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Peacock bass mortality associated with catch-and-release sport fishing in the Negro River, Amazonas State, Brazil

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ABSTRACT

Sport fishing for peacock bass *Cichla* spp. in the Brazilian Amazon has increased in popularity and attracts anglers who generate significant economic benefits in rural regions. The sustainability of this fishery is partly dependent on the survival of fish caught through catch-and-release fishing. The objective of this work was to investigate, hooking mortality of *Cichla* spp., including speckled peacock bass (*C. temensis* Humbolt), butterfly peacock bass (*C. orinocensis* Humbolt), and popoca peacock bass (*C. monoculus* Agassiz) in the basin of the Negro River, the largest tributary of the Amazon River. Fish were caught at two different sites using artificial lures, transported to pens anchored in the river and monitored for 72 hours. A total of 162 individual peacock bass were captured and hooking mortality (mean % ± 95% confidence intervals) was calculated. Mean mortality was 3.5% (± 5.0), 2.3% (± 3.5) and 5.2% (± 10.2) for speckled peacock bass, butterfly peacock bass, and popoca peacock bass, respectively. Lengths of captured fish ranged from 26 to 79 cm (standard length), however, only fish under 42 cm died. This research suggests that catch-and-release sport fishing of peacock bass does not result in substantial mortality in the Negro River basin.

KEYWORDS: Artificial bait, *Cichla* spp., Fisheries assessment

Mortalidade de tucunaré associada à pesca esportiva do pesque e solte no rio Negro, Amazonas, Brasil

RESUMO

A pesca esportiva de tucunarés *Cichla* spp., na Amazônia brasileira, aumentou em popularidade nos últimos anos e tem atraído pescadores esportivos que geram benefícios econômicos para essa região. Entretanto, a sustentabilidade dessa pescaria depende em parte da sobrevivência dos peixes capturados por meio da prática do pesque e solte. O objetivo deste trabalho foi avaliar a mortalidade de *Cichla* spp., incluindo o tucunaré paca (*C. temensis* Humbolt), o borboleta (*C. orinocensis* Humbolt) e o popoca (*C. monoculus* Agassiz) em dois locais na bacia do rio Negro, o maior tributário do rio Amazonas. Os peixes foram capturados por variados tipos de iscas artificiais e posteriormente monitorados em viveiros construídos no próprio rio por 72 horas. Um total de 162 tucunarés foi capturado, e as mortalidades (% ± intervalo de confiança 95%) foram calculadas. A mortalidade foi 3,5% (± 5,0), 2,3% (± 3,2) e 5,2% (±10,2) para o paca, o borboleta e o popoca, respectivamente. O comprimento padrão dos peixes capturados variou de 26 a 79 cm, mas apenas os peixes menores até 42 cm morreram. A pesquisa sugere que a pesca esportiva não causou substancial mortalidade na população de *Cichla* spp. na bacia do rio Negro.

PALAVRAS-CHAVE: Isca artificial, *Cichla* spp., Avaliação pesqueira

INTRODUCTION

Some mortality can occur during catch-and-release sports fishing, due to injuries sustained during capture (Muoneke and Childress 1994). In the USA, Canada and Australia, studies show low mortalities for freshwater fish released following capture. Cooke *et al.* (2003) and Pope and Wilde (2004) reported <7% mortality for largemouth bass (*Micropterus salmoides* Lacépède). Similarly, Muoneke (1992) encountered <10% mortality for white crappie (*Pomoxis annularis* Rafinesque) and spotted bass (*Micropterus punctulatus* Rafinesque), while Dunmall *et al*. (2001) reported negligible mortality for smallmouth bass (*Micropterus dolomieu* Lacépède). Mortality for Australian bass, golden perch (*Macquaria ambigua* Richardson), Murray cod (*Maccullochella peelii* Mitchell and *Macquaria novemaculeata* Steindachner) and Silver Perch (*Bidyanus bidyanus* Mitchell) ranged from 0 – 6.3% mortality (Walt *et al*. 2005; Hall *et al*. 2009; Hall *et al*. 2012).

Sport fishing in the Brazilian Amazon has increased significantly during the last 25 years. While there is little data available on sport fishing in the region, the Negro River basin receives the largest share of sport fishermen. According to Amazonastur (2012), the regional tourism authority, 7,293 anglers fished the Negro River in 2011. Considering an average price of US$3,000 for a week's fishing in this region, this represents an annual revenue of over US$ 22 million. While the Amazon basin contains thousands of fish species, only a few are sought by the sport fishing industry, with peacock bass *Cichla* spp, being the main target. Kullander and Ferreira (2006) identified three different species of peacock bass in the Negro River basin: speckled (*C. temensis* Humbolt), butterfly (*C. orinocensis* Humbolt), and popoca (*C. monoculus* Agassiz).

Commercial fishing of peacock bass is viewed as a threat to the regional sport fishing industry. This has led to roundtable discussions where sport fishing operators and commercial fishermen, have considered different strategies for achieving sustainable fish stocks (Cooke and Schramm 2007; ISA 2010). Arlinghaus *et al*. (2007) has argued that subsistence fishing is also an important sector and these anglers should be represented at these meetings. Peacock bass represents about 18% of rural fish consumption in the Negro River basin (Silva and Begossi 2009).

Anglers in the Negro River seek large speckled peacock bass (> 4.5 kg; >60 cm), which are released with the assumption that these fish can be caught again. According to Holley *et al.* (2008), commercial fishing, and also to some degree, sport fishing, may reduce the abundance of large trophy peacock bass due to mortality. Thorstad *et al.* (2004) reported 0% mortality for two large cichlids from the sport fishing industry on the subtropical Zambezi River; *Serranochromis robustus* Günther and *Oreochromis andersonii* Castelnau. However the mortality rates of peacock bass following catch-and-release in the tropical Amazon are still unknown. The purpose of this study was to investigate the catch-and-release mortality of peacock bass in the Negro River Basin, and to evaluate the influence of hook location on damage to released fish.

MATERIALS AND METHODS

The mortality of *Cichla* spp caused by catch and release fishing using artificial lures, was investigated at two different study areas. The first experiments were conducted in December 2006 along the shallow margins of the main channel of the Negro River (Figure 1), close to the Rio Negro Lodge (63º 27'00"W, 0º 34'80"S), a sport fishing resort catering mainly to international clients. The second experiments were performed in February 2007 on the Jufariz River (62º24'05"W, 0º48'46"S), a tributary of the Negro River. In both experiments, fish were captured by two or three different sport fishermen and one or two researches over the course of four days. Generally, the duration of the time from the fish being hooked until removal from the water was under 1 min, with air exposure minimized at all times. Fish were captured from 6:00 a.m. to 6:00 p.m. using bait casting fishing rods and reels spooled with 36 kg braided line from sport bass fishing boats equipped with outboard motors. Different types of artificial lures were utilized and recorded (Figure 2), including floating surface lures about 20 cm long with three sets of treble hooks, 15 to 20 cm long mid-water lures with two sets of treble hooks, and a single hook hair jig that sinks to the bottom. Injuries sustained to vital areas of the fish, including the mouth, throat, body, gills and eyes were recorded. In addition, the presence or absence of blood was noted. When hooks did not cause any deep tears or ruptures it was deemed no impact. Captured fish were identified to species, then weighed (g), measured for standard length (SL in cm), and examined for injuries. The date and hour of capture were also recorded, along with the type of lure used.

Upon capture, fish were immediately placed in aerated 100 L coolers and transported to holding areas set up along the side of the river that had been netted off for the purposes of the experiment. In some cases, fish had to be transported more than 20 km from the point of capture to the holding area. To reduce stress that could influence mortality in this first phase of the experiment, no more than ten small individuals (< 4.5 kg) or one large individual (> 4.5 kg) were housed in a single cooler. Smaller fish were never held for more than two hours in the aerated coolers, while larger fish were transported immediately upon capture.

Five holding pens were set up along the bank of the river using 1 cm nylon netting. Each pen had a total volume of 4.5 m^3. To avoid fish jumping out of the enclosures, the tops

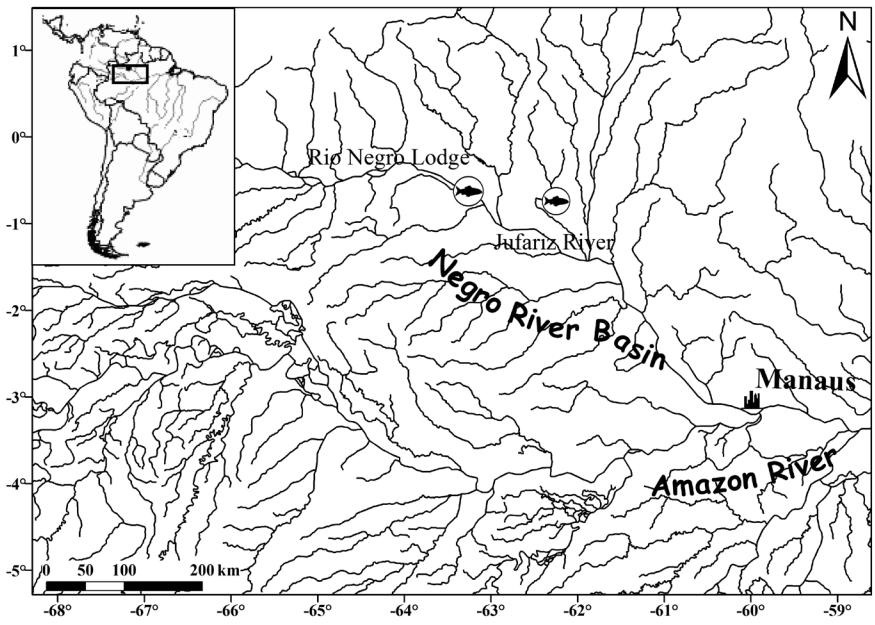

Figure 1. Map of the Negro River basin and study area: Rio Negro Lodge and Jufariz River.

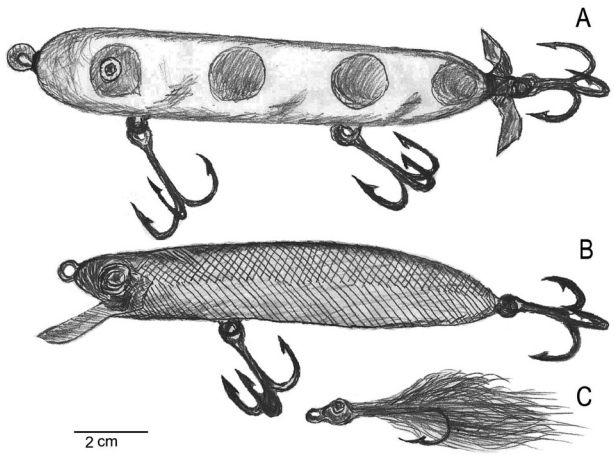

Figure 2. Type of artificial lures: A – floating surface; B – mid-water and C – Jig.

of the pens were covered with netting. The number of fish confined to each pen varied from day to day depending on the capture success rate, resulting in a minimum of 4 per pen to a maximum of 29. Fish were then monitored for 72 h, following methodology developed by Muoneke (1992). Mortality rates for each species were pooled for both sites. After the duration of the experiments, all surviving fish were released.

Fish mortality, MT, and its variability, Var (MT), were estimated using the equations proposed by Wilde (2002), with no control group:

$$MT = nR / NR,$$

$$Var(MT) = (MT \times (1 - MT)) / NR.$$

Where, MT is the catch and release mortality observed during the experiment; nR is the number of captured fish that died; and NR is the total number of fish captured. The standard error of fish mortality, SE (MT), was calculated using the square root of the Var (MT). The 95% confidence interval for MT was approximated according to:

$$MT \pm 2 \times SE(MT).$$

RESULTS

A total of 162 peacock bass were captured, transported to pens, and monitored, including 62 fish at the Rio Negro Lodge site and 100 on the Jufariz River. In total, 59% were caught with a single hook jig, 33% with the mid-water diving lures, and 8% with a surface lure. Of the species captured, 54%, 35% and 12% were butterfly, speckled, and popoca peacock bass, respectively (Table 1). Five individuals died, including two butterfly, two speckled, and one popoca peacock bass. Overall mortality (95% confidence intervals) was 2.3% (± 3.2), 3.5% (± 5.0), and 5.2% (± 10.2) for butterfly, speckled, and popoca peacock bass, respectively. In total, 60.4% did not suffer any apparent type of severe injury, like a rupture

Table 1. Experimental parameters for each species of peacock bass calculated in Negro River basin.

Species	Number of captured fish	Number of deaths and lure type that caused fatality	Hook location where fatalities occurred	Number of fish that bled	Mortality % (±CI 95%)
Speckled (*C. temensis*)	56	2 (jig)	throat and gill	4	3.5% (±5.0)
Butterfly (*C. orinocensis*)	87	2 (mid-water and jig)	gill and throat	2	2.3% (±3.2)
Popoca (*C. monoculus*)	19	1 (mid-water)	gill	1	5.2% (±10.2)

of tissue. Of the remaining fish, 23.5% were visibly injured in the mouth, 12.3% on the body, 1.9% in the gills, 1.2% in the throat and 0.6% in the eyes. Three injuries recorded in the gills and two in the throat caused fish mortality. Bleeding occurred in seven fish, and among these, four died.

Fatalities occurred 5-15 minutes after capture for four fish, while one individual lived for two hours before succumbing. There were mortalities only for the mid-water diving lures and the jig, with no deaths occurring for fish caught with the surface lure. All fish that died were less than 42 cm SL (Figure 3) and ranged in weight from 150 to 935 g. For butterfly and speckled peacock bass, the four hooking fatalities occurred in smaller individuals, with no larger fish succumbing to any injuries.

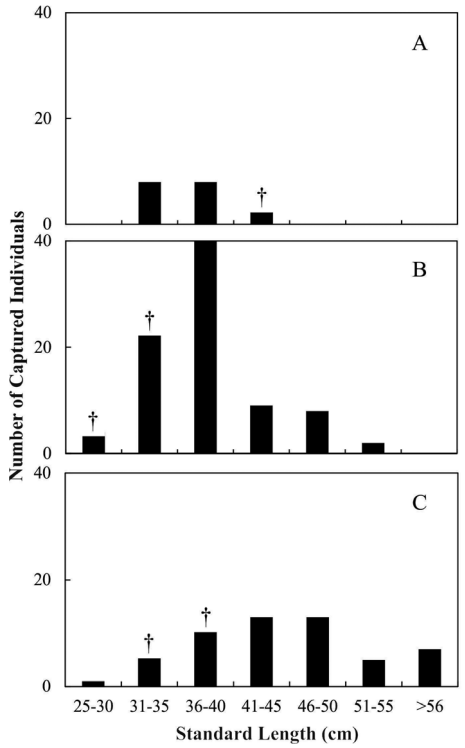

Figure 3. Number of fish *Cichla* spp. captured for different length intervals (cm SL). The symbol (†) indicates the class fish mortality: A – Popoca; B – Butterfly and C – Speckled.

DISCUSSION

Muoneke and Childress (1994) did not consider mortality due to fishing below 20% to be high. By this criterion, the peacock bass in the catch-and-release experiments described did not suffer high mortality, much in agreement with similar studies done in temperate regions (Muoneke 1992; Walt *et al*. 2005; Hall *et al*. 2012). This includes a study with Atlantic salmon (*Salmo salar* Linnaeus) in northern Norway that found a sport fishing mortality rate of 3% (Thorstad *et al*. 2003). However, some research in temperate zones has reported mortality rates that vary between seasons (Wilder *et al*. 2000; Millard *et al*. 2005; James *et al*. 2007) and this difference appears to be related to temperature.

Nelson (1998) concluded that mortality rates increased 103% with each 1 ºC increase in water temperature for striped bass. In the Negro River basin, water temperature varies very little year-round, with an average difference of only three degrees Celsius (29 - 32 ºC). No data are available on the influence of temperature on the mortality of peacock bass in the Negro River, subjected to stress or injuries caused by catch-and-release fishing. The physical and chemical characteristics of the Negro River differ from many other Amazonian rivers (Sioli 1964), with high concentrations of dissolved organic carbon, pH varying seasonally from under 5 to almost 6, conductivity ranging from 9 to 28 uS cm^{-1}, and generally low levels of suspended sediments. Future studies should focus on the influence of variation in water temperature and quality among rivers on sports fishing related mortality.

Siepker *et al*. (2007), in a review of the impacts of catch-and-release fishing, argued that hooking is a primary source of capture-related injury that can potentially cause mortality in black bass. For Cooke *et al*. (2003), individuals that suffered life-threatening injuries were typically hooked deeply in a vital organ or tissue (i.e. heart, gullet, gill arch), exhibited substantial bleeding, and were caught with hooks that were difficult to remove. Additionally, nearly all fish with throat injuries succumbed to their injuries.

The experiments in the Negro River basin showed that all peacock bass mortalities were associated with gill and

throat injuries, supporting the argument that hook location is a strong factor in fish mortality (Millard *et al*. 2003; Alós 2009; Broadhurst *et al*. 2012 a, b). Both fish which suffered throat injuries in our study died, while gill injuries resulted in death 40% of the time. Several authors reported that fish hooked in vital organs died in only a few hours (Pelzman 1978; Muoneke 1992; Muoneke and Childress 1994).

In this research, four fish died in under 15 min and another in less than 2 hours. On the other hand, no mortality was observed for fish with injuries to the lip, jaw, or mouth region, suggesting that the gills and throat in peacock bass are the most vulnerable anatomical areas. Although bleeding may occur in hooked fish, it does not necessarily indicate a likelihood of fatality. In this study, seven individuals suffered some kind of bleeding, and four of these died. In a study of catch-and-release fishing of largemouth bass, ~20% suffered some kind of hemorrhage at the time of capture, but less than 6% died (Cooke *et al*. 2003). Therefore, hook location and the occurrence of bleeding appear as the most influential variables in determining the probability of death of a hooked and released fish (Millard *et al*. 2005; Broadhurst *et al*. 2012 b), including the size of the individual (Millard *et al*. 2005; Hall *et al*. 2009; Alos 2009).

The standard lengths of fish caught in our experiments ranged from 26 - 79 cm, but all individuals that died were less than 42 cm. Millard *et al*. (2005) associated a decrease in angling mortality with increased fish size for striped bass (*Morone saxatalis* Walbaum), in agreement with the findings of Hall *et al*. (2009) and Alós (2009). Other authors found no significant effect of fish size on mortality (Nelson 1998; Cooke e*t al*. 2003; Broadhurst *et al*. 2012 a). In contrast, Hall *et al*. (2012) found that large golden perch had a greater mortality probability than their smaller conspecifics. Because of the limited number of fish collected and the unequal size-distribution in our sample, the effect of size on mortality could not be adequately evaluated. More research will be necessary to investigate this effect.

We conclude that the level of mortality in peacock bass caught with artificial lures in catch and release sport fishing operations in the Negro River Basin is low and that hooking is more dangerous to fish if it occurs in the throat or gills. Catch and release sports fishing thus represents a viable alternative for the sustainable use of this fisheries resource in the Negro River Basin. Integrated management strategies will have to consider the combined effects of sports fishing, commercial fishing and subsistence fishing the peacock bass mortality in this and future studies should evaluate all of these factors.

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