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Effect of density on the growth of *Mesoheros festae* fry, with replacement technology

Efecto de la densidad en el crecimiento de alevines de *Mesoheros festae*, con tecnología de recambio

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ABSTRACT
In Ecuador, inland water fish farming is an activity of growing importance with great economic, social and environmental interest. It involves different productive sectors and native species. (Mesoheros *festae*), is a cichlid, found along the drainages of the Pacific, specifically from the Esmeraldas River in Ecuador, through the Guayas River, to the Tumbes River in Peru. The aim of the research was to determine the effect of density on the growth of fingerlings of Mesoheros *festae*, in replacement technology. The origin of the specimens belong to the fish farming staff of the Faculty of Livestock and Biological Sciences of the State Technical University of Quevedo, the initial average weight of the animals was 1.5 g. 16 circular cages built in plastic mesh were used, with the following dimensions: 0.50 m in diameter and 0.90 m in height and 0.5 inch mesh eye, the measurements of the pond were made of concrete of 7 m by 4 m, x 0.80 m, provided with water inlet and outlet, the water exchange was 30% daily. The fry of *M. festae* used in the present work had an average initial weight of 1.5 grams, which were fed with extracted tilapia feed containing 38 % protein, The final weight at 56 days of the experiment the fry of the three treatments presented the following reports: Treatment 1: 4.7 ±0.87 a; Treatment 2: 5.3 ±0.16 treatment T3 6. 2 ±0.64, the results showed statistical differences between treatments.

Keywords: Feeding, Density, Fish, Seeding, Treatment.

1 INTRODUCTION

Global fish farming reached a record 214 million tonnes in 2020, comprising 178 million tonnes of aquatic animals, largely due to growth; the amount destined for human consumption was 20.2 kg per capita, more than double the average of 9.9 kg per capita recorded in the 1960s. Due to the constant expansion of the sector, FAO indicates that more targeted transformative changes are needed to make the fisheries and aquaculture sector more sustainable, inclusive and equitable. (Apromar , 2020)

In 2020, more than 157 million tonnes, or 89% of aquatic animal production, was used for direct human consumption, a slightly higher volume than in 2018, despite the impact of the coronavirus disease (COVID19 pandemic). Aquatic foods contributed about 17% of animal-based protein consumed in 2019 and reached 23% in lower-middle-income countries and more than 50% in parts of Asia and Africa. (Apromar , 2020)

For its part, Latin America has numerous native species with potential in aquaculture, with the Cichlidae family being one of the most important and abundant freshwater with more than 1,300 species, while North, Central and South America have 402 species. Native cichlids represent approximately 50% of the ichthyofauna of Latin America and about 60% of these are of the genus *M. festae*. The usual destination of this production has been the consumption of fish meat by the populations linked to these rural habitats through traditional and small-scale fishing systems that do not compromise the conservation of these resources (4).

In Ecuador, inland water fish farming is an activity of growing importance with great economic, social and environmental interest. It involves different productive sectors and native species, where in addition to promoting an increase in the income of small producers, it favors endogenous development, is a food producer and generates employment in disadvantaged and marginal areas with a low opportunity cost of labor; It is currently a productive alternative with a great future for rural areas (5).

The Vieja Colorada (Mesoheros *festae*) also known as: Red Terror, is a cichlid, found along the drainages of the Pacific, specifically from the Esmeraldas River in Ecuador, through the Guayas River, to the Tumbes River in Peru. It is a territorial species and is frankly aggressive, robust, its coloration is variable in relation to the age, sex and habitat in which its place of capture is located and the age of the specimens. (Prado et al., 2010)

The existing problem with the old red woman (M. *festae), is to be* a little-researched species, which prevents having specific protocols on its growth in high densities, which affects slow and pathogenic production processes, which do not cover the demand, nor allow the species to be exploited at an industrial level, despite the fact that it is considered, at a different level. *festae* as a fish, very appetizing in Ecuador, its development takes place in fresh water and its fishing is presented in impractical conditions; It lives in the headwaters of rivers and in dams to avoid being caught, it is a species of strong demand in our country, very well valued in the market but with little knowledge of its production (Chakrabarty , 2006) **.**

The alternative solution is to carry out extensive research to determine adequate protocols regarding the number of appropriate densities, which allow a greater population in a small space, which helps to reduce production costs of M. *festae* at the macro level can supply the national demand. It is important to carry out the study because there is still no certainty of the adequate population density in the growth of Mesoheros *festae fry* that guarantees the preservation of the species. To determine the effect of density on the growth of Mesoheros *festae* fry using replacement technology.

2 METHODOLOGY

The research was carried out at the Fish Farm of the Faculty of Livestock and Biological Sciences of the "La María" Experimental Campus, owned by the State Technical University of Quevedo, located at kilometer 7 1/1 of the Quevedo – El Empalme Road, entrance to the Mocache canton, province of Los Ríos. Its geographical location is 10 6' 28" south latitude and 700 27' 13" west longitude, at an altitude of 72 meters above sea level.

Experimental research consists of the management of variables in situations of extreme control, manifesting a specific phenomenon and looking at the degree to which the variable or variables involved and manipulated produce a certain effect. The information was obtained in a randomized manner, it is proposed that the sample is representative of reality. This method allowed the research to establish different hypotheses and contrast them through scientific methods.

3 RESEARCH DESIGN

In the trial, a Completely Randomized Design (DCA) was applied, consisting of three treatments and six replicates each, which will give a total of 18 randomly distributed cages. For the differentiation of means of the treatments, the Tukey test ($p \leq 0.05$) was implemented.

Table 1. ANDEVA scheme.

Source of Variation		Degrees of Freedom
Treatments	(t – 1)	2
Error Experimental	T(R-1)	15
Total	(t x r) – 1	17

Elaborated: The author

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3.1 MATHEMATICAL MODEL

$$Y\,ij = \mu + Ti + E\,ijk$$ (Polydura , 2015)

Where:

"**Y ij =** The effect of the response variable.

μ = Population average.

Ti = The "i esimo" effect of the independent variable.

***E ijk* =** The random effect or experimental error." (Piercing Pérez et al., 2019)

3.2 EXPERIMENTAL DESIGN

The experimental research consisted of the management of variables in efficient control situations.

Table 2. Analysis of treatments and repetitions in the project

S1R1	S1R2	S1R3	S1R4	S1R5	S1R6
S2R1	S2R2	S2R3	S2R4	S2R5	S2R6
S3R1	S3R2	S2R3	S3R4	S3R5	S3R6

Note. The author

3.3 BIOLOGICAL SPECIMENS USED IN RESEARCH

The fingerlings that were used in this research come from the Fish Farm of the Faculty of Livestock and Biological Sciences of the State Technical University of Quevedo, for this purpose they were sexed manually and selected 300 fingerlings with an average weight of (1.5 g) Mesoheros *festae.*

3.4 DATA PROCESSING

The statistical analysis was performed using the ANOVA analysis of variance in which the means were contrasted using Tukey's test (P≤0.05), with the use of a free software statistical package. The tables, figures and processing of the data taken were carried out in Excel Microsoft Office package.

4 RESULTS

One of the important factors in fish farming is the stocking density which is calculated in Kg of biomass per cubic meter, and the density depends on the growth stage, the optimal density

INTERNATIONAL SEVEN JOURNAL
OF MULTIDISCIPLINARY
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for Mesoheros *festae*, in the fry stage is important to rescue the species and place it as a commercial exploitation because it has the preference by consumers, compared to other cichlids.

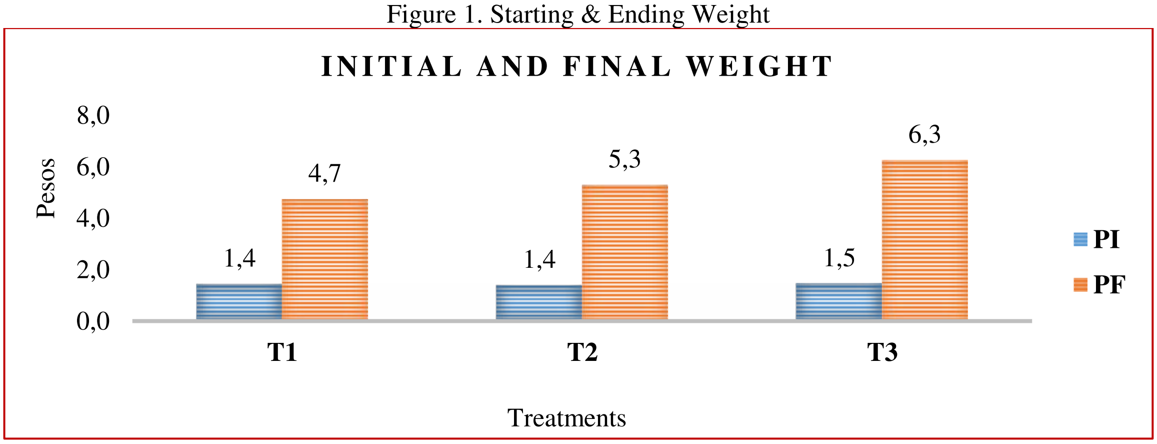
4.1 INITIAL AND FINAL WEIGHT OF FINGERLINGS

The fry were cultured using recirculation technology, a widely used and successful method in the breeding of various exotic species, such as the Asian snook. This method allows a high population density to be maintained; In the case of the tilapia cichlid, it can exceed 100 kilograms per square meter. Since (Castelló, 1993; Chou & Lee, 1997) *Mesoheros festae*, also known as vieja colorada, is a cichlid of the same family, it is assumed that it can be grown at similar extreme densities. Therefore, in this study, 10, 20 and 30 fingerlings were stocked per cage, which is equivalent to 50, 100 and 150 fish per m2

The M. festae *fingerlings* used in this study had an average starting weight of 1.5 grams and were fed a balanced extruded tilapia feed, which contained 38% protein. In this study (Figure 3), the three treatment groups had an average initial weight of T1: 1.4 ± 0.27 g; T2: 1.4 ± 0.13 g; T3: 1.5 ± 0.69 g. No statistically significant differences were found between treatments, as fingerlings of uniform weight were used.

The final weight (Figure 3), after 56 days of experiment, the fry of the three treatments reported the following weights: Treatment 1: 4.7 ± 0.87 g; Treatment 2: 5.3 ± 0.16 g; Treatment 3: 6.2 ± 0.64 g. The results showed statistically significant differences between treatments. Treatment 1, which had the highest stocking density, 150 fingerlings per cubic meter, presented the lowest weight, being treatment 3 with the lowest number of fingerlings per cubic meter, 50 fingerlings per cubic meter, and was followed by treatment 2, which had a density of 100 fingerlings per cubic meter, the statistically significant difference between the treatments was recorded after 56 days of stocking and feeding of the fish.

Figure 1. Starting & Ending Weight



INTERNATIONAL SEVEN JOURNAL
OF MULTIDISCIPLINARY
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The findings of this research are consistent with the results published in a study carried out in (Moya et al., 2015) *M. festae*, where he worked with fry of this species with an average weight of 4.1 grams. After ninety days, these fry reached an average final weight of 18 grams.

However, the results of our research present discrepancies with respect to the findings obtained by his study on the breeding densities of the white Cachama (Cientrarchus labrax), and in the work on Rachi centron canadum carried out by . In these studies, the breeding densities were different, which could explain the discrepancy in the results. (Salient et al., 2006) (Webb et al., 2007)

The significance analysis showed that there were significant differences between the treatments from the second week of the start of the experiment until the 56 days of the study. This suggests that rearing density may have a significant impact on the growth of *M. festae* fry, and that further studies may be needed to fully understand these relationships and how they can be optimized for aquaculture.

4.2 INITIAL BIOMASS FINAL BIOMASS AND BIOMASS INCREASE

The increase in biomass in fish farming is influenced by several factors, including the protein efficiency of the feed, the rearing stage of the fish, and especially, the stocking density per cubic meter in the pond. An overpopulation can trigger competition for vital resources such as oxygen and food. However, a lower density of fish per cubic meter provides a more comfortable environment, where there is less competition for available resources.

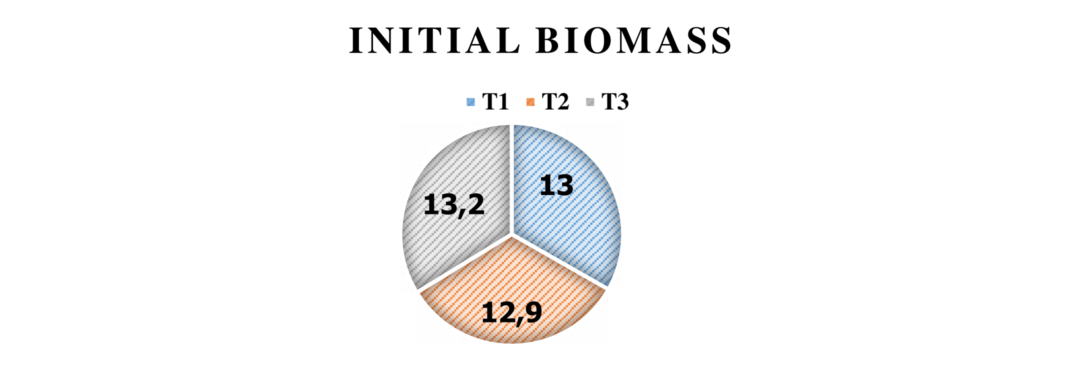
In the context of this study, the initial average biomass (see Figure 4) for Treatment 1 was 13 grams; for Treatment 2, it was 12.9 grams; and for Treatment 3, it was 13.2 grams. In contrast, the final biomass (see Figure 5) for Treatment 1 was 117 grams; for Treatment 2, it was 132.5 grams; and for Treatment 3, it was 157 grams.

These results suggest that the increase in biomass can be significantly affected by the adjustment of fish density per cubic meter in the pond. Higher density can lead to increased biomass, but this must be carefully balanced with fish welfare and available resources to avoid competition and stress issues.

As we advance our understanding of the factors influencing biomass increase in fish farming, it is clear that more research is needed to optimize these parameters. Maximizing feed protein efficiency, properly controlling the rearing stage, and fine-tuning stocking density are key strategies for optimizing biomass increase in fish farming. Not only does this benefit the productivity of the farm, but it can also improve the welfare and health of the fish.

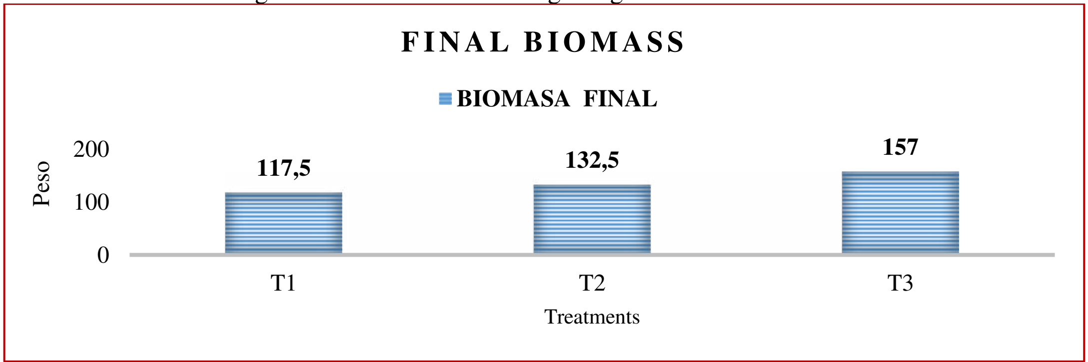
INTERNATIONAL SEVEN JOURNAL OF MULTIDISCIPLINARY
ISSN: 2764-9547

Figure 2. Initial biomass in fingerlings of Mesoheros festae



Here it is evident that the smaller the population, the greater the production of biomass. Regarding the increase in biomass (Figure 6), the research presented the following results: for treatment 1; 82 grams; For treatment 2, 96 grams and for treatment 3, 120 grams.

Figure 3. Final biomass in fingerlings of Mesoheros festae



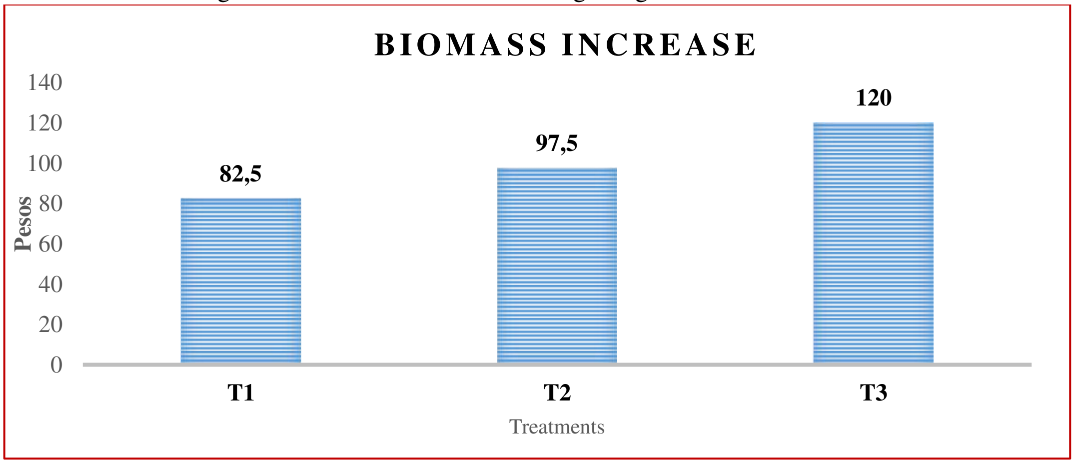
4.3 BIOMASS INCREASE

As can be seen in Figure 6, there was a statistically significant difference in biomass increase between treatments 1, 2 and 3. In this trial, the fish were fed an extruded feed specially designed for tilapia. It is relevant to note that the species used in this experiment belongs to the cichlid family, and according to the tilapia feeding and growth table provided by the Tilapia Food and Growth Table, weight increases in grams are expected when environmental conditions and water parameters are acceptable. (Vanessa, 2015)

In terms of water parameters, the dissolved oxygen in the pond water was maintained between 4 and 6 ppm during the experiment. This level is within the range recommended for cichlid culture, suggesting that the fish were kept in an aquatic environment suitable for their growth and development (Moya et al., 2015)

Balanced feeding and proper management of water parameters, such as dissolved oxygen, are critical factors for increasing biomass in fish farming. The results of this study provide further evidence of the importance of these management practices in optimizing fish growth and health in aquaculture.

Figure 4. Increase of biomass in fingerlings of Mesoheros festae



The analyses performed for the weight gain data between the different population densities of the treatments showed significant differences (P<0.05) between the densities of 50,100, and 150 fingerlings per m3.

It was observed that the fry with a density of 150 fish per cubic meter (w/m3) had the lowest average final weight (4.7 ±0.87), compared to the densities of 50 and 100 fry per m3, the fry grown at a density of 50 per m3 obtained the final weight at 56 days was 6. 2 ±0.64 while the fry grown at a stocking density of 100 fry per m3 had a Final weight of 5.3 ±0.16.

From the results obtained, it is clearly shown that the average weight of the old red fry increases with the increase in rearing space per animal, coinciding with what is indicated by (Mcdonal -Vera et al., 2020) . In the present study, weight gain was higher than in treatments with a lower population density.

INTERNATIONAL SEVEN JOURNAL OF MULTIDISCIPLINARY
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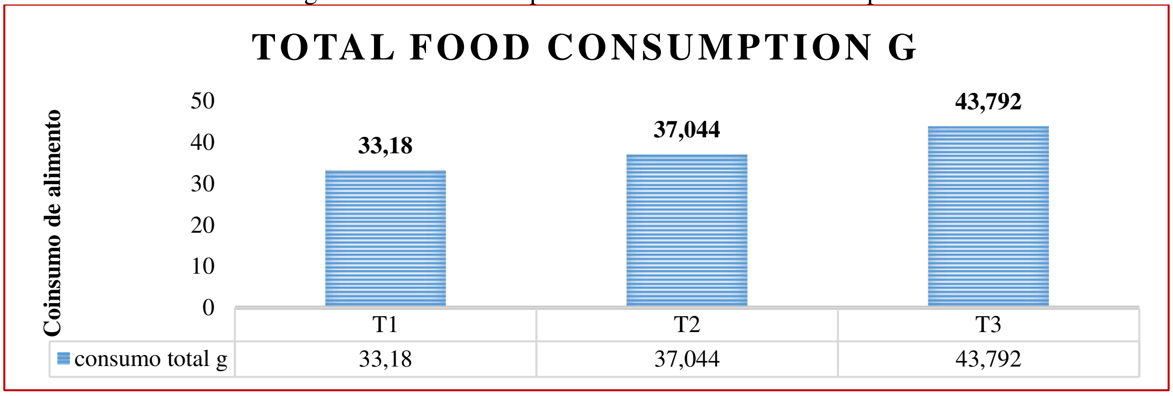
4.4 FOOD CONSUMPTION

Figure 5. Food consumption of mesoheros festae roseups



Throughout the experimental phase, a constant feeding rate of 8% was maintained, implying a controlled feed delivery, the results of which are shown in Figure 7. Feed consumption in fish is regulated by several factors, such as the duration of feeding, the amount of food per individual, the frequency of feeding, and also the influence of weight and temperature on the digestion rate. (Calderer , 2001)

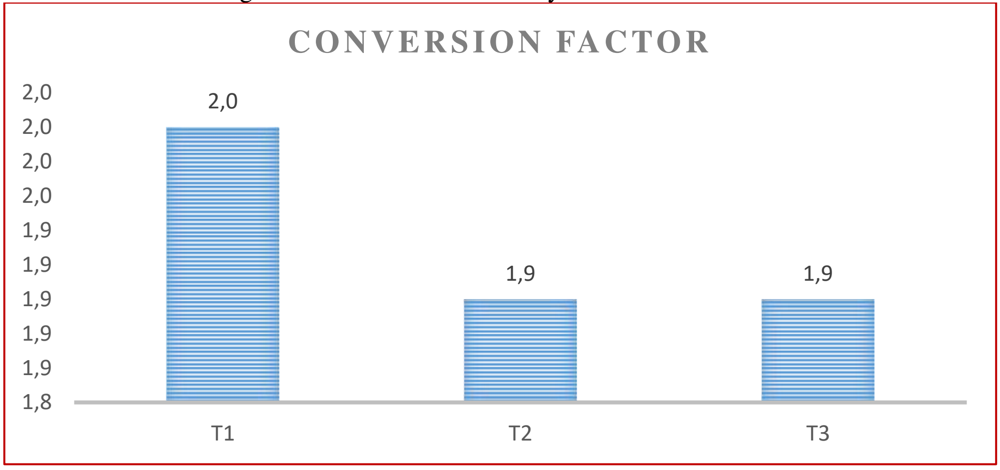
It is observed that temperature has a direct relationship with the rate of digestion in fish. As the temperature rises, the fish's metabolic processes accelerate, including digestion, which can lead to increased feed intake. On the other hand, the weight of the fish can also influence their feed intake, as larger fish generally need more feed to maintain their metabolism and growth.

Careful management of these factors can be essential to optimize feed intake and, therefore, the growth rate and health of fish in the culture. For example, adjusting the amount and frequency of feeding according to the size and weight of the fish can help ensure that each fish receives the right amount of feed.

Similarly, keeping water temperature within an optimal range can help maximize digestion rate and feed intake. Still, it's important to remember that each species of fish may have its own needs and responses to these factors. Therefore, it is essential to understand the specific biological and behavioral characteristics of the species being cultivated in order to implement feeding and management strategies

4.5 FEED CONVERSION

Figure 6. Feed conversion in fry of Mesoheros festae



In this study, feed conversion results are presented in Figure 8. Feed conversion ratios of 2.07 and 2.17 in red tilapia have been obtained in environmental and water conditions that are similar to those used in our research. (Kubitza , 2000)

Feed conversion is a crucial parameter in aquaculture as it tells us how efficiently fish transform the feed they consume into body growth. A lower feed conversion ratio indicates higher feed efficiency.

As you point out, feed intake, and therefore feed conversion, is influenced by several factors. These include feeding rate, feeding frequency, fish weight, and water temperature. Efficient management of these factors can contribute to better feed conversion, resulting in more efficient fish growth and increased productivity of aquaculture systems. (Calderer , 2001)

For example, proper feeding, adjusted to the weight of the fish and distributed with the correct frequency, can maximize feed intake and minimize waste, thus improving feed conversion. Similarly, keeping water temperatures within an optimal range can encourage healthy metabolism in fish, which can contribute to better feed conversion.

In addition, it is important to note that each species of fish may have different requirements and responses to these factors, so it is essential to consider the specific characteristics of the species being farmed.

In this regard, it is important to note that it reported a conversion of 2.07:1 to 2.17:1 with average final weights of 461.32 g to 465 g at 140 days, which corroborates the importance of proper management of the factors mentioned above to achieve optimal feed efficiency. (Angón et al., 2019)

4.6 PHYSICOCHEMICAL PARAMETERS OF WATER

The results obtained in this study regarding feed conversion are shown in Figure 9. Previous research, such as the one conducted by the University of Illinois, reported feed conversion ratios of 2.07 and 2.17 in red tilapia. These results were obtained under environmental and water conditions similar to those used in our research, providing a valuable point of comparison. (Kubitza , 2000)

Feed conversion is an essential indicator in aquaculture, as it reflects how effectively fish transform the feed consumed into body growth. A lower feed conversion ratio indicates greater feed utilization efficiency, i.e. fish gain more weight per unit of feed ingested.

(Calderer , 2001) It points out that feed intake, and therefore feed conversion, are influenced by a variety of factors. These include feeding rate and frequency, fish weight, and water temperature. Effective management of these factors can lead to better feed conversion, resulting in more efficient fish growth and increased productivity in aquaculture.

For example, providing an appropriate amount of feed for the weight of the fish and administering it at the right frequency can maximize feed intake and minimize waste, which in turn improves feed conversion. Similarly, keeping the water temperature within an optimal range can promote a healthy metabolism in fish, which can also contribute to better feed conversion.

In addition, it is important to consider that each species of fish may have specific requirements and responses to these factors, emphasizing the need to take into account the individual characteristics of the species in question. For example, it reported a conversion of 2.07:1 to 2.17:1 with average final weights of 461.32 g to 465 g at 140 days, supporting the importance of proper management of these factors to achieve optimal feed efficiency. (Moya et al., 2015)

5 CONCLUSIONS

The density of animal husbandry per land area is of great importance from an economic point of view, the more fish there are per m3 the greater the amount of biomass, the research yielded the following results for treatment 1; 82 grams; for treatment 2, 96 grams and for treatment 3, 120 grams. However, it is important to note that it is important to find the balance between the number of animals and their growth in acceptable terms.

When analyzing the influence of three densities on the growth of Mesoheros *festae* fingerlings in replacement technology through the comparison of production indicators, as a result a final weight was obtained at 56 days of the experiment for Treatment 1: 4.7 ±0.87 a; Treatment 2: 5.3 ±0.16 treatment T3 6. 2 ±0.64, the results showed statistical differences between treatments.

It was found that the lower the population per cubic meter of water, the better the results, despite having a similar feeding and feeding rate, which could also be influenced by the growth of the amount of zooplankton and phytoplankton present in the replacement system.

The physicochemical parameters of the water within the research were kept at: dissolved oxygen 5.6; pH 7.9; temperature 24.2; Transparency 40.7; ammonium 0.01; It is considered that the influence of the evaluated water parameters was null, they had no influence in establishing differences between the treatments, they were always kept within the ranges established for cichlid breeding. From the point of view of biomass production, the treatment with the lowest density presented the highest biomass weight.

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