REVISTA CIENTÍFICA IGAPÓ
Publicação da Pró-Reitoria de Pesquisa, Pós-Graduação e Inovação do Instituto Federal de Educação, Ciência e Tecnologia do Amazonas

PEACOCK BASS RESPONSE ASSOCIATED OF CATHC-AND-RELEASE SPORT FISHING IN TARUMÃ-AÇÚ RIVER BASIN, MANAUS, AMAZONAS

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ABSTRACT

The Tarumã-Açú watershed, located entirely within urban Manaus (Amazonas, Brazil), faces growing anthropogenic pressure from floating structures, navigation, and commercial activities. Because hematological and biochemical parameters reflect both fish health and habitat quality, this study evaluated the physiological profile of peacock bass (Cichla spp.) caught via sport fishing in the Tarumã-Açú basin across seasonal hydrological cycles. Across 29 field campaigns conducted through August 2026—spanning the receding-water/dry (2025) and rising-water/flood (2026) seasons—27 specimens were captured using artificial lures: 23 Cichla temensis (85%) and 4 Cichla orinocensis (15%). All captures occurred in the morning (7:00 AM–1:00 PM), mostly on sunny days, along shorelines, and exclusively in preserved areas away from floating structures. Fish were anesthetized with eugenol, measured, sampled via dorsal aorta puncture, and released with a 100% survival rate. Hematocrit (Ht), hemoglobin ([Hb]), total proteins (PRO), albumin (ALB), globulin (GLO), cholesterol (COL), and triglycerides (TRI) were analyzed. Mean Ht for C. temensis was 37.4 ± 1.9%, and [Hb] did not differ significantly (p greater than 0.05) between C. temensis (5.06 g/dL) and C. orinocensis (4.67 g/dL). Overall plasma biochemical means ± SD (n = 27) were: PRO, 3.39 ± 0.60 g/dL; ALB, 1.73 ± 0.35 g/dL; GLO, 1.65 ± 0.69 g/dL; COL, 189.62 ± 48.11 mg/dL; and TRI, 115.93 ± 56.84 mg/dL. PRO and ALB were relatively homogeneous across individuals, whereas GLO (CV: 41.82%) and TRI (CV: 49.03%) showed wider dispersion, reflecting differences in diet and prey availability. All parameters fell within normal reference ranges for Cichla, indicating healthy physiological status. Nevertheless, the restriction of captures to undeveloped shorelines highlights the urgency of conserving marginal habitats in the Tarumã-Açú watershed.

Keywords: Cichla; Hematology; Plasma biochemistry; Rio Negro; Sport fishing; Urban impact.

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1. INTRODUCTION

The Amazon is characterized as the richest subcontinental ecosystem in terms of number and diversity of species, harboring more than 10% of all plant and vertebrate species ever identified and cataloged. This rich biodiversity is distributed across less than 0.6% of the entire Earth's surface (Guayasamin et al., 2021). Beyond its fantastic exuberance, biodiversity, and scale, the Amazon is the region responsible for global ecosystem services. Among these, we can highlight terrestrial photosynthetic productivity, accounting for approximately 16% of the global total (Malhi et al., 2021), as well as the biogeochemical cycles of carbon and water (Jung et al., 2021; Costa et al., 2021).

The Amazon region is home to the most extensive river system on the planet, characterized by a complex system of different types of lakes, interconnected by floodplains. This vast water system sustains a rich biodiversity (Oliveira et al., 2025). The Rio Negro stands out in this region, being the second largest tributary in terms of water volume, with an area of over 710,000 km². In this region, the dynamics of the water system are regulated by the flood pulse, with periods of high water, low water, and drought. This seasonality is characterized by significant variations in the region's water levels. These variations alter the physical, chemical, and physicochemical parameters of the water, which in turn alter ecological parameters, impacting the behavioral and physiological dynamics of aquatic organisms, especially fish (Aride et al., 2006).

The Tarumã-Açú Hydrographic Basin is located entirely within the urban area of the city of Manaus (2°31'54.36" and 3°5'13.96", 60°11'44.78" and 59°52'16.02"). This basin has a total area of 1,388.93 square kilometers, which corresponds to approximately 12% of the area of the city of Manaus. This basin is formed by a vast drainage network due to the morphological characteristics of the basin itself, which presents tabular surfaces and hills.

The main tributaries that form it are: Tarumã-Açú, Tarumãzinho, Preguiça, Canaã, Igarapé do Leão, Igarapé da Bolívia, and Cabeça Branca. Several activities take place in the flooded and drainage area of the Tarumã-Açú Hydrographic Basin, among which we can highlight recreational activities (nautical and sport fishing), housing (floating houses and sites on the banks and dry land), floating and dry land commerce, and fuel supply pontoons. Among the

extractive activities carried out in the Amazon region, fishing involves the largest population contingent in the region (Fabré & Alonso, 1998). People from different social strata and originating from different municipalities are involved in fishing and fish farming, acting both for direct food consumption and for commercial purposes (Batista & Petrere, 2004).

In the Amazon, the importance of fishing dates back to a period prior to colonization, when indigenous communities already used fish as a primary component of their diet, constituting the main source of animal protein (Batista & Petrere, 2004). In Central Amazonia, commercial fishing activity aims at regional consumption (far from the urbanized center of the city of Manaus) and supplying the consumer market in Manaus. In the Tarumã-Açú Basin region, there is currently a spatial occupation, by floating structures, that serve as housing and leisure areas, which has recently generated some legal actions for their regularization, given the proliferation of these structures in recent years.

In the Tarumã River basin region, which is directly associated with the urban area of Manaus, we must have the necessary concern for maintaining environmental quality. Furthermore, the profile and methods of fishing developed in this region must be monitored and regulated for the planning and management of the sector (Gonçalves & Batista, 2008). To this end, we must establish methodologies for analyzing the health status of fish, so that we have not only the stress profile of these fish upon capture, but also an assessment of their general health status, which reflects the quality of the environment in which they are found. Thus, hematological and biochemical parameters are considered excellent tools in clinical evaluation.

For vertebrates, the analysis of blood patterns provides important information to aid in the diagnosis and prognosis of morbid conditions (Tavares-Dias & Moraes, 2004; Aride et al., 2017). In fish, the characterization of health status is often based on physical examination and evaluation of blood constituents, using reference values from the hemogram and plasma biochemistry. However, there are several species of aquatic organisms, mainly native species, for which blood parameters are unknown or imprecise. Variables related to the red blood cell series have been used in the diagnosis of anemic processes (Tavares-Dias & Moraes, 2004), as indicators of the systemic response to external stimuli (ARIDE ET AL., 2006), while osmoregulatory disorders and the leukogram are used to aid in the diagnosis of infectious processes (Tavares-Dias & Moraes, 2004) and other homeostatic imbalances.

Blood production in aquatic organisms occurs in myeloid and lymphoid tissues, since teleosts lack bone marrow and lymph nodes (TAVARES-DIAS AND MORAES, 2004). A characteristic of freshwater fish blood is that it possesses red blood cells with a nucleus, called erythrocytes, which are the most numerous in the blood. The function of these cells is the transport of oxygen and carbon dioxide, a task performed by their main component, hemoglobin (Tavares-Dias & Moraes, 2004; Val et al., 2015).

Regarding plasma metabolites such as glucose, triglyceride, cholesterol, total protein, urea, and chloride levels, these are usually related to dietary conditions. However, glucose levels can also be an indicator of stress conditions (Aride et al., 2010), as can chloride levels, which can indicate imbalances in ionic regulation, usually reflecting poor water quality. Despite the great importance of hematology, there is still scarce literature on the Tucunaré species in the Tarumã Hydrographic Basin region.

Thus, the aim of th present study was to classify, through physiological and biochemical analyses, the species of Peacock Bass captured in the Tarumã-Açú river basin using artificial fishing techniques. The characterization of the data obtained was correlated with the environmental conditions of the region, mainly in relation to climate change and extreme events.

2. MATERIAL AND METHODS

2.1. Study area STUDY AREA.

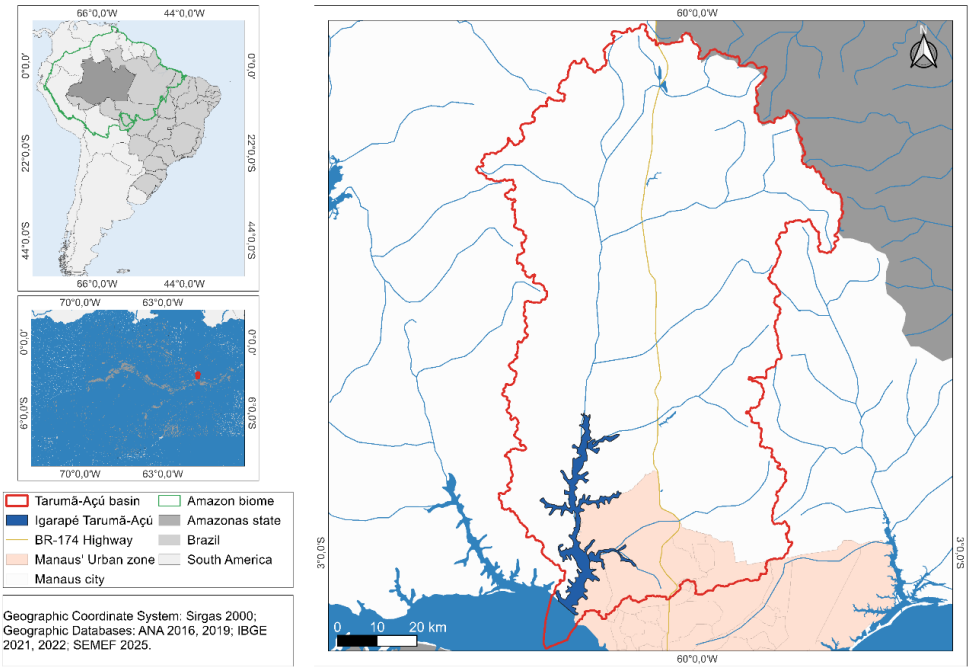
The lower Rio Negro region covers an area of 620,000 km² and is located in the Amazon sedimentary basin, with a reference orientation of ENE-WSW (FERREIRA et al., 2015). Deposition in the Amazon basin began in the Neo-Ordovician period with glacial to marine sedimentation of the Trombetas Group. The Tarumã-Açú basin region is located in the Javari Group (Alter do Chão Formation and Solimões Formation), which includes fluvial-lacustrine clastics that are part of the Cretaceous-Tertiary boundary (Paleogene and Neogene), whose evolution is linked to Andean orogenic activity (Reis et al., 2006).

The Alter do Chão Formation predominates in the Tarumã-Açú basin area, with a composition of reddish sandstones, siltstones, conglomerates, and intraformational stratigraphic gaps dated to the Upper Cretaceous-Paleogene (Kistler, 1954). These characteristics are associated with depositional environments in fluvial, lacustrine, or deltaic systems (Kistler, 1954; Caputo, 1984; Reis et al., 2006; Hoorn et al., 2010).

The climate in the study area is classified as Superhumid (Antonio, 2017), with a three-month period of mild to moderate drought (July to September), six months of wet season (December to May), and two months of transition (June and October). The average annual temperature is around 26 ºC (MeloO, 2017). The soil types found in the region are Yellow Latosol on the plateaus, Red-Yellow Podzolic soils on the slopes, and hydromorphic sands in the lowlands (PROAMBIENTE, 2002).

The Tarumã-Açu Hydrographic Basin is located in the western zone of Manaus, Amazonas, encompassing the Tarumã-Açu River, a tributary of the Rio Negro, approximately 20 km from the city center, and is accessible by river (Rio Negro) and land (BR-174 and AM-010).

Figure 1. Map with the Tarumã-Açu basin highlighted



Source: The authors (2026).

2.2 Catch, Morfometry and Blood Colection.

By August 2026, 29 field sampling events had been conducted (22 in the Tarumã-Açú and 5 in the Tarumã-Mirim). Of these, individuals of the genus Cichla were captured in 18 events. Species not targeted by the research but known to strike artificial lures were also captured. All animals underwent anesthesia (eugenol diluted in water), full morphometric measurements, and photographic documentation; blood samples were collected via puncture of the dorsal aorta at the caudal peduncle using disposable syringes containing the anticoagulant heparin (5000 IU). Following these procedures, the fish were released back into the environment as close as possible to the capture site. There was no mortality during any of the sampling events (100% survival).

Of the captured specimens (27 individuals of the family Cichlidae, genus Cichla), five exhibited some form of injury (missing an eye, or attack marks on the body or tail), indicating a low percentage of injured individuals. All captures took place during the morning, consistently near the banks of the Tarumã-Açú River (near steep banks or beaches, and always away from floating structures).

Levels of Hematocrit (Ht, %) and Hemoglobin concentration ([Hb], g/dL) were analyzed using a portable hematocrit/hemoglobin meter.

After blood separation by means of centrifugation, Plasma samples were immediately frozen. The levels of glucose (g/dL), total proteins (g/dL), triglycerides (mM/L), cholesterol (mM/L), albumin (g/dL) and globulin (g/dL) were ascertained using specific enzyme kits (Labtest) and were read by means of spectrophotometry. The Shapiro-Wilk normal test was performed on the data. All of the analyses mentioned above were based on Zar (1999) and Siegel and Castellan (2006).

3. RESULTS AND DISCUSSION

Fish collection through sport fishing, using fishing rods, reels, and artificial lures, aimed to establish a pattern of individual collection of peacock bass species present in the Tarumã-Açú hydrographic basin. Morphometry was performed immediately after the fish were captured, and they were subsequently identified (to the species level). Immediately afterwards, blood was collected via the dorsal aorta. In general, the entire

procedure (from capture to returning the animal to the water with a holding pliers to begin recovery) lasted approximately 1 minute on average. After placing the fish in the water for recovery, they were allowed to regain their balance before being released. Of the captured specimens (27 individuals of the family Cichlidae), five exhibited some form of injury (missing an eye, or attack marks on the body or tail), indicating a low percentage of injured individuals.

Regarding the seasonality of the Central Amazon water system, we have already covered a period of receding water and the dry season (2025), as well as a period of rising water and the flood season (2026). Preliminary collections and analyses indicate that individuals of the family Cichlidae strike, whether for feeding or nest defense, primarily during the morning, between 7:00 AM and 1:00 PM on sunny days, when light penetration in the euphotic zone is highest. The most effective lures are mid-water baits, which operate at depths of 30 to 60 cm below the surface. Preliminary data demonstrate that the specimens collected in the Tarumã River Basin are in excellent health. For the most part, the animals exhibited hematological and biochemical profiles ranging from satisfactory to good, thereby establishing a normal health status; this reflects their adaptive capacity in the face of environmental changes in the Tarumã basin (such as the presence of floating structures, various vessels, oil in the water, and noise, among other factors).

Based on data obtained since september 2025, the prevalence of catches is concentrated during the flood season, between October/November and May/June. Regarding the weather at the time of capture, there is a prevalence for hot and sunny days. On cloudy days, there are capture data, but in a lower percentage. In this context, we can infer that water temperature may be influencing fish activity, thus generating a more active search for food, and consequently reflecting in effective catches. Furthermore, we can verify, based on the tabulated data, that the highest percentage of catches is concentrated with mid-water lures (more than 92%). These data corroborate authors who describe the capture of peacock bass species between the same range depth (Thomé-Souza et al., 2014; Castro et al., 2021).

To date, 27 individuals of the genus Cichla have been caught via sport fishing in the Tarumã-Açú basin. Of these catches, 23 were C. temensis (85%) and 4 were C. orinocensis (15%). Six (06) catches involved shallow-running lures (maximum depth of 30 cm), while twenty one (21) involved deep-running lures (up to 200 cm depth). All catches took place during the morning, consistently near the banks of the Tarumã-Açú (near steep banks or beaches) and in areas free of floating structures. The data indicate that the captured fish are distributed across steep-bank and beach areas, specifically in locations lacking floating structures. Preliminary data show that catches are concentrated in preserved areas devoid of human presence or floating structures.

The Ht values for fish caught via sport fishing in the Tarumã basin fall within the ranges described by Castro et al. (2021) for specimens of the genus Cichla caught in the Balbina reservoir. For the species C. temensis, our result shows a mean of 37.4 (±1.9) a value higher than that described by Tavares-Dias et al. (2011) but lower than the value for C. monoculus (58.0 ± 1.0%) reported by Ranzani-Paiva et al. (2000). This difference may be related to the quality of the collection environment, food availability, and ecological balance. The Hb values showed no significant difference ($p > 0.05$) between the species in the Tarumã basin (5.06 $g \cdot dL^{-1}$ for C. temensis and 4.67 for C. orinocensis). The data are consistent with the gradient described for the species.

Table 1. Means of morfometric data and Hematological parameters of 27 peacock bass caught in the Tarumã-Açu and Tarumã-Mirim river basins.

Variables	***C. temensis***	***C. orinocensis***
Total lenght (cm)	31.94 (±21.6)	29.60 (± 6.63)
Weight (g)	582 (± 231.4)	281.1 (± 83.4)
Hematocrit (%)	37.40 (± 1.9)	36.7 (± 1.07)
Hemoglobin ($g.dL^{-1}$)	5.06 (±0.72)	4.67 (±0.93)
RBC ($x10^6/\mu l$)	1.67 (±0.26)	1.41 (± 0.23)
VCM	223,95 (± 38.1)	260.28
HCM	30,30 (±5.66)	33,12
CHCM	13,53(±2.04)	12.72
Glucose ($mg.dL^{-1}$)	32,4 (±2.79)	26.1 (±0,06)

Source: The authors (2026).

Biochemical parameters were analyzed for 27 individuals specimens, considering the concentrations of total protein (PRO), albumin (ALB), globulin (GLO), cholesterol (COL), and triglycerides (TRI) (Table 1). Descriptive statistics revealed differences in the magnitude and variability of the parameters evaluated.

Table 2. Descriptive statistics of the biochemical parameters of 27 peacock bass caught in the Tarumã-Açu and Tarumã-Mirim river basins.

Parameters [1]	Variables[2]											
	Mean	DP	Median	Q1	Q3	Mín.	Max.	Range	CV	Skewness	kurtosis	EP
PRO	3,39	0,60	3,34	2,86	3,93	2,64	4,19	1,55	17,72	0,03	-1,86	0,19
ALB	1,73	0,35	1,58	1,47	1,86	1,42	2,39	0,97	20,23	0,80	-1,03	0,11
GLO	1,65	0,69	1,64	1,22	2,00	0,73	2,74	2,01	41,82	0,18	-1,42	0,22
COL	189,62	48,11	186,30	154,40	210,30	134,92	283,73	148,81	25,37	0,58	-0,98	15,21
TRI	115,93	56,84	101,50	79,88	127,44	63,90	256,39	192,49	49,03	1,36	0,89	17,97

[1] PRO = Total Proteins (g/dL). ALB = Albumin (g/dL). GLO = Globulin (g/dL). COL = Cholesterol (mg/dL). TRI = Triglycerides (mg/dL). [2] n = number of individuals; DP = standard deviation; Q1 = first quartil; Q3 = third quartil; CV = coefficient of variation (%); EP = standard error of the mean.

Source: The authors (2026).

For PRO concentrations ranged from 2.64 to 4.19 g/dL, with a mean of 3.39 ± 0.60 g/dL and a median of 3.34 g/dL. The first and third quartiles were 2.86 and 3.93 g/dL, respectively, indicating that 50% of the individuals fell within this range. The observed total range was 1.55 g/dL. The coefficient of variation (CV) was 17.72%, the lowest among the five parameters evaluated. The proximity of the mean to the median, combined with a skewness coefficient of 0.03, demonstrates an approximately symmetrical distribution of PRO values in the sample. The data are consistent with the literature on peacock bass species (Machado & Duncan, 2017).

For ALB, concentrations ranged from 1.42 to 2.39 g/dL, with a mean of 1.73 ± 0.35 g/dL and a median of 1.58 g/dL. The interquartile range was defined by a first quartile of 1.47 g/dL and a third quartile of 1.86 g/dL. The total range was 0.97 g/dL, and the

CV was 20.23%. The mean being slightly higher than the median, along with a positive skewness coefficient (0.80), indicates a tendency for values to cluster in the lower ranges, accompanied by a few relatively higher values. The results are consistent with those found by Machado & Duncan (2017). In general, a reduction in the levels of this protein typically raises ionized calcium (Ca^{2+}) levels, since serum albumin is a major protein that transports calcium in the blood (Orrell, 1971).

Level of GLO concentrations showed greater dispersion compared to the other protein components, ranging from 0.73 to 2.74 g/dL. The mean was 1.65 ± 0.69 g/dL and the median was 1.64 g/dL—values quite close to each other. The CV was 41.82%, indicating high relative variability among individuals compared to the values observed for PRO and ALB. Despite this dispersion, the skewness coefficient was low (0.18), indicating relative symmetry in the distribution of GLO values, same results showed by Machado & Duncan (2017).

Regarding the lipid profile, COL concentrations ranged from 134.92 to 283.73 mg/dL. The mean concentration was 189.62 ± 48.11 mg/dL, while the median was 186.30 mg/dL. The first and third quartiles were 154.40 and 210.30 mg/dL, respectively, with a total range of 148.81 mg/dL. The coefficient of variation was 25.37%, indicating intermediate variability compared to the other parameters evaluated. The skewness coefficient of 0.58 demonstrates slight positive skewness, associated with the presence of higher concentrations in some individuals, with a maximum value of 283.73 mg/dL. The study by Castro et al., (2021) describes the same concentration gradient. On the other hand, Ramos et al. (2014) reported that the total cholesterol levels were higher (6.74 ± 1.85 mM.L-1) in pirarucus (Arapaima gigas) originating from black water. These differences can be related with life habits or with differences in body profile.

The TRI showed the greatest variability among the biochemical parameters analyzed. Values ranged from 63.90 to 256.39 mg/dL, with a mean of 115.93 ± 56.84 mg/dL and a median of 101.50 mg/dL. The CV was 49.03%, the highest observed among the

analyzed variables. Furthermore, TRI showed a skewness coefficient of 1.36, also the highest among the parameters. The mean exceeding the median and the positive skewness reflect the presence of high concentrations at the upper end of the distribution, particularly the maximum value of 256.39 mg/dL. Similar data have been described for tambaqui (Farias et al., 2025), and also for the tambaqui (C. macropomum) and pacu (P. brachypomus) hybrid (Silva et al., 2025).

Comparatively, PRO showed the lowest relative variability (CV = 17.72%), followed by ALB (20.23%), COL (25.37%), GLO (41.82%), and TRI (49.03%). Thus, the protein components PRO and ALB showed greater relative homogeneity among individuals, whereas GLO and, especially, TRI demonstrated greater heterogeneity. Among the lipid variables, TRI showed dispersion that was proportionally greater than that observed for COL.

The preliminary data presented in this study demonstrate the good health status of the sampled individuals, with hematological and biochemical parameters consistent with the profile described for individuals of the genus Cichla.

Regarding the capture sites, all were effectively carried out away from floating structures. Thus, areas without human presence or interference were the main collection areas for species of the genus Cichla. Captures occurred in beach and bank areas. The differences in the biochemical profile may also be related to feeding habits and resource availability, given that individuals of Cichla gender exhibits predominantly piscivorous behavior and can modify its diet according to size and location (Aguiar-Santos et al., 2018).

ACKNOWLEDGMENTS

The authors would like to thank the Federal Institute of Education, Scienceand Technology of Amazonas (IFAM), the Foundation for the Support of Teaching, Research, Extension and Outreach at IFAM (FAEPI), the Federal University of Amazonas (UFAM), Amazon State Research Support Foundation (FAPEAM), the National Council for Scientific and

TechnologicalDevelopment (CNPq) and the Center for Studies of Invertebratesand Vertebrates of the Amazon (NEIVA). PHRA is a FAPEAM Research Productivity Fellow (proc.no.01.02.016301.02472/2025-05). ATO is a CNPq Research Productivity Fellow (proc. 310966/2025-6) and Post-Doctoral studies at the Amazonas State University (UEA). The Project PDPG CAPES/FAPEAM Notice N.018/2020.

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