# Effect of rearing density on the growth and survival rate of *Lethocerus indicus* (Lepeletier & Serville, 1825) from larval stage to marketable size

[1]Truong K. Hieu, [2]Vo T. T. Van, [1]Lam Q. Huy

[1] Department of Aquaculture and Environmental Sciences, Faculty of Agriculture and Food Technology, Tien Giang University, 84000 Than Binh Hamlet, Chau Thanh Commune, Dong Thap Province, Vietnam; [2] Department of Economics, Faculty of Economics and Law, Tien Giang University, 84000 Than Binh Hamlet, Chau Thanh Commune, Dong Thap Province, Vietnam. Corresponding author: L. Q. Huy, lamquanghuy@tgu.edu.vn

**Abstract**: This study investigated the impact of varying rearing densities on the growth performance and survival of the Asian giant water bug *Lethocerus indicus* (Lepeletier & Serville, 1825) from the larval stage to marketable size. A 60-day rearing trial was conducted using newly hatched larvae under four stocking density treatments: treatment 1 (NT1), treatment 2 (NT2), treatment 3 (NT3), and treatment 4 (NT4), corresponding to 75, 100, 150, and 200 individuals per square meter, respectively, with four replicates for each treatment. The results indicated that individual growth in terms of length, width, and body weight showed no significant differences among treatments ($p > 0.05$). Although yield tended to increase with stocking density, reaching 146.36 g m$^{-2}$ (NT1), 149.13 g m$^{-2}$ (NT2), 163.87 g m$^{-2}$ (NT3), and 176.45 g m$^{-2}$ (NT4), these differences were not statistically significant ($p > 0.05$). In contrast, survival rates (SRs) declined significantly with increasing density ($p < 0.05$), with lower values observed in NT3 (10.58%) and NT4 (8.57%) compared to NT1 (19.23%) and NT2 (13.89%). These findings suggest that higher stocking densities did not result in significantly higher yields. It is therefore recommended to culture *L. indicus* at densities of 75-100 individuals m$^{-2}$, implement density reduction (thinning) before day 30, and harvest after day 45 to optimize both survival and production efficiency. These findings provide a basis for developing sustainable aquaculture practices for *L. indicus* in Southeast Asia.

**Key Words**: Giant water bug, Lethocerus indicus, cannibalism, growth rate, survival rate, stocking density.

**Introduction**. The Asian giant water bug, *Lethocerus indicus* (Lepeletier & Serville, 1825), is a large aquatic insect valued for its culinary and traditional medicinal uses in several Asian countries, including Vietnam, Thailand, India, Myanmar, and China. A synthesis of studies by Thuan et al (2025) highlights that *L. indicus* is a nutrient-rich edible insect with high protein content, and that the male produces a distinctive aromatic essential oil highly valued as a premium culinary ingredient in Southeast Asia. Due to the growing gourmet demand in Vietnam and Thailand, commercial rearing is economically promising. In Vietnam, *L. indicus* was once widespread in ponds, lakes, and other lentic or slow-flowing water bodies, but is now nearly extinct in the wild due to environmental pollution, urbanization, and excessive pesticide use (IUCN 2007).

In recent years, several studies have contributed to the initial clarification of the morphological characteristics, reproductive biology, and ecological traits of the giant water bug *L. indicus*. Ohba (2011; 2019) provided fundamental insights into the predatory behavior, feeding ecology, and ecological roles of the Belostomatidae family, highlighting their function as apex predators with diverse prey, distinctive paternal care, specialized morphological adaptations, and raising concerns regarding conservation in response to population declines caused by habitat degradation and pollution. Vu & Le (2012) further provided detailed descriptions of reproductive structures and sexually dimorphic morphological traits. Tung et al (2015) and Phommavongsa et al (2022; 2023) expanded current knowledge on habitat ecology and conducted genetic analyses of *L. indicus* populations across Southeast Asia. Devi et al (2023) investigated the nutritional composition and sex-related differences of *L. indicus* under both natural and captive conditions.

Despite these advances, most existing studies have primarily focused on fundamental biological and ecological aspects of *L. indicus*, whereas technical factors influencing aquaculture performance, particularly stocking density, remain poorly understood. In contrast, the effects of stocking density on growth and survival have been extensively documented in other aquatic species. Bashar et al (2012) reported that lower stocking densities were the most effective strategy for maximizing both growth and survival during the larval stage of *Macrobrachium rosenbergii*. Shakir et al (2014) demonstrated that increased stocking densities significantly reduced the survival rate of *Penaeus monodon* due to intensified competition for space and food, which in turn promoted aggressive behavior and cannibalism. Efrizal (2017) showed that higher stocking densities markedly decreased survival to the first crab instar and slowed developmental progress in *Portunus pelagicus*.

For *L. indicus*, a species characterized by strong predatory instincts and pronounced territorial behavior, the determination of an appropriate stocking density is a critical prerequisite for the successful development of commercial farming practices. However, to date, very limited systematic studies have comprehensively evaluated the effects of stocking density on growth and survival of *L. indicus* under intensive culture conditions, except for the preliminary findings of Phúc et al (2024), which indicated that high stocking densities reduce survival rates under laboratory conditions. Therefore, identifying an optimal rearing density is essential for advancing future commercial production.

This study was conducted to evaluate the effects of different stocking densities on growth performance and survival rate of *L. indicus* from the larval stage to marketable size. The results are expected to provide a scientific basis for the development of a standardized culture protocol for this rare and economically valuable aquatic insect in Vietnam.

## Material and Method

***Study period and location***. The experiment was conducted over 60 days (November-December 2024) at the Experimental Station of the Faculty of Agriculture and Food Technology, Tien Giang University, Vietnam.

***Experimental animals and system setup***. One-day-old nymphs of *L. indicus*, hatched from eggs sourced from hatcheries in Ho Chi Minh City, were used in the study. The initial average body length, width, and weight were 9.7 mm, 3.0 mm, and 0.05 g, respectively. Sixteen styrofoam tanks (50 × 35 × 45 cm) were used as rearing units, filled with settled well water to a depth of 20-30 cm.

The insects were fed daily (07:00-08:00) with live tadpoles and juvenile frogs. Water exchange (30-50%) and waste siphoning were carried out weekly, or more frequently if water quality deteriorated.

***Experimental design***. A completely randomized design with four stocking densities: 75 (treatment 1, NT1), 100 (treatment 2, NT2), 150 (treatment 3, NT3), and 200 individuals $m^{-2}$ (treatment 4, NT4), was implemented, with each treatment replicated four times. All experimental procedures complied with animal care guidelines for invertebrates.

***Data collection and growth indicators***. Water quality parameters (temperature, pH, $NH_4^+/NH_4$, $NO_2^-$) were monitored regularly using a thermometer and Sera test kits. Insect length, width, and weight were recorded every 15 days using a caliper and precision scale (0.01 g).

Growth performance was evaluated using specific growth rates (SGR) and daily growth increments (DG) in length, width, and weight. SR and the coefficient of variation (CV) were also calculated using standard formulas:

- SGR (% day$^{-1}$) = ($\ln X_2 - \ln X_1$) x 100 / T
- DG = ($X_2 - X_1$) / T
- SR (%) = (Final number / Initial number) × 100
- CV (%) = (Standard deviation / Mean) × 100

Where $X_1$ and $X_2$ represent length (L), width (Wi), or weight (We) at two time points; T is the number of days between measurements.

***Statistical analysis***. Data were analyzed using SPSS v20.0. One-way ANOVA and Duncan's multiple range test were used to determine significant differences among treatments at a 5% probability level ($p < 0.05$).

## Results

***Variations in environmental parameters***. Throughout the 60-day experimental period, water quality parameters, including temperature, pH, dissolved oxygen (DO), ammonia ($NH_4^+/NH_3$), and nitrite ($NO_2^-$), remained within acceptable ranges and showed no significant differences among treatments ($p > 0.05$), indicating that environmental conditions were well controlled and suitable for *L. indicus*.

Morning water temperatures ranged from 27.44 to 27.60°C and afternoon temperatures from 28.19 to 28.25°C, which are suitable for warm-water aquatic organisms. Mean pH values remained stable (7.18–7.23), minimizing physiological stress and ammonia toxicity. Dissolved oxygen concentrations ranged from 4.97 to 5.32 mg L$^{-1}$, levels considered adequate for normal metabolic activity. Total ammonia concentrations were low (0.40–0.43 mg L$^{-1}$), under the observed neutral pH and moderate temperature conditions, the proportion of toxic unionized ammonia ($NH_3$) was likely minimal and below harmful levels, as described by Boyd (1998). Nitrite concentrations remained low (0.06–0.07 mg L$^{-1}$), well within the safe limit (< 0.3 mg L$^{-1}$) recommended by Boyd (1998). Overall, water quality conditions were stable across treatments and did not confound the effects of stocking density on the growth and survival of *L. indicus* (Table 1).

Table 1

Average water quality parameters across treatments *(Mean±SD)*

| *Parameter* | *NT1* | *NT2* | *NT3* | *NT4* |
|---|---|---|---|---|
| Temperature (°C) morning | 27.60±0.50$^a$ | 27.44±0.50$^a$ | 27.50±0.53$^a$ | 27.50±0.46$^a$ |
| Temperature (°C) afternoon | 28.19±0.26$^a$ | 28.25±0.27$^a$ | 28.19±0.26$^a$ | 28.25±0.27$^a$ |
| pH | 7.19±0.26$^a$ | 7.18±0.24$^a$ | 7.23±0.26$^a$ | 7.18±0.24$^a$ |
| DO (mg L$^{-1}$) | 4.97±0.50$^a$ | 5.32±0.29$^a$ | 5.00±0.74$^a$ | 5.13±0.43$^a$ |
| $NH_4^+/NH_3$ (mg L$^{-1}$) | 0.40±0.38$^a$ | 0.43±0.40$^a$ | 0.43±0.40$^a$ | 0.40±0.35$^a$ |
| $NO_2^-$ (mg L$^{-1}$) | 0.07±0.01$^a$ | 0.07±0.01$^a$ | 0.06±0.01$^a$ | 0.06±0.01$^a$ |

Note: Values in the same row with different superscript letters are significantly different ($p < 0.05$); Mean = average; SD = standard deviation.

### *Effects of stocking density on the growth of L. indicus*

***Growth in length***. Over the 60-day rearing period, there were no statistically significant differences ($p > 0.05$) in the body length of *L. indicus* among treatments, except at day 15, where NT4 (28.08 mm) showed significantly greater growth than NT1 (26.23 mm) ($p < 0.05$). The absolute daily length gain (DLG) and specific growth rate in length (SGRL) were consistent across treatments, averaging around 1.20 mm day$^{-1}$ and from 3.55 to 3.56% per day, respectively, with no significant differences (Table 2).

Table 2
Growth in body length, daily length gain, and specific growth rate in length of *Lethocerus indicus* (Mean±STD)

| *Time (days)* | *NT1* | *NT2* | *NT3* | *NT4* |
|---|---|---|---|---|
| 15 | 26.23±0.65$^{a}$ | 27.85±1.93$^{ab}$ | 27.43±0.51$^{ab}$ | 28.08±0.43$^{b}$ |
| 30 | 33.20±6.36$^{a}$ | 29.23±9.20$^{a}$ | 29.80±4.52$^{a}$ | 27.83±3.14$^{a}$ |
| 45 | 9.35±5.92$^{a}$ | 11.45±8.82$^{a}$ | 11.55±4.55$^{a}$ | 13.13±4.15$^{a}$ |
| 60 | 2.85±0.81$^{a}$ | 2.83±1.36$^{a}$ | 2.93±0.72$^{a}$ | 3.45±1.90$^{a}$ |
| DLG (mm day$^{-1}$) | 1.20±0.00$^{a}$ | 1.20±0.00$^{a}$ | 1.20±0.00$^{a}$ | 1.20±0.00$^{a}$ |
| SGRL (% day$^{-1}$) | 3.55±0.02$^{a}$ | 3.55±0.03$^{a}$ | 3.55±0.00$^{a}$ | 3.56±0.01$^{a}$ |

Note: Values in the same row with different superscript letters are significantly different ($p < 0.05$); Mean = average; SD = standard deviation; DLG = daily length gain; SGRL = specific growth rate in length

The insects displayed rapid growth during the first 30 days, followed by slower growth from days 30 to 45 and minimal growth from days 45 to 60, consistent with molting-related physiological constraints in *L. indicus*.

***Growth in width***. Similar to body length, no statistically significant differences ($p > 0.05$) were observed in the body width of *L. indicus* among treatments throughout the experimental period. The mean body width increased rapidly during the first 15 days and then gradually slowed. The absolute daily width gain (DWiG) was approximately 0.37 mm day$^{-1}$, while the specific growth rate in width (SGRwi) ranged from 3.53 to 3.56% per day. Detailed results are presented in Table 3.

Table 3
Growth in body width, daily width gain, and specific growth rate in width of *Lethocerus indicus* (Mean±STD)

| *Time (days)* | *NT1* | *NT2* | *NT3* | *NT4* |
|---|---|---|---|---|
| 15 | 14.88±0.48$^{a}$ | 14.07±0.20$^{a}$ | 14.87±0.65$^{a}$ | 15.09±2.55$^{a}$ |
| 30 | 4.95±0.97$^{a}$ | 4.88±1.74$^{a}$ | 3.75±1.34$^{a}$ | 4.10±2.91$^{a}$ |
| 45 | 1.90±0.88$^{a}$ | 2.38±1.73$^{a}$ | 2.88±0.92$^{a}$ | 2.33±1.26$^{a}$ |
| 60 | 0.58±0.22$^{a}$ | 0.78±0.33$^{a}$ | 0.45±0.37$^{a}$ | 0.60±0.29$^{a}$ |
| DWiG (mm day$^{-1}$) | 0.37±0.00$^{b}$ | 0.37±0.00$^{ab}$ | 0.37±0.00$^{a}$ | 0.37±0.00$^{ab}$ |
| SGRwi (% day$^{-1}$) | 3.56±0.02$^{b}$ | 3.54±0.02$^{ab}$ | 3.53±0.00$^{a}$ | 3.54±0.02$^{ab}$ |

Note: Values in the same row with different superscript letters are significantly different ($p < 0.05$); Mean = average; SD = standard deviation; DwiG = daily width gain; SGRwi = specific growth rate in width.

These consistent patterns across all metrics, paralleling the results for body length, further demonstrate that stocking density had no significant effect on the width growth of *L. indicus*.

***Growth in weight***. Significant differences in individual weight were observed at day 15, with treatments NT2, NT3, and NT4 showing higher weights than NT1 ($p < 0.05$). However, no significant differences were found among treatments at later stages (30, 45, and 60 days).

The absolute daily weight gain (DWeG) remained stable at approximately 0.17 g day$^{-1}$ across treatments, while the specific growth rate in weight (SGRwe) ranged from 8.75 to 8.89% per day. These results are presented in Table 4.

Table 4
Growth in body weight, daily weight gain, and specific growth rate in weight of *Lethocerus indicus* (Mean±STD)

| *Time (days)* | *NT1* | *NT2* | *NT3* | *NT4* |
|---|---|---|---|---|
| 15 | 2.38±0.12$^a$ | 2.90±0.27$^b$ | 2.73±0.13$^b$ | 2.97±0.08$^b$ |
| 30 | 2.17±0.70$^a$ | 2.26±0.44$^a$ | 2.76±0.44$^a$ | 2.29±0.40$^a$ |
| 45 | 4.36±0.69$^a$ | 3.61±0.59$^a$ | 3.23±0.53$^a$ | 3.68±0.31$^a$ |
| 60 | 1.17±0.29$^a$ | 1.46±0.44$^a$ | 1.62±0.29$^a$ | 1.19±0.12$^a$ |
| DweG (g day$^{-1}$) | 0.17±0.01$^a$ | 0.17±0.00$^a$ | 0.17±0.01$^a$ | 0.17±0.00$^a$ |
| SGRwe (% day$^{-1}$) | 8.75±0.17$^a$ | 8.88±0.04$^a$ | 8.89±0.07$^a$ | 8.86±0.02$^a$ |

Note: Values in the same row with different superscript letters are significantly different ($p < 0.05$); Mean = average; SD = standard deviation.

In summary, although NT2, NT3, and NT4 exhibited faster early weight gain than NT1, these differences diminished rapidly, and final weights and growth rates were statistically indistinguishable across all treatments.

***Uniformity of growth and population size variation***. After 60 days of rearing, no statistically significant differences ($p > 0.05$) were observed among treatments in final body length, width, or weight. The average body length ranged from 81.30 to 82.18 mm, body width from 24.95 to 25.28 mm, and body weight from 10.12 to 10.39 g.

The coefficients of variation (CV) for length, width, and weight remained low and showed no significant differences among treatments, indicating minimal population differentiation and high uniformity within the cultured cohorts. Detailed data are presented in Table 5.

Table 5
Body length, body width, body weight, and coefficients of variation after the experiment (Mean±STD)

| *Indicator* | *Time (days)* | *NT1* | *NT2* | *NT3* | *NT4* |
|---|---|---|---|---|---|
| Body length (mm) | 1 | 9.70±0.01$^a$ | 9.70±0.01$^a$ | 9.70±0.03$^a$ | 9.70±0.02$^a$ |
| | 60 | 81.30±1.06$^a$ | 81.75±1.12$^a$ | 81.38±0.25$^a$ | 82.18±0.57$^a$ |
| Body width (mm) | 1 | 3.00±0.00$^a$ | 3.00±0.10$^a$ | 3.00±0.00$^a$ | 3.00±0.20$^a$ |
| | 60 | 25.28±0.21$^b$ | 25.08±0.15$^{ab}$ | 24.95±0.10$^a$ | 25.15±0.17$^{ab}$ |
| Body weight (g) | 1 | 0.05±0.00$^a$ | 0.05±0.00$^a$ | 0.05±0.00$^a$ | 0.05±0.00$^a$ |
| | 60 | 10.12±0.29$^a$ | 10.27±0.22$^a$ | 10.39±0.43$^a$ | 10.18±0.15$^a$ |
| CV - length (%) | | 2.90±1.07$^a$ | 1.94±1.52$^a$ | 2.58±1.30$^a$ | 3.18±1.10$^a$ |
| CV - width (%) | | 1.83±1.24$^a$ | 0.57±1.14$^a$ | 0.51±1.01$^a$ | 1.07±1.24$^a$ |
| CV - weight (%) | | 4.16±3.63$^a$ | 3.79±4.15$^a$ | 3.05±1.14$^a$ | 4.33±1.39$^a$ |

Note: Values in the same row with different superscript letters are significantly different ($p < 0.05$); Mean = average; SD = standard deviation.

The data from Table 5 reinforce the previous results on length, width, and weight growth, confirming that the experimental treatments did not significantly influence the final size or the uniformity of the cultured *L. indicus* population.

***Survival rate and yield***. The SR decreased over time and showed significant differences among treatments ($p < 0.05$). After 60 days, SRs in NT1 and NT2 (19.23% and 13.89%, respectively) were significantly higher than in NT3 and NT4 (10.58% and 8.57%, respectively). This reflects the negative impact of high stocking density on survival, primarily due to cannibalistic behavior under crowded conditions.

Although yield tended to increase with stocking density (from 146.36 g m$^{-2}$ in NT1 to 176.45 g m$^{-2}$ in NT4), the differences were not statistically significant ($p > 0.05$). Due to the low SR, reducing the number of individuals remaining in each tank, yield did not increase proportionally with stocking density. These findings are summarized in Table 6, Figures 1 and 2

Table 6

Survival rate and yield of *Lethocerus indicus* over sampling periods (Mean±STD)

| Time (days) | Indicator | NT1 | NT2 | NT3 | NT4 |
|---|---|---|---|---|---|
| 15 | SR (%) | 44.23±7.37[a] | 29.17±12.32[a] | 28.85±11.96[a] | 30.00±2.86[a] |
| | Y (g $m^{-2}$) | 81.07±17.38[a] | 88.00±35.72[a] | 119.51±46.16[a] | 179.34±20.60[b] |
| 30 | SR (%) | 28.85±3.85[b] | 20.84±10.52[ab] | 17.31±4.97[a] | 15.00±3.59[a] |
| | Y (g $m^{-2}$) | 100.44±24.76[a] | 114.60±58.80[a] | 142.20±32.79[a] | 159.83±30.60[a] |
| 45 | SR (%) | 26.93±4.44[b] | 18.06±8.33[a] | 14.42±3.68[a] | 11.35±2.34[a] |
| | Y (g $m^{-2}$) | 180.93±28.70[a] | 163.87±73.81[a] | 190.03±47.61[a] | 207.52±40.94[a] |
| 60 | SR (%) | 19.23±4.45[b] | 13.89±5.56[ab] | 10.58±3.68[a] | 8.57±2.34[a] |
| | Y (g $m^{-2}$) | 146.36±34.77[a] | 149.13±60.93[a] | 163.87±51.78[a] | 176.45±48.68[a] |

Note: Values in the same row with different superscript letters are significantly different ($p < 0.05$); Mean = average; SD = standard deviation; Y = yield.

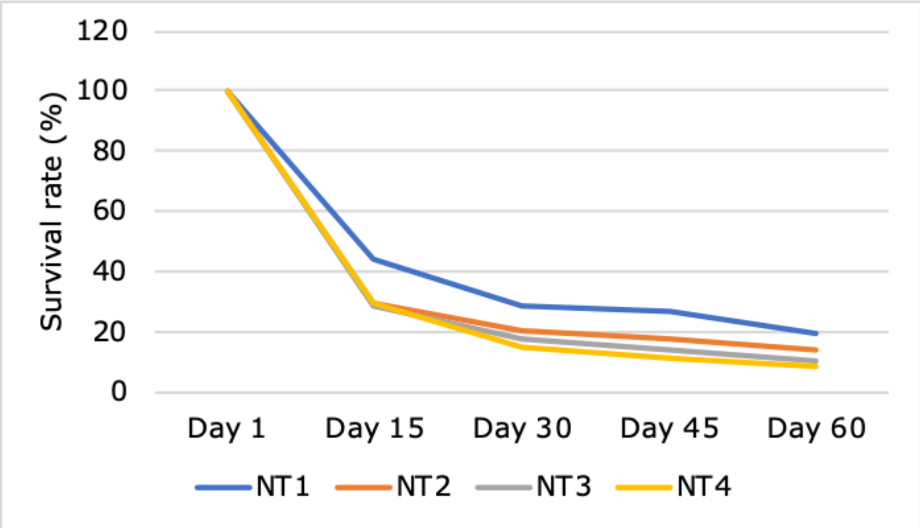


Figure 1. Survival rate of *Lethocerus indicus* over sampling periods.

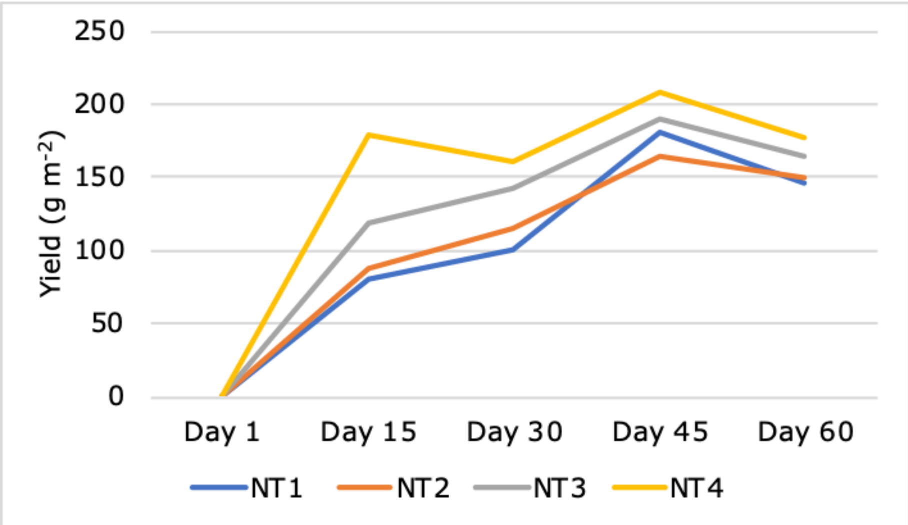


Figure 2. Yield of *Lethocerus indicus* over sampling periods.

Overall, the combined evidence from Table 6 and the graphical trends in Figures 1 and 2 indicates that higher stocking densities do not improve survival and offer no substantial advantage in final yield. This suggests that maintaining low to moderate densities is more suitable for rearing *L. indicus*, as it minimizes mortality and supports more stable production outcomes.

## Discussion

***Individual growth and population uniformity***. The experimental results showed that stocking density had no statistically significant effect on the growth indicators (length, width, and weight) of *L. indicus* after 60 days of rearing. The growth in body length and width followed a typical discontinuous pattern, consistent with the molting cycles characteristic of hemimetabolous insects. The most rapid growth phase occurred during the first 30 days, particularly following early molts. After day 45, length and width showed little to no increase due to the completion of the molting cycle, although body weight continued to rise slightly. This reflects a transition from morphological development to the accumulation of nutrients and energy in preparation for reproduction (Chapman 2013; Nation 2015). Consequently, the optimal harvest time for market-size *L. indicus* should be before or immediately after the final molt (around day 45) to maximize growth efficiency and biomass value.

Although some minor differences in initial growth were observed (e.g., higher length at day 15 in NT4 compared to NT1, and higher weight in NT2 - NT4 compared to NT1), these differences diminished in subsequent periods. This suggests that compensatory growth mechanisms or early-stage resource competition may have stabilized as weaker individuals were eliminated. Similarly, Millot et al (2025) demonstrated that increasing stocking density reduced the survival rate of post-settlement juvenile Mediterranean spider crabs (*Maja squinado*) due to enhanced cannibalism, while exerting no significant negative effect on the growth rate of surviving individuals.

Notably, despite the differences in density, all treatments demonstrated high uniformity at the end of the experiment. The CV for body length, width, and weight remained low and statistically similar among treatments. This can be explained by the biological traits of *L. indicus*, a predatory aquatic insect known for its dominance and territorial behavior. Under controlled conditions, dominant individuals tend to outgrow weaker ones, which are gradually eliminated through competition or cannibalism. Similar phenomena have been reported in other predatory aquatic organisms. Mazlum and Uzun (2022) showed that, in narrow-clawed crayfish (*Pontastacus leptodactylus*) at the instar III stage, high stocking density induced aggressive interactions and cannibalism that acted as a natural thinning mechanism. Kozłowski & Piotrowska (2024) reported that cannibalism among juvenile pikeperch (*Sander lucioperca*) led to the selective removal of weaker individuals. In both studies, increased stocking density promoted aggressive interactions and cannibalism, resulting in comparable CV values among treatments despite differences in stocking density. Such density-dependent biological regulation may similarly account for the high size uniformity observed in *L. indicus*.

***Impact on survival rate and yield***. In contrast to growth performance, the SR of *L. indicus* was significantly influenced by stocking density. High-density treatments (150-200 individuals $m^{-2}$) resulted in substantially lower SRs compared to lower-density groups (75-100 individuals $m^{-2}$), with differences exceeding 50% after 60 days. The primary factor contributing to mortality appears to be cannibalism, a common behavior among many carnivorous aquatic insects. At elevated densities, restricted space intensifies physical interactions and aggression, especially during the post-molting phase when individuals are highly vulnerable due to their soft exoskeletons.

Crowding-induced behavioral stress likely intensified cannibalism, as reported for other predatory aquatic insects (Sysiak et al 2026), and was consistent with findings by Phúc et al (2024) showing that higher stocking densities significantly increased mortality in *L. indicus* under controlled conditions. Similarly, Su et al (2024) demonstrated that high population density in *Procambarus clarkii* reduced available space, acted as a chronic stressor, and promoted aggression and cannibalism. These findings underscore the importance of appropriate stocking densities for improving survival and maintaining social stability in cultured populations.

While the biomass yield (g $m^{-2}$) showed an increasing trend with stocking density, the differences were not statistically significant. This is because the lower SRs offset the higher initial stocking numbers. Specifically, NT1 and NT2 recorded significantly higher SRs than NT3 and NT4 by day 60. This indicates that a higher density does not compensate for mortality losses.

Based on these results, it is recommended to rear *L. indicus* larvae at a density of 75–100 individuals $m^{-2}$ during the early rearing phase to optimize survival and minimize cannibalism. Maintaining densities below 100 individuals $m^{-2}$ may also reduce feed waste and energy costs in smallholder farms. Additionally, partial thinning should be applied around 15–30 days, which coincides with the third molt when individuals become more sensitive to social stress. Introducing environmental enrichments such as shelters (polyvinyl chloride, nylon netting) or substrates (sand) may also help reduce contact and mortality, as proposed in *Scylla serrata*, *Panulirus homarus*, and *Portunus pelagicus* farming systems (Hastuti et al 2020; Amiri et al 2022; Ariyati 2024).

**Conclusions**. The study indicates that a rearing density of 75-100 individuals $m^{-2}$ is appropriate to ensure optimal growth rate and survival of *L. indicus* from the larval stage to marketable size within 60 days. Although productivity per unit area increases at higher densities, SRs decline significantly, mainly due to cannibalism. Therefore, partial thinning should be implemented within 30 days, and harvesting should be conducted after 45 days to optimize production efficiency.

Future studies are recommended to investigate the effects of tank configurations (e.g., hiding objects, various substrates, and shelters), feed types, and rearing volumes to minimize aggressive behavior. Additionally, evaluating economic efficiency at commercial scale and testing under real-world environmental conditions will be essential steps toward developing a sustainable rearing protocol for this species. These results contribute to establishing baseline aquaculture protocols for an emerging high-value insect species.

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**Conflict of interest**. The authors declare that there is no conflict of interest.

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Authors:
Truong Khac Hieu, Department of Aquaculture and Environmental Sciences, Faculty of Agriculture and Food Technology, Tien Giang University, 84000 Than Binh Hamlet, Chau Thanh Commune, Dong Thap Province, Vietnam, e-mail: truongkhachieu@tgu.edu.vn
Vo Thi Thuy Van, Department of Economics, Faculty of Economics and Law, Tien Giang University, 84000 Than Binh Hamlet, Chau Thanh Commune, Dong Thap Province, Vietnam, e-mail: vothithuyvan@tgu.edu.vn
Lam Quang Huy, Department of Aquaculture and Environmental Sciences, Faculty of Agriculture and Food Technology, Tien Giang University, 84000 Than Binh Hamlet, Chau Thanh Commune, Dong Thap Province, Vietnam, e-mail: lamquanghuy@tgu.edu.vn

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