Indian Journal of Geo Marine Sciences
Vol. 47 (02), February 2018, pp. 395-401

Comparative Osteology based on premaxillary bone of Sciaenid fishes found in Indian waters

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Received 19 January 2015 ; revised 17 November 2016

Present study consists the morphological characters of premaxillary bones of six genera and twelve species of the family Sciaenidae to provide a baseline to compare with other genera of the family and also to validate the taxa assigned to the genus which could be useful to make inferences about the phylogeny of the family. Morphometric measurement of premaxillary bone were measured the length of the lower margin of the horizontal part of the premaxillary (L), length of the vertical part of the premaxillary along the ascending process (M) and length from anterior corner of the premaxillary process to posterior tip of the horizontal part of the premaxillary (N).Inter- and intra-specific relationships between these species were also evaluated using multivariate analysis, standard discriminante function analysis and cluster analysis. Premaxillary along the ascending process (M) and length from anterior corner of the premaxillary process to posterior tip of the horizontal part of the premaxillary (N).

[Key words: morphology, premaxillary, villiform, Sciaenidae]

Introduction

The premaxillary is a part of Jaw bone. Premaxillary of Sciaenids is generally varrying in their shape. Premaxillary is L- like in shape in lateral view. The vertical part of premaxillary (premaxillary pedicel) is diverged terminaly into two parts: Anterior selender bar (ascending process) and posterior Flattish plate (articular process). The process situated at the upper margin of the horizontal bar of the premaxillary is post maxillary process. Features of both ascending and post maxillary process are varying between the species in sciaenid fishes.Family sciaenidae one of the important demersal fisheries resources of India which contribute about 5.43% of total marine fish landings of India during 2012[1]. The family Sciaenidae, also known as croakers, drums and jew fishes whichcomprises 70 genera with 270 species[2].A total of 40 species of Sciaenids belongs to 27 genera are distributed in Indian Ocean[3]. The contributions made by many authors on Sciaenid taxonomy[3-7,8-9]were based on external morphological characters have cleared some of ambiguity in the taxonomy of the species occurring in the Indian Ocean. Species differentiation of few Sciaenids based on morphometric and meristic features have been commonly used to distinguish the species taxonomically, and to separate different morphotypes[10-11]. An attempt has been made on

species differentiation of sciaenids based on otolith morphometry[12].

The classification of the Sciaenid fishes of China, described based on arrangement of the pores on the outer margin of the lower jaw, classifying the Sciaenid fishes examined by them into four forms based on the characters[13]. Description and the characteristics of jaws bone was compared with osteological characters for seven species of the Sciaenid fishes from Korea[14]. The jaw bones was considered to be an important character to separate the group of Sciaenid and extensively studied the differentiation of the Sciaenid fish collected from Japan and China Sea[9]. Morphological, myological and osteological character of Sciaenids was studied to establish phylogenetic relationship of the family Sciaenidae[15].

Materials and Methods

The sample was collected from shrimp trawler bycatch operated in various fishing ground of the north-west coast of India. Twelve species viz., *Johnius glaucus* (133-180mm), *J. belangerii* (98-178mm), *J. dussumieri* (184-253mm), *J. macrorhynus* (98-258mm), *Otolithoides biauritus* (220-395mm), *Paranibea semiluctuosa* (139-272mm), *Otolithus cuvieri* (125-272mm), *O. ruber* (132-281mm), *Pennahia aneus* (137-189mm), *Protonibea diacanthus* (148-248mm), *Johneiops sina* (113-187mm) and *J. vogleri* (112-272mm) were collected, kept in ice till this sample reached to the laboratory and identified using standard books andFAO species identification sheets[16]. Osteological preparation methodology[17] was used for premaxillary bone preparation. The bone of premaxillary was carefully cleaned and stained using Alizarins' staining technique[18-19] for further osteological studies. Statistical analysis was done by statistical software SAS Institute, 2010. Cladistic analysis of morphometric traits of premaxillary bone was made by using Past 1.24 version[20].

Result

Premaxillary is a jaw bone of Sciaenids possess unspecialized shape like other Perciform fishes. The premaxillary includes four processes: the ascending process, articular process, alveolar process and post-maxillary process. In the present study it was found that the length relationship between the ascending process and alveolar processes are not uniform, the ascending process is usually longer in those Sciaenids with an inferior mouth. Alveolar process is usually longer in Sciaenids with a terminal to oblique mouth. Along its ventral border, the alveolar process has conical, uniform sized teeth (Fig. 1-2).

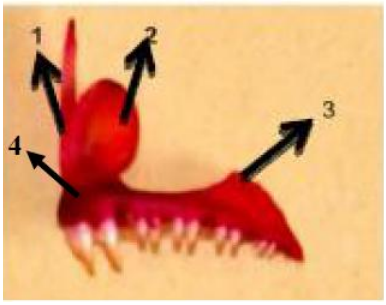

Fig.1- General description of Premaxillary bone: 1. ascending process; 2. articular process; 3. post premaxillary process; and 4. alvelolar process

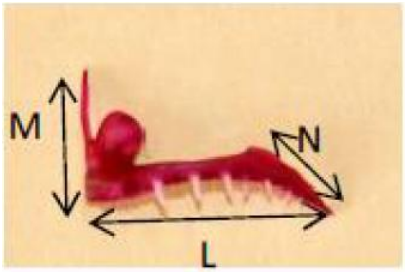

Fig.2- Lateral view of premaxillary bone: L, length of the lower margin of the horizontal part of the premaxillary; M, length of the vertical part of the premaxillary along the ascending process; N, length from anterior corner of the premaxillary process to posterior tip of the horizontal part of the premaxillary

Jaw bones are considered to be an important character to separate the group of allied species in teleostean fishes. The conical teeth of the anterior part of alveolar process are usually larger than the posterior ones. Premaxillary is resembles like L-shape in the lateral view. Vertical part of the premaxillary is diversed into two parts: the anterior slender bar (ascending process) and the posterior flattish plate (articular process) while postmaxillary process situated at the upper margin of horizontal bar (alveolar process). Morphology of these premaxillary procees varies between the genera and species (Fig. 3).

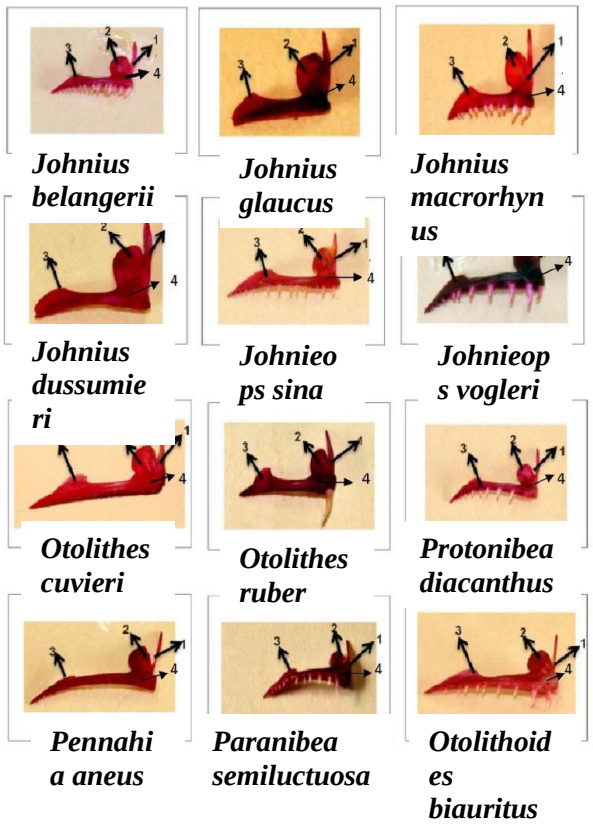

Fig.3- Lateral view of premaxillary bone of twelve sciaenid species: 1. ascending process; 2. articular process; 3. post premaxillary process; and 4. alvelolar process

All species of the genera *Johnius* except *Johnius macrorhynus*, the post maxillary process was moderate in horizontal length and the ascending process comparatively higher obsereved; M/L and N/L ratio 0.73-0.98, 0.37-0.47 respectively. Genera *Johnieops* and*Otolithes*have very less difference in the relative size of ascending process; ratio M/L is in range of 0.49-0.52 similarly post maxillary process ratio N/L was observed 0.45. Ascending process is comparatively short in genera *Otolithes*; *Otolithes cuvieri* and *Protonibea diacanthus*; the ratio M/L varies between 0.42-0.46, the post maxillary process being moderately long; the ratio N/L onserved between0.40-0.46. The species *Paranibea semiluctuosa*, the ascending process comparatively high; the ratio M/L was observed 0.60 and the post maxillar process similarly large; the ratio N/L was found 0.48. In case of *Otolithoides biauritus* the ascending process as well as post-maxillary process relatively moderate in length; the ratio of M/L and N/L was observed similar 0.44 (Table 1).

Desriptive statistics of each morphometric measurement of premaxillary bones for easch species is given in the Table 2. Multivariate analysis (MANOVA) suggested that all morphometric traits of premaxillary bone were found to be significantly deferent in the species studied. There were significant difference (MANOVA, Wilks' Lambda <1.00, df =55,314; P<0.001) in at least one of the morphometric traits of the groups (Table 3).

Table1- Ratios of M/L and N/L calculated of the premaxillary of 12 species of Sciaenid fishes giving the avertage and in parentheses the range. See the fig. 2 for the description of L, M and N

Species	Saple size	L	M	M/L	N	N/L
Johnius belangerii	12	0.60-0.90	0.43-0.72	0.73 (0.68-0.78)	0.29-0.43	0.45 (0.41-0.48)
J. glaucus	9	0.89-1.10	0.75-0.85	0.84 (0.77-0.90)	0.33-0.40	0.37 (0.34-0.40)
J. dussumieri	13	1.00-1.20	1.05-1.20	0.98 (0.95-1.00)	0.54-0.55	0.47 (0.46-0.47)
J. macrorhynus	11	0.91-1.32	0.82-1.05	0.41 (0.38-0.43)	0.35-0.51	0.41 (0.38-0.44)
Johnieops sina	10	1.20-1.57	0.57-0.81	0.51 (0.47-0.54)	0.51-0.75	0.45 (0.43-0.47)
J. vogleri	11	1.15-2.10	0.55-1.00	0.49 (0.45-0.53)	0.50-0.71	0.45 (0.43-0.47)
Otolithes cuvieri	10	1.41-2.30	0.61-1.00	0.42 (0.39-0.44)	0.68-1.11	0.46 (0.43-0.48)
O. ruber	5	1.35-2.10	0.70-1.12	0.52 (0.51-0.54)	0.53-0.90	0.40 (0.37-0.42)
Protonibea diacanthus	9	1.31-1.80	0.62-0.80	0.46 (0.45-0.47)	0.55-0.71	0.40 (0.38-0.42)
Pennahia aneus	6	1.60-1.70	0.72-0.80	0.47 (0.44-0.49)	0.69-0.75	0.44 (0.42-0.45)
Paranibea semiluctuosa	7	1.89-2.00	1.12-1.18	0.60 (0.59-0.61)	0.90-0.95	0.48 (0.47-0.48)
Otolithoides biauritus	12	1.2-2.5	0.78-1.05	0.44 (0.40-0.47)	0.70-1.10	0.44 (0.41-0.47)

Table 2-The descriptive statistics of the morphometric traits of premaxillary bone of 12 species of family Sciaenidae

	Johnius glaucus				*Johnius belangerii*				*Johnius dussumieri*				*Johnius macrorhynus*			
Variables	Min	Max	Mean±SE	CV %	Min	Max	Mean±SE	CV %	Min	Max	Mean±SE	CV %	Min	Max	Mean±SE	CV %
L	0.89	1.10	0.95±0.03	7.69	0.60	0.90	0.76±0.03	14.33	1.00	1.20	1.10 ± 0.6	9.09	0.91	1.32	1.10±0.05	12.59
M	0.75	0.85	0.80±0.01	3.68	0.43	0.72	0.57±0.03	16.55	1.05	1.18	1.12 ± 0.4	5.85	0.82	1.05	0.94±0.03	8.77
N	0.33	0.40	0.37±0.01	6.35	0.29	0.43	0.34±0.02	17.74	0.54	0.56	0.55 ± 0.1	1.82	0.35	0.51	0.45±0.02	11.49
M/L	0.77	0.90	0.84±0.01	4.95	0.69	0.80	0.74±0.01	4.91	0.95	1.03	0.99 ± 0.2	3.95	0.79	0.90	0.85±0.01	4.69
N/L	0.35	0.40	0.39±0.01	4.34	0.40	0.48	0.45±0.01	6.88	0.46	0.50	0.48 ± 0.1	4.17	0.38	0.45	0.41±0.01	5.33
	Johnius glaucus				*Johnius belangerii*				*Johnius dussumieri*				*Johnius macrorhynus*			
Variables	Min	Max	Mean±SE	CV %	Min	Max	Mean±SE	CV %	Min	Max	Mean±SE	CV %	Min	Max	Mean±SE	CV %
L	0.89	1.10	0.95±0.03	7.69	0.60	0.90	0.76±0.03	14.33	1.00	1.20	1.10 ± 0.6	9.09	0.91	1.32	1.10±0.05	12.59
M	0.75	0.85	0.80±0.01	3.68	0.43	0.72	0.57±0.03	16.55	1.05	1.18	1.12 ± 0.4	5.85	0.82	1.05	0.94±0.03	8.77
N	0.33	0.40	0.37±0.01	6.35	0.29	0.43	0.34±0.02	17.74	0.54	0.56	0.55 ± 0.1	1.82	0.35	0.51	0.45±0.02	11.49
M/L	0.77	0.90	0.84±0.01	4.95	0.69	0.80	0.74±0.01	4.91	0.95	1.03	0.99 ± 0.2	3.95	0.79	0.90	0.85±0.01	4.69
	0.35	0.40	0.39±0.01	4.34	0.40	0.48	0.45±0.01	6.88	0.46	0.50	0.48 ± 0.1	4.17	0.38	0.45	0.41±0.01	5.33
	Protonibea diacanthus				*Pennahia aneus*				*Paranibea semiluctuosa*				*Otolithoides biauritus*			
Variables	Min	Max	Mean±SE	CV %	Min	Max	Mean±SE	CV %	Min	Max	Mean±SE	CV %	Min	Max	Mean±SE	CV %
L	1.31	1.80	1.55± 0.06	10.99	1.60	1.70	1.65± 0.03	3.03	1.91	2.00	1.94 ±0.02	2.16	1.20	2.50	2.11 ± 0.11	17.70
M	0.62	0.85	0.73 ±0.03	11.21	0.72	0.86	0.78± 0.04	9.25	1.15	1.18	1.17± 0.01	1.21	0.78	1.12	0.95 ± 0.03	11.64
N	0.55	0.71	0.63 ±0.02	10.42	0.69	0.75	0.72± 0.02	4.17	0.90	0.95	0.92 ±0.01	2.35	0.70	1.10	0.94 ± 0.04	13.73
M/L	0.46	0.48	0.47 ±0.00	2.05	0.45	0.51	0.47 ±0.02	6.29	0.59	0.61	0. 60±0.01	20.60	0.40	0.65	0.46 ± 0.02	17.43
N/L	0.38	0.42	0.41 ±0.01	3.79	0.43	0.44	0.44 ± 0.0	1.14	0.47	0.48	0.47 ±0.00	18.89	0.42	0.58	0.45 ± 0.01	10.48

Table 3- Multivariate analysis of variance of premaxillary data for 12 different species of Sciaenidae

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.00125211	20.10	55	341.49	<.0001
Pillai's Trace	2.99395921	10.45	55	385	<.0001

The stepwise discriminant function analysis identified RML (ratio of length of the lower margin of the horizontal part of the premaxillary (L), length of the vertical part of the premaxillary along the ascending process (M)) is most important traits to differentiate the, the partial R-Square value for RML was found 0.95 followed by N (length from anterior corner of the premaxillary process to posterior tip of the horizontal part of the premaxillary (N), second most important traits to differentiate the species (Table 4). Canonical discrinimant function analysis also shows that MRL and N traits were able explain 90 % of differentiation of the species (Table 5).

Table 4- Results of stepwise discriminant function analysis based on the morphometric traits of premaxillary bone

Step	Entered	Partial R-Square	F Value	Pr > F	Wilks' Lambda	Pr < Lambda	Average Squared Canonical Correlation	Pr > ASCC
1	RML	0.9546	147.32	<.0001	0.04536132	<.0001	0.08678533	<.0001
2	N	0.7266	18.36	<.0001	0.01240405	<.0001	0.15257206	<.0001
3	M	0.6428	12.27	<.0001	0.00443088	<.0001	0.20800242	<.0001
4	L	0.6126	10.64	<.0001	0.00171652	<.0001	0.25103603	<.0001
5	RNL	0.2706	2.46	0.0112	0.00125211	<.0001	0.27217811	<.0001

Table 5- Results of canonical discriminant function analysis based on the morphometric traits of premaxillary bone

Canonical Correlation	Adjusted Canonical Correlation	Approximate Standard Error	Squared Canonical Correlation	Eigenvalue	Difference	Proportion	Cumulative
1	0.984077	0.981623	0.003368	30.6528	27.3886	0.8369	0.8369
2	0.874924	0.853574	0.024999	3.2642	1.5164	0.0891	0.9260
3	0.797548	0.775239	0.038794	1.7479	1.0626	0.0477	0.9737
4	0.637672	0.600191	0.063254	0.6853	0.4076	0.0187	0.9924
5	0.466210	0.429604	0.083431	0.2777		0.0076	1.0000

The Cladogram was constructed based on the morphometric traits of premaxillary bone mentioned in (Table 1, Fig.4). This cladogram was seperated these twelve species in two braod clade A and clade B. The similarity between these species was shown using Euclidean distance between the species. Clade A was completely separated from the Clade B, four genera *Johnius* with four species *Johnius macrorhynus*, *J glaucus, J. belangerii, J. dussumieri* species which have very less variation morphometrically. Clade B was well separated with 5 genera and 8 species; divided into two sub clade; subclade 1 grouped into 4 genera and 5 species; *Johnieops sina , J. vogleri, Pennahia aneus, Otolithes ruber and Protonibea diacanthus;* subclade 2 grouped into 3 genera and 3species; *Otolithes cuvier, Otolithoides biauritus, and paranibea semiluctuosa.* The well separation of *Otolithes cuvieri* from *O. ruber* indicated that morphometric traits of premaxillary bone more resemblance with *Otolithoides biauritus* than the *O. ruber*, similarly the *Johnieops vogleri* have more similarity with *Pennahia aneus* than the *Johnieops sina.*

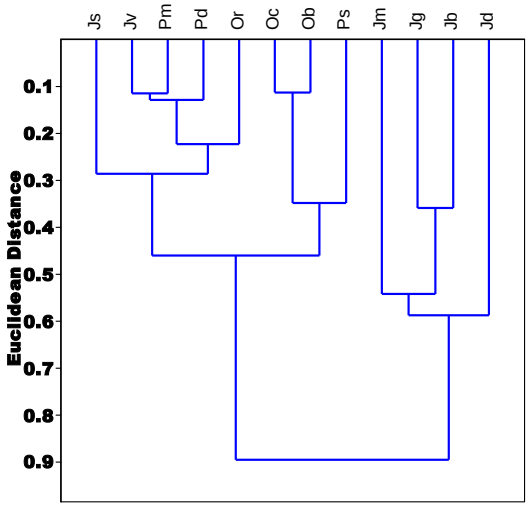

Fig 4 Allocation of the sciaenid fishes based on the ratios of three parts (see fig. 2) of the premaxillary: 1. Oc, *Otolithes cuvieri*; Jv, *Johnieops vogleri*; Js, *Johnieops sina*; Ob, *Otolithoides biauritus*; pm, *Pennahia aneus*; Pd, *Protonibea diacanthus*; Ps, *Paranibea semiluctuosa*; Or, *Otolithes ruber*; Jm, *Johnius macrorhynus*; Jb, *Johnius belangerii*; Jd, *Johnius dussumieri*; Jg, *Johnius glaucus*

Discussion

Sciaenid fish were collected from the around Japan and the China Sea, grouped into 9 genera and 16 species on the basis of characteristics of premaxillary bone (M, N, L, RML, RNL) and classified into three forms; the *Johnius*-form, *Nibea*-form and *Pseudosciaenia*- form[21]. In the present investigation, the ratio of M/L and N/L were 0.68 and 0.43, respectively of *J. belangerii* have found similar result for the same species around Japan and the China Sea[21]. The author observed, these characteristics of premaxillary

bone were found relevant in the differentiation of sciaenid fishes of Indian Ocean also.

Classification of sciaenid fishes based on the angle formed by the ascending process and the horizontal bar (alveolar process) was done, this angle wasreportedobtuse in the genera *Pseudosciaenia* and *Collichthys*, rectangular in the genera *Nibea* and *Miichthys* and intermediate in the genus *Argyrosomus*[14]. In the present study in all sciaenid species was observed angle formed by the ascending process and the horizontal bar (alveolar process) shows continuous variation except, obtuse in *Pennahia aneus* and *Otolithoides biauritus.*As the angle formed by the ascending process and the horizontal bar (alveolar process) show very less variation in most of species studied, all species shows rectangle as in genera *Nibea* and *Miichthys*[14]in except *Otolithoides* and *Pennahia*, the author cannot distinguish these species based on these characters, agreed[21].

Using multivariate technique was found useful in differentiation of closely related species as reported for many vertebrates and invertebrates[22-28]. Therefore, the findings of the present study can be used in the differentiation but for identification of the species, need more characters should be included for these species. There could also be a possible link between the variability of observed morphometric traits of premaxillary bone in the habitat, feeding behavior and prey-predator relationship. However, the true reasons for the observed morphometric variation of premaxillary bone should be studied further using appropriate sampling design that includes different localities as well as the predatory behavior of the fishes.

Conclusion

Premaxillary is the one of the important tool to differentiate the species of family Sciaenidae, but not only tool to separate the group. The width and length of the premaxillary might have functional relationship with feeding behaviour of the Sciaenid. Length of premaxillary process and ratio of these processes well differentiate the genera *Johnieops* group and *Johnius*, both have inferior mouth. There is need for further study and inclusion of more character to well differentiation of these groups.

Acknowledgement

Authors are thankful to Director, CIFE, Mumbai for providing necessary facilities for carrying out the research work. The first author acknowledges the financial assistance provided in form of fellowship by Indian council of Agricultural Research, New Delhi, India. Authors are also thankful to the Director, CIFRI, Barrackpore for his kind help in the preparation of this article.

References

1. FAO, Species identification sheet for fishery purposes, Western Indian Ocean (Fishing Area 51). *Food and Agricultural Organization of the United Nations*, Rome. Fischer, W. and Bianchi, G. (Eds). Vol. I-IV. (1983) Pg. var.
2. Kumar, P., Chakraborty, S.K., and Jaiswar,A.K., Comparative otolith morphology of Sciaenids occurring alongthe north-west coast of India. *Indian J. Fish.*,59 (2012):19-27.
3. Nelson, J.S., Fishes of the world. 4 ed. New Jersey: John Wiley & Sons, 2006, pp:601.
4. Chakraborty, S.K., *A study on the Sciaenids of Bombay waters.Ph.D. thesis*. Bombay University, India, 1988, pp:421.
5. Mohan, R.S.L., A synopsis to the Indian genera of the fishes of the family Sciaenidae. *Indian.J. Fish*.,16 (1981):82-98.
6. Mohan, R.S.L., An illustrated synopsis of the fishes of the family Sciaenidae of India. *Indian J Fish.*,28(1982):1-24.
7. Mohan, R.S.L., A review of the scianid fishery resources of the Indian Ocean. *J. mar. biol.Ass. India*.,33(1991):134-145.
8. Taniguchi, N., Comparative osteology of the Sciaenid fishes from Japan and its adjacent water- III. Premaxillary and Dentary. *Jap. J. Ichthyol.*,17(1970):135-140.
9. Tudela, S., Morphological variability in a Mediterranean, genetically homogeneous population of the European anchovy, *Engraulisencrasicolus* . *Fish. Res.*,42(3) (1999):229–243. doi: 10.1016/S0165-7836(99)00052-1.
10. Kim, Y., and Kim, I., Osteologiucal study of fishes from Korea (1), Comparative Osteology of family Sciaenidae. *Bull. Pusan Fish. Coll.*,6 (1965):61-76.
11. Mohan, R.S.L., Two new species of sciaenid fishes *Johnius elongatus* and *Johnieops macrorhynus* from India. Matsya.,1(1976):19-25.
12. Pierce, G.J., Hastie, L.C., Guerra, A., Thorpe, R.S., Howard, F.G. and Boyle, P.R. Morphometric variation in *Loligo forbesi* and *Loligo vulgaris*: regional, seasonal, sex, maturity and w orker differences. *Fish Res.*,21(1-2)(1994):127–148. doi: 10.1016/0165-7836(94)90100-7.
13. Chu, Y., Lo, Y. and Wu, H., A study on the classification of the sciaenoid fishes of china, with description of new genera and species. Shanghai Scientific and Technical Publ. Co. Shanghai: i-ii, 1963, pp:1-40.

14. Kim, Y., and Kim, I., Osteologiucal study of fishes from Korea (1), Comparative Osteology of family Sciaenidae. *Bull. Pusan Fish. Coll.*,6 (1965):61-76.
15. Sasaki, K., *Phylogeny of the family Sciaenidae with notes on its Zoogeography (Teleostei, Perciformes).* Fisheries Science at Hokkaido University, 1989, pp:1-126.
16. FAO, Species identification sheet for fishery purposes, Western Indian Ocean (Fishing Area 51). *Food and Agricultural Organization of the United Nations,* Rome. Fischer, W. and Bianchi, G. (Eds). Vol. I-IV. (1983) Pg. var.
17. James, P.S.B.R., Comparative osteology of the fishes of the family leiognathidae part i : osteology. *Indian J. Fish.*,132(2)(1985):309-358.
18. Clothier, C.R., A key to some southern California fishes based on vertebral characters. Calif Fish and Game,*Fish. Bull.*,79(1950):3-83.
19. Hollister, G., Clearing and dying of fish for bone study. *Zoologica.*,12(1934):89-101.
20. Hammer, O., Harper, D.A.T. and Ryan, P.D., Paleontological statistics.version 1.34. Natural History Museum University of Oslo, Oslo, Norway, 2001.
21. Taniguchi, N., Comparative osteology of the Sciaenid fishes from Japan and its adjacent water- III. Premaxillary and Dentary. *Jap. J. Ichthyol.*,17(1970):135-140.
22. Boetius, J., Atlantic *Anguilla*. A presentation of old and new data of total numbers of vertebrae with special reference to the occurrence of *Anguilla rostrata* in Europe. *Dana.*,1 (1980):1–28.
23. Bolles, K.L., Begg, G.A., Distinction betw een silver hake (*Merluccius bilinearis*) stocks in US w aters of the northwest Atlantic based on whole otolith morphometrics. *Fish Bull.*,98(3)(2000):451–462.
24. Fridriksson, A., The tribes of North Coast herring of Iceland with special reference to the period 1948-1955. *Rapports du Conseilpour l'Exploration de la Mer.*,143(2)(1958):36–44.
25. Pierce, G.J., Hastie, L.C., Guerra, A., Thorpe, R.S., Howard, F.G. and Boyle, P.R. Morphometric variation in *Loligo forbesi* and *Loligo vulgaris*: regional, seasonal, sex, maturity and w orker differences. *Fish Res.*,21(1-2)(1994):127–148. doi: 10.1016/0165-7836(94)90100-7.
26. Pierce, G.J., Thorpe, R.S., Hastie, L.C., Brierley, A.S., Boyle, P.R., Guerra, A., Jamieson, R.and Avila, P., Geographic variation in *Loligo forbesi* in the Northeast Atlantic: analysis of morphometric data and tests of causal hypotheses. *Mar Biol.*,119(4)(1994):541-548. doi:10.1007/BF00354316.
27. Simon, K.D., Bakar, Y., Temple, S.E.,and Mazlan, A.G., Morphometric and meristic variation in two congeneric archer fishes *Toxotes chatareus* (Hamilton 1822) and *Toxotes jaculatrix* (Pallas 1767) inhabiting Malaysian coastal waters. *J Zhejiang Univ. Sci. B.*,11(11)(2010):871–879. doi: 10.1631/jzus.B1000054.
28. Tudela, S., Morphological variability in a Mediterranean, genetically homogeneous population of the European anchovy, *Engraulisencrasicolus* . *Fish. Res.*,42(3) (1999):229–243. doi: 10.1016/S0165-7836(99)00052-1.