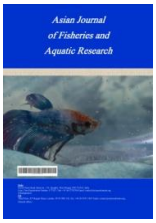

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Ethnoichthyological Study of Biological Characteristics and Ecology (*Salminus brasiliensis*: Teleostei/Characiform): Importance, Status and Conservation Challenges in the Region of Mato Grosso, Brazil

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Authors' contributions

This work was carried out in collaboration between both authors. The first ESOD author conceived and designed or scope of the study. Author DPLJ wrote and structured the manuscript. Authors ESOD and DPLJ contributed to the improvement of the article, carrying out a careful review. Both authors read and approved the final manuscript.

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ABSTRACT

Introduction: Salminus is a genus of ichthyofauna currently constituted by five species of migratory neotropical fish, predators, which are important in commercial, ecological and sport fishing.
Aims: The article reflects the conception of fishermen about the ecological interrelationships of ichthyofauna, the relationship with sport fishing, aspects of trophic interactions among fish, the use of habitats aimed at feeding or reproduction and relations with fishing activity.
Methodology: Study carried out in the state of Mato Grosso, central region of Brazil. 122 fishing

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professionals and artisanal fishermen were interviewed. The testimonies were obtained through phonographic interviews, carried out during visits in temperate sport fishing from 2018 to 2020, verifying questions related to fishing and the study specimen *S. brasiliensis.*

Results: Among the interviewees, 37 were sport fishermen (30.3%), 22 artisanal fishermen (18.1%) and 63 guide fishermen (51.6%). The interviewees reported several situations and approaches on the problems generated by sport fishing in the State. The results were consistent with the scientific literature and revealed detailed knowledge about the survival strategies of *S. brasiliensis.* The answers revealed the fishermen's observations on the decrease in fishing resources, the scarcity of species and the conflicts related to sport fishing, making it necessary to look for the best ways of recovering and conserving native species and monitoring in the surveyed places.

Conclusion: *S. brasiliensis* is an example of the ichthyofauna that is much sought after by sport fishing. The interviewees demonstrated important perceptions of the changes that are occurring in the rivers of Mato Grosso and it was found that it is necessary to intensify studies looking for ways to recover and conserve the native ichthyofauna in the region. The results obtained aim to promote social contributions and partnerships with professional and artisanal fishermen, encouraged to achieve a better harmony between fishing and nature, creating actions that can be extended to indigenous, quilombola and riverside peoples.

Keywords: Biodiversity; sport fishing; animal welfare; conservation; fresh water.

1. INTRODUCTION

The neotropical region stands out worldwide for having the largest number of freshwater fish species. The freshwater and marine fish faunas of South America are the most diverse on Earth, with current estimates of species richness above 9,100 species. In addition, in the last decade, at least 100 species have been described each year. There are currently about 5,160 species of freshwater fish, and only the estimate for freshwater fish fauna points to a final diversity between 8,000 and 9,000 species [1]; only for the Amazon basin, 2,716 species were recorded and for the rest of South America 2,434 species were estimated [2].

In Brazil, there are approximately 2,500 freshwater species [3]. Throughout South America, the Salmininae are among the most consumed fish of the Characidae family and the description of the species consider the genus Salminus as migratory, called potamodromous species, being one of the most attractive species for sport and commercial fishing and, despite this, has suffered a great reduction in their populations [4]. Information on the reproductive biology of *S. brasiliensis* is still scarce and little widespread [5].

Fishing in the Mato Grosso region is an old activity. The first historical reference on the existence of the dourado (golden) fish, dates from 1542 and 1544, made by the Spanish pioneer Álvar Nuñez Cabeza de Vaca, when he discovered the Iguaçu Falls, a region that was inhabited by the indigenous Guarani ethnicity [6].

The dourado fish, piraju, pirajuba and saijé as this representative of ichthyofauna is known in Brazil, and its parental species, taxonomically belong to the genus Salminus, Sub-family Salminae, family Characidae, order Characiformes, sub-class Actinopterygii, class Osteichthyes, infra-class Teleostei.

Inside the Teleostei infraclass are the superorder Ostariophysi. The name refers (ostar = small bone) that connect the swimming bladder (physa = bladder) to the inner ear, forming a system known as weber's apparatus. This superorder with the largest number of species in the world's rivers, has 28% of the total species of fish and more than 68% of freshwater fish [7].

It is a very diverse group, with more than 6,500 species, which include catfish, carp, barbus, electric fish, banded knife fish (tuviras) and characiformes (order that encompasses many of the fish with known scales in Brazil) [3].

Some members of this order are extremely colorful (many are silvery). Many species are popular aquarium fish (often known as tetras). In South America, many specimens of ichthyofauna are important in food, such as the genus Brycon [7].

Almost all species captured in monitoring in the areas of influence of hydroelectric plants,

rescued in drainages and/or involved in accidents in Brazil: mandi (*Pimelodus maculatus*), curimbatá (*Prochilodus* sp.), dourado fish (*Salminus* spp.), barbado fish (*Pinirampus pirinampu*), piau *(Leporinus* sp.), roncador fish (*Werteimeria maculata*), serrudo fish (*Franciscodoras marmoratus*) among others, belong to this group [3].

The group of bony fish, present enormous synomy, however, five species are considered valid and widely distributed in South America for the genus Salminus: *Salminus brasiliensis* (Cuvier, 1816), *S. hilarii* (Valencienne, 1850), *S affinis* (Steindachner, 1880), *S. iquitensis* (Nakashima, 1941) and *S. franciscanus* (Lima & Britski, 2007) (Fig. 1).

Salminus affinis is native to the Magdalena river basins in northern Colombia and the Rivers Ecuador, Bolivia and Peru; in addition to the Orinoco basin where it is known as dourado silver, dourado fish, dorada, rubia, picuda, picudo or burst fish. In Brazil, it is found in the São Francisco river basin, in the Grande and Tietê rivers of the Platina basin, in the Tocantins and Madeira rivers of the Amazon basin [8].

It is the species of the genus Salminus, which has the largest geographical distribution in South America. It is smaller in size and does not have a golden color. Steindachner [9], in describing *Salminus affinis* considered this species very similar to that described today *S. franciscanus* (= *S. cuvieri,* hence the epithet "affinis").

Salminus hilarii, is a migratory characid smaller than its best known congeneric golden relative, presenting many similarities with the dourado fish (*S. brasiliensis*), is known sport fishing of "Tabarana" or "Tubarana" and yet due to these similarities with the cousin of golden color, is also called dourado fish [10]. It has occurrence in the rivers high Tocantins and Amazonas, Araguaia, low Tocantins, Guaporé, Beni-Madre de Dios, Putumayo (Içá), Japurá, Branco, Paraná-Paraguay [2].

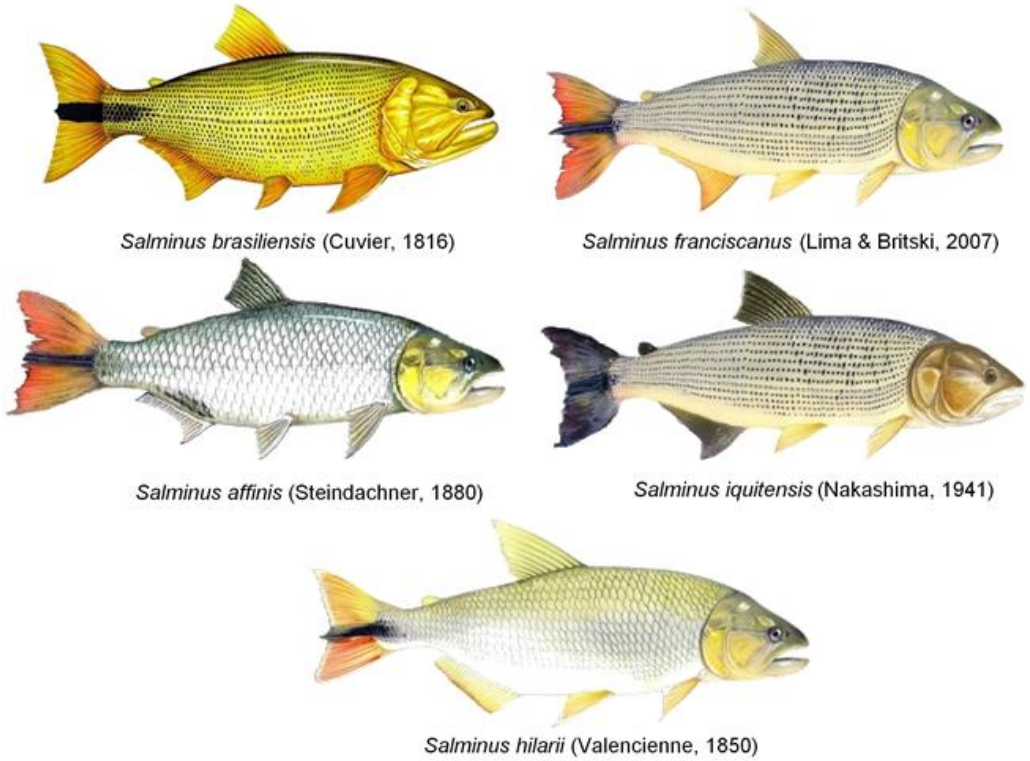


Fig. 1. Representative scheme (illustration) of species of Characidae (Salminae) representing the genus Salminus, described in this study

Illustrations of fish of the genus Salminus. Salminus brasiliensis. Source: Scalon L. Salminus franciscanus. Source: Fiote P.H. Salminus affinis, S. hilarii and S. iquitensis, Leite-Jr D.P. characterization, based on description of the species.

This species is considered an indicator of environmental integrity, due to its high degree of demand for water quality and the environment. Migrant, potamodromous, piscivorous and lives in bentopelagic environments. The specimen needs water rich in oxygen and is considered top species in the food chain. It also has a preference for small bodies of water, making *S. hilarii* susceptible to local extinctions [11,12].

Salminus franciscanus, an endemic species of Brazil, representative of the São Francisco river basin, a large typically commercial fish, is the second largest fish in the São Francisco river and despite being a known fish for centuries, its taxonomic classification was originally described in 2007 is one of the most important fish in professional and amateur fishing of the São Francisco river [13].

Following *Salminus iquitensis,* representative rivers of the High and Low Tocantins, Araguaia, Mamoré, Beni-Madre de Dios, middle Madeira, Purus, Juruá, Ucayali, Marañon-Nanay, Putumayo (Içа), Japurá, Branco, high Orinoco, Apure [2].

This species was originally described in 1941 by Japanese ichthyologist Shoji Nakashima as species from eastern Peru. The term "*iquitensis*" refers to the region where the type was collected, the surroundings of the Peruvian city of Iquitos. A species questioned because it looks like *S. hilarii*, and morphologically similar to *S. affinis*, distinguishes, from the other specimens of the genus, by presenting small and numerous longitudinal dark stripes, concentrated in the central part of the caudal fin and dark pigmentation in the interradial membranes of the caudal fin [8,13,14].

Finally, *Salminus brasiliensis* (holotype from the Cuiabá/MT river), which include synonymous *S. brevidens* and *S. maxillosus*; which are often used in the biological and fishing literature, being an instrument of documentary record of this research. Lima[14] described the classification of this species cited by other authors as: *Hydrocynus brasiliensis, Hydrocyon brevidens Salminus cuvieri, Salminus orbygnianus, Salmo auratus, Salmo vigintiseptemradiatus,* where all these names were considered synonymous with *S. brasiliensis.*

This emblematic species of ichthyofauna has a wide geographical distribution native to southern South America, naturally from the Paraná, Paraguay, Uruguay and Jacuí rivers (Prata basin) and drainages of the Laguna dos Patos, still found in Bolivia in the basins of the Mamoré river, Beni-Madre de Dios, middle-low Madeira and the upper Chaparé river and Amazon basin [1,2].

This representative of freshwater aquatic fauna, can still be found distributed in Brazil in the São Francisco and Doce rivers and Paraíba do Sul basins, covering the states of Mato Grosso, Mato Grosso do Sul, Pernambuco, Bahia, Alagoas, Sergipe, São Paulo, Minas Gerais, Paraná, Rio Grande do Sul and southern Goiás, popularly known as dourado fish is the species that has the greatest potential for fish farming. For having exuberant size and coloration, with sharp shades of yellow-gold, spread throughout the body, with reddish reflections, leading to the popular level of "king of river"; it was already very abundant in Brazilian rivers, especially in the Southeast and Midwest regions of Brazil [10].

Due to its behavior, it is highly appreciated, constituting one of the most sought after species by fishermen in commercial, sport and recreational fishing [5].

The dourado fish inhabits lotic environments, fast waters, rapids and waterfalls, as well as the banks of ravines, coryx and antlers in the middle of rivers. It usually swims in shoals, is a muscular fish, with a body similar in structure to salmon, has a large head and a mouth that reaches half of it, full of canines in conical form, with a robust caudal fin typical of inhabitants of rapids, is an example of excellent zootechnical characteristics [15].

In the early stages of development, species of the genus in free life are planctivorous and when adults present predatory behavior thus playing a fundamental role in the dynamics, functioning and structure of aquatic ecosystems [4], when adults present throughout their ontogeny, usually ichthyophagous feeding habits, being the feeding habit of this species, undoubtedly an obstacle to the success of its creation , because it is a carnivorous animal, thus requiring foods rich in high quality protein, making high expenses with its diet [15].

The average life time is 15 years and its size varies according to its habitat; specimens of 70 to 75 cm and weight from 6 to 7 kg are found in the Paraguay Basin in the Pantanal. In the Prata Basin and the São Francisco Basin, some rare

specimens can reach 20 kg. The species presents the so-called sexual dimorphism (morphological differences between the sexes), where females are usually larger than males, and can reach more than one meter in length, being frequent between Characidae and Siluridae.

According to some researchers; the dourado fish male has hook-shaped thorns "tuft" in the anal fin, and are rough, which does not occur in females [16]. In Mato Grosso, on the Juruena river, upper Tapajós river basin; Pastana et al, [17] found sexual dichromatism present in characiformes, found in a new species of lambari, characterized a sexual dimorphism for this species.

The reproductive aspect of this species of Salminae is well known, being a piracema* fish (tupi-guarani "ascent of fish for spawning") that reproduces in the high stretches of rivers in the flood season, which coincide with the hottest months of the year between October and March [18].

Salminus brasiliensis and *Salminus franciscanus* are the two Brazilian species known popularly as dourado fish. The first, whose name derives from “Brazilian” in Latin; species well distributed throughout the country; and the second species because it was found and lives in the São Francisco river and its tributaries - hence the Latin name, "*franciscanus*".

The distribution of specimens of the genus Salminus distributed throughout South America can be seen on the map, showing the location of the five species described so far (Fig. 2).

Fig. 2. Representative map of the geographic distribution of the genus Salminus by South America (larger scale) and Map of Mato Grosso, central western region of Brazil (smaller scale) showing the location of the points where the interviews were conducted in the period 2018 to 2020 and their respective hydrographic basin, highlighted in color

Map of the State of Mato Grosso, with the respective hydrographic basin (left). The stars in red indicate the location where the interviews were conducted for data collection. Map of South America, representing the geographical distribution of the species of the genus Salminus described in this study (right). In the central region of the map of Brazil (right), location of the map of Mato Grosso, center west region of the Country. Source: Dacosta & Pina [2]; Lima & Britiski [13]; Freitas [80], Machado et al; [81]. Adapted Leite-Jr, D.P.

Studies in ethnology, extended to the scope of ethnobiology, are opposed when it is intended to combine the knowledge obtained by natural sciences, in order to capture and bring together traditional zoological knowledge of local species, through the manifestations of human beings in relation to existing fauna, which has led to studies in this area to generate responses related to the way humans conceive, represent and relate to animals and the maintenance of ecological systems [19,20].

Due to the scarcity of studies related to the ichthyofauna of the regions of the Mato Grosso rivers, and studies specifically focused on the biology of the genus Salminus are still scarce for the region, despite the commercial and ecological importance presented by Salminus species, taxonomic, phylogenetic and phylogeographic knowledge are still scarce, denoting the importance of this study, aiming at the establishment of management plans and measures to preserve this species in this and other hydrographic basins.

The objective of this work was to obtain the knowledge of the fishermen about the ecological interrelationships of the ichthyofauna and the relationship with sport fishing, against the specimen *Salminus brasiliensis.*

The present study presents observational characteristics portrayed through ethnobiological reports, in this case called ethnoichthyological, because it is a fishing reference. Scientific research around the ecological aspects of dourado fish can increase the knowledge of the species so that proper management is used due to the reopening of fishing.

The results presented were acquired by evaluations and interviews conducted during 2 years and 3 months of reports of conversations with professional fishermen, which generated this review, aiming to address the descriptive aspects in relation to biology, behavior and management of the dourado fish, scientifically *Salminus brasiliensis*, investigating the perceptions of sports fishermen, artisanal fishermen and fishing guides (boatmen), about the changes resulting from anthropogenic action in local strains and municipalities, which is a representative of the Brazilian ichthyofauna that supports management well, has an intensive cultivation system, besides being a species with high market value and much sought after for sport fishing and fishing-release, due to its performance on the hook, characteristic of bravery and endurance when hooked, because they usually make spectacular jumps out of the water; becoming a species much coveted by fishermen.

2. MATERIALS AND METHODS

2.1 Target Population

To verify and analyze the sport fishing practiced in the rivers of Mato Grosso/Brazil, localities were chosen, close to the banks of the rivers Manso, Cuiabá and Paraguay, where 10 visits were made between the months of May 2018 and August 2020. For the collection of information, the usual techniques of ethnophonic recording were used, captured through an interview in a recorder for the respective phonographic records, where 122 professionals involved in sport fishing were interviewed. The interviewees were selected at random, those who were available at the time for the interview, during the 8 hours in which the researchers were present at each location of the interviews.

2.2 Study Area

The areas covered by the study were carried out in five locations that maintained sport fishing areas located in the Paraguay river basin in the Middle-west region of Brazil, in the south central part of the state of Mato Grosso; highlighting Pantanal Reserve Hotel (S16^{o}24'16.0596" W55^{o}59'36.7368") in the Barão de Melgaço city, the banks of the Cuiabá river; Rio Manso Inn (S14º52'33.8304" W55^{o}57'37.7964") located in Chapada do Guimarães, on the banks of the Manso river; Recanto do Dourado Hotel (S16^{o}15'22.4748" W57^{o}47'28.5756") located in Cáceres, on the banks of the Paraguay river; Rancho do Mano Inn (S14^{o}51'21.9492" W55^{o}48'43.434") located in Chapada dos Guimarães, the banks of the Manso river and Itaicy Inn (S15^{o}59'57.804" W55^{o}55'08.6556") located in Santo Antônio do Leverger, on the banks of the Cuiabá River (Fig. 2).

The vegetation characteristic of Mato Grosso is that of transition from Atlantic Forest to Brazilian savannah (Cerrado). Its watershed results in hundreds of springs, which spring from the mountains and give rise to several streams and streams that bathe the municipality. The study site consists of preserved vegetation with the presence of several phytophysiognomy grasses, herbaceous, shrubs and trees composing a rich

flora of the Brazilian Cerrado (riparian forest, gallery forest, dry forest, savannah-like, dirty field, clean field, paths and palm grove), with a lush biodiversity, the Brazilian savannah being the main biome of the Middle-west [21].

The climate of Mato Grosso is characterized by the semi-arid region (hot and semi-humid), with average annual precipitation of 1,500 mm and average annual temperature of 25°C to 40°C. What defines two seasons well is a dry winter and a rainy summer, with an average annual temperature of 26°C; the maximum can reach 38°C and the minimum 8°C. According to the Köppen-Geiger climate system, Mato Grosso, it is characterized as Cwa: subtropical, dry and rainy winter in the summer [22].

In Mato Grosso, central region of Brazil, no study on fishing activity and the management of species in the region has been evidenced in recent years, lacking information on local species and the current situation in which fishing is found in the state of Mato Grosso in relation to the records found in Brazil and worldwide. The genus Salminus was the species used in this context for registration, and *Salminus brasiliensis* was the migratory species (reophilic), considered of great commercial and ecological importance for the study and ethnoichthyological description.

Some of the interviewees provided photographs of the specimens of *S. brasiliensis*, captured during their fishing activities found in the sites surveyed (Fig. 3), showing the activities performed during the fishing of the Salminae specimen.

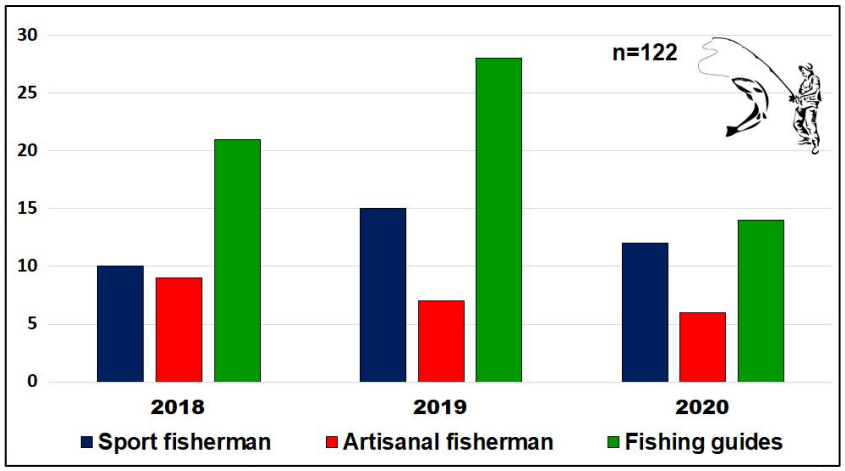
3. RESULTS AND DISCUSSION

In recent years, what has been observed are situations mainly related to the actions taken in relation to fisheries management in natural environments and reservoirs in the Region of Mato Grosso, and the records are inefficient and few conclusive, due to the reasons for failure to be attributed to factors such as scarcity of information of the species, limitations of financial resources for studies, lack of specialized human labor and, lack of monitoring and research related to fishing. Despite the various benefits attributed to sport fishing, the evaluation of the activity suffers from the lack of information and scientific studies.

In order to verify and analyze the sport fishing modality practiced in the rivers of Mato Grosso/Brazil, near the banks of the Manso, Cuiabá and Paraguay rivers, 122 individuals involved in fishing were interviewed, who were available to participate in the research, 37 of which were sport fishermen (30.3%), 22 artisanal fishermen (18.1%) and 63 fishing guides (51.6%). Among the fishing guides (n=63); 52 of them also carried out artisanal fishing (82.5%) and the remaining 11 individuals work only in the activity of guides (17.5%) (Graphic 1).

Fig. 3. Images of the capture and release of specimens of *Salminus brasiliensis* in the locations where the interviews were conducted from 2018 to 2020 in Mato Grosso, Brazil

Photographic record of the capture (image on the left), acclimatization of S. brasiliensis on the riverbed (central image) and release of the salmininae specimen back to the river (image on the right).



Graphic 1. Number of the population surveyed regarding sport fishermen, artisanal fishermen and fishing guides interviewed in the sport fishing regions of the rivers of Mato Grosso/Brazil, in the period 2018-2020

Among the sports fishermen (n=37), the interviews had the participation of fishermen visiting tourists from various regions of Brazil (27; 73%), from the States Mato Grosso do Sul, São Paulo, Minas Gerais, Rio de Janeiro and Paraná, with the majority of these interviewees, representatives of the region of São Paulo state (12, 44.4%), the others were foreign tourists from countries such as the United States and Argentina (10; 27%) (Table 1).

For the demographic aspects of the researched population, in this study, all interviewees who participated in the research were male, involved in fishing activities and had ages ranging from 21 to 68 years (mean = 42.5; SD = 13.5; 95% CI (± 1.9)), being white (26; 21.3%), black (45; 36.9%) and brown (51; 41.8%). The interviewees' time in the fishing profession ranged from six to 45 years. (Table 1).

During the interviews, it was established between the parties that names or any identifications in relation to the interviewees would not be provided and registered, thus establishing a factor of reliability and confidentiality before the answers.

3.1 Fishing Species, Habitat Preservation and Scientific Studies

The global concern to solve the population's biggest problem: lack of food is a major factor for developing countries and the unbridled growth of the population forces man to seek alternatives to solve this problem, as 3/4 of the land is composed of water, it is believed that protein of aquatic origin can be elected to combat this problem [18].

Several species, are represented in the Cuiabá River Basin and its composing our rich Mato-Grossense ichthyofauna such as jaú (*Zungaro jahu*), curimbatá (*Prochilodus lineatus*), cachara (*Pseudoplatystoma fasciatum*), piau-açu or piavuçu (*Leporinus macrocephalus*), piraíba (*Brachyplatystoma filamentosum*), pirapitinga (*Piaractus brachypolmus*), jurupoca (*Hemisorubim platyrhynchos*) and fish that are part of the matrinxã group: piraputanga (*Brycon microlepis=B. hilarii*), jaturana or matrinxã (*Brycon amazonicus=B. cephalus*), piracanjuba (*Brycon orbignyanus*) and the piabanha (*Brycon insignis*) which present as an attribute of their behaviors habits, habitats used for reproduction, growth and feeding during different stages of life of each species.

The interviewees mentioned the species appreciated by the population of Mato Grosso State, and the type of fish in the rivers of Mato Grosso is concentrated in some species, migratory, which have higher commercial value. Among the scalfish, we can highlight the representatives of the order Characiform: piraputanga (*Brycon hilarii*); pacu, (*Piaractus mesopotamicus*); peixe-cachorro fish (*Hydrolycus scomberoides*) and dourado fish (*Salminus brasiliensis*) and the so-called pacupevas (*Myloplus levis* and *Mylossoma orbignyanum*), much required by riverside populations and the local population called cuiabanos.

Table 1. Demographic aspects of the population of sport fishermen, artisanal fisherman and fishing guides interviewed in the sport fishing regions of the rivers of Mato Grosso/Brazil, in the period 2018-2020

Variables		Fishermen interviewed					
		2018		2019		2020	
	n=122	N	%	N	%	N	%
Sex	Male	40	32,8	50	41,0	32	26,2
Age Range	21 – 30 years	12	9,8	10	8,2	10	8,2
	31 – 40 years	9	7,4	8	6,6	7	5,7
	41 – 50 years	11	9,0	13	10,7	11	9,0
	51 – 68 years	11	9,0	10	8,2	10	8,2
Civil Status	Single	4	3,3	7	5,7	6	4,9
	Married	22	18,0	23	18,9	21	17,2
	Divorced	9	7,4	7	5,7	8	6,6
	Widower	6	4,9	5	4,1	4	3,3
Race	White	12	9,8	8	6,6	6	4,9
	Black	18	14,8	15	12,3	12	9,8
	Brown	19	15,6	21	17,2	11	9,0
Other Job	Yes	38	31,1	45	36,9	29	23,8
	Not	2	1,6	5	4,1	3	2,5

In research centers, currently these agencies, have been interested in the creation of the dourado fish, for two reasons: high potential for fish farming, due to its high initial growth and high market price [10]. Studies are being conducted on the behavior and eating habits of *S. brasiliensis*, demonstrating its adaptability according to the conditions of the environment, and its stage of development [15].

However, in recent years research on native species has increased considerably in the country, due to its great diversity of species and its great capacity for growth, among them stand out tambaqui (*Colossoma macropomum*), pacu (*Piaractus mesopotamicus*), surubim or pintado fish (*Pseudoplatystoma corruscans*), pirarucu (*Arapaimas gigas*), dourado fish (*Salminus brasiliensis*), trairão (*Hoplias lacerdae*), jundiá (*Rhamdia quelen* and *Learius marmoratus*) [23], tucunaré (*Cichla* spp.), recently described 15 species that have been identified today, after a large study conducted by Brazilian and Swedish researchers [24]. More recently, Sabaj et al. [25] described a new species in Venezuela called *Cichla cataractae,* composing 16 species for the genus.

Among the leather fish, of the order Siluriform, the preferences for catches mainly stand out those of the family Pimelodidae such as the pintado fish (*Pseudoplatystoma corruscans*), cachara (*Pseudoplatystoma reticulatum*) and the jaú (*Zungaru jahu*) and to a lesser extent the barbado fish (*Pinirampus pirinampu*); jurupensém (*Sorubim lima*) and jurupoca (*Hemisorubim platyrhynchos*).

Carnivorous species such as dourado fish (*S. brasiliensis*), Tucunaré (*Cichla* spp.), Surubins (*Pseudoplatystoma* spp.), and Traira (*Hoplias lacerdae* and *H. malabaricos*) have aroused great interest from researchers and fish producers, mainly due to their commercial value, high quality of meat and sports characteristics for fishing [5,26,27], which makes it necessary to know the behavior of each species, to enable its reproduction and often its creation in captivity.

In Brazil, few species of native fish are suitable for sport fishing, and the introduction of non-native species has been encouraged and even carried out by government agencies, and even by fishermen, with the aim of developing this modality of fishing in the country [28].

The genus Salminus are a very popular group of fish and much appreciated in commercial and sport fishing [5]. Despite its popularity, it has two characteristics that can be evidenced in phylogenetic studies, where they present a very well-sustained monophyly and the relationship of proximity with the genus Brycon recorded in phylogenetic analyses of the genus with the other Characiform [29].

In an observational study conducted in the rivers of the Brazilian cities of Nobres, in the State Mato Grosso and Bodoquena, in the State Mato Grosso do Sul; researchers reported that this

approach as Brycon genus, makes this specimen of the ichthyofauna *S. brasiliensis*/Characidae (dourado fish), a chain-top stalker predator in rivers. The juvenile species of *S. brasiliensis* use predatory tactics by mimetizing with species of *Brycon hilarii*/Characidae (piraputanga) of the same size, hiding among them to obtain their prey [30].

Despite its ecological and commercial importance, the Salminus taxonomy is still poorly resolved [13]. More recently, a new taxonomic rearrangement has been proposed, promoting the genus Salminus for the family Bryconidae, suggesting that Brycon is a paraphyletic group [31]. According to Nelson et al. [7] the classification of this large set of species of the order Characiform is little known, with much morphological diversity and where convergent evolution is common remains controversial.

3.2 Negative Effects of Sport Fishing: Claims or Form of Preservation?

Some authors refer to the negative effects of species considered invasive, which can affect local biodiversity through hybridization, predation and disease transmission [28,32]. Ribeiro et al [33] recorded in their studies, the invasion of *S. brasiliensis* was considered extremely harmful to the local endemic fauna of the Iguaçú River basin, where this species is outside its area of occurrence.

He believes that the biggest problems of fish populations and local wildlife may be related to habitat fragmentation, climate change and pollution. As well as other actions such as mining and illegal fishing that may endanger the conservation of dourado fish and other species of commercial importance, as well as other anthropic activities such as river pollution, eutrophication, hydroelectric dams that have changed the practice, quality and environments of sport fishing [34].

According to Barletta et al. [35] in their research, draws attention to this situation and emphasizes that habitat loss has become the main concern in all freshwater, coastal and marine ecosystems, associated with river damming, deforestation, water pollution, mining, inadequate agricultural practices or inadequate management practices.

In the case of dourado fish (*S. brasiliensis*) the interest in its breeding and the practice of sport fishing has grown continuously, as it is a kind of high economic value, not only for sports fishermen, but for professional fishermen. In the Region of the Manso River in the state of Mato Grosso this species of fish is considered an important example for sport fishing, its morphological characteristics make the dourado a fish conducive to this purpose.

Scarcity of information on taxonomy, phylogeny and phylogeography, hinder measures of adequate conservation for the genus, associated deforestation of riparian vegetation; excessive fishing effort; capture of young individuals; drainage of marginal lagoons; regulation of the hydrological regime of rivers; water pollution; and introduction of exotic species [26].

All the factors reported by the interviewees, associated with the absence of fisheries management in the region, make the decline of fishing resources even more worrying, however the real perception of the interviewees (fishermen and fishing guides) show that they have a broad environmental view of the problems they face.

The results of the interviews, carried out with 122 fishermen revealed that: (78; 64%) of the fishermen have observed the decrease of the fishing resources in the rivers; (37; 30.3%) reported that fishing species are becoming rare or scarce; (42; 34.4%) said that the dourado fish did not disappear completely from the rivers of Mato Grosso; and still (30; 24.6%) of the interviewees, said they perceive that the decrease in fish is happening due to the indiscriminate increase in fishing, influencing the amount of fishing resources. (Table 2).

According to the interviewees' answers, we can observe that the reports of the disappearance and/or scarcity of some species, especially the specimen of greatest interest to fishermen, the dourado fish, it is necessary to look for the best forms of recovery and conservation of recognized native species.

In this perspective, ethnoichthyology, adopted as an initial tool very useful in the study of environmental changes caused by human action such as: the insertion of new exotic or allochthonous species [36,37] the decrease in fishing stocks [38-40]; the disappearance of fish species [41,42] among other factors that may be linked to this event.

It is assumed that each population of a region has a way of perceiving and organizing the knowledge of events, nature and behaviors of species, together with other information such as

field work that can be used for knowledge of reproductive biology, behavior, sow areas, feeding of species, reproductive period; associated with environmental characteristics.

These manifestations of changes, including environmental factors, were perceived by the population of fishermen and local fishing guides who perform subsistence and\or recreational fishing activities in the often impacted environments, totaling (115; 94.3%) of the answers in the interviews conducted, focused on the perception of the interviewees (Table 2).

As a result of environmental factors, global warming and the lack of awareness of some sectors of capitalist society, which has been causing harmful consequences, these environmental changes can have effects on freshwater species. The Pantanal, one of the cradles of the species of ichthyofauna, may suffer catastrophic consequences due to the excessive heat that has been occurring this year of 2020, in the Midwest region of Brazil.

The systemic effect, associated with the climatic and water imbalance, caused by the devastation and fires that occurred this year, mainly associated with other biomes, such as the Amazon and the Brazilian savannah, which suffered the consequences, these factors can provide a natural phenomenon called "decoada" or " dequada "that occurs in the areas of high flooding of the rivers that form the Pantanal plain.

This phenomenon of hypoxia, according to Oliveira et al [43] is natural, and is related to the decomposition of the large mass of submerged organic matter at the beginning of the flood process. This event occurs more frequently in the Pantanal Mato-Grossense, resulting in biochemical oxygen demand, resulting from the oxidation processes of organic matter, both in flooded fields and in the water column of rivers, which consequently will lead to high fish mortality.

Worldwide, several reports of the effects of eutrophication on aquatic communities related to global climate change, in studies conducted in the Gulf of Mexico and the Mississippi River, have been reported by Rabalais et al. [44,45], Rowe [46] and more recently, the reports of Breitburg et al [47] making an alert of the decline of oxygen in the oceans.

These consequences, whether natural or caused by inadequate anthropogenization or management, show concern on the part of fishermen, and show us that they do not only dominate knowledge related to fishing, but situations that occur in nature.

According to Costa-Neto et al [19,10] report that the food preference of species, behavioral aspects or even ethnotaxonomy, are conditions of comprehensive knowledge and that populations have a broader view of what has been happening with the environment on which they depend for various purposes.

3.3 Sustainable Management and Handling of Fisheries and Its Resources

There are many conflicts between sport fishermen with other sectors that share water beds and water resources in common; such as the riverside community, commercial fishermen, environmentalists, water sports practitioners, among others [48,49,50].

We often see what happens is the lack of adequate management for the resolution of this situation, by environmental and governmental bodies, where the formulation of a management plan for sport fishing should occur together with a survey of the situation of the activity and the various sectors mentioned that share these water resources.

Some segments argue that sport or recreational fishing or even catch-release is a form of aggression and a form of decline for some captured specimens of freshwater ichthyofauna; for this action ends up "hurting" and when these fish are deposited again to the riverbed they end up dying.

This questioning emphasizes that fish caught by hooks are struggling to feed even when returning to the water, the animal faces problems sucking prey because of injuries in the mouth, causing tears, lesions on the skin and membranes around the mouth.

A warning in this sense, causes controversial questions to arise, which has generated many controversies and heated debates on the subject and brings to light many questions: Do fish feel pain or not?

Situations of suffering and discomfort, the welfare of these animals has been researched since the 1990s [51]. In the last two decades, it was believed that fish could not perceive pain

Table 2. Fishermen's opinion and reports regarding the situation of fishing, fishing resources, environment and fishing species, reported during interviews interviewed in the sport fishing regions of the rivers of Mato Grosso/Brazil, conducted in the period 2018-2019

Questions	n= 122	Opinion	%	Do not agree	%
		Agree		Unknown	
The negative effects of sport fishing	Disappearance of fischeries resources	78	64,0	44	36,1
	Fishing species becoming rare or scarce	37	30,3	85	69,7
	The dourado fish (*S. brasiliensis*) is disappearing	42	34,4	80	65,6
	Fishery resources are disappearing due to increased fishing?	30	24,6	92	75,4
Environmental perceptions	Environmental influence and impacted environments	115	94,3	7	5,7
Management and hadling	Do fish fell pain?	113	92,6	9	7,4
sustainable fisheries	Is the hook a limiting factor for fish?	50	41,0	72	59,0
	Is there awareness during fishing in favor of fish?	55	45,1	67	54,9
	The use of "Ceva" and abusive techiniques inf fishing	110	90,2	12	9,8
	Pollution of water and natural resources	77	63,1	45	36,9
	Use of "platforms" on the banks of rivers	82	67,2	40	32,8
	Stricter and less efficient inspections	40	32,8	82	67,2
Fisheries challenges and	Should fishermen be aware of fishing activity?	119	97,5	3	2,5
Perspectives	Is sport fishing a means of depredating the local ichthyofauna?	99	81,1	23	18,9
	Is sport fishing more financially beneficial?	52	100*	-	-
Sustainability and fisheries	Identification and characteristics of *S. brasiliensis*	85	69,7	37	30,3
Laws	The fisherman recognizes the sex of the animals (dimorphism)	80	65,6	37	30,3
	Does the transit of boats on rivers cause discomfort to fish?	25	20,5	97	79,5
	Is working as a fishing guide financially beneficial?	63	100**	-	-

** This percentage corresponds to part of the amount (n = 63) representing only (n = 52) referring to fishing guides who also work in artisanal fishing*

*** This percentage corresponds to the amount (n = 63) that represents only the fishing guides. The other parcels did not respond, as it was not related to its scope*

because nociceptors (receptors that detect potentially painful stimuli) had not been identified, and prevented the animals from being aware of this state [52].

Contradicting some references on the subject, in 2003 studies conducted by the fish biologist [53] after scientific experiment inserting bee venom and an acid solution on the lips of some fish, noticed a reaction of agitation and increase in heart rate, in addition to stress in these animals.

In 2009, this same researcher presented new responses clearly showing a defensive and even aggressive behavior after going through a painful situation, indicating that the fish felt pain, presented aversive physiological reactions as a response to harmful stimuli and still recalled for some period of what happened [54].

According to Rorig et al. [55], Sneddon [54] and Chandroo et al. [56] report several studies in teleosts that have proven the production of opiate use (analgesics), with pain mediation functions, in addition to the existence of their specific receptors to the effects of exposure to stress agents or stressful experiences, suggesting in their research the existence of specific neuronal structures and homologous systems in fish.

A new study by Sneddon [57] revealed yes; fish feel pain. The contraction movement would be indicative of the demonstration of pain, besides feeling emotional stress, as well as mammals. More recently, this same researcher indicated in another study that these animals have specific structures that serve to signal rapid and less harmful lesions triggering escape and avoidance responses [58].

In a technical research, conducted in Brazil in 2006, analyzing species of bony fish, and dourado fish one of the experimental species, the researchers reported that the characteristic of having the bone oral apparatus, when suffering injuries by hooks the species survived and remained stable. Even those who swallowed the hook during capture, at the end of the study, after eight months of this capture, these animals were necropsied, and were healthy, without clinical signs of malnutrition or illness [59].

American researchers Thompson et al, [60]; assessed whether there would be an impact on marine fish, but found a lower estimate than expected, a 35% reduction in the ability to feed the fish tested. Indicating that hook size should be taken into account to minimize the effects on fish.

Pollock and Pine [61] report that this approach assumes that for fishing (fishing and dropping) policies benefit the stock, and this capture and release activity results in a much lower mortality rate than would occur with another form of fishing activity.

Ceccarelli et al. [59] report that research conducted by the Instituto Brasileiro do Meio Ambiente (IBAMA) in at least 90% of cases, the fish released after capture are already fully recovered from the injuries caused by fishing. These results showed that pacu fish and matrinxã fish returned to feed the next day after being caught with hook, regardless of whether they had hook or not; and the captured specimens presented at the site injured by the fully healed hook after the sixth day of capture, without the presence of inflammatory process or infectious process usually caused by fungi at the site of the hook.

Answers presented by fishermen and fishing guides during the interview phase of this study presented opinions similar to those presented by the above-mentioned researchers; (113; 92,6%) of the interviewees agree that the fish feel pain, and the care with the release and the exposure time of the animal should be recommended.

Recently Sanches and Piana [62] report that of 70 fish caught and released, in a research conducted, these researchers concluded that deaths in air exposure time treatments, is minimal and consequently there is an individual risk of fish death at 5%, when there is an increase in air exposure greater than 600s. The researchers concluded that the exposure of the animals should occur at a shorter exposure time, to ensure the well-being of fish from an ethical point of view in sport fishing.

Cooke et al, [63] reported that the place where a fish can be hooked with the least effect on short-term mortality is in and around the membranous parts of the mouth, presumably because it causes less damage and is easier to remove the hook if it is not shaved and further emphasizes that hook size is a preponderant factor for fish survival and become a minimally invasive factor.

According to Arlinghaus et al, [48] studied the influence of hook size on sport fishing and

concluded that smaller hooks cause less injury than larger ones and the so-called circular ones are the most indicated. Still, emphasizing Ceccarelli et al. [59] indicates that the correct procedure is not to remove the fish completely out of the water, to perform this activity, which can leave the animal stressed, but keep it enough in the water for hook extraction.

In view of this premise, studies using bone fish as experimental fish need to be performed to obtain a more immediate response to this questioning. We observed that during the interviews, when it comes to the species *S. brasiliensis*, this limiting factor, for the interviewees, does not show concern, because in the reports of the fishermen emphasized that during the interviews (50; 40.9%), reported that they had already captured specimens with 2, 3 to 5 azoles attached to the mouth of the fish and it remained aggressive and in higher conditions of ichthyophagy (predation) action (Table 2).

This description may be related to the oral anatomical structure present in the Salminae, as reported by Rodrigues and Menin [64] and Della Flora [15] emphasize, these fish have smooth and slender lips, oral dentition developed pointed and curved (conical), which favor the taking and ingestion of larger prey, still relatively mobile tongue, mucosa without reliefs, short and pointed gill trails, and these anatomical adaptations are shared between *S. brasiliensis* and the other species of the genus, as well as other Characiform also ichthyophagous.

It is worth remembering that during the interviews, an awareness of fishing professionals was observed (55, 45.1%) of the interviewees, reported that after the capture of the specimens of *S. brasiliensis*, when the azoles attached to the animal's mouth were found, these professionals described that they were concerned to remove the hooks found affixed to the animal's mouth, in order to preserve the fishing specimen (Table 2).

In our opinion, this demonstrates that it is not yet clear whether the injuries to the mouth caused by the hook have an impact on the feeding performance of the fish, requiring further studies and information that show the factors that contribute to the resolution of this question.

In a fishing-release activity occurred on the Cuiabá River, in the locality of Mimoso/MT, central Region of Brazil; the fishing guides reported that a specimen of *S. brasiliensis* was captured and released on a given day, and after three days the same specimen had been captured again. The captured specimen showed the characteristic aggressiveness of the species, and without any change in its behavioral aspect. The specimen identified in this case was considered the same, as reported by the guides, the captured animal presented a peculiar "spot" in the operculum, which differentiated it from the other specimens, since this spot is not characteristic of the species, thus guaranteeing the identification of the fresh water specimen, being recognized as the same as that of the previous days' fishing.

A similar record of this event, to that reported in this study, was described the capture of the same specimen, in fishing-release activity, documented, when a specimen of Tucunaré-Açu (*Cichla temensis*) captured 2 times by different fishermen, as well as in fisheries with different dates occurred in the Água Boa River, in Roraima State/Brazil [65].

One of the fishing procedures discussed during the interviews was the use of “ceva”, an activity used to lure fish to bait (using corn or soy beans, pieces of manioc and ears of corn, etc.). This activity is undoubtedly reproached by fishermen and fishing guides, and it is considered prohibited in the State.

Among the interviewees (110; 90.2%) they repudiate this activity, and reported that the activity in question leaves the fish lazy and combed, causing the fish to stop circulating throughout the river, however activity traps the fish in certain places due to the exacerbated supply of food, thus leaving them, equally populated the rivers. The (12; 9.8%) interviewees, who said they did not believe that this activity interferes or does not provide any change in the current state of fishing (Table 2).

According to Ceccareli et al. [59] “ceva” is an ancient procedure, used by Brazilian Indians, to attract fish. However, the indiscriminate use of this technique can cause damage to the environment, both by organic pollution of water, providing growth of microorganisms, their excess, can affect the health of fish.

This perception was pointed out by artisanal fishermen and fishing guides (77; 63.1%) of the interviewees, indicated that this can be considered a factor for the reduction of fishing

resources, possibly may be related to the decrease of specimens in aquatic environments, because many of the substances released into the water are rich in nutrients, contributing to generate eutrophication (Table 2).

Wiegand et al. [66] and Mercante et al. [67] draw attention to this type of inadequate hydric management, where artificial eutrophication increases the concentration of nutrients implying not only in water quality, but also in increasing the density of the macrophyte population, algae, especially blue algae (cyanophytes) of the genera *Oscillatoria, Microcystis*, *Anabaena* and *Aphanizomenon*, causing fish and other aquatic organisms to die from asphyxiation.

Another factor mentioned by the interviewees was in relation to the platform "tablados" located on the banks of the rivers. Of the 122 interviewees (82; 67.2%), they emphasized an increase in houses built on the banks of the Cuiabá and Manso rivers, and consequently the construction of platform. This situation is prohibited by law; it also indicates that the inspection is not severe in this sense, being questioned by (26; 21.3%) of the interviewees. Some fishermen mentioned the difficulty of fishing in places where there is this type of construction (14; 11.5%) (Table 2).

3.4 Challenges and Perspectives: Conditions of Sustainability of Fish

Taking into account the facts mentioned so far, we can inform that biologically, every healthy organism, regardless of the environment in which it lives is endowed with systems that, triggered, enable the animal to face dangers, stress conditions, and even inopportune agents and with this adapt in the search for its survival.

The activation of these defense mechanisms are not different for fish and these variations can occur not only between species, but also between individuals of the same species, according to the physiological conditions in which each animal presents at the moment.

These biological adjustments only cease to exist, in case of failures in the immune defense system and it becomes deficient, weakening, causing it to suffer damage in its functions, compromising the very survival of the species and the population in which it shares, among these factors we can mention growth, immunological competence and reproductive capacity [68].

In situations where the environment does not allow leakage and escape; researchers observed the conditions of temperature, pH and excessive exposure to air, are considered stressful to fish, and the removal of the specimens out of the aquatic environment can cause a great way to fall in immune resistance.

Studies conducted by Silva et al. [69], Deriggi et al. [70] and Araújo et al. [71], evaluating various hematological, immunological, biochemical (seric ions) and metabolic in species of tambaquis fish (*Colossoma macropomum*) and tilapia (*Oreochromis niloticus*) did not find exarcebed alterations after exposure of the specimens to stressful stimuli before and after the time of air exposure events.

Caminhas [51] emphasizes that significant changes in fish behavior, such as changes in the rhythm and pattern of swimming, reduction or change in anti-predatory behavior, decreased food consumption, increased demand for shelter, reduction or increase in agonistic behaviors and changes in learning capacity, are factors to be observed when these animals are suffering periods of stress.

Sanches and Piana [62] reported in a research with the fishing-release activity (PS) using *S. brasiliensis*, stating in their study that without proper manipulation of fish, this activity can cause injuries in individuals, causing mortality; however, the results showed a gain in length and weight of fish, not significantly affecting their organic growth and with little or no mortality.

These researchers also emphasized that if the manipulation is performed correctly, there are no significant differences between fish-release with those used as control fish, suggesting that the activity can be used to assist conservation programs [62].

These questions were pointed out by the fishermen and fishing guides who were interviewed, claiming that between 1.5% and 2% of the total specimens caught per season (8 months), die due to fishing activity. It was observed that the care and satisfaction of the fishermen, in front of the trophy, which is the capture of the specimen, make due care taken with the specimen of the ichthyofauna at the time of release, returning it safely, and the photographic record, the documentary factor of the activity of great satisfaction.

Arlinghaus et al. [48] believe that these aforementioned practices should be better analyzed empirically, through a pragmatic approach; research on the capture, release and post-release of fish.

Ceccareli et al. [59] consider that the references of scientific research in the area of fishing-release are important for the decision-making of the organs responsible for the management of sport fishing in the face of the expansion of this activity, with the need for scientific basis for decision-making related to sport fishing involving the fishing-release modality and all the prerogatives that guide this theme.

Pitcher [72] already reported that for these successes to occur it is necessary a democratic and sustainable management of the sectors with attention to species and aquatic ecosystems and that have economic and social significance for the localities, regions and countries where it is practiced.

The fact is that sport fishing should be taken as an activity that prevails the awareness and respect of fishermen for the activity, fauna and environment in which they practice this activity. Some advice is impractical so that this activity does not leave sequelae in animals, as do not take too long with the fish out of the water and does not throw it abruptly into the water (the animal is stunned by the low concentration of oxygenation), being exposed to possible predation; try not to hurt the animal and avoid contact with the hands for too long so as not to remove the protective layer of mucus, which serves as a waterproofing agent against the aquatic microbiota. If these rules are complied with, the possible dam age will be minimal, avoiding too much stress and the animal is readily restored within minutes. In view of this fact, the responses were unanimous, reaching a percentage (119; 97.5%) of the interviewees agree with the care and attention to animal health (Table 2).

By far sport fishing is considered an obstacle, and that is a factor for the depredation of the ichthyofauna of a local region. Sport fishing due to its low capture of specimens by fishing effort is observed as less harmful to aquatic ecosystems than commercial fishing; which is characterized by a large capture of specimens combined with a low fishing effort, thus producing direct and indirect impacts on the natural resources involved, such as the death of large quantities of fish [48,49]. The interviewees reported that this activity was very profitable and satisfactory and did not agree that the activity could be depredating (99; 81.1%), the others said they did not know or preferred not to give their opinion (23; 18.9%) (Table 2).

During our interviews, the fishermen interviewed who work as fishing guides (n=52) and who consequently also perform artisanal fishing reported that they were more profitable to work with sport fishing, which totaled 100% of the interviewees' opinion. These reported that this activity is more advantageous and profitable financially, than continue with the artisanal fishing, due to it, besides being exhausting is unprofitable, the fisherman achieves very little with the catch of the fish, because there are fees and taxes to be paid, to sell the fish in places, such as the Porto fair (place of sale of fish in the city of Cuiabá, Mato Grosso, Brazil).

The lack of resources and support of the public authorities to artisanal fishermen end up negatively encouraging the practice of predatory fishing. What was also observed during the interviews, is that in view of these conditions the artisanal fisherman who does not have access to the most practical forms of sale, is restricted to local fairs or their own fishing colony, thus making their income lower than ideal. With this reality, it makes the professional fisherman stop believing in his craft, even denying it as a professional.

We observed that in relation to the issue of sustainability and preservation of species, within the aquatic environments of fresh water, we observed that there is care regarding the removal of specimens from rivers. For the maintenance and feeding of employees and fishermen sportsmen during their stay in the inns for sport fishing activity, it was found that in two fishing sites the owners kept, tanks containing specimens of local fishing, acquired from accredited fishing grounds.

This information was evidenced and could be verified, because the purpose of this awareness is the preservation of the species, not to remove the faunistic specimens of fresh water from their natural environment, which consequently could advocate a form of predation mimetized in sustainability, which would be erroneously incorrect.

According to Rodrigues-Olarte & Taphorn [4] species of the genus Salminus, in the region of

Venezuela, it has little commercial importance, but is an important example of local subsistence fishing, being occasionally the target of sport fishing. In other regions of the globe, such as the United States, scientific research aims to generate information to ensure the survival of ichthyofauna species.

In Argentina, researchers have shown that sport fishing is responsible for significant economic contributions. In the United Kingdom, sport fishing has been pointed out by researchers as a tool to give fishermen access to relevant scientific information, helping them to make decisions [73].

Despite this scenario, given the expectations of sport fishing and the popular and traditional concepts of the community of fishermen and municipalities of defense of fishing species, some parameters make the situation alarming, because none of the valid species for the Salminae, present in the Brazilian territory, and reported in this study, were not found included in the list of species threatened with international extinction by the International Union for Conservation of Nature [74], in the national list of endangered species, *S. hilarii* and *S. brasiliensis* have status as (LC) (Least Concern) and *S. brasiliensis* is cited as an introduced or predatory specimen of other species. *S. franciscanus* presents an NT status (Near Threatened), which makes this specimen of the ichthyofauna of the São Francisco River basin at risk [75].

Other species of the ichthyofauna Mato-grossense, and cited in this study were researched and are described with the following status: Tambaqui (*Colossoma macrocarpum*), Pacu (*Piaractus mesopotamicus*), Pintado (*Pseudoplatystoma corruscans*), Cachara (*Pseudoplatystoma punctifer* and *P. reticulatum*) have NT status (Near Threatened). Curimbatá (*Prochilodus lineatus*), Jurupoca (*Hemisorubim platyrhynchos*), Matrinxã (*Brycon amazonicus*), Piraputanga (*Brycon hilarii*), Pacupeva (*Mylopus levis*), Jurupensém (*Sorubim lima*) present status LC (Least Concern) and Piracanjuba (*Brycon orbignyanus*) presented status LC and Piabanha *(Brycon insignis*) with status EN (Endangered) presenting habitat fragmentation and decline, as researched [75].

As for conservation status, all Salminus species are experiencing a severe population decline resulting from predatory fishing, species introduction and, mainly, habitat fragmentation, according to Carolsfeld et al. [12]. According to Marques [76], the genus Salminus is a species of ichthyofauna that prevails in the "list of endangered fauna species in state of Rio Grande do Sul/Brasil", due to the intense degradation of their habitat, excessive fishing effort, dam constructions, and river pollution.

In the Paraguay Basin, *S. brasiliensis* is considered the most fished species, leading to a state of vulnerability [77]. They are still vulnerable to extinction in the Prata river basin in Argentina [78], practically extinct in the Tietê, Paranapanema and Rio Grande systems in State of São Paulo [79]. In State of Mato Grosso, Rondon [80] reports that impacts such as fishing, dam construction, introduction of exotic species, has caused negative effects for the population in several places where the species occurs, coming close to being extinct.

However, this researcher did not report the species *S. brasiliensis* in the list of threatened species, because some populations of the Paraguay basin are present in the Pantanal region, an ecosystem relatively intact and protected by conservation policies.

Phylogenetic studies conducted by Brazilian researchers show that the species *S. brasiliensis* is not the only population in the basins where this specimen was studied. Freitas [81] emphasizes that in his mitochondrial analyses found in his study, the results indicate that the populations of *S. brasiliensis* throughout the Pantanal Basin Mato-grossense are not genetically structured, showing relatively high genetic variability; population expansion with short genetic distances.

For Machado et al. [82] in a study conducted in the South American basins, their results indicated that the genus may consist of different subgroups, and that at least two new species of the genus Salminus exist and await description, totaling seven species in the genus Salminus in the future.

Rosso et al. [83] evidenced in a study conducted in Argentina, Brazil and Paraguay, the results also indicated that two different putative species could be contained under the taxonomic name *Salminus brasiliensis*, along with their haplotypes.

This leads us to believe that further study on phylogenetic analyses of this emblematic

ichthyofaunistic genus is necessary, and that new species; in addition to those mentioned in this study, they may be circulating through the rivers of Brazil reinforcing the idea of more taxonomic units in the genus Salminus in The Brazilian territory.

These results show that the absence of research and a clear taxonomic delimitation, phylogeographic and studies directed at species, need more information, because these lists emphatically define these classifications based mainly on studies and scientific reports proposed by researchers on the subject, the lack of this information contribute to what has resulted in a negligence in the organization and definition of these lists of species.

3.5 Sustainability: Laws of Prohibition and Environmental Conservation

Often environmental laws and those that refer to fishing are norms that are found in various ordinances, laws and normative instructions, which are misinterpreted and constantly undergo modifications and adjustments. This makes fishermen, whether artisanal or sporting, do not have precise knowledge of these regulations that must be applied and/or restrictive, making the acts practiced become a lack of awareness about their rights and duties to the maintenance, preservation and conservation of the ichthyological fauna and the environment.

Fish conservation in South America is an urgent issue. The biodiversity of fish is far from fully known [35]. When we face strict levels of Brazilian laws in defense of aquatic environments and freshwater species we can mention: Decree Law 11.959/2009 – of the general code of fisheries (art. 8º, item I, "a", and art. 2, item IV), of Interministerial Normative Instruction 10/2011), speak on protection and stimuli to fishing; defined that fishing as the act of capturing or extracting animals in water is classified in two modalities: commercial (artisanal and industrial) and non-commercial (scientific, amateur and subsistence) fishing [84].

According to Pitcher [72] sport fishing or leisure is a modality of amateur fishing and is defined as the capture of fish for leisure activity, constituting the release of the same, in contrast Arlinghaus et al, [48], defines differentiating from artisanal fishing that are intended to catch the specimen for food and subsistence, that is; "the one practiced directly by a professional fisherman, autonomously or under a family economy. It is still established by own means of production or by partnership contract, the use of small vessels", as recommended by decree Law 11.959/2009 [84].

As an example, anthrophic action on the Uruguay river basin, over time, associated with the deforestation of the riparian forest, pollution by organic waste, chemical products, use of dredges, erosion of river banks and even predatory fishing or overfishing has been causing the reduction of specimens of freshwater aquatic fauna native to the region such as dourado fish, piracanjuba, piava, curimbatá, are some of the species affected by the action of man, and these populations are reduced and restricted to small regions of the basin [5].

What is supposed; are that the physiological behavior of certain fish species, in certain local regions, may be associated with reproductive behavior, determined by the interaction of biotic and abiotic factors, because these failures for consecutive years can generate an imbalance in reproduction and may lead these species to extinction.

During the interviews, it was reported that, in the evaluated places, fishing guides and artisanal fishermen (n = 85), recognize the differences between the sex of the fish. In this group, they reported that during the catches in the studied period, the number of males was more abundant than females (80; 65.6%). The interviewees were argued, how they differentiated the sexes from fish (dimorphism). The fishermen reported that they differentiated morphological characteristics by size and shape, citing: *"males are smaller in size and are longer; however, females have larger sizes and are more robust for the species S. brasiliensis"*, the size is perhaps one of the most common categories for differences between the sexes in fish, which we identified as a characteristic for sexual dimorphism (Table 2).

However, no information was reported for sexual differentiation of the species *S. brasiliensis* in the case of anatomical characteristics, as the reference of the characterization of the anal fin, as recommended by Gomiero & Braga [16].

In a study carried out by Rondon [80], in the Upper Paraguay Basin (Mato Grosso/Brazil), this researcher found no differences in size between the sexes, males and females, concluding the captured specimens did not present sexual dimorphism to characterize size

in the population of *S. brasiliensis* researched in that region.

Although we cannot affirm, we believe that these characteristics may be related to the type of reproduction adopted by the species; and this higher number of males, reported by our interviewees, may be a worrisome factor for reproduction of the species. These questions may contribute important information to develop measures of management, awareness, preservation of the species and future scientific research.

Another point raised during the interviews, refer to the dourado fish matrices being affected by the fishermen's action and that the animals could be affected by the intense traffic of boats on the riverbed during the breeding period, because the excess noise leads the fish to stress, preventing multiplication. Most respondents were emphatic in answering that they are unaware of the depth of the subject approached (97; 79.5) (Table 2).

In 2017, Nedelec et al, [85] under study emphasizing the noise caused by the action of man, produced by the engines of boats, suggests possible consequences for animals with harmful effects to future proles. However, this questioning seems to be refuted by a range of other misfit's environments to which several other living beings pass.

We believe that scientific evidence that anthropogenic noise is a type of pollution that disturbs and has harmful effects on a wide variety of animal species, this is a fact, since this situation is recorded by several researchers, which included a variety of mammals, fish, amphibians, invertebrates and a range of wild species according to what had been reported in their studies conducted around the world [86-89].

This questioning may be supported and obtain answers during the closed period, which is a preventive measure that aims to protect aquatic organisms during the most critical phases of their life cycles in order to ensure the reproduction of native species or even their greatest growth, based on Brazilian laws: State Law No. 9,096 of January 16, 2009 and Federal Law No. 9,605 of February 12, 1998, regulated by Decree No. 6,514 of July 22, 2008.

According to the State Law of Mato Grosso, because it is a species widely used as a natural resource for sport and commercial fishing, *S. brasiliensis* presents its prohibited fishing in the State of Mato Grosso, according to State Law No. 9.893/SEMA (State Department of the Environment) since 2013, and in the municipality of Corumbá in the State of Mato Grosso do Sul, according to Municipal Law No. 2.237/IMASUL (Environment Institute of Mato Grosso do Sul), since 2011.

Due to this reality, throughout the state of Mato Grosso, the capture, commercialization and transport of this species has been sealed since 2012 in accordance with state law 9,794/2012, in article 17-A "The capture, marketing and transport of dourado fish (*Salminus brasiliensis*) and Piraíba (*Brachyplatystoma filamentosum*) species in the State of Mato Grosso is permitted, fishing for the two species is not permitted throughout the state territory". The ban on fishing, both amateur and professional, covers the rivers of the Hydrographic Basins of Paraguay, Amazonas and Araguaia-Tocantins.

In Brazil, many obstacles are pointed to the sustainable practice of sport fishing, especially those related to preservation and conservation. In addition to these aspects, unlike many countries, sport fishing is a tool still little explored in Brazil [73].

Sport fishing is an important activity in the economy of several countries, generating directly or indirectly billions of dollars in income and drives a developed industrial segment of great profitability [90].

In the places where the interviews were conducted, in the region of the state of Mato Grosso this reality is no different. According to the reports of the fishing guides (63; 100%) they said that the populations of fishermen who work in the face of this activity, have a higher income than they receive in subsistence fishing activity (conventional), this sports activity has been maintaining family income and the maintenance of these populations, because they contribute to a much higher quantitative increase, due to the activity of fishing guides contributing to the financial and economic increase, being considered more profitable (Table 2).

In a qualitative way, it was evidenced that there is an improvement in the quality of life of these fishing professionals and mainly contributing to the creation of an awareness about the importance of local ichthyofauna generating information, which can raise the status of this

activity for State of Mato Grosso, as recommended by Art. 6. Law 9.074/2008, published in the Official Gazette of the State, on the law of sport fishing, where the text reports: Environmental education actions will be implemented, aiming at the awareness of sports fishermen and the conservation of fishing resources.

4. CONCLUSION

The observational analyses, based on the reports of the interviews conducted during the research period, lead us to believe that additional information about the species contained in the Mato Grosso rivers lacks information, and *Salminus brasiliensis* is one of them. The lack of basic biological studies for this predatory species could provide basic information necessary to determine the abundance of the local population, guide management and cultivation, and guide the importance of this species in local subsistence fishing and thus possible to define action strategies for regional sports practice.

The results presented here reflect the importance of research related to local ichthyological fauna, considering the elaboration and implementation of public policies and sustainable use of natural resources.

Although some isolated information and research, as shown in this review and observational records, indicate high local economic importance of sport and/or recreational fishing, the total captured by sport fishing in the country is still unknown, as well as the proportion of the catch that is released through the catch-release and the total economic value of this activity. Often, the negative impacts associated with recreational fishing without monitoring evidence, in an exaggerated way, and advocates the urgency of conducting more research on the subject.

This approach regarding the management of brazilian fauna species, including Mato Grosso, seems to be an advantageous option for the regions of Mato Grosso, and so to say for Brazil as a whole, this issue incorporates a broader view of the environment, fishermen and fish fauna, because with adequate monitoring, having knowledge of regional watersheds and knowledge of the biological limitations of the species , together with political and socioeconomic actions, decision-making processes will be more comprehensive.

It was found, in the places surveyed, that sport fishing, mostly revolves around the dourado fish, this causes it to be generated in season, a lot of profit for the state of MT as well as an increase in the number of jobs and income of riverside, since there are places that employ about 25 people in the region, generating employability for the place , a high economic value and the improvement of people's quality of life, thus verifying the importance of sport fishing within the state of Mato Grosso.

Within this context, this work shows results sustained in a review carried out by means of an ethno-etiological record, demonstrates the implementation of actions, aiming to bring information on habitat conservation, awareness on the depollution and maintenance of rivers, respecting the periods of piracema and rescue , contribution and social partnership of sport fishermen, artisanal fishermen, fishing guides, including actions that can be shared by all social actors, extended to indigenous populations, quilombolas (african descendants) and riverside peoples.

CONSENT

In a clear and precise way, the research objectives were always explained at the beginning of each new interview, asking if there was the fishermen's consent to grant the information. The questions and answers occurred individually so that there was no influence on the information (answers) as recommended by Costa-Neto et al. [20].

ETHICAL APPROVAL

For the elaboration of this study, as it is research in phonographic record, in interviews in agreement with the verbalized reports by the interviewed fishermen. There was no need for a statement of ethics in research. The present study did not and did not involve the capture of experimental specimens described in this manuscript. No animal has been abused and/or disturbed, as well as injured and mutilated in its natural environment. The images (Fig. 3) presented in this manuscript, were recorded in captures made on dates prior to the period established in this research, and provided kindly as an illustrative subsidy.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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