



The nonindigenous ascidian *Molgula ficus* in California

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Abstract: The nonindigenous ascidian *Molgula ficus* was first observed in southern California in October 1994. It was incorrectly identified as the native *M. verrucifera* in Lambert & Lambert (1998) and thus was not included in Lambert & Lambert (2003) or Cohen et al. (2005), two papers on nonindigenous species in southern California. *M. ficus* is probably native to the west Pacific, most likely Australia, the location of the type specimen; it has been reported also from Hong Kong, Gulf of Siam, and Singapore. The first published east Pacific record is Chile, 1997. It is abundant and widespread on manmade structures in bays and harbors from San Diego to Los Angeles; the northernmost record in southern California is Port Hueneme. It was first recorded in San Francisco Bay in October 2005.

Résumé : L'ascidie non indigène *Molgula ficus* en Californie. *Molgula ficus* est une ascidie non indigène observée en Californie du sud en octobre 1994. Incorrectement identifiée (Lambert & Lambert, 1998) sous le nom de *M. verrucifera*, qui est une espèce indigène, elle n'avait donc pas été incluse dans Lambert & Lambert (2003) ni dans Cohen et al. (2005), deux publications sur les espèces non indigènes en Californie du sud. *Molgula ficus* est vraisemblablement originaire de l'ouest Pacifique, probablement d'Australie, la localité type de l'espèce. Elle a également été mentionnée à Hong Kong, dans le golfe de Siam et à Singapour. Elle a été signalée dans une publication pour la première fois dans le Pacifique est au Chili en 1997. L'espèce est abondante et largement répartie sur les structures artificielles des baies et des ports de San Diego à Los Angeles. En Californie du sud, sa localisation la plus au nord est Port Hueneme. Elle a été signalée pour la première fois dans la Baie de San Francisco en 2005.

Keywords: Nonindigenous • Invasive species • Ascidian • Tunicate • *Molgula ficus* • *Molgula verrucifera*

Introduction

Molgula ficus (MacDonald, 1859), unfortunately misidentified as the native species *M. verrucifera* Ritter & Forsyth, 1917 in Lambert & Lambert (1998) was first recorded at two sites in San Diego Bay in October 1994 (Table 1) during

a survey of numerous harbors and marinas from San Diego to Santa Barbara. It has subsequently spread to many more harbor sites in southern California and become more abundant, which suggests that it may have arrived shortly before 1994 to San Diego Bay. In southern California it is still most abundant in San Diego Bay though it has occurred as far north as Port Hueneme (Table 1) for a number of years. It was collected for the first time in San Francisco Bay in October 2005 at a single site (Ballena Bay) during a large number of surveys by Moss Landing Marine Lab (MLML)

Table 1. Occurrence and abundance of *Molgula ficus* in southern California, 1994-2000. 1: rare ($< 0.1 \text{ m}^{-2}$); 2: common ($\sim 1 \text{ m}^{-2}$); 3: abundant ($\sim 10 \text{ m}^{-2}$); 4: very abundant ($> 10 \text{ m}^{-2}$). (Compare with records for all other nonindigenous ascidians in Table 3 in Lambert & Lambert, 2003.)

Tableau 1. Présence et abondance de *Molgula ficus* en Californie du sud, 1994-2000. 1 rare ($< 0.1 \text{ m}^{-2}$) ; 2 commune ($\sim 1 \text{ m}^{-2}$) ; 3 abondante ($\sim 10 \text{ m}^{-2}$) ; 4 très abondante ($> 10 \text{ m}^{-2}$). (A comparer avec les données pour toutes les autres ascidies non indigènes du tableau 3 de Lambert & Lambert, 2003).

Location	Date	Abundance	Location	Date	Abundance
San Diego Bay				Spring 1997	3
Shelter Island	Spring 1995	2		Fall 1997	1
	Fall 1995	1		Spring 1998	3
	Fall 1996	3	Mission Bay Yacht Club	Spring 1997	3
	Spring 1997	3		Fall 1997	3
	Spring 1998	3		Spring 1998	3
	August 2000	4	Santa Clara Boat Launch	Spring 1997	2
Harbor Island	Spring 1995	3		Fall 1997	1
	Fall 1996	2		Spring 1998	3
	Spring 1997	3	Oceanside		
	Fall 1997	3	Back Harbor	Spring 1997	2
	Spring 1998	4		Spring 1998	3
Fiddlers Cove	Fall 1994	2	Police Floats	Fall 1996	1
	Spring 1995	3		August 2000	4
	Fall 1995	3	Newport Harbor		
	Fall 1996	4	Fun Zone	Fall 1997	2
	Spring 1997	2	Upper Bay	Fall 1996	1
	Fall 1997	2		Fall 1997	1
	Spring 1998	3	Huntington Hbr Yacht Club	Aug. 2000	4
	August 2000	4	Inner Huntington Hbr	Aug. 2000	2
24 th Street	Fall 1994	2	Long Beach Marina		
	Fall 1996	2	Spinnaker Cove	Spring 1997	1
	Spring 1997	2	Back Harbor	Spring 1997	1
	Fall 1997	1		Fall 1997	1
	Spring 1998	1		Spring 1998	3
J Street (Chula Vista Marina)	Spring 1995	3		August 2000	3
	Fall 1995	2	Long Beach/Los Angeles Harbors		
	Fall 1996	1	Impound Marina	Spring 1995	1
	Spring 1997	2		Spring 1997	2
	Fall 1997	1		Fall 1997	1
	Spring 1998	2		Spring 1998	3
	August 2000	4		August 2000	1
Mission Bay			Watchorn Marina	August 2000	2
Quivera Basin	Fall 1996	3	King Harbor	Spring 1997	1
	Spring 1997	1		Spring 1998	1
	Spring 1998	4	Marina Del Rey	Spring 1998	1
	August 2000	3		August 2000	2
Dana Landing	Fall 1996	1	Port Hueneme		
	Spring 1997	2	Jacks Landing (Entrance)	Spring 1998	3
	Spring 1998	4		August 2000	1
South Shores Boat Ramp	Fall 1997	1	Anacapa Is. Marina	Fall 1997	1
Bahia Point	Fall 1995	1		August 2000	4
	Fall 1996	3			

of many California harbor and open coast sites for non-indigenous species, for the Ballast Water Program, Office of Spill Prevention and Response, California Dept. of Fish and Game. During the spring of 2005 while identifying the

ascidians collected by MLML from numerous open coast sites, I examined many *M. verrucifera* and realized that the large individuals so common in southern California harbors were not this species. They were correctly identified for me

on 30 November 2005 by Dr. Claude Monniot, a world expert on the Molgulidae (Museum National d'Histoire Naturelle, Paris).

Molgula ficus is an Indo-west Pacific species, with records from Australia, Tasmania, Gulf of Siam, Singapore and Hong Kong (Millar, 1975; Kott & Goodbody, 1982; Kott, 1985). It apparently prefers protected habitats and has never been recorded from waveswept exposed areas. It was first recorded from Chile in 1997 in Antofagasta Bay and many times since (Clarke & Castilla, 2000; Castilla et al., 2005). *Molgula verrucifera* is native to California and its known distribution is still restricted to California, where it has only been recorded from low intertidal and subtidal rocky exposed open coast areas, including the type locality in La Jolla, California (Ritter & Forsyth, 1917).

Material examined

A. Numerous specimens of *Molgula ficus* from 25 sites in southern California collected from floating docks and associated hanging ropes, tires, etc. between October 1994 and August 2000 (Table 1). See Lambert & Lambert, 2003 for methods of sampling. Voucher specimens are housed at the Santa Barbara Museum of Natural History (SBMNH) [#369476-369481].

B. *Molgula ficus* from San Diego Bay MLML sampling sites during April and June 2005 (Table 2) and from Mission Bay, Huntington Harbor and Port Hueneme July 2006. Unless otherwise noted, all specimens were collected from floating docks and pilings. Voucher specimens # 369482, 369483 are

located at the SBMNH; the rest are vouchered at MLML, Moss Landing, California.

C. *Molgula ficus* from San Francisco Bay: 46 specimens collected by MLML 5 Oct. 2005 from a marina in Ballena Bay near Alameda, on the east side of San Francisco Bay, on a cement floating dock and wood pilings at 0.1-2.7 m depth from the surface. Vouchered at MLML.

D. *Molgula ficus* from Antofagasta Bay, Chile: 3 specimens collected in 1997 and 1998 from submerged scallop aquaculture lines. SBMNH # 359392.

E. *Molgula verrucifera* from California open coast, collected by MLML.

Bodega 18 August 2004, subtidal rocky 38 ft, 2 specimens, 1 with and 1 without larvae. Vouchered at MLML.

Pt. Dume 5 April 2005 subtidal rocky 18 ft. depth; with larvae (number of specimens not recorded). Vouchered at MLML.

Pt. Saint George 9 September 2004, rocky reef 20-25 ft; 1 specimen with larvae. SBMNH #359396.

Pt. La Jolla (reef south) 25 January 2005, intertidal rocky; 3 specimens with larvae. SBMNH #359395.

Results and Discussion

Table 1 is a record of the estimated abundance of *Molgula ficus* at numerous sites in southern California from 1994-2000. It was designed to be compared with and to supplement the much larger Table 3 in Lambert & Lambert (2003) which includes data for a number of other introduced species at these and other sites during the same survey

Table 2. San Diego Bay MLML sampling sites. Unless otherwise noted, all specimens were collected from floating docks and pilings.

Tableau 2. Sites de récoltes dans la Baie de San Diego par MLML. Sans autre indication, les spécimens proviennent tous de docks flottants ou de piliers.

Location	Date	Depth (m)	# specimens	substrate
Chula Vista Marina	4/27/05	1.2-2.7 m	6	
Coronado Cays	4/27/05	1.5-1.8 m	5	
Coronado Wharf	6/29/05	2-2.4 m	1	
Bulk carrier terminal	6/29/05	1-1.8 m	9	+ seawall
Commercial fishing fleet				
downtown San Diego	4/26/05	1.5-1.8 m	18	
offshore from Switzer Creek	4/26/05	1-1.5 m	8	+ underside of barge
Kelco dock	4/27/05, 6/29/05	1.2-1.5 m	2, 2	
Cruise ship terminal downtown	4/26/05	0-3 m	2	
Scripps pier	4/26/05	2.1 m	1	pilings, log
Navy-28 th St.	6/28/05	1.8-3.7 m	2	
Harbor Island Marina	4/26/05	0-2 m	1	
Switzer Creek (Dole)	6/28/05	2.1-4.3 m	11	+ seawall
Ballast Point-Navy sub base near Pt. Loma	6/28/05	to 4.3 m	4	
Coronado Is. Marina, Glorietta Bay	4/27/05	1-1.5 m	15	
Navy-Carrier base	6/28/05	to 3.7 m	7	+ seawall, underside of barge

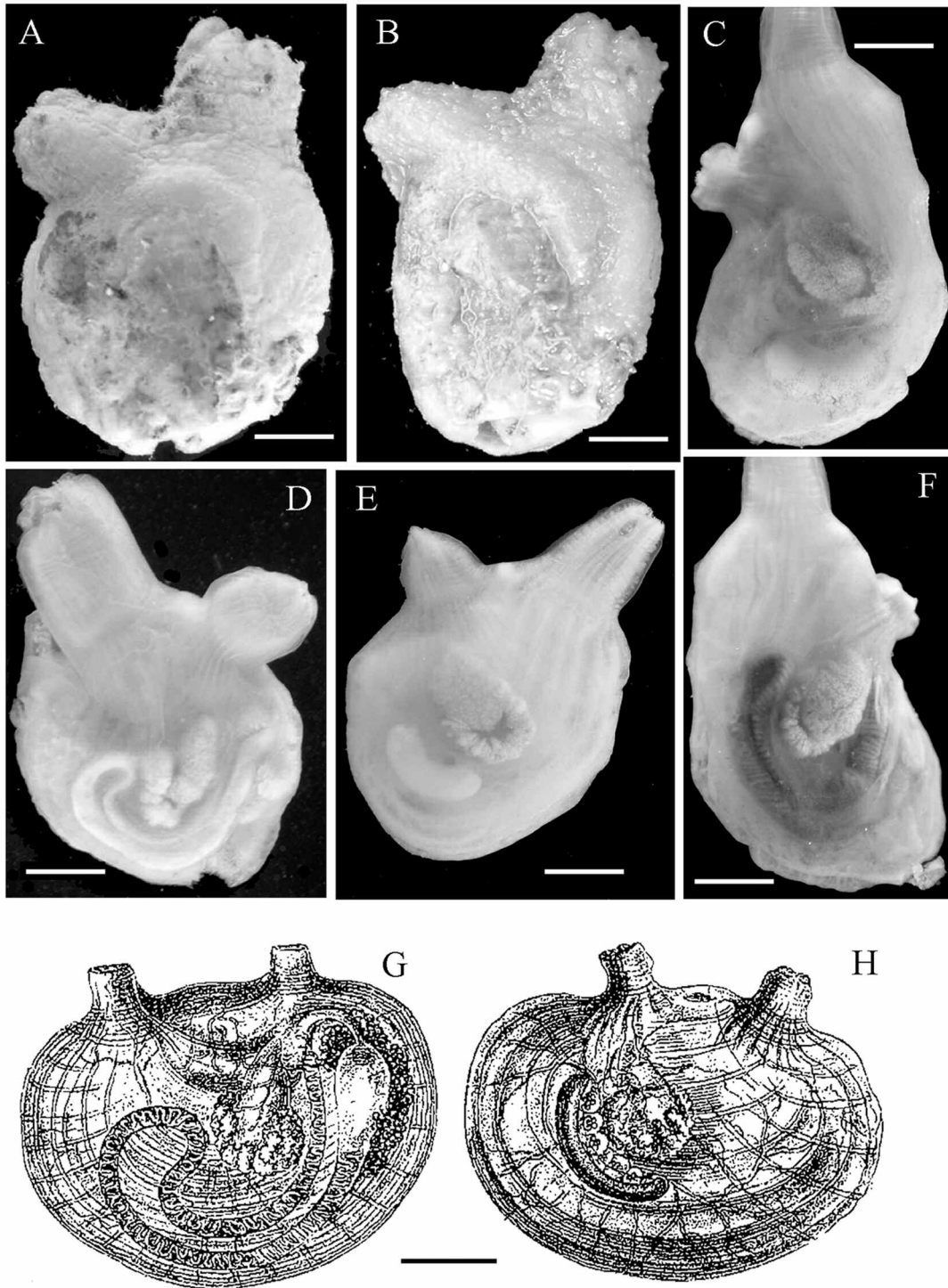


Figure 1. *Molgula ficus* (MacDonald, 1859). **A, B.** Two different individuals, external view of right side. **C.** Right side of a different animal removed from its tunic showing gonad and kidney. **D.** Left side of animal A showing intestine and gonad. **E.** Right side of animal B showing gonad and kidney. **F.** Left side of animal C showing intestine and gonad. **G, H.** Left and right sides, respectively, of the type specimen, from MacDonald (1859). Scale bar A-F = 5 mm; scale bar G-H = 1 cm.

Figure 1. *Molgula ficus* (MacDonald, 1859). **A, B.** Côté droit de deux individus en vue externe. **C.** Côté droit d'un autre animal sorti de sa tunique montrant la gonade et le rein. **D.** Côté gauche de l'animal A montrant l'intestin et la gonade. **E.** Côté droit de l'animal B montrant la gonade et le rein. **F.** Côté gauche de l'animal C montrant l'intestin et la gonade. **G, H.** Côtés gauche et droit du spécimen type d'après MacDonald (1859). Echelles : A-F = 5 mm; G-H = 1 cm.

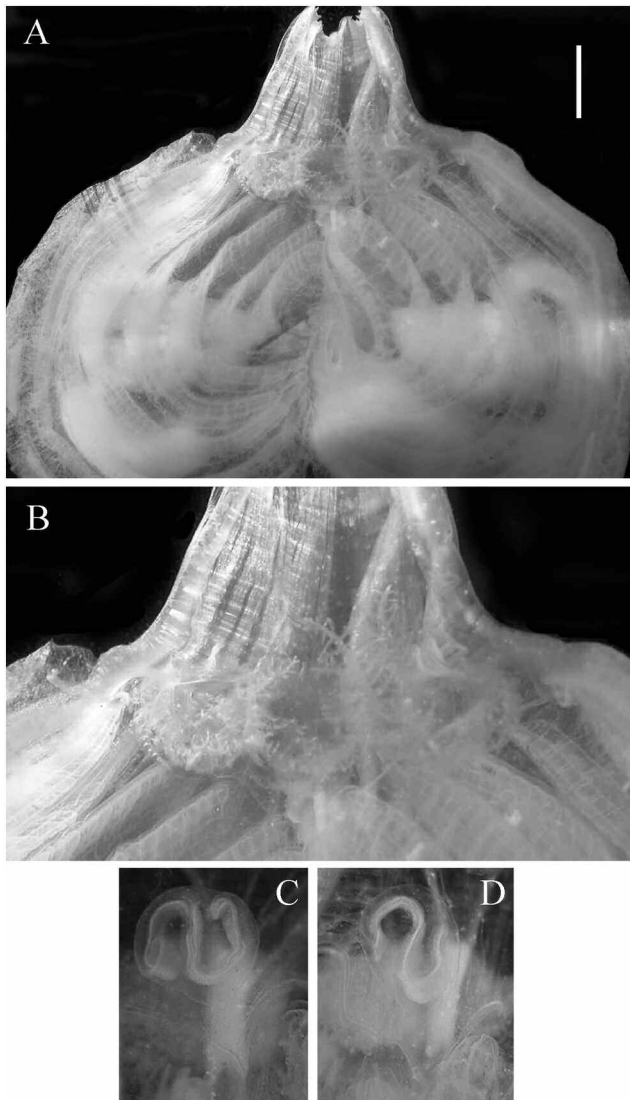


Figure 2. *Molgula ficus* (MacDonald, 1859). **A, B.** Details of the branchial sac and oral tentacles. **C, D.** Dorsal tubercle of two different individuals. Scale bar in A = 3 mm.

Figure 2. *Molgula ficus* (Macdonald, 1859). **A, B.** Détails de la branchie et des tentacules oraux. **C, D.** Tubercule dorsal de deux individus différents. Echelle : A = 3mm.

period. Sites and dates included in Lambert & Lambert, 2003 that are not included here are those at which no *M. ficus* were ever found. Though there are large variations in number between survey dates, *M. ficus* increased in abundance at some of the sites during the 6 year period and also spread to more sites. For example, while all 5 San Diego Bay sites were sampled fall 1994, *M. ficus* was initially found at only 2 of them. North of San Diego and Mission Bays, no *M. ficus* were recorded until 1997 with the exception of Impound Marina in Long Beach where 2 individuals were collected in spring 1995 but subsequently none until 1997.

Molgula verrucifera is a very small species (1 cm maximum in diameter) native to California, found only on the exposed outer coast in low intertidal and subtidal rocky areas (Ritter & Forsyth, 1917; Van Name, 1945; Fay & Johnson, 1971; Abbott, 1975). It is much smaller than *Molgula ficus* (2-4 cm in California and occasionally up to 8 cm in Australia), which is found in more protected habitats especially bays and harbors. While there is a large size difference between the two species, some other morphological characters are similar (Figs 1-3; Table 3). Both species have 7 branchial folds per side, mostly straight stigmata rather than coiled, and curious small fingerlike tunic projections around the siphonal openings (see detailed description of *M. ficus* in Kott, 1985 and *M. verrucifera* in Ritter & Forsyth, 1917). Both species have a similarly shaped gonad on each side of the body, with the testis follicles surrounding the posterior end of the ovary and imparting to each ovotestis a fig-like form (Fig. 1; see also Fig. 187g in Kott, 1985 and Fig. 3 in Clarke & Castilla, 2000 for *M. ficus*; Fig. 3 this paper and Pl. 40 Fig. 15 in Ritter & Forsyth, 1917 for *M. verrucifera*). All the *M. verrucifera* individuals examined were remarkably uniform in their morphology, while a great deal of variation was observed among *M. ficus* individuals in both external and internal features (Fig. 1 A-F).

There are several significant morphological differences between the two species in addition to the considerable size difference (Table 3). *M. verrucifera* is a brooder, never more than 1 cm in diameter and usually less, and the tunic is always closely covered with hairs and trapped sand grains (Fig. 3A). *M. ficus* is not a brooder, California adult specimens are 2-4 cm in diameter, and the tunic especially of large specimens has only a sparse covering of very short hairs that may be restricted to the posterior end (Fig. 1A, B). There is no overlapping of habitat; *M. verrucifera* occurs in the low intertidal and subtidal along the exposed open coast of California, while *M. ficus* prefers a more protected habitat and in California has been found only on artificial structures in harbors. No *M. verrucifera* were ever found at any of the harbor sites surveyed by Fay & Johnson (1971), Lambert & Lambert (2003) or MLML.

The first record of *Molgula ficus* in southern California is 1994, coincidental with the first records of several other nonindigenous ascidians in southern California (Lambert & Lambert, 1998) whose successful establishment may have been due at least in part to a major el Niño warming of these waters between 1990 and 1995 (<http://www.cdc.noaa.gov/people/cathy.smith/best/#years>), which tends to favor the establishment of nonindigenous species (Stachowicz et al., 2002). Table 1 shows that while there is not a definite seasonal difference in abundance, the species did increase dramatically both in number and distribution in southern California between 1994 and 2000. It was never recorded

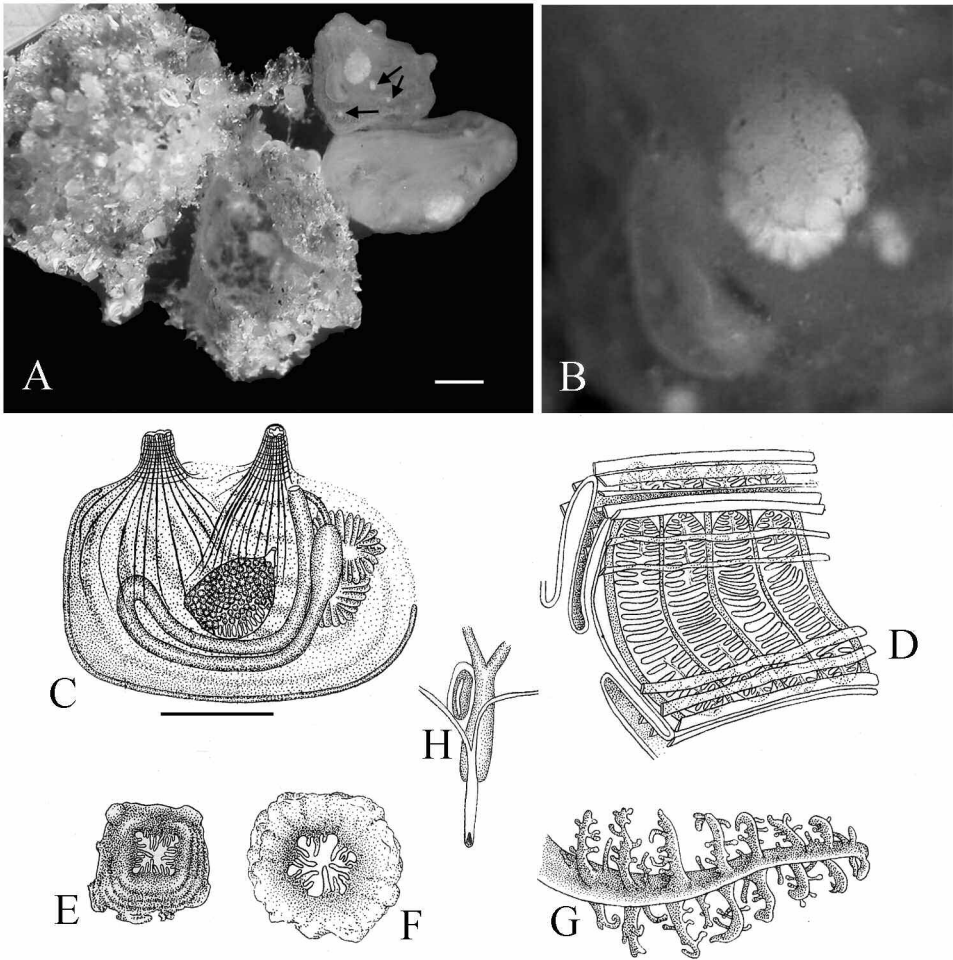


Table 3. A comparison of morphological characters in *Molgula ficus* and *M. verrucifera*
Tableau 3. Comparaison des caractères morphologiques de *Molgula ficus* et *M. verrucifera*.

	<i>M. ficus</i>	<i>M. verrucifera</i>
Diameter (mm)	40	10
Hairs on tunic	Sparse, may be confined to posterior end (though this is a variable trait). Tunic often clean, not covered with sand	Numerous; present on entire tunic. Tunic always covered with sand grains
Tiny fingerlike tunic projections in siphons, some bifurcated	+	+
Branchial folds/side	7	7
Stigmata mostly straight	+	+
Longitudinal vessels	About 8-10/fold, + either none or 1-2 between folds	About 8/fold; none between folds
Dorsal tubercle	Sideways S shaped	Small longitudinal slit
Testis confined to posterior border of ovary	+	+
Brooder	-	+

Figure 3. *Molgula verrucifera* Ritter & Forsyth (1917). **A.** Two individuals removed from their tunic; arrows indicate brooded embryos. Scale bar 1 mm. **B.** Higher magnification view of the right gonad and kidney of one of the individuals. **C-H.** Diagrams of the type specimen, from Ritter & Forsyth (1917). **C.** Left side showing intestine and gonad; scale bar 3 mm. **D.** Detail of branchial sac. **E.** **F.** Papillae in opening of atrial and oral siphon respectively. **G.** Oral tentacle. **H.** Dorsal tubercle and ganglion.

Figure 3. *Molgula verrucifera* Ritter & Forsyth (1917). **A.** Deux individus extraits de leur tunique, les flèches indiquent des embryons incubés; Echelle = 1 mm. **B.** Vue agrandie de la gonade droite et du rein de l'un des individus. **C-H.** Diagrammes du spécimen type d'après Ritter & Forsyth (1917). **C.** Intestin et gonade à gauche, Echelle = 3 mm. **D.** Détail de la branchie. **E.** **F.** Papilles des ouvertures des siphons oral et atrial. **G.** Tentacule oral. **H.** Tubercule dorsal et ganglion nerveux.

north of Port Hueneme during that time. It is not included in Abbott (1975) or Cohen & Carlton (1995); in October 2005 it was recorded for the first time from San Francisco Bay in northern California (MLML, unpublished data). *M. ficus* is a recent introduction to Chile; the first record is from 1997 in Antofagasta Bay (see Clarke & Castilla, 2000). It is common on suspended cultured scallop ropes and has been collected intertidally within dense beds of *Pyura praeputialis*, an introduced species from Australia (Castilla et al., 2002). The species is known from the Indo-Pacific, including Australia, Tasmania, Gulf of Siam, Singapore and Hong Kong (Millar, 1975; Kott & Goodbody, 1982; reviewed in Kott, 1985). It has also been collected from a marine lake in Indonesia (C. Monniot pers. comm.).

Acknowledgements

I am deeply grateful to C. Monniot for the correct identification of *Molgula ficus* and to F. Monniot for the French translations. C.C. Lambert helped in the collection of the southern California specimens. R. Fairey and the staff of the Marine Pollution Studies Lab, Moss Landing Marine Laboratories, Moss Landing, CA are thanked for the opportunity to examine numerous specimens of both *Molgula* spp. Funding was provided by the Ballast Water Program, Office of Spill Prevention and Response, California Dept. of Fish and Game. M. Carman and the library of the Marine Biol. Laboratory, Woods Hole, kindly provided a copy of the MacDonald paper. S. Kempf aided in the preparation of the figures. Two anonymous reviewers are thanked for their comments which greatly improved the manuscript. I am indebted to the University of Washington Friday Harbor Laboratories and especially the H.R. Whiteley Center for providing space and support for the preparation of this paper.

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