COMPARISON OF *KAPPAPHYCUS STRIATUS* (F. SCHMITZ) DOTY EX P.C. SILVA (RHODOPHYTA, SOLIARICIACEAE) PERFORMANCE IN GRASSY, SANDY AND ROCKY SEABEDS AT PULAU KERINDINGAN, SEMPORNA, SABAH.

Martina Irwan Khoo
Faculty of Agro-based Industry,
Universiti Malaysia Kelantan (Jeli Campus)
Locked bag 100, 17600, Jeli, Kelantan
Email: msirwankhoo@gmail.com

Lee Seong Wei
Faculty of Agro-based Industry,
Universiti Malaysia Kelantan (Jeli Campus)
Locked bag 100, 17600, Jeli, Kelantan
Email: leeseong@umk.edu.my

Ibrahim Che Omar
Faculty of Agro-based Industry,
Universiti Malaysia Kelantan (Jeli Campus)
Locked bag 100, 17600, Jeli, Kelantan
Email: ibrahim@umk.edu.my

Roselina Ahmad Saufi
Faculty of Business and Entrepreneurship
Universiti Malaysia Kelantan (City Campus),
Locked bag 36, 16100, Pengkalan Chepa, Kelantan
Email: roselina@umk.edu.my

ABSTRACT

Kappaphycus striatus was cultivated using the floating line method in three different seabeds, namely grassy, sandy and rocky seabeds in Pulau Kerindingan, Semporna, Sabah. The area around the island is surrounded by different types of substrata which includes mainly seagrass, sandy flats as well as rocky and corally bottoms. This research is carried out to observe the performance of K. striatus in terms of final wet mass and daily growth rate in a period of 21 days. Seedlings of K. striatus weighing 100 g each were tied to nylon cultivation lines at 20 cm apart using thin nylon strings. Each point on the cultivation line has a pair of "tie-tie" that accommodated for two seedlings at each point on the rope. Each rope consisted of 50 points carrying a total of 100 seedlings. The lines were then transferred to the respective plots in the grassy, sandy and rocky seabed areas. The cultivation lines were set 1 m apart from each other. Results obtained from the experiment were analysed using ANOVA and post hoc Tukey test. The cultivated K. striatus in each location were weighed on a weekly basis. The final weight of K. striatus was -50.0±5.00 in grassy seabed, 90.0±10.00 in sandy seabed and 88.3±8.78 in rocky seabed. The daily growth rate in percentage for K. striatus was -4.33±1.890 in grassy seabed, 1.12±2.724 in sandy seabed and 2.41±1.138 in rocky seabed. Based on the results, it was concluded that rocky seabed is the best location for K. striatus cultivation in Pulau Kerindingan, Semporna, Sabah followed by sandy seabed. K. striatus performance in grassy seabed was the poorest in this experiment and observation shows that it is mainly due to high susceptibility to Epiphytic Filamentous Algae (EFA) infestations,ice-ice disease and grazers. Therefore, it was concluded that sandy seabed locations are a suitable alternative to K. striatus sustainable cultivation as an alternative to the common practice to of seaweed cultivation in rocky and corally seabed locations.

Keyword**s**: Kappaphycus striatus, seagrass, seabed, commercial farming, Malaysia

Introduction

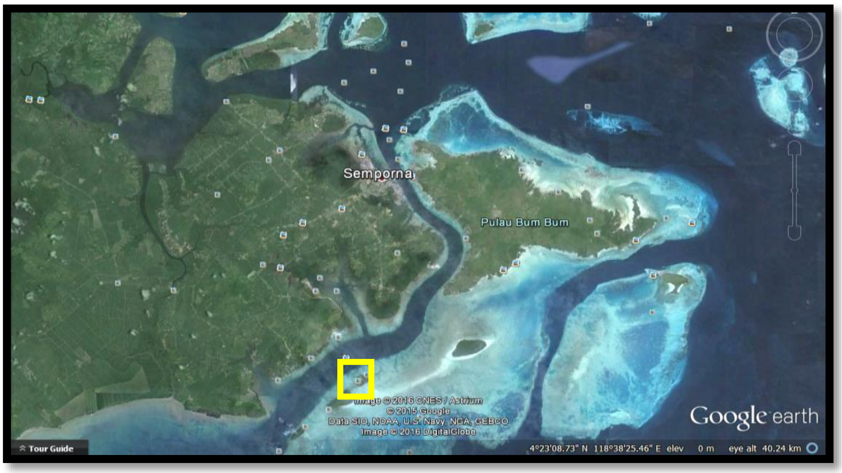
The east coast of Sabah has been known for its richness in marine biodiversity that attracted millions of tourist to the state every year. It is home to some of the most beautiful coral reefs and marine species. Having said that, it is also a suitable location for seaweed cultivation. There have always been a competition between naturally occurring seaweeds with corals for space in the reefs. Now that, seaweeds are being cultivated commercially, they are winning the race. This situation does not bring any positive impact to the ecosystem and the tourism industry of the country. Seaweed farming does not directly alter the physical environment of its cultivation site (Johnstone & Olafsson 1995, Bryceson 2002). Besides that, it is a relatively harmless activity in comparison to other mariculture (Silva, 1992). However, seaweed farming contributes to the change in natural, complex processes and the flora and fauna in its surrounding environment (Olafsson et al., 1995, Bergman et al., 2001, Semesi, 2002, Eklof et al., 2005, 2006a, 2006b). Changes in sedimentation patterns and water movement, erosion, depletion of nutrients and alteration of natural habitat are some of the potential impacts of seaweed farming activities (Silva, 1992). There are three types of environmental impacts of seaweed farming in the tropics, as explained by Zemke- White & Smith (2006) namely, the effects of seaweed introduction to a new location, effects of operation in the seaweed farm and effects of human activities in the seaweed culture. Therefore, it is necessary to find a common ground where both coral reefs and its marine biodiversity can be preserved and commercial seaweed can thrive at the same time.

Seaweed culture was introduced in Malaysia by the local government to the rural fishermen in 1978 through an American company known as Aquatic Resources Limited whose operation centralised in Hawaii. The project was managed entirely by the Department of Fisheries from 1980 until now (Mizpal *et al*, 2015). Since then, many efforts have been done by the governing authorities to improve the seaweed industry including the setting up of the Malaysian National Agro-food Policy (2011-2020) (NAP 4) where seaweed has been identified as one of the high-value commodity under the Entry Point Project 3 (EPP3) of the Agriculture National Key Economic Area (NKEA) (Suhana, 2015). The state of Sabah is one of the main seaweed producers in Malaysia with an area of 12, 895 ha dedicated to seaweed cultivation activities which includes districts in the east coast such as Kunak, Lahad Datu, Tawau and Semporna (Rashilah & Nur Fazliana, 2014). Commercial seaweed varieties that are farmed for carrageenan production in Malaysia belong to the genera *Kappaphycus* Doty and *Eucheuma* J. Agardh (Phang *et al*, 2010). Two varieties of *Kappaphycus* sp. that are commonly cultured in Southeast Asia are *Kappaphycus striatus* (F. Schmitz) Doty ex P.C. Silva and *Kappaphycus alvarezii* (Doty) Doty ex P.C. Silva. The surroundings in which seaweeds are cultivated played an important role in ensuring high productivity and yield. Therefore, the aim of this research is to observe the effects of three types of sea bottoms namely, grassy, sandy and rocky areas on the growth performance of *K. striatus*.

Research design

The experiment was carried out in an area west of Pulau Kerindingan, Semporna (4˚23'48" N and 118˚37'55' E). It is located on the east coast of Sabah where conditions are favourable for seaweed cultivation; sheltered, water salinity range of 30-35 ppm, far from estuary and a wide coral reef area (Ahemad et al., 2004). The average temperature is 26.8˚C with annual precipitation of 2025 mm (climate-data.org, 2016). The experiment began was done in three cycles (September 2014 – May 2015).

Figure 1: Seaweed cultivation sites and other aquaculture activities around the district of Semporna



Source: Google Earth

Seedling selection

K. striatus seedlings that were used in this experiment were purchased from seaweed farm operators in Pulau Sebangkat, Lohok Butun and Sanggaban. Healthy seedlings were selected carefully to maximise the success of propagation in Pulau Keridingan.

Measurement of abiotic factors

Sea water temperature and salinity were measured randomly on a weekly basis. Sea water temperatures were taken 10 cm from the water surface where the *K. striatus* was cultivated. The readings were taken using a mercury thermometer while the salinity was measured using a handheld refractrometer.

Comparison of K. striatus growth in three different sea bottoms (grassy, sandy and rocky areas)

Floating line system was used as the cultivation in this research. A survey done in Semporna district shows that the most common cultivation method is the floating line system (Rashilah et al., 2011). A pair of motherline made of thick nylon ropes with a length of approximately 3 m each, with plastic floaters (3 units on each pair) attached to them was fixed on each end, spaced at a 10-meter interval. The ends of the motherline are tied to four wooden stakes that were driven deep into the seabed.

That is the plot preparation method for the floating line method. Seedlings of *K. striatus* weighing 100g each were tied to the cultivation lines at 20 cm apart using thin nylon ropes (1mm) that are also known as tie-tie. Each point on the cultivation line has a pair of tie-tie that accommodated for two seedlings at one point on the rope. Each rope consisted of 50 tie-tie points carrying a total of 100 seedlings. The ends of *K. striatus* cultivation lines were tied at each end to the motherlines. The cultivation lines were set in rows 1 m apart from each other. Three cultivation lines were used in this experiment as triplicates (Anderson, 2005). The steps above are repeated in three different locations with mainly grassy, sandy and rocky sea bottoms.

Evaluation of sea bottom impact on the growth of K. striatus

K. striatus were weighed on a weekly basis for both floating lines and bottom lime methods. 21 days later, the daily growth rate of *K. striatum* were determined using the formula DGR (% day^{-1}) = 100 x ($\ln(W_f/W_i)/t$), where W_f=final wet weight, W*i*=initial wet weight, and *t*=cultivation days (Hurtado et al., 2001).

Statistical analysis

The differences between the mean of the final weight, daily growth rate and productivity estimation of *K. striatus* were determined using ANOVA and post hoc Tukey test at ($p<0.05$).

Results

Table 1: Mean standard deviation values of the variables subjected to ANOVA to compare *K. striatus* final wet mass (%), daily growth rate (% day^{-1}) in grassy, sandy and rocky sea bottoms at Pulau Kerindingan, Semporna, Sabah from September 2014 to May 2015.

Variable	Grassy sea bottom	Sandy sea bottom	Rocky sea bottom
Final wet mass (%)	-50.0±5.00	90.0±10.00	88.3±8.78
Daily growth rate (DGR) (% day^{-1})	-4.33±1.890	1.12± 2.724	2.41±1.138

Figure 2: Average percentage of seaweed final wet mass of *K. striatus* in a period of 21 days in grassy, sandy and rocky seabeds at Pulau Kerindingan, Semporna.

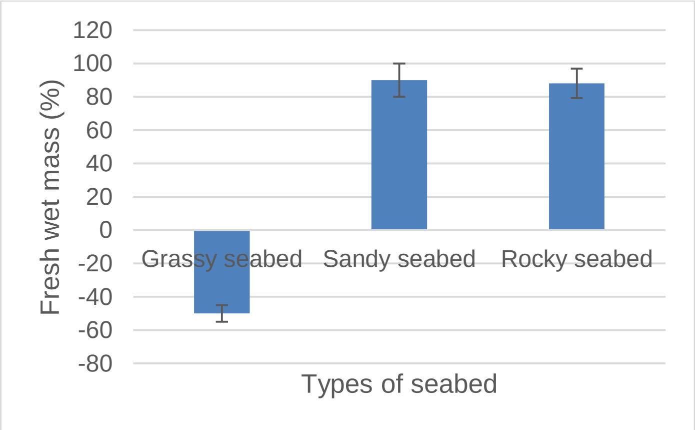
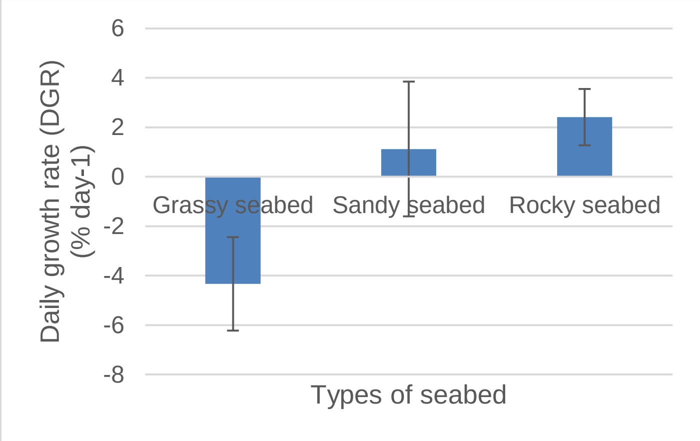


Figure 3: Daily growth rate (DGR) (% day^{-1}) of *K. striatus* in a period of 21 days days in grassy, sandy and rocky seabeds at Pulau Kerindingan, Semporna



The final wet mass (%) and DGR (% day^{-1}) of *K. striatus* cultivated in mainly grassy, sandy and rocky sea bottoms are shown in Table 1. Values in the parenthesis shows (mean±SD). The final weight (%) of *K. striatus* were -50.0±5.00 in grassy sea bottom, 90.0±10.00 in sandy sea bottom and 88.3±8.78 in rocky sea bottom. The DGR (% day^{-1}) for *K. striatus* were -4.33±1.890 in grassy sea bottom, 1.12± 2.724 in sandy sea bottom and 2.41±1.138 in rocky sea bottom. Comparison in terms of final wet mass (%) and DGR (% day^{-1}) of *K. striatus* indicated that there are significant difference between *K. striatus* cultivated in the three different seabeds. The highest final wet mass and DGR was observed in *K. striatus* cultivated in rocky sea bottom followed by *K. striatus* cultivated in sandy sea bottom. The poorest results were shown by *K. striatus* cultivated is grassy sea bottom.

Discussion

There were several reasons why *K. striatus* was selected to be used in this research. A field observation and cultivation carried out by Pang *et al.* (2015) shows that *K. striatus* performs well in intertidal zones where it is exposed to rapidly fluctuating environmental conditions. On the other hand, *K. alvarezii*, another species that was also local in Semporna waters, often succumbed to ice-ice disease in the same location. Seaweed in intertidal zones are subjected to rapid and intense physical and chemical fluctuations, such as UV radiation (UVR), high photosynthetically active radiation (PAR), dehydration, rehydration and changes in salinity (Pang *et al*, 2015). The fact that *K. striatus* are able to withstand these harsh and volatile conditions is proof that the species has developed a certain mechanism for survival in contrast to *K. alvarezii.* These results had prompted for *K. striatus* to be selected as the better specimen for this research because Pulau Kerindingan is surrounded by intertidal lagoon with different types of bottom substrata.

This experiment was carried to observe the effects of different seabeds on the growth of *K. striatus*, namely rocky and corally sea bottom, sandy sea bottom and seagrass covered seabeds. The seaweed cultivated in the corally and rocky sea bottom act as the control for comparison purposes. Sandy and seagrass covered sea bottom acted as alternative location for seaweed cultivation. The abiotic factors were recorded randomly throughout the experiment. It was assumed that the abiotic factors effects on the cultivated *K. striatus* were similar in all the seaweed cultivation locations because they were located in the same place. The substratum in which the seaweeds were cultivated was one of the major factors that determined their growth. Therefore, the parameter that will be focused on in this experiment is the effects of different seabeds on the growth performance of *K. striatus.* Based on the results obtained, it was evident that *K. striatus* cultivated in the corally sea bottom has the highest final wet mass (88.3±8.78) % and highest daily growth rate at (2.41±1.138) % day^{-1}. This comes as no surprise as coral reefs provide a conducive environment for seaweed growth. The final wet mass of *K. striatus* in sandy seabed is (90.0±10.00) % and its daily growth rate is (1.12± 2.724) % day^{-1}, coming in second place after *K. striatus* cultivated in corally sea bottom. The poorest growth performance was shown by *K. striatus* cultivated in seagrass covered sea bottoms with final wet mass of (-50.0±5.00) % and daily growth rate of -4.33±1.890 % day^{-1}. This observations showed that seagrass cover had a negative significant impact on the growth of *K. striatus* may be due to high competition of abiotic factors. K. striatus also observed to have higher susceptibility to ice-ice disease and epiphytic filamentous algae (EFA) and grazers in comparison to *K. striatus* cultured in other seabeds.

Competition for Abiotic factors

The growth of *K. striatus* in seagrass seabeds appeared to be stunted in comparison to *K. striatus* cultivated in other seabeds. This may be due to the competition for abiotic factors between *K. striatus* and seagrass*.* A study was done by Mtolera (2003) showed that seaweed cultivation on the substratum covered with seagrass reduced their growth due to the competition between farmed seaweed and the seagrass for nutrients and space. The relationship was further proven by a study done by Eklof et al. (2004) that seagrass shoot density, biomass cover and canopy were in most cases lower in seaweed farm sites than in undisturbed seagrass beds in Zanzibar. In Semporna, the common practice would be to leave the seagrass beds undisturbed when seaweed cultivation activities were carried out. The uprooting of seagrasses were only done where seagrass cover is not dense because the removal of seagrasses require a lot of time and energy, besides the operational cost that is hardly affordable by the local farmers. The physical contact between *K. striatus* and seagrasses beneath during low tides also leads to breakage of the macroalgae that lowers productivity of harvest for farmers.

Ice-ice Disease

The low final wet mass and daily growth rate of *K. striatus* was also contributed by ice-ice disease. This is a condition where infected parts of *K. striatus* thalli experienced discolouration and hardening that gradually led to breakage or disintegration. It was observed in the Philippines that *Eucheuma* sp. cultivated over seagrass beds are highly susceptible to ice-ice disease. It is a non-infectious disease that are triggered by unfavourable environmental condition such as extreme temperature, irradiance, salinity and opportunistic bacterial pathogens, *Vibrio* sp. (P11) and *Cytophaga* sp. (P25) (Largo et al., 1999). It was evident here that both abiotic and biotic factors contribute to the whitening phenomenon. In the present research, *K. striatus* had to compete with seagrasses for basic requirements such as light and nutrients. This leads to environmental stress for *K. striatus* that often causes ice-ice disease. Seaweed emits a moist organic substance when under stress that attracts bacteria in seawater that leads to the "bleaching" and hardening of seaweed thalli. Infected parts experience depigmentation leading to breakage by environmental forces while healthy parts remain unaffected (Tisera & Naguit, 2009). In a research by Largo et al. (1995), a total of 135 bacterial strains were isolated from 16 samples of *Kappaphycus alvarezii* and *Eucheuma denticulatum*, including isolates from surrounding vegetation consisting of *Sargassum* sp. and *Thalassia hemprichii*, and seawater samples for comparison, were collected from a seaweed farm in the Philippines. The bacteria population in infected branches were found to be 10 to a 100 times greater than heathy thalli. Gram-positive bacteria predominated in almost all branches, but with an increasing proportion of agar-lysing bacteria in ice-iced branches. The agar-lysing pathogens were identified as Cytophaga-Flavobacterium complex and the Vibrio group characterised by yellow and non-pigmented, spreading colonies. The weakening of algae parts due to environmental stress led to the build-up of lytic bacterial cells of vibrios and cytophagas, which are ever present in the natural seawater, on algal surface hence the development of ice-ice disease. The case may be similar to the red algae, K. striatus that was used in the current research in Pulau Kerindingan.

Epiphytic Filamentous Algae (EFA) Infestations

The presence of EFA was evident in *K. striatus* throughout the cultivation period in all three substrata at Pulau Kerindingan. EFA consist of various species of filamentous algae that attach themselves to the cortical layer of the host thalli, leaving the *K. alvarezii* poorly branched, rough and stunted. In a research done by Vairappan et al., (2006) has identified the causative organism to be *Neosiphonia apiculata* (Hollenberg) Masuda et Kogame. Indication of embedded tetrasporeling in seaweed cortex layer is the presence of black spots. Infected seaweed appeared to be "hairy" with "goose bumps" like cortical swellings upon maturation. Dark pits were evident on the cortical swelling at the end of the infection. This was when opportunistic bacteria started invading the infected seaweed. They are mainly *Alteromonas* sp., *Flavobacterium* sp. and *Vibrio* sp. Another species of epiphyte recorded in Kudat, Sabah in 2003 was *Neosiphonia savatieri*. However, there were two prominent differences; the absence of "goose bumps" and black spots at the end of the infection. Epiphyte outbreak has been a major problem in carrageenophyte-producing countries in the Philippines, Indonesia, Malaysia and Tanzania. The epidemic was caused by drastic fluctuations in seawater salinity, temperature and nutrient levels (Hurtado et al., 2006, Vairappan et al., 2006). EFA infestations can also affect photosynthetic behaviour in seaweed. A study was carried out on *K. alvarezii* in China that was infected by *N. savatieri*. The results showed damage of oxygen-evolving complex (OEC), decreased of active reaction centers (RCs) and plastiquinone (PQ) pool as well as significant reduction in the performance indexes (PI) of PS II. Photochemical reactions were not the only impacts of epiphytes. Light intensity of less than 50μmol photon m^{-2} cause decay of *K. alvarezii*. The seaweed were shielded by *N. savatieri* on the outer surface preventing it from getting enough light. *K. alvarezii* and *N. savatieri* are Rhodophytes therefore possess similar photosynthetic pigments hence the intense competition for light absorption (Pang et al, 2011).

Predation by Grazers

K. striatus were also preyed on by grazers during the culture period. Two species that appeared to be common in Pulau Kerindingan area are *Cetoscarus bicolour* (parrot fish) and *Siganus javus* (rabbit fish) (Nelsh & SuriaLink, 2003). Farmers had reported that these fishes preferred to graze on young and soft branches. They tend to nip on the buds of the young thallus. These observations were also supported by Russell, (1983) and Uy et al. (1998). The location of seaweed farm played an important role in determining the presence or absence of grazers. Seagrass beds and other areas where marine herbivores populations were endemic faced a higher chance of having problems involving grazers. Herbivores may also be introduced during the transport of seedlings from one farm to another. There were also cases where schools of fish passed through farms during certain seasons or life cycle stages (Nelsh & SuriaLink, 2003).

Conclusion

Based on the results obtained in this research, it can be concluded that sandy seabed is a suitable location for *K. striatus* cultivation as an alternative to rocky and coraly seabed. Seagrass seabed is discovered to be unconducive for *K. striatus* propagation due to high susceptibility to ice-ice disease, EFA infestations and predation by grazers. The *K. striatus* in rocky and sandy seabeds are also affected the mentioned conditions but at lower levels in comparison to grassy seabed. This problem can be avoided by proper management practices and the usage of good quality seedlings. Location of *K. striatus* cultivation also should be changed after several cycles for the replenishment of nutrient at the site. More research is required to figure out the best alternative to improve the seaweed cultivation industry with better and more sustainable methods and farm management practices to overcome the problems that has been discussed in this paper.

References

Ahemad, S., Ismail, A., Mohammad Raduan, M.A. (2004). The Seaweed Industry in Sabah, East Malaysia. Asian Fisheries Forum, Penang, Malaysia.

Anderson, R. A., (2005). Algal Culturing Techniques. Elsevier Academic Press pp. 227-229.

Ask, E. (1999) Cottonii and Spinosum Cultivaion Handbook, FMC Food Ingredients Division, Philadelphia, Pa, USA

Bergman, K.C., Svensson, S., Ohman, M.C. (2001). Influence of Algal Farming on Fish Assemblages.Marine Pollution Bulletin Vol. 42:12, pp 1379-1389

Bryceson, I. (2002) Coastal aquaculture developments in Tanzania: sustainable and non-sustainable experiences. Western Indian OceanJournal of Marine Science Science, Vol. 1:1, pp 1-10

Climate-data.org. Accessed date: (4/2/16)

de Goes, H.G., Reis, R.P. (2011). Temporal variation of the growth, carrageenan yield and quality of Kappaphycus alvarezii (Rhodophyta, Gigartinales) cultivated at Sepetiba bay, southeastern Brazilian Coast. Journal of Applied Phycology (2012) 24:173-180

Eklof, J.S., de la Torro Castro, M., Adelskold, L., Jiddawi, N.S., Kautsky, N. (2004) Differences in macrofaunal and seagrass assemblages in seagrass beds with and without seaweed farms. Estuarine, Coastal and Shelf Science 63: 385-396

Eklof, J.S., Henriksson, R., Kautsky, N. (2006) Effects of tropical open-water seaweed farming on seagrass ecosystem structure and function. Marine ecology progress series 325: 73-84

Hurtado, A. Q., Critchley, A.T., Trespoey, A., Bleicher-Lhonneur, G. (2008). Growth and carrageenan quality Of *Kappaphycus striatum* var. *Sacol* grown at different stocking densities, duration of culture and depth. Journal of Applied Phycology (2008) 20:551-555.

Hurtado, A.Q., Critchley, A.T., Trespoey, A., Lhonneur, G.B. (2006) Occurrence of Polysiphonia epiphytes in Kappaphycus farms at Calaguas Island, Camarines Norte Philipppines. Journal of Applied Phycology 18: 301-306

Largo, D.B., Fukami, K., Nishijima, T. (1995) Occasional pathogenic bacteria promoting carrageenan-producing red algae *Kappaphycus alvarezii* and *Eucheuma denticulatum* (Soliaricieae, Gigartinales, Rhodophyta). Journal of Appplied Phycology 7: 545-554

Mizpal, A., Rosazman, H., Suhaimi, M. Y., Ahmad Tarmizi, A.R. (2015). Projek Mini Estet Rumpai Laut dan Penglibatan Komuniti Nelayan di Daerah Semporna, Sabah. Journal of Borneo Transformation Studies (JOBSTS), Vol. 1. No. 1 Universiti Malaysia Sabah.

Mtolera, F.E., Ngule, M.A.K., Shunula, J.P. (1996) Effect of seagrass cover and mineral content on Kappaphycus and Eucheuma productivity in Zanzibar. Western Indian Ocean Journal od Marine Science 2: 163-170

Nelsh, I.C. & Surialink.com (2003) The ABC of Eucheuma seaplant production: Agronomy, biology and crop-handling of Betaphycus, Eucheuma and Kappaphycus the Gelatinae, Spinosum and Cottonii Of commerce. SuriaLink Infomedia

Olafsson, E., Johnstone, R.W., Ndaro, S.G.M. (1995) Effects of intensive seaweed farming on the meiobenthos in a tropical lagoon. Journal of Experimental Marine Biology and Ecology 191: 101-117

Pang, T., Liu, J.G., Liu, Q., Lin, W. (2011) Changes of photosynthetic behaviours in Kappaphycus alvarezii infected by epiphyte. Evidence-based Complementary and Alternative Medicine, Volume 2011, Hindawi Publishing Cooperation

Pang, T., Zhang, L.T., Liu, J. G., Li, H., Li, J.P. (2015) Differences in Photosynthetic behaviour of *Kappaphyucs alvarezii* and *Kappaphycus striatus* during dehydration and rehydration. Marine Biology Research Vol. 11 (7): 765-772.

Phang, S. M., Yeong, H.Y., Phaik, E. L., Adibi Rahiman, M. N., Kian, T. G. (2010). Commercial varieties of Kappaphycus and Eucheuma in Malaysia. Malaysian Journal of Science 29 (3): 214-224

Rashilah, M., Muhamad Faireal, A., Jamaluddin, K., Nor Azlina, S. (2011). Pengenalan kepada Penternakan Rumpai Laut di Sabah. Economic and Technology Review, Vol. 6: 59-65

Rashilah, M., Nur Fazliana, M. N. (2014). Ekonomi Penternakan Rumpai Laut di Sabah, Vol. 9a (2014): 11-17

Russell, D. J. (1983). Ecology of the imported red seaweed Eucheuma striatum Schmitz on Coconut Island, Oahu, Hawaii. Pac. Sci. 37, pp 87-108.

Semesi, S. (2002). Ecological and socio-economic impacts from *Eucheuma* seaweeds in Zanzibar, Tanzania. *Noragric, Agricultural University of Norway, Aas, Norway*.

Silva, P. C., & DeCew, T. C. (1992). Ahnfeltiopsis, a new genus in the *Phyllophoraceae* (Gigartinales, Rhodophyceae). *Phycologia*, *31*(6), 576-580.

Suhana, S. (2015). Prospects and Policy of Seaweed as a High-Value Commodity in Malaysia. Malaysian Agricultural Research and Development Institute (MARDI)

Tisera, W.L., Naguit, M.R.A (2009) Ice-ice disease occurrence in seaweed farms in Bais Bay, Negros Oriental and Zamboanga del Norte. The Threshold, Vol 4

Uy, W. H., Azanza, R. V., Martinez-Goss, M., Israel, A. (1998). *Kappaphycus* fish interaction studies. XVIth International Seaweed Symposium: Abstracts, Programs and Directory. Abstract, Cebu City, Philippines, pp. 62.

Vairappan, C.S. (2006) Seasonal occurences of epiphytic algae on the commercially cultivated red algae Kappaphycus alvarezii (Soliericeae, Gigartinales, Rhodophyta). Journal of Applied Phycology 18: 611-617

Zemke-White, W.L. and Smith, J.E. (2006) Environmental Impacts of Eucheuma spp.Farming. In: Critchley, A.T., Ohno, M. and Largo, D.B., Eds., World Seaweed Resources, Degussa, Amsterdam.