Indian J. Fish., 66(4): 144-150, 2019
DOI: 10.21077/ijf.2019.66.4.85109-18

Note

Species delineation of lizardfishes, *Saurida pseudotumbil* Dutt and Sagar, 1981 and *Saurida tumbil* (Bloch, 1795) using multivariate tools

P. MOHANCHANDER[1, 2], P. S. LYLA[2], S. AJMAL KHAN[2], M. ASHIQ UR RAHMAN[3] AND K. PREMDASS[4]
[1]*Madras Christian College, Tambaram, Chennai - 600 059, Tamil Nadu, India*
[2]*Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai - 608 502, Tamil Nadu, India*
[3]*Hajee Karutha Rowther Howdia College, Uthamapalayam - 625 533, Tamil Nadu, India*
[4]*Kavitha's College of Arts and Science, Vaiyappamalai, Namakkal - 637 410, Tamil Nadu, India*
e-mail: mohanchander87@gmail.com

ABSTRACT

Morphometric characters of two species of lizardfishes *viz*., *Saurida pseudotumbil* Dutt and Sagar, 1981 and *Saurida tumbil* (Bloch, 1795), were studied to delineate the species using multivariate techniques. Specimens were collected from Parangipettai and Cochin waters, southern India, for recording data on 21 morphometric characters. Principal component analysis (PCA) was done after log transformation and the first three components explained 93.36% of the total variation. The most important morphometric characters determined using the eigenvectors (coefficients) of these components were post-orbital length, snout to pectoral, snout to pelvic, snout to anal, anal fin base and dorsal fin base, which showed high loading (≥0.8) in the three components. The overlapping ratio between these species ranged from 42.59 to 89.28%. The PCA data cloud of *S. pseudotumbil* and *S. tumbil* also reflected the same trend. Therefore, canonical analysis of principal coordinates (CAP) was done which clearly separated the species with maximum case allocation success (100%) for both *S. pseudotumbil* and *S. tumbil,* which clearly showed that both the species are different.

Keywords: Canonical analysis of principal coordinates (CAP), Lizardfishes, Morphometry, Multivariate analysis, Principal component analysis (PCA), Synodontidae, Taxonomy

Morphometric and meristic characters have been reported to be useful in delineating the stocks of various exploited species of fishes (Murta, 2000; Silva, 2003; O'Reilly and Horn, 2004; Turan, 2004; Turan *et al.,* 2004; Quilang *et al.,* 2007; Kumar *et al.,* 2012; Mir *et al.,* 2013a). Morphometric characters have been used as a primary tool in fish taxonomy for centuries, and still remain the primary means of describing new species (King, 1993; Inoue and Nakabo, 2006; Iwatsuki *et al.,* 2006; Kume and Yoshino, 2006; Sakai and Nakabo, 2006; Tseng *et al.,* 2009). Morphological variations can be used to identify a discrete fish stock which is important for fisheries management purposes (Elliot *et al.,* 1995; Begg *et al.,* 1999; Begg and Waldman, 1999; Palma and Andrade, 2002, 2004). Faunal investigations using classical approach have led to the description of many new cryptic fish species which also included resurrection of several synonymised ones in well-studied groups of fishes (Victor, 2007, 2010; Baldwin *et al.,* 2009, 2011; Tornabene *et al.,* 2010; Baldwin and Weigt, 2012). Species that are closely related to each other will have more similarity in view of their shared evolutionary history (Felsenstein, 1985; Ruber and Adams, 2001; Rosenberg, 2002; Guill *et al.,* 2003). Descriptive statistics and univariate techniques were reported to be found wanting in the separation of such species (Bose and De, 2013). However, multivariate techniques such as principal component analysis (PCA), factor analysis, cluster analysis and discriminant analysis were found to be quite useful in the delineation of species (Mamuris *et al.,* 1998; Mir *et al.,* 2013b).

Lizardfishes belonging to the family Synodontidae include 74 species under four genera (Eschmeyer, 2018). They are widespread in tropical and subtropical regions besides the continental shelves (Golani, 1993). *Saurida pseudotumbil* Dutt and Sagar, 1981 is a lesser known and poorly documented species, often misidentified as *Saurida tumbil* (Bloch, 1795). The name *S. pseudotumbil* was given to this species because of its marked resemblance to *S. tumbil.* Both *S. pseudotumbil* and *S. tumbil* are indistinguishable and highly similar morphologically, leading to misidentification (Dutt and Sagar, 1981; James, 2010; Najmudeen *et al.,* 2015). The morphometric analysis of lizardfishes from different parts of India was undertaken by Rao (1977) in *Saurida* spp. occurring in the Waltair Coast and by Nandha (1980) from Parangipettai waters. No work on the morphometric analysis of *S. pseudotumbil* is available globally, except that of Dutt and Sagar (1981) who discovered the species more than three decades ago using conventional methods. No further attempts were made on the taxonomy of this species post its discovery. Therefore, the present study was undertaken on the morphological characterisation and species delineation of *S. pseudotumbil* and *S. tumbil* using multivariate tools.

Specimens of *S. pseudotumbil* were collected from Mudasalodai landing centre (11°29′25.55″N; 79°45′38.62″E) Tamil Nadu, south-east coast of India and of *S. tumbil* from Cochin backwaters (9°58’08.41”N, 76°14’40.78”E), Kerala, south-west coast of India for comparison. Identity of *S. pseudotumbil* was established following Dutt and Sagar (1981) and that of *S. tumbil* using the FAO species identification sheets for fishery purposes (Western Indian Ocean, Fishing Area 51).

Morphometric characters were measured following Shindo and Yamada (1972) and Inoue and Nakabo (2006). Logging of measurements was done to the nearest 0.5 mm by making use of live fishes (as far as possible) with fine draftsman dividers (Holden and Raitt, 1974). Twenty one morphometric characters namely fork length, total length, standard length, head length, snout length, upper jaw length, lower jaw length, eye diameter (horizontal), post-orbital length, head depth, snout to pre-opercle, body depth, dorsal fin base length, anal fin base length, snout to dorsal fin, snout to adipose fin, snout to pectoral fin, snout to pelvic fin, snout to anal fin, dorsal to adipose fin and pectoral length. The overlapping ratio of the above morphometric characters between the species was determined using the following formula:

$$\text{Percentage of overlapping} = \frac{\text{Overlapping ratio}}{\text{Extreme overlapping ratio}} \times 100$$

where, Overlapping ratio = Maximum value of species A - Minimum value of species B and Extreme overlapping ratio = Maximum value of species B - Minimum value of species A.

Statistical analysis

For determining the most important morphometric characters that can be used in further analysis, principal component analysis (PCA) was done using PAST v2.14. With these important characters, species delineation was attempted employing canonical analysis of principal coordinates (CAP) using PERMANOVA+ for PRIMER.

The log transformed data were subjected to PCA, in which the first three components explained 93.36% of the total variation (Table 1). The first, second and third axes explained 73.31, 14.85 and 5.19% of the variation respectively.

The eigenvectors (coefficients) in these three components were used to determine the morphometric characters that may be of use in separating the species. Characters such as post-orbital length, snout to pectoral, snout to pelvic, snout to anal and anal fin base showed high loading of ≥ 0.8 in the first component (Fig. 1) and the dorsal fin base had high loading (Fig. 2) in the second component. These characters were used subsequently in the analysis.

Table 1. Eigen value and percentage of variance explained by PCA for the morphometric characters of *S. pseudotumbil* from Parangipettai waters

Principal component	Eigen value	% Variation	Total variation (%)
1	4.39	73.31	73.31
2	0.89	14.85	88.17
3	0.31	5.19	93.36
4	0.24	4.15	97.52
5	0.14	2.47	100

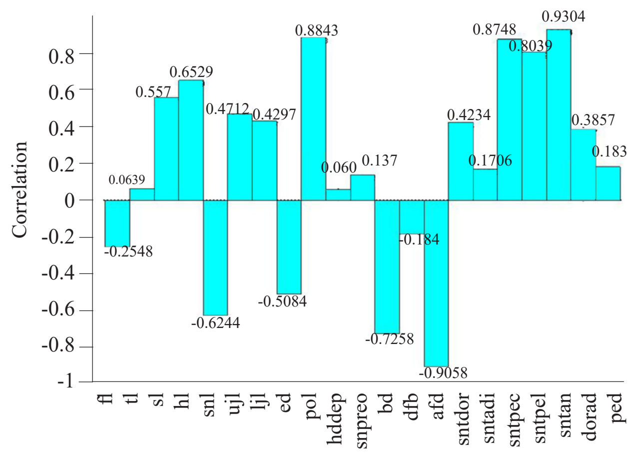

Fig. 1. Loading for factors in the first principal component based on 21 morphometric characters of *S. pseudotumbil* and *S. tumbil*

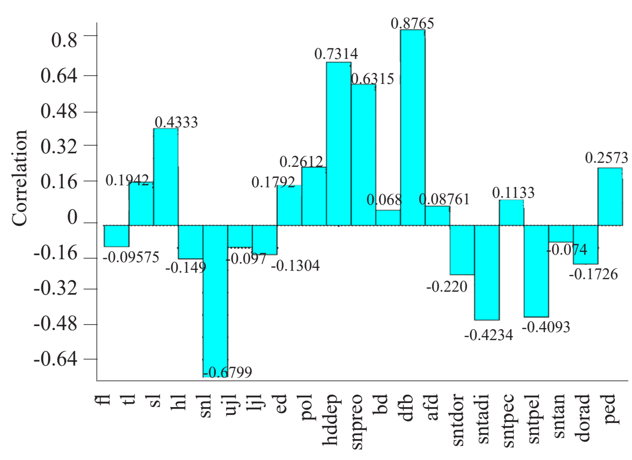

Fig. 2. Loading for factors in the second principal component based on 21 morphometric characters of *S, pseudotumbil* and *S. tumbil*

The overlapping ratio of the six morphometric characters between the two species was in the range of 42.59-89.28% (Table 2). The percentage of overlapping of post-orbital length between the two species was 56.66%; that of snout to pectoral 42.59%; snout to pelvic 73.33 %; snout to anal 62.93%; anal fin base 89.28% and dorsal fin base 75%. The points representing the morphometric characters of *S. pseudotumbil* fell on the right side and those of *S. tumbil* on the left side of the PCA plot (Fig. 3). However, overlapping of the data cloud of the two species was quite apparent. Hence the PCA analysis was not found helpful in separating the species. So canonical analysis of principal coordinates (CAP) was used to distinguish these congeners (Fig. 4).

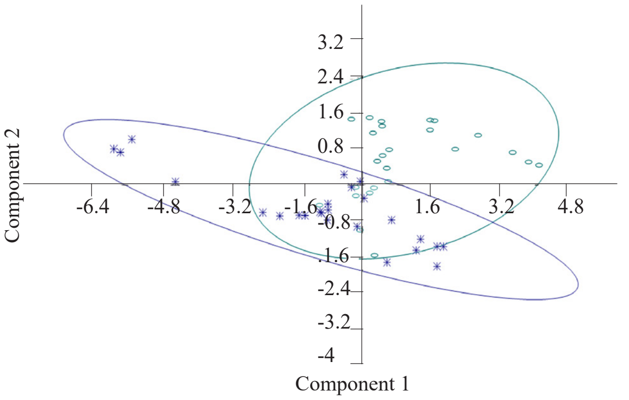

Fig. 3. Scatter diagram of principal component analysis (PCA) for morphometric data of *Saurida* spp. (Green - *S. tumbil*; Blue - *S. pseudotumbil*)

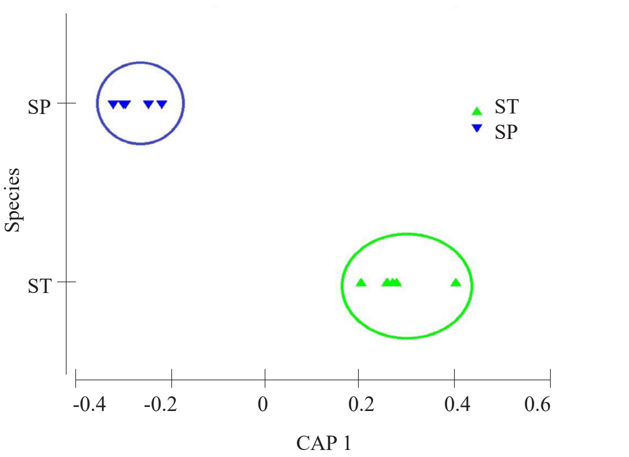

Fig. 4. Scatter diagram of CAP for morphometric data of *Saurida* spp. SP - *S. pseudotumbil*; ST - *S. tumbil*

The results of CAP analysis are given in Tables 3 and 4. The subset of axes (*m*) in the data cloud of *Saurida* spp. explained higher percentage of variation (100%). The allocation success (Table 4) of the morphometric characters to the correct species was also on the higher side (100%). In the CAP plot (Fig. 4), morphometric data of the two species did not overlap. While the data of *S. pseudotumbil* were found at the top, those of *S. tumbil* were at the bottom. Thus, CAP analysis separated the two species of *Saurida* clearly. The disadvantage of univariate approach is its inability to incorporate the hidden co-variation among morphometric parameters directly into the analysis. However multivariate approach does not have this limitation (Mir *et al.,* 2013a).

Analysis of morphological variability indicated significant differences between *S. pseudotumbil* and *S. tumbil* in external shape. Post-orbital length, snout to pectoral, snout to pelvic, snout to anal and anal fin base as well as dorsal fin base accounted for all these differences, which could possibly be attributed to habitat variability (Nicolsky, 1963). In the present study, *S. pseudotumbil* and *S. tumbil* were found to share morphometric characters and therefore overlapping persists in all six characters considered for the analysis. However the overlapping ratio was less in the snout to pectoral length (42.59%) whereas high overlapping ratio was observed in anal fin base (89.28%) of both species.

S. pseudotumbil was reported by Dutt and Sagar (1981) in Indian waters and it differs from *S. tumbil* with respect to the following characters: pectoral fins not reaching near base of pelvic fins in *S. pseudotumbil* and reaching or just short of base of pelvic fins in *S. tumbil*; caudal peduncle compressed in *S. pseudotumbil* and depressed in *S. tumbil*; inner surface of operculum black in *S. pseudotumbil* and grey in *S. tumbil* and dark grey stomach in anterior 2/3 portion of *S. pseudotumbil* and white in *S. tumbil* (Fisher and Whitehead, 1974). The findings of this study agree with those of Dutt and Sagar (1981). Besides the above, the present study found characters such as post-orbital length, snout to pectoral, snout to pelvic, snout to anal, anal fin base and dorsal fin base useful in delineating *S. pseudotumbil* from *S. tumbil*.

Many other species belonging to the genus *Saurida* have been documented by various authors. Norman (1935) reviewed nine species of lizardfishes of genus *Saurida*

Table 2. Percentage of overlapping of body proportions between the species of *Saurida*

Species	Percentage of overlapping ratio					
	Pol	Sn. to pec	Sn. to pel	Sn. to anal	Anal fin base	Dorsal fin base
S. pseudotumbil vs S. tumbil	56.66	42.59	73.33	62.93	89.28	75.00

Table 3. DIAGNOSTICS done by CAP for the morphometric data of *Saurida* spp.

M	prop.G	ssres	d_1^2	% correct
1	0.9614	1.2695	0.0206	50
2	0.9926	6.5185E-2	0.9691	100
3	0.9977	6.5426E-2	0.9771	100
4	0.9989	5.954E-2	0.9929	100
5	0.9992	4.9493E-2	0.9956	100
6	0.9995	5.0315E-2	0.9957	100
7	0.9996	5.7548E-2	0.9959	100
8	0.9998	5.4218E-2	0.999	100
9	0.9999	3.5875E-2	0.9994	100
10	1	3.4719E-2	0.9999	100
11	1	3.4719E-2	1	100

m = Subset of axes, prop.G = Proportion of variation in the data cloud described, ssres = Leave-one-out residual sum of squares, d_1^2 = Size of the first squared canonical correlation, % correct = Percentage of the left-out samples that were correctly allocated to their own group

Table 4. Cross validation of CAP results for morphometric data of *Saurida* spp. of Parangipettai waters [Leave-one-out allocation of observations to groups (for the choice of m: 2) classified]

Orig. group	*S. t*	*S. pseu*	Total	% Correct
S. t	6	0	6	100
S. pseu	0	6	6	100

Total correct: 12/12 (100%)
Mis-classification error: 0%.

from Indo-Pacific region. Norman (1939) described a new species of *S. longimanus* from the Gulf of Oman. Nandha (1980) documented the morphometric characters of lizardfishes from Parangipettai waters. Morphometric analysis was carried out for four species of lizardfish from Atlantic by Anderson *et al.* (1966). Dobzansky (1970) opined that composite effect of genotype and environment bring out changes in the morphometric characters as natural selection favours them. Shindo and Yamada (1972) recognised the species *S. filamentosa* as a valid one and described three new species *viz., S. isarankurai* and *S. micropectoralis* in Gulf of Thailand and *S. wanieso* in East China Sea. Golani (1993) studied morphometric characters of *S. undosquamis* from Mediterranean waters and made comparison with the indigenous confamilial *Synodus saurus*. Russell (1999) revised the key characters of Synodontidae of Western Central Pacific region. The morphological characters of *Trachinocephalus myops* occurring in Chennai waters were studied by Kizhakudan and Gomathy (2007). Golani and Bogorodsky (2010) described the morphometric characters of three species belonging to genus *Saurida* from Red Sea. Russell (2011) did the morphometric analysis of *S. golanii*, a new deep-water lizardfish species occurring in the Gulf of Aqaba, northern Red Sea. The morphometric and meristic characters of *S. tumbil* were derived by Rahimibashar *et al.* (2012) from north of the Persian Gulf. A systematic study was made by Frable *et al.* (2013) from Caribbean waters on a new species of western Atlantic lizardfish, *Synodus bondi*. All the studies carried out reported the existence of shared morphology and overlapping of morphological characters.

Similarly, higher overlapping in the morphometric characters of the Synodontid fishes, particularly among the species belonging to genus *Saurida,* was reported by Rao (1977), Dutt and Sagar (1981) and Russell (2011). Hence, CAP analysis was made use of here. CAP is a tool which carries out the analysis employing the principal coordinates. CAP finds axes in the multivariate cloud of data that are good in differentiating the *priori* groups. The advantage of this constrained tool is that it finds out the real differences among *a priori* group which is not possible with the unconstrained ordination methods such as PCA, multi-dimensional scaling (MDS) and principal coordinates analysis (PCO). One added advantage of this procedure is that once it has been done for a set of data, new observations that are made from the same area or other areas can be fit into the existing groups. When the model has been developed for various species of fishes belonging to a particular group, given a new fish that has values for each of these same measures, it can allocate or classify that fish into one of the groups using this routine (Anderson *et al.,* 2008). Taking into consideration this advantage, this tool was employed in the present study to separate the two species of *Saurida* (Rahman *et al.,* 2013). What is worthy of taking note is the 100% allocation success for both *S. pseudotumbil* and *S. tumbil* which clearly showed that both the species are different, as pointed out by Dutt and Sagar (1981). As this study has established separate identity of *S. pseudotumbil*, fishing strategies could be evolved for this species also for judicial management of stocks.

References

Anderson, W. W., Gehringer, J. W. and Berry, F. H. 1966. Family-Synodontidae, lizardfishes. Fishes of the Western North Atlantic, Sears Found. *Mar. Res. Mem.,* 1(5): 30-102.

Anderson, M. J., Gorley, R. N. and Clarke, K. R. 2008. *PERMANOVA for PRIMER: Guide to software and statistical methods*. PRIMER-E Ltd., Plymouth, UK, 214 pp.

Baldwin, C. C. and Weigt, L. A. 2012. A new species of soapfish (Teleostei: Serranidae: *Rypticus*), with redescription of *R. subbifrenatus* and comments on the use of DNA barcoding in systematic studies. *Copeia*, 1: 23-36. doi.org/10.1643/CG-11-035.

Baldwin, C. C., Castillo, C. I., Weigt, L. A. and Victor, B. C. 2011. Seven new species within western Atlantic *Starksia atlantica*, *S. lepicoelia* and *S. sluiteri* (Teleostei: Labrisomidae), with comments on congruence of DNA barcodes and species. *ZooKeys*, 79: 21-72. doi: 10.3897/zookeys.79.1045.

Baldwin, C. C., Weigt, L. A., Smith, D. G. and Mounts, J. H. 2009. Reconciling genetic lineages with species in western Atlantic *Coryphopterus* (Teleostei: Gobiidae). In: Lang, M. A. Mancintyre, I. G. and Rutzler, K. (Eds.), *Proceedings of the Smithsonian Marine Science Network Symposium*; 15-16 November 2007, Smithsonian Institution Scholarly Press, Washington, DC, USA, p. 113-140.

Begg, G. A. and Waldman, J. R. 1999. An holistic approach to fish stock identification. *Fish. Res.,* 43: 35-44.

Begg, G. A., Friedland, K. D. and Pearce, J. B. 1999. Stock identification and its role in stock assessment and fisheries management: An overview. *Fish. Res.,* 43: 1-8. doi.org/10.1016/S0165-7836(99)00062-4.

Bose, R. and De, A. 2013. Quantitative evaluation reveals taxonomic over-splitting in extinct marine invertebrates: Implications in conserving biodiversity. *Proc. Natl. Acad. Sci. India. Sect. B. Biol. Sci*., doi: 10.1007/407s40011-013-0179-5.

Dobzansky, T. 1970. *Genetic of evolutionary process*. Columbia University Press, New York, USA.

Dutt, S. and Vidya Sagar, J. 1981. *Saurida pseudotumbil* - A new species of lizardfish (Teleostei: Synodidae) from Indian coastal waters. *Indian Nal. Sci. Acad.,* 47: 845-851.

Elliot, N. G., Haskard, K. and Koslow, J. A. 1995. Morphometric analysis of orange roughy (*Hoplostethus atlanticus*) off the continental slope of southern Australia. *J. Fish. Biol.,* 46: 202-220. https://doi.org/10.1111/j.1095-8649.1995.tb05962.x.

Eschmeyer, W. N. 2018. *Catalog of fishes: genera, species, references*. Electronic version. http://research. calacademy.org/research/ichthyology/catalog/fishcatmain.asp (Accessed 12 February 2015).

Felsenstein, J. 1985. Confidence limits on phylogenies - an approach using the bootstrap. *Evolution*, 39: 783-791. DOI: 10.1111/j.1558-5646.1985.tb00420.x.

Fischer, W. and Whitehead, P. J. P. 1974. Nemipteridae. In: Fischer, W. and Whitehead, P. J. P. (Eds.), *FAO species identification sheets for fishery purposes, Eastern Indian Ocean*. Food and Agricultural Organisation of the United Nations, Rome, Italy. 3: 2-12.

Frable, B. W., Baldwin, C. C., Luther, B. M. and Weigt, L. A. 2013. A new species of western Atlantic lizardfish (Teleostei: Synodontidae: *Synodus*) and resurrection of *Synodus bondi* Fowler, 1939, as a valid species from the Caribbean with redescriptions of *S. bondi*, *S. foetens* (Linnaeus, 1766) and *S. intermedius* (Agassiz, 1829). *Fish. Bull*., 111(2): 122-146. DOI: https://doi.org/10.7755/FB.111.2.2.

Golani, D. 1993. The biology of the Red Sea migrant, *Saurida undosquamis* in the Mediterranean and comparison with the indigenous confamilial *Synodus saurus* (Teleostei: Synodontidae). *Hydrobiol*., 271: 109-117.

Golani, D. and Bogorodsky, S. V. 2010. The fishes of the Red Sea-Reappraisal and updated checklist. *Zootaxa*, 2463: 1-135.

Guill, J. M., Heins, D. C. and Hood, C. S. 2003. The effect of phylogeny on inter-specific body shape variation in Darters (Pisces: Percidae). *Syst. Biol*., 52: 488-500. DOI: 10.1080/10635150390197019.

Holden, M. J. and Raitt, D. F. S. 1974. Manual of fisheires science Part 2, Methods of resource investigation and their application. *FAO Fish. Tech. Pap.*, 115: 214 pp.

Inoue, T. and Nakabo, T. 2006. The *Saurida undosquamis* group (Aulopiformes: Synodontidae), with description of a new species from southern Japan. *Ichthyol. Res*., 53(4): 379-397.

Iwatsuki, Y., Kimura, S. and Yoshino, T. 2006. A new sparid, *Acanthopagrus akazakii*, from New Caledonia with notes on nominal species of *Acanthopagrus*. *Ichthyol. Res*., 53: 406-414.

James, P. S. B. R. 2010. Taxonomic status of marine pelagic fishes of India, research priorities and conservation strategies for the sustainability of their fisheries. *Indian J. Anim. Sci.,* 80: 39-45.

King, M. 1993. Species evolution. *The role of chromosome change*. Cambridge University Press, Cambridge, UK.

Kizhakudan, S. J. and Gomathy, S. 2007. Unusual landings of the blunt nose lizardfish *Trachinocephalus myops* (Forster, 1801) at Chennai, with a note on some aspects of biology. *J. Mar. Biol. Ass. India*, 49 (2): 250-253.

Kumar, T., Chakraborty, S. K., Jaiswar, A. K., Sandhya, K. M. and Panda, D. 2012. Biometric studies on *Johnieops sina* (Cuvier, 1830) along Ratnagiri coast of Maharashtra. *Indian J. Fish*., 59(1): 7-13.

Kume, M. and Yoshino, T. 2006. *Acanthopagrus chinshira*, a new sparid fish (Perciformes: Sparidae) from the East Asia. *Bull. Nat. Mus. Nat. Sci*., 2: 47-57.

Mamuris, Z., Apostolidis, A. P., Panagiotaki, P., Theodorou, A. J. and Triantaphyllidis, C. 1998. Morphological variation between red mullet populations in Greece. *J. Fish. Biol*., 52: 107-117. doi.org/10.1111/j.1095-8649.1998.tb01556.x.

Mir, J. I., Mir, F. A. and Patiyal, R. S. 2013a. Phenotypic variation among three populations of Shirruh snowtrout, *Schizothorax esocinus* (Heckel, 1838) with insights from truss network system in Kashmir Himalaya. *Proc. Natl. Acad. Sci. India. Sect. B. Biol. Sci*., doi: 10.1007/s40011-013-0194-6.

Mir, J. I., Sarkar, U. K., Dwivedi, A. K., Gusain, O. P. and Jena, J. K. 2013b. Stock structure analysis of *Labeo rohita* (Hamilton, 1822) across the Ganga basin (India) using a truss network system. *J. Appl. Ichthyol*., doi: 10.1111/jai.12141.

Murta, A. G. 2000. Morphological variation of horse mackerel (*Trachurus trachurus*) in the Iberian and North Africa Atlantic: Implications for stock identification. *ICESJ. Mar. Sci*., 57: 1240-1248. doi:10.1006/jmsc.2000.0810.

Najmudeen, T. M., Sivakami, S., Seetha, P. K., Kishore, T. G., Divya, N. D. and Zacharia, P. U. 2015. Lizardfish fishery of Kerala with some aspects of the stock characteristics of the greater lizardfish (*Saurida tumbil*). *Indian J. Fish.,* 62: 31-36.

Nandha, R. R. 1980. *Studies on the lizardfishes off Porto Novo*. Ph. D. Thesis. Annamalai University, India, 172 pp.

Nicolsky, G. V. 1963. *The ecology of fishes.* Academic Press, London, UK, 352 pp.

Norman, J. R. 1935. A revision of the lizardfishes of the genera *Synodus*, *Trachinocephalus* and *Saurida*. *Proc. Zool. Soc. London,* p. 99-135.

Norman, J. R. 1939. Fishes. *Sci. Rept. John Murray Exped*., 7(1): 23-24.

O'Reilly, K. M. and Horn, M. H. 2004. Phenotypic variation among populations of *Atherinops affinis* (Atherinopsidae) with insights from a geometric morphometric analysis. *J. Fish. Biol*., 64: 1117-1135. doi.org/10.1111/j.1095-8649.2004.00379.x.

Palma, J. and Andrade, J. P. 2002. Morphological study of *Diplodus sargus*, *D. puntazzo* and *Lithognathus mormyrus* (Sparidae) in the eastern Atlantic and Mediterranean Sea. *Fish. Res*., 57: 1-8. doi.org/10.1016/S0165-7836(01)00335-6.

Palma, J. and Andrade, J. P. 2004. Morphological study of *Pagrus pagrus*, *Pagellus bogaraveo* and *Dentex dentex* (Sparidae) in the eastern Atlantic and Mediterranean Sea. *J. Mar. Biol. Ass. UK*, 84: 449-454.

Quilang, J. P., Basiao, Z. U., Pagulayan, R. C., Roderos, R. R. and Barrios, E. B. 2007. Meristic and morphometric variation in the silver perch, *Leiopotherapon plumbeus* (Kner, 1864), from three lakes in the Philippines. *J. Appl. Ichthyol*., 23: 561-567. doi.org/10.1111/j.1439-0426.2007.00862.x.

Rahimibashar, M. R., Alipour, V., Hamidi, P. and Hakimi, B. 2012. Biometric characteristics, diet and gonad index of lizardfish (*Saurida tumbil*, Bloch 1795) in North of the Persian Gulf. *World J. Fish Mar. Sci*., 4(1): 1-6. DOI: 10.5829/idosi.wjfms.2012.04.01.61253.

Rahman, M. A. U., Ajmal Khan, S., Lyla, P. S. and Prasanna Kumar, C. 2013. DNA Barcoding resolves taxonomic ambiguity in Mugilidae of Parangipettai waters (south-east coast of India). *Turkish J. Fish. Aquat. Sci*., 13: 321-330. DOI: 10.4194/1303-2712-v13_2_14.

Rao, K. V. 1977. Systematics and comparative osteology of Indian lizard fishes (*Saurida* spp.). *Indian J. Fish*., 24(1 & 2): 143-171.

Rosenberg, M. S. 2002. Fiddler carb claw shape variation: a geometric morphometric analysis across the genus *Uca* (Vrustacea: Brachyura: Ocypodidae). *Biol. J. Linn. Soc*., 75: 147-162. DOI:10.1046/j.1095-8312.2002.00012.x.

Ruber, L. and Adams, D. C. 2001. Evolutionary convergence of body shape and trophic morphology in Cichlids from Lake Tanganyika. *J. Evol. Biol*., 14: 325-332. doi.org/10.1046/j.1420-9101.2001.00269.x.

Russell, B. C. 1999. Synodontidae. In: Carpenter, K. E. and Niem, V. H. (Eds.), *The living marine resources of the Western Central Pacific*. Food and Agricultural Organisation of the United Nations. Rome, Italy, 3(1): 1928-1945.

Russell, B. C. 2011. *Saurida golanii*, a new deep water lizardfish (Pisces: Synodontidae) from the Gulf of Aqaba, northern Red Sea. *Zootaxa*, 3098: 21-25. doi.org/10.11646/zootaxa.3098.1.2.

Sakai, K. and Nakabo, T. 2006. Taxonomic reviews of two Indo-Pacific sea chubs, *Kyphosus cinerascens* (Forsskal, 1775) and *K. sydneyanus* (Gunther, 1886). *Ichthyol. Res*., 53: 337-356.

Shindo, S. and Yamada, U. 1972. Description of three new species of the lizardfish genus *Saurida* with a key to its Indo-Pacific species. *U.O*., 12(12): 1-14.

Silva, A. 2003. Morphometric variation among sardine (*Sardina pilchardus*) populations from the north-eastern Atlantic and the western Mediterranean. *ICESJ. Mar. Sci*., 60: 1352-1360.

Tornabene, L., Baldwin, C. C., Weigt, L. A. and Pezold, F. 2010. Exploring the diversity of western Atlantic *Bathygobius* (Teleostei: Gobiidae) using mitochondrial cytochrome *c* oxidase-I, with descriptions of two new species. *Aqua. J. Icthyol. Aquat. Biol*., 16: 141-170.

Tseng, M. C., Jean, C. T., Tsai, W. L. and Chen, N. C. 2009. Distinguishing between two sympatric *Acanthopagrus* species from Dapeng Bay, Taiwan, using morphometric and genetic characters. *J. Fish. Biol*., 74: 357-376. doi.org/10.1111/j.1095-8649.2008.02049.x.

Turan, C., Erguden, D.,Turan, F. and Gurlek, M. 2004. Genetic and morphologic structure of *Liza abu* population from the rivers Orontes, Euphrates and Tigris. *Turkish J. Vet. Anim. Sci*., 28: 729-734.

Turan, C. 2004. Stock identification of Mediterranean horse mackerel (*Trachurus mediterraneus*) using morphometric and meristic characters. *ICES J. Mar. Sci*., 61: 774-781. DOI:10.1016/j.icesjms.2004.05.001.

Victor, B. C. 2007. *Coryphopterus kuna*, a new goby (Perciformes: Gobiidae: Gobiinae) from the western Caribbean, with the identification of the late larval stage and an estimate of the pelagic larval duration. *Zootaxa*, 1526: 51-61. DOI: 10.5281/zenodo.273846.

Victor, B. C. 2010. The redcheek paradox: The mismatch between genetic and phenotypic divergence among deeply divided mtDNA lineages in a coral-reef goby, with the description of two new cryptic species from the Caribbean Sea. *J. Ocean Sci*., 3: 1-16.

Date of Receipt : 24.11.2018
Date of Acceptance : 02.10.2019