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Scientific Article

Selectivity of gillnets on the main fish species caught in the floodplains of the Madeira River (Rondônia, Brazil)

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Abstract

Small-scale fishing in the floodplains of the Amazon basin has intensified, with gillnets being one of the main types of tackle used. In this study, we evaluated the length structure of fish species in a floodplain lake of the Madeira River basin, emphasizing the selectivity of the nets in the main species caught. The fisheries were collected in periods of high and low water, with nets of mesh sizes of 40, 60, 80, 100, 120, and 160 mm. Tests between the periods and also comparing the meshes were performed, and the parameters of the selectivity curves estimated with the Share Each Length Catch Total calculation code. Records of 17 new maximum lengths were presented. Among the 12 most abundant species, the selectivity of the nets in the modal lengths for *Anchovia surinamensis* were 13.3, 19.9, 26.6, and 33.2 cm in the nets with mesh sizes of 40, 60, 80, and 100 mm, respectively. In the three smallest mesh sizes, the values for *Potamorhina altamazonica* were 12.7, 19, and 25.3 cm, and for *Pellona flavipinnis* values were 15.4, 23.2, and 30.9 cm. In the two smallest mesh sizes, the following values were presented for the species *Potamorhina latior* (12.9 and 19.4 cm), *Potamorhina rutiloides* (11.3 and 16.9 cm), *Triportheus elongatus* (19.7 and 29.5 cm), *Triportheus flavus* (14.1 and 21.1 cm), and *Pimelodus blochii* (15.5 and 23 cm). The study confirmed the rich presence of Characiformes in the floodplain lake that was surveyed. The catches are effectively composed of juvenile fish. Among the highlighted species, the 40-mm mesh is not recommended for the species *P. altamazonica*, *T. flavus*, and *P. flavipinnis*.

Keywords: Amazon basin; Artisanal fishing; Juvenile fish; Multispecies; Gillnet selectivity.

Seletividade das malhadeiras sobre as principais espécies de peixes capturadas nas várzeas do Rio Madeira (Rondônia, Brasil)

Resumo

A pesca artesanal nas várzeas da Bacia Amazônica tem se intensificado, sendo a rede de emalhar um dos principais tipos de apetrecho utilizados. Neste estudo, avaliamos a estrutura de comprimento das espécies de peixe em um lago de várzea da bacia do Rio Madeira, enfatizando a seletividade das redes sobre as principais espécies capturadas. As pescarias foram coletadas em períodos de águas altas e baixas, com redes de malhas de 40, 60, 80, 100, 120 e 160 mm. Foram realizados testes entre os períodos e comparando as malhas, e também estimados os parâmetros das curvas de seletividade com o código de cálculo Share Each Length Catch Total. São apresentados registros de 17 novos comprimentos máximos. Das 12 espécies mais abundantes, a seletividade das redes nos comprimentos modais para *Anchovia surinamensis* foi de 13,3, 19,9, 26,6 e 33,2 cm nas redes com malhas de 40, 60, 80 e 100 mm, respectivamente. Nas três menores malhas, os valores para *Potamorhina altamazonica* foram 12,7, 19 e 25,3 cm, e para *Pellona flavipinnis*, 15,4, 23,2 e 30,9 cm. Nas duas menores panagens, foram apresentados os seguintes valores para as espécies *Potamorhina latior*: 12,9 e 19,4 cm; *Potamorhina rutiloides*: 11,3 e 16,9 cm; *Triportheus elongatus*: 19,7 e 29,5 cm; *Triportheus flavus*: 14,1 e 21,1 cm; e *Pimelodus blochii*, 15,5 e 23 cm. As capturas são efetivamente compostas de peixes juvenis. Entre as espécies destacadas, a malha de 40 mm não é recomendada para as espécies *P. altamazonica*, *T. flavus* e *P. flavipinnis*.

Palavras-chave: Bacia Amazônica; Pesca artesanal; Peixes juvenis; Multiespécies; Seletividade malhadeira.

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INTRODUCTION

Small-scale fishing in the Amazon is an activity that provides food and income for millions of people, especially in riverine communities in Brazil and other tropical developing countries (Abbott et al., 2007; Coomes et al., 2010; Silvano et al., 2016). The Amazon basin is the world's largest freshwater ecosystem and features a rich and diverse ichthyofauna (Welcomme, 1985; Junk et al., 2007; Dagosta and Pinna, 2019). In the basin, fishing is of paramount importance to produce animal protein (Isaac and Almeida, 2011), and it is no coincidence that the region has the highest per capita fish consumption in the world (Begossia et al., 2019).

Among the habitats situated in the Amazon basin, floodplains stand out as one of the most crucial ecosystems in terms of productivity and ecological heterogeneity (Crampton, 2011; Morales et al., 2019; Morales and Deus, 2021). The diversity of these floodplain areas has a great effect on the tributaries of the Amazon River, especially white-water tributaries such as the Madeira River (Fernandes et al., 2004), which presents the greatest diversity of fish species that has been catalogued for a tributary of the Amazon River (Queiroz et al., 2013).

Among these species, several have short, lateral migratory patterns, with the connection of rivers and their adjacent floodplain areas being used as breeding and refuge sites (Fernandes, 1997; Silvano et al., 2014), thus contributing to population dynamics and maintaining fish diversity in both environments (Freitas et al., 2010). This ecological pattern selects the fish assemblages by groups of different sizes and ages, generating modifications in population densities, changing the parameters of the reproductive biology of the populations and, consequently, the parameters of the structure of the communities of the lakes (Martins et al., 2018). The floodplain areas of Amazon are one of the few fishing regions in the world in which fish capture activities have been suboptimal (McGrath et al., 1998). However, during the last few decades, fisheries in these environments have intensified, thus causing impacts on the ichthyofauna, and increasing the need for more appropriate management policy formulations (Pinaya et al., 2016).

Fisheries management in floodplain lakes is quite complex, since in these environments the most varied aspects have to be considered, including biological aspects and the traditional knowledge of fishers who work in these areas. However, it has been suggested that external interventions should occur on a local and reduced scale (Morales and Deus, 2021). Although the individual aspects of each lake or region must be considered, in all places it is essential to estimate the selectivity of the most-used types of fishing tackle (FAO, 1995).

In Amazonian multispecies fisheries, the most used tackle is the gillnet, because it is easy for traditional people to make and use, and it also has low cost (Hallwass et al., 2023). Gillnets are considered "passive" fishing tackle, since they need fish to swim into them so that they can be caught (Sparre and Venema, 1997). This type of fishing tackle can be cast adrift or fixed, installed in a fishing spot for several hours, and each mesh size selects fish according to their morphology (Reis and Pawson, 1999; Petriki et al., 2014). Knowledge about the potential impacts of different mesh sizes and their selectivity can provide information that assists in obtaining higher fishing yields with less impact on available fish stocks (Rueda and Defeo, 2003).

Thus, when fishers understand that there is the need to protect juvenile fish, mesh sizes appropriate to the minimum catch sizes tend to be used (Stewart, 2008), and these sizes are directly associated with the biological information of stocks and their lengths of first maturation (Sparre and Venema, 1997; Froese, 2004). However, when the objective of fishing is to capture fish of different size classes, the use of meshes that consider the extraction of individuals with age and ideal size for consumption can be an effective alternative for mitigating the adverse effects of fishing on the fishery stock (Garcia et al., 2012; Law et al., 2012).

In some tropical inland fisheries, the use of meshes with varied sizes can provide a greater diversity in fish catches, even during periods characterized by reduced accessibility to these aquatic species (Silvano and Begossi, 2001). However, by knowing the specificities of each region and type of fishing stock, it is possible to use only one mesh size and, through fishery selectivity, ensure the success of this activity (Van Ostenbrugge et al., 2002; Lima and Andrade, 2018).

In this study, we evaluated the length structure of fish species caught with nets in Cujubim Lake, in the Madeira River basin, emphasizing the selectivity of the meshes in the main species caught. Information on the selectivity of these nets, which are widely used in the Amazon basin, can contribute to the management of ichthyofauna, both in lentic and lotic environments, and assist in management policies in fishing communities, thus avoiding overexploitation of the most varied fishing resources and the maintenance of this activity, which is an essential source of food and income.

MATERIAL AND METHODS

Study area and data collection

Cujubim Lake is located about 40 km from Porto Velho, capital of the state of Rondônia, Brazil. It is the main lake on the right bank of the Madeira River (Fig. 1) and strongly influenced by the flood pulse that connects it with the main river in periods of

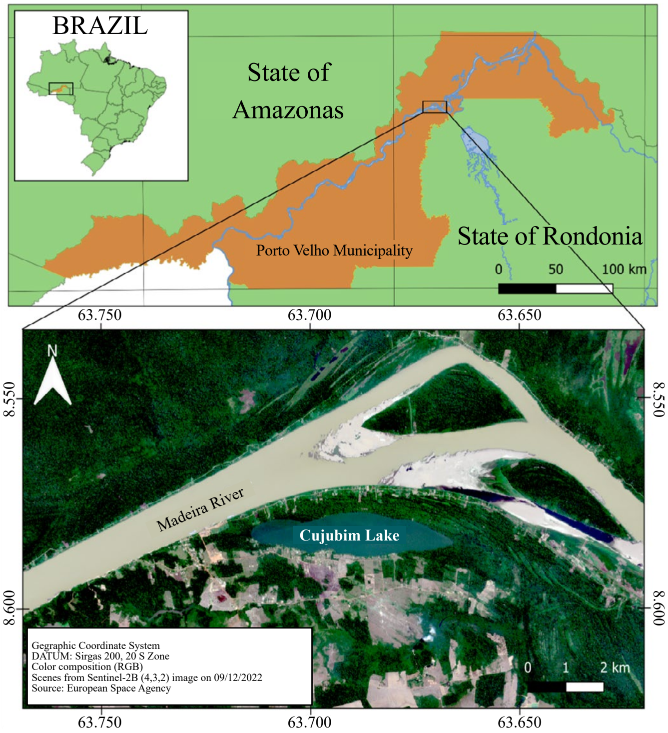


Figure 1. Study area located in Cujubim Lake on the Madeira River (Rondônia, Brazil).

high water. It has a length of approximately 5,290 m, and average width of 850 m. The average depth of the lake during the high-water period is 3.70 m, while in the low-water period it is 2.69 m. This lake is in common use, with artisanal and subsistence fishing that is carried out by the riverine populations of the region.

The experimental fisheries of this study were carried out in such a way as to contemplate as many fish species as possible and minimize any temporal or spatial bias of the lake. Thus, four collections were carried out on one day of each selected month, two in the high-water period (March 2019 and February 2020) and two in the low-water period (November 2019 and October 2020). Specimens were captured by means of three batteries of gillnets (measuring 20 m in length, 2.5 m in height and mesh sizes of 40, 60, 80, 100, 120 and 160 mm – measured between stretched opposite knots). Professional fishermen helped to place the gillnets, and nets of different mesh sizes were fixed with the use of stakes and arranged next to each other, in random positions among themselves, when each collection was performed. The nets were in place for approximately 24 hours in pre-established positions within Cujubim Lake and were positioned in the marginal and central regions of the site, with inspections for the removal of individuals at intervals of six hours to avoid the nets becoming too full. After the capture procedure, the specimens were separated and stored in plastic bags. In the field, the standard length of the fish was measured with the aid of an ichthyometer graduated in centimeters. Identification was at the species level, with the help of relevant bibliography (Queiroz et al., 2013; Ohara et al., 2017).

Data analysis

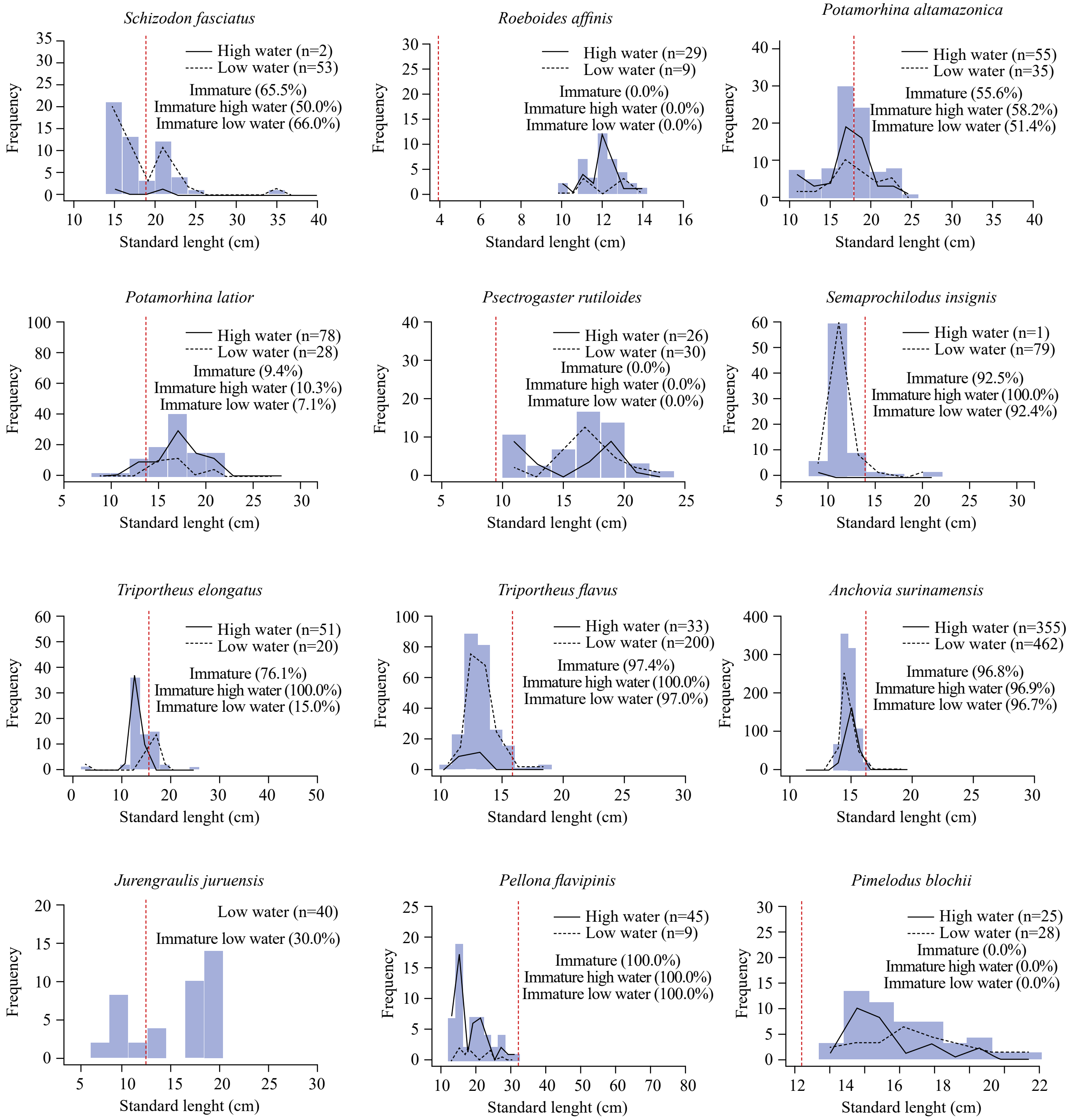
The identified species were counted and grouped according to taxonomic classification and mesh size. Mean, minimum and maximum lengths were calculated for all species (Table S1, data available on request from the authors). In addition, the maximum lengths already recorded in the literature (Froese and Pauly, 2019) were consulted for comparative effect. In the most abundant species, we verified previous information on the length of first maturation to estimate the percentages of immature individuals in the catches. For those not found, we used references of similar species to establish the percentages. Normality and homoscedasticity did not occur in the length data of the main species; therefore, nonparametric tests ($\alpha = 0.05$) were used for comparison in the periods of high and low water using the Mann-Whitney test (W test and p-value) and in the different mesh sizes using the same test for two independent samples, or the Kruskal-Wallis test (χ^2 and p-value) for three or more independent samples, with Fisher's exact test when significant differences were verified.

The parameters of the selectivity curves of the main species were estimated from the comparison of the length frequency distributions obtained with the different mesh sizes. The calculation code used was Share Each Length Catch Total (SELECT), with four different models for the shape of the selection curve (normal fixed, normal scale, lognormal and gamma), as described by Millar (1992), Millar and Holst (1997) and Millar and Fryer (1999), and performed in the TropFishR package (Mildenberger et al., 2018). To select the appropriate model among those considered, the deviations were evaluated, which are statistics related to the likelihood, in addition to the residuals of each model. All analyses were performed using the program R 4.2.1 (R Core Team, 2022).

RESULTS

A total of 2,122 individuals was captured, belonging to six orders, 18 families and 85 species, with most specimens and species captured using the 40-mm mesh (Table S1). Considering the aggregate of the nets, the most abundant species were *Schizodon fasciatus*, *Roeboides affinis*, *Potamorhina altamazonica*, *Potamorhina latior*, *Psectrogaster rutiloides*, *Semaprochilodus insignis*, *Triportheus elongatus*, *Triportheus flavus*, *Anchovia surinamensis*, *Jurengraulis juruensis*, *Pellona flavipinnis*, and *Pimelodus blochii*. In these species, only in the family Curimatidae (*P. altamazonica*, *P. latior*, and *P. rutiloides*) the catches were higher in the 60-mm mesh. Records of 17 new maximum lengths are presented herein, and they represent 20% of the species caught in Cujubim Lake (Table S1).

The lengths of the most abundant species were grouped by periods of high and low water (Fig. 2), and by the percentages of immature individuals captured, considering the information available in the literature (Table S2). The species presented



Schizodon fasciatus

Roeboides affinis

Potamorhina altamazonica

Potamorhina latior

Psectrogaster rutiloides

Semaprochilodus insignis

Triportheus elongatus

Triportheus flavus

Anchovia surinamensis

Jurengraulis juruensis

Pellona flavipinis

Pimelodus blochii

Figure 2. Polygons (lines) with the length frequencies for the periods of high and low water, and histograms with the aggregated length frequency distributions for the main species caught in Cujubim Lake, Rondônia, Brazil. Vertical dashed line in red indicates the length of first maturation of the species.

length distributions with more than one modal class: *S. fasciatus* (14–16 cm), *R. affinis* (12–12.5 cm), *P. altamazonica* (16–18 cm), *P. latior* (16–18 cm), *P. rutiloides* (16–18 cm), *S. insignis* (10–12 cm), *T. elongatus* (12–14 cm), *T. flavus* (12–13 cm), *A. surinamensis* (7–8 cm), *J. juruensis* (18–20 cm), *P. flavipinnis* (14–16 cm), and *P. blochii* (14–15 cm).

The percentages of Immature individuals captured were higher in seven species, but *R. affinis*, *P. latior*, *P. rutiloides*, *J. juruensis*, and *P. blochii* had lower percentages. Among the 12 species highlighted, in six, the numbers of individuals were higher in the low-water period and in five in the high-water period, and only *P. blochii* presented the same number of individuals in both periods. The species *S. fasciatus*, *S. insignis*, and *J. juruensis* presented a low frequency of capture, so no comparisons were made between the lengths in the high- and low-water period.

There were no significant differences between the values of lengths in the two periods for the species *R. affinis* ($W = 118.5$, $p = 0.692$), *P. altamazonica* ($W = 837.5$, $p = 0.303$), and *P. rutiloides* ($W = 335.5$, $p = 0.375$), while for the other species there were differences. In the species *P. latior* ($W = 1{,}385.5$, $p = 0.036$), the average length of the individuals in the high-water period (17.4 cm) was significantly greater than in the low-water period (16.3 cm), but the main modal class was the same in both periods. In the species *T. elongatus* ($W = 0.0$, $\mathrm{p} = 7.00 \times 10^{-11}$), the average length of the individuals in the high-water period (13.4 cm) was significantly smaller than in the low-water period (17.5 cm), with displacement of the main modal class from 10 to 12 cm (high water) to 12 and 14 cm (low water). In the species *T. flavus* ($W = 2{,}054.5$, $\mathrm{p} = 5.12 \times 10^{-4}$), the average length of the individuals in the high-water period (12.7 cm) was significantly smaller than in the low-water period (13.4 cm), but the main modal class was the same in both periods. In the species *A. surinamensis* ($W = 107{,}529.0$, $\mathrm{p} = 2.16 \times 10^{-14}$), the average length of the individuals in the high-water period (8.5 cm) was significantly greater than in the low-water period (8.1 cm), with displacement of the main modal class from 7 to 8 cm (low water) to 8 to 9 cm (high water). In the species *P. flavipinnis* ($W = 111.0$, $\mathrm{p} = 0.035$), the average length of the individuals in the high-water period (18.1 cm) was significantly smaller than in the low-water period (21.6 cm), but the main modal class was the same in both periods. In the species *P. blochii* ($W = 117.5$, $\mathrm{p} = 0.006$), the average length of the individuals in the high-water period (15.7 cm) was significantly smaller than in the low-water period (17.1 cm), with displacement of the main modal class from 14 to 15 cm (high water) to 16 and 17 cm (low water).

In the mesh-length distributions, the main modal length classes were for *S. fasciatus* (14–16 cm – M40; 20–22 cm – M60), *R. affinis* (12–12.5 cm – M40), *P. altamazonica* (10–12 cm – M40; 16–18 cm – M60; 22–24 cm – M80), *P. latior* (14–16 cm – M40; 16–18 cm – M60), *P. rutiloides* (10–12 cm – M40; 16–18 cm – M60), *S. insignis* (10–12 cm – M40), *T. elongatus* (12–14 cm – M40 and M60), *T. flavus* (12–13 cm – M40; 17–19 cm – M60; 15–16 cm – M100), *A. surinamensis* (8–9 cm – M40; 7–8 cm – M60 and M80; 10–11 cm – M100), *J. juruensis* (18–20 cm – M40; 8–12 cm – M60), *P. flavipinnis* (14–16 cm – M40; 20–22 cm – M60; 22–26 cm – M80) and *P. blochii* (14–16 cm – M40; 18–20 cm – M60) (Fig. 3).

The percentages of immature individuals of the species were generally higher in the M40 and M60 nets. The species *R. affinis* and *S. insignis* presented catches only in M40 nets. There were no significant differences between the lengths in the different nets for the species *T. elongatus* ($W = 182.0$, $\mathrm{p} = 0.756$) and *A. surinamensis* ($\chi^2 = 3.45$, DF = 3, $\mathrm{p} = 0.327$). In the species *S. fasciatus* ($W = 0.0$, $\mathrm{p} = 2.42 \times 10^{-9}$), the average length of subjects in the M40 nets (17.4 cm) was significantly smaller than in the M60 nets (22.4 cm). In the species *P. altamazonica* ($\chi^2 = 83.92$, DF = 2, $\mathrm{p} = 1.95 \times 10^{-12}$), the mean lengths of the individuals were significantly different in the nets, with M80 (22.9 cm) presenting the highest mean and M40 (13 cm) the lowest one. In the species *P. latior* ($W = 397.0$, $\mathrm{p} = 1.35 \times 10^{-9}$), the average length of individuals in the M40 nets (15.7 cm) was significantly smaller than in the M60 nets (18 cm). In the species *P. rutiloides* ($W = 13.0$, $\mathrm{p} = 3.01 \times 10^{-7}$), the average length of the subjects in the M40 nets (12.1 cm) was significantly smaller than in the M60 nets (17.5 cm). In the species *T. flavus* ($\chi^2 = 48.13$, DF = 2, $\mathrm{p} = 3.53 \times 10^{-11}$), the mean lengths of the individuals showed significant differences, with the M40 nets (13 cm) having the lowest mean and was different from the M60 (16.2 cm) and M100 (14.5 cm) nets. In the species *J. juruensis* ($W = 232.0$, $\mathrm{p} = 0.001$), the average length of individuals in the M40 nets (16.7 cm) was significantly greater than in the M60 nets (10.6 cm). In the species *P. flavipinnis* ($\chi^2 = 23.79$, DF = 3, $\mathrm{p} = 2.76 \times 10^{-5}$), the mean lengths of the individuals showed significant differences, with the M40 nets (17.6 cm) having the lowest mean, and were different from the others. In the species *P. blochii* ($W = 101.0$, $\mathrm{p} = 0.004$), the average length of individuals in the M40 nets (16.0 cm) was significantly smaller than in the M60 nets (17.6 cm).

In the species *R. affinis*, *S. insignis*, and *J. juruensis*, the parameters of the selectivity curve were not estimated, since they presented catches in only one mesh size. In the species

S. fasciatus, the models did not converge. The best models selected for the other species are presented in Table S3.

The curves with length amplitudes and modal lengths for the eight main species captured in nets with different mesh sizes are shown in Fig. 4. The modal lengths in which 100% of *P. altamazonica* specimens would be captured in the nets were 12.7, 19, and 25.3 cm for nets with mesh sizes of 40, 60 and 80 mm, respectively. The modal lengths for the species *P. latior*

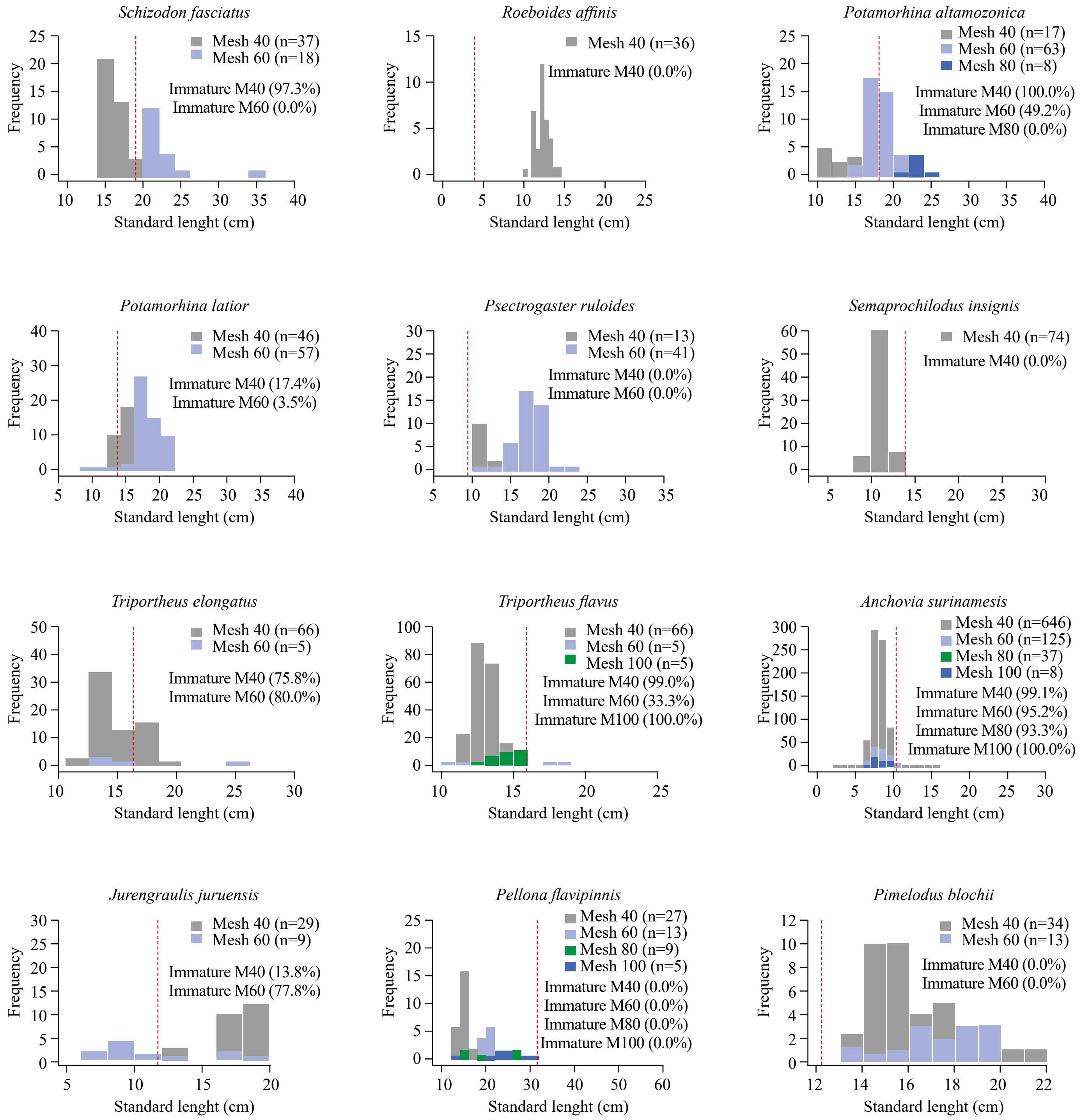


Figure 3. Histograms with the distributions of length frequencies for each mesh for the main species caught in Cujubim Lake, Rondônia, Brazil. Vertical dashed line in red indicates the length of first maturation of the species.

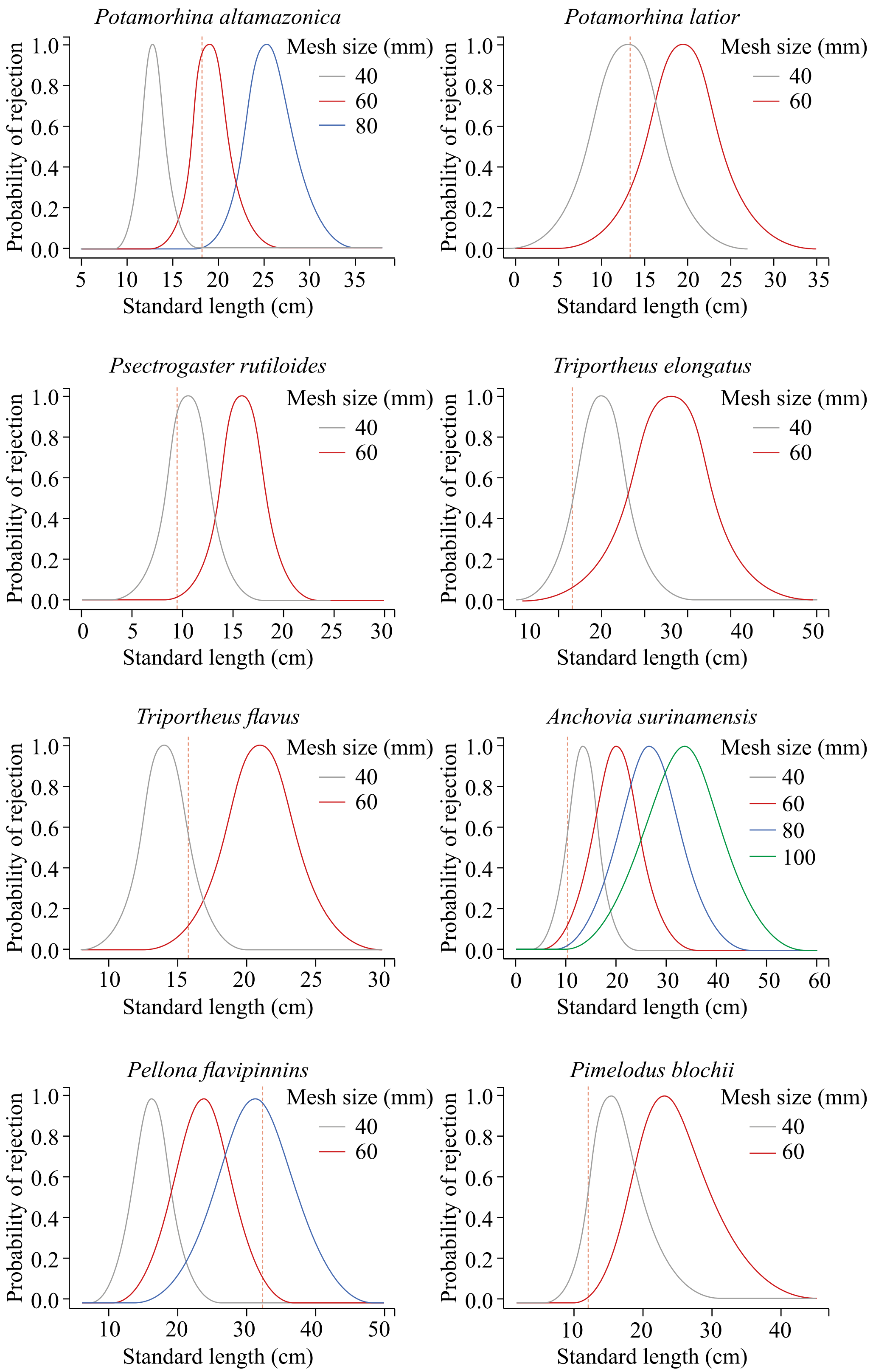


Figure 4. Selectivity curves with the selected models for the main species caught in Cujubim Lake, Rondônia, Brazil. The solid gray, red, blue, and green lines represent the curves adjusted for the 40, 60, 80 and 100 mm meshes, respectively. Vertical dashed line in red indicates the length of first maturation of the species.

presented values of 12.9 and 19.4 cm for nets with mesh sizes of 40 and 60 mm, respectively. In the species *P. rutiloides*, the values of the modal lengths were 11.3 and 16.9 cm for nets with mesh sizes of 40 and 60, respectively. In the species *T. elongatus*, the values of the modal lengths were 19.7 and 29.5 cm for nets with mesh sizes of 40 and 60, respectively. In the species *T. flavus*, the values of the modal lengths were 14.1 and 21.1 cm for nets with mesh sizes of 40 and 60, respectively. The modal lengths for the species *A. surinamensis* presented values of 13.3, 19.9, 26.6 and 33.2 cm for nets with mesh sizes of 40, 60, 80 and 100 mm, respectively. In the species *P. flavipinnis*, the values of the modal lengths were 15.4, 23.2, and 30.9 cm for nets with mesh sizes of 40, 60 and 80, respectively. The modal lengths for the species *P. blochii* presented values of 15.5 and 23 cm for nets with mesh sizes of 40 and 60 mm, respectively.

DISCUSSION

The rich and abundant presence of fish of the order Characiformes is constantly reported in studies carried out in floodplain lakes (Dagosta and Pinna, 2019; Morales et al., 2019), corroborating with the results obtained in the present study. This order of scaled fish makes short lateral migrations, mainly in search of shelter for reproductive purposes and to avoid predation, as it is the target of capture in floodplain lakes and near riverbanks (Fernandes, 1997; Martins et al., 2018).

Among the highlighted species, the ones belonging to the Curimatidae family were the sole species in the catches that yielded a higher number of individuals in the 60-mm mesh net. The highlighted species of this family exhibited higher mean sizes than the majority, except for *S. fasciatus* and *P. flavipinnis*. These exceptions had certain individuals with discrepant sizes, resulting in a distortion of the mean and caused higher values. The collections in Cujubim Lake provided the record of 17 new maximum lengths, and some of these have been reported recently, such as *Curimata inornata*, *P. latior*, *P. rutiloides*, and *J. juruensis* (Lima and Sousa, 2020) and *R. affinis* (Lima and Sousa, 2021), *Cynopotamus juruenae*, *Poptella compressa*, *Curimatella alburnus*, *Anodus orinocensis*, *Hemiodus unimaculatus*, *Triportheus elongatus*, *A. surinamensis*, *Amblydoras affinis*, *Hemidoras morrisi*, *Opsodoras stuebelii*, *Loricariichthys nudirostris*, and *Rineloricaria castroi*, which were unprecedented, and *J. juruensis* increased from 19.9 to 20 cm.

Among the main species caught, several are commercially important and make up part of the landings in the fishing ports of the Madeira River (Doria et al., 2012). The average sizes in which these species are caught in the Madeira River usually have values greater than the length of first maturation; however, in the present study, half of the species were composed of higher percentages of immature individuals, which in most cases occurred in the high-water period. The high percentages of immature individuals may not indicate lower abundance in this period since in the Amazonian rivers and, consequently, in the adjacent floodplain lakes the levels of seasonal water fluctuation in periods of high and low water affect fishery production in an equivalent manner (Castello et al., 2015). However, depending on the reproductive strategy of each species (e.g., r or k strategists), the incidence of capture of immature individuals may compromise the stock (Winemiller, 2005).

The models with the best fits that were selected for the evaluated species were of a normal scale (lognormal, normal fixed and normal scale). Thus, the normal fixed and normal scale models show that symmetries occur in the amplitudes of lengths in which fish can be caught; the normal scale model presents an increasing amplitude in catches for each increase in mesh size. In species with lognormal model, a positive asymmetry occurs, so the tail of the distribution is on the values above the modal lengths of the meshes. However, it can never be established that a given curve selection is immutable for a species (Millar and Holst, 1997).

The most appropriate mesh selectivity model for each species can vary due to numerous factors, such as those related to the type and diameter of the line used in the mesh, sample size, length range, and retention form with a higher frequency of individuals (Tesfaye et al., 2016; Lima and Andrade, 2018). In the present study, the numbers of individuals captured in most species were relatively small in the meshes greater than 40 mm, in addition to the amplitude presenting low values.

Regarding the length amplitudes, the result presented was already expected, since many species use floodplain lakes provisionally and, in some phases in their life cycle, as a protection strategy (Silvano et al., 2014), so individuals with greater lengths may be unavailable for most of the year. However, the curves obtained in this work are relevant for establishing the desired catch size of the analyzed species, especially in the Amazon region, for which there is a shortage of selectivity studies. The available information is not sufficient for fishery management, and the definition of the best mesh size is only one of the mechanisms that will serve as a basis for rethinking the needs of fishery management. In floodplain lakes, mesh size selection can be a problem, as any change in this item can favor one species over the other (Suuronen and Sardà, 2007). The necessary management in multispecies fisheries must consider several factors related to the species involved, such as reproductive strategies, distribution and amplitudes of seasonal lengths, in addition to commercial value (Thorpe et al., 2016; Karp et al., 2023).

Selectivity estimates can be used in a variety of management measures that consider protecting immature juvenile fish or breeding adults. In the present study, nets with mesh sizes larger than 40 mm often captured a low percentage of immature individuals and, for some species, even with the smallest mesh low numbers of captures of small individuals occurred. In the scenario of protecting young individuals, the meshes used showed good results, since more fish would have a chance to mature and spawn (Suuronen and Sardà, 2007). However, it is important to mention that these species have high intrinsic growth rates, high reproduction, and little parental care (r strategists), and, therefore, the total absence of immature capture results in loss of available biomass, since natural mortalities are high at this stage (e.g., Panhwar et al., 2013). As such, it could be even more important to protect adult individuals, which would effectively contribute to the reproduction of the species, thus reducing waste without harming prospects for the stock (Ferro et al., 2008).

Therefore, in the available fish stock, apparently the intermediate sizes of the fish are the most targeted, leaving the juveniles or adults out of the catches (Tesfaye et al., 2016). However, in the current context of fisheries management measures that consider size restrictions, there is an intense recommendation for the exploitation of fishery resources to be balanced (Garcia et al., 2012). Thus, other analyses (e.g., yield per recruit) besides selectivity estimates are necessary to determine the mesh size that would optimize the yield, without compromising the stock and considering all species size classes (Wolff et al., 2015; Tesfaye et al., 2016).

Gillnets, in comparison to other fishing tackle, show more promising results for fisheries that target only intermediate sizes, since it is possible to calculate the desired minimum and maximum size (Tesfaye et al., 2016), which may also be suitable for biomass-balanced fisheries of different size classes, considering the various mesh sets employed in small-scale fisheries in the Amazon. Additionally, they contribute to the increase in the relative value of the catches, their diversification, the enhancement of catch per unit of effort, and/or reduce the variance of fish harvests (Hallwass et al., 2023).

The restriction of a specific mesh size may not be easily accepted by fishers, so a balanced extraction with mesh rotation could be more easily implemented. However, for such a measure to be implemented, it should be possibly applied together with other management tools that consider management by fishing sector or extension of the closed season (Silvano et al., 2014).

CONCLUSION

The study confirmed the rich presence of Characiformes in the floodplain lake that was surveyed. Although several species are available in large sizes, the catches are effectively composed of juvenile fish. Information on the selectivity of gillnets is necessary for establishing desired catch sizes, especially in the Amazon region, where selectivity studies are limited. Among the highlighted species, the 40-mm mesh is not recommended for the species *P. altamazonica*, *T. flavus*, and *P. flavipinnis*, in cases in which management considers the minimum capture size. Actions related to nets can also consider fishery recruitment periods, alternatively applying the rotation of fishing nets, especially those of a smaller size (e.g., 30 mm) in times of low recruitment and increasing the numbers of nets in peak recruitment periods, which would therefore provide targeted fishing of fish in all size classes according to the river level.

CONFLICT OF INTERESTS

The authors declare no competing interests.

AUTHORS' CONTRIBUTIONS

Conceptualization: Lima SAO, Sousa RGC; **Methodology:** Lima SAO; **Investigation:** Sousa RGC; **Data curation:** Sousa RGC; **Formal Analysis:** Lima SAO; **Validation:** Gonzaga Junior MA; **Resources:** Sousa RGC; **Supervision:** Sousa RGC; **Funding acquisition:** Sousa RGC; **Project administration:** Sousa RGC; **Writing – original draft:** Lima SAO, Sousa RGC; **Writing – review & editing:** Lima SAO, Gonzaga Junior MA, Sousa RGC; **Final approval:** Lima SAO.

DATA AVAILABILITY STATEMENT

Data will be available upon request.

SUPPLEMENTARY MATERIALS

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