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SIZE AND GROWTH VARIATION AT MATURITY OF SIX NEMIPTERUS SPECIES IN THE SOUTH CHINA SEA

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ABSTRACT

This study was aimed to observe the variation in size and growth change at maturity stage of both sexes for six *Nemipterus* species in the southern part of the Gulf of Thailand. Sample were collected using bottom trawl net was operated on board of “MV PRAMONG 9” research vessel during April -June, 2015. Male maturity stage-III of all fish species displayed largest average fork length 19.0 ± 1.8 , 11.1 ± 2.6 , 11.3 ± 2.0 , 19.3 ± 4.4 , 19.6 ± 0.8 and 17.5 ± 0.2 , respectively. Similarly, female maturity stage-II was showed largest range of fork length 16.8 ± 1.4 , 9.8 ± 0.3 , 16.6 ± 1.1 , 16.3 ± 1.3 and 16.5 ± 0.9 , respectively except *N. mesoprion*. Male fish was found larger in size than female for all species. Growth rate was higher at early stage of life for male fish and higher in adult for female fish. All species namely *S. taeniopterus*, *N. mesoprion*, *N. furcosus*, *N. tambuloides* and *N. hexodon* showed negative allometry according to growth value “b” observation except in *N. nematophorus* (positive allometry) in different maturity stages. Therefore, this study results can be used to help the fishery managers which can be used for maintain sustainable condition of Nemipteridae fish resources in the Gulf of Thailand and leading to a greater boost in the economy of Thailand.

KEY WORDS

Gulf of Thailand, nemipteridae, maturity stage, allometric, correlation, South China Sea.

Demersal fish is the largest catch in almost every year over the past decade in the world fishery production. Among this, Nemipteridae or threadfin bream is considered one of the most productive fishes contributing to world fish production. The genus of *Nemipterus* production alone was 576,487 tons and ranked 20th among other groups of fish (FAO, 2012). Threadfin bream is extensively found in tropical Indo-Pacific regions (Russell, 1993) mainly between 34°N - 11°S latitudes and 31°E - 133°W longitudes. They are important demersal resources for many coastal countries. Along the Egyptian Mediterranean coast, they were caught throughout the year by small trawlers (ElHaweet, 2013). They formed 11-20% of the total catch of trawl landings in India (Joshi, 2005). Moreover, they were also reported as an economic species from many countries such as Japan and Taiwan (Russell, 1993), Indonesia and China (Ping *et al.*, 2011); for example, In India, at Kerala, it formed a major catch and major share of marine catch (Monojkumar, 2008). In Southeast Asian region, three genera of this family have been reported, namely *Nemipterus*, *Scolopsis* and *Parascolopsis* with the total species for each genera were 20, 11 and 2 species, respectively (Somsak, 1986).

Demersal fish was a huge portion of trawl catching in Thailand. The total percentage of demersal fish in the Gulf of Thailand was approximately 34 % (Sanitmajjaro *et al.*, 2005). Among the demersal fish, the amount of Nemipteridae family was 12.78% (Sanitmajjaro *et al.*, 2005). In Thailand, nemipterid fishes including *Nemipterus mesoprion*, *Nemipterus hexodon*, *Nemipterus nematophorus*, *Nemipterus tambuloides*, *Nemipterus furcosus* and *Scolopsis taeniopterus* have contributed a huge portion of trawl catches with the consequence of depleting trend of resources (Stobutzki *et al.*, 2006). But, ban of some gears, limitation in the mesh size of the nets and ban of trawling near shore line already help this fish to come in a sustainable condition again. Thus, the threadfin breams were available in large quantities in the intermediate depth zones during monsoon in the Gulf of Thailand.

Spawning seasonality varies widely among different species and appears to vary also between localities. Mature ova are present in species of *Nemipterus* over a prolonged period, inferring a protracted spawning season, with usually one or two periods of increased fecundity (Russell, 1993). However, the length-weight relationships are important for accessing knowledge of growth style (Petrakis and Stergiou, 1995).

Unfortunately, there were only a very few studies found about Nemipteridae and there were very few published papers in different journals that were found. This study is to observe the size range and growth pattern of this eight Nemipteridae fish species in the different stage of maturity for both sexes. To date, scientific information on the fisheries biology of these six sympatric species is limited.

MATERIALS AND METHODS OF RESEARCH

Sampling method. The sampling sites were located in the southern part of South China Sea (Fig. 1) and a bottom trawl net was operated on board of “MV PRAMONG 9” research vessel to collect the samples during April -June, 2015. The depth range were recorded 17-49 m and the target species were namely; *Nemipterus mesoprion* (Bleeker, 1853), *Nemipterus hexodon* (Quoy & Gaimard, 1824), *Nemipterus nemurus* (Bleeker, 1857), *Nemipterus nematophorus* (Bleeker, 1854), *Nemipterus tambuloides* (Bleeker, 1853), *Nemipterus furcosus* (Valenciennes, 1830) and *Scolopsis taeniopterus* (Cuvier, 1830) were randomly selected, kept frozen and brought back to the laboratory for further analysis. Additionally, fish samples were collected from bottom gill net fisheries at five main fishing ports nearby trawling areas including Surattani, Nakorn Sritammarat, Songkhla, Pattani and Narathiw provinces covering the lower part of the Gulf of Thailand.

Data processing and analysis. First, fish lengths were measured with a measuring scale. Then, fish samples were gutted open by a surgical ocular scissors, sexes were identified by gonad observation (Dan, 1977) and maturity stages (immature, maturing and matured stage) were recorded (modified from Raje, 1996 and Dan, 1977). The descriptions of the stages are as follows:

For female:

Stage 1: Small cylinder ovary, eggs transparent and not visible to the naked eye. Stage 2: Slightly enlarged ovary, eggs transparent and not visible to the naked eye. Stage 3: Advanced stage eggs are just visible to the naked eye. Eggs do not completely opaque. Stage 4: Most advanced eggs have become completely opaque. The diameters of the largest stage are 30 micrometer. Stage 5: Ovary large. Most advanced eggs have become partly transparent. The maximum diameters of the most advanced eggs are 40 micrometer divisions with a mode of at 30 micrometer divisions. Stage 6: Ovary largely enlarged.

Eggs fully transparent; the maximum diameter of the most advanced eggs are 55 diameter divisions with a mode at 40 micrometer divisions; ready to be shed. Stage 7: Spent ovary, flabby and contracted. In this research, stage 1 & 2 will be regarded as immature stage, Stage 3 will be regarded as Maturing stage, and Stage 4, 5, 6, and 7 were regarded as fully mature stage (modified from Raje, 1996).

Figure 1 – Study area in the southern Gulf of Thailand

For male fish:

Stage 1: Testis very tiny, colorless and threadlike. not easily discernible with naked eye. Stage 2: Testes are longer, threadlike, milky with rough edges. Stage 3: Testis flattened, compact with striations, appearing leaf like structure, white in color and translucent. The left lobe is slightly larger than the right and is so close but not joined together and can easily separate. Stage 4: Testis less translucent and milky in color but still in the same shape. The testes less distended and with a gentle pressure on the abdomen, milts oozes out. Stage 5: Testes apparent thinner, flabby, deflated and milky in color. Stage 6: Testes pale red, very thin and threadlike but firmer than in spent stage. In this research, stage 1 & 2 were regarded as immature stage, stage 3 were regarded as maturing stage; stage 4, 5 & 6 will be regarded as matured stage (modified from Raje, 1996).

The Fork length (FL) was measured in cm unit and weight (W) in gram unit. The length-weight relationships (LWR) were tested by using the least square method (Le-Cren., 1951) for every stage of maturity of both sexes for eight species to observe their growth pattern during different maturity stages. The equation was as followed (Eq. 1);

$$W = a FL^b \quad (1),$$

where: BW is the body weight, FL is the fork length, while “a” and “b” are constants.

Statistical analysis. Regression and correlation were performed between FL and BW. Standard deviations (SD), average, maximum and minimum were also calculated. All of the data were analyzed by using certain statistical tool in Microsoft Excel.

RESULTS AND DISCUSSION

Maturation:

For male. Total male sample for *S. taeniopterus*, *N. nematophorus*, *N. mesoprion*, *N. tambuloides*, *N. hexodon* and *N. furcosus* were 104, 37, 43, 25, 16 and 9, respectively. The largest fork length range was in stage III in all male fish species. Fork length ranged from 7.2-12.9 cm for *N. nematophorus* to 19-20.2 cm for *N. hexodon* (Table 1). Some mature males of stage-II for all species was smaller than mature stage-I (Figure 2_A, C, E, G, I & K).

For female. Total female sample for *S. taeniopterus*, *N. nematophorus*, *N. mesoprion*, *N. tambuloides*, *N. hexodon* and *N. furcosus* were 236, 40, 91, 35, 23 and 31, respectively. The largest fork length range was in stage II in all female fish species except *N. furcosus*. Stage III was the largest stage for this species. The lowest length range is 9.4-10cm for *N. nematophorus* and the largest one is 13.2-21.5cm for *N. hexodon* (Table 1). Some mature females' stage-II of all species was bigger than mature stage-II (Figure 2_B, D, F, H, J & L).

Table 1 – The size range and mean size of males and females for maturity stage-1, stage-2 and stage-3 of 6 *Nemipterus* species in the southern Gulf of Thailand.

Stage of maturity	<i>n</i>	Male Size Range (cm)	Mean±SD	<i>n</i>	Female Size Range (cm)	Mean±SD
<i>S. taeniopterus</i>						
Stage 1	47	6.8-22	16.4±3.4	85	6.8-23.2	14.9±3.5
Stage 2	40	14-21	17.3±1.9	109	13.2-21.5	16.4±1.5
Stage 3	17	16.5-22.1	19.0±1.8	42	15-20.9	16.8±1.4
<i>N. nematophorus</i>						
Stage 1	26	6.5-14	8.5±1.9	28	5.4-14.5	8.1±1.8
Stage 2	7	6.7-10	7.6±1.1	9	6.3-12.5	8.5±2.2
Stage 3	4	7.2-12.9	11.1±2.6	3	9.4-10	9.8±0.3
<i>N. mesoprion</i>						
Stage 1	37	8.3-17.5	11.3±2.3	48	8-15.7	10.9±2.0
Stage 2	3	9.5-13.3	11.3±1.9	28	8.5-16.9	12.5±2.5
Stage 3	3	9.5-13.4	11.3±2.0	15	8.3-16.3	11.7±2.6
<i>N. tambuloides</i>						
Stage 1	15	9.5-20.3	15.3±3.38	16	12.6-20.7	16.3±2.3
Stage 2	8	15.9-19.9	18.35±1.39	4	14.1-18.5	16.5±1.8
Stage 3	2	16.2-22.4	19.3±4.4	15	14.9-18	16.6±1.1
<i>N. hexodon</i>						
Stage 1	9	11-24.8	14.5±4.4	8	10.2-17.3	12.2±2.2
Stage 2	5	14.4-19.4	17.3±1.9	9	12.9-19.1	15.7±2.2
Stage 3	2	19-20.2	19.6±0.8	6	15.2-18.8	16.3±1.3
<i>N. furcosus</i>						
Stage 1	3	10.5-12.1	11.3±1.1	15	9.3-17.3	13.3±2.3
Stage 2	5	9.5-17.5	14.7±3.4	7	9-16.3	14.3±2.5
Stage 3	3	17.3-17.5	17.5±0.2	9	14.8-18	16.5±0.9

**n*= Number, *SD*= Standard Deviation.

Growth pattern in maturity stage. In all maturity stage of males and females of both species showed significant correlation ($p < 0.01$). Highest growth rate was observed during maturity stage II & III for female and in stage I & II for male (Table 2). According to “b” value observation, *S. taeniopterus* had the lowest growth rate and *N. furcosus* had the highest growth rate. Coefficient “b” value ranged from 1.93 for stage III of *S. taeniopterus* to 5.065 of *N. furcosus* for stage III. Male fish have higher growth rate than female except in *N. tambuloides* and *N. hexodon*. Both sexes of *S. taeniopterus* stage-III indicated weak negative growth allometry because of the lower “b” value was found to be 1.932 and 2.281 for male and female stage-III, respectively (Table 2 and Figure 3A). According to “b” value, female growth rate was faster than male and all stage showed a negative allometry in both male and female fish. But, *N. nematophorus* showed positive allometry for all fish except isometric for female stage I and negative allometry for female stage III (Table 2, Figure 3B).

Table 2 – LWR relationship of different stages of maturity of six *Nemipterus* species in the southern Gulf of Thailand (N: sample size; b: slope and r^2 correlation coefficient)

Species	Stage maturity	of N	LWR equation	Slope (b)	Coefficient (r^2)	Growth Pattern
<i>S. taeniopterus</i>	Stage 1 (M)	47	$y = 0.0191x^{2.9754}$	2.975	0.98	Allometric (-)
	Stage 2 (M)	40	$y = 0.0289x^{2.8209}$	2.821	0.84	Allometric (-)
	Stage 3 (M)	17	$y = 0.3698x^{1.9315}$	1.932	0.34	Allometric (-)
	Stage 1 (F)	85	$y = 0.0277x^{2.8408}$	2.841	0.99	Allometric (-)
	Stage 2 (F)	109	$y = 0.0265x^{2.8595}$	2.860	0.84	Allometric (-)
	Stage 3 (F)	42	$y = 0.1341x^{2.2814}$	2.281	0.54	Allometric (-)
<i>N. nematophorus</i>	Stage 1 (M)	26	$y = 0.0105x^{3.2564}$	3.256	0.90	Allometric (+)
	Stage 2 (M)	7	$y = 0.0021x^{3.9524}$	3.952	0.79	Allometric (+)
	Stage 3 (M)	4	$y = 0.001x^{4.2031}$	4.203	0.99	Allometric (+)
	Stage 1 (F)	28	$y = 0.0181x^{3.0135}$	3.014	0.87	Isometric
	Stage 2 (F)	9	$y = 0.011x^{3.3014}$	3.301	0.91	Allometric (+)
	Stage 3 (F)	3	$y = 0.0706x^{2.473}$	2.473	0.77	Allometric (-)
<i>N. mesoprion</i>	Stage 1 (M)	37	$y = 0.0292x^{2.8188}$	2.819	0.94	Allometric (-)
	Stage 2 (M)	3	$y = 0.0002x^{4.833}$	4.833	0.93	Allometric (+)
	Stage 3 (M)	3	$y = 0.0694x^{2.4662}$	2.466	1.00	Allometric (-)
	Stage 1 (F)	48	$y = 0.0465x^{2.6273}$	2.627	0.93	Allometric (-)
	Stage 2 (F)	28	$y = 0.0384x^{2.6808}$	2.681	0.86	Allometric (-)
	Stage 3 (F)	15	$y = 0.0606x^{2.5368}$	2.537	0.97	Allometric (-)
<i>N. tambuloides</i>	Stage 1 (M)	15	$y = 0.0148x^{3.076}$	3.076	0.98	Isometric
	Stage 2 (M)	8	$y = 0.1446x^{2.2845}$	2.285	0.92	Allometric (-)
	Stage 3 (M)	3	$y = 0.0985x^{2.4064}$	2.406	0.83	Allometric (-)
	Stage 1 (F)	16	$y = 0.0381x^{2.7726}$	2.773	0.75	Allometric (-)
	Stage 2 (F)	4	$y = 0.0333x^{2.7909}$	2.791	0.93	Allometric (-)
	Stage 3 (F)	15	$y = 0.0092x^{3.2605}$	3.261	0.87	Allometric (+)
<i>N. hexodon</i>	Stage 1 (M)	9	$y = 0.0087x^{3.2594}$	3.259	0.98	Allometric (+)
	Stage 2 (M)	5	$y = 0.0357x^{2.7938}$	2.794	0.94	Allometric (-)
	Stage 3 (M)	2	$y = 0.0133x^{3.0973}$	3.097	0.87	Isometric
	Stage 1 (F)	8	$y = 0.0231x^{2.9184}$	2.918	0.95	Allometric (-)
	Stage 2 (F)	9	$y = 0.08x^{2.4555}$	2.456	0.95	Allometric (-)
	Stage 3 (F)	6	$y = 0.0011x^{4.0574}$	4.057	0.92	Allometric (+)
<i>N. furcosus</i>	Stage 1 (M)	3	$y = 0.0082x^{3.317}$	3.317	1.00	Allometric (+)
	Stage 2 (M)	5	$y = 0.0008x^{4.1433}$	4.143	0.99	Allometric (+)
	Stage 3 (M)	3	$y = 6E-05x^{5.065}$	5.065	0.97	Allometric (+)
	Stage 1 (F)	15	$y = 0.0076x^{3.3476}$	3.348	0.96	Allometric (+)
	Stage 2 (F)	7	$y = 0.0355x^{2.7772}$	2.777	1.00	Allometric (-)
	Stage 3 (F)	9	$y = 0.0099x^{3.2479}$	3.248	0.92	Allometric (+)
Total		693				

* Note: M = male, F = female, y = BW, x = Fork Length.

For male fish, growth rate increased with maturity and for female, growth rate was higher at stage II and male fish had higher growth rate ($b > 3.25$) than female fish. Both *N. mesoprion* and *N. furcosus* showed a negative allometry (Table 2, Figure 3C and Figure 3F) except male and female stage II (positive allometry), respectively. However, all stage of *N. tambuloides* showed negative allometry (Table 2, Figure 3D) except male stage I (Isometric) and for female stage II (negative allometric). Finally, *N. hexodon* showed negative allometry except male stage I and female stage III and an isometric allometry for male stage III (Table 2, Figure 3E).

Male fish was found larger in size than female for all species which are the opposite finding of Sritakorn, 2007. It was reported from Thailand, females grow faster than males; though, finally females become a larger size than males (Sritakorn, 2007). Growth rate was higher at early stage of life for male fish and higher in adult for female fish. Scientists have found variation in the length-weight relationship in all of those species and found different growth pattern in the different geographical area and in different years. Growth rates were found to be allometric negative in all stage for this research in both male and female fish for *S. taeniopterus*. But, Yamagwa (1994) found an allometric positive growth with a “b” value of 3.280. For *N. nematophorus*, “b” value increased with maturity stages for male and “b” value decreased with maturity stages for female.

Figure 2 – The relationship between maturity stage and mantle length of both sexes for six Nemipteridae fish species; (A, B = males, females respectively for *S. taeniopterus*), (C, D= males, females respectively for *N. nematophorus*), (E, F =males, females respectively for *N. mesoprion*), (G,H= males, females respectively for *N. tambuloides*), (I,J= males, females respectively for *N. hexodon*) and (K,L =males, females respectively for *N. furcosus*)

Figure 3 – Relationship between different maturity stage and growth coefficient “b” value of six Nemipteridae fish species in the southern Gulf of Thailand.

Growth rate was higher in stage II for *N. mesoprion* in both male and female fish. The “b” values were found 3.014 and 2.814 in Chennai, India for *N. mesoprion* and *N. nematophorus* respectively by Kizhakudan and Rajapackiam (2011). Vivekanandan and James (1984) found that “b” value was 2.9692 for male and 2.1570 for female *N. mesoprion*. They found significant difference between male and female fish. However, Murty (1981) didn't find any difference in between sexes of *N. mesoprion*. Here, the ‘b’ value for *N. mesoprion* and *N. nematophorus* of this finding was 2.870 and 2.501, respectively. Kongprom et al., (2003) showing the “b” value for *N. nematophorus* 2.99. This is different from Kongprom et al., (2003). This study was reported as a first study for *N. tambuloides* and *N. furcosus* where “b” value increased with maturity stages for male and “b” value decreased with maturity stages for female. However, Yamagawa (1994) found “b” values for *N. hexodon* were 3.277. In this research, all stage of *N. hexodon* for both male and female were allometric except isometric growth rate for stage III of male *N. hexodon* with a “b” value of 3.097. Same finding was found by Sritakon et al., (2007) that “b” value for *N. hexodon* was 3.0112 for both sexes in Gulf of Thailand. Hence, this study found that females grow faster than males and growth rate was higher at early stage of life for male fish and higher in adult for female fish which are new finding and different from the above study only for males and females which are new findings. The aforementioned study was either on overall species or on the basis of separate sexes and how changes their growth pattern stage to stage. From this study, it was proved that the growth value “b” has an important relation with the maturity stage of nemipterid fishes.

CONCLUSION

We can conclude that in most of case, maturity can be assumed by size factor but it also depends on the internal body activities. Females grow faster than males; though, finally females become a larger size than males and growth rate was higher at early stage of life for male fish and higher in adult for female fish. This result can be used to develop strategies to ensure sustainability in bottom trawl fisheries in the southern Gulf of Thailand, to serve as a reference for future studies and will help fisheries scientist and management planners for future management plan of Nemipteridae family and in this area especially for the heavily exploited populations.

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