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MARUDU BAY COMMUNITY-BASED GELOINA SPP. AQUACULTURE MANAGEMENT: ENHANCING SUSTAINABLE CONSUMPTION, LIVELIHOOD AND FOOD SECURITY

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Abstract: A simple way to determine if mud clams (*Geloina spp.*) are being overharvested is to observe the average shell size of the latest catch. Due to increasing demand and price for the bivalves has motivated the Sabah Fisheries Department to support mud clam aquaculture among the communities living close to mangrove areas. This study surveyed the quantity and size of mud clams collected from two locations in Kudat district from in January to March 2017. The mangroves at Kimihang is a natural area where locals collect mud clams while the aquaculture centre in Kampung Kopunadan is run by the community. . The collected mud clams were grouped as small (< 50 mm), medium (50mm to 70 mm) and large (>70 mm). This study found that the outer mud clam shell size collected in Kampung Kopunadan is larger than the wild type from Kimihang. From the surveys and interviews, it is discovered that the majority of locals in Kimihang prefer to consume small clams while Kopunadan locals prefer large ones. The respondents who liked small clams said the flesh is easier to chew, while the ones who chose large-sized clams cited more quantity of flesh. Majority of the respondents are from the Rungus ethnic group, who are low-income earners depending on the fisheries sector as their livihood. Development of sustainable mud clam aquaculture in Kudat will ensure food security and safeguard the welfare of the locals. Collectors should be encouraged to practise sustainable harvesting management by collecting large clams or venture into aquaculture.

Keywords: Aquafarming, seafood consumption, transdisciplinary, Kampung Kopunadan, Rungus ethnic, Kimihang, Kopunadan, Kudat.

Introduction

Mangroves are a habitat for diverse marine organisms, sustaining a unique ecosystem that protects the seaside from erosion (Polidoro *et al.,* 2010). Local coastal communities also depend on the natural resources found in this unique area as a source of income (Thomas *et al.,* 2017). More than half of the mangrove forests in Malaysia is found off the shores of Sabah. Thus, the socio-economic development of many coastal communities in the state is closely intertwined with the mangrove ecosystem (Majiol *et al.,* 2016a). For coastal communities in Sabah's northern-most district of Kudat, mangrove forests are their significant source of seafood for earning income and food supply (Majiol *et al.,* 2016b). The seafood harvested by communities in Kudat coastal areas include fish and shellfish like crabs and mud clams.

Sabah is blessed with a large and wide distribution of mud clams (*Geloina spp.*), which is a cheap source of protein (Majiol *et al*., 2016a, Manjaji-Matsumoto *et al*., 2016, Harsono *et al.,* 2017, Ransangan & Soon 2018). Locally known as "lokan", it has become a delicacy and is usually served as a grilled dish (Hamdan *et al.,* 2016). A steady increase of the mud clam's economic value has been observed in recent years, which led to its high demand. Sellers have started sorting and selling clams

by size to earn more income (Hamdan *et al.,* 2016; 2017). This growing consumption trend may lead to unsustainable harvest management practices. Overexploitation of marine resources is a concern, especially for those living under the poverty income line, who may be susceptible to hardship when resources are depleted (Majiol *et al.,* 2016; Mulla & Chavan 2016). The bivalve *Geloina* spp. is being overharvested in North Borneo and their population growth in the mangroves cannot catch up with market demand (Ransangan *et al.* 2019).

In this study, a linear morphometric analysis of mud clams collected from Kampung Kimihang and Kampung Kopunadan in Kudat was performed to compare their population sizes and consumption trend. This study was based on a quantitative field survey between December 2016 and January 2017, as well as qualitative interviews in March 2017 to ascertain how community-based mud clam breeding projects, equipped with training in selective harvesting methods, can contribute to income generation and sustainable environment.

Materials and Methods

Study Sites

Kampung Kimihang (6° 57' 17.41" N 116° 43' 37.84" E) and Kampung Kopunadan (6° 41' 4.030" N 116° 45' 25.239" E) were well-known for mud clams that provided food for local communities and as a commercial harvest. The distance between these two sampling sites was about an hour's drive, and the main difference was the harvest management practices. Mud clams were publicly collected from the wild in Kampung Kimihang, while Kampung Kopunadan has an aquaculture centre managed by the local community, where the clams were cultured in cages placed in the mangroves. The location was remote and public access was restricted.

Kampung Kimihang borders the South China Sea and the natural resources there were collected by local and non-local income seekers to supply markets in Sikuati and Kudat areas. Meanwhile, Kampung Kopunadan was located off Marudu Bay in northern Sabah. The mangrove forests around the village hosted the first community-based mud clam aquaculture project in Kudat district developed by the Sabah Fisheries Department in 2014. The project was mooted by the Village Development Committee to boost the socioeconomic status of the villagers (Shah *et al*., 2018). The villagers believed that this food source could boost their livelihood with proper aquaculture training to ensure sustainable development.

Kampung Kopunadan villagers involved in the mud clam aquaculture project were allocated funding and facilities from the Sabah Fisheries Department. Their progress was closely monitored by the Matunggong District Fisheries Office.

In line with sustainable development goals, villagers were given life-long training, who would then pass down the knowledge to the younger generation.

Sample Collection

Wild mud clams at Kampung Kimihang were collected with the help of local guides near Jalan Kimihang Loro during low tide in October 2016, January 2017 and March 2017. The clams from Kampung Kopunadan were supplied directly from a breeder at the price of RM2 per kg in January and March 2017. The outer shell length, outer shell width and outer shell height were measured using a vernier caliper for linear morphometric analysis after the samples were cleaned. Mud clams were sorted according to three group sizes: small (less than 50mm), medium (between 50 mm to 70 mm) and large (bigger than 70 mm).

Surveys and Interviews

A questionnaire was prepared to analyse the quantity and size of mud clam consumption of people living at Sabah. The sociodemographic and socioeconomic details of the respondents were recorded. A pilot test was conducted and the questions were fine-tuned to ensure that respondents were able to understand the

contents in Bahasa Malaysia. There were two groups of respondents in this research, mainly (i) villagers who collected mud clams and (ii) customers at the local *tamu* (market). The questionnaire was distributed at Kampung Kimihang and Kampung Kopunadan villagers between December 2016 and January 2017. To assess if there was any significant differences in mud clam consumption in the two sites, the same questionnaire was randomly distributed to local customers at Tamu Sikuati and Tamu Matunggong.

Tamu Sikuati was located near Kampung Kimihang area, whereas Tamu Matunggong was the nearest to Kampung Kopunadan. *Tamu* customers were divided into two groups, depending on the distance of their homes to Kampung Kimihang and Kampung Kopunadan.

Direct interviews with local people, Kampung Kopunadan Village Development Committee members and Matunggong District Fisheries officers were also conducted to gain more information and supplement the questionnaire analysis. Interviews were recorded and transcribed. The language used was Bahasa Malaysia and there was a native translator to assist in case the respondents did not understand the questions and to avoid miscommunication.

Results and Discussion

Sociodemographic and Socioeconomic Survey of Northern Sabah

There were 191 respondents in this survey, of whom 32 were Kampung Kimihang villagers. There were 22 Kampung Kopunadan villagers. and all were from the Rungus ethnic group. Participants were mainly young adults with families (Figure 1). More than half of the respondents had at least secondary school education.

Many local communities in the Kudat area lived below the poverty line, where a majority did not earn more than RM1000 per household (Lim & Mansur, 2015; Majiol *et al.,* 2016b). To meet ends meet, local communities had to take on several jobs. Northern Sabah comprised diverse multi-ethnic groups, but the Rungus was dominant in the study areas (Figure 1). The Rungus had been involved in agriculture for a long time (Kodoh *et al.,* 2016) and had recently ventured into the fisheries sector (Lim & Mansur, 2015).

However, many respondents in the study had been involved in fishing for several generations (Figure 1). This might be due to the close proximity of the villages to the sea and mangrove forests, which were rich with fauna biodiversity and served as a source of food and livelihood. Little attention had been given to the study of the Rungus' involvement in fishing as an economic activity. Besides going out to the open sea, Kampung Kopunadan villagers had pioneered a community-based project to breed mud clams in cages at mangrove areas near their village. This highlighted the potential of the fisheries sector or aquafarming to improve the socioeconomic status of local communities living near mangrove forests (Thomas *et al.,* 2017).

Food Source to Commercial Product

Mud clams, widely known as *lokan* in Malaysia, were called '*tagum*' by the Rungus. The specific name in the native language indicated that *tagum* had long been an important food source to the local Rungus folk for many generations. Before the community-based mud clam breeding project was conceived, the clams were collected at various mangrove areas without proper harvest management. If the clams are hard to find, collectors had to travel far away to other areas as stated by one respondent:

> "Before the project was introduced in 2015, I collect *lokan* in many mangrove areas like Kuala Bandau…far from this village. After joining this project, the search for *lokan* had focused in breeding areas in my village".

Marine products could contribute more to household income compared to collecting mangrove wood (Majiol *et al.,* 2016b; Mulla & Chavan 2016). The mud clam aquaculture centre in Kampung Kopunadan had expanded

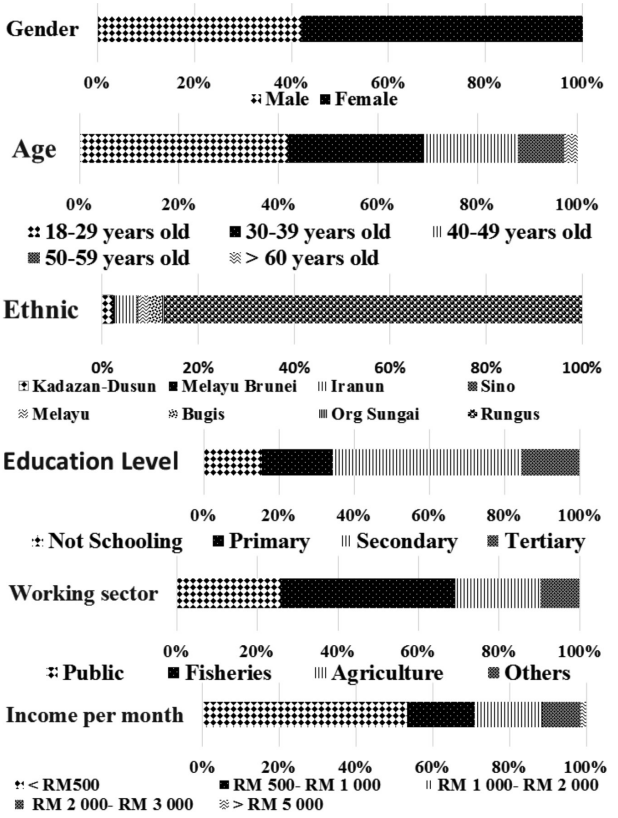

Figure 1: Sociodemographic and socioeconomic profile of respondents around North Sabah in percentages.

in terms of the number of cages and community participation (Md Shah *et al*. 2018). The villagers realised that not only could they enjoy a lucrative, sustainable income by culturing the clams, but at the same time, their products were even sold outside Kudat district, as described by one participant:

> "With these breeding concept in specific area, now it's easier to collect *lokan*. Income from this *lokan* also good. I received an order from Tambunan up to 200 kilograms, which give me around RM500 income".

Surprisingly, from this survey, a majority of respondents in Kampung Kimihang preferred to buy mud clams rather than to harvest themselves (Figure 2a). One respondent said it was time-consuming and she could not stand working in the mangrove forest. The researchers who collected the clams with the help of local guides near Kampung Kimihang found that it took many hours to collect a sizeable quantity in one day. They had to probe the mud with a machete to find the clams, which were deeply burrowed and well hidden. Besides suffering mosquito bites, collecting the clams required skill and hard work. Interviews with mud clam collecters, most of whom were women, found that the work was exhaustive and painful because they had to spend many hours bending their backs to search and collect mud clams (Figure 2b). Therefore, it was not surprising that most of the respondents preferred to buy rather than collect the clams themselves (Figure 2a).

Mud clams were the preferred source of food because of they were cheap and delicious. Although, they could be easily found in many areas of Kudat district, it was not appealing for the younger generation to venture into the

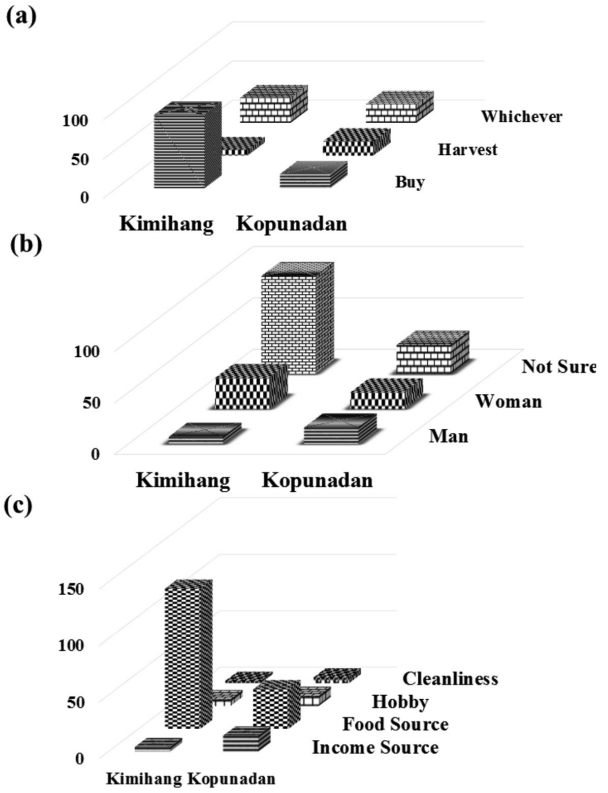

Figure 2(a): Participants from Kimihang and Kopunadan were asked whether they preferred to buy or harvest mud clams, (b) Respondents consciousness on which gender is associated with collecting mud clams, (c) Pinpoint mud clam social standing of both study areas on why locals prefer to buy or harvest mud clams themselves. Total number of respondents: Kimihang = 132, Kopunadan = 59

muddy mangroves to collect them. Moreover, people who are not familiar with the area could easily get lost and there are safety aspects to consider. As the price of mud clams were still affordable, locals preferred to just buy them from the "hardworking" collectors (Figures 2a and 2c).

Besides being an affordable food source, locals also treasured mud clams for their medicinal value. The older generation in Kampung Kimihang believed that the soup made by boiling mud clams with young papaya fruit could help nursing mothers boost their milk production.

Kampung Kopunadan villagers mostly used their hands to collect mud clams in the mud. This might be due to soil texture or mud compactness, which were observed to be different from Kampung Kimihang (Aswani *et al.,* 2014). Although Kampung Kopunadan was producing mud clams as a commercial venture, most of the harvest was consumed by the villagers themselves. The income source was a secondary factor, but the value was higher compared to Kampung Kimihang (Figure 2c). Moreover, a majority of the aqua farmers earned less than RM500 a month from selling their harvests and consumed their mud clams at least once a week (Figure 3a). Some Kampung Kopunadan respondents ate mud clams daily, which indicated that it had become their staple food.

In the Solomon Islands, women living near mangrove areas played a crucial role in food security management of their family (Aswani & Weiant, 2004). Women were the

ones who gathered marine clams either for food or income in actively managed community-based protected areas. This culture can be seen at Kampung Kimihang where many gathered mud clam occasionally only as food sources and acknowledge mud clam collecting was a woman's task (Figure 2b). On the contrary, where mud clam also supplement the household income for Kampung Kopunadan aqua farmers, man and woman were equal collectors. However all the titles to the mud clam breeding cages were owned by men.

Overfishing of mud clam might not only effect human food resources but other consumers on the trophic structure (Croisetiere *et al.,* 2006). In Kudat mangrove, mud clam is not only a food source for man. Proboscis monkeys, an iconic and protected primate species in Sabah, frequently broke into the mud clam cages of Kampung Kopunadan, which might reduce the yield of the aquaculture farmers.

Harvest Management Impact on Consumer Consumption Trend

Seafood consumption of communities living in the same area could be influenced by culture, and demographic or socioeconomic factors (Sechena *et al.,* 2003; Anacleto *et al.,* 2014). Although the demographic and socioeconomic factors of Kampung Kimihang and Kampung Kopunadan were almost similar, there is a difference in the preference of eating mud clams based on size as shown in Figure 3c.

This perception might be explained by the years of training that Kampung Kopunadan villagers received from the Fisheries Department in selectively harvesting mud clams based on size. The training that the villagers received had made them realized that the larger the size, the more income they could generate based on the clams' weight. It would also ensure that only mature clams were harvested, ensuring that their clam population in their farms was sustainable.

Customers have no choice but to consume only large clams supplied to their local markets. However, in Kota Kinabalu, mud clams were sold in different sizes to cater for customers with different socioeconomic backgrounds (Hamdan *et al.,* 2016). Smaller clams were priced cheaper, which allowed poor people to buy them as a food source.

Most of consumers preferred medium to large mud clams because of their meat volume. However, Kampung Kimihang villagers, who have the freedom to harvest mud clams, were not very fond of large clams due to their hard texture, which made it difficult to chew. They preferred small- to medium-sized clams, and this would result in the harvesting of juvenile stocks in the mangroves. Therefore, the mud clam population in Kampung Kimihang should be consistently monitored and the villagers might require awareness campaigns to manage their harvesting and consumption. These would ensure that the clams were still be available as a food source for their future generation.

Kopunadan respondents said they consumed more mud clams compared to Kimihang folk (Figure 3b). This might be due to the aquaculture project that provided an abundant supply of clams in the local market. The clams are also valued more by local residents as they knew that the products, they bought were homegrown with assured quality. Thus, consumption frequency of mud clams among Kopunadan villagers could be expected to be much higher than Kampung Kimihang (Figure 3a). Majority of Kampung Kimihang respondents only consumed mud clams once a month and, at most, once a week. Different perception of mud clam value could influence consumption size preference and frequency as shown between the villagers of Kimihang and Kopunadan.

Mud Clam Size Distribution and Selective Harvesting

The mud clams collected in the mangroves near Kampung Kimihang were small in size. (Table 1) Most villagers gathered the clams mainly as a food source and only a minority sold their extra harvest. People who are not from the village came to the mangrove areas to search for mud clam as their source of income frequently because

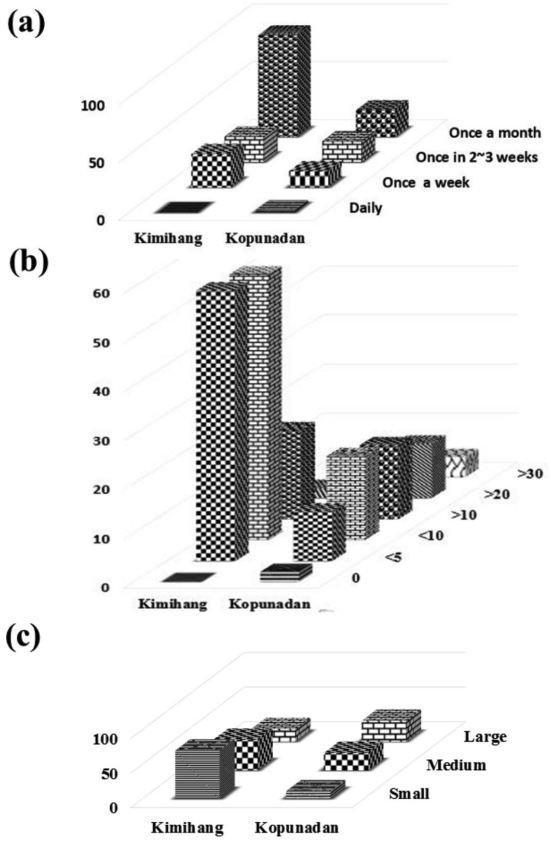

Figure 3(a): Mud clam consumption frequency of Northern Sabah consumers, (b) On average how many mud clams is consume per-meal, (c) Participant mud clam size preference. Total no. of respondents, Kimihang = 132, Kopunadan = 59.

the mangrove was open to the public. However, these collectors did not have knowledge on how to perform selective harvesting. The number of mud clams collected at Kampung Kimihang with outer shell length of more than seven cm was very small compared to Kampung Kopunadan (Table 1). In addition, there was a seasonal difference in the average shell size for January and March, but all the outer shell sizes of clams collected at Kampung Kopunadan were larger than Kampung Kimihang (Table 2).

More study is proposed to understand the spawning season of mud clams so that aquaculture development would not only produce large sized clams, but also harvesting those with good meat quality (El-Sayed *et al.,* 2011; Gimin *et al.,* 2004). Meat quality was an important factor to cater to the upscale market, such as overseas export, and could fetch a better price economically.

Transplantation of juvenile shellfish had helped to boost the native population that faced declined due to over-harvesting (Kreeger *et al.,* 2011). One of the strategies that Kopunadan aqua farmers practiced when they discovered small mud clams outside their breeding cages was to collect the juveniles and transfer them into their breeding cages. This would allow the juvenile clams to reach sustainable harvest size in the breeding cages, besides spawning eggs at least once in their lifetime (Joaquim *et al.,* 2008).

Table 1: The size distribution of mud clams collected at Kampung Kimihang and Kampung Kopunadan according to outer length shell (mm) for October 2016, January 2017 and March 2017

Study area	**Kampung Kimihang**			**Kampung Kopunadan**	
Sampling Period	**Oct 2016**	**Jan 2017**	**March 2017**	**Jan 2017**	**March 2017**
Small (<5 cm)	50	41	12	2	0
Medium (5 cm-7 cm)	12	26	16	27	29
Large (>7 cm)	0	2	6	18	5
Total	62	69	34	47	34

Table 2: Average size of outer length shell, outer width shell and outer height shell according to group size of Kampung Kimihang and Kampung Kopunadan clams collected in October 2016, January 2017 and March 2017

Study area		**Kampung Kimihang**						**Kampung Kopunadan**			
Sampling Period		**October 2016**		**January 2017**		**March 2017**		**January 2017**		**March 2017**	
Characteristic	**Size**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Outer Length Shell (mm)	S	47.22	±6.34	39.30	±7.26	43.60	±2.93	48.50	±0.50	0.00	±0.00
	M	54.60	±3.59	50.58	±3.51	59.61	±4.14	57.93	±5.48	64.20	±4.45
	L	0.00	±0.00	76.50	±4.50	74.48	±1.31	75.00	±2.94	77.48	±4.12
Outer Width Shell (mm)	S	42.12	±7.08	34.80	±6.34	38.30	±2.80	43.50	±0.50	0.00	±0.00
	M	49.86	±4.29	46.15	±3.39	52.61	±6.27	51.19	±5.62	58.00	±4.81
	L	0.00	±0.00	72.50	±0.50	68.13	±3.76	65.06	±3.75	69.59	±2.07
Outer Height Shell (mm)	S	25.67	±5.33	19.85	±4.27	23.30	±1.67	26.50	±0.50	0.00	±0.00
	M	29.21	±2.51	27.50	±2.61	35.44	±3.52	31.74	±3.28	37.00	±3.68
	L	0.00	±0.00	42.50	±0.50	46.57	±3.78	41.50	±3.29	45.57	±1.06

Conclusion

Selective harvesting method by size may prevent wild populations of mud clams from being exhausted rapidly. Knowledge dissemination of large size harvest and consumption benefits are important for sustainable development of this community-based mud clam breeding project in Kampung Kopunadan. Mud clam aquaculture helps the local community to generate more income. Community-based aquaculture harvesting management makes mud clam harvesting more structured and sustainable for future generations, contributing to food security and biodiversity conservation.

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References

Anacleto, P., Barrento, S., Nunes, M.L., Rosa, R., & Marques, A. (2014). Portuguese consumers' attitudes and perceptions of bivalve molluscs. *Food Control*, *41*, 168-177.

Aswani, S., Flores, C. F., & Broitman, B. R. (2015). Human harvesting impacts on managed areas: ecological effects of socially-compatible shellfish reserves. *Reviews in Fish Biology and Fisheries*, *25*(1), 217-230.

Aswani, S., & Weiant, P. (2004). Scientific evaluation in women's participatory management: monitoring marine invertebrate refugia in the Solomon Islands. *Human Organization*, *63*(3), 301-319.

Croisetiere, L., Hare, L., & Tessier, A. (2006). A field experiment to determine the relative importance of prey and water as sources of As, Cd, Co, Cu, Pb, and Zn for the Aquatic Invertebrate *Sialis velata*. *Environmental Science & Technology*, *40*(3), 873-879.

Gimin, R., Mohan, R., Thinh, L. V., & Griffiths, A.D (2004). The relationship of shell dimensions and shell volume to live weight and soft tissue weight in the mangrove clam, Polymesoda erosa (Solander, 1786) from northern Australia. *Naga*, 27(3-4), 32-35.

Hamdan, D. D. M., Udin, L., Tair, R., & Adnan, M.H. (2017). Communication gap of heavy metals knowledge among community in Batu Payung, Tawau and its impact on food safety, security and livelihood sustainability. *Jurnal Komunikasi Borneo Edisi Khas (Konvokesyen ke-19 UMS)*, 3-1(3), 1-25.

Hamdan, D. D. M., Tair, R., Agong, R., Adnan, M.A., & Salleh, A.R. (2016). Effective communication and interdisciplanary research on the idea that size matter for safer lokan delicacies in Sabah. *Jurnal Komunikasi Borneo Edisi Khas (Konvokesyen ke-18 UMS)*, 2-6(4), 84-106.

Harsono, N. D. B. D., Ransangan, J., Denil, D.J., & Soon, T. K. (2017). Heavy metals in marsh clam (*Polymesoda expansa*) and green mussel (*Perna viridis*) along the northwest coast of Sabah. *Borneo Journal of Marine Science and Aquaculture*, *1*, 25-32.

Jaoquim, S., Gaspar, M. B., Matias, D., Ben-Hamadou, R., & Arnold, W.S. (2008). Rebuilding viable spawner patches of the overfished *Spisula solida* (Mollusca:Bivalvia): A preliminary contribution to fishery sustainability. *ICES Journal of Marine Science*, *65*, 60-64.

Kodoh, J., Sinusun, V., Liew, K. C., Maid, M., Lintangah, W., & Mojiol, A. R. (2016). The contributions of rubber plantation to the socio-economic development: a case study in Kanibongan project-rubber smallholders community in Pitas, Sabah. *International Journal of Agriculture, Forestry and Plantation*, *2*, 207-211.

Kreeger, D., Cole, P., Bushek, D., Kraueter, J., & Adkins, J. (2011). Marine bivalve shellfish conservation priorities for the Delaware Estuary. Partnership for the Delaware Estuary (PDE) Report #11-03.54pp.

Lim, G. N., & Mansur, K. A. (2015). Understanding Poverty and Vulnerability by Utilising the Sustainable Livelihood Approach: A Comprehensive Study among Rungus Ethnic in Sabah, Malaysia. *Malaysia Journal of Business and Economics*, *2*(1), 1-24.

Majiol. A. R., Kodoh. J., Wahab. R., Majuki. M., & Wahyudi (2016a). Contribution of non-wood forest product to the local community living near mangrove forest in Kudat, Sabah. *Journal of Tropical Resources and Sustainable Science*, *4*, 38-41.

Majiol, A. R., Lintangah, W., Ismenyah, M., Alamjuri, R. H., & Jaafar, C. S. Z. (2016b). Mangroves Forest Produce (MFP): Importance and contribution to the local communities at Banggi Island Malaysia using Free Listing Technique. *International*

Journal of Agriculture, Forestry and Plantation, *3*(6), 89-94.

Manjaji-Matsumoto, B. M., Yee, J. C., Watanabe, S., & Tangah, J. (2016). Ichthyofaunal diversity of a rehabilitated tropical mangrove forest reserve in Sabah. *Sepilok Bulletin*, *23-24*, 15-35.

Md. Shah, J., Mohd Hamdan, D. D., & Tair, R. (2018). Penglibatan dan pengupayaan komuniti dalam program penternakan lokan di Kudat, Sabah. *Persatuan Sains Sosial Malaysia/ Malaysia Social Science Association*, Conference Proceeding: The Eleventh International Malaysian Studies Conference (MSCII), pp. 666-681.

Mulla, T. M., & Chavan, N. S. (2016). Socio demographic profile of fishermen communities of the selected mangrove sites from Ratnagiri coast. *International Journal of Fisheries and Aquatic Studies*, *4*(6), 407-412.

Polidoro, B. A., Carpenter, K. E., Collins, L., Duke, N. C., Ellison A. M., Ellison J. C., Farnsworth, E. J., Fernando, E. S., Kathiresan, K., Koedam, N. E., Livingstone, S. R., Miyagi, T., Moore, G. E., Ngoc Nam, V., Ong, J. E., Primavera, J. H., Salmo, S. G., Sanciangco, J. C., Sukardjo, S., Wang, Y., Yong J. W. (2010). The Loss of Species: Mangrove Extinction Risk and Geographic Areas at Global Concern. *PLoS ONE*, *5*(4), e10095.

Ransangan, J., & Soon, T. K. (2018). Occurrence and Distribution of Marsh Clam, Polymesoda spp. in Marudu Bay, Sabah, Malaysia. *Open Journal of Marine Science*, *8*, 314-322.

Ransangan, J., Soon, T. K. & Duisan, L. (2019). Population dynamics of marsh clam, Polymesoda spp. (Bivalvia: Corbiculidae) in Marudu Bay, Malaysia. *AACL Bioflux*, *12*(2), 395-403.

Sechena, R., Liao, S., Lorenzana, R., Nakano, C., Polissar, N., & Fenske, R. (2003). Asian American and Pacific Islander seafood consumption- a community-based study in King County, Washington. *Journal of Exposure Analysis and Environmental Epidemiology*, *13*, 256-266.

Thomas, N., Lucas, R., Bunting, P., Hardy, A., Rosenqvist, A., & Simard, M. (2017). Distribution and drivers of global mangrove forest change. *PLoS ONE, 12*(6), e0179302.