Bio-ecology of Sand Goby Species of the Redang Marine Park Island, Terengganu, Malaysia

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ABSTRACT

A study carried out to determine the species diversity, population abundance, natural behaviour (territorial and feeding regime) of gobies in association with other marine organisms at the three different habitats namely the fringing reefs, sandy beaches and coral rubbles at the Redang Marine Park Island. The results showed that, six genera of gobies have been successfully identified, namely Amblygobius, Cryptocentoides, Gobiopsis, Istiogobius, Stenogobius and Valencienne. Their meristic characteristic, natural behaviour (territorial and feeding behaviour) and the well-being ness of gobies species in their natural environment was assessed through the length–weight relationship. Reproductive biology of selected species of gobies also discussed.

ABSTRAK

Kajian di Taman Laut Pulau Redang telah dilakukan keatas kelimpahan spesies, populasi majmuk, tingkah laku tabii (kawasan dan daerah pemakanan) ikan tembakul yang berkaitan dengan organisma lain di tiga kawasan habitat yang berbeza iaitu kawasan karang beranting, pantai berpasir dan serpihan karang. Keputusan menunjukkan terdapat enam genera tembakul berjaya dipasti iaitu Amblygobius, Cryptocentoides, Gobiopsis, Istiogobius, Stenogobius dan Valencienne. Ciri-ciri meristik, tingkah laku tabii (sempadan dan kelakukan pemakanan) dan kesesuaian tembakul kepada kepada persekitaran semula jadi turut ditentukan dengan melihat perkaitan di antara berat dan panjang ikan. Sifat biologi pembiakan spesies tertentu tembaku turut dibincang.

Keywords: Gobiidae diversity; territorial behaviour; boundary; associated organism.

Introduction

Gobies (Order: Perciformes, Suborder: Goboidei, Family: Gobiidae) belong to the one of the largest groups of marine fishes, containing about 270 genera and approximately 2,200 species are recognized (Harvey & Hems 1973; Birdsong 1975; Hoese 1994; Paxton & Eschmeyer 1994). They are typically small (5-10 cm), elongate, blunt-headed fishes with the following characteristics: a relatively large mouth with conical teeth; gill membranes broadly attached ventrally; pelvic fins usually connected to form a cup-shaped disc, or at least very close together; one or two dorsal fin, the first with II to VIII spines, the second and the anal fin each with I weak spine. In addition, the absence of a lateral line, but numerous sensory head pores. Most species have small ctenoid or cycloid body scales but few lack scales. All but a few species that hover in the water column lack a gas bladder (Harvey & Hems 1973; Nelson 1984; Myers 1989).

The gobies first appeared in the fossil record in freshwater deposits during the Eocene, around 30 to 50 million years ago. They are a very large, cosmopolitan, marine family of shallow coastal water, particularly in tropical and temperate seas. They occur in most parts of the world, except the Artic and Antarctic oceans and in the deep sea (Berra 1981; Myers 1989; Alino & Ming 1992; Hoese 1994; Nelson 1994). Slightly less than half the species occur on coral reefs, about a third in estuaries or muddy bays, about one-tenth in fresh water, and the rest on rocky reefs, sandy beaches, or in the continental shelf (Gilbert & Randall 1979).

Most gobies spend the majority of their time sitting on the substrate, but some species are active swimmers and may occur in schools of up to 100 individuals. They feed mostly on small invertebrates (consists of zooplankton, small crustacean, polychaets, bivalves and gastropods), although some with large mouths may eat other fishes, and a few feed on algae. Many are selective and feed by attacking an individual prey item. Others take a large mouthful of mud or sand and sift out invertebrates or minute algae. The free-swimming species often feed on tiny plankton (Patzner 1991; Hoese 1994; Paxton & Eschmeyer 1994).

Most, if not all, gobies have a very similar life cycle. Nearly all species whose reproductive habits known are gonochorist that lay a small mass (five to few hundred) of demersal eggs guarded by the male. Before spawning, the males look for small cavities, crevices or other hiding places. From there they attract females to deposit their eggs on the walls or ceiling of their holes. The eggs of most gobies are longitudinal and have anchor filaments on one of the poles. The male then fertilizes the eggs. The female departs and the male is left to guard the eggs and keep them clean. The eggs hatch in one to few days into a small transparent larval stage of 2 to 10 millimetres long. The larvae are dispersed into the water column and swim for 3 to 20 days, depending on the species. The larvae then settle into a suitable habitat and rapidly develop coloration to match their surroundings (Patzner 1991; Hoese 1194; Swenson et al. 2001). This paper aimed to elucidate gobies population and their eco-biology at Redang Marine Park Island, Terengganu.

Materials and Methods

Field Observations and Sites Selection

All fieldwork was carried out at Redang Marine Park Island (5° 50' N, 103° 5'E), which is located approximately 45 km northeast of Kuala Terengganu, Malaysia. Four stations selected with different condition. At each station, visual inspections of the entire area by snorkelling or skin diving were conduct during pre-sampling. Station 1- fringing reef, Station 2- sandy bottoms and Station 3- coral patches and rubbles, was used on population and natural behaviour study, respectively. While, meristic and biology studies were conduct on the intertidal pool (Station 4). The water depth of the study areas was very shallow (approximately 1 – 4 m above the mean sea level).

Visual Censuses

Quantitative transects for fish abundance and population studies were conduct at each station at selected time interval. The procedure involved a modification of Dartnall & Jones (1986) visual census technique. All observations made by snorkelling or SCUBA diving equipped with underwater video camera recording (Sony TFV 66 in Ikelite underwater casing) at fixed time interval; in the morning (10 a.m. – 12 p.m.) and evening (3 p.m. – 5 p.m.). At each station, a 25 m transect line was laid parallel to the shoreline 15 – 30 minutes prior to data collection. This is to allow the fishes resume it normal behaviour. Visual census and underwater video recording were carried out gently with minimal disturbance within 2 m left and right along the transect line. The population counts written on the underwater slates and all behavioural activities were record with underwater video and digital camera.

Field Sampling and Sample Preserving

Gobies found in very diverse habitats, collecting them is a formidable task. Tide pool and sandy beaches conditions (Station 4) provide an excellent area to collect gobies, which can be collect during the shallow moist depressions at low tide (4 p.m. – 6 p.m.). In this study, three categories of methods were applied: spied, surrounded and caught, using suction tube, hand net and plastic bottles as traps. Traps are effective methods for gobies that like small caves and crevices. For gobies that dwell in shallow sandy or grassy area, hand net with fine mesh were use. All collected specimens kept into 4% formalin prior to detail biological analyses.

Quantitative and Qualitative Morphological Characters Measurement

All counts of meristic characters adopted by Akihito (1984). Measurements of morphometric characters followed the method described by Hubbs and Lagler (1958). Abbreviations used for characters include D = dorsal fin; A = anal fin; P_1 = pectoral fin; C = caudal fin; TL = total length; SL = standard length; S = snout length; BD = body

depth; ED = eye diameter and W = weight. Description of body coloration and shape were base on the fresh specimens. All lengths were measure to the nearest 0.01 mm using digital vernier calliper. Specimens weighted to the nearest 0.01 g on analytical balance. The identification and species descriptions followed Larson & Murdy (2001); Matsuda et al., (1984) and Nakabo (2002) respectively.

Dissection and Gonad Extraction

Dissection and gonad extraction were carried out using NOAA Fisheries Panama City Laboratory's method (2002). This was done by pushing the knife-tip toward the lower (ventral) part of the fish and with the sharp edge of the knife pointing towards the fish's head, cut into the belly carefully, and continue cutting the skin towards the gills with a shallow-incision from the anus to the ventral base of the gill cover. Then the exposed guts were gently pulled out of the abdominal cavity to allow better access to the gonads. The gonads are located at the dorsal-posterior corner of the abdominal cavity, above the anus. The gonad (either ovary or testis) will consist of two lobes joined posterior, with the anterior portion of each lobe pointing towards the fish's head. Extraction of gonad was done by cutting the posterior end at the point where it is connected to the abdominal wall to remove as much of the gonad as possible. Weight of gonad was measured using analytic balance to the nearest 0.0001 g.

Data Analysis

Data of Station 1-3

From the data obtained, the abundance and the dominance of each species of Gobiidae was calculate, which also allowed their quantitative distribution across the site to be discerned. Diversity indices such as Shannon-Wiener Diversity Index (H'), Dominance Index (D) and Species Evenness Index (E or J) was compared among stations.

Data of Station 4

The length-weight relationship was calculated using the formula: $W = aL^b$, where b is an exponent with the value nearly always between 2 – 4, and often close to 3. the value b = 3 indicates that the fish growth symmetrically or isometrically. Values other than 3 indicate allometric growth. If b >3, the growth is called positive allometric and if b < 3, it is called negative allometric. The length-weight data pairs were analyzed by non-linear iterative algorithm using ORIGIN^{tm} (MicroCalc Software Inc., 2000)

Result and Discussion

Nine species of Gobiidae were found from Station 1, 2 and 3. Three species belonging to the genus *Istigobius*, three to the genus *Amblygobius*, and three to the genus *Valenciennea*. Table 1 show the composition, number and percentage of abundance for each goby species from Station 1, 2 and 3.

TABLE 1: Number and Percentage of Gobiid Individual in the Study Areas

Species Composition	No. Individual per 150 m^2	% abundance
Istigobius goldmanni	593	93.5
Istigobius decoratus	14	2.2
Valenciennea muralis	12	1.8
Amblygobius phalaena	2	0.3
Amblygobius sp.	3	0.5
Valenciennea longipinnis	6	0.9
Amblygobius decussates	1	0.2
Valenciennea helsdingenii	1	0.2
Istigobius ornatus	2	0.3

Being small, gobies are often preyed upon by larger fishes, sea snake, and shore birds and they have developed a number of adaptations to reduce the chance of being eaten (Larson and Murdy, 2001). Many gobies send most of their time in burrows and come out only to feed. Others bury themselves in sand. Around coral reefs, many avoid predators by living in the branches of corals and others by living in the dark caves, often swimming upside down or resting upside down on the roof of the cave. Another defence form in avoiding predators is to develop cryptic coloration. For example, species living on sand develop a speckled coloration that matches the sand. On coral reef, many gobies are largely transparent, with a few coloured spots that match the coral or other invertebrate on which the fishes live. Sometime, gobies shown protean behaviour in their swimming strategy and tactic, using a zigzag movement to confuse the predators (Fig. 1).

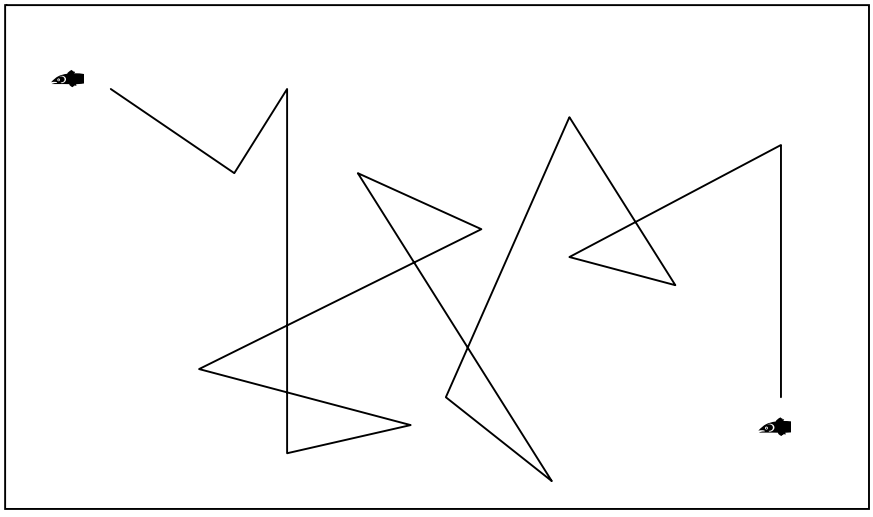

FIGURE 1: Protean Behaviour of Gobies to Confusing the Predators

Some of the species seem to be territorial at all time to defend a food supply, whereas others move around with the tides. The sedentary species probably spend their whole life within a few square metres or less of substrate. Figure 2 show the movement pattern of gobies in their territory defence. On a broader scale, territories are used to acquire space, food, mates and spawning sites. All gobies exhibit more territorial behavioural during breeding season with the males defending a small territory where the crevices or burrows for the eggs found.

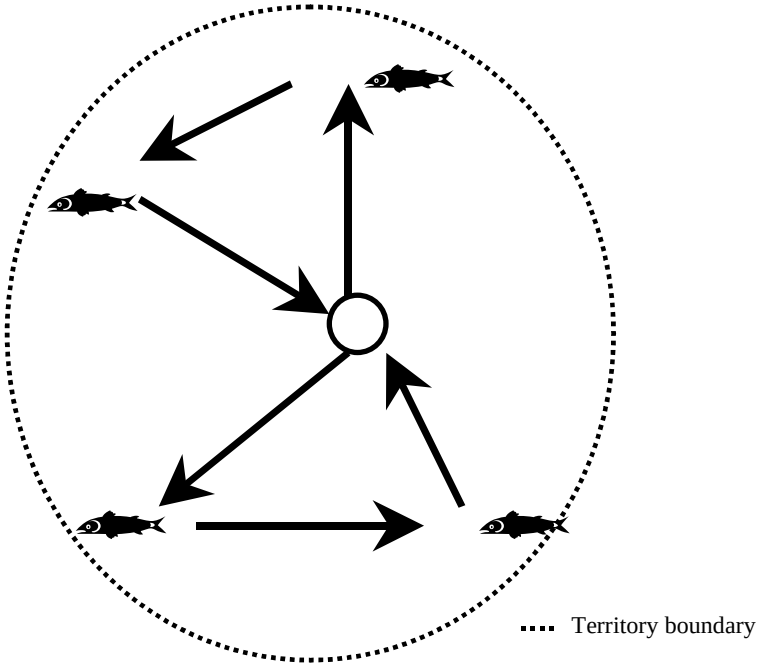

FIGURE 2: The Movement of Gobies

Within the large number of species in the goby group, some unusual life styles have been observed. One of the most interesting is the association of gobies with various marine invertebrates. Goby takes advantage of its invertebrate host by sharing its home. The goby may return the favour in another way. Species such as *Cryptocentroides insignis* share the interesting habit of living in a burrow constructed by an alpheid shrimp. The shrimp builds a burrow in sand or mud and is blind, or nearly so, and unable to see approaching danger. The goby uses the burrow as a refuge, and with its superior ability to detect danger, acts as a sentinel for the shrimp. The shrimp feeds on detritus and tiny bacteria and algae in the sand. When the shrimp brings out its load, the sand often contains small crabs or other invertebrates, which become food for the goby. This symbiotic cooperative association allows both animals to survive in its own.

Another association is that of gobies with invertebrates that are cemented to substrate, such as corals, sponges, giant clams, soft corals or sea whips. In these associations, the gobies spend their whole lives in a single coral or a small group of invertebrates, such as

sea whips. Those fishes that live in corals gain a good hiding place, but it is not clear what benefit the coral derives from the association. The sponges and sea whips enable the fish to move higher up in the water column and feed on plankton. Most of the species in this study are bottom-dwelling fish which feeding on small invertebrate, plankton and algae. They belong to *Istigobius*, *Valenciennea*, *Stenogobius*, *Cryptocentoides*, and *Gobiopsis*. While, species of *Amlygobius* are filter feeders.

Diversity Indices such as Shannon-Wiener Diversity Index, Dominance Index and Species Evenness Index were calculated and analysed to compare the values among the sampling stations (Table 2). The results showed that the sandy bottom sustained highest species dominant whiles coral patches and rubbles sustained high species diversity and evenness.

TABLE 2: Diversity Indices of Gobies in the Study Areas

Diversity Indices	Stations		
	1	2	3
Shannon-Wiener Diversity Index	0.271	0.262	0.397
Dominance Index	0.8849	0.9036	0.8484
Species Evenness Index	0.195	0.189	0.222

A total of 47 gobies, which consist of 5 species were collected from Station 4. Two species belonging to genus *Istigobius*, one species to genus *Stenogobius*, *Gobiopsis* and *Cryptocentroides*, respectively. Table 3 show the measurement of morphometric characters in each genus. The results showed that there were clear morphometric differences amongst four genera of gobies in the study areas.

TABLE 3: Measurement of Morphometric Characters According to Genus. All Length in mm Unit and Weight in g (numbers in parentheses denoted standard error)

Genus	TL	SL	S	BD	ED	W
Istigobius	52.371 (1.349)	43.114 (1.152)	3.055 (0.131)	8.436 (0.241)	3.249 (0.082)	1.529 (0.101)
Stenogobius	77.513 (1.720)	62.063 (1.274)	3.438 (0.226)	11.975 (0.438)	4.400 (0.131)	4.205 (0.264)
Gobiopsis	24.100 (3.800)	17.225 (5.675)	1.125 (0.075)	3.175 (0.025)	2.75 (1.75)	0.095 (0.025)
Cryptocentroides	51.325 (1.475)	42.550 (0.750)	1.850 (0.350)	7.450 (0.050)	3.075 (0.025)	1.000 (0.100)

Taxonomic “key” for Redang Island gobies species were established according to the meristic, morphometric and qualitative (shape and colour) characters. The study on length-weight relationship also carried out by plotting the weight against standard length (Fig. 3). The graph indicated allometric growth with positive allometry ($b > 3$), means

gobies becomes 'heavier for its length' as grows larger, that is length increases at much slower rate than mass. Which, b value was affected by factors such as sex, maturity, and season.

The gobies gonad development stage was determined based on weight and colour of gonad, where it consist of 5 stages, each stage shown differential in maturity level of the goby fishes. Identification of gobies sexually using body and gonad colour and pattern was also carried out in the study. The goby exhibits sexual dimorphism in the form of dichromatism, in which the males was differentiated from the females by body size, colour and pattern. Males often smaller and more colourful compared with females.

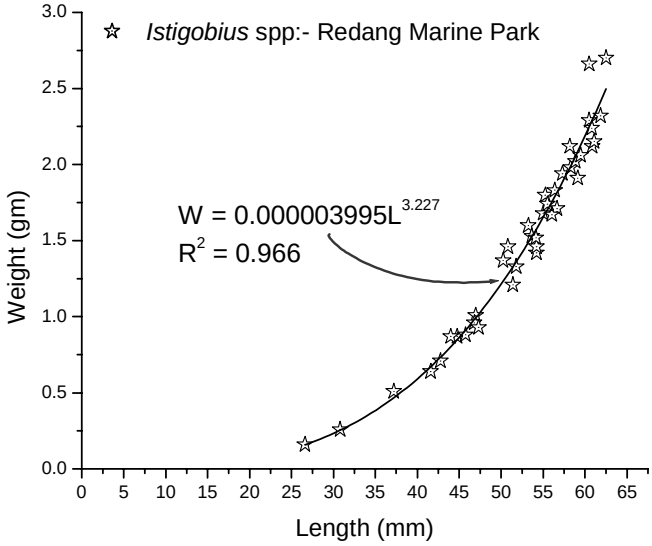

FIGURE 3: Length Weight Relationship of *Istigobius* spp of Redang Marine Park Island

Key to Species of Redang Marine Park Island, Terengganu, Malaysia.

1a Pelvic frenum simple, not folded forward, frenum without fleshy lobes around pelvic spines; Body fully scaled or mostly scaled; No barbells present on chin .....**GOBIONELLINAE: 2**

1b Pelvic frenum folded forward and a fleshy lobe present around each spines; Body naked or with a few scales on caudal peduncle; Barbells present on chin .....**GOBIINAE: 3**

2 Total first dorsal spines 6; Total second dorsal rays 10; Eye not elevated, without eyelid; Mouth terminal; Head compressed, narrower than deep; Body with transverse bands with completely ctenoid body scales.....***Stenogobius lachrymosus***

3a Total anal rays 9; Barbells present on ventral surface of head; Mouth terminal; Head depressed but body never extraordinarily elongate; Anterior body scales

cycloid, no scales on check or opercle.....***Gobiopsis arenaria***

3b Total anal rays > 9; No barbells present; Mouth sub terminal; Head rounded; Body scaled at least on posterior half, but no scales on check or opercle.....**4**

4a Soft dorsal and anal rays I, 12; Body elongate and caudal rounded; Body scales ctenoid only; colour pattern variable, often with small dark spots..... ***Cryptocentroides insignis***

4b Soft dorsal I, 10; Anal rays I, 9; Body in fusiform; Caudal rounded; Predorsal scales cycloid, trunk ctenoid; Fin rays with small dusky spots.....***Istigobius:* 5**

5a Anterior tip of first dorsal fin without bright yellow; Tips of upper pectoral fin rays not free.....***Istigobius goldmanni***

5b Anterior tip of first dorsal fin bright yellow; 3 – 4 tips of upper pectoral fin rays free.....***Istigobius ornatus***

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