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**SHORT COMMUNICATION**

# Morphological Identification of Spiny Lobster (*Panulirus* spp.) Puerulus in Palawan, Philippines

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ABSTRACT

The high buying price for spiny lobster (*Panulirus* spp.) pueruli (SLP), commonly known as "seed lobsters", has driven increasing collection efforts, particularly along the eastern coast of Palawan, Philippines. These pueruli represent a transitional stage between the phyllosoma larva and juvenile, and despite their growing commercial importance, little is known about the specific species being harvested in the region. This study aimed to document the daily morphological changes in SLP until they could be reliably identified at the species level. A total of 27 SLP were collected from various sites along Palawan's eastern coast and individually reared for 15 to 25 days in improvised aquaria made from the bottom halves of 1.5-liter soda bottles. Each container was supplied with continuous aeration and regular water changes. Boiled mussel meat was introduced as feed once the pueruli began to show signs of pigmentation. By the end of the rearing period, the pueruli developed distinct morphological features resembling miniature adults and were identified as *Panulirus ornatus, P. versicolor,* and *P. longipes longipes.* A daily photographic record of each specimen revealed that even during the early, unpigmented stages, each species exhibited unique and distinguishable traits. These findings suggest that species-level identification of SLP is possible early on and could be a valuable tool for fishers and regulatory agencies to ensure fair pricing based on species. Further studies on species composition and habitat characteristics at collection sites can support better management of the SLP fishery. Protecting key settlement habitats and ensuring accurate species identification will help promote sustainable harvest practices, support healthy lobster populations, and contribute to long-term food security.

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Spiny lobster puerulus/pueruli (SLP), commonly referred to as "seed lobster", is around 12 mm in total length (Priyambodo et al. 2020) and is in the post-larval stage of spiny lobster (Jones et al. 2010). It is a transitional, nektonic stage, well-adapted for strong, horizontal, directional swimming, which bridges the planktonic and benthic phases of the life cycle (Phillips and McWilliam 2009). An SLP is short-lived and non-feeding, relying on an energy reserve comprising fat in its body (Martínez-Calderón et al. 2018; Phillips and McWilliam 2009; Priyambodo et al. 2020). Spiny lobsters have a complex life cycle, and it includes five (5) phases: egg, larvae (phyllosoma), puerulus, juvenile, and adult (Fadragas 2005). The SLP are transparent-post larva that swims to the coast and settles in shallow vegetative substrate and moult after few days to weeks until they reach their benthic juvenile stage, after few months, they shift to coral reef habitats to seek for refuge and during this time, their exoskeleton gradually becomes pigmented and calcified, making it more suitable for their benthic existence (Phillips and McWilliam 2009; Martínez-Calderón et al. 2018; Priyambodo et al. 2020). SLPs are found in shallow, sometimes slightly turbid, coastal waters, ranging in depth from 1 to 8 m. Puerulus prefer to settle and bury in sandy substrates and habitats with coral, seagrass, or seaweed, seeking refuge and avoiding predators (Mecha et al. 2022; Radhakrishnan et al. 2019).

In the Philippine waters, there are seven species and subspecies of *Panulirus* reported, these includes *Panulirus ornatus* (Fabricius, 1798), commonly known as ornate tropical spiny lobster and locally known as "tiger" lobster, *P. versicolor* (Latreille,

1804), also known as painted spiny lobster and locally known as "green lobster" or "bamboo", *P. penicillatus,* commonly known as double-spined lobster or locally known as "aswang", *P. longipes longipes* (A. Milne-Edwards, 1868), commonly known as bluespot or white whisked spiny lobster or locally known as "red banagan", *P. longipes bispinosus, P. femoristriga and P. homarus* (Juinio-Menez and Gotanco 2004). In Palawan, four species of spiny lobster are collected, including *P. ornatus*, *P. versicolor*, *P. longipes longipes*, and *P. penicillatus* (Juinio-Menez and Gotanco 2004). However, only the first three species of marine spiny lobster are found predominant in the catches of fishers, whereas *P. ornatus* and *P. versicolor* have high commercial values for both local and foreign markets, while *P. longipes longipes* seems to have high demand for export to Japan (Gonzales and Taniguchi 1995). Despite this, the early stages of the aforementioned spiny lobster species in Palawan remain unidentified, which could be vital for aquaculture development in the province.

In other countries, such as Vietnam and Indonesia, where SLP has been identified and aquaculture has been established for a long time, collectors have used numerous settlement traps, luring materials, and installation methods to catch SLP of various species (Priyambodo et al. 2020). In Vietnam, the collection of SLPs involved the use of coral or timber, seine nets with electrical lights, and netting materials hung in bamboo or wooden stakes (Hung and Tuan 2009). In Indonesia, fishers use cement bag paper, perforated timber poles, fishing nets, and rice bags hung in a raft (Priyambodo et al. 2017). In the Philippines, particularly in Palawan, rock collectors are prominent, and fishers use substrate as settlement traps that mimic the habitat of the pueruli; these substrates are hung on bamboo poles or rafts (Mecha et al. 2022).

The collection of SLP is now becoming an emerging practice by fisherfolks, especially along the eastern coast of Palawan. There has been considerable interest in the collection of SLPs due to their high demand; however, despite widespread collection activity since 2019 (Mecha et al. 2022), no information is available on which particular species are being harvested. Understanding the changes in morphological characteristics and the differences in pigmentation of SLP may help fill the gap in the identification of spiny lobsters (puerulus) harvested, and could aid in addressing the problem of implementing and regulating the correct buying price per seed of SLP. This could help improve the profits of fisherfolk or collectors and may promote the emergence of spiny lobster aquaculture in Palawan, which could, in turn, enhance the local economy. This study photo-documented the changes in the morphological characteristics, such as coloration and physical appearance, of the SLP collected from four different collectors in Palawan, without genetic confirmation.

The SLPs were collected from four barangays: Binduyan, Tagburos, and San Jose in Puerto Princesa City, and Calasaguen in the municipality of Brooke's Point, Palawan, Philippines (Figure 1). All collection sites were located on the eastern side of Palawan, and these localities were also reported to have SLP collection activities from early 2020 to present (Mecha et al. 2022).

A total of 27 SLPs were obtained in February and March 2023 from various collectors and buyers at four collection sites in Palawan. The SLPs were collected by fishers using various stationary gears, such as bamboo traps and rock substrates that mimic the settlement habitat of the SLP (Mecha et al. 2022). Each sample was randomly selected from the fisherfolk's or collectors' main container. Additionally, due to limited funds and high SLP prices ranging from PHP 90 to PHP 125 each, a limited number of samples were obtained. Twelve samples were obtained from San Jose and five each from Tagburos, Binduyan, and Calasaguen. Each SLP was raised separately in an improvised aquarium.

Twenty-seven (27) small aquaria made from the half-lower part of 1.5 L of soda bottles filled with 300 ml seawater, provided with aeration, and labeled according to the sample and collection sites, were used to observe the samples (Figure 2). Fifty percent of the water was changed every 3 days to prevent deterioration of water quality that could cause mortality in the sample puerulus. A sliced fresh green mussel (*Perna viridis*) meat boiled for 2-3 minutes was given as food for the sample; however, feeding was only introduced once the sample puerulus had completed its first molt during the observation. The study was then terminated when natural mortality occurred, typically within 15 to 25 days of rearing.

Daily photo-documentation was conducted from the first day of rearing to monitor changes in morphological characteristics and coloration of the antennae, walking legs, antennule, abdomen, and carapace.

All samples that reached the early juvenile or pigmented-puerulus stage until the algal phase juvenile stage were identified at the species level using the works of Motoh and Kuronuma (1980) and Priyambodo et al. (2017). This study identifies the

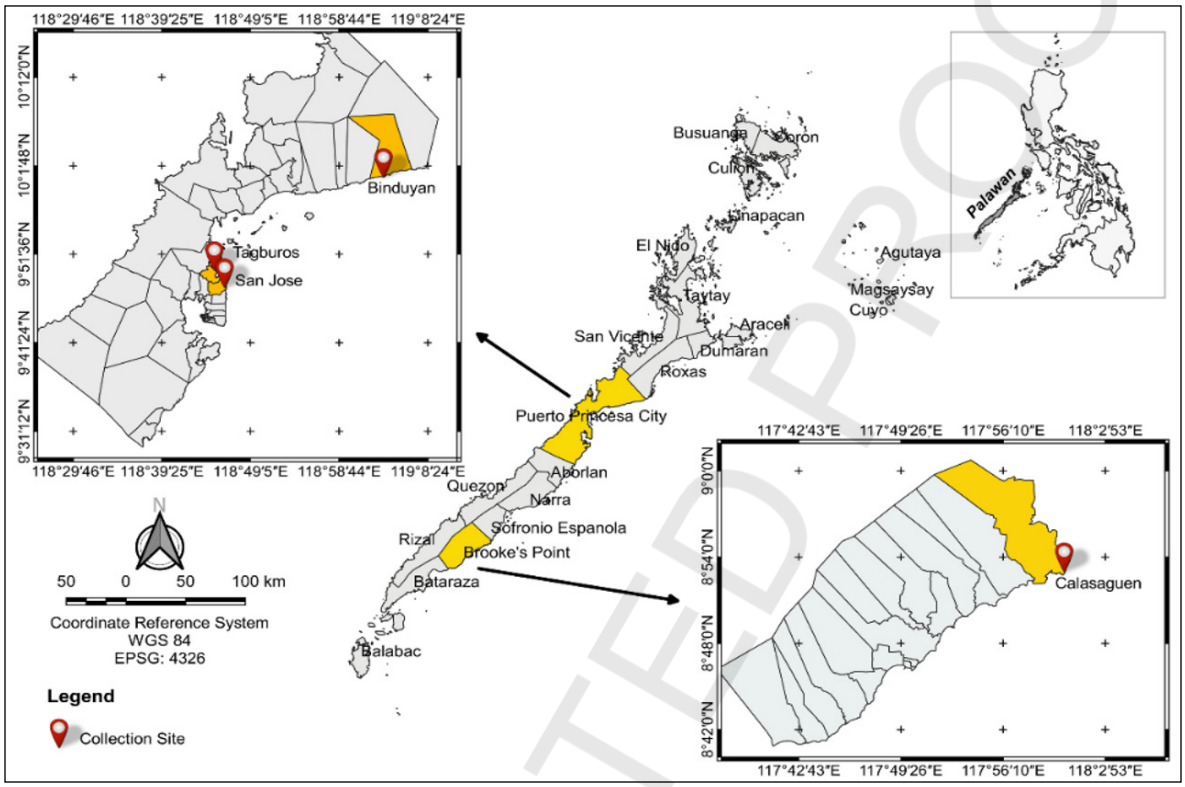


Figure 1. Maps showing the sources of spiny lobster puerulus (SLP).


Figure 2. Aquaria were made from the lower half of 1.5 L soda bottles used for the spiny lobster puerulus.

species solely through morphological characterization, without genetic confirmation.

**Species composition**

A total of 27 spiny lobster pueruli (SLP) successfully developed into the pigmented-puerulus stage. Through detailed morphological examination and pigmentation analysis, three species were identified. The majority, 16 individuals (60%), were identified as ornate spiny lobster (*Panulirus ornatus*). This was followed by 10 individuals (37%) classified as long-legged spiny lobster (*P. longipes longipes*), and one individual (4%) identified as the painted spiny lobster (*P. versicolor*) (Figure 3).

**Morphological observation and species identification**

At the time of collection, all SLP were still transparent but already exhibited distinct morphological traits, particularly in the antennae,

walking legs, and abdominal segments. These early features helped in the initial species differentiation: *P. ornatus* had antennae with a terminal bulb and a single ring or cross-sectional brown band at the midpoint. *P. longipes longipes* showed antennae with multiple, although faint, brown cross-sectional bands. *P. versicolor* had completely opaque white antennae with no visible bands (Figure 4).

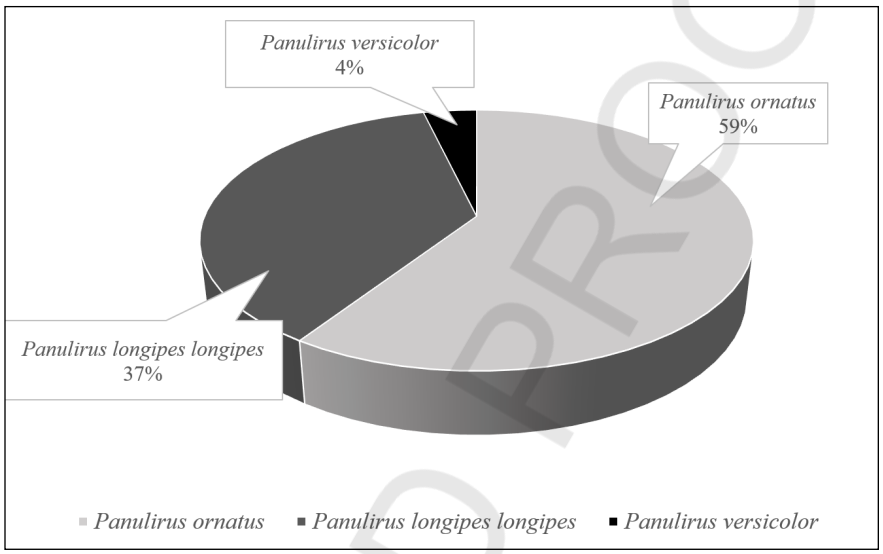


Figure 3. The percent composition of the three species of spiny lobster puerulus (SLP) identified from 27 samples

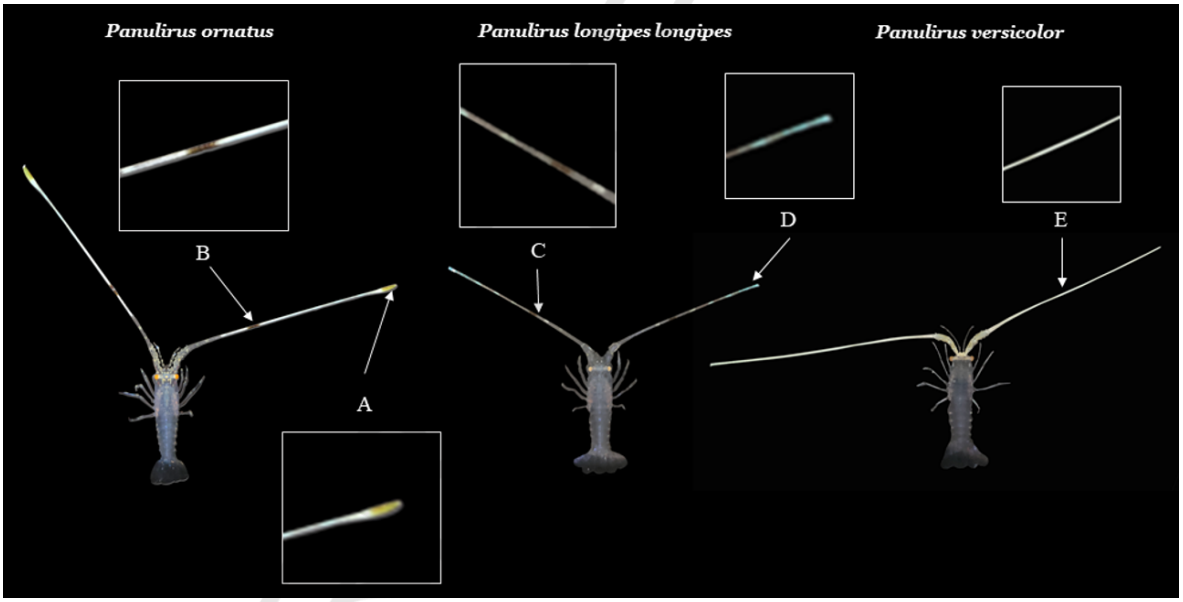


Figure 4. The three species of spiny lobster puerulus (SLP) exhibit distinct distinguishing features upon collection. *Panulirus ornatus* (A-B); *P. longipes longipes* (C-D); *P. versicolor* (E); (A) Terminal bulb; (B) Single cross-sectional white band in antenna; (C) Unclear cross-sectional white bands in antenna; (D) Greenish tip of antennae (no clove); (E) Complete white antenna.

After 4 to 7 days of rearing, the SLP began to develop pigmentation. *P. ornatus* displayed multiple brown ring-like bands across its antennae, antennules, and walking legs, accompanied by light brown, translucent pigmentation on the body. *P. longipes longipes* had more distinct alternating cross-sectional or ring brown and white bands in similar areas, with slightly darker translucent body pigments. *P. versicolor* was easily distinguished by its deep maroon body color, symmetrical white markings, a central orange stripe on the carapace, cross-banded abdomen, and a greenish translucent tail fan (Figure 5).

By days 15 to 25, species-level identification became more pronounced: *P. ornatus* developed a light yellow to white body color with symmetrical brown markings. Its antennae, antennules, and walking legs showed well-defined white cross bands. Notably, a single longitudinal white stripe ran along the middle of its abdomen, flanked by lateral white spots. A single white spot appeared on each side of

the tail fan. *P. longipes longipes* exhibited a beige body pigment with a distinct carapace pattern. The cross bands on the antennae, antennules, and legs were more closely spaced than in *P. ornatus*. The abdomen had a brown gradient, ranging from dark to light, and the tail fan was translucent, with white on top and brown underneath. *P. versicolor* was the most visually distinct. Its body showed a rich maroon hue with a central yellow stripe on the carapace, symmetrical white spots, and longitudinal striping on the walking legs. Both the antennae and tail fan were entirely white (Figure 6).

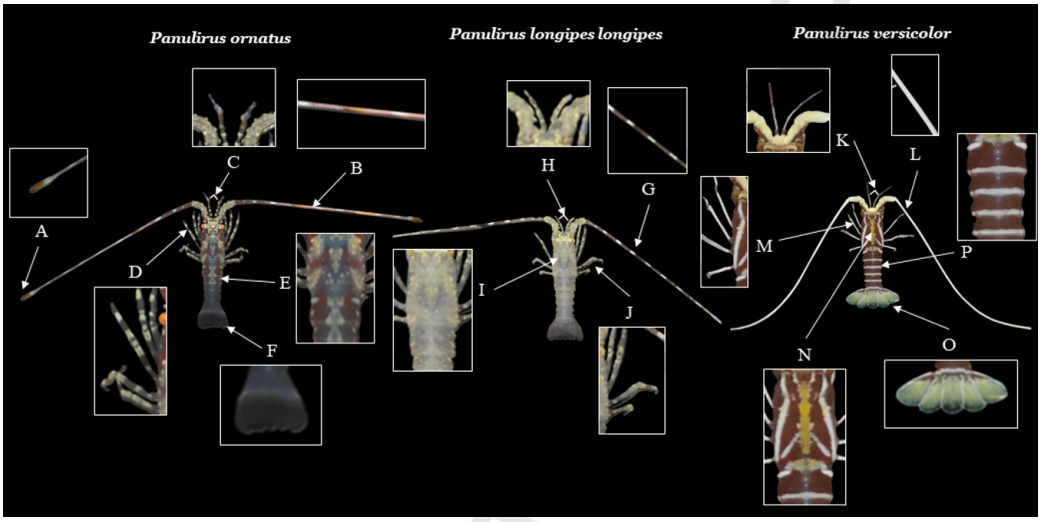


Figure 5. The three species of spiny lobster puerulus (SLP) exhibit prominent features during their 4- to 7-day observation period. *Panulirus ornatus* (A-F), *P. longipes longipes* (G-J), *P. versicolor* (K-P); (A) Terminal bulb; (B) Multiple unclear cross-sectional white bands; (C) Banded antennule; (D) Banded walking legs; (E) Pigmented carapace (brown and creamy white pattern); (F) Translucent tailfan; (G) Antennae with clearer cross-sectional white bands; (H) Banded antennule; (I) Translucent carapace; (J) Translucent band in walking legs; (K) Pigmented antennule; (L) White antenna; (M) Longitudinal band in walking legs; (N) Carapace with longitudinal orange pigment in the middle surrounded with symmetrical white pattern; (O) Translucent green tailfan; (P) Abdomen with cross-sectional white bands.

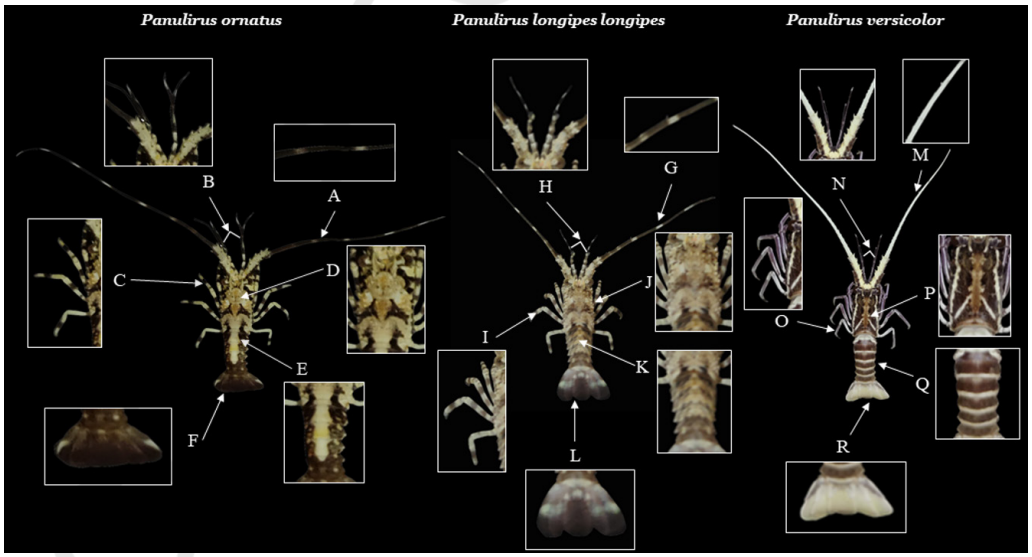


Figure 6. The spiny lobster puerulus (SLP) of the three species of spiny lobsters, after 15 to 25 days of observation, shows the characteristics of the adult species. *Panulirus ornatus* (A-F), *P. longipes longipes* (G-L), *P. versicolor* (M-R); (A) Cross-sectional white bands in antenna (distant); (B) banded antennule; (C) banded walking legs; (D) Light yellow to white pigment carapace with symmetrical brown pattern; (E) Longitudinal white stripe in the middle of abdomen with subsequent white spot on the side of abdomen; (F) Brown tailfan with white spot on each side; (G) Cross-sectional white bands in antenna (adjacent); (H) banded antennule; (I) banded walking legs; (J) Beige pigment with symmetrical brown distinctly patterned carapace; (K) Brown shading abdomen; (L) Tailfan with white pigment on top and brown in the bottom; (M) White antennae; (N) Longitudinal bands in antennule; (O) Longitudinal bands in walking legs; (P) Carapace with central longitudinal yellow stripe, and symmetrical white pattern; (Q) Cross-sectional white bands in abdomen; (R) White tailfan.

**Distinguishing features**

The three species exhibited several distinguishing features, especially in the coloration and banding patterns of their antennae, walking legs, bodies, and abdomens. A comparative summary of these characteristics is provided in Table 1.

**Identified *Panulirus* species**

This study presents significant findings on the identification of *Panulirus* species commonly found in the collection areas of fisherfolk in Palawan. Three species of the SLP were identified across the four collection sites: *Panulirus ornatus*, *P. longipes longipes*, and *P. versicolor*. These were collected during their unpigmented puerulus stage and identified based on key morphological features such as the presence of a terminal bulb, band patterns on the antennae, and differences in body pigmentation (Motoh and Kuronuma 1980; Jones et al. 2010; Priyambodo et al. 2017).

The first juvenile stage marks the first fully benthic phase in a lobster's life cycle, already exhibiting adult-like features, except pigmentation, which likely plays a role in juvenile survival (Guerao et al. 2006). Among the identified species, *P. ornatus* was the most dominant, accounting for nearly 60% of the total samples. *P. longipes longipes* made up 37%, while *P. versicolor* was the least abundant at just 4%.

The prevalence of *P. ornatus* along the eastern coast of Palawan may be linked to the abundance of wild breeding adults within the Sulu Sea. While no formal data pinpoint exact collection sites, anecdotal evidence from local collectors confirms that SLPs are frequently collected from this region (Mecha et al. 2022; Mecha and Dolorosa 2024). Although the exact reason behind this concentration remains uncertain, local fisherfolk suggest that ocean currents and sea surface winds play a significant role in the transport and settlement of pueruli. While breeding may occur throughout Palawan, these physical factors likely direct larval settlement toward the eastern coastline.

Spiny lobsters are distributed in tropical and subtropical areas, particularly in the Indo-Pacific (Macusi et al. 2019; Mecha and Dolorosa 2024; Radhakrishnan et al. 2019). They typically inhabit rocky crevices and turbid waters at depths of 1–18 meters in coral reef environments (Radhakrishnan et al. 2019). Broodstock usually migrate to deeper offshore reefs to spawn. The planktonic phyllosoma larvae then drift with ocean currents before settling into sandy or vegetated habitats, such as coral reefs, seagrasses, or seaweed beds, where they find refuge from predators and grow as benthic juveniles (Martínez-Calderón et al. 2018; Mecha and Dolorosa 2024; Radhakrishnan et al. 2019).

In Palawan, most collection sites are located in intertidal zones or embayments adjacent to mangroves, seagrass beds, and coral reefs (Mecha and Dolorosa 2024). The abundance of pueruli in these areas may be influenced by several factors, including the presence of breeding adults, habitat conditions, ocean currents, wind patterns, and local collection practices (Macusi et al. 2019; Sabino et al. 2021; Mecha and Dolorosa 2024).

**Morphological differences of the species identified**

Using morphological characteristics for species identification is a well-established method in crustacean research (Guerao et al. 2006). For example, shrimp species are often distinguished by features such as rostral teeth count, telson shape, and presence of exopods on the fifth pereiopods (Amin et al. 2021).

In spiny lobsters, identifying species during the puerulus stage is particularly challenging due to their unpigmented bodies and similar appearances.

Table 1. Distinguishing features of the puerulus of the spiny lobster *Panulirus* spp. (F4 – Figure 4, F6 – Figure 6).

| Species | Identification Key | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Antennae | | | Bands in walking legs | | | Body pigment | | | Patterns in the Abdomen/Tail | |
| | Terminal bulb (F4) | Band (F6) | Opaque (F6) | Longitudinal (F6) | Cross bands (F6) | Beige (F6) | Yellowish to white (F6) | Dark red/ maroon (F6) | Cross bands (F6) | Brown shading (F6) | White longitudinal pigment (F6) |
| *Panulirus ornatus* | ✓ | ✓ | ✕ | ✕ | ✓ | ✕ | ✓w | ✕ | ✕ | ✕ | ✓ |
| *Panulirus longipes longipes* | ✕ | ✓ | ✕ | ✕ | ✓ | ✓ | ✕ | ✕ | ✕ | ✓ | ✕ |
| *Panulirus versicolor* | ✕ | ✕ | ✓ | ✓ | ✕ | ✕ | ✕ | ✓ | ✓ | ✕ | ✕ |

However, detailed morphological inspection, especially of the antennae, can still reveal species-specific traits (Jones et al. 2010; Priyambodo et al. 2017). For instance, both *P. ornatus* and *P. longipes longipes* possess banded antennae and similar pigmentation. They can be differentiated by the presence of a terminal bulb, a feature of *P. ornatus* during the puerulus stage. Unfortunately, this bulb may fall off after molting or be damaged during collection and handling, which complicates species identification (Rajkumar et al. 2015; Priyambodo et al. 2017).

This study successfully identified three species of SLP in Palawan, each with distinct morphological features. These findings can empower collectors to accurately identify species and demand fair prices for high-value specimens. Since SLPs are unpigmented and difficult to differentiate visually, proper identification is crucial to prevent undervaluation, particularly of premium species like *P. ornatus*.

The insights from this study can serve as a valuable guide not only for fisherfolk and collectors in identifying and pricing their catch reasonably but also for government agencies in setting just and standardized seed prices. By shedding light on the abundance and high market value of local spiny lobster species, this research also has the potential to spark interest among aquaculture investors. However, it is essential to acknowledge a pressing issue: a substantial number of SLPs are still being illegally exported for aquaculture, posing a significant challenge to the industry's sustainable growth.

At the same time, strict regulatory measures must be enforced to protect breeding grounds, adult populations, and collection sites. Doing so will help ensure the sustainability of wild stocks and secure a steady supply of SLP for future aquaculture and fisheries development.

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## AUTHOR CONTRIBUTIONS

**Trestiza KAJ**: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Resources, Data curation, Writing–Original Draft, Visualization. **Mecha NJMF:** Conceptualization, Validation, Writing–Review & Editing, Visualization. **Creencia LA:** Writing–Review & Editing, Validation. **Dolorosa RG**: Conceptualization, Validation, Writing–Review & Editing, Visualization, Supervision.

## CONFLICTS OF INTEREST

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

## ETHICS STATEMENT

The researchers did not directly collect the SLP but instead purchased samples from fisherfolk engaged in legal collection and trade. All precautionary measures were followed to ensure the welfare and survival of the specimens used in this study.

## REFERENCES

Amin S, Hassanen GDI, Ahmed MS. 2021. Identification and Taxonomic Study of Shrimps in Bardawil Lagoon, North Sinai, Egypt. Sinai Journal of Applied Sciences. 10:039–046. https://sinjas.journals.ekb.eg/article_177450.html

Fadragas OM. 2005. Assessment of the Spiny Lobster (*Panulirus argus*, Latreille, 1804) in Northeastern Cuban Waters. United Nations University-Fisheries Training Program. pp. 63. https://www.grocentre.is/static/gro/publication/88/document/ofelia05prf.pdf

Gonzales BJ, Taniguchi N. 1995. Spiny lobster-fishery in Palawan, Philippines: with considerations on its conservation and Management. Bulletin of Marine Sciences and Fisheries. 15:121–130. https://www.researchgate.net/publication/279630050_Spiny_lobster-_fishery_in_Palawan_Philippines_with_considerations_on_its_conservation_and_Management

Guerao G, Díaz D, Abelló P. 2006. Morphology of puerulus and early juvenile stages of the spiny lobster *Palinurus mauritanicus* (Decapoda: Palinuridae). Journal of Crustacean Biology.

26:480–484. https://academic.oup.com/jcb/article-lookup/doi/10.1651/C-2615.1

Hung LV, Tuan LA. 2009. Spiny lobster aquaculture in the Asia–Pacific region: Lobster seacage culture in Vietnam. Proceedings of an international symposium held at Nha Trang, Vietnam. ACIAR Proceedings No. 132. Australian Centre for International Agricultural Research. pp. 10–17. https://www.aciar.gov.au/sites/default/files/legacy/node/11536/ACIAR_PR132%28online%29.pdf

Jones C, Long NV, Hoc DT, Priyambodo B. 2010. Exploitation of puerulus settlement for the development of tropical rock lobster aquaculture in the Indo-West Pacific. Journal of the Marine Biological Association of India. 52:292–303. https://www.researchgate.net/publication/257938988%0AExploitation

Juinio-Menez MA, Gotanco RR. 2004. Status of Spiny Lobster Resources of the Philippines. In: Williams KC, editor. Spiny lobster ecology and exploitation in the South China Sea region. Proceedings of a workshop held at the Institute of Oceanography, Nha Trang, Vietnam. ACIAR Proceedings No. 120. p. 73. https://www.aciar.gov.au/sites/default/files/legacy/node/590/pr120_pdf_17638.pdf

Martínez-Calderón, R, Lozano-Álvarez E, Briones-Fourzán P. 2018. Morphometric relationships and seasonal variation in size, weight, and a condition index of post-settlement stages of the Caribbean spiny lobster. PeerJ. 6:e5297 https://doi.org/10.7717/peerj.5297

Macusi ED, Laya-og ME, Abreo NAS. 2019. Wild lobster (*Panulirus ornatus*) fry fishery in Balete bay, Davao Oriental: Catch trends and implications to fisheries management. Ocean and Coastal Management. 168:340–349. https://doi.org/10.1016/j.ocecoaman.2018.11.010

Mecha NJMF, Palla HP, Creencia LA, Jontila JBS, Plasus MMG, Dolorosa RG. 2022. Settlement traps and harvesting methods for spiny lobster (*Panulirus* spp.) puerulus fishery in Palawan Island, the Philippines. Journal of Marine and Island Cultures. 11:192. https://doi.org/10.21463/jmic.2022.11.2.12

Mecha NJMF, Dolorosa RG. 2024. Distribution and Characteristics of Spiny Lobster (*Panulirus* spp.) Puerulus Collection Sites in Palawan, the Philippines. Philippine Journal of Science. 153(3):1061–1071. https://doi.org/10.56899/153.03.26

Motoh H, Kuronuma K. 1980. Field Guide for the Edible Crustacean of the Philippines. Aquaculture Department, Southeast Asian Fisheries Development Center. http://hdl.handle.net/10862/152

Phillips BF, McWilliam PS. 2009. Spiny lobster development: Where does successful metamorphosis to the puerulus occur? A review. Reviews in Fish Biology and Fisheries. 19:193–215. https://doi.org/10.1007/s11160-008-9099-5

Priyambodo B, Jones CM, Sammut J. 2017. Improved collector design for the capture of tropical spiny lobster, *Panulirus homarus* and *P. ornatus* (Decapoda: Palinuridae), pueruli in Lombok, Indonesia. Aquaculture. 479:321–332. https://doi.org/10.1016/j.aquaculture.2017.05.033

Priyambodo B, Jones CM, Sammut J. 2020. Assessment of the lobster puerulus (*Panulirus homarus* and *Panulirus ornatus*, Decapoda: Palinuridae) resource of Indonesia and its potential for sustainable harvest for aquaculture. Aquaculture. 528:735563. https://doi.org/10.1016/j.aquaculture.2020.735563

Radhakrishnan EV, Phillips BF, Lakshmi Pillai S, Padua S. 2019. Ecology and global distribution pattern of lobsters. In: Radhakrishnan EV, Phillips BF, Achamveetil G, editors. Lobsters: Biology, Fisheries and Aquaculture. p. 151–176. https://doi.org/10.1007/978-981-32-9094-5_5

Rajkumar G, Saravana Bhavan P, Udayasuriyan R, Vadivalagan C. 2015. Molecular identification

of shrimp species, *Penaeus semisulcatus*, *Metapenaeus dobsoni, Metapenaeus brevicornis, Fenneropenaeus indicus, Parapenaeopsis stylifera, and Solenocera crassicornis inhabiting the Coromandel Coast (Tamil Nadu, India),* using MT-CO. International Journal of Fisheries and Aquatic Studies. 2(4):96–106. https://www.researchgate.net/publication/297380836

Sabino MA, Govinden R, Pethybridge H, Blamey L, Le Grand F, Sardenne F, Rose M, Bustamante P, Bodin N. 2021. Habitat degradation increases interspecific trophic competition between three spiny lobster species in Seychelles. Estuarine, Coastal and Shelf Science. 256:107368. https://doi.org/10.1016/j.ecss.2021.107368