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SIZE AND GROWTH VARIATION AT MATURITY OF TWO COMMON SQUID SPECIES IN THE SOUTH CHINA SEA

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ABSTRACT

This study is aimed to observe the variation in size and growth change at maturity stage of both sexes for two common loliginidae squid species; *Photololigo chinensis* and *P. duvaucelii* in the lower part of Gulf of Thailand. Males maturity stage-III of both squid species displayed largest range of mantle length 7.9-42.2 cm (mean 24.7±6.9) and 14-24.2 cm (mean 19.7±2.3) for *P. chinensis* and *P. duvaucelii* respectively. Similarly, female maturity stage-I were showed largest range of mantle length; 4.6-18.2 cm (mean 10.8±3.4cm) and 4.9-16 cm (mean 12.8±2.9cm) for *P. chinensis* and *P. duvaucelii* respectively. Some maturity stage-III was smaller than maturity stage-II for males *P. chinensis*; some maturity stage-III females of *P. duvaucelii* showed smaller size than maturity stage-II. All of three maturity stages of both sexes exhibited negative allometric growth ($b < 3$) and growth coefficient value “ b ” inversely related with imposing their new maturity stage. Therefore, this study results can be used to help the fishery managers which can be used for maintain sustainable condition of loliginid resources in the Gulf of Thailand and leading to a greater boost in the economy of Thailand.

KEY WORDS

Gulf of Thailand, *Loliginidae*, maturity stage, allometric, correlation.

The Gulf of Thailand is an inlet of the South China Sea which inhibits the exchange of water and considered as an ecologically distinct subset area of the South China Sea (Piyakarnchana, 1989; Pauly and Christensen, 1993). The Gulf of Thailand is located in latitudes 5° 00' and 13° 30' N and longitudes 99° 00' and 106° 00' E with 720 km length and maximum depth 84 m (Cheevaporn and Menasveta, 2003). It is a high abundant resources area for Loliginidae cephalopods species where two species; *Photololigo chinensis* (Gray, 1849) are most abundant and *Photololigo duvaucelii* (d'Orbigny, 1835) is second abundant species (dominant in the Andaman Sea Coast) in the Gulf of Thailand (Chotiyaputta, 1993; Chantawong and Suksawaet, 1997). Both squid species are Indo-Pacific and well distributed in the Indian Ocean and the South China Sea between 30 - 170 m depth range and large aggregation during spawning season and (Silas et al., 1982).

It was recorded that about 15-40% of the trawl catches were *P. chinensis* in Gulf of Thailand and available in 15-170 m depth range (Jereb and Roper, 2010) and a year-round spawning season with two main peaks time March–June and August–November; a length at 50% maturity of 16 cm and 14 cm mantle length (ML) for males and females, respectively (Chotiyaputta, 1993). Subsequently, it was reported that *P. chinensis* earlier mature happen during the warmer summer period than in the cooler winter period which suggesting that maturity is governed more by individual size than by age (Jackson, 1993). It was reported as largest loliginid species in the Indo-Pacific region and mantle length up to 49 cm for males and 31 cm for females (Voss and Williamson, 1971).

P. duvaucelii spawning depends on the southwest (SW) and northeast (NE) monsoons in the western part of the Gulf of Thailand (Supongpan and Sinoda, 1998). Size at 50%

maturity; 9-13 cm ML for females and 7-15 cm ML for males and the observations on growth after sexual maturity is reached, indicating an extended reproductive phase within the life cycle (Mohamed, 1993). It was reported from Thailand, females grow faster than males; though, finally males become a larger size than females and maximum ML of males was 32 cm (Chotiyaputta, 1993). The length-weight relationships are important for accessing knowledge of growth style (Petrakis and Stergiou, 1995).

Therefore, this study is aimed to observe the size range and growth pattern of *P. chinensis* and *P. duvaucelii* in the different stage of maturity for both sexes.

MATERIALS AND METHODS

Sampling method. The sampling sites were situated lower part of Gulf of Thailand (Figure 1) and bottom trawl net was operated by “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 *P. chinensis* and *P. duvaucelii* were randomly selected, kept frozen and brought back to the laboratory for further analysis. Some samples were collected from local fishermen.

Figure 1 – Study area from where sample collected

Data processing and analysis. The macroscopic scales were assessed to identify sexes and stage of maturity (Jereb and Ragonese., 1995). Both males and females were assigned into 3 stages; immature = stage-I, maturing = stage-II and mature = stage-III. For the males, *stage-I* = Small and inconspicuous gonad with hardly visible testis and no organizing of hectocotylus. *Stage-II* = The testis is a white, flat, lanceolate body. A well-developed Spermatophoric sac (SS) found and clear visible penis and hectocotylus completely formed. *Stage-III* = The testis is conspicuous, fusiform and slightly yellowish and spermatophores filled in the SS.

Females were assigned these 3 stages of maturity according to their nidamental gland (NG), ovary and eggs; *Stage-I* = Thin and almost transparent NG and threadlike ovary is visible; *Stage-II* = Whitish and well-formed NG formed but do not cover the underlying

visceral mass. The ovary conspicuously developed and granular but does not occupy all the posterior half of the mantle cavity. *Stage-III* = Large and ripe, milk-white NG and almost completely cover the visceral mass. The specimens were too small couldn't identify the sex of these samples which assigned as 'juveniles' or 'unsexed'.

The dorsal mantle length (ML) was measured in cm unit and weight in g 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 both species to observe their growth pattern during different maturity stages. The equation was as followed (Eq. 1):

$$BW = a ML^b \quad (1),$$

Where, BW is the body weight, ML is the mantle length, while 'a' and 'b' are constants.

Statistical analysis. Regression and correlation were performed between ML and BW. Standard deviation (SD), average, max and min were also calculated. All of the data were analyzed by using certain statistical tool in Microsoft Excel.

RESULTS AND DISCUSSION

Maturation:

Males. The total male samples of *P. chinensis* were 148; and 89, 46 and 49 were the number of males stand for stage-1, with stage-2 and stage-3 respectively. Largest range in mantle length for stage-III 7.9-42.2 cm and lowest range in mantle length for stage-II 10.5-23.1 cm (Table 1). Some mature stage-III males were smaller than mature stage-II (Figure 2A).

A total 179 of males for *P. duvaucelii* and this species stage-III also showed largest range in mantle length 7.3-22 cm as like as found for *P. chinensis* species (Table 1 and Figure 2C).

Table 1 – The size range and mean size of males and females for maturity stage-1, stage-2 and stage-3 of *P. chinensis* and *P. duvaucelii* squid specimens

Stage of Maturity	<i>P. chinensis</i>			
	Male Size range (cm)	Mean $\pm$ SD	Female Size range (cm)	Mean $\pm$ SD
Stage 1	4.4-16.8	9.2 $\pm$ 2.3	4.6-18.2	10.8 $\pm$ 3.4
Stage 2	10.5-23.1	14.6 $\pm$ 3.5	9.7-19.4	16.3 $\pm$ 3.3
Stage 3	7.9-42.2	24.7 $\pm$ 6.9	14-24.2	19.7 $\pm$ 2.3
Stage of Maturity	<i>P. duvaucelii</i>			
	Male Size range (cm)	Mean $\pm$ SD	Female Size range (cm)	Mean $\pm$ SD
Stage 1	5-16.9	11.7 $\pm$ 3.6	4.9-16	12.8 $\pm$ 2.9
Stage 2	5.2-17	10.7 $\pm$ 3.5	8-14.7	10.4 $\pm$ 1.8
Stage 3	7.3-22	11.6 $\pm$ 3.6	7.3-17.1	11.0 $\pm$ 2.4

Females. Among 113 total number of female *P. chinensis* squids, the number of maturity stage-I, stage-II and stage-III were 66, 14 and 33 respectively. This species, maturity stage-I showed the largest range of mantle length 4.6-18.2 cm; while stage-II and stage-III displayed same difference of mantle length but higher mantle length found for maturity stage-III (Table 1 and Figure 2B). The total number of females *P. duvaucelii* were 138; representing number 63, 37 and 38 for stage-I, stage-II and stage-III respectively. Highest range in mantle length noticed for female maturity stage-I and range was 4.9-16 cm (Table I). It was found some female maturity stage-II were larger size in mantle length than female maturity stage-III (Figure 2D).

Growth pattern of maturity stage. In all maturity stage of males and females of both species showed significant correlation ($p < 0.01$). Coefficient "b" value was 0.73 to 0.97 for *P. chinensis* and 0.87 to 0.98 for *P. duvaucelii* (Table 2) and growth rates of stage-III were much slower than the stage-I by representing lower value of growth coefficient "b" value. However, growth rates of all stages indicated negative allometry. Coefficient "b" value of

stage-I were consistently showed highest degree for both males and females of both *P. chinensis* and *P. duvaucelii* squid (Table 2).

Figure 2 – The relationship between maturity stage and mantle length of both sexes for of *P. chinensis* (A, B = males, females respectively for *P. chinensis*) and *P. duvaucelii* (C, D= =males, females respectively for *P. duvaucelii*)

Table 2 – LWR relationship of different stages of maturity of two squid species *P. chinensis* and *P. duvaucelii* in the Gulf of Thailand (N: sample size; *b*: slope and r^2 correlation coefficient)

Species	Maturity stage	N	LWR Equation	Slope (b)	Coefficient (r ²)	Growth pattern
<i>P. chinensis</i>	Stage-1 (M)	89	$y = 0.195x^{2.246}$	2.256	0.89	Allometric (-)
	Stage-2 (M)	46	$y = 0.333x^{2.063}$	2.063	0.93	Allometric (-)
	Stage-3 (M)	49	$y = 1.053x^{1.671}$	1.671	0.95	Allometric (-)
	Stage-1 (F)	66	$y = 0.151x^{2.381}$	2.381	0.97	Allometric (-)
	Stage-2 (F)	14	$y = 0.302x^{2.142}$	2.142	0.97	Allometric (-)
	Stage-3 (F)	33	$y = 0.836x^{1.820}$	1.820	0.73	Allometric (-)
<i>P. duvaucelii</i>	Stage-1 (M)	49	$y = 0.054x^{2.774}$	2.774	0.98	Allometric (-)
	Stage-2 (M)	81	$y = 0.129x^{2.415}$	2.415	0.97	Allometric (-)
	Stage-3 (M)	49	$y = 0.194x^{2.231}$	2.231	0.97	Allometric (-)
	Stage-1 (F)	63	$y = 0.055x^{2.780}$	2.780	0.97	Allometric (-)
	Stage-2 (F)	37	$y = 0.090x^{2.618}$	2.618	0.90	Allometric (-)
	Stage-3 (F)	38	$y = 0.294x^{2.141}$	2.141	0.87	Allometric (-)

Note: M = male, F = female, y = BW, x = ML.

Figure 3 – Relationship between different maturity stage and growth coefficient “b” value of *P. chinensis* and *P. duvaucelii* (A= *P. chinensis*; B= *P. duvaucelii*).

Both sexes of *P. chinensis* stage-III indicated weak allometry because lowest “b” value 1.671 and 1.820 for male and female stage-III respectively (Table 1 and Figure 3A). According to ‘b’ value observation female’s growth rate faster than males. In *P. duvaucelii* showed “b” value >2 but this value was decreasing with attaining their stage-I to stage-III (Figure 3B). However, males stage-III “b” value was 2.231 and 2.141 for female stage-III which was the lowest value among other maturity stage I, II (Table 2 and Figure 3B). During stage-I, growth pattern almost same for both sexes; females growth rate faster than males during stage-II and during stage-III, male’s growth rate more than females (Figure 3B).

The short life-span, sexual dimorphism and nonasymptotic growth displayed by *Photololigo sp* in northern Australia. Though, *P. chinensis* were showed males obtain bigger size than females (Jackson and Choat, 1992). It was found that *P. chinensis* squid species have a close relationship between their maturation and size; though some females *Photololigo sp* were immature and make delay be mature even with their larger mantle length (Jackson, 1993). Similar attributes found that mature *Photololigo edulis* size range less than their typical maturation size in Japan (Natsukari and Tashiro, 1991). Unlikely, *Loligo vulgaris reynaudii* both sexes showed that immature size range was larger than typical maturation size in South Africa (Augustyn et al., 1992). Large range of ML of mature *Loligo gahi* loliginid specimen was observed; males 7.1 to > 30 cm and females 9.8 to > 22 cm (Hatfield et al., 1990).

This study showed mature males size range 7.9-42.2 cm and females mature size range 14-24.2 cm of *P. chinensis* where *P. duvaucelii* mature males size range 7.3-22 cm and females mature size range 7.3-17.1 cm. Though, mature males and females *P. chinensis* typical size ranges were 16 cm and 14 cm respectively (Chotiyaputta, 1993) and *P. duvaucelii* 9-13 cm for females and 7-15 cm ML for males (Mohamed, 1993). Therefore, this study exhibited, mature males *P. chinensis* ML smaller than typical maturation ML and *P. duvaucelii* showed larger range of mature ML than their typical maturation size range which also have proven the above study discussed. Genetic control (Campton and Gall, 1988) and environmental stresses (Chapman and Chapman, 1992) are playing a vital role in a different size at maturity for fishes. *Photololigo sp* showed phenotypic variation in size at maturity of sexes in Australia (Jackson and Yeatman, 1995). However, the environmental, behavioral, or genetic factors or combination of all three factors are responsible for noticing the variation in size at maturity.

Some scientists studied about the length-weight relationship of both of these species and found variation of their growth pattern in the different geographical area and different years. The overall *P. chinensis* growth coefficient value “b” were 2.579 in Marudu, Sabah, Malaysia (Siddique et al., 2014), and 2.027 in the Gulf of Thailand (Suppanirun et al., 2011). Similarly, for *P. duvaucelii* “b” value estimated for males 1.613 and females 1.672 were

calculated in the West coast of India (Mishra et al., 2012). Recently it was found in Gulf of Suez Egypt that 'b' value was 1.958 for males and 2.416 for females (Sabrah et al., 2015). Hence, this study found how the growth value "b" change with attaining new maturity stage which are new finding and different from the above study only for males and females. According to the aforementioned, their 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 the growth value "b" value is inversely related to attaining their maturity stage.

CONCLUSION

It can be concluded that most of case size is the factor to assume the maturity, but is also depend only the internal body activities. Significant change of growth with attaining new maturity stage and it is ultimately affecting the growth pattern of a mature species. However, this finding can be useful in future study as well as for management of these resources.

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