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Review

PROSPECT OF SEA CUCUMBER CULTURE IN INDONESIA AS POTENTIAL FOOD SOURCES

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ABSTRACT

Sea cucumber is one of the sea treasures which has been used not only as luxury food for certain countries but also as medicines. Sea cucumber has become one of the most important products and it has high price in international market.For this reason, the exploitation of sea cucumber turns out to be excessive and disturbs its sustainability. Aquaculture is the best way to prevent this problem. The success of sea cucumber culture is very depend on seed availability and suitable food for larvae as well as juvenile along with growing out stadia for market requirement.

Keywords: Aquaculture; sea cucumber; seed ; food

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INTRODUCTION

Sea cucumber is a marine organism which is known also as “teripang” (Indonesia), “trepang” (Malaysia), “beche de-mer” (French), “namako” (Japan), “plingkao” (Thailand), “haishen” (China), and for the international market, as“sandfish”. Sea cucumber belongs to the Family *Holothuridae* and *Stichopodidae*, Phylum*Eechinoderm* i.e marine invertebrate group that has close relation to the sea star and sea urchin. This animal moves slowly, live at the bottom of sand substrates, sand mud or in coral ecosystems. In Indonesia, sea cucumbers that have important economic value are *Holothuria scabra*, *H. atra*, *H. nobilis*, *H. edulis*and *Thelenota ananas* (Rustam, 2006; Anonimous, 2007).

Sea cucumber is in great demand by certain countries (Japan, China, Korea, Malaysia and Singapore), and exploitation to these animals increase from year to year, even caused over-fishing at some regions in Indo-Pasific (Hamel, *et al*., 2001; Battaglene and Bell, 2004; Conand, 2004; Lovatelli, *et al*., 2004; Uthicke, 2004). According to FAO, sea cucumber fisheries at 2001 reached to the point of 18,900 tonnes (Vannuccini, 2004). The same goes for the inquirement of export market, it achived about 20,000 tonnes to 30,000 tonnesper year.

Indonesia is well known as number one of sea cucumber exporter in the world, and this is appear to be regularly (Tuwo, 2004; Ferdouse, 2004). Because interest is so high on the sea cucumbers, then the pressure on these resources can jeopardize their sustainability in nature.For this reason, we need an effort to cultivate them (Conand, 2004). It is very important in a successful and sustainable aquaculture is providing best sea cucumber larvae. However, the limiting factor here is the provision of appropriate feed with larvae sea cucumber. Given the importance of the availability of feed sea cucumber, it needs an intensive study of sea cucumber feed. This paper gives some views into feed source for aquaculture sea cucumber especially *H. scabra* and *Stichopusjaponicus*.

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Nutrition Valueand the use of Sea Cucumber

From the nutritional viewpoint, sea cucumber has category as a delicacy food and has high nutrition (**Table 1**). Furthermore, the fully dried material has a protein concentration as high as 83% (Chen, 2003). Aside from being a food, sea cucumber has been used in China for medicine in hundred years. Besides, from sea cucumber can be extracted a holotoxin that has the same effect as antimicyn with the concentration of 6.25 – 25μg/ml. Recently, some new substances have been successfully isolated for some purposes in medicine such as antitumor, antivirus, anticoagulant and antimicrobe. (Kelly, 2005).

Table 1. Nutrition value of sea cucumber

Nutritious elements	Percentage
Protein	43.1
Lipid	2.2
Moisture	27.1
Ash	27.6

Source :Tuwo (2004)

The use of sea cucumbers in a modern life that is as a supplement in capsule or tablet form. Likewise also the development of using sea cucumber in treatment which is found rich in polysaccharide condroitin sulfate, that works to reduce pain in arthritis. This material can also inhibit virus (Japan has got the patent in using this material to cure the HIV)(Chen, 2003). Some research suggests that sea cucumbers also contain saponin glycosides, which have a structure similar to ginseng, ganoderma as well as some well-known herbs in China (Huizeng, 2001). Materials saponin glycosides and polysaccharides are also used as anti-cancer substances. Sea cucumbers are also rich in unsaturated fatty acids ω-3 type are important for heart health(Martoyo, *at al.,* 2006). Sea cucumbers also have campaigned as the organisms that can free the sea from pollution, through its way as a deposit feeder and suspension feeders.

Bioecology of Sea Cucumber

Sea cucumber had elongated body shape is similar to cucumber (Soltany, *et al*., 2010). Therefore, it is commonly referred to as sea cucumber. The body length starts from several millimeters up to 2 meters, and has some colour combination such as white, black, red and blue, green, yellow, violet, etc. *H. scabra* which is greatly wanted can grow up to 40 centimeters with the weight of 1.5 kg. It was found that the oldest sea cucumber fossil had the age of 400 million years (Kerr, 2000)

Sea cucumber has the important role in the food web. This animal can recycle the nutrient by filtrate the sediment, so that, the sediment become clean from all organic materials and produce the oxygen and nutrient in the bottom waters. The main food of sea cucumber is small organisms, detritus, diatome, protozoa, nematode, algae filament, copepod, ostracod andseaweeds (Chen, 2001; Abe, *et al*., 2002; Schuenhoof, *et al*., 2003). Some other foods are radiolarian, foraminifera, sand particles or pieces of corals and other animal carapax.Mouth andanus have located on both sides (Holtz and MacDonald, 2009).

Sea cucumber is dioeciously, but it is hard to differentiatethe male from the female (Despalotovic, 2004; Chen, 2003). The genital pore locatedon the posterior back of the head is very small. Most individuals only possess one genital pore, buta few have 2 or 3 pores with a spawning function. The sea cucumber breeding frequently take place external or outside of the body (Baskar, 2004).The egg and sperm produced by each individual male and female by being sprayed. Female gonadmatures on the first time at the average size about 220 mm, in age approximately two years, at weigh up around 250 grams (Kithakeni and Ndaro, 2002). Females are very fecundand can produce as much as 1–2 million eggs, sometimes even 10 million, in one spawningevent (Battaglene *et al.,* 2002; Pitt and Duy, 2004). Normally, fecundity is related to bodyweight of sea

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cucumber. During mature periods, there are 220,000–290,000 eggs per gram of ovary. When thewater temperature near the seabed reaches15–17 °C, it is a good time for broodstock collection (Xilin, 2004).

This animal's life cycle begins with the fertilized eggs that will hatch in about 2 days. After they develop into larvae, they will go down to the bottom waters and grow to be juvenile. Studies show that the time between Auricularia larvae to juveniles aged 7 to 10 days is very sensitive to environmental conditions (Asha and Muthiah, 2005; Wang and Yuan, 2004); highest mortalities willoccur during these two stages. The main problemscome from diseases of digestive duct, especiallygastritis (Xiyin, *et al.,* 2004). Hence, the key to increasing survival rateis to provide the appropriate feed and to follow sophisticatedroutine management. When entering the pre-auricularia stadia, the larvae begin to feed phytoplankton (Hamel, *et al*., 2003).

In Indonesia, for *H. scabra*, gonad maturity can reach its peak on June until October, while on November to January, there is gonad but in small amount (Tuwo, 1999). The gonad peak (two times in a year) is found to be different for each region (Philippina, New Caledonia, Papua New Guinea and India), it is assumed because of different water temperature (hot season and rainy season) and the availability of food for the larvae (Pitt, 2001a).

Sea cucumber can be found in a large number at tropic area on shallow sediment (Conand, 1997); actually, sea cucumber can be found in anywhere, either in deep water and shallow, and has a lifetime of 5 – 10 years. There are three genera of sea cucumbers are found in coastal waters of Indonesia. All three genera are *Holothuria, Muelleria* and *Stichopus*. Of the three genera were found as many as 23 new species and five species (genus *Holothuria*) that have been exploited and utilized.

Sea cucumbers prefer calm and transparent water. *H. scabra*, some of them are found on sand area or sand mix with mud at 1 – 40 m depth. Also, found on shallow water with many seagrass. While, “teripang koro” and “teripang pandan”, many found on deeper water. In habitat, some sea cucumbers live in group and there are some live in solitair. For example, *H. scabra* makes group between 3 – 10 individuals and *H.nobilis* can live in group between 10 – 30 individuals.

Sea Cucumber Culture

China and Japan are the first nation that start cultivate sea cucumber i.e *Apostichopus japonicas* (Vannuccini, 2004). Nowadays, some countries are producing sea cucumber (India, Australia, Maldive Islands, Solomon Islands and Indonesia).The most sea cucumber product is in dried form.On some countries, sea cucumber is produced in gamat oil such as in Malaysia. Sea cucumber product most come from 30 species of 1000 species that live in the world (Conand, 2004).The main internasional market who control the sea cucumber trade is Hongkong, Singapura and Taiwan. Some important economical species of sea cucumber are *Actinopyga echinites*, *A. mauritiana*, *A. miliaris*, *Bohadschia argus*, *B. vitiensis*, *Holothuria atra*, *H. edulis*, *H.fuscogilva*, *H. fuscopunctata*, *H. nobilis*, *H. scabra*, *H. coluber*, *Stichopus chloronotus*, *S.hermanni*, *Thelenota ananas* and *T. anax* (Friedman, *et al*., 2008)(**Fig. 1**). While, *Apostichopus japonicus* is the most culture species in China due to its high quality meat and the success of the method used for its culture (Huizeng, 2001).

In Indonesia, culture of sea cucumber so far is *H. Scabra*. Indonesia has potential area for culture is 720,500 ha. The progress of sea cucumber culture in Indonesia is higly expected, the use of 10 % of potency area can boost the sea cucumber product as many as 125 tonnes dried sea cucumber per year. In some countries, especially in China, sea cucumber culture area is very limited, this is a limiting factor for developing sea cucumber culture bussiness. Some positive things of sea cucumber as culture organism are:(1) they live in group;(2) cultivation method can be in simple way (Chen, 2004),(3) sea cucumber food (plankton/detrites) is abundance.

Location for sea cucumber culture: (1) Sandy or sand-muddy bottom with seagrass; (2) at the lowest tide, there is still water with the depth between 40 – 80 cm; (3) water clarity more than 75 cm; (4) protected from typhoon orstrong waves; (5) There must be no pollution

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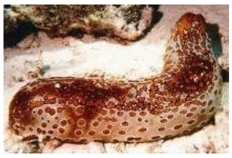
issues, (6) salinity between 24–33 ppt and temperature is 25–30 °C. In general, sea cucumber culture is devided in two phase : (1) seed production in hatchery (larvae and juvenile), and (2) grow-out phase.

			
Actinopyga echinites	*A. Mauritiana*	*A. Miliaris*	*Bohadschia argus*
			
B. vitiensis	*Holothuria atra*	*H. edulis*	*H. fuscogilva*
			
H. fuscopunctata	*H. nobilis*	*H. scabra*	*H. coluber*
			
Stichopus chloronotus	*S. hermanni*	*Thelenota ananas*	*T. anax*

Seed production phase

Sea cucumber seed can be produced in two ways : (1) collecting directly from nature, and (2) producing from hatchery. The former way, seed availability unregularly in stock. The best method to yield sea cucumber seed is through hatchery. The purpose of thehatchery is to routinely produce sea cucumberin three stages: larval culture (i.e.fertilization, embryonic development, larvalgrowth, and settlement of juvenile). So far, method to produce seed in hatchery and grow them up to ± 1g size is well documented (Pitt, 2001b; Pitt and Duy, 2004; Agudo, 2006).

Producing seed in hatchery is start from broodstock preparation. Broodstock qualification is they are in normal shape and their gonad mature enough. Breeding can be done by stripping, thermal stimulation, combination of desiccation and flowing water (Hendri, *at al.,* 2009). The last method can give result as much as 90 – 95 % of hatching rate. Good sea cucumber eggs are spherical, white and visible to the naked eye and about 177μm in size. After 32 hours, eggs will hatch become larvae and metamorphose until reach auricularia stadium (length is 430 μm and width is 280 μm). At this stadium, larvae start to consume plankton (microalgae).

Sea cucumber larvae diet

Good microalgae quality and regular feeding schedule are the key factor in successful sea cucumber culture of *H. scabra* larvae. *Auricularia* larvae will be given microalgae as food such as *Isochrysis galbana*, also mix culture of *Chaetoceros* spp. and*Skeletonema* spp. with concentration of 2 – 3 x 10^4 cells ml^{-1}

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(Baskar, 2004). Comprehensive study about life food supply toward *H. scabra* larvae has been accomplished by several scientist (Morgan,2001; Pitt, 2001b; Pitt and Duy, 2004; Giraspy and Grisilda, 2005). The number of feed given has to be adjusted with observations according to whether or not a lot of food in stomach larvae, because it can be seen visually before feeding. Food for *Apostichopus japonicas* larvae is *Dunaliella euchlaia, Chaetoceros gracilis* and *C. muelleri*, where *Dicrateria zhanjiangensis,Isochrysis galbana* and *Chlorella* sp. often given as supplement; never delivered in one species. For the best food, mixture of 2 – 3 species of microalgae is highly recomended, this is good for nutrient balance. Microalgae often given with the concentration of 1 – 4 x 10^4 cells ml^{-1}. Study toward life food supply for *A. japonicas*has done well by some researchers in China (Xilin, 2004;Wang and Yuan, 2004; Xiyin *et al*., 2004).

Juvenile phase

Juvenile phase can be reached when the sea cucumber larvae achieves the age of 10 – 18 days, with the body length of 10 – 20 mm (average 656μm). Juveniles culture in high density, then, food supplement is recommended to get good growth. Good density to culture sea cucumber juvenile can be seen in **Table 2.**

Table 2. Density for sea cucumber juvenile

Sea cucumber juvenile (Individualkg^{-1})	Stocking density (Individual m^{-3})
< 200	100 – 300
200 – 1.000	300 – 1.000
1.000 – 2.000	1.000 – 2.000
2.000 – 4.000	2.000 – 3.000
4.000 – 6.000	3.000 – 4.000
6.000 – 8.000	4.000 – 5.000
> 8 000	5.000 – 10.000

Juvenile diet

Sargassum spp. and *Syngodium isoetifolium*, which are rich in protein, are found to be the suitable food for sea cucumber juvenile. These macroalgae cut into pieces and made like paste, then, filter with 40 μm sieve. After one month, the same paste will be filtered with 80 μm sieve, and this food will be given twice a day (morning and during night day). The amount of food given beginning at 20 – 50 g m^{-3}, then, increase to 50 – 100 gm^{-3} when the body length reach 2 – 5 mm, from then on the amount of 100 - 150 g m^{-3}. Juvenile will get to size of 2 cm after 2 months and 4 cm after 4 months. Some food variation for juvenile can be seen in **Table 3** and summary of growth and survival rate of sea cucumber juvenile can be seen in **Table 4.**

Grow-out phase

Sea cucumber culture first time in Indonesia was done in South East of Sulawesi. However, until now intensive culture still not done yet. Sea cucumber culture at sea usually done with pen system, with the density of 3 – 5 individuals m^{-2} (Chen, 2003). Cultivation time regularly between 4 – 6 months, when reached size of 500 gram/individual.

Sea cucumber is filter feeder, i.e sea cucumber is very active to consume anything which is in the sediment where they live and also referred to as scavenger. Identification toward sea cucumber guts showed that their food are many kinds of plankton and organic matters (Jiaxin, 2003). The remaining residues of foodstuffs as well as sea organism faeces even sea cucumber faeces can result in an increase the number of bacteria that is an important nutrient for sea cucumber(Yang*et al*., 2001; Kang *et al*., 2003). Detail study for sea cucumber grow-out food is very few, especially for intensive culture. **Table 5** shows effort of food given to sea cucumber grow-out in Indonesian.

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Table 3. Variation of juvenile diet

Species	Stocking density (Juvenilesm^{-2})	Body size	Food	Cultivation time	Size accomplish (body length)	References
Holothuria scabra	200 – 500	± 485 µm	*Sargassum* spp., *Halimeda* spp., and *Syngodium isoetifolium*	2 months	2 cm	Baskar, 2004
Apostichopus japonicas			Diatome, *Sargassum thunbergic,* yeasts			Wang and Yuan, 2004
Apostichopus japonicas	100 – 300	13 days	*Spirulina platensis, Sargassum thunbergii*,			Xiyin *et al.*, 2004
Holothuria scabra		5 mm (in 14 days)	Diatome and powdered algae	4,5 months		Giraspy, 2008
Holothuria scabra		10 mm	*Sargassum* spp.	2 months	2 cm	James, 1999
Apostichopus japonicas	100 – 300		Comersial food (protein 25%, lipid 8%)	3 months	8,1 g	Wang *et al*., 2007

Table 4. Growth and survival rate of sea cucumber juvenile

Species	IBW[1] (g)	FBW[2] (g)	Growth rate	Survival rate (%)	Comments	References
Actinopyga mauritiana	7.4 ±0.2		10.4 ±1.4 g month^{-1}		Density 26 g m^{-2}	Ramofafia *et al.,* (1997)
Holothuria scabra			0.2 ±0.02 g day^{-1}	96	57 days, V=140 L	Battaglene (1999)
Stichopus japonicus	5.0±1.2	18.3 ± 0.63		100	90 days, V=55 L	Kang et al. (2003).
Apostichopus japonicus	1.25 ± 0.5			63.5	14 months; pond Culture	Yu and Song (1999)
Apostichopus japonicus	16.7 ± 5.24	25.8 ± 6.45	100		Density, 50 g m^{-2},	Yang *et al*. (2001)
Apostichopus japonicus			60 – 90	Indoor culture	48 days	Chang *et al*. (2003)
Apostichopus japonicus	4.54 ± 0.38	11.81 ± 3.15	2.72 ± 0.75% day^{-1}	100	36 days, V=40 L	Dong *et al*. (2005)
Apostichopus japonicus	3.5 ± 0.3	8.1 ± 0.8	118 ± 6 g month^{-1}	87	90 days	Wang *et. al.*, 2007

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Table 5. Food of sea cucumber grow-out in Indonesia

Species	Food	Comments	Results		References
			IBW[1](g)	FBW[2](g)	
Holothuria scabra	"Klekap powder 69.65%, fishmeal 10.35%,vitamin mix 1.00%, mineral mix3%, tapioca flour 10.00% andrice meal6.00%.	- 3% biomasweight - given once aday - Cultivation time in 2 months	16,69	64,03	Hartati dkk, 2005
Holothuria scabra	Manure and rice bran (1:1)	- 0.2 – 0.5 $kgm^{-2}week^{-2}$ - Cultivation time in 5 – 6 months	30–40 (per ind.)	200–250 (per ind.)	Martoyo dkk, 2006

[1]IBW = Initial body weight
[2]FBW = Final body weight

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CONCLUDING REMARKS AND FUTURE RESEARCH

Concluding remarks

Sea cucumbers are economically of important value used as food. It is believed that sea cucumber farming will become a prosperous sector of Indonesian mariculture. Thus, study on this animal as culture candidate is necessary. Food is the main factor that support culture success. Knowledge to feed larvae and juvenile sea cucumbers are well known, while the feed for the rearing (grow-out) of sea cucumbers, yet to be studied intensively.

Future Research

1. Overcoming the technique to produce sea cucumber seed for mass culture.
2. Generating good food formula to grow sea cucumber for market size (± 500 g/ind) especially for *H. scabra.*
3. Research in polyculture (e.g. Sea cucumber and bivalves or with shrimp).
4. The influence of food toward quality and flavour of sea cucumber.

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Figure 1. Some of high value sea cucumbers

			
Actinopyga echinites	*A. Mauritiana*	*A. Miliaris*	*Bohadschia argus*
			
B. vitiensis	*Holothuria atra*	*H. edulis*	*H. fuscogilva*
			
H. fuscopunctata	*H. nobilis*	*H. scabra*	*H. coluber*
			
Stichopus chloronotus	*S. hermanni*	*Thelenota ananas*	*T. anax*

Table 1. Nutritious value of sea cucumber

Nutritious elements	Percentage
Protein	43.1
Lipid	2.2
Moisture	27.1
Ash	27.6

Table 2. Density for sea cucumber juvenile

Sea cucumber juvenile (Individualkg^{-1})	Stocking density (Individual m^{-3})
< 200	100 – 300
200 – 1.000	300 – 1.000
1.000 – 2.000	1.000 – 2.000
2.000 – 4.000	2.000 – 3.000
4.000 – 6.000	3.000 – 4.000
6.000 – 8.000	4.000 – 5.000
> 8 000	5.000 – 10.000

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Table 3. Variation of juvenile diet

Species	Stocking density (Juvenilesm^{-2})	Body size	Food	Cultivation time	Size accomplish (body length)	References
Holothuria scabra	200 – 500	± 485 µm	*Sargassum* spp., *Halimeda* spp., and *Syngodium isoetifolium*	2 months	2 cm	Baskar, 2004
Apostichopus japonicas			Diatome, *Sargassum thunbergic,* yeasts			Wang and Yuan, 2004
Apostichopus japonicas	100 – 300	13 days	*Spirulina platensis, Sargassum thunbergii*,			Xiyin *et al.*, 2004
Holothuria scabra		5 mm (in 14 days)	Diatome and powdered algae	4,5 months		Giraspy, 2008
Holothuria scabra		10 mm	*Sargassum* spp.	2 months	2 cm	James, 1999
Apostichopus japonicas	100 – 300		Comersial food (protein 25%, lipid 8%)	3 months	8,1 g	Wang *et al.*, 2007

ISSN : 1410-5217
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Table 4. Growth and survival rate of sea cucumber juvenile

Species	IBW[1] (g)	FBW[2] (g)	Growth rate	Survival rate (%)	Comments	References
Actinopyga mauritiana	7.4 ±0.2		10.4 ±1.4 g $month^{-1}$		Density 26 g m^{-2}	Ramofafia et al. (1997)
Holothuria scabra			0.2 ±0.02 g day^{-1}	96	57 days, V=140 L	Battaglene (1999)
Stichopus japonicus	5.0±1.2	18.3 ± 0.63		100	90 days, V=55 L	Kang et al. (2003).
Apostichopus japonicus	1.25 ± 0.5			63.5	14 months; pond Culture	Yu and Song (1999)
Apostichopus japonicus	16.7 ± 5.24	25.8 ± 6.45		100	Density, 50 g m^{-2}, 48 days	Yang *et al*. (2001)
Apostichopus japonicus				60 – 90	Indoor culture	Chang *et al*. (2003)
Apostichopus japonicus	4.54 ±0.38	11.81± 3.15	2.72 ± 0.75% day^{-1}	100	36 days, V=40 L	Dong *et al*. (2005)
Apostichopus japonicus	3.5 ± 0.3	8.1 ± 0.81	18 ± 6 g $month^{-1}$	87	90 days	Wang *et. al.*, 2007

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Table 5. Food of sea cucumber grow-out in Indonesia

Species	Food	Comments	Results		References
			IBW[1](g)	FBW[2](g)	
Holothuria scabra	"Klekap powder 69.65%,fishmeal 10.35%,vitamin mix 1.00%,mineral mix3%, tapioca flour 10.00% andrice meal6.00%.	- 3% biomasweight - given once aday - Cultivationtime in 2 months	16,69	64,03	Hartati dkk, 2005
Holothuria scabra	Manure and rice bran (1:1)	- 0.2 – 0.5 $kgm^{-2}week^{-2}$ - Cultivation time in 5 – 6 months	30–40 (per ind.)	200–250 (per ind.)	Martoyo dkk, 2006

[1]IBW = Initial body weight
[2]FBW = Final body weight