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ZOOXANTHELLATE SCLERACTINIAN CORALS OF THE NORTHERN COAST OF SULAWESI

BY

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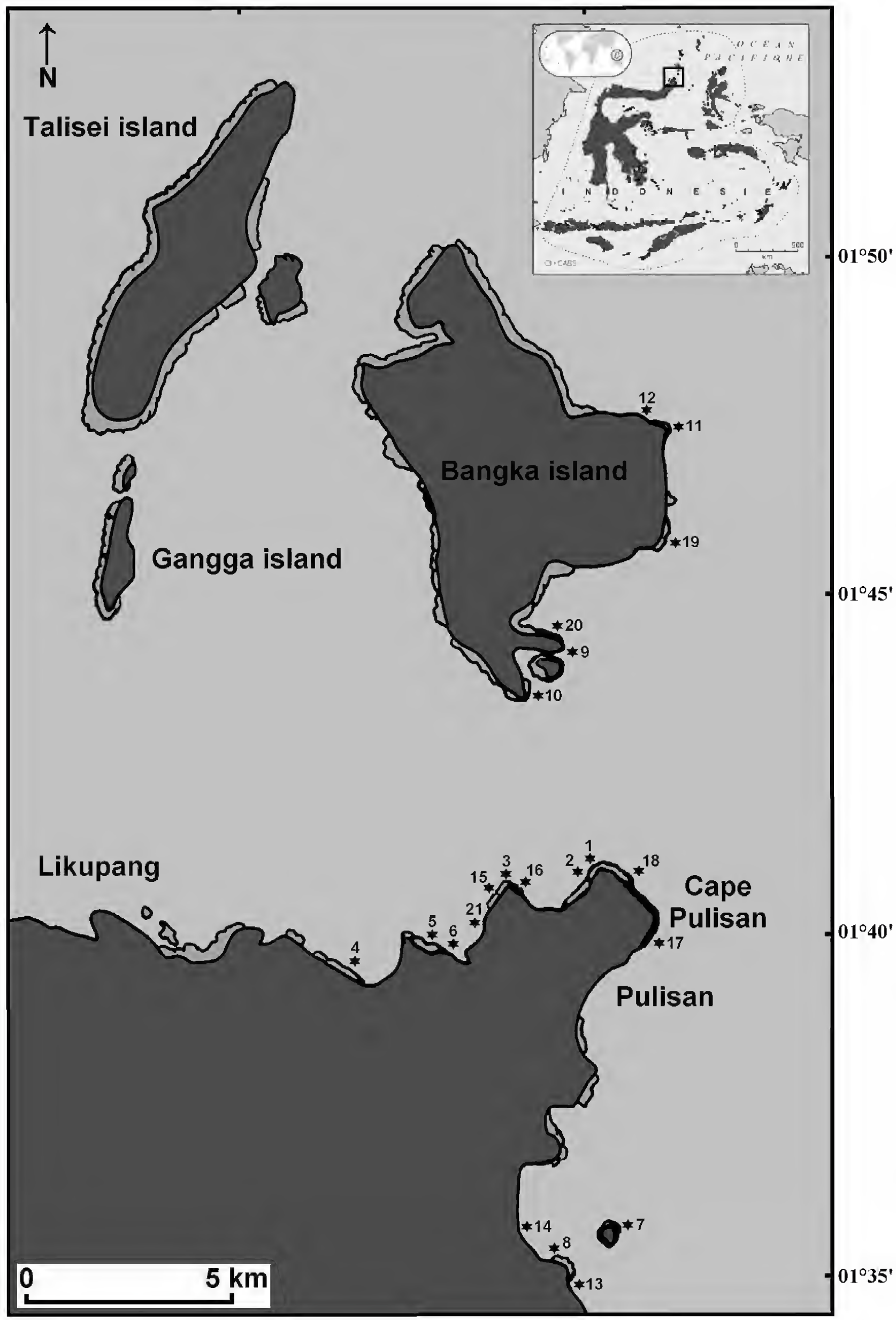

Figure 1. A map of northeast Sulawesi showing sampling locations. For details see Table 1.

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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 DeVantier and Turak (2004).
** Crown-of-thorns seastars *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 (Plylmouth 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)

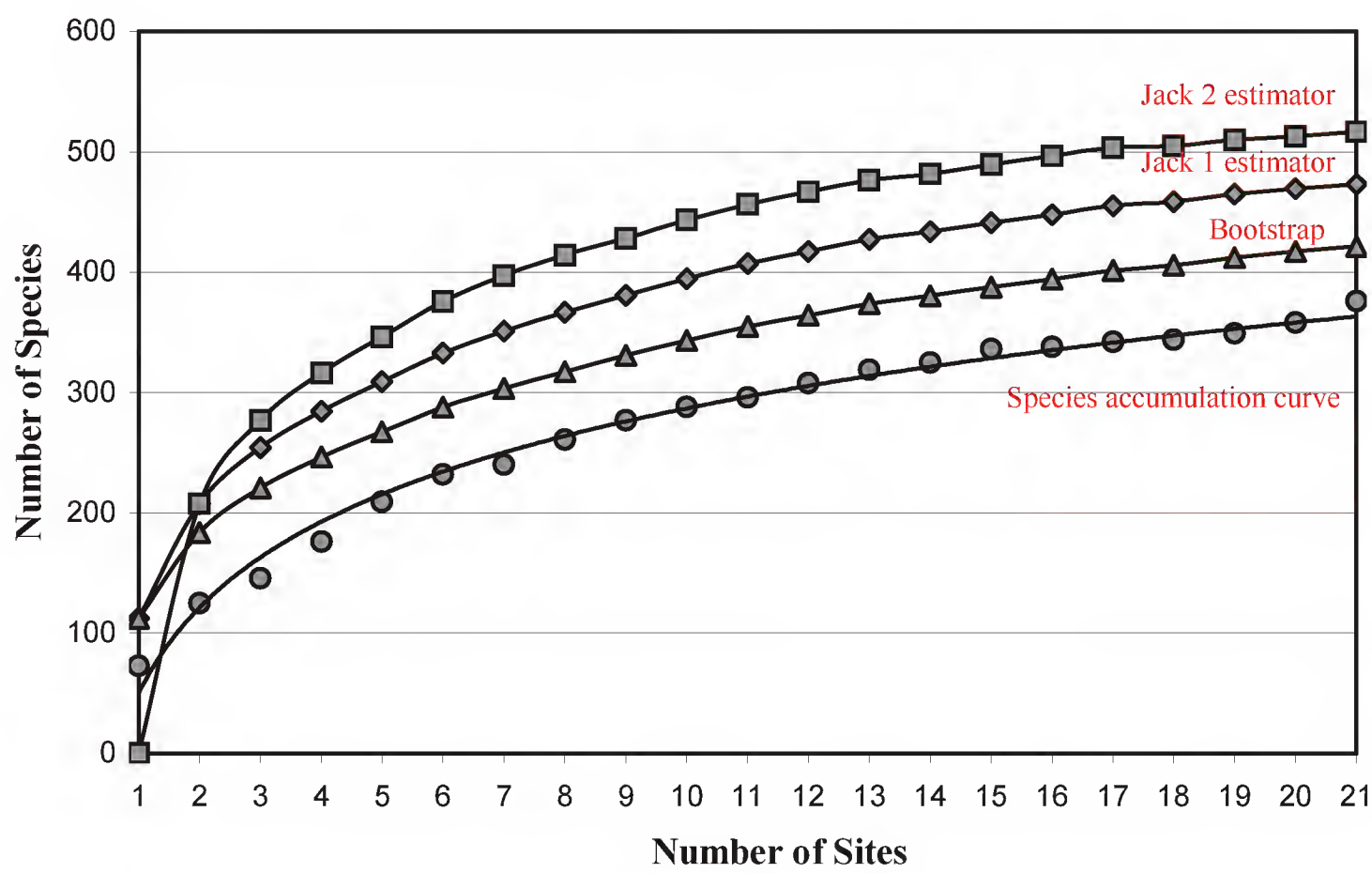

Figure 2. Species accumulation curves based on EstimateS5 (Colwell, 1989), Jackknife (Jack 1, Jack 2), and Bootstrap richness estimators.

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 Mokatamba 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	*Acropora*	64
2	*Montipora*	24
3	*Porites*	23
4	*Favia*	15
5	*Fungia*	14
6	*Leptoseris*	12
7	*Favites*	11
8	*Platygyra*	9
8	*Lobophyllia*	9
10	*Goniastrea*	8
10	*Turbinaria*	8
10	*Pavona*	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.

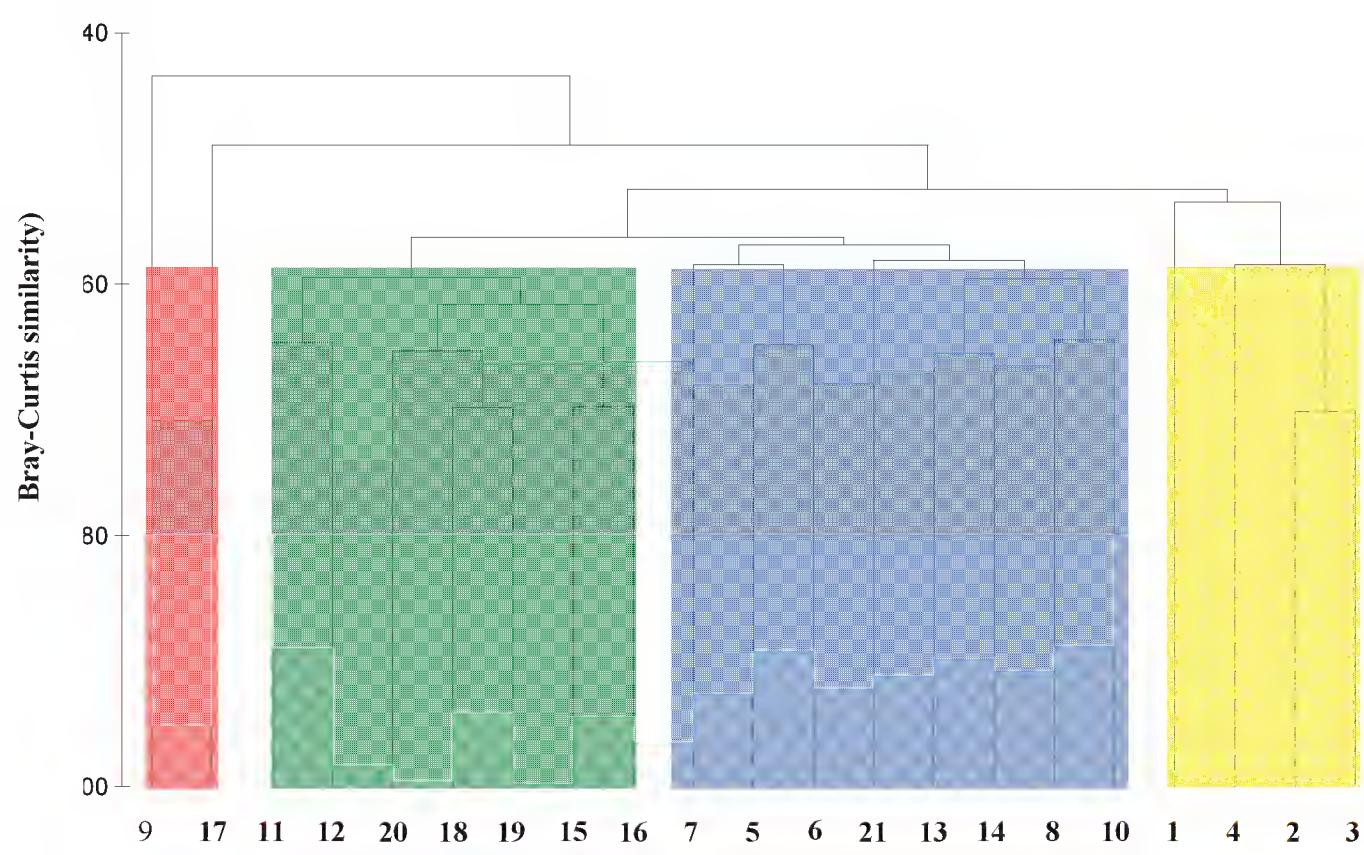

Figure 3. Hierarchical cluster analysis of 21 sites in the Pulisan region showing the 4 main groups.

Ecological Rarity

When occurence 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).

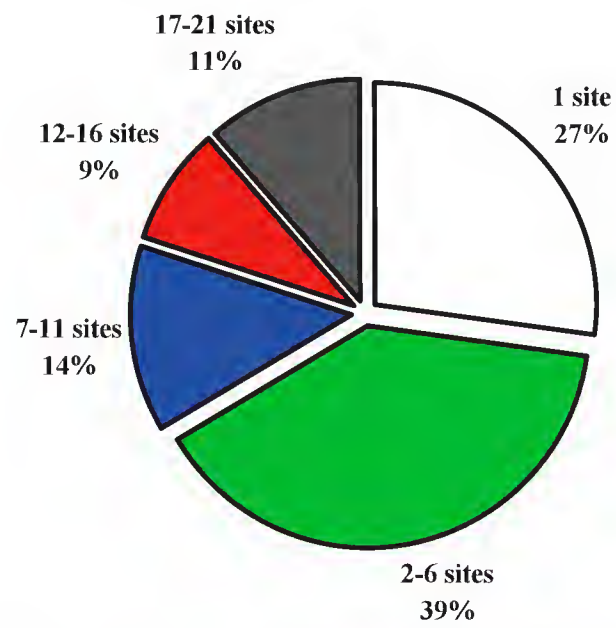

Figure 4. Ecological rarity of the zooxanthellate scleractinian corals from Pulisan.

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	*Acropora*	1
	Anacropora	14
	Astreopora	1
	Montipora	1
Agariciidae	*Coeloseris*	1
	Gardineroseris	4
	Leptoseris	1
	Pachyseris	1
	Pavona	1
Astrocoeniidae	*Palauastrea*	2
	Stylocoeniella	8
Dendrophylliidae	*Turbinaria*	1
Euphylliidae	*Euphyllia*	1
	Physogyra	3
	Plerogyra	1
Faviidae	*Barabattoia*	5
	Caulastrea	1
	Cyphastrea	1
	Diploastrea	1
	Echinopora	1
	Favia	1
	Favites	1
	Goniastrea	1
	Leptastrea	5
	Leptoria	1
	Montastrea	1

Table 4 (continued)

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

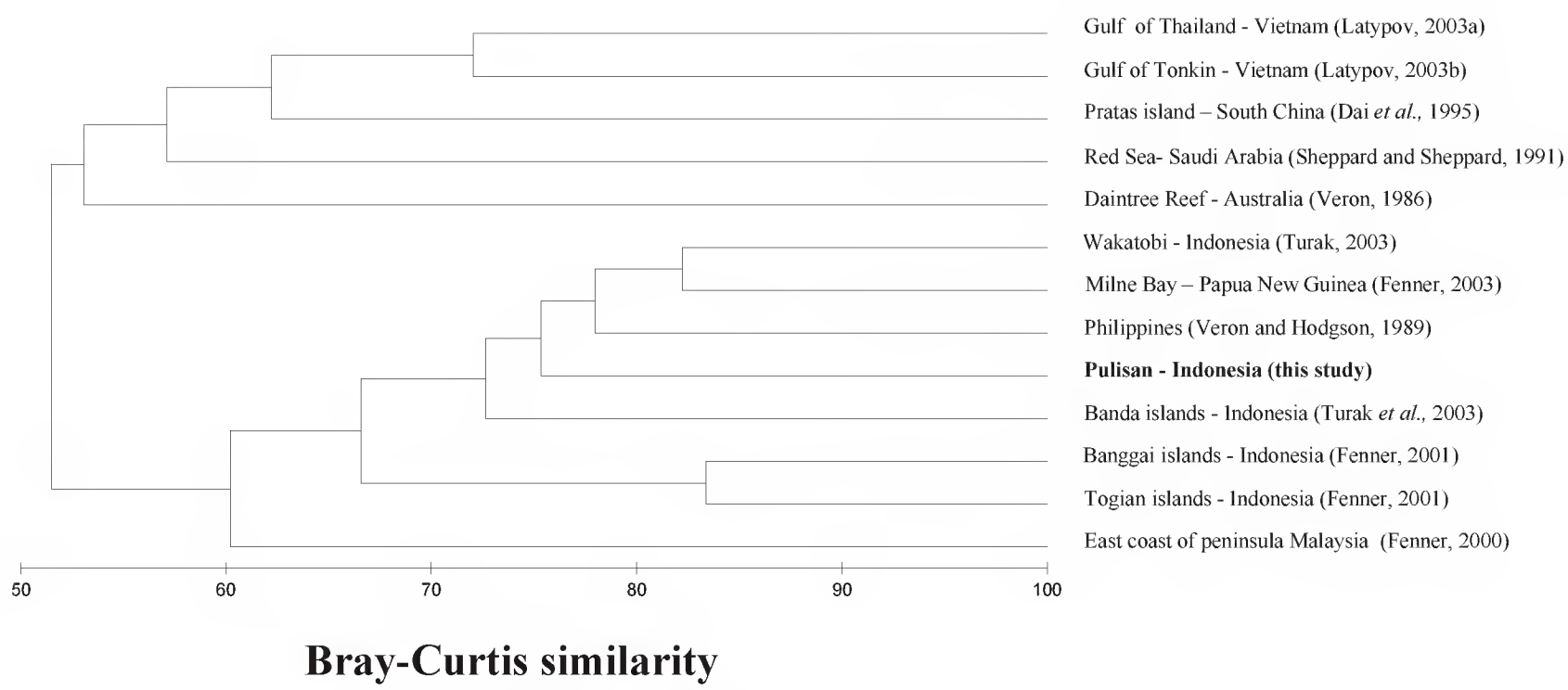

Figure 5. Hierarchical cluster analysis of zooxanthellate scleractinian corals at 13 localities.

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 km^2) compared to other surveys in the coral triangle (from 400 to 26 500 km^2, 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.

Région	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 *et al.*, 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 (km²)	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 monospecifc 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 Lembeh 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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Appendix A: Zooxanthellate scleractinian corals recorded at individual sites (Table 1) in the Pulisan region.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	sites
	Astrocoeniidae																						
1	*Palaustrea ramosa*		x			x	x																3
2	*Stylocoeniella armata*								x										x	x		x	4
	Pocilloporidae																						
3	*Pocillopora damicornis*					x	x						x			x	x	x		x	x		8
4	*Pocillopora danae*									x													1
5	*Pocillopora eydouxi*			x	x		x	x		x	x	x	x	x				x	x	x	x	x	14
6	*Pocillopora meandrina*					x						x	x			x	x				x		6
7	*Pocillopora verrucosa*	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
8	*Seriatopora caliendrum*	x	x	x	x	x	x	x	x	x	x	x				x	x		x	x		x	16
9	*Seriatopora dentritica*																	x				x	2
10	*Seriatopora guttatus*					x	x																2
11	*Seriatopora hystrix*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	21
12	*Seriatopora stellata*		x					x			x	x		x	x		x	x		x		x	10
13	*Stylophora pistillata*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	21
14	*Stylophora subseriata*			x	x	x	x	x						x	x	x			x				9
	Acroporidae																						
15	*Acropora abrolhosensis*		x			x																	2
16	*Acropora abrotanoides*										x												1
17	*Acropora aculeus*									x													1
18	*Acropora anthocercis*										x												1
19	*Acropora awi*		x																			x	2
20	*Acropora bifurcata*											x											1
21	*Acropora brueggemani*																				x		1
22	*Acropora carduus*									x													1
23	*Acropora cerealis*		x	x							x			x		x							5
24	*Acropora clathrata*									x						x				x	x	x	5
25	*Acropora cophodactyla*																			x		x	2
26	*Acropora crateriformis*												x										1
27	*Acropora cylindrica*					x																	1
28	*Acropora cytherea*					x	x	x	x			x		x	x					x		x	9
29	*Acropora desalwii*						x												x				2
30	*Acropora digitifera*	x				x		x	x		x											x	6
31	*Acropora divaricata*															x	x						2
32	*Acropora donei*						x																1
33	*Acropora elegans*																					x	1
34	*Acropora exquisita*			x	x															x		x	4
35	*Acropora florida*	x		x	x	x								x		x	x					x	8
36	*Acropora formosa*				x	x					x		x	x		x	x		x	x			9
37	*Acropora gemmifera*											x	x	x	x		x	x					6
38	*Acropora globiceps*						x			x													2
39	*Acropora grandis*							x									x						2
40	*Acropora granulosa*		x	x		x	x						x	x	x	x	x		x		x	x	12
41	*Acropora horrida*		x									x		x				x		x		x	6
42	*Acropora humilis*		x		x	x	x	x	x				x	x		x	x		x	x	x	x	14
43	*Acropora hyacinthus*		x			x						x		x		x	x		x	x	x	x	10
44	*Acropora indonesia*					x	x															x	3
45	*Acropora kimbeensis*																				x		1
46	*Acropora kirstyae*		x								x												2
47	*Acropora latistella*											x									x		2
48	*Acropora loisetteae*																					x	1
49	*Acropora loripes*		x	x			x	x			x	x	x	x	x	x	x		x	x	x	x	15
50	*Acropora microclados*					x			x		x			x								x	5
51	*Acropora microphthalma*															x	x						2
52	*Acropora millepora*	x																				x	2
53	*Acropora monticulosa*			x					x	x		x	x	x			x	x	x	x	x	x	12
54	*Acropora nana*																			x			1
55	*Acropora nasuta*								x		x				x								3
56	*Acropora nobilis*					x	x															x	3
57	*Acropora palifera*									x	x										x	x	4

58	*Acropora palmerae*											x									x		2
59	*Acropora paniculata*																			x			1
60	*Acropora pinguis*									x													1
61	*Acropora plana*								x		x											x	3
62	*Acropora plumosa*													x							x	x	3
63	*Acropora pulchra*									x									x	x	x	x	5
64	*Acropora robusta*												x										1
65	*Acropora russelli*		x																				1
66	*Acropora samoensis*											x	x										2
67	*Acropora sarmentosa*													x					x		x		3
68	*Acropora secale*										x		x	x	x						x	x	6
69	*Acropora selago*															x							1
70	*Acropora seriata*									x	x								x	x			4
71	*Acropora solitaryensis*												x							x			2
72	*Acropora speciosa*				x																		1
73	*Acropora subulata*																					x	1
74	*Acropora tenuis*															x							1
75	*Acropora valenciennesi*																				x		1
76	*Acropora valida*															x	x		x		x		4
77	*Acropora verweyi*																					x	1
78	*Acropora yongei*		x																			x	2
79	*Anacropora matthai*																					x	1
80	*Anacropora pillai*														x							x	2
81	*Astreopora expensa*																					x	1
82	*Astreopora gracilis*																				x		1
83	*Astreopora incrustans*								x														1
84	*Astreopora listeri*					x	x																2
85	*Astreopora myriophthalma*	x		x	x	x		x	x		x	x	x	x			x		x	x	x	x	15
86	*Astreopora suggesta*																			x	x	x	3
87	*Montipora aequituberculata*																	x		x	x	x	4
88	*Montipora capitata*												x										1
89	*Montipora cocosensis*											x											1
90	*Montipora confusa*								x				x	x	x	x	x	x	x	x	x	x	11
91	*Montipora corbettensis*																	x	x				2
92	*Montipora danae*									x													1
93	*Montipora digitata*	x	x	x	x	x	x	x			x	x	x						x			x	12
94	*Montipora efflorescens*																				x		1
95	*Montipora floweri*						x																1
96	*Montipora foliosa*			x		x						x											3
97	*Montipora foveolata*		x		x	x	x		x						x							x	7
98	*Montipora grisea*					x			x										x				3
99	*Montipora hodgsoni*														x								1
100	*Montipora hoffmeisteri*																				x		1
101	*Montipora informis*																	x	x	x	x	x	5
102	*Montipora mactanensis*															x							1
103	*Montipora millepora*		x									x	x							x	x		5
104	*Montipora monasteriata*		x	x	x	x	x			x	x	x					x	x		x			11
105	*Montipora palawensis*					x						x											2
106	*Montipora spumosa*												x										1
107	*Montipora tuberculosa*															x				x		x	3
108	*Montipora turgescens*												x										1
109	*Montipora undata*				x	x	x	x				x	x					x	x	x		x	10
110	*Montipora vietnamensis*															x	x						2
	Poritidae																						
111	*Alveopora allingi*																					x	1
112	*Alveopora deadalea*		x	x	x				x		x												5
113	*Alveopora excelsa*															x							1
114	*Alveopora fenestrata*					x																	1
115	*Alveopora spongiosa*								x				x				x					x	4
116	*Alveopora tizardi*				x						x							x					3
117	*Goniopora albiconus*				x		x		x					x									4
118	*Goniopora burgosi*						x														x		2
119	*Goniopora columna*						x		x		x					x	x					x	6
120	*Goniopora djiboutiensis*		x	x	x						x		x	x						x			7
121	*Goniopora eclipsensi*						x																1
122	*Goniopora fructicosa*						x		x	x													3

123	*Goniopora lobata*				x		x				x		x	x					x	x	x	x	9
124	*Goniopora minor*								x													x	2
125	*Goniopora palmensis*													x									1
126	*Goniopora polyformis*		x	x		x		x													x		5
127	*Goniopora somaliensis*						x				x												2
128	*Goniopora stuchburyi*						x		x					x									3
129	*Goniopora tenella*						x									x							2
130	*Goniopora tenuidens*		x	x	x	x	x							x	x	x	x					x	10
131	*Porites annae*					x	x		x	x	x	x				x			x	x	x	x	11
132	*Porites aranetai*						x																1
133	*Porites attenuata*								x		x	x	x			x	x		x		x	x	9
134	*Porites cocosensis*																				x		1
135	*Porites cylindrica*	x		x		x	x		x		x	x	x	x		x	x		x	x	x	x	15
136	*Porites deformis*										x					x					x		3
137	*Porites evermani*												x										1
138	*Porites horizontalata*	x						x	x			x					x		x	x	x	x	9
139	*Porites latistella*												x				x		x		x		4
140	*Porites lichen*	x	x			x		x	x	x	x		x			x	x		x	x	x		13
141	*Porites lobata*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	21
142	*Porites lutea*	x	x	x	x	x								x	x	x	x	x	x			x	12
143	*Porites monticulosa*						x				x								x	x			4
144	*Porites murrayensis*		x																				1
145	*Porites napopora*															x	x				x		3
146	*Porites negrosensis*		x	x																			2
147	*Porites nigrescens*	x			x	x	x	x	x		x	x	x	x	x	x	x		x	x	x	x	17
148	*Porites rus*	x	x	x	x	x	x	x	x	x	x	x	x			x	x		x	x	x	x	18
149	*Porites sillimaniana*																x				x		2
150	*Porites solida*									x	x	x					x	x	x	x		x	8
151	*Porites stephensoni*																		x	x	x		3
152	*Porites tuberculosa*					x																	1
153	*Porites vaughani*						x	x			x						x			x			5
	Siderastreidae																						
154	*Coscinarae columna*					x	x		x			x	x		x	x							7
155	*Coscinarae monile*				x			x										x		x	x		5
156	*Psammocora digitata*										x												1
157	*Psammocora nierstraszi*																				x		1
158	*Psammocora profundacella*		x					x			x		x										4
159	*Psammocora superficialis*									x													1
160	*Siderastrea savignyana*						x									x							2
	Agariciidae																						
161	*Coeloseris mayeri*					x										x			x		x		4
162	*Gardineroseris planulata*				x	x		x	x	x		x	x	x	x	x	x					x	12
163	*Leptoseris amitoriensis*																					x	1
164	*Leptoseris explanata*			x		x	x	x	x	x		x	x	x		x						x	11
165	*Leptoseris foliosa*			x				x		x												x	4
166	*Leptoseris gardineri*																					x	1
167	*Leptoseris hawaiiensis*				x	x		x	x	x				x	x		x	x				x	10
168	*Leptoseris incrustans*				x				x								x						3
169	*Leptoseris mycetoseroides*								x	x													2
170	*Leptoseris scabra*											x											1
171	*Leptoseris solida*								x														1
172	*Leptoseris striata*					x						x											2
173	*Leptoseris tubilifera*								x			x					x						3
174	*Leptoseris yabei*										x												1
175	*Pachyseris gemmae*	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x		x			x	17
176	*Pachyseris rugosa*	x	x	x		x	x	x	x		x		x		x	x	x		x		x	x	15
177	*Pachyseris speciosa*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x	x	17
178	*Pavona bipartita*				x	x					x												3
179	*Pavona cactus*				x										x							x	3
180	*Pavona clavus*																					x	1
181	*Pavona decussata*																					x	1
182	*Pavona duerdeni*						x										x	x				x	4
183	*Pavona explanulata*									x		x				x						x	4
184	*Pavona varians*		x			x	x			x					x	x	x						7
185	*Pavona venosa*									x													1

	Fungiidae																						
186	*Cantharellus jebbi*									x													1
187	*Ctenactis albitentaculata*													x								x	2
188	*Ctenactis crassa*		x				x																2
189	*Ctenactis echinata*	x	x	x	x	x	x	x	x		x	x		x	x	x	x		x	x	x	x	18
190	*Cycloseris costulata*													x								x	2
191	*Cycloseris curvata*										x												1
192	*Cycloseris cyclolites*								x					x	x							x	4
193	*Cycloseris erosa*				x																		1
194	*Cycloseris hexagonalis*	x												x									2
195	*Cycloseris patelliformis*							x														x	2
196	*Cycloseris somervillei*	x														x						x	3
197	*Cycloseris tenuis*														x								1
198	*Cycloseris vaughani*						x		x					x								x	4
199	*Diaseris distorta*																					x	1
200	*Diaseris fragilis*		x											x									2
201	*Fungia concinna*								x						x							x	3
202	*Fungia corona*						x		x													x	3
203	*Fungia danai*						x								x							x	3
204	*Fungia fungites*	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x		x	18
205	*Fungia granulosa*		x	x	x	x	x	x	x		x	x	x	x	x	x	x	x		x	x	x	18
206	*Fungia horrida*		x		x		x	x	x		x	x			x	x		x		x		x	12
207	*Fungia klunzingeri*	x	x		x		x							x							x	x	7
208	*Fungia moluccensis*	x							x									x				x	4
209	*Fungia paumotensis*	x	x	x	x	x	x	x	x		x	x		x	x	x		x	x	x	x	x	18
210	*Fungia repanda*		x	x																		x	3
211	*Fungia scabra*													x									1
212	*Fungia scruposa*							x														x	2
213	*Fungia scutaria*	x	x	x	x	x	x	x	x		x	x		x		x		x	x	x	x	x	17
214	*Fungia spinifer*				x																		1
215	*Halomitra clavator*						x														x		2
216	*Halomitra pileus*	x	x	x	x	x	x		x		x		x	x	x	x	x	x	x	x	x	x	18
217	*Heliofungia actiniformis*	x		x	x	x	x				x			x	x	x						x	10
218	*Herpolitha limax*		x	x	x	x	x	x	x		x	x	x	x		x	x	x	x	x		x	17
219	*Herpolitha weberi*													x									1
220	*Lithophyllon undulatum*								x														1
221	*Podobacia crustacea*				x																		1
222	*Podobacia motuporensis*				x				x		x				x					x	x	x	7
223	*Polyphyllia talpina*	x		x	x	x	x	x	x		x		x	x	x	x	x		x	x	x	x	17
224	*Sandalolitha dentata*							x															1
225	*Sandalolitha robusta*		x		x	x								x								x	5
226	*Zoopilus echinatus*							x															1
	Oculinidae																						
227	*Galaxea astreata*	x	x	x	x	x	x	x	x		x	x	x		x	x	x	x	x	x	x	x	19
228	*Galaxea cryptoramosa*				x																		1
229	*Galaxea fascicularis*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	21
230	*Galaxea paucisepta*									x							x				x	x	4
	Pectiniidae																						
231	*Echinophyllia aspera*		x					x	x		x			x		x	x		x	x	x	x	11
232	*Echinophyllia costata*					x	x	x	x	x	x	x	x			x	x		x		x	x	13
233	*Echinophyllia echinata*		x	x	x	x	x	x	x	x	x	x	x					x			x		13
234	*Echinophyllia echinoporoides*	x															x						2
235	*Echinophyllia patula*					x																	1
236	*Echinophyllia taylorae*					x																	1
237	*Mycedium elephantotus*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	21
238	*Mycedium mancaoi*			x	x	x	x	x	x	x	x	x					x				x	x	12
239	*Mycedium robokaki*				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	17
240	*Mycedium steeni*																					x	1
241	*Oxypora crassispinosa*	x								x												x	3
242	*Oxypora glabra*			x		x	x	x	x					x	x					x	x	x	10
243	*Oxypora lacera*		x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	18
244	*Pectinia alcicornis*	x					x									x	x					x	5
245	*Pectinia ayleni*				x												x		x				3
246	*Pectinia elongata*				x			x															2
247	*Pectinia lactuca*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	20
248	*Pectinia paeonia*	x	x	x	x	x	x	x	x		x	x		x	x	x	x	x	x	x	x	x	19

	Mussidae																						
249	*Acanthastrea brevis*								x					x					x		x		4
250	*Acanthastrea echinata*	x				x	x		x	x				x	x						x	x	9
251	*Acanthastrea faviaformis*													x				x	x	x	x		5
252	*Acanthastrea hemprichii*					x			x														2
253	*Acanthastrea regularis*								x														1
254	*Acanthastrea subechinata*	x	x					x	x				x		x			x	x		x	x	10
255	*Blastomussa merleti*																					x	1
256	*Blastomussa wellsi*												x	x									2
257	*Lobophyllia corymbosa*			x	x				x	x	x	x		x	x		x						9
258	*Lobophyllia dentatus*							x	x							x							3
259	*Lobophyllia diminuta*					x																	1
260	*Lobophyllia flabelliformis*			x																		x	2
261	*Lobophyllia hataii*			x	x		x	x	x		x	x			x		x				x		10
262	*Lobophyllia hemprichii*	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	19
263	*Lobophyllia pachysepta*		x				x																2
264	*Lobophyllia robusta*	x		x	x	x	x	x	x		x	x		x	x	x	x	x	x	x		x	17
265	*Lobophyllia serratus*													x						x			2
266	*Scolymia australis*								x														1
267	*Scolymia vitiensis*				x													x				x	3
268	*Symphyllia agaricia*		x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
269	*Symphyllia hassi*					x																x	2
270	*Symphyllia radians*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	20
271	*Symphyllia recta*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	21
272	*Symphyllia valenciennesi*			x																			1
	Merulinidae																						
273	*Hydnophora exesa*	x	x	x		x	x	x	x			x	x	x		x	x	x	x	x	x	x	17
274	*Hydnophora grandis*			x		x			x	x	x						x				x	x	8
275	*Hydnophora microconos*	x	x	x	x	x	x	x	x	x	x	x	x		x		x	x	x		x	x	18
276	*Hydnophora pilosa*	x	x	x	x			x	x					x		x	x		x	x	x	x	13
277	*Hydnophora rigida*	x	x	x		x	x			x	x	x	x	x			x				x	x	13
278	*Merulina ampliata*		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	19
279	*Merulina scabricula*	x	x	x	x	x	x	x	x				x	x	x	x	x		x	x	x	x	17
280	*Scapophyllia cylindrica*		x	x	x							x	x				x					x	7
	Faviidae																						
281	*Barabattoia amicorum*					x	x				x		x			x				x			6
282	*Caulastrea curvata*								x						x							x	3
283	*Caulastrea echinulata*																					x	1
284	*Caulastrea furcata*	x			x	x	x							x	x							x	7
285	*Caulastrea tumida*								x														1
286	*Cyphastrea agassizi*											x	x				x				x		4
287	*Cyphastrea chalcidicum*				x	x	x	x				x	x						x		x		8
288	*Cyphastrea microphthalma*	x				x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	17
289	*Cyphastrea ocellina*												x					x					2
290	*Cyphastrea serailia*		x	x				x					x	x			x	x	x		x	x	10
291	*Diploastrea heliopora*	x	x	x	x		x		x		x	x	x	x	x	x	x		x	x	x	x	17
292	*Echinopora gemmacea*			x		x																	2
293	*Echinopora hirsutissima*					x																	1
294	*Echinopora horrida*				x	x																	2
295	*Echinopora lamellosa*		x	x	x												x		x	x	x	x	8
296	*Echinopora mammiformis*				x																		1
297	*Echinopora pacificus*	x	x	x	x											x						x	6
298	*Favia danae*														x								1
299	*Favia favus*	x			x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
300	*Favia helianthoides*								x													x	2
301	*Favia laxa*		x	x	x					x			x		x								6
302	*Favia maritima*																					x	1
303	*Favia marshae*									x													1
304	*Favia matthaii*		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
305	*Favia pallida*					x		x	x		x	x	x	x	x		x		x	x	x	x	13
306	*Favia rosaria*										x					x	x						3
307	*Favia rotumana*													x	x								2
308	*Favia rotundata*	x					x													x		x	4
309	*Favia speciosa*		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
310	*Favia stelligera*				x																		1
311	*Favia truncatus*		x																x				2

312	*Favia veroni*		x									x	x				x	x				x	6
313	*Favites abdita*		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
314	*Favites acuticollis*					x		x						x	x		x	x	x		x		8
315	*Favites chinensis*		x			x	x		x	x					x								6
316	*Favites complanata*			x					x					x	x	x	x	x	x	x	x	x	11
317	*Favites flexuosa*	x	x	x	x	x	x		x		x	x			x	x	x	x			x	x	15
318	*Favites halicora*			x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	17
319	*Favites micropentagona*					x	x		x		x		x	x	x	x	x		x		x		11
320	*Favites paraflexuosa*	x	x	x		x	x	x	x		x			x	x		x	x		x	x	x	15
321	*Favites pentagona*			x	x	x	x		x		x	x	x		x		x	x	x	x	x	x	15
322	*Favites russelli*															x							1
323	*Favites stylifera*				x	x	x		x	x	x	x		x	x	x	x		x	x	x		14
324	*Goniastrea aspera*	x				x		x	x		x	x	x	x	x	x	x	x		x	x		14
325	*Goniastrea australensis*						x	x	x		x			x	x								6
326	*Goniastrea edwardsi*				x				x			x									x		4
327	*Goniastrea favulus*				x																	x	2
328	*Goniastrea minuta*								x	x						x		x	x		x		6
329	*Goniastrea palauensis*																					x	1
330	*Goniastrea pectinata*	x			x	x	x	x	x	x	x				x	x				x	x	x	13
331	*Goniastrea retiformis*					x	x	x		x		x			x		x	x	x		x		10
332	*Leptastrea aequalis*																				x	x	2
333	*Leptastrea bewickensis*					x																	1
334	*Leptastrea bottae*																x						1
335	*Leptastrea pruinosa*										x												1
336	*Leptastrea purpurea*						x							x			x		x	x		x	6
337	*Leptoria irregularis*					x																	1
338	*Leptoria phrygia*	x	x	x	x				x	x	x	x		x	x	x	x		x		x	x	15
339	*Montastrea annuligera*					x							x			x			x				4
340	*Montastrea colemani*												x			x	x	x			x		5
341	*Montastrea curta*																					x	1
342	*Montastrea magnistellata*						x							x							x		3
343	*Montastrea multipunctata*																		x				1
344	*Montastrea salebrosa*				x		x																2
345	*Montastrea valenciennesi*										x		x	x	x	x	x		x	x	x		9
346	*Oulastrea crispata*														x								1
347	*Oulophyllia bennetae*														x								1
348	*Oulophyllia crispa*	x		x		x	x		x		x	x	x	x		x	x		x	x	x	x	15
349	*Oulophyllia levis*																			x	x		2
350	*Platygyra acuta*	x					x			x		x	x	x	x	x	x	x	x			x	12
351	*Platygyra contorta*													x									1
352	*Platygyra daedalea*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	21
353	*Platygyra lamellina*	x			x	x		x							x	x	x						7
354	*Platygyra pini*	x				x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	17
355	*Platygyra ryukyuensis*					x						x	x	x	x		x	x			x		8
356	*Platygyra sinensis*	x	x	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	19
357	*Platygyra verweyi*		x		x	x		x				x	x			x	x	x			x	x	11
358	*Platygyra yaeyamaensis*										x												1
359	*Plesiastrea versipora*	x					x		x	x		x	x	x	x	x	x	x	x	x	x	x	15
	Euphylliidae																						
360	*Euphyllia ancora*		x	x	x		x	x	x					x	x	x	x					x	11
361	*Euphyllia cristata*												x	x	x		x					x	5
362	*Euphyllia divisa*				x		x								x								3
363	*Euphyllia glabrescens*	x	x	x			x		x		x				x		x		x			x	10
364	*Euphyllia paradivisa*		x																				1
365	*Euphyllia yaeyamaensis*	x		x										x								x	4
366	*Physogyra lichtensteini*			x			x		x		x			x	x			x			x	x	9
367	*Plerogyra simplex*	x	x	x	x	x	x	x			x			x								x	10
368	*Plerogyra sinuosa*	x	x	x	x			x	x					x	x			x				x	10
	Dendrophylliidae																						
369	*Turbinaria bifrons*			x															x	x			3
370	*Turbinaria frondens*	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
371	*Turbinaria heronensis*				x	x		x															3
372	*Turbinaria irregularis*							x						x					x	x			4
373	*Turbinaria mesenterina*		x	x			x	x	x		x	x	x	x	x	x	x			x	x	x	15
374	*Turbinaria peltata*		x	x					x	x	x			x	x	x	x		x	x	x	x	13
375	*Turbinaria reniformis*	x	x	x						x	x	x			x				x			x	9
376	*Turbinaria stellulata*							x															1