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Morphology and Morphometry Analysis of Toxic Brachyurans from Nglolang Beach, Gunungkidul

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Abstract

Toxic crabs from the families Xanthidae and Eriphiidae pose health risks due to variable toxicity influenced by diet, habitat, and environmental conditions. Xanthidae species are known to contain neurotoxins such as tetrodotoxin (TTX) and saxitoxin (STX), which can cause paralysis and poisoning in humans, whereas Eriphiidae crabs generally exhibit lower but more consistent toxin levels. Although toxic crab species have been reported across the Indo-Pacific, applied morphometric studies at local coastal scales remains limited. Thus, this research aims to characterize morphometric features of toxic Xanthidae and Eriphiidae crabs at Nglolang Beach to support species identification and risk awareness. This study was conducted at Nglolang Beach, Gunungkidul, using purposive sampling method in the intertidal zone with concurrent measurement of water temperature and salinity. Collected specimens were anesthetized, photographed, morphologically identified, and preserved in a 70% alcohol-glycerin solution at a 9:1 ratio. This study aims to characterize morphometric features of toxic Xanthidae and Eriphiidae crabs at Nglolang Beach to support species identification and risk awareness. Four toxic species were identified: *Eriphia scabricula*, *Atergatis floridus*, *Etisus laevimanus*, and *Platypodia granulosa*. These species display measured morphometric parameters, including chela dimensions and carapace surface texture, which are associated with intertidal survival. Environmental factors, particularly temperature and salinity, were observed to influence crab activity. By providing region-specific morphometric data for known toxic taxa, this study supports coastal biodiversity documentation, public safety, and sustainable tourism. Notably, crab toxins may persist after cooking, posing a continued risk if consumed.

Keywords: Eriphiidae, Gunungkidul, morphometry, toxicity, Xanthidae

1. Introduction

1.1 Toxic Crabs

Toxic crabs are species known to be mildly or occasionally poisonous, causing illness if consumed, but rarely resulting in fatality. Some of the species involved include "reef crabs" (*Carpilius* spp., Carpiliidae), "red-eyed crabs" (*Eriphia* spp., Eriphiidae), and coral reef crabs like *Etisus* spp. and *Atergatis* spp. (Xanthidae), as well as "land crabs" (*Cardisoma* spp., Gecarcinidae). These crabs are not always toxic; their level of toxicity varies with location and time of year, likely due to changes in diet and environmental factors. For instance, some crabs may become toxic after consuming poisonous fruits or leaves, as is the case with certain land crabs such as *Cardisoma*. Toxicity in marine crabs, especially those associated with dinoflagellate blooms or "red tides," can also arise when crabs feed on organisms that carry toxins. Species such as the "red egg crab" (*Atergatis integerrimus*) are occasionally poisonous due to sporadic consumption of toxic organisms, though only in small amounts. These variations in toxicity present challenges for fisheries and food safety, as crabs that are toxic in one area may be harmless in another, necessitating caution in harvesting and consumption (Carpenter & Niem, 1998).

Several cases of poisoning resulting in human fatalities and stemming from the ingestion of coral reef crabs have been reported from the Indo-Pacific region. In one specific incident in April 2004, two men in the town of Carmen, Cebu Island, Philippines, died from respiratory distress about two hours after eating a "crab" soup. The victims, aged 55 and 62, complained of dizziness, nausea, numbness, and vigorous vomiting shortly after their meal, highlighting the severity of toxic crab poisoning (Asakawa *et al*., 2010). Similarly, a severe poisoning incident occurred on March 27, 2021, in Tinh Gia District, Thanh Hoa Province, Viet Nam, when a 46-year-old fisherman died after eating crabs he had caught. He experienced severe symptoms, including fatigue, nausea, vomiting, numbness, and eventually respiratory failure and total paralysis (Ha *et al*., 2023). The crabs involved were suspected to be from the genus *Demania*, from the family Xanthidae. This tragic case, along with other similar anecdotal reports circulating among fishermen, underscores the critical lack of awareness and specific identification resources for toxic crab species.

The Xanthidae family is commonly referred to as "toxic crabs" due to the presence of potent neurotoxins such as tetrodotoxin (TTX) and saxitoxin (STX), which can cause severe symptoms including paralysis and respiratory failure in humans. Xanthidae crabs have been documented as hazardous in several Indo-Pacific regions, including Southeast Asia. However, their toxicity expression and morphological characteristics may vary across geographic locations (Zhang *et al*., 2023). In contrast, Eriphiidae crabs are less frequently associated with severe toxicity but have been reported in sporadic poisoning cases. Their toxic potential appears to be region-dependent and influenced by dietary intake, including toxic algae, small fish, or other toxin-bearing marine organisms. For instance, red-eyed crabs (*Eriphia* spp.) have been implicated in mild poisoning incidents, with symptoms generally less severe than those linked to Xanthidae (Llewellyn & Endean, 1989). For both families, toxicity is not consistently expressed and may fluctuate with location, season, and environmental conditions,

complicating efforts to classify these crabs as uniformly hazardous (Carpenter & Niem, 1998). This variability highlights the value of region-specific studies that integrate species identification with ecological context, particularly in understudied coastal areas such as Gunungkidul.

Communities around coastal areas may face risks of poisoning when consuming these crabs, as these toxins are resistant to cooking and cannot be easily neutralized (Lee, 2015). The presence of toxic Xanthidae and Eriphiidae crabs poses serious health risks for local residents who rely on marine life for subsistence. Cases of paralytic shellfish poisoning (PSP), caused by saxitoxin, are reported in various regions, particularly affecting those with limited access to alternative protein sources and health services. This raises public health concerns and economic impacts, as seafood-related illnesses deter tourism and reduce the demand for local seafood, ultimately affecting the livelihood of coastal communities (Kadiri & Isagba, 2018). Ecosystems may also experience disruptions, as toxic crabs impact marine food webs and predator species that feed on them, sometimes causing bioaccumulation of toxins. This is concerning in light of increasing toxic algae blooms and climate change, which can exacerbate the spread of harmful marine toxins and affect seafood safety more broadly in Southeast Asian coastal areas (Dao *et al*., 2021).

1.2 Nglolang Beach

Nglolang Beach, located along the Gunungkidul coast of Yogyakarta, Indonesia, is home to both Xanthidae and Eriphiidae crab species. The presence of Eriphiidae crabs, combined with Xanthidae, contributes to the area's high biodiversity and offers an opportunity to study these species' morphometric traits. Understanding the distinguishing physical characteristics of potentially toxic crabs in both families could help prevent accidental consumption and poisoning. Although toxic crabs from the families Xanthidae and Eriphiidae have been reported and studied in various Indo-Pacific regions, existing studies have largely focused on toxicity reports, biochemical analyses, or species inventories rather than applied morphometric identification at local scales. Within Gunungkidul waters, previous studies have documented coastal biodiversity; however, integrated morphometric characterization of toxic crab species with direct implications for public safety remains underrepresented in the literature (Sukmaningrum *et al*., 2018).

Given the health risks these crabs pose, especially if they are mistakenly handled or consumed as edible species, there is a need for focused research on their characteristics and distribution at Nglolang Beach. Studies from other regions have demonstrated that morphometric analysis, which examines features like carapace shape, claw structure, and coloration, can assist in differentiating potentially toxic from non-toxic crab species (Jumeini *et al*., 2022). This form of analysis is particularly valuable for community safety, as it provides local residents and tourists with visual identifiers to help avoid accidental poisonings.

1.3 Aims

While coastal biodiversity in Gunungkidul has been documented, applied and region-specific

studies focusing on the identification of toxic crab species remain limited, creating potential risks for both residents and visitors. Factors such as diet, habitat, and environmental conditions influence Xanthidae and Eriphiidae crab toxicity, underscoring the importance of localized investigations (Fredrick *et al*., 2011). Without applied morphometric references tailored to local conditions, communities may face challenges in recognizing potentially hazardous species, emphasizing the need for accessible identification resources.

This study aims to examine the morphometric characteristics of Xanthidae and Eriphiidae crabs in the area, thereby establishing a baseline for species identification. By systematically analyzing observable physical traits, this research seeks to enhance safety during beach visits and support informed decision-making. This work contributes to local safety and environmental awareness while supporting sustainable tourism and improving understanding of coastal biodiversity and potential marine hazards in Gunungkidul. The approach adopted in this study may also inform similar investigations of other hazardous marine organisms in Indonesia.

2. Method

2.1 Study Area and Sampling Time

Figure 1. Research station sample points

The research was conducted on October 19, 2024, between 02.30 and 05.00 GMT+7 at Nglolang Beach, situated in Kemadang Village, Tanjungsari District, Gunungkidul Regency, Special Region of Yogyakarta. The research location's geographic coordinates are recorded as 8°8’8.92896” South Latitude and 110°33’39.68” East Longitude, with the beach measuring 34 meters in length and 30 meters in width. The sampling points are shown on Figure 1.

2.2 Materials and Tools

The tools used in conducting the research are rolling meters, hammer, tweezers, hand nets, flashlights, trays, millimeter blocks, preservation jars, toolbox, scissors, gloves, 10 mL syringe, vernier caliper, digital camera, stationery, refractometer, thermometer, and ziplocks. The materials used for this study are glycerin, 70 % alcohol, aquadest, and clove oil.

2.3 Sampling Procedures

2.3.1 Sampling Method

Data collection was conducted in the intertidal zone of Nglolang Beach using a purposive sampling method. Specimens were collected during low tide using hand nets and tweezers to ensure the physical integrity of the samples. Environmental parameters were measured in situ to characterize the habitat; water temperature was recorded using a thermometer, while salinity levels were determined using a handheld refractometer.

2.3.2 Preservation

After sampling, the crab specimens were anesthetized using a mixture of clove oil and seawater with a ratio of 0.5-1.5 ml/L. Photographic documentation was then conducted, capturing frontal, rear, dorsal, and ventral views of each specimen, as well as close-ups of key body parts, such as the chelae and telson. The crustacean species were identified by carefully observing and comparing their morphological characteristics using the FAO Species Identification Guide for Fishery Purposes.

For specimens selected for wet preservation, individuals with intact appendages were rinsed and submerged in a solution of 70% alcohol and glycerin (9:1 ratio). Non-preserved specimens were revived in aerated seawater and returned to the sampling site.

2.3.3 Morphometric Measurement

After the specimens have been preserved, morphometric data are collected from each specimen (Figure 2). The measurements include carapace width (W), which is the distance between the tips of the right and left marginal spines, and carapace length (L), defined as the distance between the frontal margin spines and the lower edge of the carapace. Carapace height (H) is measured as the vertical distance from the carapace to the abdomen, while the optic groove width (OGW) is the distance between the frontal margin spines located between the eyes. For the chelae, the length of the right chela (RCL) is recorded from the tip of the palm to the tip of the specimen, and the right chela height (RCH) is the greatest vertical distance between the upper and lower edges. The right chela profundus length (RPL) is measured from the tip of the palm to the edge of the right specimen. Similarly, for the left side, the left chela length (LCL) is the distance from the tip of the palm to the edge of the specimen, with the left chela height (LCH) representing the greatest vertical distance between the upper and lower edges. The left chela profundus length measures (LPL) the distance from the tip of the palm to the edge of the left specimen. All measurements were obtained using digital vernier calipers. Data were processed to determine the mean and standard deviation for each morphometric character.

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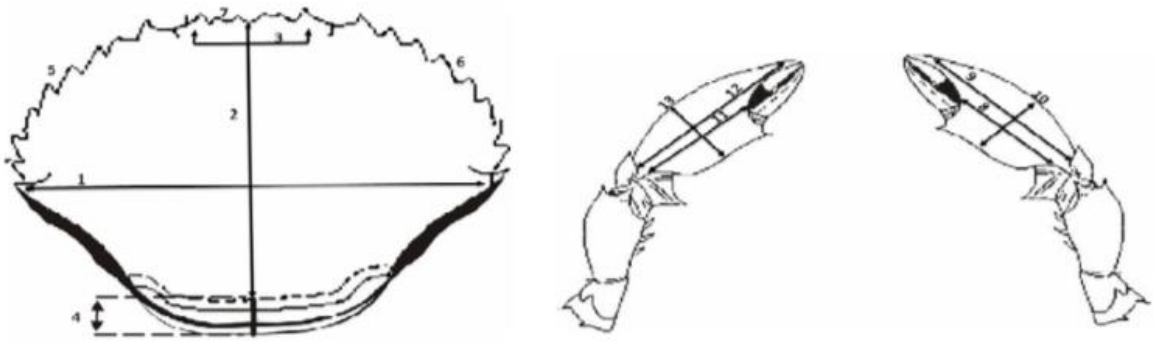
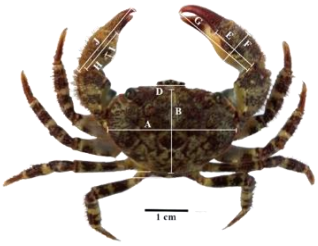
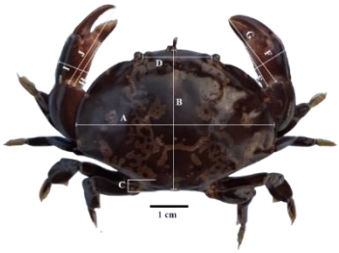
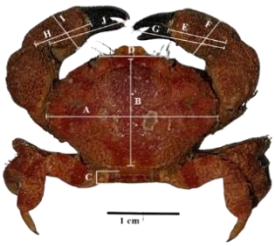


Figure 2. Morphometric and meristic characters seen dorsally and on the chela: (1) W, (2) L, (3) OGW, (4) H, (5) RCL, (6) RCH, (7) RPL, (8) LCL, (9) LCH, (10) LPL (Sitorus *et al*., 2023)

3. Results

Based on the conducted research, the following results were obtained.

Table 1. Toxic brachyurans found in the Nglolang Beach, Gunungkidul

Species	Family	Figure	
		Dorsal	Ventral
Eriphia scabricula	Eriphiidae		
Atergatis floridus	Xanthidae		
Etisus laevimanus	Xanthidae		
Platypodia granulosa	Xanthidae		

According to Table 1, two families and four species of toxic brachyuran crabs were identified at Nglolang Beach, Gunungkidul. *Eriphia scabricula* was the only representative of the family Eriphiidae, whereas *Atergatis floridus*, *Etisus laevimanus*, and *Platypodia granulosa* belonged to the family Xanthidae. Dorsal views of brachyurans show morphometric characters analyzed in this research, such as carapace width (A), length (B), height (C), OGW (D), RCL (E), RCH (F), RPL (G), LCL (H), LCH (I), and LPL (J). All of the samples found were male according to their narrow abdomen.

Table 2. Morphometry of toxic brachyurans from Nglolang Beach, Gunungkidul

No.	**Morphometric Characters**	**Average Measurement ± SD (mm)**			
		Eriphia scabricula	***Atergatis floridus***	***Etisus laevimanus***	***Platypodia granulosa***
1.	W	23.55 ± 3.21	39.38 ± 5.78	19.96 ± 0.11	24.93 ± 0.05
2	L	18.52 ± 2.32	28.38 ± 4.36	14.23 ± 0.05	17.73 ± 0.11
3	H	10.97 ± 128	17.33 ± 2.56	9.20 ± 0.10	11.90 ± 0.17
4	OGW	12.78 ± 1.66	14.68 ± 2.28	8.26 ± 0.05	10.70 ± 0.10
5	RCL	11.53 ± 1.29	11.30 ± 0.28	9.20 ± 0.10	8.93 ± 0.05
6	RCH	10.40 ± 1.36	9.95 ± 1.04	7.13 ± 0.05	7.33 ± 0.05
7	RPL	17.73 ± 2.51	17.25 ± 3.52	8.46 ± 0.05	14.63 ± 0.05
8	LCL	8.08 ± 1.58	11.75 ± 1.52	8.46 ± 0.05	9.30 ± 0.17
9	LCH	8.08 ± 1.38	11.03 ± 2.14	7.26 ± 0.05	7.77 ± 0.05
10	LPL	13.80 ± 2.20	17.88 ± 3.56	13.85 ± 0.05	12.83 ± 0.05

According to Table 2., toxic brachyurans in the Nglolang Beach, Gunungkidul show various morphometric characters. Generally, *Atergatis floridus* is the largest species with the highest number of all morphometric characters. Therefore, the smallest species is *Etisus laevimanus* with the carapace width of 19,96 ± 0,11 mm, carapace length of 14,23 ± 0,05 mm, and carapace height of 9,20 ± 0,10 mm.

Table 3. Environmental factors in the Nglolang Beach, Gunungkidul intertidal area

No	Environmental factor	Measurement
1.	Water temperature (°C)	27.33
2.	Salinity (ppm)	40.33

According to the table, the average water temperature in the Nglolang Beach intertidal area is 27.33°C. The saltwater salinity in the area region is 40.33 ppm.

4. Discussion

The research was conducted at Nglolang Beach, located in the Gunungkidul Regency of the Yogyakarta Special Region, using the purposive sampling method by collecting crabs encountered during rounds in the intertidal zone. Four toxic crab species were identified: *Atergatis floridus*, *Etisus laevimanus*, and *Platypodia granulosa* from the family Xanthidae, and *Eriphia scabricula* from the family Eriphiidae.

Eriphia scabricula is a species of crab commonly found in rocky intertidal zones and coastal areas. It has several distinctive general characteristics that make it identifiable. *Eriphia scabricula* has a robust, oval-shaped carapace with a rough, granulated texture, giving it a rugged appearance. Its coloration ranges from dark brown to grayish, often with a mix of patches that provide camouflage against rocky backgrounds. The claws, or chelae, are relatively large and strong, helping it grip prey and defend itself. This species is adapted to withstand harsh, changing tidal environments and is often found in crevices or under rocks during low tide. Its diet is mainly carnivorous, feeding on small invertebrates, which it captures with its powerful claws. These general traits help *Eriphia scabricula* survive in its specific habitat, enabling it to thrive in diverse coastal ecosystems (Koh & Ng, 2008). The morphometric measurements of *Eriphia scabricula* reveal specific size characteristics. The carapace width ranges from 20.20 to 26.60 mm, with an average of 23.55 ± 3.21 mm, while the carapace length varies from 16.30 to 20.90 mm, averaging 18.52 ± 2.32 mm. The carapace height spans from 9.80 to 12.30 mm, with a mean of 10.97 ± 1.28 mm. The width of the optical groove ranges from 11.20 to 14.40 mm, averaging 12.78 ± 1.66 mm. Measurements for the right chelae indicate a length of 10.20 to 13.10 mm (11.53 ± 1.29 mm) and a height of 8.90 to 11.70 mm (10.40 ± 1.36 mm), while its profundus length ranges from 15.10 to 20.50 mm, with an average of 17.73 ± 2.51 mm. On the left side, the chelae length is between 6.50 and 9.90 mm (8.08 ± 1.58 mm), with a height of 6.70 to 9.60 mm (8.08 ± 1.38 mm), and profundus length ranges from 11.70 to 16.00 mm, averaging 13.80 ± 2.20 mm. These measurements highlight the morphological adaptations and size range of this crab species.

Atergatis floridus has a smooth, broad carapace with a slightly convex shape, often showing vibrant coloration with reddish-brown or orange patterns, sometimes mixed with white or pale spots. Its body is relatively compact, with a carapace that is wider than it is long, tapering smoothly to the sides. The chelae, or claws, are robust and asymmetrical, with the right claw typically larger than the left. Both claws are smooth and slightly flattened, adapted for gripping. The legs are short and stout, covered with fine hairs, which enhance grip on rocky surfaces where the crab is often found (Ryanskiy, 2022). From the result, the carapace width ranges from 34.00 to 44.70 mm, with an average width of 39.38 ± 5.79 mm, while the carapace length is between 24.30 and 32.60 mm, averaging 28.38 ± 4.37 mm. The carapace height falls between 14.90 and 19.90 mm, with a mean height of 17.33 ± 2.56 mm. The optical groove width ranges from 12.50 to 16.80 mm, with an average of 14.68 ± 2.28 mm. The right chelae length is 11.00 to 11.80 mm, averaging 11.30 ± 0.28 mm, and its height is 8.90 to 11.00 mm, with an average of 9.95 ± 1.04 mm. The right chela profundus length measures 14.00 to 20.70 mm, with an average of 17.25 ± 3.53 mm. The left chelae length varies from 10.20 to 13.30 mm, with an average of 11.75 ± 1.52 mm, and its height is 8.80 to

13.10 mm, averaging 11.03 ± 2.14 mm. The left chela profundus length ranges from 14.60 to 21.20 mm, with an average length of 17.88 ± 3.56 mm.

Etisus laevimanus is a species of crab known for its robust and relatively broad, smooth carapace with rounded edges. The carapace is often adorned with subtle coloration, typically brown or reddish with occasional mottled patterns, allowing it to blend with rocky and coral environments. The claws (chelae) are strong and slightly asymmetrical, with one claw usually larger than the other, adapted for breaking and crushing hard-shelled prey. The surface of the chelae is generally smooth, and each has a row of granules along the outer edges. Its legs are short and sturdy, ending in pointed tips, which assist in gripping onto rocky surfaces, enhancing stability in strong currents where this species is commonly found (Trivedi & Vachhrajani, 2013). The morphometric characteristics of this specimen are as follows: the carapace width ranges from 19.90 to 20.01 mm, with an average of 19.96 ± 0.11 mm, while the carapace length measures between 14.20 and 14.30 mm, averaging 14.23 ± 0.05 mm. Carapace height is 9.10 to 9.30 mm, with a mean of 9.20 ± 0.10 mm. The optical groove width is 8.20 to 8.30 mm, averaging 8.26 ± 0.05 mm. The right chelae length is 9.10 to 9.30 mm, averaging 9.20 ± 0.10 mm, and its height is 7.10 to 7.20 mm, averaging 7.13 ± 0.05 mm. Right chela profundus length is 8.40 to 8.50 mm, with a mean of 8.46 ± 0.05 mm. Left chela length is 8.40 to 8.50 mm, averaging 8.46 ± 0.05 mm, and left chela height ranges from 7.20 to 7.30 mm, averaging 7.26 ± 0.05 mm. Lastly, the left chela profundus length is 13.80 to 13.90 mm, with an average of 13.85 ± 0.05 mm.

Platypodia granulosa is a crab species with a distinctive granular texture covering its carapace, giving it a rough appearance. The carapace is broadly oval and slightly convex, with well-defined lateral spines and a coarse surface that aids in camouflage. This species often displays a mottled brown, gray, or greenish coloration, allowing it to blend into rocky and coral environments. Its chelae (claws) are robust and somewhat asymmetrical, adapted for gripping and crushing prey. The legs are relatively short, with fine hair-like setae that assist in movement across uneven, rocky substrates. This crab is typically found in shallow, reef-associated habitats where its rough texture and coloration provide effective concealment (Ng *et al*., 2008). The morphological measurements for this species include carapace and chelae dimensions. From the result, the carapace width ranges from 24.90 to 25.00 mm, with an average of 24.93 ± 0.05 mm, while the carapace length measures between 17.60 and 17.80 mm, averaging 17.73 ± 0.11 mm. Carapace height falls between 11.70 and 12.00 mm, with a mean height of 11.90 ± 0.17 mm. The optical groove width is 10.60 to 10.80 mm, averaging 10.70 ± 0.10 mm. For the chelae, the right chelae length is 8.90 to 9.00 mm, with an average of 8.93 ± 0.05 mm, and its height is 7.30 to 7.40 mm, averaging 7.33 ± 0.05 mm. The right chela profundus length ranges from 14.60 to 14.70 mm, with an average of 14.63 ± 0.05 mm. The left chelae length is 9.20 to 9.50 mm, with a mean of 9.30 ± 0.17 mm, and its height ranges from 7.70 to 7.80 mm, averaging 7.77 ± 0.05 mm. The left chela profundus length is 12.80 to 12.90 mm, with an average of 12.83 ± 0.05 mm.

The environmental factors of water temperature and salinity significantly affect the physiology and behavior of *Atergatis floridus*, *Platypodia granulosa*, *Etisus laevimanus*, and *Eriphia scabricula*, crabs adapted to rocky and intertidal habitats (Hegele-Drywa & Normant,

2014). For example, *Atergatis floridus*, with its vibrant, broad carapace, thrives in warmer, stable waters, as indicated by the 27.33°C average water temperature, which is favorable for metabolic activities essential for molting and reproduction. High salinity levels (40.33 ppm) may require this species to expend additional energy for osmoregulation, a factor that could impact growth rates and reproduction if salinity rises further. Similarly, the rough-textured *Platypodia granulosa* and the robust *Etisus laevimanu*s rely on these stable conditions for camouflage and effective predation, as high temperatures support the enzymatic activities necessary for their survival. *Eriphia scabricula*, noted for its granulated carapace and preference for intertidal zones, can handle fluctuating environmental factors. However, a consistent high salinity level demands greater osmoregulatory efficiency, impacting energy allocation and possibly influencing its territorial behavior and feeding patterns. Overall, these environmental factors underscore how species-specific physiological adaptations enable these crabs to survive in specialized niches along coastlines (Parmar *et al*., 2018).

The species identified in this study, including *Atergatis floridus*, were found to be smaller than those reported in previous literature, such as from the study of Alam *et al.* (2020), which noted carapace lengths averaging ±45 mm, and chelae lengths averaging ±21 mm. The identification of *Etisus laevimanus* in this study is also smaller than the findings of Lata *et al*. (2022), who reported a carapace length of approximately ±36 mm, a carapace width of ±56 mm, and a chela length of ±41 mm.

The smaller size observed in this study could be attributed to several factors. First, the crabs in this research may be younger or not yet fully matured, which could explain the smaller carapace and chelae dimensions. This hypothesis is supported by the fact that the crabs at Nglolang Beach were sampled from the intertidal zone, an area that may host juvenile or subadult populations, which are typically smaller in size compared to mature individuals found in deeper waters or more stable environments.

This study also provides the first morphometric data for *Platypodia granulosa* and *Eriphia scabricula*, as no previous studies have conducted morphometric analyses for these species. This gap in the literature underlines the significance of this research, which contributes valuable insights into the size characteristics of these two species. Future studies will benefit from this foundational data, potentially offering comparisons across different populations or environmental conditions to better understand the growth patterns and ecological adaptations of these species.

5. Conclusion

Based on the research conducted at Nglolang Beach, Gunungkidul, four species of toxic crabs were identified: *Atergatis floridus*, *Etisus laevimanus*, and *Platypodia granulosa* (Xanthidae), alongside *Eriphia scabricula* (Eriphiidae). The study demonstrates that these species exhibit high morphological adaptation, with carapace dimensions and protective coloration evolving to suit the specific environmental pressures of the intertidal zone. The observed heterochelae (the right chela is consistently larger than the left) reflects specialized operational behaviors potentially linked to feeding and defense strategies in toxin-bearing species. Furthermore, the activity patterns of these crabs are heavily regulated by abiotic factors, particularly water temperature and tidal cycles, which dictate critical life processes such as hunting and molting.

The identification of these toxic species in a high-activity coastal area like Nglolang Beach has significant implications for public health and local fisheries. Since the toxins in these families (such as STX and TTX) are heat-resistant, these findings serve as a critical baseline for developing community-based food safety protocols and educational materials for local residents and tourists. To further this research, it is essential to conduct seasonal toxicity assays to determine if the toxin levels in these specific populations fluctuate during algal blooms. Additionally, establishing a long-term monitoring program for intertidal crustaceans in Gunungkidul would allow for a better understanding of how climate-driven temperature shifts might expand the range of these hazardous species, ultimately protecting both the local ecosystem and the communities that depend on it.

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Author contributions

Dhea Amelia, Jagad Wenang Suryoaji, Alisha Syavitri Ramadhani Arbian, Ridhwan Putra Ramadhan, and Asy Syifa Paras Ceria contributed equally to data collection and manuscript preparation. Dr. Rury Eprilurahman supervised the research and provided critical revisions to the manuscript. All authors read and approved the final manuscript. All authors read and approved the final manuscript.

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Competing interests

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.

Informed consent

Obtained.

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The Publication Ethics Committee of the Macrothink Institute.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

Open access

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