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Comparative study of the growth rates of rearing shrimp *Metapenaeus affinis* (H. Milne Edwards, 1837) in two concentraions different salinities in vitro

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Abstract

The shrimp, Metapenaeus affinis, was reared in two types of basins with water salinities of (1 and 5) mg/L with initial weights of 1540 ± 278.75 mg and final weights of 1765 ± 273.91 mg and 1891.67 ± 324.66 mg, respectively. Weight gain was 225 ± 5 mg and 347 ± 47 mg, growth rate was 0.464 ± 0.082 mg and 0.678 ± 0.033 mg/day, and survival rates were 60% and 80%, respectively. Statistical analysis showed no significant differences (P≥0.05) between weight gain, growth rate, and growth rate of the shrimp rearing at the two ponds with different salinity levels (1 and 5) mg/L. Significant differences (P≤0.05) were found in feed conversion ratios and survival rates.
Keywords: Aquaculture, crustaceans, different environments, sustainability.

Introduction

The shrimp of Metapenaeus affinis is a key component in modern aquaculture projects, and its commercial demand is increasing, therefore, it holds a strategic position in the marine economy, making it an essential component of regional fish stocks and a cornerstone of international maritime trade (Al-Maliky, 2017; Abdel Razek *et al.*, 2022; Mohamed and Abood, 2024). The shrimp *M. affinis* is affected by tides, especially the individual in its juvenile stages. It is abundant in the waters of southern Iraq, particularly in the marshlands, during the summer months (Al-Maliky, 2013). A recent study showed that females range in length from (9.0 - 13.5) cm, while males range from (8.0 - 11.0) cm (Abdel Razek *et al.*, 2022). Meanwhile, a study conducted in the Al-Musahab area, southeast of the Al-Hammar marshes, north of Basra Governorate, southern Iraq, recorded the total length of individuals of this species to range from (1.0 - 10.0) cm (Al-Maliky, 2022).

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Abdul-Sahib & Ajeel (2005) studied the biochemical components of the nutrient values of male and female shrimp *M. affinis*, which included proteins, fats, carbohydrates, ash, and moisture, in addition to energy contents at percentages of 14.356%, 2.088%, 8.9035%, 5.64%, 69.0116%, and 137.350%, respectively. Statistical analysis showed differences in the above components between the main body parts and for both sexes. It was also noted that the molting of this type of shrimp occurs approximately every two weeks. Conducted Al-Maliky (2009) a study to compare the growth rates of *M. affinis* raised in three different farming systems. The study showed the effect of the type of farming system used on the growth rates of the juveniles in 60 days. Compared the growth rates of juveniles cultured in inland ponds, water channels, and mud ponds. The highest growth rates, expressed as cumulative weight gain, were observed when cultured in mud ponds, followed by water channels, and then inland ponds. The study also recorded the maximum weight rates for juveniles that fed on mixed food, followed by Artemia, with a slight difference for those fed on feed. The study also showed the effect of temperature and type of feed provided on the metabolism of the shrimp juveniles. The study shown, the optimal temperature was 25°C.

Pointed, Natarajan *et al*. (2015) that the interaction between temperature and other environmental factors, such as salinity, dissolved oxygen, and pH, becomes more pronounced in intensive shrimp farming systems. This highlights the need for careful monitoring and control of environmental factors to maintain healthy growth in marine organisms and avoid stress caused by changing environmental conditions. Al-Maliky (2017) presented a study of some life aspects of the invasive shrimp Macrobrachium nipponense, comparing the results. Shrimp (*M. affinis*) were studied in various locations in Basra Governorate. Indicated, Abdel Razek *et al*. (2022) that growth, mortality, and stock assessment rates for *M. affinis* vary according to different Iraqi aquatic environments. Jabbar *et al*. (2025) conducted a study on *M. affinis* in Iraqi coastal waters, finding significant seasonal variations in the Condition Factor (CF), Gonadosomatic Index (GSI), and Hepatosomatic Index (HSI), the highest values were observed during the spring and summer months, these seasonal variations should be considered when assessing the physiological and reproductive indicators of this species. The study aimed to determine the optimal salinity for increasing shrimp *M. affinis* growth during laboratory rearing.

Materials and Methods

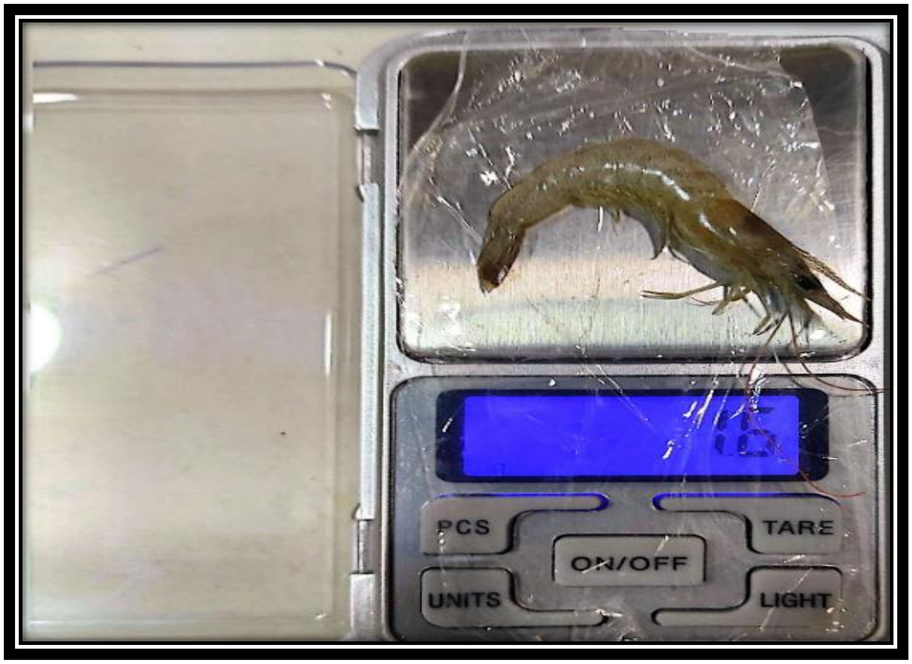
Growth Experiment

After collecting the samples and arriving at the laboratory, the live shrimp samples were transferred to six experimental basins. These were plastic basins measuring (35.5 x 27 x 21) cm (length, width, and height) and with a capacity of 25 liters each (Pic. 1). They were filled with dechlorinated water and equipped with continuous aeration and filtering systems. Nets were used to cover the basins. Each tank was filled with 24 liters of dechlorinated water. The water was replaced at a rate of (50-70)%, and the basin bottom and filters were cleaned every two to three days. Cooling systems were used on hot days to maintain the water temperature during the experiment. Specific salt concentrations (1 and 5) Mg/L were added to the basins, taking into account the salinity gradient to acclimatize the shrimp.

Picture (1). Shrimp rearing tanks *M. affinis* in two different salinities for a period of 30 days

After preparing the basins, the shrimp were distributed among the experimental basins based on their length and weight. A total of 30 shrimp were distributed, ranging in weights. Five shrimp were allocated to each replicate, resulting in three replicates per saline concentration. The shrimp were fed twice daily until satiation. Two salinity levels (1 and 5) mg/L were adopted, and weights the basic environmental factors (temperature, salinity, and pH) were measured using a Chinese-made Water Quality Meter, while the dissolved oxygen, measured by using the Winkler Method, every ten days with daily monitoring the developments of growth, the experiment lasted (30) days. (Al-Maliky, 2009).

The total weight (TW) of the shrimp's juvenile was measured using a precision balance (Chinese origin) with an accuracy of 0.01 grams. A small empty plastic container was placed on the balance and then reset (calibrated) before weighing the shrimp to en sure accuracy. The shrimp were weights in milligrams. (Pic. 2).



Picture (2). The scale used to measure the weight of the shrimp during the experiment.

Measurements used in the experiments:

Weight gain rate (mg) = Final weight - Initial weight.
Specific growth rate (%mg/day) (SGR) Based on Ricker (1979), using the equation: $SGR = (LnW_2 - LnW_1/T_2 - T_1) \times 100$.
Where W_1 and W_2 are the body weight (mg) at the beginning and the end of the growth period, respectively. T_1 and T_2 are the time (days) at the beginning and end of the experiment, respectively.
Feed Conversion Ratio (FCR): Based on Al-Hafedh *et al.* (1999), the equation was used: Feed Conversion Ratio = Intake of Feed / Weight Gain.
Survival Rate: The survival rate was calculated based on Tang *et al.* (1985), using the equation: Survival Rate = (Final number at the end of the experiment / Total number at the beginning of the experiment) × 100.

Statistical Analysis

The data were statistically analyzed using IBM SPSS Statistics (Version 20). Statistical significance was determined using two-way ANOVA to identify differences at significance levels $P \geq 0.05$, regarding the effect of different environmental factors on growth and culture within the laboratory.

Results and Discussion

Abiotic Environmental Factors

The results of the current study showed that the recorded temperature for a 1 mg/L salinity ranged from (23.7 - 23.9)°C, with a pH value of 7.7 and dissolved oxygen levels ranging from (6.0 - 6.1) mg/L. For a 5 mg/L salt concentration, the recorded temperature ranged from (24.5 - 25.0)°C, with a pH value of (7.8 - 7.9) and dissolved oxygen levels ranging from (6.1 - 6.3) mg/L. Therefore, the statistical analysis showed significant differences ($P<0.05$) in temperature between the two salt concentrations (1 and 5) mg/L. Statistical analysis showed no significant differences ($P\geq0.05$) in pH and dissolved oxygen between the two salt concentrations (Fig. 1).

The results showed that the temperature for the 1 mg/L salt concentration ranged between (23.3 - 24.3)°C, pH values were 7.5 and 7.6, and the dissolved oxygen levels ranged between (5.4 - 5.5) mg/L. For the 5 mg/L salinity, the temperature ranged between 24.8 and 25.0°C, the recorded pH values were (7.7 - 7.8), and the dissolved oxygen levels were (5.6 -5.7) mg/L. Therefore, the statistical analysis showed no significant differences ($P\geq0.05$) in temperature between the two salt concentrations (1 and 5 mg/L). However, the statistical analysis showed significant differences ($P\leq0.05$) in pH and dissolved oxygen between the two salinity.

The results also showed that the temperature for a salt concentration of 1 mg/L ranged between (24.3 - 24.7) °C, pH values were (7.6 - 7.8), and the dissolved oxygen levels ranged between (5.0 - 5.1) mg/L. For a salt concentration of (5) mg/L, the temperature ranged between (23.5 - 25.5) °C, the recorded pH values were (7.7 - 7.8), and the recorded dissolved oxygen levels were (5.1 - 5.2) mg/L. Therefore, the results of the statistical analysis showed no significant differences ($P\geq0.05$) in temperature, pH, or dissolved oxygen between the two salt concentrations.

The results showed that the temperature for a salt concentration of (1) mg/L ranged between (23.6-23.9)°C, pH values were (7.8-7.9), and the dissolved oxygen levels ranged between (4.7-4.8) mg/L. For a salt concentration of (5) mg/L, the temperature ranged between (24.1-24.6)°C, pH values were (6.7-7.7), and the dissolved oxygen levels were (4.9-5.0) mg/L. Therefore, the statistical analysis showed significant differences ($P\leq0.05$) in the environmental factors (temperature, pH, and dissolved oxygen) between the two salt concentrations (1 and 5) mg/L. Monitoring abiotic environmental factors (temperature, pH, dissolved oxygen) is essential for isolating the effect of salinity as an independent factor. If these factors remain constant, it can be verified that the changes observed in aquatic organisms are due to the effect of salinity and not to other factors (Boyd *et al.,* 2024).

They are also consistent with the study by Wang *et al.* (2018), which demonstrated that maintaining a temperature within the range of 23–25°C contributes to maintaining the normal metabolic rate of the genus *Metapenaeus*. However, the results of the current study did not agree with the study by Islam *et al.* (2018) which recorded higher temperature changes when salinity was changed, and this is due to the tight control of temperature in the laboratory compared to open systems.

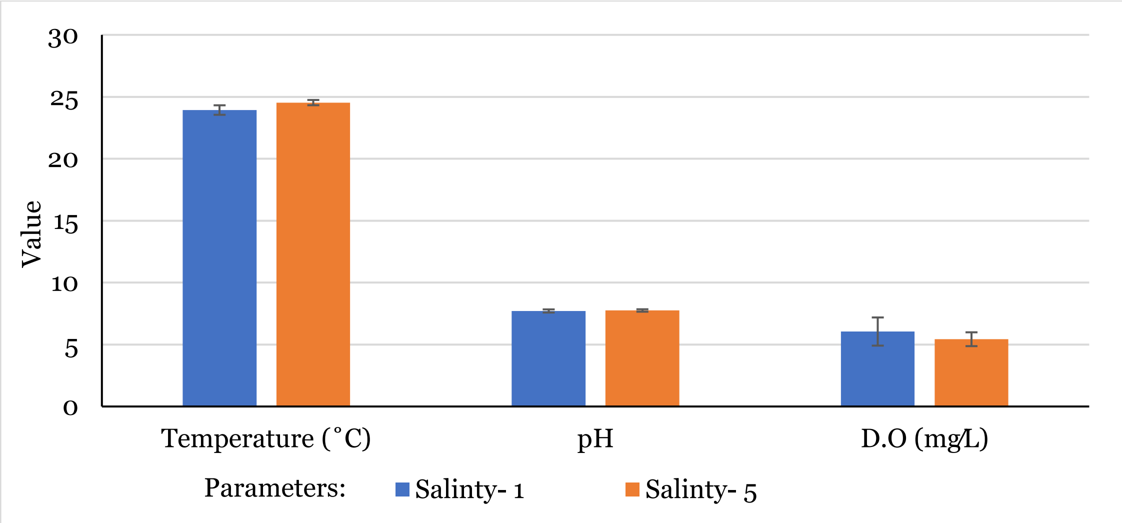


Figure 1. Measurements of some environmental conditions of water in *M.affinis* rearing at two salinities during the study period.

The results showed stability of pH values within the alkaline-neutral range (7.5-8.5), which is consistent with the guidelines adopted for crustacean aquaculture in semi-intensive systems (Li *et al*., 2026). This stability indicates the efficiency of the bicarbonate system in regulating pH (buffering capacity), which supports osmotic stability and reduces disturbances and exoskeleton formation during molting (Crump *et al*., 2026). The results of the current study are similar to those of Nazarudin *et al.* (2025), which showed that maintaining a stable pH level is ideal for minimizing acid-base imbalance. This study also indicated that low salinity (1-5) mg/L maintains bicarbonate balance and stability in brackish water, provided that the total alkalinity is stable.

In contrast, the results of the current study differed from those of Ye *et al.* (2025), as they recorded a significant increase in pH values with increases salinity in open systems. This difference is attributed to the fact that the total alkalinity of the source water differed between the two studies. The results of the current study showed a significant gradual decrease in dissolved oxygen levels as the experiment continued, which is associated with increased biomass and metabolic processes. This study is consistent with that of Maharani *et al.* (2024), which confirmed that dissolved oxygen consumption increases with increased crustacean growth and bacterial decomposition of organic waste. It should be noted that dissolved oxygen levels remained within the safe range (>4 mg/L) throughout the experiment, which is consistent with the recommended level for the growth of Penaeidae shrimp (Iber & Kasan, 2021).

Furthermore, the results of the current study did not agree with those of Nazarudin *et al.* (2025), which indicated a sharp decrease in dissolved oxygen levels at high salinity. This discrepancy may be attributed to variations in temperature between the two studies, suggesting that oxygen solubility in water is inversely proportional to temperature (Boyd, 2022). Based on the above, we conclude that the environmental factors (temperature, dissolved oxygen, and pH) in the current study were stable and similar between the two salinity concentrations (1 and 5) mg/L. Therefore, they are considered good control factors, and any changes in growth or molting are primarily attributed to the effect of salinity (Tran *et al.,* 2024).

It is important to note that these factors work together in an integrated manner. Temperature controls the increase in the rate of vital activities and also affects growth rates and molting frequency. Increased temperatures lead to an increase in the metabolic rate and oxygen consumption (Zhang and Mykles, 2024). Dissolved oxygen is essential for energy production, and any decrease in it limits growth and thus negatively affects molting and survival rates (Norin *et al*., 2023). pH affects physiological stability and the organism's efficiency in building the outer shell after molting, especially when it interacts with other factors, which clearly enhances the effect of salinity (Boyd *et al*., 2024).

Average Weight (mg) For Juvenile Shrimp

The results of the study showed that the average initial weight of shrimp cultured at a salinity of 1 mg/L was 15400.00 mg on day 0, 1611.67 mg after ten days, 1691.67 mg after 20 days, and 1765.00 mg at the end of the experiment, with an average weight gain of 225.00 mg at a concentration of 1 mg/L. As for the average weight recorded at a salinity of 5 mg/L, it was 1545.00 mg at the beginning of the experiment on day 0, 1651.67 mg after the first ten days, 1766.67 mg after 20 days, and 1891.67 mg at the end of the experiment.

The average weight gain at a salinity of 5 mg/L was 346.67 mg. Statistical analysis showed no significant differences (P≥0.05) in weight between the two salinity (1 and 5) mg/L. (Fig. 2). At very low salinity (1 mg/L), shrimp resort to consuming large amounts of energy for osmotic regulation to maintain ionic balance. This, in turn, reduces the energy available for biomass building and tissue formation. A salinity concentration of 5 mg/L, however, provides an environment closer to osmotic equilibrium, thus contributing to the allocation of energy towards growth and biomass accumulation (Rahi *et al*., 2021; Ramaglia *et al*., 2024).

This study is consistent with that of Al-Maliky (2024) and Abbas *et al*. (2024) on the same species, as it demonstrated higher metabolic efficiency and increased growth rates at a salinity concentration of 5 mg/L compared to 1 mg/L. It also agrees with Rahi *et al*. (2021), which showed that very low salinity generates a physiological burden that is clearly reflected in weight growth compared to length growth in *Penaeus monodon*. Furthermore, the results of this study disagree with those of Liu *et al*. (2024), which indicated that some shrimp species achieve the highest growth rates at salinity levels above 10 mg/L.

This suggests that the optimal salinity range varies depending on the species and age. The results of the current study showed that the average weight gain at a salinity of 1 mg/L during the 30-day experiment was 225.00 mg. The average weight gain at a salinity of 5 mg/L was 346.67 mg. Statistical analysis revealed no significant differences (P≥0.05) between the weight gain rates recorded at the two salinity concentrations during the experiment. (Fig. 1).

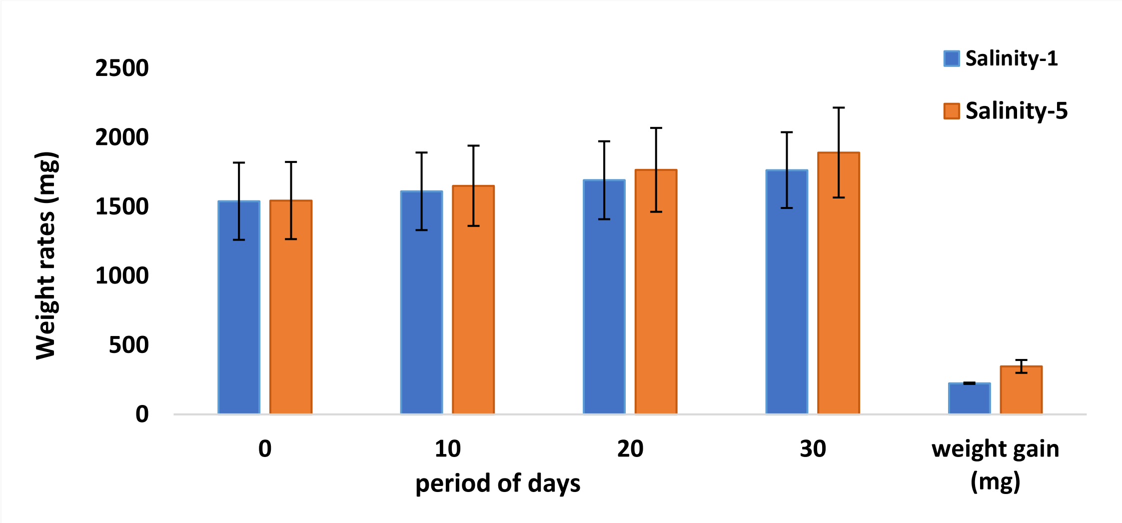


Figure 2. Average weights (mg) and weight gain (mg) of *M. affinis* rearing at two salinity levels (1 and 5) mg/L over 30 days. (Average ± Standard Deviation).

The results of the study, a 30-day growth experiment of *M. affinis* at two salinity (1 and 5) mg/L, showed that the weight gain of this species was greater at the 5 mg/L concentration compared to the 1 mg/L concentration, although no statistically significant differences were found. This suggests that this salt level contributes to creating suitable environmental conditions for growth, leading to greater weight gain (Abbas *et al*., 2024). This is attributed to the essential role of salinity in regulating physiological activities, particularly improving osmotic regulation. Low salinity causes an increase in energy consumption to maintain homeostasis, which in turn reduces the energy available for growth. Conversely, relatively higher salt levels direct a larger portion of energy towards increasing biomass and promoting weight gain (Permata *et al*., 2021; Rahi *et al*., 2021). This study is consistent with that of Abbas *et al*. (2024), which indicated improved growth in *M. affinis* at moderate salinity compared to low salinity due to reduced osmotic stress and enhanced metabolic efficiency. It is also partially consistent with the study by Parmenter (2021), which showed that the lack of significant growth differences is attributed to the shrimp's ability to adapt to a wide range of salinity levels under varying environmental conditions. We conclude that the higher weight gain at a salinity of 5 mg/L demonstrates more efficient growth physiology compared to a salinity of 1 mg/L. However, the lack of statistical significance necessitates future studies with longer time periods and larger sample sizes to more accurately confirm these results.

Specific Growth Rate (SGR)

The results of the study showed that the specific growth rate (SGR) recorded at a salinity of 1 mg/L during the experimental period was 0.464 mg/day. The weight gain at a salinity of 5 mg/L was 0.678 mg/day. The statistical analysis showed no significant differences ($P \geq 0.05$) between the specific growth rates for the two salinity concentrations recorded during the experimental period (Table 1).

This study showed that the specific growth rate (SGR) of the shrimp *M. affinis* was optimal at a salinity of 5 mg/L (0.678) compared to 1 mg/L (0.464). This improvement is attributed to the reduced costs of osmotic regulation, as shrimp in low-salinity environments require more energy to achieve ionic equilibrium, resulting in less energy available for growth (Liu *et al*., 2021). Several recent studies have confirmed that salinity affects specific growth not only by altering the growth rate but also by influencing overall physiological performance, specifically the expression of certain genes involved in osmotic regulation and metabolism (Chao *et al*., 2022). The results of the current study are consistent with the studies of both Chen *et al*. (2020) and Kumar *et al*. (2023), which indicated that with decreasing salinity, the physiological performance of the organism tends to be less stable, and this in turn leads to a decrease in the rate of specific growth. However, at balanced salinity, the energy used for growth is relatively greater, resulting in higher specific growth. That is, increasing salinity levels from (1-5) mg/L promotes the specific growth of shrimp *M. affinis*, due to better energy utilization and consequently a decrease in osmotic pressure. This highlights the importance of salinity control in aquaculture for improving the specific growth rate (SGR), (Wang *et al*., 2024).

Feed Conversion Ratio (FCR)

The results of the study showed that the feed conversion ratio at a salinity of 1 mg/L was 133.33, at a salinity of 5 mg/L reached 86.54. Statistical analysis revealed significant differences ($P \leq 0.05$) between the feed conversion ratios at the two salinity concentrations recorded (Table 1).

Feed Conversion Ratio (FCR) the results of the growth experiment showed that *M. affinis* exhibited better feed conversion efficiency, as indicated by a lower feed conversion ratio (FCR) at a salinity concentration of 5 mg/L (86.54) compared to 1 mg/L (133.33). The lower FCR at the relatively higher salinity (5 mg/L) suggests greater feed utilization efficiency, as the shrimp in this environment were able to direct more energy towards growth and efficiently convert food into body mass. This difference is attributed to the fact that very low salinity imposes severe osmotic stress, forcing the shrimp to consume a large proportion of its metabolic energy to maintain ionic balance and adapt to the osmotic pressure, at the expense of growth and feed conversion efficiency. These results are consistent with the study by Lu *et al*. (2023), which demonstrated that exposure of crustaceans to environmental stress, such as severe salinity reduction, leads them to direct metabolic energy towards maintaining osmotic balance rather than towards vital processes like growth and reproduction to support adaptation and survival mechanisms. Furthermore, the study by Lim *et al*. (2021) demonstrated that hypo-osmotic stress necessitates a significant increase in energy consumption to maintain cell membrane stability and regulate ionic balance, thereby reducing the energy available for growth and feed utilization. Additionally, the study by Li *et al*. (2024), conducted on white shrimp *Litopenaeus vannamei*, confirmed that shrimp farming in low-salinity environments requires careful intervention to improve ionic balance, compensate for physiological stress, and enhance feed conversion and growth rates. This aligns with the study by Li *et al.* (2017), which indicated that low salinity causes an increase in oxygen consumption and energy expenditure for osmotic regulation, negatively impacting feed utilization unless compensated for with specific feed additives and gradual acclimatization. Based on the above, *M. affinis* achieves optimal feed conversion rates at a moderate salinity level (5 mg/L), thus avoiding excessive energy depletion in osmotic regulation. Conserving energy and directing it towards growth rather than osmotic adaptation is crucial for improving feed utilization efficiency and increasing productivity in aquaculture systems.

Survival Rate (%)

The results of the study showed that the survival rate (%) at a salinity of 1 mg/L was 60%, while the survival rate recorded at a salinity of 5 mg/L was 80%. Statistical analysis revealed significant differences ($P \leq 0.05$) in survival rates (%) between the two salinity concentrations (1 and 5) mg/L. (Table 1).

Table 1. Preferred measures of the effect of rearing *M. affinis* in two different salinity levels (1 and 5) mg/L over 30 days. (Average ± Standard Deviation).

Parameters	Values	Salinity (mg/L)
Initial Weight (mg)	1540.00 ± 278.75	1
Final Weight (mg)	1765.00 ± 273.91	
SGR (% per day)	0.464 ± 0.082	
FCR	133.33 ± 2.96	
Survival (%)	60	
Initial Weight (mg)	1545.00 ± 278.75	5
Final Weight (mg)	1891.67 ± 324.66	
SGR (% per day)	0.678 ± 0.033	
FCR	86.54 ± 11.59	
Survival (%)	80	

This increase reflects a higher tolerance to osmotic stress, allowing metabolic energy to be directed towards growth and survival rather than adaptation to acute stress. This study is consistent with the research of Huang *et al.* (2025) on two shrimp species, *P. monodon* and *L. vannamei*, which showed that extreme salinity causes disturbances in energy and lipid metabolism, reducing biological efficiency and increasing mortality. Furthermore, the study by Xiao *et al.* (2025) demonstrated that chronic stress depletes antioxidant capacity, increases oxygen consumption and ammonia excretion, and causes physiological fatigue. Despite this, it is possible to enhance survival rates in low salinity through careful management strategies. Furthermore, a study by Saputra *et al.* (2025) confirmed that gradual acclimatization to salinity, coupled with improved water quality and nutrition, increases survival rates in white shrimp from approximately 24% to 88%. This allows shrimp to develop coping mechanisms that protect them from osmotic shock. The response depends on the species and age. Based on the above, it can be concluded that a concentration of 5 mg/L represents the optimal environmental medium for the rearing of *M. affinis*. This concentration reduces osmotic and environmental stress and contributes to the stability of antioxidant systems, which in turn leads to increased survival rates and productivity.

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دراسة مقارنة لمعدلات نمو تربية الروبيان *Metapenaeus affinis* (H. Milne Edwards, 1837) في تركيزين مختلفين من الملوحة في المختبر

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المستخلص

تمت تربية الروبيان، *Metapenaeus affinis*، في نوعين من الأحواض بملوحة مياه تبلغ (1 و5) ملغم/لتر، حيث بلغ متوسط الوزن الابتدائي 1540 ± 278.75 ملغم، ومتوسط الوزن النهائي 1765 ± 273.91 ملغم و1891.67 ± 324.66 ملغم على التوالي. بلغ معدل زيادة الوزن 225 ± 5 ملغم و347 ± 47 ملغم، ومعدل النمو 0.464 ± 0.082 ملغم و0.678 ± 0.033 ملغم/يوم، ونسبة البقاء على قيد الحياة 60% و80% على التوالي. أظهر التحليل الإحصائي عدم وجود فروق معنوية (P≥0.05) بين زيادة الوزن ومعدل النمو ومعدل نمو الروبيان المُربّى في البركتين ذواتي مستويات الملوحة المختلفة (1 و5) ملغم/لتر. بينما وُجدت فروق معنوية(P≤0.05) في نسب التحويل الغذائي ومعدلات البقاء.

الكلمات المفتاحية: الاستزراع المائي، القشريات، بيئات مختلفة، الاستدامة.