The Natural History of Santo

edited by
Philippe Bouchet, Hervé Le Guyader, Olivier Pascal

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The Position

# of Santo in Relation to the Centre of Maximum Marine Biodiversity (the Coral Triangle) Based on Mushroom Corals and their Associated Mollusc Fauna

Bert W. Hoeksema & Adriaan Gittenberger

The centre of marine maximum marine biodiversity has become increasingly important as a means to draw attention to the conservation of coral reefs. Due to its shape, it has been named the Coral Triangle, which is supposed to encompass all or some of the reefs of the Philippines, Malaysia, Indonesia, Timor-Leste, Papua New Guinea, and the Solomon Islands. The criteria used to define this diversity centre as it is presently recognized, are based on high numbers of species recorded from within this centre. However, data from within and, especially, from outside the centre's hypothetical boundaries are far from complete due to insufficient sampling. Ideally, study areas should be surveyed by the same scientists using the same methods for reaching any conclusions regarding their position in- or outside the centre of maximum marine biodiversity.

In order to get a clear picture of biodiversity patterns for various groups of animals and plants, large research teams are needed to visit many different localities. Another way to investigate species diversity patterns is by selection of representative species groups that have been well studied by means of taxonomic revisions and many field surveys. An example of such a target group is the mushroom coral family (Scleractinia: Fungiidae), which consists of at least 47 species. Most of these species were treated in a taxonomic revision: *Taxonomy, phylogeny and biogeography of mushroom corals (Scleractinia: Fungiidae)* by Hoeksema (1989), whereas additional ones were described later on, or still have to be described. Use of such target groups will give a consistent overview of species compositions over various geographic areas, in which not only the presence of species is known, but also the absence of species should be indicated with a high reliability using species richness estimators.

Reef corals, reef fish, and molluscs are usually recognized as the most important indicator groups of animals that tell us whether a reef area is rich in species or not. However, no reef-dwelling species is living on its own, since each one is part of a network of inter-specific associations such as parasitism, commensalism, predator-prey relations, etc. Some of these interrelations are very explicit, in which, for example, a parasitic snail depends on a single particular host coral. Presence or absence of particular host species is therefore also indicative for the occurrence of the associated fauna, which is demonstrated by various groups of molluscs, such as parasitic wentletrap snails (Epitoniidae), boring coral snails belonging to coral eating Coralliophilidae (*Leptoconchus* spp.), and boring mussels (Mytillidae: *Fungiacava eilatensis*, *Lithophaga* spp.).

METHODS

Mushroom corals and their associated molluscs were studied during the Santo 2006 expedition, at the Southeastern side of Espiritu Santo, in the vicinity of the base camp at Luganville. The mushroom coral species were recorded during 25 dives in a time span of 15 days (September 2006). The molluscs were recorded at the same sites and at additional localities in a period of nearly two months.

CORAL SPECIES RICHNESS

A total of 35 species of mushroom coral species was recorded (Table 39). Of these, 34 were observed during the surveys. The other one, Fungia (*Cycloseris*) cyclolites, could be listed thanks collecting efforts during a separate dive at 40 m depth by Mr. Eric Folcher, professional diver of IRD (Nouméa, New Caledonia). Of the 35 species, 16 are new records for Vanuatu and one of these, a *Sandalolitha* sp., is

Table 39: Mushroom coral species encountered at 25 localities (dive sites) during the Santo 2006 expedition. Per species the number of localities is mentioned at which it was recorded to indicate its relative abundance. One species (*) was observed during a separate occasion. Earlier records for Vanuatu are indicated by their publication.

Species	Number of dive sites	Earlier records
1. *Cantharellus jebbi* Hoeksema, 1993	17	
2. *Ctenactis albitentaculata* Hoeksema, 1989	6	
3. *Ctenactis echinata* (Pallas, 1766)	18	Veron 1990a
4. *Ctenactis crassa* Dana, 1846)	17	Veron 1990a [1]
5. *Fungia* (*Cycloseris*) *costulata* Ortmann, 1889	16	
6. *Fungia* (*Cycloseris*) *cyclolites* Lamarck, 1815	0*	
7. *Fungia* (*C.*) *fragilis* (Alcock, 1893)	4	Veron 1990a [2]
8. *Fungia* (*C.*) *hexagonalis* Milne Edwards & Haime, 1848	1	
9. *Fungia* (*C.*) *sinensis* (Milne Edwards & Haime, 1851)	7	
10. *Fungia* (*C.*) *somervillei* Gardiner, 1909	2	
11. *Fungia* (*C.*) *tenuis* Dana, 1846	1	
12. *Fungia* (*C.*) *vaughani* Boschma, 1923	3	
13. *Fungia* (*Cycloseris*) sp.	5	
14. *Fungia* (*Danafungia*) *horrida* Dana, 1846	15	Hoeksema 1989; Veron 1990a [3]
15. *Fungia* (*D.*) *scruposa* Klunzinger, 1879	13	Veron 1990a [4]
16. *Fungia* (*Fungia*) *fungites* (Linnaeus, 1758)	24	Hoeksema 1989; Veron 1990a
17. *Fungia* (*Lobactis*) *scutaria* Lamarck, 1801	12	Veron 1990a
18. *Fungia* (*Pleuractis*) *gravis* Nemenzo, 1955	9	
19. *Fungia* (*P.*) *moluccensis* Van der Horst, 1919	9	
20. *Fungia* (*P.*) *paumotensis* Stutchbury, 1833	23	Veron 1990a
21. *Fungia* (*Verrillofungia*) *concinna* Verrill, 1864	18	Veron 1990a
22. *Fungia* (*V.*) *repanda* Dana, 1846	22	Veron 1990a
23. *Fungia* (*V.*) *spinifer* Claereboudt & Hoeksema, 1987	9	
24. *Fungia* (*Wellsofungia*) *granulosa* Klunzinger, 1879	19	Veron 1990a
25. *Halomitra pileus* (Linnaeus, 1758)	1	
26. *Heliofungia actiniformis* (Quoy & Gaimard, 1833)	5	Hoeksema 1989
27. *Herpolitha limax* (Esper, 1797)	23	Hoeksema 1989; Veron 1990a
28. *Lithophyllon mokai* Hoeksema, 1989	9	Veron 1990a [5]
29. *Podabacia crustacea* (Pallas, 1766)	3	Veron 1990a
30. *Podabacia motuporensis* Veron, 1990	1	Veron, 1990a [6]
31. *Polyphyllia novaehiberniae* (Lesson, 1831)	16	Hoeksema 1989; Veron 1990a
32. *Polyphyllia talpina* (Lamarck, 1801)	15	
33. *Sandalolitha robusta* (Quelch, 1886)	22	Veron 1990a
34. *Sandalolitha* sp.	13	
35. *Zoopilus echinatus* Dana, 1846	1	Veron 1990a

Notes: (1) As *Fungia* (*Ctenactis*) *simplex* (Gardiner, 1905); (2) As *Cycloseris patelliformis* (Boschma, 1923); (3) also as *Fungia* (*D.*) *valida* Verrill, 1864, and *F.* (*D.*) *klunzingeri* Döderlein, 1901; (4) as *Fungia* (*Danafungia*) *danai* Milne Edwards & Haime, 1851; (5) as *Lithophyllon undulatum* Rehberg, 1892; (6) as *Podabacia* sp. (see Veron 1990b).

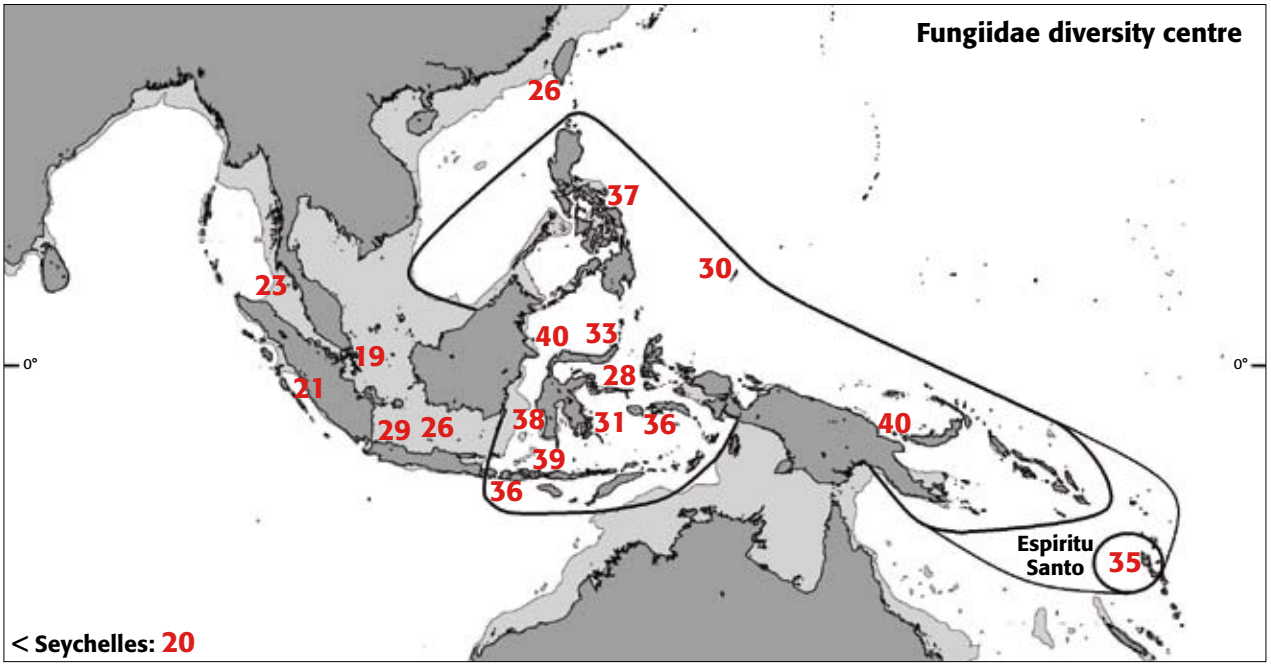

Figure 432: A hypothetical Coral Triangle based on mushroom coral data (Hoeksema 2007), with an additional southeastern extension including Espiritu Santo, based on results obtained during the Santo 2006 expedition.

new to science. It is remarkable that many species were abundant (present at almost each site), whereas other ones were quite rare (Table 39), which may be important for their role as potential host species for associated molluscs. Twelve species were absent:

- *Fungia* (*Cycloseris*) *distorta* Michelin, 1842
- *F.* (*Verrillofungia*) *scabra* Döderlein, 1901
- *F.* (*Danafungia*) *fralinae* Nemenzo, 1955
- *F.* (*Pleuractis*) *taiwanensis* Hoeksema & Dai, 1991
- *F.* (*P.*) *seychellensis* Hoeksema, 1993
- *Sandalolitha dentata* Quelch, 1884
- *Halomitra clavator* Hoeksema, 1989
- *Lithophyllon undulatum* Rehberg, 1892
- *L. ranjithi* Ditlev, 2003
- *Cantharellus doederleini* (Von Marenzeller, 1907)
- *C. noumeae* Hoeksema & Best, 1984
- *Podabacia* sp.

The 19 species (54%) that have been recorded earlier from Vanuatu were either represented in museum collections or observed during an Australian expedition. The presently reported increase in the number of mushroom coral species of the known coral fauna of Vanuatu, suggests that the number of all reef coral species (296) recorded previously by Veron in 1990, should be much higher also. On the other hand, this number also includes some synonyms (Table 39). Extrapolation of the mushroom coral species numbers projected on all reef coral species, suggests that more than 500 reef coral species are to be expected, which would be enough to consider Espiritu Santo part of the centre of coral species richness. Therefore, the present mushroom coral data suggest that the Coral Triangle should have a southeastern extension, including Espiritu Santo and adjacent parts of Vanuatu (Fig. 432).

ASSOCIATED MOLLUSCS

Just a list of coral species does not give us complete idea of marine biodiversity. Most coral species are known to act as host for symbionts, such as crustaceans and molluscs. We found representatives of various species of boring mussels (Mytilidae: *Lithophaga* spp., *Fungiacava eilatensis*) and snails (Coralliophilidae: *Leptoconchus* spp.) living as endoparasites inside mushroom corals (Table 40). Furthermore, a total of nine species of parasitic wentletrap snails (Epitoniidae) has been found in association with mushroom corals only. This number represents just more than 50% of the 17 epitoniids known to occur with Fungiidae. An additional three species were found on other coral hosts (Table 40). Such observations are only possible when the coral hosts are well known and systematically searched for their associated fauna.

Seven epitoniid species were not found despite the presence of potential coral hosts, i.e.:

- *Surrepifungium oliverioi* (Bonfitto & Sabelli, 2001) known from various host species,
- *Epitonium crassicostatum* Gittenberger & Gittenberger, 2005, known from *Fungia* (*Cycloseris*) *costulata*,
- *E. graviarmatum* Gittenberger & Gittenberger, 2005, known from *F.* (*Cycloseris*) *vaughani*,
- *Epifungium adgranulosa* Gittenberger & Gittenberger, 2005, known from *F.* (*Wellsofungia*) *granulosa*,

Table 40: Stony corals (Scleractinia) and their associated molluscan fauna observed at Espiritu Santo (Santo 2006).

Fungiidae acting as host (with miscellaneous parasites)	**Coralliophilidae**	**n**	**Epitoniidae**	**n**
Ctenactis crassa	*Leptoconchus* sp.	1	*Surrepifungium costulatum* (Kiener, 1838)	4
			Surrepifungium ingridae (Gittenberger & Goud, 2000)	1
			Surrepifungium patamakanthini Gittenberger & Gittenberger, 2005	2
Ctenactis echinata			*Surrepifungium costulatum* (Kiener, 1838)	1
Fungia (*Cycloseris*) *costulata* - 1 *Fungiacava eilatensis* - 1 *Lithophaga* sp.	*Leptoconchus* sp.	5	*Epifungium lochi* (Gittenberger & Goud, 2000)	1
Fungia (*Fungia*) *fungites*	*Leptoconchus* sp.	2	*Epifungium ulu* (Pilsbry, 1921)	1
Fungia (*Pleuractis*) *gravis*	*Leptoconchus* sp.	1		
Fungia (*Pleuractis*) *paumotensis*	*Leptoconchus* sp.	2	*Epifungium nielsi* Gittenberger & Gittenberger, 2005	3
Fungia (*Verrillofungia*) *concinna*	*Leptoconchus* sp.	2		
Fungia (*Verrillofungia*) *repanda*	*Leptoconchus* sp.	4	*Epifungium ulu* (Pilsbry, 1921)	3
Fungia (*Wellsofungia*) *granulosa* - 1 *Fungiacava eilatensis* - 1 *Coralliophila bulbiformis* (1st record *Coralliophila* on Fungiidae, M. Oliverio pers. comm.)	*Leptoconchus* sp.	2	*Epifungium adgranulosa* Gittenberger & Gittenberger, 2005	1
Halomitra pileus			*Epifungium ulu* (Pilsbry, 1921)	1
Heliofungia actiniformis	*Leptoconchus* sp.	1		
Herpolitha limax - 1 *Lithophaga* sp.	*Leptoconchus* sp.	5	*Epifungium twilae* (Gittenberger & Goud, 2000)	8
			Surrepifungium ingridae (Gittenberger & Goud, 2000)	3
Podabacia novaehibernae	*Leptoconchus* sp.	4		
Polyphyllia talpina	*Leptoconchus* sp.	1		
Sandalolitha robusta - 1 *Fungiacava eilatensis* - *Lithophaga* sp. in three specimens of *S. robusta*			*Epifungium pseudotwilae* Gittenberger & Gittenberger, 2005	7
			Epifungium ulu (Pilsbry, 1921)	1
Zoopilus echinatus			*Epifungium pseudotwilae* Gittenberger & Gittenberger, 2005	1
Scleractinia: non-Fungiidae		**n**		**n**
Plerogyra diabolotus			*Epifungium hartogi* (Gittenberger, 2003)	1
Hydnophora rigida	*Leptoconchus* sp.	1		
Tubularia sp.			*Epidendrium aureum* Gittenberger & Gittenberger, 2005	1
			Epidendrium sordidum Gittenberger & Gittenberger, 2005	3

- *E. adgravis* Gittenberger & Gittenberger, 2005, from *F. (Pleuractis) gravis*,
- *E. hoeksemai* (Gittenberger & Goud, 2000) only known from *Fungia* (*F.*) *fungites* and *Heliofungia actiniformis*,
- *E. lochi* (Gittenberger & Goud, 2000) known from various *Fungia* (*Cycloseris*) spp.

Only two wentletrap snail species were not observed, wich was due to the absence of their coral host:

- *Epifungium adscabra* Gittenberger & Gittenberger, 2005, known from *Fungia* (*Verrillofungia*) *scabra*,
- *E. marki* Gittenberger & Gittenberger, 2005, only known from a *Fungia* (*Pleuractis*) sp. at Egypt.

Obviously, potential coral hosts were sufficiently available. Some of these hosts were even abundantly present (Table 39). Epitoniid species that were not recorded were either overlooked, restricted by environmental factors, or Espiritu Santo is not included in their distribution range.

The Natural History of Santo

The islands of the Pacific are renowned for the high levels of endemism of, and threats to, their unique faunas and floras. Espiritu Santo, affectionately known simply as Santo, is an island of superlatives: the largest and highest in Vanuatu, Santo is an extraordinary geographical and cultural microcosm, combining reefs, caves, mountains, satellite islands, and a history of human habitation going back 3 000 years. In the spirit of famous voyages of discovery of the past, the Santo 2006 expedition brought together over 150 scientists, volunteers and students originating from 25 countries. With contributions by more than 100 authors, *The Natural History of Santo* is a lavishly illustrated homage to the biodiversity of this "planet-island". Bridging the gap between scientific knowledge and conservation and education, *The Natural History of Santo* was written with local stakeholders as well as armchair naturalists from all over the world in mind.

Les îles du Pacifique sont célèbres pour le très haut niveau d'endémisme et la grande vulnérabilité de leurs faunes et de leurs flores. L'île d'Espiritu Santo, ou Santo, cumule les superlatifs : la plus grande et la plus haute du Vanuatu, Santo est un extraordinaire microcosme géographique et culturel, avec récifs, grottes, montagnes, îles et îlots satellites, et une occupation humaine qui remonte à 3 000 ans. Renouant avec l'esprit des "Grandes Expéditions Naturalistes", l'expédition Santo 2006 avait mobilisé sur le terrain plus de 150 scientifiques, bénévoles et étudiants de 25 pays. Petit tour de force éditorial avec plus de 100 auteurs, ce *Natural History of Santo* est un éloge de la biodiversité de cette "île-planète". À la fois beau livre richement illustré et bilan des connaissances scientifiques, *The Natural History of Santo* se veut un outil de connaissance pour sa conservation durable. Il s'adresse autant aux acteurs locaux du développement et de l'éducation qu'aux naturalistes du monde entier.

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