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**ZOOXANTHELLATE SCLERACTINIAN CORALS OF THE NORTHERN
COAST OF SULAWESI**

BY

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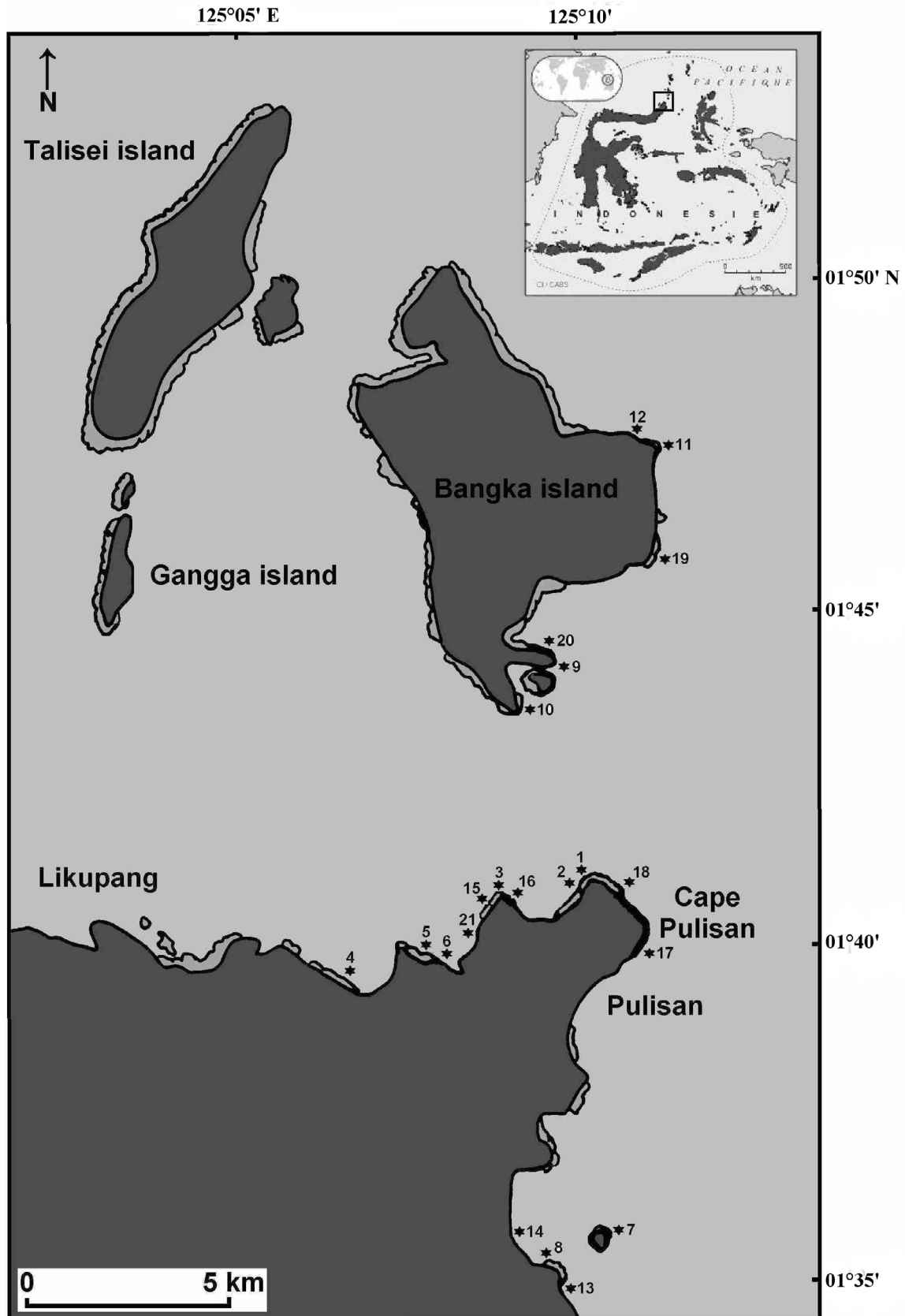


Figure 1. A map of northeast Sulawesi showing sampling locations. For details see Table 1.

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PATRICK SCAPS,¹ VIANNEY DENIS,¹ SIEGFRIED BERHIMPON,² AND FRANKY RUNTUKAHU²

ABSTRACT

The coral reefs of the Pulisan region, located at the northeast of the island of Sulawesi in Indonesia, were studied in order to acquire information concerning their richness in zooxanthellate scleractinian corals. Twenty-one sites were thus prospected covering a total surface of 74 km². In total, 376 species belonging to 65 genera and 14 families were observed during this study with an average-per-survey site of 109 species. *Acropora*, *Montipora* and *Porites* were the genera with the most species on Pulisan region reefs with 64, 24 and 23 species, respectively. Various estimates of the number of species suggest more than 400, making this area one of the most diversified in zooxanthellate scleractinian corals in the world for such a small area covered and placing it at the epicenter of the triangle of coral diversity.

INTRODUCTION

Stretching in an east-west direction for approximately 5,000 km and comprising an estimated 17,508 islands, Indonesia is the largest archipelagic nation in the world. Indonesian coral reefs cover the largest surface area in the world (85,707 km²), which represents about 14% of the world total (Tomascik *et al.*, 1997) and they are situated in the geographic zone of highest biodiversity, hence their intrinsic and patrimonial interest. Unfortunately, in the last decades, the coral reefs in Indonesia are experiencing increasing human-induced pressures, such as destructive fishing practices by using explosives and toxic chemicals; over-extraction of coral rocks, gravels and sand; and increasing land-based and marine-based pollutions. These human-induced pressures combined with natural disturbances such as volcanic activities, earthquakes, tsunamis, cyclones, climate change and the outbreak of crown-of-thorn starfish (*Acanthaster planci*) have caused many reefs in Indonesia to become severely damaged today. Suharsono (2003) reported that only about 6 percent of coral reef in Indonesia is in excellent condition (75-100% coral cover). The rest are in various degrees of damage: 33 percent in poor condition (less than 25% coral cover); 36 percent in moderate (26-50% cover); and only about 24 percent in good condition (51-75% cover).

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Considering the critical level of degradation of the coral reefs and the socioeconomic interest that they represent, it is urgent to assess tropical marine biodiversity and to increase the general awareness for the conservation of biodiversity and natural habitats. Accordingly, the principal goals of this study were to acquire data on zooxanthellate scleractinian coral richness on reefs and associated habitats in the Pulisan region (northeastern coast of Sulawesi) where a high diversity of marine environments is to be found and to compare the coral richness at different spatial scales (locally and regionally).

MATERIAL AND METHODS

The area selected for the field study is the Pulisan region located on the northeastern coast of Sulawesi, Indonesia (Fig. 1). The area lies near the center of global marine biodiversity or Coral Triangle composed of Indonesia, Philippines, Malaysia and Papua New Guinea. This region harbors the most biologically diverse coral reefs in the world. Observations were carried out in the field by diving during the summer of 2004 (08-17 August).

Corals were surveyed during about 23 hours of diving in 23 scuba dives to a maximum depth of 36 meters. For sampling locations and sites characteristics see Table 1. Each of the 21 sites were searched in one dive, with the exception of Efrata, which was particularly rich in coral species and which had three dives. During this study, the seawater temperature was between 27 and 28°C. Salinity ranged from 35-to-36‰. No difference was noticed between the surface and the bottom seawater temperature and salinity. Transparency of seawater, measured with a Secchi disk, varied from 13-to-18 m. Most of the sites were fringing reefs with developed reef crests and fairly steep reef slopes after which flat gentle slopes of sandy habitat dominated (Table 1).

The basic method consisted of underwater observations, usually during a 60-minute dive at each site. The name of each species identified underwater was marked on a plastic sheet on which species names were preprinted. A direct dive was made to the base of the reef, to-or-beyond the deepest visible coral. Dives consisted of a slow ascent along the reef in a zigzag path to the shallowest points. Sample areas of all habitats encountered were surveyed, including sandy areas, walls, overhangs, slopes and shallow reefs. Areas typically hosting few or no corals, such as seagrass beds and mangroves, were not surveyed. According to Fenner (2003), it is estimated that about 50-60 percent of the corals at an individual site can be recorded with this method due mainly to the time restriction. Many corals can be positively identified underwater to the species level but several species cannot be recognized with certainty without knowing skeleton details. In the latter case, corals were photographed in the field and representative samples were collected to enable a positive identification in the laboratory. Corals were bleached for 24-48 hours to remove tissue. They were then rinsed in freshwater, dried and identified following Dai (1989), Dai and Lin (1992), Hoeksema (1989), Hoeksema and Dai (1991), Moll and Best (1984), Sheppard and Sheppard (1991), Veron (2000, 2002), Veron and Hodgson (1989), Veron and Pichon (1976, 1980, 1982), Veron and Wallace (1984), Veron *et al.*, (1977), Wallace (1999), Wallace and Wolstenholme (1998) and Wijsman-Best (1974, 1976, 1977, 1980). These specimens of the present study were deposited in the collections of the University of Sam Ratulangi.

Table 1. Sampling locations and brief descriptions of sites.

Site	Site Name	GPS Coordinates	Depth max	Slope characteristics	Particular susceptibility and/or estimated level of use*
1	Machiko point	1°41'263" N, 125°9'895" E	14 m	pinnacle	often bombed – sedimentation heavy level of use
2	Sanders	1°40'896" N, 125°9'645" E	21 m	slope	coral bleaching - sedimentation
3	Mokotamba yuki	1°40'858" N, 125°8'821" E	15 m	slope	-
4	Paradise jetty	1°39'782" N, 125°6'189" E	17 m	slope	COT** - coral bleaching - broken corals sedimentation - heavy level of use
5	Mokotamba II	1°40'409" N, 125°7'690" E	15 m	sandy slope	sedimentation
6	Mokotamba III	1°40'145" N, 125°7'989" E	11 m	sandy slope	broken corals - sedimentation
7	Win's point	1°35'746" N, 125°10'664" E	26 m	sandy slope	-
8	Jafan point	1°35'373" N, 125°9'522" E	14 m	black sandy slope	broken corals - sedimentation
9	Tanjung sahaong	1°44'187" N, 125°9'825" E	36 m	wall	often bombed- moderate level of use
10	Sephia point	1°43'522" N, 125°9'125" E	18 m	sandy slope	-
11	Tanjung batugosoh	1°47'381" N, 125°11'137" E	14 m	pinnacles and slope	moderate level of use
12	Lihaga	1°47'612" N, 125°10'858" E	22 m	slope	broken corals - heavy level of use
13	Tanjung batu butih	1°34'851" N, 125°9'896" E	26 m	sandy slope	-
14	Magic windows	1°35'742" N, 125°8'984" E	14 m	black sandy slope	-
15	Yuki	1°40'672" N, 125°8'519" E	17 m	slope	-
16	Tanjung hell	1°40'784" N, 125°8'960" E	10 m	slope	-
17	Batu pandita	1°39'933" N, 125°10'782" E	34 m	wall	moderate level of use
18	Ferry point	1°41'010" N, 125°10'746" E	12 m	slope	-
19	Aimée point	1°45'784" N, 125°11'174" E	20 m	slope	-
20	Lihulu point	1°44'507" N, 125°9'660" E	10 m	slope	-
21	Efrata	1°40'336" N, 125°8'336" E	26 m	sandy slope	sedimentation

* After De Vantier and Turak (2004).

** Crown-of-thorns seasters *Acanthaster planci*

Cumulative curves were calculated with the EstimateS5 program (Colwell, 1999) which computes randomized species accumulation curves. We ran the program for 50 random drawings of the 21 stations. In order to compare the stations within the study area and the zooxanthellate scleractinian coral fauna of Pulisan area with other parts of southeast Asia and adjoining regions, data were analysed using the multivariate technique of agglomerative hierarchical cluster analysis based on Bray-Curtis similarities using the PRIMER v5 (Plymouth Routines in Multivariate Ecological Research, Clarke and Gorley, 2001) software.

RESULTS

Species Richness

A total of 376 species belonging to 65 genera and 14 families of zooxanthellate scleractinian corals were found in the Pulisan region survey (Appendix A).

Fig. 2 shows the correlation between the number of survey sites and the cumulative number of species identified. The curve represents a logarithmic relationship since this provides an excellent correlation ($R^2 = 0.989$). The accumulation curve indicates that species were added at a slower rate near the end of the survey, indicating that sufficient sites may have been surveyed although additional species were recorded towards the end of the present study and a further survey undoubtedly will reveal some extra species. Projections from the species accumulation curve all extrapolate the total richness at the study site over 400 species of zooxanthellate scleractinian corals: 408 species (Michaelis-Menten equation); 473 (Jack 1 resampling method); 516 (Jack 2 resampling method) and 421 (Bootstrap)

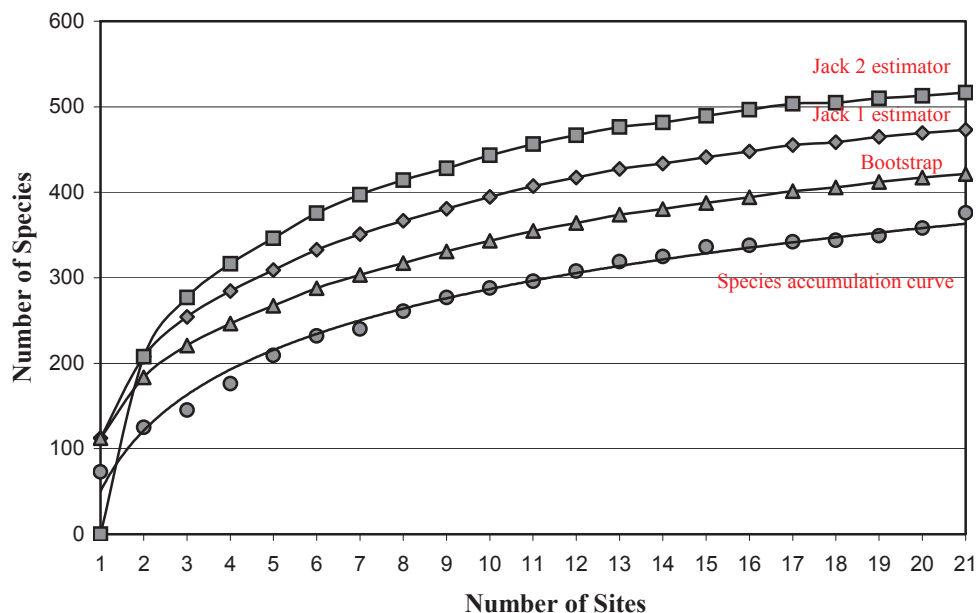


Figure 2. Species accumulation curves based on EstimateS5 (Colwell, 1989), Jackknife (Jack 1, Jack 2), and Bootstrap richness estimators.

Diversity at Individual Sites

The number of species at all sites is presented in Table 2. Species numbers at visually sampled sites ranged from 73-183, with an average of 109 per site. Efrata, Lihulu Point, Jafan Point, Mokotamba III and Mokotamba II had the highest species richness, with X, 133, 126, 126 and 124 species, respectively. Machiko point, Batu pandita and Tanjung sahaong had the lowest species richness with 73, 75 and 76 species, respectively.

Table 2. Number of species at sites.

Site	Site Name	Number of species
1	Machiko point	73
2	Sanders	96
3	Mokotamba Yuki	95
4	Paradise jetty	103
5	Mokotamba II	124
6	Mokotamba III	126
7	Win's point	94
8	Jafan point	126
9	Tanjung Sahaong	76
10	Sephia point	113
11	Tanjung Batugosoh	99
12	Lihaga	99
13	Tanjung batu butih	120
14	Magic window	106
15	Yuki	113
16	Tanjung hell	122
17	Batu pandita	75
18	Ferry point	108
19	Aimée point	104
20	Lihulu point	133
21	Efrata	183

General Faunal Composition

The genera with the largest numbers of species found were *Acropora*, *Montipora*, *Porites*, *Favia*, *Fungia*, *Leptoseris*, *Favites*, *Platygyra*, *Lobophyllia*, *Goniastrea*, *Turbinaria* and *Pavona*. These 12 genera account for about 54.5% of the total observed species (Table 3). The dominant genera were *Acropora*, *Montipora*, *Porites* with 64, 24 and 23 species, respectively. The further down the list one moves, the more variable the order becomes with both the number of species and the differences between genera decreasing.

Table 3. Most speciose genera of Pulisan zooxanthellate scleractinian corals.

Rank	Genus	Number of Species
1	<i>Acropora</i>	64
2	<i>Montipora</i>	24
3	<i>Porites</i>	23
4	<i>Favia</i>	15
5	<i>Fungia</i>	14
6	<i>Leptoseris</i>	12
7	<i>Favites</i>	11
8	<i>Platygyra</i>	9
8	<i>Lobophyllia</i>	9
10	<i>Goniastrea</i>	8
10	<i>Turbinaria</i>	8
10	<i>Pavona</i>	8

Comparison of Stations

The cluster analysis of Bray-Curtis similarity indices led to the identification of four distinct groups (Fig. 3). The first group (sites 9 and 17) was found in deep exposed stations only and was characterized by steep walls and a dominance of alcyonacean soft corals. Sites of this group had low zooxanthellate scleractinian coral species richness. The second group (sites 11, 12, 15, 16, 18, 19 and 20) was found in shallow (the reef slope reached with difficulty depths higher than 20 m) exposed sites with a prevalence of hard bottoms and high consolidated substratum. The third group (sites 5, 6, 7, 8, 10, 13, 14 and 21) was found in shallow sheltered sites with a sandy slope. The last group (sites 1, 2, 3 and 4) was found on shallow sites with moderate exposure. So this clustering analysis separated the sites strongly on depth and exposure.

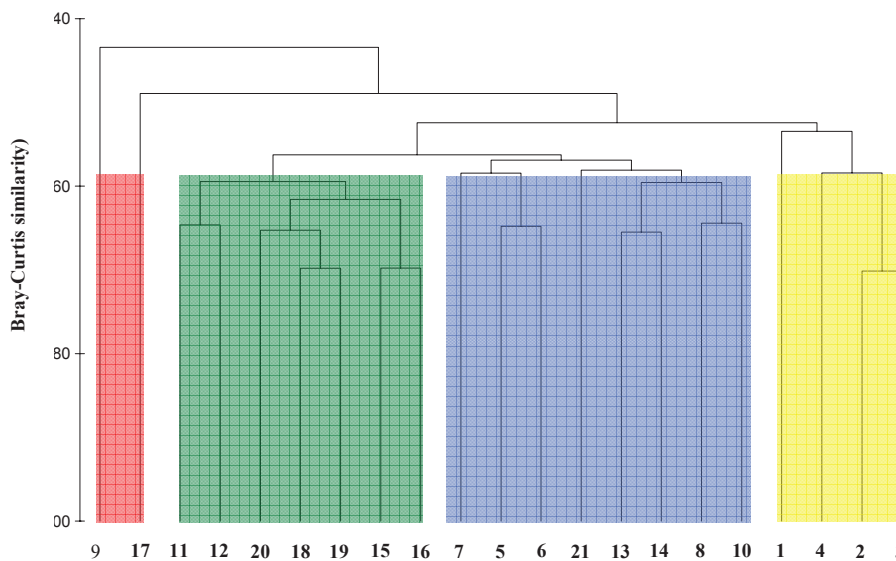


Figure 3. Hierarchical cluster analysis of 21 sites in the Pulisan region showing the 4 main groups.

Ecological Rarity

When occurrence at individual sites was considered, 27% of the species were observed at single sites (represented by single specimen or more), and only 34% were present in more than six sites (Fig. 4).

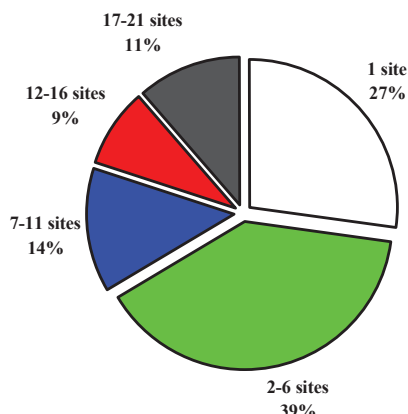


Figure 4. Ecological rarity of the zooxanthellate scleractinian corals from Pulisan.

Most of the 65 zooxanthellate scleractinian coral genera were observed at the first three sites (Table 4). The last genera, *Anacropora* and *Oulastrea*, were observed at site 14.

Table 4. Rarefaction data on genera of zooxanthellate scleractinian corals at Pulisan.

Family	Genus	First site encountered
Acroporidae	<i>Acropora</i>	1
	<i>Anacropora</i>	14
	<i>Astreopora</i>	1
	<i>Montipora</i>	1
Agariciidae	<i>Coeloseris</i>	1
	<i>Gardineroseris</i>	4
	<i>Leptoseris</i>	1
	<i>Pachyseris</i>	1
Astrocoeniidae	<i>Pavona</i>	1
	<i>Palauastrea</i>	2
	<i>Stylocoeniella</i>	8
Dendrophylliidae	<i>Turbinaria</i>	1
Euphylliidae	<i>Euphyllia</i>	1
	<i>Physogyra</i>	3
	<i>Plerogyra</i>	1
Faviidae	<i>Barabattoia</i>	5
	<i>Caulastrea</i>	1
	<i>Cyphastrea</i>	1
	<i>Diploastrea</i>	1
	<i>Echinopora</i>	1
	<i>Favia</i>	1
	<i>Favites</i>	1
	<i>Goniastrea</i>	1
	<i>Leptastrea</i>	5
	<i>Leptoria</i>	1
<i>Montastrea</i>	1	

Table 4 (continued)

	<i>Oulastrea</i>	14
	<i>Oulophyllia</i>	1
	<i>Platygyra</i>	1
	<i>Plesiastrea</i>	1
Fungiidae	<i>Cantharellus</i>	9
	<i>Ctenactis</i>	1
	<i>Cycloseris</i>	1
	<i>Diaseris</i>	2
	<i>Fungia</i>	1
	<i>Halomitra</i>	1
	<i>Heliofungia</i>	1
	<i>Herpolitha</i>	1
	<i>Lithophyllon</i>	8
	<i>Podabacia</i>	4
	<i>Polyphyllia</i>	1
	<i>Sandalolitha</i>	2
	<i>Zoopilus</i>	7
Merulinidae	<i>Hydnophora</i>	1
	<i>Merulina</i>	1
	<i>Scapophyllia</i>	2
Mussidae	<i>Acanthastrea</i>	1
	<i>Blastomussa</i>	12
	<i>Lobophyllia</i>	1
	<i>Scolymia</i>	4
	<i>Symphyllia</i>	1
Oculinidae	<i>Galaxea</i>	1
Pectiniidae	<i>Echinophyllia</i>	1
	<i>Mycedium</i>	1
	<i>Oxypora</i>	1
	<i>Pectinia</i>	1
Pocilloporidae	<i>Pocillopora</i>	1
	<i>Seriatopora</i>	1
	<i>Stylophora</i>	1
Poritidae	<i>Alveopora</i>	2
	<i>Goniopora</i>	2
	<i>Porites</i>	1
Siderastreidae	<i>Coscinarea</i>	4
	<i>Psammocora</i>	2
	<i>Siderastrea</i>	6

Zoogeographic Affinities

The comparison of the zooxanthellate scleractinian corals fauna of Pulisan region with other parts of southeast Asia and adjoining areas by a cluster analysis led to the identification of two distinct groups (Fig. 5). The first group includes the areas located at the heart of the Coral Triangle (the Philippines, central Indonesia and northern and eastern New Guinea) or to its immediate periphery (east peninsula Malaysia). Pulisan falls under this first group. The second group corresponds to more distant areas from the center of the “Coral Triangle”. The South-East Asia areas form a subgroup including the south of China and the gulf of Thailand and Tonkin in Vietnam. The areas forming this second group appear, except for the northeast of Australia, to be distinguished from the center of the Coral Triangle according to their geographical distance compared to this one.

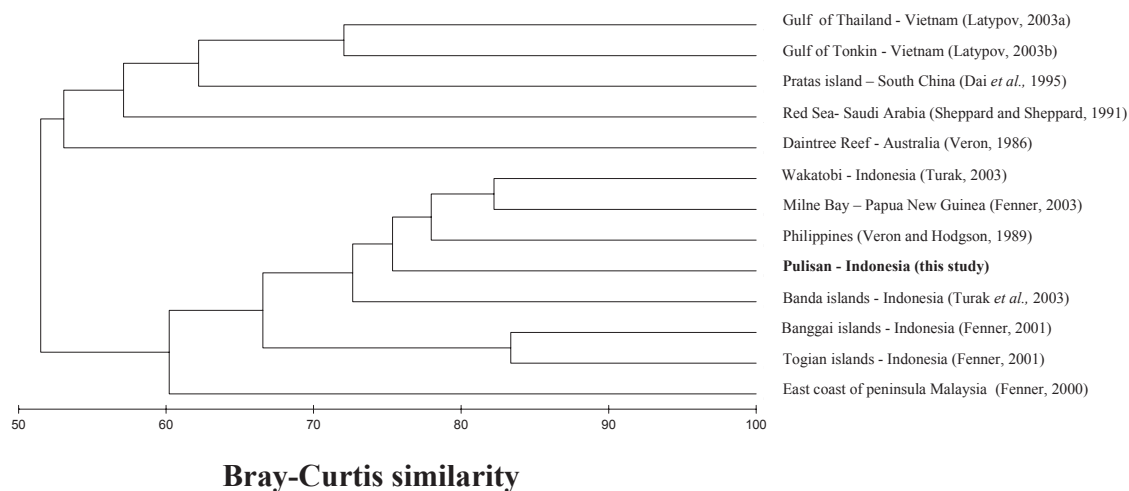


Figure 5. Hierarchical cluster analysis of zooxanthellate scleractinian corals at 13 localities.

DISCUSSION

The Pulisan region located on the northern coast of Sulawesi has a highly diverse zooxanthellate scleractinian coral fauna. A total of 376 species were observed or collected during the survey. Previous surveys have produced an average of 247 and 445 (Table 5) in other locations within the Coral Triangle area of highest diversity. Thus, the number of species per site was considerably higher than that found in several Coral Triangle areas: 247 species in the Banggai islands, Indonesia (Fenner, 2001); 252 species in the Togian islands, Indonesia, (Fenner, 2001); 294 species in Raja Ampat, Papua New Guinea (Fenner, 2002); 301 species in the Banda islands, Indonesia (Turak *et al.*, 2002); and 351 species in Kimbe Bay, Papua New Guinea (Turak and Aitsi, 2003). The total coral species count for Pulisan is somewhat less than for Wakatobi, Indonesia (396 species, Turak, 2003), Milne Bay, Papua New Guinea (Fenner, 2003) and Sangihe-Talaud, Indonesia (445 species, Turak, 2002). However in the other areas compared to Pulisan the sampling effort was more important, more sites were surveyed (27, 44 and 52 for Wakatobi, Sangihe-Talaud and Milne Bay, respectively compared to 21 for Pulisan) and the area surveyed was much smaller (Table 5). Besides what is most astonishing is the great number of species identified on such a small covered area (74 km²) compared to other surveys in the coral triangle (from 400 to 26 500 km², Table 5). This, combined with the fact that the various estimates of the number of species carry this study to more than 400 in the Pulisan region, makes this area one of the most diversified in zooxanthellate scleractinian corals in the world and places it at the epicenter of the triangle of coral diversity.

Table 5. Pulisan zooxanthellate scleractinian corals survey compared with several other areas in the Coral Triangle.

Region	Pulisan (Indonesia)	Banda islands (Indonesia)	Banggai islands (Indonesia)	Togian islands (Indonesia)	Sangihe Talaud (Indonesia)	Wakatobi (Indonesia)	Kimbe Bay (PNG)	Milne Bay (PNG)	Raja Ampat (PNG)
References	This study	Turak <i>et al.</i> , 2003	Fenner, 2001	Fenner, 2001	Turak, 2002	Turak, 2003	Turak and Aitsi, 2003	Fenner, 2003	Fenner, 2002
Total number of species	376	301	247	252	445	396	351	413	294
Maximum number of species per site	183	133	95	91	-	158	-	122	123
Number of genera	65	56	63	66	-	68	-	67	67
Number of families	14	14	14	15	-	15	-	15	15
Number of sites surveyed	21	18	19	28	52	27	27	57	44
Average number of species per site	109	106	68	65	100	124	124	82	87
% of sites with over 1/3 rd species	19	61	21	4	8	41	74	0	9
Area covered (km ²)	74	400	1912	755	23 000	10 000	1100	26 500	6000

The maximum number of species per site observed in the Pulisan region (183) is higher than those found elsewhere in the coral triangle (91-158, Table 5). This difference results from the fact that this particular site had three dives. If we take into account the average number of species at this particular site (129), then the maximum number of species per site (133) is completely in conformity with the range of the values obtained in other sites within the coral triangle and is close to the highest values (133 and 158 for the Banda islands and Wakatobi, respectively). The same observation can be made concerning the average number of species per site (109) which ranges from 65-to-124 in other locations within the coral triangle (Table 5). The percentage of sites containing more than one-third of the species is extremely variable according to the localization of the sites in the coral triangle (from 4-to-74%, Table 5). The value obtained for Pulisan (19%) is closer to that obtained for the islands of Banggai (21%) and indicates that only a few species are common to the whole of the stations. In addition, the study on the ecological rarity proved that only 34% of the species are present in more than six stations.

The number of families of zooxanthellate scleractinian corals observed in Pulisan region is identical to those observed elsewhere in the Coral Triangle (Table 5). The number of genera observed in the Pulisan region (65) is completely in conformity with the range of values obtained elsewhere in the coral triangle (56-67, Table 5) and is close to the highest values. *Acropora*, *Montipora* and *Porites* were the genera with the most species on Pulisan region reefs with 64, 24 and 23 species. These genera are usually the three more species-rich genera on rich Indo-Pacific reefs (Fenner, 2001). Some monospecific genera that were not observed in our study (*Catalaphyllia*, *Stylarea*, *Australomussa*, *Cynarina*, *Trachyphyllia*) can be considered as rare. Indeed Hoeksema (2003) observed these genera lately in the sector of Wakatobi (after 25, 17, 14, 24 and 21 dives, respectively). These genera are characteristics of very protected reef environments and sandy substrates; some of them (*Catalaphyllia*, *Cynarina* and *Trachyphyllia*) were observed on soft substrates in the Lembah strait located a few kilometers in the east of the studied area (Scaps personal observations) indicating that this kind of environment was not found or not prospected in the Pulisan region.

The scleractinian corals of Indonesia belong to the overall Indo-Pacific faunal province. Eighty-two genera and about 590 species of scleractinian corals have been recorded in Indonesia and its surrounding waters (Best *et al.*, 1989; Tomascik *et al.*, 1997; Veron, 2002). The area enclosing central and eastern Indonesia, the Philippines and northern (Hoeksema, 1992) and eastern Papua New Guinea is the central area of highest biodiversity in corals referred to as the Coral Triangle (Hoeksema, 1992). Some evidence (Best *et al.*, 1989) indicates western Indonesia may not be included in the Coral Triangle. The region of Pulisan is definitely part of the center of highest diversity regarding zooxanthellate scleractinian corals. This is consistent with its geographical position on the northern coast of Sulawesi. Most of the species found in the Pulisan region have fairly wide distributions within the Indo-Pacific. This can be explained because a majority of species have a pelagic larval stage which lasts with a minimum of a few days, pelagic development for broadcast spawners and larval settling competency lasting for at least a few weeks. A minority of species release brooded larvae that may be capable of anything from immediate settlement to a long pelagic dispersal period (Fenner, 2001).

In conclusion, all the data obtained at the time of this study are convergent and indicate that the coral reefs of the Pulisan region are part of the Coral Triangle. The peculiarity of the Pulisan region compared to the other areas of the Coral Triangle studied until now is that the various zooxanthellate scleractinian coral species are concentrated on a very small area making this region a hot spot of biodiversity.

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REFERENCES

- Best, M.B., B.W. Hoeksema, W. Moka, H. Moll, Suharsono, and I.N. Sutarna
1989. Recent scleractinian coral species collected during the Snellius-II Expedition in eastern Indonesia. *Netherlands Journal of Sea Research* 23:107-115.
- Colwell, R.K.
1999. EstimateS: statistical estimation of species richness and shared species from samples, Version 5. Available from <http://viceroy.eeb.uconn.edu/estimates/>
- Clarke, K.R., and R.N. Gorley
2001. PRIMER v5: User Manual/Tutorial, PRIMER-E Ltd: Plymouth.
- Dai, C.F.
1989. Scleractinia of Taiwan. I. Families Astrocoeniidae and Pocilloporidae. *Acta Oceanographica Taiwanica* 22:83-101.
- Dai, C.F., and C.H. Lin
1992. Scleractinia of Taiwan. III Family Agariciidae. *Acta Oceanographica Taiwanica* 28:80-101.
- Dai, C.F., T.Y. FAN., and C.S. WU
1995. Coral fauna of Tungsha Tao (Pratas Islands). *Acta Oceanographica Taiwanica* 34:1-16.
- DeVantier, L.D., and E. Turak
2004. Managing Marine Tourism in Bunaken National Park and Adjacent Waters, North Sulawesi, Indonesia. Technical Report by the Natural Resources Management, Program's Protected Areas and Agriculture Team, 157 pp.
- Fenner, D.
2004. Reef corals of the Togian and Banggai Islands, Sulawesi, Indonesia. In G.R. Allen, T.B. Werner and S. A. McKenna (eds). A rapid biodiversity assessment of the coral reefs of the Togean and Banggai islands, Sulawesi, Indonesia.

- Conservation International Washington, DC. RAP Bulletin of Biological Assessment 20, pp. 18-25 and pp. 63-71.
- Fenner, D.
2002. Reef corals of the Raja Ampat Islands, Papua Province, Indonesia. In S.A. McKenna, G. R. Allen and S. Suryadi S (eds). A marine rapid assessment of the Raja Ampat Islands, Papua Province, Indonesia. Conservation International Washington, DC. RAP Bulletin of Biological Assessment 22, pp. 29-36 and pp. 104-112.
- Fenner, D.
2002. Corals of Milne Bay Province, Papua New Guinea. In G. R. Allen, J. P. Kinch, S. A. McKenna and P. Seeto (eds). A rapid marine biodiversity assessment of Milne Bay Province, Papua New Guinea Conservation International Washington, DC. RAP Bulletin of Biological Assessment 29, pp. 20-26.
- Harborne, A., D. Fenner, A. Barnes, M. Beger, S. Harding S, and T. Roxburgh
2000. Status report on the coral reefs of the east coast of peninsula malaysia. Report by the Coral Cay Conservation, LTD, 88 pp.
- Hoeksema, B.W.
1989. Taxonomy, phylogeny and biogeography of mushroom corals (Scleractinia: Fungiidae). *Zoologische Verhandelingen* 254:1-295.
- Hoeksema, B.W.
1992. The position of northern New Guinea in the center of marine benthic diversity: a reef coral perspective. *Proceedings of the Seventh International Coral Reef Symposium* 2:710-717.
- Hoeksema, B.W.
2003. Mushroom coral species and scleractinian genera. In L. Pet-Soedee and M. Erdmann (eds). Rapid Ecological Assessment of Wakatobi National Park, Southeast Sulawesi, Indonesia. The Nature Conservancy and WWF, pp. 65-74.
- Hoeksema, B.W., and C.F. Dai
1991. Scleractinia of Taiwan. II. Family Fungiidae. *Bulletin of the Institute of Zoology, Academia Sinica* 30:201-226.
- Latypov, Y.Y.
2003a. Reef-Building Corals and Reefs of Vietnam: 1. The Gulf of Thailand. *Russian Journal of Marine Biology* 29:22-34.
- Latypov, Y.Y.
2003b. Reef-Building Corals and Reefs of Vietnam: 2. The Gulf of Tonkin. *Russian Journal of Marine Biology* 29:34-45.
- Moll, H., and M. B. Best
1984. New scleractinian corals (Anthozoa: Scleractinia) from the spermonde Archipelago, south Sulawesi, Indonesia. *Zoologische Mededelingen* 58:47-58.
- Sheppard, C.R.C., and A. L.S. Sheppard
1991. Corals and coral communities of Arabia. *Fauna of Saudi Arabia* 12:3-170.
- Suharsono
2003. A summary comparison of the status coral reef in Indonesia, 648 stations. LIPI (Lembaga Ilmu Pengetahuan Indonesia).

- Tomascik, T., A.J. Mah, A. Nontji, and M.K. Moosa
1997. *The Ecology of the Indonesian Seas, Vols 1-2*. Singapore: Periplus.
- Turak, E.
2002. Assessment of coral biodiversity and coral reef health of the Sangihe-Talaud Islands, North Sulawesi, Indonesia, 2002. TNC Report.
- Turak, E.
2003. Coral diversity and distribution. In L. Pet-Soede and M. Erdmann (eds). *Rapid Ecological Assessment of Wakatobi National Park, Southeast Sulawesi, Indonesia*. The Nature Conservancy and WWF, pp. 33-50 and pp. 142-161.
- Turak, E., and J. Aitsi
2003. Assessment of coral biodiversity and status of coral reefs of East Kimbe Bay, New Britain, Papua New Guinea, 2002. TNC Report.
- Turak, E., M. Wakeford, and T. Done
2003. Banda Islands rapid ecological assessment, May 2002: Assessment of coral biodiversity and coral reef health. In J. Mous editor. Report on a rapid ecological assessment of the Banda Islands, Maluku, Eastern Indonesia, held April 28 – May 5 2002. The Nature Conservancy and UNESCO publication, pp 1-150.
- Veron, J.E.N.
1986. Checklist of corals from Daintree Reefs. *Great Barrier Reef Marine Park Authority Workshop Series* 9:99-103.
- Veron, J.E.N.
2000. *Corals of the World, Vols 1-3*. Townsville: Australian Institute of Marine Science.
- Veron J.E.N.
2002. New species described in Corals of the World. *Australian Institute of Marine Science Monograph Series* 11:1-206.
- Veron J.E.N., and G. Hodgson
1989. Annotated checklist of the hematypic corals of the Philippines. *Pacific Science* 43:234-287.
- Veron J.E.N., and M. Pichon
1976. Scleractinia of Eastern Australia. I. Families Thamnasteriidae, Astrocoeniidae, Pocilloporidae. *Australian Institute of Marine Science Monograph Series* 1:1-86.
- Veron J.E.N., and M. Pichon
1980. Scleractinia of Eastern Australia. III. Famille Agariciidae, Siderastreidae, Fungiidae, Oculinidae, Merulinidae, Mussidae, Pectinidae, Caryophyllidae, Dendrophyllidae. *Australian Institute of Marine Science Monograph Series* 4:1-422.
- Veron J.E.N., and M. Pichon
1982. Scleractinia of Eastern Australia. IV. Family Poritidae. *Australian Institute of Marine Science Monograph Series* 5:1-210.
- Veron J.E.N., and C.C. Wallace
1984. Scleractinia of Eastern Australia. V. Family Acroporidae. *Australian Institute of Marine Science Monograph Series* 6:1-485.

- Veron, J.E.N., M. Pichon, and M. Wijsman-Best
1977. Scleractinia of Eastern Australia. II. Families Faviidae, Trachyphyllidae. *Australian Institute of Marine Science Monograph Series* 3:1-233.
- Wallace, C.C.
1999. Staghorn corals of the world, a revision of the genus *Acropora*. Collingwood, Australia: CSIRO Publishing. 422 pp.
- Wallace, C.C., and J. Wolstenholme
1998. Revision of the coral genus *Acropora* in Indonesia. *Zoological Journal of the Linnean Society* 123:189-384.
- Wijsman-Best, M.
1974. Biological results of the Snellius expedition XXV. Faviidae collected by the Snellius expedition. I. The genus *Favia*. *Zoologische Mededelingen* 48:249-261.
- Wijsman-Best, M.
1976. Biological results of the Snellius expedition XXVII. Faviidae collected by the Snellius expedition. II. The genera *Favites*, *Goniastrea*, *Platygyra*, *Oulophyllia*, *Leptoria*, *Hydnophora* and *Caulastrea*. *Zoologische Mededelingen* 50: 45-63.
- Wijsman-Best, M.
1977. Indo-Pacific coral species belonging to the subfamily Montastreinae Vaughan & Wells, 1943 (Scleractinia-Coelenterata) Part I. The genera *Montastrea* and *Plesiastrea*. *Zoologische Mededelingen* 52:83-97.
- Wijsman-Best, M.
1980. Indo-Pacific coral species belonging to the subfamily Montastreinae Vaughan & Wells, 1943 (Scleractinia-Coelenterata) Part II. The genera *Cyphastrea*, *Leptastrea*, *Echinopora* and *Diploastrea*. *Zoologische Mededelingen* 55:235-263.

