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# Two New Records of Thaliacea (Chordata: Tunicata) in Korea

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## ABSTRACT

Two pelagic thaliacean tunicates, *Pyrosoma atlanticum* and *Cyclosalpa quadriluminis*, with bioluminescent organ, were collected from Jejudo Island and Korea Strait. In this study, the Pyrosomatida, which is holoplanktonic colonial tunicate with ascidiozooids embedded in a common test, and to which *P. atlanticum* belongs, is reported for the first time in Korea. The *Cyclosalpa* in the Salpida has a bar-shaped alimentary canal beside the branchial bar in both oozooids and blastozooids. *Cyclosalpa quadriluminis* is added to make *Cyclosalpa* species in Korea from four to five (*C. affinis*, *C. bakeri*, *C. polae*, *C. sewelli*, and *C. quadriluminis*). As a result of this study, 27 species of thaliaceans have been reported from Korea.

**Keywords:** taxonomy, pelagic tunicates, *Pyrosoma atlanticum*, *Cyclosalpa quadriluminis*, Korean fauna

## INTRODUCTION

There are three orders (Salpida Forbes, 1853; Pyrosomatida Lahille, 1888; Doliolida Delage and Hérouard, 1898) in the class Thaliacea Van der Haeven, 1850. Thaliaceans get their name from their propensity to proliferate rapidly when environmental conditions are favourable (thalia means 'blooming' in Greek) (Gershwin et al., 2014). To date, 25 species of thaliaceans in two orders (four species in Doliolida and 21 species in Salpida) have been reported from Korean waters (Rho, 1967; Kim et al., 2010a, 2010b, 2011, 2012, 2017; Seo et al., 2020).

The Pyrosomatida has its name from Greek words pyro (fire) and soma (body) because of its fiery bioluminescence. The Pyrosomatida is a monotypic order and the family Pyrosomatidae consists of eight species worldwide (Madin, 2022a). In Korea, none of them reported until now. They are holoplanktonic colonial tunicates with ascidiozooids embedded in a common test (Neumann, 1913; van Soest, 1979). *Pyrosoma atlanticum* Péron, 1804 is the commonest and the most widespread species. Its distribution is restricted to the warmer open ocean waters, between approximately 50°N and 50°S in all oceans (van Soest, 1981). It is known to form high density blooms in the southeast Atlantic (Drits et al., 1992). However, *P. atlanticum* was rarely found in Korean waters. It was first collected from the southern sea of Jejudo Island in May 2012. In May 2022, several colonies of *P. atlanticum* were found in Jejudo Island and Korea Strait. All specimens of *P. atlanticum* were collected in May. The Pyrosomatida is firstly recorded from Korean waters in this study.

The Salpida also has a single family, Salpidae, consisting of 45 species in the world, with both solitary zooids (oozooids) and aggregate zooids (blastozooids) in the life cycle (Yount, 1954; WoRMS, 2022). In salps, the shape of alimentary canal and arrangement of body muscles are the main keys to determine the genus of Salpidae. The genus *Cyclosalpa* de Blainville, 1827 has body muscles interrupted ventrally and a bar-shaped alimentary canal beside the branchial bar in both oozooids and blastozooids (Chihara and Murano, 1997; Esnal and Daponte, 1999). Eleven species of *Cyclosalpa* have been reported in the world (Madin, 2022b) and four species [*C. bakeri* Ritter, 1905; *C. affinis* (Chamisso, 1819); *C. polae* Sigl, 1912; and *C. sewelli* Metcalf, 1927] were known from Korea (Kim et al., 2012). In this study, *Cyclosalpa quadriluminis* Berner, 1955 is added.

So, there are 27 species of thaliaceans in three orders (one



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species of Pyrosomatida, four species of Doliolida and 22 species of Salpida) in Korean waters.

## MATERIALS AND METHODS

Specimens of *Pyrosoma atlanticum* examined in this study were collected from the subtidal zones of southern and southeastern waters in Jejudo island and Korea Strait by scuba diving or using a trawl net. Specimens of *Cyclosalpa quadriluminis* examined in this study were collected from the subtidal zone of Beomseom in Jejudo island by scuba diving.

After collection, all living specimens were preserved in 4% buffered formalin with seawater. For identification, each specimen was examined for morphological characteristics such as muscle, branchial aperture, atrial aperture, branchial bar, endostyle, alimentary canal and gonads. To see the muscle bands, specimens of *C. quadriluminis* were stained by hematoxylin after removing the test. Images of collected living samples were taken with a digital camera (Tough TG-6; Olympus, Tokyo, Japan). Images of preserved specimens were taken with a stereomicroscope (SMZ 745T; Nikon, Tokyo, Japan) equipped with a camera (UHCCD05000KPA; Touptek Photonics, Zhejiang, China). The size of the zooid was then measured using an image analyzer (Toupview 3.7; Touptek Photonics) and a ruler.

All specimens examined in this study were deposited at National Marine Biodiversity Institute of Korea (MABIK IV 00172414–IV00172415, MABIK IV00172755–IV00172758) and the Natural History Museum of Ewha Womans University (EWNHMAS4317, EWNHMAS4315).

## SYSTEMATIC ACCOUNTS

Class Thaliacea Van der Haeven, 1850
[1*]Order Pyrosomatida Jones, 1848
[2*]Family Pyrosomatidae Lahille, 1888

**Diagnosis.** Colonies holoplanktonic, bioluminescent, numerous zooids imbedded in gelatinous tube, zooids with broad and round branchial sac.

[3*]Genus Pyrosoma Péron, 1804
[4*]***Pyrosoma atlanticum* Péron, 1804 (Fig. 1)**

*Pyrosoma atlanticum* Péron, 1804: 440 (type locality: Pacific Ocean); van Soest, 1979: 200; 1981: 612; Chihara and Murano, 1997: 1353; Palma and Apablaza, 2004: 134; Gershwin et al., 2014: 10.
*Pyrosoma elegans*: Lesueur, 1813: 283.
*Pyrosoma giganteum*: Lesueur, 1815: 70.
*Pyrosoma rufum*: Quoy and Gaimard, 1824: 75; 1825: 329; 1826: 617.
*Pyrosoma ellipticum*: Brooks, 1906: 151.
*Pyrosoma triangulum*: Neumann, 1909: 709.
*Pyrosoma benthica*: Monniot C. and Monniot F., 1966: 368.

**Material examined.** Korea: 1 colony, Jejudo Island, Seogwipo-si, Munseom, 33°13′39″N, 126°34′02″E, 16 May 2022, Park SW by SCUBA diving (MABIK IV00172414); 1 colony, Jejudo Island, Seogwipo-si, Beomseom, 33°13′46″N, 126°30′47″E, 8 May 2022, Park SW by SCUBA diving (EWNHMAS4317); 1 colony, Jejudo Island, Seogwipo-si, 33°24′56.94″N, 126°55′21.66″E, 24 May 2012, Kim SW by SCUBA diving (MABIK IV00172757); 1 colony, Korea Strait, 33°32′43.22″N, 127°36′56.90″E, 1 May 2022, Bycatch in a trawlnet (MABIK IV00172756); 2 colonies, Korea Strait, 33°24′17.38″N, 127°46′38.96″E, 1 May 2022, Bycatch in a trawlnet (MABIK IV00172755).

**Description.** Pelagic colonial tunicate. Colony hollow, cylindrical, finger shaped, open at one end and closed at the other narrow end. Colony about 120–140 mm long, 30 mm wide at open end and 13 mm at closed end. Colony in living and in 4% formalin reddish orange (Fig. 1A). Colony white in specimen preserved long in ethyl alcohol (Fig. 1B). Open end has strong diaphragm (Fig. 1C). Open hole of colony collected in Beomseom blocked by gastropod. Colony test very tough with some processes and fine acanthose around oral siphons. Test processes 2.8–5.5 mm long, backward pointed and a lot on surface (Fig. 1D).

Zooids closely embedded in gelatinous test. Zooids semitransparent, 1.0–1.8 mm wide and 1.9–3.0 mm long without those of both siphons. Oral siphon 0.3–0.8 mm in length, opens upward and has round edge. Cloacal siphon 0.6–0.8 mm in length and opens obliquely downward. Ganglion simple and red. Each zooid contained light organ upper side of branchial sac. 12–15 longitudinal vessels and no folds in branchial sac. Stigmata raw 40–50. Stomach barrel shape, 0.4–0.5 mm long, yellow and red small spots in surface. Constriction between stomach and intestine. Hermaphrodite gonad on underside of body. Large testis 0.8–1.0 mm in diameter and orange. Embryo 3–4 and about 0.2 mm in diameter (Fig. 1E–I).

**Distribution.** Korea (present study), Pacific Ocean, Atlantic Ocean, Indian Ocean, Mediterranean Sea.

**Remarks.** *Pyrosoma atlanticum* is similar to *Pyrosoma aherniosum* Seeliger, 1895 in that the shape of colony is cylindrical (Seeliger, 1895; van Soest, 1981). However, the present species is different from *P. aherniosum* in that the size of sex-

Korean name: [1*]불우렁쉥이목(신칭), [2*]불우렁쉥이과(신칭), [3*]불우렁쉥이속(신칭), [4*]불우렁쉥이(신칭)

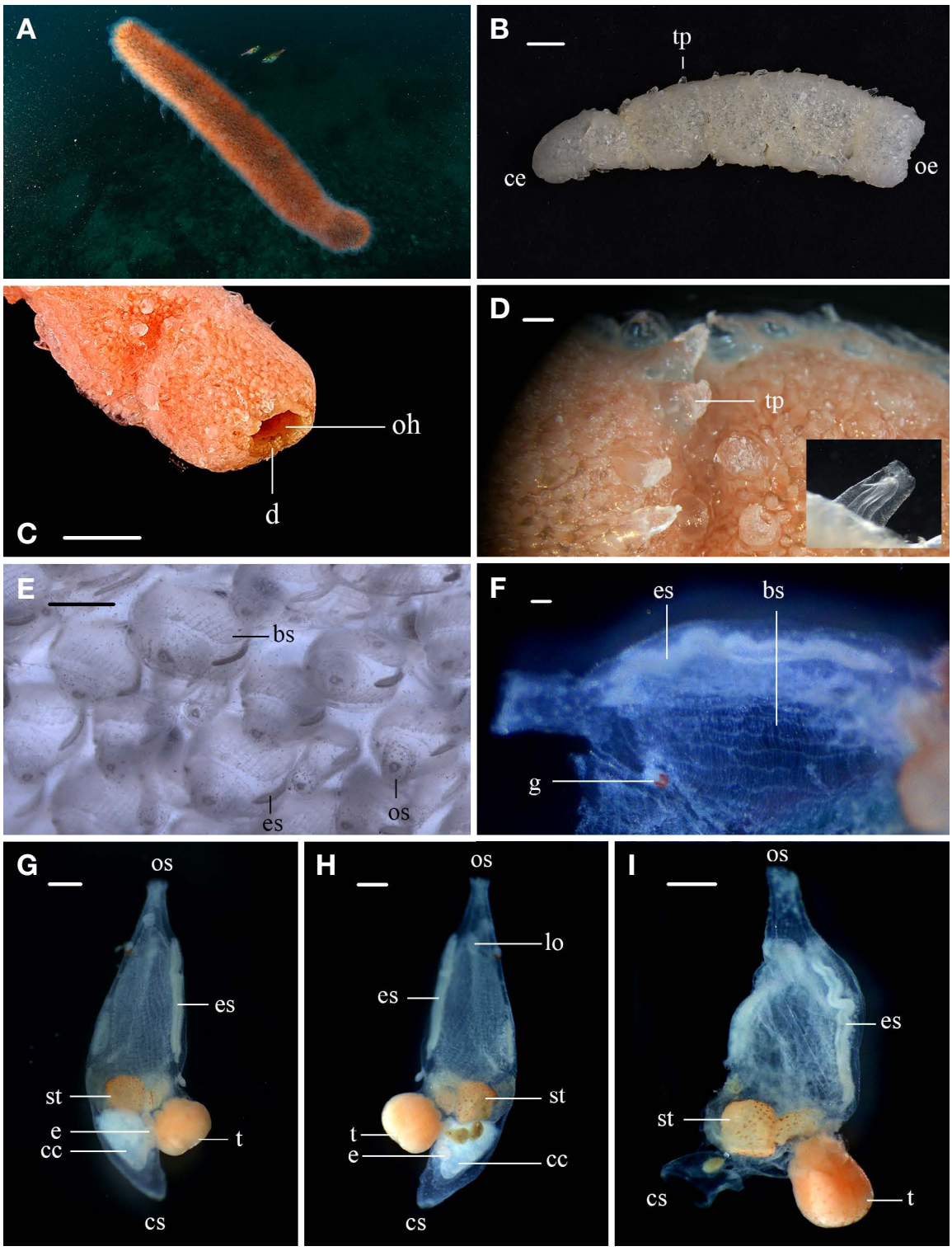


**Fig. 1.** *Pyrosoma atlanticum* (A–I). A, Colony in living; B, Colony in preservative; C, Open end view of colony; D, Test process of colony; E, Zooids in colony; F–I, Zooid. bs, branchial sac; cc, cloacal cavity; ce, closed end; cs, Cloacal siphon; d, diaphragm; e, embryo; es, endostyle; g, ganglion; lo, light organ; oe, open end; oh, open hole; os, oral siphon; st, stomach; t, testis; tp, test process. Scale bars: B, C = 10 mm, D = 0.2 mm, E = 10 mm, F–I = 0.5 mm.

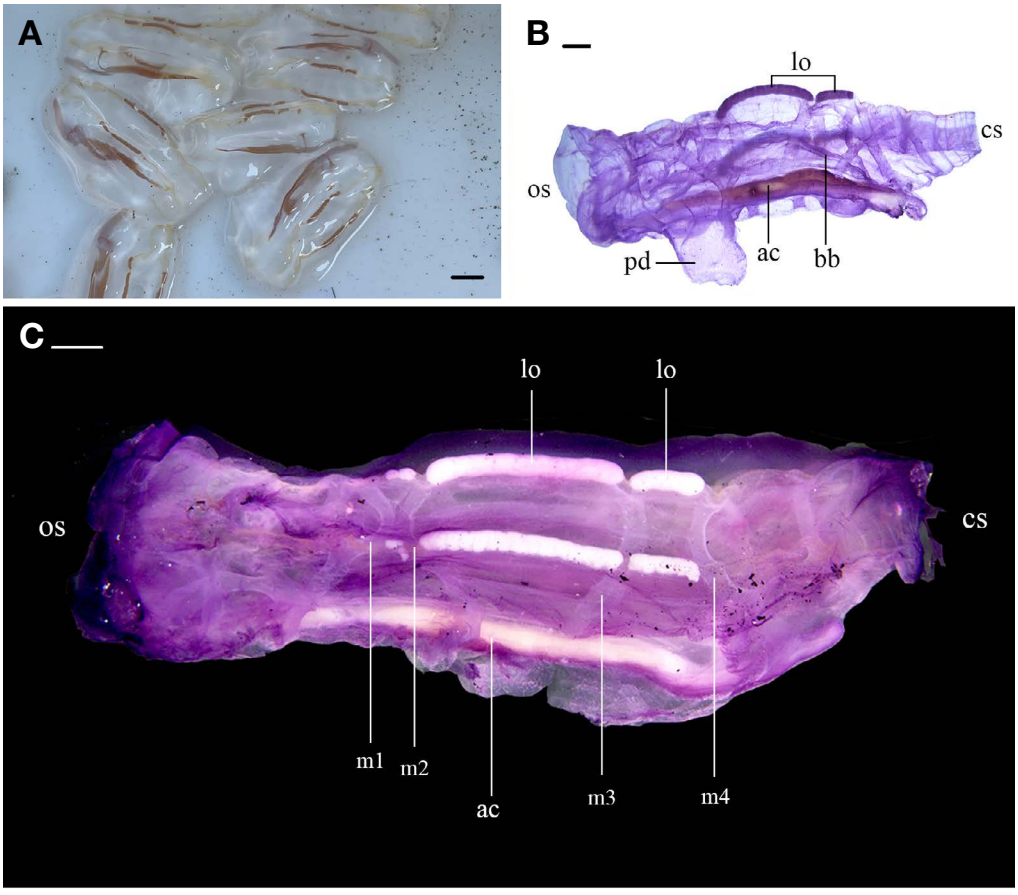


**Fig. 2.** *Cyclosalpa quadriluminis* (A–C). A, Specimens of aggregate zooids immediately after collection; B, C, Specimen of zooid stained by hematoxylin after removing the test; B, Lateral view of specimen; C, Dorsal-lateral view showing arrangement of body muscle and light organs. ac, alimentary canal; bb, branchial bar; cs, cloacal siphon; lo, light organ; m1–m4, muscle; os, oral siphon; pd, peduncle. Scale bars: A = 10 mm, B, C = 3 mm.

ual mature colony is large (40–60 mm) and branchial aperture is narrower than the branchial basket (van Soest, 1981).

Class Thaliacea Van der Haeven, 1850
Order Salpida Forbes, 1853
Family Salpidae Lahille, 1888
Genus *Cyclosalpa* de Blainville, 1827

[1*]***Cyclosalpa quadriluminis* Berner, 1955 (Fig. 2)**

*Cyclosalpa pinnata* Herdman, 1888: 87; Swell, 1926: 68; Tokioka, 1937: 219; Thomson, 1948: 103; Yount, 1954: 283.

*Cyclosalpa pinnata quadriluminis*: Berner, 1955: 251; van Soest, 1974: 25.

*Cyclosalpa quadriluminis* f. *parallela*: van Soest, 1974: 25; Godeaux, 1998: 290.

*Cyclosalpa quadriluminis* f. *quadriluminis*: van Soest, 1974: 25.

*Cyclosalpa quadriluminis*: Godeaux, 1998: 290.

**Material examined.** Korea: 10 aggregated zooids, Jejudo Island, Seogwipo-si, Beomseom, 33°13′46″N, 126°30′47″E, 8 May 2022, Park SW by SCUBA diving (MABIK IV0017 2415, MABIK IV00172758, EWNHMAS4315).

**Description.** Only aggregate forms observed. Test thick, flabby, and not solid (Fig. 2A). Zooids about 50.0 mm long and 30.1 mm wide. Peduncle about 16.7 mm long and 10.2 mm wide. Oral siphon and Cloacal siphon in opposite directions (Fig. 2B).

Body muscles four and continuous dorsally. Muscles 1 and 2 fused over dorsal midline and Muscles 3 and 4 approaching dorsally fused. Muscles 1 and 2 ventrally and extend into

Korean name: [1*]네빛곧은장살파(신칭)

the peduncle (Fig. 2C). Intermediate muscles join with body muscle 1 mid-ventrally. Muscles made up of about 36 muscle fibers. Dorsal tubercle U-shaped. Branchial bar about 22.2 mm long. Alimentary canal straight and lies below endostyle. Anus anterior close to peduncle. Light organs two pairs. Two light organs long (about 10.3 mm) and present laterally between muscle 2 and muscle 3. Two light organs short (about 3.6 mm) and present laterally between muscles 3 and muscle 4 (Fig. 2C).

**Distribution.** Korea (present study), Indo-Pacific Ocean.

**Remarks.** How many pairs of light organs they have is an important key in the genus *Cyclosalpa*. *Cyclosalpa pinnata* has one pair of elongated light organs between muscle 2 and muscle 3 in aggregate form (Godeaux, 1998). However, in Siboga Expedition collection of this species, one aberrant zooid with two pairs of light organ was found (Thomson, 1948). Tokioka (1937) reported salpas in Japan and distinguished *C. pinnata* with two pairs of light organs from *C. pinnata* var. *polae* with one pair. Yount (1954) described that *C. pinnata* usually has one pair of light organs (sometimes two pairs are found in large specimens). This might be due to age difference. Berner (1955) reported this aberrant type as a new subspecies *C. p. quadriluminis*. Van Soest (1974) renamed *C. p. quadriluminis* as *C. quadriluminis quadriluminis* and described that the aggregate form of *C. quadriluminis parallela* strongly resembled *C. q. quadriluminis*. However, they were different in that *C. q. quadriluminis* had muscle 3−4 fused dorsally whereas *C. q. parallela* had muscle 3−4 approaching or touching (Godeaux, 1998). Since the difference between these two species is very weak, it might be proper to consider them as one species, *C. quadriluminis*.

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## CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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