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Behavioral Response of Giant Freshwater Prawn (*Macrobrachium rosenbergii*) to the Folding Traps

Riska Fatmawati[1]*, Romie Jhonnerie[1], Nofrizal[1], Dhita Widhiastika[1], Andri Hendrizal[2], Eko Prianto[2], Yossi Oktorini[3]

[1]*Department of Fisheries Resources Utilization, Faculty of Fisheries and Marine Sciences, Universitas Riau, Binawidya Campus KM. 12,5, Pekanbaru, Riau, Indonesia 28293*
riskafatmawati@lecturer.unri.ac.id; romie.jhonnerie@lecturer.unri.ac.id; nofrizal@lecturer.unri.ac.id; dhita.widhiastika@lecturer.unri.ac.id
[2]*Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Universitas Riau, Binawidya Campus KM. 12,5, Pekanbaru, Riau, Indonesia 28293*
andri.h@lecturer.unri.ac.id; ekobrppu@gmail.com
[3] *Department of Forestry, Faculty of Agriculture, Universitas Riau, Binawidya Campus KM. 12,5, Pekanbaru, Riau, Indonesia 28293*
oktorini.yossi@lecturer.unri.ac.id

**Correspondence*: *riskafatmawati@lecturer.unri.ac.id*

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ABSTRACT

The behavior of the giant freshwater prawn (Macrobrachium rosenbergii) towards folding traps is significant to identify, given its complex movement patterns and dependence on the fishing gear. This study aimed to investigate the behavioral responses of M. rosenbergii to folding traps by examining spatial movement patterns and assessing trap effectiveness across three time periods (morning, noon, and night). To achieve this, an experiment using a behavioral event analysis approach was employed to reconstruct movement trajectories, X–Y coordinates, and behavioral phases. Furthermore, the Mann–Whitney U test was utilized to compare the distributions of entry and exit frequencies as an indicator of trap retention efficiency. The results showed that prawns exhibited adaptive, stepwise spatial behavior, beginning with external exploration characterized by zigzag paths, circular movements, and approach–retract cycles, before entering the trap with an average latency of 8–10 minutes. Furthermore, 95 of 160 individuals (59.38%) successfully entered the trap, whereas 65 (40.62%) exited after initial contact. The Mann–Whitney test confirmed a significant difference between entry and escape numbers (U=63;p<0.05), with the number of successful entries being significantly higher than the number of escapes, thereby validating the structural effectiveness of the folding trap. The temporal distribution indicated that nighttime was the most effective period, with 60 individuals entering, substantially more than in the morning (28) or at noon (7). These findings highlight that the effectiveness of folding traps is closely linked to the nocturnal behavioral patterns of M. rosenbergii.

Keywords: *Behavioral event analysis; folding trap; Macrobrachium rosenbergii; movement pattern; trap retention effectiveness*

INTRODUCTION

Giant freshwater prawns (*M. rosenbergii*) are a high-value commodity in the freshwater fishery and play an essential role in aquaculture and traditional fishing sectors in tropical regions, including Indonesia (Fatmawati *et al*. 2026). Increasing market demand has placed pressure on populations in public waters, necessitating more selective and sustainable resource use (Psuty 2022). In line with this, passive fishing gear, such as folding traps, is increasingly used because it is considered environmentally friendly, selective, and associated with low bycatch rates (Pacho *et al.* 2021; Thorbjørnsen *et al.* 2023). However, the effectiveness of fishing gear is strongly influenced by the target organism's behavioral responses, especially in decapod species that exhibit complex exploratory behavior, spatial navigation, and high sensitivity to chemical and mechanical stimuli (Fatmawati *et al.* 2020; Costa *et al.* 2022; Campbell and Lee 2025). In this context, a deep understanding of how *M. rosenbergii* interacts with traps, including movement patterns, activity times, and entry–escape tendencies, is key to optimizing the design of efficient and sustainable fishing gear.

The behavior of *M. rosenbergii* in response to physical traps is not random but is influenced by foraging processes, sensory abilities, and tendencies to explore new spaces (Qi *et al.* 2025). Recent studies indicate that decapods exhibit complex movement patterns, comprising initial exploration, orientation, and decision-making phases in response to chemical and visual stimuli (Florko *et al.* 2021). In addition, *M. rosenbergii* are known to exhibit nocturnal activity and a preference for increased exploration under low-light conditions (Pontes *et al.* 2020; Wei *et al.* 2021). These behavioral dynamics have direct implications for the effectiveness of fishing gear, as the ability of target organisms to enter and escape is strongly influenced by environmental conditions, trap orientation, and trap design (Nofrizal *et al.* 2023).

Folding traps, as passive fishing gears, rely on a retention mechanism: the ability to attract, direct, and retain organisms. Retention effectiveness is primarily determined by the interaction between the behavior of organisms and the trap's physical structure. Research on modern crustacean fishing gear shows that modifications to the size of the escape gap, funnel design, entrance color, and internal space structure can significantly improve retention performance (Rahman *et al.* 2021; Tupamahu *et al.* 2024; Susanto *et al.* 2025). However, to date, research on the behavioral interactions of M. rosenbergii with folding traps—particularly regarding spatial movement patterns and the timing of entry and exit—remains limited. The gap in this information will have a negative impact on efforts to develop trap designs that align with the ethological characteristics of the target species.

The gap in this study is the limited data on the behavioural responses and distribution patterns of *M. rosenbergii* in folding traps. Behavioural event analysis-based research can provide a detailed picture of the behavioural response and distribution patterns of *M. rosenbergii* in folding traps. In addition, statistical analyses such as the Mann–Whitney test can be used to assess the significance of differences in the numbers of shrimps entering and exiting the folding trap, as an indicator of the fishing gear's effectiveness. The integration of these two approaches allows for a more comprehensive understanding of the effectiveness of behaviour-based folding traps. Based on this necessity, this study was conducted with two main objectives: (1) to investigate the behavioral response of giant freshwater prawn (*M. rosenbergii*) to folding traps through the observation of spatial movement patterns; and (2) to analyze the effectiveness of the folding trap based on the distribution of successful prawn entry and escape, both in terms of total individuals and temporally (morning, day, and night). This study is expected to contribute scientifically to the development of more selective, efficient, and sustainable folding trap designs, as well as to strengthen the basis for environmentally friendly management of giant freshwater prawn fishing.

METHODS

Experiments were conducted in October 2025 at the Fish Behavior Laboratory, Universitas Riau. A behavioral event analysis approach was conducted to observe and interpret the behavioral responses of *M. rosenbergii* to folding traps. The behavioral event analysis method was chosen because it can more comprehensively explain the behavioral dynamics of aquatic organisms, including intensity, chronology, and transitions between behaviors. This approach has been widely used in crustacean studies to understand the processes of exploration, sensory responses, and risk evaluation in relation to new objects or artificial structures. Behavioral event analysis can reveal the sequence of exploration leading up to the *M. rosenbergii* organism entering the trap (Zhang *et al.* 2025). Campbell and Lee (2025) also emphasize that this method is effective for measuring latency, locomotor activity, and decision-making patterns in penaeid and *M. rosenbergii* under experimental conditions. Meanwhile, Florko *et al.* (2021) state that spatiotemporal movement-based approaches are crucial for understanding how decapods orient themselves and identify structures within their environment. Thus, the use of behavioral event analysis in this study provides a strong foundation for evaluating the effectiveness of folding trap designs based on target organisms' behavioral responses. Each individual was observed at-minute intervals to document position changes (X–Y), trajectory patterns, exploration phases, and the time to reach point 0 (the center of the trap).

Behavioral Event Analysis Observation of Giant Freshwater Prawn (*M. rosenbergii*)

The behavioral observations of *M. rosenbergii* were analyzed using behavioral event analysis, a hybrid quantitative-qualitative method that systematically identifies, codes, and sequences behavioral transitions. The research process was structured into the following stages:

Data Acquisition and Processing:

All *M. rosenbergii* activities were video-recorded and digitized using movement analysis software. This software extracted the *M. rosenbergii's* position X-Y coordinates at one minute intervals. Each recorded shift in position was logged as a discrete event, forming a chronological dataset for analyzing movement patterns and behavioral transitions over the observation period.

Spatial and Behavioral Metrics

The collected data were evaluated through three primary analytical lenses:

a. Trajectory Analysis Movement pathways were reconstructed to visualize the prawns' spatial orientation and exploratory strategies. This analysis identified specific patterns, including zigzagging, circular motions, and approach-retract cycles, to pinpoint the zone of high activity concentration.

b. Behavioral Phase Classification Events were categorized into three distinct phases based on movement dynamics:
   - Initial Exploration (Minutes 1-3), characterized by slow movement and orientation outside the trap
   - Directed Movement (Minutes 4-6), Marked by purposeful navigation toward the funnel structure
   - Entry Assessment (Minutes 7-10), defined by intensive investigation at the trap entrance before entry

c. Latency to Entry Measurement, this metric calculates the duration taken for an individual to reach the center coordinates (Point 0). Latency served as a key indicator of the prawn's decision-making process and its readiness to enter the trap

Observation of Prawn Entry and Escape Distribution in Folding Traps

The number of prawns successfully entering and escaping the trap was recorded for each replicate (n=16). The number of replicates was determined based on the statistical requirement adapted from Tribudi and Prihandini (2020), as follows:

$$t(r-1) \geq 15$$

With:

t = number of treatments

r = number of replications

15 = general degrees of freedom

Since the number of treatments in this study was 1, the required number of replications was calculated as:

$t(r-1) \geq 15$

$1(r-1) \geq 15$

$1r - 1 \geq 15$

$1r \geq 15 + 1$

$1r \geq 16$

$r \geq 16:1$

$r \geq 16$

The analysis was performed across two primary categories: the total number of individuals per replicate and the temporal distribution across morning, afternoon, and evening periods. Before the experiment, the prawns were acclimated in an experimental holding tank measuring 100 × 250 × 50 cm. The observations were conducted using a folding trap measuring 45 × 30 × 15 cm. To maintain environmental stability, the water temperature was kept between 26.02°C and 28.15°C, with a pH ranging from 4 to 6.5. In each treatment, 10 distinct individual prawns were housed in the experimental area, and all prawns used across the nine replicates were different individuals, ensuring that each individual experienced only one trial to prevent behavioral bias from prior exposure.

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A 1080p video camera recording at 60 fps was used to document prawn activities, including approaching the trap mouth, entering the trap, or attempting to escape. Data processing and trajectory analysis were performed on a laptop using Image-J, while a digital caliper was used to precisely measure prawn carapace length (4–8 cm). Additional tools included a mobile stopwatch for timing behavioral latencies and writing instruments for field notes. To stimulate movement, a standardized attractant (bait) was placed inside the center of the trap to create a consistent chemical stimuli zone.

Each treatment was replicated nine times and tested across three specific daily periods: morning (07:00–10:00 AM), afternoon (11:00 AM–02:00 PM), and evening (06:00–09:00 PM). During these 3-hour sessions, the number of prawns entering and escaping the trap was recorded, and each individual was monitored at 1-minute intervals to document changes in position (X–Y coordinates), trajectory patterns, exploratory phases, and the time required to reach reference point 0 (the center of the trap). This entire procedure was repeated 16 times on subsequent days, following a protocol adapted from Zakaria and Saragih (2021).

Analysis *Mann–Whitney (Wilcoxon Rank-Sum Test)*

The Mann-Whitney U Test (or Wilcoxon Rank-Sum Test) was employed to evaluate the difference between prawn entry and escape frequencies. Given that the behavioral datasets were non-normally distributed and used an ordinal or non-parametric continuous scale, this non-parametric approach was deemed superior to the conventional independent-samples t-test. Furthermore, the analysis accounted for the independence of replicates within the entry and escape categories, satisfying the test's fundamental assumptions. As noted by Barret *et al.* (2022), this method is particularly effective for organismal behavioral data because it does not require homogeneity of variances. Consequently, the application of this statistical framework offers a robust empirical basis for assessing the operational efficiency of folding trap designs relative to the behavioral responses of the *M. rosenbergii.* Mathematically, the calculation of the U value is based on the combined ranks of the two groups, using the formula:

$$U_1 = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - R_1$$

$$U_2 = n_1 n_2 + \frac{n_2 (n_2 + 1)}{2} - R_2$$

Where n_1 and n_2 are the sample sizes of the respective groups, and R_1 and R_2 are the sums of the ranks for each group. The U value is then converted into a p-value through normal distribution approximation, allowing for the testing of significance with the following criterion:

$$p < 0.05$$
$$\rightarrow \text{A significant difference exists between the groups}$$

RESULTS

A total of 16 trials (replicates) were conducted for this study, involving a total of 160 wild-caught individuals of giant freshwater prawn (*M. rosenbergii*). Each replicate consisted of 10 distinct individuals that experienced only one trial to ensure behavioral independence. The observations were categorized into three daily periods: morning, afternoon, and evening.

Movement Patterns of Giant Freshwater Prawn (M. rosenbergii) Around Folding Traps

Based on X–Y coordinate data, the movement patterns indicate that individuals follow the trap's construction pattern rather than moving randomly. All individuals initiated movement from the starting line and progressed through zigzag, circular, and intersecting patterns. Trajectory visualization (Figure 1) shows multidirectional paths encircling the trap perimeter before the prawns approach the entry path. All individuals begin their movement from the starting line and then explore progressively in zigzag, circular, and intersecting patterns, which illustrate their sensory responses to bait stimuli and the construction of the trap. The movement patterns of individuals such as Prawns A, C, and G follow a broader trajectory, while Prawns D and H tend to repeat their movements or remain in the same area.

The trajectory visualization shows that the prawns form multidirectional paths surrounding the trap before approaching the entrance. The paths indicate areas of accumulation, which represent the prawns' zone of attraction to the trap due to the bait stimulus placed inside the trap. The pattern of moving away before returning to approach (approach-retreat cycle) at the trap entrance indicates that shrimp engage in specific behavior to identify the trap before deciding to enter. The trajectory that ultimately converges

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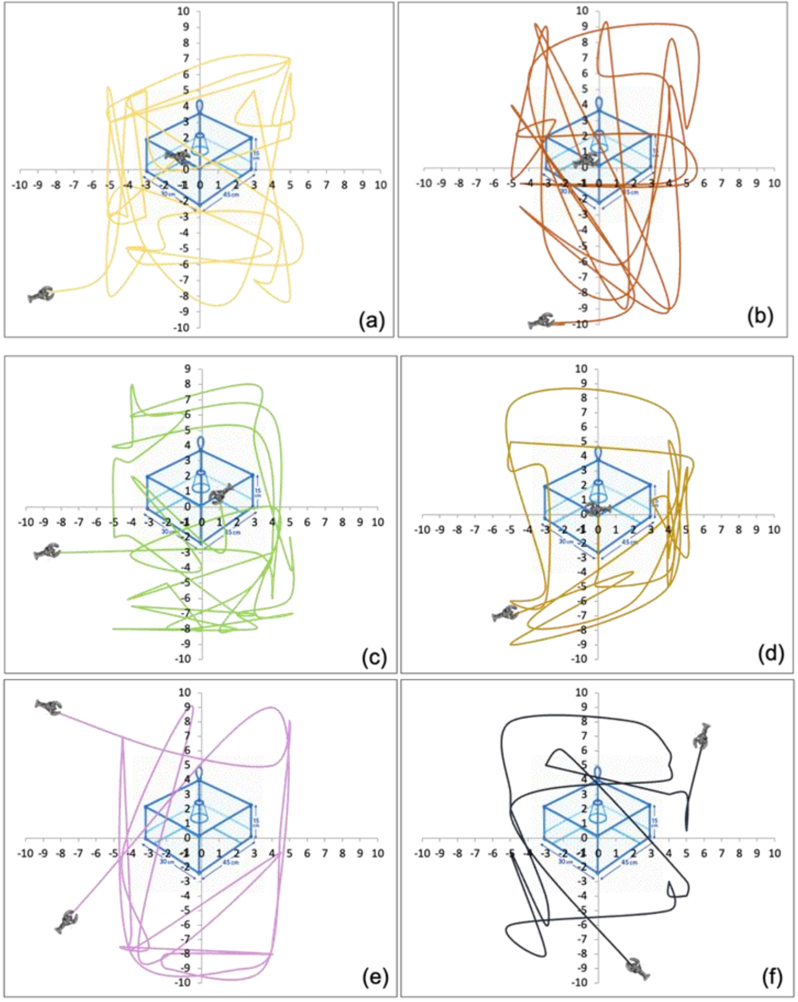
on the center of the trap suggests that the trap's construction influences the prawn's movement patterns upon entry.

From a temporal perspective, the analysis of time distribution per minute shows that the process undertaken by the prawns consists of three main phases: (1) initial exploration (minutes 1–3), (2) directed movement (minutes 4–6), and (3) entry assessment (minutes 7–10). It is in this final phase that the majority of prawns reach the center coordinate (point 0) as an indicator of successful entry into the trap. Based on overall individual movement patterns, the average time for the prawns to reach point 0 (the center of the trap) was approximately 8–10 minutes. This value reflects the duration of intensive evaluative behavior before the prawns fully entered the trap. This average aligns with the trajectory pattern, which showed increased trajectory density in the final minutes before entry.

Overall, the integration of three indicators, spatial coordinates, visual trajectories, and temporal distribution, suggests that the locomotor response of the giant freshwater prawn to the folding trap is an adaptive process involving spatial orientation, sensory response to bait, and structural assessment of the entrance before the final decision to enter is made. With an average entry time of 8 to 10 minutes, this finding confirms that effective folding-trap design must account for these exploratory and evaluative behavioral dynamics, particularly the funnel structure, bait position, and entry access, which can guide the prawn's movement more efficiently.



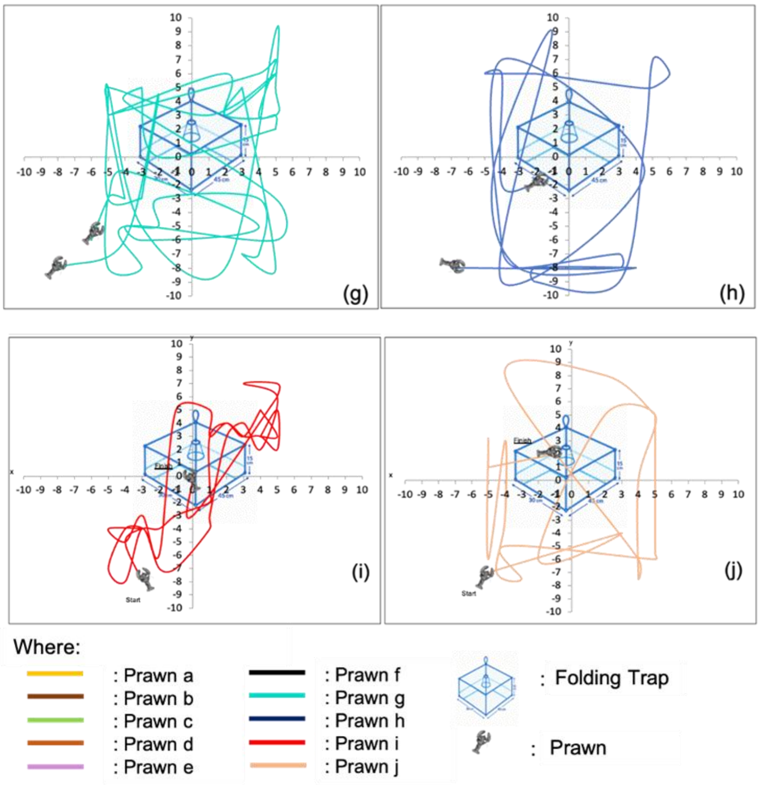


Figure 1 Results of observations of the trajectories and movement patterns of Prawn a–j around the fold trap based on X–Y coordinate data collected during the observation. The movement patterns indicate that the individuals follow the trap’s structural layout rather than moving randomly. All individuals began at the starting line and moved through zigzag, circular, and crisscross patterns.

Distribution of Entry Success of Giant Freshwater Prawn (*M. rosenbergii*) in Folding Traps Based on Total Individuals

The distribution of capture success for giant freshwater prawn (*M. rosenbergii*) in the folding traps exhibited variations in individual behavioral responses to the trapping device, as presented in Table 1. Out of the 160 recorded interactions, 95 individuals (59.38%) successfully entered the trap, while 65 (40.63%) escaped after initial contact. The capture success rate varied across replicates, ranging from 10% to 90%. This proportion indicates that the folding trap design was capable of attracting and retaining the majority of prawns that interacted with it, despite a relatively high rate of observed escape behavior. This pattern suggests that the trap’s effectiveness is determined by behavioral factors such as foraging motivation, response to spatial structure, and the prawn's navigational ability within a confined environment.

Variations between replicates were notable, with trapping success ranging from 10% to 90%. Replicate 6, for instance, recorded only 10% success, while replicates 10 and 16 achieved 90%. This disparity illustrates that *M. rosenbergii’s* response is not constant but is influenced by microhabitat conditions, stress levels, the presence of competitors, and potential individual variability, a key determinant of aquatic organism behavior. Replicates showing a 50% success rate (replicates 3, 13, and 14) indicate a neutral condition, in which the probability of the prawn remaining inside or escaping the trap was roughly equal, reflecting behavioral ambivalence during exploration and avoidance.

Upon closer examination, several replicates that exhibited a high rate of prawn escape (e.g., replicates 5 and 6 with 80–90% escape) suggest that the structure of the entrance and the internal space of the trap were not fully capable of inhibiting escape behavior. From an ethological perspective, giant freshwater prawns are known for their high locomotor capabilities and rapid avoidance responses. Therefore, a trap design that fails to create sufficient mechanical barriers or significant light/space-gradient differences may inadvertently facilitate their escape. Conversely, replicates with 70–90% success rates demonstrate that, under specific conditions, the folding trap functioned optimally to facilitate entry and limit escape opportunities, likely influenced by the entrance orientation, bait placement, and water turbulence around the device.

The resulting distribution pattern suggests that the folding trap has a moderate-to-high success rate, but its effectiveness is highly sensitive to variability in prawn behavior across replicates. This finding provides an essential basis for developing a more selective and efficient trap design, for example, by modifying the entrance (funnel angle), using more attractive bait, or rearranging the internal space to reduce the likelihood of escape.

The boxplot results presented in Figure 2 illustrate a differential distribution pattern in the number of giant freshwater prawn (*M. rosenbergii*) that successfully enter the folding trap versus those that escape it. The Entry group had a median of 6 individuals, an interquartile range (IQR) of 5–8 individuals, and a maximum of 9 individuals. This pattern indicates relatively high consistency in the trap's ability to retain prawns across most replicates. In contrast, the Escape group showed a lower median of 4 individuals, an IQR of 2–5 individuals, and a maximum value of 9 individuals. The greater variation observed in the Escape group suggests that the prawn's escape behavior is highly influenced by specific conditions in each replicate, including individual response to confined spaces, stress levels, and adaptation to the trap structure. The distribution being more "spread out" in the Escape group than in the Entry group further emphasizes the dynamic nature of the prawn's exploratory behavior, which can differ inter-individually, thereby affecting the stability of the trap's effectiveness.

The Mann–Whitney U Test confirmed a significant difference between the distribution of entry and escape numbers (U=63;p=0.0146<0.05), with the number of prawns entering the trap being significantly higher than the number of prawns escaping .The Entry group showed a median of 6 individuals with an IQR of 5–8, while the Escape group showed a lower median of 4 individuals with an IQR of 2–5.

Table 1 Distribution of Entry Giant Freshwater Prawn (*M. rosenbergii*) in Folding Traps Based on Total Individuals

Replicate	Prawn Entering of the Traps (Individuals)	Prawn Escaping of the Traps (Individual)	Total (Individual)	Percentage of Prawn Entering the Trap (%)	Percentage of Prawn Escaping the Trap (%)
1	8	2	10	80	20
2	6	4	10	60	40
3	5	5	10	50	50
4	8	2	10	80	20
5	2	8	10	20	80
6	1	9	10	10	90
7	3	7	10	30	70
8	6	4	10	60	40
9	8	2	10	80	20
10	9	1	10	90	10
11	6	4	10	60	40
12	7	3	10	70	30
13	5	5	10	50	50
14	5	5	10	50	50
15	7	3	10	70	30
16	9	1	10	90	10
Total	95	65	160	59,38	40,63

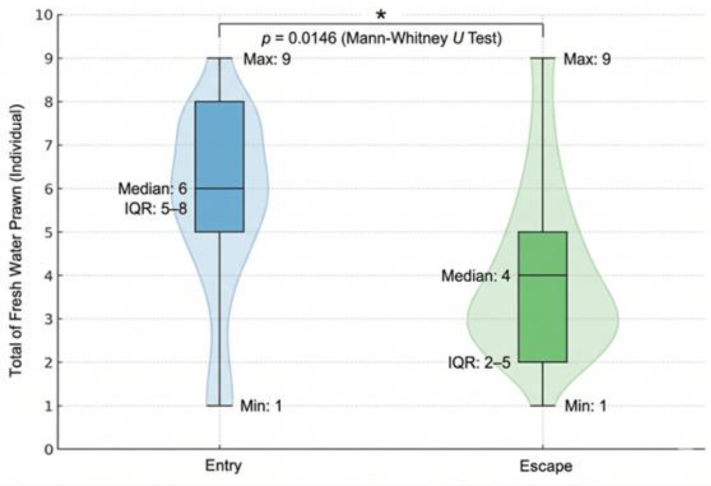


Figure 2 Results of box plots showing different distribution patterns between the number of giant freshwater shrimp (M. rosenbergii) that were successfully captured in the folding trap and those that managed to escape from the folding trap

Distribution of Entry Success of Giant Freshwater Prawn (*M. rosenbergii*) in Folding Traps Based on Time (Morning, Day, and Night)

The distribution shown in Figure 3 illustrates the successful entry of the giant freshwater prawn (*M. rosenbergii*) into the folding traps over three time periods, revealing a distinct diel activity pattern. The number of prawns entering during the morning was recorded at 28 individuals, decreased sharply to 7 individuals during the daytime, and then increased significantly to 60 during the night. This pattern indicates that prawn entry into the trap is substantially higher at night than during the other two periods. This pronounced difference reflects the giant freshwater prawn’s nocturnal dominance, with foraging behavior, spatial exploration, and responses to bait stimuli occurring more intensively at night.

Conversely, the pattern of prawn escape from the trap exhibited different dynamics. Ten individuals were recorded escaping in the morning, which number sharply increased throughout the day to 36 individuals, then decreased again at night to 19 individuals. The rise in the number of escaping prawns during the day suggests that the period of high illumination stimulates escape behavior. Highlight conditions, changes in surface temperature, and increased potential for visual or predator disturbance may reinforce the prawn's drive to leave a confined space, such as the trap. This phenomenon aligns with the light-intensity sensitivity of *M. rosenbergii*, in which individuals tend to be more active in fleeing perceived unsafe environments during the daytime phase.

Overall, this distribution indicates that the effectiveness of the folding trap as fishing gear is significantly higher at night, as evidenced by the high number of entering prawns (60 individuals) and the relatively low number of escaping prawns compared with the morning and day. During the daytime, the high escape rate (36 individuals) and low entry rate (7 individuals) indicate that daylight conditions represent the period of lowest retention effectiveness. This temporal pattern confirms that the operational strategy for folding traps would be most optimal when deployed at night, when the prawn's behavioral response to bait and the trap structure is strongest, and the chance of escape is minimized. This finding provides a preliminary basis for determining a more selective and efficient capture operation time.

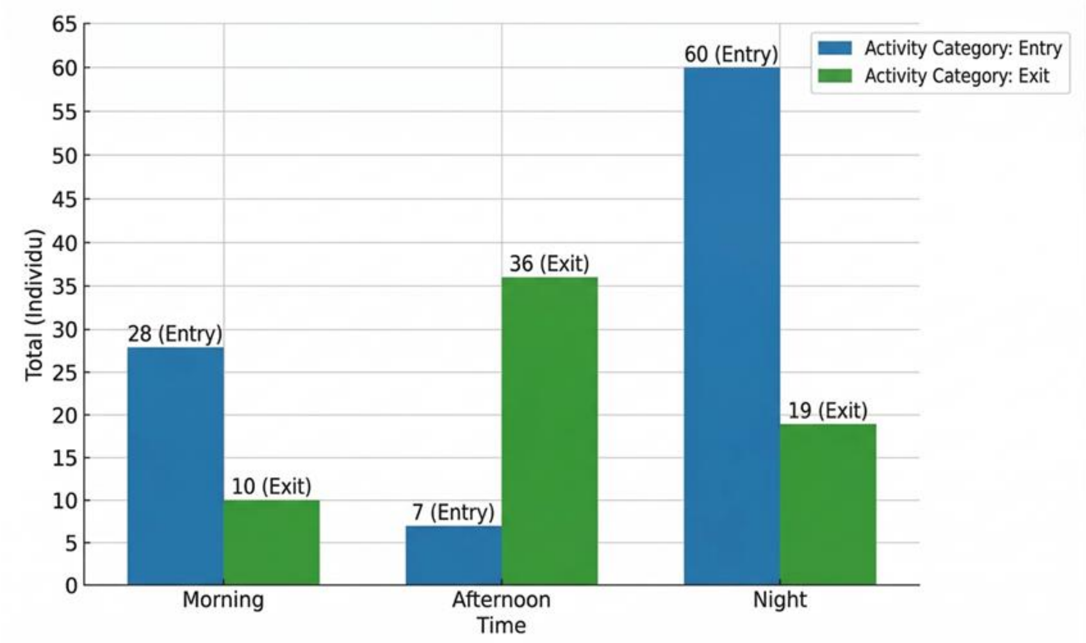


Figure 3 The distribution data shows the success of giant freshwater shrimp (M. rosenbergii) in entering the folding traps during three time periods (morning, afternoon, and night), which indicates a clear daily activity pattern. The number of shrimp entering in the morning was recorded at 28, decreased sharply to 7 in the afternoon, and then increased significantly to 60 at night.

DISCUSSION

Movement Patterns of Giant Freshwater Prawn (*M. rosenbergii*) Around Folding Traps

The movement patterns of giant freshwater prawn (*M. rosenbergii*), based on X–Y coordinate data, indicate that individuals do not move randomly around the folding trap but rather follow a staged sequence of spatial behaviors. All individuals initiated movement from the outer trap area and then conducted gradual exploration with zigzag, circular, and intersecting trajectories. This finding aligns with the review by Florko *et al.* (2021), which explains that decapods exhibit complex movement patterns comprising initial exploration, spatial orientation, and sensory-based decision-making. Individuals such as Prawn A, C, and G displayed wider foraging distances. At the same time, Prawn D and H exhibited repetitive patterns when assessing the trap's entrance, supporting the concept of searching and exploratory circling phases described by Zhang *et al.* (2025) for decapod interactions with trapping devices.

The trajectory visualization reinforces this finding through multidirectional pathways that encircled the trap perimeter before the prawns approached the entry path. The accumulation of trajectories at specific points suggests the presence of an “attraction zone,” most likely influenced by chemical stimuli from the bait and by the trap’s visual and structural characteristics. These conditions are consistent with the findings of Costa *et al.* (2022), who reported that *M. rosenbergii* shows visual preferences sensitive to environmental color and brightness. The approach–retract cycle behavior observed in the prawn trajectories also illustrates a risk evaluation of the confined space before entering the trap, as discussed by Kawamura *et al.* (2020) regarding changes in visual preference and cautious tendencies from the post-larval to adult phases.

Temporal analysis based on minutes revealed three main behavioral phases: initial exploration (minutes 1–3), directed movement (minutes 4–6), and entry assessment (minutes 7–10). The average time to reach point 0, indicating successful entry, was approximately 8–10 minutes. This behavioral latency duration is consistent with the review by Campbell and Lee (2025), which states that decapods exhibit exploratory and decision-making latencies that reflect an evaluative process toward new structures before entering the space. This finding is also consistent with the framework for decapod interaction with pots/traps compiled by Zhang *et al.* (2025), which comprises the phases of searching, exploration, entry, and escape.

Overall, the integration of spatial coordinates, visual trajectories, and temporal patterns indicates that the movement response of *M. rosenbergii* to the folding trap is an adaptive process involving spatial orientation, sensory perception, and structural evaluation before the final decision to enter is made. With an average entry time of 8–10 minutes, this finding provides an empirical basis for optimizing the folding trap design, particularly regarding the funnel shape, bait position, and entrance configuration, to better align with the exploratory and evaluative behavioral dynamics of the giant freshwater prawn.

However, it is essential to acknowledge the limitations of extrapolating these laboratory-based observations to real fishing environments. While the controlled setting allowed for precise trajectory analysis, natural habitats present a much higher degree of environmental complexity. Factors such as hydrodynamics, including water currents and turbulence, could significantly influence the dispersal of chemical stimuli from the bait, potentially altering the 'attraction zone' and the prawns' orientation efficiency. Furthermore, light variability in murky or deep riverine systems may affect the visual preferences observed in this study, as prawns might shift their reliance from visual cues to chemosensory or tactile inputs in low-visibility conditions.

Additionally, real-world fishing operations introduce stressors such as interspecific competition, predator presence, and fluctuating water quality, which were not present in the laboratory. The 8–10-minute entry latency observed here may also vary with the trap's soak time and its structural stability under current-driven conditions. Therefore, while these findings provide a foundational understanding of *M. rosenbergii's* ethology toward folding traps, future field-based research using underwater telemetry or high-definition cameras is required to validate the applicability of these behavioral models in stochastic natural environments.

Distribution of Entry of Giant Freshwater Prawn (*M. rosenbergii*) in Folding Traps Based on Total Individuals

The distribution of entry success for giant freshwater prawn (*M. rosenbergii*) in folding traps indicates that the prawn's behavioral response is influenced not only by bait presence but also by ethological factors and trap structure. The study on stock-based fisheries culture by Digamadulla *et al.* (2023) confirmed that *M. rosenbergii* is a species with a high degree of behavioral plasticity, particularly in response to changes in space and microhabitat structures. This explains why the prawn's interactions with the folding traps varied between replicates, even though the testing conditions were relatively uniform. This high adaptive capability allows the giant freshwater prawn to evaluate the internal spatial conditions of the trap, including the presence of structural gaps or differences in light intensity, before deciding whether to remain in the trap or leave it.

The escape behavior observed in certain replicates aligns with the findings of Hongjamrassilp and Blumstein (2021), who reported that freshwater prawns exhibit rapid locomotor decision-making, including the decision to leave a perceived as unfavorable space. This pattern is also reinforced by the research of Davenport *et al.* (2023), which showed that benthic scavenger organisms exhibit a strong tendency to explore space, mainly when physical structures or environmental cues can serve as escape routes. Therefore, the fluctuation in retention success rates in this study reflects the prawn's active ability to evaluate the folding trap structure.

In the context of fishing gear design, it is essential to understand that modern crustacean traps generally integrate more adaptive selectivity principles. For instance, the study by Rahman *et al.* (2021) on crab traps showed that modifying the escape vent significantly improved the balance between target catch and the release of smaller individuals. Furthermore, research by Tupamahu *et al.* (2024) found that the size of the escape gap in reef fish traps directly influences the probability of fish retention or escape, underscoring the importance of precise design in enhancing gear performance. These findings are relevant to the development of folding traps for giant freshwater prawns, particularly regarding the entrance structure, funnel angle, and internal spatial configuration, all of which can affect the prawn's movement pattern.

A recent study by Susanto *et al.* (2025) also indicated that the color of the entrance and the mesh size can increase the efficiency and selectivity of traps without increasing fishing pressure. In the case of folding traps for giant freshwater prawns, adapting visual strategies, such as using contrasting coloration at the entrance or manipulating light-dark contrasts, can help direct the prawns deeper into the trap and reduce their tendency to escape. Meanwhile, an estuarine fisheries analysis by Monteiro *et al.* (2025); Fatmawati *et al.* (2025) asserted that the combination of structural design, organism movement dynamics, and local hydrodynamic conditions highly influences trap performance. This implies that for folding traps used for giant freshwater prawn, a design more compatible with the prawn's natural behavior, for example, adding internal barriers or reducing structural gaps, could lower the chance of escape and increase retention.

The Mann–Whitney U Test results, which showed a significant difference between the number of prawns entering and escaping the folding trap (U=63;p=0.0146), indicate that the prawn's response to the trap structure is not random but is influenced by an effective retention mechanism. The higher median of the entry group suggests that the folding trap design supports the movement pattern of entry and retention, consistent with Hongjamrassilp and Blumstein (2021)'s explanation that prawns make movement decisions based on the evaluation of spatial conditions and environmental stimuli. This retention effectiveness is also supported by the benthic behavioral characteristic of tending to explore confined spaces without immediately seeking an escape route, as explained by Davenport *et al.* (2023); hence, the funnel structure of the folding trap serves as a movement guide, reducing the likelihood of escape.

Moreover, this significant result aligns with findings in modern crustacean trap design, underscoring the importance of matching the target organism's behavior with the capture device's configuration. The research by Rahman *et al.* (2021) showed that retention efficiency increases when the entrance structure and escape ventilation are designed to facilitate entry but make exiting difficult. The study by Monteiro *et al.* (2025) also found that gear performance is strongly influenced by the design's compatibility with the target species' natural movement patterns. Thus, the statistical significance found in this study confirms that the folding trap operates according to principles of selectivity and retention that are compatible with giant freshwater prawn behavior, and it holds potential for further optimization through minor modifications to the entrance or internal spatial patterns.

Overall, this research reveals a complex interaction between the behavior of giant freshwater prawns and the design of folding traps. Considering the findings of Digamadulla *et al.* (2023), Hongjamrassilp and Blumstein (2021), Tupamahu *et al.* (2024), and Susanto *et al.* (2025), it can be concluded that improving trap effectiveness cannot rely on a single design element alone. Instead, a multi-dimensional approach is necessary that considers the prawn's exploratory behavior, sensory properties, microhabitat structure dynamics, and the technical characteristics of the folding trap. This discussion also places the distribution of prawn success within the broader scientific context of aquatic organism behavior and sustainable engineering of fishing gear.

Distribution of Entry of Giant Freshwater Prawn (*M. rosenbergii*) in Folding Traps Based on Time (Morning, Day, and Night)

The distribution of entry and escape success of the giant freshwater prawn (*M. rosenbergii*) in the folding traps across the three time periods demonstrates an activity pattern highly influenced by light conditions. The data reveal that the number of individuals entering the trap is substantially higher at night, while it is shallow during the day. This phenomenon is consistent with the report by Pontes *et al.* (2020), which indicates that *M. rosenbergii* is a species that is more active during the dark phase and exhibits more exploratory behavior when the risk of visual disturbance is low. This nocturnal activity is also linked to an opportunistic foraging strategy, as explained by Cei *et al.* (2025) in their study on the giant freshwater prawn's role as an opportunistic predator in the Amazon estuary. They found that prawns are more active at night, when low-light conditions increase opportunities for safe movement. Based on Xu *et al.* (2024) research, feeding behavior is a primary activity for *M. rosenbergii*, and they are more likely to feed during the dark phase. Therefore, fishing gear that mimics natural food sources or their natural feeding conditions (e.g., bait type, scent, or food structure) can enhance capture efficiency.

The behavioral response during the daytime appears different, characterized by a low entry count but a very high number of escapes from the trap. This suggests that bright light intensity triggers escape behavior. Studies by Wei *et al.* (2021) and

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Constantinidis *et al.* (2024) indicate that high light conditions or specific light spectra can induce stress, reduce spatial comfort, and alter locomotor activity patterns in *M. rosenbergii*. Consequently, the high daytime escape rate observed in this study can be interpreted as a sensory response to unconditioned light, prompting the prawns to leave the confined structure. In the context of fishing gear, this finding also aligns with Naimullah *et al.* (2022), who asserted that the effectiveness of trapping devices is highly influenced by operating time, with night captures yielding more stable retention rates and lower escape rates. Overall, this integration of biological behavior and environmental conditions reinforces the idea that folding traps operate most optimally at night, when the prawn's activity pattern aligns with the gear's retention mechanism.

CONCLUSION

The conclusions derived from the study on the Behavioral Response of Giant Freshwater Prawn (*M. rosenbergii*) to Folding Traps are as follows:

1. The giant freshwater prawn's behavioral response to the folding trap demonstrates an adaptive, staged, and sensory-based spatial movement pattern. Prawns conduct initial exploration in the outer trap area through zigzag, circular, and approach–retract cycle trajectories before deciding to enter. Trajectory and X–Y coordinate analysis indicate that the prawn's interaction with the trap follows three primary behavioral phases—initial exploration, directed movement, and entry assessment—with the average latency to entry ranging from 8 to 10 minutes.
2. The effectiveness of the folding trap was high, as evidenced by the distribution of successful prawn entries relative to escapes, both in terms of total individuals and temporal distribution. Of 160 interactions between giant freshwater prawns and the folding trap, 95 individuals (59.38%) successfully entered, while 65 (40.62%) escaped, demonstrating the gear's high retention success. The Mann–Whitney U Test results confirmed a significant difference in the number of entries and escapes ($U=63; p<0.05$), thus statistically validating the trap's structural effectiveness. Temporally, the night period was the most effective, with 60 prawns successfully entering, significantly more than in the morning (28 individuals) and the day (7 individuals). These results highlight nocturnal activity in *M. rosenbergii* as a key driver of trapping success. However, caution should be exercised when extrapolating these laboratory-based observations to open-water fisheries. While the data suggests a strategic advantage for nighttime operations, the influence of natural currents, predator presence, and varying turbidity remains to be fully explored in situ.

SUGGESTION

Future research is recommended to integrate automated tracking technologies, such as machine vision or acoustic sensors, to obtain more precise data on movement patterns and to experimentally test variations in folding-trap design, including funnel shape, material, and bait placement, to optimize retention effectiveness. Furthermore, controlled experiments should be conducted to isolate the effects of environmental factors, such as light intensity, current, and turbidity, and to conduct more in-depth studies of the giant freshwater prawn's sensory mechanisms in response to chemical and mechanical stimuli. Field trials in natural habitats with varying population densities, accompanied by predictive modeling based on agent-based or machine-learning approaches, are also necessary to enhance operational validity. Finally, the evaluation of organism welfare aspects should be conducted to ensure that the folding trap design remains selective, efficient, and environmentally friendly.

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