



Alternative bait usage during the piracatinga (*Calophysus macropterus*) fishery in the Manacapuru region, located at the lower Solimões-Amazonas River, Amazon basin, Brazil

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Abstract. Commercial fishing of piracatinga, *Calophysus macropterus* (Lichtenstein 1819), is currently in moratorium since January of 2015 until January of 2020. The ban was imposed because piracatinga fishermen from some remote areas of the Central Amazon used as bait, freshwater dolphins and caimans meat (species protected by law) to attract piracatinga which has omnivore/necrophagous habits. In this study, we describe the technique characteristics of how to catch the piracatinga practiced by urban fishermen at the Manacapuru region, during the months of January and June 2013, using alternative bait (bovine's viscera and rest of fish) in substitution illegal bait. Fishing data were collected from 31 fishermen involved in this activity. Our study has shown that using alternative bait has a positive effect in the catch, averaging 431.6 kg (\pm 196.5) per fishery event. The periods of great production fishery occurred between January/April and September/December (coinciding with the closed period of other commercial species). The using alternative baits proves to be effective eliminating the need for usage of freshwater dolphins and caimans as baits, thus, having efficient fiscalization, not needing criminalize piracatinga fishing since it is a very abundant species serving as a source of income for hundreds of local communities in the Amazon.

Keywords: Caimans, Freshwater dolphins, Small-scale fishing, Sustainability, Central Amazon

Resumo. O uso de iscas alternativas para a pesca da piracatinga (*Calophysus macropterus*) na região de Manacapuru, localizada no baixo rio Solimões-Amazonas, bacia Amazônica, Brasil. A pesca comercial da piracatinga, *Calophysus macropterus* (Lichtenstein 1819) está atualmente em moratória desde janeiro de 2015 até janeiro de 2020. A proibição foi imposta porque os pescadores de piracatinga de algumas áreas remotas da Amazônia Central utilizavam como isca a carne de golfinhos de água doce e jacarés (espécies protegidas por lei) para atrair a piracatinga que tem hábitos omnívoro/necrófago. Neste estudo, descrevemos as características das técnicas de captura praticadas por pescadores urbanos na região de Manacapuru, durante os meses de janeiro a junho de 2013, utilizando iscas alternativas (vísceras bovinas e restos de peixes) em substituição a iscas ilegais. Foram analisados dados de pescarias de 31 pescadores envolvidos nesta atividade. Nosso estudo mostrou que o uso de isca alternativa tem um efeito positivo na captura, com média de 431,6 kg (\pm 196,5) por evento de pesca. O pico da safra (maior produção) ocorria entre Janeiro/Abril e Setembro/Dezembro (coincidindo com o período de defeso de outras espécies comerciais). O uso de iscas alternativas revela-se eficaz eliminando a necessidade de uso de golfinhos de água doce e jacarés como iscas, portanto, existindo

fiscalização eficiente, não é necessário criminalizar a pesca da piracatinga, uma vez que é uma espécie muito abundante e que serve como fonte de renda para centenas de comunidades ribeirinhas na Amazônia.

Palavras-chave: Jacarés, Golfinhos de água doce, Pesca artesanal, Sustentabilidade, Amazônia Central

Introduction

The piracatinga fishery at white water rivers in the Central Amazon region: The name piracatinga, *Calophysus macropterus* (Lichtenstein 1819), has an indigenous root which means Pirá (= fish) and catinga (= bad odour). The piracatinga is a catfish belonging to the Pimelodidae Family (Siluriformes) that can reach total length and weight of 50.00 cm and 1.0 Kg respectively. The piracatinga has a small head and mouth proportionally large compared its body which contains small dark spots all over it. The head and fins have a darker shade of gray and it has two rows of teeth in the premaxilla differing from other catfish of Pimelodidae family (who have villiform teeth and incisors). This species does not have spines in the fins instead it possesses a long adipose fin (Ferreira *et al.* 1998; Santos *et al.* 2006). This species inhabits rivers of white water, clear and black in Amazon basin, being quite abundant in areas of floodplains of the Solimões-Amazonas River system (Saint-Paul *et al.* 2000; Soares *et al.* 2007). The piracatinga has extremely voracious food habits is an omnivore/necrophagous fish eating fruits, invertebrates, fish, carcase of dead animals. Due to this necrophage feeding habit this fish it's not so much consumed or even rejected its consumption by riverine people (Ferreira *et al.* 1998; Granado-Lorencio *et al.* 2005; Soares *et al.* 2007).

Piracatinga did not have significant economic importance in commercial fishing until the mid-1990s (Ferreira *et al.* 1998). However, during the early 2000s production increased considerably in the upper and middle Solimões-Amazonas region becoming an source of income to the fishermen (Estupiñán *et al.* 2003; Santos *et al.* 2006; Botero-Arias *et al.* 2014). In 2002, Tabatinga was the only municipality at the Amazonas State to register the landing of piracatinga, about 230 tons (Ruffino *et al.* 2005). In 2003, piracatinga accounted to 1.1% of the total landing at the State of Amazonas (about 410 tons at five municipalities) (Ruffino *et al.* 2006). On the Colombian side the piracatinga was introduced and sold at the urban centres (Bogotá and Medellín) in late 1990 to replace another catfish species known as (*Pimelodus grosskopfii* Steindachner 1879) due to overfishing declining it's population mainly the

Magdalena River basin (Córdoba *et al.* 2000; Gómez *et al.* 2008).

During the last 14 years (2000 to 2014) it has been seen a growth of demand at both the Colombian and the Brazilian market (outside the Amazon region, especially Southeast and Northeast) where piracatinga is sold as douradinha fillet (generic name). At Manaus, the douradinha fillet is widely accepted at lunch rooms in factories, university restaurants, commercial establishments and even sold to Boa Vista (Roraima State) (personal observation). It latest years (2011-2014), piracatinga yields in Amazonas State, Brazil, the main center of piracatinga fishing, estimates were around 4,000 to 5,000 tons annually (Amazonas Secretary of Rural Production -SEPROR, unpublished data). The Piracatinga fishing then became of great relevance. The Fishermen syndicate of the Amazonas State (SindPesca) showed that of the 100,000 associates about 70,000 worked in the piracatinga fishing, many of them exclusively (Farias 2015). In the Manacapuru city about 1,670 fishermen they were associated with the Fishermen Association of the Municipality of Manacapuru, of these, about 300-400 fishermen lived direct or indirectly from piracatinga fishing (Yran Mendes, President of the Syndicate of Owners of Fishing Vessels of Manacapuru Municipality-SINDARP, personal communication).

The process to capture piracatinga occurs at night due to its nocturnal habits and a bait used (usually viscera or muscle with fat of a dead animal) to attract the fish to a cage locally called "corral" (fenced area). Once the fish are feeding need to direct the bait for the corral or fisherman just catch then the fish with their hands and lance the in corral (Botero-Arias *et al.* 2014).

Commercial piracatinga fishing began as an alternative to use discarded part of other fishes as bait (Botero-Arias *et al.* 2014). However, with increase in demand fishermen in several areas of Central Amazon began using black caiman "jacaré-açu" meat (*Melanosuchus niger* Spix 1825), common caiman "jacaretinga" (*Caiman crocodilus* Linnaeus 1758), boto or freshwater pink dolphin (*Inia geoffrensis* Blainville 1817) and the freshwater tucuxi dolphin (*Sotalia fluviatilis* Gervais & Deville

1853) to satisfy the bait needs to fisheries. Unfortunately, this practice imposes a serious threat to the piracatinga fishing since the four species mentioned previously are protected under Brazilian law (Botero-Arias *et al.* 2014; Brum *et al.* 2015; Franco *et al.* 2016).

The uncontrolled killing of caimans and freshwater dolphin used as bait made the piracatinga fishing illegal for 5 years (January/2015–January/2020): A complete shutdown of the piracatinga fishing was put in place January 2015 (Interministerial Instruction No. 06/2014, Ministry of Environment-MMA and Ministry of Fisheries and Aquaculture-MPA), making it illegal to fish and sell these fish throughout the Brazilian territory for a period of five years, in order to protect the freshwater pink dolphin, freshwater tucuxi dolphin and caimans (IBAMA 2014).

The ban on the piracatinga came after a decline in numbers of freshwater pink dolphin, freshwater tucuxi dolphin and caimans at the Mamirauá region (middle Solimões/Amazonas River) (Brum *et al.* 2015). It was estimated that, in this region, annually up to 170 freshwater pink dolphin and 2,300 caimans were killed to be used as bait (Brum 2011; Botero-Arias *et al.* 2014; Franco *et al.* 2016). The natural mortality rate of freshwater pink dolphins is estimated at 16 animals per year, so environmentalists concluded that its usage as bait causes a risk to already small population of freshwater pink and tucuxi dolphins of that principally in Mamirauá Reserve region (Brum 2011).

It is extremely difficult to collect fishery data about the piracatinga due to its informality and fear of the fishermen to be punished because they may have used freshwater dolphins and caimans as bait. This study aims to characterize the piracatinga fishing activity in the lower Solimões-Amazonas River, in the Manacapuru city, Amazonas State, identifying the capture sites, activity times, fisherman's profile and the types of baits used.

Materials and Methods

Study area: The study was performed in the city of Manacapuru (03°18'17" S; 60°37'12" W), located about 100 km from Manaus (capital of the Amazonas State), in hydrological distance (Figure 1). Manacapuru has a population of 95,330 inhabitants and it is the fourth most populous city in Amazonas State (IBGE 2016). Its economy is focused on agriculture and livestock, however, by far fisheries is the strongest source of income which can

be seen by the presence of floating warehouses and fish freezing industry equipped to buy and storing fish production from local riverine fishermen and even process the catch on site for exportation and interstate and international sale.

The piracatinga fishery in the proximity of Manacapuru occurs at the Solimões-Amazonas River between Barroso island and mouth Santana lake, including the Pesqueiro coast, Ressaca of the Pesqueiro, Paran Supa and Marreco island. The range of this area is proximally 35 Km in a straight line and it is located at the countryside of Manacapuru (Figures 1 and 2).

Methodology development: During the period of January to July of 2013 interviews were conducted to collect information to obtain the profile of the piracatinga fishermen based at Manacapuru. However, not all fishermen agreed to be interviewed. The interviews took place mainly at the floating warehouses where they sell their production. The fishermen were asked about the characteristics of fishing environments, type of structures used to catch the fish, type of lures, how much they catch, how long the traps were in the water, how they held the fish after catching it and if they fished for self-consumption or sale. Additionally, to these pre-formulated questions the interviewer could add questions on spot while engaged on informal conversation, also measurements of the total length-TL (in centimeters) of the fish captured were taken. The information collected during the interviews were added to the database and analysed using descriptive statistics for averaging, standard deviation and frequency.

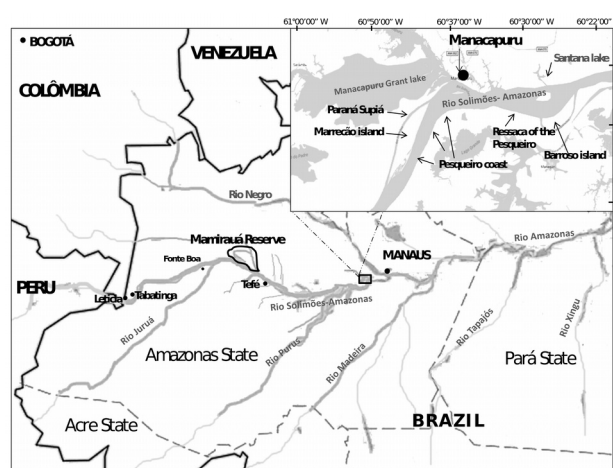


Figure 1. Map of northern Brazil and adjacent countries, showing details of the piracatinga fishing sites used by urban and semi-urban fishermen in the municipality of Manacapuru, Amazonas.



Figure 2. Margin of the Solim es-Amazonas River near Manacapuru. (A) Pesqueiro coast (drying period) and (B) community in Paran  Supi  (flooding period), areas frequently used for piracatinga fishery until December of 2014.

Results

We interviewed a total of 31 piracatinga fishermen, three were accompanied by their wives who also participated in fisheries. Five other fishermen did not agree to be interviewed because they did not want to talk about their activity. Much of the fishermen ($n=26$; 83.8%) were interviewed at landing warehouses and five fishermen (16.1%) were interviewed at the fishing sites near the municipality communities. Most piracatinga fishermen live in the city of Manacapuru, and only 10 (32.2%) maintained vinculum with small fishing communities located along the riverbanks. Fishing sites were located on both margins of the Solim es-Amazonas River, these areas near the riverside communities was the preferred place for piracatinga fishing.

The age of the fishermen ranged between 32-56 years, averaging 44.6 years (± 6.1). All piracatinga fishermen declared that they catch piracatinga was an important source of family income and complement your income with other large catfish species explored at commercial fishing. They fished piracatinga during the flood season (from January to April, and sometimes until June), fisherman also fished piracatinga during the dry season from September to December.

Piracatinga was only targeted to be sold at the buying floating stations and never for family consumption. The fishermen sold their production to the floating warehouses where there was already a pre-agreement for the sale of its production and a fixed price per kilogram. The price paid for the kilogram of piracatinga ranged from R\$ 1.00 to R\$

2.00 (US\$ 0.33 to US\$ 0.66). The average price paid to the piracatinga fishermen in general was R\$ 1.50 (US\$ 0.50). The price varied according with supply and demand for the fish during different times of the year. When there is abundance of piracatinga (flooding and drying periods) the prices decreased, and when there was scarcity (usually in the flood period), the price increase. The responsibility for processing, gutting, filleting and storing the fish remained in the hand of the fish freezing industry owners.

Piracatinga fishery in Manacapuru using alternative bait: The piracatinga fishery at Manacapuru is relatively simple, the fisherman usually work alone ($n=28$; 90% of the interviews) or with a close family member, usually wife ($n=3$; 10% of the interviews). Usually the fisherman work at a place near the community where they consenting to fishery during all fishing seasons ($n=31$, 100%). The bait is usually bovine's viscera (residues) bought at slaughterhouse and butchers beyond of fish viscera collected in freezing industry at Manacapuru. Sometimes fisherman are able to reuse bait ($n=15$, 48.4%) when possible and none of them use protected species as bait. The fisherman reported 5-10 kg of bovine viscera cost R\$ 4.00 to R\$ 5.00 (US\$ 1.33 to US\$ 1.66) and 20 fishermen (64.5%) reported that they use between 5 and 6 bags per fishery trip, and 11 fishermen (35.5%) uses between 3 to 4 bags of viscera per fishery. About 15 piracatinga fishermen also mentioned that they use fish viscera together with bovine viscera when they were available and the catch results are equally excellent.

The bags with unused bait returned to the municipality. In the floating warehouses, these baits were stored in thermal boxes, manually constructed, generally measuring 1.0 m³ in volume. The proportion of ice was 1 kg for every 1 kg of viscera. These baits were conserved until the next fishery, where the bags were placed in the canoe and used again.

Fisherman travelled before sundown to the main river margin on small motorized canoes (5-6m long and 4.0 -5.5 HP of power) where they would assemble the traps denominated locally as "corral" in depth between 1 the 4 meter. This equipment usually made by the fisherman himself using nylon screen (2 mm mesh) forming a large tank trap or corral (measuring 4 m width, 5 m length and 1.0 meter depth) usually with a door on the entrance (50x50 cm) (Figure 3). With this method, the corral demountable serves as a storage place and were fixed to the bottom of the river per 8-10 wood sticks and the door were located ever downstream of the current flow (Figure 3). The fishermen reported that they can capture up to 1.2 tons of piracatinga in each fishery, this is what they can carry at maximum in their canoes.

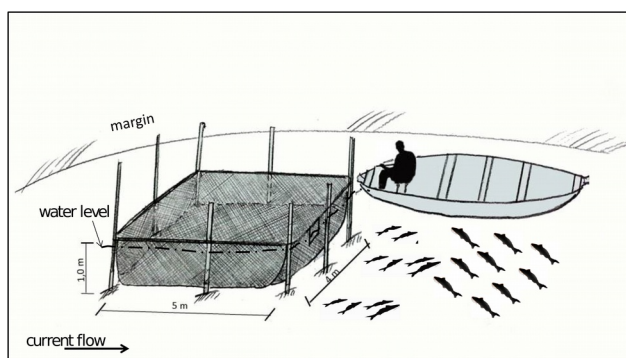


Figure 3. Illustrative drawing of the beginning of fishing with the equipment (corral) already set up for the imprisonment/capture of piracatingas (with approximately 20m³) used in the region of the municipality of Manacapuru, AM.

Fisherman tie the baits using a local herb called "envira" (*Onychopetalum amazonicum* Fries 1931) to put the bait on the water surface without losing in other to lure the fish into the trap, once there is a considerable amount of fish feeding, the bait is directed to inside the trap the fisherman closes the door trapping the fish inside, this process was repeated dozens or hundreds of times on a fishing trip with break only for feeding. The piracatinga fisherman begin work at 5:00 pm, when they leave to the fishing areas and until 6:00 am of the

following day. Because trap was made of nylon cloth with 2 mm meshes the corral did not let the smaller fish escape. After the end of the fishery, all the fish were removed from the corral with the aid of a dip net (puçá) and placed inside the canoe. The fisherman only sold their production to the floating buy stations in the middle of the river because they usually reserve their production to specific floating warehouses.

The landing of piracatinga at the floating warehouses varied between 135 to 735 kg per fishery (n= 31), in average in a fishing event they caught 431.6 kg/fishery (± 196.5). Productivity varies according to the fishing season, fishing location and the fisherman's experience. The period with higher production was during the flood season between January and April and sometime they extended these fisheries until June, and a second fishing season occurs during the dry season between September and December. The fisherman fished two or three times a week since fishing sites were close to the place they resided and sold the fish. However, they reported that at least one of the weekly fishing events was frustrated (with little quantity fish in the fishery). Fishery below 100 kg which sometime did not make the fishing trip worthwhile profit wise, do not cover the cost of travel with fuel price, bait bag, fisherman feeding and ice (conserve viscera when returning). Fish that did not made the minimum commercial length were discarded as waste.

Discarding by catch and accompanying fauna: The discarding for each fishery varied between 35 and 175 individuals with a mean of 85.8 (± 41.4) piracatinga juvenile and fishermen separated their catch only by size of the piracatinga and in addition they removed the small fishes from the catch (Figures 4 and 5). This separation happened at the floating warehouses manually by the fisherman himself. Where fish large size is separated and the smaller fish and accompanying fauna catch aside. Accepted size for commercialization is between >20 to 50 cm of total length, selected fish are kept inside thermal boxes and fish smaller than 20 cm are thrown into the water along with the accompanying fauna catch. Fishermen reported that they did not separate the by catch fauna on spot because of the amount of work they had during a night fishing. According to the total size of the piracatinga catch caught during the interview process 12% had body length between 40 to 50 cm TL; 36% had body length between 30 to 40 cm TL; 40% had body length between 20 at 30 cm TL, and 12% had body length below 20 cm TL (5% in class 10-19 cm TL

and 7% <10 up to 8 cm TL). Fishermen caught juvenile fish with 8 cm (TL) which means that juveniles already eat dead carcase and are opportunistic feeders.

There were also six species as an accompanying fauna caught as by catch, *Cetopsis candiru* (Spix & Agassiz 1829); *Cetopsis coecutiens* (Lichtenstein 1819) (Cetopsidae), *Pareiodon microps* Kner 1855 (Trichomycteridae), *Pimelodus blochi* Valenciennes 1840; *Pinirampus pirinampu*

(Spix & Agassiz 1829) (Pimelodidae) and *Centromochus heckelii* (De Filippi 1853) (Auchenipteridae). Fishermen removed between 45 to 252 individual fish as by catch each fishery, the main specie caught was *C. candiru* (90%) (Figures 4 and 5). These proportions reveal that the piracatinga forms a mixed shoal with *C. candiru*, eventually when they are feeding on carcasses of some dead animal.



Figure 4. (A) Exemplary commercially available piracatinga (*Calophysus macropterus*) (47,5 cm TL); (B) Piracatinga fisherman, landing his production, with detail of some other trap used in the fisheries, like canoe and support sticks of the corral; (C) Production of a successful piracatinga fishing, approximately 600 kg of fish; (D) bovine viscera used as baits in the fishing of the piracatinga in Manacapuru (packed in plastic bags), with details for the baits already used tied with envira, a kind of natural string; (E) Piracatinga discard below the standard size for sale (<20 cm of TL) and, (F) accompanying fauna, usually a large amount of Candirus (*Cetopsis candiru*) and other species.

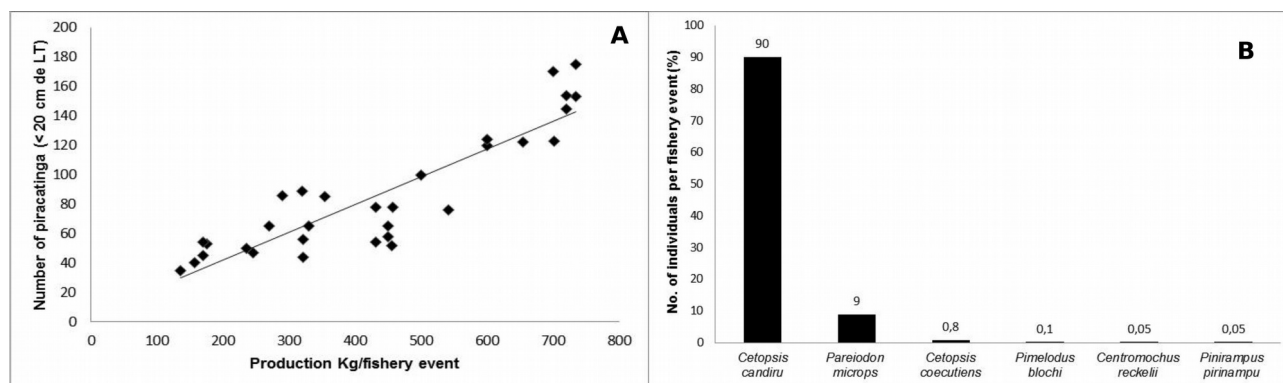


Figure 5. (A) Relation between the productivity of the piracatinga fishery (Kg/fishery event) and the number of individuals discarded below the minimum length (< 20 cm of TL). (B) Mean percentage of the number of individuals of the companion fauna species per fishery event.

Discussion

The piracatinga fishery is performed at the lower Solimões/Amazonas River is different from other fisheries, such as performed at riverine communities located in the Mamirauá Sustainable Development Reserve area (middle Solimões/Amazonas River) because the fishermen working on it live in urban or semi-urban areas of Manacapuru.

While in Manacapuru the fishermen work alone with the help of their wives using demountable traps to imprison the piracatinga. In Mamirauá, the fishermen form groups of two to five participants helping each other with different tasks performed during the fishery, such as: the construction of a wooden box to trap the fish, to obtain the bait, the fishery and, finally, the evisceration of the fish (Botero-Arias *et al.* 2014).

According to Franco *et al.* (2016), the most common technique used at Mamirauá was the corral without a door (60%), followed by a corral with a door (34.7%) and without a trap (5.3%). The fish were then caught by hand and thrown into the corral without a door or into the canoe where the bait was held with fisherman's legs (bait used was caiman tail or leg) (Botero-Arias *et al.* 2014; Franco *et al.* 2016). In Mamirauá, all corrals contained cracks between the plates varying from 1 to 2 cm to facilitate the exit of smaller fish keeping only the largest ones (Botero-Arias *et al.* 2014), such practice did not occur at Manacapuru.

To compare, Manacapuru fishermen always used bovine viscera or fish as bait and the piracatinga caught were sold to the floating warehouses without removing viceras and fresh, with the animals been caught in the same of fishing day, as opposed to the Mamirauá region were they

used caimans and freshwater pink dolphins as bait (Iriarte & Marmontel 2013; Botero-Arias *et al.* 2014; Brum *et al.* 2015; Franco *et al.* 2016) and after the fish was caught the gut was removed and stored in a ice box that was taken to the nearest municipality for sale (generally cities as Tefé and Fonte Boa). The profit was equally divided among the fishermen group (Franco *et al.* 2016).

Botero-Arias *et al.* (2014), Brum *et al.* (2015) and Franco *et al.* (2016) mentioned that fishermen at the Mamirauá region prefer baits, which they believe attracts more fish increasing productivity. These fishermen at Mamirauá prefer to use as bait the freshwater pink dolphin (*Inia geoffrensis*), followed by the black caiman (*Melanosuchus niger*), the common caiman (*Caiman crocodilus*) and occasionally the freshwater tucuxi dolphin (*Sotalia fluviatilis*). Although black caiman was the most frequently used bait (60%), due to its abundance (Botero-Arias *et al.* 2014; Franco *et al.* 2016).

The average productivity recorded in the Manacapuru fisheries was 431.6 kg/fishery event. Franco *et al.* (2016) mentioned that the average productivity in the fisheries in the Mamirauá region was 560.0 kg/fishery event. The higher productivity observed in Mamirauá can be caused by several factors, such as the storage capacity in wood corral (usually 3.0 tons) and/or the most common technique used (corral without a door) Which did not allow commercially-caught fish to escape (Franco *et al.* 2016). In Manacapuru, nylon screen yards had a smaller storage capacity (1.2 tons), mainly because of the cargo carrying capacity of the fisherman, the canoe used could not generally exceed 1.2 tons of load, though, the storage capacity (tons) of the screen corral has effectively not been tested so far. In addition, all the corrals used in Manacapuru

contained a door, which usually let escaped specimens out the corral, every time the fisherman opened the door to direct the bait in again. These leaks were also mentioned for the fisheries in Mamirauá, where 34.7% of the fishermen used wooden corral with door (Franco *et al.* 2016).

In the present study, if we consider the average weekly catch of (431.6 kg/per fisherman), we will have approximately 6.9 tons of fish caught per fisherman in 4 months (January to April, harvest period). If we consider the 31 fishermen, about 213.9 tons were caught during a harvest, a very expressive production number. The survey of information about the piracatinga fishery activity practiced by these fishermen, made it possible to enrich the knowledge about piracatinga fishery carried out by the urban and semi-urban fishermen of Manacapuru. This information on the dynamics of the piracatinga fishery, the strategies used, the fish commercialization and the model fishery, are relevant in an area that very little known, but of great importance socioeconomic for riverine communities and all piracatinga fishermen.

The baits used by fishermen from Manacapuru (with viscera of bovines and fish) are as efficient as the baits used by fishermen from Mamirauá (caimans and freshwater dolphins meat, protected by law). Apparently, there is no preference for baits by piracatinga, instead, a preference of the fisherman for the baits of lower costs, greater ease and availability, as is the case of the caimans (abundant in the reserve of Mamirauá) and in smaller proportions the freshwater pink dolphin.

Botero-Aries *et al.* (2014) mention that piracatinga fishing activity up to 2011 had expanded its geographic reach due to new technologies and new commercial relationships aiming at higher productivity. The difference in fishing in the two regions (Manacapuru and Mamirauá) is also related to mobility. While in Manacapuru, the equipment (corral with nylon screen) can be easily assembled and dismantled. At the Mamirauá region this equipment was built (corral or wooden box) and transported to the fishing point of the group of fishermen. In Mamirauá the wooden box were generally used for one and at most two fishing seasons (2 years) until they deteriorated. Another characteristic of the boxes used at Mamirauá was at the opening or slit between the boards allowing smaller fish to escape (Botero-Aries *et al.* 2014). The screen nylon equipment used at Manacapuru did not allow any fish escape, thus generating fish that was not wanted because of its size and it was not the

main target specie. To avoid mortality, fishermen from Manacapuru should preselect the fish before transporting the production to the floating warehouse, thus avoiding waste of small fish. A type of gillnet with larger mesh should be placed in the corral in order to catch only the large fishes and release the juveniles, thus avoiding the unnecessary excess fish.

The future of piracatinga fishing: The future of piracatinga fishing, with a moratorium until January of 2020, is still unclear. One of the obstacles of this activity is the type of bait used to attract the fish. The use of caimans and freshwater dolphins as bait for this type of fishing in some remote regions of Central Amazon (mainly Mamirauá) made this fishery somehow uncontrolled and dangerous to the preservation of species protected by law.

Works has been done (Serrano *et al.* 2007; Brum 2011; Da Silva *et al.* 2011; Brum *et al.* 2015) regarding the killing of freshwater dolphins to obtain bait for capturing of piracatinga, however, it is not known to what extent the piracatinga fishery contributes to the decline of these species. The numbers are not precise, for example, the numbers for the mortality of freshwater pink dolphin is estimated on three different papers giving three different numbers: 600 animals (Serrano *et al.* 2007), 1650 animals (Da Silva *et al.* 2011) and 170 animals (Brum 2011). These variations are certainly related to the uncertainties of the variables used in the calculations, such as baits productivity and, mainly, the proportion of freshwater pink dolphins used for the activity. Often these estimates consider the production of piracatinga based only on the reports of some workers fishing company, without, however, considering authentic fishery statistics in general. In addition, considerations about Catch Per Unit Effort (CPUE) or average real productivity per fisherman are ignored or absent.

Others important factors are the lack of basic information on the biology and population dynamics of the target species used as bait (sense of abundance, mortality rate and reproduction associated with age, growth and migration) are also problems that must be resolved (Mintzer *et al.* 2016). The omission of which type of bait piracatinga fishermen used can also cause a problem to diagnose the amount of bait used, and finally a inefficient fiscalization and control by the competent environmental institutions.

In the last 14 years (2000- 2014), the piracatinga fishery has become a important activity as a source of income for fishermen at the Solimões-

Amazonas River System (Estupiñán *et al.* 2003; Botero-Aries *et al.* 2014). The increase in demand made the piracatinga fishery start to be considered as an activity of commercial relevance (Botero-Aries *et al.* 2014; Franco *et al.* 2016). However, actions that may restrain the productivity may influence the future performance when the moratorium is lifted. Is crucial to expand and deepen the studies to understand the effect of this type of fishing on the mortality of freshwater dolphins and caimans. Also, the ecology of the piracatinga has to be better studied as well as the motivations for fishermen in some remote regions to the use freshwater dolphins and caimans as baits.

It is known that freshwater dolphins and caimans have been threatened for decades. The caiman (*Melanosuchus niger* Spix 1825) have been targets of commercial exploitation (skin and salted meat) the since 1904 until 1969 about 3,900,000 to 4,800,000 animals had hunted (Antunes *et al.* 2016). Since the 1970s it became illegal to exploit caimans due to a decline in population however, they were still hunted (Thorbjarnarson 2010). The freshwater pink dolphins with mortality resulting from negative interactions with fishermen since they alleged the dolphins damaged the fishing equipment and competed for the fish (Da Silva 1990; Brum 2011), although a deeper study has not been done until this time (Da Silva & Martin 2007; Brum 2011; Iriarte & Marmontel 2011; Iriarte & Marmontel 2013; Botero-Aries *et al.* 2014; Mintzer *et al.* 2016).

Even with the lift of the moratorium of the piracatinga fishing, freshwater dolphins and caimans will continue to be victims of fishing nets and from confrontation with fishermen for competing for the same resource (Loch *et al.* 2009; Alves *et al.* 2012; Iriarte & Marmontel 2013). Brum (2011) in a study at the Mamirauá region alone, estimated that 238 freshwater dolphins were killed accidentally or in reprisal in conflicts with fishermen for damaging their nets. Black caimans and common caimans were mainly targeted for the sale of their meat been captured 3,562 captured caimans (37,050 kg) annually only in the lower Purus region (Mendonça *et al.* 2016).

The initiative to create a moratorium restricting the piracatinga fishing creates a social problem because it opens precedent to illegally fishing for a species of fish that is abundant and not threatened (Botero-Aries *et al.* 2014). In addition, such fishing serves as an source of income for traditional populations of hundreds of communities that often lack alternative sources of income.

With the moratorium near the end (January of 2020) we still do not have answers regarding how to protect the threatened species and how to proceed?. How these measures will benefit the protection of these species?. However, any solution will require efficient fiscalization. According to Franco *et al.* (2016) caimans are the most hunted (60%), the pressure of illegal poaching is more intense on them. In our view, the prohibition of piracatinga fishing after the five-year moratorium may not have positive effect desired due principally to the lack of larger volume of researches directed to the problem, lack of efficient fiscalization mainly of the fishermen and fish freezing industry buyers of piracatinga (that use illegal bait) and to possible hostilities fishermen or communities to provide information regarding the fishery, after the moratorium.

The absence of fiscalization and researches (justified by investment lack) is be extremely important to carry out a comprehensive geographic monitoring englobing a population spread at a immense area such as the Amazon forest and without these type of studies it is hard to point out the threats that these endangered mammals and reptiles population suffer. Fishery data for piracatinga is not much published (like data for many other species in the Amazon), however it is imperative to collect these data to develop good monitoring systems that should be implemented conserve the freshwater dolphin, caimans and piracatinga in the long term.

Due the effectiveness of the moratorium being uncertain, one of the simple and efficient measures as observed in the piracatinga fishery in Manacapuru would be the incentive to use alternative baits in all remote communities piracatinga fishery the Central Amazon. Almost half of the fishermen in Manacapuru (48.4%) showed that they also used other types of baits, such as, fish viscera with results excellent catches like what was caught with bovine viscera. However, they argue that the main difficulty obtaining bait from the fish freezing industry was fear of sanitary inspection that did not release the fish viscera. In our view, fish freezing industry should be encouraged to release these alternative baits for fishermen to catch piracatinga even been difficult to maintain conserved, but still minimizes the difficulties to obtain baits, as well as avoid seeking in baits from animals protected by law.

The fish industry do not liberate the viscera because of fear of the composition with rich organic and inorganic compounds (with a certain amount of contaminants, such as bacteria, and stomach

enzymes responsible for tissue autolysis and fast decomposition of this tissue). This generates relative concerns of the potential negative environmental impacts resulting from the disposal of this material directly in the environment or offered *in natura* to the cultured fish, or in this case, the capture of piracatinga in wild.

However, the current legislation (Decree 9.013, 29th March, 2017) and the Regulation of the Industrial and Sanitary Inspection of Animal Products (RIISPOA) of the Inspection Department of Animal Products (DIPOA) of the Ministry of Agriculture, Livestock and Supply (MAPA), mentions that the residues resulting from the fish can be used as baits provided that they are followed by designation of the conservation method.

The new alternative for the use of fish residues (mainly viscera's) would be a way of adding value to this material, under the "clean baits" approach, and an alternative adequate way to maintain piracatinga fishing. The viability of the residues use of fish industry for the production of piracatinga baits also depends, fundamentally, on the quality of this residues. Considering, in particular, that the perishability of fish tissue is greater than that of other animal species (Pessatti 2001; Nunes 2001). This quality of the residues is directly related to the care in the manipulation and conservation at low temperatures and the application of adequate procedures of cleaning and sanitization of the establishment (Morales-Ulloa & Oetterer 1995; Feltes *et al.* 2010).

Possibly the conservation of these viscera in salting and the use of vegetable oil increase the attractiveness of baits, likewise as in the capture of some ornamental fish from the Negro River, where the fisherman (piabeiro) uses fried fish, rather than *in natura* fish, to attract the ornamental fish (Prang 2001; Chao *et al.* 2001). Remains of regional fruits such as tucumã (*Astrocaryum aculeatum* Huber) and pupunha (*Bactris gasipaes* Kunth), which contain vegetal oils, are quite abundant and should be tested to verify if it attracts and as a new alternative for fisheries.

At remote communities, distant from the cities where the slaughterhouses and fish industry are located there is no logistics for fishermen to obtain alternatives bait that substitutes freshwater mammals and reptiles, so they have to go through environmental education activities where fisherman are encouraged to obtain alternatives bait, such as, fish with low market acceptance and abundant in these localities. Also, work planned to test new baits

types is need it ensuring both a source of income for fishermen and the conservation of species protected by law, as well as avoiding the criminalization of populations to the development of participatory and sustainable options.

According to Botero-Arias *et al.* (2009), the community-based caimans management initiative being implemented in the Mamirauá Reserve represent a way to engage the piracatinga bait hunters in a legal and sustainable activity, thus reducing, illegal hunted practices. Besides the management of caimans, educational campaigns regarding the protection and preservation of freshwater dolphins should be intensified in the schools of these remote communities, causing future potential fishermen to have an consciousness since young, making them change their concepts about different aspects regarding that freshwater dolphin and the nature, without interfering with local cultures.

Finally, the conservation of the Amazonian biodiversity must be idealized in conjunction with the traditional populations, respecting the particularities of these communities, which is a fundamental step towards achieving sustainability. In this sense, Environmental Education Programs and conscience of the traditional populations should be encouraged, even before we seek any radical alternative to fishing prohibitions, facilitating like this the life of these traditional populations to find viable alternatives for sustainability and especially for the conservation of the Amazonian biota.

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