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Nandus prolixus, a new species of leaf fish from northeastern Borneo (Teleostei: Perciformes: Nandidae)

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Abstract

Nandus prolixus **sp. nov.** is described from the Sepilok River drainage in Sabah, northeastern Borneo. This species is distinguished from its only Sundaic southeastern Asian congener, *N. nebulosus*, in having a longer, more produced snout (25.7–30.6% HL vs. 18.5–26.1), more lateral-line scales (33–37 vs. 24–34), more scales below the lateral line (12 vs. 10–11), fewer spines in the dorsal fin (XIV vs. XV–XVI), and fewer pectoral-fin rays (15–16 vs. 17–19). It differs from *N. nandus* (from India) in having fewer lateral-line scales (33–37 vs. 42–55), fewer scales above the lateral line (4–5 vs. 6–7), fewer scales below the lateral line (12 vs. 14–18), more dorsal spines (XIV vs. XII–XIII), and the absence (vs. presence) of a distinct dark spot at the base of the caudal peduncle. It differs from *N. oxyrhynchus* (from mainland southeastern Asia) in having a more slender body (body depth 37.6–40.5% SL vs. 41.3–44.1) and a less steeply sloping predorsal profile.

Key words: *Nandus oxyrhynchus, Nandus nandus, Nandus nebulosus,* Sabah

Introduction

Fishes of the genus *Nandus* Valenciennes in Cuvier & Valenciennes, 1831 are medium-sized freshwater perciforms found in lentic and lotic habitats throughout southern and southeastern Asia and are easily distinguished by their compressed bodies, strongly protrusible jaws, and cryptic coloration. There are three species currently recognized: *Nandus nandus* (Hamilton, 1822) from southern Asia; *Nandus nebulosus* (Gray, 1835) from Sundaic southeastern Asia; and *Nandus oxyrhynchus* Ng, Vidthayanon & Ng 1996 from mainland southeastern Asia.

The freshwater ichthyofauna of northeastern Borneo (largely consisting of the state of

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Sabah, Malaysia) has been recognized for some time as containing a significant number of endemic species (Inger & Chin, 1962). Here we test and find support for the hypothesis that the northeastern Borneo population of *Nandus* (previously identified as *N. nebulosus*) belongs to a distinct species, and describe it below as *Nandus prolixus*, new species.

Materials and methods

Measurements and counts were made on representatives of the new species and compared with those made on the three existing *Nandus* species, following Hubbs & Lagler (2004) except for lateral line scale counts, in which all scales bearing a lateral line canal were counted. Counts and measurements were made on the left side of specimens whenever possible. Measurements were made point to point with dial calipers and data were recorded to 0.1 mm. Measurements of body parts, including head length, are given as proportions of standard length (SL). Subunits of the head are presented as proportions of head length (HL).

Fin rays and scales were counted under a binocular dissecting microscope using transmitted light. Material for this study is deposited in the following institutions: California Academy of Sciences, San Francisco (CAS), Field Museum of Natural History, Chicago (FMNH), Museum of Zoology, University of Michigan, Ann Arbor (UMMZ), and National Museum of Natural History, Washington DC (USNM).

For the Principal Component Analysis (PCA), digital images were taken from the left side of each specimen. Only specimens that were preserved unbent and of adult size (at least 50 mm SL, following Inger & Chin, 1962) were used in this analysis. Landmarks (putatively homologous points on anatomical structures) were chosen in order to best represent the external shape of the body (Fig. 1). *TPSdig* (Rohlf, 1998) was used to digitize the landmarks on the images.

Generalized Least Squares (GLS) Procrustes superimposition was performed to remove size from the data. In the optimal superimposition, the distance minimized is the Procrustes distance, calculated as the square root of the summed squared distances between homologous landmarks (Goodall, 1991; Rohlf and Slice, 1990). This superimposition, and the PCA, was performed in *PCAgen* (Sheets, 2001).

Nandus prolixus sp. nov.
(Fig. 2)

Nandus nebulosus (non Gray) Inger & Chin, 1962: 164, Fig. 85.

Type material. *Holotype*. FMNH 44907, 83.4 mm SL; Borneo: Sabah, Sandakan District, Km 26, North Road, Sandakan; A.M. Anderson, 3 August, 1950.

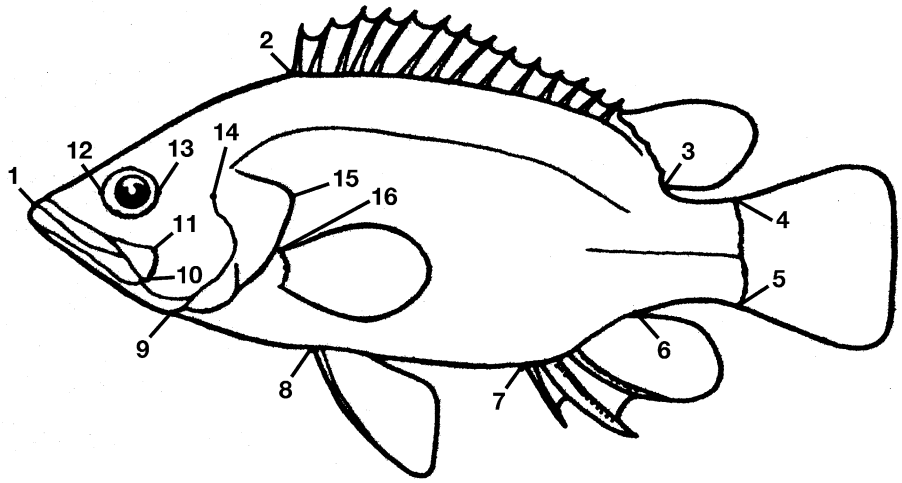

FIGURE 1. Landmarks used for Principal Component Analysis. (1) rostral tip of premaxilla, (2) anterior insertion of dorsal fin, (3) posterior insertion of dorsal fin, (4) dorsal insertion of caudal fin, (5) ventral insertion of caudal fin, (6) posterior insertion of anal fin, (7) anterior insertion of anal fin, (8) dorsal base of pelvic fin, (9) ventral end of opercular membrane, (10) posterior junction of upper and lower jaw, (11) posterordorsal margin of mouth, (12) anterior margin of midline through eye, (13) posterior margin through midline of eye, (14) dorsal end of preopercule, (15) caudal end of opercle, (16) pectoral fin origin. Base figure modified from Nelson (2006).

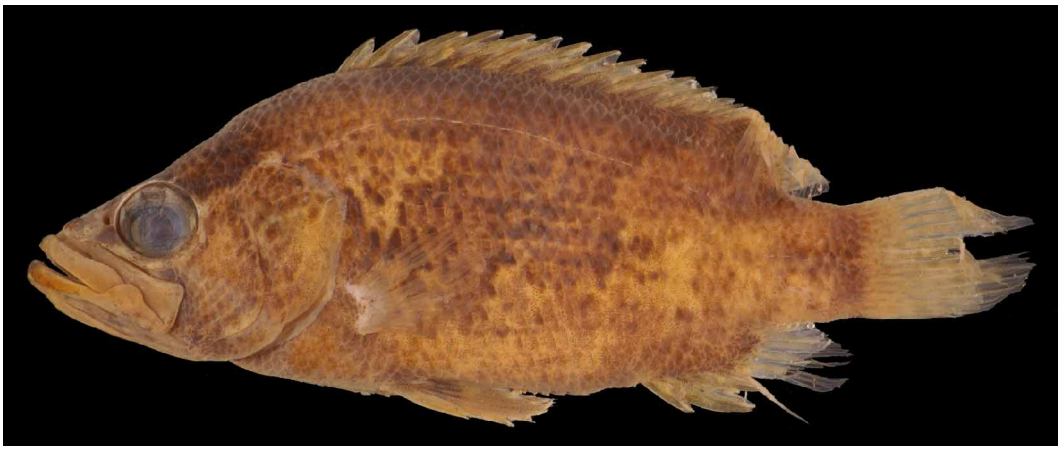

FIGURE 2. *Nandus prolixus*, holotype, FMNH 44907, 83.4 mm SL; Borneo: Sabah, Sandakan District, Km 26, North Road, Sandakan.

Paratypes. FMNH 51964 (6), 47.0–81.3 mm SL; Borneo: Sabah, 26 km NW of Sandakan; R.F. Inger, 8 August, 1950. FMNH 117232 (2), 71.9–76.8 mm SL; data as for holotype.

Diagnosis. *Nandus prolixus* is distinguished from its only Sundaic southeastern Asian congener, *N. nebulosus*, in having a longer, more produced snout (25.7–30.6% HL vs. 18.5–26.1; Fig. 3), more lateral-line scales (33–37 vs. 24–34), more scales below the

lateral line (12 vs. 10–11), fewer spines in the dorsal fin (XIV vs. XV–XVI), and fewer pectoral fin rays (15–16 vs. 17–19). It differs from *N. nandus* (from India) in having fewer lateral-line scales (33–37 vs. 42–55), fewer scales above the lateral line (4–5 vs. 6–7), fewer scales below the lateral line (12 vs. 14–18), a greater number of dorsal spines (XIV vs. XII–XIII), and the absence (vs. presence) of a distinct dark spot at the base of the caudal peduncle. *Nandus prolixus* differs from *N. oxyrhynchus* (from mainland southeastern Asia) in having a more slender body (body depth 37.6–40.5% SL vs. 41.3–44.1) and a less steeply sloping predorsal profile (Fig. 3).

Description. Morphometric data as in Table 1; meristic data as in Table 2. Body compressed, moderately elongate; dorsal profile evenly sloping, with noticeable concavity in interorbital region. Snout profile acute. Mouth moderately large, protrusible. Posterior end of maxilla extending just beyond vertical through middle of orbit. Eye large, diameter about one third of head length, circular. Posterior edge of preopercle with fine serrations. Gill rakers short and club-shaped, bearing sharp apical denticles. Teeth short, unicuspid, closely set and in many irregular rows on both upper and lower jaw.

TABLE 1. Morphometric data for *Nandus prolixus* (n=7).

	Holotype	Range	Mean±SD
In % SL			
Predorsal length	43.4	40.5–44.4	42.4±1.30
Preanal length	76.1	70.6–80.8	75.1±2.90
Prepelvic length	46.4	44.6–50.9	48.0±1.94
Prepectoral length	39.7	37.4–43.6	40.2±1.64
Length of dorsal-fin base	57.4	52.0–58.0	55.6±2.10
Length of anal-fin base	14.6	14.6–18.3	15.9±1.04
Pelvic fin length	21.6	21.1–25.4	23.0±1.42
Pectoral fin length	19.8	18.5–24.2	20.9±2.04
Caudal fin length	25.1	24.4–28.8	26.2±1.47
Body depth	39.8	37.6–40.5	39.0±1.00
Caudal peduncle depth	14	13.0–15.2	13.7±0.78
Caudal peduncle length	13.5	12.4–15.2	13.6±0.81
Head length	39.9	37.1–40.5	39.4±1.04
Head width	19.2	16.3–19.7	18.2±1.27
Head depth	28.5	25.0–30.3	27.1±1.65
In % HL			
Snouth length	26.4	25.7–30.6	27.1±1.52
Interorbital distance	15	15.0–17.5	16.3±0.90
Eye diameter	25.2	23.1–29.7	25.4±2.13

TABLE 2. Meristic data for *Nandus* material examined. Values given are the mode (range in brackets).

		N. nandus	*N. oxyrhynchus*	*N. nebulosus*
N		8	20	12
No. of scales	LL, anterior	33(29–36)	28(26–32)	23(22–25)
	LL, posterior	9,10,12(9–15)	10(6–12)	3,4(3–5)*
	above LL	6(6–7)	6(5–6)	5(5)
	below LL	14(14–18)	13(12–14)	11(10–11)
	circumpeduncular	26(22–29)	25(24–27)	20,22(20–23)
	predorsal	14(12–19)	17(11–20)	15(12–16)
No. of fin rays	dorsal	XIII(XII–XIII), 10(10–12)	XIII(XI–XIV), 10(9–10)	XVI(XV–XVI), 10(10–12)
	pectoral	16(15–16)	17(16–19)	17(17–19)
	pelvic	I,5(I,5)	I,5(I,4–5)	I,5(I,5)
	anal	III(III),7(6–7)	III(III),6(5–7)	III(III),5(5-6)
	caudal	14(14)	14(14)	14(14)
	branchiostegal	6(6)	6(6)	6(6)
	ceratrobranchial	7(7–8)	7,8(6–8)	6(6–7)*
	epibranchial	3(3–4)	3(2–3)	3(3)*
	vertebral centra	23(23–24)	23(22–24), n=17	23(23–24)

continued.

		N. prolixus	*N. prolixus*
N		9	holotype
No. of scales	LL, anterior	28,29(27–30)	30
	LL, posterior	7(5–7)	4
	above LL	5(4–5)	5
	below LL	12(12)	12
	circumpeduncular	23(22–24)	23
	predorsal	15(12–18)	13
No. of fin rays	dorsal	XIV(XIV),10,11(10–12)	XIV,10
	pectoral	15(15–16)	16
	pelvic	I,5(I,5)	I,5
	anal	III(III),6(5–7)	III,6
	caudal	14(14)	14
	branchiostegal	6(6)	6
	ceratrobranchial	6(4–9)	9
	epibranchial	3(3)	3
	vertebral centra	24(23–24)	24

*n=11

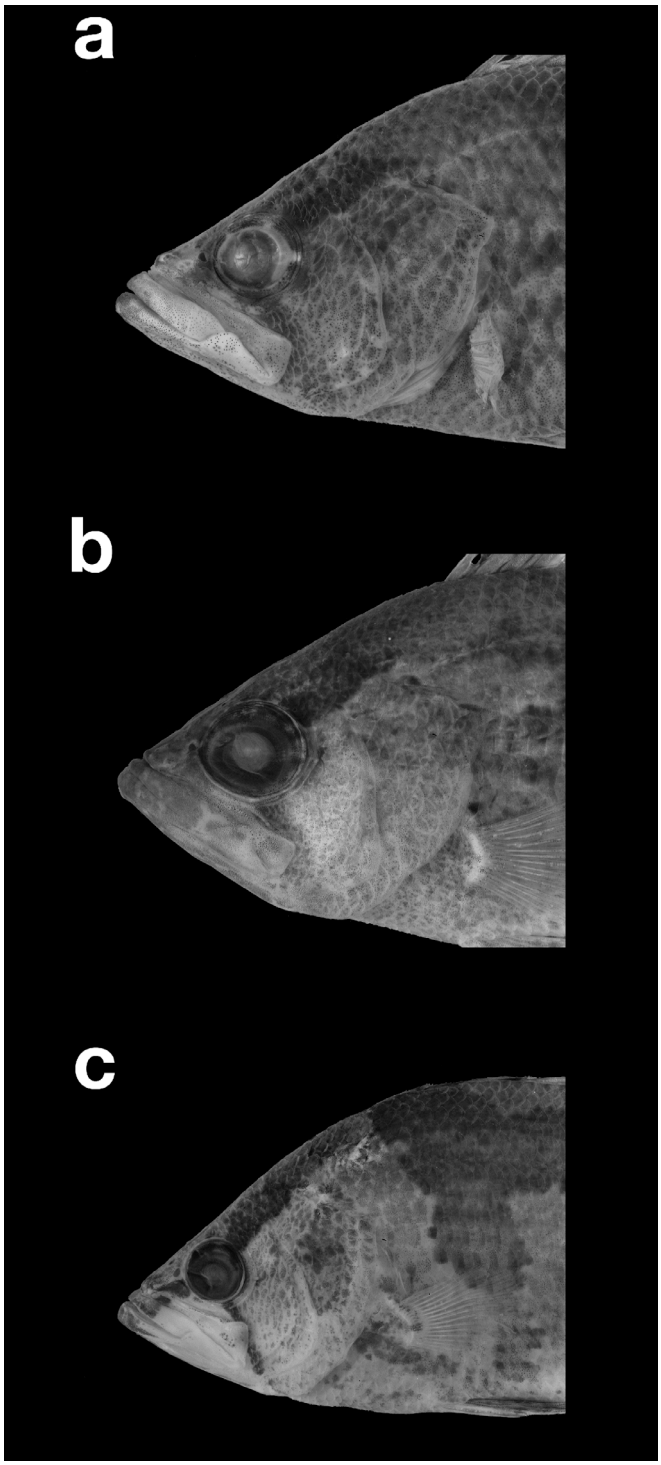

FIGURE 3. Lateral views of heads of: a. *Nandus prolixus*, FMNH 51964, paratype, 81.3 mm SL, b. *N. nebulosus*, CAS 49450, 80.6 mm SL, showing shorter snout in this species and c. *N. oxyrhynchus*, UMMZ 195557, 70.0 mm SL showing more steeply-sloping predorsal profile in this species.

Lateral line divided into two segments, with anterior segment more dorsally located than posterior segment. Upper lateral line beginning at dorsal origin of operculum, rising for distance equivalent to two or three scales rows and reaching greatest height above pectoral fin, thereafter sloping ventrally and ending at vertical through middle of anal-fin base. Lower lateral line beginning at vertical through middle of anal-fin base, vertically centered along length of caudal peduncle, and continuing slightly past end of hypural plate.

Scales ctenoid, imbricate, and nearly uniform in size throughout body. Scales present throughout cheek region, preopercle, opercle, and area around eye, absent along midline of interorbital region. Area around nares and upper lip scaleless. Gular region and ventral region of head immediately adjacent scaleless; sensory pores present in this region. Sheath of scales surrounding proximal regions of dorsal and anal fins, forming ridges along sides of hard rays and attached to soft-fin rays. Caudal fin scaled for about one quarter of length.

Dorsal fin with long base, anterior insertion at vertical through posteriormost extent of opercle and posterior insertion at vertical through base of last anal-fin ray. Length of longest dorsal-fin ray reaching slightly beyond vertical through origin of caudal fin. Pectoral-fin insertion anterior to pelvic-fin insertion; pectoral fin shorter than pelvic fin. Pelvic fins reaching urogenital opening, but not reaching origin of anal fin. Longest ray of anal fin reaching vertical through, and rarely beyond, base of caudal fin.

Coloration. In 70% ethanol: Light brown color on body, with mottled darker areas randomly distributed over body, but never forming distinct vertical bars. Two dark stripes running from eye: one dorsoposteriorly towards dorsal origin of operculum, and second running posteroventrally and passing under posterior edge of maxilla. All fins except pectoral fins with series of small brown spots forming irregular transverse bars across fin membranes.

Distribution. *Nandus prolixus* is known only from the Sepilok River drainage in northeastern Borneo (Fig. 4). Inger & Chin (1962) also recorded *Nandus* from the Kinabatangan River drainage to the south, and we surmise that this record may refer to *N. prolixus*. However, we were unable to examine this material to confirm its identity.

Habitat and biology. Inger & Chin (1962) collected specimens of *N. prolixus* in "very slow moving water of shallow streams in swampy forested areas…ten were collected hiding in dead leaves that covered the bottom." The area where the fish were collected consisted of: "Short vegetation primary dipterocarp forest. Roots of trees but no other living submerged or emergent vascular plants. Banks steep; 1–2 meters high. Bottom mud with dead leaves and other plant fragments." Examination by Inger & Chin (1962) of gut contents of three specimens recovered various insect larvae and a single "unidentifiable fish". These specimens were captured with *Nematabramis everetti* (Cyprinidae), *Leptobarbus melanotaenia* (Cyprinidae), *Systomus sealei* (Cyprinidae), *S. binotatus* (Cyprinidae), *Hampala macrolepidota* (Cyprinidae), *Cyclocheilichthys repasson*

(Cyprinidae), *Osteochilus microcephalus* (Cyprinidae), *Nemacheilus olivaceus* (Balitoridae), *Pangio mariarum* (Cobitidae), *Acantopsis choirorhynchus* (Cobitidae), *Ompok sabanus* (Siluridae), *Hemibagrus nemurus* (Bagridae), *Clarias leiacanthus* (Clariidae), *Dermogenys pusillus* (Hemiramphidae), and *Channa melasoma* (Channidae).

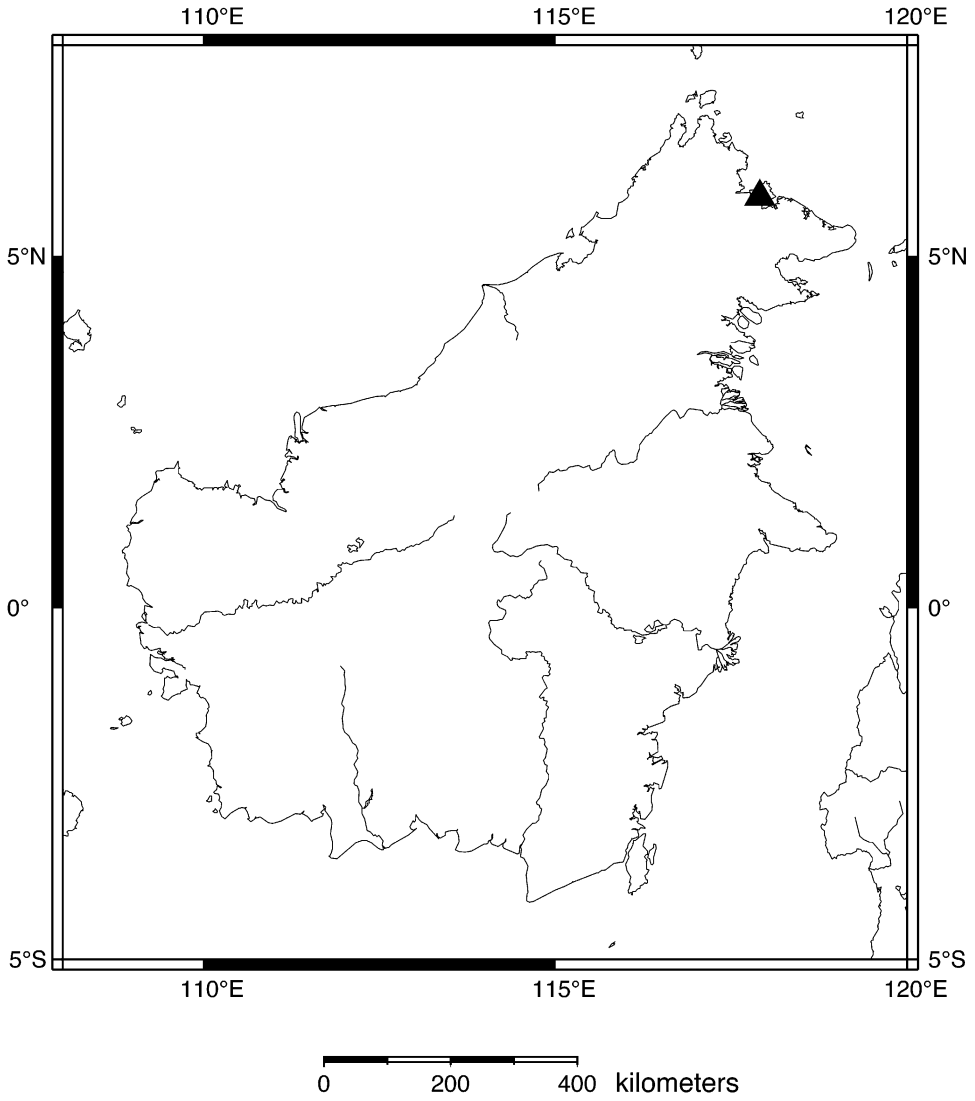

FIGURE 4. Map showing type locality of *Nandus prolixus*.

Etymology. The specific epithet comes from the Latin *prolixus*, meaning stretched out, in reference to the relatively elongate head of this species when compared to its Sundaic congener (*N. nebulosus*). Used as an adjective.

Discussion

The four discrete shape groups recovered in the PCA analysis supports the hypothesis that there are four *Nandus* species. The Principal Component Analysis reveals that each

Nandus species groups separately on a plot of Principal component 1 versus PC2 (Fig. 5). Principal component 1 explains 29% of the variation among specimens; PC2 explains 22%, and PC3 explains 11%. Despite forming a discrete group on PC1 vs. PC2, *Nandus prolixus* overlaps with *N. oxyrhynchus* and *N. nandus* on the PC1 and the PC2 axis. There is no overlap between *Nandus prolixus* and *N. nebulosus* on either PC1 or PC2. *Nandus prolixus* also forms a distinct group separate from the other *Nandus* species on plots of PC2 vs. PC3, and PC1 vs. PC3 (not shown). Principal component 1 explains much of the variation in mouth size, eye size and body length among specimens. Principle component 2 explains much of the variation in body depth, caudal peduncle depth, preopercular height, and the slope of the head among specimens.

Given the proximity of the type locality of *Nandus borneensis* Steindachner, 1901 (considered a junior subjective synonym of *N. nebulosus* by Ng *et al.*, 1996) to that of *N. prolixus* (both are in northern Borneo), a further discussion of the distinctiveness of the two species is necessary. Ng *et al.* (1996) considered *N. borneensis* and *N. nandus* as conspecific because, apart from a slightly lower number of total lateral line scales (24–30 vs. 29–34) in near-topotypic material (from the Baram River) of *N. borneensis*, no other distinct differences could be found between populations ascribed to the two nominal species. In any case, the total number of lateral line scales in *N. prolixus* (33–37) is always higher than that reported in either the original description of *N. borneensis* (27–29), or in near-topotypic material (24–30). We therefore follow Ng *et al.* (1996) in treating *N. borneensis* and *N. nebulosus* as conspecific.

The freshwater ichthyofauna of northeastern Borneo (Sabah) is different from those of neighboring areas on the Sunda Shelf, with a considerable number of species endemic to this region (Inger & Chin, 1962). It is hypothesized that this high level of endemism is most likely the result of vicariant speciation due to the isolation of the river drainages in northeastern Borneo from the other major southeast Asian river drainages (Ng, 2004). This isolation may have occurred sometime during the late Oligocene (ca. 25 million years ago) as a result of the orogenesis of the central Bornean highlands, which formed a regional drainage divide between drainages to the north and east and those to the south and west (Hall, 1998).

Comparative material

Nandus nandus: UMMZ 208417 (1), 60.9 mm SL; Bangladesh: Noakhali, Meghna River at island opposite Hajimara. UMMZ 208525 (1), 66.2 mm SL; Bangladesh: S Dakatia river at Faridganj, SE of Chandpur. UMMZ 208616 (1), 83.0 mm SL; Bangladesh: Comilla, Kunti Choumohani, P.S. Kaska, roadside ditch 27 km S of Brahmabaria. UMMZ 208718 (4), 59.7–76.5 mm SL; Bangladesh: Comilla, Surma River at Lubachara, 51 km E NE of Sylhet at Indian border. UMMZ 244771 (1), 58.2 mm SL; India: West Bengal, market at Barobisha.

Nandus nebulosus: CAS 49450 (7), 9.1–80.6 mm SL; Borneo: Kalimantan Barat, Kapuas River Basin, Sungai Tekam, small forest stream, where it enters right side of

Kapuas mainstream ca. 5–6 km upstream from Sanggau, 0°6'30"N 110°37'E. CAS 49451 (2), 30.5–34.5 mm SL; Borneo: Kalimantan Barat, Kapuas River Basin, Sungai Gentu, near where it falls into Kapuas River, 55 km NE of Sintang, 0°27"N 111°49'E. FMNH 16053 (1), 39.5 mm SL; Sumatra: Ogan River. UMMZ 246606 (1), 23.6 mm SL; Cambodia: Kampot, Prek Toek Sap, just above waterfalls; coastal drainage to Gulf of Thailand. USNM 328105 (11), 12.5–46.8 mm SL; Borneo: Brunei, Belait District, Sungai Arang tributary, stream of Ulu Belait, downstream from Sungai Tempine and Sungai Jagit. USNM 328127 (15), 13.7–48.5 mm SL; Borneo: Brunei, Belait, Sungai Bau, tributary stream of Sungai Belait, upstream from Kampung Melilas. USNM 328129 (10), 6.8–53.1 mm SL; Borneo: Brunei, Belait, Sungai Jagit, tributary stream of Sungai Belait, downstream from Kampung Melilas.

Nandus oxyrhynchus: UMMZ 218861 (21), 21.9–72.3 mm SL; Thailand: Khon Kaen, Nam Pong (Ubol Ratana) Reservoir, 2.5 km S of fish landing on E shore. UMMZ 195557 (4), 66.8–72.0 mm SL; Thailand: Sakol Nakorn Fish Market. UMMZ 236920 (6), 55.0–70.7 mm SL; Thailand: Sun Chieng Mai in Kuran Payas.

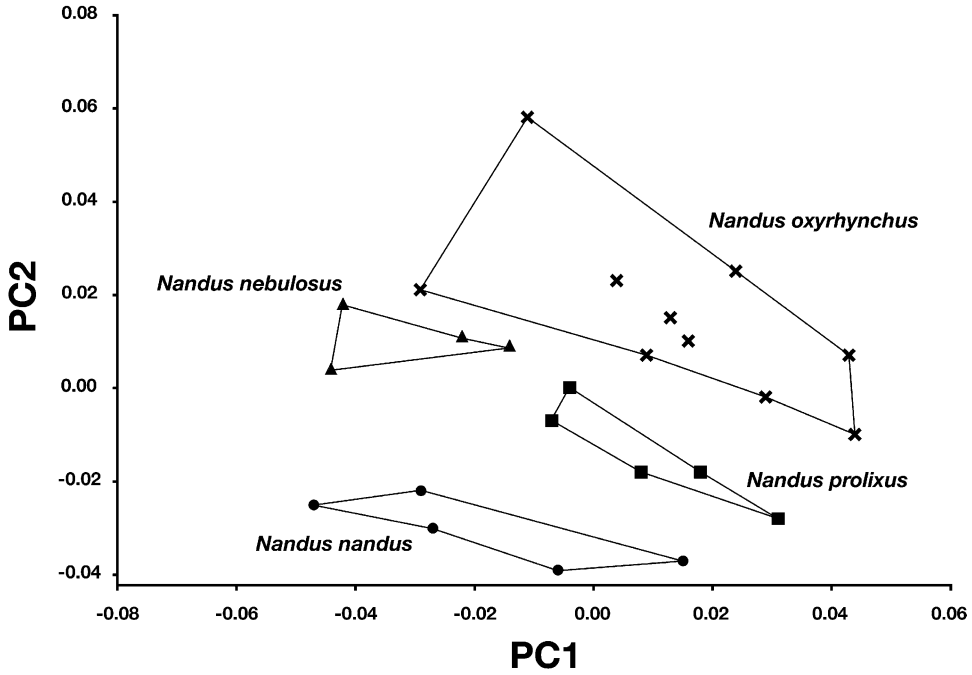

FIGURE 5. Principal Component Analysis, PC1 vs. PC2. *Nandus oxyrhynchus* specimens are represented by squares, *N. nebulosus* by triangles, *N. prolixus* by stars, and *N. nandus* by circles.

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