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Morphometric Characteristics of Freshwater Shrimp in Lotic and Lentic Habitats of Ogan Ilir Regency, South Sumatra

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Abstract: This study aimed to analyze the length–weight relationship and morphometric variation of three freshwater shrimp species from lotic and lentic habitats in Ogan Ilir Regency, South Sumatra, Indonesia. The study was conducted from November 2025 to May 2026 using purposive sampling at six aquatic stations, comprising three lotic and three lentic habitats. A total of 300 shrimp specimens were collected using baited traps (*bubu*) and hand nets. The observed parameters included total length and body weight. Length–weight relationships were analyzed using the allometric equation $W = aL^b$, whereas morphometric variation was evaluated using Principal Component Analysis (PCA). The results showed that *Palaemon carcinus* exhibited positive allometric growth in both lotic ($b = 5.805$) and lentic habitats ($b = 6.963$). Similarly, *Macrobrachium rosenbergii* showed positive allometric growth in lotic ($b = 8.230$) and lentic habitats ($b = 3.973$). In contrast, *Macrobrachium nipponense* demonstrated positive allometric growth in lotic habitats ($b = 4.960$) but negative allometric growth in lentic habitats ($b = 0.899$). PCA revealed that most morphometric variation was explained by the first principal component (PC1), indicating a strong association between total length and body weight. These findings suggest that habitat type, particularly differences between lotic and lentic aquatic systems, influences growth patterns and morphometric variation in freshwater shrimps in South Sumatra.
Keywords: Allometry; freshwater shrimp; lentic habitat; lotic habitat; morphometry

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INTRODUCTION

Ogan Ilir Regency, South Sumatra, contains diverse inland freshwater ecosystems, including swamps, rivers, floodplains, irrigation channels, and other freshwater bodies that provide potential habitats for freshwater shrimp. This region is strongly influenced by floodplain dynamics, in which seasonal hydrological connectivity may alter habitat availability, water quality, and species distribution. The waters of Ogan Ilir are predominantly characterized by lentic or slow-flowing ecosystems with relatively acidic conditions, although lotic habitats with distinct hydrological characteristics are also present. In limnological terms, differences between lentic and lotic ecosystems are associated with variation in water movement, residence time, substrate stability, oxygen dynamics, and organic matter availability (Wetzel, 2001). Such environmental heterogeneity can influence the survival, growth, and spatial distribution of aquatic organisms, including freshwater shrimp (Arhab & Junianto, 2024). Differences in substrate type, water depth, current velocity, vegetation cover, and food availability among habitats may further contribute to habitat-specific adaptation and phenotypic variation in resident species.

Freshwater shrimp are important decapod crustaceans that perform both ecological and economic functions in inland aquatic ecosystems. Globally, freshwater caridean shrimp represent an important component of freshwater biodiversity and are widely distributed across major biogeographical regions, particularly in tropical areas (de Grave et al., 2008). Ecologically, freshwater shrimp contribute to organic matter processing, nutrient cycling, detritus fragmentation, and aquatic food-web dynamics. Their feeding activities can influence leaf-litter decomposition and link detrital resources with higher trophic levels in freshwater ecosystems (Crowl et al., 2001; March et al., 2001). Economically, several freshwater shrimp species support local fisheries, aquaculture, and household-level livelihoods, particularly in tropical inland waters. However, freshwater ecosystems are increasingly exposed to ecological pressures, including habitat degradation, pollution, hydrological alteration, and land-use change, which may affect aquatic biodiversity and species distribution patterns (Dudgeon, 2019). Therefore, understanding the biological responses of freshwater shrimp to habitat variation is important for both ecological assessment and resource management.

Lotic habitats are characterized by flowing water, whereas lentic habitats generally consist of stagnant or slow-moving waters. These two habitat types differ in current velocity, substrate composition, dissolved organic matter, food availability, and environmental stability. Such differences may influence the growth strategies, body proportions, and morphological adaptation of freshwater shrimp. Organisms inhabiting lotic environments generally experience stronger hydrodynamic pressure and may require greater swimming capacity, stronger appendages, or more streamlined body forms to maintain position in flowing waters. In contrast, lentic habitats usually provide more stable hydrological conditions, although they may show greater accumulation of organic matter and stronger fluctuations in water quality (Wahidah et al., 2018; Wetzel, 2001). Consequently, habitat-specific environmental conditions may generate measurable variation in shrimp growth patterns and morphometric traits.

Length–weight relationship analysis is commonly used to evaluate growth patterns, body condition, and allometric responses in aquatic organisms. The relationship between body length and body weight provides biological information on whether growth is isometric or allometric and can reflect variation in nutrition, habitat quality, reproductive condition, and environmental stress (Le Cren, 1951; Froese, 2006). In freshwater shrimp, this approach is useful for comparing growth performance among populations or habitats because body mass accumulation may differ under different hydrological and ecological conditions. When combined with morphometric analysis, length–weight relationships can provide a more comprehensive understanding of how habitat variation affects both growth and body form.

Morphometric analysis is widely applied to evaluate morphological variation, biological shape differences, and population differentiation in aquatic organisms (Bookstein, 1991). In crustaceans, morphometric traits are frequently used to assess phenotypic plasticity, population structure, stock differentiation, and ecological adaptation. In freshwater shrimp, morphometric approaches can explain variation in body shape, appendage proportions, and population-level responses to habitat conditions. Previous studies have shown that habitat characteristics and hydrological dynamics can influence morphometric variation in crustaceans and freshwater shrimp populations (Mulyono et al., 2016; Torres et al., 2014). Principal component analysis (PCA) is particularly useful in morphometric studies because it reduces multiple correlated measurements into major axes of variation, thereby facilitating the identification of morphological patterns among species, populations, or habitat groups.

Several studies have investigated morphometric variation in freshwater shrimp and related decapod crustaceans across different regions. Radzi et al. (2024) reported that environmental variation and local adaptation may contribute to phenotypic variation in *Thenus* spp. from southern Thailand and Malaysia. Okomoda et al. (2023) showed that morphometric variation, length–weight relationships, and condition factors in *Macrobrachium rosenbergii* were associated with morphological differences among individuals from the Nyatoh River, Malaysia. Torres et al. (2014) further demonstrated that geometric morphometric analysis can be used to detect shape variation in *Macrobrachium borellii* populations within a floodplain system. In Indonesia, freshwater shrimp diversity in South Sumatra has been documented by Pratiwi et al. (2025), who reported the occurrence of several *Macrobrachium* and *Caridina* species across different freshwater habitats. However, information on growth patterns and morphometric variation of freshwater shrimp between lotic and lentic habitats in Ogan Ilir Regency remains limited.

The novelty of this study lies in its comparative assessment of freshwater shrimp growth patterns and morphometric variation between lotic and lentic ecosystems in inland waters of South Sumatra. By integrating length–weight relationship analysis with PCA-based morphometric assessment, this study provides a habitat-based evaluation of shrimp growth and body-form variation. This approach is expected to clarify whether hydrological differences between lotic and lentic habitats are reflected in measurable biological and morphological traits of freshwater shrimp. Therefore, this study aimed to analyze the length–weight relationships and morphometric variation of three freshwater shrimp species inhabiting lotic and lentic waters in Ogan Ilir Regency, South Sumatra.

METHOD

Study Design and Location

This study was conducted from November 2025 to May 2026 in freshwater ecosystems in Ogan Ilir Regency, South Sumatra, Indonesia. Species identification and morphometric measurements were performed at the Biology Laboratory, Faculty of Mathematics and Natural Sciences, Sriwijaya University.

Sampling was carried out at six stations representing two types of aquatic habitats: three lotic habitats and three lentic habitats. The lotic habitats consisted of the Tanjung Lubuk River, Tanjung Raja River, and Kuang River, whereas the lentic habitats consisted of Gembala Swamp, Meranjat Swamp, and Tambang Rambang Swamp. Sampling sites were selected based on differences in water-flow characteristics and habitat conditions.

Sampling

Freshwater shrimp specimens were collected using a purposive sampling method. A total of 300 specimens were obtained from the six sampling stations, with approximately 50 individuals collected from each station. Shrimps were captured using baited traps (*bubu*) and hand nets. Sampling was conducted in the afternoon at approximately 17:30 Western Indonesian Time (WIB), and the traps were retrieved the following morning at 07:00 WIB. The traps were placed near aquatic vegetation, submerged branches, and leaf litter, which represent natural microhabitats for freshwater shrimps. All collected specimens were preserved in 70% ethanol prior to laboratory-based species identification and morphometric measurement.

Research Instruments and Procedures

The instruments used in this study included baited traps (*bubu*) for shrimp collection, a GPS device to determine the geographic coordinates of each sampling station, a thermometer to measure water temperature, a digital balance to measure body weight, calipers for morphometric measurements, a digital camera for specimen documentation, and other supporting morphometric measurement tools. Morphometric measurements followed the procedures described by Short (2004), Kusrini et al. (2009), and Safitri et al. (2022). In this study, two morphometric variables were recorded, namely total length and body weight.

Data Analysis

Morphometric data and environmental variables were analyzed using descriptive and inferential approaches. Principal Component Analysis (PCA) was applied to identify the morphometric variables that contributed most strongly to variation in the body form of freshwater shrimps from lotic and lentic habitats. Multivariate morphometric approaches, including PCA, are useful for identifying dominant patterns of variation among biological populations (Rohlf & Marcus, 1993; Zelditch et al., 2012). Prior to analysis, morphometric data were logarithmically transformed to reduce data variability and improve the accuracy of statistical analysis. The length–weight relationship was analyzed using the allometric equation $W = aL^b$, where W represents body weight, L represents total length, and a and b are constants. The b value was used to determine the growth pattern of the shrimp, namely isometric growth ($b = 3$), positive allometric growth ($b > 3$), or negative allometric growth ($b < 3$). Descriptive analysis was also conducted to interpret the PC1 and PC2 values.

RESULTS AND DISCUSSION

The Relationship of Total Growth Length and Weight in *Palaemon carcinus*

Analysis of the length–weight relationship indicated that *Palaemon carcinus* exhibited positive allometric growth in both lotic and lentic habitats. The allometric coefficient (*b*) was 5.805 in the lotic habitat and 6.963 in the lentic habitat. According to Le Cren (1951), a *b* value greater than 3 reflects positive allometric growth, indicating that body weight increases at a proportionally faster rate than body length. This pattern suggests that, as individuals grow, they tend to become heavier relative to their length, reflecting changes in body form, condition, and biomass accumulation.

The higher *b* value recorded in the lentic habitat suggests that shrimp inhabiting calmer waters tended to accumulate body mass more rapidly than those occupying lotic habitats. Environmental measurements obtained during the study showed that lentic habitats were characterized by relatively stable water conditions, lower current velocity, and greater accumulation of organic matter compared with lotic habitats. Such environmental conditions may provide a more favorable setting for feeding activity and energy retention, as reduced water flow can lower the energetic costs associated with maintaining position and movement. In addition, the higher availability of organic matter may contribute to greater food resources, thereby supporting more efficient energy allocation toward somatic growth and increased body mass.

By contrast, lotic habitats were characterized by stronger water currents and more dynamic environmental conditions. These conditions may require shrimp to allocate more energy to movement, swimming performance, and positional maintenance rather than biomass accumulation. Consequently, although positive allometric growth was also observed in lotic habitats, the lower *b* value may reflect the influence of higher hydrodynamic stress and more variable habitat conditions on growth performance. Comparable findings were reported by Radzi et al. (2024), who stated that habitat conditions can affect morphometric variation and phenotypic responses in crustaceans. Therefore, differences in growth patterns between lotic and lentic habitats may reflect the combined influence of water flow, habitat stability, food availability, and energy allocation strategies in *P. carcinus*.

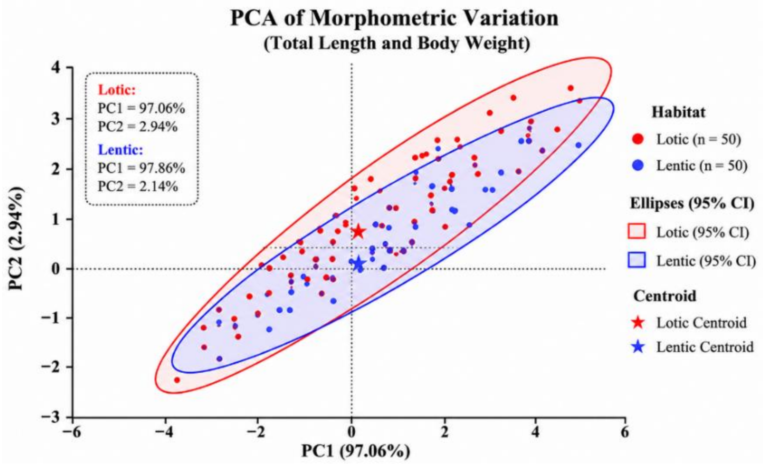

Figure 1. PCA distribution of morphometric variation of Palaemon carcinus in lotic and lentic habitats.

Principal component analysis (PCA) indicated that most morphometric variation was explained by the first principal component (PC1). In the lotic habitat, PC1 accounted for 97.06% of the total variation, while PC2 explained only 2.94%. A similar pattern was observed in the lentic habitat, where PC1 explained 97.86% of the variation and PC2 accounted for 2.14%. These high PC1 contributions indicate a strong association between total length and body weight, which together represented the dominant source of morphometric variation.

The PCA ordination showed a positive diagonal pattern between total length and body weight, suggesting a positive relationship between the two variables. Although some overlap among groups was observed, shifts in centroid positions indicated morphometric differentiation between the lotic and lentic populations. This differentiation may be related to differences in environmental conditions recorded during the study, particularly water current, habitat stability, and substrate characteristics. These findings are consistent with those of Wowor et al. (2009) and Pratiwi et al. (2025), who reported substantial morphological variability in freshwater shrimp across different aquatic habitats.

Length–Weight Relationship in *Macrobrachium rosenbergii*

The length–weight relationship analysis showed that *Macrobrachium rosenbergii* exhibited positive allometric growth in both lotic and lentic habitats. The allometric coefficient (*b*) was 8.230 in the lotic habitat and 3.973 in the lentic habitat. Because both values exceeded 3, these results indicate that body weight increased at a faster rate than body length.

The higher *b* value recorded in the lotic habitat suggests that shrimp inhabiting flowing waters experienced a greater increase in body mass than those from lentic habitats. Environmental measurements conducted during the study indicated that lotic habitats were characterized by higher current velocity and more dynamic water conditions than lentic habitats. These environmental differences may contribute to variation in growth responses and morphometric patterns in *M. rosenbergii*.

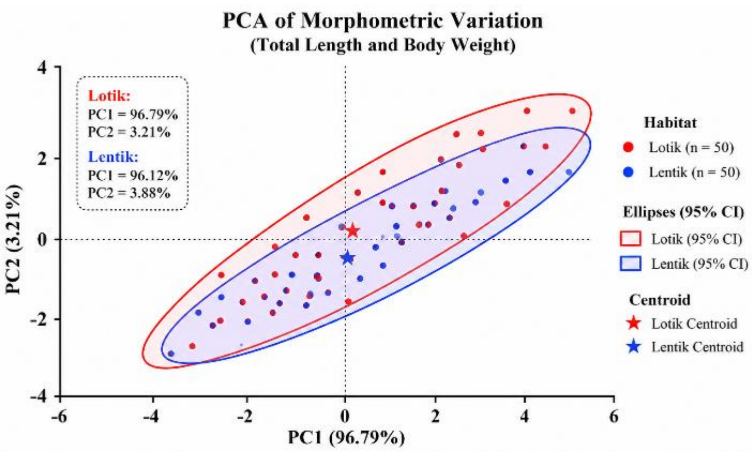

Figure 2. PCA distribution of morphometric variation in *Macrobrachium rosenbergii* from lotic and lentic habitats

The PCA results revealed a positive diagonal distribution pattern between total length and body weight, indicating a positive relationship between these two variables. The ellipse distribution for the lotic habitat was narrower and more concentrated along PC1, suggesting a relatively consistent morphometric pattern among individuals from flowing-water environments. In contrast, the lentic habitat showed a wider ellipse distribution, indicating comparatively greater morphometric variation.

Although overlap was observed between habitat groups, centroid shifts indicated a degree of morphometric differentiation between populations. Similar findings were reported by Okomoda et al. (2023) and Radzi et al. (2024), who demonstrated that habitat characteristics can influence morphometric variation in freshwater crustaceans.

Differences in environmental parameters measured during the study, including current velocity, habitat stability, and substrate composition, may have contributed to the observed morphometric variation. However, further statistical analyses integrating environmental variables with morphometric responses are required to confirm these ecological relationships. Comparable morphometric overlap and habitat-related variation in *M. rosenbergii* were also reported by Okomoda et al. (2023).

Differences between lotic and lentic habitats are also likely to influence the morphometric growth patterns of *M. rosenbergii*. Lotic habitats, which are characterized by stronger currents and more dynamic food distribution, may increase shrimp movement activity and thereby affect morphometric development. In contrast, the calmer conditions of lentic habitats may allow a greater proportion of energy to be allocated to body mass accumulation, although the present results showed a stronger positive allometric pattern in lotic habitats. Radzi et al. (2024) reported that environmental variation affects morphometric traits and phenotypic adaptation in crustaceans. In addition, Arhab & Junianto (2024) stated that the physical and chemical characteristics of aquatic environments, such as current velocity and water quality, play important roles in shaping the adaptation of aquatic organisms.

Length–Weight Relationship in *Macrobrachium nipponense*

The length–weight relationship analysis of *Macrobrachium nipponense* revealed different growth patterns between lotic and lentic habitats. In the lotic habitat, the allometric coefficient (*b*) was 4.960, indicating positive allometric growth. In contrast, the lentic habitat had a *b* value of 0.899, indicating negative allometric growth because *b* was less than 3.

Negative allometric growth indicates that body length increases more rapidly than body weight. Therefore, the previous interpretation stating that all habitats exhibited positive allometric growth was conceptually inaccurate and has been revised according to the growth classification proposed by Le Cren (1951).

The positive allometric growth observed in the lotic habitat indicates that body weight increased faster than body length. Environmental measurements conducted during the study showed that lotic habitats had stronger water currents and more fluctuating environmental conditions than lentic habitats. These habitat differences may influence shrimp activity and growth responses. In contrast, lentic habitats were characterized by more stable water conditions and slower currents, which may contribute to differences in morphometric growth patterns.

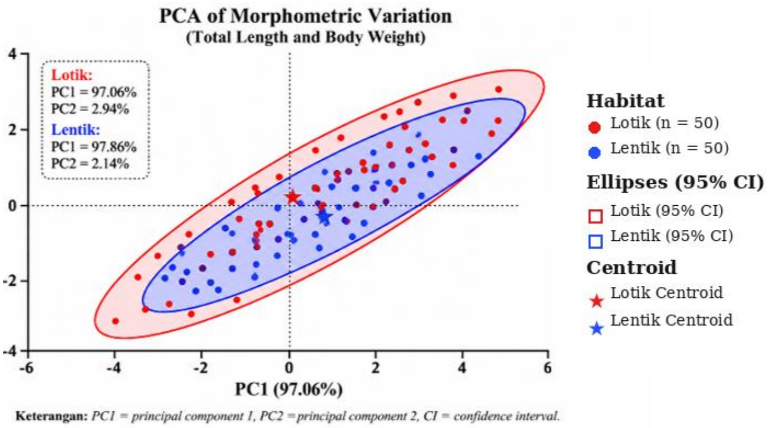

Figure 3. PCA distribution of morphometric variation in *Macrobrachium nipponense* from lotic and lentic habitats

The PCA results showed that most morphometric variation was explained by PC1. In the lotic habitat, PC1 accounted for 99.444% of the variation, whereas PC2 accounted for 0.556%. In the lentic habitat, PC1 explained 99.401% of the variation, while PC2 explained 0.599%. These findings indicate that total length and body weight were the dominant sources of morphometric variation in both habitat types.

The PCA distribution pattern showed overlap between habitat groups, suggesting relatively similar morphometric characteristics. However, centroid shifts indicated the presence of morphometric differentiation between populations. Similar observations were reported by Wowor and Pratiwi, who demonstrated that freshwater shrimp populations may exhibit morphometric variability across different habitats.

Differences in environmental parameters measured during the study, including current velocity and habitat characteristics, may have contributed to the observed morphometric variation. Nevertheless, further statistical correlation analyses between environmental variables and morphometric responses are needed to strengthen the ecological interpretation of these findings (Saleh et al., 2023).

CONCLUSION

This study demonstrates that freshwater shrimps inhabiting lotic and lentic ecosystems in Ogan Ilir Regency exhibit distinct growth patterns and morphometric variations. *Palaemon carcinus* and *Macrobrachium rosenbergii* showed positive allometric growth in both habitat types, indicating that body weight increased at a faster rate than body length. In contrast, *Macrobrachium nipponense* exhibited positive allometric growth in lotic habitats but negative allometric growth in lentic habitats. Principal Component Analysis (PCA) revealed that most morphometric variation was strongly associated with the relationship between total length and body weight. Differences in PCA distribution patterns between lotic and lentic habitats further indicate morphometric variation among freshwater shrimp populations across habitat types. Overall, these findings provide important baseline information for understanding freshwater shrimp ecology, supporting habitat management, and promoting the sustainable use of inland freshwater fisheries resources in South Sumatra.

RECOMMENDATION

Further research is recommended to examine the relationship between environmental factors and freshwater shrimp growth and morphometric variation. The application of landmark-based geometric morphometrics and molecular approaches is also suggested to improve species identification and population differentiation. In addition, broader spatial coverage and longer observation periods are needed to provide a more comprehensive understanding of freshwater shrimp population dynamics in South Sumatra.

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