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SHORT COMMUNICATION

Simultaneous impacts of salinity and temperature on the survival, growth and metamorphosis of yellowtail clownfish (*Amphiprion clarkii*) during larviculture

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Abstract Salinity and temperature are essential abiotic factors that have a significant impact on the survival and growth of marine aquatic organisms, especially fish larvae. The aim of this research was to evaluate the combined effects of different salinities (20‰ and 30‰) and temperatures (26°C and 30°C) on the survival, growth, and metamorphosis of yellowtail clownfish (*Amphiprion clarkii*) larvae. A total of 1,008 newly hatched larvae from one spawning were divided into four treatments in a 2×2 factorial design, with salinities of 20‰ and 30‰ and temperatures of 26 °C and 30 °C. Each treatment had six replicates, and the experiment lasted for 17 days. The interaction between salinity and temperature had a significant impact ($p < 0.05$) on the average daily growth, which was significantly higher (0.39 ± 0.08 mm/day) in the 30‰-30 °C treatment, compared with the 30‰-26 °C (0.29 ± 0.06 mm/day) and 20‰-26 °C (0.34 ± 0.07 mm/day) treatments, however it did not differ from the 20‰-30 °C treatment (0.38 ± 0.08 mm/day). Survival, total length, weight, weight gain, and metamorphosis were not affected by the interaction of the factors. In isolation, the salinity factor significantly affected ($p < 0.05$) larval growth. Total length and weight were significantly higher ($p < 0.05$) at 20‰ compared to 30‰ salinity. Salinity had no significant effect on metamorphosis parameters. Larval development was significantly improved at 30 °C, leading to a faster development rate, earlier onset of metamorphosis (8.8 days after hatching - DAH), and shorter larval duration (12.7 DAH) compared to 26 °C. In conclusion, the most suitable conditions for yellowtail clownfish larviculture are 20‰ salinity and 30 °C temperature.

Keywords Aquaculture . Abiotic factors . Environmental stress . Ornamental fish farming

Introduction

Reef fish are highly sought after by aquarists and hobbyists worldwide, and the cultivation of ornamental marine fish can help alleviate pressure on wild populations by providing a sustainable supply of fish for display in aquaria (Moorhead and Zeng 2010; Calado et al. 2017; Pouil et al. 2020). To ensure the success of this practice, it is important to understand how environmental changes affect fish physiology during the early stages of life (Agarwal et al. 2024). For example, abrupt changes in temperature can have severe negative effects on reef fishes, which rely on ambient temperature to regulate their physiological functions as ectothermic organisms (McCosker et al. 2022). Similarly, salinity plays a crucial role in the survival

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and physiological balance of reef fishes, as they require a consistent salinity level to maintain their vital functions and homeostasis. Abrupt changes in salinity can impact larval survival and ultimately jeopardise population sustainability (Coles and Jokiel 2018; McCosker et al. 2022). Therefore, sudden fluctuations in temperature and salinity can be detrimental to animals, hindering their ability to adapt. Gradual changes are preferable, as these allow sufficient time for adjustment and adaptation to new environments (Owatari et al. 2023).

Abiotic factors such as salinity and temperature can affect various aspects of fish larvae, including food intake, energy balance, feed conversion, oxygen consumption, behaviour, and swimming (Agarwal et al. 2024). The interaction between salinity and temperature may either enhance or diminish the individual effects of these factors on the growth and survival of fish larvae (Boeuf and Payan 2001; Agarwal et al. 2024), such as the yellowtail clownfish (*Amphiprion clarkii*). Therefore, optimal combinations of temperature and salinity levels could potentially increase aquaculture production of yellowtail clownfish. Moreover, the ability to rear fish at lower salinities may be advantageous for hatcheries located far from the coast, reducing costs associated with artificial seawater (Carneiro et al. 2024).

The yellowtail clownfish, also known as an anemonefish, is a popular species in the ornamental pet fish trade and can be found in coral reefs (Olivotto and Geffroy 2017; Pouil et al. 2020). Although this species has been successfully bred commercially since the 1950s, there have been limited studies on the specific impacts of salinity and temperature on larval rearing (Green and Fisher 2004; Ye et al. 2011; Ghosh et al. 2011; Ghosh et al. 2012), whilst the combined effects of different temperatures and salinities remain unknown.

This study aimed to explore how the optimal temperatures and salinities, identified in previous research, could be combined to improve the larval rearing of yellowtail clownfish.

Materials and methods

Broodstock maintenance

A pair of clownfish (*A. clarkii*) was maintained in a net cage (1.0 × 1.0 × 1.0 m) submerged within a rectangular tank with a capacity of 8,000 L at the Laboratory of Fish and Marine Ornamentals (LAPOM). The breeders were maintained in a continuous, open-flow seawater system with a temperature range of 25-27 °C and salinity of 33-35‰. The fish were fed three times daily until apparent satiation, with a diet consisting of marine ornamental fish food (Tetra Marine®, Germany) and a prepared frozen mix of fresh oysters, mussels, squid, marine fish, and shrimp. A clay pot was placed inside the net cage to serve as a shelter for the pair and for egg laying. The male incubated the fertilised eggs for seven days, after which the pot containing the eggs was removed and placed in a 30-L plastic box. After two hours in darkness, the eggs hatched. The water temperature and salinity in the hatching tank were maintained at 26 °C and 25‰, respectively, based on successful hatching in preliminary tests.

Experimental design

The experimental design was randomised, with treatments arranged in a 2 × 2 factorial scheme (salinity × temperature) to investigate the combined effects of 20‰ and 30‰ salinities with temperatures of 26 °C and 30 °C, resulting in four treatments (20‰–26 °C, 20‰–30 °C, 30‰–26 °C, and 30‰–30 °C), each with six replicates. As a salinity of 30‰ and a temperature of 26 °C are commonly used in marine ornamental fish larviculture, this treatment also served as the control group.

A total of 1,024 newly hatched larvae (0 days after hatching - DAH) from a single spawning were utilised. Sixteen larvae were initially sampled (see section on sampling and evaluated parameters). The remaining larvae were distributed into 24 experimental units, each consisting of 2.5-L cylindrical glass containers, with 42 larvae per unit. The experimental units were equipped with gentle aeration and placed in a water bath inside dark PVC boxes to reduce light reflections on the sides and bottom, as well as to enhance the contrast of live prey (Wittenrich 2007).

Following larval transfer, the water temperature in the experimental units was increased at a rate of 0.5

°C per hour until the desired temperature for the study was reached. The temperatures of 26 °C and 30 °C were maintained using thermostat heaters (MT 511Ri Full Gauge, Brazil, with 0.01 °C accuracy). Salinity adjustments were made on the first day after hatching. To achieve this, partial water changes (25%) were carried out every two hours until the desired experimental salinities (20‰ and 30‰) were attained.

To maintain water quality in the experimental units, approximately 30% of the water volume in each unit was replaced with clean water at the same temperature and salinity as the treatments. The water renewal rate was increased every two days until reaching 100% at the end of the experiment. Light intensity was maintained at 2,000 lux, with a photoperiod of 16 h of light.

Temperature was monitored daily, and salinities were measured using a refractometer (Instrutherm®, RTS-101 ATC, Brazil) with 1‰ accuracy. Non-ionised ammonia, nitrite, and pH levels were checked every three days, using colourimetric kits (Toxic ammonia – Saltwater, Labcon Test, Alcon®, Brazil), until the end of the experimental period. On the day of larval transfer (0 DAH), water quality indicators showed a pH 8.0, with non-ionised ammonia and nitrite concentrations of 0.0 mg/L. Throughout the experimental period, the pH remained at an average of 8.0 ± 0.1 across all treatments. Nitrite levels ranged from 0.1 to 0.3 mg/L, and non-ionised ammonia levels ranged from 0 to 0.06 mg/L across treatments. The end of the experimental period was determined when 70% of the larvae completed metamorphosis in each experimental unit. This percentage was chosen based on preliminary tests, which indicated that 70% of the animals metamorphosed almost simultaneously, whilst the remaining 30% took longer to reach metamorphosis. Therefore, the duration of the experimental period varied among the tested treatments. The onset of the metamorphosis process is recognisable when the larvae's pigmentation darkens, ranging from brown to black, with the appearance of the first white band. Complete metamorphosis was defined when the larvae transitioned into the juvenile phase, characterised by the pigmentation of three white bands and blackish body pigmentation.

Larval Feeding

Clownfish larvae were reared in clean water without microalgae and were initially fed *Brachionus* sp. rotifers (10-20 ind/mL) until the 8th DAH. From the 6th DAH onwards, brine shrimp nauplii (*Artemia* sp.) were introduced at a density of 2-5 ind/mL alongside the rotifers. From the 8th to the 12th DAH, in addition to the *Artemia* sp. nauplii, metanauplii enriched with fatty acids (Easy Selco® - Inve Aquaculture, Belgium) were provided at a 1:1 ratio of nauplii to metanauplii (2-5 ind/mL).

On the 10th DAH, a weaning diet for marine fish (Otohime Fish Diet®, 250 µm, Japan) was provided at 7% of the fish biomass, divided into four daily portions, together with enriched *Artemia* sp. nauplii and metanauplii. From the 13th DAH until the end of the experiment, only enriched metanauplii and an inert diet were offered. This feeding regime was consistent across all treatments, irrespective of larval size.

Live feed residues were counted each morning in every experimental unit and replenished as required to maintain the specified density. Daily live feed counts were conducted prior to water changes to estimate larval consumption. Rotifers were supplied at a density of 10 ind/mL in the morning, with the remaining amount to reach 20 ind/mL provided in the afternoon based on the residual count. Brine shrimp were supplied at a density of 1 ind/mL in the morning, with the remaining amount given in the afternoon to reach 5 ind/mL, according to the residual count (Figure 1).

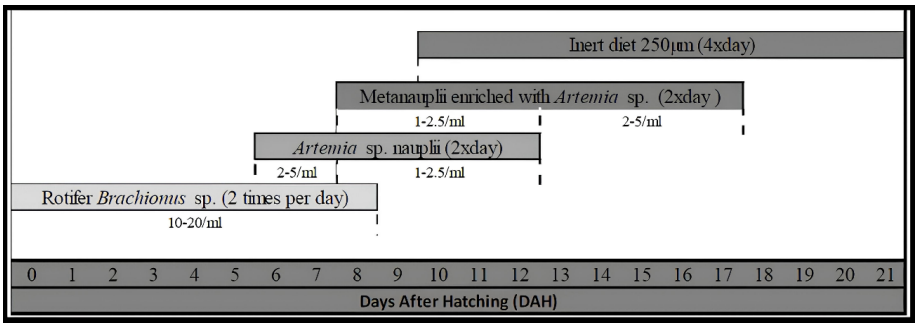


Fig. 1 Feeding management of yellowtail clownfish (*Amphiprion clarkii*) during larviculture in different combinations of salinity and temperature.

Sampling and parameters evaluated

On day 0 (0 DAH), sixteen newly hatched larvae were sampled. Newly hatched larvae had a mean total length of 4.4 ± 0.3 mm and weighed 0.7 ± 0.0 mg. At the conclusion of the experiment, shortly after metamorphosis, one hundred and twenty specimens (five juveniles from each experimental unit) were randomly collected to measure total length (mm) and wet weight (mg). A stereoscopic microscope (Olympus SZ40 - 0.01 mm, Japan) and a precision balance (Shimadzu AUW220D - 0.00001 g, Japan) were utilised for measurements. All samples were preserved in 5% formalin prior to measurement. The daily count of dead larvae was recorded to determine the survival rate using the following equation:

$$S\ (\%) = 100\ x\ (Ni\ -\ Nd)/Ni \quad (1)$$

where Ni is the initial number of newly hatched larvae, Nd is the number of larvae that died during the experiment.

For growth parameters, the following indicators were analysed:

$$\text{Average daily Growth}\ (mm/day)\ = (TLf\ -\ TLi)/t \quad (2)$$

where TLf is the final total length, TLi is the initial total length, and *t* represents the experimental duration for each treatment.

$$\text{Specific Growth Rate}\ (\%/day) = 100\ x\ [(\ln Wf) - (\ln Wi)]/t \quad (3)$$

where Wf is the final weight, Wi is the initial weight, t represents the experimental duration for each treatment.

$$\text{Weight Gain}\ (mg) = Wf\ -\ Wi \quad (4)$$

For metamorphosis evaluation, the following parameters were assessed:

Onset of metamorphosis (OM): day in which the first juvenile appeared at each treatment.
Pelagic larval duration (PLD): duration in days of the larval period at each treatment (metamorphosed larvae counted daily).

$$\text{Rate of development}\ \ (RD) = 1/D \quad (5)$$

where D represents the days of pelagic larvae duration at each experimental unit.

Statistical analysis

Normality and homoscedasticity were assessed using the Shapiro–Wilk and Cochran tests, respectively. Fish performance parameters were analysed with two-way ANOVA, with means compared by Tukey's test at a significance level of 5%. An arcsine transformation was applied to percentage data (survival rate and specific growth rate) prior to analysis. Statistical analysis was performed using Statistic software 10.0.

Results

The temperatures and salinities remained within the recommended experimental ranges. In the 20‰–26 °C treatment, the salinity and temperature were maintained at 20.0 ± 0.16‰ and 25.8 ± 0.21 °C, respectively. In the 20‰–30 °C treatment, the salinity and temperature were maintained at 19.8 ± 0.4‰ and 29.8 ± 0.3 °C, respectively. For the 30‰–26 °C treatment, the salinity and temperature were maintained at 30.0 ± 0.2‰ and 25.8 ± 0.2 °C, and in the 30‰–30 °C treatment, they were maintained at 29.8 ± 0.5‰ and 29.8 ± 0.3 °C, respectively.

There was a significant interaction ($p < 0.05$) between the factors. The average daily growth of yellowtail clownfish (*A. clarkii*) was significantly affected ($p < 0.006$) by the interaction of salinity and temperature. At 30‰ salinity, the average daily growth of yellowtail clownfish larvae was significantly higher ($p < 0.05$) in the 30 °C treatment compared to the 26 °C treatment. At 26 °C, the average daily growth was significantly higher ($p < 0.05$) at 20‰ salinity compared to 30‰ salinity (Figure 2).

The other larval growth parameters were not affected by the interaction of factors. However, it is note-

worthy that survival rates were high in all treatments (46% to 53%).

In isolation, salinity significantly affected the growth performance of yellowtail clownfish. The fish exhibited a significant increase ($p < 0.05$) in total length, final weight, and weight gain when exposed to the 20‰ salinity treatment compared to the 30‰ salinity treatment. However, the specific growth rate of the yellowtail clownfish was not significantly affected ($p > 0.05$) by salinity (Table 1 and Figure 3).

Conversely, in isolation, the different temperatures (26 °C or 30 °C) did not significantly affect ($p > 0.05$) the total length, final weight, and weight gain of yellowtail clownfish larvae. However, in the 30 °C treatments, the specific growth rate was significantly higher ($p < 0.05$) than in the 26 °C treatment (Table 1).

Salinity did not significantly affect ($p > 0.05$) the onset of metamorphosis, pelagic larval duration, or the rate of larval development. However, there was a significant delay ($p < 0.05$) of nearly two days in the

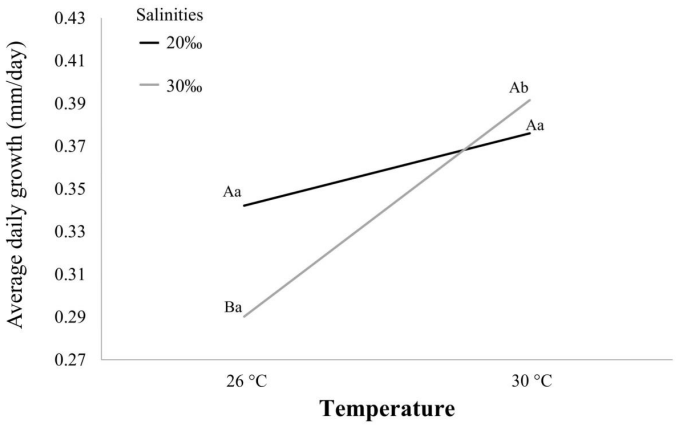


Fig. 2 Average daily growth (mm/day) of yellowtail clownfish larvae (*Amphiprion clarkii*) reared under different salinities (20‰ and 30‰) in combination with different temperatures (26 °C and 30 °C). Different lowercase letters indicate significant differences ($p < 0.05$) for the same salinity at different temperatures, and different capital letters indicate significant differences ($p < 0.05$) for the same temperature at different salinities.

Table 1 Growth performance (mean ± SD) of yellowtail clownfish larvae (*Amphiprion clarkii*) reared under different salinities (20‰ and 30‰) in combination with different temperatures (26 °C and 30 °C). Different lowercase letters in the same line indicate significant differences ($p < 0.05$) among treatments (salinity or temperature).

Parameters	Salinity (‰)		Temperature (°C)	
	20	30	26	30
Survival rate (%)	53.0 ± 13.0	46.4 ± 15.0	50.0 ± 17.4	49.0 ± 10.6
Weight gain (mg)	15.2 ± 5.7^{a}	12.3 ± 4.4^{b}	13.5 ± 5.2	14.0 ± 5.4
Specific growth rate (%/day)	19.3 ± 2.7	20.0 ± 3.3	17.9 ± 2.3^{b}	21.4 ± 2.6^{a}
Onset of metamorphosis (DAH)	9.5 ± 1.0	9.4 ± 1.3	10.2 ± 0.9^{a}	8.8 ± 0.9^{b}
Pelagic larval duration (day)	14.5 ± 1.6	13.8 ± 1.9	15.6 ± 0.7^{a}	12.7 ± 1.2^{b}
Rate of larval development	0.07 ± 0.01	0.07 ± 0.01	0.06 ± 0.003^{b}	0.08 ± 0.01^{a}

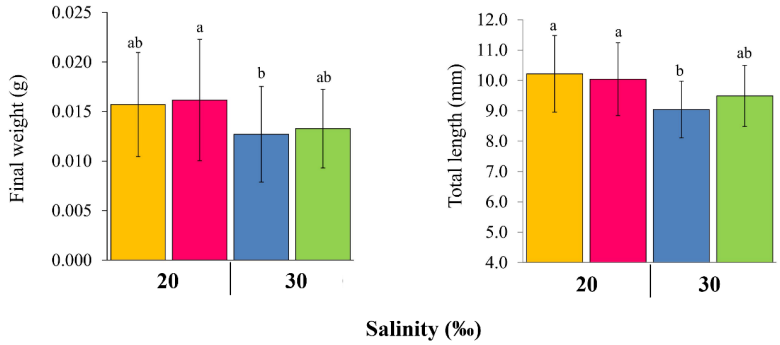


Fig. 3 Isolated effects of salinity on growth performance (mean ± SD) of yellowtail clownfish larvae (*Amphiprion clarkii*) reared under different temperatures 26 °C (orange and blue) and 30 °C (pink and green). Different lowercase letters in the same line indicate significant differences ($p < 0.05$) among treatments.

onset of metamorphosis for larvae kept at 26 °C compared to those at 30 °C. Additionally, the pelagic larval duration was significantly longer ($p < 0.05$) (by almost three days) at 26 °C than at 30 °C, whilst the rate of development was significantly faster ($p < 0.05$) at 30 °C (Figure 4 and Table 1).

Discussion

This study examined how different temperatures and salinities can affect the larviculture of yellowtail clownfish (*A. clarkii*). Prior to this study, there was no information available on how the combination of these two factors could impact the larval development of this species. These findings are valuable for aquaculture practices and for gaining insight into how variations in temperature and salinity may affect fish physiology in natural environments influenced by climate change.

The present study found that the survival rate of *A. clarkii* larvae was approximately 50%, consistent with previous research on clownfish (Olivotto et al. 2011; Ghosh et al. 2012; Olivotto et al. 2012; Olivotto and Geffroy 2017; Salleh et al. 2024). This survival rate is considered high for aquacultured marine fish (Tucker Jr 2012), particularly in this study, as it was assessed up to the completion of the larval stage. The highest mortality rates were observed during the first week of the experiment, especially on the third day after hatching, but these rates gradually declined until metamorphosis. This pattern is consistent with mortality rates (ranging from 10% to 20%) reported in the larviculture of clownfish species such as *Amphiprion akallopisos* (Dhaneesh et al. 2012a) and *Amphiprion percula* (Dhaneesh et al. 2009; Dhaneesh et al. 2012b), which may be attributed to the stress of tank transfer and the dietary shift from rotifers to *Artemia* sp. nauplii. The quality of live feed provided can influence larval survival, with *A. clarkii* potentially achieving higher survival rates (up to 90%) when fed copepods (Olivotto et al. 2008).

In the present study, the growth and development of clownfish (*A. clarkii*) larvae were found to be influenced by either salinity or temperature. Specifically, optimal total length, final weight, and weight gain were observed at a salinity of 20‰, with no significant impact from temperature. Some researchers suggest that higher salinities may lead to increased energy expenditure for osmoregulation, resulting in reduced growth (Boeuf and Payan 2001; Agarwal et al. 2024). After complete hatching, *A. clarkii* larvae (3.7–4.1 mm) reared at a salinity of 20‰ and a density of 33.33 larvae/L exhibited accelerated growth, reaching 11.3 mm in approximately 25 days (Ye et al. 2009). In the present study, 4.4 mm newly hatched larvae at a density

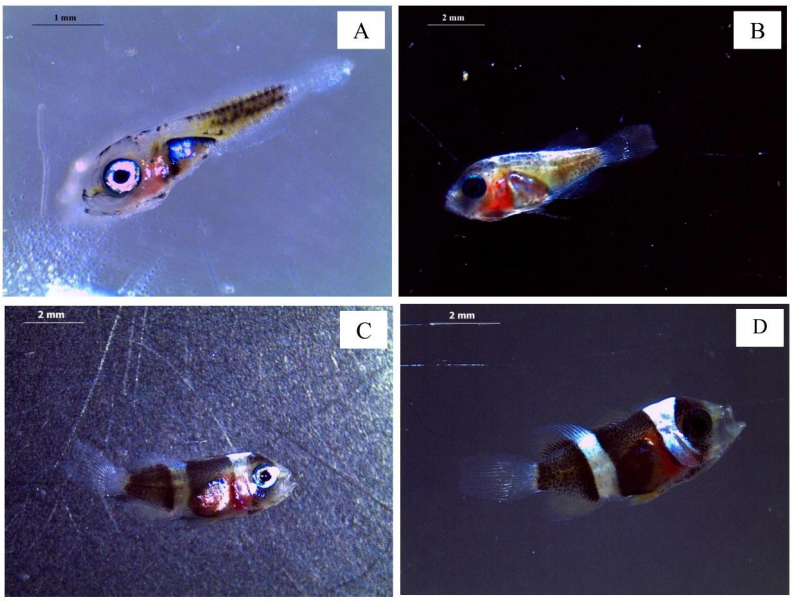


Fig. 4 Metamorphosis of yellowtail clownfish larvae (*Amphiprion clarkii*) reared under different salinities (20‰ and 30‰) in combination with different temperatures (26 °C and 30 °C). (A) Yellowtail clownfish larvae in the 26 °C treatment on the second day after hatching. (B) Yellowtail clownfish larvae showing the beginning of band appearance. (C) Final metamorphosis of yellowtail clownfish larvae in the 30 °C treatment with a silvery abdomen. At this stage, the larvae display behaviour of staying at the tank bottom, lying on their sides. (D) Yellowtail clownfish larvae in the 30 °C treatment showing complete metamorphosis, with normalised swimming typical of juveniles.

of 16.8 larvae/L, similar growth was achieved in just 14.5 days at the same salinity, which is 11 days faster. This highlights the significant impact of stocking density on larval development in our experimental setup.

Water salinity is an important environmental factor that can have a direct impact on the development of fish larvae, influencing aspects such as survival rate, growth, metabolism, and behaviour (Agarwal et al. 2024). Carneiro et al. (2024) conducted a study on the impact of various salinities (5, 15, 25, or 35‰) on the survival, growth, and oxidative stress responses of juvenile clownfish *A. ocellaris*. The results showed that rearing juvenile clownfish in water with a salinity of 15‰ did not affect growth or induce oxidative stress, which could potentially reduce the costs associated with water salinisation. In contrast to the present study, Carneiro et al. (2024) employed a constant temperature of 26.0 ± 1.0 °C throughout their research, which may have limited the insights into the effects of these interacting factors on the early developmental stages of clownfish.

Indeed, the growth rates of clownfish species can be affected by water temperature. Soman et al. (2021) demonstrated this by studying the impact of various temperatures (26, 27, 28, 29, or 30 °C) on the embryonic development of clownfish (*A. ocellaris*). They found that higher incubation temperatures, specifically 29 °C and 30 °C, led to a faster embryonic development rate, resulting in a shorter incubation period and increased hatching efficiency. Additionally, yolk volume decreased as temperature increased, with a significant reduction observed at 30 °C. Similarly, Rodríguez-Ibarra et al. (2024) observed that eggs incubated at different temperatures (26, 28, 30, 32, or 34 °C) exhibited slower growth at 26 °C and larger sizes at 34 °C. Larvae reared at 34 °C also had a higher incidence of malformations (lordosis), highlighting temperatures between 28 °C and 30 °C as optimal for *A. ocellaris*. These changes in embryonic development and yolk volume are likely influenced by temperature-induced alterations in the physiological performance of the fish (Agarwal et al. 2024). Similarly, in the current study, temperature was the sole factor influencing the onset of metamorphosis, pelagic larval duration, and fish development rate. Larval metamorphosis started earlier, and the pelagic larval duration was shorter at 30 °C. Therefore, *A. clarkii* larvae reared at 30 °C could begin metamorphosis up to seven days earlier compared to other *A. clarkii* larvae and up to 10 days earlier than larvae of other clownfish species reared under different temperature and salinity conditions (Table 2).

In the present study, a correlation was found between salinity and temperature in relation to daily growth rate. Lower salinity and higher temperatures resulted in faster growth rates. Fish maintained at 30 °C exhibited higher specific growth rates and larval development rates compared to those reared at 26 °C. This difference can be attributed to the shorter pelagic larval duration, as each treatment concluded at different times. The duration of the pelagic larval stage is crucial in ornamental fish farming, as it determines the time required to obtain juveniles suitable for commercial purposes. In the present investigation, this duration was defined as the point at which 70% of the fish in each treatment had completed metamorphosis. Con-

Table 2 Influence of different salinities (20‰ and 30‰) in combination with different temperatures (26 °C and 30 °C) on the larviculture of yellowtail clownfish larvae (*Amphiprion clarkii*). The data from the present research is provided for comparison with several other studies with the genus *Amphiprion*. (-) Not reported by authors or not clear in article. * Values tested and recommended by the authors. ** More than 70% of the larvae underwent metamorphosis. (-) Not reported by authors or not clear in article.

Species	Salinity (‰)	Temperature (°C)	Metamorphosis (DAH)	Pelagic larval duration (DAH)	Survival (%)	Key references
A. clarkii	20	26 - 30	9.5	14.5**	53.0	Present study
	30	26 - 30	9.4	13.8**	46.4	
	20 - 30	26	10.2	15.6**	50.0	
	20 - 30	30	8.8	12.7**	49.0	
A. clarkii	20 a 25	23	-	24.7**	~25	Ye et al. 2011
		26 *	-	16**	~60	
		29 *	-	11.3**	~70	
A. clarkii	10 and 15*	26 - 27.5	7 - 8	15 - 16	12.04 and 50.37	Ye et al. 2009
	20*and 25		8	17 - 19	~48.52	
	30 and 35		9	19 - 21	18.52 and 17.59	
A. clarkii	26*	-	15	25	53.67	Ghosh et al. (2012)
A. clarkii	30	28	12	13	90; 55; 62	Olivotto et al. (2008)
A. melanopus	-	25	-	12.3**	-	Green and Fisher (2004)
		28	-	9**	-	
A. ocellaris	32 to 35	24 - 28	9 - 10	15 - 17	95.0	Madhu et al. (2006)
A. ocellaris	30	28	9 - 12	-	58.0	Olivotto et al (2011)
A. sebae	26	28	15 - 17	20	68.2	Divya et al. (2011)
A. akallopisos	24 to 26	27	-	15 - 16	-	Dhaneesh et al. 2012a
A. percula	24*	27	-	13 - 15	65.5	Dhaneesh et al. 2012b
A. polymnus	30	26	-	8 - 10	58.0	Olivotto et al. (2012)

sequently, a three-day difference in pelagic larval duration was observed between the tested temperatures (12.7 days at 30 °C and 15.6 days at 26 °C). These results are likely primarily associated with fish metabolism, which is influenced by increasing temperatures. As ectothermic animals, fish have body temperatures that are governed by the surrounding water. Elevated temperatures can affect metabolic pathways, such as cellular respiration and energy metabolism, leading to changes in fish physiology, behaviour, and survival. Such effects may result in the degradation of structural and functional proteins, thereby impairing growth and immunity (Agarwal et al. 2024; Zhang et al. 2025).

The results of the study showed that survival rates were consistent across the different salinities and temperatures, remaining within the typical range reported for this species in previous studies. Adjusting the duration of larval rearing or implementing a low-salinity rearing strategy could help to reduce production costs, particularly those associated with live feed, or in marine ornamental fish farming using artificial seawater.

Conclusion

This study demonstrated that both salinity and temperature play crucial roles in the growth and development of yellow clownfish larvae. Although the interaction between salinity and temperature influenced daily growth, other parameters, such as survival, total length, weight, and metamorphosis, were not affected by this interaction. Salinity alone had a significant effect on growth, with greater length and weight observed at 20‰. A temperature of 30 °C accelerated larval development, resulting in a shorter time to metamorphosis. Therefore, to enhance the production of *A. clarkii* larvae, it is recommended that salinity be maintained at 20‰ and temperature at 30 °C in order to optimise larval growth and development.

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Ethical approval This study was conducted in accordance with the ethical principles established for research involving animals and was approved by the Federal University of Santa Catarina (UFSC), Brazil.

Data availability The data related to this research are available upon prior request.

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Competing interests The authors declare that there are no competing interests.

Declaration of generative AI and AI-assisted technologies in the writing process The authors used Grammar Labs for language editing to ensure the readability of the work. No AI tools were used for data analysis or interpretation.

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