Regular paper

Junior synonymy of *Mulloides armatus* and intraspecific comparisons of the yellowstripe goatfish *Mulloidichthys flavolineatus* (Mullidae) using a comprehensive alpha-taxonomy approach

by

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Abstract. – The main objectives of this study were to clarify the taxonomic status of *Mulloides armatus*, listed as *incertae sedis* in current taxonomic literature, and to examine the extent of phenotypic differentiation among subspecies and populations of the yellowstripe goatfish *Mulloidichthys flavolineatus* (Mullidae) in the Indo-Pacific. In total, 53 quantitative morphometric and meristic characters and the visual detectability of the first dorsal-fin spine were gathered from 116 specimens split according to size into juveniles and adults. In addition, fresh colour imagery was studied. The *Mulloides armatus* holotype, which is broken into two pieces, could be identified as *M. flavolineatus* after reconstruction of standard length and detailed comparisons involving specimens from nearby the assumed type locality in the Southwestern (SW) Pacific. Then, the recently described subspecies *M. f. flavicaudus* of the Red Sea and populations of the nominal subspecies *M. f. flavolineatus* from the Indian Ocean and the Pacific, with additional subdivision into four smaller populations (SW Pacific, Wake Atoll, Hawaiian Archipelago and remaining Pacific), were studied by direct comparisons and uni- and multivariate statistical methods. For the first time, marked size differences (i.e. allometry) in morphometric characters in *M. flavolineatus* were documented. *Mulloidichthys f. flavicaudus* overlaps in all characters, singly and in combination, and under consideration of a whitish-grey vs. yellow caudal-fin colour (a diagnostic character used in the original description) with *M. f. flavolineatus*. These results do not support the elevation to species level in a recently published list of Red Sea fish species. Our data suggest a well-differentiated population in agreement with genetic data presented in the original description of *Mulloidichthys f. flavicaudus*. Statistical differences in morphometric and meristic characters were also found between the Indian Ocean and Pacific populations of *M. f. flavolineatus*, though at a much lower degree than between the two subspecies. Interestingly, considerable variation occurs within the Pacific populations with three specimens from Wake Atoll being distinct from nearly all other conspecifics, in having larger heads and eyes and longer barbels and pectoral fins. Therefore, we stress the significance of intraspecific differentiation in populations from remote oceanic island and atoll areas and the need to collect more data. Important is also to use results on intraspecific regional or local differentiation in widely distributed species such as *M. flavolineatus* in fisheries management and conservation efforts at biologically relevant scales, as well as adopting appropriate common names to facilitate the information exchange with local stakeholders.

Résumé. – Synonymie junior de *Mulloides armatus* et comparaisons intraspécifiques du capucin à bande jaune *Mulloidichthys flavolineatus* (Mullidae) en utilisant une approche alpha-taxonomique approfondie.

Les principaux objectifs de cette étude sont de clarifier le statut taxinomique de *Mulloides armatus*, répertorié comme *incertae sedis* dans la littérature taxinomique actuelle, et d'examiner l'étendue de la différenciation phénotypique parmi les sous-espèces et les populations du capucin à bande jaune *Mulloidichthys flavolineatus* (Mullidae) dans l'Indo-Pacifique. Au total, 53 caractères morphométriques et méristiques, ainsi que la détectabilité visuelle de la première épine dorsale ont été recueillis sur 116 spécimens répartis selon leur taille en juvéniles et en adultes. De plus, des images en couleurs sur le vivant ont été étudiées. L'holotype de *Mulloides armatus*, qui est brisé en deux morceaux, a pu être identifié comme correspondant à *M. flavolineatus* après reconstruction de la longueur standard et comparaisons détaillées impliquant des spécimens d'origine proche de la localité type présumée dans le sud-ouest du Pacifique. Ensuite, la sous-espèce récemment décrite de la mer Rouge *M. f. flavicaudus* et les populations de la sous-espèce nominale *M. f. flavolineatus* de l'océan Indien et du Pacifique, avec une subdivision supplémentaire en quatre populations plus petites (Pacifique Sud-Ouest, atoll de Wake, archipel d'Hawaï et reste du Pacifique), ont été étudiées par comparaisons directes et par des méthodes statistiques uni- et

We dedicate this study to the memory of Dr. John E. Randall (1924-2020).

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multivariées. Pour la première fois, des différences marquées liées à la taille (i.e. allométriques) dans les caractères morphométriques de *M. flavolineatus* ont été documentées. *Mulloidichthys f. flavicaudus* et *M. f. flavolineatus* ont des caractères qui, seuls et en combinaison, se superposent même en considérant la couleur de la nageoire caudale (gris blanchâtre *vs* jaune), un caractère de diagnostic pourtant utilisé dans la description originale. Ces résultats ne confirment pas l'élévation au niveau d'espèces comme prôné dans une liste d'espèces de poissons de la mer Rouge récemment publiée. Nos données suggèrent plutôt l'existence de deux populations bien différenciées, en accord avec les données génétiques présentées dans la description originale de *M. f. flavicaudus*. Des différences statistiques dans les caractères morphométriques et méristiques ont également été constatées entre les populations de *M. f. flavolineatus* de l'océan Indien et du Pacifique, bien qu'à un degré bien moindre qu'entre les deux sous-espèces. Il est intéressant de noter qu'il existe des variations considérables au sein des populations du Pacifique, trois spécimens de l'atoll de Wake se distinguant de presque tous les autres congénères conspécifiques par leur tête et leurs yeux plus grands, ainsi que par leurs barbillons et leurs nageoires pectorales plus longs. Par conséquent, nous soulignons l'importance de la différenciation intraspécifique dans les populations des îles et atolls océaniques éloignés et la nécessité de collecter davantage de données. Il est également important d'utiliser les résultats sur la différenciation intraspécifique régionale ou locale chez des espèces largement répandues telles que *M. flavolineatus* dans la gestion des pêches et les efforts de conservation à des échelles biologiquement pertinentes, ainsi que d'adopter des noms communs appropriés pour faciliter l'échange d'informations avec les parties prenantes locales.

INTRODUCTION

The goatfish genus *Mulloidichthys* Whitley, 1929 (Mullidae) consists of seven valid species of which the yellowstripe goatfish *Mulloidichthys flavolineatus* (Lacepède, 1801) is distributed most widely, ranging from the Red Sea and South Africa to Hawaii and the Pitcairn Islands, and from the Ryukyu Islands, Japan, to New South Wales, Australia (Randall, 2007; Uiblein, 2011). In a taxonomic review of *Mulloidichthys* species of the Western Indian Ocean (WIO), Uiblein (2011) provided diagnoses for the genus and the four species occurring in that area, *M. flavolineatus*, *M. pfluegeri* (Steindachner, 1900), *M. vanicolensis* (Valenciennes, 1831) and the then newly described *M. ayliffe* Uiblein, 2011. Each species was compared to all other congenerics, including the Pacific *M. dentatus* (Gill, 1862) and *M. mimicus* Randall & Guézé, 1980, and the Atlantic *M. martinicus* (Cuvier, 1829). According to this study, important diagnostic characters for the genus *Mulloidichthys* are small, conical teeth on both jaws, eight spines in the first dorsal fin, 15-18 pectoral-fin rays, 26-35 total gill rakers, 33-39 lateral-line scales (plus 3-4 on the caudal-fin), and the snout longer than the postorbital distance. *Mulloidichthys flavolineatus* was found to be best distinguished from the other six congenerics by a shallow body and head, a yellow mid-body stripe in fresh specimens, a dark oval or rectangular blotch frequently present below the first dorsal-fin base, and 19-22 gill rakers on the lower limb.

During a research visit to the fish collection of the Queensland Museum, Brisbane (Australia) in 2015, the first author examined the holotype of *Mulloides armatus* De Vis, 1884, a goatfish from Queensland, Australia, that had been listed as "*incertae sedis*" by Hoese and Bray (2006) in their account of the Mullidae of Australia. No detailed type locality is provided, with the original description and catalogue entry simply stating "Queensland". As the specimen was one of the earliest deposited in the Queensland Museum, it is most likely that the specimen was collected along or off the east coast of Queensland between Cape York and Moreton Bay, along with other specimens acquired at that time. Hence, the type region could be specified as "Queensland, Australia, most probably western Coral Sea, SW Pacific". This unique type specimen was encountered in rather bad condition, broken into two pieces and with parts of the body and the first dorsal fin missing. Thus, it was impossible to determine the length of this specimen by direct measurement. In the original description, De Vis (1884) stated "Length, 6 inches", "Teeth of lower jaw minute in a broad band, of upper, small but distinct", and "Colour uniform; fins, immaculate". Furthermore, seven dorsal-fin spines and 40 lateral-line scales are indicated.

After a preliminary inspection of the holotype of *Mulloides armatus*, we hypothesized it to belong to the genus *Mulloidichthys* and most probably to the species *M. flavolineatus*. To properly examine this hypothesis, several challenges had to be faced: (1) the specimen was in poor condition, (2) meristic data given in the original description deviated from the diagnosis of *M. flavolineatus* by Uiblein (2011), (3) no other type or associated reference material was available, and (4) the apparent lack of comparative taxonomic studies involving *M. flavolineatus* specimens from or near the assumed type region of *M. armatus*, i.e. the SW Pacific. For instance, in the WIO review of *Mulloidichthys,* no specimens from the Coral Sea were studied and only a single specimen from New Zealand was included (Uiblein, 2011).

Coinciding with our emerging plans to clarify the status of *Mulloides armatus*, two papers featuring *M. flavolineatus* phylogeography and taxonomy were published (Fernández-Silva *et al.*, 2015, 2016). The latter study appeared especially important for consideration, as it provides the description of a new subspecies, *M. f. flavicaudus* Fernández-Silva & Randall *in* Fernández-Silva *et al.*, 2016, from the Red Sea across to Oman and the Maldives. For the area ranging from Oman to the Maldives, the authors reported overlapping occurrence with the second subspecies *M. f. flavolineatus* which ranges further south in the WIO and eastwards into the Pacific. For the species *M. flavolineatus,* the authors assigned a neotype from Mauritius, assumedly close to the area of the original species description (Fernández-Silva *et al.*, 2016). According to the latter authors, the two subspecies can be best distinguished by genetic data and phenotypically by colour of the caudal fin, the latter being yellow in *M. f. flavicaudus*, while whitish grey or sometimes yellowish in *M. f. flavolineatus*. Several meristic and morphometric characters, all showing considerable overlap, were also listed as being important for the distinction of the two subspecies (Fernández-Silva *et al.*, 2016).

Since the description of *M. f. flavicaudus,* two regional fish-species lists for subareas of its distributional range have been published, one for the Red Sea (Golani and Fricke, 2018) and one for the Socotra Archipelago (Zajonz *et al.*, 2019) that refer to this subspecies rather differently. In the latter, the subspecies is included in the list based on photographic documentation provided in the original subspecies description. In the Red-Sea fish species list, however, the subspecies is elevated to species level without any scientific justification. As communicated by the second author of that list (R. Fricke, pers. comm.), the justification of this elevation was based on practically oriented reasoning, i.e., to use the species category as the lowest taxonomic level for conservation and related management issues.

Here, we adopted a comprehensive alpha-taxonomy approach (e.g. Uiblein *et al.* 2016, 2018, 2019), based on a large set of morphometric and meristic characters, considering also qualitative characters including colour patterns. Specimens from a wider size range than in the WIO review by Uiblein (2011) were examined (65-287 mm SL vs. 125-287 mm SL) to consider size-related changes in body structure, as has been recently done for other goatfish genera (*Parupeneus*: Uiblein *et al.,* 2017b, 2018; *Upeneus*: Uiblein *et al.,* 2016, 2017a, 2019). We clarified the status of *Mulloides armatus* and investigated the degree of intraspecific differentiation of *M. flavolineatus* in more detail than in previous studies. Populations from selected areas were studied comparatively. These areas are the SW Pacific, the Wake Atoll, a remote atoll consisting of three islands in the central Northwestern (NW) Pacific (Lobel and Lobel, 2004; Dijkstra and Raines, 2013) and the Hawaiian archipelago including the Midway Atoll (Eble *et al.*, 2011). Furthermore, large-scale comparisons between the Indian Ocean and Pacific were conducted, involving analyses of ranges and the application of univariate and multivariate methods. An updated taxonomic account for *M. flavolineatus* was prepared and the significance of considering intraspecific variation in goatfish taxonomy at various levels of integration and for practical use in management is briefly discussed.

MATERIALS AND METHODS

The holotype of *Mulloides armatus* and 115 specimens of *M. flavolineatus,* including the neotype of *M. f. flavolineatus* and five paratypes of *M. f. flavicaudus,* were studied. Due to intermittent closure of the Senckenberg Museum, Frankfurt, Germany (SMF), the holotype of *M. f. flavicaudus* could not be studied. To include comparative material from close to the type locality of *M. f. flavicaudus* (Sanganeb Atoll, Sudan), five specimens were collected at the Port Sudan fish market and included in our study. *Mulloidichthys f. flavolineatus* from the following regions (further specifications and sample size in parentheses) were examined: the SW Pacific (western Coral Sea, the assumed type region of *M. armatus*, and southern Indonesia to Solomon Islands and New Zealand; $n = 15$, 12 specimens with intact caudal fin, allowing determination of total length), Wake Island (one of three islands of Wake Atoll, central NW Pacific, northeast of Micronesia; $n = 3$), the Hawaiian Archipelago (main Hawaiian Islands to Midway Atoll, central Pacific; $n = 10$), other areas of the Pacific (Vietnam to Polynesia; $n = 21$), and the Indian Ocean proper (excluding the Maldives and the NW Indian Ocean; $n = 37$). For *M. f. flavicaudus*, 29 specimens from the Red Sea were examined.

Measurements of total length (TL), standard length (SL) and 40 other morphometric characters, expressed in % SL for direct comparisons, and counts of 11 meristic characters were obtained. The minute, first dorsal-fin spine could not be easily detected in all specimens; hence the degree of visual detectability was qualitatively identified by the first author using the categories "well detectable" and "difficult to detect", based on examination with a needle under a dissecting microscope.

As the holotype of *M. armatus* is broken into two pieces (Fig. 1A) and only a size measurement indicated as "Length" is known from the original description, the SL was determined by the following process. Head length was measured, but when expressed in % of the length indicated by De Vis (1884), resulted in a value of less than 24%, which was clearly too small for any known goatfish species. Hence, we concluded that TL was provided instead of SL in the original description. As the next step, SL was plotted against TL for 12 *M. f. flavolineatus* specimens from the SW Pacific (Fig. 2) and the resulting linear regression line connected by a horizontal line at 152 mm TL (i.e. six inches) from the y-axis. Then, from the crossing point of the two lines, a vertical line was inserted and the value for SL read from the x-axis. As a control, the proportional value of SL in % TL obtained for the HT was compared with the corresponding value obtained from the 12 reference specimens, as well as with specimens from *M. f. flavicaudus* and the other populations of *M. flavolineatus*.

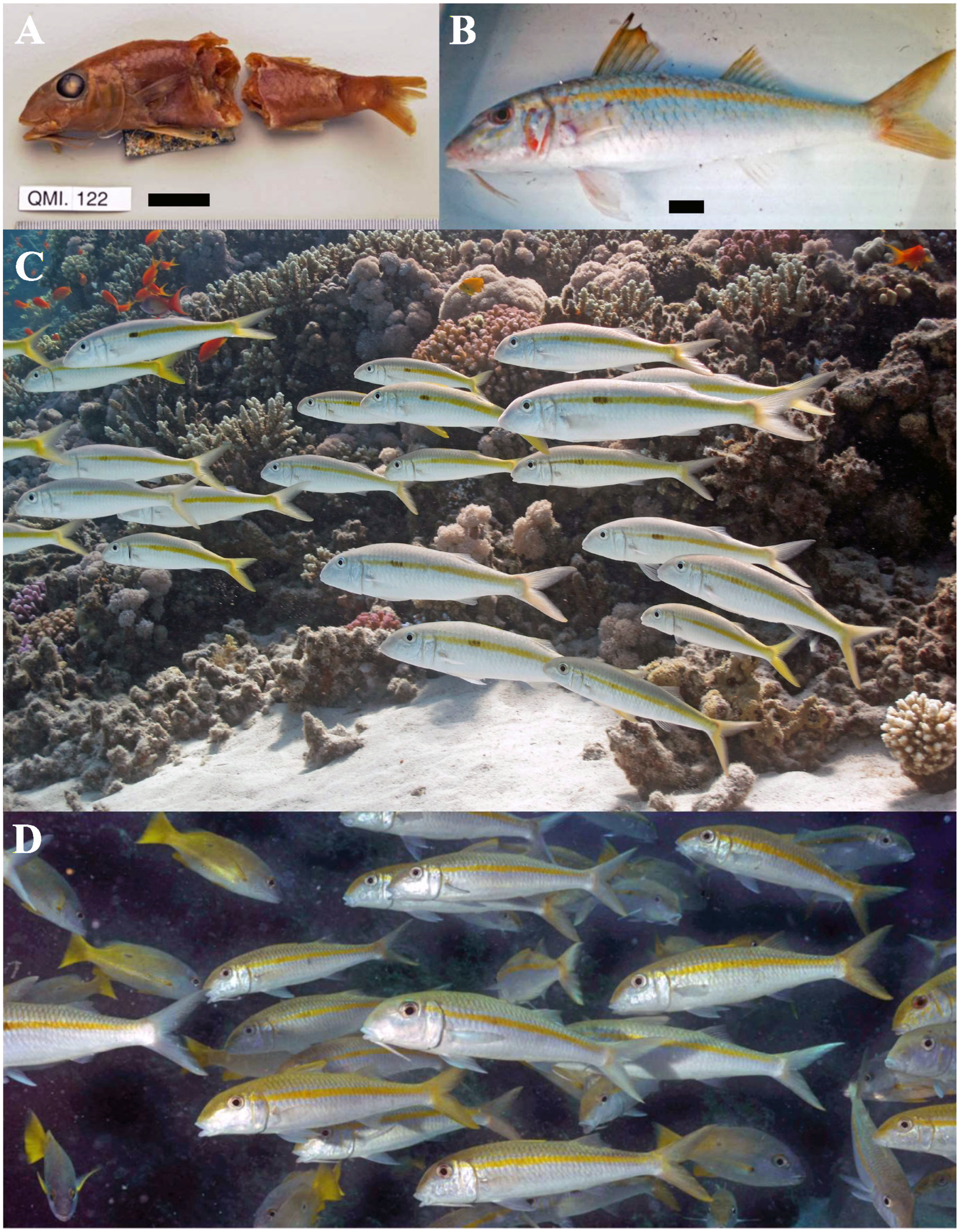

Figure 1. – **A**: HT of *Mulloides armatus*, QM I.122, 118 mm SL, Queensland, E Australia, western SW Pacific (Jeff Johnson); **B**: *M. flavolineatus flavolineatus*, AMS I.20269-007, 253 mm SL, Norfolk Island, E Australia, SW Pacific (Doug Hoese); **C**: Shoal of adult/subadult *M. f. flavicaudus*, Dahab, Egypt, Gulf of Aqaba, Red Sea (Kristina Vackova); **D**: Shoal of adult/subadult *M. f. flavolineatus*, associated with snappers, La Digue and Inner Islands, Seychelles, Indian Ocean proper (Massimiliano Finzi). Scale bars = 2 cm for the respective fish on top.

For the presentation of results, ranges and single values of morphometric characters were rounded to the nearest first decimal for values < 10 and larger values were rounded to the first digit. Means of both morphometric and meristic

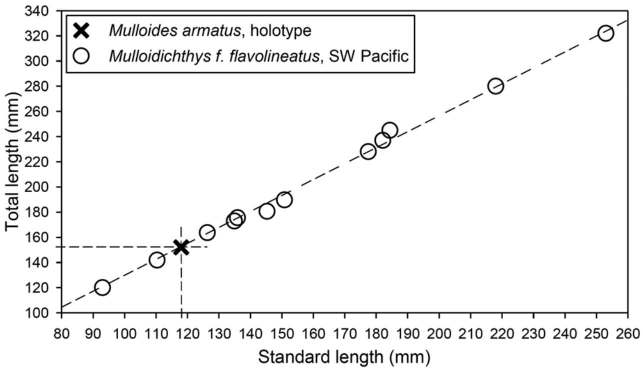

Figure 2. – Standard length against total length in 12 adult/subadult specimens of *Mulloidichthys flavolineatus flavolineatus* from the SW Pacific, with projected placement of the HT of *M. armatus*, allowing approximation of standard length.

characters were rounded to the first decimal value. Several morphometric characters showed allometry and, hence, the data were split into two major size groups, one consisting of adult or subadult specimens ≥ 90 mm SL ("adult fish") and the other of juvenile specimens < 90 mm SL ("juvenile fish"). This size limitation coincides well with data reporting the maximum size for juvenile *M. flavolineatus* (Pothin *et al.*, 2006; Kolasinski *et al.*, 2009).

Univariate quantitative statistical analyses of morphological data were conducted to provide detailed comparative information for populations with larger sample sizes. For this purpose, the morphometric data of adult fish populations from the Pacific and Indian Ocean *M. f. flavolineatus* and *M. f. flavicaudus*, all having sample sizes over 19 (≥ 20), were size-adjusted using the residuals derived from log-log regressions against SL (Uiblein and Winkler, 1994). All regressions were highly correlated and significant ($p < 0.0001$). Then, One-way ANOVA comparisons of populations and subspecies were conducted, using the Scheffe-test for multiple comparisons.

In addition, Principal Components Analysis (PCA; SYSTAT software) was carried out for the size-adjusted morphometric data set to examine the degree to which the above-indicated populations can be differentiated when considering the overall variation among morphometric characters and individuals. This analysis also allows screening of the data set for *a posteriori* detection of similarity and distinction beyond any prior groupings (Uiblein and Winkler, 1994; Uiblein and Gouws, 2014).

Meristic characters did not show any size-dependency and hence these data were pooled for both the diagnosis and quantitative comparisons. As done with morphometric characters (see further above) three populations with large numbers of specimens ($n \geq 20$) were statistically compared using Fisher's exact test for 2 × 2 tables and Chi^2 test for trends for larger tables (one degree of freedom in all cases; GraphPad Prism for Windows, GraphPad Software, La Jolla California USA, www.graphpad.com). The significance level was globally set at $p \leq 0.01$.

Colour is of diagnostic importance only in live or recently deceased (= "fresh") *M. flavicaudus* (Uiblein, 2011). For comparisons of fresh colour patterns among subspecies and populations photographs and video footage available in earlier publications (e.g. Uiblein, 2011; Fernández-Silva *et al.*, 2016) and through online searches were screened with the emphasis on covering as many subareas of the overall distribution as possible, paying attention to caudal-fin colour (yellow or whitish-grey), in particular. Because fresh-colour documentation for juveniles from various areas is still rare and was limited to very few available images only, the comparisons of colour patterns were restricted to adult specimens.

For interspecific comparisons with congeneric species, data published by Uiblein (2011) were used. Institutional abbreviations follow Sabaj (2019; https://asih.org/standard-symbolic-codes/about-symbolic-codes). Other abbreviations are: HT = holotype; NT = neotype; PT = paratype; ST = syntype.

RESULTS

Taxonomic status of *Mulloides armatus* De Vis, 1884

In the holotype of *Mulloides armatus* the snout is clearly longer than the postorbital distance (13 vs. 9.9% SL; see Tab. I). Also, dentition, preserved colour (Fig. 1A), and the 27 total gill rakers and 16 pectoral-fin rays counted for this specimen (Tab. I) agree well with the generic diagnosis of *Mulloidichthys* (Uiblein, 2011). The number of gill rakers on the lower limb ($n = 19$) agrees with the diagnosis of *M. flavolineatus*, but also with other congeners such as *M. pfluegeri* (Uiblein, 2011). Based on the supposed TL of 6 inches (= 152 mm) reported in the original description, the SL of the *M. armatus* HT could be calculated when plotting SL against the TL in 12 SW Pacific specimens of *M. flavolineatus* (Fig. 2) The resulting SL value of 118 mm expressed in % TL (= 78%) closely matches the average values obtained for the reference population (Tab. I) as well as for all studied populations (Tabs I, II), *M. f. flavicaudus* (Tab. II), and adult and juvenile *M. flavolineatus* (overall range 75-81% for adults and 78-80% for juveniles; Tab. III). Of the total 40 morphometric body- and fin-shape characters, 30 characters could be obtained from the HT, expressed in % SL using the determined SL value and subsequently compared (Tab. I). Two important meristic characters, first dorsal-fin spines and the number of lateral-line scales, could not be obtained from the type due to damage.

The holotype of *M. armatus* overlaps with the SW Pacific reference population in morphological and meristic characters except for a minimal deviation in pectoral-fin width

Table I. – Quantitative morphological and meristic characters and one qualitative character for the holotype of *Mulloides armatus* and adults of *M. flavolineatus flavolineatus* of four Pacific populations. * For determination of SL in this specimen see Materials & Methods section.

	Mulloides armatus	*Mulloidichthys flavolineatus flavolineatus*															
		SW Pacific				Wake Atoll				Hawaiian archipelago				Other Pacific			
	HT	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n
Morphometric characters																	
Total length (mm)	152	120	204.7	322	12	268	276.3	286	3	154	209.6	287	7	120	199.0	275	12
SL (mm)	118*	93	165.7	253	14	206	213.3	221	3	119	179.6	287	10	95	156.3	235	15
in % TL																	
SL	78	75	77.8	80	12	77	77.2	77	3	76	78.4	80	7	76	77.7	79	12
in % SL																	
Body depth at first dorsal-fin origin	23	22	23.7	25	14	21	22.0	23	3	22	23.8	26	10	22	23.6	25	15
Body depth at anal-fin origin		19	20.0	21	14	17	18.5	19	3	19	20.4	22	10	18	19.9	21	15
Half body depth at first dorsal fin origin	18	18	19.2	21	14	16	16.9	18	3	17	19.5	21	10	17	19.1	21	15
Half body depth at anal fin origin		13	14.3	15	14	12	12.5	13	3	14	14.9	16	10	13	14.5	16	15
Caudal-peduncle depth	8.9	8.6	9.0	9.6	14	9.1	9.4	9.7	3	8.5	9.2	9.7	10	8.4	9.1	9.5	15
Caudal-peduncle width	4.2	3.6	3.9	4.2	14	3.4	3.6	3.7	3	3.2	4.0	4.6	10	3.0	4.0	4.5	15
Maximum head depth	20	19	20.3	22	14	21	21.4	22	3	19	20.5	22	10	19	20.7	22	15
Head depth through eye	17	16	16.9	18	14	18	18.2	18	3	16	16.4	17	10	16	17.0	18	15
Suborbital depth	10	9.0	10.0	11	14	9.9	11.0	12	3	8.5	9.7	11	10	8.2	9.6	10	15
Interorbital length	8.1	7.6	8.6	9.3	14	8.0	8.2	8.4	3	7.4	8.3	8.8	10	7.8	8.5	9.5	15
Head length	31	28	29.7	31	14	32	32.1	33	3	27	29.0	30	10	28	30.0	32	15
Snout length	13	12	13.5	15	14	14	14.2	15	3	12	13.0	14	10	12	13.0	14	15
Postorbital length	9.9	9.3	10.3	11	14	10	10.4	10	3	9.3	10.0	11	10	9.3	10.1	11	15
Orbit length	7.6	5.6	7.3	8.2	14	7.8	7.9	8.1	3	5.8	6.9	8.3	10	6.5	7.4	8.6	15
Orbit depth	6.7	5.1	6.4	7.2	14	6.8	6.9	7.0	3	5.1	6.0	6.9	10	5.8	6.5	7.7	15
Upper-jaw length	9.6	8.3	9.0	9.8	14	8.9	9.6	10	3	8.7	8.9	9.3	10	8.4	8.9	9.9	15
Lower-jaw length	9.2	8.0	8.6	9.3	14	8.6	9.3	9.7	3	8.3	8.6	8.9	10	7.8	8.6	9.5	15
Snout width	7.4	6.1	7.1	8.4	14	5.6	5.9	6.3	3	5.9	6.7	7.4	10	5.9	6.6	7.7	14
Barbel length	21	19	20.5	23	14	23	23.0	23	3	18	19.0	20	10	18	19.9	22	15
Maximum barbel width	0.6	0.6	0.8	1.0	14	0.7	0.8	0.9	3	0.6	0.7	0.9	10	0.6	0.8	1.1	15
First predorsal length	40	37	40.0	42	14	41	42.2	43	3	38	39.4	41	10	38	39.9	42	15
Second predorsal length		65	66.5	69	14	66	67.1	69	3	65	66.8	68	10	64	66.2	68	15
Interdorsal distance		13	15.0	16	14	14	15.1	16	3	14	15.7	17	10	13	15.2	17	15
Caudal-peduncle length	20	20	22.2	24	14	20	20.9	22	3	21	22.2	24	10	21	22.4	24	15
Preanal length		65	67.4	71	14	64	67.3	71	3	67	67.6	70	10	65	66.8	69	15
Prepelvic length	33	31	33.6	36	14	34	35.9	37	3	31	33.1	35	10	32	33.7	36	15
Prepectoral length	31	30	31.6	33	14	33	34.4	35	3	30	31.4	34	10	30	32.0	34	15
Second dorsal-fin depth		19	20.6	21	14	17	18.8	20	3	19	21.2	22	10	18	20.7	22	15
Pelvic-fin depth	23	22	23.9	25	14	22	22.3	22	3	23	24.3	26	10	22	23.9	26	15
Pectoral-fin depth	16	16	17.4	19	14	16	16.2	16	3	16	17.7	19	10	16	17.6	19	15
Length of first dorsal-fin base		12	14.5	16	14	14	13.6	14	3	13	14.5	16	10	13	14.4	16	15
Length of second dorsal-fin base	13	11	12.4	14	14	11	12.3	13	3	11	12.2	13	10	11	12.0	13	15
Caudal-fin length		29	30.7	32	11	32	32.2	32	3	28	30.0	32	6	29	31.1	33	12
Length of anal-fin base	11	8.6	9.5	11	14	8.5	8.6	8.7	3	8.6	9.7	11	10	8.1	9.4	11	15
Anal-fin height	13	12	13.5	15	14	15	15.1	16	3	13	13.8	15	9	13	14.5	16	13
Pelvic-fin length	21	19	20.8	22	14	20	21.1	22	3	19	20.4	22	10	19	21.2	23	15
Pectoral-fin length	19	18	19.8	21	14	22	22.7	23	3	18	19.8	22	10	19	20.4	22	14
Pectoral-fin width	4.0	4.1	4.5	4.9	13	4.5	4.8	5.1	3	3.9	4.4	5.0	10	4.1	4.5	5.1	15
First dorsal-fin height		19	20.8	22	14	22	23.6	25	3	20	20.4	22	10	19	20.9	23	15
Second dorsal-fin height		13	14.2	16	14	15	15.5	16	3	14	14.3	15	10	13	14.9	16	15

Table I. – Continued.

	Mulloides armatus	*Mulloidichthys flavolineatus flavolineatus*															
		SW Pacific				Wake Atoll				Hawaiian archipelago				Other Pacific			
	HT	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n
Meristic characters																	
Pectoral-fin rays	16	16	16.6	17	14	17	17.0	17	3	17	17.2	18	10	16	16.8	17	15
Rudimentary gill rakers on upper limb	3	1	2.2	4	14	1	2.0	3	3	1	2.1	4	10	0	1.6	3	15
Developed gill rakers on upper limb	5	4	5.6	7	14	6	6.3	7	3	5	6.3	8	10	5	6.5	8	15
Developed gill rakers on lower limb	14	13	15.6	17	14	17	17.7	18	3	15	16.5	18	10	15	16.9	18	15
Rudimentary gill rakers on lower limb	5.0	2.0	4.1	6.0	14	2.0	2.7	3.0	3	2	3.5	5	10	2	3.4	7	15
Total gill rakers on upper limb	8.0	7.0	7.9	9.0	14	8.0	8.3	9.0	3	8	8.4	10	10	7	8.1	9	15
Total gill rakers on lower limb	19	19	19.7	22	14	20	20.3	21	3	19	20.0	21	10	19	20.3	22	15
Total gill rakers	27	26	27.6	30	14	28	28.7	30	3	27	28.4	30	10	27	28.3	31	15
Scales along lateral line		34	35.5	37	13	36.0	36.3	37	3	35	36.1	37	10	35	36.1	38	15
Qualitative character																	
1st dorsal-fin spine detectability (%)			64.3		14		66.7		3		90.0		10		80.0		15

Table II. – Quantitative morphological and meristic characters and one qualitative character for adults of two populations of *Mulloidichthys flavolineatus flavolineatus* and *M. f. flavicaudus*.

	Mulloidichthys flavolineatus flavolineatus								*M. f. flavicaudus*			
	Pacific				Indian Ocean				Red Sea			
	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n
Morphometric characters												
Total length (mm)	120	208.4	322	35	125	204.7	340	26	117	190.4	260	25
SL (mm)	93	167.9	287	43	95	163.6	288	29	91	153.9	253	28
in % TL												
SL	75	78.0	83	35	76	78.3	81	26	77	78.6	81	25
in % SL												
Body depth at first dorsal-fin origin	21	23.5	26	43	22	23.6	26	29	21	22.8	25	28
Body depth at anal-fin origin	17	19.9	22	42	17	19.3	21	29	16	18.8	21	28
Half body depth at first dorsal fin origin	16	19.0	21	43	17	19.2	21	27	16	18.9	21	26
Half body depth at anal fin origin	12	14.4	16	42	13	14.2	16	29	12	13.6	16	27
Caudal-peduncle depth	8.4	9.1	9.7	43	8.0	8.8	9.5	29	7.9	8.4	9.2	28
Caudal-peduncle width	3.0	3.9	4.6	43	2.7	3.8	4.5	29	3.2	4.0	4.5	28
Maximum head depth	19	20.6	22	43	19	20.7	22	29	18	19.9	21	28
Head depth through eye	16	16.9	18	43	15	17.3	19	29	16	16.8	19	28
Suborbital depth	8.2	9.9	12	43	8.0	10.3	12	29	8.9	10.0	11	28
Interorbital length	7.4	8.5	9.5	43	7.7	8.6	9.8	29	7.7	8.4	9.5	28
Head length	27	29.8	33	43	28	30.3	32	29	29	30.1	32	28
Snout length	12	13.2	15	43	12	13.5	16	29	12	13.1	15	28
Postorbital length	9.3	10.1	11.3	43	9.7	10.4	12	29	9.1	10.2	11	28
Orbit length	5.6	7.3	8.6	43	6.3	7.4	9.0	29	6.0	7.4	9.0	28
Orbit depth	5.1	6.4	7.7	43	5.7	6.4	7.6	29	5.3	6.5	8.1	28
Upper-jaw length	8.3	9.0	10.1	43	8.2	9.1	10	29	8.4	9.0	9.7	28
Lower-jaw length	7.8	8.6	9.7	43	7.6	8.6	10	29	7.6	8.6	9.3	28
Snout width	5.6	6.8	8.4	42	5.8	7.1	8.9	29	5.6	6.8	8.0	28
Barbel length	18	20.1	23	43	19	20.7	23	29	19	21.0	23	28
Maximum barbel width	0.6	0.8	1.1	43	0.6	0.8	1.0	29	0.7	0.9	1.1	28
First predorsal length	37	40.0	43	43	37	39.8	43	29	38	39.6	41	28
Second predorsal length	64	66.5	69	42	63	66.6	69	29	64	66.6	69	28

Table II. – Continued.

	Mulloidichthys flavolineatus flavolineatus								*M. f. flavicaudus*			
	Pacific				Indian Ocean				Red Sea			
	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n
Interdorsal distance	13	15.2	17	42	12	14.5	17	29	12	15.1	17	28
Caudal-peduncle length	20	22.1	24	43	19	22.1	24	29	20	21.7	23	28
Preanal length	64	67.2	71	42	64	66.6	71	29	65	67.9	70	28
Prepelvic length	31	33.7	37	43	31	33.9	38	29	31	33.4	36	28
Prepectoral length	30	31.9	35	43	30	32.4	35	29	30	31.8	34	28
Second dorsal-fin depth	17	20.6	22	42	17	20.1	21	29	17	19.1	21	28
Pelvic-fin depth	22	23.9	26	43	22	23.9	26	29	21	22.9	25	28
Pectoral-fin depth	16	17.4	19	43	16	17.2	19	29	14	16.4	18	28
Length of first dorsal-fin base	12	14.4	16	42	13	14.7	16	29	12	14.5	16	28
Length of second dorsal-fin base	11	12.2	14	43	10	12.1	13	29	11	12.5	14	28
Caudal-fin length	28	30.8	33	32	28	30.4	32	25	28	29.6	31	23
Length of anal-fin base	8.1	9.5	11	43	8.9	9.9	12	29	8.8	10.1	11	28
Anal-fin height	12	14.0	16	40	12	14.2	16	29	12	13.2	16	28
Pelvic-fin length	19	20.8	23	43	19	21.2	23	29	18	19.9	22	28
Pectoral-fin length	18	20.2	23	42	19	20.2	22	29	18	19.4	23	28
Pectoral-fin width	3.9	4.5	5.1	42	3.6	4.5	5.3	29	4.1	4.6	5.0	28
First dorsal-fin height	19	20.9	25	42	19	21.5	24	29	18	20.4	23	27
Second dorsal-fin height	13	14.6	16	42	13	14.7	16	28	12	13.6	16	26
Meristic characters												
Pectoral-fin rays	16	16.8	18	43	15	16.5	18	29	15	16.3	17	28
Rudimentary gill rakers on upper limb	0	2.0	4	43	1	2.7	5	29	0	2.3	4	27
Developed gill rakers on upper limb	4	6.1	8	43	3	5.2	8	29	3	5.4	8	28
Developed gill rakers on lower limb	13	16.3	18	43	13	15.9	18	29	13	15.4	18	28
Rudimentary gill rakers on lower limb	2	3.7	7	43	2	3.9	6	29	1	3.5	5	28
Total gill rakers on upper limb	7	8.1	10	43	7	8.0	9	29	7	7.7	9	28
Total gill rakers on lower limb	19	20.0	22	43	19	19.8	21	29	18	18.9	20	28
Total gill rakers	26	28.1	31	43	26	27.8	30	29	25	26.6	29	28
Scales along lateral line	34	35.9	38	41	34	35.4	37	26	33	33.9	35	20
Qualitative character												
1st dorsal-fin spine detectability (%)		76.2		42		58.6		29		25.0		28

Table III. – Quantitative morphological and meristic characters and one qualitative character in juveniles of two populations of *Mulloidichthys flavolineatus flavolineatus*, one specimen of *M. f. flavicaudus* ("*M.f.fc.*") and all juvenile and adult *M. flavolineatus* studied.

	Mulloidichthys f. flavolineatus								*M.f.fc.*	*M. flavolineatus*							
	Pacific				Indian Ocean				Red Sea	All juveniles				All adults			
	Min	Mean	Max	n	Min	Mean	Max	n	n = 1	Min	Mean	Max	n	Min	Mean	Max	n
Morphometric characters																	
TL (mm)	90	100.2	108	6	82	92.4	105	8	104	82	96.3	108	15	117	202.0	340	86
SL (mm)	72	80.4	87	7	65	73.0	82	8	82	65	76.8	87	16	91	162.7	288	100
in % TL																	
SL	78	79.5	80	6	78	79.1	80	8	79	78	79.2	80	15	75	78.2	81	86
in % SL																	
Body depth at first dorsal-fin origin	21	21.3	22	7	19	20.4	22	8	23	19	20.9	23	16	21	23.3	26	100
Body depth at anal-fin origin	18	18.7	20	7	15	16.2	18	8	19	15	17.5	20	16	16	19.4	22	99
Half body depth at first dorsal fin origin	17	17.4	18	6	16	16.6	17	7	17	16	17.0	18	14	16	19.1	21	96
Half body depth at anal fin origin	12	13.1	14	7	11	12.3	13	7	15	11	12.9	15	15	12	14.1	16	98

Table III. – Continued.

	Mulloidichthys f. flavolineatus								*M.f.fc.*	*M. flavolineatus*							
	Pacific				Indian Ocean				Red Sea	All juveniles				All adults			
	Min	Mean	Max	n	Min	Mean	Max	n	n = 1	Min	Mean	Max	n	Min	Mean	Max	n
Caudal-peduncle depth	7.8	8.7	9.0	7	7.7	8.0	8.4	8	8.6	7.7	8.3	9.0	16	7.9	8.8	9.7	100
Caudal-peduncle width	3.4	3.6	3.8	7	2.7	3.2	3.7	8	3.6	2.7	3.4	3.8	16	2.7	3.9	4.6	100
Maximum head depth	17	18.1	19	7	17	17.9	19	8	20	17	18.2	20	16	18	20.4	22	100
Head depth through eye	13	14.9	17	7	13	14.5	17	8	17	13	14.8	17	16	15	17.0	19	100
Suborbital depth	6.2	7.3	8.9	7	6.0	6.9	8.5	8	9.3	6.0	7.2	9.3	16	8.0	10.0	12	100
Interorbital length	7.6	8.0	8.5	7	7.4	7.9	8.3	8	8.1	7.4	7.9	8.5	16	7.4	8.5	9.8	100
Head length	27	27.7	29	7	26	28.1	29	8	30	26	28.0	30	16	27	30.1	33	100
Snout length	8.6	9.8	11	7	9.0	10.3	12	8	12	8.6	10.2	12	16	12	13.3	16	100
Postorbital length	9.8	10.6	11	7	10	10.8	11	8	11.1	9.8	10.7	11	16	9.1	10.2	12	100
Orbit length	6.6	7.3	8.0	7	7.3	7.9	8.8	8	9.0	6.6	7.7	9.0	16	5.6	7.4	9.0	100
Orbit depth	6.1	6.5	6.8	7	6.1	6.8	7.5	8	7.7	6.1	6.7	7.7	16	5.1	6.4	8.1	100
Upper-jaw length	7.6	7.9	8.4	7	8.0	8.3	8.6	8	8.9	7.6	8.2	8.9	16	8.2	9.0	10	100
Lower-jaw length	6.6	7.3	7.7	7	6.8	7.7	8.5	8	8.5	6.6	7.6	8.5	16	7.6	8.6	10	100
Snout width	6.6	7.2	7.6	7	6.5	7.1	7.7	8	8.6	6.5	7.2	8.6	16	5.6	6.9	8.9	99
Barbel length	14	15.7	18	7	15	17.9	20	8	21	14	17.1	21	16	18	20.5	23	100
Maximum barbel width	0.6	0.7	0.8	7	0.7	0.8	0.9	8	1.0	0.6	0.8	1.0	16	0.6	0.8	1.1	100
First predorsal length	35	36.5	38	7	33	36.4	39	8	41	33	36.7	41	16	37	39.8	43	100
Second predorsal length	64	64.5	65	7	63	64.5	67	8	66	63	64.6	67	16	63	66.6	69	99
Interdorsal distance	13	14.4	16	7	13	15.1	17	8	13	13	14.6	17	16	12	15.0	17	99
Caudal-peduncle length	24	24.2	25	7	22	24.0	26	8	21	21	23.9	26	16	19	22.0	24	100
Pre-anal length	65	66.2	67	7	62	64.8	68	8	69	62	65.7	69	16	64	67.2	71	99
Prepelvic length	32	34.0	36	7	32	33.8	36	8	33	32	33.9	36	16	31	33.7	38	100
Prepectoral length	28	30.5	33	7	30	31.2	34	8	34	28	31.1	34	16	30	32.0	35	100
Second dorsal-fin depth	18	19.3	21	7	16	17.0	18	8	19	16	18.1	21	16	17	20.0	22	99
Pelvic-fin depth	20	21.6	23	7	20	20.4	22	8	23	20	21.0	23	16	21	23.6	26	100
Pectoral-fin depth	14	15.8	17	7	13	14.7	16	8	16	13	15.3	17	16	14	17.1	19	100
Length of first dorsal-fin base	13	14.4	16	7	12	13.8	15	8	15	12	14.1	16	16	12	14.5	16	99
Length of second dorsal-fin base	11	12.3	13	7	11	11.7	13	8	13	11	12.0	13	16	10	12.3	14	100
Caudal-fin length	26	28.1	29	6	27	28.5	31	8	30	26	28.4	31	15	28	30.3	33	80
Length of anal-fin base	10	10.4	11	7	8.9	10.2	12	8	9.6	8.9	10.3	12	16	8.1	9.8	12	100
Anal-fin height	13	14.1	16	7	13	14.6	16	8	13	13	14.3	16	16	12	13.8	16	97
Pelvic-fin length	19	19.8	21	7	19	21.0	23	8	21	19	20.5	23	16	18	20.7	23	100
Pectoral-fin length	16	17.3	21	7	16	18.3	21	8	21	16	18.0	21	16	18	20.0	23	99
Pectoral-fin width	3.5	3.9	4.2	7	3.4	3.7	3.9	8	3.8	3.4	3.8	4.2	16	3.6	4.5	5.3	99
First dorsal-fin height	18	19.6	21	7	19	20.0	21	8	22	18	19.9	22	16	18	20.9	25	98
Second dorsal-fin height	13	14.0	15	7	13	13.7	14	8	15	13	13.9	15	16	12	14.3	16	96
Meristic characters																	
Pectoral-fin rays	16	16.6	17	7	16	16.4	17	8	16	16	16.4	17	16	15	16.6	18	100
Rudimentary gill rakers on upper limb	0	1.4	2	7	0	1.1	2	8	3	0	1.4	3	16	0	2.3	5	99
Developed gill rakers on upper limb	5	6.0	7	7	5	6.1	7	8	5	5	6.0	7	16	3	5.7	8	100
Developed gill rakers on lower limb	16	18.1	20	7	17	17.6	19	8	17	16	17.8	20	16	13	16.0	18	100
Rudimentary gill rakers on lower limb	0	2.1	4	7	1	2.1	3	8	2	0	2.1	4	16	1	3.7	7	100
Total gill rakers on upper limb	7	7.4	8	7	7	7.3	8	8	8	7	7.4	8	16	7	7.9	10	100
Total gill rakers on lower limb	20	20.3	21	7	19	19.8	22	8	19	19	19.9	22	16	18	19.6	22	100
Total gill rakers	27	27.7	29	7	26	27.0	29	8	27	26	27.3	29	16	25	27.6	31	100
Scales along lateral line	34	35.0	36	6	35	35.4	36	5	34	34	35.1	36	12	33	35.3	38	87
Qualitative character																	
1st dorsal-fin spine detectability (%)		71.4		7		100		8			81.3		16		56.6		99

Table IV. – Counts of (I) high and low dorsal-fin spine detectability, number of pectoral-fin rays and number of lateral-line scales, and (II) number of gill rakers in six populations of *Mulloidichthys flavolineatus flavolineatus* and in *M. f. flavicaudus*. For three groups with sufficiently high sample size ($n \geq 20$) indicated by letters the results of pairwise comparisons using contingency tables are provided, with pairs of letters in parentheses referring to groups showing no significant differences. [1] only adults; [2] adults and juveniles; * $p < 0.01$; ** $p < 0.0001$.

I	1st dorsal-fin spine detectability[1]		Number of pectoral-fin rays[2]				Number of lateral-line scales[2]					
Area/Subspecies	High	Low	15	16	17	18	33	34	35	36	37	38
SW Pacific	9	5		7	9			2	4	5	2	
Wake Atoll	2	1			3					2	1	
Hawaiian Archipelago	9	1			8	2			1	7	2	
Other areas of Pacific	12	3		5	16			1	9	6	4	1
Entire Pacific (A)	32	10		12	36	2		4	14	22	10	1
Indian Ocean (B)	17	12	1	19	16	1		4	12	14	1	
M. f. flavicaudus (C)	7	21	3	14	12		9	5	7			
Fisher's exact or Chi² test	(A, B) (B, C)**		A (B, C)*				(A, B) C**					

II	Number of gill rakers[2]															
	On upper limb				On lower limb					In total						
Area/Subspecies	7	8	9	10	18	19	20	21	22	25	26	27	28	29	30	31
Western SW Pacific	3	12	1			8	6	1	1		2	7	5		2	
Wake Atoll		2	1				2	1					2		1	
Hawaiian Archipelago		7	2	1		2	6	2				2	3	4	1	
Other areas of Pacific	7	10	4			1	14	5	1			6	9	4	1	1
Entire Pacific (A)	10	31	8	1		11	28	9	2		2	15	19	8	5	1
Indian Ocean (B)	10	24	3			14	18	4	1		6	11	13	6	1	
M. f. flavicaudus (C)	10	18	1		8	16	5			3	11	11	3	1		
Chi² test:	ns				(A, B) C**					(A, B) C*						

(Tabs I, IV). Its body is uniformly brownish and the fins uniformly pale brown and partly hyaline, very similar to many preserved specimens examined. The number of lateral-line scales, indicated in the original description to be 40, would be clearly out of the range for all *M. flavolineatus* examined (33-38). The most plausible explanation for this deviation is that De Vis (1884) included the 3-4 scales on the base of the caudal fin. Eight spines in the first dorsal fin were encountered in all specimens examined of *M. flavolineatus*, which is also in contrast to the seven spines indicated in the original description of *M. armatus*. When examining this character qualitatively, we found that it was well detectable only in only nine of 14 adult SW Pacific specimens (64.3%; Tabs I, IV), while the minute first spine is difficult to detect in five specimens (35.7%) and, hence, could be easily overlooked. Difficulties to detect this spine have been also documented in all other populations studied (see also the intraspecific comparisons below).

We conclude that *Mulloides armatus* is a junior synonym of *M. flavolineatus*.

Mulloidichthys flavolineatus intraspecific comparisons

Size groups

Juvenile *M. flavolineatus* differ from the larger adult conspecifics in a shorter snout (8.6-12 vs. 12-16% SL), slightly shallower body and head, slightly shorter jaws, barbels and pectoral fins, and the first dorsal-fin spine being well detectable more often (81.3 vs. 56.6%) (Tab. III, Fig. 3).

Subspecies and populations

In adult specimens, considerable overlap occurs among subspecies and populations in morphometric and meristic characters (Tabs I, II, IV; Fig. 3). In morphometric characters, size-related allometric variation, i.e. between juveniles and adults (see above), is often much larger than body-shape variation among subspecies and populations (Tabs I-III; Fig. 3).

Mulloidichthys f. flavolineatus and *M. f. flavicaudus* show considerable overlap in all morphometric and several meristic characters when compared directly. Slight differences exist in the number of lateral-line scales (34-38 in *M. f. flavolineatus* vs. 33-35 in *M. f. flavicaudus*; Tabs II-IV) and in a lower first dorsal-fin spine detectability in adult *M. f. flavicaudus* (25% vs. 58.6% in *M. f. flavolineatus* in the Indian Ocean and 76.2% in the Pacific; Tabs II, IV). However, no clear and consistent distinction is reached even when combining number of lateral-line scales and first dorsal-fin spine detectability with any other characters.

The populations of *M. f. flavolineatus* from the Indian Ocean and Pacific overlap considerably in morphometric and meristic characters (Tabs I-IV; Fig. 4). Dorsal-fin spine detectability is slightly higher in the Pacific compared to the Indian Ocean population (76.2 vs. 58.6%), being highest in the Hawaiian Archipelago (90%; Tabs I, II, IV). The most prominent distinction among the four Pacific populations occurs in the three specimens from Wake Atoll, which show longer heads, barbels and pectoral fins, and larger eyes than similar-size specimens of all other *M. f. flavolineatus* populations and *M. f. flavicaudus* (Fig. 4). In addition, the Wake specimens differ from the Hawaiian Archipelago population in deeper head through eye, slightly shorter anal-fin base and slightly shallower body and higher anal and first dorsal fins (Tab. I; Fig. 4). Several specimens of the Hawaiian popula-

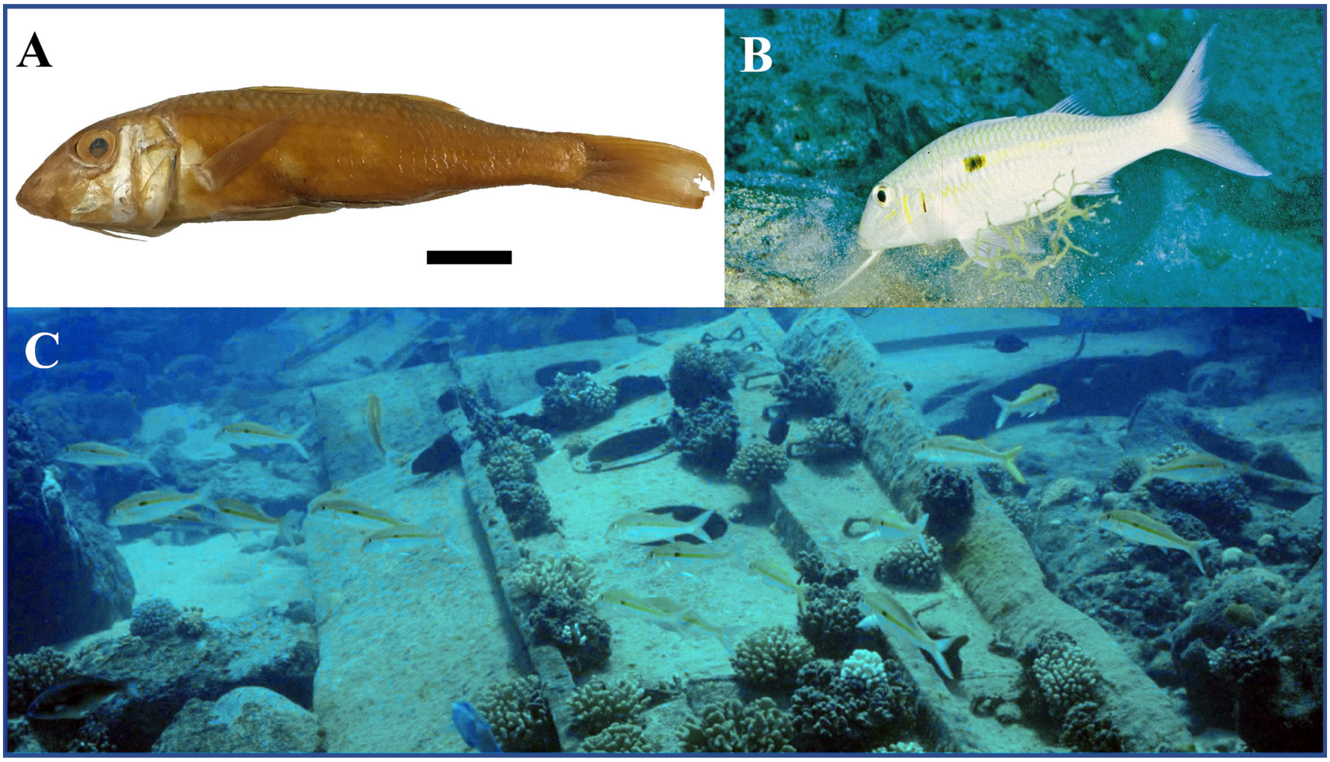

Figure 3. – *Mulloidichthys flavolineatus flavolineatus* from Wake Island. **A**: BPBM 4089, 286 mm SL (Loreen O'Hara); **B**: Adult (Phillip & Lisa Lobel); **C**: Several adults or subadults; one of the four fish at top right has a yellow caudal fin (Phillip & Lisa Lobel). Scale bar = 4 cm.

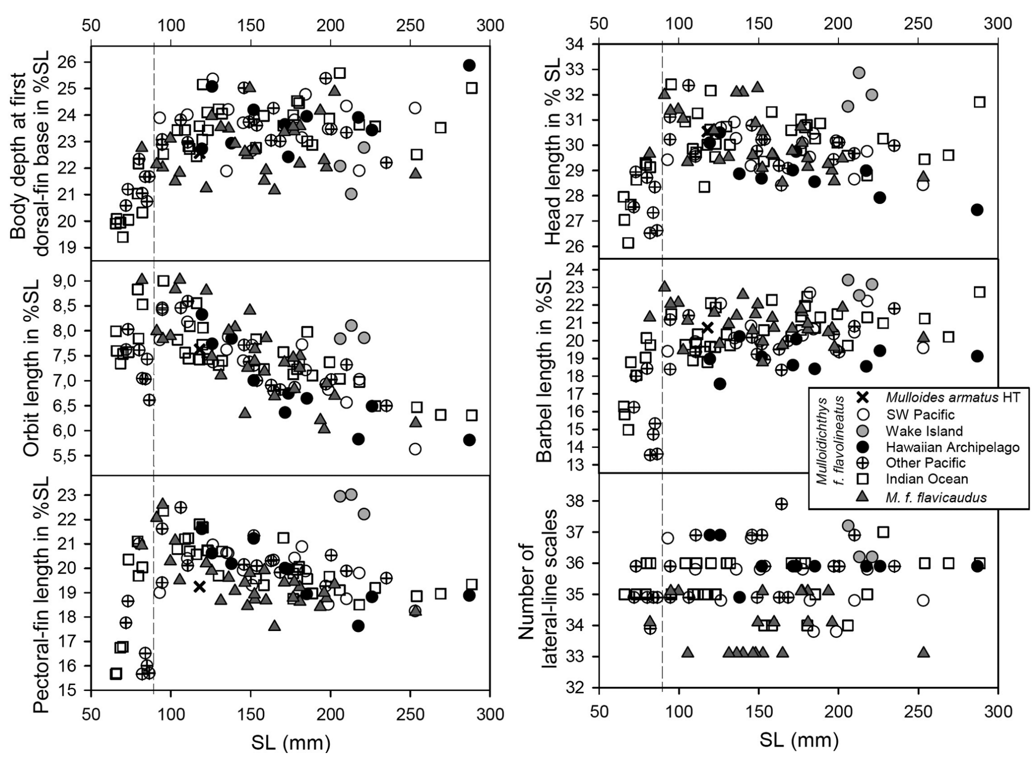

Figure 4. – Standard length against five morphometric characters and one meristic character in *Mulloidichthys flavolineatus* and the HT of *M. armatus* with distinction of *M. f. flavicaudus* and populations of *M. f. flavolineatus* from selected regions by different symbols. The hatched line indicates the minimum size for adult/subadult fish.

tion show relatively short heads, small eyes and short barbels, as apparent when plotting these characters against SL (Fig. 4).

Caudal-fin colour, indicated to be an important diagnostic character for *M. f. flavicaudus* in the original description (Fernández-Silva and Randall *in* Fernández-Silva *et al.*, 2016), is either yellow or whitish-grey in both subspecies. Evidence for the occurrence of whitish-grey caudal fins in *M. f. flavicaudus* comes from an *in situ* photograph of a shoal encountered off Dahab, Gulf of Aqaba, northern Red Sea (Fig. 1C). Similarly as documented by photographs from Oman and the Maldives published in Fernández-Silva *et al.* (2016), the northern Red Sea shoal consists of several individuals with either yellow or whitish-grey caudal fins. Further evidence comes from a video footage from off Marsa Alam, Egypt (northern Red Sea), which can be inspected by using the following link: https://www.shutterstock.com/de/video/clip-10310861-red-sea-goatfish-parupeneus-forsskali-feeding-on. An original copy of this footage has been obtained by the first author from the online provider. It shows five *M. flavolineatus* associated with two Red Sea goatfish *Parupeneus forsskali* (Fourmanoir & Guézé, 1976). Only two of the five specimens show a yellowish caudal fin, while the other three show a whitish-grey caudal fin. Though yellow caudal fins appear to occur rather infrequently in *M. f. flavolineatus* (Fernández-Silva *et al.*, 2016), they can be encountered in many areas of the Indo-Pacific and as widely separated as Sodwana Bay, South Africa, WIO (Plate 1D in Uiblein, 2011), the Seychelles, WIO (Fig. 1D), the Coral Sea, Queensland, SW Pacific (Fig. 1B), and the Wake Atoll, central NW Pacific (Fig. 3C).

Among juveniles of the two subspecies and two populations, slight differences in morphometric characters can be found such as a shallower body at anal-fin origin in the Indian Ocean population of *M. f. flavolineatus*, and longer barbels, shorter caudal peduncle and higher first dorsal fin in *M. f. flavicaudus* (Tab. III) However, because only a relatively small data set is available for juveniles these results need to be interpreted with caution.

The univariate statistical comparisons among *M. f. flavicaudus* and the Indian Ocean and Pacific populations of *M. f. flavolineatus* detected significant differences in 18 of 40 morphometric characters (Tab. V). *Mulloidichthys f. flavicaudus* and *M. f. flavolineatus* of the Pacific differ from each other in 16, *M. f. flavicaudus* and *M. f. flavolineatus* of the Indian Ocean differ in 12, and the two populations of *M. f. flavolineatus* differ in two morphometric characters (Tab. V). Regarding six important meristic characters, *M. f. flavicaudus* and *M. f. flavolineatus* of the Pacific differ significantly in five, *M. f. flavicaudus* and *M. f. flavolineatus* of the Indian Ocean in three and the two populations of *M. f. flavolineatus* in a single character (Tab. IV).

The results of PCA based on morphometric characters are shown in Tab. VI and Fig. 5. No clear distinction among data grouped into subspecies and large-scale populations (Indian Ocean and Pacific) occurs, but statistical differences among these groups can be found for loadings of three of the first four principal components (Tab. V). The best separation of *M. f. flavicaudus* results from combining the second and third principal components, which have highest loadings for body depth (PC2; Tab. VI), and second dorsal- and anal-fin height (PC3; Tab. VI). Still, overlap along these component axes occurs between *M. f. flavicaudus* and three Indian Ocean and three Pacific specimens (Fig. 5). The Pacific population is statistically separable from the Indian Ocean population based on the fourth component, which has highest loadings for eye size and interdorsal distance (Tab. VI), though considerable overlap occurs (Fig. 5). Along the first principal component, which accumulates 21.9% of total variance explained, the three Wake Atoll specimens separate well from nearly all other conspecifics, the only exception being the smallest adult of the Indian Ocean population (Fig. 5). Head, snout, barbel and pectoral-fin length, and head depth through eye have the highest first component loadings (Tab. VI).

We conclude that the two subspecies can at best be understood as two well-differentiated populations. The Wake Atoll specimens are considerably differentiated from most other conspecifics in body shape, while no evidence for differentiation in meristic characters and colour patterns was found.

Taxonomy

Mulloidichthys flavolineatus (Lacepède, 1801)
(Tabs I-IV; Figs 1, 3, 4)

Mullus flavolineatus Lacepède, 1801: 384, 406; no locality stated. No original types known.

Mulloidichthys flavolineatus: Uiblein, 2011; Fernández-Silva *et al.*, 2015.

Two subspecies: *Mulloidichthys f. flavolineatus and M. f. flavicaudus* Fernández-Silva & Randall *in* Fernández-Silva *et al.*, 2016

Material examined

Mulloidichthys flavolineatus flavolineatus (n = 87)

Types (n = 3): BPBM 20135, NT, 162 mm SL, Indian Ocean, Mauritius, East Coast, Oyster Bay (= Baie aux Huîtres), 19°43'S, 63°21'E, 1.5 m depth; QM I.122, HT of *Mulloides armatus*, 118 mm SL, SW Pacific, E Australia, Queensland, most probably Western Coral Sea (Fig. 1A); MNHN B-2352, ST of *Mulloidichthys vanicolensis*, 85 mm SL, SW Pacific, Solomon Islands: Vanikoro, Sta. Cruz.

Non-types: SW Pacific (n = 14): Indonesia: Java: RMNH 13300, 1 (of 4), 145 mm SL, Jakarta, Bay of Batavia; Sumbawa: RMNH 29994, 218 mm SL, Bay of Sanggar, N of Sumbawa, near edge of coastal reef flat; Komodo: NCIP

Table V. – Means of residuals of morphometric characters (values transformed by multiplication with 10^3) in two populations of *Mulloidichthys flavolineatus flavolineatus* and *M. f. flavicaudus* (each with a reference letter used in the group comparisons). F-values of comparisons by one-way ANOVA, probability information ($p \leq 0.01$ significance level), and results from multiple comparisons (Scheffe test) are also provided. Letters in parentheses refer to groups showing no significant differences.

	Mulloidichthys f. flavolineatus		*M. f. flavicaudus*			
	Pacific	Indian Ocean	Red Sea			
	(A)	(B)	(C)	F-value	*p*	Scheffe test
Body depth at first dorsal-fin origin	3.1	5.7	–10.7	7.00	< 0.01	(A, B) C
Body depth at anal-fin origin	10.1	–1.8	–13.5	10.27	< 0.0001	(A, B) (B, C)
Half body depth at first dorsal fin origin	–0.8	4.4	–3.2	0.72	ns	
Half body depth at anal fin origin	7.1	1.7	–12.9	5.44	< 0.01	(A, B) (B, C)
Caudal-peduncle depth	13.3	–2.3	–18.1	35.84	< 0.0001	A, B, C
Caudal-peduncle width	1.8	–15.2	12.8	3.85	ns	
Maximum head depth	2.5	5.7	–10.0	7.27	< 0.01	(A, B) C
Head depth through eye	–2.4	8.4	–5.2	3.61	ns	
Suborbital depth	–8.7	10.6	2.4	4.42	ns	
Interorbital length	–1.7	4.6	–2.1	0.85	ns	
Head length	–2.6	4.0	–0.1	1.85	ns	
Snout length	–3.3	7.9	–3.0	2.91	ns	
Postorbital length	–2.6	7.5	–3.6	2.25	ns	
Orbit length	–1.1	3.3	–1.8	0.28	ns	
Orbit depth	–0.6	–0.2	1.1	0.02	ns	
Upper-jaw length	–1.1	4.2	–2.5	1.16	ns	
Lower-jaw length	–0.7	0.5	0.5	0.04	ns	
Snout width	–5.2	12.9	–5.5	1.82	ns	
Barbel length	–9.1	4.2	9.6	5.45	< 0.01	(A, B) (B, C)
Maximum barbel width	–25.1	10.8	27.4	7.35	< 0.01	A (B, C)
First predorsal length	1.9	–0.2	–2.8	1.05	ns	
Second predorsal length	–0.4	0.4	0.4	0.12	ns	
Interdorsal distance	4.9	–14.0	7.2	3.67	ns	
Caudal-peduncle length	3.2	2.1	–6.9	2.15	ns	
Pre-anal length	–0.4	–3.8	4.4	5.62	< 0.01	(A, B) (A, C)
Prepelvic length	0.9	2.7	–4.2	1.25	ns	
Prepectoral length	–0.8	4.8	–3.8	2.52	ns	
Second dorsal-fin depth	11.4	1.0	–18.2	15.39	< 0.0001	(A, B) C
Pelvic-fin depth	4.6	5.5	–13.0	9.94	0.0001	(A, B) C
Pectoral-fin depth	7.7	4.9	–16.8	12.58	< 0.0001	(A, B) C
Length of first dorsal-fin base	–3.7	5.9	–0.6	1.31	ns	
Length of second dorsal-fin base	–1.8	–5.5	8.4	2.69	ns	
Caudal-fin length	7.5	1.0	–11.5	9.71	< 0.001	(A, B) (B, C)
Length of anal-fin base	–12.2	5.3	13.3	6.27	< 0.01	(A, B) (B, C)
Anal-fin height	7.6	10.4	–21.4	12.24	< 0.0001	(A, B) C
Pelvic-fin length	5.3	10.0	–18.5	22.73	< 0.0001	(A, B) C
Pectoral-fin length	6.3	4.4	–13.8	9.17	< 0.001	(A, B) C
Pectoral-fin width	–4.1	–3.9	10.3	2.25	ns	
First dorsal-fin height	2.0	12.0	–15.5	7.86	< 0.001	(A, B) (A, C)
Second dorsal-fin height	9.4	11.4	–26.5	18.68	< 0.0001	(A, B) C

244, 199 mm SL, Nusa Merapu; RMNH 29720, 2, 135-151 mm SL, Java Sea, Selat Linta, E of Komodo, 8°30'S, 119°34.6'E; Moluccas: NCIP 8421, 184 mm SL, Ambon, Kampung Said; Eastern Australia: Queensland, Coral Sea:

Table VI. – Results of PCA with loadings of the first four principal components (PC1-PC4), variance explained, and results from one-way ANOVA of the three groups indicated by letters as explained in Tab. V. For each principal component loading values > 0.6 or the three highest loading values are emphasized with bold italics.

	PC1	PC2	PC3	PC4
Body depth at first dorsal-fin origin	–0.10	***0.87***	0.20	–0.07
Body depth at anal-fin origin	–0.51	***0.62***	–0.03	0.39
Half body depth at first dorsal fin origin	–0.15	***0.67***	0.22	–0.09
Half body depth at anal fin origin	***–0.61***	0.59	–0.04	0.14
Caudal-peduncle depth	–0.02	0.60	–0.32	0.44
Caudal-peduncle width	–0.46	–0.09	0.14	0.23
Maximum head depth	***0.63***	0.58	–0.07	–0.16
Head depth through eye	***0.71***	0.33	0.23	–0.03
Suborbital depth	0.56	0.04	0.47	–0.06
Interorbital length	0.09	0.38	0.12	–0.25
Head length	***0.88***	–0.03	0.10	0.13
Snout length	***0.70***	0.20	0.38	–0.17
Postorbital length	0.49	0.19	0.20	–0.27
Orbit length	0.48	–0.29	–0.14	***0.53***
Orbit depth	0.39	–0.35	–0.05	***0.57***
Upper-jaw length	0.54	0.15	0.31	0.11
Lower-jaw length	0.48	0.14	0.40	0.12
Snout width	0.11	0.41	0.25	–0.38
Barbel length	***0.65***	–0.19	0.23	0.08
Maximum barbel width	0.18	0.05	0.36	–0.20
First predorsal length	0.52	0.16	0.26	0.42
Second predorsal length	0.13	0.24	0.48	0.47
Interdorsal distance	–0.47	0.19	0.18	***0.49***
Caudal-peduncle length	–0.31	0.18	–0.24	0.28
Pre-anal length	0.14	–0.10	0.45	0.21
Prepelvic length	***0.76***	0.13	0.04	–0.05
Prepectoral length	***0.86***	0.00	–0.06	0.12
Second dorsal-fin depth	–0.46	***0.71***	–0.05	0.29
Pelvic-fin depth	–0.07	***0.88***	0.14	–0.11
Pectoral-fin depth	–0.14	***0.77***	0.04	–0.12
Length of first dorsal-fin base	–0.21	–0.10	0.10	–0.01
Length of second dorsal-fin base	–0.04	–0.16	0.42	0.16
Caudal-fin length	0.53	0.24	–0.48	0.14
Length of anal-fin base	–0.24	–0.07	0.10	–0.42
Anal-fin height	0.46	0.16	***–0.60***	–0.16
Pelvic-fin length	0.37	0.36	–0.43	–0.02
Pectoral-fin length	***0.66***	0.01	***–0.53***	0.00
Pectoral-fin width	0.15	–0.01	0.29	0.25
First dorsal-fin height	0.53	0.15	–0.41	0.04
Second dorsal-fin height	0.40	0.37	***–0.62***	0.06
Variance explained (Eigenvalues)	8.75	5.86	3.72	2.66
% Total variance explained	21.9	14.6	9.29	5.63
F-value	1.17	9.27	15.49	6.30
p	ns	< 0.01	< 0.0001	< 0.01
Scheffe test		(A, B) C	(A, B) C	(A, C) (B, C)

AMS I.19467-020, 1 (of 3), 93 mm SL, Lizard Island, Fisherman's Beach, 14°40'S, 145°27'E; QM I.25925, 182 mm SL, Herald Cay; Norfolk Island, N Tasman Sea: AMS I.20269-007, 253 mm SL, Emily Bay, Sydney beach, 29°04'S, 167°57'E (fresh colour photo, Fig. 1B); Vanuatu: AMS I.37308-017, 1 (of 5), 110 mm SL, Erromango Island, S side of Dillon's Bay, N side Williams Point, 18°49'36"S, 169°00'23"E, 3 m depth; AMS I.37903-008, 126 mm SL, Efate Island, Emten Lagoon, 17°45'S, 168°21'E, 0.6 m depth; AMS I.6458, 136 mm SL, Santo, 15°00'S, 167°00'E; BPBM 962, 178 mm SL, Efate Island; New Zealand: RMNH. PISC.11308, 210 mm SL (no further information).

Wake Island, Wake Atoll, Central NW Pacific (n = 3): BPBM 4089, 3, 206-221 mm (largest specimen, Fig. 3A).

Hawaiian Archipelago (n = 10): Midway Atoll: BPBM 25517, 119 mm SL and BPBM 15308, 152 mm SL; NW Hawaiian Islands: BPBM 4087, 287 mm SL, Laysan Island; BPBM 4088, 2, 138-226 mm SL, Lisianski Island; Hawaii: Oahu: BPBM 1749, 185 mm SL, Honolulu; BPBM 1750, 172 mm SL, Honolulu; BPBM 25457, 126 mm SL, Waianae coast; BPBM 25674, 174 mm SL, Honolulu; NHMO J 2135, 217 mm SL, no locality information.

Other areas of the Pacific (n = 21): South China Sea, Vietnam: HIFIRE 58228, 149 mm SL, Nha Trang, Hon Tre Island; Micronesia: Caroline Islands: BPBM 24628, 2 (of 13), 95-163 mm SL, Puluwat Atoll, lagoon side, 07°20'N, 149°11'E; Mariana Islands: BPBM 77, 1 (of 8), 235 mm SL, Guam; Palau: CAS 206563, 111 mm SL, reef flat off Ngajangel Island on east side of atoll, 8°4'47"N, 134°43'52"E; Japan, Marcos Island: BPBM 7087, 210 mm SL, N end, reef flat, 1 m depth; BPBM 7088, 197 mm SL, reef flat, 1.5 m depth; Polynesia: Samoa: ZMUC 49452, 95 mm SL, Pago Pago, harbour; Tonga: ZMUC 49491, 168 mm SL, Nukualofa; Rapa Island: BPBM 12937, 164 mm SL, E side of Akatamiro Bay, 3 m depth; Kiribati, Phoenix Islands: BPBM 15299, 3 (of 18), 146-154 mm SL, Hull Island, Orona Atoll; BPBM 25645, 3, 72-80 mm SL, Kanton Island; French Polynesia: ZMUC 49500, 106 mm, Tahiti; ANSP

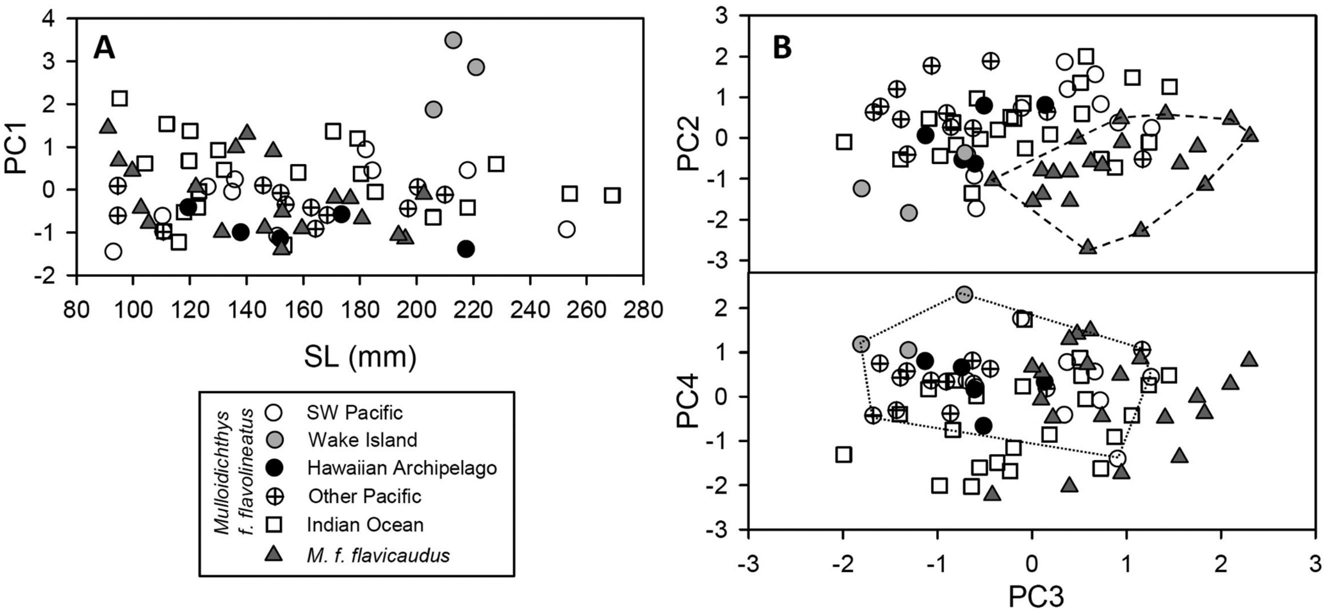

Figure 5. – Results of PCA for *Mulloidichthys flavolineatus* body shape showing (**A**) relationships between SL and the first principal component (PC1) and (**B**) relationships between the second to fourth principal components (PC2-4). The subspecies *M. f. flavicaudus* and populations of *M. f. flavolineatus* from selected regions are indicated by different symbols. The dashed line encloses *M. f. flavicaudus* and the dotted line encloses the population of *M. f. flavolineatus* from the entire Pacific.

83811, 3 (of 4), 82-87 mm, Tuamoto Archipelago, Takaroa; Marquesas Islands: BPBM 2136, 200 mm SL, Nukuhiva.

Indian Ocean, except for NW Indian Ocean and Red Sea (n = 36): Western Indian Ocean: Mozambique: SAIAB 18072, 3, 109-116 mm SL, Delagoa Bay, 25°58'40"S, 32°35'20"E; South Africa: SAIAB 86370, 254 mm SL, KwaZulu-Natal, Ribbon Reef, Sodwana Bay, 27°29.37'S 32°41.38'E, 12-18 m depth; Seychelles: SAIAB 77080, 70 mm, Mahé, Baie Ternay, 4°38'47"S, 55°22'43"E; ANSP 108690, 3 (of 12), 65-68 mm SL, Aldabra Island near Ile Picard, 9°25'S 46°15'E; ANSP 114425, 2 (of 51), 185-218 mm SL, Amirante Islands, St. Joseph Island, coral bank SW of Resource Island, 5°26'S, 53°22'E, 0-6 m; Chagos: SAIAB 15361, 2, 170-179 mm SL, NW corner of Isle Boddam on ocean side; Mascarenes: Mauritius: MNHN 1994-0552, 288 mm SL; SAIAB 58605, 7 (of 19), 73-120 mm SL, just South of Pointe Petite, 20°12'S, 57°24'E; SAIAB 86582, 3, 289-206 mm SL, fish market, La Morne, South-West Mauritius, 20°28.190'S, 57°20.658'E; Réunion: MNHN 1965-27, 153 mm SL, Reunion, –21°7'1"S, 55°34'59"E; Rodrigues: SAIAB 68799, 5, 95-132 mm SL, off Port Mathurin, Ile Hollandaise; SAIAB 70580, 180 mm SL, north of Grand Bay; Eastern Indian Ocean: Indonesia, Sumatra: RMNH 13299, 3 (of 8), 123-177 mm SL, Sumatra, Sabang Bay, Pulau Weh; ZMA 132457, 123 mm SL, Sumatra, Aceh, Simaloer Island, Labuan Badjan; W Australia, Cocos-Keeling Islands: ANSP 159138, 269 mm SL, West Island, 1.5-3 km E of N end of island, 12°7'35"S, 96°50'55"E; ANSP 159142, 228 mm SL, West Island, 1.5-3 km E of north end of island, 12°7'40"S, 96°49'50"E, 6-7.5 m depth.

Mulloidichthys flavolineatus flavicaudus (n = 29)

Paratypes (n = 5): CAS 237352, 4: 107-147 mm SL, and BPBM 41246, 102 mm SL, Red Sea, Saudi Arabia, Thuwal, 22°13'50"N, 39°01'43"E.

Non-types (n = 24). Red Sea: Israel, Gulf of Aqaba, Eilat: CAS 58876, 252 mm SL; CAS 206559, 146 mm SL; CAS 206715, 133 mm SL; CAS 206726, 198 mm SL; CAS 206736, 167 mm SL; SAIAB 4146 and 4160, 2, 126-152 mm SL, 29°33'S, 34°57'E; SAIAB 65788, 3, 91-100 mm SL, north beach; Egypt, Gulf of Suez: MNHN 1980-1504, 2, 194-203 mm SL; N Red Sea, possibly Egypt: MNHN 1980-1501, 177 mm SL, unknown locality "Kaded el hamden" (coll. Dollfus); MNHN 1980-1502, 159 mm SL, unknown locality "El had yayah" (coll. Dollfus); possibly Egypt or northern Sudan: MNHN A.3515, 2, 171-196 mm SL (coll. Botta); Sudan: HIFIRE 58445, 5, 148-181 mm SL and HIFIRE 58446, 181 mm SL, Port Sudan, fish market; Saudi Arabia: RMNH 25004, 82 mm, Jeddah; Eritrea: MNHN A.3514, 136 mm SL, Massawa, 15°37'1"N, 39°28'1"E.

Diagnosis

First dorsal fin VIII, the first minute spine sometimes considerably reduced and/or hidden below skin and hence difficult to detect; pectoral fins 15-18; gill rakers 7-10 + 18-22 = 25-31; lateral-line scales 33-38; morphometric characters in adult fish (≥ 90 mm SL): body depth at first dorsal-fin origin 21–26; body depth at anus 16-22; caudal-peduncle depth 7.9-9.7; caudal-peduncle width 2.7-4.6; maximum head depth 18-22; head depth through eye 15-19; head length 27-33; snout length 12-16; orbit length 5.6-9.0; upper jaw length 8.2-10; barbel length 18-23; caudal-fin length 28-33; anal-fin height 12-16; pelvic-fin length 18-23; pectoral-fin length 18-23; pectoral-fin width 3.6-5.3; first dorsal-fin height 18-25; second dorsal-fin height 12-16; body silvery white, sometimes infused with yellow, darker above lateral line; head silvery white to yellowish, darker on dorsal part of snout and dorsally from mid-orbit; one straight yellow mid-lateral body stripe, its width subequal to pupil diameter frequently with a dark oval to rectangular blotch on yellow mid-lateral body stripe below first dorsal-fin base; stripe and/or blotch sometimes only faintly or not visible due to colour changes, blotch often retained in preserved fish; dorsal and caudal fins whitish-grey or yellowish, pectoral, pelvic and anal fins pale whitish-grey or rose, partly transparent; barbels white; in preserved fish body generally pale brown to brown or ventrally pale and dorsally darkened; head pale brown to brown; fins uniformly pale-brown, partly hyaline.

Morphometric characters in juvenile fish (< 90 mm SL): body depth at first dorsal-fin origin 19-23; body depth at anus 15-20; caudal-peduncle depth 7.7-9.0; caudal-peduncle width 2.7-3.8; maximum head depth 17-20; head depth through eye 13-17; head length 26-30; snout length 8.6-12; orbit length 6.6-9.0; upper jaw length 7.6-8.9; barbel length 14-21; caudal-fin length 26-31; anal-fin height 13-16; pelvic-fin length 19-23; pectoral-fin length 16-21; pectoral-fin width 3.4-4.2; first dorsal-fin height 18-22; second dorsal-fin height 13-15.

Meristic characters in subspecies: *Mulloidichthys f. flavicaudus*: First dorsal fin VIII, the first minute spine well detectable in 25% of adults; pectoral fins 15-17; gill rakers 7-9 + 18-20 = 25-29; lateral-line scales 33-35; *M. f. flavolineatus*: First dorsal fin VIII, the first minute spine well detectable in over 50% of adults; pectoral fins 15-18; gill rakers 7-10 + 19-22 = 26-31; lateral-line scales 34-38.

Distribution, size, depth and habitat

Mulloidichthys flavolineatus occurs in the Indian Ocean to Central Pacific: Red Sea, East and South Africa, Madagascar and Mascarenes east to the Hawaiian Islands, Line Islands and Pitcairn Group, north to southern Japan and Midway Islands, south to North West Cape (Western Australia), New South Wales (Eastern Australia) at 36°S, Lord Howe Island, and New Caledonia, a single record from New Zealand (RMNH.PISC.11308). It attains at least 34 cm SL and occurs from close to the surface to 99 m depth, on or slightly above soft or hard bottoms, often on or in the vicinity of coral reefs.

Interspecific comparisons and differential diagnoses

Adult *Mulloidichthys flavolineatus* differs from all other congeners in a shallower body (e.g. body depth at dorsal-fin origin 21-26 vs. 25-30% SL; body depth at anal-fin origin 16-22 vs. 21-27% SL) and the frequent presence of a dark oval or rectangular blotch at mid-body below the first dorsal-fin base; in addition, it differs from *M. ayliffe* and *M. mimicus* in a shallower caudal peduncle (7.9-9.7 vs. 10-11% SL) and a single yellow vs. several yellow and bluish lateral body stripes; it differs from *M. pfluegeri* in fewer lateral line scales (mostly 33-37 vs. 38-39), in a narrower caudal peduncle (2.7-4.6 vs. 4.6-6.0% SL), shallower suborbital (8.0-12 vs. 12-14% SL), shorter jaws (upper-jaw length 8.2-10 vs. 11-12% SL), narrower pectoral fin (3.6-5.3 vs. 5.4-5.7% SL) and the presence of mid-lateral body stripe vs. absence; and it differs from *M. vanicolensis* in fewer gill rakers (gill rakers on lower limb 18-22 vs. 23-26; total gill rakers 25-31 vs. 31-35).

Juvenile *M. flavolineatus* differs from *M. mimicus* (a single 79 mm SL specimen examined by Uiblein, 2011) in a shallower body (e.g. body depth at dorsal-fin origin 19-23 vs. 24% SL; body depth at anal-fin origin 15-20 vs. 22% SL), shallower caudal peduncle (7.7-9.0 vs. 9.4% SL), longer upper jaw (7.6-8.9 vs. 9.3% SL), wider interdorsal distance (13-17 vs. 12% SL), shorter second dorsal-fin base (11-13 vs. 16% SL), shallower anal fin (13-16 vs. 17% SL), and shallower dorsal fins (first dorsal fin height 18-22 vs. 23% SL; second dorsal-fin height 13-15 vs. 16% SL). No other comparative data for juveniles of *Mulloidichthys* species are currently available.

DISCUSSION

Our study documents considerable phenotypic variability among size-groups, populations and subspecies of *Mulloidichthys flavolineatus*. It does not support the recognition of *Mulloides armatus* as a distinct species, nor the elevation of *M. f. flavicaudus* to species status. Rather, the two subspecies were identified as well-differentiated populations based on statistically detectable differences in morphology. Also, the available imagery of live or freshly deceased fish suggests that yellow caudal fins occur more frequently in the Red Sea than in other areas (Fernández-Silva *et al.*, 2016; current study). It is not feasible to consistently distinguish *M. f. flavicaudus* from *M. f. flavolineatus* by any single or combination of morphometric, meristic and qualitative characters, including first dorsal-fin spine detectability and colour patterns.

Fernández-Silva *et al.* (2015, 2016) genetic analyses (based on cytochrome *b* sequence data and microsatellites, and a combined cytochrome *b* + ATPase 6 + ATPase 8 dataset, respectively) provide evidence for intraspecific differentiation of *M. flavolineatus* of the Red Sea from conspecifics in other areas with an overlap occurring in the NW Indian Ocean. This overlap indicates still ongoing contact between the two subspecies and does not justify the erection of a separate species. Fernández-Silva *et al.* (2016) decision to not regard the Red-Sea form as a distinctly different species is in full agreement with our findings.

This is the first study to provide evidence of considerable allometric variation in body shape of *M. flavolineatus* making it necessary to provide a separate diagnosis for juveniles. The degree of morphometric differentiation between juveniles and adults partly overrides the level of differentiation of subspecies and populations (Fig. 4). Earlier workers such as e.g. Fernández-Silva *et al.* (2016) studied specimens from a similar size range (75-288 vs. 65-288 mm SL), but did not consider size-related body-shape variation in intraspecific comparisons. The present study shows that splitting the sample into two size groups to study juveniles and adults/subadults separately allows one to account for important allometric changes that coincide well with ontogenetic shifts in resource use (Kolasinski *et al.*, 2009). During later life, less intense and more gradual changes appear. Comparative studies of larger samples of juveniles from various populations would be required to gain more information about this size- and life-history-related differentiation process and to search for possible differences in the timing and/or degree of differentiation among populations, subspecies and congeners.

The large-scale comparisons between the entire Pacific and Indian Ocean populations of *M. f. flavolineatus* do reveal much less differentiation than the comparisons of these populations with *M. f. flavicaudus*. These findings contrast with the considerable distinction in body shape of the three Wake Atoll specimens from most other conspecifics. Small-scale geographic differentiation may occur in response to specific local conditions in the rather short term (phenotypic plasticity; e.g. Uiblein *et al.*, 1998), as an evolutionary process (local adaptation; e.g. Uiblein and Heemstra, 2011), and/or as a result of restricted gene flow due to isolation (e.g. Stepien *et al.*, 1994). Larger heads and eyes, longer barbels and longer pectoral fins may all indicate adaptive differentiation in foraging mode and behaviour. No deviations in meristic characters were found and the fresh colour photographs available do not indicate any difference in colour patterns compared to other populations.

To our knowledge, no genetic data are currently available from the Wake Atoll population. The hitherto available genetic data include remote islands, such as e.g. the Johnson Atoll (Lessios and Robertson, 2013; Fernández-Silva *et al.*, 2015, 2016), but do not suggest any marked genetically based differentiation for small and rather remote areas like a single atoll. Rather, connectivity within the wider Hawaiian Archipelago, including Johnston atoll is suggested by the authors. Wide-ranging connectivity has been assumed to occur in *M. flavolineatus* due to a large body size, a long pelagic larval period, and flexibility in habitat choice and foraging behaviour (Kolasinski *et al.*, 2009; Lessios and Robertson, 2013).

The three studied specimens from Wake Atoll were collected during the Tanager expedition in 1923 and have been curated at the BPBM fish collection since. Although this species appears to be rather common (e.g. Fig. 3) and has been exploited by the local fishers for many years (Phillip Lobel, pers. obs.), no additional scientific reference material has been collected since. Because of the low sample size and the long preservation period, possibly leading to distortion in body shape, additional specimens should be collected. This would allow for the collection of tissue samples for genetic analyses and more information on morphology and fresh colour patterns.

The yellowstripe goatfish *Mulloidichthys flavolineatus*, like many other common and widely distributed goatfish species (e.g. Uiblein, 2007; Uiblein *et al.*, 2019), is frequently found at fish markets, and targeted or landed as a bycatch by local fisheries in many parts of the Indo-Pacific (e.g. Wray, 1979; Al-Abdessalaam, 1995; White *et al.*, 2013; Mehanna *et al.*, 2017; Kamikawa *et al.*, 2019). While this species appears to be of least concern regarding conservation issues at the large scale of the entire distribution (Smith-Vaniz and Williams, 2016), it would be of advantage that future population studies consider intraspecific diversity, as well as fisheries biology and influences through local ecological factors and processes.

Goatfishes qualify as valuable indicators in coastal habitat monitoring and management (Uiblein, 2007). Giving a subspecies name to a well-differentiated population may contribute to focus the attention of local fisheries and managers to an appropriate, biologically-relevant geographical unit that encompasses the respective population of the region or country where exploitation takes place. Of even higher importance, however, would be the adoption of an easily comprehensible, local common name for a distinct population under exploitation that has been, shall be or should be scientifically studied, to facilitate the communication between scientists and local stakeholders required to establish appropriate monitoring and management measures.

In agreement with the currently available scientific evidence for the Red Sea population of *Mulloidichthys flavolineatus*, here referred to under its subspecies name *M. f. flavicaudus*, we suggest the adoption of the common name “Red Sea yellowstripe goatfish”, translated into Arabic “Barbouni Shareet Asfar Al Bahr Al Ahmar”, or, in shortened version, “Barbouni Shareet Asfar”. By this way, the common name “Yellowstripe goatfish” for the valid species will be retained for the entire distribution area of *M. flavolineatus* and could be used for association with any local or regional population-related additions for management purposes. Preferably, the common name should not refer to a yellow caudal-fin colour that occurs in many areas of this widely distributed species.

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