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The stream fish fauna from the rio Machado basin, Rondônia State, Brazil

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Abstract: The rio Machado (also known as Ji-Paraná) is a tributary of the rio Madeira in the Amazon basin. Currently, the rio Madeira contains the greatest fish species richness of the world, with approximately 1,000 species. The present study presents the fish inventory from streams of the rio Machado basin. In total, 75 stream reaches, 80 meter-length, randomly selected, were sampled in 2011 (August to October) and 2012 (June to July). Overall, 22,875 fish in eight orders, 32 families, 89 genera, and 140 species were collected. Richness estimators indicate that almost 90% of the expected richness was registered. The great majority of specimens (52.2%) was represented by small sized piabas such as *Serrapinnus* aff. *notomelas*, *Moenkhausia collettii*, *Serrapinnus microdon*, and *Hemigrammus melanochrous*. Of the total richness, 25 species were restricted to 9°00' S and 10°00' S; among them, 14 were exclusive to the lower portion of the basin, which exhibits the larger proportion of native vegetation covering.

Introduction

In the Brazilian Amazon, the Rondônia State has been widely exposed to the effects resulting from deforestation. In 2001, 50.9% of the total area had been cleared; in 2004, this percentage increased to 57.1%; and in 2006, this percentage increased to 65.9% (INPE 2010). According to Dale *et al.* (1993), during 70's and 80's, the deforestation rate in the state of Rondônia has increased at a faster rate than anywhere else in the world. The highest level of deforestation occurs in the rio Machado basin, which drains the most populated area of the state because of its proximity to highway BR-364 (Fernandes and Guimarães 2002); within this basin, the central portion is the most deforested due to the occurrence of eutrophic soils (Krusche *et al.* 2005). Along the rio Machado basin, many upland streams have intermittent dry stretches in the dry season, and this situation has become more common recently because of the complete deforestation of many headwaters (Fernandes and Guimarães 2002).

Neotropical streams are very special ecosystems because they have many endemic species and are dominated by small-size species that generally correspond to approximately 50% of the known fish diversity (Castro *et al.* 2003). Proportional to the water volume available, streams are environments with high richness and, as noted by Castro and Menezes (1998) approximately 15 years ago, the study of systematics, evolution and the general biology of small fish species is undoubtedly the greatest challenge of Neotropical ichthyology. This knowledge starts with inventory studies, which are essential to manage and preserve an area or ecosystem due to the basic information provided. This type of study is even more urgent and necessary in situations in which there is a high threat of habitat loss, such as in the rio Machado basin. Therefore, our aim was to present the results of an inventory conducted in the streams of the rio Machado basin, with a species estimation analysis and an analysis of the latitudinal species distribution.

Materials and Methods

Study area and site selection

The rio Machado basin, formed by the confluence of the Comemoração and Pimenta Bueno rivers (Figure 1), has 75,400 km^2. The rio Machado is approximately 1,200 km long and receives five other tributaries (Rolim de Moura, Urupá, Jaru, Machadinho, and Preto rivers), flowing on the right bank of the rio Madeira (Krusche *et al.* 2005). Its flood regime, obtained from the data set for a five-year (2008-2012) period monthly average, is characterized by rising water between November and December, high water between January and March, with the highest water level in February; the falling water period is between April and July, the low water period between August and October with the minimum water level in September (ANA 2013). The basin has an average slope of 0.62 degrees. The climate is humid tropical, with temperatures from 19°C to 33°C and annual rainfall of 2,500 mm (Krusche *et al.* 2005). The land cover of the region includes primary forest (open humid tropical forest), secondary forest, and pasture (Ferraz *et al*. 2009).

The sampling design, local variable assessment, and fish collections were conducted during 2011 and 2012. The watershed limits were generated with the hydrological model ArcSWAT and digital elevation models (DEM) SRTM (90 x 90 m resolution) produced by the National Aeronautics and Space Administration (NASA) and are available from the United States Geological Survey (USGS). All the selected microbasins had a minimum contribution area between 1,500 and 5,000 ha.

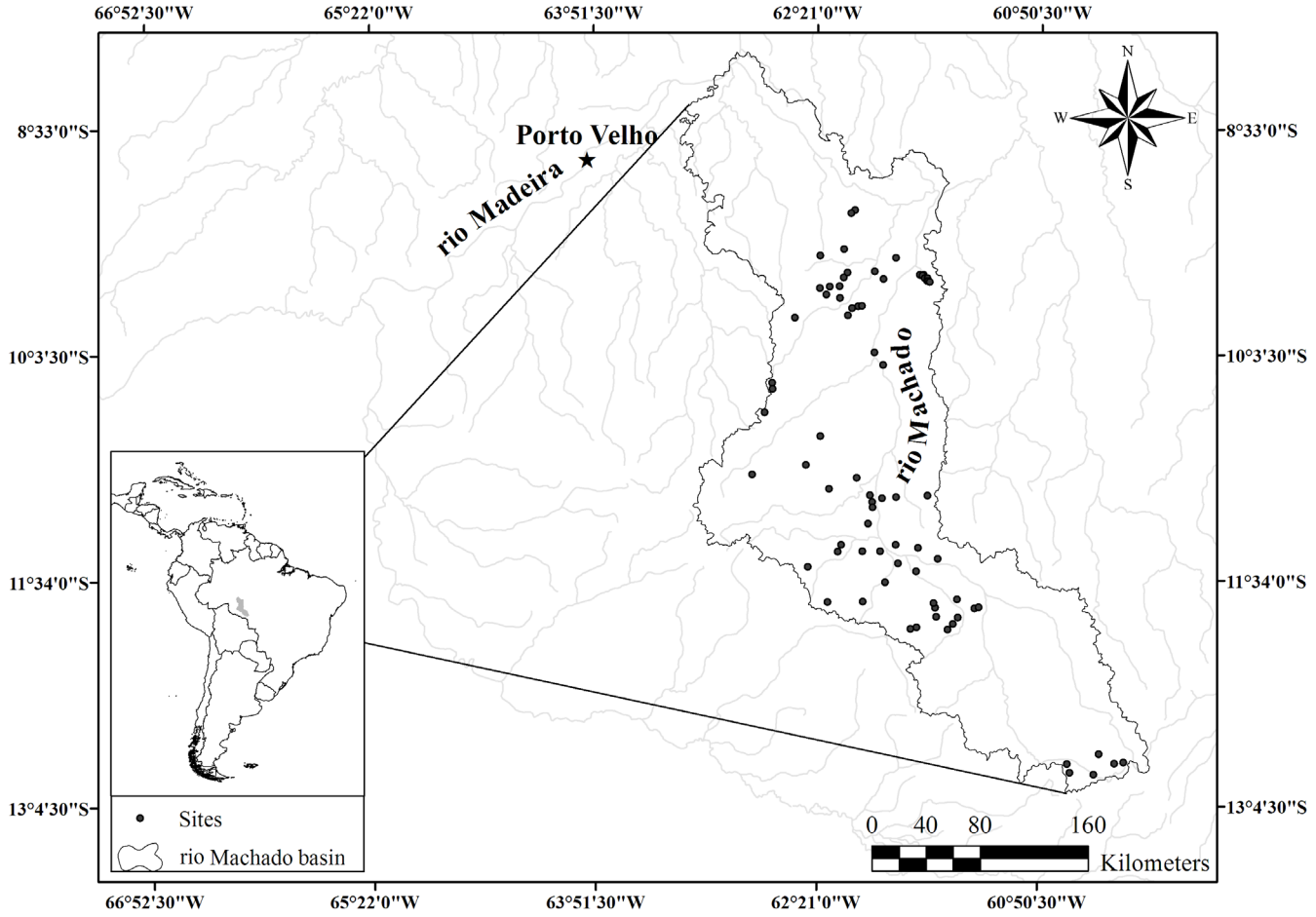

Figure 1. Location of the rio Machado basin in South America (small box on the left) and 75 sampling reaches in the rio Machado, Rondônia State, Brazil (black dots on the right). Some symbols are superimposed due to the proximity of sites.

Fish collection and identification

A total of 75 reaches (Table 1) were sampled once during the dry season (August to October, 2011 and June to July, 2012). Each headwater stream reach (1st to 3rd order reaches according to Sthraler 1957) was 80 m long and was sampled after blocking the reaches up- and downstream using block nets (5 mm mesh). During one hour, two collectors sampled fish with a seine (1.5 × 2 m, 2 mm mesh) and a dip net (0.5 × 0.8 m, 2 mm mesh). Fish were collected under ICMBio (Instituto Chico Mendes de Conservação da Biodiversidade) permits (4355-1/2012). The fish identification was conducted by consulting specialists, and voucher specimens are deposited in the Coleção de Peixes do Departamento de Zoologia e Botânica (DZSJRP) at the Universidade Estadual Paulista "Júlio de Mesquita Filho", São José do Rio Preto, São Paulo State, Brazil (Table 2).

Data analysis

To evaluate the inventory representativeness, the Coleman rarefaction (Colwell *et al.* 2004) was obtained and compared to two non parametric richness estimators, the ICE (Incidence Coverage Estimator, Lee and Chao 1994) and the ACE (Abundance Coverage Estimator, Lee and Chao 1994), using the software EstimateS 7.5.2 (Cowell 2005). The latitudinal distribution of the fish fauna was evaluated by calculating the average and extreme values of latitude, considering all stream reaches in which each species occurs.

Results and Discussion

A total of 22,875 specimens belonging to 140 species, 89 genera, 32 families, and eight orders were collected (Table 2). The Characiformes and Siluriformes, representing 51 and 31% of the total species, respectively, were predominant, which is consistent with the prevalence previously noted for the streams and rivers of the Neotropical region (Lowe-McConnell 1999). The families with the highest abundance in the sampled reaches were Characidae, Cichlidae, and Loricariidae, which are taxa that are broadly distributed in the Amazon basin (Reis *et al.* 2003). *Aequidens tetramerus*, *Bryconops caudomaculatus*, *Characidium* aff. *zebra*, *Creagrutus petilus*, *Crenicichla santosi*, *Moenkhausia oligolepis*, *M. collettii*, *Phenacogaster retropinnus*, and *Rineloricaria heteroptera* were broadly distributed in the rio Machado basin; they were recorded in more than 50% of the reaches. In contrast, 26 species (18.6%) occurred only in one site; most of them were recorded from the lower portion of the basin. Non-native species were represented by two specimens of *Tilapia rendalli*, and currently, the non-native threats appear to be of minor concern in the rio Machado basin. However, because of the recent development of aquaculture in the basin (author's observation), it is critical that appropriate precautions are taken so that non-native species do not become a threat to the local fish fauna.

The largest percentage of the fish abundance (52.2%) was represented by small-sized "piabas" of the family Characidae, such as *Serrapinnus* aff.

notomelas, *Moenkhausia collettii*, *Serrapinnus microdon*, *Hemigrammus melanochrous*, *Hyphessobrycon agulha*, *Creagrutus petilus*, and *Bryconops caudomaculatus*, in this order. The predominance of small fish species is in agreement with the overall pattern for South American stream fish and was explained by Castro (1999) as a result of selective pressures of the lotic environment in addition to the combination of geological history of South American basins, vicariant processes and allopatric speciation. Another common pattern is the great number of rare species. Of the total richness, 53 species (37.9%) were represented by less than ten specimens, and 14 species (10%) were represented by a single specimen, such as *Corydoras bondi* and *Miuroglanis platycephalus*, which indeed are species represented in fish collections by only a few records (≤ 10) (*Species*Link 2013).

The richness estimated with ACE and ICE was 148 and 157 species, respectively, which indicates that more than 90% of the estimated species richness was registered and shows good representativeness of the inventory (Figure 2). Inventories of ichthyofauna for the western Amazon region are scarce. Among those that have been conducted in the rio Madeira basin, we highlight the study by Perin *et al.* (2007), which recorded 48 fish species in an urban area of Rondônia; the study by Camargo and Giarrizzo (2007), which recorded 133 species in 23 streams and three rivers of the Marmelos Preservation Area; and the study by Barros *et al.* (2011), which recorded 78 species in 22 streams in the Madeira-Purus interfluvial region. Despite the different sampling methodologies employed among these studies, they clearly demonstrate the great fish diversity in the rio Madeira basin, with a high percentage of species yet to be found and described.

Of the total species collected, 97 (69.3%) were identified to species level, 43 (30.7%) are of uncertain taxonomic status, because they are not formally described (16 species)

Figure 1. Municipality, altitude (m), and geographical coordinates of the 75 stream reaches sampled in the rio Machado basin. Sites 24 to 31 are located in the Reserva Biológica (REBio) Jaru, 33 to 35 in the Reserva Extrativista (RESEX) Rio Preto-Jacundá, 38 and 39 in the RESEX Castanheira, and 43 to 45 in the RESEX Aquariquara.

SITES	MUNICIPALITY	ELEVATION	GEOGRAPHICAL COORDINATES
1	Presidente Médici	196.64	62°00'21"W, 11°12'06"S
2	Alvorada d'Oeste	251.97	62°24'55"W, 11°29'31"S
3	Teixerópolis	193.24	62°16'18"W, 10°58'06"S
4	Ji-Paraná	183.93	62°05'03"W, 10°53'45"S
5	Nova União	198.81	62°47'28"W, 10°52'20"S
6	Nova União	199.44	62°25'38"W, 10°48'38"S
7	Ouro Preto d'Oeste	226.68	62°19'56"W, 10°36'52"S
8	Castanheiras	190.74	61°55'23"W, 11°23'15"S
9	Nova Brasilândia d'Oeste	286.23	62°16'48"W, 11°43'38"S
10	Rolim de Moura	236.09	62°02'26"W, 11°43'27"S
11	Santa Luzia d'Oeste	254.74	61°40'24"W, 11°53'45"S
12	Santa Luzia d'Oeste	248.89	61°42'53"W, 11°54'21"S
13	Presidente Médici	180.28	61°54'42"W, 11°01'51"S
14	Cujubim	178.86	62°20'05"W, 09°24'21"S
15	Machadinho d'Oeste	184.77	62°10'22"W, 09°21'47"S
16	São Felix	143.06	61°49'19"W, 09°25'17"S
17	Vale do Anari	174.88	62°12'09"W, 09°36'42"S
18	Vale do Anari	198.53	62°16'08"W, 09°36'58"S
19	Vale do Anari	192.34	62°20'13"W, 09°37'28"S
20	Vale do Anari	182.19	62°17'29"W, 09°40'06"S
21	Vale do Anari	175.20	62°30'11"W, 09°49'26"S
22	Vale do Anari	119.48	61°58'09"W, 10°04'14"S
23	Theobroma	119.48	61°54'32"W, 10°08'35"S
24	Vale do Anari	103.87	61°39'15"W, 09°32'10"S
25	Vale do Anari	151.50	61°38'53"W, 09°32'37"S
26	Vale do Anari	126.54	61°38'40"W, 09°32'31"S
27	Vale do Anari	107.91	61°37'42"W, 09°32'54"S
28	Vale do Anari	103.91	61°36'39"W, 09°33'25"S
29	Vale do Anari	126.98	61°36'50"W, 09°34'20"S
30	Vale do Anari	115.46	61°36'26"W, 09°34'43"S
31	Vale do Anari	155.00	61°36'17"W, 09°35'42"S
32	Machadinho d'Oeste	192.98	62°09'44"W, 09°40'03"S
33	Machadinho d'Oeste	189.14	62°05'55"W, 09°06'15"S
34	Machadinho d'Oeste	163.65	62°07'28"W, 09°07'17"S
35	Machadinho d'Oeste	158.76	62°07'33"W, 09°07'20"S
36	Machadinho d'Oeste	129.13	61°57'55"W, 09°30'52"S
37	Machadinho d'Oeste	218.32	61°55'45"W, 09°33'19"S
38	Machadinho d'Oeste	186.78	62°10'30"W, 09°33'15"S
39	Machadinho d'Oeste	188.66	62°08'49"W, 09°31'21"S
40	Ariquemes	198.49	62°39'13"W, 10°15'28"S
41	Theobroma	202.45	62°38'40"W, 10°18'12"S
42	Jaru	199.19	62°42'33"W, 10°27'24"S
43	Vale do Anari	182.46	62°07'01"W, 09°45'33"S
44	Vale do Anari	199.70	62°05'58"W, 09°45'00"S
45	Vale do Anari	192.08	62°03'10"W, 09°44'35"S
46	Vale do Anari	194.09	62°08'53"W, 09°48'24"S
47	Ministro Adreazza	298.80	61°36'15"W, 11°00'55"S
48	Presidente Médici	210.56	61°50'10"W, 11°00'10"S
49	Nova Brasilândia d'Oeste	200.01	62°03'19"W, 11°21'51"S
50	Presidente Médici	195.01	61°49'04"W, 11°20'14"S
51	Cacoal	200.37	61°39'51"W, 11°21'59"S
52	Ji-Paraná	188.47	61°59'34"W, 11°00'54"S
53	Ji-Paraná	184.21	61°58'46"W, 11°03'27"S
54	Ji-Paraná	185.33	61°58'39"W, 11°05'31"S
55	Alvorada d'Oeste	200.42	62°11'05"W, 11°20'23"S
56	Alvorada d'Oeste	204.94	62°12'49"W, 11°23'24"S
57	Cacoal	191.29	61°32'04"W, 11°25'47"S
58	Cacoal	198.01	61°40'41"W, 11°31'09"S
59	Castanheiras	198.10	61°47'50"W, 11°28'10"S
60	Castanheiras	201.51	61°52'20"W, 11°35'36"S
61	Vilhena	333.78	60°27'46"W, 12°52'24"S
62	Vilhena	518.15	60°18'50"W, 12°47'36"S
63	Vilhena	565.15	60°15'12"W, 12°47'48"S
64	Vilhena	507.51	60°24'33"W, 12°47'08"S
65	Chupinguaia	375.68	60°39'14"W, 12°48'39"S
66	Chupinguaia	410.26	60°37'58"W, 12°51'05"S
67	Primavera de Rondônia	201.15	61°16'29"W, 11°45'45"S
68	Primavera de Rondônia	206.21	61°15'55"W, 11°46'20"S
69	Primavera de Rondônia	210.23	61°23'19"W, 11°44'04"S
70	São Felipe d'Oeste	236.71	61°24'10"W, 11°49'53"S
71	Rolim de Moura	296.40	61°33'41"W, 11°50'17"S
72	Rolim de Moura	222.27	61°32'55"W, 11°45'47"S
73	Rolim de Moura	213.46	61°32'50"W, 11°44'44"S
74	São Felipe d'Oeste	288.21	61°28'07"W, 11°56'08"S
75	São Felipe d'Oeste	258.46	61°25'36"W, 11°52'13"S

or belong to genera that need more detailed review (27 species), such as *Brachyhypopomus*, *Cetopsorhamdia*, and *Moenkhausia*. The percentage of species with uncertain taxonomic situations is high compared with the South and Southeast regions of Brazil, but it is small when compared to other Amazonian ecoregions. Advances in the knowledge on the fish fauna from the rio Madeira basin result from recent inventories that were led by the ichthyology team at the Federal University of Rondônia (UNIR). The rio Madeira basin, among all tributaries of the Amazon basin and even when compared with another rivers in the world, has the richest freshwater fish fauna of the world, in which approximately 1,000 freshwater fish species have been recognized (W. Ohara, pers. comm.). However, in Rondônia State, accelerated deforestation is the main source of degradation to the streams, making it urgent to acquire the taxonomic, geographical, and ecological knowledge of the ichthyofauna in these environments. As a potential additional threat to this fish fauna we can cite the expansion of hydroelectric power plants.

According to the species latitudinal distribution analysis, 25 species (18%) only occur between 9°00'S and 10°00'S (Figure 3); among them, nine were exclusively registered in streams reaches inside protected areas (REBio Jaru, RESEX Rio Preto-Jacundá, RESEX Castanheira, and RESEX Aquariquara). Extractive reserves of Rondônia, such as the RESEX Rio Preto-Jacundá, have adopted forest management as an activity that is capable of generating a better quality of life for the extractive region while preserving the forest. However, as described by Martins (2008) and Moreira *et al.* (2010), the current forest management is not able to secure these goals, which represents a potential threat to the conservation of the regional species pool, endangering one of the world's most diverse ichthyofauna.

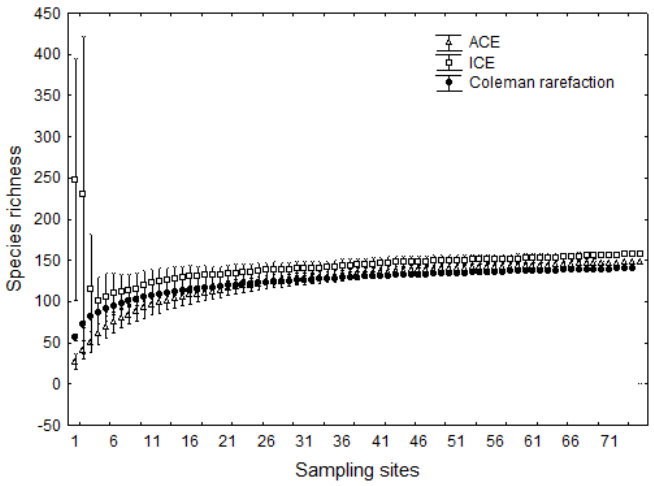

Figure 2. Coleman rarefaction curve, showing the observed richness, and curves of estimated number of species derived from ICE (Incidence Coverage Estimator) and ACE (Abundance Coverage Estimator) by 50 randomizations against cumulative samples.

Table 2. Fish species sampled in headwater streams of the rio Machado basin, with their abundance (N) and the catalogue number of the voucher specimens. Classification follows Reis *et al.* (2003); except for Serrasalmidae that follows Calcagnotto *et al.* (2005) and *Parauchenipterus porosus* that follows Buckup *et al.* (2007). Single quotation marks indicate provisional genera and asterisk indicate non-native species.

TAXON	N	VOUCHER
MYLIOBATIFORMES		
Potamotrygonidae		
Potamotrygon orbignyi (Castelnau, 1855)	1	DZSJRP 17112
CHARACIFORMES		
Parodontidae		
Parodon nasus Kner, 1859	4	DZSJRP 14506
Curimatidae		
Curimatopsis macrolepis (Steindachner, 1876)	6	DZSJRP 16692
Cyphocharax plumbeus (Eigenmann and Eigenmann, 1889)	1	DZSJRP 17238
Cyphocharax spiluropsis (Eigenmann and Eigenmann, 1889)	40	DZSJRP 16630
Steindachnerina cf. *dobula* (Günther, 1868)	4	DZSJRP 14512
Steindachnerina fasciata (Vari and Géry, 1985)	57	DZSJRP 14661
Steindachnerina guentheri (Eigenmann and Eigenmann, 1889)	3	DZSJRP 16782
Prochilodontidae		
Prochilodus nigricans Spix and Agassiz, 1829	1	DZSJRP 16799
Anostomidae		
Anostomus ternetzi Fernández-Yépez, 1949	5	DZSJRP 14664
Leporinus friderici (Block, 1794)	36	DZSJRP 14763
Crenuchidae		
Characidium aff. *gomesi* Travassos, 1956	7	DZSJRP 14704
Characidium aff. *zebra* Eigenmann, 1909	762	DZSJRP 14703
Characidium sp.	8	DZSJRP 14335
Elachocharax pulcher Myers, 1927	79	DZSJRP 15057
Microcharacidium sp.	50	DZSJRP 16653
Microcharacidium aff. *weitzmani* Buckup, 1996	38	DZSJRP 14986
Melanocharacidium dispilomma Buckup, 1993	1	DZSJRP 17205
Melanocharacidium pectorale Buckup, 1993	1	DZSJRP 16678
Hemiodontidae		
Hemiodus unimaculatus (Block, 1794)	2	DZSJRP 14672
Gasteropelecidae		

Table 2. ***Continued.***

TAXON	N	VOUCHER
Carnegiella strigata (Günther, 1864)	40	DZSJRP 14886
Characidae		
Amazonspinther dalmata Bührnheim, Carvalho, Malabarba and Weitzman, 2008	7	DZSJRP 14947
Astyanax cf. *bimaculatus* (Linnaeus, 1758)	108	DZSJRP 14419
Astyanax cf. *maximus* (Steindachner, 1876)	18	DZSJRP 14460
Astyanax maculisquamis Garutti and Britski, 1997	43	DZSJRP 14700
Bario steindachneri (Eigenmann, 1893)	3	DZSJRP 15090
Brachychalcinus copei (Steindachner, 1822)	147	DZSJRP 14769
Bryconops caudomaculatus (Günther, 1864)	912	DZSJRP 14628
Bryconops piracolina Wingert and Malabarba, 2011	23	DZSJRP 17278
Bryconella pallidifrons (Fowler, 1946)	695	DZSJRP 16651
'Cheirodon' troemneri Fowler, 1942	62	DZSJRP 14668
Creagrutus petilus Vari and Harold, 2001	1021	DZSJRP 14733
Hemigrammus sp.	14	DZSJRP 15101
Hemigrammus aff. *ocellifer* (Steindachner, 1882)	62	DZSJRP 15009
Hemigrammus bellotti (Steindachner, 1882)	152	DZSJRP 14524
Hemigrammus melanochrous Fowler, 1913	1418	DZSJRP 15100
Hemigrammus neptunus Zarske and Géry, 2002	60	DZSJRP 14710
Hyphessobrycon aff. *heterorhabdus* (Ulrey, 1894)	144	DZSJRP 16929
Hyphessobrycon agulha Fowler, 1913	1131	DZSJRP 15103
Hyphessobrycon bentosi Durbin, 1908	178	DZSJRP 15011
Hyphessobrycon copelandi Durbin, 1908	151	DZSJRP 14673
Jupiaba citrina Zanata and Ohara, 2009	273	DZSJRP 14701
Jupiaba poranga Zanata, 1997	9	DZSJRP 15107
Jupiaba zonata (Eigenmann, 1908)	55	DZSJRP 19916
Knodus cf. *smithi* Fowler, 1913	827	DZSJRP 14715
Knodus heteresthes Eigenmann, 1908	736	DZSJRP 14651
Microschemobrycon guaporensis Eigenmann, 1915	166	DZSJRP 14476
Moenkhausia aff. *gracilima* Eigenmann, 1908	1	DZSJRP 16817
Moenkhausia cf. *bonita* Benine, Castro and Sabino, 2004	339	DZSJRP 14717
Moenkhausia cf. *justae* Eigenmann, 1908	41	DZSJRP 14526
Moenkhausia collettii (Steindachner, 1882)	1924	DZSJRP 14639
Moenkhausia cotinho Eigenmann, 1908	259	DZSJRP 14478
Moenkhausia grandisquamis Müller and Troschel, 1845	11	DZSJRP 14962
Moenkhausia mikia Marinho and Langeani, 2010	105	DZSJRP 14447
Moenkhausia oligolepis (Günther, 1864)	330	DZSJRP 14479
Moenkhausia pirauba Zanata, Birindelli and Moreira, 2010	19	DZSJRP 15112
Odontostilbe fugitiva Cope, 1870	307	DZSJRP 14545
Phenacogaster retropinnus Lucena and Malabarba, 2010	386	DZSJRP 14450
Serrapinnus aff. *notomelas* (Eigenmann, 1915)	3642	DZSJRP 14659
Serrapinnus microdon (Eigenmann, 1915)	1901	DZSJRP 14658
Tetragonopterus argenteus Cuvier, 1816	2	DZSJRP 17040
Triportheus angulatus (Spix and Agassiz, 1829)	2	DZSJRP 14456
Tyttocharax madeirae Fowler, 1913	32	DZSJRP 14945
Serrasalmidae		
Myleus sp.	12	DZSJRP 14741
Serrasalmus rhombeus (Linnaeus, 1766)	1	DZSJRP 14695
Acestrorhynchidae		
Acestrorhynchus falcatus (Bloch, 1794)	3	DZSJRP 17072
Erythrinidae		
Erythrinus erythrinus (Bloch and Schneider, 1801)	11	DZSJRP 16650
Hoplerythrinus unitaeniatus (Spix and Agassiz, 1829)	3	DZSJRP 16764
Hoplias malabaricus (Bloch, 1794)	88	DZSJRP 14538
Lebiasinidae		
Nannostomus trifasciatus Steindachner, 1876	1	DZSJRP 14963
Pyrrhulina cf. *australis* Eigenmann and Kennedy, 1903	193	DZSJRP 14634
Pyrrhulina cf. *brevis* Steindachner, 1876	65	DZSJRP 15115
Pyrrhulina cf. *zigzag* Zarske and Géry, 1997	9	DZSJRP 17280
SILURIFORMES		
Cetopsidae		
Denticetopsis seducta (Vari, Ferraris and de Pinna, 2005)	4	DZSJRP 14887
Helogenes gouldingi Vari and Ortega, 1986	22	DZSJRP 15099

Table 2. ***Continued.***

TAXON	N	VOUCHER
Aspredinidae		
Pseudobunocephalus amazonicus (Mees, 1989)	37	DZSJRP 14940
Trichomycteridae		
Ituglanis amazonicus (Steindachner, 1882)	108	DZSJRP 14676
Miuroglanis platycephalus Eigenmann and Eigenmann, 1889	1	DZSJRP 14963
Paracanthopoma sp.	19	DZSJRP 14905
Callichthyidae		
Corydoras acutus Cope, 1872	5	DZSJRP 15023
Corydoras aff. *ambiacus* Cope, 1872	3	DZSJRP 17229
Corydoras cf. *melanistius* Regan, 1912	55	DZSJRP 15124
Corydoras bondi Gosline, 1940	1	DZSJRP 17263
Corydoras elegans Steindachner, 1876	7	DZSJRP 14422
Corydoras stenocephalus Eigenmann and Allen, 1942	5	DZSJRP 16757
Corydoras trilineatus Cope, 1872	82	DZSJRP 14755
Hoplosternum littorale (Hancock, 1828)	7	DZSJRP 14423
Megalechis picta (Müller and Troschel, 1849)	49	DZSJRP 16753
Loricariidae		
Ancistrus lithurgicus Eigenmann, 1912	290	DZSJRP 14418
Farlowella cf. *oxyrryncha* (Kner, 1853)	120	DZSJRP 14671
Squaliforma emarginata (Valenciennes, 1840)	22	DZSJRP 14712
Hypostomus sp.	1	DZSJRP 17290
Hypostomus pyrineusi (Miranda Ribeiro, 1920)	34	DZSJRP 14424
Lasiancistrus schomburgkii (Günther, 1864)	61	DZSJRP 14697
Loricaria cataphracta Linnaeus, 1758	4	DZSJRP 14499
Otocinclus hoppei Miranda Ribeiro, 1939	119	DZSJRP 14685
Parotocinclus aff. *aripuanensis* Garavello, 1988	24	DZSJRP 14895
Rineloricaria sp.	6	DZSJRP 14635
Rineloricaria heteroptera Isbrücker and Nijssen, 1976	164	DZSJRP 14427
Spatuloricaria evansii (Boulenger, 1892)	4	DZSJRP 14511
Pseudopimelodidae		
Batrochoglanis cf. *raninus* (Valenciennes, 1840)	16	DZSJRP 14969
Batrochoglanis villosus (Eigenmann, 1912)	5	DZSJRP 14665
Microglanis poecilus Eigenmann, 1912	1	DZSJRP 16655
Heptapteridae		
Cetopsorhamdia sp. 1	24	DZSJRP 17295
Cetopsorhamdia sp. 2	8	DZSJRP 17279
Cetopsorhamdia sp. 3	6	DZSJRP 17216
Imparfinis cf. *hasemani* Steindachner, 1917	124	DZSJRP 14714
Imparfinis stictonotus (Fowler, 1940)	49	DZSJRP 14471
Phenacorhamdia cf. *boliviana* (Pearson, 1924)	4	DZSJRP 14688
Phenacorhamdia sp.	70	DZSJRP 15019
Pimelodella sp.	11	DZSJRP 14527
Pimelodella cf. *howesi* Fowler, 1940	55	DZSJRP 14656
Rhamdia quelen (Quoy and Gaimard, 1824)	6	DZSJRP 14770
Doradidae		
Acanthodoras cataphractus (Linnaeus, 1758)	19	DZSJRP 16687
Auchenipteridae		
Centromochlus cf. *perugiae* Steindachner, 1882	1	DZSJRP 17261
Tatia aulopygia (Kner, 1858)	2	DZSJRP 14696
Parauchenipterus porosus (Eigenmann and Eigenmann, 1888)	5	DZSJRP 17038
GYMNOTIFORMES		
Gymnotidae		
Gymnotus aff. *arapaima* Albert and Crampton, 2001	26	DZSJRP 14649
Gymnotus carapo Linnaeus, 1758	35	DZSJRP 14648
Gymnotus coropinae Hoederman, 1962	81	DZSJRP 15006
Sternopygidae		
Eigenmannia trilineata López and Castello, 1966	196	DZSJRP 14406
Sternopygus macrurus (Bloch and Schneider, 1801)	99	DZSJRP 14484
Rhamphichthyidae		
Gymnorhamphichthys petiti Géry and Vu-Tân-Tuê, 1964	287	DZSJRP 14631
Hypopomidae		
Brachyhypopomus sp. 1	2	DZSJRP 14627

Table 2. ***Continued.***

TAXON	N	VOUCHER
Brachyhypopomus sp. 2	15	DZSJRP 15091
Brachyhypopomus sp. 3	26	DZSJRP 15092
Hypopygus lepturus Hoedeman, 1962	128	DZSJRP 14632
Apteronotidae		
Apteronotus albifrons (Linnaeus, 1766)	6	DZSJRP 14641
Platyurosternarchus macrostomus (Günter, 1864)	2	DZSJRP 14690
CYPRINODONTIFORMES		
Rivulidae		
Rivulus sp.	4	DZSJRP 14942
BELONIFORMES		
Belonidae		
Potamorrhaphis eigenmanni Miranda Ribeiro, 1915	2	DZSJRP 14949
SYNBRANCHIFORMES		
Synbranchidae		
Synbranchus marmoratus Bloch, 1795	22	DZSJRP 14485
PERCIFORMES		
Cichlidae		
Aequidens tetramerus (Heckel, 1840)	199	DZSJRP 14626
Apistogramma cf. *resticulosa* Kullander, 1980	563	DZSJRP 14994
Cichlasoma amazonarum Kullander, 1983	46	DZSJRP 14462
Crenicichla johanna Heckel, 1840	2	DZSJRP 14758
Crenicichla santosi Ploeg, 1991	163	DZSJRP 14757
Geophagus megasema Heckel, 1840	1	DZSJRP 15004
Satanoperca jurupari (Heckel, 1840)	60	DZSJRP 14636
Tilapia rendalli (Boulenguer, 1897) *	2	DZSJRP 14431
TOTAL	22875	

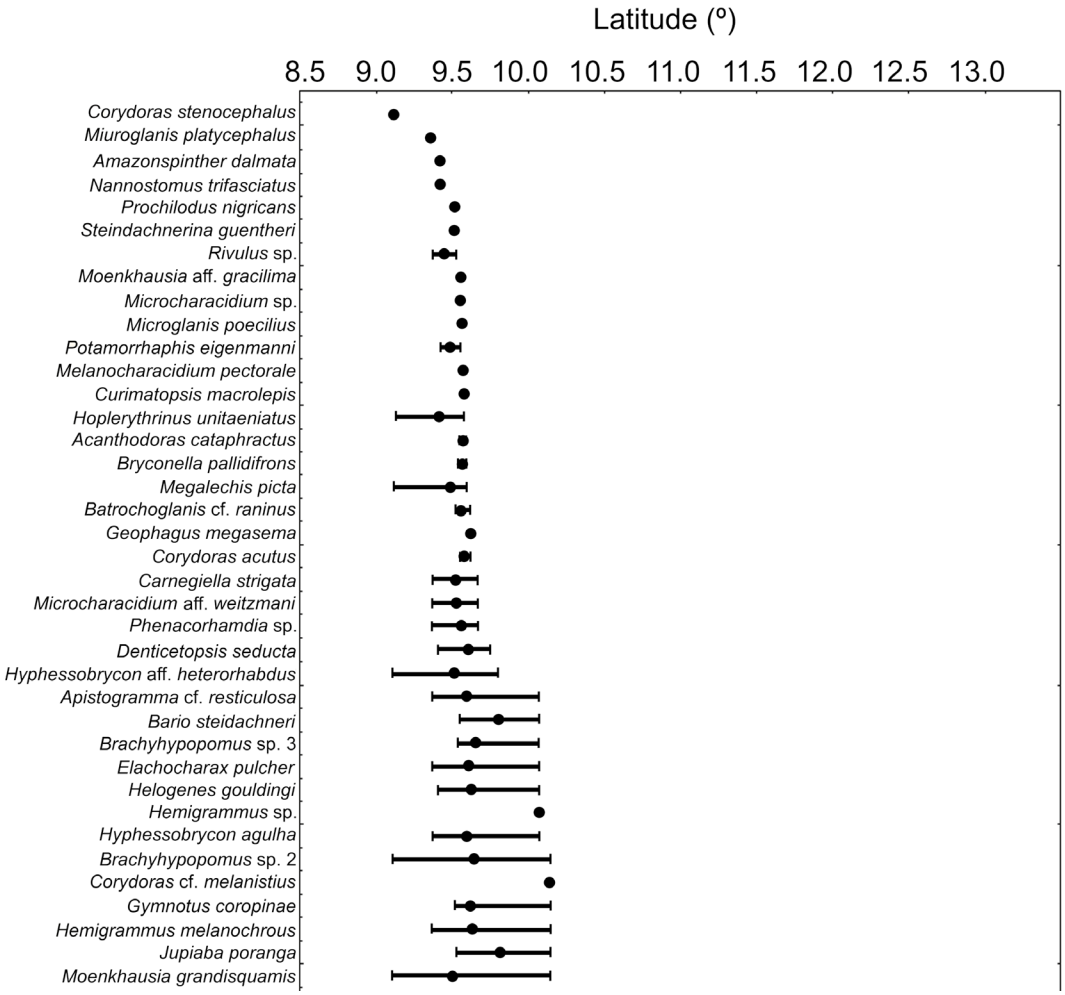

Figure 3. Latitudinal distribution of 140 species collected in the rio Machado basin. Bars indicate latitudinal range for each species, dots indicate average latitude.

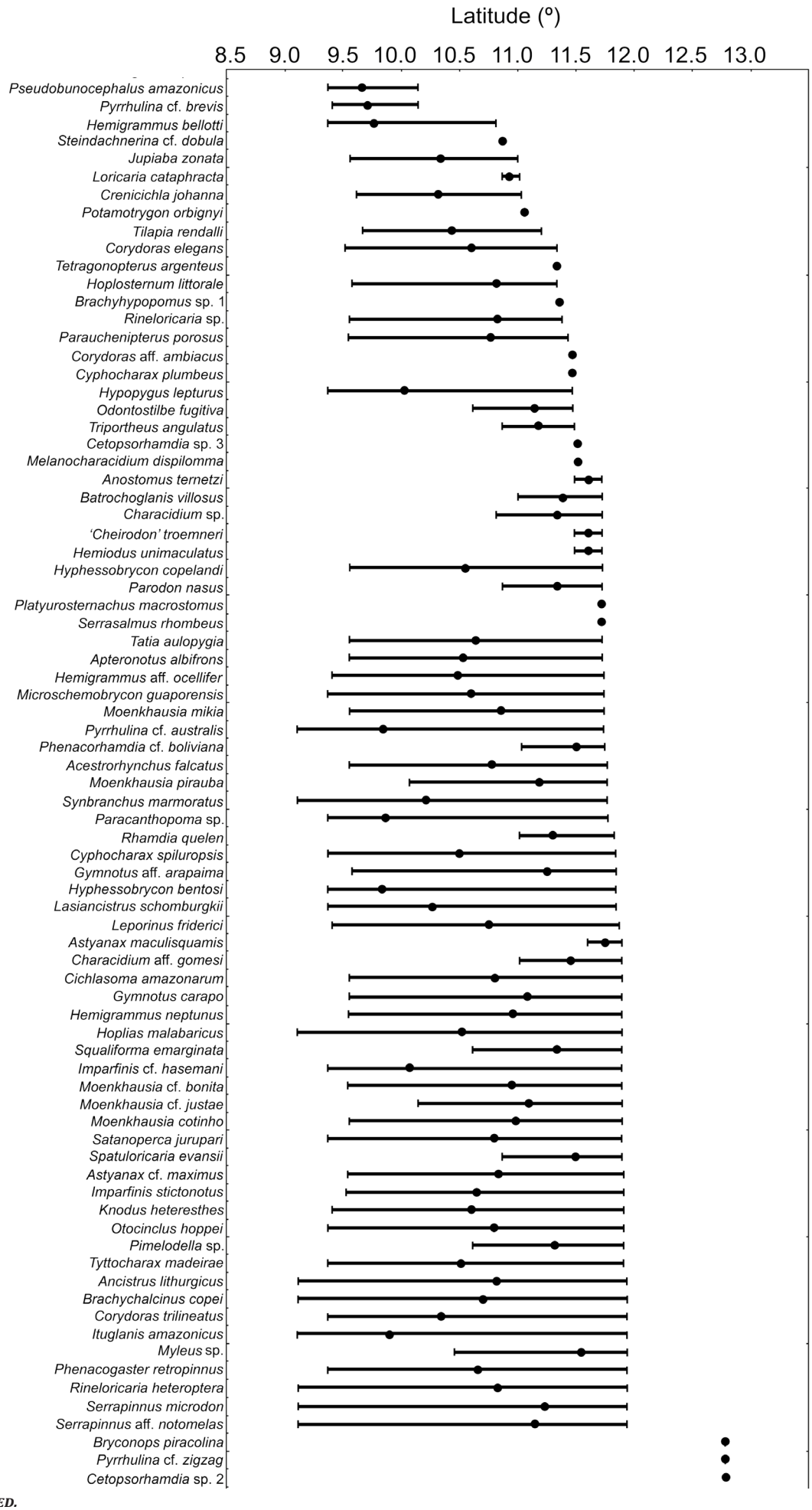

FIGURE 3. ***CONTINUED.***

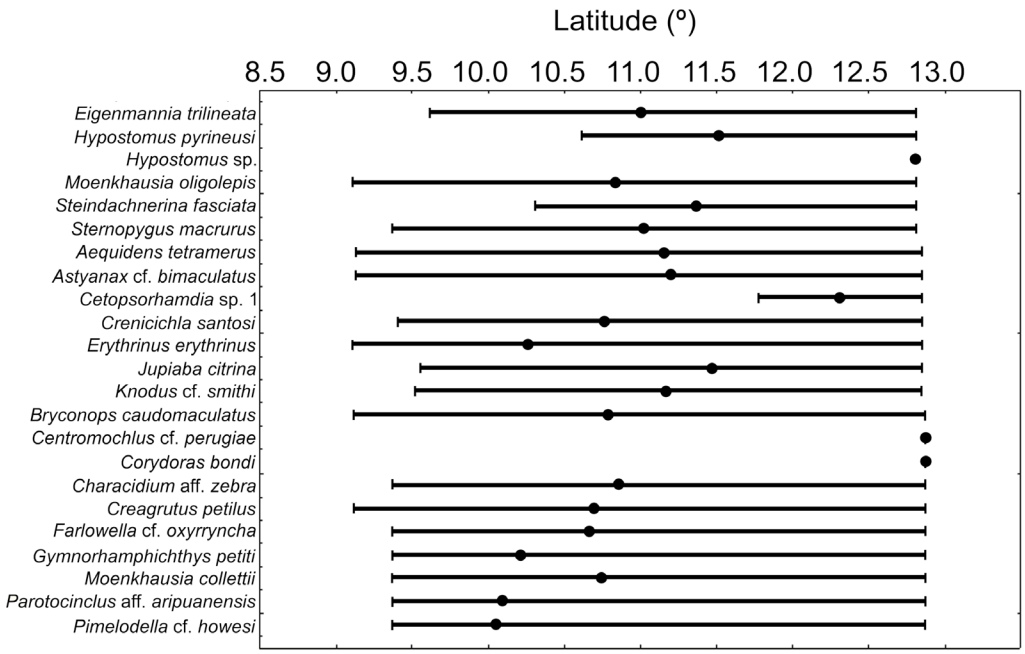

Figure 3. ***Continued.***

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