton et Williams
Genus *Heterocapsa* Stein
Hetrocapsa circularisquama Horiguchi C
Hetrocapsa horiguchii Iwataki, Takayama et Matsuoka C
Hetrocapsa lanceolata Iwataki et Fukuyo C
Heterocapsa ovata Iwataki et Fukuyo C
Heterocapsa psammophila Tamura, Iwataki et Horiguchi C
Heterocapsa pseudotriquetra Iwataki, Hansen et Fukuyo C
Heterocpasa pygmaea Lobelich III, Schmidt et Sherley C
Heterocapsa rotundata (Lohmann) Hansen C
Heterocapsa triquetra (Ehrenberg) Stein C

Taxonomic description of unrecorded dinoflagellates

Genus *Dinophysis* Ehrenberg 1839

Holotype species: *Dinophysis acuta* Ehrenberg.

Description: Small to medium sized (25−100 μm) laterally more or less compressed dinoflagellate. The cells is cellulosic thecal plates. Two large prominent hypothecal and epithecal plates joined by a serrated sagittal dorsal suture. The cingulum is located very much anteriorly. The right sulcal list is part of the right hypothecal plate and has one or two rids. Nucleus is spherical or ovoid (Guiry and Guiry 2018).

Numbers of names and species: There are 230 species names in the database at present, as well as 58 infraspecific names. Of the species names, 122 have been flagged as currently accepted taxonomically (Guiry and Guiry 2018).

***Dinophysis elongata* (Jörgensen) Abé 1967**
(Fig. 1a and b)

Basionym: *Phalacroma elongatum* Jörgensen

Homotypic synonym: *Phalacroma elongatum* Jörgensen

References: Omura *et al*. 2012, p. 61.

Specimen examined: Serial No. LJB2016001 (winter) / NIBR No. NIBRDN0000000415.

Description: Cells are almost oval. Epitheca is smaller

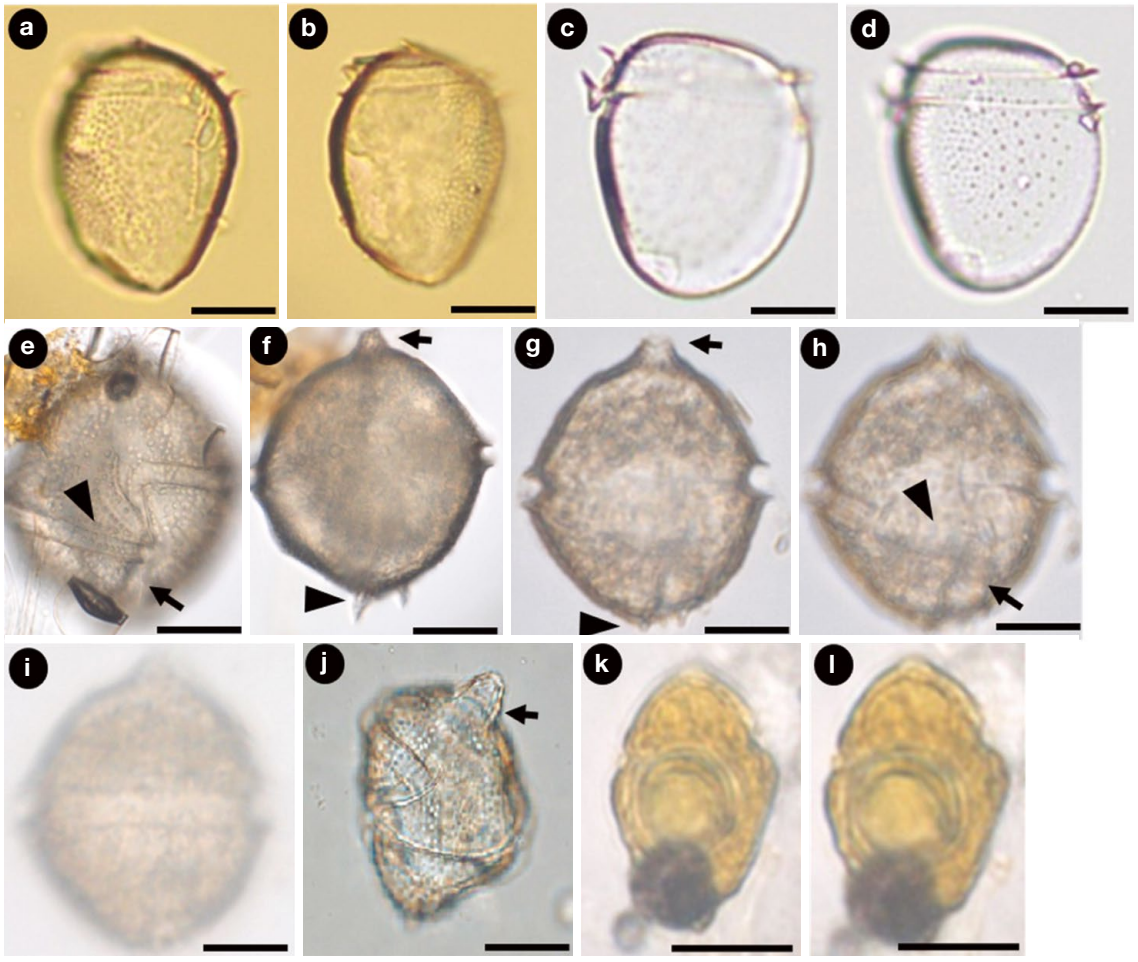

Fig. 1. Light micrographs of the genus *Dinophysis*, *Gonyaulax*, and *Amphidinium*. (a), (b) *D. elongata*, lateral view, (c), (d) *D. nasuta*, lateral view, (e) *G. alaskensis*, ventral view, arrowhead; cingulum, arrow; sulcus, (f) *G. alaskensis*, ventral view, arrowhead; spines, arrow; apical horn, (g) *G. diegensis*, ventral view, arrowhead; spines, arrow; apical horn, (h) *G. diegensis*, ventral view, arrowhead; cingulum, arrow; sulcus, (i) *G. diegensis*, dorsal view, (j) *G. monospina*, lateral view, arrow; apical horn, and (k), (l) *A. flagellans*, ventral view (Scale bars, a–i: 20 μm; j–l: 10 μm).

than the hypotheca and is hemispherical, and the cingulum groove protrudes upward. The hypotheca is large and cone shape, and has no spines. The sulcus list takes up about two-thirds of the hypotheca and has three ribs.

Size: 50–55 μm long, 35–37.5 μm wide in the ventral view.

Sampling: Dec. 2016. Geoje coast (Yeocha Mongdol) in Korea (34°42′47.03″N, 128°37′38.81″E).

Habitat: Marine species.

Distribution: Europe: Britain (Parke and Dixon 1976).

Note: This species was reported as an unrecorded indigenous species by NIBR in 2016 and reported as a newly recorded species in the coastal waters of Korea in the present study.

***Dinophysis nasuta* (Stein) Parke et Dixon 1968 (Fig. 1c and d)**

Basionym: *Phalacroma nasutum* Stein.

Homotypic synonym: *Phalacroma nasutum* Stein 1883; *Pseudophalacroma nasutum* (Stein) Jørgensen 1923.

Heterotypic Synonym: *Prodinophysis nasutum* Loeblich 1965.

References: Dodge 1982, pp. 51–52, fig. 4G.

Specimen examined: Serial No. LJB2016002 (winter) / NIBR No. NIBRDN0000000416.

Description: Cells are hemispherical. The epitheca is not obscured by the cingular lists. Characteristically, the sulcus extends to about two-thirds of the distance from cingulum

to apex. The hypotheca is large and has not any spines. The sulcus list is narrow, unobtrusive and has not a clear ribs.
Size: 43–49 μm long, 38–43 μm wide in the ventral view.
Sampling: Dec. 2016. Geoje coast (Yeocha Mongdol) in Korea (34°42′47.03″N, 128°37′38.81″E).
Habitat: Marine species.
Distribution: Europe: Mediterranean (Gómez 2003); Britain (Parke and Dixon 1976; Dodge 1982).
Note: This species was reported as an unrecorded indigenous species by NIBR in 2016 and reported as a newly recorded species in the coastal waters of Korea in the present study.

Genus *Gonyaulax* Diesing 1866
Holotype species: *Gonyaulax spinifera* (Claparéde et Lachmann) Diesing.
Description: Small to large sized (25–175 μm) dinoflagellate of circular shape. The cells show asymmetry due to torsion. Hypotheca plates have few to several spines. The cingulum starts median ventrally, turning to the left in a descending spiral, making more than one loop. The sulcus starts cingulum mid-ventrally. Chloroplast exists. Nucleus is U-shaped (Guiry and Guiry 2018).
Numbers of names and species: There are 122 species names in the database at present, as well as 7 infraspecific names. Of the species names, 75 have been flagged as currently accepted taxonomically (Guiry and Guiry 2018).

***Gonyaulax alaskensis* Kofoid 1911 (Fig. 1e and f)**
Synonym: No synonym.
References: Dodge 1982, pp. 207–208, fig. 25K; Omura *et al*. 2012, p. 104.
Specimen examined: Serial No. LJB2016003 (winter) / NIBR No. NIBRDN0000000417.
Description: Cells are almost spherical. Epitheca has short apical horn. Hypotheca has two sulcal list spine and is antapex flattened. Thecal plates are randomly reticulate except along either side of cingulum. Cingulum is much higher on one side and is obliquely present. Cells has chloroplast.
Size: 65–75 μm long and wide in the ventral view.
Sampling: July 2015. Chagwi-do coast in Jeju Island (33°19.02′N, 126°08.03′E).
Habitat: Marine species.
Distribution: Europe: Portugal (Moita and Vilarinho 1999); New Zealand (Taylor 1974).
Note: This species was reported as an unrecorded indigenous species by Shin (2016) and reported as a newly recorded species in the coastal waters of Korea in the present study.

***Gonyaulax diegensis* Kofoid 1911 (Fig. 1g–i)**
Synonym: No synonym.
References: Dodge 1982, p. 208, fig. 26G; Omura *et al*. 2012, p. 105.
Specimen examined: Serial No. LJB2017002.
Description: Cells are almost spherical. Epitheca has short apical horn and is convex along it. Thecal plates are thick and have reticulations. Hypotheca is round and has two to four very short spines. Cingulum is located in the middle and no list exists. Sulcus is sinuous.
Size: 56–100 μm long, 50–82 μm wide in the ventral view.
Sampling: May 2016. Geomundo coast in Korea (34°1′ 25.46″ N, 127°18′30.37″ E).
Habitat: Marine species.
Distribution: Europe: Black Sea (Goméz and Boicenco 2004), Britain (Dodge 1982), Helgoland (Hoppenrath 2004), Mediterranean (Gómez 2003); Asia: China (Liu 2008).
Note: This species was reported as an unrecorded indigenous species by Shin (2016) and reported as a newly recorded species in the coastal waters of Korea in the present study.

***Gonyaulax monospina* Rampi 1952 (Fig. 1j)**
Synonym: No synonym.
References: Naik 2010, p. 33, fig. 2.10 (a).
Specimen examined: Serial No. LJB2008010.
Description: The upper part of epitheca has a cone. Hypotheca is round as a whole and has a small cone at the bottom. The cingulum and sulcus meet and cross each other in Z-shape.
Size: 33 μm long, 27 μm wide in the ventral view.
Sampling: Sep. 2008. Yellow Sea (35°00′N, 125°40′E).
Habitat: Marine species.
Distribution: Europe: Black Sea (Goméz and Boicenco 2004), Mediterranean (Gómez 2003), Portugal (Moita and Vilarinho 1999).
Note: This species was reported as an unrecorded indigenous species by Shin (2016) and reported as a newly re-

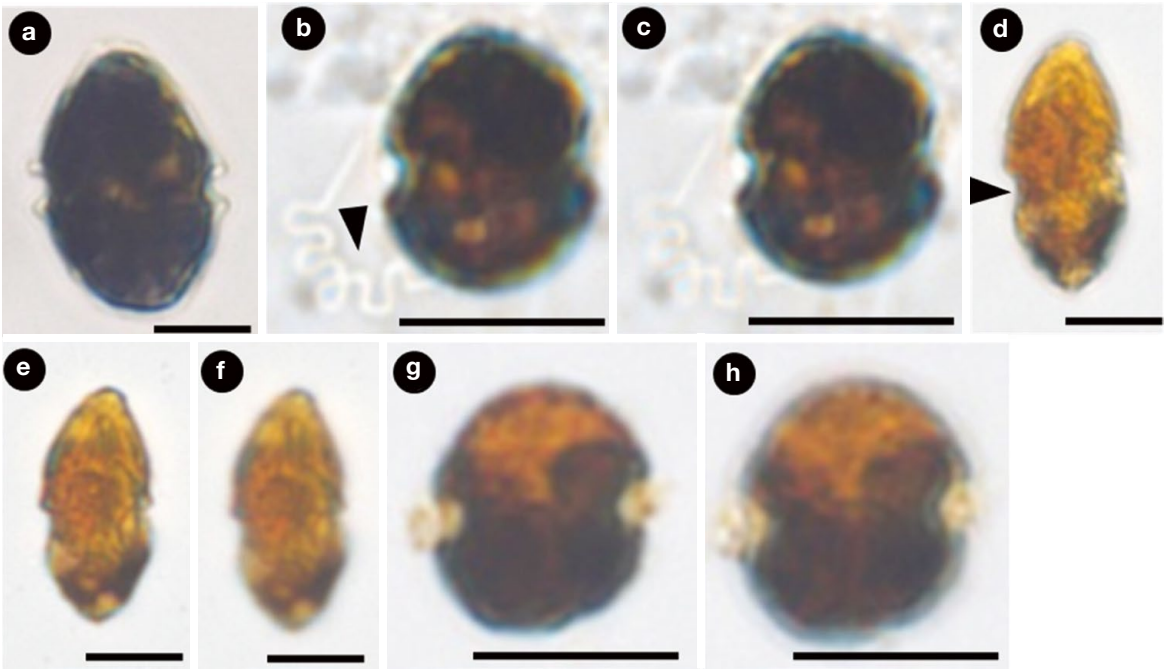

Fig. 2. Light micrographs of the genus *Heterocapsa*. (a) *H. circularisquama*, lateral view, (b), (c) *H. horiguchii*, lateral view, arrowhead; flagellum, (d) *H. lanceolata*, lateral view, arrowhead; cingulum, (e), (f) *H. lanceolata*, lateral view, and (g), (h) *H. pygmaea*, ventral view (Scale bars, a–h: 10 μm).

corded species in the coastal waters of Korea in the present study.

Genus *Amphidinium* Claparéde et Lachmann 1859

Holotype species: *Amphidinium operculatum* Claparéde et Lachmann.

Description: Small to large (10–100 μm) unarmored dinoflagellates. Cells were globular to fusiform, laterally or dorsoventrally compressed. Cingulum circular or little displaced. Sulcus extends from cingulum to antapex. Epicone is small and hypcone is large, as the cingulum is located in the anterior part of the cell. Chloroplasts were present or absent (Guiry and Guiry 2018).

Numbers of names and species: There are 192 species names in the database at present, as well as 12 infraspecific names. Of the species names, 113 have been flagged as accepted taxonomically (Guiry and Guiry 2018).

Amphidinium flagellans Schiller 1928 (Fig. 1k and l)

Synonym: No synonym.

References: Omura *et al*. 2012, p. 71.

Specimen examined: Serial No. LJB2017003.

Description: Cell is thick in the middle, narrow fusiform and not flat. The epicone almost conical and has a sharp end. The hypocone is round, but it also has a sharp end. The cingulum is deep and board. The sulcus is narrow at epicone, wide at hypocone and sharply end.

Size: 20–25 μm long, 8–9 μm wide in the ventral view.

Sampling: May 2017. Seongsan (Tongbatal) in Jeju Island (33°27′10.95″ N, 126°55′5.09″ E).

Habitat: Marine species.

Distribution: Europe: Black Sea (Goméz and Boicenco 2004), Mediterranean (Goméz 2003); North America: Mexico (Escobar-Morales and Hernández-Becerril 2015).

Note: This species was reported as an unrecorded indigenous species by NIBR in 2017 and reported as a newly recorded species in the coastal waters of Korea in the present study.

Genus *Heterocapsa* Stein 1883

Holotype species: *Heterocapsa triquetra* (Ehrenberg) Stein

Description: Medium-sized (20–40 μm) biflagellated thecate dinoflagellates, irregularly spindle shaped or ovoid with a medium and circular cingulum, sulcus restricted to

Table 1. Checklist of genus *Dinophysis*, *Gonyaulax*, *Amphidinium*, and *Heterocapsa* described from Korean waters (The newly recorded and the re-described species are marked with asterisks (*) and sharps (#), respectively, and 'n' indicates a newly recorded species in Korean waters by Shin (2016), 'f' indicates a species recorded only in floristic list (Lee and Kim 2015) and 'syn' refers to the synonym, respectively).

Species name	Shim *et al.* (1981)	Han and Yoo (1983a)	Han and Yoo (1983b)	Lee *et al.* (1993)	Shim (1994)	Shin *et al.* (2004)	Kim *et al.* (2013)	Shah *et al.* (2013)	Lee and Kim (2015)	Lee *et al.* (2015)	Shin (2016)	Lee and Kang (2017)	Lee and Kim (2017)	Present study
Dinophysis acuminata		●		●	●	●			●		●			
Dinophysis acuta[f]									●		●			
Dinophysis acuta = syn. *Dinophysis dens*						●			●		●			
Dinophysis argus[n]											●			
Dinophysis caudata	●			●	●	●			●					
Dinophysis contracta[n]											●			
**Dinophysis elongata*														●
Dinophysis exigua[n]											●			
Dinophysis fortii				●	●	●			●		●			
Dinophysis fortii = syn. *Dinophysis lapidistrigiliformis*						●					●			
Dinophysis hastata							●		●					
Dinophysis infundibulum						●			●	●	●			
Dinophysis irregularis						●			●		●			
Dinophysis joergensenii[f]									●					
Dinophysis laevis					●				●					
Dinophysis micropterygia										●				
Dinophysis miles										●				
**Dinophysis nasuta*														●
Dinophysis norvegica										●				
Dinophysis ovum	●				●				●		●			
Dinophysis parvula						●			●	●	●			
Dinophysis punctata										●				
Dinophysis recurva					●				●		●			
Dinophysis rudgei									●	●				
Dinophysis schroederi[n]											●			
Dinophysis schuettii							●		●		●			
Dinophysis similis[n]											●			
Dinophysis tripos									●	●	●			
#Gonyaulax alaskensis[n]											●			●
Gonyaulax brevisulcataum[n]											●			
Gonyaulax bruunii[n]											●			
#Gonyaulax diegensis[n]											●			●
Gonyaulax digitale					●				●		●			
Gonyaulax fragilis[n]											●			
Gonyaulax hyaline[n]											●			
Gonyaulax lebouriae[f]									●					
Gonyaulax macroporus[n]											●			
Gonyaulax monacantha	●				●				●					
#Gonyaulax monospina[n]											●			●
Gonyaulax orientalis[f]									●					

Table 1. Continued.

Species name	Shim *et al.* (1981)	Han and Yoo (1983a)	Han and Yoo (1983b)	Lee *et al.* (1993)	Shim (1994)	Shin *et al.* (2004)	Kim *et al.* (2013)	Shah *et al.* (2013)	Lee and Kim (2015)	Lee *et al.* (2015)	Shin (2016)	Lee and Kang (2017)	Lee and Kim (2017)	Present study
Gonyaulax pavillardii[n]											●			
Gonyaulax polygramma		●	●		●				●		●			
Gonyaulax scrippsae[f]									●		●			
Gonyaulax spinifera	●	●	●		●				●					
Gonyaulax spinifera = syn. *Gonyaulax apiculata* [f]									●					
Gonyaulax spinifera = syn. *Gonyaulax buxus* [n]											●			
Gonyaulax spinifera = syn. *Gonyaulax levanderi*[f]									●					
Gonyaulax striata[n]											●			
Gonyaulax turbynei[f]									●		●			
Gonyaulax verior		●	●		●				●		●			
Amphidinium acutissimum[f]									●					
Amphidinium carterae								●	●					
Amphidinium corpulentum[f]									●					
Amphidinium crassum					●				●					
**Amphidinium flagellans*														●
Amphidinium flexum[f]									●					
Amphidinium fusiforme[f]									●					
Amphidinium gibbosum								●	●					
Amphidinium globosum[f]									●					
Amphidinium herdmanii								●	●					
Amphidinium incoloratum								●	●					
Amphidinium inflatum[f]									●					
Amphidinium kesslitzii[f]									●					
Amphidinium longum		●			●				●					
Amphidinium massartii								●	●					
Amphidinium mootonorum								●	●					
Amphidinium operculatum								●	●					
Amphidinium ovum[f]									●					
Amphidinium scissum								●	●					
Amphidinium steinii								●	●					
Amphidinium stigmatum[f]									●					
Amphidinium thermaeum													●	
Amphidinium trulla								●	●					
**Hetrocapsa circularisquama*														●
**Hetrocapsa horiguchii*														●
**Hetrocapsa lanceolata*														●
Heterocapsa ovata												●		
Heterocapsa psammophila								●	●		●			
Heterocapsa pseudotriquetra												●		
**Heterocpasa pygmaea*														●
Heterocapsa rotundata									●					
Heterocapsa triquetra		●	●						●					
No. of species	4	6	4	3	13	8	2	11	51	8	34	2	1	10

the hypocone. The plate pattern is difficult to establish and has been disputed. Numerous chloroplasts and an ovoid nucleus. Marine plankton, worldwide distribution mainly in coastal waters (Guiry and Guiry 2018).

Numbers of names and species: There are 22 species names in the database at present, as well as 3 infraspecific names. Of the species names, 19 have been flagged as currently accepted taxonomically (Guiry and Guiry 2018).

***Heterocapsa circularisquama* Horiguchi 1995 (Fig. 2a)**

Synonym: No synonym.

References: Horiguchi 1995, p. 130, figs. 1–11; Iwataki 2008, p. 139, figs. 3–4; Omura *et al*. 2012, p. 130.

Specimen examined: Serial No. LJB2017006.

Description: Cells are entirely elliptical. The epitheca is almost equal to the hypotheca. The epitheca is in cone shape and the hypotheca is in round form. Cingulum is relatively wide, and sulcus is narrow and almost to the antapex. Chloroplasts present.

Size: 20–25 μm long, 13–20 μm wide in lateral view.

Sampling: Jun. 2017. Jeju coast (Geonip-dong) in Jeju Island (33°12′39.026″ N, 126°35′1.750″ E).

Habitat: Marine species.

Distribution: Japan (Iwataki *et al*. 2004).

Note: This species was reported as an unrecorded indigenous species by NIBR in 2017 and reported as a newly recorded species in the coastal waters of Korea in the present study.

***Heterocapsa horiguchii* Iwataki, Takayama et Matsuoka 2002 (Fig. 2b and c)**

Synonym: No synonym.

References: Iwataki 2008, p. 139, figs. 3–4; Omura *et al*. 2012, p. 130.

Specimen examined: Serial No. LJB2017007.

Description: Cells are oval. The epitheca and hypotheca are about the same size and are in the hemisphere. Cingulum is central and relatively wide. Sulcus is wide and almost reached antapex.

Size: 13–21 μm long, 10–15 μm wide in lateral view.

Sampling: Aug. 2017. Seogwipo coast in Jeju Island (33°19′23.387″ N, 126°51′59.928″ E).

Habitat: Marine species.

Distribution: Japan (Iwataki *et al*. 2004).

Note: This species was reported as an unrecorded indigenous species by NIBR in 2017 and reported as a newly recorded species in the coastal waters of Korea in the present study.

***Heterocapsa lanceolata* Iwataki et Fukuyo 2002 (Fig. 2d–f)**

Synonym: No synonym.

References: Iwataki 2008, p. 139, figs. 3–4; Omura *et al*. 2012, p. 130.

Specimen examined: Serial No. LJB2017008.

Description: Cells have the shape of spear. The epitheca is greater than the hypotheca, and both cone. Cingulum is relatively wide. In the case of thecal plates, it is relatively thin.

Size: 22–25 μm long, 10–15 μm wide in lateral view.

Sampling: Aug. 2017. Seogwipo coast in Jeju Island (33°19′423.387″ N, 126°51′59.929″ E)

Habitat: Marine species.

Distribution: Europe: Mediterranean (Gómez 2003); Asia: Japan (Iwataki *et al*. 2004).

Note: This species was reported as an unrecorded indigenous species by NIBR in 2017 and reported as a newly recorded species in the coastal waters of Korea in the present study.

***Heterocapsa pygmaea* Lobelich III, Schmidt et Sherley 1981 (Fig. 2g and h)**

Synonym: No synonym.

References: Iwataki 2008, p. 139, figs. 3–4; Omura *et al*. 2012, p. 130.

Specimen examined: Serial No. LJB2017009.

Description: Cells are oval. The epitheca is almost equal to the hypotheca and hypotheca is round. Cingulum is relatively wide and slightly up on the left. Sulcus is relative wide

Size: 22–25 μm long, 10–15 μm wide in lateral view.

Sampling: Aug. 2017. Tongbatal in Jeju Island (33°37′ 10.95″ N, 126°55′5.09″ E).

Habitat: Marine species.

Distribution: Japan (Iwataki *et al*. 2004).

Note: This species was reported as an unrecorded indigenous species by NIBR in 2017 and reported as a newly recorded species in the coastal waters of Korea in the present study.

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