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Growth Response and Final Biomass of Amphipods *Phronima* sp. to Gradual Salinity Reduction in Controlled Culture System

Meisi Auliani[1*], Thoy Batun Citra Rahmadani[1], Warih Hardanu[2]

[1]Aquaculture Study Program, Departemen of Fisheries and Marine Science, Faculty of Agriculture, University of Mataram
Pendidikan Street No. 37 Mataram, West Nusa Tenggara, Indonesia
[2]Research Center for Marine Aquaculture, Agriculture and Food Research Organization, National Research and Innovation Agency (BRIN), Malaka, North Lombok
Senggigi Street, Malaka Village, Pemenang District, North Lombok West Nusa Tenggara, Indonesia

Correspondence:
mesiaulyawangi@gmail.com

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ABSTRACT

Phronima sp. is a marine amphipod with potential as a natural feed in fisheries cultivation activities. One of the challenges in its development is its ability to adapt to salinity changes during the research process. This study aims to analyze the effect of salinity decrease frequency on the growth of *Phronima* sp. The research used an experimental design with four treatments: salinity reduction of 5 ppt every 3 days (P1), every 2 days (P2), daily (P3), and control without salinity reduction (P4). *Phronima* sp. was reared for 21 days in 20 L containers with a density of 10 individuals/L. Observed parameters included absolute weight growth, absolute length growth, Specific Growth Rate (SGR), population growth rate, and water quality parameters. Data were analyzed using ANOVA or Welch ANOVA at a 95% confidence level. The results showed that salinity reduction frequency had no significant effect (P>0.05) on all growth pa rameters of both broodstock and juvenile *Phronima* sp. However, the P2 treatment showed the highest average values for absolute weight growth, SGR, and population growth rate. Water quality during the study remained within suitable ranges for *Phronima* sp. growth, with temperature of 26.5–29.6°C, pH of 8.25–8.50, and dissolved oxygen of 5.52–6.68 mg/L. These findings indicate that gradual salinity reduction to 0 ppt with different frequencies remains within the physiological tolerance of *Phronima* sp. and does not significantly affect its growth.

INTRODUCTION

Natural feed is an important component of aquaculture activities because it provides essential nutrients such as proteins, amino acids, lipids, vitamins, and minerals that support the growth and development of aquaculture organisms, especially in the larval and juvenile phases (Hamre *et al*., 2013). Zooplankton as live feed has a suitable size, is easy to digest, and is able to increase the feeding response of aquatic organisms because it has natural movement in the waters (Suhaimi *et al*., 2024).

Several types of zooplankton such as rotiferas, copepods, and *Artemia* have been widely used in hatchery activities (Khan & Rahman, 2025). However, the use of *Artemia* has limitations due to the relatively high price so that a more economical natural feed alternative is needed. Amphipods are one of the groups of zooplankton that have the potential to be developed because they have good nutritional content and can be used as an alternative natural feed in aquaculture activities (Baeza *et al*., 2014).

One type of amphipod that has the potential to be a natural feed is *Phronima* sp. This organism has a wide distribution in marine to brackish waters and plays a role in the food chain as a link between primary producers and higher trophic level organisms. The nutritional content of *Phronima* sp. which supports growth has the potential to be used as natural feed for fish and crustaceans (Yusuf *et al*., 2020).

Development of *Phronima* sp. still faces obstacles, especially related to the success of sustainable maintenance. Environmental factors such as air quality and salinity play an important role in influencing physiological processes, metabolism, and growth of organisms. Changes in salinity can affect osmoregulatory ability as well as energy use efficiency for growth (Jiménez *et al*., 2018).

Phronima sp. is known to have the ability to adapt to the salinity range of 20–35 ppt, but information on the effect of the frequency of gradual salinity changes on biomass growth and production is still limited (Nailulmuna *et al*., 2020). Therefore, this study was conducted to analyze the effect of the frequency of salinity decrease on the growth and final biomass of *Phronima* sp. in a controlled maintenance system as an effort to support the development of alternative natural feed cultures in aquaculture activities.

METHODS

This study was conducted over a 22-day period from 20 April – 12 May 2026 at the Kurnaen Sumadiharga Science and Technology Park (KST) Laboratory, under the Research Institute for Mariculture, Agriculture and Food Research Organization – National Research and Innovation Agency (BRIN), in Malaka, North Lombok. An experimental method employing a Completely Randomized Design (CRD) was used. The study examined the growth response of amphipods (*Phronima* sp.) to decreased salinity; it comprised 4 treatments and 3 replicates, resulting in a total of 12 experimental units. This aligns with the findings of Nailulmuna *et al*. (2020), who investigated the growth response of *Phronima* sp. to salinity changes using salinity treatments of 20, 25, 30, and 35 ppt. The results demonstrated that *Phronima* sp. was able to survive within this salinity range, with a salinity of 25 ppt yielding the best growth. This indicates that *Phronima* sp. possesses the ability to adapt to changes in environmental osmotic conditions.

Table 1. Treatment in the Study

No	Treatment	Remarks
1.	P1	Reduction of 5 ppt every 3 days
2.	P2	Reduction of 5 ppt every 2 days
3.	P3	Reduction of 5 ppt every day
4.	P4	Control (35 ppt)

Data analysis was carried out using SPSS Statistics version 16 on growth parameters including absolute weight, absolute length, Specific Growth Rate (SGR), population growth rate, and water quality. The data were tested for Shapiro-Wilk normality and Levene homogeneity, then analyzed using one-way ANOVA at a 95% confidence level. If there is a real difference ($p<0.05$), Duncan's further test is carried out. Data that did not meet the assumptions were analyzed using Welch ANOVA and Games-Howell, while water quality was analyzed descriptively.

Absolute Weight Growth

Absolute weight growth is the average weight growth rate of shrimp from the beginning to the end of rearing. According to Effendi (2004) in Ismail *et al.* (2021) Absolute weight growth can be calculated using the following formula:

$$Wm = Wt - Wo$$

Where:

Wm = Absolute weight growth (g)
Wt = Average final weight (g)
Wo = Average starting weight (g)

Absolute Length Growth

Absolute length growth is the average length growth rate of shrimp from the beginning to the end of rearing. According to Effendi (1997) in Ismail *et al.* (2021) Absolute length growth can be calculated using the following formula:

$$Pm = Lt - Lo$$

Where:

Pm = Absolute growth length (cm)
Lt = Average final length (cm)
Lo = Average initial length (cm)

Specific Growth Rate (SGR)

The specific growth rate is calculated using the formula of Agharid (2020), as follows:

$$\mathrm{SGR} = \frac{\mathrm{LnWt} - \mathrm{LnWo}}{\mathrm{t}} \times 100\%$$

Where:

SGR = Specific Growth Rate (%/day)
Wt = Weight of biota at the end of maintenance
Wo = Weight of biota at the beginning of maintenance
t = Length of study (days)

Population Growth Rate

The population growth rate *of Phronima* sp. is calculated using the formula that was used in the research of Cheng *et al*. (2011) in Yusuf *et al*. (2020), which is as follows:

$$\mathrm{r} = \frac{\mathrm{lnNt} - \mathrm{lnNo}}{\mathrm{t}} \mathrm{x}100\%$$

Description:

r : Growth rate (%)
Nt : Final density (ind)
No : Initial density (ind)
t : Observation time (days)

Dilution

$$V1 \times N1 = V2 \times N2$$

Where:

V1 = Volume added (liters)

N1 = Initial salinity (ppt)
V2 = Initial volume (liters)
N2 = Desired salinity (ppt)

Water Quality

Measurement of water quality parameters which include temperature, pH, DO, and salinity. Measurements of temperature, pH, DO, salinity are carried out daily to maintain the quality of the treatment medium. The tools used, namely pH & temperature meters to measure the acidity level (pH) and water temperature of the maintenance medium, as well as refractometers to measure the salinity level of the maintenance medium.

RESULTS

Absolute Weight Growth of Broodstock

The results of the absolute weight measurement of *Phronima* sp. in each treatment are presented in Figure 1. Descriptively, the mean absolute weight value shows that the average is 1.19 ± 0.23 g - 2.06 ± 1.31 g.

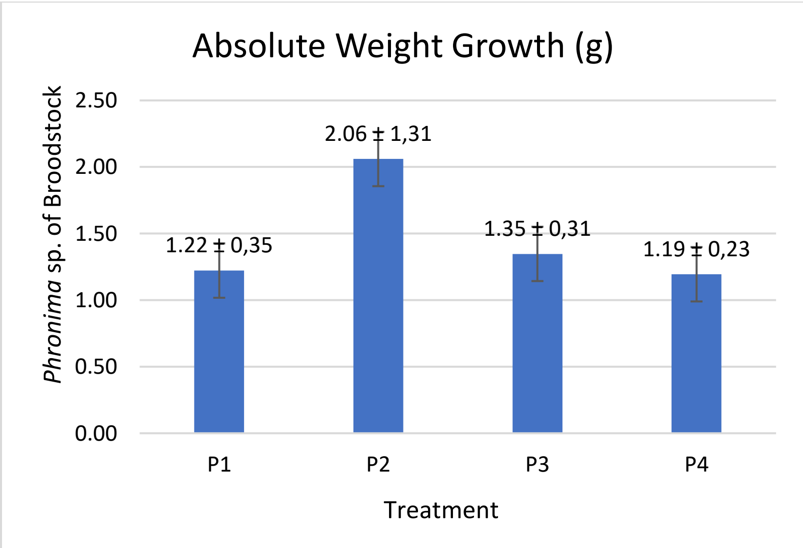

Figure 1. Average Absolute Weight Values Over 21 Days of Maintenance

Based on the results of the Welch ANOVA test, the treatment showed that there was no significant effect on the absolute weight value of *Phronima* sp. broodstock, with a significance value of 0.841 ($P > 0.05$). This indicates that the average absolute weight values for the observed treatments are relatively similar. Therefore, no further testing was conducted.

Absolute Weight Growth of Seeds

The results of the absolute weight measurement of *Phronima* sp. in each treatment are presented in Figure 2. Descriptively, the absolute mean weight value shows that the mean is 1.27 ± 0.23 g - 2.04 ± 0.29 g.

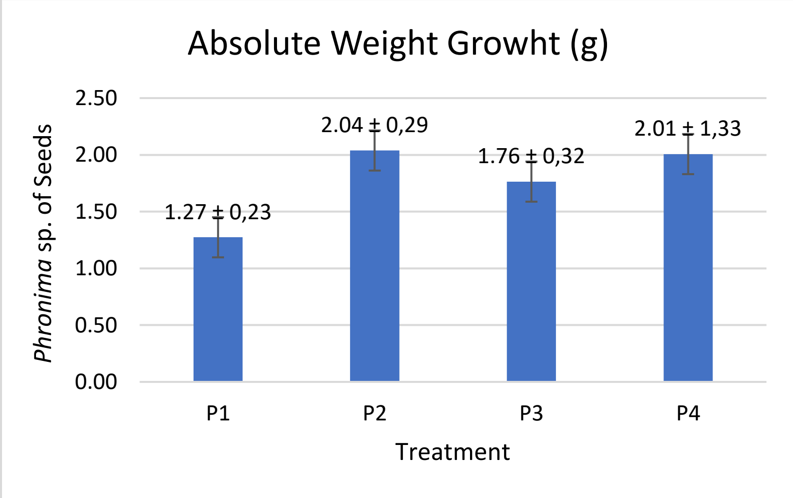

Figure 2. Average Absolute Weight Values Over 21 Days of Maintenance

Based on the results of the Welch ANOVA test, the treatment showed that there was no significant effect on the absolute weight value of *Phronima* sp. seedlings, with a significance value of 0.204 (P > 0.05 This indicates that the average absolute weight values for the observed treatments are relatively similar. Therefore, no further testing was conducted.

Absolute Growth Length of Broodstock

The results of the absolute length measurement of *Phronima* sp. in each treatment are presented in Figure 3. Descriptively, the absolute mean length value shows that the average is 6.1 ± 0.73 mm - 6.7 ± 0.74 mm.

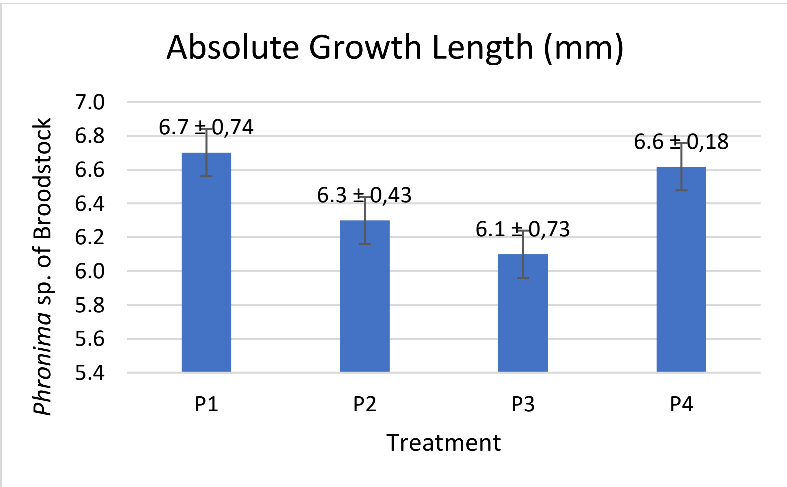

Figure 3. Average Absolute Length Values Over 21 Days of Maintenance

Based on the results of the ANOVA test, the treatment showed that there was no significant effect on the absolute length value of *Phronima* sp. broodstock, with a significance value of 0.705 (P > 0.05). This indicates that the average absolute weight values for the observed treatments are relatively similar. Therefore, no further testing was conducted.

Absolute Growth Length of Seeds

The results of the absolute length measurement of *Phronima* sp. in each treatment are presented in Figure 4. Descriptively, the mean value of absolute length shows that the average is 3.5 ± 0.10 mm - 4.0 ± 0.11 mm.

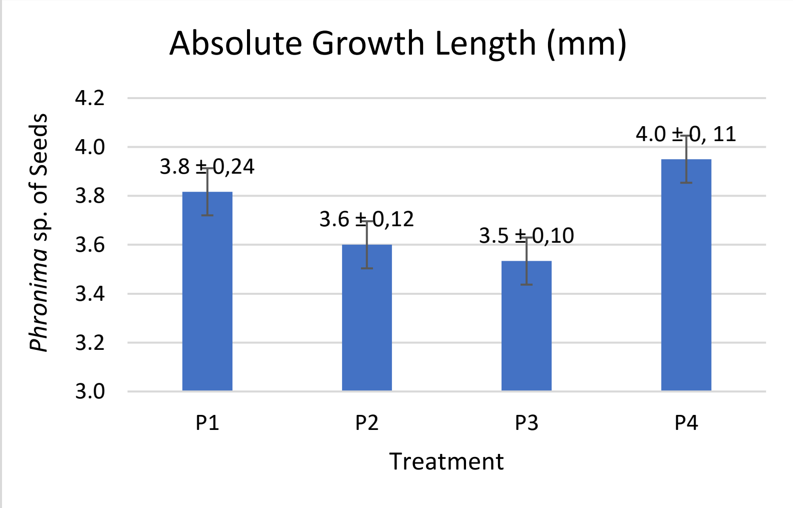

Figure 4. Average Absolute Length Values Over 21 Days of Maintenance

Based on the results of the ANOVA test, the treatment showed that there was no significant effect on the absolute length value in *Phronima* sp. seedlings, with a significance value of 0.087 (P > 0.05). This indicates that the average absolute weight values for the observed treatments are relatively similar. Therefore, no further testing was conducted.

Specific Growth Rate (SGR) of Broodstock

The results of the measurement of the Specific Growth Rate (SGR) *of Phronima* sp. in each treatment are presented in Figure 5. Descriptively, the average value of SGR shows that the average is 5.49 ± 1.22%/day - 8.28 ± 2.13%/day.

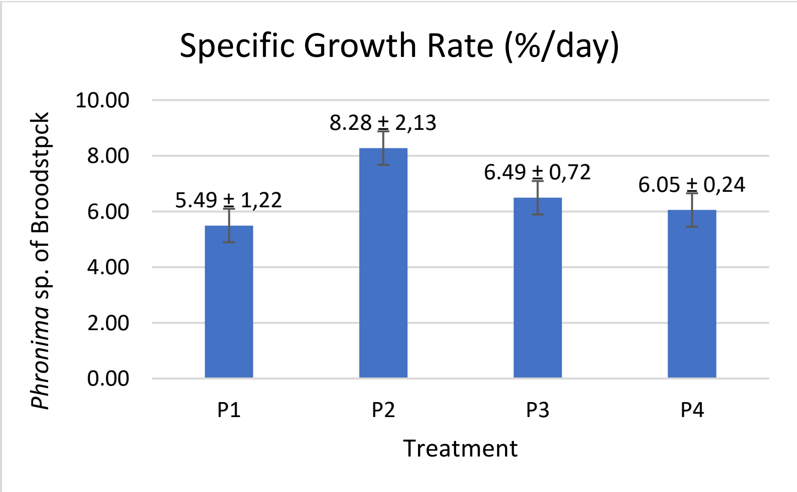

Figure 5. The Average SGR Value For 21 Days of Maintenance

Based on the results of the Welch ANOVA test, the treatment showed that there was no significant effect on the SGR value, with a significance value of 0.440 (P > 0.05). This indicates that the average absolute weight values for the observed treatments are relatively similar. Therefore, no further testing was conducted.

Specific Growth Rate (SGR) of Seeds

The results of the measurement of *Phronima* sp. specific growth rate (SGR) in each treatment are presented in Figure 6. Descriptively, the average SGR value shows that the average is 4.28 ± 0.83%/day - 6.39 ± 0.65%/day.

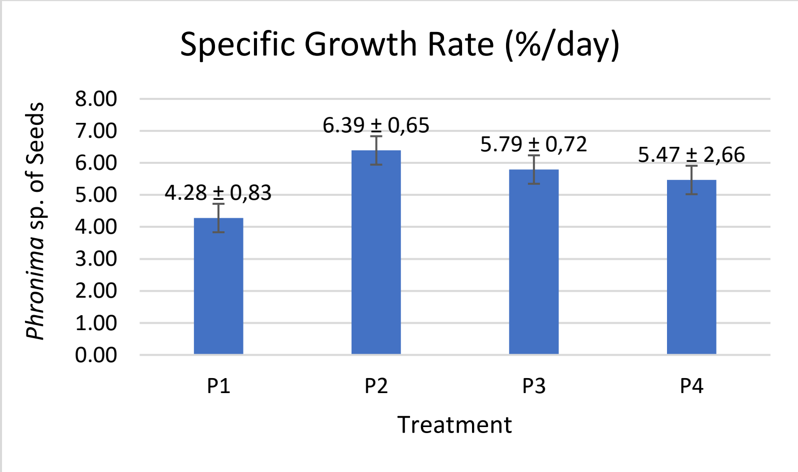

Figure 6. The Average SGR Value For 21 Days of Maintenance

Based on the results of the Welch ANOVA test, the treatment showed that there was no significant effect on the SGR value, with a significance value of 0.562 (P>0.05). This indicates that the average absolute weight values for the observed treatments are relatively similar. Therefore, no further testing was conducted.

Population Growth Rate of Broodstock

The results of the measurement of the population growth rate of *Phronima* sp. in each treatment are presented in Figure 7. Descriptively, the average value of the population growth rate shows that the average is 214.67 ± 8.73% - 245.67 ± 30.74%.

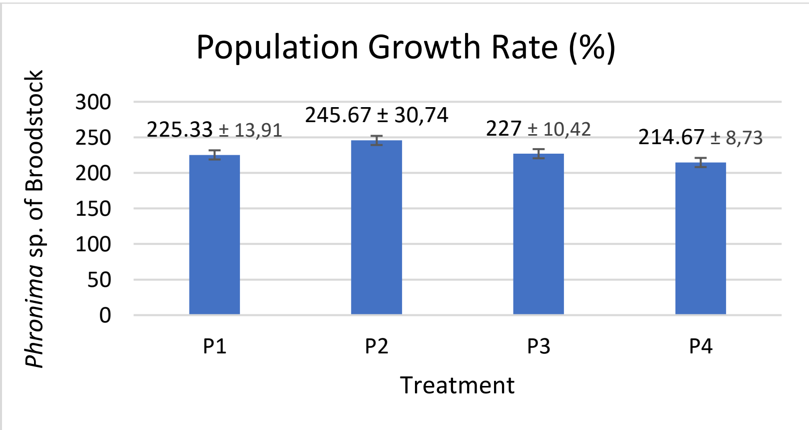

Figure 7. The Average Value of the Population Growth Rate During 21 Days of Maintenance

Based on the results of the ANOVA test, the treatment showed that there was no significant effect on the value of the population growth rate in *Phronima* sp. broodstock, with a significance value of 0.440 (P > 0.05). This indicates that the average absolute weight values for the observed treatments are relatively similar. Therefore, no further testing was conducted.

Population Growth Rate of Seeds

The results of the measurement of the population growth rate of *Phronima* sp. in each treatment is presented in Figure 4.8. Descriptively, the average value of the population growth rate shows that the average is 823 ± 57.49% - 897.67 ± 27.35%.

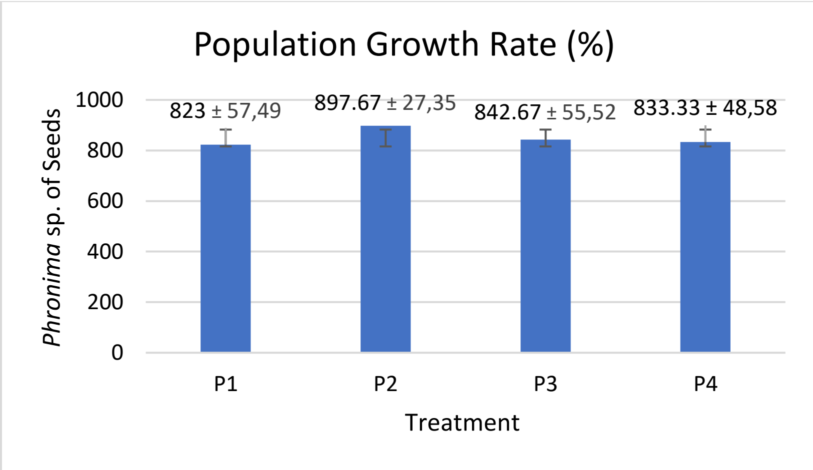

Figure 8. The Average Value of the Population Growth Rate During 21 Days of Maintenance

Based on the results of the ANOVA test, the treatment showed that there was no significant effect on the value of the population growth rate in *Phronima* sp. seeds, with a significance value of 0.467 ($P > 0.05$). This indicates that the average absolute weight values for the observed treatments are relatively similar. Therefore, no further testing was conducted.

Water Quality Parameters

The measured water quality parameters, namely temperature, pH, DO (Dissolved Oxygen), and salinity, showed values that were in a fairly similar range between the four treatments. The temperature is in the range of 26.5 – 29.6°C, pH at 8.25 – 8.5, and DO at 5.52 – 6.68 mg/L. This uniformity of water quality values indicates that the difference in the frequency of salinity decrease does not significantly affect the condition of the cultivation medium in which *Phronima* sp. is kept.

Table 2. Standard Water Quality Parameters

Parameter	Treatment				Optimum Range	Literature
	P1	P2	P3	P4		
Temperature (°C)	26.7 – 29.5	26.5 - 29.1	27 - 29.2	27 – 29.6	27 - 31	Fattah *et al*. (2014)
pH	8.27 - 8.5	8.25 - 8.5	8.26 - 8.4	8.27 – 8.5	7.8 – 8.2	Laramore *et al*. (2025)
DO (mg/L)	5.78 - 6.68	5.75 - 6.67	5.52 - 6.68	5.77 - 6.66	> 4	Wahyuni *et al*. (2022)
Salinity (ppt)	35	35	35	35	35	Yusuf *et al*. (2026)

DISCUSSION

Absolute Weight Growth of Broodstock

The frequency of salinity reduces from 35–0 ppt had no significant effect on the absolute weight growth of *Phronima* sp. ($P > 0.05$). The highest value obtained in the P2 treatment was 2.06 ± 1.31 g. This shows that *Phronima* sp. able to adapt to changes in salinity through osmoregulatory mechanisms in maintaining the balance of body fluids and ions. Amphipods have the ability to regulate the movement of air and ions through physiological mechanisms so that they are still able to maintain metabolism and growth in changing environmental conditions (Morritt, 1988).

Absolute Weight Growth of Seeds

Absolute weight growth of *Phronima* sp. also showed no significant effect on salinity reduction treatment (P > 0.05), with the highest value at P2 of 2.04 ± 0.29 g. This growth is supported by the feeding of Feng Li which has a high protein content so that it can support tissue formation and the molting process. The optimal nutritional content of feed can increase the efficiency of energy utilization for the growth of aquatic organisms (Ahmad & Aminin, 2025). In addition, the ability of amphipods to survive changes in salinity is related to an effective osmoregulatory mechanism in maintaining the body's physiological balance (Lowry & Myers, 2017).

Absolute Growth Length of Broodstock

The results showed that the frequency of salinity decrease did not have a significant effect on the absolute length of *Phronima* sp. (P > 0.05). The highest length value obtained in the P1 treatment was 6.7 ± 0.74 mm. Length growth is influenced by environmental conditions, nutrient availability, and molting processes that play a role in increasing the body size of crustaceans. Yusuf *et al*. (2020) stated that the growth of *Phronima* sp. It is characterized by a change in body size from the juvenile to adult phase through the process of skin change.

Absolute Growth Length of Seeds

The absolute length of the seeds *Phronima* sp. nor did it show any real effect due to salinity reduction treatment. The highest value obtained in the P4 treatment was 4.0 ± 0.11 mm. This condition is thought to be related to the availability of proteins in Feng Li feed that support the formation of new tissues after the molting process. Protein content which can adequately increase energy utilization for the growth and development of crustacean organisms (Nguyen *et al*., 2014).

Specific Growth Rate (SGR) of Broodstock

The Specific Growth Rate (SGR) value of *Phronima* sp. did not show any significant effect due to salinity reduction treatment (P > 0.05). The highest SGR value was obtained in P2 of 8.28 ± 2.13%/day. This shows that the variation in the frequency of salinity decrease has not been a growth inhibition factor because all treatments are still within the range of physiological tolerance of *Phronima* sp. The SGR value describes the ability of an organism to utilize feed nutrients into body biomass during the maintenance period (Islam *et al*., 2023).

Specific Growth Rate (SGR) of Seeds

SGR seeds *Phronima* sp. also showed no real effect between treatments (P > 0.05), with the highest value at P2 of 6.39 ± 0.65%/day. This condition shows that *Phronima* sp. able to adapt to changes in salinity through osmoregulation mechanisms. The ability to tolerate salinity changes allows energy to remain allocated for growth as osmotic pressure is still within the organism's controllable limits (Nailulmuna *et al*., 2020).

Population Growth Rate of Broodstock

The growth rate of the broodstock population of *Phronima* sp. did not show a significant effect on salinity reduction treatment (P > 0.05). The highest score obtained in the P2 treatment was 245.67 ± 30.74%. This condition is supported by stable air quality and the availability of sufficient nutrients to support the reproductive process. The reproductive system of amphipods is ovoviviparous, that is, eggs develop in marsupiums until they become juveniles. Reproductive success is influenced by the physiological conditions of the parent and the availability of nutrients (Hyne, 2011).

Population Growth Rate of Seeds

Population growth of *Phronima* sp. not did it show a significant effect between treatments (P > 0.05). The highest score obtained in P2 was 897.67 ± 27.35%. This condition is influenced by the relatively stable air quality and the feeding of Feng Li which has a high protein content to support juvenile growth. The protein content in feed plays a role in tissue formation and increased growth of aquatic organisms (Aji *et al*., 2020). In addition, *Phronima* sp. has a relatively fast life cycle so that it is able to increase the population in a short maintenance time (Yusuf *et al*., 2020).

Water Quality Parameters

The water quality parameters during the study were within the range that supported the maintenance of *Phronima* sp. The temperature ranges from 26.5–29.6°C, pH 8.25–8.5, and DO 5.52–6.68 mg/L. These conditions show that changes in the frequency of salinity decrease do not cause changes in air quality that can inhibit the growth of organisms. Temperature plays a role in regulating the metabolism and physiological activity of aquatic organisms. The temperature range of the study is still in accordance with the optimal conditions for the maintenance of *Phronima* sp. which is around 27–31°C (Fattah *et al*., 2014). The pH value during the study was also still within the tolerance limits of crustaceans so that the metabolic process could take place properly (Laramore *et al*., 2025). The dissolved oxygen content above 4 mg/L indicates that the maintenance media conditions still support respiration and physiological activity of *Phronima* sp. (Erlangga, 2012).

CONCLUSION

The frequency of salinity decrease does not have a real effect on the growth of *Phronima* sp. on the parameters of absolute weight, absolute length, SGR, and population growth rate (P>0.05). The P2 treatment with a salinity decreases of 5 ppt every 2 days showed the highest growth value descriptively, but did not differ significantly from the other treatments. The air quality conditions during the study still supported the growth of *Phronima* sp. with a temperature range of 26.5–29.6°C, pH 8.25–8.5, and DO 5.52–6.68 mg/L. This shows that *Phronima* sp. able to adapt to changes in salinity through osmoregulatory mechanisms.

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