On the erroneous records of *Nannostomus nitidus* and *N. unifasciatus* for the state of Maranhão, Brazil, and the distribution of *Nannostomus beckfordi* along the coastal river basins of the state (Characiformes: Lebiasinidae).

Erick Cristofore Guimarães[1,2*], Pâmella Silva de Brito[1,2] & Felipe Polivanov Ottoni[1,2]

[1] Universidade Federal do Maranhão, Laboratório de Sistemática e Ecologia de Organismos Aquáticos, Centro de Ciências Agrárias e Ambientais, Campus Universitário, CCAA, BR-222, KM 04, S/N, Boa Vista, CEP 65500-000, Chapadinha, MA, Brazil
[2] Universidade Federal do Maranhão, Programa de Pós-Graduação em Biodiversidade e Biotecnologia da Amazônia Legal, Av. dos Portugueses 1966, Cidade Universitária Dom Delgado, CEP 65080-805, São Luís, MA, Brazil
[*] erick.ictio@yahoo.com.br

Abstract

In order to discover which species of the genus *Nannostomus* occurs in the coastal river basins and drainages of the State of Maranhão, Brazil, the present study used a methodology based on the following criteria: examined material, information obtained in collection expeditions, and collections database provided by their curators, or accessed consulting online databases, such as, Global Biodiversity Information Facility (GBIF) and Species Link. Based on this methodology, the present study concluded that only one species of the genus *Nannostomus* that occurs in the costal river basins from the State of Maranhão is *N. beckfordi.* Therefore, the records of the species *Nannostomus nitidus* and *N. unifasciatus* for this studied region are considered to be erroneous.
Keywords: biodiversity, coastal basins, freshwater fishes, pencilfish.

Resumo

Com o intuito de desvendar qual(ais) espécie(s) do gênero *Nannostomus* ocorre(m) nas bacias e drenagens costeiras do Estado do Maranhão, Brasil, o presente estudo utilizou uma metodologia baseada nos seguintes critérios: material examinado, informações obtidas em expedições de coleta, e banco de dados de coleções fornecidos por seus curadores, ou acessados consultando bancos de dados online, tais como, "Global Biodiversity Information Facility (GBIF)" e "Species Link". Com base nessa metodologia o presente estudo concluiu que apenas uma espécie do gênero *Nannostomus*, *N. beckfordi*, ocorre nas bacias costeiras do Estado do Maranhão. Sendo assim, o registro das espécies *Nannostomus nitidus* e *N. unifasciatus* para a região estudada são aqui considerados erros de identificação.
Palavras-chave: bacias costeiras, biodiversidade, peixes de água doce, peixe-lápis.

Introduction

Lebiasinidae is a family of freshwater fishes, popularly known as pencil fishes, distributed in the south of Costa Rica, Panama, and South America (Weitzman & Weitzman, 2003, Marinho & Menezes, 2017, Nelson et al. 2016, Netto-Ferreira, 2018). In South America its geographic distribution reaches to the La Plata River basin, not occurring naturally in Chile, and in the Southeastern and Eastern Brazilian Costal river basins, as well as in the São Francisco River basin (Weitzman & Weitzman, 2003, Marinho & Menezes, 2017, Netto-Ferreira, 2018). The family comprises about 75 valid species, distributed in two subfamilies: Lebiasininae and Pyrrhulininae (Nelson et al. 2016, Marinho & Menezes 2017, Netto-Ferreira 2018, Vieira & Netto-Ferreira 2019, Fricke et al. 2020a), with 29 and 46 valid species, respectively (Fricke et al. 2020a). Pyrrhulininae includes five genera: *Copeina* Fowler

fig. 1. *Nannostomus beckfordi*, holotype, BMNH 1871.12.28.10, Coast of Demerara, Guyana

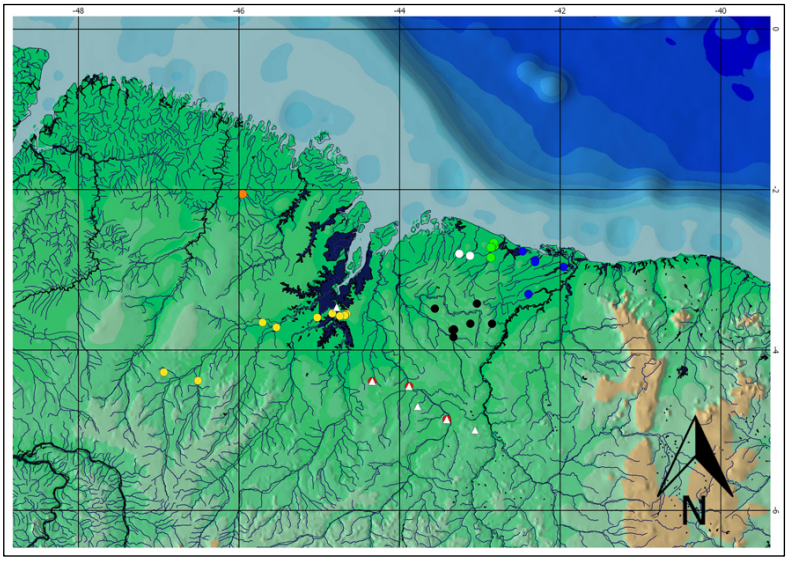

fig. 2. Detailed geographical distribution of *Nannostomus beckfordi* Günther 1872 along the coastal river basins of the Maranhão state, northeastern Brazil. orange dots: Maracaçumé river basin; yellow dots: Mearim river basin; red dots: Itapecuru river basin; black dots: Munim river basin; blue dots: Parnaíba river basin; green dots: Preguiças river basin; white dots: Periá river basin; white triangle: specimens not examined in the present study

1906, *Copella* Myers, 1956, *Derhamia* Géry & Zarske, 2002, *Nannostomus* Günther, 1872, and *Pyrrhulina* Valenciennes, 1846 (Netto-Ferreira 2018, Vieira & Netto-Ferreira 2019).
The genus *Nannostomus*, currently includes 20 valid species: *Nannostomus anduzei* Fernandez & Weitzman, 1987, *N. beckfordi* Günther, 1872, *N. bifasciatus* Hoedeman, 1954, *N. britskii* Weitzman, 1978, *N. digrammus* (Fowler, 1913), *N. eques* Steindachner, 1876, *N. erythrurus* (Eigenmann, 1909), *N. espei* (Meinken, 1956), *N. grandis* Zarske, 2011, *N. harrisoni* (Eigenmann, 1909), *N. limatus* Weitzman, 1978, *N. marginatus* Eigenmann, 1909, *N. marilynae* Weitzman & Cobb, 1975, *N. minimus* Eigenmann, 1909, *N. mortenthaleri*, Paepke & Arendt, 2001; *N. nigrotaeniatus* Zarske, 2013, *N. nitidus* Weitzman, 1978, *N. rubrocaudatus* Zarske, 2009, *N. trifasciatus* Steindachner, 1876, and *N. unifasciatus* Steindachner, 1876 (Fricke et al. 2020a). The genus is widely distributed, occurring in the coastal river basins of the Brazilian and Guiana Shields, Orinoco, Tocantins-Araguaia and Amazon river basins, as well as in the coastal river systems Eastern of the Amazon river's mouth (Weitzman 1978, Benzaquem et al. 2015, Teixeira et al. 2017, Netto-Ferreira 2018, Guimarães et al. 2018, Brito et al. 2019, Fricke et al. 2020a, this study).
Nannostomus nitidus and *Nannostomus unifasciatus* were recently recorded for freshwaters systems of the Maranhão state by Matavelli et al. (2015) for Munim and Parnaíba river basins, and Abreu et al. (2019) for the Mearim river basin. However, according to Fricke et al. (2020b), *N. nitidus* is known to occur only in Capim River basin in Pará state, Brazil; and *N. unifasciatus* occurs in the Amazon river basin in Bolivia, Brazil and Colombia, upper Orinoco basin in Venezuela, hydrographic systems of Guyana, and introduced in Trinidad and Tobago.
The aims of the present study is to investigate which species of the genus *Nannostomus* actually occur/s in the coastal river basins of the Maranhão state, based on extensive examined material and available online database from museum collections.

Material and Methods

Taxa sampling, specimen collection, and preservation
Specimens captured for this study were collected with manual trail-net (2 m long × 1.8m high; mesh size, 2mm) and euthanized in a buffered solution of ethyl-3-amino-benzoat-methanesulfonate (MS-

222) at a concentration of 250 mg/l until completely ceasing opercular movements, according to animal welfare laws and guidelines (Leary *et al*. 2013; Close *et al*. 1996, 1997). Specimens selected for morphological analysis were fixed in formalin and left for 10 days, after which they were preserved in 70% ethanol.

Data, Databases, and Database Management

Information about the occurrence of *Nannostomus* specimens in the coastal river basins of the Maranhão state was resulted from: extensive fieldwork made by the authors in the past fifteen years; examination of material deposited in the British Museum of Natural History, London (BMNH), fish collection of Centro de Ciências Agrárias e Ambientais, da Universidade Federal do Maranhão (CICCAA), and Coleção de Peixes da Universidade Federal do Maranhão (CPUFMA); and collections database from other fish collections provided by their curators or accessed consulting Global Biodiversity Information Facility (GBIF) and Species Link (MCP, MNRJ, MCP, MPEG, MZUEL). We also examined material from outside the Maranhão state to help in the specimens identification. The complete list of information obtained through the methodology applied here is shown in tables 1 and 2. Unfortunately, the material used by Matavelli et al. (2015) was rendered unusable by dehydratedthe lack of adequate preservative fluid. In addition, Abreu et al. (2019) did not specify the basis of identifications of the listed species. Therefore, it is not possible to know whether their record of *Nannostomus unifasciatus* was based on literature, direct material examination, or both.

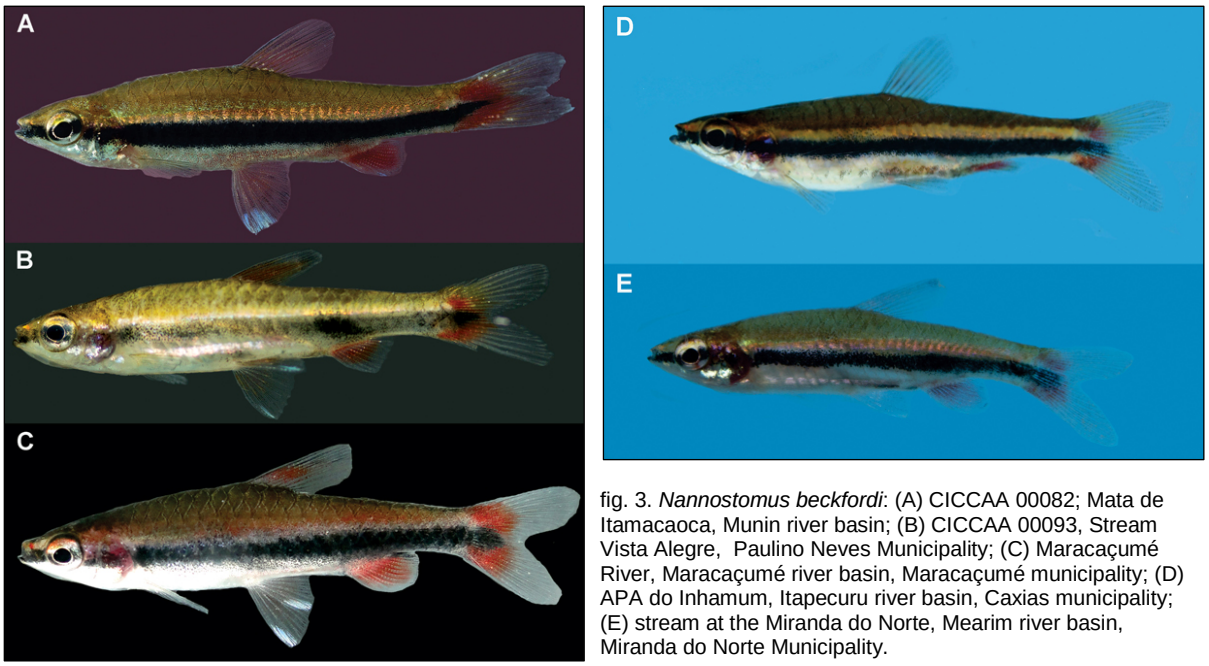

fig. 3. *Nannostomus beckfordi*: (A) CICCAA 00082; Mata de Itamacaoca, Munin river basin; (B) CICCAA 00093, Stream Vista Alegre, Paulino Neves Municipality; (C) Maracaçumé River, Maracaçumé river basin, Maracaçumé municipality; (D) APA do Inhamum, Itapecuru river basin, Caxias municipality; (E) stream at the Miranda do Norte, Mearim river basin, Miranda do Norte Municipality.

Results

Identification of examined specimens

All the specimens herein examined (figs. 2, 3, table 1) were identified as *N. beckfordi* (fig. 1). This species differs from congeners, except *N. grandis*, by the following character states: 10 principal caudal-fin rays in the dorsal lobe, nine principal caudal-fin rays in the ventral lobe, absence of adipose fin, primary horizontal stripe well developed, secondary horizontal stripe poorly developed, and absence of tertiary horizontal stripe (fig. 3; Weitzman & Cobb, 1975; figs. 9 and 10; Zarske 2011; figs. 6-9) Besides, the specimens herein examined differ from N. grandis mainly by having a milky white coloration in the tips of the ventral fins in N. beckfordi (fig. 3 and Zarske 2011; figs. 6–8) *vs.* the ventral fins colourless in *N. grandis* (Zarske 2011; fig. 3).

Type localities and distributions

Nannostomus beckfordi Günther 1872 (fig. 1)

o type locality. Goedverwagting, a plantation on the coast of Demerara [Guyana].

- distribution. widespread in rivers systems of the Guiana Shield and in the Amazon river basin, as well as in the coastal river systems eastern to the Amazon river mouth (Weitzman, 1978, Benzaquem et al. 2015, Teixeira et al. 2017, Netto-Ferreira, 2018, Brito et al. 2019 , Frike et al. 2020b , this study).
- countries. Brazil, French Guiana, Guyana and Suriname (Weitzman, 1978, Benzaquem et al. 2015, Teixeira et al. 2017, Netto-Ferreira, 2018, Brito et al. 2019, Frike et al. 2020b, this study).

Nannostomus nitidus Weitzman, 1978

- type locality. Brazil, State of Para, Igarape Candiru-Mirim near Badajos, Rio Capim.
- distribution. Capim River basin in Pará state (Fricke et al. 2020b).
- countries. Brazil (Fricke et al. 2020b).

Nannostomus unifasciatus Steindachner, 1876

- type locality: zunächst der Mündung des Rio Negro in kleinen Ausständen und Nebenarmen. [Amazonas, Brazil].
- distribution: Amazon River in Bolivia, Brazil and Colombia; upper Orinoco basin in Venezuela; and hydrographic systems of Guyana (Fricke et al. 2020b).
- countries: Bolivia, Brazil, Guyana, Trinidad and Tobago (introduced) and Venezuela (Fricke et al. 2020b).

Discussion

Based on the examination of material (from CICCAA, CPUFMA, MPEG, listed in table 1) and data provided by curators or accessed through online databses of other fish collections (table 2) it was concluded that only one species of the genus *Nannostomus* (*N. beckfordi*) occurs in the costal river basins of the Maranhão state (tables 1, 2, figs. 2, 3). Both the examination of material conducted by the present study, as well as, information from other fish collections data bases corroborate this conclusion. Therefore, the record of the species *Nannostomus nitidus* and *N. unifasciatus* for the coastal river basin of the Maranhão state, made by Matavelli et al. (2015) and Abreu et al. (2019), is considered here as misidentifications.

The species *N. nitidus* identified by Matavelli et al. (2015) (CPUFMA 10771) is clearly a case of misidentification. Examining carefully the Figure 3 of Matavelli et al. (2015) we can notice that this species does not possess an adipose fin, but a scale raised in the same location of the supposed adipose fin, which may have been the cause of the misidentification. Furthermore, those authors also wrongly named the illustrated *Nannostomus* as *Poecilia vivipara* Bloch & Schneider 1801.

The species *N. unifasciatus*, reported by Abreu et al. (2019) for the Mearim basin, which its distribution is not known for the Maranhão (Weitzman 1978, Dagosta & Pinna 2019, Fricke et al. 2020b), was never reported by any inventory carried out in the state that we had access (e.g. Garavello et al. 1998, Piorski 1998, Castro 2001, Castro et al. 2002, Piorski et al. 2003, Soares 2005, Piorski et al. 2007, Castro et al. 2010, Barros et al. 2011, Martins & Oliveira 2011, Sousa et al. 2011, Fraga et al. 2012, Almeida et al. 2013, Viana et al. 2014, Ribeiro et al. 2014, Lima et al. 2015, Matavelli et al. 2015, Ramos et al. 2014, Melo et al. 2016 , Piorski et al. 2017, Brito et al. 2019, Lima et al. 2019, Teixeira et al. 2019), and was also not collected in long-term expeditions carried out in the Mearim river basin conducted by Guimarães et al. (in press). In addition, no specimens of *N. unifasciatus* and *N. nitidus* were found occurring in any coastal river system of the Maranhão state in the two largest fish collections of Maranhão (CICCAA and CPUFMA), that together host some 10,000 fish lots, about 80% of them corresponding to samples from Maranhão's hydrographic systems, as well as in MPEG.

We cannot ignore, however, that the type locality of *N. beckfordi* is "Coast of Demerara, Guyana", and this species is widely distributed, occurring in the rivers systems of the Guiana Shield and in the Amazon river basin, as well as in the coastal river systems eastern to the Amazon river mouth, in the following countries: Brazil, French Guiana, Guyana and Suriname (Weitzman 1978, Benzaquem et al. 2015, Teixeira et al. 2017, Netto-Ferreira 2018, Brito et al. 2019, Fricke et al. 2020a, this study); many of these river systems are isolated for several thousands or even milions of years. In addition, Benzaquem et al. (2015) affirmed that some *Nannostomus* species are still taxonomically poorly defined, possibly being species complexes needing taxonomic revision (e.g. *N. beckfordi*, *N. eques*, *N. marginatus*, and *N. trifasciatus*). Taking into account the great distance in relation to the type locality and the populations of *N. beckfordi* from the Maranhão state, the wide geographic distribution of the species, and the lack of detailed taxonomic studies in populations of this species, we can ignore the fact these populations of the Maranhão state could be actually one or more undescribed species, hidden within this possible species complex (*N. beckfordi*). Although, with the current state of taxonomic knowledge of the genus, the populations occurring along the coastal river systems of Maranhão today must be addressed as *N. beckfordi.*

table 1. Specimens of *Nannostomus beckfordi* from the state of Maranhão examined for the present study. The species identification of the lots from MPEG were corroborated by the examination of the material by the first author of this study, as well as by researchers from MPEG, or visiting researchers.

Voucher	Number	Status	Municipality	Basin	Coordinates
CICCAA 28	8	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 31	7	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 36	4	C&S	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 39	59	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 40	10	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 43	1	DNA	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 71	58	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 74	14	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 82	2	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 85	3	DNA	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 123	5	DNA	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 181	93	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 204	109	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 228	24	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 565	132	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 652	178	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 658	75	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 746	6	DNA	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 785	130	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 953	210	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 1453	126	ALC	Chapadinha	Munim	03°44'45.2"S 43°19'15.1"W
CICCAA 200	21	ALC	Chapadinha	Munim	03°44'58.2"S 43°20'23.9"W
CICCAA 3722	25	ALC	Chapadinha	Munim	03°44'58.2"S 43°20'23.9"W
CICCAA 3745	5	ALC	Chapadinha	Munim	03°44'58.2"S 43°20'23.9"W
CICCAA 3886	31	ALC	Chapadinha	Munim	03°44'58.2"S 43°20'23.9"W
CICCAA 201	25	ALC	Chapadinha	Munim	03°44'27.1"S 43°19'36.4"W
CICCAA 2480	500	ALC	Chapadinha	Munim	03°44'55.16"S 43°19'57.10"W
CICCAA 3882	416	ALC	Chapadinha	Munim	03°44'55.16"S 43°19'57.10"W
CICCAA 2508	84	ALC	Chapadinha	Munim	03°45'08.1"S 43°20'04.1"W
CICCAA 34	8	ALC	São Benedito do Rio Preto	Munim	03°29'01"S 43°33'39.5"W
CICCAA 434	5	ALC	Anapurus	Munim	03°40'14"S 43° 7'10"W
CICCAA 435	5	ALC	Anapurus	Munim	03°40'14"S 43° 7'10"W
CICCAA 2025	2	ALC	Anapurus	Munim	03°40'14"S 43° 7'10"W
CICCAA 2920	6	ALC	Anapurus	Munim	03°40'14"S 43° 7'10"W
CICCAA 4246	9	ALC	Anapurus	Munim	03°40'14"S 43° 7'10"W
CICCAA 4252	2	ALC	Anapurus	Munim	03°40'14"S 43° 7'10"W
CICCAA 2928	44	ALC	Mata Roma	Munim	03°25'16.23"S 43°02'15.14"W
CICCAA 2929	2	ALC	Mata Roma	Munim	03°25'16.23"S 43°02'15.14"W
CICCAA 2930	2	ALC	Mata Roma	Munim	03°25'16.23"S 43°02'15.14"W
CICCAA 2933	4	ALC	Mata Roma	Munim	03°25'16.23"S 43°02'15.14"W
CICCAA 2934	32	ALC	Mata Roma	Munim	03°25'16.23"S 43°02'15.14"W
CICCAA 2935	17	ALC	Mata Roma	Munim	03°25'16.23"S 43°02'15.14"W
CICCAA 2951	15	ALC	Brejo	Munim	03°40'19.1"S 042°50'55.9"W
CICCAA 4226	1	ALC	Chapadinha	Munim	03°50'20.23"S 43°19'45.85"W
CICCAA 1324	10	ALC	Bom Jesus das Selvas	Mearim	04º16'32.3" S 46º56'7.8" W
CICCAA 1426	18	ALC	Buriticupu	Mearim	04°22'52.0"S 46°30'35.3"W
CICCAA 1123	29	ALC	Igarapé do Meio	Mearim	03°35'38.10"S 45° 1'35.05"W
CPUFMA 172440	2	ALC	Arari	Mearim	03°34'33.24"S 44°44'41.23"W
CPUFMA 172469	1	ALC	Miranda do Norte	Mearim	03°32'57.67"S 44°39'37.22"W
CPUFMA 172472	14	ALC	Arari	Mearim	03°33'51.06"S 44°40'44.09"W

table 1. continuation

MPEG 20970	4	ALC	Arará	Mearim	03°32'57.67"S 44°39'37.22"W
MPEG 20971	11	ALC	Arará	Mearim	03°34'3.15"S 44°40'59.00"W
MPEG 20995	2	ALC	Arará	Mearim	03°33'51.06"S 44°40'44.09"W
MPEG 21151	1	ALC	Pindaré-Mirim	Mearim	03°43'2.22"S 45°32'2.92"W
MPEG 21152	17	ALC	Igarapé do Meio	Mearim	03°35'38.10"S 45° 1'35.05"W
MPEG 21153	1	ALC	Pindaré-Mearim	Mearim	03°39'21.35"S 45°42'22.78"W
MPEG 24551	1	ALC	Pindaré-Mirim	Mearim	03°43'2.22"S 45°32'2.92"W
MPEG 24741	1	ALC	Arará	Mearim	03°33'51.06"S 44°40'44.09"W
MPEG 24747	5	ALC	Arará	Mearim	03°34'3.15"S 44°40'59.00"W
MPEG 24754	2	ALC	Igarapé do Meio	Mearim	03°35'38.10"S 45° 1'35.05"W
MPEG 24764	1	ALC	Vitória do Mearim	Mearim	03°32'36.08"S 44°50'19.81"W
MPEG 24771	13	ALC	Arará	Mearim	03°34'33.24"S 44°44'41.23"W
MPEG 24782	1	ALC	Miranda do Norte	Mearim	03°32'57.67"S 44°39'37.22"W
CICCAA 1319	69	ALC	Maracaçumé	Maracaçumé	02° 3'15.94"S 45°57'19.87"W
CICCAA 799	11	DNA	Barreirinhas	Preguiças	02°39'54.60"S 42°49'44.60"W
CICCAA 824	1	DNA	Barreirinhas	Preguiças	02°42'4.13"S 42°49'14.01"W
CICCAA 825	7	DNA	Barreirinhas	Preguiças	02°50'45.77"S 42°51'49.25"W
CICCAA 830	8	DNA	Barreirinhas	Preguiças	02°50'45.77"S 42°51'49.25"W
CPUFMA 172197	6	ALC	Barreirinhas	Preguiças	02°42'4.13"S 42°49'14.01"W
CPUFMA 172198	27	ALC	Barreirinhas	Preguiças	02°50'45.77"S 42°51'49.25"W
CPUFMA 172199	23	ALC	Barreirinhas	Preguiças	02°50'45.77"S 42°51'49.25"W
CPUFMA 172200	2	ALC	Barreirinhas	Preguiças	02°42'4.13"S 42°49'14.01"W
CPUFMA 172201	37	ALC	Barreirinhas	Preguiças	02°43'12.05"S 42°51'11.39"W
CPUFMA 172203	7	ALC	Barreirinhas	Preguiças	02°43'14.92"S 42°51'49.88"W
CPUFMA 172204	18	ALC	Barreirinhas	Preguiças	02°49'27.86"S 43° 7'22.52"W
CPUFMA 172202	10	ALC	Santo Amaro	Periá	02°47'58.53"S 43°15'26.39"W
CICCAA 2856	44	ALC	Caxias	Itapecuru	04°51'57.37"S 43°24'46.69"W
CICCAA 92	2	DNA	Paulino Neves	Parnaíba	02°46'02.8"S 042°28'07.5" W
CICCAA 93	1	DNA	Tutóia	Parnaíba	02°54'00.6"S 42°18'48.2"W
CICCAA 106	1	DNA	Tutóia	Parnaíba	02°52'48.5"S 42°18'47.1"W
CICCAA 3553	19	ALC	Araioses	Parnaíba	02°57'47.6"S 41°57'32.4"W
CICCAA 3563	52	ALC	São Bernardo	Parnaíba	03°18'07.8"S 42°23'43.6"W

table 2. Specimens of *Nannostomus beckfordi* from the state of Maranhão not examined personally for the present study. Data as available from online resources

Voucher	**Number**	**Status**	**Municipality**	**Basin**	**Coordinates**
MCP 24783	11	ALC	Caxias	Itapecuru	04°42'4.90"S 43°46'29.79"W
MCP 24926	9	ALC	Caxias	Itapecuru	04°42'4.90"S 43°46'29.79"W
MCP 24931	27	ALC	Peritoro	Itapecuru	04°23'21.07"S 44°20'26.78"W
MCP 24940	?	ALC	Codó	Itapecuru	04°27'5.93"S 43°52'57.28"W
MNRJ 29231	-	ALC	-	Mearim	-
MNRJ 29232	-	ALC	Arari	Mearim	-
MNRJ 49369	?	ALC	Caxias	Itapecuru	-
MZUEL 10441	1	ALC	Caxias	Itapecuru	04°51'57.37"S 43°24'46.69"W

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