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PERTUMBUHAN DAN KELANGSUNGAN HIDUP AMPHIPODA (*Phronima* sp.) PADA KULTUR SALINITAS RENDAH DENGAN VARIASI TINGKAT SALINITAS

Growth and Survival of Amphipods (*Phronima* sp.) Cultured Under Low-Salinity Conditions with Different Salinity Levels

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ABSTRAK

Penelitian ini bertujuan untuk mengetahui pengaruh variasi salinitas terhadap pertumbuhan dan kelangsungan hidup Amphipoda (*Phronima* sp.) pada kultur salinitas rendah serta menentukan salinitas yang paling optimal untuk pemeliharaan. Penelitian dilakukan menggunakan Rancangan Acak Lengkap (RAL) dengan empat perlakuan salinitas, yaitu 15 ppt, 10 ppt, 5 ppt, dan 0 ppt, masing-masing dengan empat ulangan. Parameter yang diamati meliputi jumlah telur, jumlah anakan, kepadatan populasi, *survival rate* (SR), uji proksimat, dan kualitas air. Hasil penelitian menunjukkan bahwa perbedaan salinitas berpengaruh nyata terhadap pertumbuhan dan kelangsungan hidup *Phronima* sp. Perlakuan 15 ppt memberikan hasil terbaik pada jumlah telur, jumlah anakan, kepadatan populasi, dan SR, sedangkan perlakuan 0 ppt menunjukkan hasil terendah pada sebagian besar parameter pengamatan. Nilai SR selama pemeliharaan berkisar antara 60,8–86,1%, dengan nilai tertinggi terdapat pada perlakuan 15 ppt. Hasil uji proksimat juga menunjukkan bahwa perlakuan 15 ppt menghasilkan kandungan protein dan lemak lebih tinggi dibandingkan perlakuan lainnya. Selama pemeliharaan, parameter kualitas air seperti suhu, pH, DO, nitrat, amonia, dan fosfat masih berada dalam kisaran yang mendukung pertumbuhan dan kelangsungan hidup organisme. Berdasarkan hasil tersebut, salinitas 15 ppt dapat dinyatakan sebagai kondisi paling optimal untuk kultur *Phronima* sp. pada salinitas rendah dan berpotensi dikembangkan sebagai pakan alami alternatif dalam budidaya perairan.

Kata Kunci: Kelangsungan Hidup, Pertumbuhan, *Phronima* sp., Salinitas

ABSTRACT

This study aimed to determine the effect of different salinity levels on the growth and survival rate of Amphipoda (*Phronima* sp.) cultured under low-salinity conditions and to identify the most optimal salinity level for cultivation. The study used a Completely Randomized Design (CRD) consisting of four salinity treatments, namely 15 ppt, 10 ppt, 5 ppt, and 0 ppt, with four replications each. Parameters observed included egg production, number of juveniles, population density, survival rate (SR), proximate analysis, and water quality. The results showed that salinity differences significantly affected the growth and survival of *Phronima* sp. The 15 ppt treatment produced the best results in terms of egg production, juvenile number, population density, and survival rate, while the 0 ppt treatment showed the lowest values for most observed parameters. The survival rate during the maintenance period ranged from 60.8% to 86.1%, with the highest value obtained at 15 ppt salinity. Proximate analysis also revealed that the 15 ppt treatment had higher protein and lipid contents compared to the other treatments. During the culture period, water quality parameters such as temperature, pH, dissolved oxygen, nitrate, ammonia, and phosphate remained within suitable ranges to support the growth and survival of the organisms. Based on the results, a salinity level of 15 ppt was considered the most optimal condition for culturing *Phronima* sp. under low-salinity conditions and has potential as an alternative natural feed source in aquaculture.

Key words: Growth, *Phronima* sp., Salinity, Survival Rate

INTRODUCTION

Marine amphipods are important organisms in aquatic ecosystems as part of the food chain and also have the potential to serve as natural food in aquaculture. Amphipod species, *Grandidierella bonnieroides*, *Grandidierella japonica*, and *Melita plumulosa*, are benthic amphipods that live in coastal and estuarine sediments and play a role in the ecology of the aquatic bottom. Meanwhile, *Phronima* sp. is a pelagic amphipod that lives in seawater and is an important part of the zooplankton community (Hamiyati *et al*., 2023). Amphipods serve as an alternative food source in aquaculture because they have high nutritional content, are easily digested, and support growth and survival (Jiménez-Prada *et al*., 2018).

Amphipods' ability to survive in relatively stable environments, such as salinity, significantly influences their growth and survival. Salinity and temperature are considered the most important factors influencing distribution, population structure, and ecological function. Adequate dissolved oxygen is essential to support metabolism, growth, and survival. A pH that is too acidic or alkaline can disrupt biological activity and reduce the body's resistance (Nailulmuna *et al*., 2020).

Phronima sp. can be used as an alternative natural feed or substitute for Artemia sp. Phronima sp. has a high nutritional content, a size suitable for the mouth openings of fish and shrimp, and is easy to cultivate on a large scale (Sulaiman *et al*., 2020). *Phronima* sp. has the potential to be used as a natural feed in pond cultivation systems because it plays a crucial role in maintaining the balance of aquatic ecosystems through the utilization of organic matter and suspended particles (Yusuf *et al*., 2020).

Research on low salinity in *Phronima* sp. cultivation is important to identify the organism's physiological tolerance limits to changes in osmotic pressure. Although naturally belonging to marine pelagic amphipods, conditions in cultivation systems often experience salinity variations due to environmental factors and water management, so information on the tolerable salinity range is essential. Salinity mismatches can trigger osmoregulatory stress, which impacts growth, activity, and survival rates. Furthermore, low salinity has the potential to increase cultivation efficiency through the use of brackish water, expanding potential locations for culture, and the ecophysiological adaptability of *Phronima* sp. to aquatic environments (Magouz *et al*., 2021). Therefore, research is needed to improve students' knowledge and skills in amphipod (*Phronima* sp.) culture, as well as to understand the growth and survival of amphipods (*Phronima* sp.).

METHODS

Time and Location

This research was conducted over 14 days from April to May 2026. The location was the Kurnaen Sumadiharga Science and Technology Area (KST) Laboratory, Marine Cultivation Research Center, Agriculture and Food Research Organization, National Research and Innovation Agency (BRIN), Pemenang, North Lombok.

Research Methods

The method used in this study is a Completely Randomized Design (CRD). Observed aspects include population growth, water quality, and the biology of *Phronima* sp., including egg and juvenile production per individu, and the life cycle from egg hatching to adulthood. This study consisted of four treatments and four replications, resulting in 16 experimental units.

Table 1. Treatments in the Study

No	Treatment	Salinity
1.	S1	15 ppt
2.	S3	10 ppt
3.	S4	5 ppt
4.	S5	0 ppt

Research Procedures

The study began with the preparation of the containers and rearing media. The containers used were clear plastic jars measuring 1000 ml for the adult *Phronima s*p. and 3000 ml for the larvae and juvenile *Phronima* sp. Before use, all containers were thoroughly washed and dried to prevent contamination. The rearing media consisted of seawater diluted with freshwater to reach the treatment salinities of 15 ppt, 10 ppt, 5 ppt, and 0 ppt. The *Phronima* sp. broodstock used were adult broodstock carrying eggs, approximately 3–5 mm in size, and were stocked at a density of one per container. The broodstock were sourced from the Gondol Center for Mariculture Research and Fisheries Extension, Bali. They were reared until all eggs hatched to determine egg and juvenile production. Newly hatched larvae were then carefully transferred using a plastic pipette to a 3000 ml rearing container at the treatment salinity until they reached adulthood.

The salinity reduction mechanism was carried out directly until it reached the predetermined treatment salinity, namely 15 ppt, 10 ppt, 5 ppt, and 0 ppt. This method was implemented by considering the adaptability of *Phronima* sp. to changes in salinity so as to minimize physiological disturbances and maintain the survival of the organism during maintenance. During the study, the feed provided was in the form of powdered shrimp pellets size 0 with a dose of ±0.01 grams per container with a capacity of 3000 ml and was given once a day. Feeding was carried out carefully so as not to be excessive and still be able to be optimally utilized by the organism. The powdered feed form was chosen because it is easier to consume and digest by small organisms such as *Phronima* sp.

Research Parameters

a) Number of Eggs per Broodstock

The number of eggs laid by the female broodstock in a 1000 ml plastic jar was observed. Eggs were counted after they hatched into larvae and developed to the adult stage. They were then carefully separated using a plastic pipette or small spoon into an observation container to avoid stress. To count the eggs, the broodstock was observed under a stereomicroscope or magnifying glass, ensuring that eggs attached to the ventral body were clearly visible. All observed eggs were counted and recorded as the number of eggs per broodstock in each treatment.

b) Number of Offspring Produced

Observations on the number of offspring were conducted after the eggs hatched. The hatching container was observed daily to detect the hatching process. Hatched offspring were counted directly using a visual counting method using a pipette and a small observation container. The number of offspring produced was recorded as the total number of individuals hatched from a single female parent. Counting was carried out carefully to minimize errors and stress on the organisms.

c) Population Density Calculation

Population density is the level of abundance of organisms in a culture vessel, used to assess research success and growth. According to Yusuf *et al.* (2020), population density can be calculated using the following formula:

$$Population\ Density = \frac{Total\ Individuals}{Volume} = \left(\frac{Ind}{Vol}\right)$$

where:

Total of individuals	: Total *Phronima* sp. in the culture container
Volume	: Volume of maintenance media (L)
Ind/Vol	: Density unit (ind/L)

d) Survival Rate (SR)

The survival rate (SR) is the survival rate from the start of stocking to the end of cultivation. According to Bahri *et al.*, 2023, the survival rate can be calculated using the following formula:

$$SR\ (\%) = \frac{Nt}{N0} x\ 100\%$$

where:

SR	: Survival rate (%)
Nt	: Number of *Phronima* sp. living at the end of maintenance
N0	: Number of *Phronima* sp. at the beginning of maintenance

e) Proximate Testing

Proximate testing is conducted to determine the nutritional content of *Phronima* sp. Proximate analysis is a method used to identify the nutritional content of feed or food ingredients. Proximate analysis groups feed components based on their chemical composition and function. The methods used in proximate analysis are the Kjeldhal method for protein testing, the Soxhlet method for fat testing, the oven method for water content testing, and the dry ashing method for ash content testing (Iskandar & Fitriadi, 2017).

f) Water Quality

Water quality parameters, including temperature, salinity, and pH, are measured daily to ensure the stability of the *Phronima* sp. culture medium. DO, ammonia, nitrate, and phosphate levels are measured weekly.

Data Analysis

The research data were analyzed using ANOVA with SPSS 16 at a 95% significance level. Prior to the ANOVA, normality and homogeneity tests were performed with the requirement (P>0.05). If the ANOVA results showed a significant difference (P<0.05), Duncan's test was performed.

RESULT

***Phronima* sp. Egg Count**

The results showed that the number of eggs in each treatment ranged from 10.4 to 12. The highest number of eggs was found in treatment S1, while the lowest was found in treatment S4. A graph of the number of eggs produced is presented in Figure 1.

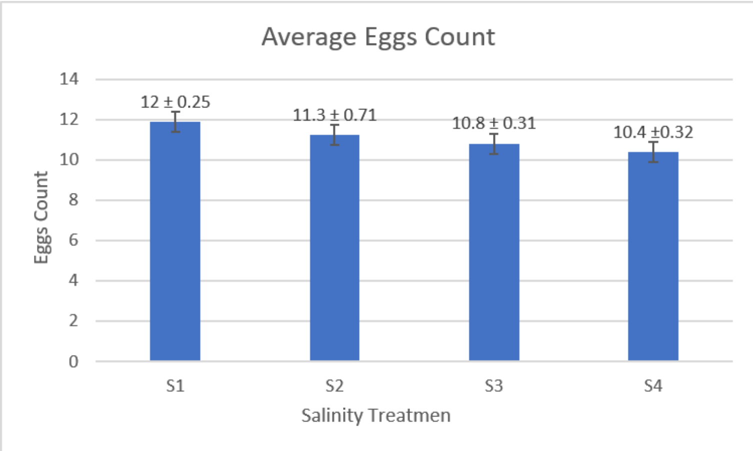

Figure 1. Number of *Phronima* sp. Eggs.

Number of *Phronima* sp. Offspring

The results showed that the number of offspring in each treatment ranged from 7.3 to 14.5. The highest number of offspring was found in treatment S1, while the lowest was found in treatment S4. The average number of Phronima sp. offspring that successfully hatched from the egg stage is shown in Figure 2.

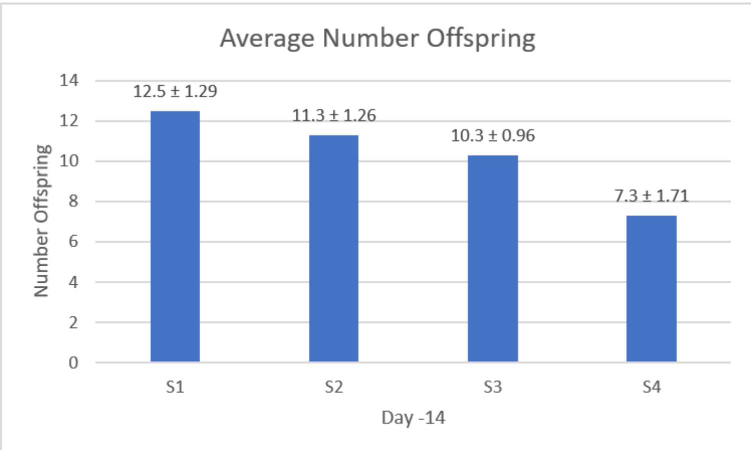

Figure 2. Number of *Phronima* sp. offspring.

Population Density of *Phronima* sp.

The results showed that the population density in each treatment ranged from 2.4 to 14.8 individuals/L. The highest number of offspring was found in treatment S1, while the lowest was found in treatment S4. The population density graph is shown in Figure 3.

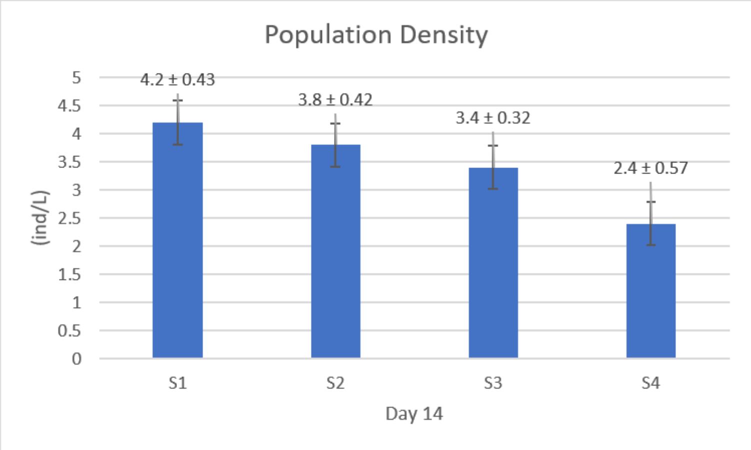

Figure 3. Population Density Graph of *Phronima* sp.

Survival Rate (SR)

The results of the study showed that the survival rate of Phronima sp. during 14 days of culture in each treatment ranged from 86.1 to 60.8%. The survival rate graph for Phronima sp. cultured at low salinity is shown in Figure 4.

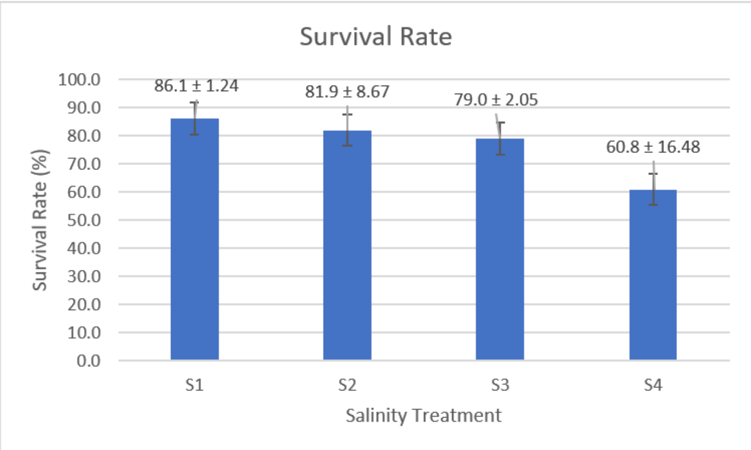

Figure 4. Survival Rate Graph of *Phronima* sp

Proximate Test

The proximate test results indicate that the sample contains nutrients in the form of moisture, ash, protein, fat, carbohydrate, and fiber. The test results are presented in Table 2.

Table 2. Proximate Test of *Phronima* sp

Treatment	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Fiber (%)
S1	79.67	5.12	7.55	1.34	6.32	5.40
S2	81.52	5.19	6.58	0.86	5.86	6.61
S3	81.22	4.88	6.20	0.96	6.74	4.99
S4	81.28	6.09	4.92	0.64	7.07	3.54

The test results showed that there were differences in nutritional content in each treatment. These differences may be influenced by the treatment given, thus affecting the nutritional composition of the sample. This difference in nutritional content may be related to the organism's ability to utilize nutrients during maintenance.

Water Quality

The results of water quality observations, including temperature, pH, DO, phosphate, nitrate, and ammonia, over 14 days, are shown in Table 3.

Table 3. Water Quality Parameters

Treatment	Temperature (°C)	pH	DO (mg/L)	Phosphat (mg/L)	Nitrate (mg/L)	Ammonia (mg/L)
S1	26-29	8.27-8.71	4,5-5	1-5	10	0.3-0.5
S2	27-29	8.14-8.77	4,3-4	0.5-2	7-10	0.4
S3	27-28	8.23-8.86	4-5	0.8-1	5-8	0.2-0.5
S4	27-29	8.53-8.88	4	2-5	8-10	0.3-0.4
Reference	26-29°C (Laramore & Albright, 2025)	8.0-9.0 (Nailulmuna *et al.*, 2020)	4-5 (Yusuf *et al.*, 2020)	0,1-5 (Suprakto *et al.*, 2024)	<50 (Gunarto *et al.*, 2022)	<0,5 (Nazarudin *et al.*, 2025)

DISCUSSION

The analysis results showed that 15 ppt salinity produced the highest number of eggs compared to other treatments. The high number of eggs at a salinity of 15 ppt is because environmental conditions are still in the optimal range for the reproduction process of *Phronima* sp. At appropriate salinity, the osmoregulation process takes place better so that the energy possessed by the organism can be utilized for gonad formation and egg production. With low salinity, namely 5 ppt and 0 ppt, the number of eggs produced is lower because organisms need more energy to adjust the balance of body fluids to an environment with low salt levels. The energy that should be used for reproduction is reduced so that egg production decreases. The 10 ppt treatment which was not significantly different from 15 ppt showed that *Phronima* sp. still able to adapt to the medium salinity range, although the best results are still obtained at 15 ppt. According to Nailulmuna *et al.*, (2020) who stated that salinity affects the growth and reproduction of *Phronima* sp., and supported by Sainte-Marie, (2021) who explained that salinity can influence reproductive success and the number of eggs in amphipods.

The results of the study showed that salinity treatment significantly affected the number of *Phronima* sp. offspring. Treatment S1 produced the highest number of offspring compared to other treatments, while treatment S4 produced the lowest number of offspring. The decrease in the number of offspring from day 2 to day 14 was caused by the offspring's ability to adapt to the rearing environment and the increased energy requirements during growth. At low salinities such as S3 and S4, organisms require more energy for the osmoregulation process so that the offspring's survival rate decreases. The number of offspring that survived was less than in treatment S1. According to Maranhão & Marques (2003) who stated that changes in salinity can affect larval development, growth, and survival of crustaceans because they are closely related to the organism's physiological processes. In addition, Torres *et al.*, (2011) also stated that larvae reared at inappropriate salinities will experience osmotic stress so that their growth and endurance decrease.

The high density at 15 ppt salinity indicates that these conditions are more optimal for supporting the growth and survival of organisms. The low density at low salinity occurs because organisms experience environmental stress due to excessively large differences in osmotic pressure. This condition causes more energy to be used to maintain body balance than for growth and reproduction. According to McLusky (1968), salinity is a major environmental factor influencing the distribution, growth, and density of estuarine organisms, including amphipods.

The results of the study showed that salinity treatment significantly affected the SR value of *Phronima* sp. Treatment S1 produced the highest SR value of 86.1%, while treatment S4 showed the lowest value of 60.8%. The high SR value in treatment S1 indicates that a salinity of 15 ppt is more optimal in supporting the survival of *Phronima* sp. The low SR value in treatment S4 was caused by salinity that was too low so that the organism required more energy to adjust the body's fluid balance. The energy used to maintain survival was reduced. Yusuf *et al*., (2020) stated that suitable environmental conditions can support the growth and life performance of *Phronima* sp. In addition, Hattah *et al*., (2019) explained that a high value of 95% indicates that *Phronima* sp. has good survival ability during the maintenance process. A high SR value also indicates that *Phronima* sp. has the potential as a natural food organism in fisheries cultivation.

The proximate test results showed that each treatment produced different nutritional content. Treatment S1 had the highest protein and fat content, at 7.55% and 1.34%, respectively, while treatment S4 showed the lowest protein and fat content, at 4.92% and 0.64%. This difference indicates that the treatment given affected the nutritional composition of the sample. Protein and fat play an important role in supporting growth and providing energy for organisms. According to Herawati *et al*., (2021), the low proximate value in this study can be influenced by the type of feed, the quality of the rearing media, salinity, and the high water content in the sample. The higher the water content, the lower the measured proximate value percentage on a wet basis.

Based on the results of observations over 14 days, *Phronima* sp. ranged between 26-29°C, the temperature range obtained was included in the optimal temperature for the growth and survival of *Phronima* sp. According to Laramore & Albright, (2025) who stated that the optimal temperature for zooplankton maintenance is in the range of 26-29°C. In addition, Herawati *et al*., (2020) also stated that *Phronima* sp. culture in this range can improve growth and nutritional quality.

pH is a water quality parameter that affects an organism's metabolism. The pH value during *Phronima* sp. maintenance ranged from 8.14 to 8.88, which is still within the optimal range to support the life of *Phronima* sp. According to Nailulmuna *et al*., (2020), the optimal pH value for good growth and survival of *Phronima* sp. is 8.0 to 9.0. A good pH can support the growth and nutritional quality of *Phronima* sp.

DO value during maintenance of *Phronima* sp. ranging between 4-5 mg/L which was found to be still in the optimal range to support the life of *Phronima* sp. A stable DO condition indicates that the maintenance media still has good water quality. According to Mulyani *et al*., (2023) who stated that good water quality is able to support the growth and survival of *Phronima* sp. Apart from that, Nailulmuna *et al*., (2020) also stated that the optimal DO for the growth of *Phronima* sp. namely 4-5 mg/L.

The results of the research carried out showed that the ammonia obtained during maintenance was between 0.2-0.5, which was still within the optimal range to support the growth and survival of *Phronima* sp. during maintenance. According to Fatah *et al*. (2014) who stated that environmental quality greatly influences the growth of *Phronima* sp. Ammonia is optimal for the growth and survival of *Phronima* sp. i.e. <0.5.

Nitrate is the conversion of ammonia to nitrite and then to nitrate by nitrifying bacteria. The presence of nitrate in water is generally influenced by leftover feed, feces, and other organic materials that decompose during maintenance. The results of the research conducted that the nitrate obtained during maintenance ranged between 5-10 mg/L, which is still within the optimal range to support the growth and survival of *Phronima* sp. during maintenance. According to Gunarto *et al*. (2022) who stated that a good nitrate concentration for aquatic organisms is in the range of <50 mg/L and still supports physiological processes and growth. In addition, Effendi (2003) also stated that nitrate is an important nutrient for water, but if the amount is excessive it can trigger a decline in the quality of the aquatic environment. The nitrate value in this study indicates that the maintenance medium is still in a suitable condition to support the life of *Phronima* sp.

Phosphate is an essential nutrient that plays a vital role in the metabolic process, energy production, and growth of *Phronima* sp. The phosphate levels obtained during *Phronima* sp. maintenance, i.e., 1-5 mg/L, are within the optimal range to support the growth and survival of *Phronima* sp. According to Rahmawati *et al*. (2021), optimal phosphate levels for culture activities range from 0.1–5 mg/L and still support the life of aquatic organisms. Furthermore, Effendi (2003) stated that phosphate is an important water quality parameter because it influences aquatic productivity. The phosphate values in this study were within the optimal range and were sufficient to support the growth and survival of *Phronima* sp.

CONCLUSION

Salinity differences affect the growth and survival of *Phronima* sp. in low salinity cultures. The 15 ppt treatment gave the best results in terms of egg number, offspring number, population density, and survival rate, while the 0 ppt treatment showed the lowest results. Survival rates during the study ranged from 60.8–86.1%, with the highest value obtained in the 15 ppt treatment. Proximate test results also showed that the 15 ppt treatment had higher protein and fat content than the other treatments. A salinity of 15 ppt was the most optimal condition for *Phronima* sp. culture.

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