Occurrence and habit of shore crab (*Varuna litterata*) rafting on seaweed floaters in Camarines, Norte, Philippines

Darwin C. Biag, Sheena F. Furio

Institute of Fisheries and Marine Sciences, Camarines Norte State College, Mercedes Campus, San Roque, Mercedes Camarines Norte, Philippines, 4601. Corresponding author: D. C. Biag, darwin.biag@gmail.com

Abstract. The province of Camarines Norte has been producing *Kappaphycus* seaweed since the 1970s, becoming the leading producer in the Bicol Region. However, the occurrence and habit of shore crabs within seaweed farms have not yet been previously recorded. Assessment of shore crabs in seven seaweed farms was conducted for one year. Snorkeling surveys were conducted to record the occurrence and observe the habits of shore crabs on seaweed floaters. Additionally, field interviews with 110 seaweed farmers were carried out to obtain data on floater utilization, farm size, and planting season. Results showed a total of 1,019 shore crabs among 2,081 styrofoam floaters recorded, resulting in a 49.0% occurrence rate and a density of 42.52 crabs per hectare. The majority (84.2%) of shore crabs occurred during the planting season (February to July). Findings revealed that shore crabs exhibit solitary rafting behavior on styrofoam floaters, maintaining a consistent 1:1 ratio (crab to float). Shore crabs actively dismantle styrofoam floaters, emerging as the primary cause of rapid loss and fragmentation. In contrast to other types of floaters used by seaweed farmers, styrofoam floaters appeared to be attractive to shore crabs for rafting, posing a potential risk of ingestion. Regulating the use of styrofoam floaters in the area is recommended to prevent microplastic contamination, promoting responsible aquaculture and fisheries management. Additionally, flat-surfaced floats that are sturdy and more eco-friendly can be used as alternative floaters and as a basis for redesigning floaters to support the crab's rafting population.
Key Words: *Kappaphycus*, microplastic, rafting behavior, styrofoam floats, *Varuna litterata*.

Introduction. The euryhaline crab, *Varuna litterata* (Fabricius, 1798) belongs to the family Varunidae under the phylum Arthropoda and infraorder Brachyura (WoRMS 2023). They are called grapsid crab, commonly known as the 'herring bow crab' (Devi et al 2013) or paddler crab (Bouchard et al 2013), locally known in the Philippines as "Talangka" in Tagalog dialect, "Katang" and "Calampay" in Ilongo, "Kalampay" in Cebuano (Motoh 1980), "Kalimpay" in Cuyono (Jumawan et al 2022), "Kappi" in Ilocos (Mendoza et al 2023; Rojas 2023), while also called as "Talangka", and sometimes "Kimpi" or "Ulok" in the Bicol region. *V. litterata* are euryhaline and can be found in rivers, brackishwater, or at sea (Bouchard et al 2013), inhabiting mangrove creeks, rivers, freshwater canals, brackishwater fishponds, and rice fields (Ryan & Choy 1990). Usually, they are found under rocks, logs, dead leaves, and live-in burrows along the embankments or sides of pools, creeks, and shallow banks (Devi et al 2013).

V. litterata occur in the tropical Indo-West Pacific (Waltham et al 2014; Davie 2002), and recorded in Indonesia in Halmahera, Moluccas (Cai & Ng 2001), Special Region of Yogyakarta in the central part of Java (Eprilurahman et al 2015), Gorontalo in the northern part of Sulawesi (Lapolo et al 2018), and recently in the southern coast of East Java, Indonesia facing the Indian Ocean (Susilo et al 2020a). In the Philippines *V. litterata* has been widely reported as shown in different studies (Motoh 1980; Jingkatal & Ramos 2019; Lagare et al 2020; Masagca 2020; Subang et al 2020; Jumawan et al 2022; Taguiam et al 2022; Siares & Bradecina 2022; Rojas 2023), and sporadically recorded in Luzon, Negros, Panay and Palawan Islands, Mindanao Island, in Zamboanga provinces, Davao provinces, Sarangani province, and Misamis Oriental (Lagare et al

2020), and recently in Caraga Region (Jumawan et al 2022). It is also listed as an economically important crustacean food under the Bureau of Fisheries and Aquatic Resources Fisheries Administrative Order (BFAR FAO) No. 233 series of 2010. *V. litterata* is considered an important fishery product in Southeast Asia collected as food (Carpenter & Niem 1998), caught through trapping "pakat" using a fyke net and crab trap during daytime and nighttime (Mendoza et al 2023). Overexploitation of *V. litterata* in the country has also been reported due to demand for protein food resulting in a reduction of its population in natural habitats (Subang et al 2020). However, regardless of its big catch, *V. litterata* has little commercial value because of its small size (Motoh 1980).

In Mercedes, Camarines Norte, *V. litterata* are locally harvested and marketed as a source of food and income. Commercial seaweed farming in Camarines Norte can be dated back to the 1970s, but no occurrences of *V. litterata* were reported and there are no records yet in the Philippines of their occurrence in seaweed farms. Additionally, though they are known to have a unique lifestyle (Connell & Robertson 1986; Mos et al 2017), and reported to be drifting with debris at sea following floods (Bouchard et al 2013), and adhering to floating timber, bamboo, and coconut shells (Motoh 1980), they have not yet been discovered in commercial seaweed farms with high biomass. There are also limited field studies conducted on its natural habitat, especially on its rafting behavior at sea and its occurrence in unique habitats such as natural or man-made floating objects, particularly seaweed farms. Most studies in the Philippines are limited to its biology, identification, and distribution, as shown in previous studies conducted (Jingkatal & Ramos 2019; Lagare et al 2020; Subang et al 2020; Jumawan et al 2022; Taguiam et al 2022).

Understanding the distribution of organism populations including when, where, and how they are found, is a central focus of marine biological research (Lindsay 2012), since some changes affect arthropod communities over time in different habitats as urbanization progresses (Argañaraz & Gleiser 2017). Reporting the areas with the presence of *V. litterata* is beneficial for future studies related to biogeography, genetic analysis, the source of stocks for aquaculture, and understanding population dynamics (Jumawan et al 2022). Reporting new records of *V. litterata*, especially in man-made habitats like seaweed farms, is an important baseline data for future studies, conservation, management, and aquaculture development. In this work, we reported the occurrence and habit of *V. litterata* in commercial seaweed farms for the first time. Their occurrence in such habitat is fundamental to understanding their responses to changing environmental conditions, their relationship to seaweed farming, conserving and managing their population, and developing strategies for more sustainable seaweed aquaculture.

Material and Method

Description of the study sites. The seaweed farms assessed in this study were situated in the municipality of Mercedes, Camarines Norte. Camarines Norte is bounded by three key fishing grounds: Lamon Bay, San Miguel Bay, and the Philippine Sea (Biag et al 2022a). It contains 12 municipalities and 28 barangays, with 9 of them being fishing towns. Located at 14.0215° N, 123.0676° E, Mercedes is one of the coastal municipalities of the province, with a land area of 173.69 km^2 which constitutes 7.62% of the province's total area. Mercedes, in particular, is a major landing site for diverse marine fishery resources in the province and is considered the "fishbowl" capital of the Bicol Region. It is considered one important landing point in the province for various fishery products from both the capture and aquaculture sectors. Aside from being an important fishing town and landing area, Mercedes is a significant seaweed producer in the province, encompassing coastal and island barangays that actively engage in seaweed farming. Primarily, the seaweed being produced is *Kappaphycus* and the culture methods are fixed-off-bottom and floating-line methods (Figure 1).

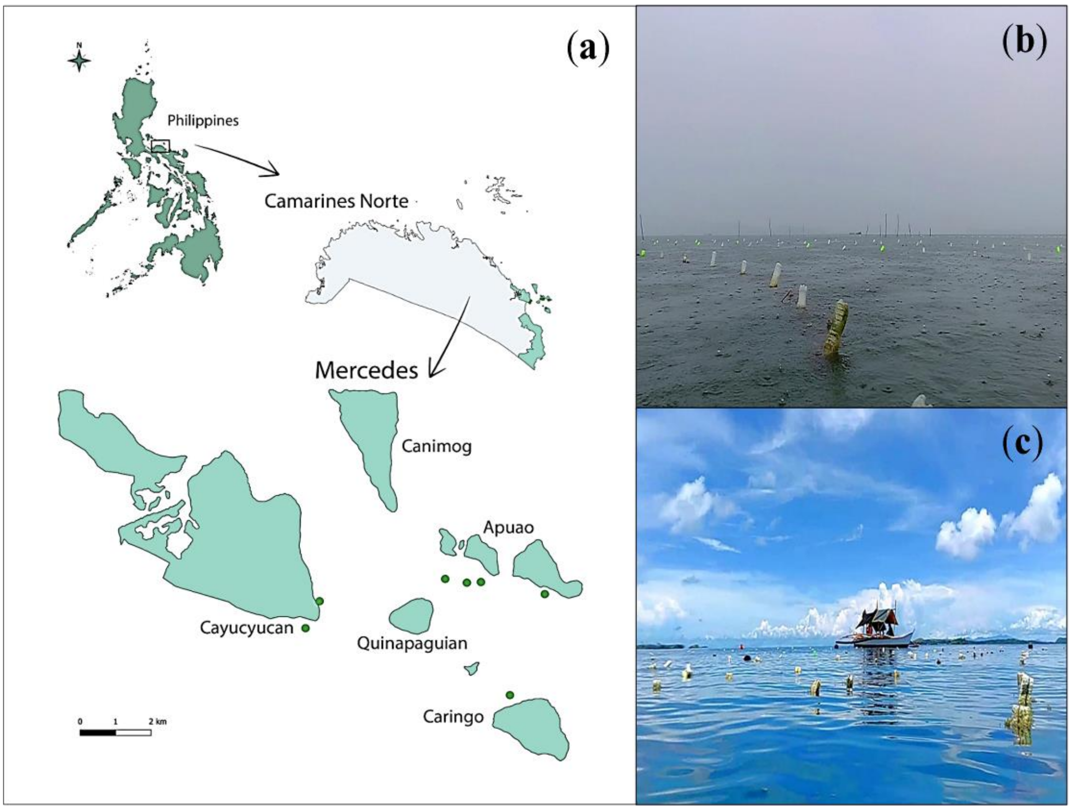


Figure 1. Map of Mercedes, Camarines Norte Philippines, showing the location of commercial seaweed farms of *Kappaphycus* in green dots (a), using the fixed-off-bottom method (b), and deep-sea floating line method (c).

Review of existing records. Existing distribution records of *V. litterata* were reviewed using the Google Scholar search engine, employing Boolean operators "*Varuna litterata*" and "*Varuna litterata*, Philippines", sorted by relevance without any specific time constraints. Information was extracted from the title, methodology, and results sections of each article, including the English name used in the study, the scientific name of the crab, the country/location, distribution/collection site where the crab is recorded or collected.

Sampling method. The occurrence of the shore crab, *V. litterata* was assessed in seven (7) major seaweed farms at four (4) barangays consisting of Cayucyucan (2), Quinapaguian Island (1), Apuao Island (3), and Caringo Island (1) (Table 1).

Table 1

Location and coordinates of seaweed production areas in Mercedes

Stations	*Sampling sites*	*Latitude*	*Longitude*
1	Brgy. Cayucyucan site 1	14°4′24″	123°2′50″
2	Brgy. Cayucyucan site 2	14°3′57″	123°2′43″
3	Brgy. Quinapaguian Is.	14°4′44″	123°4′54″
4	Brgy. Apuao Is. site 1	14°4′41″	123°5′27″
5	Brgy. Apuao Is. site 2	14°4′40″	123°5′14″
6	Brgy. Apua Is. site 3	14°4′29″	123°6′27″
7	Brgy. Caringo Is.	14°2′52″	123°5′54″

The coordinates of the seaweed farms were obtained through onsite geotagging using a handheld global positioning system (GPS) and plotted on a map using a geographic information system (GIS) program called Quantum Geographic Information System (QGIS). For one (1) year starting April 2022 to March 2023, seaweed farms were monitored, taking note of the occurrence, behavior, and life habits of shore crabs using an underwater slate and camera while swimming. Snorkeling surveys were conducted following Biag et al (2022b) swimming pattern in seaweed farms to record the frequency of shore crabs and the type of floats used in seaweed farms through visual observation.

Species identification. Species identification was carried out through field observations of crab specimens and cross-referencing with photographs and key morphometrics using various field guides. The observations were done by closely studying the crabs in their natural habitat, relying on phenotypic characteristics outlined in relevant field guides. Specifically, the edible crustacea of the Philippines field guide by Motoh (1980), the species identification guide for fishery purposes by Carpenter & Niem (1998), and the works of Ng (2004) and Jumawan et al (2022) were consulted for identification. The English name "shore crab", as specified in Motoh's field guide (1980), in the Philippines was used in this study. Secondary data regarding the biological information of *V. litterata* were gathered from published literature, books, and articles on the internet.

Field interview. Data on the utilization of floaters, the area of seaweed farms, the season of planting, and other important information relative to seaweed farming were obtained through face-to-face interviews. Using total enumeration, a total of 110 seaweed farmers who actively engaged in seaweed farming were interviewed. The total number and list of seaweed farmers was obtained from the Bureau of Fisheries and Aquatic Resources-Provincial Fishery Office of Mercedes, Camarines Norte, and the Local Government Unit-Municipal Agriculture Office of Mercedes. A signature over the printed name of seaweed farmers was affixed at the end of the survey questionnaire, serving as proof of consent, validity, and certified correctness of the provided information.

Data analysis. The collected data were analyzed utilizing Microsoft Excel 2016 Office 365, while charts were graphed using OriginPro Learning Edition 2024b (10.1.5.132). Descriptive techniques were employed to construct frequency tables and calculate measures such as mean, standard deviation, and percentages. Additionally, other analyses, including float utilization rate, total production area, average production area, occurrence rate, and density of shore crabs, were conducted based on the actual data in the locality, considering the applicability of relevant formulas as shown below:

$$\text{Utilization (U)} = \frac{RC}{N} \times 100$$

where: U (%) = the utilization rate of floaters;
RC = the total respondents' citations per floaters;
N = the total number of respondents interviewed, respectively.

$$\text{Total Production Area (TP)} = \bar{x}LCR \times \bar{x}DCR \times TCR$$

where: TP = the total seaweed production area (ha);
$\bar{x}$LCR = the average length of culture ropes (m);
$\bar{x}$DCR = the average distance of culture ropes (m);
TCR = the total number of culture ropes (pcs).

$$\text{Average Production Area (AP)} = \bar{x}LCR \times \bar{x}DCR \times \bar{x}TCR$$

where: AP = the average seaweed production area (m^2);
$\bar{x}$LCR = the average length of culture ropes (m);
$\bar{x}$DCR = the average distance of culture ropes (m);
$\bar{x}$TCR = the average number of culture ropes (pcs).

$$\text{Occurrence rate (OR)} = \frac{TC}{TF} \times 100$$

where: OR (%) = the occurrence rate of crabs;
TC = the total number of crabs observed per floater;
TF = the total number of floaters recorded.

$$Density\ (D) = N / TP$$

where: D = the density of crabs per area;
N = the total number of crabs recorded;
TP = the total production area or size of the sampling unit, respectively.

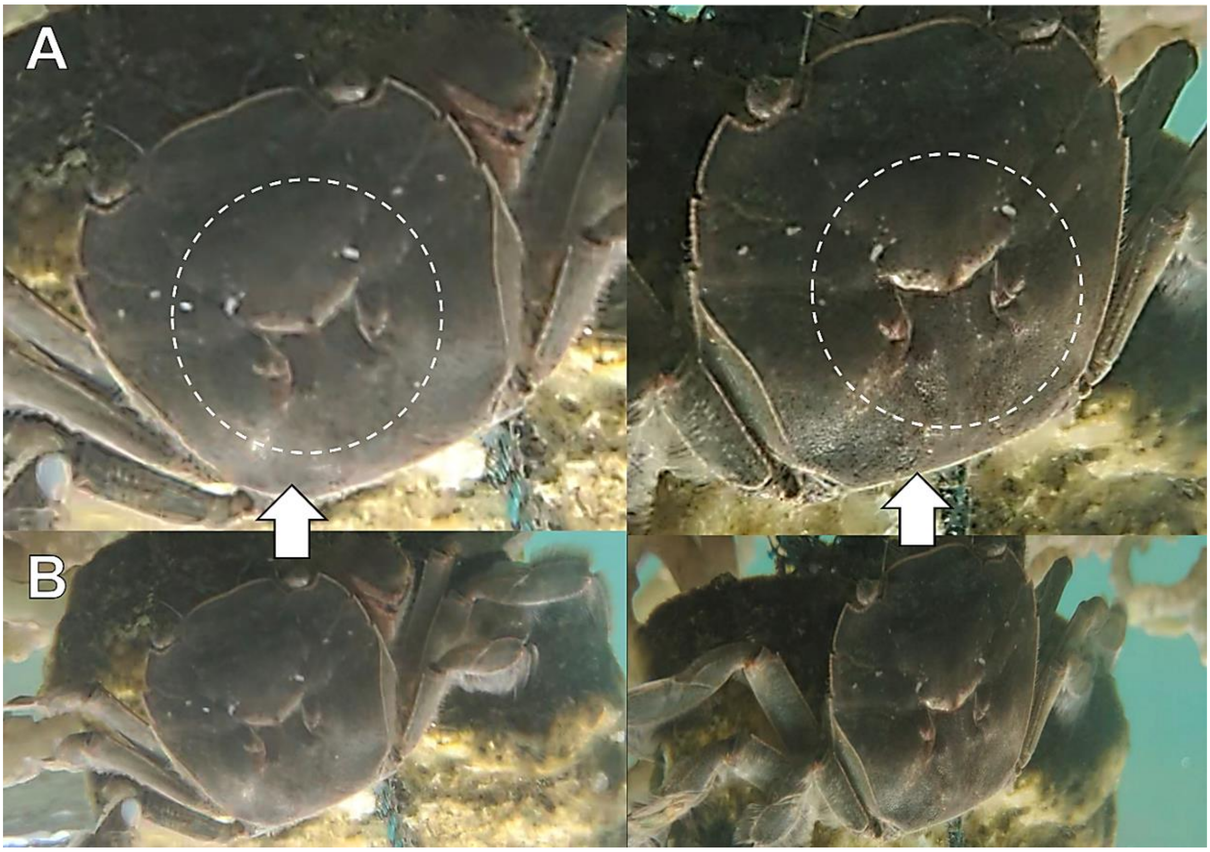
Results. The current distribution records of *V. litterata* demonstrate the species' remarkable adaptability to a diverse array of aquatic environments. Their adaptability spans coastal areas, brackish waters, rivers, creeks, ponds, swamps, streams, canals, and rice fields. The species' ability to thrive in such varied aquatic landscapes shows its ecological resilience and versatility, contributing to its widespread presence across different geographical regions. The species has been identified in various locations, including Thailand, Fiji, Australia, India, Indonesia, and South Africa. Furthermore, in the Philippines, *V. litterata* was previously reported in several regions, namely Caraga, Palawan, Basilan, Mindanao, Aparri in Cagayan, Vigan in Ilocos Sur, and numerous locations in Cavite, Albay, Virac in Catanduanes, Batangas, and Camarines Sur (Table 2).

Table 2
Distribution record of *Varuna litterata* in several countries and areas in the Philippines

English name	*Country/location*	*Distribution record/ collection site*	*Source*
Oceanic paddle crab	Thailand	Coast	Suppapan et al (2017)
	Suva, Fiji	Creek	Ryan & Choy (1990)
Euryhaline crab	New South Wales, Australia	River basins	Mos et al (2017)
Freshwater crab	West Bengal, India	Freshwater bodies	Deyashi & Chakraborty (2022a, b)
	West Bengal, India	Freshwater streams, canals and ponds	Deyashi et al (2016)
	Indonesia	River	Susilo et al (2020b)
	South Africa	River	Burnett et al (2023)
	Maputaland coast, South Africa	Estuary	Connell & Robertson (1986)
	Caraga Region, Philippines	River	Jumawan et al (2022)
Edible freshwater crab	West Bengal, India	Ponds	Das et al (2015)
Freshwater grapsid crab	West Bengal, India	Freshwater streams, canals and ponds	Deyashi et al (2019)
	West Bengal, India	River delta	Mahapatra et al (2017)
Herring bow crab	India	Backwaters	Devi & Joseph (2017)
	Indonesia	River	Fariedah et al (2023)
	Indonesia	River	Susilo et al (2020a)
	Indonesia	River and estuary	Fani et al (2021)
	Indonesia	Fishponds	Lapolo et al (2018)
Shore crab, herring bow crab	Palawan, Philippines	Marine, brackishwater	Subang et al (2020)
	Basilan, Mindanao Philippines	Coastal and freshwater areas	Jingkatal & Ramos (2019)
River swimming crab	Aparri, Cagayan	Nipa swamp	Taguiam et al (2022)
	Vigan, Ilocos Sur, Philippines	River	Rojas (2023)
	Cavite; Tabaco City (Albay); Virac, Catanduanes; Batangas, Philippines	Ricefield and river	Masagca (2020)
	Camarines Sur, Philippines	River	Siares & Bradecina (2022)
Shore crab	Camarines Norte, Philippines	Commercial seaweed farms	This study

***Description**.* The euryhaline crab, *V. litterata*, in this paper, was found to have a unique living condition, inhabiting seaweed farms by colonizing seaweed floats with a 1:1 crab-to-float ratio. Usually, they range from light-brown to brownish-grey ground colorations on the dorsal surfaces with numerous blackish patches and can grow up to 5 cm long; the carapace is flattish and squarish (Motoh 1980; Palomares & Pauly 2022), with legs shaped like paddles used for swimming (Bouchard et al 2013). One distinct feature of *V. litterata* is the unique marking on its carapace that can be perceived as the letter "H" or "M". The presence of the letter "H" on its carapace is what the species name "litterata" alludes to (Viray-Mendoza 2018). However, the carapace mark can be easily observed in the field as the letter "M" since it is more visible in all positions (transverse and cross-sectional views). This distinct marking was observed to be more visible in adults than in juveniles.

***Rafting behavior**.* On seaweed farms, they are discovered to be rafting on styrofoam floats, and like all crabs, they also breathe with gills by staying on top of the float with a strategic view of upcoming predators. They are found to be resting on the float, exposed to direct sunlight, and immersing themselves in the water to avoid desiccation. They also dive into the water and hide behind floats and seaweed when they sense incoming predators or any danger. Adults are more active and sensitive to incoming observers and fishermen; thus, they hide around the floats by maneuvering their positions without leaving, jumping off, or moving to other floats or the culture ropes to prevent them from being caught. While juveniles are observed to be less active and stay on the float even when being observed or moved. They are less sensitive to incoming observers but are far more active in destroying styrofoam floats than adults. They used their claws to tear down styrofoam floats and are suspected of consuming them in the field (Figure 2).



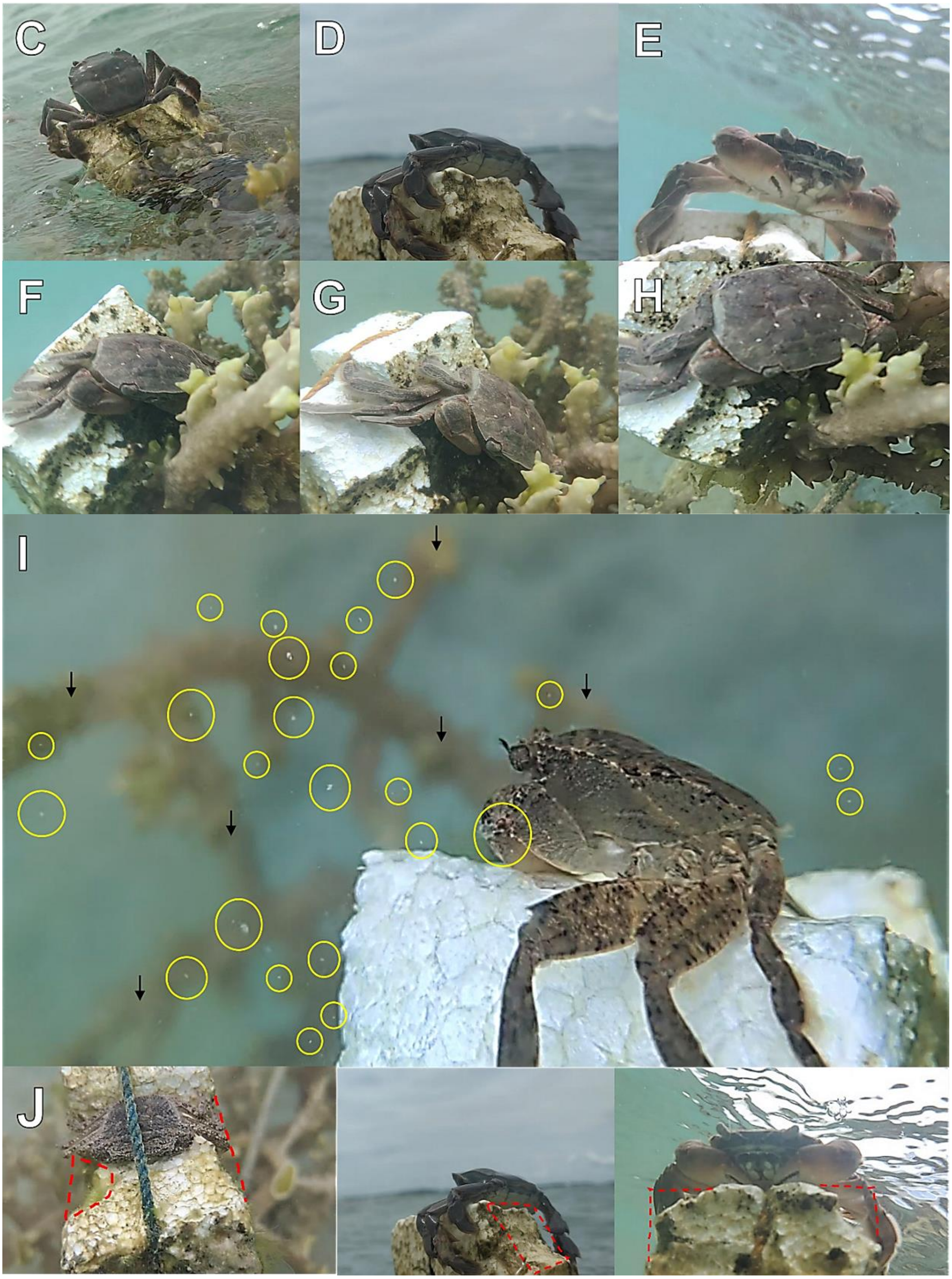


Figure 2. Letter A-B: a magnified image of *V. litterata* showing its distinctive carapace mark, clearly visible as the letter "M" (white broken line). Letters C-E shows its life habit of rafting on styrofoam floaters, and F-H shows its maneuvering mechanism underwater when disturbed. Letter I show the juvenile's active behavior of destroying styrofoam floats, represented by micro-fragments floating underwater (yellow circles) along cultivated seaweeds, *Kappaphycus* (small black arrows), while letter J is the natural habit of the crab when undisturbed, showing the extent of damage made to styrofoam floaters (red broken line).

Float utilization. Seaweed floaters in Mercedes, Camarines Norte include different types of materials such as recycled extruded polystyrene (styrofoam), recycled plastic bottles, single-use plastic, and high-density polyethylene (HDPE) locally known as hard plastics. Styrofoam floats, made from chunked or extruded polystyrene foam, are secured with ropes and possess specifications such as a weight of 13.1 grams, a length of 78.20 mm, a width of 71.32 mm, and a height of 75.14 mm. Recycled plastic bottle floats, repurposed from drinking bottled water and cola drinks, feature a weight of 203 grams, a diameter of 54.59 mm, and a height of 193.64 mm. Single-use plastic floats are double-layered, air-filled plastic bags that primarily come from grocery bags and food packaging. HDPE floats come in various designs, with the ball-shaped variant featuring a cap on top and an ear at the bottom for tying, functioning as a hollow structure designed for water submersion. It weighs 100.6 grams, has a diameter of 115.41 mm, and a height of 148.83 mm. The torus-shaped HDPE float, resembling a donut with a hole/eye in the middle for tying ropes, weighs 44.7 grams, with a diameter of 94.89 mm and a width of 80.74 mm. The ball-shaped HDPE float with protruding eyes on both ends, locally known as "ears" for tying ropes, weighs 102.3 grams, has a diameter of 115.56 mm, and a height of 148.91 mm.

Respondents' citations (RC) showed that among the different floaters, styrofoam and plastic bottles emerged as the most utilized types of floats in seaweed farming, both recording a 100% utilization rate. HDPE ranked third in utilization, with a utilization rate of 51.82%. Single-use plastic exhibits the lowest utilization among the four types (14.55%) (Table 3).

Table 3

Utilization and rank of different types of floats used in seaweed farming

Type of float	*Code*	*RC (n = 110)*	*Utilization (%)*	*Rank*
Styrofoam	SF	110	100.00	1
Plastic bottle	PB	110	100.00	2
High-density polyethylene	HDPE	57	51.82	3
Single-use plastic	SUP	16	14.55	4

Note: RC = respondents' citation.

Occurrence in floaters. A total of 1,019 shore crabs were recorded from the 2,081 styrofoam floats, accounting for a 49.0% occurrence rate. Of the seven (7) seaweed farms visited, the highest number of occurrences was recorded in Cayucyucan (532), followed by Apuao Island (245), Quinapaguian Island (153), and Caringo Island (89). Hence, the occurrence rate relative to the number of styrofoam floats recorded was highest in Quinapaguian Island (65.7%) and in Cayucyucan (62.9%), followed by Apuao Island (36.1%) and Caringo Island (27.5%) (Figure 3). Occurrences of *V. litterata* were not recorded in other floats and were discovered solely in styrofoam floats. These chunks of extruded polystyrene foam used as floaters, commonly known as "styrofoam floats," come in a variety of sizes and shapes depending on material availability, but the majority are square and rectangular.

Size structure of seaweed farm and density of V. litterata. The total seaweed production area in Mercedes was assessed at 239,652 m² (23.97 ha), with an average production area size of 2,444.40 m² per farmer. This comprises a mean length of culture ropes of 45.0±10.4 m, a mean distance between culture ropes of 1.4±1.0 m, and a mean total culture ropes of 38.8±58.8 pieces. The total number of shore crabs recorded across the entire production area indicates a density of 42.52 crabs per hectare (Table 4).

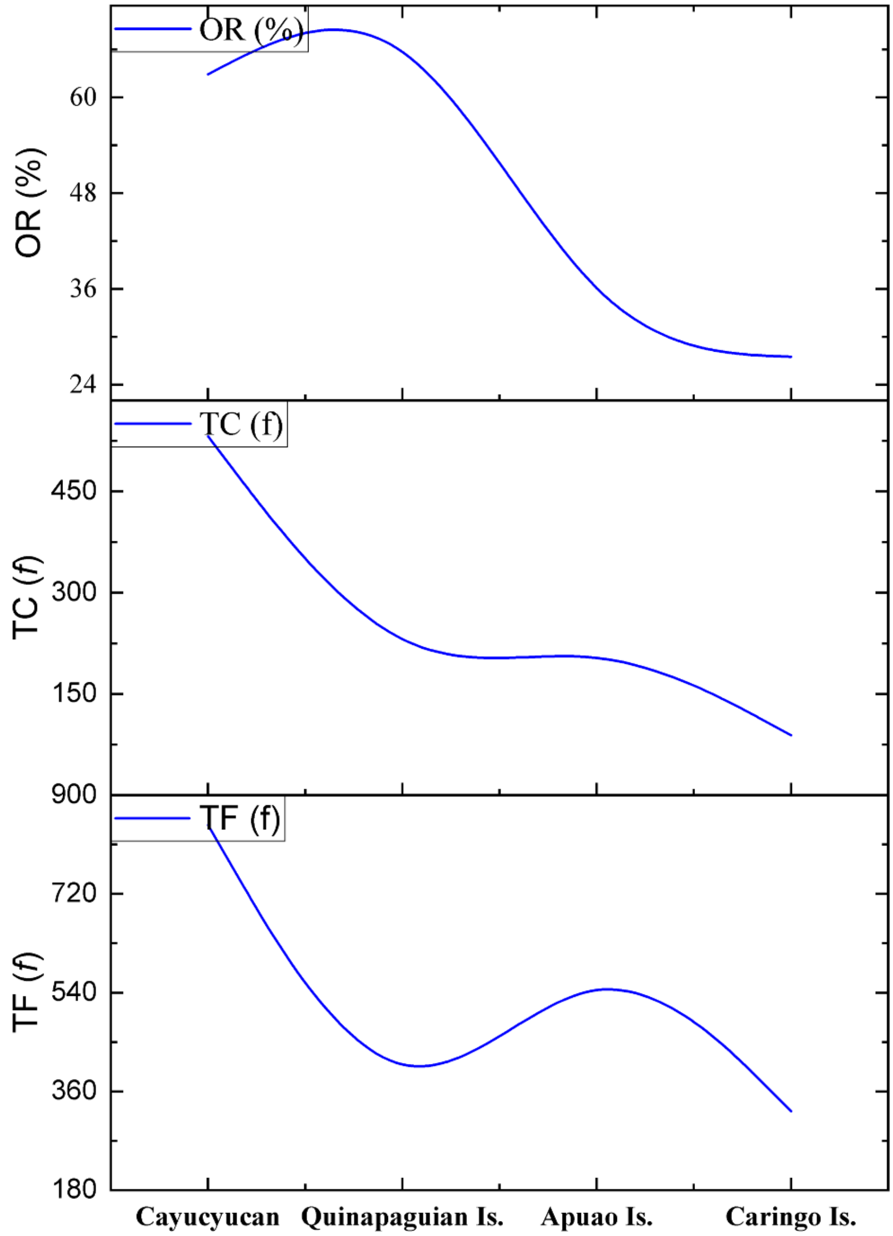


Figure 3. The occurrence rate (OR) of shore crabs in seaweed farms showing the total number of observed crab populations (TC) over the total number of styrofoam floaters (TF) recorded per station.

Table 4

The overall density of shore crabs in commercial seaweed farms, showing the size and structural measurement of seaweed farms

Parameters	*LCR (m)*	*DCR (m)*	*TCR (pcs)*
Range	20-100-86.36	0.1-5.2	1-500
Mean	45.0±10.4	1.4±1.0	38.8±58.8
Total number of culture ropes (TCR)		3,804	
Total production area (TP)		23.97 ha / 239,652 m²	
Average production area (AP)		2,444.40 m^2	
Total number of crabs (N)		1,019 pcs	
Density (D)		42.52 crabs ha^{-1}	

Note: LCR = length of culture ropes; DCR = distance between culture ropes; TCR = total culture ropes.

Seasonal abundance. The highest number of occurrences was recorded during the planting season, with the lowest during the nursery and off-season. These populations of *V. litterata* in terms of recorded occurrence were highest between February and July, accounting for 84.2% of the total population (1,019), consisting of February (132), March (148), April (241), May (126), June (109), and July (102) with the highest abundance during April. The lowest abundance was recorded between August to January (15.8%), consisting of August (42), September (44), October (36), November (8), December (12), and January (19). The planting season for seaweeds in Mercedes spans from February to July, with the most seaweed growers planting in February (62, 56%), March (74, 67.3%), April (63, 57.3%), May (53, 48.2%), June (37, 33.6%), and July (24, 21.8%). While August to January consisted of August (21, 19.1%), September (22, 20.0%), October (18, 16.4%), November (4, 3.6%), December (6, 5.5%), and January (46, 41.8%), was the off and nursery season. During this time, most farmers stopped growing seaweed due to bad weather and rough seas, but some continued to maintain nurseries of seedlings in preparation for the next cropping (Figure 4).

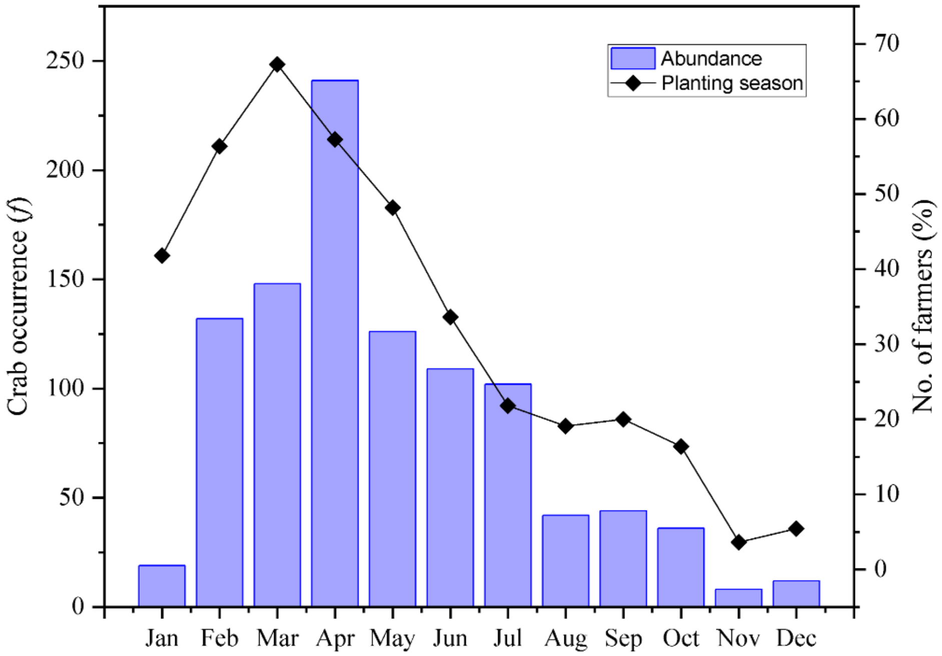


Figure 4. Seasonal abundance of *V. litterata* relative to the planting season of seaweed, *Kappaphycus*, in Mercedes, Camarines Norte.

V. litterata has been identified as having a broad distribution across several countries, as indicated by various studies examined. The English name assigned to the species varies among different studies, locations, and authors. Additionally, distribution records and collection sites of specimens demonstrate a diverse range, encompassing both freshwater and marine environments. *V. litterata* exhibits a remarkable ability to thrive in diverse environments, ranging from coastal areas and rivers to freshwater bodies, estuaries, and seaweed farms. This adaptability shows the ecological resilience and versatility of the species across a wide geographical range. *V. litterata* are edible crustaceans listed in the field guide for edible crustacea in the Philippines by Motoh (1980), and as an important aquatic organism for food purposes in 2010, under Fisheries Administrative Order 233, Annex A, released by the Bureau of Fisheries and Aquatic Resources (BFAR). Farmers harvest them occasionally as a source of food and income, but they are considered pests since they destroy styrofoam floaters in seaweed farms. Hence, their occurrence in styrofoam floats can be a means for their fast exploitation due to easy access. They can be caught only through handpicking or scoop nets. It is suspected that one reason for their high occurrence in styrofoam floats and their absence in all other floats used in seaweed farming is feeding. Hence, there is no evidence of grazing activity observed in planted seaweed where it occurs. Styrofoam floats are easy to break using their claws and can be easily consumed compared with other floats that are made of hard plastic. Studies have shown that *V. litterata* are known to be opportunistic omnivores capable of ingesting both animal and plant tissues (Devi et al 2013); thus, their diet and feeding habits are found to be diverse, where the type of food consumed is significantly dependent on their habitat (Freire & Gonzalez-Gurriaran 1995; Hegele-Drywa & Normant 2009; Devi et al 2013).

Another reason for their high occurrence in seaweed farms may be attributable to their life cycle. Their rafting behavior on styrofoam floats can be one of their defense mechanisms during migration at some stage of their life cycle. Previous studies have shown that *V. literata* migrates in rivers (Kemp 1915; Ryan & Choy 1990) and is sometimes found clinging to floating timber, bamboo, and coconut shells (Motoh 1980) and debris after floods (Bouchard et al 2013). Thus, styrofoam floats, being flat, are far more suitable for rafting than any other float compared with recycled plastic bottles and HDPE floats that are spherical. As a result, in addition to the possibility of ingesting styrofoam, their habit of destroying styrofoam floats may be due to their natural habits. Styrofoam float destruction will not only impact cultivated seaweeds but may also contribute to microplastic pollution and contamination. Evidence of styrofoam floaters washed up on the beaches of Camarines Norte has been recorded (Elep Jr. & Azuelo 2024), primarily attributed to being discarded, lost during operations, or loosened from ties due to crab activity. Like plastics, styrofoam also leaches out chemicals (Stachowitsch 2019), while tiny particles of styrofoam floating in the water can be suspected as food by fish, especially seaweed-associated species. However, their occurrence in seaweed farms also provides a positive ecological function. Studies have shown that crabs can be a source of food for other organisms (Taylor & Rees 1998), can recycle nutrients (Ng 2004), and can contribute to secondary production via a coprophagous food chain (Gillikin & Schubart 2004).

Conclusions. Shore crabs have been found to occupy styrofoam floats in seaweed farms because of their flat surface and capacity to aid them while rafting at sea. Their high occurrence through the months is influenced by the number of styrofoam floats present at sea, which is attributed to the planting season of seaweed farmers. As a result of their abundance and active behavior of destroying floaters, there is a high likelihood of styrofoam ingestion. Their habit of breaking styrofoam floats may endanger other marine species as well as farmed seaweed due to microplastic contamination. Therefore, the use of styrofoam as floaters in seaweed farms shall be regulated to avoid species ingestion, health problems, and aquatic pollution. Though limiting the occurrence of *Varuna litterata*, floater destruction may be avoided if other materials than styrofoam floats are employed. Flat-surfaced floats that are sturdy and more eco-friendly can be used as alternative floaters and as a basis for redesigning floaters to support their rafting population.

Acknowledgements. This research was conducted under the project Production and Technology Assessment of Seaweeds (ProTechASeaweeds) in Camarines Norte, funded by the Department of Agriculture under the Philippine Rural Development Project (DA-PRDP). Special thanks are given to different partner agencies: Bureau of Fisheries and Aquatic Resources (BFAR) Region 5; Office of the Provincial Agriculture (OPAG) Camarines Norte; Local Government Unit of Mercedes; Municipal Agriculture Office; Barangay Officials and Staff; Seaweed Farmers; and Research Assistants.

Conflict of interest. The authors declare that there is no conflict of interest.

References

Argañaraz C. I., Gleiser R. M., 2017 Does urbanization have positive or negative effects on crab spider (Araneae: Thomisidae) diversity? Zoologia 34:e19987.

Biag D. C., Mendoza Jr. A. B., Bobiles R. U., Camaya A. P., De Jesus S. C., Nieves P. M., 2022a Tidal periodicity of molting in giant mud crab, *Scylla serrata* (Forskål, 1775). World Journal of Advanced Research and Reviews 16(1):122-132.

Biag D. C., Hombre R. S., Edoria C. L. T., Visitacion M. R., Sape J. C. S., Elep Jr. L. O., 2022b First record of potential epiphyte grazing species in commercial seaweeds (*Kappaphycus* spp.), Philippines. World Journal of Biology Pharmacy and Health Sciences 12(2):61-66.

Bouchard J. M., Poupin J., Cleva R., Dumas J., Dinhut V., 2013 Land, mangrove and freshwater decapod crustaceans of Mayotte region (Crustacea, Decapoda). Atoll Research Bulletin No. 592. Smithsonian Institution Scholarly Press, 69 pp.

Bureau of Fisheries and Aquatic Resources, 2010 Fisheries Administrative Order No. 233 Series of 2010: Aquatic wildlife conservation. Available at: https://www.bfar.da.gov.ph/wp-content/uploads/2021/04/FAO-No.-233-s.-2010.pdf. Accessed: April, 2023.

Burnett M. J., Van Zyl B., Downs C. T., 2023 The migration of aquatic macrocrustaceans over an artificial barrier in the uThukela River, South Africa. African Journal of Ecology 62(1):e13234.

Cai Y., Ng P. K., 2001 The freshwater decapod crustaceans of Halmahera, Indonesia. Journal of Crustacean Biology 21(3):665-695.

Carpenter K. E., Niem V. H., 1998 FAO species identification guide for fishery purposes: the living marine resources of the Western Central Pacific. Volume 2: Cephalopods, crustaceans, holothurians and shark. FAO, Rome, pp. 687-1396.

Connell A. D., Robertson W., 1986 Recent records of megalopae of the crab *Varuna litterata* (Fabr.) entering Natal estuaries. South African Journal of Zoology 21(2): 184-185.

Das M., Kundu J. K., Misra K. K., 2015 Major lipid classes and their fatty acids in the flesh and hepatopancreas of an edible freshwater crab *Varuna litterata* (Fabricius 1798). International Journal of Research in Fisheries and Aquaculture 5(1):19-32.

Davie P. J. F., 2002 Crustacea: Malacostraca: Eucarida (Part 2), Decapoda: Anomura, Brachyura. In: Zoological catalogue of Australia. Vol. 19.3b. Wells A., Houston W. W. K. (eds), CSIRO Publishing, Melbourne, Australia, 641 pp.

Devi P. L, Joseph A., 2017 On the record of herring bow crab *Varuna litterata* (Fabricius, 1798) from Cochin Backwaters, India. Indian Journal of Geo Marine Science 46(5):995-999.

Devi P. L., Nair D. G., Joseph A., 2013 Habitat ecology and food and feeding of the herring bow crab *Varuna litterata* (Fabricius, 1798) of Cochin Backwaters, Kerala, India. Arthropods 2(4):172-188.

Deyashi M., Chakraborty S. B., 2022a Acute exposure to a neem based biopesticide and mahua oil cake changes haemocyte parameters in freshwater crab, *Varuna litterata* (Decapoda, Crustacea). Fish and Shellfish Immunology 131:505-517.

Deyashi M., Chakraborty S. B., 2022b Cytomorphological characterization, classification and counting of haemocytes in freshwater crab, *Varuna litterata* (Crustacea: Decapoda). Invertebrate Zoology 19:120-134.

Deyashi M., Misra K. K., Bhattacharya S. S., Chakraborty S. B., 2016 Acute toxicity of a neem seed kernel based biopesticide, nimbecidine plus on an edible fresh water crab, *Varuna litterata* (Fabricius, 1798). International Journal of Advanced Research in Biological Sciences 3(10):122-130.

Deyashi M., Misra K. K., Chakraborty S. B., 2019 Evaluation of the acute toxicity of mahua oil cake aqueous extract and its effect on the behavioral responses of the freshwater grapsid crab, *Varuna litterata* (Fabricius, 1798). Environmental Science and Pollution Research International 26(15):15631-15640.

Elep Jr. L. O., Azuelo M. C. C., 2024 Characterisation of macro-plastic waste along the Philippines' longest coastal boulevard: basis for solid waste management and policy formulation. Journal of Applied Life Sciences and Environment 57(2):183-196.

Eprilurahman R., Baskoro W. T., Trijoko, 2015 [Diversity of crab species (Decapoda: Brachyura) in the Opak River, Special Region of Yogyakarta]. Biogenesis: Jurnal Ilmiah Biologi 3(2):100-108. [in Indonesian]

Fani F., Sri W. M., Rani Y., 2021 Gonad maturity level of *Varuna litterata* in the Kalimireng River Estuary of Manyar Gresik District, East Java, Indonesia. Russian Journal of Agricultural and Socio-Economic Sciences 119(11):229-233.
Fariedah F., Rahayu S., Marhendra A. P. W., Arfiati D., 2023 The habitat of *Varuna litterata* in the Bengawan Solo River. IOP Conference Series: Earth and Environmental Science 1911:012003.
Freire J., Gonzalez-Gurriaran E., 1995 Feeding ecology of the velvet swimming crab *Necora puber* in mussel raft areas of the Ria de Arousa (Galicia, NW Spain). Marine Ecology Progress Series 119:139-154.
Gillikin D. P., Schubart C. D., 2004 Ecology and systematics of mangrove crabs of the genus *Perisesarma* (Crustacea: Brachyura: Sesarmidae) from East Africa. Zoological Journal of the Linnean Society 141(3):435-445.
Hegele-Drywa J., Normant M., 2009 Feeding ecology of the American crab *Rhithropanopeus harrisii* (Crustacea: Decapoda) in the coastal waters of the Baltic Sea. Oceanologia 51(3):361-375.
Jingkatal A. M., Ramos K. P., 2019 Brachyuran crabs in the selected coastal and freshwater areas in Basilan, Mindanao, Philippines. Ciencia 38:58-76.
Jumawan J. H., Ruales J. J. J., Avila M. C. A., 2022 New distribution record of *Varuna litterata* from Caraga Region, Philippines: analysis on morphometry, length/width-weight relationship, and condition factor. Biodiversitas Journal of Biological Diversity 23(6):2935-2942.
Kemp S. W., 1915 Fauna of the Chilka lake. Crustacea Decapoda. Memoirs vol. 5, Indian Museum, Calcutta, pp. 199-325.
Lagare N. J. S., Mapi-Ot E. F., Molina Z. S., Neri J. B., Nuneza O. M., Mendoza J. C. E., 2020 On a collection of freshwater and estuarine crabs (Crustacea: Brachyura) from Mindanao Island, the Philippines. Zootaxa 4868(3):301-330.
Lapolo N., Utina R., Baderan D. W. K., 2018 Diversity and density of crabs in degraded mangrove area at Tanjung Panjang Nature Reserve in Gorontalo, Indonesia. Biodiversitas Journal of Biological Diversity 19(3):1154-1159.
Lindsay S. M., 2012 Dispersal of marine organisms and the grand challenges in biology: an introduction to the symposium. Integrative and Comparative Biology 52(4):443-446.
Mahapatra B. K., Bhattacharya S., Pradhan A., 2017 Some aspects of biology of Chiti kankra, *Varuna litterata* (Fabricius, 1798) from Sundarbans, West Bengal, India. Journal of Entomology and Zoology Studies 5(5):178-183.
Masagca J. T., 2020 Freshwater and semi-terrestrial crab fauna of selected areas in Southern Luzon, Philippines. American Journal of Zoology 3(1):26-34.
Mendoza D. M., Aquino M. G. B., Mendoza G. C., Rosario G. R., 2022 Edible crustacean fishery resources in Infanta, Pangasinan, Philippines: an assessment. AACL Bioflux 15(3):1276-1292.
Mos B., Ahyong S. T., Burnes C. N., Davie P. J., McCormack R. B., 2017 Range extension of a euryhaline crab, *Varuna litterata* (Fabricius, 1798) (Brachyura: Varunidae), in a climate change hot-spot. Journal of Crustacean Biology 37(3):258-262.
Motoh H., 1980 Field guide for the edible crustacea of the Philippines. Southeast Asian Fisheries Development Center, Aquaculture Department, Iloilo, Philippines, 96 pp.
Ng P. K. L., 2004 Crustacea: Decapoda, Brachyura. In: Freshwater invertebrates of the Malaysian Region. Yule C. M., Yong H. S. (eds), Malaysian Academy of Sciences, Kuala Lumpur, pp. 311-336.
Palomares M. L. D., Pauly D., 2022 SeaLifeBase: world wide web electronic publication. Available at: www.sealifebase.org, version (12/2022).
Rojas C. B., 2023 Assessment of the diversity of macrofauna of Govantes River in Vigan City, Ilocos Sur, Philippines. Asian Journal of Biodiversity 14(1):73-87.
Ryan P. A., Choy S. C., 1990 Observations on the mass upstream migration of *Varuna litterata* (Fabricius) megalopae (Decapoda, Brachyura, Grapsidae) in Fiji. Crustaceana 58(3):237-249.

Siares I. F. N., Bradecina S. R. B., 2022 Diversity and distribution of ichthyofauna and macro-invertebrates in Inarihan River, Calabanga, Camarines Sur. Agrikultura CRI Journal 3(1):26-40.
Stachowitsch M., 2019 Foamed plastic (styrofoam). In: The beachcomber's guide to marine debris. Springer, Cham, pp. 159-169.
Subang Jr. B. P., San Juan R. G., Ventura G. F. C., Aspe N. M., 2020 An annotated checklist to the commonly harvested crabs (Crustacea: Decapoda) from marine and brackish water ecosystems of Palawan, Philippines. Journal of Environment and Aquatic Resources 5:61-82.
Suppapan J., Pechsiri J., O-Thong S., Vanichanon A., Sangthong P., Supmee V., 2017 Population genetic analysis of oceanic paddle crab (*Varuna litterata*) in Thailand. Sains Malaysiana 46(12):2251-2261.
Susilo V. E., Wowor D., Suratno, Abror M. N., 2020a New record of *Varuna litterata* (Fabricius, 1798) from Meru Betiri National Park, East Java, Indonesia. IOP Conference Series: Earth and Environmental Science 457(1):012016.
Susilo V. E., Suratno, Wowor D., Abror M. N., 2020b Diversity of freshwater crab (Decapoda) in Meru Betiri National Park. Journal of Physics: Conference Series 1465(1):012008.
Taguiam J. M. B., Bayani G. U., Pacris Jr. F. A., Banadero R. R., Baloloy M. V., 2022 Assessment of macro-faunal diversity of Nipa swamp in Bisagu, Aparri, Cagayan, Philippines. Biodiversitas Journal of Biological Diversity 23(4):1852-1856.
Taylor R., Rees T. A. V., 1998 Excretory products of mobile epifauna as a nitrogen source for seaweeds. Limnology and Oceanography 43(4):600-606.
Viray-Mendoza V., 2018 Talangka crabs in the Philippines. The Maritime Review. Available at: https://maritimereview.ph/talangka-crabs-in-the-philippines/. Accessed: April, 2023.
Waltham N., Hughes J., Davie P., 2014 Freshwater crabs occupying tropical north Queensland coastal creeks. Australian Zoologist 37(2):256-262.
WoRMS Editorial Board, 2023 World Register of Marine Species. Available at: https://www.marinespecies.org at VLIZ. Accessed: April, 2023.

Received: 24 September 2024. Accepted: 02 December 2024. Published online: 04 February 2025.
Authors:
Darwin Camacho Biag, Institute of Fisheries and Marine Sciences, Camarines Norte State College, Mercedes Campus, San Roque, Mercedes Camarines Norte, Philippines, 4601, e-mail: darwin.biag@gmail.com
Sheena Forteo Furio, Institute of Fisheries and Marine Sciences, Camarines Norte State College, Mercedes Campus, San Roque, Mercedes Camarines Norte, Philippines, 4601, e-mail: sheenaforteofurio16@gmail.com

How to cite this article:
Biag D. C., Furio S. F., 2025 Occurrence and habit of shore crab (*Varuna litterata*) rafting on seaweed floaters in Camarines, Norte, Philippines. AACL Bioflux 18(1):285-298.