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‘On *Psilorhynchus sucatio* and *P. nudithoracicus*’, the sequel: Unnecessary and unscientific names lead to rapid synonymization and taxonomic time wasting—A response to Arunachalam *et al*. (2018)

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The Torrent minnows *Psilorhynchus sucatio* (Hamilton, 1822) and *P. nudithoracicus* Tilak & Husain, 1980 are widespread throughout the Ganges-Brahmaputra drainage of India, Bangladesh and Nepal (Conway *et al*., 2013). Like many widespread species, *P. sucatio* and *P. nudithoracicus* exhibit high levels of variation in morphological traits (particularly colour pattern) across their respective ranges and both have been described on more than one occasion by different authors examining material obtained from different parts of their range and/or unaware of earlier works. The distinctive, long-snouted torrent minnow *Psilorhynchus sucatio* was described by Hamilton (1822: 347) based on material from “Northern Bengal” (no types known). David (1953) introduced the name *P. sucatio damodarai* for a “variety” (=subspecies; ICZN, 1999; art. 45.6.4) of *P. sucatio* from the Damodar River (Jharkhand and West Bengal) and Tilak & Husain (1980) described the subspecies *P. sucatio nudithoracicus* based on material from Uttar Pradesh. In 1983, Rainboth described *Psilorhynchus gracilis* based on a smaller, more slender series of *Psilorhynchus* with a shorter snout than *P. sucatio*, collected in the tributaries of the Ganges and Brahmaptura rivers in northern Bangladesh. In 2013, Conway *et al*. argued that the names *P. s. nudithoracicus* and *P. gracilis* referred to the same species, placed the latter in the synonymy of the former, and elevated *P. nudithoracicus* to species status. As part of their redescription of *P. sucatio* and *P. nudithoracicus*, Conway *et al*. (2013) examined large series of specimens representing a range of body sizes (462 specimens of *P. sucatio* [13–67 mm SL] and 97 of *P. nudithoracicus* = [10–68 mm SL]), and encompassing almost the entire range of both species, provided multiple figures illustrating the important anatomical features of both species and, most importantly, provided clear diagnoses.

In a recent paper, Arunachalam, Vijayakumar and Mayden (2018; *FishTaxa*, 2(4): 210–225) described two species of *Psilorhynchus* (*P. platydorsalis* and *P. kuwana*) based on characters that do not distinguish them from *P. sucatio* and *P. nudithoracicus*. In the following paragraphs, I outline why I consider the description of these two species to be unjustified in the hope that this taxonomic fiasco will draw further attention to the larger issue of the rapidly growing enterprise of publishing substandard taxonomic ‘studies’ on South Asian freshwater fishes (Raghavan *et al*., 2014).

Problems with the diagnosis of *Psilorhynchus platydorsalis*

Arunachalam *et al*. (2018) described *Psilorhynchus platydorsalis* based on three specimens collected from a single location (Son River, Koilwar Village, Bhojpur District, Bihar, India). Based on the characters listed in the description of *P. platydorsalis* (Arunachalam *et al*., 2018: 217–218) and based on the gestalt of the holotype (Arunachalam *et al*., 2018; Fig. 1) it is apparent that this newly described species is very similar in external appearance to *P. nudithoracicus* (compare the holotype specimen of *P. platydorsalis* shown in figure 1 of Arunachalam *et al*., 2018 with any specimen of *P. nudithoracicus* illustrated in Conway *et al*., 2013 [figures 15–17, 20]). In the diagnosis of *P. platydorsalis,* Arunachalam *et al*. (2018: 214) list 20 characters, including counts of fin rays and scales and measurements of the fins, body and head, which serve to differentiate the allegedly new species from *P. nudithoracicus*. Critical appraisal (Table 1) of these 20 characters reveals that the differences reported between *P. platydorsalis* and *P. nudithoracicus* are either: (1) negligible (e.g., “distance between dorsal-fin origin and pectoral-fin insertion (28.7–29.3 [in *P. platydorsalis*] vs. 30.6–32.2 %SL [in *P. nudithoracicus*])” a difference of 1.3 % which equates to ~0.5 mm when one considers the size of the specimens or “caudal peduncle [width] (3.1–3.2 [in *P. platydorsalis*] vs. 1.9–2.9 %SL [in *P. nudithoracicus*])” a difference of 0.2 % which equates to less than 0.1 mm when one considers the size of the specimens); (2) ephemeral, and likely to disappear when the actual variation in *P. nudithoracicus* is considered (e.g., pre-anal length, pre-pelvic length,

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pectoral-fin length, pelvic-fin length, post-dorsal length etc; Table 1 in Conway *et al*., 2013 and Table 1 herein); or (3) entirely suspect because the values reported in the diagnosis are either in conflict with information provided elsewhere in the text (e.g., number of "pre-anal scales" listed as 7 for *P. platydorsalis* in diagnosis but "anal scale rows [=pre-anal scales]" listed as "8.5–9" in Table 3 in Arunachalam *et al*., 2018) or unlikely to be obtainable from material in the way it was examined by Arunachalam *et al*. (2018) (e.g., the values reported for the length of the upper or lower jaws, which cannot be observed in preserved specimens due to the thick skin that contributes to the rostral cap, upper lip and lower jaw cushion in *Psilorhynchus*).

This demonstrates that Arunachalam *et al*. (2018) have not provided convincing character evidence that *P. platydorsalis* can be distinguished from *P. nudithoracicus* and therefore *P. platydorsalis* is a junior synonym of *P. nudithoracicus*.

Problems with the diagnosis of *Psilorhynchus kuwana*

Arunachalam *et al*. (2018) described *P. kunawa* based on 16 specimens collected from a single location (Kuwana River, Pathar Village, Devario District, Uttar Pradesh, India). Based on the characters listed in the description of *P. kuwana* (Arunachalam *et al*., 2018: 218–222) and based on the gestalt of the holotype (Arunachalam *et al*., 2018; Fig. 5) it is apparent that this species is very similar in external appearance to *P. sucatio* (compare the holotype specimen of *P. kuwana* shown in figure 5 of Arunachalam *et al*., 2018 with any specimen of *P. sucatio* illustrated in Conway *et al*., 2013 [figures 3–7]). In the diagnosis of *P. kuwana,* Arunachalam *et al*. (2018: 219) list eight characters (Table 2) that serve to differentiate the allegedly new species from *P. sucatio*. Again, critical reappraisal of these characters (Table 2) reveals the same issues as raised above for *P. platydorsalis*. The diagnosis of *P. kuwana*, however, is especially plagued by "ephemeral" characters, which are no longer valid when the actual variation present within *P. sucatio* is considered. Worryingly, Arunachalam *et al*. (2018) report the upper jaw to be of widely different lengths in *P. kuwana* ("11.3–16.5") and *P. sucatio* ("26.3–30.1%HL") and thus of some use in distinguishing between the two species. Given that (1) the length of the upper jaw is relatively uniform across *Psilorhynchus* (e.g., see Figure 7 in Conway, 2011) and (2) that the upper jaw is not visible externally and cannot be measured accurately using point to point calipers (the method reported by Arunachalam *et al*., 2018) the differences reported in this character between *P. kuwana* and *P. sucatio* by Arunachalam *et al*. (2018) cannot be explained or credited.

Arunachalam *et al*. (2018) have failed to provide convincing character evidence that *P. kuwana* is distinguishable from *P. sucatio* and therefore *P. kuwana* is a junior synonym of *P. sucatio*.

Ignoring Available Names and Other Problems

There are no data to support a scenario in which *P. sucatio* and *P. nudithoracicus* (as defined by Conway *et al*., 2013) might represent a complex comprised of multiple, similar-looking (i.e., cryptic) species with discrete geographic ranges. Thus, there is no justification to split these well-defined species. If such data did become available to support such a scenario, then the next step should be to assess whether names that are currently in the synonymy of *P. sucatio* or *P. nudithoracicus* should, or should not, be applied to such populations. Unfortunately, this important and standard step was not implemented by Arunachalam *et al*. (2018), who make no mention of the species epithet *gracilis* (available from Rainboth [1983] and currently in the synonymy of *P. nudithoracicus* [Conway *et al*., 2013]) or *damodarai* (available from David [1953] and currently in the synonymy of *P. sucatio* [Talwar & Jhingran, 1991]), which should have been considered as potential names for the forms they described as species. Remarkably, the type locality for *P. s. damodarai* (12 miles below the confluence of the Barakar and Damodar River; David, 1953) is included (though not identified) in the area of the map of Arunachalam *et al*. (2018: fig. 3).

Another clear problem with Arunachalam *et al*. (2018) is the seemingly high precision reported for the measurements that they have obtained "point to point with digital calipers" from the material that they examined. For example, one of the smallest measurements reported by these authors is the length of the mandible (lower jaw) of *P. platydorsalis* in their Table 2, which is reported as 6.87 (range 6.83–6.92) % of the head length, which equates to ~0.5 mm. Of course, it would be possible to obtain a measurement of 0.5 mm using digital calipers but extremely difficult to repeatedly obtain the same measurement from soft and fleshy structures, which would be susceptible to drying and distortion once removed from preservative. The two-decimal point values declared for the majority of the measurements reported by Arunachalam *et al*. (2018) suggests a level of precision that is unlikely to be attained, and certainly not repeatable, using the methods reported.

TABLE 1. Reassessment of characters reported to distinguish *Psilorhynchus platydorsalis* from *P. nudithoracicus* in Arunachalam *et al.* (2018) in comparison to information available from Conway *et al.* (2013) or derived subsequent to that study but based on the same material (***). Values in bold indicate those which can not be repeated based either on information available in Arunachalam *et al.* (2018) or examination of material of *P. nudithoracicus*.

Character	*P. platydorsalis*	*P. nudithoracicus* (Arunachalam *et al.*, 2018)	*P. nudithoracicus* (Conway *et al.*, 2013/present study***)	Notes
Pectoral fin rays	v,9	iv,10	v-iv.10–12	Number of unbranched rays overlap when variation across range of *P. nudithoracicus* is considered. The tiny branched/unbranched inner pectoral-fin rays are difficult to count in *Psilorhynchus* without consulting cleared and stained material (which was not attempted by Arunachalam *et al*., 2018).
"Pre-anal scales" (=Anal-scale rows?)	7	**6**	8–10	Value reported for *P. nudithoracicus* by Arunachalam *et al.* (2018) suspiciously low based on range reported in Conway *et al.* (2013). Mismatch between diagnosis and information elsewhere in Arunachalam *et al.* (2018): "more pre-anal scales (7 vs. 6)" listed in diagnosis as a difference between *P. platydorsalis* and *P. nudithoracicus* but the count "pre-anal scales" does not appear in Table 3. This count is interpreted to be equivalent to the count "Anal scale rows" in Table 3 for which a range of "8.5-9" is provided for *P. platydorsalis*, which overlaps with the range of pre-anal scale rows present in *P. nudithoracicus*
Pre-anal length	79.8–83.1 % SL	74–78.5 % SL	75.8–81.6 % SL	Characters overlap when variation across range of *P. nudithoracicus* is considered
Pre-pelvic length	53.2–53.8 % SL	45.7–49.5 % SL	47.1–52.4 % SL	Minor difference when variation across range of *P. nudithoracicus* is considered
Caudal-fin length	21.2–22.8 % SL	**29.9–34.5 % SL**	19.0–22.0 % SL***	Range of values reported for *P. nudithoracicus* could not be verified (a range of 19.0–22.0 % SL obtained by present author based on rexamination of material listed in Conway *et al.*, 2013; ranges overlap).
Pectoral-fin length	19.0–20.5 % SL	23.8–25.4 % SL	17.9–25.2 % SL	Characters overlap when variation across range of *P. nudithoracicus* is considered
Pelvic-fin length	16.7–17.6 % SL	19.5–20.3 % SL	16.0–20.1 % SL	Characters overlap when variation across range of *P. nudithoracicus* is considered
Pelvic axillary scale length	2.7–3.5 % SL	4.2–5.7 % SL	-	Pelvic axillary scale length exhibits high interspecific variation (Conway, pers. obs.) and is unlikely to be useful for diagnosis between similar looking and closely related species
Dorsal-fin origin to pectoral-fin insertion	28.7–29.3 % SL	30.6–32.2 % SL	-	Minor difference reported; unlikely to be useful for diagnosis between similar looking and closely related species

... ...continued on the next page

TABLE 1. (Continued)

Dorsal-fin origin (insertion?) to base of caudal fin	38.7–40.6 % SL	41.1–45.1 % SL	-	Minor difference reported; unlikely to be useful for diagnosis between similar looking and closely related species. Mismatch between diagnosis and information elsewhere in Arunachalam *et al.* (2018): "shorter length from dorsal-fin origin to base of caudal fin (38.7-40.6 vs. 41.1-45.1 %SL)" listed in diagnosis but measurement is not listed in Table 1. Values reported instead match those listed for "Dorsal-fin insertion to caudal fin base" in Table 1 ("38.79-40.62") suggesting an error in the diagnosis. This measurement is not explained in the materials and methods of Arunachalam *et al.* (2018) nor by Hubbs & Lagler (1964) but is unlikely to represent the distance between the dorsal-fin origin and the base of the caudal fin because this distance is referred to as "Post-dorsal length" by Arunachalam *et al*. (2018).
Post-dorsal length	51.5–54.6 % SL	**36.9–41.6 % SL**	52.0–54.0 % SL***	Range of values reported for *P. nudithoracicus* could not be verified (a range of 52.0–54.0 % SL obtained by present author based on rexamination of material listed in Conway *et al.*, 2013; ranges overlap).
Caudal-peduncle width	3.1–3.2 % SL	1.9–2.9 % SL	1.1–3.3 % SL	Characters overlap when variation across range of *P. nudithoracicus* is considered
Upper jaw length	11.7–11.8 % HL	29.3–34.3 % HL	-	Measurement is suspect; measuring the length of the upper jaw would be difficult (if not impossible) due to the thick skin contributing to the rostral cap and thick skin surrounding the jaws in *Psilorhynchus*
Internasal width	24.9–29.7 % HL	32.1–34.5 % HL	27.8–31.8 % HL***	Characters overlap when variation across range of *P. nudithoracicus* is considered
Width of gape	20.9–21.4 % HL	24.6–29.3 % HL	17.9–28.6 % HL	Characters overlap when variation across range of *P. nudithoracicus* is considered
Mandible to isthmus distance	51.9–52.4 % HL	46.2–49.5 % HL	-	Measurement not explained by Arunachalam *et al*., 2018 or Hubbs & Lagler (1964)
Head depth at nostril	33.2–33.5 % HL	**24.2–26.2 % HL**	34.7–37.5 % HL***	Range of values reported for *P. nudithoracicus* could not be verified (a range of 34.7–37.5 % HL obtained by present author based on reexamination of material listed in Conway *et al.*, 2013; only a minor difference exists between ranges when actual variation across range of *P. nudithoracicus* is considered).
Head depth at pupil	44.7–46.3 % HL	53.1–61.9 % HL	36.7–57.7 % HL	Characters overlap when variation across range of *P. nudithoracicus* is considered
Head depth at occiput	52.5–55.5 % HL	**37.5–39.1 % HL**	54.0–65.0 % HL***	Range of values reported for *P. nudithoracicus* could not be verified (a range of 54.0–65.0 % HL obtained by present author based on reexamination of material listed in Conway *et al*., 2013; ranges overlap)
Mandible length	6.83–6.9% HL	18.1–21.9% HL	-	Measurement is suspect; measuring the length of the lower jaw would be difficult due to the thick skin surrounding the jaws in *Psilorhynchus*; values reported by Arunachalam *et al.* (2018) would suggest that the lower jaw is 2 or 3 times longer in *P. nudithoracicus* than in *P. platydorsalis* which is unlikely to be the case (e.g., see figure 7 in Conway, 2011).

TABLE 2. Reassessment of characters reported to distinguish *Psilorhynchus kuwana* from *P. sucatio* in Arunachalam *et al.* (2018) in comparison to information available from Conway *et al.* (2013) or derived subsequent to that study but based on the same material (***). Values in bold indicate those which can not be repeated based either on information available in Arunachalam *et al.* (2018) or examination of material of *P. sucatio*.

Character	*P. kuwana*	*P. sucatio* (Arunachalam *et al.*, 2018)	*P.sucatio* (Conway *et al.*, 2013/present study***)	Notes
Branched (?) caudal-fin rays	8+8	9+9	7-9+6-8 (actual number of branched caudal-fin rays)	Though the term "branched" is used in the diagnosis it is unclear whether Arunachalam *et al.* (2018) are referring only to branched caudal-fin rays or principal caudal-fin rays (which would include branched+unbranched) based on conflicting information presented in the diagnosis and Table 2 (which lists caudal-fin rays [presumably principal] as 8+8 for *P. kunawa* and 9+9 for *P. sucatio*, which would make the number of branched caudal-fin rays 7+7 and 8+8 respectively); characters overlap when variation across range of *P. sucatio* is considered
Scale rows between anus and anal fin	9–10	10–11	9–12	Characters overlap when variation across range of *P. sucatio* is considered
Pre-pectoral length	21.6–24.3 % SL	16.6–20.2 % SL	19.7–25.8 % SL	Characters overlap when variation across range of *P. sucatio* is considered
Post-dorsal length	54.2–58.7 % SL	**40.6-46.2 % SL**	56.0–58.0 % SL***	Range of values reported for *P. sucatio* could not be verified (a range of 56.0-58.0 % SL obtained by present author based on reexamination of material listed in Conway *et al.*, 2013; ranges overlap)
Upper jaw length	11.3–16.5 % HL	26.3–30.1 % HL	-	Measurement is suspect; measuring the length of the upper jaw would be difficult (if not impossible) due to the thick skin contributing to the rostral cap and thick skin surrounding the jaws in *Psilorhynchus*
Interorbital width	31–36.4 % HL	41.5–45 % HL	32.0–51.4 % HL	Characters overlap when variation across range of *P. sucatio* is considered
Internasal width	39.7–42.9 % HL	**32.6–34.9 % HL**	41.0–42.0 % HL***	Range of values reported for *P. sucatio* could not be verified (a range of 41.0–42.0 % SL obtained by present author based on reexamination of material listed in Conway *et al.*, 2013; ranges overlap)
Mandible length	9.6–14.7 % HL	16.3–18.4 % HL	-	Measurement is suspect; measuring the length of the lower jaw would be difficult due to the thick skin surrounding the jaws in *Psilorhynchus*

In addition to the issues raised above, the text of Arunachalam *et al*. (2018) is riddled with diverse errors that call into question the reliability of their work. For example, the first sentence of the introduction describes the Psilorhynchidae as "recently recognized" and attributed to Conway & Mayden (2007) and Nelson *et al*. (2016) when it was actually first recognized by Hora (1926). The brief materials and methods (pg. 211) makes reference to numbered "landmarks" in Table 2 ("Morphometric characters from landmarks 8, 17-31, 33-34 and 36-37 (Table 2) were additional truss measurements") but there are no such numbers in their table, the standard length of *P. platydorsalis* is listed as "38.39" mm SL in the section "Holotype:" on pg. 211 but then again as "38.79" mm SL in Table 2, and the size range of the paratype series of *P. kuwana* listed in the section "Paratypes:" on pg. 218 is 45.2–62.6 mm SL but is listed as "46.2-.57.6 [sic]" mm SL in Table 2. These types of minor errors should have been identified during the review process (if indeed there was such a process) and corrected prior to publication. The presence of these errors in the final published version of the manuscript combined with the numerous taxonomic shortcomings (outlined above) that it contains raises questions about the peer-review process that this manuscript has undergone.

Unfortunately, I am not the first to raise concern over the publication of substandard taxonomic studies on Indian freshwater fishes (see Raghavan *et al*., 2014); nor am I the first researcher that has had to invest time to rectify the suspect nomenclatural acts proposed in such publications (for another example see Ali *et al*., 2014). The 2012 amendment to the International Code of Zoological Nomenclatural (ICZN, 2012; Zhang, 2012) has made it much easier for substandard taxonomic works (complete with nomenclatural acts) to be published in newly-established online journals that, in most cases, do not appear to have passed through a critical peer-review or apparently, underwent no review at all (Raghavan *et al*., 2014). Unfortunately, the nomenclatural acts in these substandard taxonomic 'studies' nevertheless have significance and the proposed names will have to be treated as available and valid by the broader scientific community, at least initially. Arunachalam *et al*. (2018: 223) also explain that their study was "initiated, intended, and completed as part of a collaborative international initiative to develop infrastructure in the taxonomy and systematics of Cypriniformes [sic]." It is unclear (at least to the present author) how substandard taxonomic works that introduce new names with serious scientific shortcomings can contribute to the development of anything other than nomenclatural chaos (and certainly not infrastructure) in the taxonomy of cypriniform fishes.

In conclusion, Arunachalam *et al*. (2018) have disregarded information or names made available to them in preceding taxonomic studies (David, 1953; Rainboth, 1983; Conway *et al*., 2013) and utilize a "clutch at straws" or "science mimicry" approach to species diagnosis, which relies on minutiae and potentially even some story-telling to differentiate the "species" which they intended to describe as new. Rather than test a hypothesis through robust scientific method, these authors have merely made new names available, leaving it to later workers to clean up the mess. This is a substandard and unscientific approach to taxonomy that can only lead to problems for *bona fide* taxonomists by causing unnecessary and unwelcome distractions. In other branches of vertebrate zoology (e.g., herpetology) the work of Arunachalam *et al*. (2018) would likely be considered "unscientific taxonomy" or even "taxonomic vandalism" (Kaiser *et al*., 2013). Kaiser *et al*. (2013) offered clear recommendations for dealing with unscientific taxonomic studies and the products of such studies in herpetology, including: (1) "text in which unscientific taxon names originate should only be cited in the scientific literature when a new taxon is being proposed to overwrite the unscientific name [sic]"; and (2) "where it is necessary to cite a text in which an unscientific name originated, authors should not use the unscientific name itself [sic]". In addition to adopting these guidelines, those working to correct the products of unscientific taxonomic study of South Asian fishes are also encouraged to cite unscientific studies only in the body of their works and not in the Literature Cited or References section. This would work to remove citations of unscientific publications from the mainstream scientific literature and would prevent unscientific studies from receiving citations and other metrics. This will thus act as a deterrent both to the authors that practice unscientific taxonomy and to the journals that publish their work.

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