

Patterns of Association between Marine Sponges and the Associated Organisms: Case Study, Losin Island, Pattani, Thailand

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Abstract

Ko Losin, the southernmost offshore islet in the Gulf of Thailand is one of the most naturally, less anthropogenic disturbed coral reefs in Thailand and the home of the major sessile organisms: corals and sponges. This study aims to investigate the natural patterns of association (interactions) between marine sponges and the associated organisms. The types of interaction were classified into 4 categories: Gap, Overgrown, Tissue contact, and Overgrow. The investigation focused on four genera of sponges: *Chondrilla*, *Hyrtios*, *Cinachyrella*, and *Xestospongia*. *Chondrillid* sponge showed the high frequency of inhabiting associated organisms. Some hermatypic corals such as *Montiporian* corals and *Porites* corals were highly proportioned to the associated organisms. The gap and overgrown interactions were recorded in this study.

Keywords: *Chondrilla*, *Cinachyrella*, *Hyrtios*, *Xestospongia*, Gap, Overgrown, Overgrow, Tissue contact

Introduction

Generally, space is one of the limited resources in marine ecosystem, particularly coral reef ecology. Such a limited resource often leads to competition for space among sessile organisms (such as Algae, sponges (Porifera), corals (Cnidaria), moss animal (Bryozoa), and sea squirt (Chordata). Corals are considered as the major groups of sessile animals, which occupy the reefs. However, some coral reefs are not dominated by corals, but sponges [1]. Sponges are expected to be the potential competitors for corals in many places such as NE Columbia and Puerto Rico [2,3]. Being the potential competitor for space, sponges need to have various abilities/mechanisms/tactics in order to lead the competition. *Cliona delitrix* bores and destructs the colony of *Montrastrea* coral [1]. Likewise, *Desmapsamma anchorata*, *Dysidea janiae* and *Iotrochota birotulata* overgrow/smoothen species of gorgonians [4]. However, it cannot be concluded that the sponge density is related to the coral coverage area due to competition interaction. In the Wakatubi Marine national park in Indonesia, sponge density showed positive yet weak relationship with regard to its percentage of hard coral cover. Additionally, sponge densities seem to vary from site to site, when the influence of environmental variability is discussed [5]. The mechanisms of competition are mechanically and/or chemically unique to species of organisms. Acontarian sea anemone (*Exaiptasia pallida*) uses thread loaded with nematocyst batteries, known as acontia to defend themselves [6]. Sponges have been known to be as the aggressive space competitor for reef building corals and other coral organisms [2,7]. Studies reported that some sponge genera, (such as *Chondrilla*, *Hemectyon*, *Ircinia* and *Verongia*) are more aggressive in the deeper water of the Caribbean coral reef community. They overgrow corals gorgonians and other sponges [2]. On the contrary, sponge (*Agelus conifer*) is observed

to be overgrown by lettuce coral (*Halioseris cucullata*) with uninvestigated mechanisms [8]. However, competition between sponge and algae are complex with regard to nutrient levels in water column; shading; abrasion and; allelopathy [9]. Sponge's mechanisms to compete with competitors varies. Furthermore, secondary metabolites of sponge are known to be an anti-predator as well as allelopathy to some coral competitors [10]. Morphologically, sponges are capable of plastic morphology to overgrowth, epizoism other associated organisms [1,11,12]. In addition, the interference interactions between sponges and corals have been classified as over growth, peripheral contact, tissue contact and non-contact interactions [3]. The interference interactions of sponges with associated organisms are useful to understand the hierarchical levels or the complexity role of sponges in inhibiting the community. The objective of this study is to investigate the proportion of interference interactions between sponges and associate organism at Ko Losin.

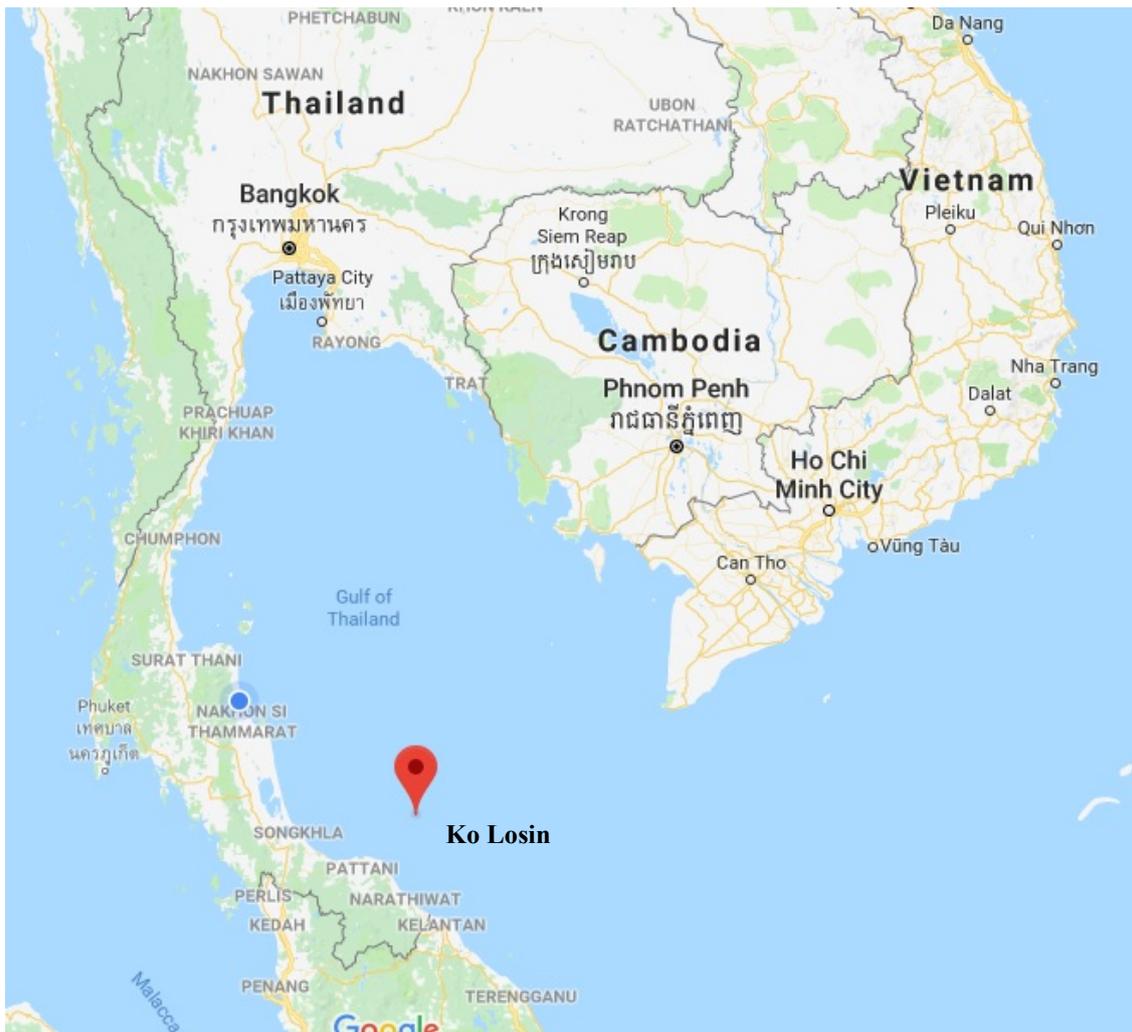


Figure 1 Location of Ko Losin.

Materials and methods

Site description

Ko Losin, the southernmost islet of Thailand, has been published in Government Gazette as a sea boundary of Thailand (Government Gazette, 1992). It is located on 7° 19' 54'' N, 101° 59' 54'' E. It is about 153 km east of Songkla province and is about 64 km northeast of Pattani province (**Figure 1**). Ko Losin appears as a small rock in the open sea (southern of the Gulf of Thailand). The above sea level area is about several hundred square meters and its averaged is 3 m height above sea level. There are no trees or shrubs inhabiting on Ko Losin. The underwater substrate is rock base, deep down to about 40 m. There are clefs and valleys scattering around, which provide diverse habitats for sessile marine organisms. The major sessile organisms are species of hermatypic corals and sponges.

Field survey

A scuba equipment was used to survey the islet. The depth range of this investigation was 5 - 30 m in South, Southwest, and Northwest areas. The east area of Ko Losin was not investigated due to the limitation of the current. A stratified diving from the deepest to the shallowest area of Ko Losin was made. The patterns of interaction between sponge and associated organisms were recorded and photographed during diving.

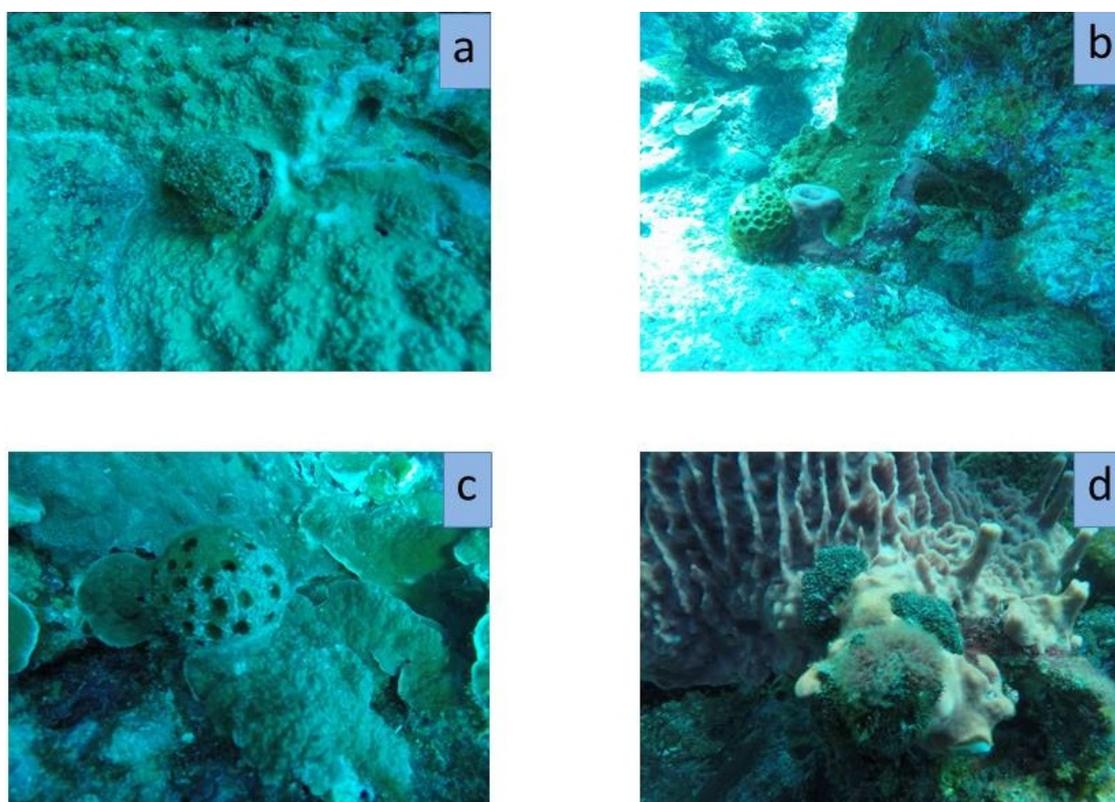


Figure 2 Types of interaction of sponge associated with organisms: (a) Gap interaction between *Cinachyrellaid* sponge and *Montiporian* coral; (b) Tissue contact interaction between *Xestospongia* sponge and *Montiporian* coral and *Cinachyrellaid* sponge; (c) Overgrown interaction, *Cinachyrellaid* sponge overgrown by *Montiporian* coral; (d) Overgrown interaction, *Hyrtios* sponge overgrow *Xestospongia* sponge.

Patterns of interaction

The patterns of interaction between sponge and associated organisms in this study were modified from Aerts and Soest 1997. There are four categories classified. These are; gap, tissue contact, overgrown, and overgrow. **Gap** means there is no contact of the tissue between sponge and associated organisms. **Tissue contact** means that there is contact of the tissue between sponge and associated organisms. **Overgrown** means that the sponges are overgrown by associated organisms which caused the overgrown tissue of sponge to be shaped by the overgrow tissue of associated organisms. **Overgrow** means that the sponge grows over the tissue of associated organisms, including the epizoism by sponge (Figure 2).

Data analysis

The interaction patterns of six genera of commonly found sponge were recorded. Then, data were processed and were expressed in proportionate to types of interaction and types of associated organisms (Microsoft Excel 2010).

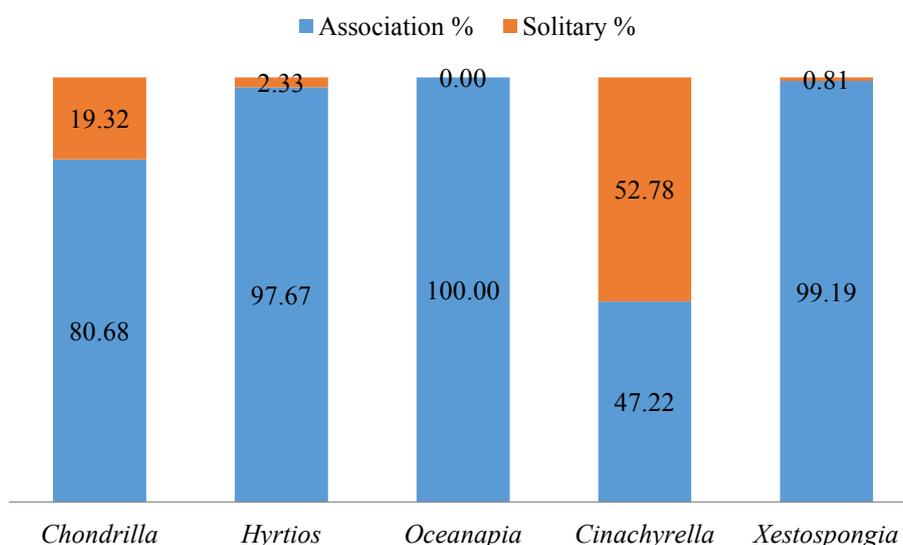


Figure 3 The proportion of living mode of sponge genera

Results and discussion

The overall sponge surveyed at Ko Losin showed that there are both solitary and association living modes. *Cinachyrellaid* sponge explores the highest solitary living mode (52.78 %), *Chondrillid* sponge (19.32 %), *Hyrtios* sponge (2.33 %) and *Xestospongian* sponge (0.81 %), respectively (Figure 3). It is noted that only one *Oceanapian* sponge was found in this survey. It explored associate living mode. The most frequency of sponge recorded with interaction were the following genera, *Chondrilla* (41.65 %); *Xestospongia* (30.67 %), *Cinachyrella* (16.96 %) and *Hyrtios* (10.47 %), respectively (Figure 4). However, the abundance of sponge genera varies around Ko Losin. *Cinachyrellaid* sponge dominated the north and northeast of Ko losin. Their abundances were 59.59 and 55.93 %, respectively. In the southeast, south and southwest parts of Ko Losin, the most abundant sponge genus was *Chondrilla*. They were 62.30 % (southeast), 51.58 % (south) and 62.30 % (southwest). However, this was not true in the northwest of Ko Losin, where the dominant genus of sponge was obscure (Figure 5). With regard to sssociated organisms, the most frequently reported was hermatypic corals such as *Montiporian* coral; 47.78 %, *Porites* corals; 30.70 % and *Pocilloporian* coral; 12.34 %, respectively.

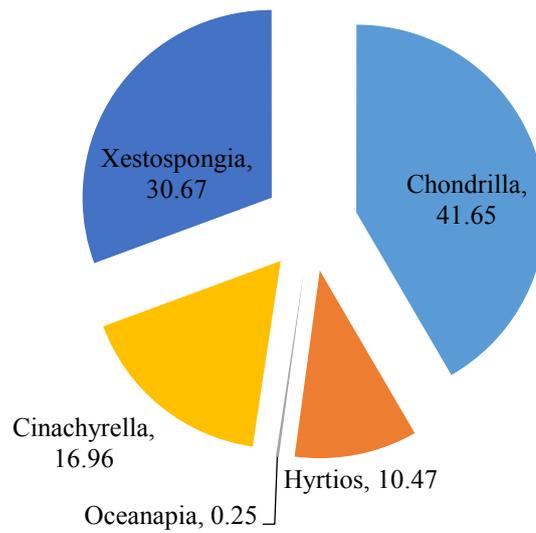


Figure 4 Percentage of sponge genera found with associated organisms.

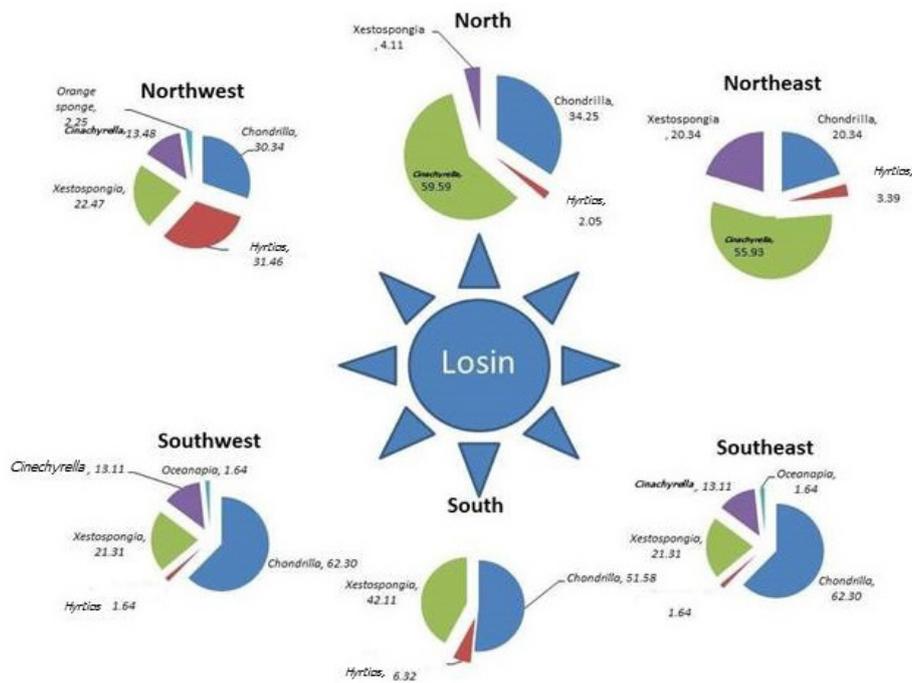


Figure 5 The percentage abundance of sponge genera around Ko Losin.

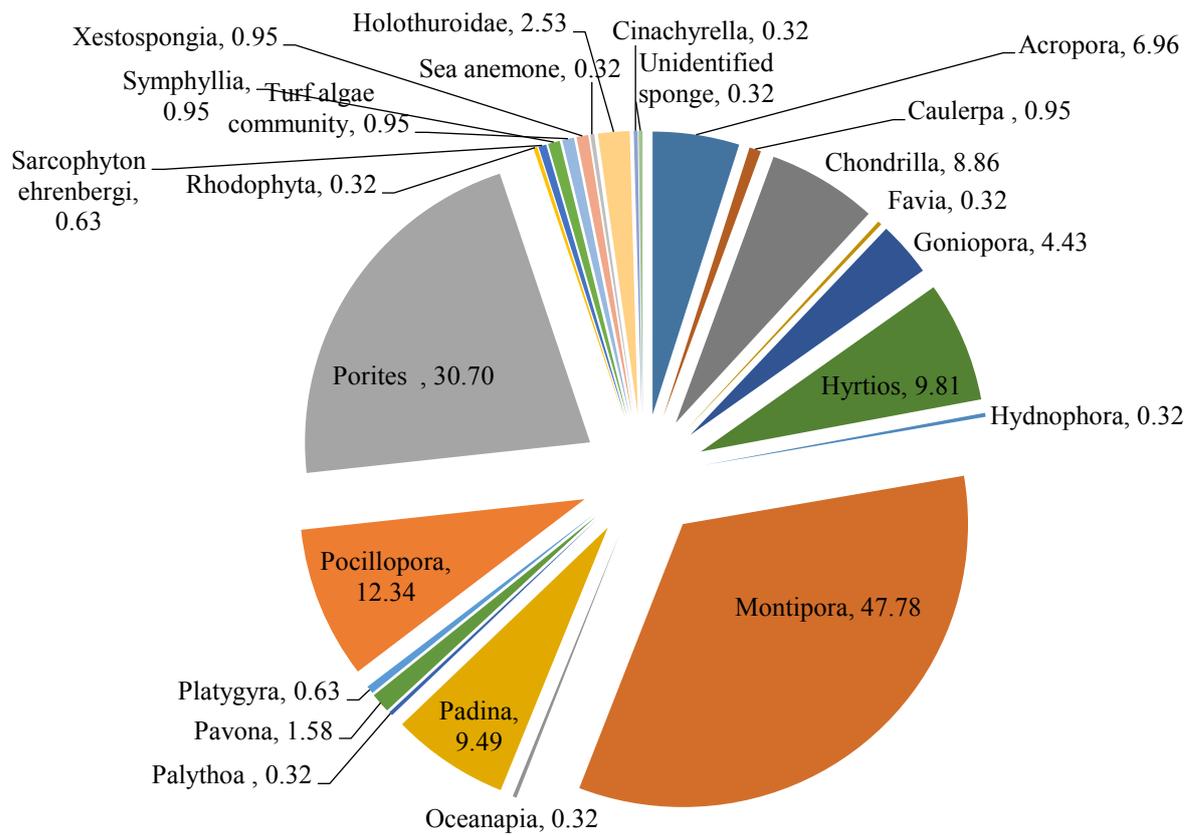


Figure 6 Percentage of overall taxa associated with sponges.

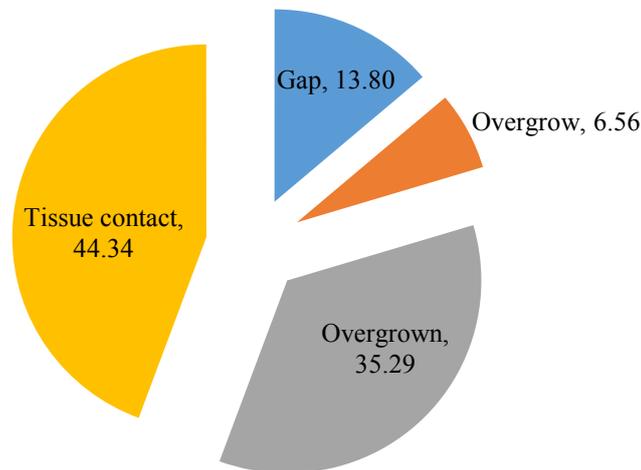


Figure 7 Overall percentage of associate Interaction of sponges.

The second most frequent, whereas, were diverse in groups. They were sponges, algae and staghorn corals (*Hyrtios* sponge; 9.81 %, *Padina* algae; 9.49 %, *Acroporian* corals 6.96 % and *Chondrillid* sponge; 8.86 %), respectively (**Figure 6**). The three fourths of overall interactions of sponge genera of Ko Losin were overgrown (35.29 %) and tissue contact (43.39 %) (**Figure 7**). The Gap and Overgrown interactions were the most frequently found in *Chondrillid* sponge (64.06 and 55.47 %, respectively). Whereas, *Xestospongian* sponge and *Hyrtios* sponge have made 39.20 % of tissue contact and 89.29 % of Overgrow interaction, respectively (**Table 1**). Associated organism that has dominantly made Gap interaction was *Montiporian* coral (43.75 % of Gap interaction). *Montiporian* coral, also, made major proportion of Overgrown interaction to sponge (37.50 %). In tissue contact interaction, the most frequently associated organism found was *Porites* coral (25.57 %). In addition, there are three slightly equal proportion groups that showed high values. They were *Montiporian* coral, *Chondrillid* sponge and *Hyrtios* sponge (19.98, 17.61 and 14.77 %), respectively. However, only *Xestospongian* sponge has made the only high proportion of associated organisms in the overgrow interaction (**Table 2**).

Chondrillid sponge showed the two high values of interaction pattern as Tissue contact (43.39 %) and Overgrown (35.29 %), respectively (**Figure 8**). *Montiporian* coral was found the highest value of associated organisms of *Chondrillid* sponge (**Figure 9**). In addition, *Montiporian* coral has made the gap and overgrown interaction with *Chondrillid* sponge. *Hyrtios* sponge showed the highest values of interaction pattern as Overgrow (**Figure 10**). *Porites* coral was found the highest value of associated organisms of *Hyrtios* sponge (**Figure 11**). In addition, *Porites* coral has made an overgrow interaction with *Hyrtios* sponge.

Xestospongian sponge showed the highest values of interaction pattern as tissue contact (**Figure 12**). *Montiporian* coral was found the highest value of associated organisms of *Xestospongian* sponge (**Figure 13**). In addition, *Montiporian* coral made an Overgrown interaction with *Xestospongian* sponge. *Cinachyrellaid* sponge showed the highest values of interaction pattern as tissue contact (**Figure 14**). *Chondrillid* sponge was found the highest value of associated organisms of *Cinachyrellaid* sponge (**Figure 15**). In addition, *Chondrillid* sponge has made the tissue contact and overgrown interaction with *Cinachyrellaid* sponge.

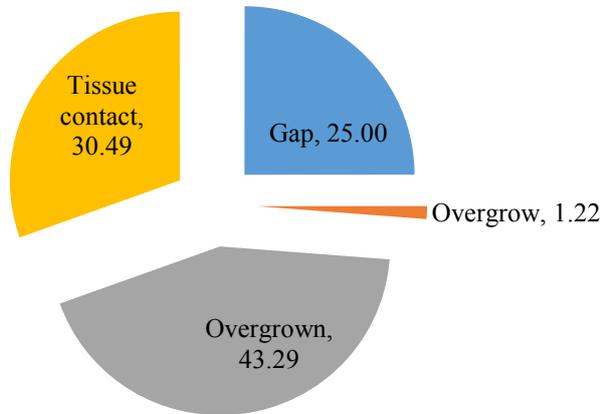


Figure 8 The percentage of interactions of *Chondrillid* sponge.

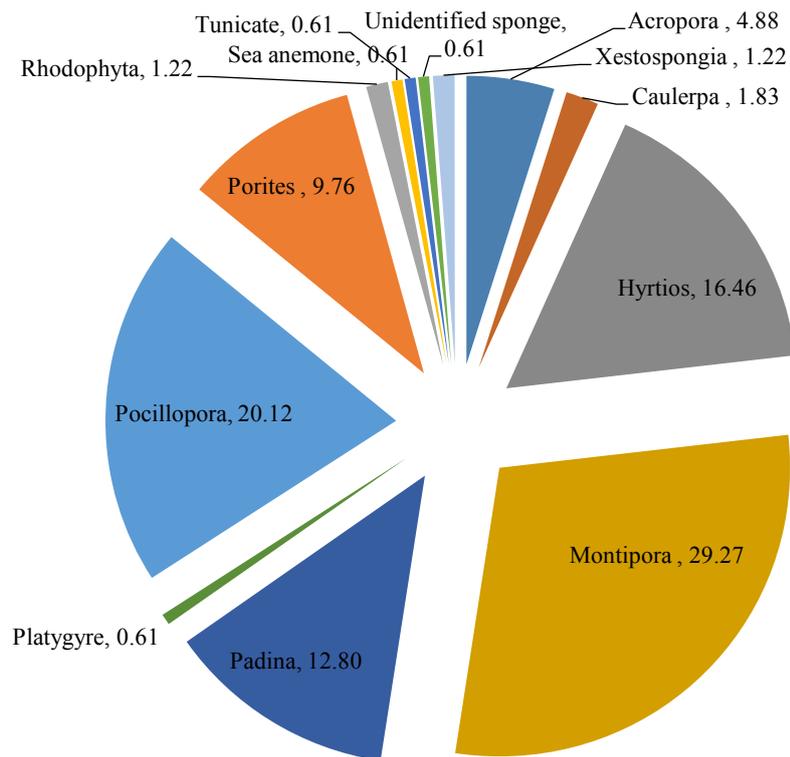


Figure 9 Percentage of organisms associated with *Chondrillid* sponge.

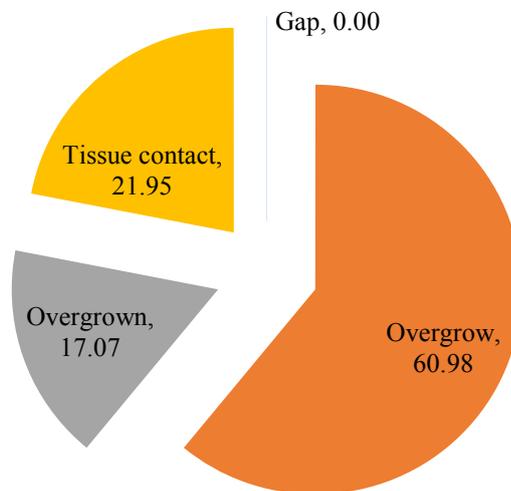


Figure 10 The percentage of interactions of *Hyrtios* sponge.

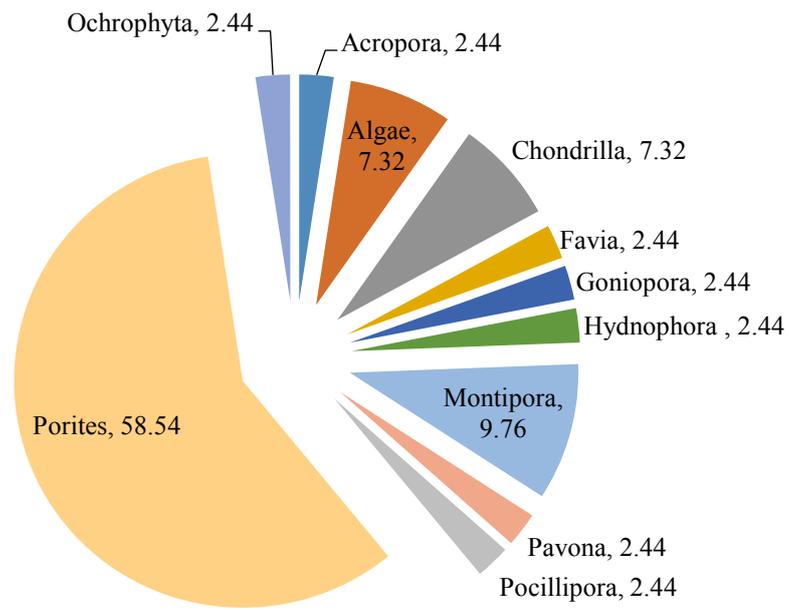


Figure 11 Percentage of organisms associated with *Hyrtios* sponge.

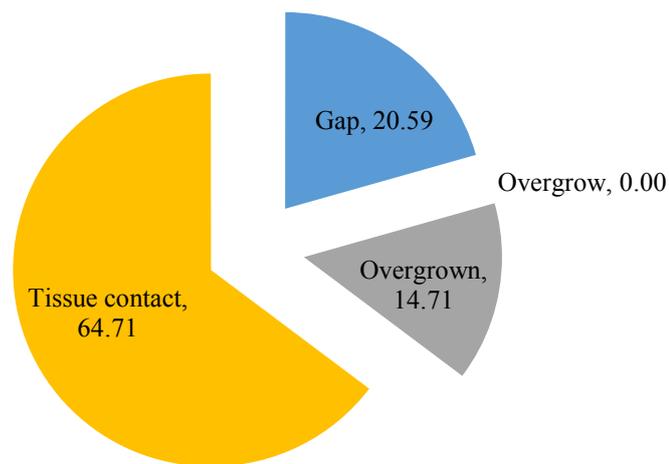


Figure 12 The percentage of interactions of *Cinachyrellaid* sponge.

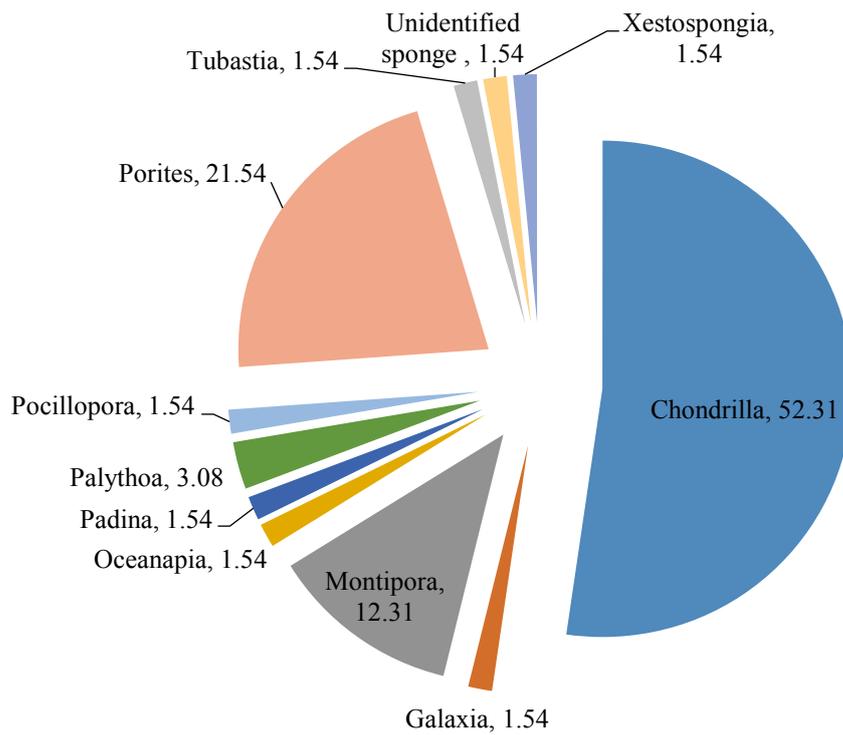


Figure 13 Percentage of organisms associated with *Cinachyrellaid* sponge.

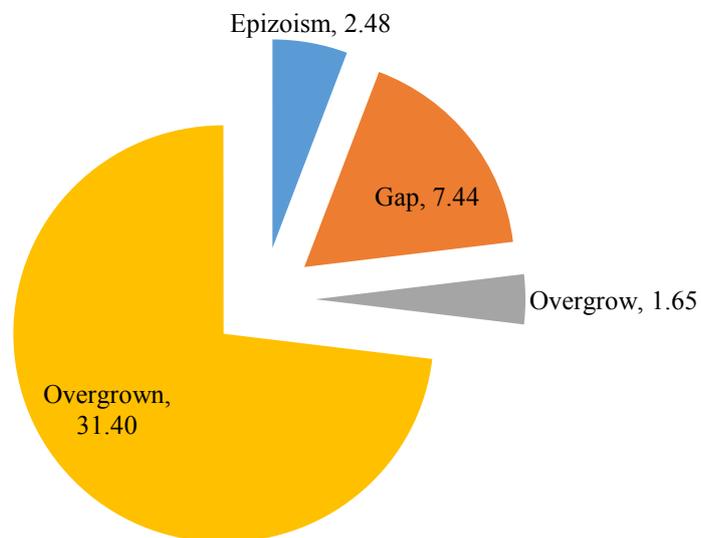


Figure 14 The percentage of interactions of *Xestospongian* sponge.

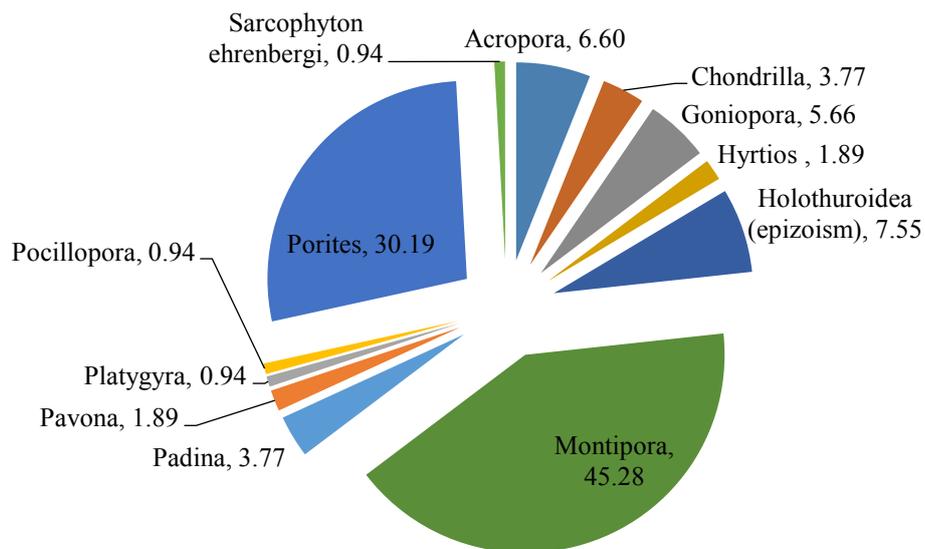


Figure 15 Percentage of organisms associated with *Xestospongia* sponge.

The association pattern of marine sponges and the associated organisms at Ko Losin, the less anthropogenic disturbed coral reef can be concluded as the followings. First, Tissue contact and Overgrown interactions were the most frequently found patterns. Secondly, different genus of sponges showed different patterns of interaction associated with other sessile organisms. Thirdly, the sponge community of Ko Losin is driven by physical factor, like the expected wave stress; and biological factors, such as the expected competition for space.

Table 1 The percentage of sponge genera exploring the interaction pattern with associated organism

Interaction patterns	Gap (n = 64)	Overgrown (n = 128)	Tissue contact (n = 176)	Overgrow (n = 28)
Sponge Genera	%	%	%	%
<i>Chondrilla</i>	64.06	55.47	28.41	7.14
<i>Hyrtios</i>	-	7.81	5.68	89.29
<i>Oceanapia</i>	-	0.78	-	-
Orange sponge	-	-	1.70	-
<i>Cinachyrella</i>	21.88	3.91	25.00	-
<i>Xestospongia</i>	14.06	32.03	39.20	3.57

- means interaction is not observed

Table 2 List of associated organisms inhabiting in sponges and percentage of interactions for each associated taxa

Interaction patterns	Gap (n = 64)	Overgrown (n = 128)	Tissue contact (n = 176)	Overgrow (n = 28)
Associated organisms	%	%	%	%
Phylum Porifera				
<i>Chondrilla</i>	12.5	3.91	17.61	3.57
<i>Cinachyrella</i>	1.56	-	-	-
<i>Hyrtios</i>	-	2.34	14.77	-
<i>Oceanapia</i>	-	-	0.57	-
<i>Xestospongia</i>	1.56	-	1.14	89.29
Unidentified sponge	-	-	1.14	-
Phylum Cnidaria				
<i>Acropora</i>	12.50	0.78	4.55	-
<i>Favia</i>	-	-	-	3.57
<i>Goniopora</i>	-	-	4.55	-
<i>Hydnophora</i>	-	-	0.57	-
<i>Montipora</i>	43.75	37.50	19.89	3.57
<i>Palythoa</i>	-	-	1.14	-
<i>Pavona</i>	-	0.78	1.14	-
<i>Platygyra</i>	1.56	0.78	-	-
<i>Pocillopora</i>	4.69	23.44	3.41	-
<i>Porites</i>	20.31	2.34	25.57	-
<i>Symphyllia</i>	-	-	0.57	-
<i>Sarcophyton ehrenbergi</i>	-	-	0.57	-
Sea anemone	-	0.78	-	-
<i>Galaxia</i>	-	-	0.57	-
<i>Tubastia</i>	-	-	0.57	-
Phylum Chordata				
Tunicata	-	-	0.57	-
Division Rhodophyta				
	-	0.78	-	-
Division Ochrophyta				
Padina	-	1.56	1.14	-
	-	20.31	-	-
Division Chlorophyta				
<i>Caulerpa</i> sp.	-	2.34	-	-
Turf algae community	1.56	2.34	-	-

- means interaction is not observed

Discussion

Ko Losin is the offshore islet in the Gulf of Thailand. Its ecological profile is unique, due to the different impacted factors to other offshore islets, particularly wave action. For example, Sumpayae islet, in the northeast of Sichang island Chonburi province, which is affected by waves, industrial estate and urbanization showed that blue sponge (*Xestospongia* sp.) and sea anemone (personal survey) are abundant in the area. All sponges at Ko Losin found attached to the hard substrate. The shapes were found to be a suitable habitat. *Chondrillid* sponge that explored the encrust lifeform protrude the short body part into water column. *Hyrtios* sponge formed the small cluster of small cushion shape with broad body part attached to substrate. *Cinachyrellaid* sponge, the semispherical body shape, was attached to rock base. Therefore, the underneath circle area was attached to rock base. *Xestospongia* sponge, may be an exceptional as it exhibited in the urn or barrel shape into water column with extending attached area on substrate (this study). Sponge was thought to be the potential competitor of space with stony corals [7,13-15]. The mechanisms of competitions and the effect of competition between sponges and associated organisms were outstanding as demonstrated by Chadwick and Morrow in year, 2011 [14]. In nature, the patterns of competition of sponges and corals were shown in varieties of pattern as overgrowth, peripheral contact, tissue contact and non- contact (see detail in [3]). Pioneer filaments were also used by sponges to perforate the live tissue of corals or even induce polyp retraction and death [16]. This mechanism may result to the gap interaction in this study. In addition, the interaction between sponges and corals promoted by an aggressiveness of sponges themselves rather than physical stress that the coral faces [3]. In this study, 99.19 % of *Xestospongia* sponge and 97.67 % were found with associate sponge. Only 47.22 % of *Cinachyrellaid* sponge was inhabited with associate organisms. *Montiporian* coral and *Porites* coral were the most frequently associated organisms to sponges. These two coral species were inferable and less aggressive in its interaction to sponges.

However, the classifications of interaction between sponges and other space competitors may differently depend on author(s) or researcher(s) point of view in the studied areas. Suchanek *et al.* [2], used the overgrow interaction as criteria interactions to discriminate aggressive or subordinate sponge groups. De Voogd *et al.* [17] have classified the interactions between sponge and their spatial competitors into 5 categories: Overgrowth of neighbor, Peripheral tissue contact, Tissue contact, Non-contact, and Overgrowth by neighbor. The classifications were also similar to this study. Overgrowth of neighbor seems as Overgrow (this study), Peripheral tissue contact and Tissue contact seem as Tissue contact (this study, but the parallel distances between sponges and the tissue contacted organisms were not measured); Non contact seems as Gap (this study, but the distances between sponges and the tissue contacted organisms were not measured). Overgrowth by neighbor seems as Overgrown (this study).

Competitive abilities among plants and animals have been studied for decades. Many studies have shown the hierarchical of competitive ability of sessile organisms [18-21]. However, the outcomes of the competition of space in marine environments are complicated. The combination of size dependent, habitat facilitation (may be through the intraspecific competition of the higher hierarchical competitive species themselves) microhabitats, ocean acidification and anthropogenic impacts are able to modify the hierarchical competitive results [22-25]. Consequences of the above combinations of interaction can lead to phase shift alone the zonation of coral reef communities [24,26]. Chemical warfare, the secondary metabolites have been proven to be the chemical defense among sessile marine organisms [10,27]. Future studies of interaction pattern of sponges and association organisms at Ko Losin should deal with the deeper inspection in the combination of physical factors on the frequency of interaction patterns, such as, wave actions and light penetration (quality and quantity).

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