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SHORT COMMUNICATION: MORPHOMETRIC CHARACTERISTICS OF COCONUT CRABS *(BIRGUS LATRO)* ON PACIFIC RIM ISLANDS FROM NORTH MALUKU, INDONESIA

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Abstract

Coconut crabs (Birgus latro) are iconic crustaceans inhabiting tropical coastal regions of the Indo-Pacific, renowned for their impressive size and unique ecological role. However, coconut crab populations face various threats, necessitating research to inform conservation efforts. This study investigates the morphometric characteristics of coconut crabs from two distinct habitats, Liwo Island and Sayafi Island, in North Maluku, Indonesia. Morphometric data, including thorax length, chela dimensions, carpus length, and merus length, were collected and compared between populations to identify potential differences and explore underlying factors. Our findings reveal significant differences in morphometric traits, indicating habitat-specific influences. Environmental factors such as temperature, humidity, substrate type, and food availability likely contribute to these variations. Understanding these differences is crucial for implementing effective conservation strategies tailored to the specific needs of coconut crab populations. This research contributes to the broader understanding of coconut crab biology and ecology, informing evidence-based management practices for their sustainable conservation.

Keywords: Coconut Crab, Conservation, Habitat Differences, Morphometrics, North Maluku.

INTRODUCTION

Coconut crabs (Birgus latro), also known as robber crabs or palm thieves, are iconic crustaceans found in tropical coastal regions of the Indo-Pacific. Renowned for their impressive size and unique biology, coconut crabs play a significant role in marine ecosystems and cultural traditions across their range. However, despite their ecological importance and cultural significance, coconut crab populations face various threats, including habitat loss, overharvesting, and climate change, highlighting the need for comprehensive research to inform conservation and management efforts. Research on coconut crabs has delved into various aspects of their biology and conservation. Studies have focused on topics such as the growth of coconut crabs 1, impacts of harvesting on reproduction 2, influence of size- and sex-biased harvesting on reproduction 3, reproductive season and female maturity size 4, prediction of timing of mating and egg extrusion 5, and identification of individual coconut crabs based on carapace patterns 6. These studies provide valuable insights into the life history, reproductive behavior, and management strategies for coconut crabs. Furthermore, the distribution and conservation need of coconut crabs have been explored in different regions. For instance, research has been conducted on the stock status of

coconut crabs in specific locations like Daeo, Morotai Island District, North Maluku, Indonesia 7, and the Nicobar Islands, India 8. Additionally, studies have highlighted the global threats faced by coconut crabs and proposed conservation solutions 9.

The morphometric characteristics and growth patterns of coconut crabs are essential for understanding population dynamics, resource utilization, and ecosystem interactions. Morphometric data offer valuable insights into size distribution, growth rates, and morphological variations within populations, shedding light on the influence of environmental factors, genetic diversity, and reproductive strategies on phenotypic traits. A study focused on estimating the growth of the coconut crab Birgus latro using mark-recapture techniques with passive integrated transponder (PIT) tags, providing crucial information for stock assessment and management 1. Published research explored the growth of coconut crabs at their northernmost range, estimating growth parameters essential for resource management and conservation strategies 10. Furthermore, a study investigated the superior mechanical resistance in the exoskeleton of coconut crabs, highlighting their unique adaptations and offering insights into their evolutionary adaptations and ecological roles 11.

Understanding the morphometric characteristics and growth patterns of coconut crabs is essential for assessing population dynamics, resource utilization, and ecosystem interactions. Morphometric data provide valuable insights into the size distribution, growth rates, and morphological variations among individuals within a population. Moreover, morphometric analyses can elucidate the influence of environmental factors, genetic diversity, and reproductive strategies on the phenotypic traits of coconut crabs.

In this context, the present study aims to investigate the morphometric characteristics of coconut crabs from two distinct habitats: Liwo Island and Sayafi Island, both located in the North Maluku region of Indonesia. By comparing morphometric data between these two populations, we seek to identify potential differences in size, shape, and other morphological features, and explore the underlying factors driving such variations. Specifically, we examine parameters such as thorax length, chela dimensions, carpus length, and merus length, among others, to assess whether habitat-specific environmental conditions influence the morphometric traits of coconut crabs.

Previous research by 7 has suggested significant differences in morphometric characteristics between coconut crabs from Liwo Island and Sayafi Island. However, the specific factors contributing to these differences remain poorly understood. By building upon this previous work and incorporating additional environmental data, our study aims to provide a more comprehensive understanding of the morphological variability within coconut crab populations and its implications for their conservation and management.

Overall, this research contributes to the broader scientific knowledge of coconut crab biology and ecology, informing evidence-based conservation strategies tailored to the unique characteristics of coconut crab populations in different habitats. By elucidating the factors driving morphometric variations, we aim to promote the sustainable management of coconut crab resources and ensure the long-term viability of these iconic crustaceans in their natural environments.

MATERIAL AND METHODS

Study area

This research was conducted in November 2022. Sampling of test animals (B. latro) was carried out on Liwo Island, Central Halmahera Regency, North Maluku, Indonesia (Figure 1), for 3 weeks.

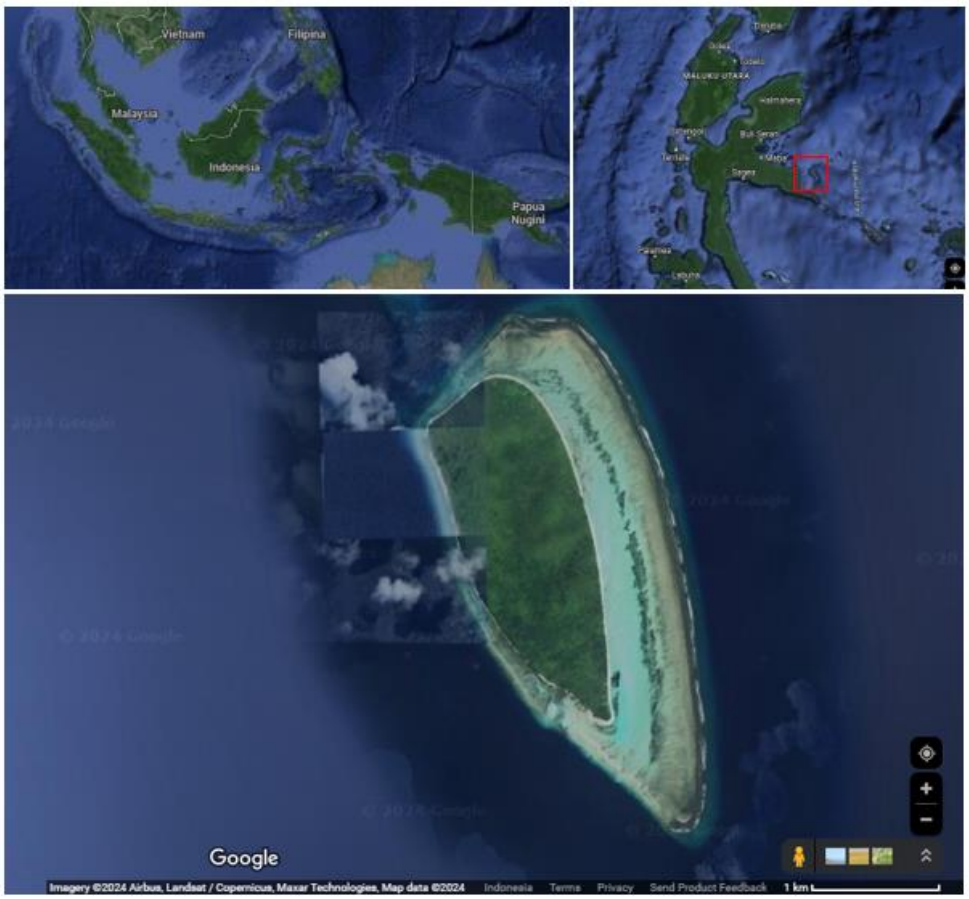

Figure 1: Sampling Location in Liwo Island, Central Halmahera Regency, North Maluku, Indonesia

Sample collection

Samples of coconut crabs (B. latro) were obtained from their natural habitat in Liwo Island, Central Halmahera Regency. The collected crabs were divided into three groups based on their thorax length: Juvenile (J) with thorax length less than 10 mm, Adolescent (A) with thorax length equal to or less than 24.5 mm, and Adult (D) with thorax length equal to or greater than 24.5 mm. The capture of the crabs was facilitated by local fishermen using the hand-catching method. The involvement of these fishermen in the collection process offers numerous advantages. Their extensive knowledge of the local ecosystems and species can provide valuable insights to researchers and conservationists.

Morphometrics Data collection

Data collection for morphometric analysis of coconut crabs (Birgus latro) in North Maluku, Indonesia, involved systematic sampling from diverse habitats across the region. Crabs were captured from various locations to ensure representation of

different ecological conditions. Morphometric measurements were then taken using a vernier caliper (figure 2), encompassing key parameters according to several publication methods 10–12 such as thorax length (ThL), carapace width (CW), carapace length (CL), length of chela propodus for both right (RPL) and left (LPL) chelae, height of chelae for both right (RCH) and left (LCH) chelae, length and height of carpus (CaL, CaH), and length and height of merus (MeL, MeH). These measurements adhered to established methodologies outlined by 1,7 for consistency and comparability. Careful attention was paid to ensure accuracy and precision during data collection, with instruments calibrated regularly. Additionally, ethical guidelines and permits were obtained to ensure compliance with regulations governing animal research. The collected morphometric data were subsequently subjected to statistical analysis to explore variations and correlations among the measured parameters.

Figure 2: Measurement of several morphometric characters, namely Right Propundus Length (RPL), Carpus Length (CaL), Left Claw Height (LDH), Left Dactylus Length (LDL), Carapace Width (CW), and Thorax Length (ThL)

DATA ANALYSIS

Analysis of the average thoracic length $(THL)^{-}$ of coconut crabs was carried out to group crabs based on age groups (Sparee and Venema, 1999). The assumption used is that the distribution of coconut crab thorax lengths follows the normal distribution. The formula used to obtain the average value of thoracic length is:

$$\overline{THL} = \frac{THL_{(1)} + THL_{(2)} + \ldots + THL_{(n)}}{n} = \frac{1}{n}\sum_{i=1}^{n} THL_{(i)}$$

Where : ThL = Crab thorax length (mm)
$\overline{ThL}$ = Average crab thorax length (mm) for each age group
n = Number of crab samples

RESULT AND DISCUSSION

Morphometric Characteristics Morphometric measurements were conducted on 16 individuals of coconut crabs (B. latro) collected from Liwo Island. The measurement results for each morphometric characteristic of coconut crabs (B. latro) are presented in Table 1. The range of thorax length (ThL) of coconut crabs (B. latro) during the study on Liwo Island was 7.00 - 39.5 mm, with ThL ranges for juvenile phase crabs being 7.0 - 10.0 mm, developing phase crabs 14.5 - 22.0 mm, and adult phase crabs 25.4 - 39.5 mm. The average thorax length ($\overline{(ThL)}$) of coconut crabs for the juvenile phase was 8.5 mm, developing phase 18.8 mm, and adult phase 33.1 mm. references

Table 1: Morphometric data of various characteristics of coconut crabs (B. latro) during the research at different ages, ranging from juvenile (J), through developing (B), to adult (D) phases

Age	Morphometric Character Size of Coconut Crab (mm)										
	ThL	CL	CW	RPL	RCH	LPL	LCH	CaL	CaH	MeL	MeH
J	7.0	5.1	11.1	8.5	5.1	11.1	7.3	6.2	5.0	8.7	6.3
J	10.0	7.3	15.9	12.2	7.3	15.9	10.4	8.8	7.1	12.4	9.0
B	14.5	10.6	23.0	17.6	10.6	23.0	15.1	12.8	10.3	18.0	13.1
B	17.0	12.5	27.0	20.7	12.5	27.0	17.7	15.0	12.1	21.0	15.3
B	20.0	14.7	31.8	24.3	14.7	31.8	20.8	17.7	14.3	24.8	18.0
B	20.5	15.0	32.6	24.9	15.0	32.6	21.3	18.1	14.6	25.4	18.5
B	22.0	16.1	35.0	26.7	16.1	35.0	22.9	19.5	15.7	27.2	19.8
D	25.4	18.6	40.4	30.9	18.6	40.4	26.4	22.5	18.1	31.4	22.9
D	27.0	19.8	42.9	32.8	19.8	42.9	28.1	23.9	19.3	33.4	24.4
D	27.4	20.1	43.5	33.3	20.1	43.5	28.5	24.2	19.5	33.9	24.7
D	30.0	22.0	47.7	36.5	22.0	47.7	31.2	26.5	21.4	37.1	27.1
D	32.0	23.5	50.8	38.9	23.5	50.8	33.3	28.3	22.8	39.6	28.9
D	34.5	25.3	54.8	41.9	25.3	54.8	35.9	30.5	24.6	42.7	31.1
D	35.0	25.7	55.6	42.5	25.7	55.6	36.4	31.0	25.0	43.3	31.6
D	39.5	29.0	62.8	48.0	29.0	62.8	41.1	34.9	28.2	48.9	35.6
D	39.5	29.0	62.8	48.0	29.0	62.8	41.1	34.9	28.2	48.9	35.6

The morphometric characteristics of coconut crabs from Liwo Island and Sayafi Island exhibit significant differences. These differences encompass thorax length, right and left propodus length, height of the right and left chelae (dactylus), as well as carpus length and height, and merus length and height 13.

However, other morphometric characteristics such as rostrum length, carapace length and width, length of the right and left chelae (dactylus), length of the 3rd and 4th legs, and tergal length did not differ significantly between the two islands. This variance in morphometric characteristics may be attributed to differences in food type and quantity, influencing growth or the distribution of coconut crab samples captured on both islands.

The morphometric characteristics of coconut crabs in a habitat can be influenced by the crab's adaptation to its environment or microhabitat, including coconut crabs on Liwo Island. Even within the same or nearby geographical areas, microhabitat separation can lead to environmental conditions in each microhabitat, such as temperature and food availability, subsequently affecting growth patterns reflected in morphometric characteristics.

Differences in substrate type and environmental parameters such as air temperature, soil temperature, and soil pH significantly impact the morphometric characteristics of coconut crabs in a location. Liwo Island has an air temperature of 27.31°C, soil temperature of 27.81°C, and a sandy substrate. The lower temperature creates good humidity as a habitat for crabs. The cooler and more humid environmental conditions affect the morphometric characteristics of coconut crabs. Coconut crabs from Sayafi Island have longer thoraxes and first and second pereopods compared to coconut crabs from Liwo Island. Additionally, the chelae (dactylus) of coconut crabs from Sayafi Island are taller than those from Liwo Island.

Growth Patterns

The morphometric data of coconut crabs (B. latro) reveals distinct growth patterns as individuals progress from juvenile to adult stages. Across all measured parameters, including thorax length (ThL), carapace length (CL), carapace width (CW), and various chela dimensions (RPL, RCH, LPL, LCH), as well as other appendages (CaL, CaH, MeL, MeH), there is a consistent trend of increasing size with advancing age.

During the juvenile phase, coconut crabs exhibit relatively smaller measurements compared to the developing and adult phases. This phase is characterized by rapid growth and considerable variation in size as individuals transition towards maturity. Notably, the range of measurements within the juvenile phase reflects the early stages of growth and development, where individuals may experience different environmental conditions and resource availability, influencing their growth rates 1,10.

As coconut crabs enter the developing phase, there is a significant increase in size across all measured parameters. This period is marked by accelerated growth rates as individuals undergo physiological and morphological changes necessary for maturation. The growth trajectory during this phase suggests an active accumulation of biomass and structural development, indicative of the transition towards reproductive maturity.

In the adult phase, coconut crabs reach their maximum size, exhibiting the largest measurements among all age categories. This phase represents the endpoint of growth and development, where individuals have attained sexual maturity and reached their full potential size 1,5,10. The observed size differences between adult and juvenile phases highlight the substantial growth potential and ontogenetic changes experienced by coconut crabs throughout their life cycle.

Understanding the growth patterns of coconut crabs is crucial for assessing population dynamics, resource utilization, and ecosystem interactions. Monitoring changes in size distribution and growth rates over time can provide valuable insights into population health, recruitment dynamics, and potential impacts of environmental stressors on coconut crab populations.

Variability in Size

The morphometric data of coconut crabs (B. latro) illustrates notable variability in size within each age category. While there is a general trend of increasing size with advancing age, the observed variability highlights the complex interplay of genetic, environmental, and individual factors influencing growth dynamics in coconut crab populations 1.

One explanation for the observed variability is genetic diversity within the population. Genetic differences can influence growth rates, body size, and morphological characteristics among individuals. Variations in genetic composition may result in phenotypic differences, leading to the observed size variability within the same age category 14. Further genetic studies could elucidate the extent to which genetic factors contribute to size variability in coconut crabs.

Environmental factors also play a significant role in shaping size variability in coconut crabs. Variation in habitat quality, food availability, temperature regimes, and predation pressure can impact growth rates and ultimately influence individual size. For instance, individuals inhabiting resource-rich environments may exhibit faster growth rates and attain larger sizes compared to those in less favorable habitats. Additionally, environmental stressors such as pollution or habitat degradation may constrain growth, leading to size disparities among individuals within the same population 15.

Individual variations in physiological condition, behavior, and competitive interactions can further contribute to size variability in coconut crabs. Factors such as access to food resources, reproductive status, and social hierarchy can influence growth trajectories and resource allocation, resulting in size differences among individuals. Intraspecific competition for resources may also play a role, with dominant individuals potentially outcompeting others and attaining larger sizes.

The observed variability in size has implications for population dynamics, ecological interactions, and conservation efforts. Understanding the factors driving size variability is essential for assessing population health, predicting responses to environmental change, and implementing effective management strategies. Monitoring changes in size distribution and identifying the underlying drivers of size variability can provide valuable insights into the resilience and adaptive capacity of coconut crab populations in the face of environmental challenges. Moreover, incorporating size variability data into conservation plans can help ensure the preservation of genetic diversity and the long-term sustainability of coconut crab populations in their natural habitats.

CONCLUSION

The significance of habitat-specific influences on the morphometric characteristics of coconut crabs (Birgus latro) in North Maluku, Indonesia. The observed differences in morphometric traits between populations from Liwo Island and Sayafi Island underscore the importance of environmental factors such as temperature, humidity, substrate type, and food availability in shaping coconut crab morphology. These findings emphasize the need for tailored conservation strategies that consider habitat variability and its impact on coconut crab populations. By understanding the drivers of morphometric variations, we can implement more effective management practices to ensure the long-term sustainability of coconut crab populations in their natural habitats.

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