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Two new species of the genus *Parosphromenus* (Teleostei: Osphronemidae) from Sumatra

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> Abstract

Parosphromenus gunawani spec. nov. (previously known as *P.* spec. "Danau Rasau") and *P. phoenicurus* spec. nov. (previously known as *P*. spec. "Langgam") are described from Sumatra, Indonesia. *Parosphromenus gunawani* is similar to *P. bintan* but differs from it by lacking the prominent broad blue band in the caudal fin of males. It is distinguished from the remaining species of the genus by an unique combination of meristic and colour character states. *Parosphromenus phoenicurus* can be distinguished from all the other species of the genus by the rhombic caudal-fin shape in males (versus round or lanceolate with filaments).

> Key words

Teleostei, Osphronemidae, *Parosphromenus*, taxonomy, new species, Sumatra, Indonesia, biodiversity.

Introduction

Species of the osphronemid genus *Parosphromenus* are small labyrinthfishes (usually <30 mm SL) which inhabit swamps and slow-flowing forest streams in peninsular Thailand (Narathiwat Province), peninsular Malaysia, Sumatra (including the affiliated islands of Bintan and Bangka and the Riau Archipelago), and Borneo (Tweedie, 1952; Kottelat & Ng, 1998; Kottelat & Ng, 2005).

Parosphromenus was established by Bleeker, 1877. The type species, is *P. deissneri* (Bleeker, 1859), and the genus remained monotypic for almost a century following its erection. The next species, *P. paludicola*, was described by Tweedie (1952), followed shortly thereafter by the subspecies *P. deissneri sumatranus* Klausewitz, 1955 (now *P. sumatranus*). Vierke (1979; 1981) described *P. parvulus* in 1979 and *P. filamentosus* in 1981, both from Borneo. Schaller (1985) added *P. nagyi* from the east coast of peninsular Malaysia. The next two taxa, *P. harveyi* (from peninsular Malaysia) and *P. allani* (from Borneo), were created without comparative description in a small note in an aquarium magazine (Brown, 1987). In 1991 Kottelat described three further species from Borneo, namely *P. ornaticauda*, *P. linkei*, and *P. anjunganensis* (see Kottelat, 1991). *Parosphromenus bintan* was introduced by Kottelat & Ng in 1998 along with a redescription of *P. deissneri*. Some years later Kottelat & Ng (2005) described *P. alfredi*, *P. rubrimontis*, and *P. tweediei* from peninsular Malaysia and *P. opallios*, *P. pahuensis*, and *P. quindecim* from Borneo. Kottelat & Ng (2005) also provided an artificial key for all the described species and re-diagnosed *P. allani* and *P. harveyi*.

In their survey of the labyrinthfishes from Sumatra, Tan & Ng (2005) listed *P. bintan* and *P. deissneri* from the islands of Bangka and Biliton, and *P. sumatranus* from Sumatra. This does not, however, complete the picture of the species diversity of the genus *Parosphromenus* from Sumatra. In the last decade Linke (2008) discovered a series of putative new *Parosphromenus* from Sumatra and adjacent islands. Comparison with the available descriptions and redescriptions showed that the material collected from Sumatra included two new species. The objective of

Fig. 1. Holotype (MTD 32798) of *Parosphromenus gunawani* spec. nov. (adult male, 27.7 mm SL).

this paper is, therefore, to provide descriptions and formal scientific names for these two new species of *Parosphromenus* from Sumatra.

Material and methods

Methods for taking measurements follow SCHINDLER & SCHMIDT (2006). Measurements are taken as straight lines (to 0.1 mm accuracy) between two landmarks (see SCHINDLER & SCHMIDT, 2006: Fig. 1) with an electronic digital caliper. Proportions are expressed as percentages of standard length (SL). Counts were made as in WITTE & SCHMIDT (1992) except for the number of predorsal scales which were counted continuously. Numbers in brackets indicate the number of specimens examined.

To ensure the optimally objective comparison of colours, all photos of live specimens were taken under the same conditions. The photos were taken using a camera flash light with a colour temperature of about 5600 Kelvin, without any influence from any other light source.

Water parameters were measured in the field with the following instruments: wtw-Weilheim, type pH 320 with pH electrode SenTix 21 for the hydrogen ion concentration and water temperature, and Sera Handmessgerät (tolerance of 0.2%) for the electrical conductivity.

The material examined is listed under the description of each species. Types are deposited in the Museum für Tierkunde (MTD), Senckenberg Naturhistorische Sammlungen Dresden (Germany). Specimens not indicated as the holotype or paratypes are non-type material. The descriptions follow the general format used by KOTTELAT & NG (2005). In addition to the data obtained from material examined, data from KOTTELAT & NG (1998; 2005), TAN & NG (2005), and other previously published descriptions (see introduction) were also used.

Fig. 2. *Parosphromenus gunawani* spec. nov. (adult male) in the aquarium.

In accordance with previous publications on the taxonomy of the genus *Parosphromenus* (see KOTTELAT & NG, 1998; 2005), the species are diagnosed and described using characteristics of external morphology (meristic and morphometric data) and colour pattern. The species concept used is the diagnostic variant of the 'phylogenetic species concept' as advocated by NIXON & WHEELER (1990). Populations which are differentiated by fixed diagnostic characters, divergent character states, or an unique combination of such characters are treated as representatives of separate species. Putative undescribed species are labelled by 'spec.' and an accessory toponym indicating the collecting site.

Table 1. Morphometric data (as percentages of standard length; SL in mm) of *Parosphromenus gunawani* spec. nov. (n = 7) and *P. phoenicurus* spec. nov. (n = 5). Mean = arithmetic mean; min = lowest value; max = highest value; sd = standard deviation.

	P. gunawani				*P. phoenicurus*			
	min	max	mean	sd	min	max	mean	sd
Standard length	24.0	27.7	25.8	1.12	27.9	29.0	28.5	0.44
Total length	124.2	129.6	126.0	2.15	128.6	133.2	130.9	1.79
Head length	31.1	32.7	31.9	0.52	29.3	32.5	30.8	1.24
Snout length	8.1	9.3	8.5	0.43	8.2	9.0	8.5	0.29
Postorbital length	13.9	15.0	14.5	0.44	12.8	14.8	13.8	0.72
Predorsal length	31.8	37.6	35.5	2.00	35.2	37.5	35.8	0.95
Prepelvic length	33.9	36.6	35.5	0.91	33.1	35.7	34.4	1.25
Preanal length	43.2	49.1	47.1	2.00	45.9	49.0	47.5	1.34
Body depth	30.2	33.1	31.3	1.12	28.3	32.5	29.9	1.63
Caudal-peduncle depth	14.1	15.0	14.5	0.35	12.2	14.8	14.0	1.10
Orbit diameter	10.0	10.6	10.4	0.23	10.0	10.2	10.1	0.13
Interorbital distance	8.5	9.1	8.9	0.26	7.9	8.5	8.3	0.23
Dorsal-fin base length	39.8	42.8	41.4	1.18	40.6	43.0	41.5	1.08
Anal-fin base length	49.6	52.7	51.1	1.19	52.1	53.8	52.6	0.71
Pelvic-fin length	25.5	34.8	30.4	3.14	25.0	42.0	33.4	6.71
Pectoral-fin length	22.0	23.6	22.9	0.57	21.1	22.1	21.6	0.33

Results

Parosphromenus gunawani spec. nov.

Figs. 1–2

Holotype. MTD 32798, male, 27.7 mm SL; Indonesia, Sumatra, province of Jambi, about 45 km north-east of Jambi; approx. 1° 22′ N, 103° 56′ E; *leg*. H. Linke *et al*., June 2008.

Paratypes. MTD 32799–32807, 9 specimens, 24.0–27.5 mm SL; same data as for holotype.

Diagnosis. The species is diagnosed by the following unique combination of character states: 11–13 spines in dorsal fin, 11–12 spines in anal fin, 8–10 segmented rays in anal fin, round caudal fin with narrow bluish vertical band bounded anteriorly by brownish patch and posteriorly by black subdistal band, absence of blotch on posterior part of dorsal fin and reddish-brown bands on anal and dorsal fins.

Description. For general appearance see fig. 1 and 2. Measurements are summarised in table 1. Dorsal origin usually above 3rd or 4th scale of lateral row. Dorsal fin pointed, extending beyond caudal-fin base in males, rounded and shorter in females. Dorsal fin with XI,7 (3), XI,8 (1), XII,6 (2), XII,7 (2), XIII,5 (1) or XIII,6 (1) rays, total 18 (6) or 19 (4). Anal-fin origin below 3rd spine of dorsal fin and 6th or 7th scale of lateral row, fin pointed in males, round in females. Anal fin with XI,10 (3), XII,8 (2), XII,9 (3) or XII,10 (2) rays, total 20 (2), 21 (6) or 22 (2). Caudal fin round in both adult males and females. Pectoral fin rounded, with 11–13 rays. Pelvic fin with spine, 1 simple and 4 branched rays, first branched ray filamentous elongated; pelvic-fin length up to 35 % of SL in adult males. Scales in longitudinal series 27 (3), 28 (5) or 29 (2) and 2 to 3 scales on caudal-fin base; 9 scales in transverse series (counted upward from 4th anal-fin spine).

Preserved coloration. Male (fig. 1): Head and body ground colour yellowish or light brown; dark brown stripe from tip of snout through eye and dorsally part of pectoral-fin base to ventrally half of caudal-fin base, at base of caudal fin appearing as blackish blotch; second stripe from upper margin of eye to dorsally part of caudal-fin base; third stripe from dorsal tip of snout along middle of dorsum to dorsal-fin origin. Ventral part of head with short dark oblique stripe, sometimes interrupted to form dashes or vermiculate markings. Belly dark brown. Dorsal with dark grey proximal band (in posterior part appearing as blackish), dark brown-reddish subdistal band, area between proximal and subdistal bands light grey, margin hyaline. Anal fin similar to dorsal fin without blackish area in posterior part. Caudal fin dark at base to brownish-reddish, subdistal band blackish, narrow light zone between bands. Pectoral fin hyaline. Pelvic fin blackish. Female: Body

as for males but paler, belly brownish. Ventral part of head and throat without dark markings. Dorsal, anal and caudal fins dark grey with hyaline margin and brownish subdistal band. Pectoral fin hyaline. Pelvic fin brownish.

Live coloration. Male (fig. 2): Ground colour of head and body yellowish to light brownish. Belly and ventral part of head dark. Dark stripes on body as described above. Dorsal and anal fins with blackish band at fin base, followed by iridescent light blue band; subdistal band brown-reddish, margin light blue. Caudal fin dark at base to brown, surrounded by light blue margin, subdistal band reddish-brown, followed by narrow light blue margin. Pelvic fin vivid bluish-turquoise, filament darker. Pectoral fin hyaline.

Distribution. The species occurs in the north-east of the province of Jambi on the Indonesian island of Sumatra (fig. 5).

Habitat notes. The type locality of *P. gunawani* is a peat swamp associated with a shallow pond (water depth about 30 to 100 cm). The surface was in parts densely covered with aquatic plants. The water was shadowed by trees and shrubs. At time of the observations (May) the water was dark brown, and because of heavy rainfall it exhibited a slight current. The water had a temperature of about 29 °C, a pH value of 4.1, and an electrical conductivity of 30 µS/cm.

Comparative notes. *Parosphromenus gunawani* spec. nov. is distinguished from *P. parvulus* and *P. ornaticauda* by a higher number of spines in the anal fin (> 10 versus < 10), from *P. paludicola* and *P. quindecim* by a lower number of spines in the dorsal fin (< 14 in *P. gunawani* versus > 16 in *P. paludicola* and usually > 13 in *P. quindecim*). The lack of a conspicuous bright red band or red patches on the dorsal, anal, and caudal fins differentiate it from *P. alfredi*, *P. phoenicurus*, *P. opallios*, and *P. tweediei*. It may distinguished by a round caudal fin from *P. phoenicurus* (rhombic caudal fin) and *P. deissneri*, *P. filamentosus*, and *P. paludicola* (all with a lanceolate caudal fin with filamentous rays). It is distinguished from *P. allani*, *P. opallios*, and *P. sumatranus* by the absence of a black blotch on the posterior part of the dorsal fin (versus dark blotch present) and from *P. linkei*, *P. pahuensis*, and *P. paludicola* by the absence of 1–3 conspicous black dots in the middle of the midlateral stripe (versus present). It differs from *P. anjunganensis*, *P. filamentosus*, *P. linkei*, *P. paludicola*, and *P. sumatranus* by having a pattern of bands on the caudal fin (versus caudal fin plain or with spots). *Parosphromenus bintan*, *P. harveyi*, and *P. nagyi* can be distinguished from the new species by the presence of a broad bluish band on the caudal fin (versus a narrow bluish stripe bounded anteriorly by a brownish zone in *P. gunawani*).

Etymology. The species is named in honour of Gunawan 'Thomas' KASIM, who, together with Horst LINKE and others, collected the type specimens of this taxon. The name is a masculine singular genitive.

Remarks. This species is known as *Parosphromenus* spec. "Danau Rasau" in the aquarium trade and hobby literature (LINKE, 2008).

Parosphromenus phoenicurus spec. nov.

Figs. 3–4

Holotype. MTD 32808, male, 29.0 mm SL; Indonesia, Sumatra, province of Riau, Langgam (about 40 km south-east of Pekanbaru); approx. 0° 11′ N, 101° 38′ E; *leg*. H. LINKE *et al*., Jan. 2008.

Paratypes. MTD 32809–32813, 5 specimens, 17.6–28.8 mm SL; same data as for holotype.

Diagnosis. The species is characterised by 11–13 spines in dorsal fin, 6–7 segmented rays in dorsal fin, 11–13 spines in anal fin, 8–11 segmented rays in anal fin, and is distinguished from other species of genus by rhombic shape of caudal fin in adult males (versus round or lanceolate with filaments).

Description. For general appearance see fig. 3 and 4. Measurements are summarised in table 1. Dorsal origin usually above 3rd or 4th scale of lateral row. Dorsal fin pointed, extending beyond caudal-fin base in males, rounded and shorter in females. Dorsal fin with XI,6 (1), XI,7 (2), XII,7 (2) or XIII,7 (1) rays, total 17 (1), 18 (2), 19 (2), or 20 (1). Anal-fin origin below 3rd spine of dorsal fin and 6th or 7th scale of lateral series, fin pointed in males, round in females. Anal fin with XI,11 (2), XII,9 (2), XIII,8 (1), or XIII,11 (1), total 21 (3), 22 (2), or 24 (1). Caudal fin rhombic in larger males, round in young males and females. Pectoral fin rounded, with 12 or 13 rays. Pelvic fin with spine, 1 simple and 4 branched rays, first branched ray prolonged into filament; pelvic-fin length up to 45% of SL in adult males. Scales in longitudinal series 28 (3), 29 (2), or 30 (1), and 2 to 3 scales on caudal-fin base; 9 or 10 scales in transverse series (counted upward from 4th anal-fin spine).

Preserved coloration. Male (fig. 3): head and body ground colour yellowish brown; a dark brown stripe from tip of snout through eye and dorsally part of pectoral-fin base to ventrally half of caudal-fin base; sec-

Fig. 3. Holotype (MTD 32808) of *Parosphromenus phoenicurus* spec. nov. (adult male, 29.0 mm SL).

Fig. 4. *Parosphromenus phoenicurus* spec. nov. (adult male) in the aquarium.

ond stripe from upper margin of eye to dorsally part of caudal-fin base; third stripe from dorsal tip of snout along middle of dorsum to dorsal-fin origin. Ventral part of head with some short dark oblique dashes and/or vermiculated markings. Belly dark brown or blackish. Dorsal and anal fin with five longitudinal bands or thin lines, from distal to proximal: thin hyaline band, blackish band, thin hyaline line, reddish-brown band, dark band at fin base. Caudal fin with conspicuous almost triangular dark patch, surrounded by broad reddish-brown band, followed by narrow hyaline band, blackish subdistal band, and narrow hyaline margin. Pectoral fin hyaline. Pelvic fin blackish. Female: Body and head as for male but paler, belly brownish. Dorsal, anal, and caudal fins dark grey with hyaline margin and dark brownish subdistal band. Pectoral fin hyaline. Pelvic fin dark brownish.

Live coloration. Male (fig. 4): Ground colour of head and body yellowish to light brownish. Belly and ventral part of head dark. Stripes (as described above) blackish. Dorsal and anal fin with blackish band at fin base, followed by vivid red or crimson band, narrow iridescent light bluish band (more turquoise anteriorly), subdistal black band, and light blue margin. Caudal fin with almost triangular dark black patch, surrounded by vivid red or crimson band, light bluish band, subdistal black band, and light blue margin. Pelvic fin iridescent bluish-turquoise, filament black. Pectoral fin hyaline.

Distribution. Currently known only from the Sungai Kampar river drainage at Langgam (about 40 km south-east of Pekanbaru), province of Riau in the centre of Sumatra, Indonesia (Fig. 5).

Habitat notes. The type locality is a blackwater swamp area near to Kota Kerincikiri, Sumatra Riau. In January 2008 Linke measured the following water parameters: pH 5.25, conductivity 7 µS/cm, and water temperature 26.8 °C.

Comparative notes. *Parosphromenus phoenicurus* spec. nov. is diagnosed by the rhombic caudal fin in adult males. It is further distinguished from *P. parvulus* and *P. onaticauda* by a higher number of spines in the anal fin (> 10 versus < 10), from *P. paludicola* and *P. quindecim* by a lower number of spines in dorsal fin (< 14 in *P. phoenicurus* versus > 16 in *P. paludicola* and usually > 13 in *P. quindecim*). It differs from *P. rubrimontis* in usually having more than 8 segmented rays in the anal fin (versus < 9 in *P. rubrimontis*). It may be differentiated from *P. anjunganensis*, *P. bintan*, *P. deissneri*, *P. filamentosus*, *P. gunawani* spec. nov., *P. harveyi*, *P. linkei*, *P. nagyi*, *P. ornaticauda*,

P. paludicola, *P. parvulus*, and *P. sumatranus* by a bright, conspicuous crimson band in the dorsal, anal, and caudal fins. It differs from *P. tweediei* by the presence of a light bluish band between subdistal black and bright red bands in the unpaired fins (versus blue band strongly reduced or absent). It is distinguished from *P. allani*, *P. opallios*, and *P. sumatranus* by the absence of a black blotch on the posterior part of the dorsal fin (versus dark blotch present), and from *P. linkei*, *P. pahuensis*, and *P. paludicola* by the absence of 1–3 conspicuous black blotches in the middle of the midlateral stripe (versus presence of such blotches).

Etymology. The species name (a noun in apposition) is derived from the Greek words *phoinix* (crimson) and *oura* (tail), and is an allusion to the colour pattern of the caudal fin.

Remarks. The species was introduced in the aquarium literature as *Parosphromenus* spec. "Langgam" by LINKE (2008).

Fig. 5. Island of Sumatra, showing collecting sites for *P. phoenicurus* spec. nov. (yellow dot) and *P. gunawani* spec. nov. (red dot).

Discussion

The species treated here are similar to the type species of the genus, *Parosphromenus deissneri* (as far as is known endemic to the island of Bangka), in general appearance and meristic data (cf. KOTTELAT & NG, 1998; 2005). Thus, the inclusion of the two new species in the genus *Parosphromenus* is beyond dispute. During phylogenetic analysis of the labyrinthfishes (Anabantoidei) based on molecular data, *Parosphromenus* was found to be a monophyletic assemblage (RÜBER *et al*., 2006).

There are only a few clear-cut interspecific differences in meristic characters within the genus (KOTTELAT & NG, 2005). The main criteria for species determination are the colour pattern and the caudal-fin shape in males (KOTTELAT & NG, 1998; 2005). The species from Sumatra are morphologically similar and almost indistinguishable in their meristic characters. Hence the taxonomic conclusions presented herein and the differentiation of *Parosphromenus* species from Sumatra are based on the observed caudal-fin shape and colour patterns of males. These characters (colour pattern and caudal-fin shape in males) are assumed to be a major factor in female mate preference in *Betta* and *Parosphromenus* (e.g. SCHMIDT, 1996; WITTE & SCHMIDT, 1992; KOTTELAT & NG, 2005). Sexual selection has been recognised as a possible force that drives speciation and maintains species distinctness (e.g. PANHUIS *et al*., 2001; KOCHER, 2004). There are several cases known within the aplocheiloid killifishes from

Fig. 6. *Parosphromenus bintan* (adult male).

Africa and South America (among others, the species of the genera *Aphyosemion* and *Rivulus*) where closely-related species differ in colour pattern and/or fin shape in males only (HUBER, 1998; COSTA, 2006). Those differences are documented as playing an important role in mate choice (HUBER, 1998). These species of tropical African and Neotropical aplocheiloid killifish share the often bright coloration and size of, and occupy a similar ecological niche to, the species of *Parosphromenus* (pers. obs.; cf. HUBER, 1998; COSTA, 2006). Hence it is valid to suppose that a similar mechanism of speciation to that described for the killifishes also occurs in *Parosphromenus*. Thus colour pattern and fin shape may be regarded as producing a kind of pre-mating reproductive isolation, and hence these characters or character states (used to diagnose the species) not only represent phenotypical differences

but also have biological significance. Fin shape and colour pattern are regarded as reliable diagnostic characters within the genus (Kottelat & Ng, 2005).

Based on the shared colour pattern, *P. phoenicurus* is hypothesised to be closely related to *P. alfredi* and *P. tweediei* (both from the Malayan Peninsula). Males of these three species exhibit bright red colour in the unpaired fins and a reduction in (*P. alfredi*, *P. phoenicurus*) or even lack of (*P. tweediei*) blue colour in the anal and caudal fins. Such a pattern might be seen as a synapomorphic trait of these species, because blue colours are more common in osphronemids and *Parosphromenus* species in particular (Kottelat, 1991; Kottelat & Ng, 1998; 2005). *Parosphromenus phoenicurus* is most similar to *P. alfredi*, but differs as stated in the diagnosis (see above). Furthermore, the ranges of the two species are separated by the Strait of Malacca (*P. phoenicurus* is restricted to Sumatra and *P. alfredi* to eastern Johor, peninsular Malaysia), at present a physical barrier for osphronemid fishes. There are known cases of closely-related species where one is restricted to Sumatra and the other to the Malayan Peninsula (e. g. Tan & Ng, 2005a; 2005b). Therefore it is reasonable to assume that *P. phoenicurus* represents not only a unit that can be diagnosed but also an independently evolving lineage.

Parosphromenus gunawani is similar (and hypothesised to be related) to *P. bintan*, a species known from Palembang (Sumatra), Bintan, and Bangka, an island adjacent to Sumatra. The two species share a round caudal-fin shape in males and the bluish (instead of bright red) band (more narrow and less prominent in *P. gunawani* than in *P. bintan*) in the unpaired fins. *Parosphromenus gunawani* differs in the characters listed in the diagnosis and comparative notes (see Fig. 2 and Fig. 6 for comparison of live colour pattern in adult males). Thus *P. gunawani* represents an independent species-group taxon in accordance with the principle of the phylogenetic species concept.

Only *P. sumatranus* (from Jambi and Sumatra Selatan) and *P. bintan* (from Palembang) have previously been recorded from Sumatra (Kottelat & Ng, 1998; Tan & Ng, 2005b). *Parosphromenus sumatranus* is distinguished from the other species from Sumatra by possessing a conspicuous black spot on the posterior part of the dorsal-fin base (Tan & Ng, 2005b).

In conclusion, the following four species are now recognised from Sumatra: *P. bintan*, *P. gunawani*, *P. phoenicurus*, and *P. sumatranus*. This, however, does not paint the complete picture of the species diversity of *Parosphromenus* from Sumatra. We are aware of forms which may deserve taxonomic treatment as separate species. Some are well-known both in the aquarium trade and the hobbyist literature (Linke, 2008). Lack of sufficient material has prevented their inclusion in the present work, and (for the time being, at least) a definitive decision as to whether they represent further new species or populations of those already described.

Dramatic ecological changes are taking place in South-East Asia as a result of deforestation and other environmental destruction (Sodhi *et al*., 2004; Sodhi *et al*., 2010). This geographical region harbours a high number of endemic species but also has the highest annual rates of deforestation and habitat loss in the tropics (Sodhi *et al*., 2010). The human-driven landscape change is expected to cause the extinction of almost the half of the region's biodiversity by 2100 (Sodhi *et al*., 2004). *Parosphromenus* species are adapted to peat swamps, marshes, and forest creeks (Kottelat & Ng, 1998; 2005; Linke, 2008; pers. obs.; see Habitat Notes above). So, the loss of wetland areas and the dramatic increase in deforestation are a serious threat to this kind of fish. Taxonomy may have a positive impact on conservation efforts by recognising particular populations as separate species (Morrison *et al*., 2009). Hence the description of distinct forms (units with fixed diagnostic features) as different species is an important taxonomic act.

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