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Razor Clam (*Solen* spp.) Fishery in Sarawak, Malaysia

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Abstract
Razor clams (*Solen* spp.) , locally known as 'ambal', are highly priced marine bivalves in Sarawak and are harvested for human consumption mainly from the mudflats of Kuching and Samarahan Division. This paper reports on the state and current razor clam fishery practices in major areas and on the impact on natural resources. The supply of this clam is drawn mainly from wild catch leading to indiscriminate harvesting resulting in the depletion of natural stocks. Some comparison of razor clam fishery as between the western part of Sarawak, and Ehime Prefecture, Japan also will be discussed. The shell length data from clams collected in major razor clamming sites during peak clamming season in several consecutive years when analyzed showed a deterioration of the resources. We would like to highlight the impacts of some current practices which can create problems for razor clam fisheries that depend fully on natural stocks, to make suggestions on how the local community can conduct ustainable management of razor clams in Sarawak. The achievements and challenges faced in razor clam research regarding establishing seed production will also be highlighted.

Key words: Ehime Prefecture, razor clam, Solenidae, Sarawak, sustainable management

1. Introduction

Razor clams, locally known as "ambal", are one of the main species of economically important bivalves collected from mudflats in the western part of Sarawak. This bivalve has a pair of elongated thin shells which are nearly straight and sub-cylindrical with parallel margins and terminal beaks and they are gaping at both ends. It has a large and powerful foot that is particularly useful as a feeding and burrowing mechanism. As currently classified, Sarawak razor clams fall under the Family Solenidae which comprises three different species namely: *Solen regularis* Dunker 1962, *S. lamarckii* Deshayes 1839 and *S. sarawakensis* Cosel 2002 (Hung and Ruhana, 2007). Among these three, *S. regularis* is the most dominant (Rahim and Tan, 2008) and is preferred by consumers due to its meat's softer texture.

The last report on Sarawak razor clams fishery was published 16 years ago by Pang (1994). Therefore, there is a need to understand the current status of the razor clam population, and to gather ecological and biological information which is crucial for sustainable management and future stock enhancement. At the end of 2005 a comprehensive study on natural stock of the Solenidae razor clam natural stock in the western part of Sarawak was started by a team of researchers from the Universiti Malaysia Sarawak (UNIMAS). This paper explains the present status of Solenidae razor clam fishery during the razor clamming seasons from 2005 to 2009 and the impacts on natural resources. A brief note on Solenidae razor clams in Japan is included based on the author's experience in Ehime Prefecture. Some recommendations are also made on how the local community and government agencies could conduct a control and sustainable management program for razor clams in Sarawak. This paper concludes with an account of the achievements and constraints faced in doing razor clam research in Sarawak.

2. Razor Clams in Sarawak

1) Distribution and economic importance of razor clams

Solen species have a wide distribution around intertidal mudflats, sandy bars and beaches in the western part of Sarawak, particularly near Kuching and Samarahan Division (Pang, 1992; Ruhana *et al.,* 2006; Rahim and Tan, 2008). Among the popular razor clamming areas are Buntal, Bako, Muara Tebas, Sambir, Sebandi, Moyan Laut, Asajaya Laut and Sampun (Fig. 1). Razor clams

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have been providing subsistence income to coastal communities in Sarawak and as a popular delicacy in seafood restaurants. The current selling price in the wet market of fresh razor clams with shell has doubled compared to 18 years ago (Pang, 1994), currently ranging from RM15.00 to RM20.00/kg (exchange rate RM3.70 = USD1.00) depending on their availability.

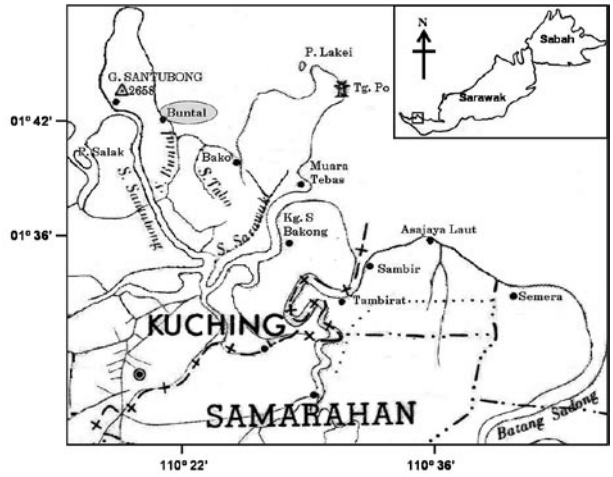

Fig. 1. Major razor clamming sites (shaded) in the western part of Sarawak, Malaysia.

2) Razor clams fishery in Sarawak

Sarawak's razor clam fishery started to grow from the early 1970s after these clams began to be served in seafood restaurants in Kuching (Pang, 1994). To date, Sarawak is still the only state in Malaysia that is able to land razor clams commercially. Nature regulates the open and closed seasons for clamming activity which is only effective during low tides in the spring tidal cycle which occurs in daytime from October to February(5 months). There is a one week interval between two clam collection cycles because the best time to do razor clamming is during spring tides and each cycle is about one week. The collection of razor clams by local people is conducted using a traditional method (Fig. 2) whereby the surface of a mudflat is tapped with a wooden stick which has one sharpened end (locally called "penugal", about 1 m in length) in order to detect razor clam burrows. Subsequently, a slender, elongated stick ("lidi", about 30 cm in length) is inserted into the burrow. This stick is coated with a paste mixture containing slaked lime, ash and salt which act as irritants that force clams out of their burrows. Another method used by local people in Buntal and Bako used to collect *S. sarawakensis* in particular is to stab a slender, elongated metal rod with a hook at one end ("penguris", about 60 cm in length) into a clam burrow. Other catching methods are not permitted due to the inherited taboo from previous generations prohibiting collectors from bringing metal objects to clamming areas (Ruhana *et al.,* 2007). Another taboo that must be followed by clam collectors in order to get high catches is the prohibition against shoes or slipper, or clothes with pockets.

Fig. 2. Razor clamming on a mudflat using traditional methods.
(a) searching for clam burrows and (b) inducing the clam to come out from its burrow.

3) Present status of razor clam fishery

Although this fishery has a long history, the traditional catching method is still being utilized, which is good for conservation because it is a very selective fishing technique which reduces unwanted catches and causes less disturbance of sediment compared to the dredge, scoop and clam gun methods (Sinclair and Valdimarsson, 2003). The breadth of exposed mudflats is about one to three kilometers during low tide. This varies by location, dates, local coastal morphology and water levels during low tide. Although the populations of razor clam were widely dispersed across the mudflats (Rahim and Tan, 2008), clamming activity was concentrated mainly in the low-tide region targeting bigger clams. Currently, nobody is monitoring the annual total landing of razor clams orthe effects of catch effort on the natural population, but local people commented that their catches are declining each year. The coastal communities involved in razor clam fishery in Asajaya Laut and Buntal are mainly ethnic Malays. The majority of clam collectors are women and children as young as seven years old who are actively involved during school holidays. The number of collectors involved varies with the time of year and usually increases very significantly during school holidays (November to December) when it easily excees 1,000 people.

After five hours of effort on the mudflat, the clam collectors will gather at the selling spot in the village

to sell their catch to the middlemen (Fig. 3). The price of razor clams at landing points is being controlled by middlemen because they provide boat fuel and pay the transportation cost (RM2.00 per person for round trips) of local people who are willing to sell catch to them. Although the catch consists of three different species, no sorting procedure takes place prior to marketing. The average price offered by middlemen were RM10.00 and RM15.00 per kg for Asajaya Laut and Buntal, respectively (Ruhana and Florence, 2008). If the total landing exceeds demand, the offered price will be lower (RM6.00/kg or less) with small clams having no value. This marketing system works to the advantage of middleman and does not benefit the local coastal communities.

Fig. 3. Selling of razor clams to middlemen at a village after collection by local people.

3. Impacts of Current Practices on the Natural Supply of Razor Clams

1) Razor clam populations in two study sites

The main goal of fisheries management is to maintain the stock level of a resource so as to permit adequate fishing indefinitely (Dore, 1991). Successful management thus depends heavily on gathering good information about the resource. Currently, razor clamming in Sarawak is not a regulated fishery activity and local clam collectors have been complaining that their catches are declining compared to previous years. Since there is no specific management regulation yet for Sarawak razor clam fishery, the natural supply may face serious overfishing pressures. Therefore, in order to assess the current status of this fishery, data from two razor clam (*S. regularis*) populations (Asajaya Laut and Buntal) which were collected for distribution pattern study in December of 2005 and 2006 were analyzed (Table 1).

Table 1. Comparison of clam density and shell length (cm) of Solen regularis sampled from mudflats of Asajaya Laut and Buntal in two consecutive years.
(Source: Rahim & Ruhana, 2009)

	December, 2005		December, 2006	
	Asajaya Laut	Buntal	Asajaya Laut	Buntal
Length of transect (m)	1,800	1,000	2,300	2,450
Total no. of clam sampled	365	45	209	105
Maximum clam density (no. of individuals/100 m^2)	480	112	176	144

Data showed that the total number of clams sampled was higher in Asajaya Laut than in Buntal in both years, but a reduction of 42.7% was shown in Asajaya Laut in 2006. For Buntal, there was an increase in 2006 because only one out of three transects used consisted of *S. regularis* in 2005, but this species were found in all transects in 2006. Asajaya Laut recorded the highest estimated maximum density of 480 individuals/100m^2 in 2005 but it declined by 63.3% the next year which forced local people to find a neighboring clamming area. Comparing the clam density of Asajaya Laut in 2006 with Mae Klong estuary, Thailand in 1989 (6,551 individuals/100 m2) (Gajaseni, 1992), the latter density was 37 times higher than that of Asajaya Laut. Such a dense population might have been present in Sarawak in the early 1990s, when the annual landings were estimated to be around 80 to 100 metric tons (Pang, 1994).

A razor clam population can collapse if the total fishing efforts goes beyond the fishing capacity and people start to collect smaller sized clams. More clams are needed in order to get one kg of catch while trying to sustain a subsistence income. This will have a negative impact on the success of new recruitment. Records of shell length of *S. regularis* from Asajaya Laut and Buntal collected from two separate clamming seasons in December, were compared to discover any sign of overfishing (Fig. 4). Although *S. regularis* could reach a length of 8.00 cm, most of the clams in this study had lengths ranging from 3.50 to 5.49 cm. In 2005, the dominant size class in Asajaya Laut (26.3%) was 3.50 – 3.99 cm, while in Buntal (37.8%) it was 5.00 – 5.49 cm. For 2006, clam size in Asajaya Laut increased, the dominant size class was 4.00 – 4.49 cm (22.5%), while clams from Buntal decreased in size (26.7%, 3.50 – 3.99 cm).

Another clear sign of clam size reduction was observed in specimens collected from Asajaya Laut as part of a reproduction study which compared cumulative

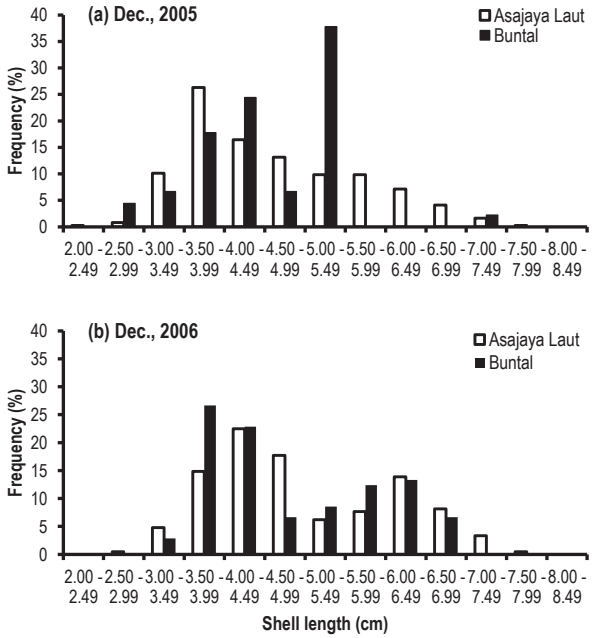

Fig. 4. Comparison of size class distribution of razor clams, *Solen regularis* sampled from Asajaya Laut and Buntal in December (a) 2005 and (b) 2006.
(Source: Rahim and Ruhana, 2009)

data in December and January over four years (2005/06, 2006/07, 2007/08 and 2008/09) (Fig. 5). In the first three seasons, the dominant size class increased by one class each year but decreased in their percentage dominance : 5.50 – 5.99 cm (2005/06, 43.3%), 6.00 – 6.49 cm (2006/07, 34.0%) and 6.50 – 6.99 cm (2007/08, 23.3%). However, recently (2008/09), the dominant size class decreased drastically to 4.00 – 4.49 cm (30.7%). Based on these two analyses, it can be concluded that the population of *S. regularis* is being overfished.

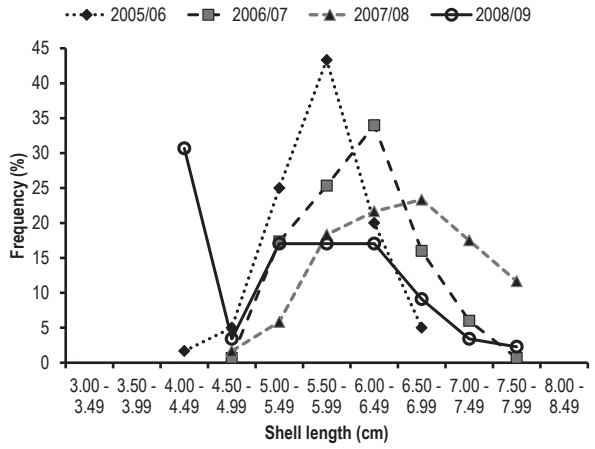

Fig. 5. Overall trends in the size distribution of razor clams, *Solen regularis* sampled from Asajaya Laut as used in a reproduction study (cumulative data from December and January) over four different seasons (2005/06, 2006/07, 2007/08 and 2008/09).
(Source: Rahim and Ruhana, 2009)

2) A brief note on the Solenidae razor clam in Ehime Prefecture, Japan

A one day trip was made on 27 September 2008 to visit the razor clamming area in the Seki River (Sekigawa), Ehime Prefecture, Japan. It was observed that only two razor clam collectors were present and they used different clamming methods compared to Sarawak. The upper layer of sediment is carefully scraped using a gardening scoop until the hole of a clam burrow is revealed. Then, table salt is sprinkled on top of the hole in order to force the clam out of its burrow (Fig. 6). It is possible to use this method since the texture of the mudflats is firmer and less watery than those in Sarawak. Only one species is available in that area which is *S. strictus* and its shell length is longer than that of Solenidae razor clams of Sarawak. The estimated density of clams is four times higher (1,800 individuals/ 100 m^2) compared to Sarawak (480 individuals/ 100 m^2). The selling price of this razor clam in Japan is 500 yen for 20 clams.

There is a sign informing visitors about access to the mudflat and outlining entrance fees which is seen

Fig. 6. Razor clamming at the intertidal area of Seki River, Ehime Prefecture, Japan.

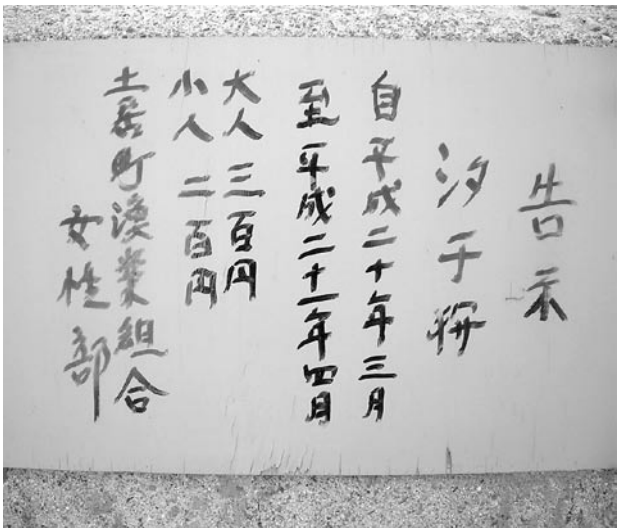

Fig. 7. A sign on the seawall to inform visitors about entrance regulations and beach access charges for collecting marine resources.

before entering the mudflat area (Fig. 7). This shows that there is at least one kind of marine resource management by the local community at the Seki River mudflat. The stated entrance fee that must be paid to the local community association is 300 yen for adults and 200 yen for children. Although the management seems to be very small scale, it is nevertheless effective in monitoring the level of resource exploitation as reflected in the clam density data mentioned above.

4. Anthropogenic Threats and Its Future Prospects

1) Anthropogenic threats to razor clam resources

Other than fishing pressure, anthropogenic threats can also reduce the natural stock of razor clams. The ocean ecosystem is interconnected with the terrestrial landscape and disturbances from human activities on land will spread to the ocean. For example, the deforestation of bay watersheds as human population expands along with sand dredging activity will result in two major environmental impacts to benthic habitats: (1) alteration of the mudflat texture due to increases in sediment input in intertidal zones (Tuck *et al.,* 1999) and (2) high sedimentation or siltation. The first impact will change benthic communities particularly the razor clam which prefers to inhabit certain types of sediment (Rahim and Tan, 2008). Although razor clams are fast burrowers, the adults cannot burrow into sediment that is too soft or too compact. As a result, they will be exposed to increased predation by gastropods and birds. The later can affect razor clam larval settlement and spat survival. These effects will contribute to higher natural mortality rates and the failure of new recruitment into the population.

There may however be additional razor clams inhabiting the subtidal zones which would not be accessible using the traditional clamming methods and these stocks help to sustain the intertidal population. However, if their habitats are subjected to severe environmental deterioration, no clams can survive and stocks will crash. Moreover, food safety issues regarding the consumption of razor clams will arise if their habitats become polluted with untreated effluent from unsystematic settlements and industries near the mudflats. Contaminated clams will have no market value and cannot provide subsistence income to coastal communities.

2) Way forward for sustainable management of razor clams in Sarawak

In order to reduce the fishing pressure on the razor clam population and to facilitate the initial set up of a sustainable resource management system, there is a need to have a regulating institution which can run by forming a Local Cooperative Association (LCA) within the coastal community around the clamming areas. This approach is also known as Community Based of Fishery Management (CBFM). The LCA can be given the exclusive right to conduct razor clam fishing operations and conduct activities that must be perceived as providing benefits or incentives to its members (Caddy, 1989), for instance by taking steps towards the improvement of the natural resources and the socioeconomic conditions of people who depend on the razor clam for income.

Since the razor clam fishery is a flagship project for Sarawak, a plan which can be organized by the LCA has been proposed to incorporate this project into an ecotourism industry (Rahim and Ruhana, 2009). The reduction in razor clam landings was acknowledged by the local community and they are ready to get involved in ecotourism in order to reduce the fishing pressure. Table 2 compares the possible incomes that could be generated under (a) present practices and (b) a community based management scheme. With the formation of an LCA, tourists and non-members must pay an access fee per entry to the clamming area. Furthermore, all landings must be pooled and recorded by the LCA before being auctioned to middlemen so as to attain a higher and more stable price than at present. About 5% of the selling price will go to the LCA for administrative purposes. Indirectly, there will be a proper record on catch per unit effort (CPUE) and total landings which is a very useful measurement for resource management and fishery statistics. A minimum annual membership fee needs to be paid to the LCA in order to organize activities and also to instill a sense of belonging among members thus increasing their participation. As a member of the LCA, one will gain many benefits such as the right to participate in any activities related to razor clam fishery, higher and continuous income during the razor clam 'off-season' by becoming a tour guide, selling traditional handicrafts, local fruits and other side products. The benefits of the CBFM approach could not only manage to reduce fishing pressure on the clam population by diversifying income sources, but could also benefit local communities by sharing resources across the society through creating downstream industries. Further detailed discussions between local community members and government agencies such as the Malaysia Tourism Board, the Fisheries Development Authority of Malaysia and the Department of Fisheries are needed in order to implement the proposed plan.

Table 2. Comparison of local incomes generated by (a) present practices and (b) community based management (forecasted income). (Modified from: Rahim and Ruhana, 2009)

(a)	Present practice	Income per trip (RM)
1.	Selling razor clam (e.g. 2 kg) to middleman. Maximum price is fixed by middlemen @RM10.00/kg.	20.00 or less
2.	Boat owner gets paid by middleman to transport people to clamming area, RM2.00 per person (8 persons/boat)	16.00
	Incomes of local people range from:	20.00 – 36.00

(b)	Community based management	Income per trip (RM)
	Minimal annual membership fee to join a cooperative. Non-members have to pay access fees as do tourists	(Adult=10.00) (Child=6.00)
1.	Selling razor clam (e.g. 2 kg) to middlemen via a local cooperative association (LCA) using an auction system, e.g. @RM15.00/kg 5% of selling price goes to the cooperative Data recording on CPUE to pay members Cooperative can also sell directly to other outlets/ ecotourism groups	30.00
2.	Ecotourism Cost range from RM16.00 to RM41.00 per tourist Boat owner (8 tourists/trip) A tour guide (5 tourists/guide) Access fee @RM5.00/tourist goes to LCA	48.00 40.00 – 50.00
3.	Selling handicrafts/ side products/ local fruits/ fruit juice	++.00
	Incomes of local people starts from:	30.00

3) Achievements and challenges in razor clam research

Marine fish resources in Malaysia are based on wild catch for supply. Without any effort to manage the natural stock, the limited resources will continue to dwindle with the increase in fishing pressure. Therefore, it is important to mitigate this problem using artificial production to achieve natural stock enhancement. The crucial scientific information regarding the seed production of razor clams includes: (1) reproductive biology, (2) brood stock handling, (3) induced spawning method, (4) larval biology and (5) juvenile culture. Some beneficial findings have been drawn in area, such as reproductive biology, brood stock handling and with regard to induced spawning methods. Through monitoring the gonadal condition index for a one year period, it has already been understood that the razor clam *S. regularis* spawns from early April to early September and enters a resting period from late October to the end of December before the gonad starts to develop again for the next cycle (Fig. 8).

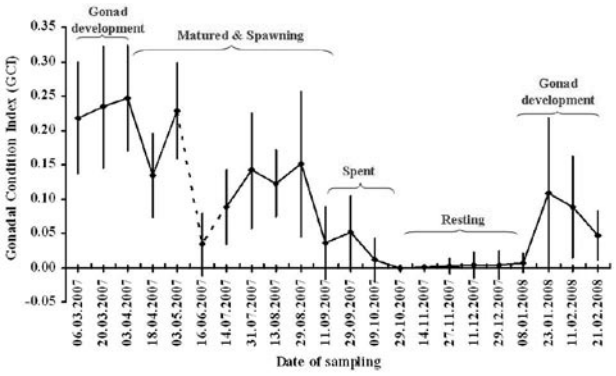

Fig. 8. Reproductive cycle of razor clam *Solen regularis* based on its gonadal condition index. (Source: Aileen and Rahim, 2009)

Several induced spawning methods to produce larvae were implemented. Thermal manipulation (dry chilling at 6°C followed by exposure to 27°C) and chemical stimuli (potassium chloride) managed to spawn ripe clams (Diomira and Rahim, 2009a). However, the larval culture is not stable yet and needs further improvement. Throughout the research on seed production, some constraints were faced. These include the difficulty to get brood stock supply during spawning season due to natural annual tidal cycles. The lowest low tides occur at night preventing the collection of enough spawners. Furthermore, the brood stocks cannot be maintained for a long period under laboratory conditions before experiments and they become weak and die after spawninghas ben induced.

A secondary finding which resulted from the reproductive study of *S. regularis* relates to the presence of endoparasites (trematode and nematode) within the clam's body cavity which may pose a threat to clam population and fishery (Diomira and Rahim, 2009b). The trematode was identified as a digenean trematode of the family Gymnophallidae but the nematode could not be further identified (Fig. 9). The site of infection is along the reproduction area, mainly within the gonad and digestive tract. This was noted by a bright beige color resembling the color of the male gonad. Clams which were infected were those that could not be successfully induced in the spawning experiments. However, the effects of the parasitism of these endoparasites are still unknown for this razor clam however it is thought that

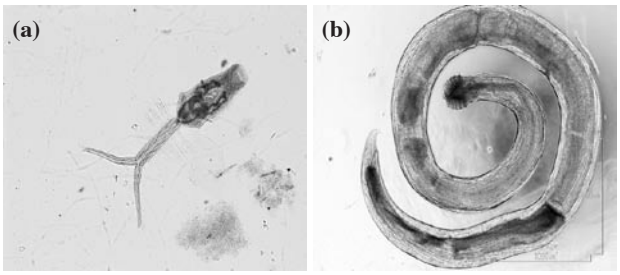

Fig. 9. Two types of endoparasite (a) trematode and (b) nematode found in razor clam *Solen regularis*. (Source: Diomira and Rahim, 2009b)

full invasion could make the clam sterile.

5. Conclusion

The natural supply of razor clams in the western part of Sarawak showed signs of overfishing. This could be due to unregulated fishing efforts which reduce the number of spawning adults and influence the population structure of razor clams. It is thought that enhancing the quality of the livelihoods of local communities can help to reduce the fishing pressure on razor clams. A promising ongoing project in UNIMAS to produce spat artificially and release them to their natural habitats is giving some hope and can form part of the natural stock enhancement in future. With the existence of community based management, it would be easier for researchers to provide technical support and manage the razor clam fishery and aquaculture in the future.

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