

# A New Record of Invasive Alien Colonial Tunicate *Clavelina lepadiformis* (Ascidiacea: Aplousobranchia: Clavelinidae) in Korea

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## ABSTRACT

Tunicates were collected from three harbors (Gampo, Bangeojin, Daebyeon) in Gyeongsangnam-do and one harbor (Seogwipo) in Jeju Island during the period from August 2008 to January 2011 and were identified on the basis of their morphological characteristics. Among them, colonial tunicate *Clavelina lepadiformis* (Müller, 1776) belonging to the family Clavelinidae was found to be an invasive alien species introduced from the North Atlantic, and this is the first record of its occurrence in Korea.

**Keywords:** taxonomy, invasive alien species, tunicate, Aplousobranchia, *Clavelina*, Korea

## INTRODUCTION

Ascidians comprise one of four classes belonging to the subphylum Tunicata of the phylum Chordata and are commonly called sea squirts or tunicates. All ascidians are filter feeders and are either solitary or colonial, and their individual forms called zooids, are often arranged in systems around a common cloacal opening. The class Ascidiacea includes three orders, Aplousobranchia, Phlebobranchia, and Stolidobranchia (Kott, 1992). Aplousobranchia is represented by a colonial form, and Stolidobranchia and Phlebobranchia mainly by solitary species (Shirley, 2003). Zooids of Aplousobranchia have their gut loop below their branchial sac. The structure of the branchial sac, the gut, and the position and structure of the gonads are all important characteristics in identifying the various genera and species (Kott, 1992). Aplousobranchia consists of 13 families, including Clavelinidae. Genus *Clavelina* is one of two genera belonging to family Clavelinidae and is characterized by the following features: large zooids of usually 20 mm or more in length of all compound ascidians; zooids may be separate for their whole length and only connected by a basal stolon, or partly embedded leaving the anterior part of the body, or wholly embedded as in most compound ascidians with a stolon arising from the posterior part of the body (Van Name, 1945). Genus *Clavelina* includes 47 species all over the world (Sanamyan and Monniot, 2011), whereas in Korea only, *C. fasciculata* has been reported in the

Korea Strait (Rho, 1977). In this study, many tunicates were collected from Gampo, Bangeojin and Daebyeon harbors of the Korea Strait, and Seogwipo harbor of Jeju Island from August 2008 to January 2011 and were identified on the basis of their morphological characteristics. Among them, colonial tunicate *C. lepadiformis* is the first record of its appearance in Korea and turned out to be an invasive alien species introduced from the North Atlantic. This species was described based on the specimens attached to the dock wall of Gampo Harbor. The clavate of this species is connected with a stolon arising from the posterior part of the body and other morphological characteristics of this species were photographed using an underwater camera and stereomicroscope (Nikon SMZ1000; Nikon Co., Tokyo, Japan). The systematic scheme of the identified ascidians was adopted from those of Kott (1992), and Sanamyan and Monniot (2011).

## SYSTEMATIC ACCOUNTS

Phylum Chordata Bateson, 1885  
Subphylum Tunicata Lamarck, 1816  
Class Ascidiacea Nielsen, 1995  
Order Aplousobranchia Lahille, 1886  
Family Clavelinidae Forbes and Hanley, 1848  
Genus *Clavelina* Savigny, 1816

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<sup>1</sup>\**Clavelina lepadiformis* (Müller, 1776) (Fig. 1A-G)

*Ascidia lepadiformis* Müller, 1776: 119; Sanamyan, 2010: 252057.

*Clavelina lepadiformis*: Milne-Edwards, 1841: 226, Pl. 1, fig. 1, Pl. 2, fig. 1; Alder and Hancock, 1905: 32; 1907: 152, Pls. 49, 50, figs. 1, 2; Lohmann, 1915: 57, fig. 1; Hayward and Ryland, 1990: 300; De Caralt et al., 2002: 125; Reinhardt et al., 2010: 185; Sanamyan and Monniot, 2011: 103552.

*Clavelina savigniana* Milne-Edwards, 1841: 278, Pl. 1, fig. 2, Pl. 2, fig. 3.

*Clavelina pumillo* Milne-Edwards, 1841: 279, Pl. 2, fig. 2.

**Materials examined.** 32 zooids, Seogwipo, 15 Aug 2008, Shin S, attached to ropes at 2.3 m depth; 21 zooids, Daebyeon, 14 Aug 2009, Shin S, attached to dock wall at 2.5 m depth; 202 zooids, Gampo, 24 Jun 2010, Lee T, attached to ropes at 2 m depth; 124 zooids, Bangeojin, 25 Jun 2010, Shin S, attached to bivalve (*Mytilus galloprovincialis*) shells and dock wall at 1.5 m depth; 75 zooids, Seogwipo, 28 Jun 2010, Lee T, attached to ropes at 5 m depth; 44 zooids, Gampo, 19 Oct 2010, Pyo J, attached to dock wall at 3 m depth; 35 zooids, Bangeojin, 20 Oct 2010, Shin S, attached to dock wall at 2 m depth; 89 zooids, Daebyeon, 20 Oct 2010, Pyo J, attached to dock wall at 3.5 m depth; 32 zooids, Seogwipo, 6 Jan 2011, Shin S, attached to ropes at 3 m depth.

**Description.** Zooids 15-42 mm long × 2.0-4.7 mm diameter. Colony elongated, living in groups of dozens to hundreds of zooids attached to base by stolons. Zooid transparent but marked with pale yellow or white lines comprising small white rings around two siphons and large conspicuous white ring around pharynx at top of brachial sac and two longitudinal lines along endostyle and dorsal lamina, as well as white ring around lowest part of thorax. Additional white pigments usually on edge of oral siphon which more apparent than that of atrial siphon. Both siphons rounded orifices not far from each other, with oral siphon larger than atrial one. Tunic perfectly transparent, colorless, but usually marked with opaque white lines, through which internal organ visible to naked eye. Thorax corresponding to about a third of entire length, sometimes nearly one half in life. A few widely separated longitudinal fibers observed in thoracic portion. Mantle diaphanous, very delicate, and torn easily. Branchial sac nearly fills thoracic portion, with 14 or 15 rows of about equal sized meshes placed at regular intervals, making branchial membrane form simple rectangular network with narrow and longer meshes. Endostyle well developed, opaque white color,

extended whole length of branchial sac, and almost met with margin of oral siphon. Stomach looks like orange bilobed mass with white lines, round but sometimes elongated and considerably wider than rest of alimentary tract, hanging from esophagus, and occupying half way down peduncle. Intestine running along lower end of stomach, continuing downwards and then immediately upwards to anus. Gonads rather conspicuous and located between loops of intestine near posterior part of abdominal cavity. Ovary forms like a bunch of grapes, and many various sized eggs usually found near anus. Testis forms a much-branched organ, with extremely fine ramifications terminating in numerous elongated vesicles usually bifurcated or rarely trifurcated, spread around ovary, and gonoduct passed up along right side of intestine and terminated by side of anus.

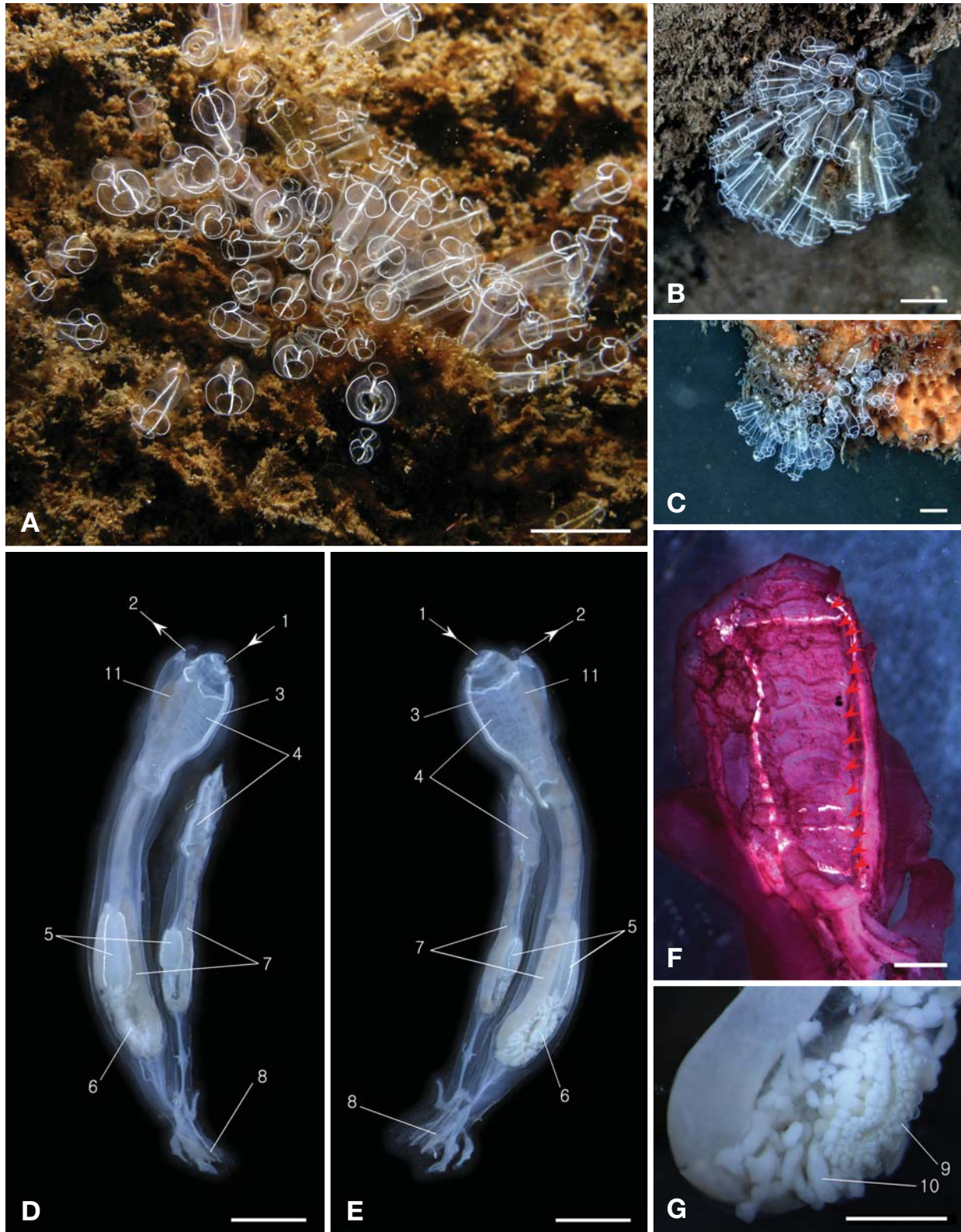
**Distribution.** Korea (Korea Strait, Jeju Island), North East Atlantic (England, Scotland, Norway-Mediterranean), North West Atlantic (Connecticut), and South Africa.

**Remarks.** This species is a colonial tunicate commonly called the light bulb sea squirt (Reinhardt et al., 2010) due to its zooid appearance marked with white rings around two siphons and pharynx and with white longitudinal lines along the endostyle and dorsal lamina. Zooids usually had white pigmentation around the oral siphon. Zooids were composed of perfectly transparent and colorless tunics, and were usually associated in clusters, forming a colony united by stolonious bases. This species turned out to be an invasive alien species, which was initially reported from Norway (Müller, 1776), and thereafter in North East Atlantic (Wirtz, 1998), in South Africa (Robinson et al., 2005) and Connecticut of North West Atlantic (Reinhardt et al., 2010). Thus this species observed from only few ports of Korea was presumed to have been introduced recently from northwest Europe and the Mediterranean in the same way as hull fouling or ballast water. This suspension feeder was usually found attached to disturbed hard substrates between depths of 1-5 m, especially on vertical faces of docks or ropes at the four harbors in Korea.

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**Fig. 1.** *Clavelina lepadiformis*. A-C, Colony in life; D, Left side of two zooids; E, Right side of two zooids; F, Stigmata in dyed branchial sac (arrowheads); G, Gonads. 1, oral siphon; 2, atrial siphon; 3, endostyle; 4, branchial sac; 5, stomach; 6, gonads; 7, intestine; 8, stolon; 9, ovary; 10, testis; 11, dorsal lamina. Scale bars: A-C=2 cm, D, E=3 mm, F, G=1 mm.

## REFERENCES

- Alder J, Hancock A, 1905. The British Tunicata: an unfinished monograph, Vol. 1. Ray Society, London, pp. 1-146.
- Alder J, Hancock A, 1907. The British Tunicata: an unfinished monograph, Vol. 2. Ray Society, London, pp. 1-164.
- De Caralt S, López-Legentil S, Tarjuelo I, Uriz MJ, Turon X, 2002. Contrasting biological traits of *Clavelina lepadiformis* (Ascidacea) populations from inside and outside harbours in the western Mediterranean. *Marine Ecology Progress Series*, 244:125-137.
- Hayward PJ, Ryland JS, 1990. The marine fauna of the British Isles and north-west Europe. Vol. 2, Molluscs to Chordates. Clarendon Press, Oxford, pp. 1-367.
- Kott P, 1992. The Australian Ascidacea Part 3, Aplousobranchia (2). *Memoirs of the Queensland Museum*, 32:375-620.
- Lohmann H, 1915. Tunicata. In: *Handwörterbuch der naturwissenschaften* (Eds., Korschelt E, Linck G, Oltmanns F, Schaum K, Simon HTh, Verworn M, Teichmann E). Verlag von Gustav Fischer, Jena, pp. 57-89.
- Milne-Edwards M, 1841. Observation sur les Ascidiées composées des côtes de la Manche. Member of the Academy of Sciences of the Institute, France, 18:217-326.
- Müller OF, 1776. *Zoologiae Danicae Prodromus, seu animalium Daniae et Norvegiae Indigenarum characteres, nomina, et synonyma imprimis popularum. Typis Hallageriis, Havniae* (Copenhagen), pp. 1-282.
- Reinhardt JF, Stefaniak LM, Hudson DM, Mangiafico J, Gladych R, Whitlatch RB, 2010. First record of the non-native light bulb tunicate *Clavelina lepadiformis* (Müller, 1776) in the northwest Atlantic. *Aquatic Invasions*, 5:185-190.
- Rho BJ, 1977. *Illustrated flora and fauna of Korea (Porifera, Hydrozoa and Ascidacea)*, Vol. 20. Ministry of Education, Seoul, pp. 101-136, 289-374.
- Robinson TB, Griffiths CL, McQuaid CD, Ruis M, 2005. Marine alien species of South Africa: status and impacts. *African Journal of Marine Science*, 27:297-306.
- Sanamyan K, 2010. *Ascidia lepadiformis* Mueller, 1776. In: Shenkar N, Gittenberger A, Lambert G, Rius M, Rocha RMD, Swalla BJ (2010) *Ascidacea World Database. World Register of Marine Species*, Accessed 27 Apr 2011, <<http://www.marinespecies.org/aphia.php?p=taxdetails&id=252057>>.
- Sanamyan K, Monniot C, 2011. *Clavelina lepadiformis*. In: Shenkar N, Gittenberger A, Lambert G, Rius M, Rocha RMD, Swalla BJ (2010) *Ascidacea World Database. World Register of Marine Species*, Accessed 27 Apr 2011, <<http://www.marinespecies.org/aphia.php?p=taxdetails&id=103552>>.
- Shirley PN, 2003. *Aplousobranch ascidians (Tunicata: Ascidacea) from southern Africa*. PhD dissertation, University of Port Elizabeth, Port Elizabeth, South Africa, pp. 1-199.
- Van Name WG, 1945. The North and South American ascidians. *Bulletin of American Museum of Natural History*, 84: 1-476.
- Wirtz P, 1998. Twelve invertebrate and eight fish species new to the marine fauna of Madeira, and a discussion of the zoogeography of the area. *Helgoländer Meeresuntersuchungen*, 52:197-207.

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