TWO SPECIES OF THE CORAL *TUBASTRAEA* (CNIDARIA, SCLERACTINIA) IN BRAZIL: A CASE OF ACCIDENTAL INTRODUCTION

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ABSTRACT

Although scleractinian corals have been described for the Brazilian coast and despite the fact that the genus *Tubastraea* Lesson 1829 (Scleractinia: Dendrophylliidae) is a very common ahermatypic azooxanthellate coral with a wide geographical distribution in the world, it has not, until recently, been reported from Brazil. Therefore, this coral is interpreted as a non-indigenous genus to the south Atlantic, probably arriving in Brazil in the late 1980s. The present study re-describes and compares two species of the genus, *Tubastraea coccinea* Lesson, 1829 and *Tubastraea tagusensis* Wells, 1982 from the rocky shores of Ilha Grande Bay, Angra dos Reis, Brazil. These corals are found on protected, shallow-water rocky shores. Of the six species of genus *Tubastraea* that are known, *T. coccinea* is the most common species in tropical regions, while *T. tagusensis* was previously known only from the Galápagos archipelago. Ilha Grande Bay is a site with shipping traffic (ships and oil platforms), which probably brought these corals to the region. Results of this study expand the reported distribution of this genus in the world.

The first list of shallow water scleractinian corals of the southeast region of Brazil was compiled by Laborel (1967, 1969, 1970) who recorded some azooxanthellate coral genera such as *Astrangia* Milne-Edwards and Haime, 1848, *Madracis* Milne-Edwards and Haime, 1849, and *Phyllangia* Milne-Edwards and Haime, 1848. Among the shallow-water Anthozoa reported from the rocky shores of Ilha Grande Bay, Rio de Janeiro by Castro et al. (1999), four scleractinian corals have been recognized: *Astrangia rathbuni* Vaughan, 1906; *Madracis decactis* (Lyman, 1859), *Mussismilia hispida* (Verrill, 1901), and *Phyllangia americana* (Milne-Edwards and Haime, 1849).

The scleractinian *Tubastraea* Lesson 1829, family Dendrophylliidae, has only recently been reported from Brazil (Castro and Pires, 2001). Dendrophylliidae are easily recognized by their bright yellow, orange, and red colors. It is thought to be non-indigenous to the southwestern Atlantic because, although conspicuous, it was not previously reported by coral specialists in studies of Ilha Grande Bay (Castro et al., 1999).

Although this shallow-water azooxanthellate coral is generally absent from areas of dense coral growth (Wood, 1983), *Tubastraea coccinea* Lesson, 1829 is the most widely distributed azooxanthellate species in tropical regions of the Pacific and Atlantic oceans (Cairns, 1994). Considered a fouling and reef species (Fenner, 2001), it seems to be an opportunist.

The earliest record of the genus *Tubastraea* in the western Atlantic was 1943, but the first date-documented specimens were reported in 1951 (Cairns, 2000). Interestingly, some of these specimens were attached to a ship's bottom and afterwards *Tubastraea* seemed to increase its range to most of the Caribbean region as well as increase in abundance (Cairns, 2000). For example, *T. coccinea* was reported in Belize and Cozumel (Fenner, 1999), and Fenner (2001) reported the expansion of *T. coccinea* to the Gulf of Mexico where it is found on oil platforms.

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Tubastraea was probably introduced to the Brazilian coast in the late 1980s (P.S. Young and C.B. Castro, Museu Nacional/Universidade Federal do Rio de Janeiro, pers. comm.) when the first sightings were made on an offshore oil platform working in the Campos Basin, north of the state of Rio de Janeiro. However, this genus was recognized on rocky shores at Ilha Grande Bay only in the late 1990s (P.S. Young, Museu Nacional/ Universidade Federal do Rio de Janeiro, pers. comm.). Recently it has been observed on the Marlin platform in the Campos Basin (1999; C.B. Castro, Museu Nacional/ Universidade Federal do Rio de Janeiro, pers. comm.), photographed on the platform PXIV at Itajaí, Santa Catarina state (2000), and observed and sampled on an oil platform PXIII from the Campos Basin, which was docked for repair in 2001 in Guanabara Bay, Rio de Janeiro (pers. obs.). Therefore, evidence suggests that *Tubastraea* was introduced into Brazil by a ship and/or oil platform transit just as Cairns (2000) suggested its appearance in the Caribbean.

Six species of *Tubastraea* are recognized in the world, but only *T. coccinea* is cosmopolitan. The other five species, *Tubastraea diaphana* Dana, 1846; *Tubastraea faulkneri* Wells 1982; *Tubastraea floreana* Wells, 1982; *Tubastraea micranthus* (Ehrenberg, 1834); and *Tubastraea tagusensis* Wells, 1982 occur only in the Indo-Pacific (Cairns, 1994). The aim of this study was to describe and compare the recent arrival of *Tubastraea* in Brazil with those species known worldwide.

Material and Methods

Study Site.—The state of Rio de Janeiro is positioned at a transition zone between tropical and temperate faunas and has a coastline with large bays (Castro et al., 1999). Ilha Grande Bay (22º50′–23º20′S and 44º00′–44º45′W), Angra dos Reis, in the south of Rio de Janeiro state, consists of two bodies of water separated by a constriction formed between the continent and an island, Ilha Grande (Signorini, 1980). Ilha Grande is an island of 190 km^2, which has exposed south-facing and protected north-facing coastlines. The position of the island encloses the Sepetiba and Ilha Grande Bays (Fig. 1), the latter of which contains 365 islands. The region receives rainfall of 2500 mm annually, much of which runs into these bays, although salinity is 35–36. During the summer, an increase in water temperature occurs as warm water from nearby regions moves into the Bay. Consequently, the tropical waters in Ilha Grande vary in temperature from 21–32ºC during the year.

The study location was situated on the inner (protected) side of Ilha Grande along the Canal Central, as defined by Mahiques and Furtado (1989) (Fig. 1). The rocky shores alternate between rock and boulder fields that give way to a sediment (sand) plain that starts at about 3–7 m depth. Because of the reduced circulation, small tidal range (1.4 m), and restricted fetch, the shores are relatively protected. Both Ilha Grande and Sepetiba Bay (Fig.1), and in particular, the study site (Canal Central of Ilha Grande Bay), are areas of intense ship traffic due to the presence of three important ports and a shipyard that receives oil platforms.

Material Examined.—Specimens representing naturally-occurring variation in color, size, and form were collected during 2000 in shallow water (0–4.2 m) in the inter- and subtidal rocky shores of Ilha Grande. In general, these corals occur in greater abundance on accentuated slopes (underhangs), caves, or boulders, but can also occur at exposed sites on larger walls at all angles. Material was collected by snorkel and SCUBA divers. Samples of large adult colonies, which were chosen to represent the variation present, were removed from the rock at the base with a hammer and chisel. External characteristics were noted and the colonies separated based on color. The colonies were fixed in 10% formalin. Subsequently, the soft parts were removed with NaOCl (bleach) to expose the skeleton.

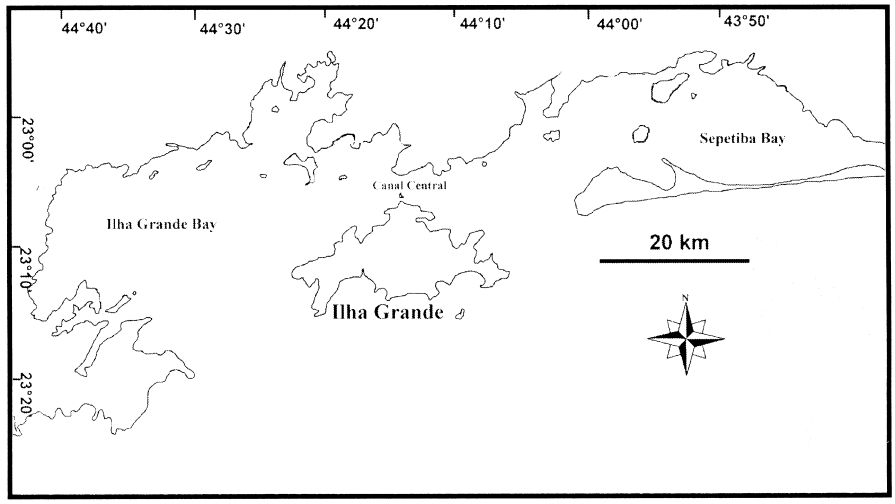

Figure 1. Map of Ilha Grande, study area

Specimens were deposited in the Cnidaria collection of the Museu Nacional, Rio de Janeiro (MNUFRJ). Ten coralla of each species were used for measurement and description.

The identification of the coral species was based on the literature in relation to septal number, fusion and arrangement of septa, corallite arrangement and costae, although it differed in a few characteristics. The material was compared with descriptions in revisions by Cairns (1991) from the Galápagos and Cocos Islands, Cairns (1994) from north-western Pacific and Wells (1982) from the Galápagos archipelago, as well as analyses of digital photography of coralla, septa, and columella. The coralla were examined for the following parameters: septal number, fusion of septa, axial septal edges, calicular diameter, projection of corallites (exertness from coenosteum), spacing of coenosteum, columella diameter, depth of fossa, color of coenosarc (and tentacles), and ratio of the calicular diameter to the columella diameter. Callipers and a dissecting microscope with a scale were used for the linear measurements.

Results

Examination revealed two species of the genus *Tubastraea* at Ilha Grande Bay, Brazil: *Tubastraea coccinea* Lesson, 1829 and *T. tagusensis* Wells, 1982, which are new records for Brazil.

Order Scleractinia Bourne 1900

Suborder Dendrophylliina Vaughan and Wells, 1943

Family Dendrophylliidae Gray, 1847

Genus *Tubastraea* Lesson, 1829

Diagnosis.—Colonies dendroid, bushy, or plocoid, all achieved by extratentacular budding. Costae poorly defined; no epitheca. Septa arranged normally (not in a Pourtalès plan). Pali absent; columella usually small and spongy (Cairns, 2000).

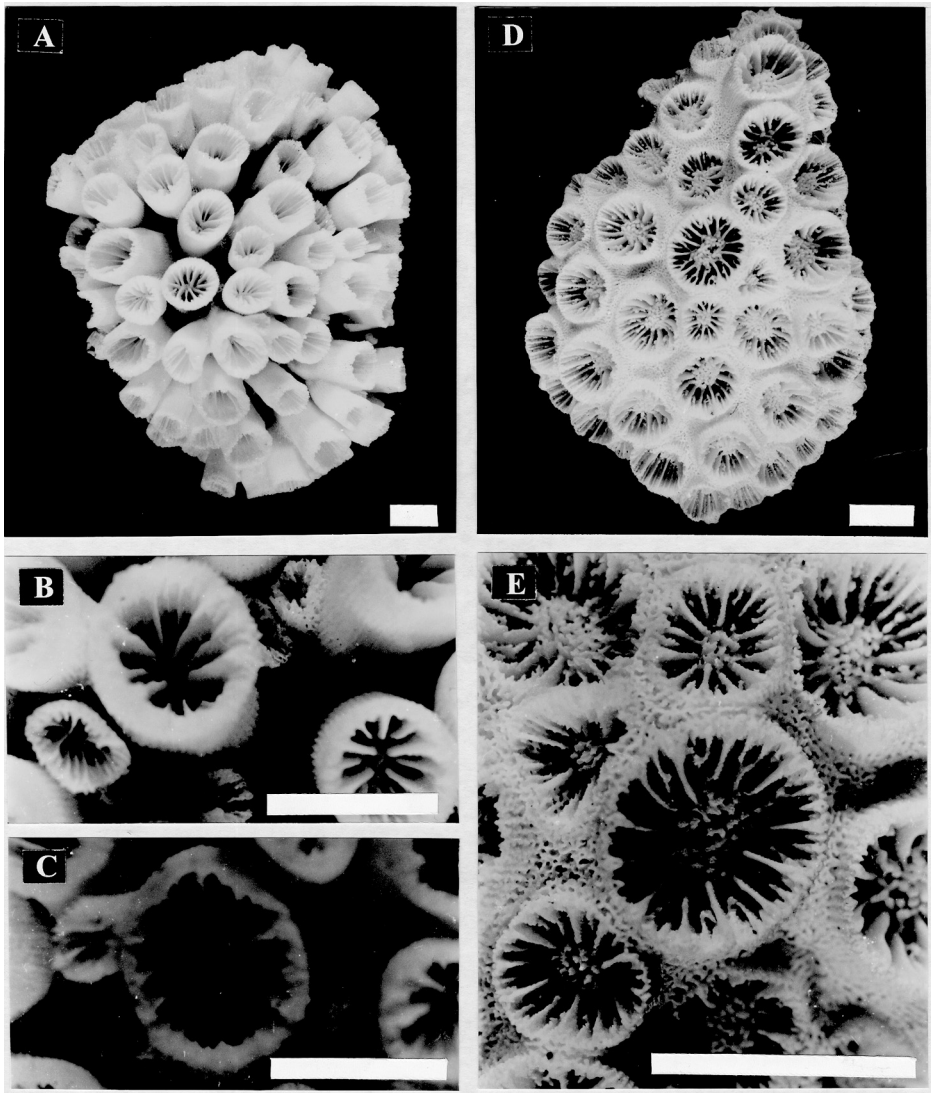

Figure 2. A–C *Tubastraea tagusensis*, A whole corallum, B corallite showing budding, C septa arrangement. D–E *Tubastraea coccinea*, D whole corallum, E corallite, columella and septa arrangement. Bar = 1 cm.

Tubastraea coccinea Lesson, 1829
(Figs. 2 D–E)

Material examined.—Ilha dos Macacos, Ilha Grande, Brazil; Abraãozinho, Ilha Grande, Brazil.

Description.—Colonies roughly spherical with coenosarc orange-red in color. Corallum white; plocoid or cerioid; porous. Corallum up to 105 mm in diameter; firmly attached to substratum due to large base. Corallites small; slightly spaced; projecting 2–13 mm above

coenosteum on average. Extratentacular budding from intercorallite coenosteum, occurring between older corallites and at colony edge. Calices usually circular, sometimes elliptical; 7.2–15 mm diameter; calicular edges often directly adjacent to one another. Columella spongy; up to 4.6 mm in diameter, composed of a mass of slender trabeculae. Fossa shallow to moderately deep. Septa hexamerally arranged in four cycles, S1–2 >S3 >S4. Axial septal edges of S1 and S2 vertical and straight, virtually equal in size, attaining columella, and are much broader than S3–4. S3 as broad as S4 or S4 rudimentary. S3 having laciniate axial edges. Usually S3–4 fused, extend toward columella. Costae granular, poorly defined, with equal porous intercoastal grooves.

New records.—Three colonies, MNUFRJ (4743, 4744 and 4447)

Tubastraea tagusensis Wells, 1982
(Fig. 2 A–C)

Material examined.—Ilha dos Macacos, Ilha Grande, Brazil; Abraãozinho, Ilha Grande, Brazil.

Description.—Colonies roughly spherical, usually globular, convex, with coenosarc yellow in color. Corallum white; plocoid or phaceloid; porous (perforate). Corallum up to 150 mm in diameter. Usually attached to substratum; base narrower than corallum. Large corallites; cylindrical or slightly compressed; closely spaced. Corallites project 5–35 mm on average above coenosteum. New corallites bud intra- and extra-tentacularly all over colony (Fig. 2B). Calices elliptical (sometimes compressed because of greater budding); 7.5–12.8 mm diameter. Columella spongy; up to 3.5 mm diameter; composed of mass of slender trabeculae. Sometimes columella absent. Fossa deep or moderately deep. Septa hexamerrally in four cycles (or three cycles); S1–2 > S3 > S4. Axial edges S1–2 vertical; lobes paliform near columella. S1–3 having laciniate axial edges in larger corallites. S1 broader; slightly thicker; wider than other septa. S4 rudimentary or absent. Costae granular, poorly defined, with equal porous intercoastal grooves.

Table 1. Comparison between two species of *Tubastraea* found in Ilha Grande Bay (RJ), Brazil.

Character	*Tubastraea tagusensis*	*Tubastraea coccinea*
Colony diameter	30–145 mm	45–105 mm
Septal number	48: S1–2 > S3 > S4; S4 sometimes absent	48: S1–2 > S3 > S4
Fusion of septa	All septa independent	S3–4 fuse, subsequently columella
Axial edges of septa	S1 with paliform lobes; sometimes S1–3 with laciniate axial edge	S3 with laciniate axial edges
Calicular diameter	7.5–12.8 mm	7.2–15 mm
Projection of corallites (exsertness from coenosteum)	18.5 mm average; 0–35 mm	3.2 mm average; or 2.0–13 mm
Spacing of corallites	Closely spaced	Little or no spacing
Columella diameter	Absent to 3.5 mm (rudimentary)	2.8–4.6 mm (large)
Fossa	Deep or moderately deep	Moderately deep or shallow
Color of coenosarc	Yellow	Orange-red
Ratio calicular diameter to columella diameter	0.41 mm average; 0.19–0.62 mm	0.24 mm average; 0.23–0.28 mm

New records.—Three colonies, MNUFRJ (4745, 4746, and 4448).

The principal characteristics which were used to differentiate the two species are presented in Table 1.

Discussion

Although the whole range of morphological variability of these corals in Brazil is unknown, the distinction between *T. coccinea* and *T. tagusensis* is clear. Morphological characteristics and color were used to separate these two new occurrences of *Tubastraea* in Brazil. Though color is not a taxonomic characteristic that is generally used, at Ilha Grande Bay, it could be used with success equal to other morphological characteristics as in this description. The distinction by color (of the coenosarc), with the exception of recently settled single polyps, allows species to be distinguished in the field underwater with the naked eye.

The coralla of specimens of *T. coccinea* from the Caribbean, Galápagos, Japan, and Southwest Indian Ocean were considered by Cairns (1994) as indistinguishable, but some coralla characters differed in the Brazilian *T. coccinea*. Corallite projection and calicular diameter had greater variation in Brazil compared to the descriptions of Cairns (1991, 1994), probably because the environmental conditions differed between the Galápagos and Ilha Grande. The corallites had small minimum values and greater maximum values for these characters compared to the two *Tubastraea* species from the other locations.

Tubastraea coccinea encountered in the Colombian Pacific had a calicular diameter of 10 mm (Prahl, 1987), near the value of *T. coccinea* in Ilha Grande (7.2–15 mm). The maximum projection of corallites (exsertness from coenosteum) of *T. coccinea* found in Brazil (13 mm) was larger than encountered in Galápagos (12 mm) and for the northwestern Pacific (10 mm) (Cairns, 1991, 1994).

In Brazil, *T. tagusensis* rarely presents fourth-cycle septa (S4 usually absent), the projection of corallites (exsertness from coenosteum) is much larger (5–35 mm compared with 20 mm (Cairns, 1991), and 3–15 mm (Wells, 1982) at the Galápagos archipelago. The maximum diameter of corallites and corallum were also larger, for corallites: 12.8 mm at Ilha Grande compared with 10 mm at Galápagos (Wells, 1982; Cairns 1991); for corallum: 145 mm in Brazil, 100 mm (Wells, 1982) and 120 mm (Cairns, 1991) at Galápagos. Possibly, these corals encountered better conditions for growth and development at Ilha Grande. In the Galápagos, *Tubastraea* grows preferentially in caves, on shallow slopes in shallow waters and can be found at great depths (1–54 m; Cairns, 1991). In Ilha Grande, *Tubastraea* occurred in shallow waters 0–4.2 m (and was fairly regularly observed exposed to air at low tides). The corals occurred in both protected locations at reduced light intensity as well as in more exposed (to light and water movement) sites, and probably occurred deeper as well.

Tubastraea tagusensis is distinguished from the cosmopolitan *T. coccinea* by the smaller calicular diameter and greater size range of their corallites, yellow colored coenosarc and presence of paliform lobes. Both *T. coccinea* and *T. tagusensis* maintain their form (plocoid structure) during growth and increase in size, although *T. tagusensis* buds intra- and extra-tentacularly from corallites distributed over the whole colony. *Tubastraea coccinea* has little intervening coenosteum, and consequently fewer buds; whereas, *T. tagusensis* frequently has compressed corallites, probably due to its frequent budding.

Table 2. Distribution of extant species the genus *Tubastraea* in the world. Modified from Cairns et al., 1999.

Species of Tubastraea	Northwestern Atlantic	Southwestern Atlantic	Eastern Atlantic	Western and central Pacific	Eastern Pacific	Indian Ocean
Tubastraea coccinea Lesson, 1829	X	X	X	X	X	X
Tubastraea diaphana Dana, 1846				X		X
Tubastraea faulkneri Wells, 1982				X	X	
Tubastraea floreana Wells, 1982					X	
Tubastraea micranthus (Ehrenberg, 1834)				X		X
Tubastraea tagusensis Wells, 1982		X			X	

Presently, *T. coccinea* is the coral with the highest number of local populations on the coast of western Mexico and in the eastern Pacific (Reyes-Bonilla et al., 1997). It is circumtropical, occurring in Fiji (type location; Wells, 1982), Costa Rica, Colombia, the Red Sea (Prahl, 1987; Cairns, 1991), Pacific Mexico (Wilson, 1990; Reyes-Bonilla et al., 1997), Belize, and Cozumel (Fenner, 1999). *Tubastraea tagusensis* is only known from the Galápagos archipelago (Wells, 1982; Cairns, 1991).

Scleractinian corals typically are not part of the fouling communities that ships contact in harbor areas (Zibrowius 1992). Yet the stony corals *T. coccinea* and *O. patagonica* were reported as exotic to the Caribbean and Mediterranean respectively (Zibrowius, 1992; Cairns, 2000) where they foul artificial structures. Until now, *T. coccinea* was the only introduced (exotic) scleractinian coral known for the western Atlantic (Cairns, 2000) and now southwestern Atlantic Ocean. The apparent spread of *T. coccinea* throughout the Caribbean indicates that the western Atlantic was not within its original range (Cairns, 1994). Cairns suggested that the broad distribution of this coral in the Caribbean America is a result of introductions caused by transport on ship hulls. Apparently in Brazil, the coral also arrived as a fouling organism, through probably on a transported oil platform. Both Ilha Grande and Sepetiba Bay (Fig.1), and in particular the study site (Canal Central of Ilha Grande Bay), are areas of intense ship traffic due to the presence of three important ports and a shipyard that receives oil platforms. Laborel (1970) recognized that Brazil's coral fauna is isolated from the Caribbean region because of the Amazon River barrier, and this reinforces the hypothesis of an anthropic introduction of the genus into Brazil.

Tubastraea has been observed at other sites in Brazil: the Campos Basin, on oil platforms (P.S. Young and C.B. Castro, Museu Nacional/Universidade Federal do Rio de Janeiro, pers. comm.); at Arraial do Cabo, Rio de Janeiro state on the rocky shore (C. Ferreira, Instituto de Estudos do Mar Almirante Paulo Moreira, pers. comm.); and at Itajaí, Santa Catarina state on oil platforms from 1980 onwards.

The coral *T. coccinea* is one of the most common ahermatypes in shallow water at low latitudes in the Pacific and Atlantic Oceans (Reyes-Bonilla, 1997), it is a very common coral with a circumtropical distribution (Cairns 1994), and it is not surprising that its range has been extended. In contrast, *T. tagusensis* was, until now, endemic to the Galápagos archipelago and now occurs at Ilha Grande, Brazil. These new records represent a multi-species introduction of exotic corals with known invasive ability, presumably through marine transport by vessel fouling or ballast water, and an increase in the geographical distribution of these species.

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