Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 202 (2025) 27-33 EISSN 2392-2192

Evaluating the Ecological Significance of *Macrobrachium macrobrachion* and *Macrobrachium vollenhovenii* in Sustaining Ecosystem Services of the Calabar River, Nigeria

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ABSTRACT

Aquatic ecosystems are complex habitats hosting diverse species with distinct morphological adaptations to ecological pressures. This study investigates the morphometric characteristics of two prawn species, *Macrobrachium macrobrachion* and *M. vollenhovenii*, from the Calabar River, Nigeria. Morphometric data were gathered from 100 individuals of *M. vollenhovenii* and 85 of *M. macrobrachion*. Measurements included total length, carapace length, and rostrum length. An independent samples t-test compared these traits between the species. Results showed significant differences in several parameters, with *M. vollenhovenii* displaying larger mean values in total length, carapace length, head length, telson length, and appendage dimensions ($p < 0.05$). These differences suggest size-related adaptations, feeding strategies, and habitat preferences contributing to niche partitioning and coexistence. Eye diameter showed no significant difference ($p = 0.81$), indicating conserved visual needs. The morphometric variations highlight the interaction between morphology and adaptive strategies in response to habitat dynamics. The larger size of *M. vollenhovenii* may offer competitive and reproductive advantages. Differences in appendage measurements suggest specialization in feeding and substrate use. This study enriches our understanding of prawn biology, their ecological roles, and potential responses to environmental changes, aiding in conservation efforts and sustainable management of the Calabar River ecosystem.

Keywords: Morphometric characteristics, *Macrobrachium* species, Ecological adaptations, Calabar River ecosystem.

(Received 10 January 2025; Accepted 15 March 2025; Date of Publication 9 April 2025)

1. INTRODUCTION

Aquatic ecosystems are crucial for maintaining biodiversity and supporting the livelihoods of communities worldwide. They provide essential services, such as water purification, climate regulation, and habitat for a variety of species. In Nigeria, the Calabar River serves as a significant aquatic ecosystem, rich in biodiversity and supporting numerous flora and fauna. Among the notable inhabitants of this river are prawn species, particularly *Macrobrachium macrobrachion* and *M. vollenhovenii*, which play vital ecological and economic roles (Akinwunmi & Moruf, 2021; Oladokun *et al*., 2020).

The *Macrobrachium* species are integral to the aquatic food web, contributing to nutrient cycling and energy transfer within the ecosystem. These prawns are not only ecologically significant but also economically valuable. They provide a livelihood for local communities through subsistence fishing and commercial exploitation. Given their importance, understanding the biology and ecology of these species is essential for sustainable management and conservation efforts (Ekpenyong *et al*., 2019).

Morphometric analysis, which involves the quantitative measurement of physical characteristics, is a crucial tool in studying aquatic organisms. It helps in understanding the variations, adaptations, and ecological dynamics of species. Morphometric studies provide insights into growth patterns, population structure, and potential responses to environmental changes, which are critical for effective conservation strategies (Yakubu & Udo, 2016). The data obtained from morphometric analysis can inform management practices, aiding in the development of policies aimed at preserving biodiversity and ensuring the sustainability of fishery resources (Okoye & Anyanwu, 2018).

Research on *Macrobrachium* species is particularly important as these prawns are subject to environmental pressures such as habitat degradation, pollution, and overfishing. These factors can lead to changes in population dynamics, affecting the ecological balance and the economic stability of communities that depend on these resources. Understanding the morphometric variations of *M. macrobrachion* and *M. vollenhovenii* can provide valuable information on how these species adapt to environmental changes and anthropogenic impacts (Udo *et al*., 2021).

The Calabar River, with its dynamic ecosystem, offers a unique opportunity to study these prawn species. The river's diverse habitats, ranging from freshwater to brackish environments, support a wide variety of aquatic organisms. The *Macrobrachium* species in this river exhibit distinct morphological traits that reflect their adaptations to different environmental conditions. By examining these traits, researchers can gain insights into the ecological roles of these species and their responses to habitat variations (Ekanem & Anwana, 2017).

This study aims to conduct a comprehensive morphometric assessment of *M. macrobrachion* and *M. vollenhovenii* populations in the Calabar River. By employing rigorous measurement and analysis techniques, the research seeks to characterize variations in size, shape, and proportions among individuals. Such insights are crucial for understanding the biology, ecology, taxonomy, and conservation of these species. Moreover, this study aims to contribute to the broader understanding of how environmental factors influence morphometric traits and how these changes can impact the sustainability of prawn populations in the region.

In conclusion, the morphometric analysis of *Macrobrachium* species in the Calabar River is essential for developing effective conservation strategies and sustainable management practices. By understanding the physical characteristics and ecological roles of these prawns, we can better address the challenges posed by environmental changes and human activities. This research will provide valuable data to support the conservation of *Macrobrachium* species and the overall health of the Calabar River ecosystem.

2. MATERIALS AND METHODS

2.1. Study Area

This research was carried out in the Calabar River, an important aquatic habitat in Nigeria. The specific segment studied spans 11.5 km, situated between longitudes 8°15'E and 8°20'E, and latitudes 4°54'N and 5°00'N. The river experiences semi-diurnal tides, with maximum surface tidal current velocities reaching 120 cm/s during flood tides and 130 cm/s during ebb tides (Ekpo *et al*., 2022). The Calabar River supports diverse aquatic life, playing a critical role in the regional ecology and economy.

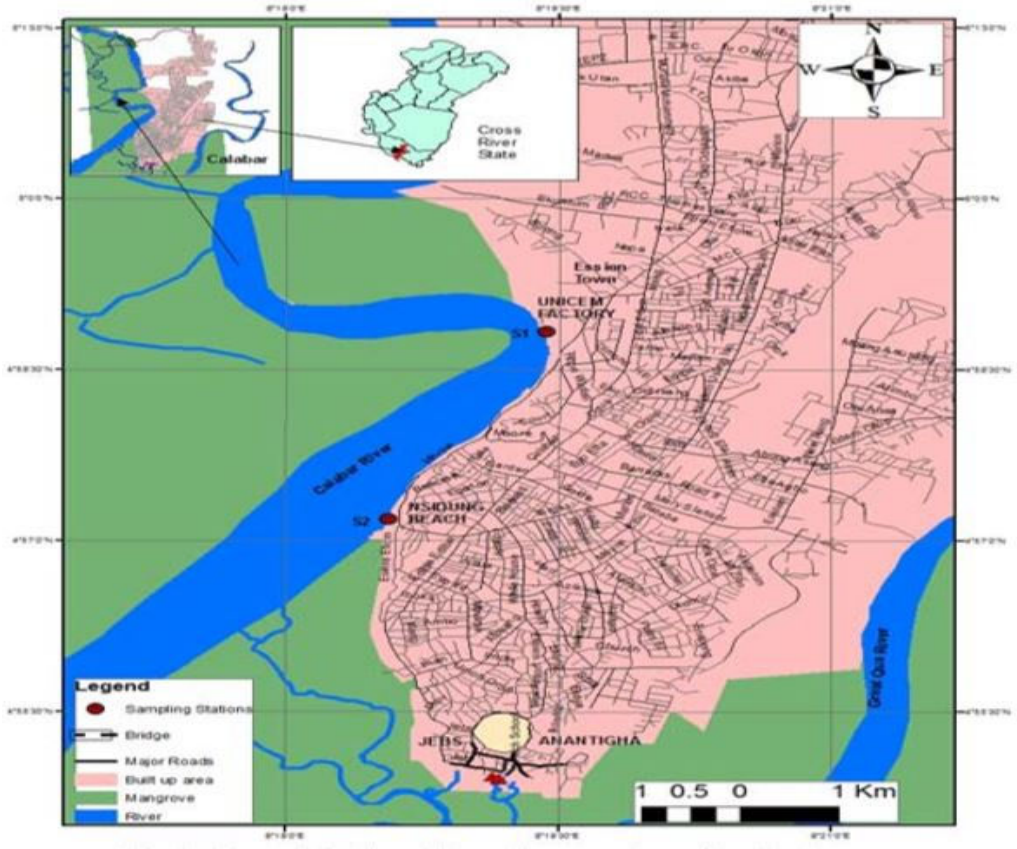

Figure 1. Map of Calabar River Showing Sampling Station (Andem *et al.,* 2013).

2.2. Sample Collection

Prawn specimens of Macrobrachium macrobrachion and M. vollenhovenii were collected from artisanal prawn catch landings at Nsidung Beach along the Calabar River.

Sampling was conducted over six months, ensuring comprehensive coverage of both wet and dry seasons to account for seasonal variations in prawn populations (Kumar *et al*., 2020). The prawns were collected using cast nets with a mesh size of 20 mm, deployed by local fishers during both high and low tide periods (Islam *et al*., 2019). Once landed, the prawns were immediately placed in aerated containers to preserve their condition for accurate morphometric assessment.

This approach allowed for the collection of a representative sample of the prawn populations in the river (Sahoo *et al*., 2022). Morphometric measurements were taken using a vernier caliper with precision to the nearest 0.1 mm. Parameters measured included total length, carapace length, and rostrum length. In total, 185 prawns were analyzed, consisting of 100 M. vollenhovenii and 85 M. macrobrachion. The extended sampling period ensured the collection of a robust dataset, reflecting the population dynamics and morphological variations of the prawns.

Data collected were systematically recorded and analyzed statistically to identify significant differences in morphometric traits between the two species. This standardized approach provided valuable insights into the growth patterns, ecological adaptations, and potential environmental influences on prawn populations in the Calabar River. Upon collection, individual prawns were carefully examined and measured for a range of morphometric characteristics. These included total length, carapace length, rostrum length, head length, telson length, telson width, carapace width, palm width, and eye diameter among others. Measurements were taken using Vernier calipers and a measuring Board (0.01 cm accuracy). The collected morphometric data were subjected to statistical analysis using SPSS (ver. 20) Descriptive statistics such as mean and standard deviation were calculated for each measured trait. Additionally, independent t-tests were performed to assess differences in morphometric characteristics between both prawn species.

3. RESULTS AND DISCUSSION

The morphometric assessment of prawn species, *M. vollenhovenii* and *M. macrobrachion*, in the Calabar River revealed significant differences in various morphometric characteristics between the two species (Table 1). These findings indicate that *M. vollenhovenii* generally exhibits larger mean values for various morphometric traits compared to *M. macrobrachion*. Notably, the total length, carapace length, rostrum length, head length, telson length, telson width, carapace width, carapace depth, pereiopod length, ischium length, merus length, carpus length, palm length, dactylus length, distal tooth fixed digit tip, ischium width, merus width, carpus width, and palm width were all significantly larger in *M. vollenhovenii* ($p < 0.05$).

Table 1. Results of Independent Samples T-Test for Morphometric Characteristics of the Prawn Species.

Morphometric parameters	***M. vollehovenii* (N=100)** Mean (cm)	SD	***M. macrobrachion* (N=85)** Mean (cm)	SD	P-value	Remark
Total length	11.35	0.38	9.63	0.58	0.03	Significant
Carapace length	2.61	0.11	2.03	0.14	0.01	Significant
Rostrum length	2.66	0.12	2.27	0.14	0.05	Significant
Head length	5.31	0.21	4.30	0.27	0.01	Significant
Telson length	1.42	0.06	1.22	0.06	0.04	Significant
Telson width	1.51	0.07	1.23	0.09	0.03	Significant
Carapace width	2.46	0.11	1.93	0.16	0.02	Significant
Carapace depth	2.38	0.12	1.89	0.14	0.02	Significant
Pereiopod length	10.43	0.67	7.29	0.47	0.00	Significant
Ischium length	1.43	0.07	1.20	0.06	0.02	Significant
Merus length	1.93	0.13	1.37	0.11	0.00	Significant
Carpus length	1.80	0.12	1.36	0.11	0.01	Significant
Palm length	3.12	0.26	2.05	0.16	0.00	Significant
Dactylus length	2.34	0.15	1.51	0.11	0.00	Significant
Distal tooth fixed digit tip	1.32	0.07	0.99	0.04	0.00	Significant
Ischium width	0.36	0.02	0.26	0.02	0.00	Significant
Merus width	0.60	0.04	0.44	0.03	0.01	Significant
Carpus width	0.68	0.04	0.45	0.04	0.00	Significant
Palm width	0.70	0.09	0.50	0.03	0.05	Significant
Eye diameter	0.40	0.02	0.39	0.01	0.81	Not significant

The lack of significant difference in eye diameter between *Macrobrachium vollenhovenii* and *M. macrobrachion* ($p = 0.81$) suggests that visual adaptations may be less pronounced in these species. This indicates that their visual requirements may be similar, potentially due to the shared ecological conditions they inhabit. Eye diameter, as a fundamental sensory trait, may be conserved across these species, reflecting their need for basic visual functions in the river environment (Thorne & Howland, 2019). Similar findings were observed by Agbugui *et al.* (2021), who reported no significant difference in eye diameter in *Gymnarchus niloticus* in the Lower River Niger, Nigeria. Their study highlighted how certain morphological traits remain conserved across species, likely influenced by shared environmental pressures and sensory needs (Agbugui *et al.,* 2021).

In contrast, other morphometric traits, such as total length, carapace length, and various appendage dimensions, exhibited significant differences between the two prawn species. *M. vollenhovenii* generally displayed larger mean values for these traits, suggesting a species-specific advantage in terms of size and fitness. According to Brewer *et al*. (1991), larger individuals often demonstrate enhanced competitive abilities, more efficient foraging behavior, and better resistance to predation. These size-related adaptations may contribute to the higher reproductive success and resource exploitation of *M. vollenhovenii* in comparison to *M. macrobrachion*.

Differences in rostrum length, telson width, and pereiopod length further suggest that these species occupy distinct ecological niches, with species-specific feeding strategies and habitat preferences. Lifjeld (1984) proposed that variations in appendage dimensions are reflective of adaptations for particular feeding behaviors or environmental conditions. For example, *M. vollenhovenii*'s longer rostrum and telson may be linked to its adaptation for preying on specific food sources, while the longer pereiopods could indicate a preference for particular substrates or current conditions. These morphological distinctions underscore the potential for niche partitioning, allowing both species to coexist in the same ecosystem by utilizing different resources (Higgins & Macdonald, 1996; Ekpo *et al*., 2022, 2024)

The reproductive strategies of these species may also be influenced by morphometric traits. Anger and Moreira (1998) found that larger individuals in some aquatic species tend to be more efficient at carrying eggs and may exhibit different reproductive timings. In the case of *M. vollenhovenii*, the larger palm length, dactylus length, and other appendage measurements could be linked to its ability to perform more efficient mating behaviors or parental care, potentially increasing reproductive success (Singh & Singh, 2017).

Ultimately, the observed differences in morphometric traits between *M. vollenhovenii* and *M. macrobrachion* highlight how these species adapt to their environment in ways that optimize their ecological roles and survival strategies. While their visual adaptations appear similar, other traits, such as size and appendage characteristics, reflect distinct ecological niches and reproductive strategies, contributing to the maintenance and success of their populations in the Calabar River (Ekpo *et al*. (2017, 2021).

4. CONCLUSIONS

The morphometric differences observed between *M. vollenhovenii* and *M. macrobrachion* offer important insights into how each species adapts to its ecological niche in the Calabar River. These variations highlight the connection between morphological traits and ecological functions, demonstrating how the species have evolved to exploit available resources effectively. The distinct morphometric profiles of these prawns reflect their specialized roles within the ecosystem, influencing their feeding behaviors, habitat preferences, and interactions with other species. By adapting to their respective environments, both species contribute to the river's ecological balance, emphasizing the complexity of interspecies relationships and the importance of morphological adaptations in survival and resource utilization. These findings enhance our understanding of the prawn populations' roles in the river ecosystem, highlighting their significance in maintaining ecological processes and biodiversity.

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