



New records of genus *Triplos* (Dinophyceae) around Jeju Island, Korea

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Abstract

The morphology of 26 species of the genus *Triplos* was studied among a total of 51 species of this genus, which were taken using 20 µm net samples from June 2006 to January 2011 at 14 stations around Jeju Island. Of these, 23 species were first described as new records in Korean waters and 3 species were redescribed. Short descriptions and synonyms are given for each species in the present study. The dinoflagellates of family Ceratiaceae include marine and freshwater species, belonged to originally the genus *Ceratium*. Recently, this genus were divided into a new combination with the genus *Triplos*, which contains the marine species, and the original genus *Ceratium*, including the freshwater species. We used the *Triplos* genus for the marine species in this study as a valid name.

Key words: Ceratiaceae, *Ceratium*, dinoflagellates, Jeju Island, new records, *Neoceratium*, *Triplos*

INTRODUCTION

As one genus of Dinophyceae, the genus *Ceratium* created by Schrank (1793) is one of the most important phytoplankton. The common size of *Ceratium* is large, which make them easy to collect. Morphological features of the *Ceratium* based on the tough theca are essential for taxonomic analysis. The genus includes a large number of species as plankton, and is widely distributed in all over the world ocean as well as rarely in freshwaters, such as lake and river. Over 120 marine species including varieties or forms have been described, but 62 among them are considered valid (Gómez 2005). Only four species with several varieties belong to freshwater species (Popovski and Pfister 1990).

Many marine species belonged to the genus *Ceratium* have been moved to a new genus, *Neoceratium*, by Gómez et al. (2010), while freshwater species remains in the original genus *Ceratium*. The number of cingular plates and the considerable evolutionary distance of their re-

spective small subunit ribosomal RNA gene (SSU rDNA) sequences are suggested as diagnosis to transfer to the *Neoceratium* genus for the marine species (Gómez et al. 2010, Tunin-Ley et al. 2012). However, Calado and Huisman (2010) remarked the priority for older synonyms of the *Ceratium* such as *Triplos* and other nomenclatural problems. Gómez (2010) insisted a confusion in using the *Triplos*, but recently Gómez (2013) reinstated the genus name of *Triplos* to replace the genus *Neoceratium*. To date, a total of 51 *Ceratium* species were identified around Jeju Island, which appeared in taxonomical monographs and ecological reports. Of these, 23 species were reported as new records in Korean waters. This study describes the newly recorded species with respect to classification and an easy taxonomical key based on light microscopy (LM) and scanning electron microscopy (SEM) criteria, and also provides the checklist of the genus *Triplos* based on the new combination.

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MATERIALS AND METHODS

Samplings were done from 14 stations located around Jeju Island during the period from June 2006 to May 2011 (Table 1). Plankton samples were obtained using a 20 µm pore size plankton net and fixed with formaldehyde (final concentration of 0.4%) or glutaraldehyde (final concentration of about 1%). Planktonic dinoflagellates were identified using an Axioplan microscope (Carl Zeiss, Oberkochen, Germany). To make slide specimens for one species, the dinoflagellate samples were washed with distilled water, and then proceeded by the method described in Kim et al. (2013). For more detail observation, dinoflagellate cells were isolated with a micropipette, placed on a cover slip, air-dried, and coated with gold for observation with a Field Emission Scanning Electron microscope (JSM-6700F; JEOL, Tokyo, Japan). For identification, several monographs were used that were reported from different oceans, such as the Indian Ocean (Taylor 1976), the seas adjacent to Japan (Yamaji 1984: 97-158), the British and the Atlantic Ocean (Dodge 1982, 1985), the Kuroshio Current (Fujioka 1990) and Korean waters (Shim 1994: 349-419). For classification, the new combination with the genus *Triplos* was cited from Gómez (2013).

RESULTS

A total of 51 species of the genus *Triplos* were identified and classified from Jeju Island, as shown below. Among them, 23 species are described as a new record in Korean waters and 3 species are redescribed in this paper. An

Table 1. Sampling stations around Jeju Island, Korea, June 2006 – May 2011

Stations	Location	Geographic coordinates	
J1	Bukchon-ri coast	33°34'30.8" N	126°41'02.6" E
J2	Samyang coast	33°32'08.1" N	126°35'59.7" E
J3	Tap-dong coast	33°32'18.7" N	126°33'02.9" E
J4	Iho coast	33°30'18.7" N	126°27'05.1" E
J5	Aewol-ri coast	33°29'37.7" N	126°20'31.1" E
J6	Hallim-ri coast	33°26'34.2" N	126°14'01.3" E
J7	Chagwido coast	33°19'02.7" N	126°08'02.4" E
J8	Gosan-ri coast	33°15'31.8" N	126°09'52.6" E
J9	Hamo-ri coast	33°11'44.7" N	126°13'57.5" E
J10	Hwasun-ri coast	33°10'56.5" N	126°20'00.0" E
J11	Seogwipo coast	33°13'31.4" N	126°34'17.1" E
J12	Namwon-ri coast	33°14'53.0" N	126°43'10.6" E
J13	Pyoseon-ri coast	33°17'01.3" N	126°49'27.8" E
J14	Seongsan-ri coast	33°26'26.8" N	126°57'11.7" E

asterisk (*) mark indicates a newly recorded species and two asterisk (**) mark indicates a redescribed species. The criteria for the identification of this genus include cell shape, apical and antapical horn shape, girdle displacement, thecal tabulation and ornamentation, apical and antapical spine or wing shape, etc. Photos were taken by LM and SEM focused on the criteria from the dorsal and ventral views.

Checklist of the genus *Triplos* occurred around Jeju Island

Class Dinophyceae G.S. West & Fritsch 1927

Order Gonyaulacales F.J.R. Taylor 1980

Family Ceratiaceae Kofoid 1907

Genus *Triplos* Bory 1823

- Triplos arietinus* (Cleve 1900) F. Gómez 2013
= *Ceratium arietinum* Cleve 1900
- **Triplos axialis* (Kofoid 1907) F. Gómez 2013
= *Ceratium axiale* Kofoid 1907
- Triplos azoricus* (Cleve 1900) F. Gómez 2013
= *Ceratium azoricum* Cleve 1900
- Triplos brevis* (Ostenfeld & Johannes Schmidt 1901) F. Gómez 2013
= *Ceratium breve* (Ostenfeld & Johannes Schmidt 1901) Schröder 1906
- Triplos candelabrus* (Ehrenberg 1859) F. Gómez 2013
= *Ceratium candelabrum* (Ehrenberg 1859) F. Stein 1883
- Triplos carriensis* (Gourret 1883) F. Gómez 2013
= *Ceratium carriense* Gourret 1883
- ***Triplos contortus* (Gourret 1883) F. Gómez 2013
= *Ceratium contortum* (Gourret 1883) Cleve 1900
- Triplos deflexus* (Kofoid 1907) F. Gómez 2013
= *Ceratium deflexum* (Kofoid 1907) Jørgensen 1911
- Triplos extensus* (Gourret 1883) F. Gómez 2013
= *Ceratium extensum* (Gourret 1883) Cleve 1900
- Triplos furca* (Ehrenberg 1834) F. Gómez 2013
= *Ceratium furca* (Ehrenberg 1834) Claparède & J. Lachmann 1859
- Triplos fusus* (Ehrenberg 1834) F. Gómez 2013
= *Ceratium fusus* (Ehrenberg 1834) Claparède & J. Lachmann 1859
- **Triplos fusus* var. *schuettii* (Lemmermann 1899) F. Gómez 2013
= *Ceratium fusus* var. *schuettii* Lemmermann 1899
- **Triplos geniculatus* (Lemmermann 1899) F. Gómez 2013
= *Ceratium geniculatum* (Lemmermann 1899) Cleve 1900

- Tripes gibberus* (Gourret 1883) F. Gómez 2013
= *Ceratium gibberum* Gourret 1883
- **Tripes gibberus* f. *sinistrus* (Gourret 1883) F. Gómez 2013
= *Ceratium gibberum* f. *sinistrum* (Gourret 1883) Jørgensen 1911
- Tripes gracilis* (Pavillard 1905) F. Gómez 2013
= *Ceratium gracile* Pavillard 1905
- **Tripes gracilis* var. *symmetricus* (Pavillard 1905) F. Gómez 2013
= *Ceratium gracile* var. *symmetricum* (Pavillard 1905) Jørgensen 1911
- Tripes horridus* var. *claviger* (Kofoid 1907) F. Gómez 2013
= *Ceratium horridum* var. *claviger* (Kofoid 1907) H.W. Graham & Bronik. 1944
- **Tripes incisus* (G. Karsten 1906) F. Gómez 2013
= *Ceratium incisum* (G. Karsten 1906) Jørgensen 1911
- Tripes inflatus* (Kofoid 1907) F. Gómez 2013
= *Ceratium inflatum* (Kofoid 1907) Jørgensen 1911
- Tripes kofoidii* (Jørgensen 1911) F. Gómez 2013
= *Ceratium kofoidii* Jørgensen 1911
- **Tripes lamellicornis* (Kofoid 1908) F. Gómez 2013
= *Ceratium lamellicorne* Kofoid 1908
- **Tripes limulus* (C.H.G. Pouchet 1883) F. Gómez 2013
= *Ceratium limulus* (C.H.G. Pouchet 1883) Gourret 1883
- Tripes lineatus* (Ehrenberg 1854) F. Gómez 2013
= *Ceratium lineatum* (Ehrenberg 1854) Cleve 1900
- Tripes longirostrus* (Gourret 1883) F. Gómez 2013
= *Ceratium longirostrum* Gourret 1883
- **Tripes longissimus* (Schröder 1900) F. Gómez 2013
= *Ceratium longissimum* (Schröder 1900) Kofoid 1907
- Tripes lunula* (Schimper 1900 ex G. Karsten 1906) F. Gómez 2013
= *Ceratium lunula* Schimper 1900 ex G. Karsten 1906
- Tripes macroceros* (Ehrenberg 1840) F. Gómez 2013
= *Ceratium macroceros* (Ehrenberg 1840) Cleve 1899
- ***Tripes macroceros* var. *gallicus* (Kofoid 1907) F. Gómez 2013
= *Ceratium macroceros* var. *gallicum* (Kofoid 1907) N. Peters 1934
- Tripes massiliensis* (Gourret 1883) F. Gómez 2013
= *Ceratium massiliense* (Gourret 1883) G. Karsten 1906
- **Tripes massiliensis* var. *massiliensis* (Gourret 1883) F. Gómez 2013
= *Ceratium massiliense* var. *massiliense* (Gourret 1883) Balech
- **Tripes mollis* (Kofoid 1907) F. Gómez 2013
= *Ceratium molle* Kofoid 1907
- Tripes muelleri* Bory 1825
= *Ceratium tripos* (O.F. Müller 1776) Nitzsch 1817
- **Tripes muelleri* var. *atlanticus* (Ostenfeld 1903) F. Gómez 2013
= *Ceratium tripos* var. *atlanticum* (Ostenfeld 1903) Paulsen 1908
- **Tripes muelleri* var. *pulchellus* (Schröder 1906) F. Gómez 2013
= *Ceratium tripos* var. *pulchellum* (Schröder 1906) López 1955 ex Sournia 1973
- **Tripes palmatus* (Schröder 1900) F. Gómez 2013
= *Ceratium palmatum* (Schröder 1900) G. Karsten 1907
- **Tripes paradoxides* (Cleve 1900) F. Gómez 2013
= *Ceratium paradoxides* Cleve 1900
- Tripes pentagonus* (Gourret 1883) F. Gómez 2013
= *Ceratium pentagonum* Gourret 1883
- **Tripes platycornis* var. *cuneatus* (Jørgensen 1911) F. Gómez 2013
= *Ceratium platycorne* var. *cuneatum* Jørgensen 1911
- **Tripes porrectus* f. *megasomus* (Jørgensen 1911) F. Gómez 2013
= *Ceratium porrectum* f. *megasomum* Jørgensen 1911
- Tripes praelongus* (Lemmermann 1899) F. Gómez 2013
= *Ceratium praelongum* (Lemmermann 1899) Kofoid ex Jørgensen 1911
- Tripes pulchellus* (Schröder 1906) F. Gómez 2013
= *Ceratium pulchellum* Schröder 1906
- **Tripes pulchellus* f. *semipulchellus* (Jørgensen 1920) F. Gómez 2013
= *Ceratium pulchellum* f. *semipulchellum* Jørgensen 1920
- **Tripes ranipes* var. *palmatus* (Schröder 1900) F. Gómez 2013
= *Ceratium ranipes* var. *palmatum* (Schröder 1900) Jørgensen 1920
- **Tripes reflexus* (Cleve 1900) F. Gómez 2013
= *Ceratium reflexum* Cleve 1900
- ***Tripes symmetricus* (Pavillard 1905) F. Gómez 2013
= *Ceratium symmetricum* Pavillard 1905
- **Tripes teres* (Kofoid 1907) F. Gómez 2013
= *Ceratium teres* Kofoid 1907
- Tripes trichoceros* (Ehrenberg 1859) F. Gómez 2013
= *Ceratium trichoceros* (Ehrenberg 1859) Kent 1881
- Tripes vultur* (Cleve 1900) F. Gómez 2013
= *Ceratium vultur* Cleve 1900
- **Tripes vultur* f. *angulatus* (Jørgensen 1911) F. Gómez 2013
= *Ceratium vultur* f. *angulatum* (Jørgensen 1911) J. Schiller 1937

**Triplos vulture* f. *robustus* (Ostenfeld & Johannes Schmidt 1901) F. Gómez 2013
= *Ceratium vultur* f. *robustum* (Ostenfeld & Johannes Schmidt 1901) F.J.R. Taylor 1976

Taxonomic description of unrecorded dinoflagellates

Genus *Triplos* Bory 1823

Triplos axialis (Kofoid 1907) F. Gómez 2013 (Fig. 1a)

Basionym: *Ceratium axiale* Kofoid 1907.

Synonym: *Neoceratium axiale* (Kofoid 1907) F. Gómez; D. Moreira & P. López-García 2010.

References: Kofoid 1907, p. 170, pl. 4, fig. 26; Fujioka 1990, p. 51, pl. 25, fig. 3.

Specimen examined: NIBRFL0000125563 at the National Institute of Biological Resources (NIBR), Incheon.

Description: The antapical horn is asymmetrically curved, like a bow. The apical horn is fine and long, with 1.5–2 times the length of the body. The part that links the epithelial body and the apical horn is smoothly curved.

Size: Length 220–240 µm, width 50–60 µm.

Sampling: November 2009 in J7 (Chagwido coast, see Table 1 for the sign of sampling sites).

Triplos contortus (Gourret 1883) F. Gómez 2013 (Fig. 1b)

Basionym: *Ceratium gibberum* var. *contortum* Gourret 1883.

Synonym: *Ceratium contortum* (Gourret 1883) Cleve 1900; *Neoceratium contortum* (Gourret 1883) F. Gómez, D. Moreira & P. López-García 2010.

References: Gourret 1883, T. 2, fig. 33; Yamaji 1984, p. 140, pl. 46, fig. 10; Shim 1994, p. 362, fig. 430; Okolodkov 2010, pl. 4, fig. 8, pl. 5, fig. 1, pl. 8, fig. 6, pl. 11, fig. 8, pl. 12, fig. 1.

Specimen examined: NIBRFL0000125588.

Description: The cell shape is long, with a quite long apical horn that is slightly curved. The antapical horns stretch in both directions, the right antapical horn is more curved in the middle part.

Size: Length 190–200 µm, width 50–60 µm.

Sampling: September 2010 in the southern sea of Jeju Island.

Triplos fusus var. *schuettii* (Lemmermann 1899) F. Gómez 2013 (Fig. 1c)

Basionym: *Ceratium fusus* var. *schuettii* Lemmermann 1899.

Synonym: *Ceratium fusus* var. *schuettii* Lemmermann 1899.

Reference: Yamaji 1984, p. 139, pl. 45, fig. 5.

Specimen examined: NIBRFL0000125589; Unrecorded species no. LJB2013-04 at the National Institute of Biological Resources (NIBR), Incheon.

Description: The body shape seems similar to that of the *Ceratium fusus*. The difference is that the epitheca is bulbous in shape and extends to a strong apical horn cone. The antapical horn has a single curved as long as the calyx. The apical horn is relatively short compared to the antapical horn.

Size: Length 250–350 µm, width 30–40 µm.

Sampling: July 2010 in J7 (Chagwido coast).

Triplos geniculatus (Lemmermann 1899) F. Gómez 2013 (Fig. 1d)

Basionym: *Ceratium fusus* var. *geniculatum* Lemmermann 1899.

Synonym: *Ceratium geniculatum* (Lemmermann 1899) Cleve 1900; *Neoceratium geniculatum* (Lemmermann 1899) F. Gómez, D. Moreira & P. López-García 2010; *Ceratium tricarinatum* Kofoid.

References: Karsten 1907, pl. 50, fig. 3a, b; Subrahmanyan 1968, p. 28, figs. 43-45; Fujioka 1990, p. 55, pl. 27, figs. 2a, b; Okolodkov 2010, pl. 1, fig. 3, pl. 10, fig. 2.

Specimen examined: Unrecorded species no. LJB2013-08.

Description: The cells are spindle-shaped and relatively long. The cell body is long and clearly constricted in the middle. The epitheca is inflated, its distal part suddenly draws into an apical horn, and the hypotheca tapers into a long left antapical horn that is slightly curved. The apical horn is positioned closer to the left side of the cell, and is notably deflected to the left at its base. A reduced right antapical horn is present. The widest point is adjacent to the cingulum and also to the front of the constriction in the middle of the cell body.

Size: Length 150–160 µm, width 10–20 µm.

Sampling: July 2010 in J7 (Chagwido coast).

Triplos gibberus f. *sinistrus* (Gourret 1883) F. Gómez 2013 (Fig. 1e)

Basionym: *Ceratium gibberum* var. *sinistrum* Gourret 1883.

Synonym: *Ceratium gibberum* f. *sinistrum* (Gourret 1883) Jørgensen 1911.

Reference: Yamaji 1984, p. 140, pl. 46, fig. 5.

Specimen examined: NIBRFL0000125591.

Description: The cell shape is slightly thick and flat. The apical horn is relatively stretched and the antapical horn is severely curved towards the dorsal side.

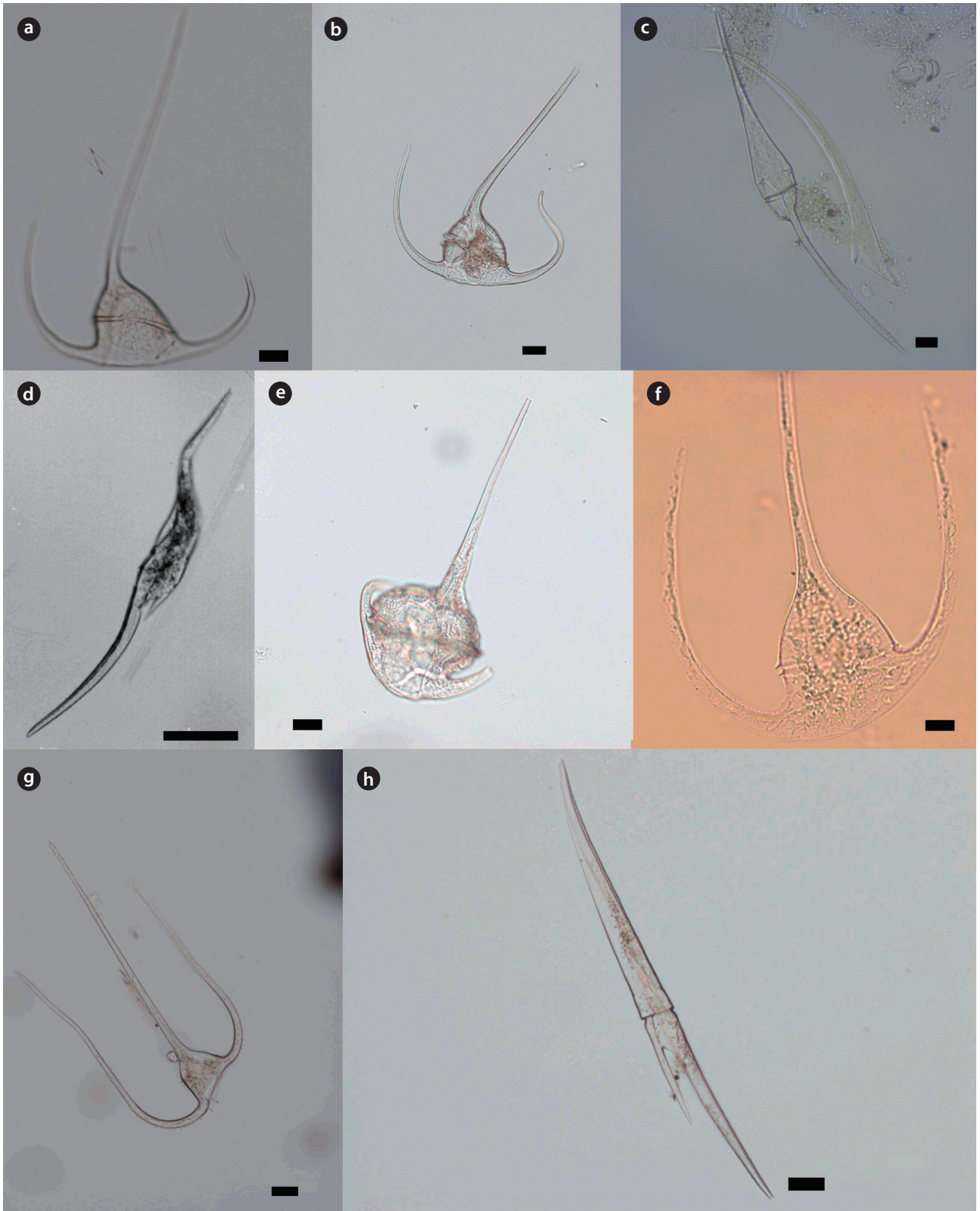


Fig. 1. Light micrographs of the genus *Triplos*. (a) *T. axialis* (DV), (b) *T. contortus* (DV), (c) *T. fusus* var. *schuettii* (DV), (d) *T. geniculatus* (DV), (e) *T. gibberus* var. *sinistrus* (VV), (f) *T. gracilis* var. *symmetricus* (DV), (g) *T. mollis* (DV), (h) *T. incisus* (VV). Scale bars, 20 μ m; DV, dorsal view; VV, ventral view.

Size: Length 150–230 µm, width 100–130 µm.

Sampling: January 2011 in J14 (Seongsan-ri coast).

***Tripes gracilis* var. *symmetricus* (Pavillard 1905) F. Gómez 2013 (Fig. 1f)**

Basionym: *Ceratium symmetricum* Pavillard 1905.

Synonym: *Ceratium gracile* var. *symmetricum* (Pavillard 1905) Jørgensen 1911.

Reference: Yamaji 1984, p. 145, pl. 47, fig. 13.

Specimen examined: NIBRFL0000125594.

Description: The cell is medium in size and slightly thin. The apical horn is slightly curved and upright, but both antapical horns have the same length and thickness. The girdle furrow is distinct and never converges.

Size: Length 100–130 µm, width 50–70 µm.

Sampling: January 2011 in J14 (Seongsan-ri coast).

***Tripes incisus* (G. Karsten 1906) F. Gómez 2013 (Fig. 1h)**

Basionym: *Ceratium furca* var. *incisum* G. Karsten 1906.

Synonym: *Ceratium incisum* (G. Karsten 1906) Jørgensen 1911; *Neoceratium incisum* (G. Karsten 1906) F. Gómez, D. Moreira & P. López-García 2010.

Reference: Karsten 1907, T. 23, fig. 6a, b; Fujioka 1990, p. 55, pl. 27, fig. 8.

Specimen examined: NIBRFL0000125565.

Description: The antapical horn stretches downward sharply. The left antapical horn is 2 times longer and 1.5 times thicker than right one. The apical horn is not distinguished.

Size: Length 260–280 µm, width 15–20 µm.

Sampling: January 2010 in J14 (Seongsan-ri coast).

***Tripes lamellicornis* (Kofoid 1908) F. Gómez 2013 (Fig. 2f)**

Basionym: *Ceratium lamellicorne* Kofoid 1908.

Synonym: *Ceratium lamellicorne* Kofoid 1908.

Reference: Yamaji 1984, p. 146, pl. 48, fig. 8.

Specimen examined: Unrecorded species no. LJB2007-02.

Description: The antapical base is narrow and long, and stretched to the apical horn. The widest wing of the antapical horn is 2–2.5 times wider than the base part and is separate from the apical horn. The outside of the antapical horn has many gearwheel-like protuberances.

Size: Length 140–150 µm, width 48–54 µm.

Sampling: November 2006 in J7 (Chagwido coast).

***Tripes limulus* (C.H.G. Pouchet 1883) F. Gómez 2013 (Fig. 2a)**

Basionym: *Ceratium tripes* var. *limulus* C.H.G. Pouchet

1883.

Synonym: *Ceratium limulus* (C.H.G. Pouchet 1883) Gourret 1883; *Neoceratium limulus* (C.H.G. Pouchet 1883) F. Gómez, D. Moreira & P. López-García 2010.

References: Gourret 1883, p. 33, T. 1, fig. 7; Fujioka 1990, p. 57, pl. 28, fig. 1; Okolodkov 2010, pl. 4, fig. 3, pl. 11, fig. 4.

Specimen examined: NIBRFL0000125566.

Description: The apical horn length is relatively short, and there are protruding horns from both sides of the epitheca. The antapical horn is thick and stretches out and upward.

Size: Length 160–170 µm, width 80–90 µm.

Sampling: January 2010 in J14 (Seongsan-ri coast).

***Tripes longissimus* (Schröder 1900) F. Gómez 2013 (Fig. 2b)**

Basionym: *Ceratium tripes* f. *longissimum* Schröder 1900.

Synonym: *Ceratium longissimum* (Schröder 1900) Kofoid 1907; *Neoceratium longissimum* (Schröder 1900) F. Gómez, D. Moreira & P. López-García 2010.

Reference: Schröder 1900, p. 16, T. 1, fig. 171; Wood 1963, p. 298, fig. 228.

Specimen examined: NIBRFL0000125564.

Description: Both sides of the antapical horn stretch upward with almost equal length, and the apical horn also has a straight, upright line. The bodies of the epitheca and the hypotheca are slightly small, but the whole body is bigger than the normal middle size of the genus *Ceratium*.

Size: Length 200–210 µm, width 30–40 µm.

Sampling: January 2010 in J7 (Chagwido coast).

***Tripes macroceros* var. *gallicus* (Kofoid 1907) F. Gómez 2013 (Fig. 2c)**

Basionym: *Ceratium gallicum* Kofoid 1907.

Synonym: *Ceratium macroceros* var. *gallicum* (Kofoid 1907) N. Peters 1934.

Reference: Dodge 1982, p. 235, fig. 31a; Yamaji 1984, p. 146, pl. 48, fig. 13; Shim 1994, p. 374, fig. 448; Okolodkov 2010, pl. 6, fig. 4, pl. 8, fig. 4, pl. 13, fig. 3.

Specimen examined: Unrecorded species no. LJB2010-04.

Description: The apical horn is slightly obliquely stretched, and the antapical horn is separated in a fan shape. The back side of the antapical horn has many spines, and the girdle furrow has a clear, oblique line.

Size: Length 250–350 µm.

Sampling: November 2010 in J8 (Gosan-ri coast).

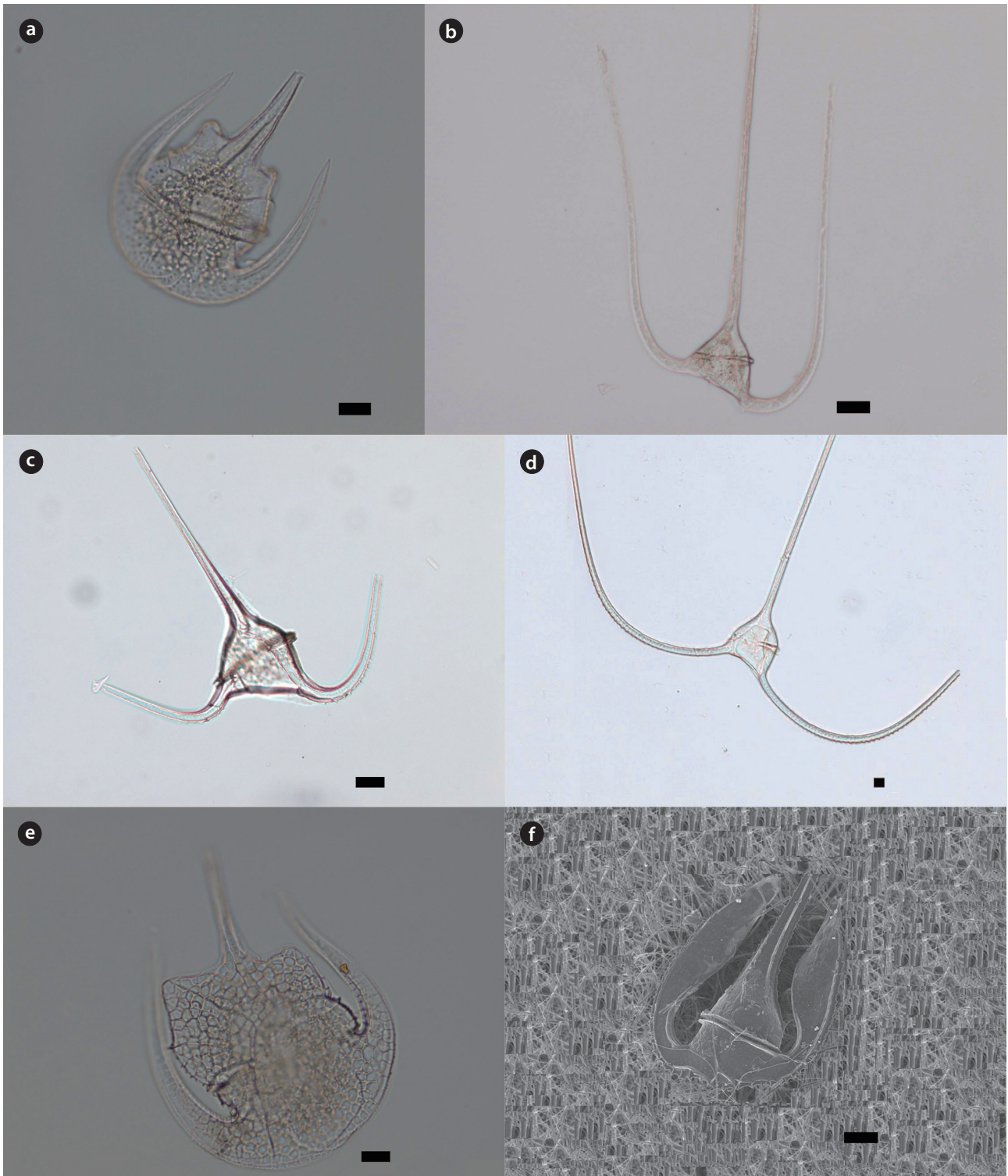


Fig. 2. Light micrographs and scanning electron micrograph (SEM) of the genus *Tripos*. (a) *T. limulus* (VV), (b) *T. longissimus* (DV), (c) *T. macroceros* var. *gallicus* (DV), (d) *T. massiliensis* var. *massiliensis* (DV), (e) *T. paradoxides* (VV), (f) *T. lamellicornis* (SEM, DV). Scale bars, 20 µm; DV, dorsal view; VV, ventral view.

***Triplos massiliensis* var. *massiliensis* (Gourret 1883) F. Gómez 2013 (Fig. 2d)**

Basionym: *Ceratium triplos* var. *massiliense* Gourret 1883.

Synonym: *Ceratium massiliense* var. *massiliense* (Gourret 1883) Balech.

Reference: Gourret 1883, p. 27, T. 1, fig. 2; Fujioka 1990, p. 57, pl. 28, fig. 7; Licea et al. 1995, pl. 19, fig. 6.

Specimen examined: Unrecorded species no. LJB2008-03.

Description: The antapical horn is very long, curved like a bow. The apical horn is slightly shorter than the antapical horn. The main body is relatively small, compared to the three long horns, but it looks well balanced in shape to float.

Size: Length 400–500 µm, width 80–90 µm.

Sampling: September 2008 in J14 (Seongsan-ri coast).

***Triplos mollis* (Kofoid 1907) F. Gómez 2013 (Fig. 1g)**

Basionym: *Ceratium molle* Kofoid 1907.

Synonym: *Ceratium molle* Kofoid 1907; *Ceratium intermedium* (Jørgensen) Jørgensen; *Ceratium claviger* Kofoid.

Reference: Yamaji 1984, p. 152, pl. 50, fig. 10.

Specimen examined: NIBRFL0000125567.

Description: The antapical horn is fine, long, and stretches upward. Numerous spines are visible around the base of the hypotheca. The apical horn is as long as the antapical one and has a similar length, but the cell body is relatively small.

Size: Length 210–220 µm, width 30–40 µm.

Sampling: November 2009 in J7 (Chagwido coast).

***Triplos muelleri* var. *atlanticus* (Ostenfeld 1903) F. Gómez 2013 (Fig. 4c)**

Basionym: *Ceratium triplos* f. *atlanticum* Ostenfeld 1903.

Synonym: *Ceratium triplos* var. *atlanticum* (Ostenfeld 1903) Paulsen 1908; *Neoceratium triplos* var. *atlanticum* (Ostenfeld 1903) A.F. Krachmalny 2011.

Reference: Jørgensen 1911, pl. 10; Yamaji 1984, p. 145, pl. 47, fig. 4-; Fujioka 1990, p. 61, pl. 30, fig. 2.

Specimen examined: NIBRFL0000125604; Unrecorded species no. LJB2013-07.

Description: The body shape is similar to that of the *Ceratium triplos*, but it is concave at the bottom of the body. The furrow of the girdle has a characteristic curvature. The left horn is slightly smaller than the right horn.

Size: Length 90–120 µm, width 45–60 µm.

Sampling: July 2010 in J7 (Chagwido coast).

***Triplos muelleri* var. *pulchellus* (Schröder 1906) F. Gómez 2013 (Fig. 4d)**

Basionym: *Ceratium pulchellum* Schröder 1906.

Synonym: *Ceratium triplos* var. *pulchellum* (Schröder 1906) López 1955 ex Sournia 1973.

Reference: Schröder 1906, p. 358, fig. 27; Fujioka 1990, p. 61, pl. 30, fig. 3.

Specimen examined: Unrecorded species no. LJB2008-04.

Description: The whole body shape is similar to the *Ceratium triplos*. The hypothecal body is swollen, and the right antapical horn is curved towards the inner side.

Size: Length 190–200 µm, width 80–90 µm.

Sampling: October 2008 in J9 (Hamo-ri coast).

***Triplos palmatus* (Schröder 1900) F. Gómez 2013 (Fig. 3d)**

Basionym: *Ceratium triplos* var. *macroceros* Schröder 1900.

Synonym: *Ceratium palmatum* (Schröder 1900) G. Karsten 1907.

Reference: Cleve 1900, p. 15, T. 7, fig. 1; Yamaji 1984, p. 146, pl. 48, fig. 10.

Specimen examined: NIBRFL0000125599.

Description: The apical horn is bent as it stretches upward, and the end of the antapical horn is split in the shape of fingers. Numerous spines are located around the outside of the antapical horn and the base of the hypothecal body.

Size: Length 130–150 µm, width 30–40 µm.

Sampling: January 2011 in J14 (Seongsan-ri coast).

***Triplos paradoxides* (Cleve 1900) F. Gómez 2013 (Fig. 2e)**

Basionym: *Ceratium paradoxides* Cleve 1900.

Synonym: *Neoceratium paradoxides* (Cleve 1900) F. Gómez, D. Moreira & P. López-García 2010.

Reference: Cleve 1900, p. 15, T. 7, fig. 14; Yamaji 1984, p. 146, pl. 50, fig. 5; Fujioka 1990, p. 57, pl. 28, fig. 8.

Specimen examined: NIBRFL0000125568.

Description: The apical horn is short and slightly thick. The upper side of the epitheca displays swelling in the shape of a half quadrangle around the right and left side of the apical horn. The antapical horn is very thick, but becomes thinner towards the end of the horn. A net shape of mesh is visible on a wide surface area of the epithecal upper body.

Size: Length 230–250 µm, width 110–120 µm.

Sampling: January 2010 in J14 (Seongsan-ri coast).

***Tripes platycornis* var. *cuneatus* (Jørgensen 1911) F. Gómez 2013 (Fig. 3a)**

Basionym: *Ceratium platycorne* var. *cuneatum* Jørgensen 1911.

Synonym: *Ceratium platycorne* var. *cuneatum* Jørgensen 1911.

Reference: Jørgensen 1911, p. 59, fig. 126.

Specimen examined: Unrecorded species no. LJB2007-03.

Description: The hypothecal base is relatively narrow, and both antapical horns have flat and wide wings that stretch upward. The widest part of the wing is 2 times the length of the base part of the antapical horn. The wing is separate from the epithecal body and the apical horn. The end of the antapical horn is truncated, like a knife face.

Size: Length 350–400 µm, width 80–90 µm.

Sampling: February 2007 in J7 (Chagwido coast).

***Tripes porrectus* f. *megasomus* (Jørgensen 1911) F. Gómez 2013 (Fig. 3b)**

Basionym: *Ceratium porrectum* f. *megasomum* Jørgensen 1911.

Synonym: *Ceratium porrectum* f. *megasomum* Jørgensen 1911; *Ceratium ponectum* f. *megasoma* Jørgensen.

Reference: Jørgensen 1911, p. 34, fig. 64; Schiller 1937, pp. 590; Subrahmanyam 1968, p. 129; Yamaji 1984, p. 159, pl. 51, fig. 4; Fujioka 1990, p. 59, pl. 29, fig. 2.

Specimen examined: NIBRFL0000125603 (*Ceratium ponectum* f. *megasoma* Jørgensen); Unrecorded species no. LJB2013-05 (*Ceratium porrectum* f. *megasoma*).

Description: This is a robust species. The left contour of the epitheca become strongly convex and is abruptly drawn out into a robust, short anterior horn, which is strikingly broadened at the base and covered with toothed ridges in old, large individuals. The distal portion is narrowed. The antapical horns are uniformly arched and are generally rather short; they are approximately as long as or at times longer than the cell body, diverging at the apex, and parallel to rarely somewhat converging; the right horn is usually somewhat slender and shorter. The armor is robust, with lists, pores, and winged lists.

Size: Length 130–150 µm, width 50–70 µm.

Sampling: May 2010, January 2011 in J14 (Seongsan-ri coast).

***Tripes pulchellus* f. *semipulchellus* (Jørgensen 1920) F. Gómez 2013 (Fig. 3c)**

Basionym: *Ceratium pulchellum* f. *semipulchellum* Jørgensen 1920.

Synonym: *Ceratium pulchellum* f. *semipulchellum* Jørgensen 1920.

gensen 1920.

Reference: Schröder 1906, p. 358, fig. 27.

Specimen examined: NIBRFL0000125606; Unrecorded species no. LJB2013-06.

Description: The body is always longer than it is broad. The posterior contour is clearly convex, particularly on the right side. The apical horn is strikingly long and robust, uniformly broad up to the apex, and rarely broader in the middle than at the end. The hypotheca is slightly concave, almost straight, and slightly inclined to the left side contour. The posterior contour of the cell is convex, usually uniformly merging with the left antapical horn, whereas the right is clearly delimited (slightly so with a very small right horn). The antapical horns are rather short and less robust than the apical horn; the left one is particularly beautifully and uniformly arched, with the ends directed almost parallel to the apical horn, or the left sometimes somewhat divergent. The right horn is clearly more weakly developed than the left. The winged lists are absent.

Size: Length 120–150 µm, width 45–55 µm.

Sampling: July 2010 in J13 (Pyosun-ri coast).

***Tripes ranipes* var. *palmaris* (Schröder 1900) F. Gómez 2013 (Fig. 3e)**

Basionym: *Ceratium tripes* var. *macroceros* f. *palmaris* Schröder 1900.

Synonym: *Ceratium ranipes* var. *palmaris* (Schröder 1900) Jørgensen 1920.

Reference: Cleve 1900, p. 15, T. 7, fig. 1; Fujioka 1990, p. 59, pl. 29, fig. 4.

Specimen examined: Unrecorded species no. LJB2007-05.

Description: The end of the antapical horns looks like a fan shape and is characterized with fine projects. The projects have 6 radial axes stretching outside of them.

Size: Length 300–350 µm, width 60–80 µm.

Sampling: February 2007 in J7 (Chagwido coast).

***Tripes reflexus* (Cleve 1900) F. Gómez 2013 (Fig. 3f)**

Basionym: *Ceratium reflexum* Cleve 1900.

Synonym: *Neoceratium reflexum* (Cleve 1900) F. Gómez, D. Moreira & P. López-García 2010.

Reference: Cleve 1900, p. 15, T. 7, figs. 8, 9; Yamaji 1984, p. 159, pl. 51, fig. 5-; Fujioka 1990, p. 59, pl. 29, fig. 6.

Specimen examined: Unrecorded species no. LJB2013-09.

Description: The species is of a medium size and has very characteristic features. The body is slightly compressed. The epitheca is broad and low. The hypotheca is

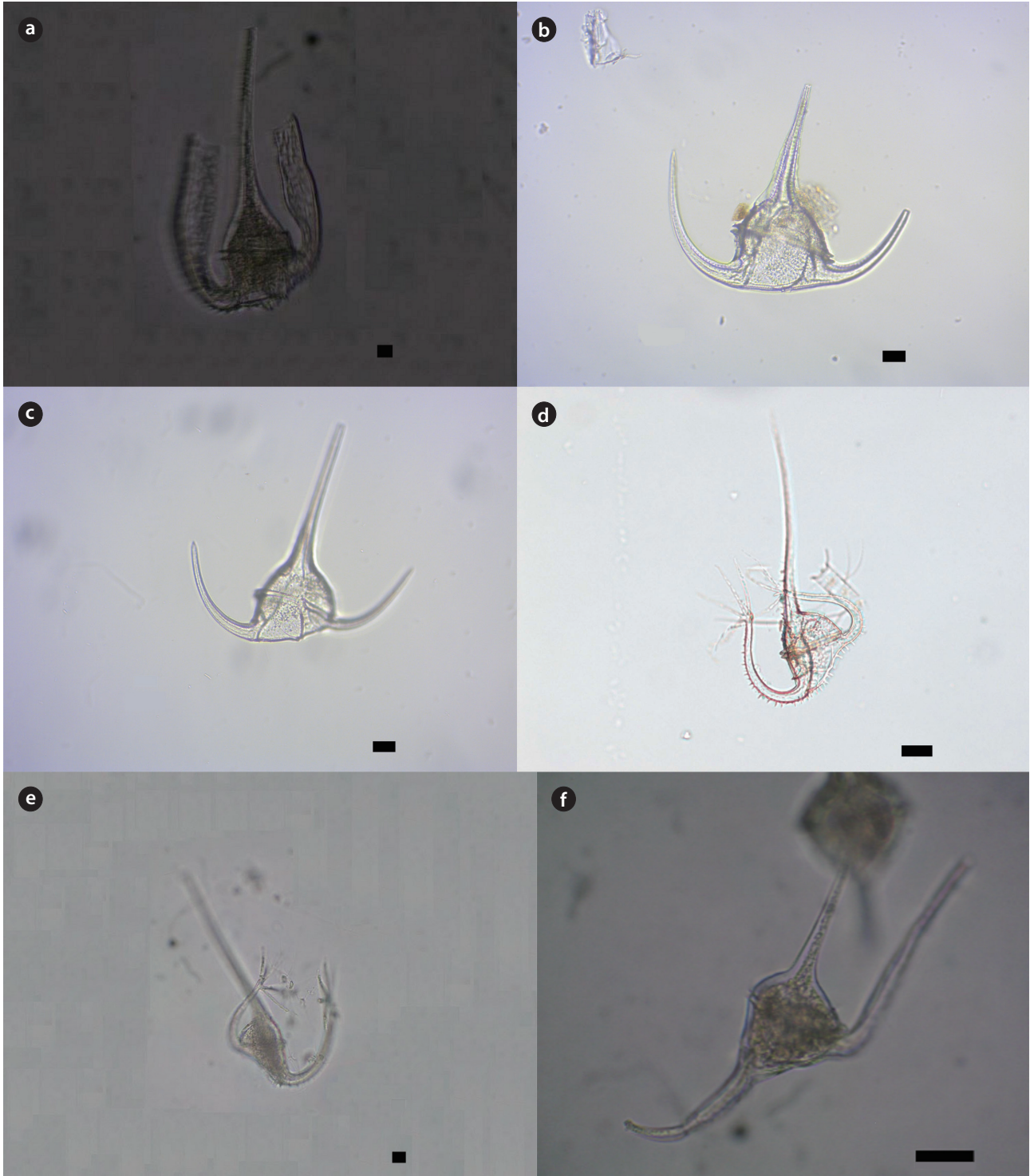


Fig. 3. Light micrographs of the genus *Tripos*. (a) *T. platycornis* var. *cuneatus* (DV), (b) *T. porrectus* f. *megasomus* (DV), (c) *T. pulchellum* f. *semipulchellum* (DV), (d) *T. palmatus* (DV), (e) *T. ranipes* var. *palmatus* (VV), (f) *T. reflexus* (DV). Scale bars, 20 μ m; DV, dorsal view; VV, ventral view.

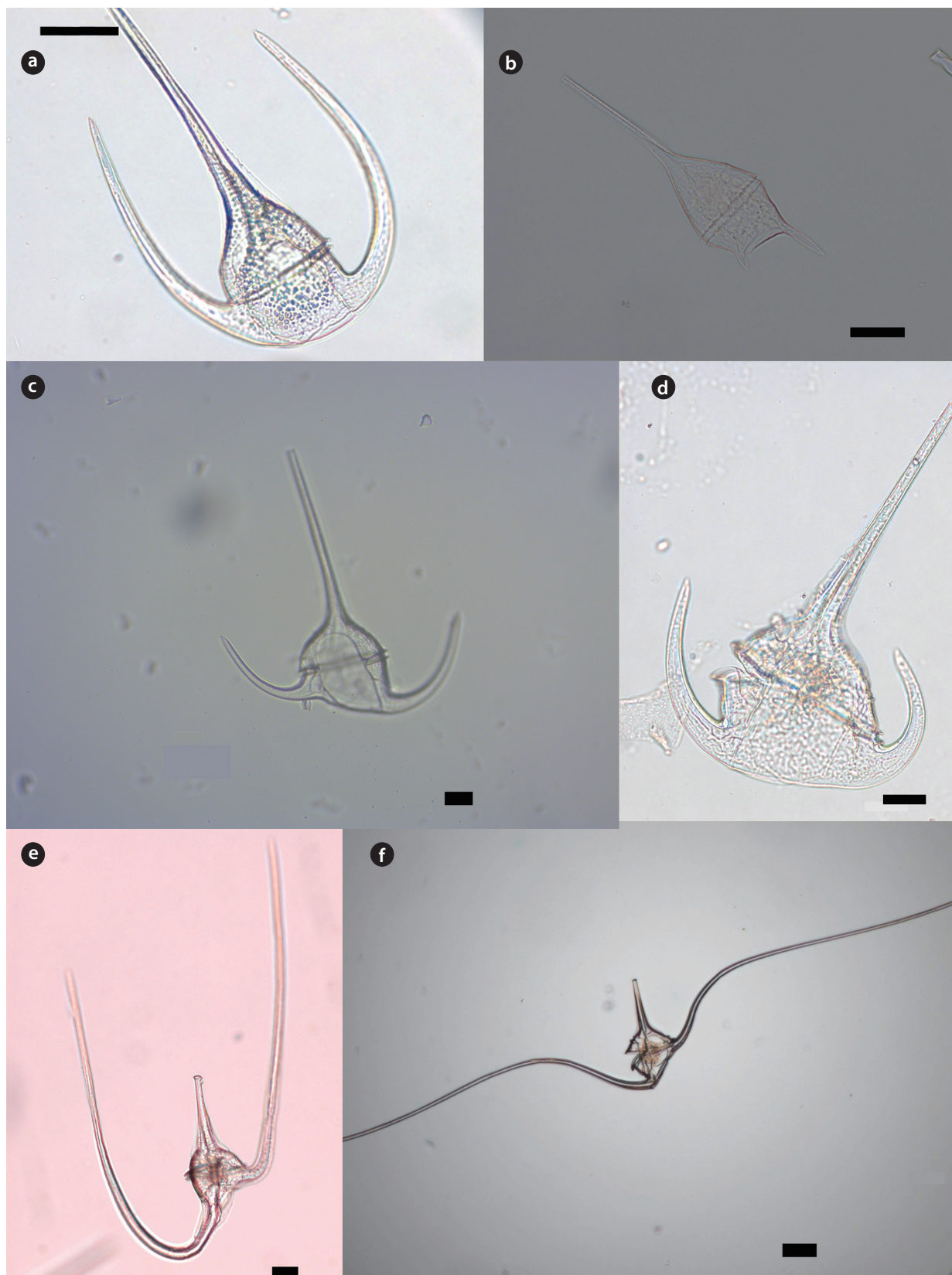


Fig. 4. Light micrographs of the genus *Tripos*. (a) *T. symmetricus* (VV), (b) *T. teres* (DV), (c) *T. muelleri* var. *atlanticus* (VV), (d) *T. muelleri* var. *pulchellus* (DV), (e) *T. vultur* f. *robustus* (DV), (f) *T. vultur* f. *angulatum* (DV). Scale bars, 20 μ m; DV, dorsal view; VV, ventral view.

almost double the length of the epitheca. All three horns, particularly the apical one, have a widened base and a thick wall towards the apex, are narrow and thin walled at the proximal part, and are beset with more or less clear and somewhat dentate winged lists. The lists are well developed on the transverse furrow. The left horn at the base is at first oblique and points backward, then bends back and is somewhat twisted. The right horn is approximately the same length or usually somewhat longer. The base is perpendicular to the body, then suddenly bends forward and is almost straight; it diverges less than 20–25° relative to the apical horn. The armor usually clears with small but robust, twisted lists and striking pores. In the orientation of the posterior, the horn of this species is unique.

Size: Length 200–250 µm.

Sampling: October 2010 in J7 (Chagwido coast).

***Tripes symmetricus* (Pavillard 1905) F. Gómez 2013 (Fig. 4a)**

Basionym: *Ceratium symmetricum* Pavillard 1905.

Synonym: *Neoceratium symmetricum* (Pavillard 1905) F. Gómez, D. Moreira & P. López-García 2010; *Ceratium gracile* (Gourret) Jørgensen.

References: Pavillard 1905, p. 52, T. 1, fig. 4; Shim 1994, p. 378, fig. 454; Okolodkov 2010, pl. 5, fig. 9, pl. 12, fig. 9.

Specimen examined: Unrecorded species no. LJB2013-10.

Description: The cell body has convex sides, sometimes slightly inflated on the left side, with a notably convex posterior margin that lacks a notch between the antapical horns, which are slightly longer than they are wide. The apical horn is rather short, slightly curved, and positioned centrally. The antapical horns are relatively long, continuously curved, directed anteriorly, and positioned at about equal distance from the cell body. The widest point is adjacent to the cingulum and the antapical horns.

Size: Length 100–130 µm, width 50–70 µm.

Sampling: July 2010 in J7 (Chagwido coast).

***Tripes teres* (Kofoid 1907) F. Gómez 2013 (Fig. 4b)**

Basionym: *Ceratium teres* Kofoid 1907.

Synonym: *Neoceratium teres* (Kofoid 1907) F. Gómez, D. Moreira & P. López-García 2010.

Reference: Kofoid 1907, p. 308, T. 29, figs. 34-36; Yamaji 1984, p. 134, pl. 44, fig. 17; Okolodkov 2010, pl. 3, fig. 4, pl. 10., fig. 12.

Specimen examined: NIBRFL0000125569.

Description: The apical horn is very thin, long, and upwardly straight. The main body is relatively big compared to the horn. The antapical horn is very short and blunt. The right antapical horn is 2 times longer than the left one.

Size: Length 90–100 µm, width 15–20 µm.

Sampling: January 2010 in J7 (Chagwido coast).

***Tripes vultur f. angulatus* (Jørgensen 1911) F. Gómez 2013 (Fig. 4f)**

Basionym: *Ceratium sumatranum f. angulatum* Jørgensen 1911.

Synonym: *Ceratium vultur f. angulatum* (Jørgensen 1911) J. Schiller 1937.

Reference: Cleve 1900, p. 15, T. 7, fig. 5.

Specimen examined: Unrecorded species no. LJB2014-02.

Description: The whole shape is similar to the *Ceratium vultur*, but the distance between both antapical horns is very wide (about 1,800 µm). The epithecal and the hypothecal body are rigid.

Size: Length 60–70 µm (apical horn only), width 20–40 µm.

Sampling: September 2008 in the northeastern sea of Jeju Island.

***Tripes vultur f. robustus* (Ostenfeld & Johannes Schmidt 1901) F. Gómez 2013 (Fig. 4e)**

Basionym: *Ceratium robustum* Ostenfeld & Johannes Schmidt 1901.

Synonym: *Ceratium vultur f. robustum* (Ostenfeld & Johannes Schmidt 1901) F.J.R. Taylor 1976.

Reference: Cleve 1990, p. 15, T. 7, fig. 5; Fujioka 1990, p. 61, pl. 30, fig. 6.

Specimen examined: Unrecorded species no. LJB2014-03.

Description: The epitheca is relatively small, and the apical horn is short. Both antapical horns are long, and the right antapical horn is longer. The wings in the antapical horn and the hypotheca are characterized.

Size: Length 300–400 µm, width 50–90 µm.

Sampling: July 2010 in J8 (Gosan-ri coast).

DISCUSSION

Gómez et al. (2010) insisted the separation of the genus *Ceratium* into two distinct genera, a new genus name *Neoceratium* for the marine species and the *Ceratium* for the freshwater species, on the basis of both the number of cingular plates and the considerable evolutionary distance of their respective SSU rDNA sequences, which form two well-defined monophyletic clades. However, Calado and Huisman (2010) commented a priority of the new genus name *Neoceratium* as they proposed a valid

genus name *Tripes*. Recently, Gómez (2013) moved all species of the genus *Neoceratium* to the genus *Tripes* with a checklist. Regarding the name of species in the both genera, the *Ceratium* is neuter, but the *Tripes* is masculine. Therefore, most of the adjectival epithets should be changed accordingly. Thus, the use of the *Tripes* genus name and the new combinations will induce numerous misspellings of the epithets and considerable confusion. The present study follows the new combination of the genus *Tripes* Bory 1823 and the treatment of basionym and homotypic synonym proposed by Gómez (2013). *Cercaria tripos* O.F. Müller 1776 is the basionym of the genus *Tripes*, where many varieties and forma are included, and the name of type species is also changed to *Tripes muel-leri* according to nomenclature priority (Gómez 2013).

A total of 36 *Ceratium* species in Korean waters were described by Shim (1994). Shim et al. (1981) described 10 *Ceratium* species in Yeosu Bay, and Han and Yoo (1983) described 5 *Ceratium* species in Jinhae Bay. In addition Kim et al. (2013) reported 4 *Ceratium* species as first record in Korean waters. The present study suggests that all marine *Ceratium* species should move to the genus *Tripes* proposed by Gómez (2013). Over the last several years, we have found a total of 51 *Tripes* species that were identified around Jeju Island. Of these, 23 species were recorded for the first time in the adjacent sea of Jeju Island, as well as in Korean waters.

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