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Short Note

Name changes and additions to the southern African freshwater fish fauna

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Changes made to the scientific names of southern African freshwater fishes since 2001 are explained and discussed. Adjustments to the phylogeny and classification of the fauna are outlined. Recent systematic studies on cyprinines are discussed and changes to the genera *Labeobarbus* (expanded concept), *Pseudobarbus* (expanded concept), and *Enteromius* are supported. The introduction of the family names Alestidae and Nothobranchiidae is discussed. Adjustments made to the genera *Nannocharax*, *Micropanchax*, *Tilapia*, *Coptodon* and *Mastacembelus* are explained. Species name changes for *Hepsetus* and *Zaireichthys* are detailed. New species described from the region, or resurrected from synonymy, since 2001 are listed.

Keywords: classification, molecular DNA, nomenclature, phylogenetic relationships, phylogeny, systematics, taxonomy

The formal scientific names given to organisms are important for several reasons, firstly as a reliable and consistent means of communicating information about the organisms. Secondly, as expressions of scientific theory, the names are gateways to repositories of information about the organisms, their relationships and the natural order of life on earth. In 1758 Carolus Linnaeus bequeathed to humanity an enduring binomial system of formally naming plants and animals. In 1859, just one hundred years later, Charles Darwin provided an explanation and understanding of biological evolution that underpins the relationships and gives the logic for the natural order and classification of organisms, as embedded in their formal nomenclature. Taxonomic names are settled only once their specific status and interrelationships with other species are clearly understood. This knowledge frequently shifts as new species are discovered and new insights on relationships are revealed through research and the application of new techniques.

The advent of genetic and molecular DNA analysis has rejuvenated systematic biology in unprecedented ways over the past few decades. Digital technologies and approaches to the assembly and statistical analysis of large data sets have given further impetus to new knowledge and understandings of the interrelationships of organisms. As a consequence there has been a deluge of biodiversity discovery, sometimes in places where exploration was considered long complete or unproductive through the law of diminishing returns. The use of genetic data to identify organisms (DNA barcoding) has been introduced as a solution to deal with this unfolding discovery of new taxa. The need to establish as comprehensive a DNA reference library in the shortest possible time has itself driven the discovery of new biodiversity.

Fishes are relevant to humans in many ways and therefore are frequent subjects of scientific enquiry. In times when names are changing frequently it is useful to provide an update and explanation for interested parties.

This note updates the changes to the names of southern African freshwater fishes since the publication of the keys and species accounts by Skelton (2001). It lists only species that have been formally described or names changed through scientific enquiry. It does not consider species known, but not yet formally described, of which there are many, as indicated in the IUCN list of species from southern Africa (Darwall et al. 2009).

In 2010 Wiley and Johnson (2010) published a teleost classification based on monophyletic groups. In the same year Chen and Mayden (2010) presented a 'phylogenomic perspective on the new era of ichthyology' that presaged a series of high-level studies using genomic analyses to determine the interrelationships of fishes. Near et al. (2012) provided the first multiple nuclear gene analysis across the spectrum of ray-finned fish diversity that adjusted the relationships for several groups where past resolution was uncertain. These include the sister-group relationships of the Ostariophysi with the Clupeomorph fishes, the relationships of salmoniform fishes and the reordering of several lineages leading to the 'superradiation' of spiny-rayed fishes. Near et al. (2013) provided a more detailed account of the 'superradiation' of spiny-rayed fishes or acanthomorphs. Two recent global level classifications of fishes based on these and other studies have been published on line under the 'DeepFin' Tree of Life banner (Betancur-R et al. 2013, 2014).

The classification by Wiley and Johnson (2010) made advances into disentangling the 'spiny-rayed bush' and extracted among others the mastacembelids and Cyprinodontiformes into a Series Smegmamorpharia. In the DeepFin classification (Betancur-R et al. 2014) these arrangements are adjusted again – so that the mastacembelids and

the anabantids are aligned within the series Anabantaria, whereas the Cyprinodontiformes are placed into the Series Ovalentaria, together with the cichlids, following Wainwright et al. (2012).

The name changes to genera and species have been recorded as follows:

1. Cyprinidae: Interrelationships within the large subfamily Cyprininae are complex, due in part to the fact that a high proportion of species (~400 species, >30%) are polyploid, either tetraploid, hexaploid or, in a few extreme cases, even octaploid. The discovery of polyploidy in African species of *Barbus* (Oellermann and Skelton 1990; Golubtsov and Krysanov 1993) attracted the attention of European researchers (Berrebi et al. 1996; Berrebi et al. 2014). Berrebi et al. (1996) proposed an initial division of the traditional genus *Barbus* along ploidy lines. The type species *Barbus barbu*s and related species in Europe are tetraploid, and the genus was restricted to this clade. The African hexaploid species were placed in *Labeobarbus*. However, the African diploid and tetraploid species were recognised as not belonging to this genus, and were designated as '*Barbus*' (Berrebi et al. 2014). The use of inverted commas here indicates uncertain placement, pending generic revision. Further resolution of the relationships of the African species came through molecular studies by Machordom and Doadrio (2001) and Tsigenopoulos et al. (2002, 2010).

   The most detailed high-level molecular analysis of the cyprinine fishes to date (Yang et al. 2015), considered 117 genera and 612 species in four data sets, including five mitochondrial and cloned RAG1 nuclear genes. From the outcome the authors reclassified the Cyprininae into 11 tribes, 3 of them new, with relationships as indicated in Figure 1. African species are included in the tribes Labeonini, Torini and Smiliogastrini and the study confirmed that sub-Saharan African cyprinines are not closely related to European lineages. This therefore has nomenclatural implications for southern African species. Yang et al. (2015) suggested the following changes: (1) Hexaploid species previously included in *Barbus* be allocated to the genus *Labeobarbus*. The bounds of the genus *Labeobarbus* were expanded to include three large groups or lineages, the African labeobarbs, the '*Carasobarbus* lineage' from the Arabian peninsula and the '*Pterocapoeta* lineage' from the Levant and Middle East. (2) The tribe Smiliogastrini includes the minnows of Asia (*Puntius* and allies) as well as the diploid and tetraploid African species formerly included in *Barbus* or '*Barbus*'. The African tetraploid smiliogastrins are monophyletic, and so it was suggested that all these species be included in the genus *Pseudobarbus*, with the additional species tentatively as '*Pseudobarbus*'. The diploid African species formerly known as *Barbus* or '*Barbus*' were placed in the genus *Enteromius*.

   The suggestions by Yang et al. (2015) have already been implemented in various studies (e.g. Skelton 2015; Armbruster et al. 2016; Decru et al. 2016; Vreven et al. 2016) and in the Catalogue of Fishes (Eschmeyer et al. n.d.). However, Schmidt and Bart (2015), in a letter to the editor of 'Molecular Phylogenetics and Evolution', lodged objections and rejected the names suggested for African smiliogastrins. Consequently, certain authors (e.g. Ren and Mayden 2016; Stiassny et al. 2016; Stiassny and Sakharova 2016) have retained the use of "*Barbus*" or '*Barbus*' for African smiliogastrins. This taxonomic uncertainty is undesirable, and the decision to accept the suggestions by Yang et al. (2015) here is discussed further below.

   The letter by Schmidt and Bart (2015) was titled 'Nomenclatural changes should not be based on equivocally supported phylogenies: Reply to Yang et al. 2015'. They accepted that Yang et al. provided 'reasonably well-supported hypotheses of relationships among 11 proposed tribes of cyprinine fishes' (Figure 1). However, they pointed out that support for the proposed relationships within some of the tribes was 'equivocal', i.e. they had less than 50% bootstrap support and that the results actually 'support multiple equally likely interpretations of relationships'. They pointed out that one clade within the smiliogastrins, including the genera *Systomus*, '*Barbus*' (*Enteromius*), *Barboides*, *Pseudobarbus* and *Clypeobarbus*, is well supported, but that 'collapsing branches with less than 50% support' resulted in a polytomy of the various intratribal clades. Therefore, they argued that the results within the smiliogastrine lineage were limited through taxon sampling, and that 'the poor resolution provides no support' for revalidation of the generic name *Enteromius* to accommodate all African diploid '*Barbus*'. They also rejected the suggestion designation by Yang et al. (2015) of '*Pseudobarbus*' for those southern African tetraploid barbs that don't fit into *Pseudobarbus* as it currently stands, and that a more apt treatment was to designate a new genus, or genera, for such species, or to revise *Pseudobarbus* appropriately.

   African barbs are not closely related to *Barbus* (tribe Barbini) (Figure 1), and therefore the retention of the name *Barbus* for the African species is contrary to what a scientific genus name is intended to imply. To continue to use an interim, informal generic name linked to *Barbus*, i.e. '*Barbus*', does not solve the problem – it perpetuates it. Therefore, the African smiliogastrins require a more appropriate genus or genera within the tribe, and *Enteromius* is the earliest available name. Although the interrelationships of African smiliogastrins are relatively poorly understood, progress towards understanding these relationships is already in hand (Ren and Mayden 2016) and a more sustainable nomenclature is anticipated.

   Yang et al. (2015) expand *Pseudobarbus* to include all tetraploid smiliogastrins from southern Africa, but indicated the generic uncertainties involved by placing the additional species in inverted commas as '*Pseudobarbus*'. The genus *Pseudobarbus* was defined by Skelton (1988) on morphological criteria, and included only the flexible dorsal rayed redfin minnows. Subsequently it was discovered that these species are tetraploid, as are certain other Cape cyprinids, including the cluster of 'serrated rayed' species from the region (Naran et al. 2006). The clustering by Yang et al. (2015) of southern African tetraploid cyprinids into

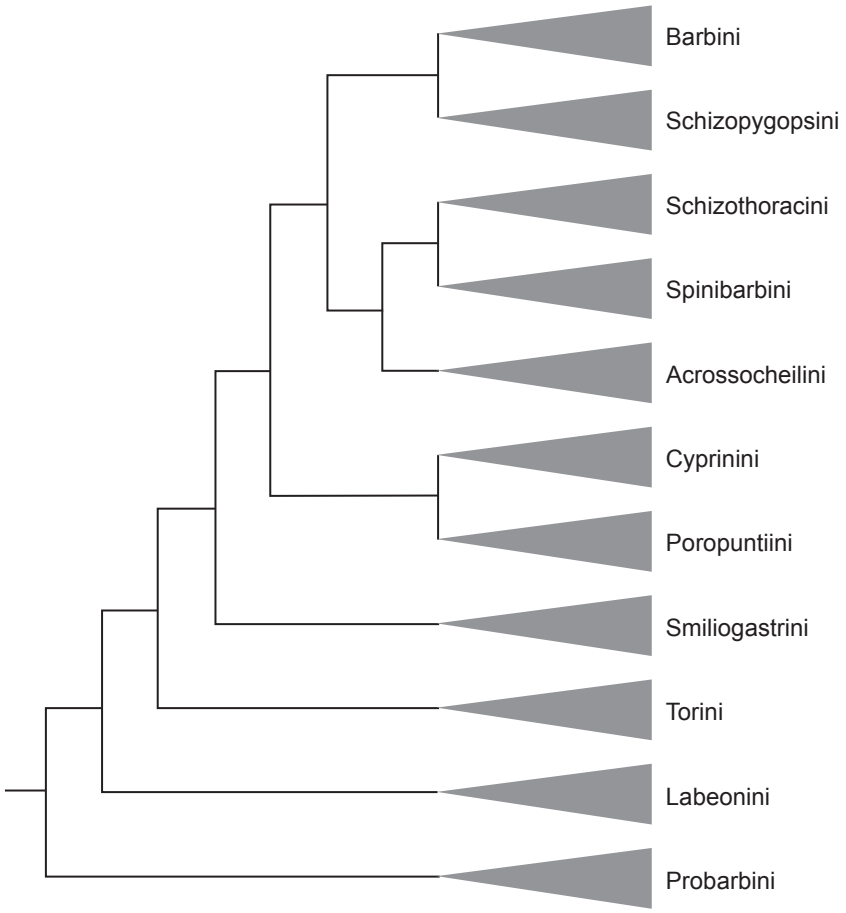

Figure 1: The relationships of cyprinine tribes, after Yang et al. (2015). African species are included in the tribes Labeonini, Torini and Smiliogastrini. The Barbini, including the genus *Barbus*, do not occur in Africa south of the Sahara

a well-supported clade is corroborated by molecular data from Tsigenopoulos et al. (2002, 2010), Berrebi et al. (2014) and unpublished molecular data (Swartz 2005; L da Costa, Lisbon, Portugal, pers. comm.). Within the framework of current African cyprinid taxonomy, an expanded genus *Pseudobarbus* for this clade, as suggested by Yang et al. (2015), is perfectly in order. Further deeper analysis of the lineage may well result in the newly added taxa being assigned to genera in their own right. Such is taxonomy!

Vreven et al. (2016) reviewed in detail the African tribe Torini, which includes the *Labeobarbus* and *Varicorhinus* species. Several significant taxonomic changes to southern African species emerged: (1) All the southern African *Varicorhinus* species were synonymised with *Labeobarbus*, which now includes *Labeobarbus dimidiatus*, *Labeobarbus nelspruitensis*, *Labeobarbus pungweensis* and *Labeobarbus xyrocheilus*. (2) The names of the Clanwilliam yellowfish (previously *Labeobarbus capensis*) and the Cape whitefish or witvis (previously *Barbus andrewi*) were changed to *Labeobarbus seeberi* (Gilchrist & Thompson, 1913), and *'Pseudobarbus' capensis* (Smith, 1841), respectively. These nomenclatural changes were made because the type specimen on which the name *Barbus capensis* was based was re-identified as the Cape whitefish or witvis, and not the Clanwilliam yellowfish, as previously thought. The name '*Pseudobarbus' capensis* (Smith, 1841) for the Cape whitefish or witvis is in tune with the generic alignment of Yang et al. (2015). *Labeobarbus seeberi* (Gilchrist & Thompson, 1913) was resurrected as the earliest available name for the Clanwilliam yellowfish. In a detailed molecular phylogenetic study on the genus *Labeobarbus*, Beshera et al. (2016) confirm the relationships and realignment of *Varicorhinus nelspruitensis* to *Labeobarbus nelspruitensis*.

Barbus bellcrossi was included in the genus *Clypeobarbus* by Conway and Stiassny (2008). Stiassny and Sakharova (2016) provide a revised definition of the genus *Clypeobarbus*.

2. *Hepsetus*: Formerly, *Hepsetus odoe* was considered a monotypic genus distributed from the Senegal River to the upper Zambezi. The lineage has since been divided into six species, of which one, *Hepsetus cuvieri* Castelnau, 1861, occurs in southern Africa (Zengeya et al. 2011).
3. *Nannocharax*: The generic status of *Hemigrammocharax*, distinguished from *Nannocharax* on the dubious difference of an incomplete versus a complete lateral

Table 1: Additions to the list and changes to the names of southern African freshwater fishes since 2001. Species are presented in alphabetical order within systematic categories, according to the classification of Betancur-R (2014)

Former name	New name	New or resurrected species	Reference
		A. New species	
		Hippopotamyrus longilateralis	Kramer and Swartz 2010
		Hippopotamyrus szaboi	Kramer et al. 2004
		Marcusenius altisambesi	Kramer et al. 2007
		Marcusenius caudisquamatus	Maake et al. 2014
		Marcusenius desertus	Kramer et al. 2016
		Marcusenius krameri	Maake et al. 2014
		Marcusenius multisquamatus	Kramer and Wink 2013
		Marcusenius pongolensis	Kramer et al. 2007
		Petrocephalus longianalis	Kramer et al. 2012
		Petrocephalus longicapitis	Kramer et al. 2012
		Petrocephalus magnitrunci	Kramer et al. 2012
		Petrocephalus magnoculis	Kramer et al. 2012
		Petrocephalus okavangoensis	Kramer et al. 2012
		Petrocephalus petersi	Kramer et al. 2012
		Pollimyrus cuandoensis	Kramer et al. 2014
		Pollimyrus marianne	Kramer et al. 2003
		Pseudobarbus skeltoni	Chakona and Swartz 2013
		Pseudobarbus verloreni	Chakona et al. 2014
		Zaireichthys conspicuus	Eccles et al. 2011
Zaireichthys rotundiceps		*Zaireichthys kafuensis*	Eccles et al. 2011
		Zaireichthys kavangoensis	Eccles et al. 2011
Zaireichthys rotundiceps		*Zaireichthys kunenensis*	Eccles et al. 2011
Zaireichthys rotundiceps		*Zaireichthys monomotapia*	Eccles et al. 2011
		Zaireichthys pallidus	Eccles et al. 2011
		Chetia brevicauda	Bills and Weyl 2002
		Nothobranchius boklundi	Valdesalici 2010
		Nothobranchius capriviensis	Watters et al. 2015
		Nothobranchius kadleci	Reichard 2010
Nothobranchius rachovii (in part)		*Nothobranchius krysanovi*	Schidlovskiy et al. 2010
Nothobranchius rachovii (in part)		*Nothobranchius pienaari*	Schidlovskiy et al. 2010
		B. Resurrected species	
Marcusenius cubangoensis Pellegrin, 1936		*Cyphomyrus cubangoensis*	Kramer and van der Bank 2011
Fundulus mkuziensis Fowler, 1934		*Nothobranchius mkuziensis*	Wildekamp 2004
		C. Renamed species	
Barbus bellcrossi	*Clypeobarbus bellcrossi*		Conway and Stiassny 2008
Barbus spp.	*Enteromius* spp.		Yang et al. 2015
Barbus andrewi	'*Pseudobarbus*' *capensis*		Yang et al. 2015; Vreven et al. 2016
Barbus serra	'*Pseudobarbus*' *serra*		Yang et al. 2015
Barbus calidus	'*Pseudobarbus*' *calidus*		Yang et al. 2015
Barbus erubescens	'*Pseudobarbus*' *erubescens*		Yang et al. 2015
Barbus hospes	'*Pseudobarbus*' *hospes*		Yang et al. 2015
Barbus trevelyani	'*Pseudobarbus*' *trevelyani*		Yang *et al.* 2015
Labeobarbus capensis	*Labeobarbus seeberi*		Vreven et al. 2016
Varicorhinus dimidiatus	*Labeobarbus dimidiatus*		Vreven et al. 2016
Varicorhinus nelspruitensis	*Labeobarbus nelspruitensis*		Vreven et al. 2016
Varicorhinus pungweensis	*Labeobarbus pungweensis*		Vreven et al. 2016
Varicorhinus xyrocheilus	*Labeobarbus xyrocheilus*		Vreven et al. 2016
Hemigrammocharax machadoi	*Nannocharax machadoi*		Jerep and Vari 2013
Hemigrammocharax multifasciatus	*Nannocharax multifasciatus*		Jerep and Vari 2013
Hepsetus odoe	*Hepsetus cuvieri*		Zengeya et al. 2011
Aethiomastacembelus spp.	*Mastacembelus* spp.		Vreven 2005
Tilapia rendalli	*Coptodon rendalli*		Dunz and Schliewen 2013
Aplocheilichthys hutereaui	*Micropanchax hutereaui*		Ghedotti 2000
Aplocheilichthys johnstoni	*Micropanchax johnstoni*		Ghedotti 2000
Aplocheilichthys katangae	*Micropanchax katangae*		Ghedotti 2000
Aplocheilichthys myaposae	*Micropanchax myaposae*		Ghedotti 2000
Aplocheilichthys sp.	*Micropanchax* sp.		Ghedotti 2000

line, was reviewed by Jerep and Vari (2013) and synonymised with *Nannocharax.* Two southern African species are affected by the outcome, viz. *Nannocharax machadoi* and *Nannocharax multifasciatus*.

4. Alestidae: The African characiform family Alestidae was regarded as monophyletic by Zanata and Vari (2005) and Calcagnotto et al. (2005) by using morphology and nuclear and mitochondrial gene sequences, respectively. Arroyave and Stiassny (2011) indicated that the family was not strictly monophyletic, because in their analysis two African genera, *Arnoldichthys* and *Lepidarchus*, were nested within Neotropical lineages. They suggested that the two genera be excluded from the family in order to maintain the monophyletic integrity of the Alestidae. These latter authors also found that, *inter alia*, the alestid genera *Brycinus* and *Rhabdalestes* were paraphyletic, but refrained from making taxonomic adjustments to the affected species, on the basis of these decisions being premature in the face of restricted taxon sampling.
5. *Zaireichthys*: Skelton (2001) included two sand catlets of the genus *Zaireichthys* (*Z. rotundiceps* and *Z.* sp.) from southern Africa. Eccles et al. (2011) revised the genus and showed that *Z. rotundiceps* in southern Africa is a set of three species, *Zaireichthys kafuensis*, *Z. kunenensis* and *Z. monomotapa*. The second undescribed species in Skelton (2001) was described as *Z. pallidus* and two additional species new to the region were described as *Z. conspicuus* and *Z. kavangoensis.*
6. Nothobranchiidae: Skelton (2001) used the family Aplocheilidae for the *Nothobranchius* killifishes. The classification of the family was updated by Lazara (2000), and consequently the appropriate family is now Nothobranchiidae Garman, 1895 (van der Laan et al. 2014).
7. *Micropanchax*: The genus names of cyprinodontiform fishes are difficult to determine accurately, because the literature is a mixture of popular, semi-scientific and sound systematic scientific studies. The fishes are widespread, speciose and embrace challenging evolutionary, ecological and biological characteristics. Skelton (2001) used the genus *Aplocheilichthys* for the aplocheilichthyine topminnows. This genus is now restricted to a single species, *Aplocheilichthys spilauchen*, from coastal West Africa, and the other species are placed in the genus *Micropanchax* Myers, 1924, following the phylogenetic analysis and taxonomy of Ghedotti (2000).
8. Cichlidae: Traditionally, the cichlids of East and southern Africa have been aligned in two clusters, the 'tilapiines' and the 'haplochromines', in accordance with morphological characters. Their manner of breeding (substrate spawning vs mouthbrooding) was important in defining the genera within each cluster. The mouthbrooding tilapiines were transferred to the genus *Oreochromis* by Trewavas (1983). Genetic studies have since provided new insight into African cichlid interrelationships, resetting the generic boundaries. Schwarzer et al. (2009) showed that the haplochromines and the tilapiines were completely integrated in a paraphyletic assemblage (conveniently called the haplotilapiines). Dunz and Schliewen (2013), assembling a large mitochondrial and nuclear gene data set from 76 species, untangled the haplotilapiine phylogeny sufficiently to reclassify the assemblage at the tribal and generic level. In southern Africa there are three tribes and genera: Coptodonini with the species *Coptodon rendalli*; Oreochromini with the genus *Oreochromis*; and Tilapiini with the genus *Tilapia*, which now contains only the southern African species *T. sparrmanii*, *T. baloni*, *T. ruweti* and *T. guinasana.*
9. Mastacembelidae: Vreven (2005) found no justification for subdividing the African spiny-eels at generic level, and therefore the genus *Aethiomastacembelus*, as used by Skelton (2001), is discarded in favour of *Mastacembelus*.

A total of 32 species have been described since 2001 (Table 1). Apart from the *Zaireichthys* sand catlets described by Eccles et al. (2011), as mentioned above, the new species are derived from only two families, 16 mormyrids, and six new species of *Nothobranchius* (family Nothobranchiidae). The mormyrid species were discovered by Kramer and his collaborators through studies on electric organ discharges, in combination with morphological and genetic characters.

There is a sustained interest in *Nothobranchius* annual killifish, because of their extremophile life-history traits and attractiveness as aquarium species. One of the newly described species, *Nothobranchius capriviensis* Watters et al. (2015), refers to *Nothobranchius* sp. of Skelton (2001). *Nothobranchius rachovii* has been split into three different species (Schidlovskiy et al. 2010). Wildekamp (2004) resurrected *Nothobranchius mkuziensis* from, and placed *N. kuhntae* in synonymy with *N. othonotus.*

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