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Diseases and Pest Encountered on Seaweeds *Eucheuma-Kappaphycus* Production in the Selected Municipalities in the Province of Palawan, Philippines

EDGARDO C. ZABALA, JR.
ORCID NO. 0000-0002-3851-8708
edzabjr@yahoo.com
Office of the Provincial Agriculturist, Fisheries and
Aquatic Resources Management Division
Palawan, Philippines

MARIA MOJENA GONZALES-PLASUS
ORCID NO. 0000-0003-4556-4056
mojenagonzales@yahoo.com
Western Philippines University
Aborlan, Palawan, Philippines

ABSTRACT

There is a continuous decrease in seaweed production as reflected in the annual seaweed production of the Province of Palawan which were attributed to the occurrence of diseases and pests in the seaweed farms. To monitor the number of diseases and pest present in seaweed farms in Palawan, a total of 13 selected municipalities in the province of Palawan that engage in seaweeds farming were monitored from any presence of diseases and pest from 2003 to 2018. Based on the result, a total of six diseases and one problem were identified to be present in the seaweed farms in the selected municipalities in Palawan. The ice-ice disease had highest frequency of occurrence followed by the epiphytes, tip discoloration, sudden whitening of the planted seaweeds, sedimentation, pitting and grazing respectively. Ice-ice disease caused thallus breakage results in the decrease of volume to be harvested by the farmers coupled with the slow growth rate of the plant thus regularly forces seaweed farmers to stop planting for months. Several mitigation strategies were already applied in the seaweed farms by the affected municipalities in Palawan but still, some diseases and pests arise from time to time.

Keywords: Culture, ice-ice, epiphytes, stress, mitigation

INTRODUCTION

The Philippine seaweed industry mainly depends on *Kappaphycus* and *Eucheuma* species (Ronquillo and Gabral-Llana, 1989). Palawan is an island province with so many potential areas for seaweed *Eucheuma-Kappaphycus* farming. The coastal area, thriving with wild stocks of seaweed, is strong evidence that seaweed farming is suitable in most parts of the province. Trono et al. (2000) categorized seaweed farming as the most productive form of livelihood among coastal communities in the Philippines. The province of Palawan is consistently the number one producer of raw seaweeds in the country for many years up to the present (Philippine Statistical Authority, 2019). The major producing seaweed *Eucheuma-Kappaphycus* municipalities in the province of Palawan were classified into three based on the seasonality of production: Class A, which produces seaweeds year-round – this includes Agutaya, Cuyo Island (Cuyo and Magsaysay), Cagayancillo, Balabac, and Calamianes Group of Island; Class B, which produces seaweeds year-round but need to transfer from one area to another - Dumaran, Roxas and Taytay; and Class C, which utilized seasonal planting strategies- El Nido, San Vicente, Aborlan, Narra, Bataraza, Rizal and Quezon (Mundo et al., 2002).

Seaweed farming has become the most important means of livelihood among coastal and island communities due to the increased demand for carrageenophytes raw material and the opportunities to earn higher income (Simbajon and Ricohermoso, 2001). These red seaweeds, locally known as "guso, tambalang, or agar-agar", are grown to produce a whitish powdery extract called carrageenan. The extract is used extensively for gelling, thickening, binding, and stabilizing agents in cosmetics, pharmaceuticals, industrial products, and convenience foods such as ice cream, cakes, juices, processed meats, and jellies (Hindley, 1999). The species have been renamed according to the type of carrageenan they produced. *Kappaphycus* produces kappa-carrageenan, while *Eucheuma* produces iota, beta, or other carrageenans (Doty, 1988). Iota is a soft gelling carrageenan which limited use and low value in contrast to the hard-gelling kappa-carrageenan, which has a wide variety of uses and a high demand (Hindley, 1999).

In the Philippines, the losses of eucheumatoid stocks because of diseases and pests have resulted in a 15 % reduction in production yields, which is equivalent to almost $100 million annually (Cottier-Cook et al., 2016). In the province of

Palawan, the production of seaweeds is continuously decreasing for almost five years now, as reflected in the annual seaweed production (Philippine Statistical Authority, 2019).

Seaweed diseases continue to affect the plant's normal structure and function by altering its growth rate, appearance or decreased its economic importance (Andrews, 1976). On the other hand, Roces (2002) classified health problems affecting seaweeds as environmental and pathogenic. Environmental problems were caused by adverse environmental factors such as irradiance, turbidity fluctuations, high salinity, low oxygen, high pH, less than ideal temperatures, nutritional deficiency, pollution, and, epiphytes while pathogenic diseases are caused by pathogens like bacteria and fungi (Roces, 2002).

The ice–ice disease and epiphyte infestations that have resulted in diminishing culture stocks and reduced carrageenan quality, which in turn leads to low market value, loss of income, and loss of job opportunities, particularly for marginal seaweed farmers, were the most common disease affecting the seaweed industry in the Philippines (Ward et al., 2019). No report has been published on the long-term observation on the number of diseases present and frequency of occurrence of diseases in seaweeds in the different municipalities in the province of Palawan.

OBJECTIVES OF THE STUDY

This study aimed to identify and monitor the existing diseases and pest of seaweed *Eucheuma-Kappaphycus*. Specifically, it aimed to: a) monitor the month in a year where diseases and pest usually appears; b) identify the most frequently occurring diseases and pest, and c) suggests possible treatments and mitigation strategies to avoid or minimize these diseases. The result of this study contributes to the knowledge in assessing the current status of the seaweeds industry in Palawan.

MATERIALS AND METHODS

The data collection was conducted through ocular field monitoring at Green Island, Agutaya, Magsaysay, Roxas, Taytay, El Nido, Dumaran, Araceli, Coron, Culion, Balabac, Narra, and Quezon on the selected month from 2003 to 2018 (Figure 1). The selected municipalities represent the three classes of seaweeds seasonality production in Palawan. We added Green Island and Araceli as sampling sites because, based on our initial data, these sites also contribute to the

production of seaweeds in Palawan.

Photo documentation on the area where seaweed farms were located and the affected seaweeds was taken as part of this study. The observation and recordings were conducted within the culture period of seaweeds in each area.

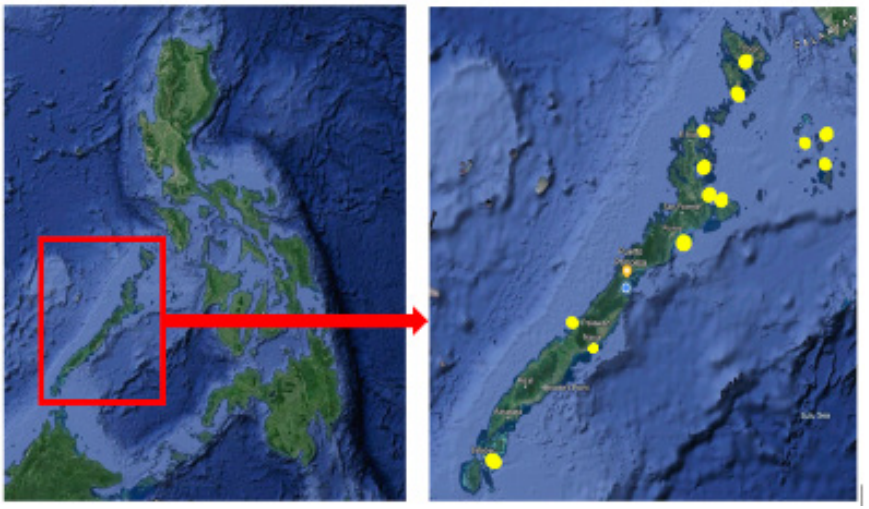

Figure 1. The study site in Palawan (with yellow markings on the map).

On the initial visit to the site, the proponent identified factors including the number of diseases present in the areas, the month when the disease was observed, the characteristics of the affected seagrass, and the frequency of occurrence of disease in the area (Table 1; Figure 2). Also, an informal interview with the seaweeds farmer was conducted to gather more information on the knowledge and insights of the farmers regarding the effect of the disease in their culture.

The frequency of occurrence (%) of disease was determined using the formula of point prevalence adopted from Noordzij et al. (2010). To compute the frequency occurrence, the number of municipalities with the present disease at one point in time was divided by the total number of the municipality at one point in time.

RESULTS AND DISCUSSION

Based on the result, six diseases and one problem were identified to be present in the seaweed farms. Ice-ice is the major problem in all the planting areas of seaweeds in the selected municipalities in the province of Palawan with 92.31% frequency of occurrence followed by epiphytes (84.62%), tip discoloration (76.92%), sedimentation (23.08%), sudden whitening of planted seaweeds (23.08%) and grazing (23.08%) respectively (Table 1; Figure 2).

The ice-ice disease caused thallus breakage that decreased the volume to be harvested by the seaweed farmer. Infected seaweeds also exhibit a slow growth rate of the plant, thus regularly forces seaweed farmers to stop planting for months. The occurrence of ice-ice disease was previously reported in Bohol, Batangas, Iloilo, Zamboanga Peninsula, and Negros Oriental (Largo, 2002; Tisera & Naguit, 2009).

The early signs of ice-ice include slow growth rate accompanied by paling and loss of glow of thalli followed by roughening of the surface of the branches (Trono, 1993). Hurtado and Agbayani (2000) noted that this disease could also be caused by low salinity, high temperature, and strong light intensity. The ice-ice disease could also be triggered by bacteria if there is a slow movement of water in the cultivation ground; invasion of some pathogens, especially those bacteria that are highly motile and can easily invade seaweed surfaces; if the cultivation ground is near freshwater sources, such as rivers or creeks the salinity of seawater reduces creating a stressful environment for seaweeds (Collen et al., 1995; Tisera & Naguit, 2009). All those mentioned above explain why ice-ice disease in the selected municipalities of Palawan usually appears during summertime and the situation with long dry spell and sudden pour of rain which in turn affects the salinity of the water, making the seaweeds culture vulnerable and exposed to the ice-ice disease.

Initial report on the ice-ice disease in *Eucheuma* and *Gracilaria* farms suggests that this disease was caused by the interplay of various ecological factors with the physiological state of the alga and that no specific bacteria have been found associated with the disease (Pedersen et al., 1996). However, Largo et al. (1995) have discovered occasional pathogenic bacteria promoting ice-ice disease; these were *Cytophage sp.* and *Vibrio sp.* Largo et al. (1999), in their follow-up study, found out that these two ice-ice promoters have different intensities of infection. *Vibrio sp.* promotes the disease much faster and has a high affinity for the seaweed, especially when stressed. The more stressed the thalli, the faster the buildup

of bacteria (Collen et al., 1995; Largo et al., 1999). *Kappaphycus alvarezii* and *Eucheuma denticulatum* showed different resistance to ice-ice disease, according to time (month), strain and location, and differences in carrageenan types and genetic makeup further explained the higher susceptibility of *K. alvarezii* relative to *E. denticulatum*. *Eucheuma denticulatum* was more resistant and less susceptible to ice-ice (Tisera & Naguit, 2009).

Therefore, it is advised to culture resistant species and varieties of seaweed *Kappaphycus* and *Eucheuma* during the season where ice-ice is dominant (summertime, March to May). It is further advised to avoid using plants already exhibiting ice-ice as propagules or planting materials and instead plant only healthy plants without any trace of diseases. New plantlets of seaweeds that are produced from seaweed laboratories should also be used. There is a need to establish a seaweed laboratory in the province is also recommended for the steady supply of seaweeds in the province. Besides, the method of farming also contributes to the occurrence of ice-ice. The floating method with better buoyancy usually experiences less ice-ice occurrence relative to fixed bottom monoline or without the use of any floatation device/materials. Further, make sure that the planting site must be far from freshwater sources.

There is a report that ice-ice disease enhances the attachment and growth of epiphytes and the accumulation of silt. Ultimately, white sores appear on the surfaces of the branches where the tissue softens and dissolve away, causing the breakage of the thallus from the plant (Trono, 1993). This was also observed in the present study wherein after identifying the occurrence of ice-ice, we also notice the growth of epiphytes on the seaweeds culture.

The growth of *Kappaphycus* and *Eucheuma* was reported to be adversely affected by the bloom of epiphytes and associated weed species from January to May (Trono, 1993). Epiphytes refer to organisms, small or large, that colonize the surfaces of seaweeds (Tisera & Naguit, 2009). Factors such as light, temperature, currents, nutrients, and trophic interactions influenced the settlement of epiphytes species (Largo, 2002). Among the epiphytes, the outbreaks of *Polysiphonia* have caused massive declines in *K. alvarezii* production in the Philippines (Hurtado & Critchley, 2006). This disease was also reported to be present in Calaguas Island, Camarines Norte (Largo, 2002; Hurtado & Critchley, 2006).

Usual algae epiphytes conspicuous at different seaweed farms in the selected municipalities in the province of Palawan were *Ulva reticulata*, *Sargassum sp.*, *Acanthopora sp.*, *Hydroclathrus tenuis*, *Padina sp.*, and the filamentous red algae (*Polysiphonia sp.*) (Table 1; Figure 2). Among all epiphytes, the seaweed

farmers' fear most was the red filamentous algae. This epiphyte is locally known in the different seaweed-producing municipalities of the province as "bulbol," "balahibo," or "siring." Based on our informal interview, seaweed farmers usually experienced higher profit loss when *Polysiphonia sp.* is present in their farms compared to when other epiphytes are present in their farms.

It was observed that this red filamentous algal, when detached from thalli, produced a hole. Then the *Polysiphonia sp.* penetrates the thallus of the host plant giving goosebumps appearance to the thali surface. After a few days, small red filamentous algae with hairy structures will evolve from these convex and grow and increase in number quickly. In the long run, the cultured seaweed is damaged and sometimes causing death (Largo, 2002). An increased in the level of epiphytes can block sunlight or affect nutrients uptakes; thus, high abundance of epiphytes is considered detrimental to the plants they grow on often causing damage or death of the seaweeds.

Growth of epiphytes on the selected municipalities in Palawan is very imminent at the onset of summer until summertime which falls from March to May and sometimes even the early month of February. During this time, extra effort to clean the plant from other seaweed is needed in the case of macro epiphytes like *Sargassum*, *Ulva*, and the likes. However, for micro epiphytes like "siring," more than extra effort is needed. Seaweed farmers must ensure the culture seaweed propagules that are free from this kind of epiphyte and plant it in areas where the occurrence of the said epiphyte is absent. The proper distancing of plants (not less than 1 foot) from each other will also minimize the occurrence of epiphytes. Overcrowding of plants also promotes the occurrence of this epiphyte, as observed in the field during the summer season. The cultivation site should have strong water current to minimize the occurrence of "siring." It is also advised to let the area with the occurrence of "siring" be rested for even just one planting season and find another place/area to plant seaweed. Farming in deeper waters also helps in minimizing this kind of health problem.

Figure 2. Actual site during the harvest of seaweeds (Photo A - Green Island; photo B - seaweed farm in Green island; Photo C - harvested seaweeds; Photo D - seaweeds with ice-ice and epiphytes; E - seaweeds with ice-ice). Photo credits to Mr. Nerben Salazar.

Problems in tip discoloration are characterized by a change in color towards pinkness, then tips eventually soften, discolor further, become white and dissolve away (Doty, 1986). Hurtado and Agbayani (2000) noted that this health problem was due to aerial exposure and intolerance to warm water. The affected part of the thallus of the planted seaweeds was usually the tip portion of the plant protruding above the seawater level and exposed to wind and sunlight (Southeast Asian Fisheries Development Center-Aquaculture Department, 1999).

Of all the diseases mentioned in this paper, tip discoloration is the most controllable problem. Seaweed farmers will need to ensure that no parts of the planted seaweeds are exposed above the seawater surface. The usual farming method where this kind of health problem occurs is with the use of bamboo poles as a floatation device.

Sudden Whitening of the planted seaweeds is rarely experienced now a day but usually a major health problem in the late 1990s. Sudden whitening of the planted seaweeds is immediately noticeable for just an overnight period. The cultured seaweed can suddenly change in color to a whitish appearance, followed

by general decay through the softening of all tissues of the healthy plants. As experienced, this occurs when someone used an obnoxious substance or cyanide within the vicinity of an existing seaweed farm. Illegal fishing activities such as the use of explosive and obnoxious substances must be absent in the area. These illegal fishing activities must be controlled; if not, it will be an epidemic to seaweed farm/s. Seaweed farmers must be vigilant in safeguarding their areas so that these activities be avoided in their area.

The sedimentation, pitting, and grazing in cultured seaweeds had a similar percentage of occurrence, which is 23.08% and was present in the Northern and Southern municipalities of Palawan. Although the frequency of occurrence of these diseases and pests was lower than other diseases mentioned above, these diseases and pest problems should be monitored closely because reports on the increasing incidence of these problems in the Philippines were already reported (SEAFDEC-AQD, 1999).

The sedimentation or locally known as "cemento-cemento" health problem, is usually experienced during July, August, and December when the southwest wind blows. Sedimentation in Green island, Roxas, and Araceli result from the accumulation of silt or sediments to the thallus of seaweeds being cultured brought about the prevailing wind during these months. The accumulated sediments in the seaweeds eventually harden and affect the photosynthetic activity, and hamper the growth of the seaweeds. When the harvested seaweeds affected by this health problem were dried, the sediment or silt will contribute to the whitish appearance of the dried seaweed affecting its quality and price.

To avoid sedimentation problems, site selection is very important. Further, regular visitation and cleaning of planted seaweed by shaking the lines are needed. The addition of floating devices/materials to the mainline will also help since it will make the lines more buoyant and wobbly.

Pitting is seldomly observed in the monitored farms in Palawan but occurs occasionally. Pitting of seaweeds was observed in the North of Palawan, specifically in Roxas and Taytay, and in the south of Palawan in Balabac. Pitting is characterized by the formation of a cavity in the thallus of the plant penetrating the cortex in one place and expanding in the medullary regions beneath that that leads to thallus breakage (Doty, 1986). It is believed caused by bacteria and usually observed in areas with a limited flow of water current. To avoid this kind of problem, ensure that the planting sites have the desired water movement. The ideal water movement or current in a seaweed farm is 20-40meter/minute (Hurtado & Agbayani, 2000). The use of healthy seaweed propagules is also

advised.

The grazing of marine animals in seaweed farms is inevitable but a seasonal problem. Seaweed farms located near rocky or coral reefs were reported to be prone to grazing activity of marine organisms (Roces, 2002; Simbajon & Ricohermoso, 2001). This is because these organism, used the area as shelter hence loss of production of seaweeds is more vulnerable and eminent in these types of culture area. Macro grazers observed and reported siganids, wrasses, triggerfishes, and marine turtles.

Prominent grazing activities usually observed in the farms were bites of small fishes at the tips of the thallus and the frenzied feeding of marine turtles. Grazing by fishes is especially destructive to the seaweeds if a big school attack (Doty, 1986). The latter is the most destructive grazing activity in seaweed farms and very prominent in the municipalities of Balabac, El Nido, and Araceli from 2003 to 2018.

In areas where macro grazing is a problem, especially of marine turtles, the use of the basket method in farming will help a lot. Though it will entail additional cost to the farmer, the cultured seaweed will be protected as well as the endangered species. This kind of farming is the one currently used by the Provincial Government of Palawan in their seaweed nursery at El Nido, Palawan.

Table 1

Summary of disease and pest present on the selected municipalities in the province of Palawan

Disease/ pest	Location	Month/ years observed	Frequency of occurrence (%)	Characteristics (source)	Cause
Ice-Ice	Provincewide	March - December	92.31	Paling and loss of glow of thalli followed by roughening of the surface of the branches (Trono 1993)	*Cytophage sp.* and *Vibrio sp.* (Largo et al. 1999)

Table 1 continued.

Disease/ pest	Location	Month/ years observed	Frequency of occurrence (%)	Characteristics (source)	Cause
Epiphytes ("siring")	Provincewide	February – May	84.62	Presence of small red filamentous algae with hairy structure will evolve from the thallus and grow and increase in number quickly	*Polysiphonia* sp. (Critchley et al. 2004) *Ulva reticulata*, *Sargassum* sp., *Acanthopora sp.*, *Hydroclathrus tenuis*, *Padina* sp. (based on the present study)
Tip discoloration	Provincewide	March-May	76.92	Usually, a color change towards pinkness and eventually the tips soften, discolor further, become white and dissolve away (Doty 1986)	Aerial exposure and intolerance to warm water (Hurtado and Agbayani 2000)
Sudden Whitening of the Planted Seaweeds	Balabac, Roxas, Taytay, and Narra, Kumaran	During rainy season or when there is an illegal fishing activity using cyanide in nearby farms	38.46	Sudden change in color to whitish appearance followed by general decay through softening of all tissues(Doty 1986)	The intrusion of freshwater or use of obnoxious substance or cyanide within the vicinity of an existing seaweed farm

Table 1 continued.

Disease/ pest	Location	Month/ years observed	Frequency of occurrence (%)	Characteristics (source)	Cause
Sedimentation ("Cemento-cemento")	Green Island, Roxas, and Araceli	July, August, and December	23.08	The cemented appearance of seaweeds	Accumulation of silt or sediments
Pitting	Roxas, Taytay, and Balabac	April-May	23.08	Formation of a cavity in the thallus of the plant penetrating the cortex in one place and expanding in the medullary regions beneath that may lead to thallus breakage (Doty 1986)	Is believed caused by bacteria and usually observed in areas with the limited flow of water current (Doty 1986).
Grazing of Fish and other marine life	Balabac, El Nido, and Araceli	Summer season	23.08	Presence of bites usually on the tips of the thallus of the seaweed	Grazing of siganids, wrasses, triggerfishes, and marine turtles

CONCLUSIONS

This study was able to identify the number and frequency of seaweed diseases present in the selected municipalities in the province of Palawan. A total of six diseases (ice-ice, epiphytes, sedimentation, tip discoloration, pitting, and sudden whitening of planted seaweeds) and one problem (grazing of fish and other marine life) were identified to be present in seaweed farms in the selected municipalities in the province of Palawan from 2003 to 2018. Among these diseases and problems, the ice-ice disease was the frequently occurring disease in all sampling sites in this study. To eliminate or mitigate the impact and spread of disease and pest on seaweed aquaculture, several mitigation strategies were already applied by the affected

municipalities in Palawan but still, some diseases and pest arise from time to time. Hence, it is important that the farmers must have enough knowledge and a basic understanding of the onset and occurrence of diseases and pest on their seaweeds culture to mitigate the effect of these diseases and pest.

RECOMMENDATIONS

To improve the monitoring and data gathering of this kind of study, it is recommended that details such as monitoring of physicochemical parameters, survey the substrate or benthic composition, and monitoring the growth of the propagules is recommended. Further, technical assistance from the government should be given to the seaweed farmers during the culture period of seaweeds to impart knowledge and help seaweeds farmers mitigate the effect of disease and best in their culture.

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