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Short Communication

# Species Composition and Distribution Pattern of Stingrays in the Coastal Waters of Terengganu, Malaysia, the South China Sea

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## Abstract

Stingrays are part of commercial fisheries worldwide; Malaysia is ranked as the eighth-largest stingray fishery in the world. Samples were collected monthly from January 2018 to December 2018 with supplementary samplings on February 2019 and October 2019 by using stingray gill nets in Coastal South China seawaters of Terengganu. The present study aimed to determine the abundance and distribution of stingrays based on species and sizes at different habitat and seasons in the Terengganu, Malaysia coastal waters. A total of 10 stingray species were collected from 122 samples. Stingray species are distributed differently according to habitat and seasonal. The result of a two-way ANOVA showed that habitat significantly ($P< 0.005$) and season highly significant affects the abundance of stingrays ($P < 0.001$). Most catches were in 20 m depth during the dry season. The result of a non-metric multidimensional scaling ordination indicates that the grouping overlapped in habitat and season with similar species collected.

**Keyword:** ray, stingray, habitat, seasonal, gill net, Terengganu, coastal South China sea

## 1. Introduction

Stingrays have become a major part of commercial fisheries around the world due to the high interest from the market [1]. Most catches of elasmobranch are from bycatch cases, which are incidentally caught by the fisherman during the fishing activity. From previous studies, stingrays were caught as the bycatch species mostly by using pelagic longline and hook, bottom longline, surface longline, trawl and gillnets as fishing gear [2-5].

Most marine population dynamics are influenced by behavioural responses towards the ecological process, including both abiotic and biotic factors [6, 7]. Understanding the factors that affect habitat shifts is important for better awareness of population dynamics in fisheries that are target or bycatch species [6, 7]. Abiotic factors can trigger movement and changes in behaviour and habitat of elasmobranchs [8, 9]. Salinity and water temperature are most selective factors in most studies; however, turbidity, dissolved oxygen concentration and pH also provide an important aspect for the spatial distribution and ecology of rays [8, 9]. Changes in the environment can trigger the movement and changes in behaviour and habitat for elasmobranch species [8]. Temperature affects the physiology of most sharks and rays; they are sensitive to temperature changes. Most rays are strictly stenohaline; it gives a strong influence towards salinity on physiology. Salinity influences the distribution and abundance of sharks and rays such as *Carcharhinus amboinensis* (pigeye sharks) and *Rhinoptera bonasus* (cownose rays) [8]. For studying the ecology of rays, it is important to understand the role of the species in the marine ecosystem and their trophic relations. Understanding these trophic interactions and the position of a species within a food web is an important step in defining the dynamics of marine communities and the impacts to species. Failure to identify those important aspects will lead to gaps in understanding the importance of rays in the marine ecosystem. Changes in the food web can affect the system intensely, resulting in changes in abundance and web connectivity with other species. Rays are considered a keystone species in marine ecosystems with an important role to maintain the sustainability of the ecosystem [10].

In Malaysia, the demand for stingrays has increased [11, 12]. Stingrays (Dasyatidae) are one of the most important batoid fishes in commercial fisheries, consisting of small to very large sizes; adult's specimens can reach between 22 cm and 260 cm DW with diverse distribution in Asia [13]. In Asia, there is less known about ray ecology compared to the Americas [9]; within Asia, Malaysia has less research compared to other countries such as Indonesia [14]. In Malaysia, previous studies have focused on fishing gear such as barrier nets, gill nets and beam trawls to catch stingrays in coastal mudflats in Kuala Selangor to study the length-weight relationship [15]. Fewer studies have focused on stingray distribution in Malaysia. From the previous research in Malaysia, a total of six species of stingrays were sampled: *Himantura walga*, *Dasyatis bennetti*, *Dasyatis zugei*, *Neotrygon kuhlii*, *Taeniura lymma* and *Himantura pastinacoides* [15].

The research conducted on stingrays in Malaysia is still in its early stages with most of the research focused on other marine organisms such as sharks and turtle. This study is the first investigation of the habitat and seasonal patterns of abundance and distribution of stingray species in Terengganu coastal waters. The objectives of this study are to determine the abundance and distribution of stingrays based on species and sizes at different habitats and seasons in the Terengganu, Malaysia coastal waters. There is less knowledge of habitat, characteristics and distribution of stingray species in Malaysia compared to other Asian countries. This study examined the influence of habitat and seasonal divisions on the abundance and distribution of stingray species in Malaysia. Moreover, it contributes data on the population size of stingrays caught in Terengganu waters. This study may help to achieve a sustainable stingray stock in Malaysia and provide information on stingrays for artisanal fisheries.

## 2. MATERIAL AND METHODS

### 2.1 Study Area

Three different depth contours along the coastal area of Terengganu were selected: 10 m, 15 m and 20 m depths. Three sub-stations were on the line transect based on locality: Bidong Island, Kapak Island and Gelok Island were chosen for each depth contour (Figure 1). All the depths at

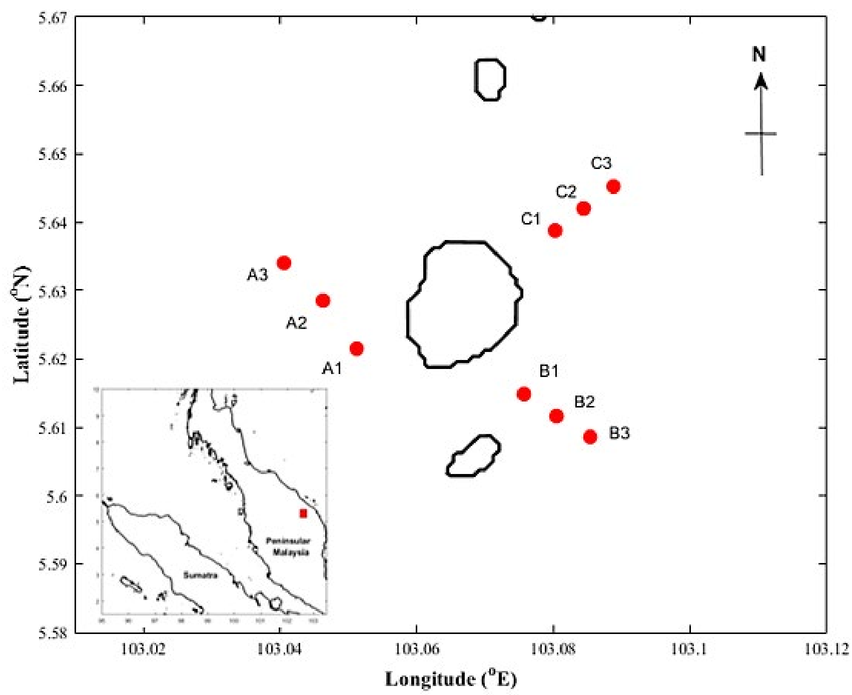


**Figure 1.** Three sub-stations as line transect based on locality; Bidong Island (A), Kapak Island (B) and Gelok Island (C) with different depth contour (A1, B1, C1: 10m; A2, B2, C2: 15m; A3, B3, C3: 20m).

each sampling station were measured by sonar SIMRAD EK 15. The stingray is the main target organism caught by local fishermen using gill nets.

### 2.2 Collection of Samples

Samples were collected monthly from January 2018 to December 2018 with supplementary samplings on February 2019 and October 2019 by using stingray gill nets in Terengganu waters. At each sub-station of each depth contour, a net was set up with 2.00 m deep, 2,100 m long and 26 cm stretch mesh size. The gears were set at 0600 hours in morning, left overnight for 24 hours and hauled on board the next morning (Figure 2). Altogether, 6,300 m of netting were sampled at each depth contour totalling 18,900 m from all three depth contours each sampling months. For seasonal division based on Hisam et al. (2015), three different seasons were based on the quantity of rainfall: (1) the rainy season was from September to December, (2) the moderately rainy season was from May to August and (3) the dry season was from January to April. The stingray samples were removed from the nets and transported to the laboratory for further analysis.

Field samplings were done monthly from January 2018 to December 2018, with supplementary samplings on February 2019 and October 2019 to complement existing data based on seasonal, sizes, sex, habitat change and seasons for the same months in 2018.

### 2.3 Laboratory Work

In the laboratory, stingray sizes were measured by disc width (DW), disc length (DL) and total length (TL) using a measuring tape. The total

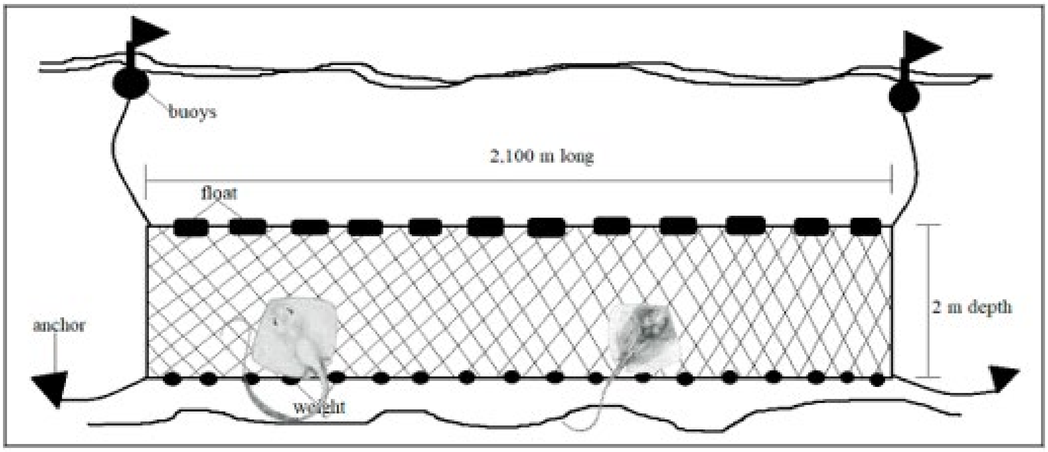


**Figure 2.** Characteristic of stingray gillnets used during sampling.

length (TL) was taken from the tip of snout to the end of the tail, disc width (DW) was taken from the maximum distance between wingtips and disc length (DL) was taken from the tip of the snout to the posterior edge of the disc [16]. Stingray weights were measure with an electronic weight balance; the calibration was done before weighing. Stingrays were sexed based on the occurrence of clasper. The presence of a clasper indicates that a stingray is male [17].

### 2.4 Statistical Analysis

A two-way analysis of variance was used to test whether the abundance of stingrays collected differed significantly amongst season and habitat. Abundance data were log(x+1) transformed to reduce non-normality before analysis. Once the difference was detected, a post hoc analysis was conducted using the Tukey Test. A two-way analysis of variance was used to test whether numbers of stingrays differ significantly amongst habitat and season. The raw data was log(x+1) transformed to reduce non-normality before analysis. A Tukey test was used once the difference detected. The relationship between mean disc width (cm), weight (g) of the stingray and water depth (m) were measured to quantify a habitat shift.

A non-metric multidimensional scaling (nMDS) ordination was conducted to assess the extent to which individual groupings were based on habitats and seasons for particular areas. The nMDS was performed using PRIMER statistical package version 5.0. A Bray-Curtis similarity based on log(x+1) transformations was used to examine the differences between stingray community assemblages in all habitats and seasons. Analysis of similarity (ANOSIM) was used to determine differences in stingray assemblages separated by nMDS ordination. Once the significant differences were found, a similarity percentage (SIMPER) was used to examine which stingray species contributed most to the difference

## 3. Results

A total of 122 stingrays were collected with gill nets; 16 (10 m), 29 (15 m) and 77 (20 m) stingrays were caught in this study (Table 1). Ten stingray species were present in this study (Figure 4). The results from 20 m depth caught larger-sized stingrays compared to 10 m and 15 m depth. For example, the size of stingrays caught were 78.49 ± 36.85 cm, 95.47 ± 31.42 cm, 70.27 ±28.94 cm in 20 m during the dry, moderate and rainy seasons, respectively. There were more catches of female

**Table 1.** Total abundance, sex, size, and weight of stingray species caught from gill nets each habitat from January 2018 to December 2018.

| Source | Total | Male | Female | BW±SD (kg) | DW±SD (cm) |
|---|---|---|---|---|---|
| 10 m | | | | | |
| Dry | 10 | 5 | 5 | 3.64 ± 6.50 | 35.79 ± 12.53 |
| Moderate | 1 | 1 | 0 | 4.90 | 58.60 |
| Rainy | 5 | 2 | 3 | 4.40 ± 1.82 | 59.40 ± 15.46 |
| Total | 16 | 8 | 8 | | |
| 15 m | | | | | |
| Dry | 14 | 7 | 7 | 13.93 ± 14.83 | 69.07 ± 39.84 |
| Moderate | 13 | 4 | 9 | 20.05 ± 13.47 | 98.86 ± 32.22 |
| Rainy | 2 | 1 | 1 | 8.05 ± 2.47 | 61.35 ± 4.88 |
| Total | 29 | 12 | 17 | | |
| 20 m | | | | | |
| Dry | 43 | 16 | 27 | 15.22 ± 16.70 | 78.49 ± 36.85 |
| Moderate | 31 | 22 | 9 | 19.92 ± 14.71 | 95.47 ± 31.42 |
| Rainy | 3 | 1 | 2 | 12.93 ± 12.33 | 70.27 ± 28.94 |
| Total | 77 | 39 | 38 | | |

*BW= body weight, DW= disc weight, SD= standard deviation.

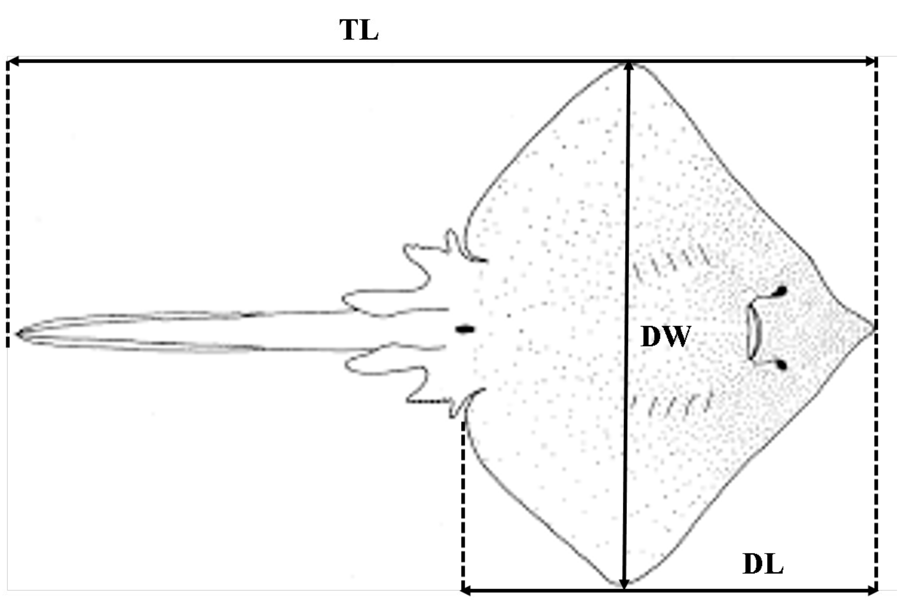


**Figure 3.** Measurement of disc width (DW), disc length (DL) and total length (TL).

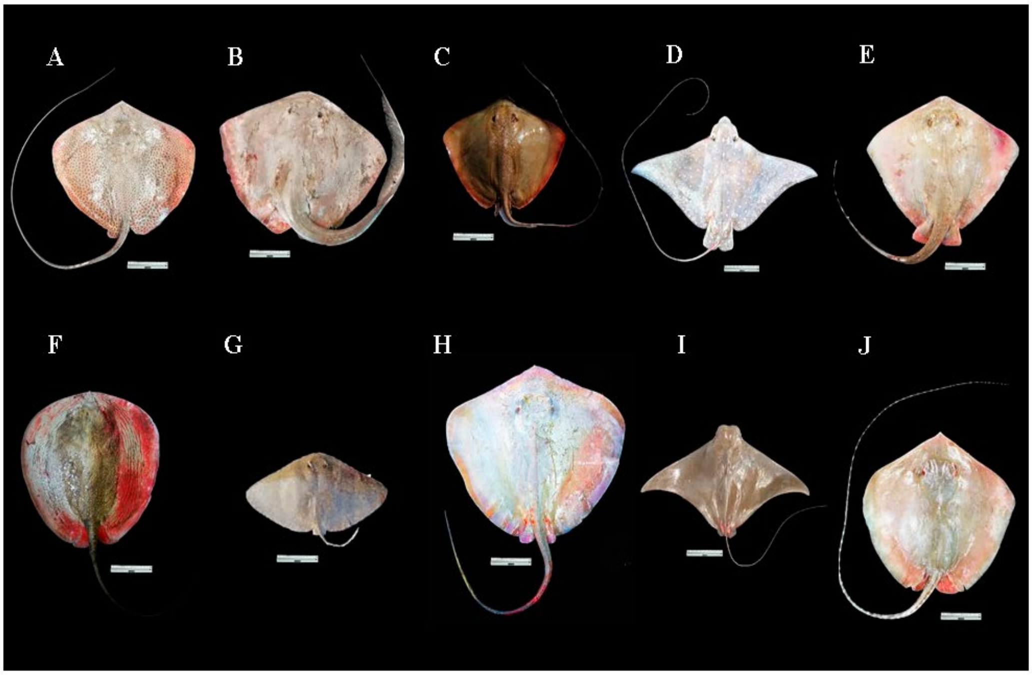


**Figure 4.** Stingray's species collected, A, *Himantura uarnak*; B, *Pastinachus ater*; C, *Maculabatis gerrardi*; D, *Aetobatus acellatus*; E, *Hemitrygon parvonigra*; F, *Urogymnus asperrimus*; G, *Gymnura poecilura*; H, *Pateobatis jenkinsii*; I, *Rhinoptera javanica*; J, *Brevitrygon walgai*.

**Table 2.** Two-way analysis of variance of the effects of habitat and season on abundance of stingrays collected by gill nets.

| Source | Abundance | | |
|---|---|---|---|
| | df | MS | P-value |
| Habitat (h) | 2 | 0.67 | $2.29 \times 10^{-3}$ |
| Season (s) | 2 | 0.94 | $4.47 \times 10^{-4}$ |
| h × s | 4 | 0.24 | $3.97 \times 10^{-2}$ |

stingrays than male stingrays (Table 1).

The results from the ANOVA found that the catches of stingray species were significantly influenced by habitat ($P < 0.005$) and highly significant influenced by season ($P < 0.001$) (Table 2). Detail of results for Tukey HSD test for habitat can be found in Tables 3 and 4. Both mean abundance of stingrays was no significant different at depth of 10 m and 15 m, and also at dry and moderate season. Monthly catches of stingray species from different habitats and seasons are detailed in Table 5.

Result from nMDS plots revealed that the grouping of stingray species overlapped based on different habitat depths (Figure 5). However, all habitat assemblages were similar to each

**Table 3.** Tukey HSD test on mean abundance of stingrays collected by gill nets in different habitat.

| | Habitat (mean abundance) | | |
|---|---|---|---|
| | **10 m** | **15 m** | **20 m** |
| 10 m | - | - | - |
| 15 m | >0.05 | - | - |
| 20 m | <0.05 | <0.05 | - |

**Table 4.** Tukey HSD test on mean abundance of stingrays collected by gill nets during different season.

| | Season (mean abundance) | | |
|---|---|---|---|
| | **Dry** | **Moderate** | **Rainy** |
| Dry | - | - | - |
| Moderate | >0.05 | - | - |
| Rainy | <0.05 | <0.05 | - |

**Table 5.** Number of stingray's species caught at each habitat and season in each month at the sampling site of Terengganu waters from January 2018 to December 2018.

| **Months** | **Habitat** | | | | | | | | | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Dry** | | | **Moderate** | | | **Rainy** | | | |
| | **10 m** | **15 m** | **20 m** | **10 m** | **15 m** | **20 m** | **10 m** | **15 m** | **20 m** | |
| January | 1 | 3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| February | 8 | 8 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 26 |
| March | 0 | 2 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 19 |
| April | 1 | 1 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| May | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 5 |
| June | 0 | 0 | 0 | 1 | 3 | 7 | 0 | 0 | 0 | 11 |
| July | 0 | 0 | 0 | 0 | 3 | 10 | 0 | 0 | 0 | 13 |
| August | 0 | 0 | 0 | 0 | 6 | 10 | 0 | 0 | 0 | 16 |
| September | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 4 |
| October | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| November | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 4 |
| December | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Total | 10 | 14 | 43 | 1 | 13 | 31 | 5 | 2 | 3 | 122 |

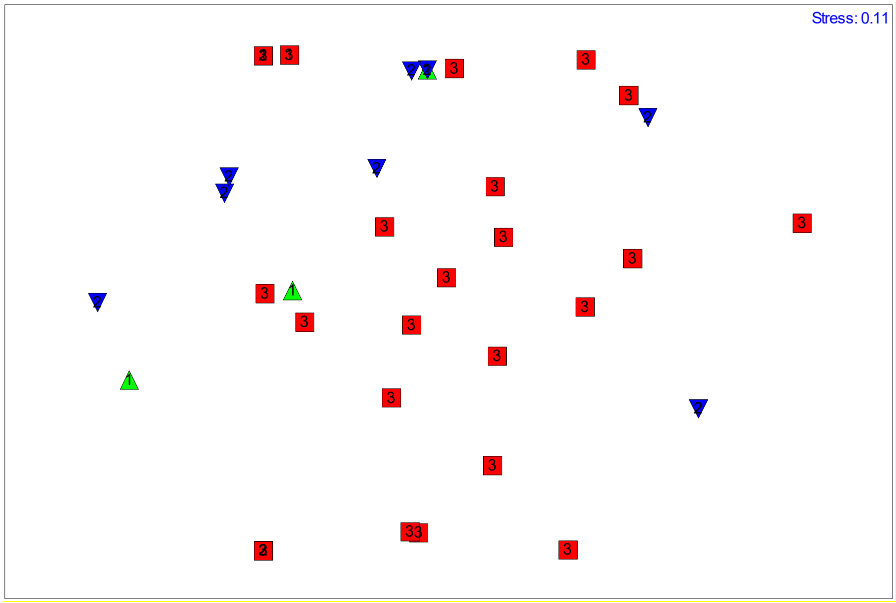


**Figure 5.** The nMDS plot for assemblages at various habitat of stingray species collected by gill net in Bidong, Gelok and Kapak islands. (1=10m, 2=15m, 3=20m)

other. The nMDS plots revealed that the stingray species distribution overlapped based on different seasons (Figure 6). Species of stingrays in each of habitat and season were identified by similarity of percentage (Table 6).

Body weight and disc width of stingray species increased towards the deeper water depth (Figure 7). Body weight of stingray species from each habitat was significantly different as the smaller size stingray tended to inhabit shallow waters and migrate to deeper water when growing larger.

## 4. Discussion

Total of 10 stingray species were collected based on habitat and season. This study shows that habitat and season have an impact on the abundance of stingray species in Terengganu waters. There are significant differences between the interaction of habitat and season with the abundance of stingrays caught (Table 2). This is due to different physical and biological conditions between the different habitats and seasons. However, for the habitats at 10 m and 15 m depth, there was no significant effect on species abundance compared to 10 m with 20 m and 15 m with 20 m depth (Table 3). Stingrays tended to locate at a deeper depth compared to shallow water. The seasonal factor showed a significant difference of the species abundance between dry and rainy and between moderate and rainy seasons; there was no difference between the dry and moderate seasons (Table 4).

This study shows that most of the stingray catches occurred in deeper water (20 m) and during the dry season (Table 5). Previous research stated that some of the stingray species react differently during day and night; they search for prey in shallow water during the night and rest in deeper places during the day. The distribution of young stingrays was closely related to the shallow water and sandy beaches [18, 19]. Some large stingrays occupied locations with different depths

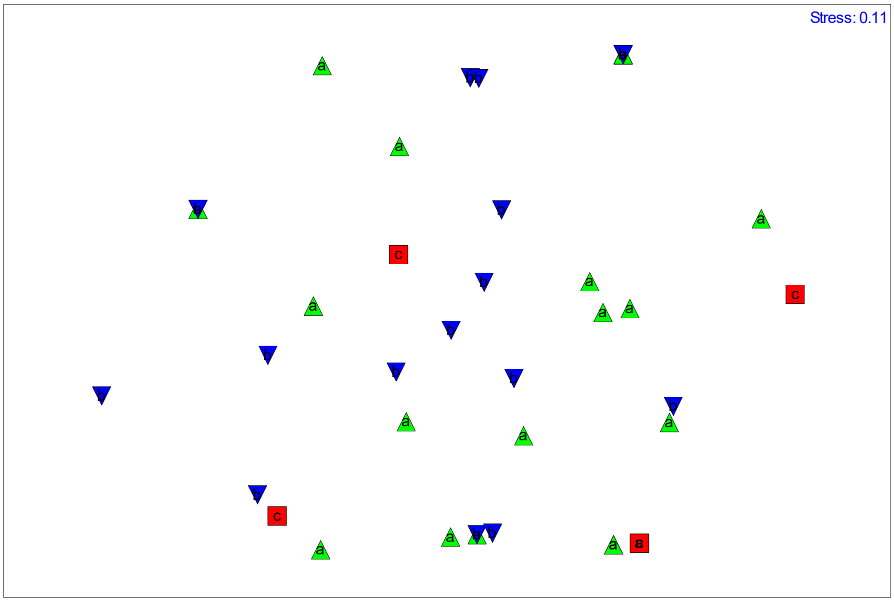


**Figure 6.** The nMDS plot for assemblages at different season of stingray species collected by gill net in Bidong, Gelok and Kapak islands (a= dry, b= moderate, c= rainy).

**Table 6.** Stingray species assemblages in habitat and season based on nMDS plots.

| Habitat | Season | Species | %Contribution |
|---|---|---|---|
| 10 m | Dry | *Hemitrygon parvonigra* | 50 |
| | | *Brevitrygon walga* | 50 |
| | Moderate | No similarities | 0 |
| | Rainy | No similarities | 0 |
| 15 m | Dry | *Maculabatis gerrardi* | 53.28 |
| | | *Hemitrygon parvonigra* | 24.82 |
| | Moderate | *Maculabatis gerrardi* | 64.52 |
| | | *Pastinachus ater* | 19.35 |
| | Rainy | No similarities | 0 |
| 20 m | Dry | *Pateobatis jenkinsii* | 28.49 |
| | | *Pastinachus ater* | 23.48 |
| | | *Aetobatus acellatus* | 16.75 |
| | Moderate | *Maculabatis gerrardi* | 26.58 |
| | | *Rhinoptera javanica* | 26.60 |
| | | *Himantura uarnak* | 22.21 |
| | Rainy | No similarities | 0 |

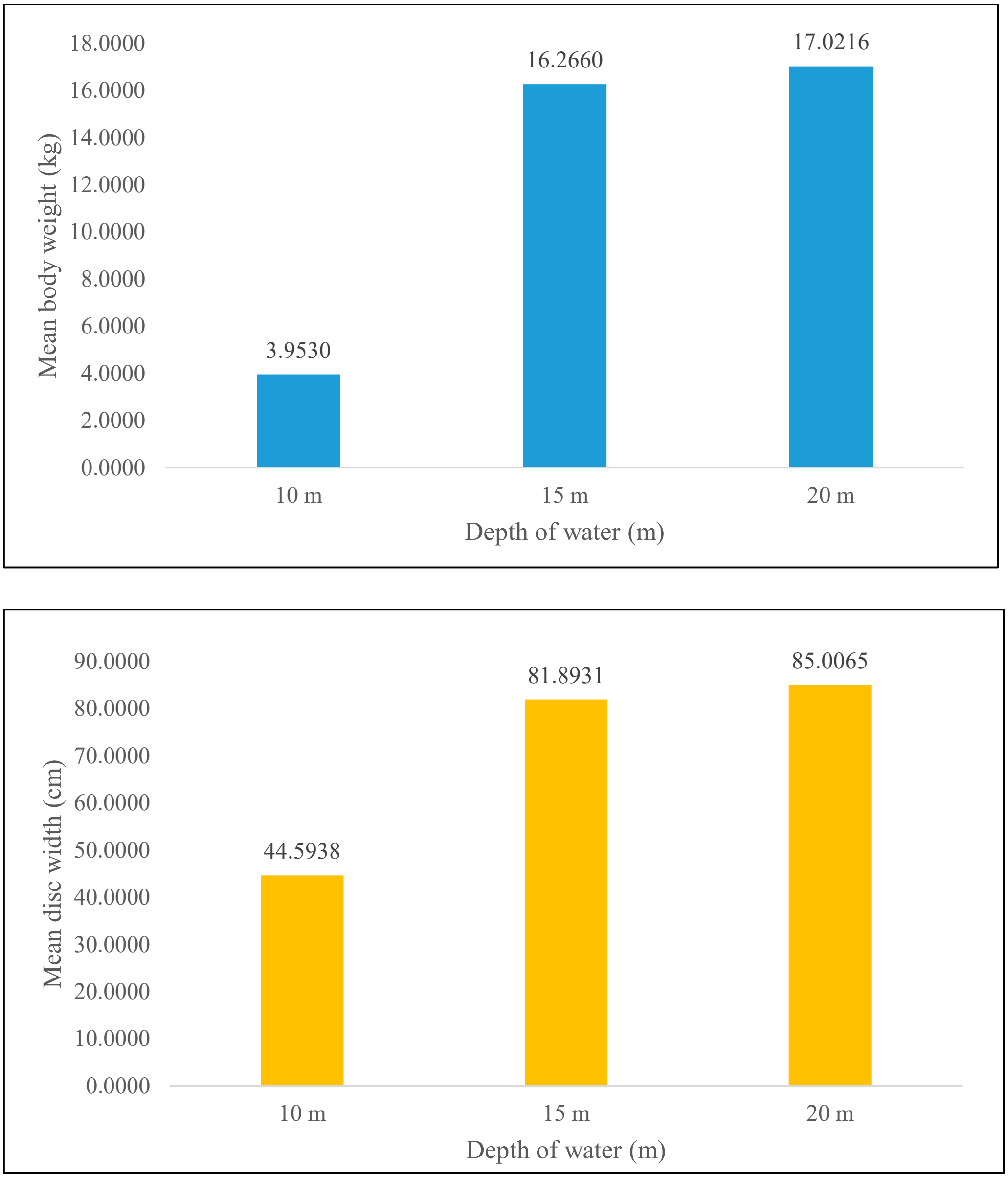


**Figure 7.** Relationship between water depth (m) and body weight (a) and disc width of stingray species caught by gill net (b).

during day and night, also known as bathymetric migrations [18, 19]. In present study, it is likely that more individuals were caught in the 20 m habitat because we hauled during the daytime when stingrays were located in deeper habitats. The seasonal factor showed a significant impact on the species abundance between dry and rainy and between moderate and rainy seasons, but not between the dry and moderate seasons. The movement of stingray species during the seasonal division may be due to biological factors such as reproduction, feeding or predator avoidance, or because of seasonal physical changes such as temperature, currents and photoperiod [20].

The species abundance of stingrays in Terengganu waters was influenced both by habitat and season. Based on nMDS ordination, the response of stingray assemblages was similar in each habitat and season. This may lead to a conclusion that the species assemblages collected by stingray gill net fisheries are generally similar from different habitat and season. The stingray species were similar from different habitats and seasons. This reflects that marine organisms in that community structure are geographically connected.

The deeper the seabed, the bigger the size of stingray caught in stingray gill nets (Figure 6). The present finding is considered the first study reporting and testing directly between the depth and size of stingrays, apart from indirect observation by some previous studies [9, 14, 15, 21]. Normally the sizes of female stingrays are much bigger that male stingrays. Previous research focused on the maximum and minimum disc width sizes of males and females for certain stingray species. *Dasyatis violacea* caught as bycatch on longlines for swordfish and tuna was a relatively small ray with an of 800 mm [21].

In Indonesia, *Rhinobatos jimbaranensis* females ranged from 491 to 994 mm, whereas males ranged from 506 to 953 mm. The size of *Dasyatis* cf. *kuhlii* (Java form) for females is from 118 to 379 mm and for males is from 128 to 324 mm WD, while the size of *Dasyatis* cf. *kuhlii* (Bali form) for female's ranges from 240 to 471 mm and males is from 172 to 450 mm WD, respectively. Moreover, *Dasyatis* cf. *ushiei* has been reported for the females to range from 729 to 2,020 mm WD and males range from 629 to 1,624 mm WD. Most of the female stingrays caught were larger than male stingrays in this study (Table 1).

## 5. Conclusions

Stingray species are distributed widely in different habitats and seasons. The abundance of stingray species caught was significantly affected by both habitat and season. The species abundance was similar among habitat and season. This study also confirms that young stingrays prefer shallow water compared to deeper water, demonstrating that habitat shifted.

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