

A new species of *Campylorhamphus* (Aves: Dendrocolaptidae) from the Tapajós – Xingu interfluve in Amazonian Brazil

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The difficulty in visually separating the Amazonian endemic Curve-billed Scythebill *Campylorhamphus*⁸ *procurvoides* from the sympatric taxa grouped under the more widespread Red-billed Scythebill (*C. trochilirostris*), both in the hand and in the field, is notorious among ornithologists working in the Neotropics. J. T. Zimmer (1934) listed several morphological characters separating these two polytypic species, and he was the first to classify the different *Campylorhamphus* taxa occurring in lowland Amazonia as either *C. procurvoides* or *C. trochilirostris*, according to the theoretical background of the Biological Species Concept (BSC). Over the next 76 years, Zimmer's taxonomic treatment of *C. procurvoides* and *C. trochilirostris* has been followed without change (e.g. Todd 1948, Peters 1951, Ridgely and Tudor 1994, Marantz *et al.* 2003), despite some qualitative evidence indicating that some taxa grouped under *C. procurvoides* (the so-called *multostriatus* group) are in fact vocally and morphologically more similar to *C. trochilirostris* (Marantz *et al.* 2003).

More recently, two of us (AW and KJZ) noticed that even the *multostriatus* group was vocally heterogeneous, with birds from the Carajás region of south-eastern Amazonian Brazil singing very differently from birds found across the Xingu River. Consistent with this finding, a molecular phylogeny, based on mitochondrial DNA data, showed that the two populations separated by the Xingu River and attributed to *multostriatus* are not each other's closest relatives, with birds from the eastern bank (labeled as *C. p. multostriatus*) appearing outside the core Amazonian *Campylorhamphus* clade with unresolved affinities within the genus *Campylorhamphus* (Fig. 1). In contrast, populations from the west bank of the Xingu (labeled in Fig. 1 as the new taxon described herein) grouped with strong support and were vocally close to *probatas* from the neighboring Madeira – Tapajós interfluve, with those two groups clustering together as sisters of *C. trochilirostris* (Fig. 1).

As shown below, birds found between the west bank of the Xingu and the east bank of the Tapajós rivers are morphologically and genetically diagnosed from all remaining *Campylorhamphus* taxa, including those in the closely related *probatas*. However, due to their overall plumage similarity, historically they have all been treated under the name *multostriatus*, which in fact applies only to birds from the Xingu – Tocantins interfluve (Sneath 1907; Figs. 1 and 2). Therefore, since no valid name is applicable to birds from the fully diagnosable population in the Tapajós – Xingu interfluve, we propose to name these as:

Campylorhamphus cardosoi

Tapajós Scythebill

arapaçu-do-tapajós (Portuguese)



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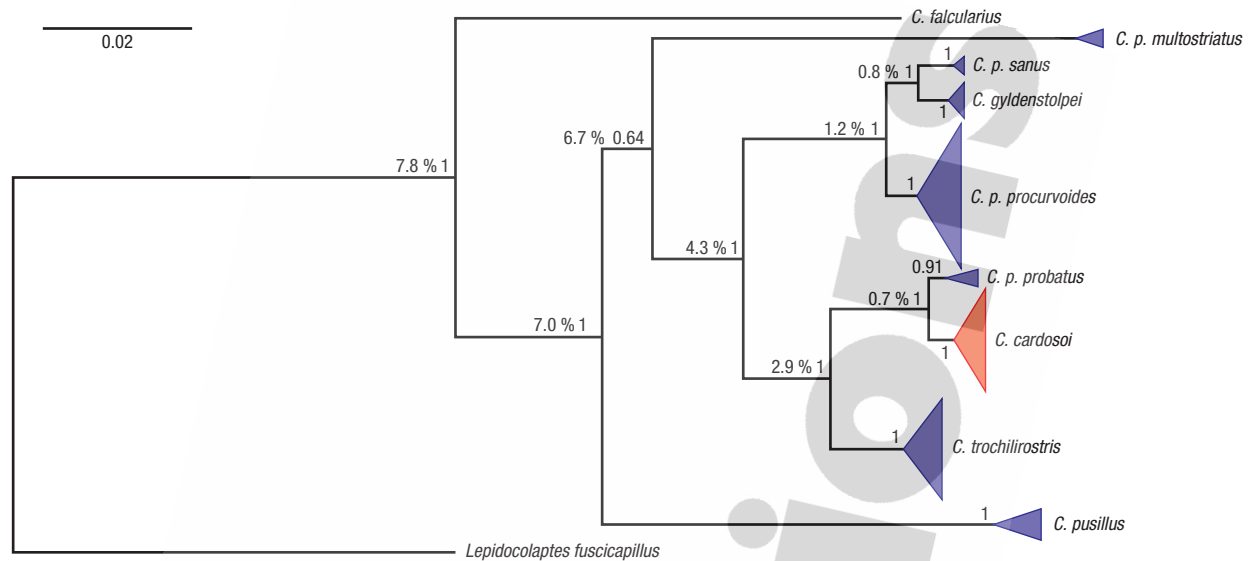
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Figure 1.
Bayesian estimate of the phylogeny of the genus *Campylorhamphus* based on two mitochondrial genes (*cyt b* and *ND2*). Numbers refer to posterior probability values and genetic distances (% of average uncorrected p sequence divergence) between sister groups associated with the labeled nodes. Note the polyphyly of taxa currently grouped under *C. procurvoides* (*multostriatus*, *probatas*, *procurvoides*, and *sanus*) and the new taxa *cardosoi* and *gyldenstolpei* described in this volume.



Holotype.— Museu Paraense Emilio Goeldi (MPEG) 63875, skin, adult female, skull 85% ossified, no bursa of fabricius; 38 g; ovary 7×4 mm with ova minute; oviduct convoluted; little fat and tail molt. Collected (shot) in the understory of upland (*terra-firme*) forest by AA on 22 November 2007 at Floresta Nacional de Altamira, municipality of Altamira, Pará, Brazil ($06^{\circ} 04'S$; $55^{\circ} 19'W$); prepared by Fabíola Poletto under field number TM 002. Pectoral muscle tissue preserved in approximately 96% alcohol; field number TM 002. Hologenotype (Chakrabarty 2010) sequences of the mitochondrial genes cytochrome *b* (1,048 bp) and NADH subunit 2 (1,041bp) deposited in GenBank (accession numbers KC237254 and KC242876, respectively).

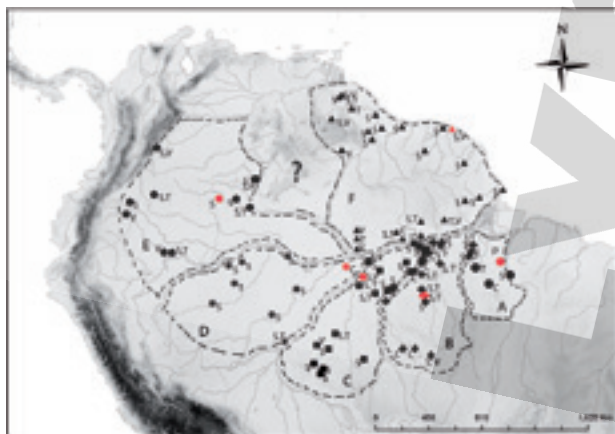
Diagnosis: Morphology.— Alphanumeric color designations determined through direct comparison with Smithe (1975). Phenotypically, the new species can be unambiguously assigned to the genus *Campylorhamphus* (Dendrocolaptidae) based on its narrow, long, and curved bill, which readily characterizes the genus. Within *Campylorhamphus*, it is morphologically similar to the phylogenetically distant taxon *multostriatus* (Fig. 1) but distinguished from it by the following features: 1) reddish-brown maxilla, the latter distinctly blackish in live or recently collected *multostriatus* specimens; 2) much narrower dorsal streaks typically not extending all the way onto the lower back; and 3) whiter rather than buffier pectoral streaks, resulting in the blackish edge of the buffy-yellow pectoral streaks being conspicuously more contrasting than in *multostriatus*. A secondary effect, easily observed when the pectoral (and to a lesser extent the dorsal) streaks of *cardosoi* and *multostriatus* are compared, is that in *cardosoi* the contrasting blackish edge is visible along the edges and towards the tip of each individual stripe, whereas in *multostriatus* they are usually barely visible and only along the edges, resulting in *multostriatus* having pectoral streaks not acutely shaped as in *cardosoi*. From the remaining taxa currently grouped in the “*procurvoides*” group (*gyldenstolpei*, *procurvoid-*

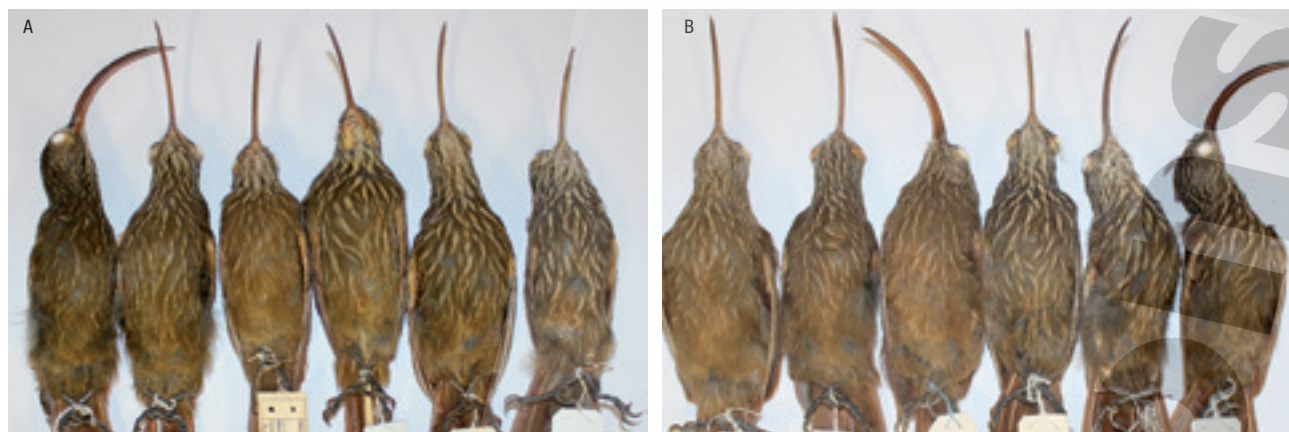
es, and *sanus*; see Fig. 1), *cardosoi* is diagnosed by significantly bigger and more cylinder-like buffy pectoral streaks, with more pronounced black edges and a Raw Umber 223 belly (vs. Cinnamon-Brown-33 or Russet-34). From its sister taxon *probatas*, *cardosoi* can be unambiguously diagnosed by a conspicuously contrasting blackish head, significantly broader head and pectoral spots, mantle covered with longer and broader buffy-whitish streaks (vs unmarked), and significantly shorter tarsi (Fig. 3; Table 3 in SI). **Voice.**— The loudsong is immediately distinguished in the field and in spectrographic analysis from those of all other members of the polytypic *C. procurvoides*, except *probatas*, by the shape and syntax of the notes (described below; see Figs. 4 and 5). Along with *probatas*, *cardosoi* is the only taxon in the polytypic *C. procurvoides* possessing E note types (characterized by a typical bell shape; Fig. 3E) in its loudsong, followed by a sequence of C note types (Fig. 5E,F). No clear-cut differences could be detected between the loudsongs of *cardosoi* and *probatas*, but there is a tendency for the first note (C type) to be higher in frequency in *probatas* than in *cardosoi*. Furthermore, loudsong pace tends to be faster in *cardosoi* than in *probatas*. **Genetic divergence.**— Separated from its sister taxon *probatas* by approximately 0.7% sequence divergence in the mitochondrial genes cytochrome *b* and NADH subunit 2 (Fig. 1). Based on these genes, both *cardosoi* and *probatas* diverge from their sister group (*C. trochilirostris*) by 2.9% and from the remaining taxa in the polytypic *C. procurvoides* by ca. 4.3% (Fig. 1).

Distribution.— *Campylorhamphus cardosoi* has been documented from several localities in the Tapajós-Xingu interfluvium (i.e. Tapajós area of endemism; *sensu* Silva *et al.* 2005) in the Brazilian states of Pará and northern Mato Grosso. Its distribution is thus bounded to the north by the Amazon River, to the east by the Xingu River and to the west by the Tapajós River. The southern limit of the species' range is unclear. The southernmost records come from *terra firme* forest on both banks of the middle Teles Pires River (Zimmer *et al.* 1997) but the species was unrecorded from transitional white sand forest 90 km south of there (Lees *et al.* 2008), a vegetative physiognomy that may mark the species' distributional limit.

Description of holotype.— See color illustration. Alphanumeric color designations determined through direct comparison with Smithe (1975). Plumage fresh and unworn, tail in molt; skull 85% ossified. Forehead, lores, crown and upper neck black covered with buff streaks. Cheeks Dark Brownish Olive (129) heavily covered with buff streaks of varying lengths. Mantle Dark Brownish Olive (129), with conspicuous buff streaks possessing a contrasting black edge, gradually turning thinner and obsolete towards the lower back. Primaries, secondaries, and wing coverts unmarked and Warm Sepia (221A) in color. Tips and inner webs of primaries with a contrasting Fuscous (21) tinge. Rump Warm Sepia. Rectrices essentially concolorous with lower rump. Tail graduated, each rectrix with a stiff shaft, softer at the tips. Upper throat Dark Brownish Olive (129) heavily covered with broad whitish-creamy scaly-shaped spots, which become gradually smaller

Figure 2.
Geographic distribution of specimens, vocalizations, and tissues of *Campylorhamphus procurvoides* taxa analyzed in this study. Asterisks = *C. gyldenstolpei*; circles = *C. p. multostriatus*; crosses = *C. cardosoi*; triangles = *C. p. procurvoides*; squares = *C. p. probatus*; and pentagons = *C. p. sanus*. Type localities for each individual taxon are shown as red symbols. Letters next to a symbol represent material available for that given locality: “P” = photographs only; “S” = skins only; “V” = tape-recordings only; “T” = tissues only; “S,V” = skins and vocalizations only; “S,T” = skins and tissues only; “C” = tape-recordings, skins, and tissues. Dashed lines delimit main lineages recovered by a molecular phylogeny and interpreted as natural populations as follows: A = *multostriatus*, B = *cardosoi*, C = *probatas*, D = *gyldenstolpei*, E = *sanus*, and F = *procurvoides*. The question mark denotes an area between the Branco and Negro rivers where the taxonomic identity of any taxon of *C. procurvoides* is unknown.





towards the lower throat and chest, resulting in a nearly mottled whitish-brownish lower throat and chest. Chest Dark Brownish Olive (129) covered with arrow-shaped Buff (124) streaks with thin but contrasting black edges. Upper belly Cinnamon-Brown (33), with some indistinct thin and rather long buff streaks. Lower belly concolor with upper belly, nearly unstreaked, with only a few indistinct buff streaks. Undertail coverts Cinnamon-Brown (33) with feathers having contrasting whitish shafts. **Soft parts in life:** Iris dark brown with a contrasting yellow-mustard eyering. Maxilla Burnt Orange (116) with a dark brownish wash around the nostrils; mandible Burnt Orange (116) becoming blackish at the tip; tarsi and feet greenish-gray. **Measurements of holotype:** wing 86.9 mm, tail 91.9 mm, tarsometatarsus 18.5 mm, bill length 46.4 mm, bill height 5.6 mm, and bill width at nares 4.9 mm.

Etymology.— We are pleased to name the new species after our colleague José Maria Cardoso da Silva, whose biogeographic studies led to the subdivision of the former Pará center of endemism (*sensu* Cracraft 1985) into the Tapajós and Xingu centers of endemism (Silva *et al.* 1995, 2002, 2005). The new species described herein was formerly lumped with a distantly related taxon, and both were treated under the same subspecies name (*C. p. multostriatus*), and thought to be endemic to the Pará center of endemism. Our studies, on the other hand, showed that they are only distantly related evolutionary units, each endemic to a distinct interfluvium within the former Pará center of endemism, thus supporting Silva's treatment of separating this center of endemism into two: the Tapajós and Xingu centers of endemism (Silva *et al.* 2002, 2005).

REMARKS

Type series.— The allotype of *C. cardosoi* is MPEG 51427, skin, adult male, testes 9×5 mm, no molt; netted in the understory of *terra-firme* forest by a MPEG team led by Jürgen Haffer on 9 December 1993 at Mato Grosso; Alta Floresta, left bank of Teles Pires River, ca. 7 km above the mouth of the Cristalino River; prepared by Dionísio C. Pimentel Neto under field number JH 444. Paratypes of *C. cardosoi* are the following four specimens: MPEG 63454: skin, adult female, ovary 7×4 mm; oviduct straight; collected (netted) in *terra-firme* forest on 7 November 2007 by a MPEG team at Pará; left bank of the Xingu River, Arroz Cru, Igarapé de Maria; prepared by Manoel Santa Brígida under field number BMP 009; tissue sample deposited at MPEG and mitochondrial cytochrome *b* and NADH subunit 2 sequences deposited in GenBank (KC237257 and KC242879, respectively). MPEG 65687: skin, male, apparently immature; testes 2×1 mm; netted by Marcos Pérsio D. Santos and M. Villegas at Pará; Jacareacanga, Floresta Nacional do Crepori, Cocho River, on 1 August 2008; tissue sample deposited at MPEG under field number MPDS 1315; mitochondrial cytochrome *b* and NADH subunit 2 sequences deposited in GenBank (KC237258 and KC242880, respectively). MPEG 69378: skin, adult male, gonads not measured; collected by Marcos Pérsio D. Santos and team at Mato Grosso; Paranaíta, left bank of Paranaíta River, Fazenda Aliança (09°34'S; 56°42'W) on 29 September 2009; tissue sample deposited at MPEG under field number TLP(A) 314; mitochondrial cytochrome *b* and NADH subunit 2 sequences deposited in GenBank (KC237260 and

KC242882, respectively). **Variation in the type series:** No apparent sexual dimorphism exists in plumage. The most noticeable variation in the type series pertains to the overall plumage brightness, with MPEG 51427 and 69378 from northern Mato Grosso having drabber underparts and upperparts than the remaining specimens in the type series from further north in Pará. Apparently, this variation has no seasonal or ontogenetic basis, since the type series includes adult and immature specimens collected between August and December, with the drabber adult Mato Grosso specimens collected in September and December. Thus, unless future studies show a significant genetic subdivision between northern and southern populations of *C. cardosoi*, it is more likely that plumage brightness has an individual basis that could possibly be explained by individual differences in the amount of wear due to individual differences in foraging and roosting, for example. The only apparent immature specimen of the type series (inferred as such based on gonad size data) has a visibly shorter culmen, wing, and tail than the adult specimens, but plumage is essentially undifferentiated.

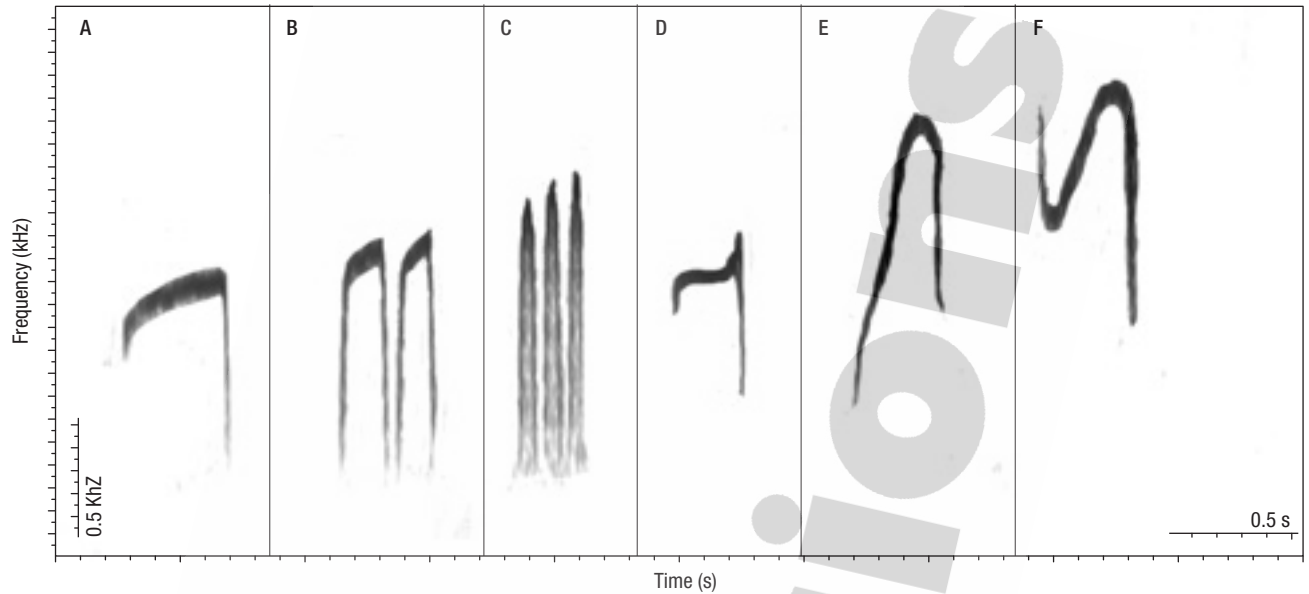
Ecology and behavior.— *Campylorhamphus cardosoi*, like other members of the genus, forages alone or in pairs in the understory and midstory of *terra firme* forest, often along creeks (venturing occasionally into adjacent seasonally flooded forests), and virtually always forages in association with mixed-species flocks and, occasionally, army-ant swarms passing through its territory. It is known to show a strong affinity for *Guadua* sp. bamboo thickets, or vine tangles e.g. around Alta Floresta (Zimmer *et al.* 1997), and is probably largely dependent on structurally complex forest microhabitats within primary forest. Individuals typically forage by hitching along tree trunks, where they glean for arthropods from the surface or underneath the bark, and they may also use their long bills to procure prey items in dead bamboo shoots and tree trunks. Populations may not be temporally stable: periodic disappearances have been reported from well-inventoried sites (e.g. Zimmer *et al.* 1997), which may be associated with periodic large-scale *Guadua* die-offs. Its nest and eggs remain unknown.

Vocalizations.— When compared to loudsongs of other taxa in the polytypic *C. procurvoides*, the loudsong type shared by *cardosoi* and *probatus* is unique in the shape and syntax of the notes. The syntax of the loudsong in *cardosoi* typically begins with a single introductory E note, followed by a series of 12-33 C notes (N = 24, Figs. 4 and 5E), being very close to that of *probatus* (1E followed by 12-29C; N = 16, Figs. 4 and 5F). There is a tendency for the first loudsong note (E type) to be higher in frequency in *probatus* than in *cardosoi*, and the two taxa also tend to differ in traits such as pace and change in pace. Among members of the polytypic *C. procurvoides*, both *cardosoi* and *probatus* also uniquely possess a distinct vocal type that we name the “long-call”, consisting of a long series of C-type notes gradually rising in frequency towards the middle part of the vocalization, then stabilizing for a variable amount of time, before gradually descending (Fig. 6). The number of “long-call” notes is highly variable, but tends to average higher in *probatus* (40; range 28-63; N = 8) than in *cardosoi* (35; range 10-57; N = 12).

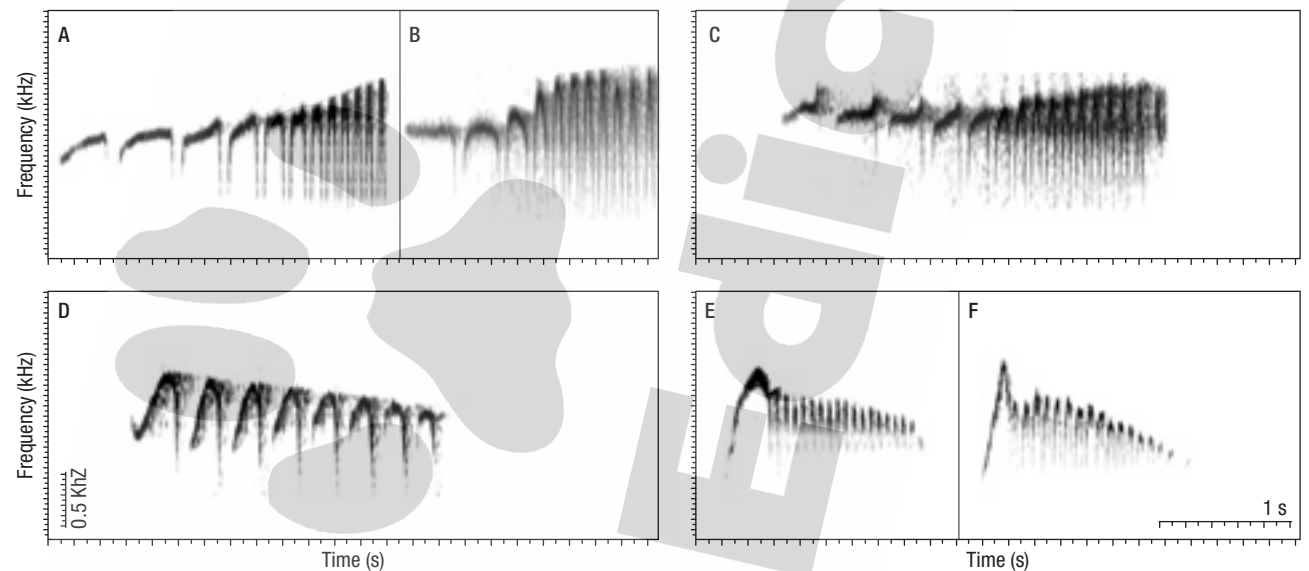
Figure 3. Ventral views of representative specimens illustrating plumage differences between *Campylorhamphus cardosoi* and its sister species *C. probatus*. (A) Males; from left to right: first three *C. probatus* (MPEG 75591, MPEG 69627, MPEG 39677) and second three paratypes of *C. cardosoi* (MPEG 69378, MPEG 51427, MPEG 65687). (B) Females; from left to right: first three *C. probatus* (MPEG 57584, MPEG 64133, MPEG 37033) and second three holotype (MPEG 63875) and paratypes (MPEG 69002 and MPEG 63454) of *C. cardosoi*. Note the characteristic broader pectoral streaks of *C. cardosoi*, which had until now been regarded as belonging to taxon *multostriatus* based on overall appearance and similarities in streak widths, while sister *C. probatus* is closest in plumage to the distantly related *C. procurvoides*. Photos: Alexander C. Lees.

Figure 4.

Representative spectrograms of note-types used to diagnose the loudsongs of taxa currently grouped under the polytypic *Campylorhamphus procurvoides*. Letters refer to the note-type nomenclature used in this study. Notes A, B, and D are restricted to the so called "procurvoides group" (sensu Marantz et al. 2003; which includes the new taxon *gyldenstolpei*, described by Aleixo et al. (2013) in this volume). Note E is uniquely shared by *cardosoi* and *probatas*, whereas F notes are unique to *multostriatus* from the Xingu – Tocantins interfluvium.

**Figure 5.**

Representative spectrograms of loudsongs of taxa currently grouped under the polytypic *Campylorhamphus procurvoides* and the new taxa described in this volume: A) *procurvoides*: Venezuela, Rio Grande, El Palmar (LNS-65702_2c); B) *sanus*: Venezuela, Amazonas, San Carlos (LNS-65706_6); C) *gyldenstolpei*: Brazil, Amazonas, Tupana Lodge (AW3B3_2b); D) *multostriatus*: Brazil, Pará, Salobo Road, Carajás (AW5A2_10); E) *cardosoi*: Brazil, Mato Grosso, Alta Floresta, Rio Cristalino (LNS-106114_24b); and F) *probatas*: Brazil, Amazonas, Borba, eastern bank of the Madeira River (LNS-127698_3b).

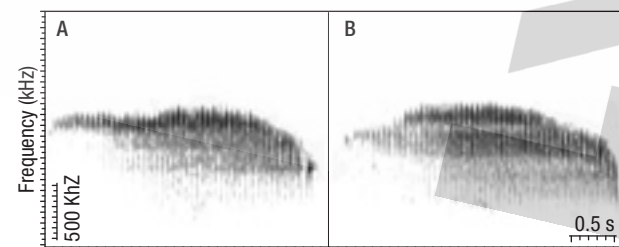


Phylogenetic relationships.— DNA sequence data for the mitochondrial genes cytochrome *b* (*cyt b*, 1048 base pairs) and NADH subunit 2 (ND2, 1041 base pairs) were obtained for 41 individuals (see Table 4 in the SI file for a list of specimens sequenced) of all species in the genus *Campylorhamphus*, including all taxa currently grouped under the polytypic *C. procurvoides* (sensu Marantz et al. 2003; i.e., *multostriatus*, *probatas*, *procurvoides*, and *sanus*), and *C. gyldenstolpei* (Fig. 1). Trees were rooted on *Lepidocolaptes fuscicapillus*, which is one of the sister genera of *Campylorhamphus* (Derryberry et al. 2011). The phylogeny obtained with Bayesian inference strongly supports the idea that *C. procurvoides*, as currently defined, represents a polyphyletic species, with taxa currently classified as subspecies of *procurvoides* found in three separate clades with disparate phylogenetic affinities (Fig. 1). The three highly supported and reciprocally monophyletic clades that group taxa currently classified as subspecies of the polyphyletic *C. procurvoides* are as follows: (1) birds occurring south of the Amazon and east of the Xingu River in the Xingu center of endemism (Silva et al. 2005; corresponding to

the taxon *multostriatus*, whose type locality lies in this area of endemism; Fig. 2); (2) birds found south of the Amazon and west of the Madeira rivers (in the Inambari center of endemism, corresponding to the other new *Campylorhamphus* taxon described by Aleixo et al. (2013) in this volume, i.e. *gyldenstolpei*) and birds distributed north of the Amazon, which correspond to the taxa *sanus* (found in the Napo and Imeri areas of endemism) and *procurvoides* (corresponding to the Guiana area of endemism; Fig. 2); and (3) birds found south of the Amazon and between the Madeira and Xingu rivers, corresponding to the taxa *probatas* (distributed in the Madeira center of endemism; Fig. 2) and *cardosoi*, endemic to the Tapajós area of endemism; Figs. 1 and 2). Since *C. multostriatus* appears to be the sister group to all remaining taxa grouped until now in *C. procurvoides* and *C. trochilirostris*, and the clade *C. probatus* / *cardosoi* was recovered with high statistical support as sister to *C. trochilirostris* (Fig. 1), the *C. procurvoides* complex cannot include *C. multostriatus*, *C. probatus*, and *C. cardosoi* (see also the *C. gyldenstolpei* account). The fact that the Bayesian phylogeny recovered *multostriatus*, *probatas*, and *cardosoi* as reciprocally monophyletic taxa with strong statistical support (Fig. 1), in conjunction with morphological and (in the case of *multostriatus*) vocal diagnoses of these taxa, supports their recognition as valid species level taxa (De Queiroz 2007) as follows: Sneath's Scythebill (*C. multostriatus*; distributed in the northern portion of the Xingu – Tocantins interfluvium; lineage A in Fig. 2); Rondonia Scythebill (*C. probatus*; distributed in the Madeira – Tapajós interfluvium; lineage C in Fig. 2); and Tapajós Scythebill (*C. cardosoi*; distributed in the Tapajós – Xingu interfluvium; lineage B in Fig. 2).

Figure 6.

Representative spectrograms of "long-calls" of *cardosoi* (A; Brazil, Mato Grosso, Cristalino Lodge; KJZ 634B0000_2b) and *probatas* (B; Brazil, Amazonas, Borba, eastern bank of the Madeira River; LNS-127699_3e).



Conservation.— *Campylorhamphus cardosoi* is generally uncommon but it can be locally common in its preferred habitats (e.g., vine tangles near forest creeks). It occurs in several conservation units, e.g. Floresta Nacional do Tapajós (Henriques *et al.* 2003); Parque Estadual do Cristalino and RPPN Cristalino (Zimmer *et al.* 1997); the Reserva Biológica Nascentes da Serra do Cachimbo (Santos *et al.* 2011); Parque Nacional do Jamanxin and Floresta Nacional de Altamira (AA pers. obs. and specimens deposited at MPEG). Nevertheless, it has one of the most restricted global populations of any species in the genus *Campylorhamphus*, being endemic to one of the most heavily anthropogenically affected parts of Amazonia (the Tapajós area of endemism) which has already lost 25% of its primary forest cover (Vale *et al.* 2008). This species is restricted to primary forest habitats and, although it does appear to tolerate light selective-logging, it was not found in burnt primary forest nor secondary forest during an extensive survey around Santarém (A. C. Lees *et al.* unpublished data). Much of this species' distribution is threatened by the expanding agricultural frontier (particularly cattle ranching and soybean plantations) and hydroelectric schemes; these and other infrastructure improvements (such as road-paving) may catalyze forest loss and hence imperil this and many other endemic *terra-firme* species within the interfluvium unless adequate government controls on deforestation are enforced. Based on past and predicted future forest loss, fragmentation and degradation within this species' limited range (cf. Bird *et al.* 2012) this species is likely to qualify for Vulnerable status on the IUCN Red List and the Brazilian National List of Endangered Species, currently under revision.

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