Diversity of coral species composition (scleractinia species) in Vietnam's Truong Sa archipelago

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Abstract

Coral reefs in the Truong Sa (Spratlys) archipelago of Vietnam are very rich and diverse. Research and investigation results from 2018 to 2021 have recorded 185 scleractinia species in 6 islands Southwest Cay (Song Tu Tay), South Reef (Da Nam), Great Discovery Reef (Da Lon), Nam Yet Island Allison Atoll (Toc Tan), Barque Canada Reef (Thyen Chai), in which, recorded at Song Tu Tay are 81 species, Da Nam is 63 species, Da Lon is 63 species, Nam Yet is 162 species, Toc Tan is 121 species, Thuyen Chai is 28 species.

Keywords: Truong Sa, coral, species

Introdution

Coral reef ecosystem is one of three important marine ecosystems, in which coral reefs play a core role in maintaining coral reef ecosystems. Coral reefs are likened to undersea forests, where many species of creatures reside, reproduce and develop. Under pressure from climate change, human impact, especially the change of temperature in the conditions of climate change, coral reefs become very sensitive and vulnerable leading to deterioration ecosystem quality, affecting marine resources. The Truong Sa archipelago is located on a deep-water depression, the marine ecosystems have their own characteristics of the archipelago and the characteristics of the offshore waters. Most of the islands in the archipelago are coral and rocky islands, the important ecosystem here is the coral reef ecosystem. Scientists had expected coral reefs in the Spratlys to resemble the Great Barrier Reef in the Coral Sea area, Queensland, northeastern Australia. With many types of ecosystems (coastal sea type; islands and waters around the island; deep sea), the genetic resources of this place are rich and endemic, playing an important role in economic, social and economic development and development. environment in Vietnam, is the basis to ensure the maintenance of genetic resources, providing seafood resources, raw materials, pharmaceuticals, etc. However, under the conditions of climate change, the coral reefs here there are negative fluctuations in the richness and diversity of species composition, coverage and distribution of species.

The Spratlys adjoin the western border of the Coral Triangle with the maximum species diversity of reef-forming corals and contain more than 80 genera of scleractinians (Latypov, 2012), thus potentially more than 400 species of corals can be found in the water area (Veron, 2000).

Among the natural threats to the coral communities of the Spratly Islands, in addition to the aforementioned temperature anomalies causing massive bleaching (bleaching) of corals, outbreaks of the number of the main coral phage, the sea star *Acanthaster planci*, also become relevant (Hughes et al. 2012).

Material and Methods

To study coral communities in the water area of the Spratly archipelago, 30 hydrobiological stations were made during the cruise from 2018 to 2021 (Fig. 1). The collection of material was carried out according to the standard method using diving equipment at points accessible under weather conditions for carrying out diving operations. The collection of the material was carried out by the method of photo-sections (phototranssect) along isobaths along the reef profile at depths from 30 to 2 meters, depending on the relief and features of the vertical distribution of dominant corals. The survey was carried out in two zones of ring reefs (atolls) - in the lagoon and on the outer slope, as well as in two zones of the vertical profile of the reef - on the reef flat (depth 2-5 m) and on the reef slope (depths 10-20 m). The species of scleractinia was established according to Veron (2000), Latypov (2014).

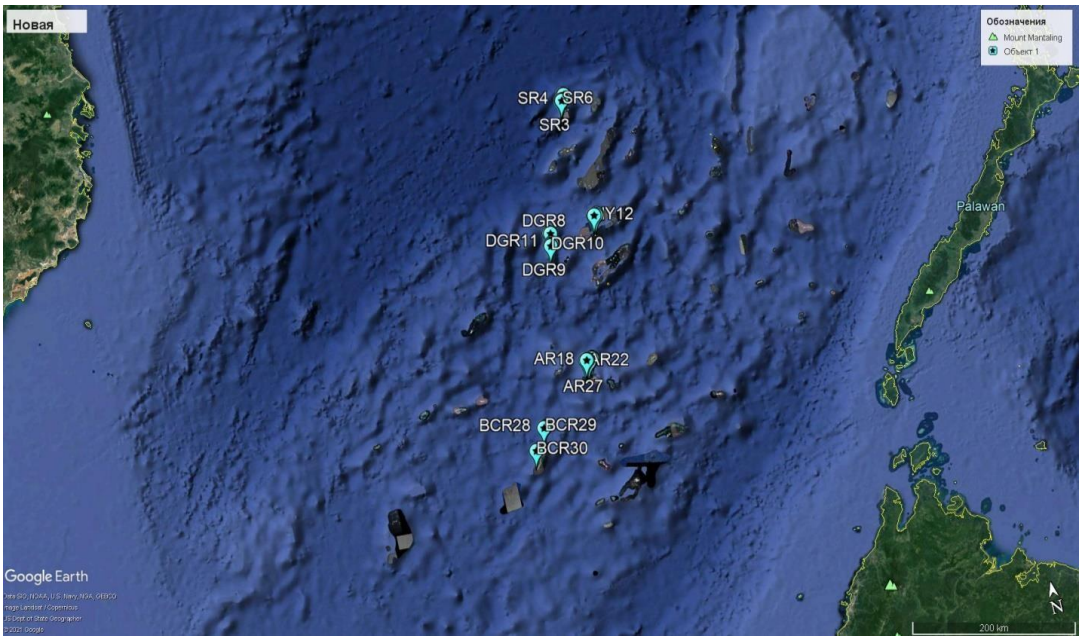


Figure 1. General view of the investigated area of the Spratly archipelago (Truong Sa) and the location of hydrobiological stations

Results

The coral reefs on the Truong Sa archipelago are evaluated for diversity and richness in species composition.

Table 1. List of scleractinia species on Truong Sa (Spratly) archipelago, period from 2018 to 2021

STT	Species	Southwest Cay (Song Tu Tay)	South Reef (Da Nam)	Great Discovery Reef (Da Lon)	Nam Yet Island	Allison Atoll (Toc Tan)	Barque Canada Reef (Thyen Chai)
1	*Acantastrea echinata*	+			+		
2	*Acropora abrolhosensis*				+		
3	*Acropora abrotonoides*	+	+	+	+	+	
4	*Acropora acuminata*				+		
5	*Acropora anthocercis*	+	+		+	+	
6	*Acropora aspera*		+				
7	*Acropora austera*				+	+	
8	*Acropora bifurcata*			+	+	+	
9	*Acropora caroliniana*				+	+	
10	*Acropora carduus*				+	+	
11	*Acropora cerealis*	+	+	+	+	+	+
12	*Acropora cytherea*		+	+	+	+	
13	*Acropora digitifera*	+			+		
14	*Acropora divaricata*				+	+	
15	*Acropora donei*					+	
16	*Acropora elseyi*				+	+	
17	*Acropora florida*				+	+	
18	*Acropora gemmifera*	+	+	+	+	+	
19	*Acropora glauca*				+		
20	*Acropora grandis*				+	+	
21	*Acropora granulosa*				+	+	
22	*Acropora horrida*				+		

23	*Acropora humilis*	+	+	+	+		
24	*Acropora hyacinthus*	+	+		+	+	
25	*Acropora intermedia*	+			+	+	
26	*Acropora latistella*				+	+	
27	*Acropora longicyathus*				+		
28	*Acropora microclados*				+	+	
29	*Acropora microphthalma*				+		
30	*Acropora millepora*	+			+		
31	*Acropora monticulosa*	+		+	+	+	
32	*Acropora muricata*				+	+	
33	*Acropora nasuta*			+	+		
34	*Acropora nana*				+	+	
35	*Acropora paniculata*					+	
36	*Acropora plumosa*				+	+	
37	*Acropora pulchra*				+	+	
38	*Acropora robusta*	+	+	+	+	+	
39	*Acropora sarmentosa*				+		
40	*Acropora secale*				+	+	
41	*Acropora selago*				+	+	
42	*Acropora solitaryensis*					+	
43	*Acropora subglabra*				+	+	
44	*Acropora tenuis*		+		+	+	
45	*Acropora valenciennesi*				+	+	
46	*Acropora valida*				+		
47	*Acropora vermiculata*					+	
48	*Acropora verweyi*				+		
49	*Acropora yongei*				+		
50	*Anacropora forbesi*					+	
51	*Alveopora verrilliana*			+			
52	*Astreopora myriophthalma*	+			+	+	

53	*Astreopora ocellata*	+			+	+	
54	*Caulastrea furcata*	+			+	+	
55	*Coeloseris mayeri*	+		+	+		
56	*Coscinaraea columna*			+	+		
57	*Ctenactis echinata*	+		+	+	+	
58	*Cyphastrea chalcidicum*	+	+		+	+	
59	*Cyphastrea microphthalma*	+	+	+	+		
60	*Cyphastrea serailia*	+			+	+	
61	*Dendrophyllia robusta*				+		
62	*Diploastrea heliopora*	+	+	+	+	+	+
63	*Echinophyllia aspera*	+			+	+	
64	*Echinophyllia orpheensis*				+		
65	*Echinopora gemmacea*	+	+		+	+	
66	*Echinopora lamellosa*		+		+	+	
67	*Euphyllia ancora*				+		
68	*Euphyllia glabrescens*				+	+	
69	*Favia favus*	+	+	+	+	+	
70	*Favia lizardensis*	+		+	+		
71	*Favia maritima*	+	+				
72	*Favia matthai*				+	+	
73	*Favia maxima*		+		+	+	
74	*Favia pallida*	+	+	+	+	+	+
75	*Favia speciosa*	+	+		+	+	
76	*Favia stelligera*	+	+	+	+	+	
77	*Favites abdita*	+	+	+	+		
78	*Favites complanata*		+		+	+	
79	*Favites halicora*	+	+		+		
80	*Favites flexuosa*	+	+	+	+	+	
81	*Favites pentagona*	+		+	+		
82	*Fungia fungites*	+	+	+	+	+	

83	*Fungia concinna*	+			+	+	
84	*Fungia corona*				+		
85	*Fungia repanda*			+	+	+	
86	*Fungia scutaria*				+		
87	*Galaxea astreata*	+	+	+	+	+	
88	*Galaxea fascicularis*	+	+		+	+	
89	*Galaxea horrescens*				+		
90	*Gardineroseris planulata*	+				+	
91	*Goniastrea aspera*	+	+	+	+	+	
92	*Goniastrea edwardsi*	+	+				
93	*Goniastrea pectinata*	+	+		+	+	+
94	*Goniastrea retiformis*	+	+	+	+	+	
95	*Goniopora columna*				+		
96	*Goniopora lobata*		+	+	+	+	
97	*Heliofungia actiniformis*				+	+	
98	*Herpolitha limax*	+	+	+	+	+	
99	*Hydnophora exesa*	+	+		+	+	
100	*Hydnophora microconos*	+	+		+		
101	*Hydnophora rigida*		+	+	+	+	
102	*Isopora cuneata*			+		+	+
103	*Isopora brueggemanni*			+	+	+	
104	*Isopora palifera*		+	+	+	+	+
105	*Leptastrea pruinosa*	+	+	+	+		
106	*Leptastrea purpurea*	+			+		
107	*Leptastrea transversa*	+			+		
108	*Leptoria phrygia*	+	+	+	+	+	
109	*Leptoseris explanata*				+	+	
110	*Leptoseris yabei*			+	+		
111	*Lithophyllon undulatum*				+		
112	*Lobophyllia corymbosa*				+	+	

113	*Lobophyllia hattai*		+		+	+	
114	*Lobophyllia hemprichii*		+		+	+	
115	*Merulina ampliata*	+	+	+	+	+	
116	*Montastrea annuligera*	+			+		
117	*Montastrea curta*	+	+	+	+	+	
118	*Montastrea valenciennesi*				+		
119	*Montipora aequituberculata*	+			+		
120	*Montipora cactus*		+	+			
121	*Montipora capricornis*					+	
122	*Montipora crassituberculata*				+	+	
123	*Montipora digitata*	+		+	+		+
124	*Montipora informis*	+					
125	*Montipora foveolata*				+		+
126	*Montipora friabilis*					+	
127	*Montipora grisea*	+	+		+	+	+
128	*Montipora hispida*		+		+		
129	*Montipora millepora*				+		
130	*Montipora monasteriata*	+		+	+	+	+
131	*Montipora mollis*					+	
132	*Montipora spongodes*						
133	*Montipora stellata*		+	+	+		
134	*Montipora tuberculosa*				+	+	
135	*Montipora turgescens*				+	+	
136	*Montipora undata*			+		+	+
137	*Montipora verrucosa*	+			+	+	
138	*Mycedium elephantotus*				+	+	
139	*Oulophyllia crispa*	+	+		+	+	
140	*Oxypora lacera*				+	+	
141	*Pachyseris rugosa*	+	+	+	+	+	+

142	*Pachyseris speciosa*				+	+	
143	*Pavona clavus*	+	+	+	+		+
144	*Pavona frondifera*					+	+
145	*Pavona varians*	+				+	
146	*Pavona venosa*					+	+
147	*Pectinia lactuca*				+	+	
148	*Pectinia paeonia*				+	+	
149	*Physogyra lichtensteini*			+	+	+	+
150	*Platygyra daedalia*	+	+	+		+	
151	*Platygyra lamellina*	+	+	+	+	+	
152	*Platygyra pini*	+	+	+	+	+	
153	*Platygyra ryukyuensis*	+		+	+	+	
154	*Platygyra sinensis*	+	+		+		+
155	*Plerogyra sinuosa*				+		
156	*Plesiastrea versipora*	+	+		+		
157	*Pocillopora damicornis*	+			+	+	
158	*Pocillopora eydouxi*	+	+	+	+	+	+
159	*Pocillopora meandrina*	+	+	+	+		+
160	*Pocillopora verrucosa*	+	+	+	+	+	+
161	*Pocillopora woodjonesi*	+	+	+	+	+	+
162	*Podabacia crustacea*				+		
163	*Porites attenuata*			+	+		+
164	*Porites australiensis*	+			+		
165	*Porites cylindrica*				+	+	
166	*Porites lichen*	+			+		
167	*Porites lobata*	+	+	+	+	+	+
168	*Porites lutea*	+	+	+	+	+	
169	*Porites negrosensis*				+		
170	*Porites nigrescens*		+	+	+	+	+
171	*Porites rus*	+	+	+	+		+

172	*Sandalolitha dentata*				+	+	
173	*Sandalolitha robusta*	+			+	+	
174	*Seriatopora hystrix*				+	+	
175	*Seriatopora caliendrum*				+	+	
176	*Stylophora pistillata*			+		+	+
177	*Symphyllia agaricia*				+	+	
178	*Symphyllia radians*	+			+	+	+
179	*Symphyllia recta*	+		+	+	+	+
180	*Tubastrea coccinea*				+		
181	*Tubastrea micrantha*				+		
182	*Turbinaria mesenterina*		+		+	+	
183	*Turbinaria peltata*				+		
184	*Turbinaria reniformis*				+	+	
185	*Turbinaria stellulata*	+		+	+	+	
	Species number	81	63	63	162	121	28

Discussion

The total number of coral species in 6 islands of the Truong Sa archipelago was 185 species. In which, the number of coral species belonging to Nam Yet island is the most diverse, (162 species, equivalent to 87.57% of the total number of species), the lowest number is the number of coral species on Thuyen Chai islands (28 species, equivalent to 15.1% of the total species)

There are not many databases to compare the biodiversity of coral species in the Truong Sa archipelago.

Nam Yet island coral reef is the most diverse and abundant in the surveyed locations with 162 species of scleractinia, with the presence of rare species in the reef area with depth 20- 30 m, the predominance of heat-sensitive corals with relatively high coral composition and coverage is concentrated in the northern reef of the island. The southern coral reefs have the largest coral cover and species composition at the depth (20-30m)

Assessment of changes in coral reefs According to the announcement of Nguyen Dang Ngai (2006), the total number of coral species in 2006 on Nam Yet island was 222

species belonging to 23 families. The family Acroporidae has the largest number of species at 77 species; The families Astrocoenidae, Elliselidae, Isididae, Helioporidae, Milleporidae all have only one species. According to research by Do Van Khuong et al. (2016), the total number of coral species in Nam Yet island is 137 species belonging to 17 families. The family Faviidae has the largest number of species with 39 species. The family Astrocoeniidae has at least 1 species. Thus, the results show that, the total number of species in the period 2006 - 2021, there is a clear change in the published documents. There are many reasons for this result such as: wide research scope, incomplete research time of each work, underrepresented research sites, etc. However, an important reason is the Scientists believe that it is due to the impact of climate change, natural and human factors, and other harmful organisms. The effects of these impacts reduce the coverage, decrease the diversity and richness of species Starting from the global temperature anomaly in 1998, the water surface of the Spratly Islands up to the present time (in 2021) has experienced 7 more temperature anomalies. The variation in coral communities under the influence of these anomalies is reflected in the change of hard coral species from heat sensitive to heat tolerant, as well as changes in species composition, biomass and younger age of adaptive species. The average coral cover in the studied areas of the archipelago is up to 36.6%, and is mainly composed of three genera of reef-forming corals: Acropora, Porites and Pocillopora. The Spratly Islands abut the western edge of the Coral Triangle with species diversity of reef-forming corals and more than 80 genera of hard corals (Latypov, 2012), therefore, in the Spratly archipelago area. Sa can have more than 400 species of coral (Veron, 2000). Natural threats to the coral reefs of the Spratlys, in addition to the anomalous temperatures causing coral bleaching, include large outbreaks of the starfish *Acanthaster planci*.

The Spratly archipelago (Truong Sa) in Vietnam are a large group of coral reefs, atolls, islands and shores located in the center of the South China Sea. Bordering the Coral Triangle with the highest coral diversity, the Truong Sa archipelago is said to have a diversity of coral species and is identified by scientists as the Center of genetic resources. The fact that some coral species belonging to the order of hard corals are rare in the Truong Sa archipelago but found in the Nam Yet island area alone is one of the alarming signs of the decline in the species composition of the area by many species in the list. The continent has a wide distribution and is very common in many seas around the world, including the East Sea of Vietnam. The findings of this study indicate that the coral communities of the Spratlys are in transition at the community and population level. This has led to a change in the taxonomic composition, coverage and age of the reef. The first evidence of environmental impacts on the Spratlys coral reefs was the predominance of heat-resistant varieties in most of the study sites. Such a response of a coral community to environmental stressors is characterized by a “strategic shift” (Done, 1999) when

highly tolerant corals replace sensitive species. have a cold. The influence of thermal impact in the Spratly Islands is also reflected in most prominent coral species in small and medium size groups. This size frequency distribution confirms that regional coral communities have experienced a recent, apparent severe stress impact over the past decade. In addition, during the survey, no large tabular Acropora conglomerates (>100 cm at the largest group size) were encountered at any of the 30 study sites and in either region. geomorphology (before reefs and lagoons), the largest size of Acropora plate varies in the range of 50-70 cm in diameter. Therefore, their major portion at the study sites consisted of young species and colonies between the ages of 2–3 years, the largest being at the age of 6–7 years old. A similar distribution in age groups is associated with another heat-sensitive genus of the Pocilopora group, which is the predominant group of coral reefs of the Spratlys. Such clear features are probably most related to the heat stresses of the past decade with the most significant incident occurring in 2010 that could have resulted in mass coral deaths in the archipelago.

The reef biomes of the Spratly archipelago demonstrate at least two of four scenarios for reef succession under global stressors such as thermal anomalies: 1) faster rotation. suggested that coral reefs experience an increase in mortality, which reduces lifespan and shifts the biome to a younger age structure; 2) coral reefs have been replaced by highly resistant varieties of coral. Predictions for the frequency, intensity of coral bleaching, and mortality have projected an increase in coral reef degradation. Coral bleaching in two atolls of the Spratlys in June 2007 changed 27-30% of the coral area. The frequency of El Niño quadrupled over 60 years in the last century to the late 1980s and in the current 15 years, i.e. during the climate change period starting from the 1990s to the present inevitably leads to obvious consequences including worldwide coral reef destruction. Thermal adaptation can completely reverse the susceptibility of coral species. The two genera (Acropora and Porites) facing heat susceptibility exhibited the highest bleaching response while Agariciidae (Pavona) showed the highest heat tolerance. In the Spratlys Pavona was most affected (~95%), followed by Acropora (~61%), while Porites was affected the least (~20%). There are several physiological and morphological characteristics of corals that are closely related to heat tolerance and bleaching response. The following characteristics have been shown to contribute to coral survival, adaptation and adaptation: 1) heat-tolerant genotype of the symbiotic zooxanthellae; 2) higher density of zooxanthellae in coral tissue; 3) higher biomass and coral tissue thickness; 4) large growth forms with large corallites and the ability to withdraw coral polyp tissues deep into a corallite under temperature stress; 5) possibility for alternative heterotrophic nutrition during the bleaching phase; 6) the ability to produce fluorescent proteins, mycosporine-like amino acids, and antioxidant enzymes reduces the effects of temperature shock and UV radiation (Baker et al., 2004; Ladner et al., 2012;

Grottoli et al. , 2006; Wooldridge, 2014; Brown, 1997; Baird et al., 2009; Tkachenko, 2016). This study demonstrated the tendency of heat- and stress-tolerant corals to dominate the coral communities of the Spratlys (73% of the study sites dominated by these corals) according to intensity and frequency of temperature anomalies are caused by global climate change, while heat-sensitive varieties are decreasing in coverage and undergoing population structural changes towards reduced lifespan and the predominance of the younger generations. Global coral bleaching and post-temperature increases in mortality over the past two decades, from 1998 until the most recent global coral bleaching in 2016-2017, have reorganized the population structure. coral communities with shifts in stress-resistant large corals and local disappearances of vulnerable branched, plate-type corals of the genera Acropora, Pocillopora and Montipora in several areas across India- Pacific

Conclusion

Researched and established a list of 185 scleractinia species in 6 islands in the Truong Sa archipelago of Vietnam in the period from 2018 to 2021. The largest number of coral species belonging to Nam Yet island is 162 species, followed by Toc Tan with 121 species, but Tu Tay with 81 species, Da Nam and Da Lon with 63 species, the lowest is Thuyen Chai with 28 species. In the face of global climate change, natural and human impacts, urgent solutions are needed to preserve the diversity of coral species composition and restore coral reefs in the Truong Sa archipelago of Vietnam.

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Some pictures of coral reefs in Vietnam's Truong Sa archipelago









