

REPRODUCTIVE PATTERNS OF *HOLOTHURIA SCABRA* (ECHINODERMATA: HOLOTHUROIDEA) IN INDONESIAN WATERS

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ABSTRACT

During 1993 to 1996, reproductive aspects of *Holothuria scabra*, one of the commercially important holothurian species in Indonesian waters were studied, which involved populations of Ambon Bay (eastern Indonesian waters), Saugi Island (central Indonesian waters) and Lampung Bay (western Indonesian waters). Those studies were reviewed in this paper, not only to reveal general patterns of reproductive seasons of populations throughout Indonesian waters, but also to provide more knowledge on gonadal-tubule-development that has been rarely investigated on Indonesian holothurians. The review showed that the development of gonadal tubules amongst populations of Indonesian *H. scabra* were similar. Those included that: tubules across a gonad grew for one single reproductive cycle, and each tubule had equal opportunity to release their gametes in the same spawning event. These features conformed to general characteristics of this species throughout the world, and were different from the proposed tubule recruitment model of Smiley (1988). Each observed population showed fluctuation on gonad index, and individuals with fecund and/or post spawning gonads were recorded in most sampling occasions, resulting in fluctuation of gonad index. This attribute gave clue to through-year spawning activity with more intense during one or two periods in a year.

Keywords: *Holothuria scabra*, Indonesia, reproductive pattern, tubule development

INTRODUCTION

Research on holothurian reproduction in Indonesia is limited despite this country has been a major supplier of *beche-de-mer* to world market. More than 20 holothurian species have been commercially harvested throughout the tropical Indonesian waters (Purwati, 2005), and *Holothuria scabra* is the most popular among the fishers. Since mid 90's, culture efforts have been initiated with the main objectives are to enhance population recoveries. The efforts begin with conducting reproductive studies to achieve

knowledge on reproductive characters and spawning patterns of the populations.

In holothurians, gonad consists of tubules, which protrude from a gonadal basis located at the anterior part of the body cavity. Generally, gonadal tubules grow as the gametes inside develop (Hyman, 1955; Smiley, 1988; Tuwo and Conand, 1990; Purwati, 2001). One model of tubule recruitment has been characterized by *Parastichopus californicus* (Smiley, 1988) and *Holothuria forskali* (Sewell *et al.* 1997; Tuwo and Conand, 1990). Other species including *Holothuria leucospilota* of tropical Darwin

waters (Purwati and Luong-van 2003), *Actinopyga mauritiana*, *Holothuria fuscogilva* and *H.scabra* of the Solomon Islands (Ramofafia and Byrne, 2001; Ramofafia *et al.*, 2001), and several species evaluated by Sewell *et al.*, (1997) exhibit differently in number of tubule groups and synchronization in tubule development across the gonad.

Reproductive cycle of populations at areas near equator tends to demonstrate longer spawning period than those farther away, due to less seasonal fluctuation of water temperature (Pearse, 1968). However, *H.leucospilota* in tropical Darwin Harbor (Purwati and Luong-van, 2003) shows more restricted spawning period than that in subtropical Heron reef (Franklin, 1980). Whilst, population in north hemisphere subtropical Hong Kong waters lacks of synchronization (Che, 1997).

Three populations of *H.scabra* that inhabit eastern, central and western Indonesian waters have been examined separately during 1993-1996 by Darsono *et al.* (1995), Kailola (1997), Susetiono (1996) and Tuwo (1999). Those studies aimed to determine the reproductive season of the populations for culture efforts. This paper scrutinized results of those studies to gain more knowledge on tubule development and

reproductive activities. Do those populations show variations in terms of reproductive pattern? Further, reassessing spawning patterns of various populations of *H.scabra* may reveal other tubule recruitment model that may not in agreement with Smiley's (1988). It is hope that this review provides more information on Indonesian holothurians.

METHODS USED IN REVIEWED STUDIES

Studies on reproductive pattern of *H.scabra* reviewed in this paper were derived from the works of Darsono *et al.* (1995) who examined *H.scabra* of Lampung Bay (western Indonesian waters) from September 1993 to August 1994; Tuwo (1999) who studied population of Saugi Island, South Sulawesi (center Indonesian waters) from November 1995 to October 1996; Kailola (1997) and Susetiono (1996) who investigated population of Ambon Bay, Maluku (eastern Indonesian waters) from June 1995-May 1996 (Fig.1).

Gonad index (GI) was estimated as a weight ratio of fresh gonad and excised body wall in percentage. Studies on Ambon population used 9-20 individuals per month, weighing more than

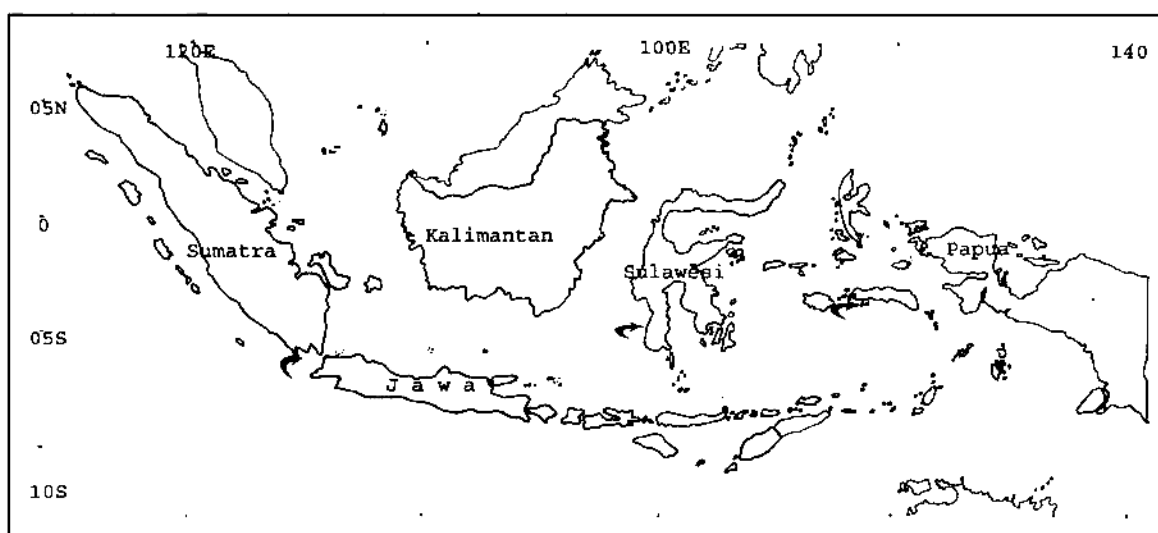


Figure 1. Map of Indonesia showing studied areas (bend arrows)

200 grams wet body weight. From Lampung Bay and Saugi Island, 30 individuals were collected on monthly basis, but no information on the individual size. It was likely that all individuals examined were in adult stage.

Histological examination on gonads was performed to categorize the maturity stage (detail methods see reviewed papers). Measurement on oocyte diameter was only done on Ambon population.

TUBULE DEVELOPMENT IN INDIVIDUAL LEVEL

Three populations of *H.scabra* living in Indonesian waters share common characteristics as shown in Table 1. In some cases, individuals may appear to carry two groups of tubules such as found in a female and a male of Ambon population, in which each group represented early developed and developed tubules, or, fecund and developed stage (Fig. 2). In the population of Saugi Island, the presence of fecund tubules in maturing gonads (Tuwo, 1999) making them possible to release gametes any time in the year. Supporting this evidence was that individuals without visible gonads or carried only after-spawned tubules were easily found. Thus, tubules in a gonad were more likely to be prepared only

for a single spawning event. This phenomenon also occurs in *H.fuscogilva*, *Actinopyga mauritiana* and *H.scabra* in Solomon Island (Hamel *et al.*, 2001; Ramofafia and Byrne, 2001), in which spawned or un-spawned tubules are absorbed after the spawning period is over.

Occurrence of few individuals with invisible gonadal tubules in Ambon population led to the indication of resting stage during which tubules disappeared prior to entering the following reproductive cycle, that may not take long. In the Solomon Islands, similar condition among individuals of *H.fuscogilva* and *A.mauritiana* are found easily during certain period, because, unlike *H.scabra*, these populations have synchronous gonad development across population (Ramofafia and Byrne, 2001). In *H.leucospilota* of Darwin waters which shows synchronous gonad development, resting stage occurs during mid-year for 1-2 months (Purwati and Luong-van, 2003). Other species such as *Psolus fabricii* (Hamel *et al.*, 1993) and *Aslia levefrei* (Costello, 1988) on the other hand, maintain and re-grow their after-spawned-tubules.

Tubule recruitment model of *H.scabra* from Indonesian waters did not correspond to that proposed by Smiley (1988). This population may be added to those inconsistent with Smiley's model, together with *H.scabra* populating in

Table 1. Features of gonadal tubules and reproductive activities of *H.scabra*.

Gonad condition	Lampung Bay (Darsono et al.,1995)	Saugi Island (Tuwo, 1999)	Ambon Bay (Susetiono,1996, Kailola,1997)
<i>At individual level</i>			
No. of gonads	single	single	single
Cohorts of tubules	one	one	one
Develop.among tubules	synchronous	synchronous	synchronous
Afterspawnd tubules	absorbed	absorbed	absorbed
<i>At population level</i>			
Gonad development	asynchronous	asynchronous	asynchronous
Presence of after spawn and/or fecund ind.	throughout the year	throughout the year	throughout the year
Type of breeding	continues	continues	continues
Spawning peaks	March-May/Nov.Jan	Oct-Feb/Apr-July	Oct-Des/March-April
GI female to male	not available	not available	Greater

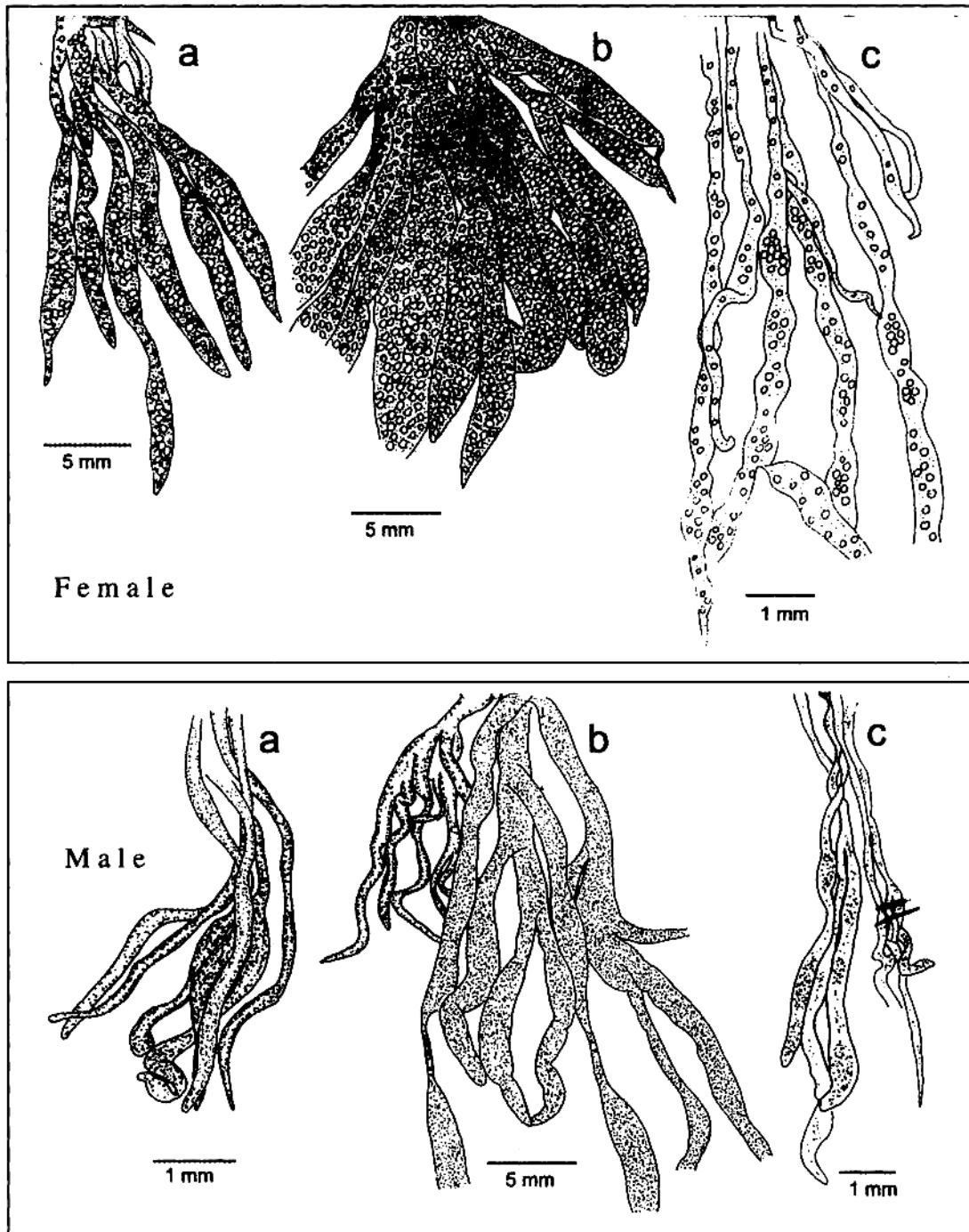


Figure 2. Gonadal tubules of *H. scabra*, representing, a: early stage; b: fecund; c: after spawned tubules (drawn under camera lucida)

Calatagan, the Philippines (Che and Gomez, 1985) and New Caledonian lagoon (Conand, 1993), and also other species *H. leucospilota* from Darwin waters (Purwati and Luong-van, 2003) and those assessed by Sewell *et al.* (1997) and Ramofafia and Byrne (2001), including *H. fuscogilva* and *A. mauritiana*.

Since species excluding Smiley's model have been growing, and similarities among those species have been revealed, therefore, other model should be proposed that covered mainly aspidochirote species. The main principles of the proposed model are:

- An individual only possesses single tuft of tubules which develops synchronously across gonad
- Tubules are prepared only for one single cycle, after-spawned tubules are reabsorbed and new tubules grow in every reproductive cycle
- It takes up to 12 months for gonadal tubules to reach fecundity

Population showing synchronous gonad development provided easy estimation of required time taken for one reproductive cycle. The occurrence of resting stage during which gonad disappeared from the population offered easy prediction for not only the commencing of reproductive cycle, but also the time required for gametogenesis. Example is *H.leucospilota* from tropical Darwin Harbor (Purwati and Luong-van, 2003). Such ease did not seem to be offered by most *H.scabra* populations.

REPRODUCTIVE CYCLE OF THE POPULATIONS

Reports on Lampung and Saugi populations presented combined GI rather than separated male and female GI. This may cause inaccuracy in the fluctuation, because males may initiate spawning, and spawn longer in several cases such as in *S.mollis* (Sewell, 1990). Further, higher female GI than male as demonstrated in Ambon population, could not be determined in the other two populations (Fig. 3 - 4). These kinds of sex capacities have also been reported to occur in most holothurians including *H.scabra* of New Caledonian Lagoon (Conand, 1993) and Krusadi Is., Gulf of Myanmar (Khrisnaswamy and Krishnan, 1967), and other species such as *H.fuscopunctata*, *H.nobilis*, *Actinopyga mauritiana*, *A.echinites* and *Thelenota ananas* (Conand, 1993).

Heterogeneity in gonadal stages in any time of the year, which reflected asynchronous development among individuals in the population was prominent in *H.scabra* of Indonesian waters. Monthly percentage of fecund individuals in Ambon population had been estimated 5.0-45.0% (average 16.1%) and after spawned

individuals were 5.0-67.0% (average 21.8%) of the total collected individuals. The highest number of fecund individuals had been reported to occur in April. For Lampung population, the range was 0-50.0% and 0-16.7% for fecund and after spawned individuals, respectively. Percentage of fecund individuals was maximal in June, November and March.

Heterogeneity in gonad stages was also indicated by a great variation on GI values in each sampling occasion (Fig. 3-4). Range of monthly GI was relatively wide in each sex of Ambon population and combined GI of Lampung population (no information for Saugi population).

GI with the smallest and largest standard deviation (SD) showed in female GI $0.4\% \pm 0.2SD$ - $5.1\% \pm 6.4$ (SD mostly exceeded 2.0%) and male GI $0.3 \pm 0.2\%$ - $2.3 \pm 4.5\%$ (SD mostly more than 1.0%) for Ambon population. Combined GI of Lampung with smallest and largest SD was $0.1 \pm 0.1\%$ and $0.9 \pm 1.1\%$. Large variation has also been reported in *H.scabra* of New Caledonian Lagoon with a range of $5.4 \pm 2.4\%$ in male and $7.2 \pm 3.8\%$ in female (Conand, 1993), and also the same species inhabiting Calatagan, Batangas waters, the Philippines (Che and Gomez, 1985).

GI of Lampung population showed lower than those of Ambon and Saugi populations (Fig. 3). It was not clear yet, if this indicated low reproductive capacity. The GI average of Lampung population seemed more fluctuated than that of Ambon and Saugi population (Fig. 3-6). In Ambon population, maximum value of GI following with a sharp drop occurred in October (which decreased until December). Change in average of oocyte diameter of Ambon population supported the tendency of GI (Fig. 4). It maximized in October followed with abruptly decreased until December. It also occurred in June, which was possibly followed with sharp drop until August. For Saugi population, maximum value was reached in April (sharply drop to July) and October (drop to January). Lampung population demonstrated maximum value occurring in November (drops to January) and March (drop to May). However, intensive spawning was likely to occur in June-July as well.

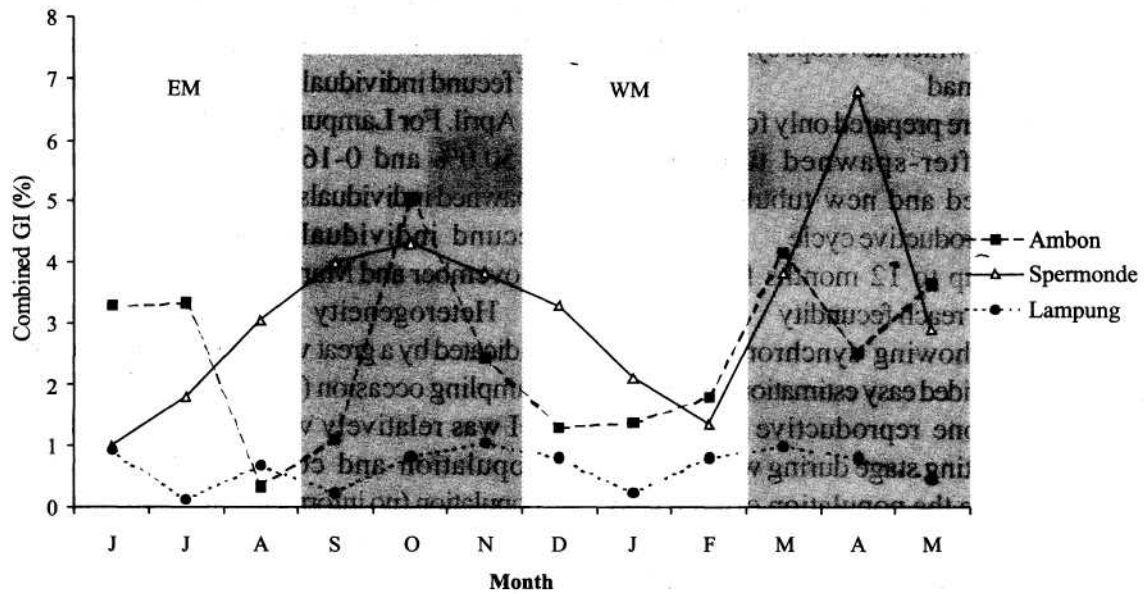


Figure 3. Combined GI's of three populations of *H. scabra* inhabiting Indonesian waters. EM: east monsoon; WM: west monsoon.

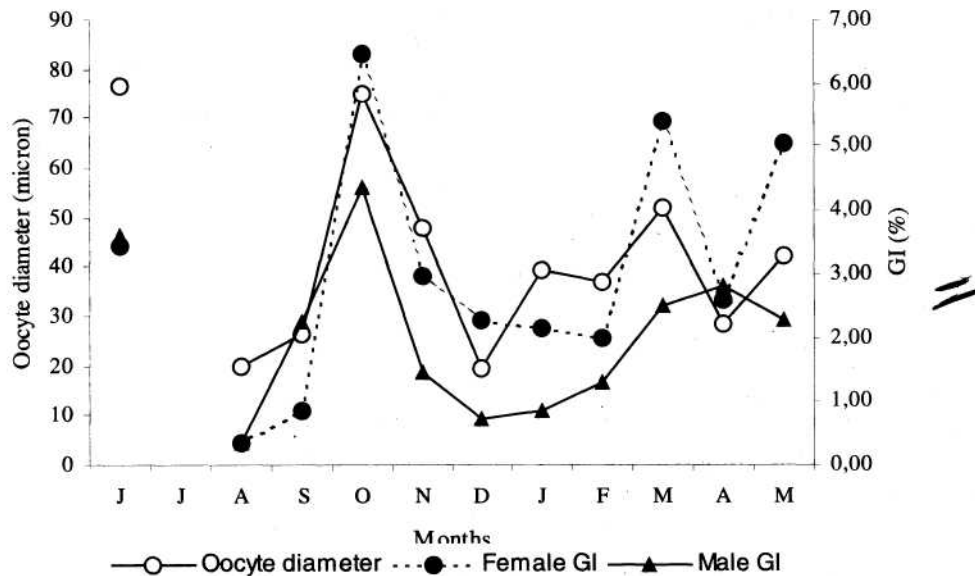


Figure 4. Changes in average of GI and oocyte diameter in *H. scabra* population of Ambon (Susetiono, 1996; Kailola, 1997).

Indonesia is dominated with west (from December to February) and east monsoon (from June to August). Ambon shows similar condition with Saugi Island, but different from Lampung. During west monsoon, rainfall is minimum, water temperature and salinity are maximum, and sea state is relatively rough in the first two areas. During east monsoon, rainfall maximizes, water temperature and salinity reach maximum and sea

state is rough. Lampung is in the other way around: west monsoon brings water temperature and salinity to minimum, and east monsoon brings those factors maximizing. During transitional season, all areas show relatively calm sea state. Considering these water conditions, spawning of the populations of Ambon and Saugi island occurred during transitional season, when the waters were relatively calm, and the temperature

Table 2. Spawning pattern of *H.scabra* throughout the world

Geography	Spawning pattern	Spawning season/peaks	References
Solomon Is.	continuous	September-October	Battaglène(1999)
Tuticorin, India		March-may and Oct-Dec	James (1999)
Calatagan, Philippines	continuous	July-August; Jan-Feb.	Che and Gomez (1985)
New Caledonian lagoon	continuous	Sept and Dec-Jan	Conand (1993)
Moreton Bay, Australia	seasonal	November-Feb.	Morgan (2000)
Gulf of Myanmar	continuous	July-Oct.	Khrishnaswamy and Krishnan (1967)
Indonesian waters - Lampung - Saugi - Ambon	continuous	March-May; Nov-Jan April-July, Oct.-February Oct-Dec and March-April	Darsono et al. (1995) Tuwo (1999) Susetiono (1996) and Kailola (1997)

altered to maximum or minimum. Spawning seemed more intense when season altered to west monsoon when water temperature went up.

In Lampung, prediction on spawning season was rather difficult. At least, GI dropped in relatively similar degree from November to January coinciding with the beginning of west monsoon when the water temperature went down, and from March to May during transitional season to east monsoon with relatively calm waters and increasing temperature.

Asynchronous progression of gonads across population appears also in *H.scabra* from tropical Solomon Island (Battaglène, 1999; Ramofafia and Byrne, 2001), Hongkong (Che and Gomez, 1985) and New Caledonian Lagoon (Conand, 1993). At Tuticorin, India, reproductive season of *H.scabra* occurs during March-May (major) and October-December (minor) (James, 1989). While in the Solomon Island, the population spawns during September and October (Battaglène, 1999).

Time required for one cycle of reproduction had not been uncovered in the three studied populations. Same species inhabiting subtropical Moreton Bay (Australia), on the other hand, shows synchronous gonad development and the spawning occurs only during certain periods (November-February), while resting stage takes in February (Morgan, 2000). In account of that, time taken for one reproductive cycle may be estimated up to one year, which starts in March or April.

CONCLUSION

H.scabra populating in Indonesian waters release gametes throughout the year. Such fluctuation on GI showed in three populations brings up ambiguity, whether or not gamete release peaks during certain period. Moreover, inter-year variation on spawning peaks is common to occur amongst tropical holothurian species. In account on these features, extending sampling period is necessary to a minimum of two reproductive cycles (2 years). However, collecting sample may be a problem due to limited natural stocks. If possible, all larva sampling will be useful not only in estimating spawning peak but also predicting recruitment.

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