Edible crustacean fishery resources in Infanta, Pangasinan, Philippines: An assessment

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Abstract: Infanta is one of the coastal municipalities of Pangasinan located in the western seaboard of Luzon Island, Philippines. The town is known for its handline tuna fishing fleet; however, fishers may resort to other resources during periods when tuna fishing is restricted by inclement weather. Among these resources were crustaceans that can be caught in municipal waters. Crustaceans are vital resources in capture and culture fisheries of the town. However, various species differ in their economic value. Moreover, the demand varied depending to the season and period of their abundance. The documentation on the status of crustacean fishery resources in the area is still lacking. Hence, an assessment was conducted in 2021 to identify edible crustaceans including their capture methods and consumption habits of the target respondents. The results revealed a total of 26 species belonging to 15 families, which are exploited as food source. Varying methods were also identified, of which grasping is the most common. The method does not require any gear or device but lights during night time and receptacles made of bamboo are commonly used as accessories. With regards to the consumption habits of the respondents, most of the undervalued species are harvested and consumed primarily during lean periods while highly valued ones were prepared to the fisher's table, when there is abundance of catch during the harvest season.

Key Words: crustaceans, edible, richness, capture methods, consumption habits.

Introduction. Infanta is a coastal municipality situated in the western portion of Pangasinan covering 4.67% (98.18 mi^2) of the province total land area (Mendoza et al 2020; PhilAtlas 2022). The town is bounded by two river systems, Bayambang River on the north and Nayom River on the south, and on the west there is the West Philippine Sea (Aban et al 2017), one of the country's prominent fishing grounds. Its coastal waters and the inland bodies of waters traversing the town are rich in fisheries resources like fish, mollusks and crustaceans. Fishing is one of the major industries in the town (Province of Pangasinan 2022), where the municipal catches are dominated by tuna species (Aban et al 2017). Gleaning of bivalve resources is also considered as other sources of food for local consumption and as an additional source of income to town residents. Mendoza et al (2020) assessed that the coastal areas of the municipality hosted 30 species of bivalves belonging to 17 families. The species richness and abundance in the coastal waters of the town reflects the presence of important aquatic habitats such as seagrass beds, mangrove areas and coralline rubbles (Mendoza et al 2020). The sustainability of the town's fishery resources is attained through the strict implementation of fishery laws and local ordinances, mangrove reforestations, coastal clean-ups, and educating the local residents about the coastal resource management (Aban et al 2017).

Despite of the known richness of the town in terms of fisheries resources, there are few studies that has been conducted in the assessment of its economically important species, particularly crustaceans. The Philippines, which is located within the Indo-Malayan Triangle, known as the epicenter of global marine biodiversity (Burke et al 2002; Asian Development Bank 2014), is a home for a vast number of species. Crustaceans alone had 522 recorded species in the country, which belong to 207 genera under 58

families (Estampador 1959). Over the years, researches have been conducted and found new species in different islands of the country, including the recently recorded 6 species of brachyuran crabs and 2 species of mud lobsters, *Thalassina spinosa* and *T. kelanang* (Lagare et al 2020; Albarico et al 2020; Bedi & Primavera 2018). Some of the described and taxonomically identified species are of economic importance, providing food for the human consumption and commercial benefits. Other species were used as bioindicators in assessing the success of coastal habitat rehabilitations (Walton et al 2007). The study of Motoh & Kuronuma (1980) is one of the pioneering works on describing the common and edible crustaceans that are found in the Philippines. Studies on the assessment of the crustacean fishery resources have been done in several parts of the country, mostly in southern Luzon, Visayas and Mindanao (Subang et al 2020; Baobao et al 2014; Lagare et al 2020). However, the current knowledge on the crustacean fauna of Infanta, Pangasinan and the catching methods used by fishers are still not documented. Therefore, this study was undertaken to provide baseline information on the edible crustaceans caught in the coastal waters of the town, their habitat and conservation status and the fishing methods and practices of the local residents.

Material and Method. The study was conducted in the coastal town of Infanta, Pangasinan. A random interview was undertaken in the 6 coastal barangays of the town, namely: Bayambang, Batang, Cato, Patima, Poblacion and Nayom (Figure 1). Most of the communities in these areas are dependent on fishing and harvesting of aquatic resources from mangrove swamps, seagrass beds, coralline areas, brakishwater and freshwater rivers, and coastal ponds. A total of 100 fishermen were requested for a convenient interview. Basic information obtained includes the local name, fishing, fishing profile and consumption habits of edible crustaceans. In terms of consumption habits, the respondents were asked if the crustaceans that they have mentioned were consumed frequently or occasionally, during lean period or during harvest/catch season. The interview took place during the period of June to August 2021. After providing the local names of these crustaceans, live samples were requested from the fishers and photographs were taken using NTT Docomo tablet built-in camera. The specimens were stored at freezing temperatures for further characterization. Identification was based on the phenotypic characteristics of the crustaceans as compared to the published reference materials available online. In addition, the conservation status of the identified crustaceans was determined based from International Union for the Conservation of Nature (IUCN 2021). The taxonomy was determined and presented in a tabular form as well as the fishing profile for each group of identified crustaceans. Moreover, the data on consumption habits were organized and statistically analyzed using percentages.

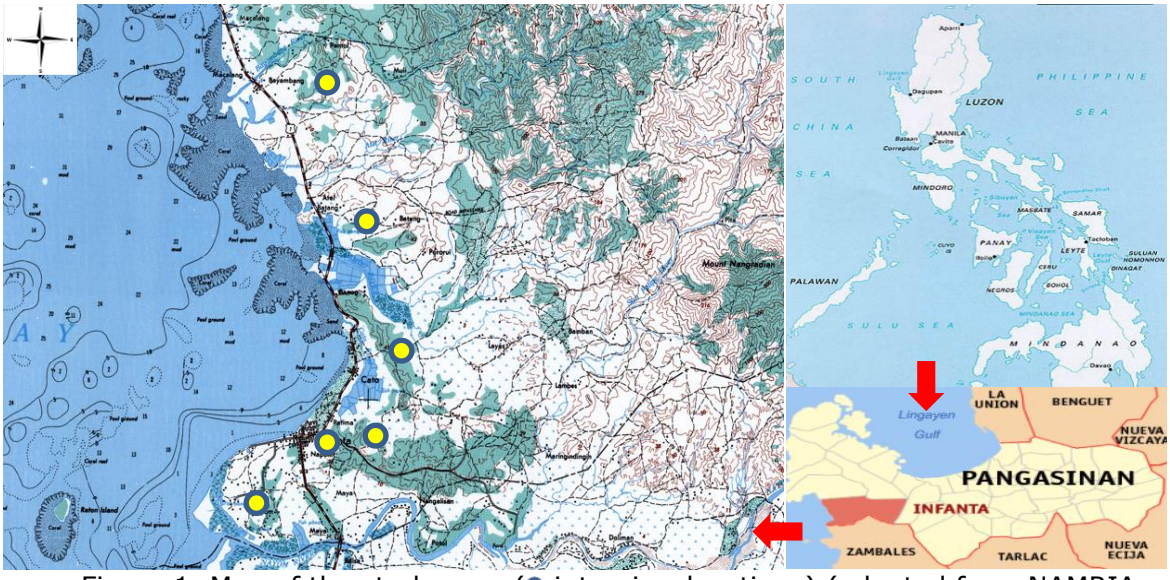

Figure 1. Map of the study area (o interview locations) (adapted from NAMRIA downloadable maps).

Results and Discussion. The result of the assessment showed that there are 26 species of crustaceans belonging to 15 families that are commonly caught in the municipal waters of Infanta, Pangasinan (Table 1).

Table 1

Taxonomy and conservation status of edible crustaceans consumed in Infanta, Pangasinan

Family	*Species*	*Common name*	*Local name*	*Conservation status (IUCN)*
Portunidae	*Portunus pelagicus*	Blue swimming crab	Dariway	Not evaluated
	Portunus sanguinolentus	Three-spot swimming crab	Dariway	Not evaluated
	Scylla serrata	Mangrove king crab	Rasa	Not evaluated
	Scylla olivacea	Orange mangrove crab	Rasa	Not evaluated
	Thalamita crenata	Crenate swimming crab	Arembukeng	Not evaluated
	Charybdis hellerii	Indo-Pacific swimming crab	Arembukeng	Not evaluated
	Charybdis feriata	Striped swimming crab	Arembukeng	Not evaluated
Gecarcinidae	*Cardisoma carnifex*	Brown land crab	Dakumo	Not evaluated
Varunidae	*Varuna litterata*	Shore crab	Kappi	Not evaluated
Macrophthalmidae	*Macrophthalmus* sp 1	Macrophthalmid crab	Apsay	Not evaluated
	Macrophthalmus sp 2	Macrophthalmid crab	Apsay	Not evaluated
Ocypopidae	*Ocypode cordimana*	Ghost crab	Tarukoy	Not evaluated
Carpiliidae	*Carpilius maculatus*	Spotted reef crab	Kummo	Not evaluated
Matutidae	*Ashtoret lunaris*	Moon crab	Kummo	Not evaluated
Sesarmidae	*Episesarma singaporense*	Sesarmid crab	Susulbo	Not evaluated
	Episesarma mederi	Sesarmid crab	Susulbo	Not evaluated
	Neosarmatium asiaticum	Sesarmid crab	Alais	Not evaluated
Penaeidae	*Penaeus monodon*	Black tiger prawn	Padaw	Not evaluated
	Penaeus vannamei	Pacific white shrimp	Pasayan	Not evaluated
	Metapenaeus ensis	Greasy back shrimp	Pasayan	Not evaluated
Palaemonidae	*Macrobrachium rosenbergii*	Giant freshwater prawn	Udang	Not evaluated
Atyidae	*Caridinia* sp	Freshwater atyid shrimp	Budto	Not evaluated
Alpheidae	*Alpheus* sp	Snapping shrimp	Tatala	Not evaluated
Palinuridae	*Panulirus longipes*	Longlegged spiny lobster	Kising kissing	Least Concern
Thalassinidae	*Thalassina* sp	Mud lobster	Ballasoy	Not evaluated
Squillidae	*Oratosquilla oratoria*	Mantis shrimp	Balbaltik	Not evaluated

Findings revealed that the catch is dominated by species of crabs (n=7) belonging to family Portunidae, followed by the family Penaeidae and Sesarmidae (both n=3), family Macrophthalmidae (n=2), and the remaining families were represented by a single species. Most of the identified edible crustaceans, namely: *Portunus pelagicus, P. sanguinolentus, Scylla serrata*, *Thalamita crenata*, *Charybdis feriata*, *Cardisoma carnifex*, *Varuna litterata*, *Ocypode cordimana*, *Ashtoret lunaris*, *Penaeus monodon*, *Metapenaeus ensis*, *Macrobrachium rosenbergii*, *Panulirus longipes*, and *Thalassina sp.* were already described in the works of Motoh & Kuronoma (1980) based on English and Philippine names, the biological descriptions, geographical distributions, as well as their economic importance.

Also, some of the identified species such as *P. pelagicus*, *S. serrata*, *P. monodon*, *P. vannamei*, *M. ensis*, *M. rosenbergii* and *P. longipes* were introduced for aquaculture production. The *P. pelagicus* commonly known as the blue swimming crab has been introduced for hatchery and seedstock production to address the increasing market demands on crabs and for resource enhancement purposes (Cabacaba & Salamida 2014). The two *Scylla* species, mud crabs or mangrove crabs, on the other hand are known to occur naturally in the Philippines, however, *S. serrata* is the preferred species for farming (Quinitio 2017). Preference in farming of *S. serrata* compared to *S. olivacea* may be attributed to the size, since the former known as the "giant mud crab" (Butcher et al 2012) has a higher value than the latter. Subang et al (2020) cited that the well-known sources of *S. serrata* for commercial purposes are located in the areas of Quezon and Roxas. *S. serrata* as described by Motoh & Kuronuma (1980) is one of the delicacies in the Philippine dishes, thus reaching a higher market price, ranging between USD 4.79–7.66 in Puerto Princesa, and USD 5.70-9.50 in Manila (Subang et al 2020). Moreover, not only this crab is sold in regular state but also farmed for soft-shell crab production. Soft-shell crabs has a higher economic value as it can be totally consumed when cooked, and also provides dollar income opportunity since there is an international market demand in countries like Hong Kong, Singapore, South Korea, Japan, Europe and the United States (Calpe 2015). Just like with the *P. pelagicus,* hatchery production for *S. serrata* were established to reduce pressure in the wildstock population, in order to suffice the increasing market demand in the mud crab industry. Furthermore, to minimize the intense pressure in the collection of crabs in the wild population, government regulations have been created. The Blue Swimming Crab Management Plan (BSCMP) has been developed in 2011, by the Department of Agriculture–Bureau of Fisheries and Aquatic Resources (DA-BFAR) along with the stakeholders in the crab industry, to ensure the sustainability of blue-swimming crab *(P. pelagicus)* in the country, through the Joint DA–Department of Interior and Local Government (DILG) Administrative Order No.01, series of 2014 (Yap et al 2020). On the other hand, the Fisheries Administrative Order No. 264, series of 2020, regulates the catching, possession, transporting, selling, trading and exporting of mangrove crablets, juveniles and mangrove crablets <12 cm CW of the wild and gravid mangrove crab populations. However, the FAO 264 has been temporarily suspended to support the economic recovery in the aquaculture sector, which was affected by the COVID-19 pandemic (The Fish Site 2021; Cudis 2021). In terms of shrimp and prawn industry, the country largely contributes to the global aquaculture shrimp production (Vergel 2017). As of 2013, there are 271 registered shrimp farms (3,617.8 ha) in the country, wherein 48% of them produce *P. monodon,* mostly polycultured with milkfish, while *P. vannamei* is cultivated by 27% (909.4 ha) of the total shrimp farms (Vergel 2017). The *M. ensis* are usually grown in extensive and semi-intensive systems in Thailand (Wattanamahard 1993). The *M. rosenbergii* is the only freshwater prawn cultivated in ponds and produced in several hatcheries in the Philippines. However, broodstock used in the hatchery production are mostly sourced from the wild. Based on Tayamen (2001), this species is reported to occur in lakes, rivers, tributaries and other freshwater bodies of water in numerous provinces of the country, such as: Ilocos, Cagayan, Pangasinan, Pampanga, Bulacan, Laguna, Palawan, Bicol region, Leyte, Samar, Cotabato, Lanao Provinces, Maguindanao, Agusan Provinces and some areas in Mindanao. Lobsters, as mentioned in the works of Becira & Orcajada (2006), have an excellent market demands in many countries, due to its fine flavor, and

generating higher revenues, particularly when it is sold live. The *Panulirus longipes longipes* is documented in the works of Gonzales & Taniguchi (1995) as one of the predominant lobsters caught in the province of Palawan and cited to be the most demanded species for export to Japan. In local markets, *P. longipes longipes* were sold at a price of USD 4.31–8.62 kg^{-1}, for good sized individuals (350–550 g) (Gonzales & Taniguchi 1995). Based on the International Union for the Conservation of Nature (IUCN), this lobster is in least concern status. However, Liu & Pu (2021) stated that there are still no population figures available for this species, which is likely to become vulnerable to the over-exploitation, due to its local and international market demands. Therefore, several researches have been conducted studies on the biology and culture of *P. longipes* (Becira & Orcajada 2006; Matsuda & Yamakawa 2000). Recently, the DA-FAO No. 265, series of 2020, has been introduced by the Philippine government, which regulates the catching, possession, transporting, selling, trading and exporting of puerulus, juvenile and gravid spiny lobster (Palinuridae), to address the significant drop in lobster production, caused by the fishing pressure in the country.

The conservation status of other commonly harvested edible crustaceans caught in Infanta, Pangasinan, such as: *Portunus sanguinolentus*, *Thalamita crenata*, *Charybdis helleri*, *C. feriata*, *Cardisoma carnifex*, *Varuna litterata*, *Macrophthalmus* spp., *Ocypode cordimana*, *Carpilius maculatus*, *Ashtoret lunaris*, *Episesarma singaporense*, *E. mederi*, *Neosarmatium asiaticum*, *Caridinia* sp., *Alpheus* sp., *Thalasinna* sp., and *Oratosquilla oratoria*, were not yet evaluated, based on the IUCN.

P. sanguinolentus, known as the three-spotted (or blood-spotted) swimming crab (Yang et al 2014), has a lower commercial value compared to the *P. pelagicus* because of its poor population and smaller size (Motoh & Kuronuma 1980). Subang et al (2020) state that this species is caught along with the *P. pelagicus* using crab traps, gill nets, "bintol" and trawler in Palawan. At present, however, findings of Subang et al (2020) showed that this species is sold for the same price as *P. pelagicus,* ranging from USD 2.87 to 3.83 in Puerto Princesa and USD 1.91–3.83 outside Palawan. However, little is known about the geographical distribution of this species in the Philippines.

T. crenata is distributed in Indo-Pacific region and preferably thrives in brackishwater, particularly in river mouths, extreme seaward fringe of the mangrove swamp and the intertidal platform in front of the mangal, and rarely inhabits in the clear sea water like coral reefs (Motoh & Kuronuma 1980; Cannicci et al 1996). This species is documented in the study of Subang et al (2020) where in it is caught in Palawan waters by artisanal fishermen, using crab pots or fishing nets. Due to its relatively smaller size, this species is sold for USD 1.15 kg^{-1} in Puerto Princesa (Subang et al 2020). Moreover, this species can be used as biological indicator in the effectiveness of mangrove rehabilitation, as seen in the works of Walton et al (2007).

The two species of *Charybdis, C. hellerii* and *C. feriata,* have been described in the study of Chung (2002). In its works, *C. hellerii* was known to be distributed in Africa, Red Sea, Mediterranean, Madagascar, Australia, Japan, China, Malaysia, Singapore and the coast of Center and South Vietnam, in which it was found to inhabit the intertidal area, rocky coasts and coral reefs. *C. feriata* is distributed in Africa, India, Madagascar, Australia, Japan, China, Malaysia, Singapore and in Vietnam (Tonkin Gulf, the coast of Central and South Vietnam). This species also thrives in rocky coast at 5–30 m deep. In 2004, *C. feriata* was first-ever recorded to be present in the Mediterranean Sea through tin gillnet catch, in the coastal waters of Barcelona, at a depth of 60–70 m (Abello & Hispano 2006). The authors assumed that the introduction of this exotic species was done through the ballast water tanks of the merchant ship. In the study of Subang et al (2020), it was reported that *C. feriata* is a by-catch of *P. pelagicus* fisheries in Puerto Princesa and that it is sold on the market at USD 2.87–3.83.

C. carnifex is a well-adapted terrestrial crab, inhabiting holes constructed in muddy substrates, in mangrove swamps or mudflats, near river mouths (Motoh & Kuronuma 1980). This species was reported to occur in Negros, Palawan, Balabac, Dinagat Island (NE of Mindanao) and recently in Zamboanga del Norte (Estampador 1959; Lagare et al 2020). Moreover, this species is usually caught for local consumption (Motoh & Kuronuma 1980; Subang et al 2020). *C. carnifex* is considered as toxic

(Jingkatal & Ramos 2019), but is not always poisonous, since its toxicity may be linked to the food consumed by the crab (e.g. poisonous fruits or leaves) (Ng 1998).

V. litterata, locally known as "talangka", is commonly found in mangrove areas, in the brackishwater and freshwater environments, in shallow sub-tidal regions, hiding under the rocks, logs and even dead leaves, and also thriving in burrows along the embankments of pools, creeks and shallow banks (Devi et al 2013). This crab has been recorded in the Philippines, as documented in the studies of Motoh & Kuronuma (1980), Subang et al (2020) and Lagare et al (2020). *V. litterata* is known as one of the delicacies in the Philippines for its *"aligue"* or crab roe. The *"aligue"* is detached from the carapace, processed and stored in glass jars. This is sold in Pangasinan for a price starting from USD 4.79.

Macrophthalmus spp. of the family Macrophthalmidae is distributed in the Indian Ocean, the West and Central Pacific Ocean from South Africa, the Red Sea and the Arabian Gulf in the west, to the Sea of Japan in the north, to Hawaii and Tuamotu Archipelago in the east, and to Tasmania and New Zealand in the south (Pancucci-Papadopoulou et al 2010). Aziz & Saher (2016) described this genus as a deposit feeder that thrives in sandy muddy substrates, with various morphological adaptations like having a spatulate chela utilized in collecting soft mud and sandy substrates for extraction of organic matter, and possessing specialized setae on their mouth appendages for the extraction of food from the sediment particles.

O. cordimana is a species of crab that is found in sandy beaches and known to occur in tropical Indo-Pacific region (Motoh & Kuronuma 1980). There is little information on the distribution of this species in the Philippines. However, this is reported by Subang et al (2020) to be present in the municipalities of El Nido and Sofronio España in Palawan, Philippines. This species is caught by people living in rural areas for own consumption only (Motoh & Kuronuma 1980).

C. maculatus of the genus *Carpilius* is classified under second category of toxic crabs, mildly poisonous and/or occasionally poisonous, that causes illness but rarely death when consumed. Poisonous characteristics of this crab varies in most instances and may associated in the food habits of the crabs like when the crabs have consumed toxic algae during red tide or dinoflagellate blooms (Ng 1998).

Ashtoret lunaris, formerly *Matuta lunaris* as mentioned by Subang et al (2020), is a species of crab usually inhabiting in the surf zone of tropical sandy shores, with a depth of 15–20 m (Turan et al 2015). This crab is widespread in the Indo-Pacific area including Japan, China, Philippines, Red Sea, South Africa, Australia (Motoh & Kuronuma 1980), and firstly reported to be present in Turkish water on August 2015 (Turan et al 2015). In the Philippines, this species has been reported to be present in the waters of Palawan and Basilan (Subang et al 2020; Jingkatal & Ramos 2019). However, this crab has no commercial value and is considered a part of the by-catch of beach seine fishery (Subang et al 2020). But it is also collected by some coastal dwellers for direct table consumption (Motoh & Kuronuma 1980; Subang et al 2020).

Episesarma genus was described by Sivasothi (2000) as herbivorous, burrow-dwelling and facultative tree-climbers. Its herbivorous food habit is observed primarily with the morphology of its partially excavated tip cheliped and gut content which contains mainly vascular plant materials, while its burrowing and climbing habit is synchronized with the rising and ebbing tides (Sivasothi 2000). In the Philippines, studies on feeding and behavior patterns of mangrove climbing sesarmid crabs have been conducted by Masagca (2009) and Matillano et al (2018). In addition to the food preference of *Episesarma,* Matillano et al (2018) observed that this genus was also fed on senescent and decayed leaves, and fragments of roots and twigs. In terms of tree climbing patterns, the observations of Matillano et al (2018) are in accordance to the findings of Sivasothi (2000), where the sesarmid crabs climbing behaviours is influenced by tidal patterns. Further, *Episesarma* spp. were observed to burrow and hide in mangrove crevices, in between roots and buttresses, and dead mangrove logs (Matillano et al 2018), but when high tide approaches their resting place, they climb up to the mangrove trunks and branches (Matillano et al 2018; Masagca 2009). In Asian countries, *Episesarma* spp were consumed as food, either pickled in black sauce with vinegar or

salted, with the roe or fried (Ng & Sivasothi 2001). In this study, there are two sesarmid crabs that have been identified, namely *E. singaporense* and *E. mederi. E. singaporense* is one of the more common species of *Episesarma,* but it is sometimes confounded with *E. chentongense,* as there is a close similarity of the colour of their chela, except for the colour of granules on the proximal half of the palms of the chela which are white, while in *E. chentongense* they have a red colour (Lee et al 2015). *E. mederi* can be distinguished through its palm colour: purple to violet on the top half to the dactylar finger, red from the bottom half to the propodal finger, its finger tips are white (Lee et al 2015). In addition, *E. mederi* is sexually dimorphic, whereas males are larger and heavier than females; in terms of gonadal development, males are undergoing two stages, while females had five stages (Leonida et al 2020). Further, *E. mederi* is reported to be present in Capiz, Philippines while *E. singaporense* was reported in Anibong Bay, Tacloban City, Philippines (Leonida et al 2020; Matillano et al 2018).

Neosarmatium asiaticum is one of the new species described in the work of Ragioneri et al (2012) in the revision of the *Neosarmatium meinerti* species. Recently, *N. asiaticum* has been reported by Lagare et al (2020) as one of the newly recorded species of brachyuran fauna in Mindanao Island. The crab was distinct with other *Neosarmatium* spp with its light yellow cheliped, brownish carapace with a thin yellow margin on the anterolateral and supraorbital margins, and with a reddish-orange coloration of its ambulatory legs (Lagare et al 2020). Further, this crab was observed to inhabit in muddy burrows, underneath the dead palm branches in mangrove swamps, in the same habitat as *Cardisoma carnifex* and other sesarmid crabs, such as *N. fourmanoiri* and *Tiomanium indicum* (Ragionieri et al 2012; Lagare et al 2020).

The genus *Caridina* of Atyidae family is diversified, comprising 302 species, and is reported to occur in the Indo-Pacific region (De Grave et al 2015; Chen et al 2020). In the Philippines, the recorded species under this genus were described in the published works of Cai & Shokita (2006) and Blanco (1939). This genus includes the species of *C. laoagensis*, *C. sumatrensis*, *C. serratirostris*, *C. celebensis*, *C. villadolidi*, *C. brevicarpalis*, *C. endehensis*, *C. peninsularis*, *C. elongapoda*, *C. gracilipes*, *C. gracilirostris*, *C. cebuensis*, *C. buhi*, *C. palawensis*, *C. mindanao*, *C. leytensis*, and *C. celestenoi.*

The genus *Alpheus,* snapping shrimp, has more than 250 known species worldwide and thrives on live and dead corals, in tide pools, in intertidal areas, in burrows, in sand and muddy substrate, seldom found under rocks and frequently found in association with some invertebrates and fishes (Kim & Abele 1988). In the Philippines, the study of Baobao et al (2014) demonstrated that abundance of *Alpheus* sp. declined, with an average catch per gatherer of 75 pieces per day, as compared to the average daily catch in the 1980s and 1990s, ranging from 150–300 pieces per day. Findings suggest that conversion of mangrove swamps into fishponds, cutting of mangroves for firewood production and unrestricted collection of the snapping shrimps for local and commercial consumption were the probable cause for the decline of the wild snapping shrimp population.

Based from the review of Sakai & Türkay (2012) and the works of Lin et al (2016), the genus *Thalassina* currently comprises 10 species that are distributed in the subtropical and tropical regions of the Indo-West Pacific Ocean. At present, there are four species of *Thalassina* recorded in the Philippines, namely *T. anomala* (Motoh & Kuronuma 1980), *T. squamifera* (Ngoc-Ho & de Saint Laurent 2009), *T. spinosa* collected in the mangrove swamp in Panay Island (Bedi & Primavera 2018), and recently discovered *T. kelanang* which is found in the mangrove forest of Suyac Island, Sagay City, Province of Negros Occidental (Albarico et al 2020). Further, *T. anomala* was included in the list of edible crustaceans in the Philippines and it is reported to be occasionally sold in local fish markets (Motoh & Kuronuma 1980).

Oratosquilla oratoria is widespread in the coastal waters of Japan, China, the Philippines, the Malay Peninsula, the Hawaiian Islands, Korea, Vietnam, Siberia and Australia (Chen et al 2019; Yan et al 2017). This shrimp inhabits the muddy or sandy mud substrates, at a water depth of 10–20 m, and are also observed to occur in substrates with high silt and clay content (Yan et al 2018; Li et al 2020). During the breeding season, Li et al (2020) found that this species tends to aggregate in inshore

waters, when the sea bottom temperature is relatively high, while in offshore they are found during winter season. This shrimp is an economically important food resource (Kim et al 2017) and is frequently caught by commercial trawls (Manning 1998).

The result of the study may suggest that Infanta, Pangasinan harbors diverse species of edible crustaceans, important to sustenance fishing. Findings reflect the presence of suitable habitats in the area, such as coral reefs, mangrove areas, seagrass beds and sandy and muddy bottom substrates (Mendoza et al 2020). However, there is no consolidated information on the status of the identified fishery resources in the municipality. As such, comprehensive studies on the biology, ecology and assessment on the abundance of each species should be conducted to provide baseline information in the management of these resources. The identified crustacean species are shown in Figure 2.

Figure 2. Edible crustaceans in Infanta, Pangasinan: (a) *Portunus pelagicus*; (b) *Portunus sanguinolentus*; (c) *Scylla serrata*; (d) *S. olivacea*; (e) *Thalamita crenata*; (f) *Chraybdis hellerii*; (g) *Chraybdis feriata*; (h) *Cardisoma carnifex*; (i) *Varuna litterata*; (j.1) *Macrophthalmus* sp. 1; (j.2) *Macrophthalmus* sp. 2; (k) *Ocypode cordimana*; (l) *Carpilius maculatus*; (m) *Ashtoret lunaris*; (n) *Episesarma singaporense*; (o) *E. mederi*; (p) *Neosarmatium asiaticum*; (q) *Penaeus monodon*; (r) *P. vannamei*; (s) *Metapenaeus ensis*; (t) *Macrobrachium rosenbergii*; (u) *Caridinia* sp.; (v) *Alpheus* sp.; (w) *Palinurus longipes*; (x) *Thalassina* sp.; and (y) *Oratosquilla oratoria*.

The methods employed in capturing edible crustaceans including the gear used, accessories and harvesting period are indicated in Table 2. Assessment revealed that there are 7 methods used by fishers in the area to catch edible crustaceans. Of these, the most common one is the use of only bare hands, such as grasping, hand catching or picking. In this method, the fishers are usually departed from their homes with their woven bamboo splits receptacles to their traditional fishing areas (intertidal zone, mangrove area and freshwater creeks). The fishers are patiently searching in a small area using their bare hands until crustaceans hiding in dead coral crevices, sand and mud are groped and then sudden grasp will be made. According to fishers, this method is the most practical, but with the least efficiency.

Table 2

Methods used in capturing edible crustaceans

Crustacean group	*Fishing environment*	*Method*	*Gear used*	*Accessories*	*Harvesting period*
Mangrove crabs (Rasa)	Brackishwater rivers and ponds	Grasping/grappling (kammel, sabal), Trapping (pakat)	Tong (pang-ipit), Fyke net (puket)	Receptacle (alat)	Daytime, night time
Swimming crabs (Dariway)	Maine	Grasping (kammel), Entangling, Scooping	Crab net (sigay), Scoopnet (karwas, sagsag), Push net (sagap), crab/fish pot (tapangan)	Receptacle (alat), Fishing light (Petromax, Rechargeable light)	Daytime, night time
Coral and smaller swimming crabs (Arembukeng)	Marine	Skin/free diving (batok), Grasping (kammel), Entangling, Scooping	Crab net (sigay), Scoopnet (karwas, sagsag), Push net (sagap)	Receptacle (alat), Fishing light (Petromax, Rechargeable light)	Daytime, night time
Brackishwater prawns and shrimps (Padaw, Pasayan)	Brackishwater rivers and ponds	Grasping (kammel), Wounding (tagbat), Tapping (pakat), Scooping	Bolo (buneng), Fyke net (puket), Push net (sagap)	Receptacle (alat), Fishing light (Petromax, Rechargeable light)	Night time
Freshwater shrimps and Prawns (Budto, Udang)	Freshwater rivers	Grasping (kammel), Wounding (tagbat), Trapping (pakat), Scooping	Bolo (buneng), Shrimp trap (barekbek), Push net (sagap)	Receptacle (alat)	Daytime
Moon crabs (Kummo)	Marine	Grasping (kammel), Scooping	Scoopnet (karwas, sagsag)	Receptacle (alat), Fishing light (Petromax, Rechargeable light)	Daytime, night time
Lobster (kising kising)	Marine	Skin/free diving (batok)	Scoopnet (karwas, sagsag)	Polaroid goggle, paddle fins, fishing light (flashlight)	Daytime, night time
Mud lobster (Ballasoy)	Brackishwater rivers	Trapping (pakat)	Bamboo trap (saltok)	Receptacle (alat)	Daytime
Large land crab (Dakumo)	Terrestrial; Bracksihwater	Digging (kali), Hand catching (sabal), trapping (pakat)	Bolo (buneng), Steel hook (pagsukit), bamboo jungle trap (saltok)	Receptacle (alat)	Daytime

Crustacean group	*Fishing environment*	*Method*	*Gear used*	*Accessories*	*Harvesting period*
Purple marsh crab (Susulbo)	Terrestrial; Brackishwater	Grasping/handpicking (kammel, piduten),	-	Receptacle (alat) fishing light (flashlight)	Night time
Small semi-terrestrial crab (Alais)	Terrestrial; Brackishwater	Grasping/handpicking (kammel, piduten),	-	Receptacle (alat) fishing light (flashlight)	Night time
Shore crab (Kappi)	Brackishwater; Freshwater	Trapping (pakat)	Fyke net (puket), crab trap (barekbek)	Receptacle (alat)	Daytime, night time
Mantis shrimp (Balbaltik)	Marine	Grasping (kammel), Wounding (tagbat), Scooping	Bolo (buneng), Push net (sagap)	Receptacle (alat), Fishing light (Petromax, Rechargeable light)	Night time
Snapping shrimp (Tatala)	Brackishwater	Grasping (kammel), Wounding (tagbat), Scooping, trapping (pakat)	Bolo (buneng), Push net (sagap), Fyke net (puket)	Receptacle (alat)	Daytime
Ghost crab (Tarukoy)	Terrestrial; Marine	Digging (kali), Hand catching (kammel, sabal)	Bolo (buneng), Steel hook (pagsukit)	Receptacle (alat) fishing light (flashlight)	Daytime, night time
Macropthalmid crab (apsay)	Brackishwater rivers	Trapping (pakat)	Fyke net (puket)	Receptacle (alat)	Daytime, night time

Grouping of the identified crustaceans was made based on their taxonomy and local names given by the respondents. Based on the results, the most frequently cited groups are swimming crabs (dariway), mangrove crabs (rasa), brackishwater shrimps and prawns (padaw, pasayan), coraline and other smaller swimming crabs (arembukeng), and freshwater shrimps and prawns (udang) (Figure 3). This result suggests the importance of these groups as sources of proteins and other nutrients for fishing communities.

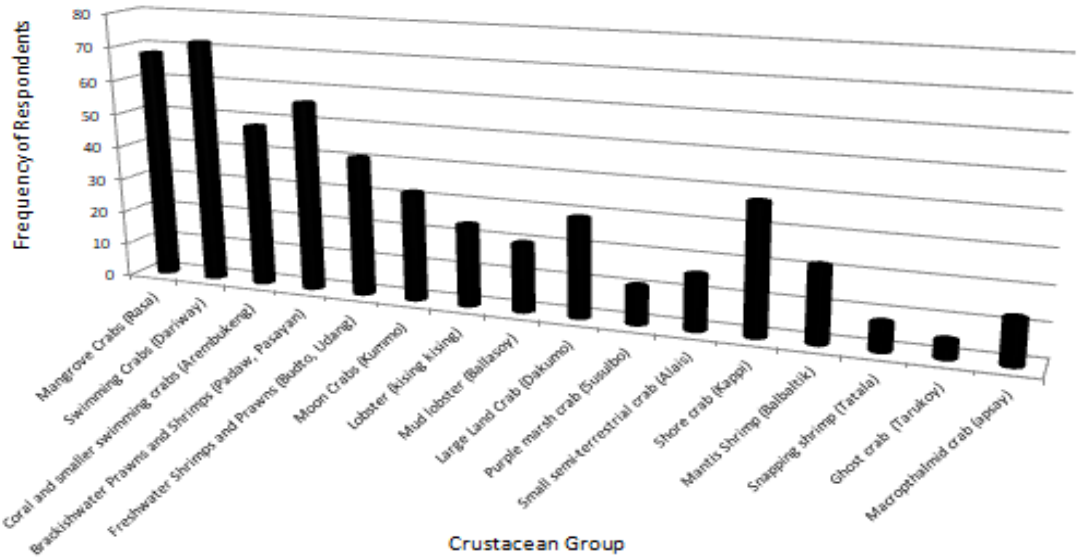

Figure 3. Commonly group of edible crustaceans.

The use of traps is also common in the area. Fishers used different types of hand-made traps such as fyke nets (puket), crab/fish pots (tapangan), shrimp traps (barekbek) and bamboo trap (saltok). Fyke nets in the area are smaller compared to those utilized in other municipalities. This could be due to the smaller width of the river where these are installed. The gear is stationary and primarily made from bamboo post and netting panels. During setting, the mouth is oriented to the current flow and filters the water that passes towards the codend where the crustaceans are trapped and ultimately caught. Since the gear is used in brackishwater rivers, fishing effect is dependent on tidal cycles. Most crab/fish pots in the area are commonly made from woven bamboo strips with an opening and non-return-valve. The gear is used for catching swimming crabs (dariway). Crab fishers claimed that they are deploying 20-30 crab pots during a fishing operation. The gear is commonly baited with trash fish. Setting is done during night time and hauling of gear and catch is carried out in the morning. Similarly, shrimp traps are woven bamboo splits. The traps are set in shallow freshwater creeks to capture freshwater prawn and shrimp (udang, budto). Meanwhile, saltok is similar to the bamboo trap used in the jungle. This gear is considered among the primitive technologies used in capturing burrowing crustaceans. It is tubular in shape with a trigger. When the animal hits the trigger, the entrance will be closed by a piece of bamboo stick connected to the trigger by a nylon string. The gear is set by positioning the entrance of the tube, to the hole where the target crustacean is living. Prior to setting, the mound is removed and water is pour into the hole to disturb the target. The fisher will wait for 2-3 hours before returning to the area and assess if the gear has caught the target.

The entangling method involves the use of a crab net. This gear is quite similar to gill net. However, it comprises two layers of netting with different mesh size. It is set in the coastal waters and rivers perpendicular to the current. Fishing operation is made both in daytime and night time. Scooping is another method that is considered more efficient in catching crustaceans. Two types of gears use this method, the scoopnet (karwas) and the push net (sagap, sagsag). The push net is a portable gear that resembles a big

scoopnet made from a fine-meshed netting material with a collapsible bamboo frame and "slippers" (coconut husk, wood). The gear is operated in coastal waters and rivers by walking along a certain distance. According to the fishers, common catches include *Penaeid* shrimps, swimming crabs, crenate crabs and juvenile fishes. Scoop net on the hand is a type of netting fastened to a circular metal or bamboo frame with a bamboo handle. This is used in shallow waters and canals. In some cases, this gear is used as a receptacle.

Wounding and grappling methods involves the use of simple gears such as sticks, bolo and tongs. Wounding is commonly employed in targets that move quickly. However, this method may affect the quality of the catch. Meanwhile, grappling may require tongs and strings/cords when the crustacean is bigger and difficult to handle by only using bare hands. In some cases, wounding and grappling is employed by skin/free divers in addition to handpicking of lobsters and coral crabs.

Fishing light is an important accessory during night time fishing. Three types of fishing lights are identified in the area: pressurized kerosene lamps (Petromax), rechargeable lights and battery-operated lights. This fishing aid is required in almost all methods used in capturing edible crustaceans.

It can be seen from the result that the methods used by the fishers of edible crustaceans in the area are holistic. Also, the identified methods were not prohibited by the existing law for fisheries management (The Philippine Fisheries Code of 1998). Some of the gears and accessories identified in this study were already described by Motoh (1980). In his publication, the gears used in the shallow water fishery of shrimp and prawn are mostly made from synthetic netting and bamboo materials. However, in the field guide of Motoh & Kuronuma (1980) for the edible crustaceans of the Philippines, some active gears were used which are no longer allowed at present in municipal and inland waters. Moreover, recent studies indicated that some of these methods belong to the traditional techniques employed in different areas of the Philippines (Asia et al 2015; Baleta et al 2017; Balisco et al 2019).

As shown in Figure 4, the assessment revealed that most of the edible crustaceans identified in Infanta, Pangasinan are commonly consumed during lean periods. Meanwhile, there are groups such as mangrove crabs, swimming crabs, shrimps and prawns, lobster and shore crabs that are usually prepared in the table during their harvest or catch season. Moreover, the resources are not frequently or occasionally consumed due to market value, seasonal abundance and demand.

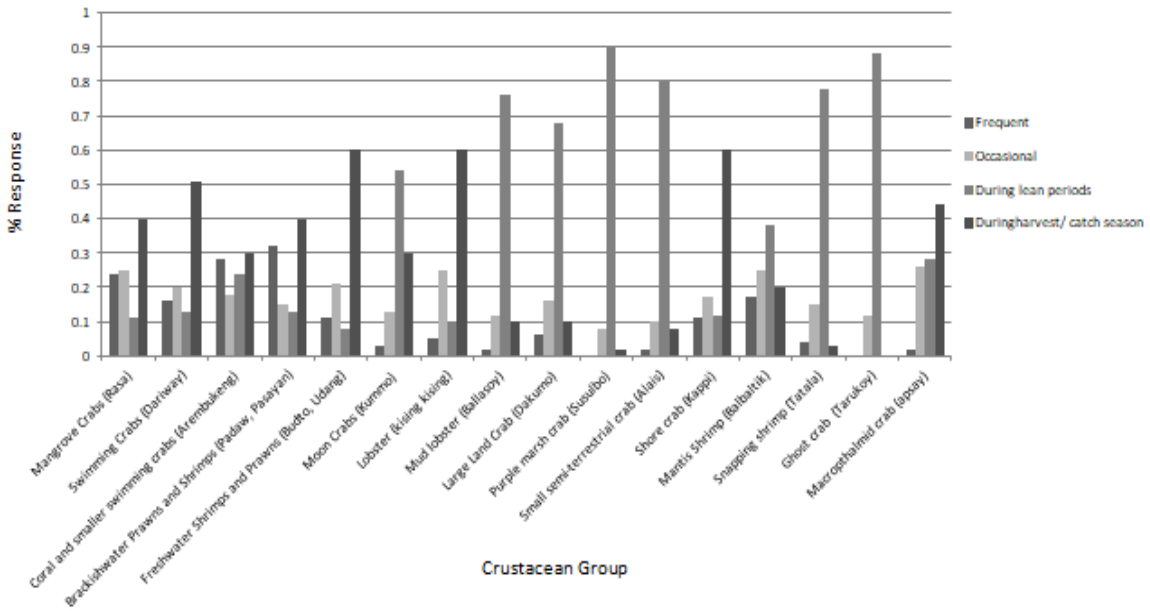

Figure 4. Consumption habits of the respondents regarding edible crustaceans.

The respondents claimed that highly valued catches such as mangrove crab, swimming crabs and lobsters were directly sold to the neighborhood or middlemen to earn some cash for the family's basic needs instead of serving to their plate. They only serve portions of their catch during periods when there is abundance of these highly valued species. Meanwhile, the demand of undervalued species like as moon crab, mud lobster, terrestrial crab, mantis shrimp, snapping shrimp and ghost crab increases during lean periods. In this period, fishing in commercial waters is restricted due to the effect of monsoon rains and incoming typhoons. Thus, these resources played a preponderant role in the diet of the fishing communities during lean periods.

Conclusions. Based from the result of the preliminary assessment, it was concluded that there are 26 species belonging to 16 families considered as edible crustaceans in the municipality of Infanta, Pangasinan. The conservation status of the resources is still not evaluated, except for *P. longiseps*, with a least concern status according to the International Union for the Conservation of Nature (IUCN). Moreover, the resources are captured in different fishing environments using various types of sustainable fishing methods such as grasping, trapping, entangling, free-diving, wounding, digging and scooping. Consumption habits can be considered frequent but still occasional, when there is no other option and during periods of harvest abundance. However, most edible crustaceans, particularly the undervalued species, are commonly exploited during lean periods when commercial fishing is restricted by inclement weather condition. The current study only provides baseline information on the richness of edible crustaceans in the municipality, but is an important initiative for further and deeper assessments. There is still dearth of information regarding the status of identified edible crustaceans in the area and even in the entire Philippines. Some of the species observed remained uninvestigated or undocumented and were first reported in this study. These species were considered by the locals to have a significant contribution to their diet during the lean periods. Thus, these species have a great potential for the food security. However, further investigation is highly indispensable to determine the overall status of these resources. It was observed that several anthropogenic activities are now conducted in the study area that could alter their habitats and may endanger their population. Thus, future research supporting the sustainable use of these resources is strongly recommended.

Conflict of interest. The authors declare no conflict of interest.

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