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The Occurrence of *Cynoglossus macrolepidotus* (Bleeker, 1851) and *Cynoglossus arel* (Bloch & Schneider, 1801) Along the Mumbai Coast, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The results of the morphometric, meristic, and osteological study, including scale, otoliths, and radiographs for distinguishing *Cynoglossus arel* (Bloch & Schneider, 1801) and *C. macrolepidotus* (Bleeker, 1851) presented here. A total of 72 specimens of *C. arel* and 37 specimens of *C. macrolepidotus* collected from the Indian coast (Mumbai, Ratnagiri, and Veraval) from August 2013 to May 2014. It was found that the shape, structure of otoliths; vertebrae number species through

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radiographs; type, shape, and ctenii structure and number are the primary tool for taxonomy and used for species discrimination. In this study, two species C. *arel* and *C. macrolepidotus,* are discriminated based on their morphological and osteological characters. It proved that *C. macrolepidotus* is a valid species, and also found in the west coast of India along with *C. arel.*

Keywords: Cynoglossus arel; Cynoglossus macrolepidotus; scales; otoliths; radiographs.

1. INTRODUCTION

Aquatic biodiversity, particularly that of fishery resources, is showing a decreasing trend due to many human-related activities, especially overexploitation and habitat destruction. Thus, sustainable management of these resources has become imperative. In this context, for assessment of stocks and population, and finally conservation and management of biodiversity, correct identification of species is the primary prerequisite. The catch statistics of any fishery resources will be projected incorrectly if the species is misidentified, which leads to the formulation of an incorrect management plan.

Identification and position are ambiguous in hierarchical order in many groups of fishes. Family Cynoglossidae, which incorporates 146 species worldwide and 21 species in India [1], shows ambiguity in species identity due to overlapping of taxonomic characters, including two large-scale tongue soles viz. *Cynoglossus arel* and *C. macrolepidotus*. Temporal scale composition and abundance of fish species might have changed due to the introduction of bottom trawlers in India [2], or might be earlier *C. semifasciatus* were misidentified. New species are sometimes described based on a single specimen and a small set of characters. The limited set of characters may not be enough to identify and discriminate from other similar (cryptic) species [2]. The relevant taxonomic research on family Cynoglossidae carried out in other parts of world includes Kaup [3]; Günther, [4]; Jordan, [5]; Torchio, [6]; Menon, [7]; Hussain et al., [8]; Masuda, [9]; Ahlstrom et al., [10]; Kottelat, [11]; Heemstra, [12]; Roberts, [13]; Yokogawa et al., [14]; Teugels, [15]. The work of Punpoka [16] on the flatfishes of the Gulf of Thailand is the latest detailed taxonomic work in the Indo-Pacific region. In India, significant contributors are Day [17], Weber and Beaufort [18], Norman [19], Munro [1], Ramanathan, et al. [20], and Chapleau [21]. For the Indian species of the family Cynoglossidae, the most related taxonomic account is that of Norman [19] and Menon [7]. Weber and Beaufort [18] included some of the Indian species in their descriptive account of the family. As Norman's work [19] was based primarily on Indian material, it would be more reliable to follow his key for identification purposes; however, the publications of Punpoka [16] and Weber and Beaufort [18] are also being used for comparative purposes.

Some of the authors are of the view that *C. macrolepidotus* is not a valid species, it just a synonym of *C. arel* [22,23]. Others [24,25] opined that it is a valid species but does not occur in India. In this context, present study deals with the validity and occurrence of *C. macrolepidotus* in India along with *C. arel.*

2. MATERIALS AND METHODS

The specimens were collected from three landing centres of Mumbai (Sassoon dock, New Ferry Wharf, and Versova), Veraval and Ratnagiri captured by trawls operated at a depth of 20 to 30 fathoms. Fresh fishes caught by dot and gill nets landed in the morning at Versova were mostly collected. The collections were made twice a week from August 2013 to April 2014. Morphological characters were studied in fresh conditions, later, the scale and the outlets were extracted, cleaned with KOH, photographed and studied for their morphological traits. Some of the specimens were subjected to radiography.

Morphometric: The morphometric characters were measured on the ocular side of each specimen, using a pair of needlepoint dividers and recording to the nearest one-tenth of a millimeter by Vernier Caliper in the fresh condition following (Simpson, 1995). All the specimens were segregated into Type I matching with *Cynoglossus arel* and Type II matching with *Cynoglossus macrolepidotus*. A total of 72 specimens of type I and 35 specimens of type II were used for the study. A total of 10 morphometric and seven meristic characters was selected for the study. The morphometric characters selected were the total length (TL),

Standard length (SL), Body depth (BD), Head length (HL), Snout length (Snout length), Eye diameter (ED), Inter-orbital distance (IOL), Snout to mouth distance (SM), Mouth to gill distance (MG) and Mouth distance (MD). From the data of morphometric measurements, specific ratios commonly used in taxonomy *viz.,* head in total length, head in standard length, height in total length, body length in total length, body height in total length, snout in head length, eye diameter in snout length, eye diameter in head length, and the inter-orbital width in eye diameter, were calculated. Pearson's coefficients of variation (i.e. the percentage levels of the standard deviations in the mean values of the ratios) have been used for studying the variability of the ratios [26-28].

The meristic characters considered in the present study were numbers of dorsal fin rays, anal fin rays, caudal-fin rays, pectoral fin rays, rows of scales between above and mid-lateral line on eyed side and number of scales on mid-lateral line (from the cephalic junction or commissure to the base of caudal fin).

Multivariate analyses: In this study, we adopted discriminant analysis for testing hypotheses of morphologic similarities or differences employing pairwise comparisons between two groups, by projecting a multivariate data set down to one dimension and maximizing separation between groups separated a prior. Discriminant analysis is therefore useful for testing hypotheses of morphological similarities, and a significant 90% or greater separation between two groups is considered enough to support the presence of two different morphotypes. In paleontology, this multivariate approach previously has been used, for example, to test variations within a single population and to identify isolated dinosaur teeth. Other than being a support for PCA, discriminant analysis therefore is employed herein to test if measurements are useful to differentiate the two species, assigning them to a specific taxon, and to infer phylogenetic hypotheses. The significance (p-value) of each pairwise comparison was determined using Hoteling's T2 distribution- test to determine significance at $p < 0.05$ [29,30].

Scales– During the study, 4 scales were extracted from 4 fixed locations belonging to Eyed above normal (EAN), Eyed above lateral line (EAL), Eyed mid-lateral line (EML) and Non-eyed above normal (NAN) and preserved in alcohol: glycerin (50:50) + water solution at room temperature. After extraction, the attached tissue was removed by cleaning with a high concentration of KOH solution. Therefore, these scales were photographed by the Leica Stereo zoom microscope for further study of the morphological characters.

Otoliths **–** Otoliths were extracted from 5 specimens of both species. After rinsing with alcohol slowly, the otoliths were preserved in the alcohol in 5 ml tubes at room temperature. For further study on morphology and shape, the otoliths were photographed with the Leica Stereo zoom microscope.

Radiographs– The specimens were radiographed by soft X-rays. In this method the fishes were taped closer to the film holder containing high contrast film and exposed at 22 kv. 124 milliamp-seconds, with the X ray unit focused about 20 inches from the object.

Statistical analysis: This study differentiated *Cynoglossus macrolepidotus* from *Cynoglossus arel* by employing multivariate analysis and descriptive analysis via PAST software.

3. RESULTS AND DISCUSSION

The study on taxonomic differentiation of two close species of Cynoglossus was conducted based on specimens of morphological characters and hard parts (vertebrae, otoliths and scales).

Observation –

1. The number of ctenii is not a prominent character as it is not fixed within a species.
2. The shapes of scales, position of lateral line groove, and length of lateral line groove are significant in differentiation of these fishes.
3. The shape of the scales of specimen of Type I and Type II are rounded and rectangular, respectively.
4. From the same size of fish, the Type II has larger and angular scales from the non-eyed above normal scales.

3.1 Comparative Study of Type I and Type II Based on their Radiographs

Comments –From every vertebral spine, there are two dorsal and anal fins originated.

Table 1. Descriptive analysis of selected morphometric traits of *Cynoglossus* Type I and Type II

Species	Parameters	Type I	Type II
Standard length	Range	164.33 – 293.45	137.72 – 250.01
	Mean and S.D.	223.61 ± 38.95	184.94 ± 27.40
	S.E. and P.C.	4.59 and 14.12	4.80 and 14.81
Total length	Range	179.25 - 303.63	148.69 – 272.92
	Mean and S.D.	243.43 ±39.87	204.20 ± 32.67
	S.E. and P.C.	4.69 and 16.37	5.37 and 15.99
Body depth 1	Range	35.68-61.28	28.9 – 55.02
	Mean and S.D.	46.57± 7.87	39.24 ± 6.13
	S.E. and P.C.	0.92 and16.99	1.00 and 15.62
Body depth 2	Range	46.31 – 69.24	31.93 – 59.21
	Mean and S.D.	52.63 ± 8.87	42.91 ± 6.28
	S.E. and P.C.	1.04 and 16.85	1.02 and 14.63
Length at body depth 2	Range	39.58 – 77.65	35.35 – 69.18
	Mean and S.D.	59.09 ± 11.03	50.39 ± 9.17
	S.E. and P.C.	1.30 and 18.66	1.50 and 18.19
Eye diameter	Range	2.56 – 4.69	2.3 – 5.13
	Mean and S.D.	3.47 ± 0.64	3.11 ± 0.59
	S.E. and P.C.	0.07 and 18.44	0.097 and 18.97
Inter-orbital length	Range	1.33 – 5.18	0.84 – 4.2
	Mean and S.D.	2.69 ± 1.01	1.91 ± 0.74
	S.E. and P.C.	0.11 and 37.54	0.12 and 38.74
Snout length	Range	13.18 – 30.36	13.53 – 24.43
	Mean and S.D.	20.62 ± 3.86	17.72 ± 3.34
	S.E. and P.C.	0.45 and 18.71	0.55 and 18.85
Head length	Range	35.03 – 68.72	30.48 – 60.14
	Mean and S.D.	52.29 ± 9.76	43.25 ± 8.01
	S.E. and P.C.	1.15 and 18.66	1.31 and 18.52
Snout to mouth	Range	15.68 – 36.39	17.44 – 32.64
	Mean and S.D.	26.31 ± 4.63	23.32 ± 4.91
	S.E. and P.C.	0.54 and 17.59	0.80 and 21.05
Mouth to gill	Range	22.68 – 40.61	16.91 – 34.91

Species	Parameters	Type I	Type II
	Mean and S.D.	30.69 ± 4.97	26.36 ± 3.61
	S.E. and P.C.	0.58 and 16.19	0.59 and 13.69
Mouth distance	Range	6.38 – 14.28	6.55 – 11.54
	Mean and S.D.	10.28 ± 2.16	8.73 ± 1.21
	S.E. and P.C.	0.25 and 21.01	0.20 and 13.86

Table 2. Comparative table of the range, mean values and standard deviation (S.D) and standard error (S.E) and Pearson's Coefficient (P.C) for selected morphometric ratios of Type I and Type II

Species	Parameters	Type I	Type II
Head in total length (TL/HL)	Range	4.047– 5.60	4.30 – 5.26
	Mean	4.7	4.74
Head in standard length (SL/HL)	Range	3.8057 – 5.015	3.8057 – 4.886
	Mean	4.299	4.314
Body depth in total length (TL/BD1)	Range	4.491 – 6.78	4.69 – 5.75
	Mean	5.24	5.20
Body depth in total length (TL/BD2)	Range	3.974 – 6.004	4.35 – 5.28
	Mean	4.64	4.75
Body depth in Standard length (SL/BD1)	Range	4.2067 – 6.075	4.238 – 5.2127
	Mean	4.807	4.724
Body depth in Standard length (SL/BD2)	Range	3.72 – 5.37	3.93 – 4.79
	Mean.	4.25	4.31
LB/HL	Range	1.13 – 1.43	1.1269 – 1.2237
	Mean	1.56	1.1656
Standard length in total length (TL/SL)	Range	0.912 – 1.12	1.0519 – 1.147
	Mean	1.09	1.10
Mouth-gill distance to head length (HL/SM)	Range	1.616 – 2.616	1.639 – 2.552
	Mean	1.99	1.871
Mouth distance to head length (HL/MD)	Range	4.42 – 6.63	3.829 – 6.059
	Mean	5.13	4.9189
Snout in head length (HL/SN)	Range	2.185 – 2.894	2.1894 – 2.894
	Mean	2.54	2.44
Eye diameter in snout length (SN/ED)	Range	4.51 – 7.84	4.64 – 7

Species	Parameters	Type I	Type II
Eye diameter in head length (HL/ED)	Mean	5.97	5.73
	Range	11.99 – 18.87	10.939 – 17.378
Interorbital width in eye diameter (ED/IOL)	Mean	15.13	14.01
	Range	0.722 – 2.535	0.8976 – 3.95
	Mean	1.40	1.8859

Table 3. Morphology of a specimen of Type I and Type II

Parameters	Type I	Type II
Snout shape	Triangular or pointed	Circular
Position of eye	Second starts at point where first one completes half	First and second starts simultaneously or little difference is there
Presence of dark band along the dorsal and anal fin	Absent	Present
Presence of small patch near operculum	Absent	Present
Hook length	Just crosses the hind portion of the second eye/lower eye	Runs one eye diameter after the hind part of the second/lower eye.
Colour (in fresh condition)	Pinkish or slightly brownish	Brownish (dark) with dark bluish band along dorsal and anal borders of the body.
Scales	Very much deciduous	A little bit strong and not deciduous
Tinge on scales	No any tinge	A golden tinge on all over the body scales, dorsal side prominent.

Table 4. Comparative study of Type I and Type II *Cynoglossus* based on scale shape form 4 different locations

Position	Type I	Type II
Eyed above normal	Width is not uniform, radii are distorted, start of radii formation far from the lateral line groove formation, anterior portion is much broader as compared to posterior, ctenii does not form a triangular shape at the posterior part	Width is uniform, radii are not distorted, the start of radii is just from the end of lateral line grooves end, ctenii are able to form a triangular shape at the posterior part,
Eyed above lateral line	The end of lateral line groove and the radii are not so much close, the scale is somewhat rounded, the groove of lateral line is conical but bulged at the end.	The end of lateral line groove and the radii are overlapped, the scale is somewhat rectangular, the groove of the lateral line is conical and pointed.
Eyed mid lateral line	The shape of scale is rounded,	The shape of scales is rectangular,
Non eyed normal	The shape of scale is rounded	The shape of scales is rectangular and angular in structure.

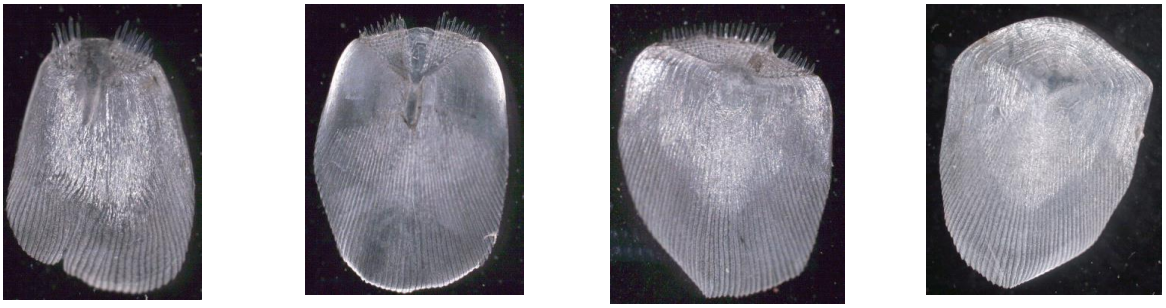
Table 5. Morphometric measurements and meristic counts of *Cynoglossus macrolepidotus* described by different authors

Authors	Dorsal fin rays	Ventral fin rays	Anal fin rays	Caudal fin rays	No. of scales on lateral line	HL in TL	BD in TL	SN in HL	ED in HL	ED in SL	SBL
Day [17]	116-118	4	86-90	11	50-55	4.33-4.67	4.50-4.75	---	14.0-15.0	4.0-4.50	6-7
Weber and Beufort [18]	107-118	4	82-89	----	48-55	4.3-4.5	4.2-4.3	-----	11.0-15.0	---	6-7
Munro [1]	105-130	---	80-96	--	56-66	--	-----	----	----	----	7-9
Moorthy and Josheph [26]	115-120	4	84-90	11	50-59	3.65-4.8	3.6-5.12	2.07-2.52	7.38-11.67	3.25-8.4	6-8
Present study (2014)	91-121	4	57-96	10	57-79	4.30-5.26	4.69-5.75	2.1-2.8	10.9-17.3	-----	8-10

Table 6. Morphometric measurements and meristic counts of *Cynoglossus arel* described by different authors

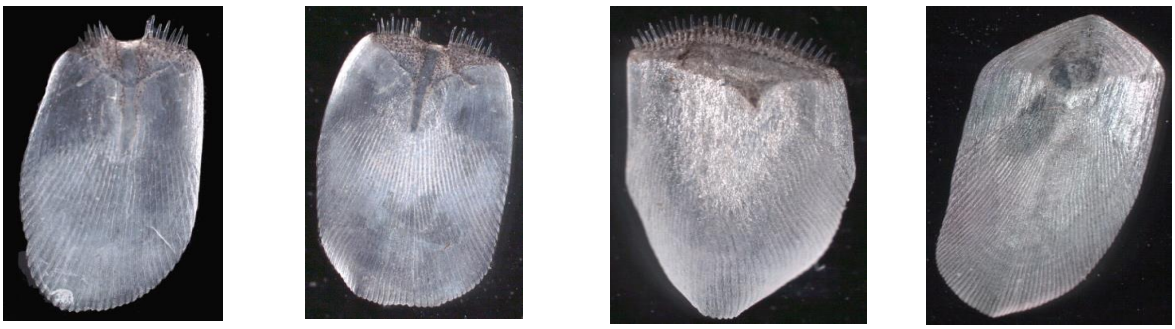
Authors	Dorsal fin rays	Ventral fin rays	Anal fin rays	Caudal fin rays	No. of scales on lateral line	HL in TL	BD in TL	SN in HL	ED in HL	SBL
Day [17]	104-114	4	85	12	95	4.75	5	---	----	7
Munro [1]	122-138	----	90-109	------	60-65	-----	-----	------	-----	8-10
Hussain and Alikhan [8]	119-126	-	92-106	-----	50-53	4.5-4.6	4.4-5.0	2.2-2.7	16-17.2	7-9
Talwar and Kacker [27]	116-130	-----	85-98	10	56-70	---	----	-----	-------	7-9
Menon [7]	116-130	4	85-98	10	56-70	3.52-5.99	3.87-5.01	2.38-4.84	9.21-15.12	7-9
Present study (2014)	104-127	4	82-97	10	57-73	4.04-5.6	4.49-6.78	2.57-2.72	14.12-15.7	7-9

***Cynoglossus arel* (I)**



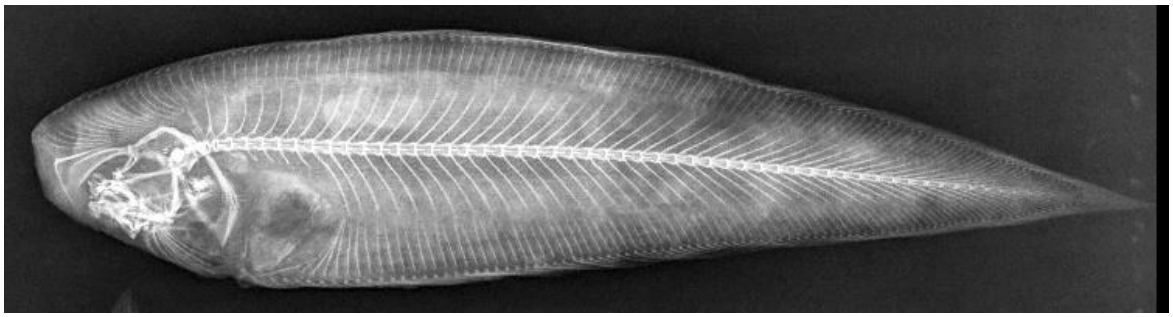
A **B** **C** **D**

***Cynoglossus macrolepidotus* (II)**



A **B** **C** **D**

Type I: *Cynoglossus arel*



Type II: *Cynoglossus macrolepidotus*

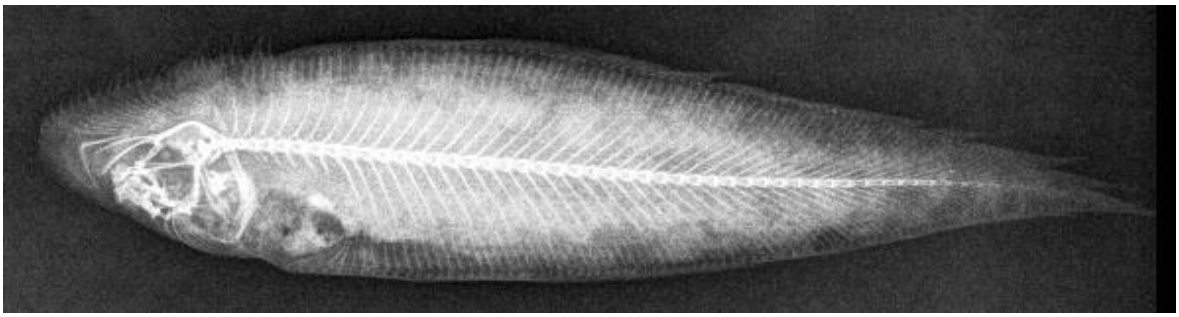


Plate 1. Photos of Scales of *Cynoglossus arel* (I) and *Cynoglossus macrolepidotus* (II) (A: eyed above lateral, B: eyed mid lateral, C: eyed mid normal and D: non-eyed mid normal)

Abdominal vertebrae have only dorsal spines and no anal spines while in caudal vertebrae both the dorsal and anal fin rays are present. This is so because after the anus anal fin is originated. The number of vertebral column in Type I is (9 + 41) and those in Type II is (9 + 38). The study revealed that Type I and Type II are two distinct species namely *C. arel and C. macrolepidotus* respectively.

Different authors have described *C. arel* and *C. macrolepidotus* based upon their own study, either from their collection or from museum samples. The description given by various authors is presented here.

3.2 History as per Catalogue of Fishes

1. *Cynoglossus macrolepidotus* is first reported by Bleeker from Jakarta, Java, Indonesia, in 1951 as *Plagusia macrolepidota* in his book "Natuurkundig Tijdschriftvoor NederlandschIndië" page number – 415,
2. Some authors reported it as synonym of *Cynoglossus arel* – M. Dor in "Checklist of the fishes of the Red Sea" published in 1984, page number- 271 and T.A. Munroe in "Families Soleidae, Cynoglossidae" in 2001, page number – 3896.
3. But some authors still regarded as valid species [24,25].

4. CONCLUSION

Cynoglossus arel and *Cynoglossus macrolepidotus*, both occur along west coast of India.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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