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SHORT COMMUNICATION

How Filipino Fishers Use Traditional Knowledge in Identifying Species of Juvenile Mangrove Crabs for Grow-out Culture

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ABSTRACT

Mangrove crab growers in the Philippines still rely on wild-caught late instar to early juvenile mangrove crablets, as supplies from hatcheries are limited. Any batch of crablets caught from the wild is a mix of the three native species under the genus *Scylla*. *Scylla* species have different growth rates. Since grow-out culture depends heavily on species' growth, growers should be able to distinguish the species as early as the juvenile stage, which is taxonomically difficult. This study was done to consolidate low-cost traditional identification techniques for juvenile Scylla from fishers of the Philippines for future validation. Focused group discussions were done in fishing communities from Bataan, Pangasinan, and Cagayan on the island of Luzon. The study was continued through online surveys, as travel was restricted due to the Covid-19 pandemic. Results indicate that 70.58% of respondents identify the species of crabs by looking at their claws and 55.88% observe the color of the crabs. Almost half, or 41.17% of respondents, consider the width and size of the carapace. Unique methods in certain Philippine regions include observation of the behavior patterns, carapace texture, rate of weight gain, and seasonality. Validation of the traditional practices identified in this study would result in a reliable "at-a-glance" method of identifying juvenile *Scylla* in the Philippines, which would shorten the culture period, improve production gains, and manage local populations.

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Mangrove crabs (*Scylla* spp.), locally known as "alimango," are high-value commodities with large local and export markets. Of the four species in the genus *Scylla*, only three species have been recorded in wild populations in the Philippines, namely *Scylla serrata*, *S. olivacea*, and *S. tranquebarica* (Fig. 1). The Philippines produced over 16,000 MT of farmed mangrove crabs and was second only to China as the world's largest producer of mangrove crabs in the year 2013 (FAO 2015 as cited in Quinitio and Parado-Estepa 2017), and the production rate was steadily increasing in the recent years with 18,100 MT in 2017; 20,769 MT in 2018; and 20,771 MT in 2019 (Fig. 2) (Philippine Statistics Authority 2020).

Despite *Scylla* cultivation being one of the fastest-growing fisheries industries in the Philippines and the Indo-Pacific region, growers would still grow wild-sourced crablets due to the limited supply from hatcheries (Vince Cruz-Abeledo et al. 2020). Growers produce wild-caught late instar to early juvenile mangrove crabs with carapace width ranging from 10 to 60 mm in fishponds (Vince Cruz-Abeledo et al. 2018). Any batch of crablets captured from the wild is a mix of the three species due to their overlapping ranges (Walton et al. 2006). Therefore, fishers need to differentiate the crablets to species before crab farming as the species are ideally not grown together due to their different morphologies and capacities for growth to maximize production gain. For example, *Scylla olivacea*, which grows relatively smaller, is more prone to predation of the bigger species (Waiho et al. 2015). Its smaller size, however, is best suited for soft-

Figure 1. Representative samples of the three *Scylla* species native to the Philippines, confirmed through molecular identification. Photos taken by Dr. Chona Camille VinceCruz-Abeledo

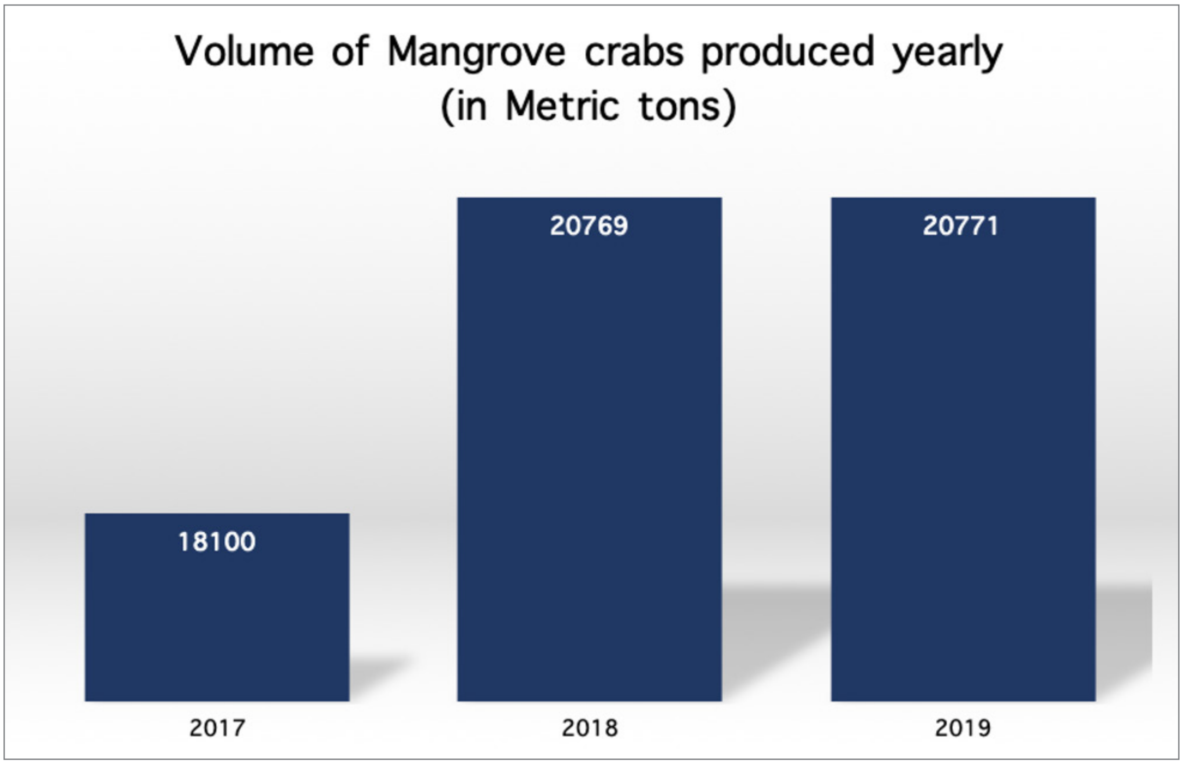

Figure 2. Production rate of mangrove crabs in the Philippines in the recent years

shell crab farming. On the other hand, *Scylla serrata* is preferred as it grows relatively faster and remains robust in various conditions (Hastuti et al. 2019 as cited in Vince Cruz-Abeledo et al. 2020).

Taxonomic identification of decapod crustaceans, where mangrove crabs belong, is quite complicated even to a technical person due to the complex morphological structure of this group. A combination of morphological, morphometric, and molecular techniques has been used to identify the species. In adults, the distinctness and location of geometric patterns in swimming and walking legs is found to be the primary diagnostic character as confirmed by molecular species identification. Geometric patterns on appendages; presence or absence of inner carpus spine; conformation of dactyl prominence; frontal lobe spine shape (Fig. 3); and carapace color can also be used (Vince Cruz-Abeledo and Lagman 2018).

These diagnostic markers that are useful for adults only become evident when the carapace width reaches at least 80 mm (Keenan et al. 1998), and there are not many studies on diagnostic markers to identify species in earlier stages. Although the use of frontal lobe spine shape has been proven useful, the subtle differences in morphology can only be accurately detected using image analysis technology (Vince Cruz-Abeledo et al. 2018).

Several reference materials such as manuals, handbooks, and field guides on identifying crab species

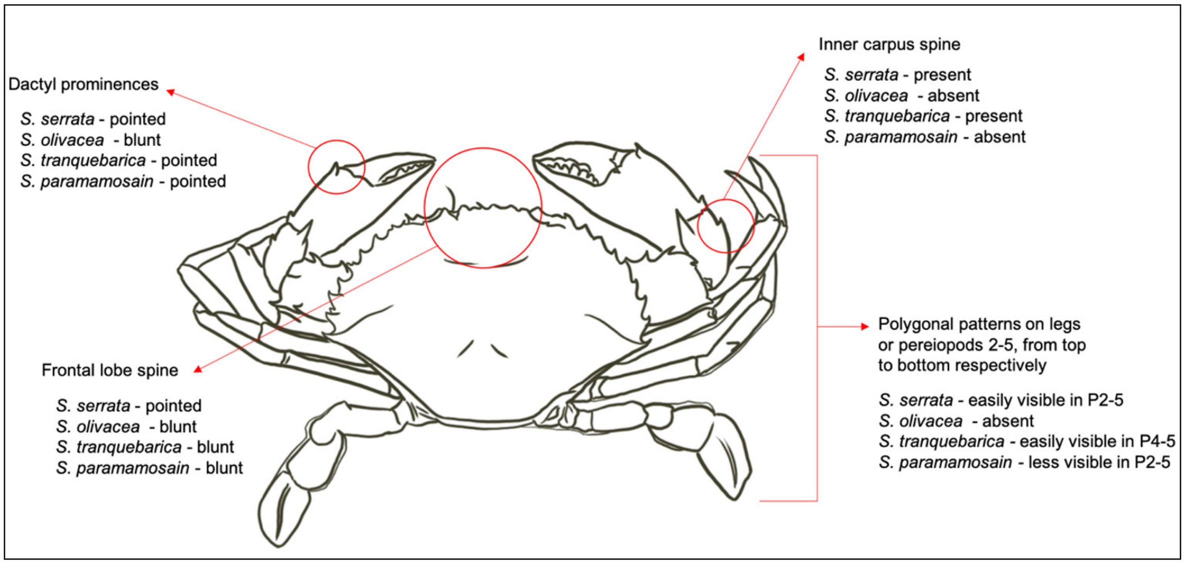

Figure 3. Morphological characters that distinguish adult *Scylla* species based on the dichotomous key developed by Keenan et al. (1998). *Scylla* composite drawing by Ms. Courtney Anne Ngo.

have been published. However, these materials are not readily accessible to the fishing communities and are highly technical for the stakeholders to understand. As more and more people depend on crab farming as their livelihood due to the steady increase in trading rates, growers have to rely on the traditional ecological knowledge or TEK to address the issues on the identification of juvenile Scylla for grow-out culture. TEK has been referred to as the system of knowledge production by indigenous peoples. It consists of know-how accumulated across generations, renewed in each coming generation, and guides the interactions of human societies with their environment (Nakashima et al. 2012).

This study involving focused group discussions and online interviews was carried out in different localities to consolidate traditional "at-a-glance" methods used by Filipino fishers in identifying juvenile Scylla species.

Focused group discussions were done with mangrove crab fishers, growers, and traders from high-production localities in Luzon such as Cagayan, Pangasinan, and Bataan (Fig. 4). A total of 80 participants were involved, with 30 from Cagayan, 20 from Pangasinan, and 30 from Bataan. Participants were randomly divided into 10 participants per group at each site.

The study was continued through interviews involving mangrove crab growers and traders from different regions in the Philippines done via online platforms due to travel restrictions brought about by the Covid-19 pandemic. Participants in the study were from Regions III and V in Luzon, Regions VI and VIII in Visayas, and Regions IX, X, and CARAGA in Mindanao (Fig. 4), all with high productions of mangrove crabs. A total of 34 respondents were interviewed thru Facebook Groups, Messenger, and Google Forms. In addition, cellular texts and calls were also made to follow up on respondents who do not have easy access to the internet.

Participants in interviews and focused group discussions were asked how they identify juvenile crabs, what features or parts they look at to identify juvenile crabs, the effect of misidentification on production, and the effect of environmental changes on production, and pond management practices.

Participants were made aware of the purpose of the study and what their participation involved. Informed consent forms validated by De La Salle University's Ethics Review Committee were also provided and signed by the participants. Standards in the handling of collected information were followed in this study.

Focused group discussions indicate a preference for the larger *Scylla serrata* species and a preference for the use of carapace color for species identification. Mangrove crab fishers and growers from Luzon all prefer the species *Scylla serrata*, which the majority call by the local name "bulik." The growers prefer them due to their hardiness and capacity to grow well across varying environmental conditions. In addition, they prefer to have a reliable means of species identification as they have reported issues with

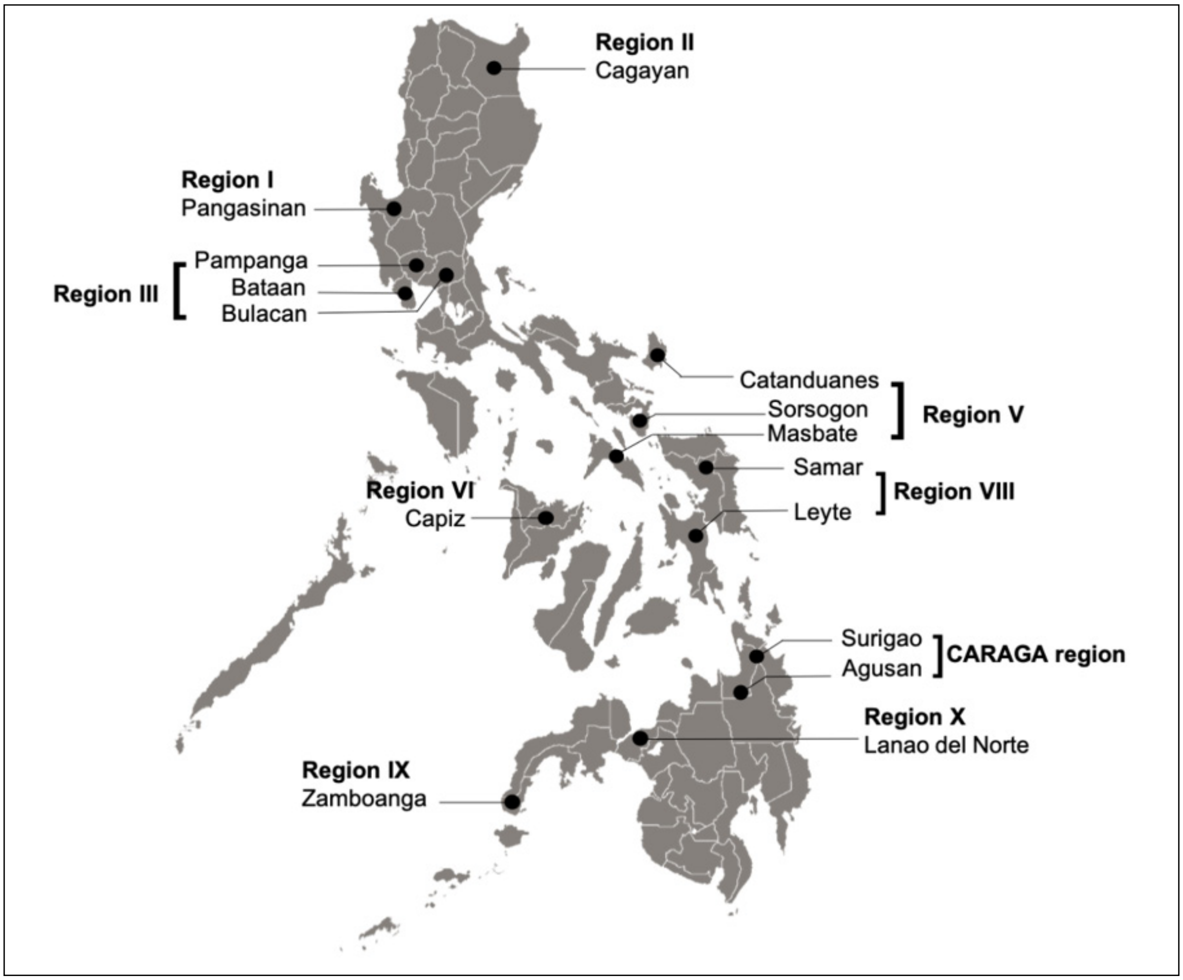

Figure 4. The locations of the sites visited and surveyed, representing some of the major production sites of mangrove crabs in the Philippines based on Fisheries Statistics of the Philippines 2017-2019 by PSA, p. 266 (2020).

traders who claim to be selling the preferred species of juveniles but would end up being the local smaller species they call "pulahan", which is *S. olivacea.*

Growers from different localities speak of different characteristic coloration of the species. For example, growers in Pangasinan speak of three colorations: "pulahan" or reddish, "maberde" or greenish, and purplish. They can specify the greenish specimens as *S. serrata* as it grows bigger while the smaller *S. olivacea* is referred to as reddish. The purplish species, most likely *S. tranquebarica*, are kept for their own consumption. In Cagayan, farmers only speak of two colorations, "mapula" or reddish, and "maputi" or whitish. Like the farmers in Pangasinan, they were able to specify the bigger one, *S. serrata*, and refer to it as the whitish specimen. On the other hand, they could not state the species of the reddish specimens but simply indicated that these do not grow as big. Additionally, fishers from Luzon also look at the ventral carapace and legs (Fig. 5) to distinguish one species from another. Reddish joints are said to belong to the "pulahan" species, which is the local name for *S. olivacea*. Still, no means to differentiate between *S. serrata* and *S. tranquebarica* were given.

However, the use of coloration in ventral carapace to identify species has previously been shown as unreliable (Vince Cruz-Abeledo et al. 2020). Individuals with red pigmentation in the ventral carapace, verified by molecular techniques, were still seen as a mix of all three species. As *S. olivacea* has less tolerance to heat (Baylon 2011 as cited in Vince Cruz-Abeledo et al. 2020), its carapace may redden faster. Therefore, the distinguishing characteristic is not characteristic of the species but is brought about by its environment and which would vary with season and locality. Apart from this, mangrove crab diseases that have been documented in the area might cause the ventral carapace to turn red.

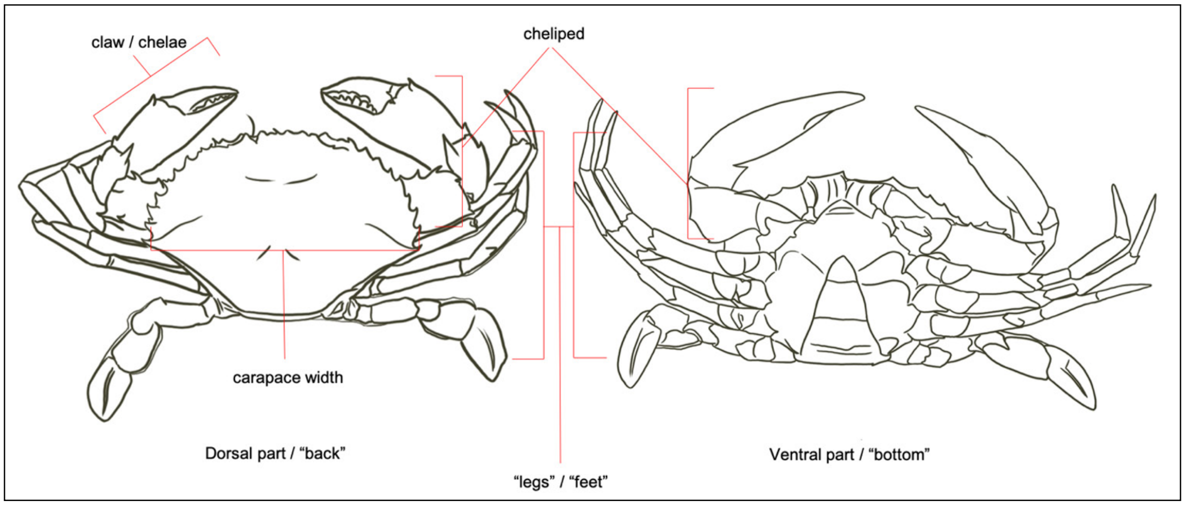

Figure 5. Morphological features that stakeholders look at to identify juvenile *Scylla*. *Scylla* composite drawing by Ms. Courtney Anne Ngo.

Online interviews revealed the techniques commonly used to identify juvenile Scylla in different regions (Fig. 6). The majority of the respondents identify mangrove crab species by observing their claws (Fig. 5). These respondents mentioned that the claws of *Scylla serrata* are usually larger than the claws of the other species, that the edges of the claws of *S. serrata* have visibly sharper "edges" or spines, and that its color varies from dark green to purple.

More than half of the respondents observe the carapace and chelae color (Fig. 5). These respondents pointed out that the chelae color of *S. serrata* usually is dark green or blue-green, *S. olivacea* has a reddish-brown hue, *S. tranquebarica* is purplish, and *S. paramamosain*, which only 2.94% of the respondents are familiar with, has a light green color. Consistent with the claims of FGD participants from Pangasinan, respondents from Region III mentioned that the carapace of *S. olivacea* is reddish, while *S. serrata*'s is greenish.

Almost half of the respondents also compare the width and size of the carapace (Fig. 5) to identify the species. In a study done in Aklan, Philippines, the size of the crabs recorded ranged between 20.8-140.0 mm CW for *S. olivacea*, 40.0-195.0 mm CW for *S. tranquebarica*, while *S. serrata* ranges from 24.4 to 172.0 mm CW (Lebata et al. 2007). Seasonal variations are said to affect size such that it increases

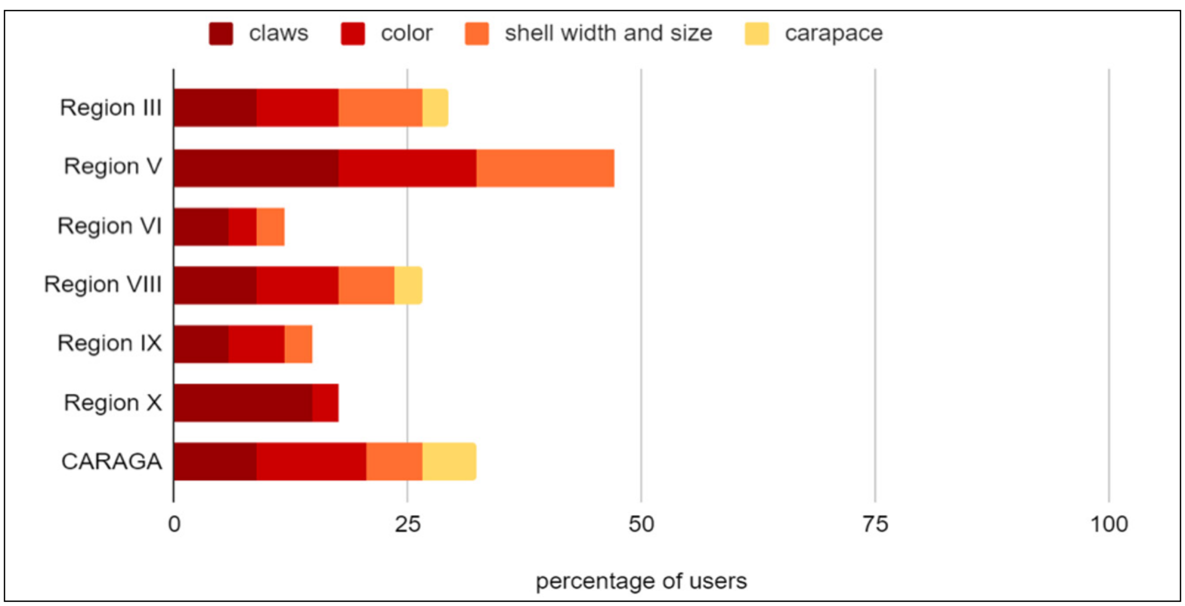

Figure 6. Morphological features commonly used for species identification of juvenile *Scylla* in different regions of the Philippines based on online interviews.

during the wet season and declines during the dry season (Lebata et al. 2007).

A minority of the respondents compare the relative size and spines of the entire leg containing the claw called chelipeds instead of just the claw (Fig. 5). A unique feature reported by a small percentage of the respondents also mentioned the presence of white spots on the claws and the dorsal carapace (Fig. 5) of *Scylla serrata*.

There were also techniques unique to specific regions (Fig. 7). For example, a respondent from Region III mentioned that he observes the overall shape of the crab, although he did not elaborate on the shape distinct to each species. Respondents from Region V said several unique techniques, including observation of a crab's back and feet, feeling the texture of the shell, observation of the color of a crab's bottom, sizing the claws, and observation of vein-like patterns at the back and legs of a crab (Fig. 5).

Regarding texture, the carapace of *S. olivacea* is said to have a relatively harder shell with a bump, while *S. serrata* has a rougher shell texture. Additionally, the posterior portion of the dorsal carapace of *S. olivacea* is said to be consistently reddish.

A respondent from Region V mentioned that *S. serrata* have clear vein-like patterns on its bluish-green carapace, while they knew that red-breasted crabs, which may have vein-like patterns with whitish spots, were not *S. serrata*. They did not bother to distinguish *S. olivacea* and *S. tranquebarica* as neither have a market in their area.

A respondent from Region VI mentioned weighing the crabs regularly, as *S. serrata* crablets tend to weigh much more than *S. olivacea* crablets. Another respondent from the same region stated that he considers the season as certain species are more common at certain times of the year.

Observation of the crab's mouth and how the crab's walk are techniques mentioned only by a few respondents from Region IX. The mouths of the larger species are described as having more prominent appendages that are used to hold food more securely, while the smaller species usually have more bristles. The fishermen had difficulty describing how each species were different through the online interview but were confident that different crabs have a distinct manner of walking. This is congruent to some reports that juvenile *S. serrata* finds it more difficult to get out of a concave container than the nimbler *S. olivacea*.

Frontal lobe spine shape serves as the primary diagnostic character for juvenile Scylla species. However, this technique is limited by technology as the morphological differences are too subtle for the naked eye to distinguish, hence the need for an image analysis technology (VinceCruz-Abeledo et al. 2018). This limitation has been overcome in another study by VinceCruz-Abeledo et al. (2020), where the

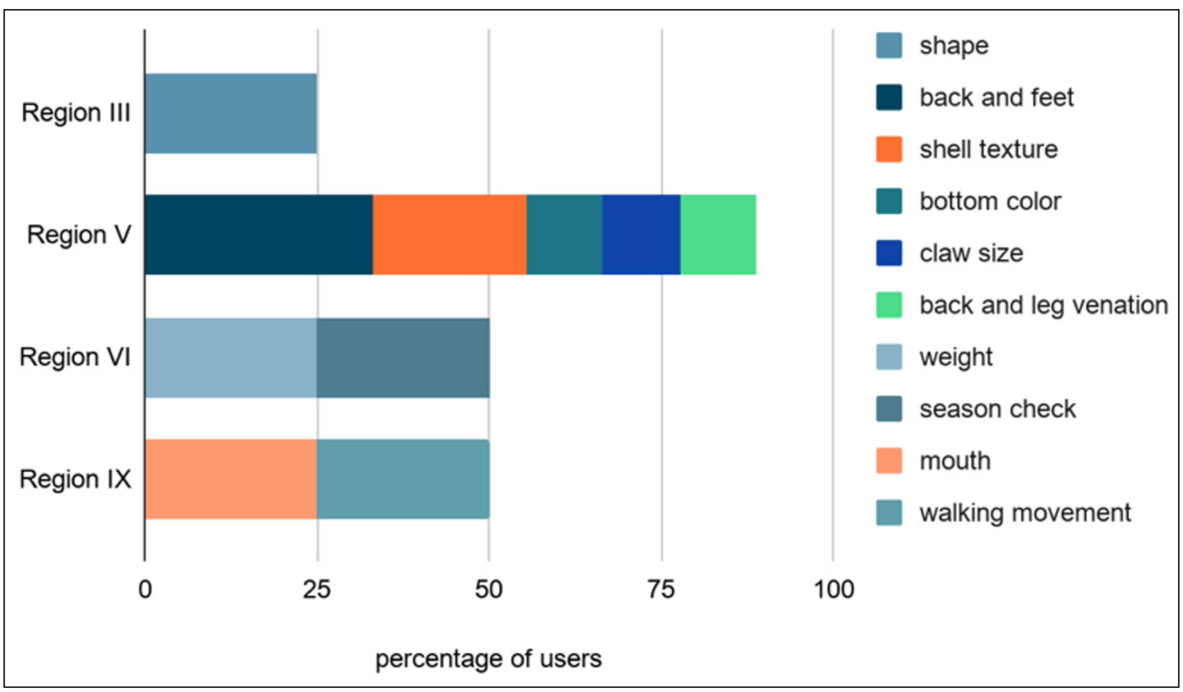

Figure 7. Unique morphological and behavioral features used for species identification in certain regions of the Philippines based on online interviews.

flatness of *S. olivacea*'s frontal lobe spines relative to its frontal width has been found to be obvious enough to distinguish it from juvenile *S. tranquebarica* and *S. serrata* without the need for a device. Still, a more prominent marker that farmers can use to spot all three species at a glance would be helpful.

Certain characteristics that farmers look at when classifying the species may be brought about by the environment or the species' behavior. For example, variation in color of different individuals of the same species is commonly observed in invertebrates (Trivedi and Vachhrajani 2012). The occurrence of different colors in species can also be brought about by many factors, including geographic isolation of the population, predator avoidance, age, diet, pathogen infection, and genetic inheritance (Trivedi and Vachhrajani 2012).

The study by Silbiger and Munguia (2008) found that changes in temperature brought about changes in the color of the fiddler crab *U. pugilator*, whereby warm and cold temperatures make the carapaces light and dark, respectively. Furthermore, the color change occurred differently between day and night, suggesting sex-specific constraints in response to temperature like body mass to surface area ratios and different diel activities performed by each sex or visual cues related to mating behaviors. pH stress is also said to affect carapace color such that Chinese mitten crabs *Eriocheir sinensis* grown in high pH conditions develop a pale color as the astaxanthin, which is said to be responsible for creating a bright color function to neutralize oxidative stress brought about by high pH conditions (Wang et al. 2018).

Spine-based carapace features may exhibit continuity in shape because of friction from burrowing and are therefore most useful only shortly after molting. Additionally, differentiating between the carapace features can be relative and dependent on the viewer's perception (VinceCruz-Abeledo and Lagman 2018).

The texture of the carapace, on the other hand, is said to be affected by carbonate ions (Abdou et al. 2019; Sanka et al. 2016 as cited in VinceCruz-Abeledo et al. 2020). Although there have not been reports on significant differences in the composition of carapace across Scylla species, varying levels of CaCO3, MgSO4, and KCl in the environment is said to affect the hardening and development of the carapace of mangrove crabs (Kurkute et al. 2019 as cited in VinceCruz-Abeledo et al. 2020).

Diseases like red sternum syndrome, pink crab disease, and other diseases associated with *Hematodinium* infection also bring about changes in crabs' texture or color. The red sternum syndrome includes symptoms such as soft carapace and reddening of the chelae or chelipeds and joint (Fig. 8) (Salaenoi et al. 2006; Areekijseree et al. 2010). Pink crab disease, on the other hand, include symptoms such as hyperpigmentation (pink) of the carapace and discoloration (yellowing) of arthrodial membranes and genital pores (Stentiford et al. 2002).

Analysis of these commonly considered attributes for identification, such as color, texture, and other carapace features, could be done to validate these traditional methods. Mangrove crab farmers that are more experienced and are well acquainted with the morphology of crablets may use validated techniques as at-a-glance methods. These validated traditional techniques may be converted to image analysis technologies to benefit mangrove crab stakeholders with less experience in handling mangrove crabs. Additionally, identifying which practices are effective would directly help crab farmers as it could give them better chances of maximizing production gain. Finally, the availability of a wider variety of species identification methods can make research more efficient and lead to wiser use of resources.

This exemplifies that TEK, which has been perceived as an authority that competes with science (Kofinas 2005; McGregor 2008), can be considered as "intellectual twin to science" (Kimmerer 2002), and that it should be understood as collaborative such that it invites stakeholders to learn from one another and work together to better steward and manage the environment and natural resources (Whyte 2013).

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AUTHOR CONTRIBUTIONS

Orario HP: Conceptualization, Methodology, Formal analysis, Writing – Original Draft, Review & Editing, Visualization. **Cai QW:** Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing - Original Draft. **Chua JKC:** Conceptualization, Methodology,

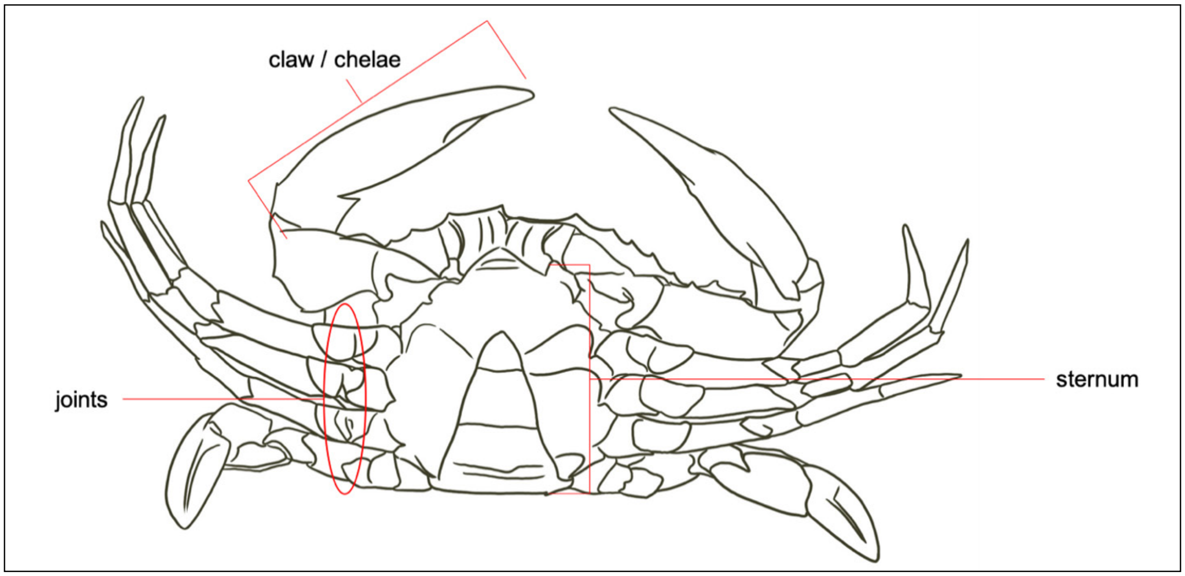

Figure 8. Parts where reddening primarily occurs in a mangrove crab with red sternum syndrome. The sternum, claws, and joints of mangrove crab exhibit a pale orange coloration during the early stages. However, the said parts and eventually the whole ventral carapace become reddish-orange as the red sternum syndrome progresses to its later stages. *Scylla* composite drawing by Ms. Courtney Anne Ngo.

Formal analysis, Investigation, Resources, Writing - Original Draft. **Magpayo ESN:** Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing - Original Draft. **Po AHG:** Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing - Original Draft. **Sanchez JO:** Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing - Original Draft. **Perez KCQ:** Conceptualization, Methodology, Formal analysis, Visualization. **Solis KJ:** Conceptualization, Methodology, Formal analysis, Visualization. **Ngo CAM:** Conceptualization, Methodology, Formal analysis, Visualization. **VinceCruz-Abeledo CC:** Conceptualization, Methodology, Formal analysis, Writing - Review & Editing, Visualization, Supervision, Project Management

CONFLICTS OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICS STATEMENT

Participants were made aware of the purpose of the study and what their participation involved. Informed consent forms validated by De La Salle University's Ethics Review Committee were also provided and signed by the participants. Standards in the handling of collected information were followed in this study.

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