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Impact of Temperature, Photoperiod and Salinity on Growth, Survival and Molting in the Intertidal Molecrab *Emerita asiatica*

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ABSTRACT

Environmental factors have a significant impact on the physiologically complex and energy-intensive process of molting, which is controlled by endocrine pathways. As a result, in crustaceans, development, survival, and molting are all interconnected processes that react strongly to variations in external abiotic variables. In the marine ecosystem, intertidal crustaceans are exposed to some of the harshest and fluctuating environmental circumstances. The present study demonstrates that environmental factors such as temperature, photoperiod and salinity directly regulate the growth, survival, and molting of Emerita asiatica, with temperature and salinity having the strongest physiological impact and photoperiod mainly influencing behaviour and post-molt survival. Stress conditions such as high temperature and continuous light resulted in post-molt mortality, highlighting the vulnerability of individuals during the recovery phase. Salinity played a critical role in maintaining physiological balance. Optimal conditions at 35 ppt supported maximum survival and consistent molting, while deviations at both low (20 ppt) and high (42 ppt) levels caused stress, reduced molting, and increased mortality, indicating a narrow tolerance range of mole crabs. Overall, the findings show that growth in E. asiatica is indirectly controlled by environmental conditions through their effects on molting and survival. Stable conditions resembling the natural habitat are essential, as any deviation leads to physiological stress, impaired molting, and increased mortality, particularly during the post-molt stage.

Keywords: *Emerita, intertidal, moulting, environmental factors, growth.*

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Introduction

One of the most varied and ecologically important groups of arthropods, crustaceans inhabit a variety of aquatic environments from freshwater to marine habitats. Their irregular growth pattern, which is distinguished by a repeated process called molting or ecdysis, is a characteristic of crustacean biology (1). A newly synthesized cuticle replaces the stiff exoskeleton during molting, allowing for tissue expansion and an increase in body size . Environmental factors have a significant impact on the physiologically complex and energy-intensive process of molting, which is controlled by endocrine pathways. As a result, in crustaceans, development, survival, and molting are all interconnected processes that react strongly to variations in external abiotic variables (3).

In the marine ecosystem, intertidal (the area where the ocean meets the land between high and low tides) crustaceans are exposed to some of the harshest and fluctuating environmental circumstances. During brief time periods, variables like temperature, photoperiod and salinity, wave action, freshwater inflow vary greatly because of tidal cycles (4). Growth and molting are strongly impacted by these environmental factors, which are essential for controlling metabolic activity, eating behaviour, osmoregulation, and hormonal control (5). Deviations from ideal conditions may result in mortality, slower development rates, delayed molting, or greater susceptibility during the post-molt phases.

The genus *Emerita* (Family: Hippidae), commonly known as mole crabs or sand crabs, is a characteristic inhabitant of sandy beach ecosystems (6). The current study focuses on Emerita obtained from Thiruvanmiyur Beach, on the southeast coast of Chennai, Tamil Nadu, India. Thiruvanmiyur Beach is a typical sandy shore impacted by tidal movement, seasonal monsoon rainfall, and changing levels of human activity. The intertidal zone of this beach suffers significant changes in temperature, salinity, and light exposure, making it an ideal natural setting for researching the environmental regulation of growth and molting in intertidal crustaceans (7). The selection of Thiruvanmiyur Beach as the collection site provides ecological relevance to the study, as the environmental conditions of this region reflect those commonly experienced by Emerita along the southeast Indian coastline.

Light is an important ecological factor influencing biological rhythms, behavior, and endocrine regulation in crustaceans (8). Photoperiod and light intensity can affect feeding activity, locomotion, and neurohormonal secretion associated with molting (9).

In *Emerita*, light exposure is irregular due to continuous burrowing behavior and sediment movement caused by wave action (10). Variations in light conditions at the intertidal zone of Thiruvanmiyur Beach may influence the feeding and activity patterns of Emerita, thereby indirectly affecting growth rate and molting frequency.
Temperature is one of the most critical abiotic factors affecting physiological processes in ectothermic organisms such as crustaceans and directly influences metabolic rate, enzyme activity, feeding efficiency, and endocrine signaling. Optimal temperature conditions promote efficient metabolism and regular molting cycles, whereas extreme temperatures may induce stress, prolong intermolt duration, or result in mortality (11). Surface and sediment temperatures at Thiruvanmiyur Beach vary greatly depending on tidal exposure and seasonal variations, which may affect Emerita's physiological performance.
Salinity controls osmoregulation and ionic balance in marine crustaceans. Salinity levels on coastal sandy beaches frequently fluctuate due to rainfall, freshwater flow, and evaporation. Emerita taken from Thiruvanmiyur Beach may thus be subjected to fluctuating salt conditions, notably during monsoon seasons. Maintaining osmotic equilibrium under such conditions necessitates greater metabolic energy, which may limit energy allocation to development and molting, compromising survival (12).
Growth and molting in Emerita are closely linked, as size increment occurs only during molting events (13) . The timing and success of molting depend on both internal hormonal control and external environmental cues . Disruptions in environmental parameters such as temperature, photoperiod and salinity can interfere with normal molting cycles, leading to reduced growth and survival .Despite the ecological importance of Emerita in sandy beach ecosystems, systematic studies examining the effects of these environmental factors on its growth and molting under controlled conditions remain limited. Intertidal species like Emerita have received very little attention in the majority of studies on environmental regulation of growth and molting, which have concentrated on commercially significant crustaceans. Moreover, there are few studies that focus only on communities along India's southeast coast. Thus, by examining the effects of temperature, photoperiod and salinity on growth, survival, and molting in Emerita collected from Thiruvanmiyur Beach under carefully monitored laboratory circumstances, the current work seeks to close this information gap.In addition to expanding our understanding of how environmental variability impacts intertidal crustaceans, the study's findings should provide crucial baseline data on Emerita's physiological ecology. This knowledge is useful for environmental monitoring, studying coastal ecosystems, and evaluating the potential effects of environmental change on sandy beach species .

Materials and Methods

Experimental animal

Emerita asiatica, commonly known as the mole crab or sand crab, is a small burrowing crustacean belonging to the family Hippidae under infraorder Anomura, commonly found along sandy beaches of the Indian coast, especially in the swash zon**e.** Unlike true crabs (Brachyura), it has an elongated, oval and smooth body adapted for rapid burrowing rather than sideways walking. The body is divided into cephalothorax and abdomen, covered by a hard carapace.
It is a filter feeder, extending its long feathery second antennae above the sand to capture plankton and organic particles carried by waves.
Growth occurs through a molting cycle (ecdysis) because of its rigid exoskeleton, with larvae molting every 3–7 days, juveniles every 10–20 days, and adults approximately every 3–6 weeks; the cycle includes intermolt, premolt, ecdysis, and postmolt stages regulated by molting hormones. Ecologically, Molecrabs plays an important role in sandy shore food chains as prey for higher trophic levels and serves as an indicator species reflecting the health of coastal ecosystem.

Collection Of Specimens

Live adult specimens of *Emerita asiatica* were collected from the intertidal sandy zone of Thiruvanmiyur, Chennai, Tamil Nadu, during early morning low tide to minimize thermal stress. The specimens were transported to the laboratory within 1–2 hours of collection and acclimatized for a period of seven days in tubs containing filtered seawater at 35 ppt salinity. A 5 cm thick layer of beach sand was provided to simulate natural burrowing habitat. Continuous aeration was supplied using an air pump to maintain dissolved oxygen levels. Temperature was maintained at 28°C under a 12:12 hour light and dark photoperiod. Approximately 20-30 % of the water was replaced every 48 hours to maintain stable water quality parameters.

Experimental Setup

Separate experimental setups were maintained to evaluate the independent effects of temperature, photoperiod and salinity on growth, survival, and molting of *Emerita asiatica.* For temperature and salinity experiments, four treatment levels were maintained: control, low,
moderate, and high. For the photoperiod experiment, two treatments were established: 24 hours light and 24 hours dark. Each treatment consisted of four individuals maintained together in a single plastic tub (one tub per treatment). The experimental duration for all treatments was 30 days. During each experiment, only the selected environmental factor was altered, while all other parameters were kept constant to avoid confounding effects.

Effect Of Photoperiod

For 24 hours dark treatment, the tubs were completely covered with opaque black sheets to block all external light. Care was taken to ensure that no light entered through the sides or top of the container. For 24 hours light treatment, the tubs were exposed to 24-hour illumination using LED light sources placed at a fixed distance above the tank. Uniform light exposure was given throughout the experiment
Treatments were maintained for 30 days. During this period, temperature (28°C), salinity (35 ppt), sand substrate depth and aeration were kept constant so that light remained the only variable influencing growth, survival, and molting responses. Behavioral changes such as burrowing activity, surface movement, and stress responses were also observed and recorded daily.

Effect Of Temperature

The control tub was maintained at 28°C, whereas moderate treatment was maintained at 22°C. Temperature regulation was achieved using a manual water bath technique. Each tub was placed inside a larger plastic tray containing water.

To increase the temperature for high (32°C) treatment, hot water was gradually added to the outer tray. To reduce temperature for the low (15°C) treatment, ice cubes were added to the outer tray.

Temperature was monitored frequently using a digital thermometer to ensure that the desired temperature range was maintained. Adjustments using hot water or ice cubes were made slowly to avoid rapid fluctuations. Care was taken to maintain stable temperature conditions as consistently as possible throughout the 30-day experimental period. During the temperature experiment, salinity (35 ppt), light conditions (12:12 hours photoperiod) and aeration were kept constant to ensure that temperature remained the only variable influencing growth, survival, and molting.

Effect Of Salinity

The control (35 ppt) represented the natural seawater condition of the collection site. Salinity was adjusted using sodium chloride (NaCl). For low salinity (20ppt) treatment, seawater was diluted with distilled water. For high salinity (42ppt) treatment, calculated amounts of NaCl were dissolved in seawater and mixed thoroughly to obtain the required concentration. Salinity was measured daily using a handheld refractometer to ensure maintenance of the desired levels throughout the experimental period.

During the salinity experiment, temperature (28°C) and photoperiod (12:12 hours light and dark cycle) were maintained constant so that salinity remained the only variable influencing the observed responses.

Assessment Of Growth:

Growth parameters were assessed by measuring carapace length and body weight of individual crabs. Carapace length was measured using a thread and scale method. A fine cotton thread was carefully placed along the dorsal curvature of the carapace from the anterior to posterior margin. The length of the thread was then straightened and measured against a stainless steel ruler calibrated in millimeters.

Net growth of carapace length =Lf- Li

where, Lf denotes the mean of final recorded carapace length (cm) and Li denotes the mean of initial carapace length (cm).

Body weight was measured using a digital analytical balance. The body weight was determined using an indirect method. A beaker containing a known volume of seawater was first weighed using a digital balance to obtain the initial weight. Subsequently, an individual mole crab was gently introduced into the beaker, and the combined weight was recorded. The weight of the organism was calculated by subtracting the initial weight of the beaker with water from the final recorded weight. Weight was recorded in grams (g). Initial weight (Wi) was recorded at Day 0. Final weight (Wf) was recorded either at the end of the experimental period or at the time of mortality.

Net Change in Body weight = Wf - Wi

where, Wf denotes the mean of final body weight (g) and Wi denotes the mean of initial body weight (g).

Survival Rate

Survival was monitored daily throughout the experimental period.

Mortality was recorded immediately, and dead individuals were removed to prevent water contamination. Survival percentage was calculated as:

$$\text{Survival (\%)} = \frac{\text{Number of surviving individuals}}{\text{Initial number stocked}} \times 100$$

Behavioral changes such as reduced activity, failure to burrow, and abnormal movements were also noted as indicators of environmental stress.

Molting Frequency:

Molting activity was monitored daily by visual examination of tubs for shed exoskeletons. Although intact exuviae were not retrieved, fragmented exoskeletal residues were consistently observed on the sand surface, indicating active molting. The fragile nature of the exuviae and burrowing behavior of the species likely resulted in rapid disintegration and mixing with substrate. Molting rate was calculated based on the number of visibly molted individuals.

Molting rate was calculated as:

$$\text{Molting Rate (\%)} = \frac{\text{Number of individuals molted}}{\text{Total individuals per tank}} \times 100$$

Results

Effect of temperature on growth of *E. asiatica*

The effect of different temperature treatments on the carapace length of *E. asiatica* is presented in Table 1. The control group maintained at 28°C showed an increase in mean carapace length from 4.93 ± 0.22 mm to 5.02 ± 0.26 mm, resulting in a net growth of 0.09 ±
0.34 mm, which was the highest growth recorded among the treatments. In the low temperature treatment (15°C), the initial and final carapace lengths remained the same (5.15 ± 0.13 mm), indicating no measurable growth (0.00 ± 0.00 mm) during the experimental period. The moderate temperature treatment (22°C) showed a slight increase in carapace length from 4.75
± 0.21 mm to 4.80 ± 0.16 mm, with a net growth of 0.05 ± 0.06 mm. Similarly, in the high temperature treatment (33°C), the mean carapace length increased marginally from 4.90 ± 0.12 mm to 4.95 ± 0.13 mm, with a net growth of 0.05 ± 0.06 mm. Overall, measurable growth was observed in the control, moderate, and high temperature treatments, whereas no growth occurred under low temperature conditions.

The changes in body weight of *E. asiatica* under different temperature treatments are shown in Table 2. The control group (28°C) exhibited the greatest weight gain that increasing from 17.90 ± 2.40 g to 18.83 ± 2.43 g resulting in a net weight gain of +0.93 g. In contrast, the low temperature treatment (15°C) showed a decrease in body weight from 20.45 ± 1.37 g to
19.10 ± 1.83 g corresponding to a net weight loss of −1.35 g, indicating adverse effects of low temperature on body mass. The moderate temperature treatment (22°C) recorded a slight increase in body weight from 16.15 ± 2.13 g to 16.43 ± 2.21 g, resulting in a net gain of +0.28
g. Similarly, the high temperature treatment (32°C) showed a small increase from 17.55 ± 1.28 g to 17.70 ± 1.25 g, corresponding to a net gain of +0.15 g. Among all treatments, maximum weight gain was observed in the control temperature whereas weight loss occurred under low temperature conditions.

Effect of photoperiod on growth of *E. asiatica*

The influence of different photoperiod conditions on carapace length is presented in Table 3. The control treatment (12:12 hours light/dark cycle) showed an increase in carapace length from 4.93 ± 0.22 mm to 5.02 ± 0.26 mm, resulting in a net growth of 0.09 ± 0.34 mm. Under 24 hours light treatment, the mean carapace length increased slightly from 4.72 ± 0.28 mm to 4.80 ± 0.22 mm, with a net growth of 0.08 ± 0.08 mm. The 24 hours dark treatment recorded the highest increase in carapace length, rising from 4.67 ± 0.24 mm to 4.87 ± 0.33 mm, resulting in a net growth of 0.20 ± 0.13 mm. Among the photoperiod treatments, 24 hours dark resulted in the highest carapace length growth whereas 24 hours light showed comparatively lower growth.Changes in body weight under different photoperiod conditions are presented in Table 4. The control group (12:12 hours) showed a weight increase from 17.90 ± 2.40 g to 18.83 ± 2.43 g, corresponding to a net gain of +0.93 g. In 24 hours light treatment, the body weight increased marginally from 17.23 ± 0.85 g to 17.25 ± 0.92 g, resulting in a net gain of +0.03 g, indicating minimal weight change. In 24 hours dark treatment, body weight increased from 15.25 ± 2.33 g to 15.60 ± 2.28 g, corresponding to a net gain of +0.35 g. Overall, weight gain occurred in all photoperiod treatments, although the magnitude of increase varied, with the highest gain observed in the control treatment.

Effect of salinity on growth of *E. asiatica*

The effect of different salinity levels on carapace length growth is shown in Table 5. The control treatment (35 ppt) exhibited an increase in mean carapace length from 4.70 ± 0.14 mm to 4.82 ± 0.29 mm, resulting in a net growth of 0.13 ± 0.15 mm, which was the highest growth recorded among the salinity treatments. In the low salinity treatment (20 ppt), the initial and final carapace lengths remained unchanged (4.20 ± 0.29 mm), indicating no growth during the experimental period. The moderate salinity treatment (25 ppt) showed a slight increase from 4.40 ± 0.22 mm to 4.47 ± 0.31 mm, with a net growth of 0.08 ± 0.10 mm. Similarly, the high salinity treatment (42 ppt) recorded a small increase in carapace length from 4.45 ± 0.25 mm to 4.50 ± 0.28 mm, resulting in a net growth of 0.05 ± 0.06 mm. Overall, growth was highest at the control salinity, whereas no growth was observed under low salinity conditions.

The changes in body weight under different salinity conditions are presented in Table 6. The control treatment (35 ppt) showed an increase in body weight from 15.48 ± 1.32 g to16.05 ± 1.42 g, corresponding to a net gain of +0.58 g. In contrast, the low salinity treatment (20 ppt) showed a decrease in body weight from 10.93 ± 1.89 g to 10.53 ± 1.88 g, resulting in a net weight loss of −0.40 g. The moderate salinity treatment (25 ppt) exhibited a slight increase in weight from 12.18 ± 1.04 g to 12.33 ± 1.29 g, corresponding to a net gain of +0.15 g. However, the high salinity treatment (42 ppt) showed a small decrease in weight from 13.08 ±2.16 g to 12.88 ± 2.35 g, resulting in a net weight loss of −0.20 g. Among the salinity treatments, maximum weight gain was observed at the control salinity, whereas weight loss occurred under both low and high salinity conditions.

Effect of temperature on Survival of *E. asiatica*

The survival of *Emerita asiatica* under different temperature treatments is presented in Table 7. Each treatment initially contained four individuals. In the control treatment (28°C), all four individuals remained alive at the end of the experimental period, resulting in 100% survival with no mortality. Similarly, in the moderate temperature treatment (22°C), all four animals survived throughout the experiment, also showing 100% survival. In contrast, reduced survival was observed at extreme temperatures. In the low temperature treatment (15°C), only two individuals survived, while two individuals died, resulting in 50% survival. A similar trend was observed in the high temperature treatment (32°C), where two individuals survived and two died, also corresponding to 50% survival. Overall, complete survival was observed at moderate and control temperatures, whereas both low and high temperature conditions resulted in reduced survival of *E. asiatica*.

Effect of photoperiod on Survival of *E. asiatica*

The survival of *E. asiatica* under different photoperiod conditions is presented in Table 8. In the control photoperiod (12:12 hours light:dark cycle), all four individuals survived throughout the experiment, resulting in 100% survival. Similarly, under 24 hours dark, all four animals remained alive, also showing 100% survival. However, reduced survival was observed under 24 hours light treatment. In this treatment, only two individuals survived, while two individuals died, resulting in 50% survival. Among the photoperiod treatments, complete survival occurred under control and 24 hours dark conditions, whereas 24 hours light exposure resulted in reduced survival.

Effect of salinity on survival of *E. asiatica*:

The survival of *E. asiatic*a under different salinity treatments is shown in Table 9. In the control salinity (35 ppt), all four individuals survived throughout the experiment, resulting in 100% survival. The moderate salinity treatment (25 ppt) showed three individuals surviving and one mortality, resulting in 75% survival. Lower survival was recorded at both extreme salinity conditions. In the high salinity treatment (42 ppt), two individuals survived while two died, corresponding to 50% survival. The lowest survival rate was observed under low salinity conditions (20 ppt), where only one individual survived and three individuals died, resulting in 25% survival. Overall, highest survival was observed at control salinity, while reduced survival occurred under both low and high salinity conditions, with the lowest survival recorded at low salinity.

Effect of temperature on molting of *E. asiatica*:

The molting frequency of *E. asiatica* under different temperature treatments is presented in Table 10. Each treatment consisted of four individuals. In the control treatment (28°C), molting was observed in two out of four individuals, resulting in a molting frequency of 50%. In the low temperature treatment (15°C), no molting was observed during the experimental period, giving a molting frequency of 0%. The moderate temperature treatment (22°C) showed molting in two individuals, corresponding to a 50% molting frequency, which was similar to the control treatment. Similarly, in the high temperature treatment (32°C), two individuals underwent molting, resulting in a 50% molting frequency. Overall, molting occurred in control, moderate, and high temperature treatments, whereas no molting was observed under low temperature conditions.

Effect of photoperiod on molting of *Emerita asiatica*

The effect of different photoperiod conditions on molting frequency is presented in Table 11.

Under the control photoperiod (12:12 hours light/dark cycle), two out of four individuals molted, corresponding to a molting frequency of 50%. In 24 hours light, molting was also observed in two individuals, resulting in a 50% molting frequency, similar to the control condition. However, 24 hours dark treatment recorded the highest molting frequency, with three out of four individuals undergoing molting, corresponding to 75% molting. Among the photoperiod treatments, 24 hours dark treatment resulted in the highest molting frequency, whereas control and 24 hours light conditions showed similar molting levels.

Effect of salinity on molting of *Emerita asiatica*

The molting frequency of *E. asiatica* under different salinity treatments is shown in Table 12. In the control salinity (35 ppt), two individuals out of four underwent molting, resulting in a molting frequency of 50%. In the low salinity treatment (20 ppt), no molting was observed, giving a molting frequency of 0%. The moderate salinity treatment (25 ppt) showed molting in two individuals, corresponding to a 50% molting frequency, which was similar to the control treatment. In contrast, the high salinity treatment (42 ppt) recorded molting in one individual only, resulting in a molting frequency of 25%. Overall, molting occurred mainly under control and moderate salinity conditions, whereas low salinity completely inhibited molting and high salinity showed reduced molting frequency.

Table 1: Effect of temperature on carapace length of E.asiatica

Treatment	Initial carapace length (cm) (Mean ± SD)	Final carapace length (cm) (Mean ± SD)	Net growth (cm) (Mean ± SD)
Control (28°C)	4.93 ± 0.22	5.02 ± 0.26	0.09 ± 0.34
Low (15°C)	5.15 ± 0.13	5.15 ± 0.13	0.00 ± 0.00
Moderate (22°C)	4.75 ± 0.21	4.80 ± 0.16	0.05 ± 0.06
High (32°C)	4.90 ± 0.12	4.95 ± 0.13	0.05 ± 0.06

Table 2: Effect of temperature on body weight of E. asiatica

Treatment	Initial weight (g) (Mean ± SD)	Final weight (g) (Mean ± SD)	Net weight change (g)
Control (28°C)	17.90 ± 2.40	18.83 ± 2.43	+0.93
Low (15°C)	20.45 ± 1.37	19.10 ± 1.83	−1.35
Moderate (22°C)	16.15 ± 2.13	16.43 ± 2.21	+0.28
High (32°C)	17.55 ± 1.28	17.70 ± 1.25	+0.15

Table 3: Effect of photoperiod on carapace length of E.asiatica

Treatment	Initial carapace length (cm) (Mean ± SD)	Final carapace length (cm) (Mean ± SD)	Net growth (cm) (Mean ± SD)
Control (12:12 hours)	4.93 ± 0.22	5.02 ± 0.26	0.09 ± 0.34
Light (24 hours)	4.72 ± 0.28	4.80 ± 0.22	0.08 ± 0.08
Dark (24 hours)	4.67 ± 0.24	4.87 ± 0.33	0.20 ± 0.13

Table 4: Effect of photoperiod on body weight of E. asiatica

Treatment	Initial Weight (g) (Mean ± SD)	Final Weight (g) (Mean ± SD)	Net Weight Change (g)
Control (12:12 hours)	17.90 ± 2.40	18.83 ± 2.43	+0.93
Light (24 hours)	17.23 ± 0.85	17.25 ± 0.92	+0.03
Dark (24 hours)	15.25 ± 2.33	15.60 ± 2.28	+0.35

Table 5: Effect of salinity on carapace length of E.asiatica

Treatment	Initial carapace length (cm) (Mean ± SD)	Final carapace length (cm) (Mean ± SD)	Net growth (cm) (Mean ± SD)
Control (35 ppt)	4.70 ± 0.14	4.82 ± 0.29	0.13 ± 0.15
Low (20 ppt)	4.20 ± 0.29	4.20 ± 0.29	0.00 ± 0.00
Moderate (25 ppt)	4.40 ± 0.22	4.47 ± 0.31	0.08 ± 0.10
High (42 ppt)	4.45 ± 0.25	4.50 ± 0.28	0.05 ± 0.06

Table 6: Effect of salinity on body weight of E. asiatica

Treatment	Initial weight (g) (Mean ± SD)	Final weight (g) (Mean ± SD)	Net weight change (g)
Control (35 ppt)	15.48 ± 1.32	16.05 ± 1.42	+0.58
Low (20 ppt)	10.93 ± 1.89	10.53 ± 1.88	−0.40
Moderate (25 ppt)	12.18 ± 1.04	12.33 ± 1.29	+0.15
High (42 ppt)	13.08 ± 2.16	12.88 ± 2.35	−0.20

Table 7: Effect of temperature on survival of E. asiatica

Treatment	Initial No. of animals	Final alive	Mortality	Survival (%)
Control (28°C)	**4**	**4**	**0**	**100%**
Low (15°C)	**4**	**2**	**2**	**50%**
Moderate (22°C)	**4**	**4**	**0**	**100%**
High (32°C)	**4**	**2**	**2**	**50%**

Table 8: Effect of photoperiod on survival of E. asiatica

Treatment	Initial No. of animals	Final alive	Mortality	Survival (%)
Control (12:12 hours)	4	4	0	100%
Light (24 hours)	4	2	2	50%
Dark (24 hours)	4	4	0	100%

Table 9. Effect of salinity on survival of E. asiatica

Treatment	Initial No. of animals	Final alive	Mortality	Survival (%)
Control (35 ppt)	4	4	0	100%
Low (20 ppt)	4	1	3	25%
Moderate (25 ppt)	4	3	1	75%
High (42 ppt)	4	2	2	50%

Table 10: Effect of temperature on molting of E. asiatica

Treatment	Total animals	Molting observed	Molting (%)
Control (28°C)	4	2	50%
Low (15°C)	4	0	0%
Moderate (22°C)	4	2	50%
High (32°C)	4	2	50%

Table 11: Effect of photoperiod on molting of E. asiatica

Treatment	Total animals	Molting observed	Molting (%)
Control (12:12 hours)	**4**	**2**	**50%**
Light (24 hours)	**4**	**2**	**50%**
Dark (24 hours)	**4**	**3**	**75%**

Table 12: Effect of salinity on molting of E. asiatica

Treatment	Total animals	Molting observed	Molting (%)
Control (35 ppt)	4	2	50%
Low (20 ppt)	4	0	0%
Moderate (25 ppt)	4	2	50%
High (42 ppt)	4	1	25%

Discussion and Conclusion

The present study investigated the influence of three important environmental parameters such as temperature, photoperiod and salinity on the growth, survival and molting of *Emerita asiatica.* Environmental conditions play a major role in regulating physiological and behavioral processes in marine crustaceans. Since crustaceans possess a rigid exoskeleton, growth occurs only through periodic molting, making environmental factors that affect molting particularly important in determining the overall growth and survival.

Temperature is one of the most important environmental factors influencing the metabolic and physiological processes of ectothermic organisms. In the present study, the control temperature (28°C) supported relatively better growth and survival compared to other treatments, indicating that this temperature range is favourable for *Emerita asiatica*. Similar observations were reported by (14), who demonstrated that *E. asiatica* exhibits optimal metabolic activity and survival within a narrow temperature range while extreme temperatures lead to physiological stress and mortality.

Moderate (22°C) and high (33°C) temperature treatments showed only slight increases in carapace length. However, it is important to note that growth in these treatments was associated with molting events confirming that growth in *E. asiatica* is directly dependent on molting rather than continuous tissue expansion. A similar relationship between molting and growth has been reported (13), who stated that size increment in mole crabs occurs only during molting cycles. Despite similar molting frequency, a clear difference was observed in post-molt survival between moderate and high temperature treatments. In the high temperature condition, the mole crabs that molted died shortly after molting whereas in the moderate temperature condition, they survived. This indicates that higher temperatures may not completely inhibit molting, they may adversely affect the organism's ability to recover during the post-molt stage. Similar findings were reported by (15) in crabs, where elevated temperatures increased molting frequency but significantly reduced post-molt survival due to thermal stress. The post-molt phase is highly critical since the organism remains soft-bodied and physiologically unstable until the new exoskeleton hardens. Elevated temperatures may increase metabolic demand and physiological stress which can interfere with cuticle hardening and ionic regulation, ultimately leading to mortality (16). In contrast, low temperature (15°C) had a strong inhibitory effect on growth and molting. No increase in carapace length and no molting were observed under this condition. Behavioural observations revealed that individuals maintained at low temperature exhibited sluggish movement and reduced activity levels with minimal locomotion. This reduction in activity can be attributed to decreased metabolic rate at lower temperatures which limits energy availability for essential processes such as molting and growth. Similar findings were reported by (17,18), who observed delayed development and reduced molting frequency at low temperatures due to suppressed metabolic activity. Survival patterns also reflect the influence of temperature stress. Both control and moderate temperature treatments showed 100% survival, whereas low and high temperature treatments showed reduced survival (50%). These findings indicate that both extremes of temperature are unfavourable for the survival and physiological activities of *E. asiatica*. A similar trend has been reported by (19) who demonstrated that extreme temperatures significantly increase mortality in crustacean larvae, particularly during sensitive developmental stages.

Photoperiod plays an important role in regulating behavioural and physiological activities in crustaceans including feeding, locomotion and molting. In the present study, differences in growth, molting and survival under varying light conditions indicate that photoperiod significantly influences the performance of *Emerita asiatica*. Under control conditions (12:12 h light:dark), the organisms exhibited the highest overall growth along with successful molting and survival. This suggests that a balanced light–dark cycle provides optimal conditions for metabolic activity and energy utilization, supporting normal growth and physiological stability. Twenty four hours darkness resulted in a higher molting frequency and complete survival after molting, along with moderate growth. This may be attributed to the natural burrowing behaviour of *E. asiatica*, which is adapted to low-light environments. Since growth in crustaceans occurs only during molting, increased molting under dark conditions contributes to improved growth . In contrast, continuous light conditions exhibited limited growth and poor survival despite the occurrence of molting. The individuals that molted were unable to survive the post-molt stage, indicating that continuous illumination may act as a stress factor. Similar observations have been reported in *Scylla paramamosain*. under stressful environmental conditions where molting occurs but survival is compromised (20). Continuous exposure to light may disrupt essential behaviours such as feeding and burrowing which are critical for maintaining energy balance and protection in sand-dwelling organisms. As *E. asiatica* naturally inhabits buried sandy environments, prolonged light exposure may create unnatural and stressful conditions which will ultimately affect growth and survival. Overall, the results indicate that natural photoperiod and darker conditions are more favourable for growth, molting and survival in *Emerita asiatica* whereas continuous 24 hours light negatively impacts survival, especially during the post-molt stage.

Salinity is one of the most important environmental factors affecting marine crustaceans as it directly influences osmoregulation, metabolism and overall physiological performance. In the present study, salinity variations had a clear effect on growth, survival and molting of *Emerita asiatica*. The control salinity (35 ppt) supported the highest growth, successful molting and maximum survival, indicating that conditions close to natural seawater are optimal for the species. Moderate salinity (25 ppt) also supported growth and molting, although slightly reduced compared to the control. This suggests that *E. asiatica* can tolerate a certain range of salinity variation but performs best near its natural habitat conditions. Similar tolerance has been reported in other crustaceans such as *Scylla paramamosain*., where stable growth and survival were observed within a moderate salinity range (21). In contrast, low salinity (20ppt) conditions resulted in no observable growth, absence of molting and poor survival. This indicates that reduced salinity imposes significant osmotic stress, forcing the organism to divert energy towards maintaining ionic balance rather than growth and development. Comparable findings have been reported in palaemonid shrimps, where salinity below optimal levels led to the failure of osmoregulatory mechanisms and high mortality (22). High salinity conditions also negatively affected the organisms, limiting molting frequencies and reducing growth and survival, compared to control conditions. This suggests that excessively high salinity creates hyperosmotic stress which disrupts normal physiological functioning. Similar observations were made in *Scylla paramamosain,* where higher salinity levels reduced growth efficiency despite some degree of tolerance (23). Overall, the results indicate that *E. asiatica* performs best under salinity conditions close to natural seawater, while both low and high salinity levels adversely affect growth, molting and survival. These findings highlight the importance of maintaining optimal salinity conditions for physiological stability and successful development in marine crustaceans. The present study demonstrates that environmental factors such as temperature, photoperiod and salinity directly regulate the growth, survival, and molting of *Emerita asiatica*, with temperature and salinity having the strongest physiological impact and photoperiod mainly influencing behaviour and post-molt survival. Growth was strictly dependent on molting, but successful molting did not guarantee survival. Stress conditions such as high temperature and continuous light resulted in post-molt mortality, highlighting the vulnerability of individuals during the recovery phase. In contrast, moderate temperature and dark or natural photoperiod conditions supported both survival and molting, making them optimal for overall performance.

Low temperature completely inhibited molting and reduced activity, indicating suppressed metabolism. Twenty-four hours light exposure increased stress and reduced survival, likely due to the stress. Salinity played a critical role in maintaining physiological balance. Optimal conditions at 35 ppt supported maximum survival and consistent molting, while deviations at both low (20 ppt) and high (42 ppt) levels caused stress, reduced molting, and increased mortality, indicating a narrow tolerance range of mole crabs. Overall, the findings show that growth in *E. asiatica* is indirectly controlled by environmental conditions through their effects on molting and survival. Stable conditions resembling the natural habitat are essential, as any deviation leads to physiological stress, impaired molting, and increased mortality, particularly during the post-molt stage.

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