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Research Article

Preliminary Study on the Morphology and Biology of Coexist *Nemipterus furcosus* and *Nemipterus tambuloides* from Terengganu Waters, Peninsular Malaysia

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Abstract

Background and Objective: Ichthyological study in Malaysia are still lacking and generally bycatch are received little attention. The study describes the differences between two coexist commercially important dominant species *Nemipterus furcosus* and *Nemipterus tambuloides* for morphological characteristics, length-weight relationship and some biological aspects. **Materials and Methods:** The specimen were collected from Pulau Kambing fish landing port, Terengganu during October, 2013. Fishes were examined for their systematic account differences. Length-weight relationships were calculated using the allometric regression analysis ($W = aL^b$). Trophic levels were assessed by relative length of gut (RLG) and reproductive information obtained by gonadosomatic index (GSI) and hepatosomatic index (HSI). **Results:** *Nemipterus furcosus* and *N. tambuloides* were easily distinguished in fresh condition, but displayed almost similar appearances in faint or preservation condition. Through detailed examination on morphological parameters both species had high similarities in meristic counts and morphometric measurements. There were however, three parameters, that significantly differentiated the two species: length of dorsal fin base, predorsal length and length of pectoral fin. In similar unit of standard length, *N. furcosus* had greater body weight compare to *N. tambuloides*. The population growth pattern indicated both *N. furcosus* (2.71$\pm$0.17) and *N. tambuloides* (2.54$\pm$0.16) experience negative allometric growth, i.e., both species became more slender as their lengths increased. The estimated mean RLG for *N. furcosus* and *N. tambuloides* were >1 (1.28$\pm$0.18 and 1.17$\pm$0.09, respectively), which indicated that both species were omnivorous fish. However, a negative relationship between RLG and total length was also found suggesting that both species tended towards a carnivorous diet as they grew bigger, especially for *N. tambuloides*. The gut lengths and RLG values for *N. furcosus* were greater than *N. tambuloides*. Gonad and liver weights for both species increased with body weight and the rate of increase in gonad weight was greater than liver weight. However, the GSI and HSI values almost remain constant for both species, revealing all samples were in the same state of gonad maturation in present study. **Conclusion:** The *N. furcosus* having shorter predorsal and pectoral fin length but longer dorsal fin base compare to *N. tambuloides*. Both species have newly discovered as omnivorous fish but tended towards a carnivorous diet during growth. These coexist species share similar pattern on population growth and reproductive biology.

Key words: Morphological characteristic, length-weight relationship, relative length of gut, gonadosomatic index, hepatosomatic index

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Trawling, as one of the most widely used fishing techniques of the Malaysian fisheries industry[1], often produce large amounts of non-target and unwanted fish also known as 'Bycatch'. In Malaysia, bycatch of threadfin bream, croaker, bigeye fish, lizard fish and goatfish have recently been considered as an important resource for the surimi industry[2]. This has increased the market profitability of bycatch, generating extra income for fishermen as well as helping to reduce the wastage from trawling[3].

In the past, little attention has been spared for ichthyological study of bycatch resources in Malaysia, especially with regards to detailed accounting of their systematic description and biological information[4]. The nemipterids (family Nemipteridae) also known as threadfin bream or "Ikan kerisi" in malay language are common bycatch fish from trawling activities and are now considered one of the most important economic groups of marine fishes in the tropical Indo-West Pacific region. They are however, also one of the most taxonomically challenging fish families to deal with. Nemipterids are bottom-living fishes widely distributed across the Indo-Pacific region[5]. Although each genus are found in distinct habitats and distributions, most species found in shallower to offshore shelf waters at depth ranges to about 300 m with muddy and sandy bottoms (i.e., prime trawling areas) belong to the genus *Nemipterus*[6]. Nemipterids can occur either solitarily or in aggregations but do not appear as territorial. Their spawning seasons also vary widely among the nemipterid species and localities[5].

Nemipterus are remarkably uniform in external anatomy, careful observation of minute morphological differences on fresh specimen is usually required for reliable species-level identification. As thread fin bream is an economically important in Malaysia, this study aims to examine the morphological characteristics, population growth condition and some biological information of two *Nemipterus* species dominantly landed from Terengganu waters, Peninsular Malaysia.

MATERIALS AND METHODS

Field sampling and morphological examination: Sampling was carried out in the fish landing port of Fisheries Development Authority of Malaysia (LKIM) at Pulau Kambing, Kuala Terengganu during October, 2013. The dominant trawl species bycatch were *Nemipterus furcosus* and *Nemipterus tambuloides*. All catches were sorted in accordance to the standard protocol listed by Sparre and Venema[7]. The procedure of fixation, photograph and preservation for the specimen are followed Seah *et al.*[3]. Methods of counting and measuring are generally followed Hubbs and Lagler[8] and terminology of morphological features and descriptions are modified from Seah *et al.*[4]. Species identifications were made following Russell[5], Nakabo[9] and Matsunuma *et al.*[6]. Measurement was made with an absolute vernier caliper (Mitutoyo, Japan) to the nearest 0.1 cm and the weight was obtained to the nearest 0.1 g using triple-beam digital balance. Length-weight relationships were calculated using the allometric regression analysis ($W = aL^b$)[10].

Biological information [Relative length of gut (RLG), gonadosomatic index (GSI) and hepatosomatic index (HSI)]: The gut sacs (esophagus, stomach and intestine) were extracted from each species. The feeding habits of the fish was determined by using the relationship of relative length of the gut (RLG), where RLG>1 represents herbivore, RLG<1 represents carnivore and intermediate RLG value represents omnivore[11]. The RLG was calculated by the equation, RLG = length of the gut/total body length. Identification of gut contents was not possible due to severe rigor mortis for the fishes examined in this study. In order to obtain the GSI and HSI for each species, cleaned body weight (gut extracted) was measured to the nearest 0.1 g, while gonad and liver weight to the nearest 0.0001 g. The GSI and HSI were calculated by the equations[12]:

$$GSI = \frac{\text{Gonad weight}}{\text{Fish cleaned body weight}} \times 100$$

and:

$$HSI = \frac{\text{Liver weight}}{\text{Fish cleaned body weight}} \times 100$$

RESULTS

Morphological characteristics, meristic counts and morphometric measurements: In the present study, a total number of 119 *Nemipterus furcosus* and 103 *Nemipterus tambuloides* were sampled from the fish landing port of Chendering, Terengganu (Fig. 1). Species identification were made based on the external morphological characteristics and coloration of fresh specimens. *Nemipterus fursocus* sampled ranged from 14.1-21.5 cm in standard length and

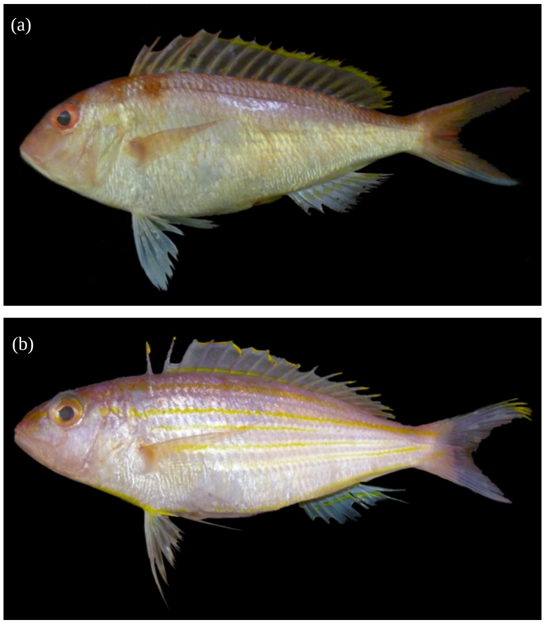

Fig. 1(a-b): Photographs of (a) *N. fursosus* and (b) *N. tambuloides* from Terengganu waters

70.0-292.4 g in total body weight whilst samples of *N. tambuloides* ranged from 14.0-21.4 cm in standard length and 84.7-264.3 g in total body weight. The meristic counts and morphometric measurements of *N. furcosus* and *N. tambuloides* were obtained from 10 selected good condition samples, respectively given in range, mean value and standard deviation (Table 1). Morphometric measurements were expressed in relative percentage to standard length. Specimen were selected to determine the similarity and dissimilarity of morphological characteristics. Both species shared high similarities in both meristic counts and morphometric measurements. There were however, three distinct morphometric parameters that can used to significantly differentiate the *N. furcosus* and *N. tambuloides* ($p<0.01$), except length of dorsal fin base for *N. furcosus* ($p<0.05$) namely length of dorsal fin base, predorsal length and length of pectoral fin. *Nemipterus furcosus* has a longer dorsal fin base but shorter predorsal length and pectoral fin compared to *N. tambuloides* (Fig. 2).

Length-weight relationship: *Nemipterus furcosus* was estimated to have greater body weight compared to *N. tambuloides* in similar unit of standard length (Fig. 3). However, both had almost similar body weight at standard lengths below 16 cm. The intercept a and coefficient of determination (r^2) for *N. fuscosus* were 0.07 and 0.64 and *N. tambuloides* were 0.11 and 0.90. The values of the slope or regression coefficient b for *N. furcosus* was 2.71±0.17 and *N. tambuloides* was 2.54±0.16. Both were significantly ($p<0.01$) lower than 3, indicating a negative allometric population growth pattern. Therefore, the weight for both species increased slower than their lengths.

Table 1: Meristic counts and morphometric measurements of *N. furcosus* and *N. tambuloides*

Parameters	*N. furcosus* (n = 10)	*N. tambuloides* (n = 10)
TL (cm)	20-28 (25.0)	19-24.9 (21.3)
FL (cm)	17-24 (20.7)	16.5-21.9 (18.7)
SL (cm)	15-21 (19.0)	15.1-19.8 (17.0)
Counts		
Dorsal fin rays	IX-X, 9-10	X, 9-10
Anal fin rays	II-III, 7-8	II-III, 7-8
Pectoral fin rays	12-15	13-15
Pelvic fin rays	I, 5	I, 5
Lateral line scales	42-48 (44.6)	39-44 (42.2)
Scales above lateral line	2-4 (2.9)	2-4 (2.7)
Scales below lateral line	7-12 (9.1)	7-8 (7.8)
Measurements as percentage of standard length		
Body depth	29-39 (32.7±2.5)	31-32 (31.8±0.4)
Eye diameter	6-9 (8.2±0.8)	7-8 (7.8±0.2)
Head length	22-33 (29.4±3.3)	27-30 (29.4±0.9)
Head depth	23-27 (25.1±1.2)	21-26 (24.3±1.6)
Head width	10-15 (13.0±1.3)	12-13 (13.3±0.6)
Length of caudal peduncle	1-3 (2.9±0.6)	1-3 (2.1±0.4)
Depth of caudal peduncle	8-10 (9.0±0.6)	8-10 (9.9±0.5)
Length of upper jaw	8-10 (9.9±0.8)	9-10 (10.1±0.3)
Length of lower jaw	7-9 (8.6±0.8)	7-9 (8.6±0.6)
Length of dorsal fin	67-78 (71.7±3.5)	63-70 (67.2±3.3)
Length of pectoral fin	23-29 (24.6±2.1)	25-29 (27.5±1.5)
Length of pelvic fin	18-25 (22.1±1.8)	20-26 (23.4±2.3)
Length of anal fin	16-32 (28.6±5.1)	29-32 (30.9±1.4)
Length of caudal fin	28-39 (34.4±3.1)	27-34 (31.1±2.9)
Length of dorsal fin base	50-61 (56.4±3.6)	48-52 (50.1±1.3)
Pre dorsal length	28-33 (29.6±1.9)	31-33 (32.4±0.6)
Pre pectoral length	29-34 (31.6±1.6)	30-33 (32.2±1.0)
Pre pelvic length	31-37 (34.6±2.1)	33-34 (33.9±0.4)
Pre anal length	60-72 (66.2±3.4)	64-65 (64.8±0.5)

Figures in parentheses indicate mean value and standard deviation

Relative length of gut (RLG): A total of 10 individual random samples were analyzed for RLG determination. The gut lengths for *N. furcosus* were ranged from 24.0-43.3 cm (TL: 20.0-28.3 cm) and *N. tambuloides* were 23.2-32.5 cm (TL: 19.0-27.3 cm). Through the linear regression, both species have proportional gut length greater than total length. Linear regression showed that the gut lengths for both species significantly increased with the increases in total length (Fig. 4a), *N. furcosus* ($r = 0.70$, $p<0.05$) and *N. tambuloides* ($r = 0.85$, $p<0.01$). However, the linear regression of RLG values against total length was not significant for *N. furcosus* but significant for *N. tambuloides* ($p<0.05$) (Fig. 4b). The RLG values for *N. tambuloides* decreased with fish size ($r = -0.62$) (Fig. 4b), while RLG values for *N. furcosus* increased with fish

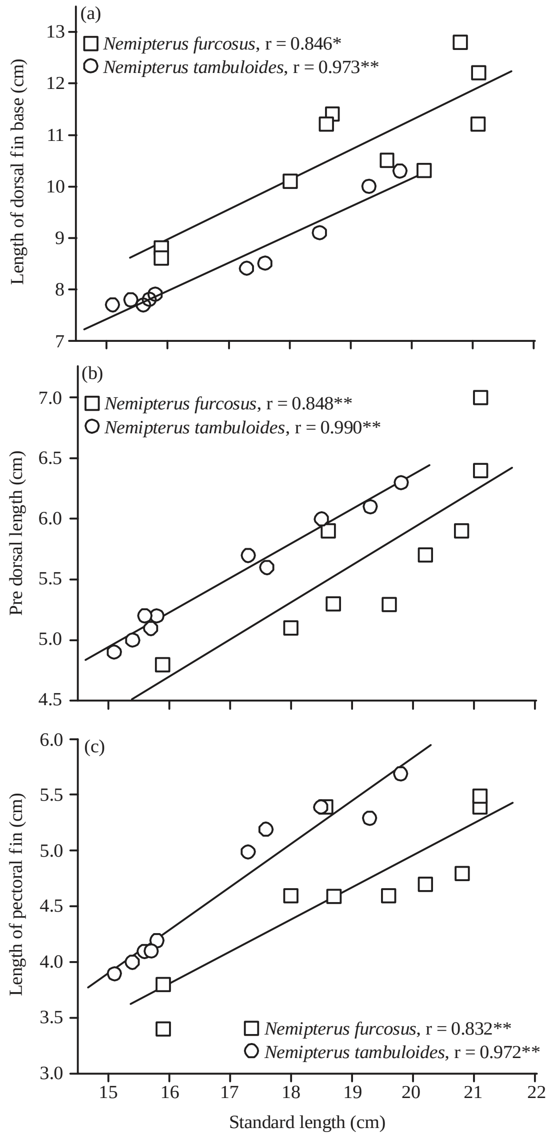

Fig. 2(a-c): Differences of morphometric parameters in standard length between *N. fursosus* and *N. tambuloides*, (a) Length of dorsal fin base, (b) Predorsal length and (c) Length of pectoral fin. The line represents the linear fit; *p<0.05, **p<0.01

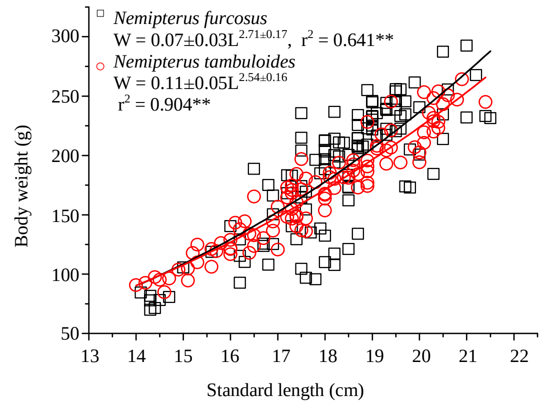

Fig. 3: Length-weight relationships of *N. furcosus* and *N. tambuloides*. The line represents the non-linear curve fit

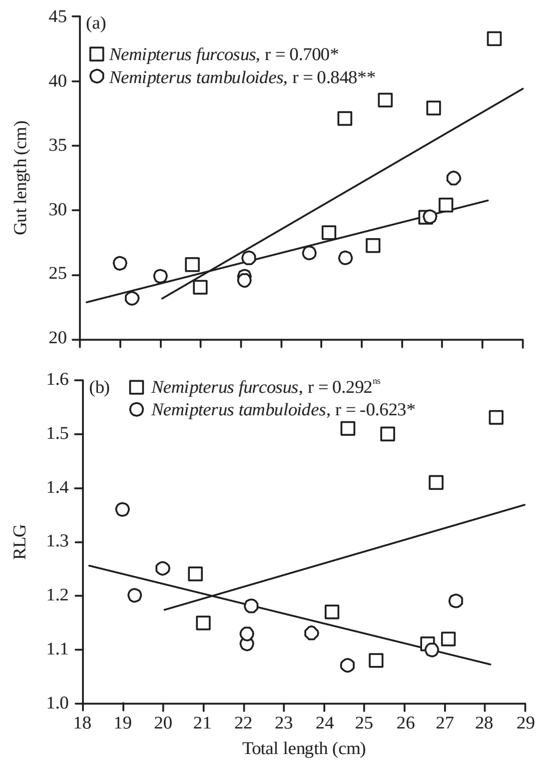

Fig. 4(a-b): Relationships between total length (a) Gut length and (b) Relative length of gut (RLG) of *N. fursosus* and *N. tambuloides.* The line represents the linear fit; *p<0.05, **p<0.01 and ns: Not significant

size (r = 0.30). The range and mean value of RLG for *N. furcosus* were 1.08-1.53 and 1.28±0.18, while *N. tambuloides* were 1.07-1.36 and 1.17±0.09. The results showed that the gut length and RLG values for *N. furcosus* were greater than *N. tambuloides*.

Gonadosomatic index (GSI) and hepatosomatic index: A total of 20 individual random samples were used to analysis the relationship of GSI and HSI. There was a significant positive relationship between gonad and liver weights with fish body weight (p<0.01) (Fig. 5). However, the increment rate of gonad weight was greater than liver weight for both species *N. furcosus*, r = 0.94 (GW) vs. 0.84 (LW), *N. tambuloides*, r = 0.83 (GW) vs 0.73 (LW). Both species also had gonad

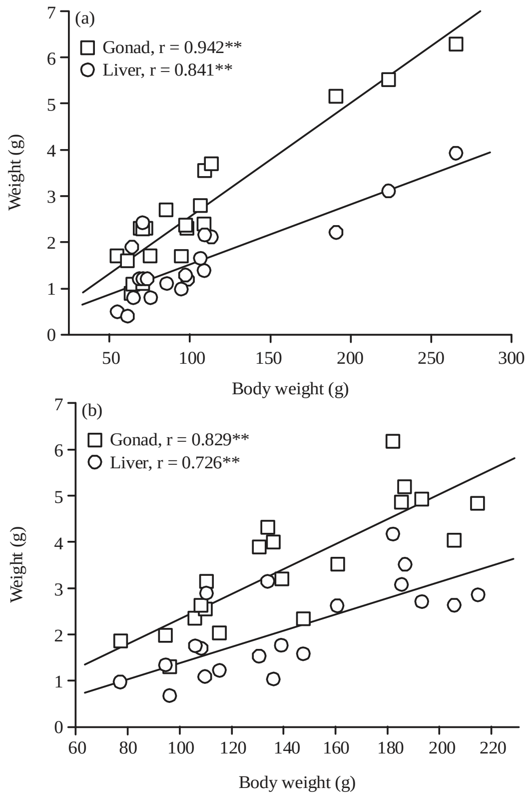

Fig. 5(a-b): Relationships between gonad and liver weight against body weight for (a) *N. furcosus* and (b) *N. tambuloides.* The line represents the linear fit

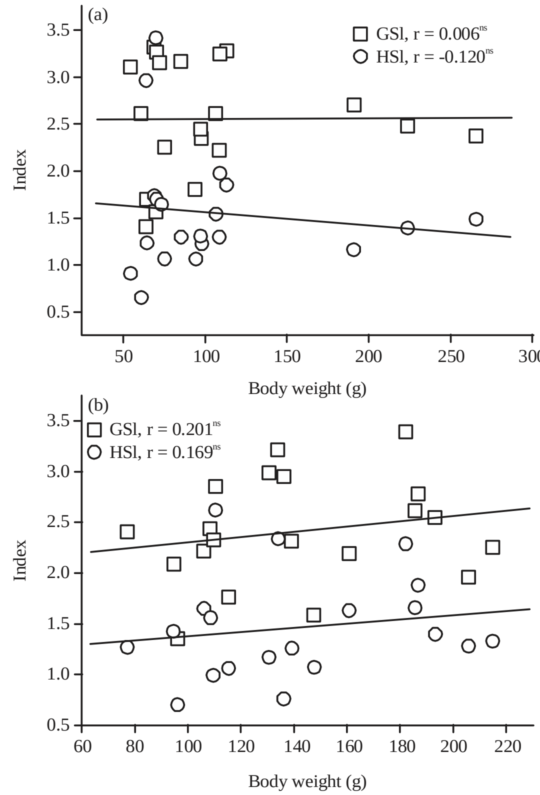

Fig. 6(a-b): Relationships between gonadosomatic index (GSI) and hepatosomatic index (HIS) against body weight for (a) *N. furcosus* and (b) *N. tambuloides.* The line represents the linear fit

weights which are higher than liver weights, which became more apparent with increasing fish sizes. Although the gonad and liver weights increased with body weight, both GSI and HSI values remained unchanged for both species (Fig. 6). From the perspective of body weight, the GSI increased but HSI decreased for *N. furcosus*: r = 0.01 (GSI) vs -0.12 (HSI) while the GSI and HSI both increased for *N. tambuloides*: r = 0.20 (GSI) vs 0.17 (HSI). However, the relationship of GSI and HSI against body weight were not significant. The mean of GSI and HSI were 2.55$\pm$0.01 and 1.51$\pm$0.01 for *N. furcosus* and 2.41$\pm$0.01 and 1.47$\pm$0.01 for *N. tambuloides.*

DISCUSSION

In the present study, *N. furcosus* and *N. tambuloides* were found to be distinguishable in fresh condition. The *N. furcosus* have 9 indistinct reddish saddle bars on dorsolateral but normally the reddish saddle bars on predorsal are distinct, posterior upper lobe of caudal fin is red and lower margin of caudal fin is white. These characteristics are not present in other species of *Nemipterus*[13]. The *N. tambuloides* have 5 distinct yellow stripes running horizontally along the body. It also has a yellow mark on the end of the upper caudal fin which, although present in other species is not significantly longer than the lower caudal fin[6]. In preservation condition, both species looked almost identical. However, there are a few important morphometric differences distinguishing the two species. In general, each species have its own remarkable morphometric characteristics but otherwise share almost the same meristic characteristics[4,14]. The differences in the average percentage of standard length can be an indicator to determine the differences between similar species[15]. In addition, linear regression analyses do assist in differentiate the species statistically. Both species were significantly dissimilarity in dorsal fin base length, predorsal length and pectoral fin length. Although technological advances have allowed scientists to determine the species of an organism using DNA technology but determination using morphological parameters (conventional approach) are still cheaper and much more convenient *in situ*[16,17].

Through the current study, we have determined that *N. furcosus* and *N. tambuloides* displayed similar allometrically negative population growth patterns, which is the fishes collected from Terengganu waters are become more slender as their lengths increases[4]. The length-weight relationships of both species have not been previously recorded in Terengganu waters. The estimated regression coefficient b (*N. furcosus*: 2.71 and *N. tambuloides*: 2.54) fell in the expected range (2-4) for these fishes. The high value of coefficient of determination for *N. tambuloides* had showing the high degree of allometric relationship between length and weight. While, there were 36% of the total variation in body weight remain unexplained for *N. furcosus*. Based on results, the graph have not included enough data of smaller size fishes probably due to size-selective fishing gears from the sampling site. This can influence the accuracy for the length-weight relationship estimation[18]. The regression coefficient b can be used to investigate the body shape (anteroposterior, dorsoventral or lateral) of the species[4]. Through observation in the same population, *N. furcosus* have robust and fleshy body shape compare to *N. tambuloides*, strongly supported by the b values (2.71 vs 2.54). There are various factors may be had direct impact to alter the b value seasonally due to the changes in physiological growth condition (condition factors) such as sex, gonad development, food availability, habitat, environmental changes and preservation techniques for the particular population[4,19,20].

In this study, it is showed that *N. furcosus* and *N. tambuloides* had RLG just slightly above one. As such, they can be considered as an omnivorous fishes. According to Mohammadizadeh *et al.*[21], a fish with a RLG of under 1 is considered a carnivorous fish as protein ingested requires less processing in the gut in order for it to be absorbed by the fish. Omnivorous fish have an RLG near to 1, while herbivorous fish tend to have higher values of RLG. However, Russell[5] and Matsunuma *et al.*[6] stated that thread fin breams feed mostly on small fishes, crustaceans, cephalopods and polychaetes they are carnivorous fishes. In this study, both species showed high RLG values for smaller size fish. But the RLG values were significantly reduced as the fish grow bigger for *N. tambuloides.* This showed the species have changes in gastrointestinal system, which inclined toward a carnivorous diet and may suggested that its diet is become more specific. However, *N. furcosus* was contrary with *N. tambuloides*, RLG values was increased as the fish grow bigger but insignificant through linear regression analyses. Details examination for the diet composition is needed to strongly evaluate the relationship between diet and RLG for Nemipteridae[4].

According to Ghaffari *et al.*[12], there should be a correlation between GSI and HSI and higher GSI values coinciding with lowered values of HSI. The value of HSI can be considered a rough proxy for stored energy in a fish's body. As the female gonad matures it draws energy from the liver causing the value of HSI to decrease. These results showed no differences between GSI and HSI for all specimens of both species, which suggest that all samples analysed were in the same state of gonad maturation. A year-long study of the GSI and HSI of *N. furcosus* and *N. tambuloides* should be done in order to determine specific relationship between GSI and HSI for these species.

CONCLUSION

In conclusion, the present study revealed *N. furcosus* and *N. tambuloides* had high similarities of morphological characteristics in faint condition but showing three distinct parameters to differentiate the two species. There were length of dorsal fin base, predorsal length and length of pectoral fin. We observed that both species collected from Terengganu waters exhibited similar negative allometric population growth patterns by the regression coefficient b values derived from length-weight relationship. The estimated mean relative length of gut demonstrates that both species were omnivorous fish but tended towards a carnivorous diet as they grew bigger by changing the gastrointestinal system. The estimated gonadosomatic index and hepatosomatic index revealed all samples of both species were in the same state of gonad maturation. Further studies are needed to obtain more information about the fish diet and reproductive biology of this two dominant food fish from Terengganu waters. As no detail information provided on the morphology and biology aspects of these two fishes in Malaysian waters, the study findings will be used as a references for future study.

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