

**DIVERSITY AND ABUNDANCE OF SELECTED CRYPTIC INVERTEBRATES
IN REEF HABITATS OFF PULAU LAYANGAN, PULAU DINAWAN
AND PULAU SEPANGAR, SABAH**

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**PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH**

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
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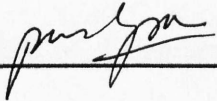
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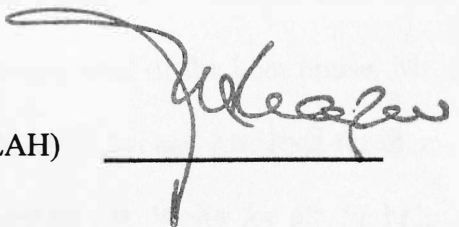
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ABSTRACT

The abundance and diversity of selected cryptic invertebrates in Pulau Layangan, Pulau Dinawan and Pulau Sepangar were determined using Invertebrate Belt Transects of 20 m length and 5 m width. The belt transects were laid at depths of 5 m and 10 m and in coral reefs as well as reef rubble. A total of eight invertebrate belt transects were laid in each island at four different reef sites. A total of 26 species of selected cryptic invertebrates were found in the three study areas. Pulau Layangan had 20 species, Pulau Dinawan 11 species and five species in Pulau Sepangar. Out of the 26 found species, one species was giant clam and three were flatworms while the other 22 species were nudibranchs. Pulau Dinawan had the highest abundance of selected cryptic invertebrates (28 ind/400m²), followed by Pulau Layangan (23 ind/400m²) and finally Pulau Sepangar (14 ind/400m²). *Fryeria picta* was the most abundant species of cryptic invertebrates, followed by *Phyllidiella pustulosa* and these were the only two species found in all three study areas. Depth differences of 5 m and 10 m and reef substrate did not result in large difference in abundance or diversity. This same pattern was seen in all islands where, 36 individuals from 12 species were found at 5 m depth compared to 29 individuals from nine species at 10 m depth. In total 29 individuals from nine species were found in coral reefs and 36 individuals from 11 species in reef rubbles. Shell measurements of *Tridacna squamosa* clams showed that clams in Pulau Sepangar were the smallest and were approximately 2-3 years old. In Pulau Layangan the estimated age was about 3-4 years old and the largest clams from Pulau Dinawan, with an average size of 23.75 cm were estimated to be approximately 5-6 years old.

ABSTRAK

Kelimpahan dan diversiti invertebrata terpilih di Pulau Layangan, Pulau Dinawan dan Pulau Sepangar telah ditentukan dengan menggunakan teknik *Invertebrate Belt Transect* yang panjang 20 m dan lebar 5 m. Transek diletak pada kedalaman air 5 m dan 10 m dan pada terumbu karang dan juga di serpihan karang. Sejumlah lapan *Invertebrate Belt Transect* di letak di setiap pulau pada empat lokasi yang berbeza. Sebanyak 26 spesis invertebrata terpilih telah dikumpul dari tiga kawasan kajian. Dua puluh spesis dari Pulau Layangan, sebelas spesis dari Pulau Dinawan dan lima spesis dari Pulau Sepangar. Daripada 26 spesis, satu merupakan kima, tiga merupakan spesis cacing pipih dan 22 spesis nudibranchia. Pulau Dinawan mempunyai kelimpahan invertebrata tertinggi (28 ind/400m²), diikuti Pulau Layangan (23 ind/400m²) dan Pulau Sepangar (14 ind/400m²). *Fryeria picta* mempunyai kelimpahan spesis tertinggi diikuti *Phyllidiella pustulosa* dan hanya dua spesis ini dijumpai di semua kawasan kajian. Kedalaman air 5 m dan 10 m serta struktur habitat tidak mengubah kelimpahan dan diversiti spesis. Taburan yang sama dilihat di semua kawasan kajian, 36 individu dari 12 spesis dijumpai pada kedalaman air 5 m berbanding 29 individu dari sembilan spesis pada kedalaman air 10 m. Sejumlah 29 individu daripada sembilan spesis dijumpai di terumbu karang dan 36 individu daripada 11 spesis dijumpai di serpihan karang. Ukuran cangkerang *Tridacna squamosa* menunjukkan bahawa kima di Pulau Sepangar paling kecil dan berumur 2-3 tahun. Di Pulau Layangan anggaran umur bagi kima di sana ialah 3-4 tahun dan kima dari Pulau Sepangar dengan saiz purata 23.75 cm dianggarkan berumur 5-6 tahun.

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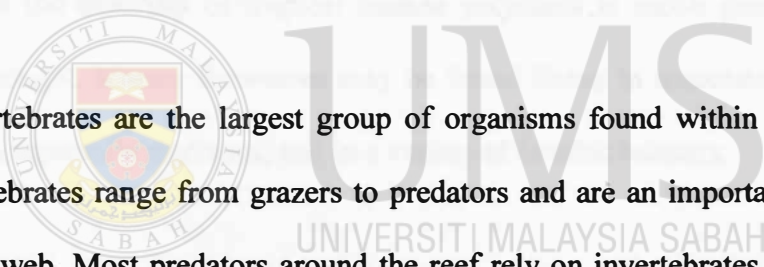
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CHAPTER 1

INTRODUCTION

1.1 Marine Invertebrates



Marine invertebrates are the largest group of organisms found within reef habitats. These invertebrates range from grazers to predators and are an important part of the marine food-web. Most predators around the reef rely on invertebrates as their main source of food. Species such as bivalves and crustaceans are also a major part of our diet and have high economic value in the fisheries sector. Marine invertebrates are among the most beautiful and brightly coloured organisms on the reef, making them the favourite among divers, underwater photographers and collectors (Castro & Huber, 2007). However these invertebrates are also among the least studied among reef inhabitants and thus we know very little about their biology and habits. In this study, diversity and abundance of three cryptic invertebrates: flatworms, nudibranch, and giant clams were investigated.

1.2 Flatworms

Marine flatworms are free living, non-parasitic invertebrates belonging to the diverse class Turbellaria. According to Castro & Huber (2007) twenty thousand species from this class have been described worldwide. However, marine flatworms are generally poorly studied and it has been estimated that an enormous number of species remain to be discovered and described (Faubel *et al.*, 1994; Newman & Cannon, 2003). From 1989 to 1993, Newman & Cannon (1994) documented 134 species of flatworms (over 90% new) from two locations in the southern Great Barrier Reef. Their findings indicated that the diversity of tropical marine polyclads is much greater than was previously thought. Marine flatworms may be found living in association with other invertebrates, especially molluscs, and in a variety of benthic habitats.

Pelagic species may live among surface plankton or floating sea weed (Hyman, 1951; Prudhoe, 1982a; Faubel 1984). Despite being prominent inhabitants of shallow water reefs, little is known about either their biology, diversity, ecology or their interaction with the biotic and abiotic surroundings (Newman *et al.*, 1994). Ponders *et al.*, (2002) quoted that the lack of knowledge regarding marine flatworms is partly due to the fact that there are currently only a few specialists worldwide dealing with the study of free-living Platyhelminthes, thus large areas of the world have not been studied. There are no records of published studies on marine flatworms in Malaysia.

1.3 Nudibranchs

Nudibranchs are gastropods from the order Opisthobranchia, suborder Nudibranchia. The suborder Nudibranchia contains about 3000 species and the members of this suborder display a high diversity in shape and biology (Wagele & Klussmann-Kolb, 2005). Some species display colourful branches of the gut or exposed gills making nudibranch among the most beautiful of all marine animals. These bizarre looking creatures get their name from the Latin words, *nudus branchia* which means naked gills (Garrison, 2007). Biologists have only recently begun to study the role of nudibranch in the ecological communities (Debelius, 1996).

Nudibranchs can be separated into two ecological groups (Franz, 1975). One group is characterised by species with numerous generations per year which feed on seasonally transitory prey, have a tendency to be small in size and frequently cryptic in colouration (Nybakken, 1978). According to Franz (1975), these nudibranchs are termed sub-annuals with the characteristics of r-strategists, do not maintain stable populations, and demonstrate large fluctuations in abundance over short periods of time. The other group is characterised by species with one generation per year which feed on encrusting colonial prey animals, have a tendency to be large in size and often are coloured in striking stand out against to their background (Nybakken, 1978). According to Franz (1975), these nudibranchs are termed annual species or K-strategists and maintain stable populations.

Nudibranchs are considered to be among the most specialised organisms of the benthic marine system and in the food-web, both as predator and prey because they

show a definite choice of their diet (Ibrahim, 1959; Megina & Cervera, 2003). Surprisingly very little quantitative ecological work has been done on nudibranch despite their obvious presence in many areas (Nybakkan, 1978; Pratt & Grason, 2007).

1.4 Giant Clams

Giant clams are the largest marine bivalves and may reach sizes larger than 1 m in shell length and are found in coastal reef areas of the Indo-Pacific region where eight species of giant clams of varying size and habitat preference have been described (*Tridacna gigas*, *T. derasa*, *T. squamosa*, *T. maxima*, *T. crocea*, *T. tevora*, *Hippopus hippopus* and *H. porcellanus*) (Hunro & Heslinga, 1983).

Giant clams have been depleted from coral reefs because they are slow-growing and rather easily accessible to fisherman (Teitelbaum & Friedman, 2008). Habitat degradation is also responsible for declines in abundance, especially in waters close to large urban centres.

Due to these pressures, giant clams have been listed under Annex II of the Convention on International Trade in Endangered Species (CITES, 1983), and are considered vulnerable under the International Union for Conservation of Nature (IUCN) red list of threatened species (Govan, 1988).

1.5 Significance of Study

The significance of this research is to be able to identify existing species of flatworms, nudibranchs, and giant clams in the coral and rubble reef habitats off Pulau Layangan, Pulau Dinawan and Pulau Sepangar. These selected invertebrates have not been studied in great detail in these islands and there are also no published studies on the diversity and abundance of these selected invertebrates in these areas.

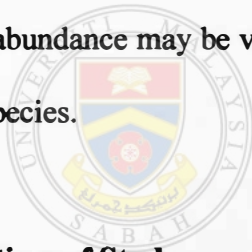
This study aims to provide information about these selected invertebrates in the study areas. Giant clams are an endangered species and information about their diversity and abundance may be valuable for government agencies to protect and keep track of this species.

1.6 Objectives of Study

The objective of this study was to assess the diversity and abundance of selected benthic invertebrates in the surrounding coral and rubble reef habitats off Pulau Dinawan, Pulau Layangan and Pulau Sepangar.

The specific objectives are:

1. To determine the diversity and abundance of selected cryptic invertebrates in Pulau Dinawan, Pulau Layangan and Pulau Sepangar.



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2. To compare the diversity and abundance of selected cryptic invertebrates between coral and reef rubble at 5 m and 10 m depths.
3. To compare the size of invertebrates with emphasis on giant clams.




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CHAPTER 2

LITERATURE REVIEW

2.1 Basic Morphology

2.1.1 Marine Flatworms



Marine flatworms are free-living turbellarians of the order Polycladida that have flat leaf-like body structures and can reach 15 cm in length. They are evidently coloured and exhibit striking colour patterns. These colour patterns represent valid systematic characteristics and are important for taxonomic identifications of polyclads (Hyman, 1951).

Polycladida is divided into two-suborders, Cotylea and Acotylea. Cotylea are marine flatworms with a muscular sucker on the ventral surface posterior to the female genital pore and tentacles (when present) are typically marginal. Cotylea includes the colourful pseudocerotids and euryleptids. On the contrary, Acotylea are marine flatworms without a ventral sucker and tentacles (when present) are typically

nuchal type, and the copulatory complex is usually in the posterior half body (Newman & Cannon, 2003; Prudhoe, 1982b, 1985).

2.1.2 Nudibranchs

Unlike other molluscs, nudibranchs do not have the protection of a shell in their adult form (Debelius, 1996). All members of the suborder opisthobranchia have lost their outer shell and thus do not look like the typical gastropod like snails (Wagele & Klussmann-Kolb, 2005).

2.1.3 Giant Clams

Giant clams are aquatic, laterally compressed, typically bilaterally symmetrical molluscs with a calcareous exoskeleton shell composed of two hinged valves (Ponder *et al.*, 2002; Verma, 2005). The true giant clam (*T. Gigas*), is easily identified by its large size (1 m) and the triangular projections of the upper margins of the shell. The mantle is brown/green with blue or green dots (Ellis, 1997).

The smooth or southern giant clam (*Tridacna derasa*) is the second largest species with a shell length of up to 60 cm. The shell is smooth, and the mantle has elongate brown, green and blue patterns. The fluted or scaly giant clam (*T. Squamosa*) is easily identified by the large fluted scales on its shell. The mantle is generally mottled in blue, brown and green and it can grow to 40 cm.

The rugose or small giant clam (*T. Maxima*) is a boring clam and is the most wide-ranging giant clam species, which can be found from the east coast of Africa to as far east as the Red Sea and eastern Polynesia (Ellis, 1997). It is recognisable by its brightly coloured mantle (blue, green and brown) and boring habit. *Tridacna crocea* (crocus or boring giant clam) is similar to *T. maxima* in that it is a boring species and has a brightly coloured mantle. This species is generally smaller (less than 1 m) and more triangularly ovate in shape than *T. maxima*. *Tridacna tevoroa* (deep water devil clam) is a rare species that lives at depths of greater than 20 m in the northern Tonga Islands and eastern Fiji Islands. *Tridacna rosewateri* is similar to *T. squamosa* and only occurs on the Saya de Malha Bank in the Indian Ocean (Ellis, 1997).

Hippopus hippopus (horse's hoof or strawberry giant clam) has a heavy, thick shell composed of triangular valves with sharp, jagged teeth. The mantle is a dull yellow-brown and does not extend over the margin of the shell. *Hippopus porcellanus* (China clam) differs from *H. hippopus* as it has a lighter, less ribbed shell although the mantle colour is similar. *H. porcellanus* can only be found in the region of Indonesia, the Philippines and Palau (Ellis, 1997).

2.2 Habitat Preferences

2.2.1 Marine Flatworms

Marine flatworms inhabit a variety of marine habitats, and range from interstitial species in marine mud and sands to benthic and pelagic species (Faubel *et al.*, 1994). These free-living flatworms are common in the littoral and sub littoral zones

throughout the world, but especially in the tropics (Prudhoe, 1982a; Brusca & Brusca, 1990). Their vertical distribution is limited by temperature, substrate preferences or biotic associations with seaweeds, corals, sponges, or ascidians (Prudhoe, 1982a). The interaction of flatworm with these biotic and abiotic surroundings and data on other aspects of their biology are unknown or very limited (Faubel *et al.*, 1994).

2.2.2 Nudibranchs

Nudibranchs can be found in various habitats in the marine environment, from intertidal zone to the ocean depths in excess of 100 m. Yet it is the intertidal and inner subtidal zones which support the greatest number of species (Coleman, 2001). Their maximum distribution is throughout the seas of the Indo-Pacific. Nudibranchs can be found exposed on top of corals and sponges or hidden underneath rocks and in crevices, but seldom seen swimming in open water (Godfrey, 1997).

The easiest method to find a nudibranch is to search for its source of food, which includes sponges, hard and soft corals, bryozoans and hydroids. Nudibranchs are commonly found in coral reefs which are high in productivity and species diversity (Allen & Steene, 1999).

2.2.3 Giant Clams

Giant clams are sedentary, and are sometimes found living within limestone substrates, but there are also larger free-living species that are found near coral reefs,