A new species of *Corydoras* Lacépède (Siluriformes: Callichthyidae) from the Rio Tapajós basin and its phylogenetic implications

Vinicius C. Espíndola, Marcelo R.S. Spencer, Leandro R. Rocha, Marcelo R. Britto

ABSTRACT

A new species of *Corydoras* is described from tributaries of the rio Arinos, rio Têles Pires and rio Preto, all in the rio Tapajós basin. The new species is a member of a group that includes 36 species with spots on the body. Within this group, the new species can be readily distinguished by having a smaller dorsal-fin spine than the first three subsequent soft dorsal-fin rays; pectoral, pelvic and anal fins hyaline; dorsal-fin interradial membrane hyaline; rounded spots on trunk restricted to dorsolateral body plates and dorsal portion of ventrolateral body plates, not reaching the base of pelvic and anal fins. The new species can be further distinguished from *Corydoras xinguensis* by having spots with diffuse edges, and from all other species of spotted *Corydoras* except *C. multimaculatus*, by the absence of ventral platelets. A phylogenetic analysis recovered the new species plus *Corydoras metae* and *C. araguaiensis* in a clade sharing the presence of a pointed process on the maxilla for insertion of the retractor tentaculi muscle. In addition, the presence in the new species of an elongated anterior portion of the mesethmoid and a triangular uncinate process of the epibranchial 3 suggests a close relationship with *Corydoras metae*.

Key-Words: Corydoradinae; Neotropical; Phylogeny; Taxonomy; Biodiversity.

INTRODUCTION

*Corydoras* Lacépède is the most diversified catfish genus, currently including more than 160 valid species (Eschmeyer, 2013). The species of *Corydoras* are widely distributed throughout cis-Andean South America in habitats such as shallow marginal areas of rivers, pools, and smaller tributaries (Reis, 2003). Despite the huge diversity of shapes and color patterns among the species of *Corydoras*, the limits and definitions of a large amount of species are still unknown (Gosline, 1940; Nijssen & Isbrücker, 1980, 1986; Reis, 1998, 2003; Britto, 2003).
Two species of *Corydoras* were originally described from the rio Tapajós basin: *C. bifasciatus* Nijsen 1972 and *C. ornatus* Nijsen & Isbrücker 1976. *Corydoras aeneus* (Gill, 1858) and *C. splendens* (Castelnau, 1855) were also recorded from the same basin (Britto *et al.*, 2007), and there are many other forms yet to be described (Fuller & Evers, 2005).

Nijssen (1970) proposed an assembly of *Corydoras* species, the “*C. punctatus-group*,” grouping all species with spots scattered over the body, and divided into six subgroups according to the following features: (a) dark spot on the upper part of the dorsal fin; (b) dark mask across the eye; (c) long snout; (d) relatively elongate body; (e) deep body; and (f) relatively long dorsal-fin spine. The author also mentioned that the spotted *Corydoras* group has a large range of distribution, with records from the northern to central Neotropical region, and that it includes almost 35% of all described species. The present study will focus on specimens of the Nijssen’s (1970) subgroups (a) and (e), plus *Corydoras araguaiaensis* and *C. haraldschulzei*.

Recent material sampled from tributaries of rio Teles Pires, rio Arinos, and rio Preto revealed a spotted *Corydoras*, somewhat resembling species like *C. albolineatus* Knack, *C. maculifer* Nijsen & Isbrücker, *C. multimaculatus* Steindachner, *C. polystictus* Regan and *C. xinguensis* Nijsen. Examination of the material revealed that this is a new species of *Corydoras*, which is described herein.

**MATERIALS AND METHODS**

Morphometric and meristic data were taken following Reis (1997), except for the length of the anal-fin spine, which is absent in all members of Corydoradinae. Length of the ossified portion of the pectoral-fin spine was measured from the point of articulation of the spine to the pectoral girdle to the distal tip of the spine (Reis, 1997). Measurements were taken with calipers to the nearest 0.1 mm. Teeth and vertebral counts were made from cleared-and-stained (cs) specimens prepared according to Taylor & Van Dyke (1985). Vertebral counts include 27-30 vertebrae, with the compound caudal central (preural 1 + ural 1) counted as a single element. Lateral plate counts include all dorsolateral and ventrolateral plates, except for the small, irregular plates on the caudal peduncle. Throughout the description, the numbers in parentheses following each count represent the total number of specimens with that value, and an asterisk indicates data for the holotype. Nomenclature of latero-sensory canals follows Schaefer & Aquino (2000), and that of preopercular pores follows Schaefer (1988). Osteological terminology follows Reis (1998), except that parieto-supraoccipital is used instead of supraoccipital (Arratia & Gayet, 1995), and compound pterotic instead of pterotic-supracleithrum (Aquino & Schaefer, 2002). Homology of barbels follows Britto & Lima (2003). Institutional abbreviations follow Sabaj Pérez (2010).

Phylogenetic analysis was performed using the morphological character data matrix exactly as published by Britto (2003) with the addition of the new taxon. The analysis was undertaken using T.N.T. software (Goloboff *et al.*, 2008) via a traditional heuristic search performed using the stepwise addition algorithm associated with tree bisection reconnection in a total of 10,000 samples. Attributes of connectivity and ambiguity among character-states were treated in the same way as in Britto (2003).

**RESULTS**

*Corydoras apiaka*, new species

Fig. 1A, Fig. 1B, Table 1


FIGURA 1: *Corydoras apiaka* MNRJ 40720, 28.4 mm, Ribeirão Oito de Julho, a tributary of the right margin of rio Arinos. Dorsal (upper), lateral (middle) and ventral (lower) views.
**Diagnosis**

*Corydoras apiaka* differs from its spotted congener by having the dorsal-fin spine smaller than the three anterior branched dorsal-fin rays (*vs*. dorsal-fin spine smaller than just two anterior dorsal-fin rays, or equal in size). *Corydoras apiaka* is distinguished from its congeners, except *C. albolineatus*, *C. araguaiaensis*, *C. haraldschultzi*, *C. julii*, *C. polystictus*, *C. multimaculatus* and *C. xinguensis* by the presence of numerous dark-brown spots over the head and body (*vs*. spots absent). *Corydoras apiaka* differs from *C. albolineatus*, *C. araguaiaensis* and *C. haraldschultzi* by having several spots scattered all over the head and trunk in a somewhat random pattern (*vs*. spots more concentrated and with a single pale horizontal stripe in the middle of the body in *C. albolineatus*; or spots arranged in three or more stripes along the trunk in *C. araguaiaensis* and *C. haraldschultzi*); pectoral, pelvic and anal fins hyaline (*vs*. several series of small blotches over fin rays), and adipose fin hyaline or bearing one spot (*vs*. two or more spots). The new species can be further distinguished from *C. multimaculatus* and *C. xinguensis* by blotches on interradial membrane of dorsal fin absent (*vs*. present); adipose fin hyaline or with a single spot (*vs*. two or three well defined spots); spots not reaching over the anal fin base (*vs*. spots extending to anal-fin base). *Corydoras apiaka* is distinguished from *C. xinguensis* by spots on anal fin absent (*vs*. present); body spots with diffuse border (*vs*. spots with well delimited edge). *Corydoras apiaka* further differs from all other spotted species, with the exception of *C. multimaculatus*, by the naked ventral region (*vs*. belly with small platelets).

**TABLE 1: Morphometric data for Corydoras apiaka.**

<table>
<thead>
<tr>
<th></th>
<th>Holotype (MNR)</th>
<th>Paratypes (n=23)</th>
<th>Mean</th>
<th>SD</th>
</tr>
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<tr>
<td>Standard length (mm)</td>
<td>28.4</td>
<td>28.9-38.8</td>
<td>32.3</td>
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<tr>
<td>Head length (mm)</td>
<td>13.1</td>
<td>10.4-13.3</td>
<td>11.8</td>
<td>1.53</td>
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<tr>
<td><strong>Percentages of standard length</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Depth of body</td>
<td>39.5</td>
<td>36.9-42.6</td>
<td>39.9</td>
<td>1.48</td>
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<td>Predorsal distance</td>
<td>50.9</td>
<td>48.1-53.9</td>
<td>51.3</td>
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<td>Prepelvic distance</td>
<td>45.4</td>
<td>43.5-51.7</td>
<td>47.1</td>
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<td>Preanal distance</td>
<td>75.7</td>
<td>68.8-81.5</td>
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<td>Preadipose distance</td>
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<td>75.5-85.2</td>
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<td>Length of dorsal spine</td>
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<td>16.1-24.6</td>
<td>20.2</td>
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</tr>
<tr>
<td>Length of pectoral spine</td>
<td>28.8</td>
<td>21.9-28.6</td>
<td>24.8</td>
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<td>Length of adipose-fin spine</td>
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<td>5.7-11.0</td>
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<td>Depth of caudal peduncle</td>
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<td>15.2</td>
<td>9.24</td>
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<td>16.6-39.2</td>
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<tr>
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<td>8.9-29.9</td>
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<td>Length of longer barbel</td>
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<td>12.1-20.9</td>
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<td>Head depth</td>
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<td>Least interorbital distance</td>
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<td>5.3-9.1</td>
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<td>Snout length</td>
<td>8.7</td>
<td>7.2-16.6</td>
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<tr>
<td>Least internareal distance</td>
<td>7.2</td>
<td>6.7-10.5</td>
<td>8.3</td>
<td>2.68</td>
</tr>
</tbody>
</table>

**Description:** Morphometric data presented in Table 1. Head compressed with slight convex dorsal profile (Fig. 1); roughly triangular in dorsal view. Snout rounded. Head profile convex from upper lip to tip of parioeto-supraoccipital expansion. Dorsal profile of body slightly convex from tip of parioeto-supraoccipital expansion to base of last dorsal-fin ray. Body slightly concave from last ray of dorsal fin to base of adipose-
fin spine; straight to slightly concave from that point to caudal-fin base. Ventral profile of body straight from isthmus to pelvic-fin origin, slightly convex from that point to anal-fin origin. Profile slightly concave from first anal-fin ray to caudal-fin base. Body roughly triangular in cross section at pectoral girdle, gradually becoming more compressed toward caudal fin.

Eye round, dorsolateral on head; orbit delimited dorsally by frontal and sphenotic, ventrally by infraorbitals. Anterior and posterior nares close to each other and only separated by flap of skin. Anterior naris tubular. Posterior naris close to anterodorsal margin of orbit, separated from orbit by distance slightly smaller than naris diameter. Mouth small, subterminal, width nearly equal to bony orbit diameter. Maxillary barbel not reaching anterocentral limit of gill opening. Length of maxillary barbel nearly equal to that of outer mental barbel. Inner mental barbel fleshy. Small rounded papillae covering entire surface of all barbels, upper and lower lips, and isthmus. Gill membranes united to isthmus. Four branchiostegal rays covered by thin layer of skin; two distal branchiostegal rays united at their tips by branchiostegal cartilage. Teeth on upper pharyngeal tooth plate 46(1), and on fifth ceratobranchial 45(1).

Posterior area of mesethmoid, frontal, sphenotic, compound pterotic, and parieto-supra奥林匹克 visible externally, all covered by thin layer of skin and bearing minute scattered odontodes. Frontal fontanel elongate, ellipsoid, covered by thin layer of skin; posterior portion extending into parieto-supra奥林匹克. Nasal slender, curved laterally, mesial border contacting frontal. Frontal rectangular; anterior expansion in contact with nasal bone, posterior portion contacting sphenotic and parieto-supra奥林匹克. Sphenotic trapezoid in shape, contacting parieto-supra奥林匹克 dorsally, compound pterotic posteriorly, second infraorbital ventrally. Compound pterotic roughly pipe-shaped, with posterior expansion contacting first lateral-line ossicle. Ventral margin of compound pterotic contacting opercle and cleithrum. Parieto-supra奥林匹克 quadrangular with posterior expansion notched at its tip, sutured with nuchal plate.

Two infraorbital bones, externally visible, covered by thin layer of skin. First infraorbital with anterior expansion. Second infraorbital bone contacting only sphenotic posteriorly. Opercle exposed, slender in shape, with smooth free border. Preopercle externally visible, slender and covered by thin layer of skin.

Trunk lateral line with three laterosensory canals; two anteriormost canals reduced to small ossicles. Last lateral-line canal encased in second dorsolateral body plate. Lateral-line canal entering neurocranium through compound pterotic, splitting into three branches before entering sphenotic: pterotic and preoperculomandibular, each with single pore. Sensory canal continuing through compound pterotic, entering sphenotic as temporal canal, which splits into two branches: one branch giving rise to infraorbital canal, the other branch entering frontal through supraorbital canal. Supraorbital canal not branched, running through nasal bone. Epiphysial pore opening at supraorbital main canal. Nasal canal with single opening at each end. Infraorbital canal running through entire second infraorbital, extending to infraorbital 1 and opening into three pores. Preoperculomandibular branch giving rise to preoperculomandibular canal, which runs through entire preopercle with three openings, leading to pores 3, 4, and 5, respectively.

Body plates with minute odontodes restricted to posterior margins. Nuchal plate exposed. Posterior tip of cleithrum along vertical through dorsal-fin spine. Cleithrum and mesial process of scapulocoracoid exposed. Body plates not touching counterparts ventrally, leaving narrow naked area. Dorsolateral body plates 23(2), 24*(24); ventrolateral body plates 21*(25), 21*(25); dorsal body plates along dorsal-fin base 6(7), 7*(19); dorsal body plates from adipose fin to caudal-fin base 8*(23), 9(3); preadipose platelets 1(1), 4*(3), 5*(18), 6(4). Precaudal vertebrae 10, and caudal vertebrae 11. Six pairs of ribs, first pair conspicuously larger than others.

**Color in alcohol:** Ground coloration of head light brown to brown, light brown ventrally. Interorbital to supraoccipital region darker than snout, anterior and posterior margins of the eye to opercle. Several small irregular chromatophores scattered over snout to parieto-supraoccipital. Chromatophores less concentrated over lower anterior and posterior margins on opercle and superior surfaces. Mental barbels dark brown, remaining barbels yellowish light brown.


**FIGURA 3:** Map of northern South America showing the distribution of *Corydoras apiaka* (circle) holotype; rio Arinos (triangles); rio Teles Pires (squares); rio Preto (star).

**FIGURA 4:** Detail of distribution of *Corydoras apiaka* shown in Fig. 2. (circle) holotype; rio Arinos (triangles); rio Teles Pires (squares); rio Preto (star).
Phylogenetic relationships: Insertion of the new species in Britto’s (2003) data matrix, recovered the following clade: (Corydoras araguaiensis (Corydoras metae + Corydoras apiaka)). The monophyletic clade including Corydoras apiaka and C. metae is supported by two synapomorphies: anterior portion of mesethmoid long and unincise process of epibranchial 3 triangular. The monophyletic clade including Corydoras araguaiensis (C. metae + C. apiaka) is supported by just one synapomorphy: pointed process on the maxilla for insertion of the retractor tentaculi muscle. Also, the new species shows the following homoplastic features: process on anterolateral margin of frontal bone (also present in Corydoras britskii, C. rabauti, C. aeneus, C. pygmaeus, C. viattatus, C. septentrionalis, C. stenocephalus, C. gracilis, C. ephippiifer, C. juli, C. diffluviatilis, C. flaveolus, C. arcuatus, C. babrosus, C. axelrodi, C. coehui, C. nattereri, C. aureofrenatus, and C. loretoensis), complex vertebra slender (also including Corydoras zygatus, C. acatus, C. ellisa, C. stenocephalus, Corydoras diffluviatilis, C. undulatus, C. gracilis, C. osteocarus, C. garbei, C. ornatus, C. paleatus), a fully interdigitated junction between metapterygoid and hyomandibular (including Corydoras zygatus, C. acatus, C. ellisa, C. stenocephalus, C. undulatus, C. gracilis, C. nanus, C. napoensis, C. elegans, C. bicolor, C. trilinatus, C. osteocarus, C. juli, C. araguaiensis, C. flaveolus, C. arcuatus, C. baderi, C. habrosus and C. coehui) and dorsal lamina on anguloarticular triangular (present in Corydoras reticulatus, C. diffluviatilis, C. ornatus, and C. agasizii).

Sexual dimorphism: No sexually dimorphic characters found. Corydoradine catfishes often have dimorphic genital papillae (see Britto, 2003), but specimens of Corydoras apiaka have no pectoral-fin spine serration modifications.

Distribution: Corydoras apiaka is only known from tributaries of the rio Arinos, rio Teles Pires and rio Preto, clearwater tributaries of the upper rio Tapijos in Mato Grosso State, Brazil (Figs. 3, 4).

Habitat and ecological notes: Corydoras apiaka was mostly found in lotic habitats in the rio Arinos and its tributaries. The rio Arinos has a muddy-brown color, with soft bottom of clay and sand. Most of the specimens were captured in the small forest streams of black or clear water, or in marginal ponds.

Etymology: The specific name apiaka is treated as a noun in apposition and is named for the indigenous tribe Apiaká (means “people” in Tupi language), which originally occupied the middle and lower rio Arinos, lower rio Juruen, but is nowadays restricted to the lower rio Juruen (Menéndez, 1992). The tribe is known for facial tattoos and bravery in battles, as well as by anthropophagic rites after fights (Castel-nau, 1850).

DISCUSSION

All evidence assigns the non-monophyly of a spotted group of Corydoras. A recent published study about mimetic lineages in Corydoras performed by Alexandrou et al. (2011) shows relationships and patterns among co-mimics of certain regions. The authors pointed out that those sympatric co-mimics are more similar in coloration than those in allopa-tryy. The test suggested a highly significant relationship between color pattern and geographical distribution. The authors identified 52 species belonging to 24 different mimicry rings, combining phylogenetic analysis and geographic distribution, each composed of two or three species. The co-mimic rings are composed of different evolutionary lineages corroborating Britto’s (2003) hypothesis that color pattern is convergent and recovers weak phylogenetic signal. The new species, Corydoras apiaka (not included in the analysis) is the only described spotted Corydoras from Tapijos basin; another three described species from same basin (C. aeneus, C. bifasciatus and C. ornatus) have no spotted pattern. Yet many Corydoras morphotypes are still undescribed and demand taxonomic review (e.g., Fuller & Evers, 2005:280-361).

We agree with Britto’s (2003) and Alexandrou et al. (2011) hypothesis that go against Nijssen’s (1970) division of Corydoras into eight groups, one of them being the “punctatus-group” represented by the spotted Corydoras. The highly homoplasic spotted color patterns serve as evidence for the complexity of the evolution in the genus.

Comparative material: Listed in Britto & Lima (2003) and Britto (2003) with the addition of: Corydoras albolineatus MNRJ 33864 (5); Corydoras araguaiensis MNRJ 25495 (2); MNRJ 24937 (2); MZUSP 86269 (67, 1 cs); Corydoras cervinus MNRJ 33867 (1); Corydoras xinguensis MZUSP 38980 (1), paratype; MNRJ 24871 (1); MZUSP 38974 (1) paratype; MZUSP 87047 (15); MZUSP 87098 (1); Corydoras haraldschultzi MZUSP 94996 (299); Corydoras juli MNRJ 33869 (35); MNRJ 33870 (3); Corydoras multimaculatus MNRJ 16118 (6); Corydo-ras polystictus MNRJ 12418 (9).
RESUMO

Uma nova espécie de Corydoras é descrita dos tributários dos rios Arinos, Teles Pires e Preto, bacia do rio Tapajós. A nova espécie é membro de um grupo com pontilhados no corpo que inclui 36 espécies. Dentro desse grupo, a nova espécie pode ser facilmente distinguida pelo espinho dorsal menor que os três primeiros raios ramificados da nadadeira dorsal; nadadeiras pêlorais, pêloes e anal hialinas; membranas inter-radiais da nadadeira dorsal hialina; presença de pontilhados redondos no tronco restritas às placas dorso-laterais do corpo e porções dorsais das placas ventrolaterais não alcançando a base das nadadeiras pêloes e anal. A nova espécie pode ser distinguida de Corydoras xinguensis por pontilhados com margens difusas e das demais espécies de Corydoras com pontilhado, exceto em C. multimaculatus, pela ausência de pequenas placas ventrais. Uma análise filogenética recuperou a nova espécie mais Corydoras metae e C. araguaiensis em um agrupamento compartilhando a presença de um processo pontiagudo para inserção do músculo retractor tentaculi no maxilar. A porção anterior do mesetmóide alongada e pontiaguda para inserção do músculo retractor tentaculi.

PALAVRAS-CHAVE: Corydoradinae; Neotropical; Filogenia; Taxonomia; Biodiversidade.

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