Comparative study of biological and metabolic indicators in males and females *Pseudocurimata boulengeri* of lotic ecosystems

Estudio comparativo de indicadores biológicos y metabólicos en machos y hembras de *Pseudocurimata boulengeri* de ecosistemas lóticos

Estudo comparativo de indicadores biológicos e metabólicos em machos e fêmeas de *Pseudocurimata boulengeri* de ecossistemas lóticos.

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Abstract

With the objective of evaluating different biological and metabolic indicators in males and females *Pseudocurimata boulengeri* in three ecosystems of Los Ríos, Ecuador, specimens were captured in the areas of Ventana, Quevedo and Buena Fe (60 per area, 180 total), and proceeded to perform the sexing. The following were determined: size, weight, thickness of the head, trunk and tail, as well as the size-weight relationship. Stomasomatic, gonadal, hepatosomatic, vicerosomatic indices and condition factor. Glucose, total protein, cholesterol and triglyceride were also evaluated. A 3×2 factorial arrangement was used. Regression analysis to establish the functional relationship between length and weight. For the morphometric indicators, differences between interactions were shown, although higher values were observed in females regardless of the locality, with a weight of 185 g, a length of 23.43 cm and head thickness that exceeded 6 cm. The biological indices reflected differences between the interactions, thus the hepatosomatic, gonadal, and vicerosomatic indexes were higher for females in the locality of Ventanas with 0.97, 12.76, and 20.04, respectively. For the metabolic indicators, differences were shown between the interactions with greater variability for sex. It was shown that for the morphometric indicators, sex did not prevail. The biological indices were influenced by sex, with superiority for females except the stomasomatic. While metabolic indicators showed variability with respect to areas and sex.

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Resumen

Con el objetivo de evaluar diferentes indicadores biológicos y metabólicos en machos y hembras de *Pseudocurimata boulengeri* en tres ecosistemas de Los Ríos, Ecuador, se capturaron ejemplares en las zonas de Ventana, Quevedo y Buena Fe (60 por zona, 180 total), y se procedió a realizar el sexado. Se determinaron: talla, peso, grosor de la cabeza, tronco y cola, la relación talla-peso; así como los índices estomasomático, gonádico, hepatosomático, vicerosomático y el factor de condición. También se evaluó la glucosa, proteínas totales, colesterol y triglicérido. Se empleó un arreglo factorial 3×2. Para los índicadores moformétricos se mostraron diferencias entre las interacciones, aunque se apreciaron valores superiores en las hembras independientemente de la localidad, con peso de 185 g, talla de 23,43 cm y grosos de la cabeza que superó los 6 cm. Los índices biológicos reflejaron diferencias entre las interacciones, así los índices hepatosomático, gonádico y vicerosomático fue superior para las hembras en la localidad de Ventanas con 0,97; 12,76 y 20,04, respectivamente. Para los indicadores metabólicos se mostraron diferencias entre las interacciones con una mayor variabilidad para el sexo. Se demostró que para los indicadores morfométricos no prevaleció el sexo. Los índices biológicos se vieron influenciados por el sexo, con superioridad para las hembras excepto el estomasomático. Mientras que en indicadores metabólicos mostraron variabilidad con respecto a las zonas y al sexo.

Palabras clave: índice gonádico, glucosa, peso vivo, proteínas, triglicéridos.

Resumo

A fim de avaliar diferentes indicadores biológicos e metabólicos em machos e fêmeas de *Pseudocurimata boulengeri* em três ecossistemas de Los Ríos, Equador, espécimes foram capturados nas áreas de Ventana, Quevedo e Buena Fe (60 por área, 180 no total), e procedeu-se a realizar a sexagem. Foram estudados: tamanho, peso, espessura da cabeça, tronco e cauda, bem como a relação tamanho-peso. Índices estomasomáticos, gonadais, hepatossomáticos, vice-somáticos e fator de condição. Glicose, proteína total, colesterol e triglicerídeos também foram avaliados. Utilizou-se o delineamento casualizado com arranjo fatorial 3×2. Para os indicadores morfométricos, mostraram-se diferenças entre as interações, embora tenham sido observados valores mais elevados nas fêmeas independentemente da localidade, com peso de 185 g, altura de 23,43 cm e espessura da cabeça superior a 6 cm. Os índices biológicos refletiram diferenças entre os interações, assim os índices hepatossomático, gonadal e vice-somático foram maiores para as fêmeas na localidade de Ventanas com 0,97; 12,76 e 20,04, respectivamente. Para os indicadores metabólicos, mostraram-se diferenças entre os interações com maior variabilidade para o sexo. Foi demonstrado que para os indicadores morfométricos, o sexo não prevaleceu. Os biológicos foram influenciados pelo sexo, com superioridade para o sexo feminino, exceto os estomasomáticos. Enquanto a indicadores metabólicos apresentou variabilidade com relação a áreas e sexo.

Palavras-chave: índice gonadal, glicose, peso vivo, proteínas, triglicerídeos.

Introduction

Aquaculture emerged as a practice for supplying proteins of high biological value to low-income rural families, who used the existing resources in the ecosystem (Ahmadniaye-Motlagh *et al*., 2020; Méndez-Martínez *et al.*, 2021). However, regardless of the importance of native species in many regions, specifically those of Ecuador, many of these are threatened, which causes vulnerability in ecosystems and associated rural populations (Méndez-Martínez *et al.*, 2022a).

In recent years, various investigations have been carried out on many of the native species existing in the ecosystems of Ecuador (Escanta and Jiménez-Prado, 2019). However, the literature refers to the need for these to be more specific, with the aim of knowing more effectively the behavior of these aquaculture species that live in these ecological niches in the region. This will make it possible to act more precisely on ecosystems, with the aim of preserving and conserving them, which would lead to sustainable and human-friendly development (Súarez and Petrere, 2007). Thus, one of the species that inhabits these niches is the dica (*Pseudocurimata boulengeri*), which is endemic to Ecuador and belongs to the Curimatiadae family. It is characterize for being a fish that is widely accept by consumers due to its appetizing flavor and supports an important group of fishing families (Chicaiza and Flores, 2016).

On the other hand, the eco systemic value that these species represent for human health and the environment is in antagonism with the decrease in natural stocks, caused among other aspects by overfishing (Hilborn *et al*., 2020), which brings with it the reduction of biologically sustainable populations. Thus, it is argued that about 13% of the world population whose livelihood depends on inland capture fisheries is at risk of survival (Méndez-Martínez *et al*., 2022c). To the above described must be added the impact caused by environmental deterioration and the fragility of ecosystems due to the replacement of native species by those introduced from foreign countries (FAO, 2020). In addition, it is vital to improve knowledge about biological and metabolic aspects that allow appropriate management technologies for these species. Especially the second, since specific studies on indicators such as triglyceride, cholesterol, glucose and total proteins in plasma can provide more precise information on the physiological state of the fish (Erhunmwunse and Ainerua, 2013). This will undoubtedly allow man to act more effectively in ecosystems, and therefore improve the relationship with them (Defeo and Vasconcellos, 2020). Therefore, to evaluate different biological and metabolic indicators of the fish *Pseudocurimata boulengeri*in three lotic ecosystems in the province of Los Ríos, Ecuador was the objective of this work.

Materials and methods

Location

The present investigation was carried out in three areas of the province of Los Ríos, in the waters of rivers that cross the cantons of Buena Fe and Quevedo, as well as the river that crosses the canton of Ventanas. The fish were captured in the three sites mentioned, which have the following weather conditions in table 1.

Table 1. Approximate meteorological conditions of the cantons of Ventanas, Quevedo and Buena Fe.

Data	Average values		
	Ventanas	Quevedo	Buena Fe
Geographical coordinates	10°31'41 S 79°027´36" W	1°01′43 S 79°27´W	0° 53' S 79°29´ W
RH	86.00	80.84	82.90
Temperature Average	27.00 °C	26.47 °C	24.40 °C
Height Average	570 masl	74 masl	100 masl
Annual precipitation	3071.26 mm	2,223.85 mm	2,000 mm
Heliophany	626 $h.L^{-1}$	898.66 $h.L^{-1}$	638.8 $h.L^{-1}$
Ecological zone	Tropical semi-humid forest	Tropical semi-humid forest	Tropical semi-humid forest

Ethical statement

The study was carried out in accordance with the Standard Operating Procedures (SOP) for the use of experimental animals, established by the protocols and procedures for animal care of State Technical University of Quevedo.

Experimental procedure

For this research, 3×2 factorial arrangement was used. The interactions are described depending on the location and sex: Females/Ventanas (1/V), Males/Ventanas (2/V), Females/Quevedo (1/Q), Males/Quevedo (2/Q), Females/Buena Fe (1/B), Males /Buena Fe (2/B). Ten samples of fields were carried out between the months of November 2019 and April 2020. This stage constitutes the season of greatest rainfall in the province for animal care of State Technical University of Quevedo. 60 specimens were captured with fishing nets for each area (180 total), and sexing was carried out taking into account the morphological characteristics (Nugra *et al*., 2018).

Water indicators

Control of physical-chemical parameters on the water was carried out, the temperature was measured with a mercury thermometer (0 to 50 ºC), and the Nitrate ($N0_3$), nitrite (NO_2), ammonium (NH_4), pH and hardness with the colorimetric kit (Saltwater Master Test, OH, USA), respectively (Méndez-Martínez *et al*., 2021).

Morphometry and biological indices

The variables or morphometric indicators were studied, such as: size, weight, thickness of the head, thickness of the trunk, thickness of the tail and size-weight relationship. The weight of the animals was carried out individually with a digital balance of precision ± 0.01 g (PE 3600 Mettler-Toledo, Columbus, Ohio, USA), the length was determined with the help of a tape measure (Truper, 3m-Fh, Distrito Federal, MX), measuring from the tip of the mouth to the end of the tail. To measure the width of the head, body and tail, a digital vernier caliper (GT-MA15 Gester, ± 0.001 mm, Xiamen, CN) was used. The Condition Factor is determined through the following formula (Moreno *et al*., 2019):

- Condition Factor = (body weight / total length^3) x 100

The animals were dissected according to Holden and Raitt (1975). The following indexes were calculated:

- Hepatosomatic index = (liver weight / total weight) x 100
- Stomasomatic index = (stomach weight / total weight) x100
- Gonadic index = (gonad weight / total weight) x100
- Vicerosomatic index= (visceral weight / total weight) x100

Metabolic indicators (blood biochemistry)

One mL of blood was extracted by puncture of the caudal artery at the level of the hemal arch, using 3 mL disposable syringes (Bio-In, Guayaquil, EC), which were placed in capillary tubes (Isolab, Laborgeräte GmbH, Eschau, DE) with heparinized inner surface, then centrifuged (Gemmy, PLC-05, Taipei, TW) at 1200 rpm for 10 min to obtain blood plasma in order to after performing the biochemical tests for total proteins, glucose, cholesterol and triglycerides (Méndez-Martínez *et al*., 2021, 2022b), reagents (Liquicolor, Wiesbaden, DE) were subsequently applied, respectively, and allowed to incubate for 10 min for total proteins and 25 min for the others at 37ºC, respectively (Trinder, 1969). Readings were made in a spectrophotometer (SunostIk, SBA-733 Plus, Kunshan Road, CHN) at ABS: 456 nm for total proteins,510 nm for glucose, 500 nm for cholesterol and triglycerides, respectively. The analyzes were carried out in triplicate.

Statistical analysis

The Bartletttest was performed to determine the homogeneity of the variances and the Kolmogorov - Smirnov test to verify the normal distribution of the data. An analysis of variance was performed depending on the established design and the means were compared with the Newman Keuls multiple range test ($p<0.05$). The data in percentages were transformed through the square root of the arcsine, only for statistical processing.

Linear regression models were used to establish the functional relationship between length and weight. Data processing was performed with the help of SPSS v22 statistical software. Data results will be presented as means ± standard error (SE).

Results and discussion

The results of the water indicators in the three lotic ecosystems showed adequate conditions for the growth and development of the fish (table 2). Fish can live in a wide range of temperatures, however the immune system does not work the same in all of them, logically, the optimal ones are the best. The increase of 1 °C increases metabolism by 15 %, affecting feed efficiency (Volkoff and Rønnestad, 2020; Méndez-Martínez *et al*., 2021). What brings with it alterations in metabolic indicators.

Furthermore, the oxygen requirement of aquatic beings increases as temperatures rise. Sudden changes in temperature, whether hotter or colder, are often detrimental (Súarez and Petrere, 2007). The suitable temperature is around 25 °C. Although there are also studies that argue that the best of all is that the water is at 27 °C for raising fish (Ayazo *et al.*, 2018).

Table 2. Physical-chemical parameters of water in the lotic ecosystems of Los Ríos province.

Parameters	Ventanas	Quevedo	Buena Fe
pH	7.43	7.40	8.44
Ammonium ($mg.L^{-1}$)	0.17	0.25	0.22
Nitrate ($mg.L^{-1}$)	0.15	0.15	0.12
Nitrite ($mg.L^{-1}$)	0.14	0.20	0.22
Hardness (ppm)	54.00	48.04	45.20
Temperature (°C)	27.60	26.50	27.00

In pH that are in ranges between 7.5 and 8.5 they are ideal for the growth of fish and other aquatic organisms such as shrimps since it has good productions, very acid pH below 6 are detrimental for the growth and development of fish. When the pH of the pond is less than 5, liming is recommended to regulate it (Súarez and Petrere, 2007). Which agrees whit the results of this work. Some similar occurred for nitrites and nitrates, these are values considered low and adequate for fish farming (Ayazo *et al*., 2018).

The comparison between the proportions for sex (table 3) reflected in the three lotic ecosystems of the province of Los Ríos that the highest percentage corresponds to females. Showing Quevedo the largest number of females from the numerical point of view, since they were not compared between them.

Table 3. Sex ratio in *Pseudocurimata boulengeri* of lotic ecosystems.

Lotic sector	% Females	% Males	SE±	p
Ventanas	82.41	17.59	2,34	0.001
Quevedo	87.84	12.16	3,08	0.002
Buena Fe	81.45	18.55	2,89	0.001

A study in Ecuador reported percentages of 67.2 for females and 32.8 for males when evaluating a period between January 2003 and July 2009 (Chicaiza and Flores, 2016). These same authors reported higher percentages for females when studying the months of November to April, a factor that can influence the growth and development of this species. Result of Guzmán (2016), found proportions of 54 for females and 44 for males, when evaluating an area of the province of Los Ríos. This could be related to environmental conditions depending on the season.

By establishing the functional relationship between length and weight by sex and independently in each locality, a linear and direct relationship between these two variables was observed (table 4). In all cases, the regression coefficients (R^2) were higher than 0.70 with high significance. An investigation in Ecuador in the species Bocachico (*Ichthyoelephas humeralis)* reported by Méndez-Martínez *et al*. (2022b), reflected third degree exponential equations to describe the relationship between weight and size in this species, which differs from this work. These authors pointed out that the differences between the growth of the species may be related to many factors, such as the size of the samples, size ranges, genetic aspects between groups of species and environmental conditions. Also, the weight-length relationship can behave differently not only between species, but also within populations of the same species, since growth depends on environmental, nutritional and genetic variations. This justifies the results of this work.

Table 4. Weight-length relationship of *Pseudocurimata boulengeri* in lotic ecosystem

Sex/Lotic Sector Interactions	Linear regression	R^2
1/V	*y = 0.0421x + 15.638*	$R^2 = 0.8375$
2/V	*y = 0.0407x + 16.719*	$R^2 = 0.7405$
1/Q	*y = 0.036x + 16.784*	$R^2 = 0.7784$
2/Q	*y = 0.0455x + 15.647*	$R^2 = 0.8796$
1/B	*y = 0.0394x + 15.98*	$R^2 = 0.8787$
2/B	*y = 0.0483x + 14.905*	$R^2 = 0.7151$

Ochoa-Ubilla *et al*. (2016), when evaluating the functional relationship between weight and size of species such as: *Ichthyoelephas humeralis, Leporinus ecuadoriensis, Brycon* spp., *Rhamdia cinerascens, Andinoacara rivulatus, Hoplias microlepis, Pseudocurimata* spp., which are considered of economic value in Ecuador; obtained potential equations for growth. Although they highlighted that *I. humeralis, A. rivulatus* and *Pseudocurimata* spp showed negative allometric growth, while *H. microlepis, L. ecuadoriensis, Brycon* spp. and *R. cinerascens* showed isometric growth. This justifies and accentuates the above.

The morphometric indicators evaluated reflected differences (table 5). In the case of weight, the highest values are observed for females in the Quevedo and Buena Fé cantons (1/Q and 1/B). Thus, the minors appear for the males in the cantons of Ventanas, Quevedo and Buena Fé (2/V, 2/Q and 2/B), with no differences between them.

For length, something different occurred, the lowest value was reflected by2/B with differences compared to the rest. The remaining interactions did not show differences between them with sizes in all cases exceeding 23 cm. Something similar occurred for the thickness of the head, where 4.03 cm was shown as the lowest value in 2/B with differences compared to the rest, which were similar among them. The latter reached values above 4.35 cm, regarding length, a study in Ecuador was reported (Pacheco, 2020), values similar to those of this research. Note that some specimens exceeded 26 cm, and also the percentage of females exceeded that of males as manifested in this work.

For its part, the thickness of the trunk showed significant differences in interactions 2/V, 2/Q and 2/B, compared to 1/V, 1/Q and 1/B. In the first three cases mentioned, the values exceed 6 cm.

For the thickness of the tail, no differences are shown between interactions 1/V, 1/Q and 1/B, in all three cases the values exceeded 2.50 cm. The remaining interactions did not differ between them, but with those mentioned above, except 1/V and 2/V. The total length morphological indicator (table 5) was higher than that found by Caez *et al.* (2019), when evaluating the species *A. rivulatus* in wild conditions in the Quevedo canton, belonging to the Los Ríos Province. These authors selected 52 fishes, and expressed total lengths between 14.8-21.8 cm. However, when they analyzed the size of the head, the values reached 6.6 cm, higher than those shown in this investigation, which could be given by the species, since the living conditions were very similar.

Table 5. Morphometry in *Pseudocurimata boulengeri* in lotic ecosystems.

Sex/Lotic Sector Interactions	Weight (g)	Size (cm)	Head thickness (cm)	Trunk thickness (cm)	Tail thickness (cm)
1/V	185.29^{bc}	23.43^{b}	4.43^{b}	6.12^{b}	2.51^{bc}
2/V	164.07^{ab}	23.39^{b}	4.36^{b}	5.45^{a}	2.40^{ab}
1/Q	191.75^{c}	23.69^{b}	4.39^{b}	6.33^{b}	2.60^{c}
2/Q	161.46^{a}	23.00^{ab}	4.30^{b}	5.38^{a}	2.38^{a}
1/B	185.98^{c}	23.31^{ab}	4.35^{b}	6.16^{b}	2.55^{c}
2/B	153.98^{a}	22.34^{a}	4.03^{a}	5.39^{a}	2.30^{a}
SE±	22.3	1.31	0.25	0.38	0,15
p	0.03	0.03	0.02	0,04	0,04

Unequal letters in the same column differs for p<0.05 according to Newman Keuls.

Table 6. Biological indices in *Pseudocurimata boulengeri* of lotic ecosystems.

Sex/Lotic Sector Interactions	IHS	ISS	IGS	IVS	FC
1/V	0.97^{b}	1.04^{a}	12.76^{b}	20.04^{b}	1.43^{b}
2/V	0.74^{a}	1.20^{b}	7.06^{a}	13.01^{a}	1.28^{a}
1/Q	0.92^{b}	1.02^{a}	13.58^{b}	20.45^{b}	1.43^{b}
2/Q	0.70^{a}	1.19^{b}	6.73^{a}	12.33^{a}	1.32^{a}
1/B	0.93^{b}	1.06^{a}	12.64^{b}	20.09^{b}	1.46^{b}
2/B	0.76^{a}	1.13^{b}	6.32^{a}	13.96^{a}	1.38^{b}
SE±	0.07	0.09	1,86	2.12	0.10
p	0.05	0.06	0.03	0,07	0.06

Unequal letters in the same column differ for P<0.05 according to Newman Keuls. Expressed in percentage IHS=hepatosomatic index, ISS=stomasomatic index, IGS=gonadic index, IVS=vicerosomatic index, FC=condition factor.

Moreno *et al*. (2019), when studying the species *Eremophilus mutisii*, analyzed morphometric indicators. These authors used 33 animals captured in the Bogotá River, of these 27 females and six males. They reported weight 222.7 g for males and for females 181.1 g, for body length reflected 28.6 and 28.1 cm, respectively. For head width, they reported values of 3.2 cm (males) and 3.1 cm (females), with a condition factor of 0.9 and 0.8, respectively. It was possible to appreciate better behavior from the numerical point of view for the females, these results coincide with those of this investigation. It is important to highlight that the literature shows that morphometric indicators can have variability in responses to environmental conditions, consistent with the evolutionary hypothesis where it is stated that divergent habitats drive interspecific phenotypic diversification, important aspects to predict adaptive responses of freshwater fish species. These somatic differences between populations of a species may be related to habitat conditions such as: temperature, turbidity, food availability, depth and water flow (Foster *et al*., 2015).

Biological indices reflected differences between interactions (table 6). The hepatosomatic (IHS) reflected the lowest values for interactions 2/V, 2/Q and 2/B, without differences between them and with the rest. These last 1/V, 1/Q and 1/B showed the highest percentages, in the three chaos above 0.90. For the stomasomatic index (ISS) the opposite occurred, the highest values appear for the males in the three cantons studied, with differences with respect to the rest. In all cases, the percentage found was greater than one.

An investigation carried out in Ecuador in the species *Eremophilus mutisii* reflected similar results to that of this investigation (Moreno *et al*., 2019). These authors reported that females have a higher gonadosomatic and hepatosomatic index than males. This was reaffirmed by Méndez-Martínez *et al*. (2022c) in the *Andinoacara rivulatus* species, obtaining results similar to those provided in this work. These indicated that the females, after starting the maturation process of the gonads, must allocate a large amount of energy and nutrients for reproduction, which allows them to support the development of said gonads, much higher than that of the males.

The gonadal index had a behavior similar to the IHS. The females in the three ecotypes studied were the ones that presented the highest percentages, with values higher than 12, with differences to the rest. The latter did not show differences between them. Something similar happened for the vicerosomatic index (IVS). Where the females showed the highest values (above 20 %), without differences between them and with the males. The latter presented similar behavior regardless of the locality where the study was carried out. The condition factor showed different results from the previously evaluated indicators, interactions 2/V and 2/Q did not differ between them, but with the rest. The highest percentages are seen above 1.38 for the remaining interactions without differences between them.

Leyton (2015), reported in Ecuador in five species of native fish, reflected that the condition factor was greater than one, similar to what happened in this investigation. This author reported that values below one denote difficulties in the growth of the fish, due to pressures in the production environment, while valuesabove one reflect favorable environmental conditions for growth. On the other hand, other research highlights that values greater than one are associated with spawning times, among other aspects (Méndez-Martínez *et al*., 2022b). Thus, temperature is considered another factor that affects the body condition of fish, the amount of oxygen they absorb through the gills, plant cover and food availability (Foster *et al*., 2015).

Moreno *et al*. (2019), when evaluating the vicerosomatic and hepatosomatic indices in the species *Eremophilus mutisii*, reported lower values than those reported in this work, which is undoubtedly due to the species, in addition to other factors such as habitat and weather conditions. It is important to highlight that these authors found the highest values for these indices in females, a result that coincides with those exposed in this investigation.

The metabolic indicators showed differences between the different interactions (table 7). Triglycerides reflected the highest values for 1/Q (417.33 mg.dL^{-1}) with differences compared to the rest. Thus, the lowest content appears for males in the Buena Fe canton. Note that there were no differences between interactions1/V and 1/B (table 7). For its part, cholesterol showed the highest amount in interactions2/V and 2/Q, those that did not present differences between them and did with the rest. The lowest value (142 mg.dL^{-1}) appeared for 1/V and 1/Q.

Table 7. Metabolic indicators in *Pseudocurimata boulengeri* of lotic ecosystems.

Sex/Lotic Sector Interactions	Triglyceride (mg.dL^{-1})	Cholesterol (mg.dL^{-1})	Glucose (mg.dL^{-1})	protein (g.dL^{-1})
1/V	362.67^{d}	139.00^{a}	51.33^{b}	3.75^{b}
2/V	259.67^{b}	161.33^{d}	102.05^{e}	3.92^{d}
1/Q	417.33^{e}	142.00^{a}	40.00^{a}	3.83^{c}
2/Q	348.00^{c}	161.00^{d}	101.67^{e}	3.97^{d}
1/B	358.67^{d}	153.00^{c}	58.00^{c}	3.65^{a}
2/B	226.33^{a}	147.67^{b}	90.00^{d}	3.65^{a}
SE±	6.33	3.46	2.00	0.03
p	0.002	0.003	0.001	0.001

Unequal letters in the same column differs for P<0.05 according to Newman Keuls.

Glucose reflected differences between interactions except between 2/V and 2/Q, these constitute the highest values in the study (101.67 and 102.05 mg.dL^{-1}, respectively). The smallest amount of glucose appears in 1/Q (40), this showed differences with all. It is important to note that the highest values appear for males regardless of where they were captured. The proteins reflected the highest amount in 2/Q, with differences compared to the other interactions. The lowest was shown for 1/B and 2/B (3.65).

Méndez-Martínez *et al*. (2022c) reported cholesterol and glucose values in the species *Andinoacara rivulatus* higher than those of this investigation. For example, they reported 185 mg.dL^{-1} for glucose in males and 222 for females. In the case of cholesterol, values of 164 and 161 mg.dL^{-1}, respectively, appear. However, when studying triglycerides, the results are below those discussed in this research. What is undoubtedly due to the species and sex among other aspects. Ahmadniaye-Motlagh *et al*. (2020), reported that such variations may be due to various factors such as sex, age, maturation of the gonads, genetic variation, habitat, climate and stress caused during handling. Thus, the literature refers that hematology and serum biochemistry in fish can assess the animal response to different factors such as stress, diseases, nutritional imbalances (Gonzales-Flores *et al*., 2020).

The disorders that occur due to these factors depend on the species, age, physiological phase, according to Erhunmwunse and Ainerua (2013) the concentration of cortisol, glucose and cholesterol can be affected by hypoxic stress, which in turn can be altered by animal density, consequently, these parameters are essential to know the state of the animal, it is possible to recognize the failures that are occurring in the system due to internal factors such as water quality and management. Although it is necessary to highlight that the water indicators were within the appropriate parameters for fish. While in the town of Quevedo where the highest values for total length, head length, as well as metabolic indicators were observed, these were somewhat higher from the numerical point of view. This could haves influenced these results depending on what was reported by Ayazo *et al.* (2018).

Conclusions

In this study, it was shown that for the morphometric indicators, sex did not prevail, since weight, condition factor, thickness of the trunk and tail were higher for females, while the rest were higher for males, regardless of age, location. Biological indicators were influenced by sex, with superiority for females except for the stomasomatic. While metabolic indicators showed variability with respect to areas and sex.

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