https://doi.org/10.33451/florafauna.v30i2pp343-351

FLORA AND FAUNA
2024 Vol. 30 No.2 PP 343-351

ISSN 2456 - 9364 (Online)
ISSN 0971 - 6920 (Print)

Scale morphology an additional tool for taxonomy and fish identification with reference to Nemipteridae fishes *(N. japonicus, N. bipunctatus* and *N. randalli)*

***N.C.Ujjania[1] and A.K. Jaiswar[2]**

[1]Department of Aquatic Biology
(VNSGU) SURAT-395007 (GUJARAT), INDIA
[2]ICAR-Central Institute of Fisheries Education,
MUMBAI-400061 (MAHARASHTRA), INDIA
*Corresponding Author
E-mail : ncujjania@vnsgu.ac.in

Received : 29.07.2024; ***Accepted*** : 08.09.2024

ABSTRACT

Fish scales are the exoskeleton which provide structural support to the fishes and it is the validated tool for taxonomy, classification and identification of the fish. In present study, three marine fish species *N. japonicus*, *N. bipunctatus* and *N. randalli* were collected from the three locations namely Sassoon dock, (Colaba), Versova fish landing center (Versova) and Bhayander fish landing center (Bhayandar) situated on west coast of India and are used to compare the morphological variations of scales. During the study, cycloid type were analyzed under 4P scale reader to measure the different morphometric measurements (L1: A-B, L2: B-C, L3: C-D, L4: D-E, L5: E-F, L6: F-A, L7: A-G, L8: B-G, L9: C-G, L10: D-G, L11: E-G, L12: F-G) between the different landmarks to find out the morphological variations among scale of studied fish species.The minimum and maximum morphological measurement of the scale were noted 2.863±0.053 to 12.864±0.172 in *N. japonicus*, 2.633±0.090 to 13.417±0.343in *N. bipunctatus* and 2.594±0.069 to 12.083±0.258 in *N. randalli*. Whereas, correlation metrix of scale variables was strong between L6 and L7 (0.877) in *N. japonicus*, L3 and L6 (0.901) in *N. bipunctatus*and L12 and L5 (0.936) in *N. randalli* while relationship of L11 with all variable show the weak correlation. The variation in the scale morphology was verified by the descriptive statistical analysis like principle component analysis, correlation matrix *etc*. These findings revealed the morphological variation in the scale *i.e.* scale size is different in different fish species which quantify the fish taxonomy and could be considered an essential tool for fish identification.

Figures : 04 References : 32 Tables : 03

KEY WORDS : Cycloid scale, Fish identification, Morphology of scale, Nemipteridae fishes, Taxonomy

Introduction

The threadfin breams are small to medium-sized commercially important perciforms fishes and widespread in the tropical and subtropical Indo-West Pacific region. These bottom-dwelling fishes constitute an important components in traditional and commercial fisheries which are frequently consumed in fresh condition[4,26]. In India, the threadfin are represented by *N. japonicas*, *N. bipunctatus* and *N. randalli*[1,25] that contribute about 1.07 lakh tone of total threadfin fish landings and 2.41% of total marine fish landings[6].

Finfish scales and their sculptural including circuli, radii, ctenii, lateral line canal *etc.* can be helpful in describing the species, identification and classification[5,11,12,16], phylogeny, sexual dimorphism, age determination; past environment experienced by the fish, migration, discriminating between hatchery-reared and wild populations[8]. The detailed properties of fish scale was traced back to the late nineteenth century and first time used in fish taxonomy[24]. Fish scales commonly contain layers of collagen, organic and bony materials[32] which are helpful to determine the age of fish[15,29,31].

The fish scale morphology was used for taxonomy and on the evolution of the fish[14,16,21,28]. Early workers[13,17] carried out comparative study on scale morphology of *Sauridatumbil* and identified the most useful characters for future systematic studies. Fish scale morphology not only shows the differentiation between species of fishes but also detect the intraspecific differences of individuals same ecosystem[22]. Identification of local populations and their connectivity is major aspect for the maintenance and management of vulnerable fish species[10].

Therefore, the present study was undertaken to differentiate the nemipateride species, *N. japonicus*, *Nemipterus bipunctatus* and *Nemipterusrandalli* on the

TABLE-1 : The observation of scale morphological parameters of *Nemipteridae* fishes on west coast of India

Scale Morphological Parameters	*N. japonicus*				*N. bipunctatus*				*N. randalli*			
	Min.	**Max.**	**Mean**	**SE**	**Min.**	**Max.**	**Mean**	**SE**	**Min.**	**Max.**	**Mean**	**SE**
L1	3.400	14.500	7.761	0.140	3.200	13.200	7.675	0.342	3.600	13.200	7.191	0.197
L2	3.400	13.000	7.563	0.141	4.200	12.900	7.667	0.314	4.200	12.800	6.905	0.205
L3	4.500	16.000	10.866	0.124	7.000	14.300	10.658	0.263	6.500	14.500	10.308	0.184
L4	2.000	12.000	7.480	0.111	5.000	10.500	7.338	0.211	4.900	11.200	7.403	0.145
L5	4.000	12.300	7.650	0.113	5.500	11.000	7.996	0.192	4.500	11.000	7.305	0.145
L6	5.300	16.300	10.961	0.124	6.900	15.000	10.977	0.273	6.000	15.000	10.240	0.175
L7	6.000	20.000	**12.864**	**0.172**	8.300	19.500	**13.417**	**0.343**	7.000	19.800	12.011	0.235
L8	1.300	17.700	10.902	0.150	7.000	17.700	11.746	0.336	6.200	17.700	10.492	0.227
L9	1.500	20.000	12.825	0.184	7.900	18.900	13.344	0.405	7.500	18.900	**12.083**	**0.258**
L10	2.000	13.900	6.950	0.112	4.100	10.000	6.540	0.206	3.700	10.400	6.484	0.149
L11	1.200	5.500	**2.863**	**0.053**	1.700	4.000	**2.633**	**0.090**	1.500	4.200	**2.594**	**0.069**
L12	3.500	12.200	7.158	0.108	5.200	9.600	7.246	0.187	4.000	9.800	6.849	0.152

(L1 is A-B, L2 isB-C, L3 is C-D, L4 is D-E, L5 is E-F, L6 is F-A, L7 is A-G, L8 is B-G, L9 is C-G, L10 is D-G, L11 is E-G and L12 is F-G)

TABLE-2 : Correlation matrix in various morphological parameters of scale

Para.	**Fish**	**L1**	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**L9**	**L10**	**L11**	**L12**
L1	*N. japonicus*	1.000											
	N. bipunctatus	1.000											
	N. randali	1.000											
L2	*N. japonicus*	0.796**	1.000										
	N. bipunctatus	0.864**	1.000										
	N. randali	0.842**	1.000										
L3	*N. japonicus*	0.602**	0.605**	1.000									
	N. bipunctatus	0.606**	0.613**	1.000									
	N. randali	0.437**	0.402**	1.000									
L4	*N. japonicus*	0.723**	0.808**	0.500**	1.000								
	N. bipunctatus	0.822**	0.794**	0.654**	1.000								
	N. randali	0.722**	0.803**	0.336**	1.000								
L5	*N. japonicus*	0.809**	0.764**	0.527**	0.745**	1.000							
	N. bipunctatus	0.764**	0.758**	0.447**	0.788**	1.000							
	N. randali	0.865**	0.838**	0.350**	0.797**	1.000							
L6	*N. japonicus*	0.673**	0.602**	0.828**	0.567**	0.588**	1.000						
	N. bipunctatus	0.674**	0.642**	**0.901****	0.704**	0.491**	1.000						
	N. randali	0.634**	0.587**	0.821**	0.462**	0.594**	1.000						

Para.	Fish	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
L7	*N. japonicus*	0.824**	0.730**	0.772**	0.644**	0.760**	0.877**	1.000					
	N. bipunctatus	0.723**	0.802**	0.677**	0.713**	0.664**	0.735**	1.000					
	N. randali	0.764**	0.709**	0.720**	0.597**	0.730**	0.899**	1.000					
L8	*N. japonicus*	0.558**	0.494**	0.726**	0.455**	0.459**	0.733**	0.734**	1.000				
	N. bipunctatus	0.645**	0.621**	0.695**	0.674**	0.508**	0.695**	0.801**	1.000				
	N. randali	0.473**	0.427**	0.870**	0.414**	0.381**	0.801**	0.762**	1.000				
L9	*N. japonicus*	0.729**	0.776**	0.827**	0.693**	0.589**	0.769**	0.777**	0.722**	1.000			
	N. bipunctatus	0.750**	0.734**	0.663**	0.766**	0.625**	0.699**	0.878**	0.889**	1.000			
	N. randali	0.546**	0.569**	0.770**	0.539**	0.464**	0.763**	0.758**	0.826**	1.000			
L10	*N. japonicus*	0.760**	0.824**	0.572**	0.822**	0.760**	0.533**	0.601**	0.435**	0.679**	1.000		
	N. bipunctatus	0.829**	0.755**	0.541**	0.849**	0.706**	0.588**	0.610**	0.652**	0.719**	1.000		
	N. randali	0.692**	0.813**	0.339**	0.856**	0.726**	0.454**	0.546**	0.406**	0.562**	1.000		
L11	*N. japonicus*	0.226**	0.211**	0.118	0.351**	0.389**	0.120	0.072	-0.090	0.015	0.387**	1.000	
	N. bipunctatus	-0.286*	-0.385**	-0.286*	-0.269	-0.206	-0.257	-0.427**	-0.352*	-0.392**	-0.207	1.000	
	N. randali	0.333**	0.258**	0.016	0.298**	0.372**	0.141	0.121	0.010	0.117	0.342**	1.000	
L12	*N. japonicus*	0.795**	0.769**	0.499**	0.735**	0.902**	0.590**	0.732**	0.429**	0.554**	0.738**	0.497**	1.000
	N. bipunctatus	0.814**	0.823**	0.628**	0.814**	0.838**	0.608**	0.612**	0.481**	0.561**	0.743**	-0.149	1.000
	N. randali	0.815**	0.805**	0.283**	0.777**	**0.936****	0.519**	0.702**	0.351**	0.445**	0.695**	0.361**	1.000

(L1 is A-B, L2 isB-C, L3 is C-D, L4 is D-E, L5 is E-F, L6 is F-A, L7 is A-G, L8 is B-G, L9 is C-G, L10 is D-G, L11 is E-G and L12 is F-G)**signi., 99%

TABLE-3 : Principal components analysis of various scale components for studied fish

Parameter	Eigenvalues			Variance (%)			Cumulative (%)		
Fish	**NJ**	**NB**	**NR**	**NJ**	**NB**	**NR**	**NJ**	**NB**	**NR**
1	7.918	8.178	7.484	65.984	68.148	62.364	65.984	68.148	62.364
2	1.658	1.193	2.076	13.820	9.945	17.298	79.804	78.093	79.662
3	0.697	0.855	0.807	5.812	7.129	6.724	85.616	85.221	86.386
4	0.521	0.570	0.590	4.344	4.748	4.915	89.960	89.969	91.300
5	0.296	0.365	0.233	2.467	3.045	1.938	92.427	93.014	93.238
6	0.232	0.249	0.197	1.931	2.072	1.645	94.358	95.087	94.883
7	0.185	0.162	0.168	1.543	1.351	1.400	95.900	96.437	96.283
8	0.161	0.138	0.127	1.341	1.147	1.058	97.241	97.584	97.341
9	0.128	0.103	0.117	1.067	0.858	0.971	98.308	98.442	98.313
10	0.083	0.078	0.098	0.694	0.650	0.819	99.002	99.092	99.132
11	0.073	0.062	0.063	0.606	0.520	0.521	99.608	99.612	99.653
12	0.047	0.047	0.042	0.392	0.388	0.347	100.000	100.000	100.000

	Loadings			Variance (%)			Cumulative (%)		
	NJ	**NB**	**NR**	**NJ**	**NB**	**NR**	**NJ**	**NB**	**NR**
	5.251	5.589	5.049	43.762	46.572	42.075	43.762	46.572	42.075
	4.325	3.782	4.510	36.042	31.521	37.587	79.804	78.093	79.662

Note: CP for Components of scale, NJ for *N. japonicus*, NP for *N. bipunctatus*, NR for*N randali*

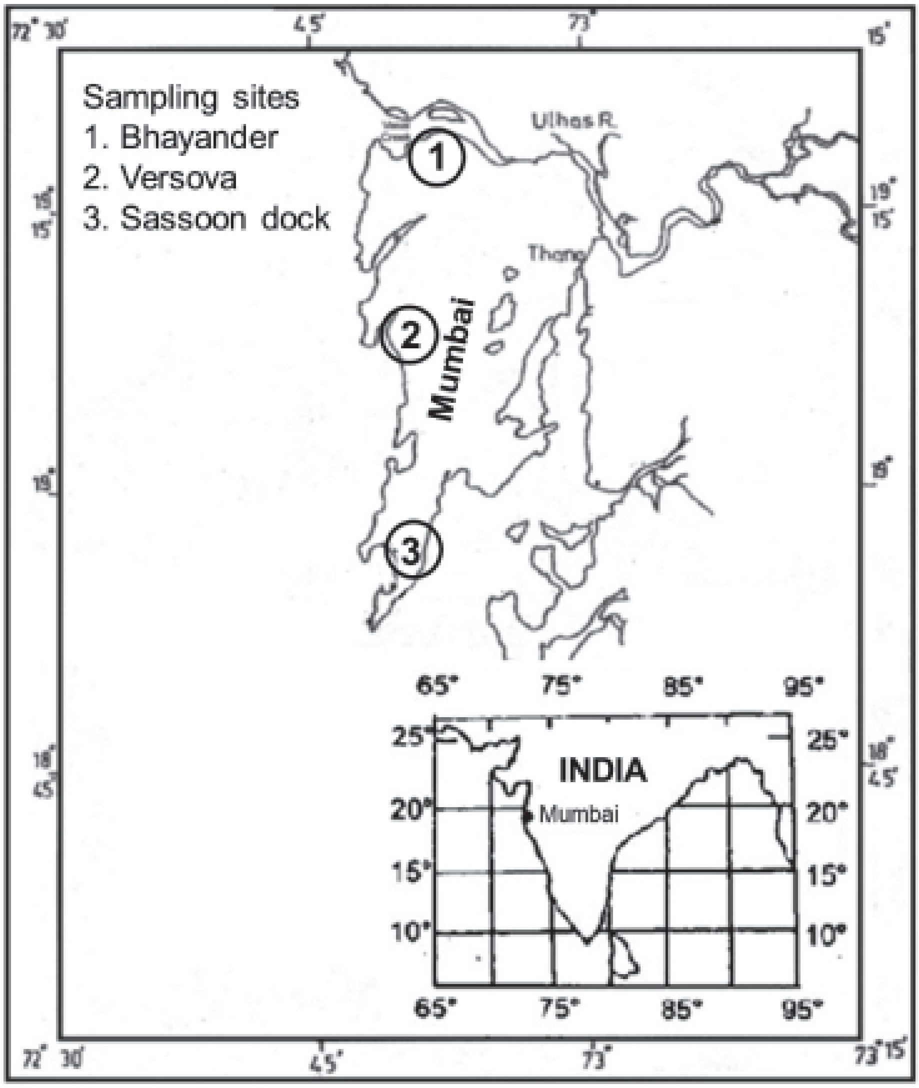

Fig. 1 : Map of study area (fish landing center)

long west coast of India.

Materials and Methods

Scale morphometric characters were measured from randomly collected 386fish specimens (232,52 and 102 of *N. japonicus*, *N. bipunctatus* and *N. randalli* respectively) during the fishing year 2020-21 from different landing centers namely Sassoon dock, (Colaba), Versova fish landing center (Versova) and Bhayander fish landing center (Bhayandar) in Mumbai along the west coast of India (Fig. 1). Scales were extracted from the region in between of the dorsal fin and the lateral line from the left side of the fish. The collected scales were soaked in 5% KOH solution and washed with tape water. Then after, clean scales were used to measure the different morphometric measurements (L1: A-B, L2: B-C, L3: C-D, L4: D-E, L5: E-F, L6: F-A, L7: A-G, L8: B-G, L9: C-G, L10: D-G, L11: E-G, L12: F-G) between the landmarks of the fish scale (Fig. 2) to under 4P scale reader by measuring the tap at the accuracy of ±0.01 mm. These morphological variables were used for statistical analysis including principal component analysis (PCA), Correlation matrix *etc.* with the help of SPSS 21.0.

Result and Discussion

The morphological distances of the scales ranged as 2.863±0.053 to 12.864±0.172 in *N. japonicus*, 2.633±0.090 to 13.417±0.343of the scales of*N. bipunctatus* and 2.594±0.069 to 12.083±0.258of the scales of *N. randalli* (Table-1). The correlation metric of different scale variables shows strong correlation, L6 with L7(0.877) in *N. japonicus*, L3 with L6(0.901) in *N. bipunctatus* and L12 with L5 (0.936) in *N. randalli* while relationship of L11 with all variables shows the weak correlation (Table-2).

The coefficients are essential to measure the covariance of character on that principal component. The

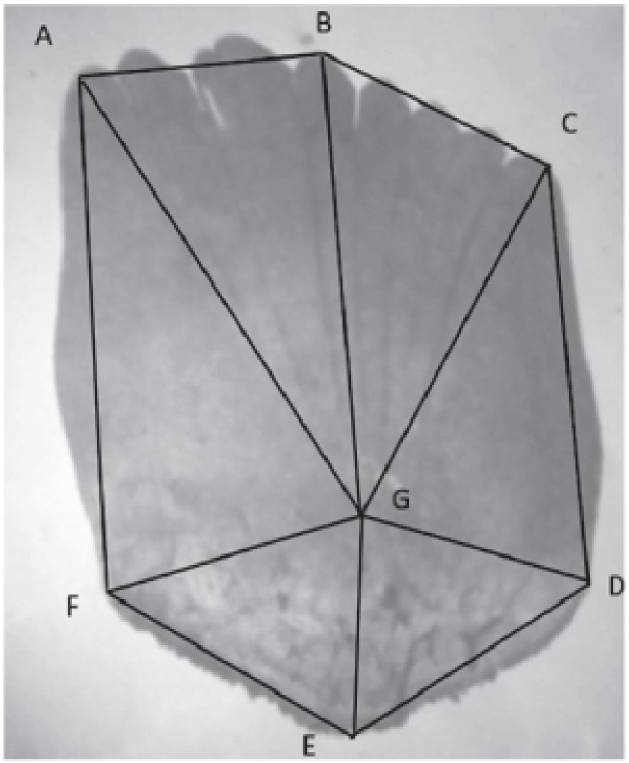

Fig. 2 : Measurement of morphometric parameters in typical fish scale. (L1: A-B, L2: B-C, L3: C-D, L4: D-E, L5: E-F, L6: F-A, L7: A-G, L8: B-G, L9: C-G, L10: D-G, L11: E-G, L12: F-G)

eigen value is a measure of variability explained by a particular principal component and sum of eigen values equals the total variability in the variables. The scale morphometric lengths of fishes were subjected to principal component analysis and results show that two principal components (PCs) and eigenvalue (>1 scale are one dimensional) of these PCs were 7.918 & 1.658; 8.178 & 1.193; 7.484 & 2.076, variance (%) 65.98 & 13.82; 68.14 & 9.94; 62.36 & 17.29 and cumulative (%) 79.804, 78.093 and 79.662 were noted for *N. japonicus*, *N. bipunctatus*and *N. randalli* respectively (Table 3 and Fig. 3). The above results on scales morphology for studied fishes indicated that these two groups of principal components (PCs) are strong enough to explain the variability in fish species. The principal component (PC2) is the independent of PC1 and second largest component of variation in variables[3,9]. The plot of PC1 against PC2 scores of these scale variables produced three separate cluster (Fig. 4) which indicated that the morphological variation in the scale of these studied fishes. Similarly, a worker[22] reported that scale morphology can detect spatial structure in fish populations. Moreover, other studies[18,19,20] showed that the morphology of the scale in cichlids is less likely to result from convergent evolution and potential for phylogenetic studies. Other workers[8] reported significant variations in shapes were observed within and between

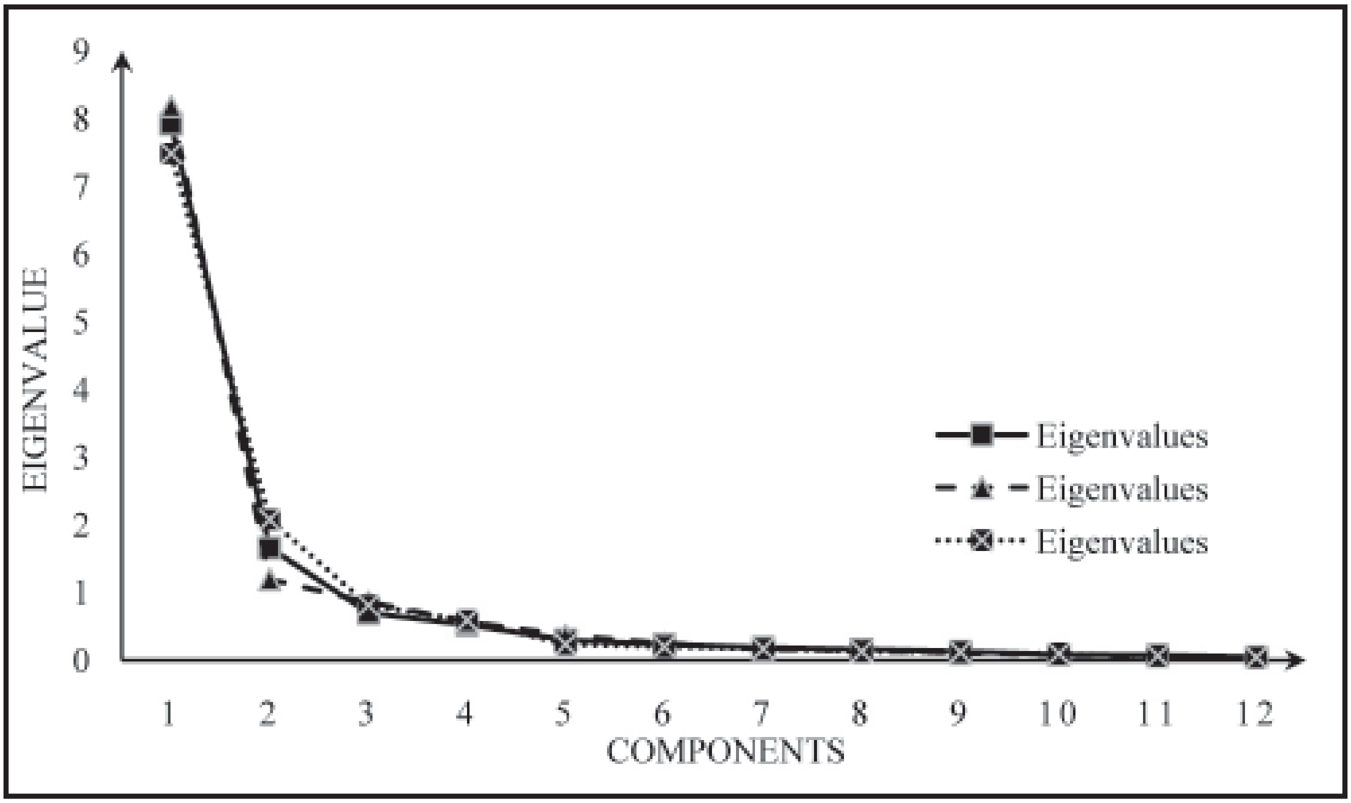

Fig. 3 : Screen plot (component v/s Eigen value) for morphometric parameters of fish scales (Njis *N. japonicus*, Np is *N. bipunctatus* and Nr is *N. randali*)

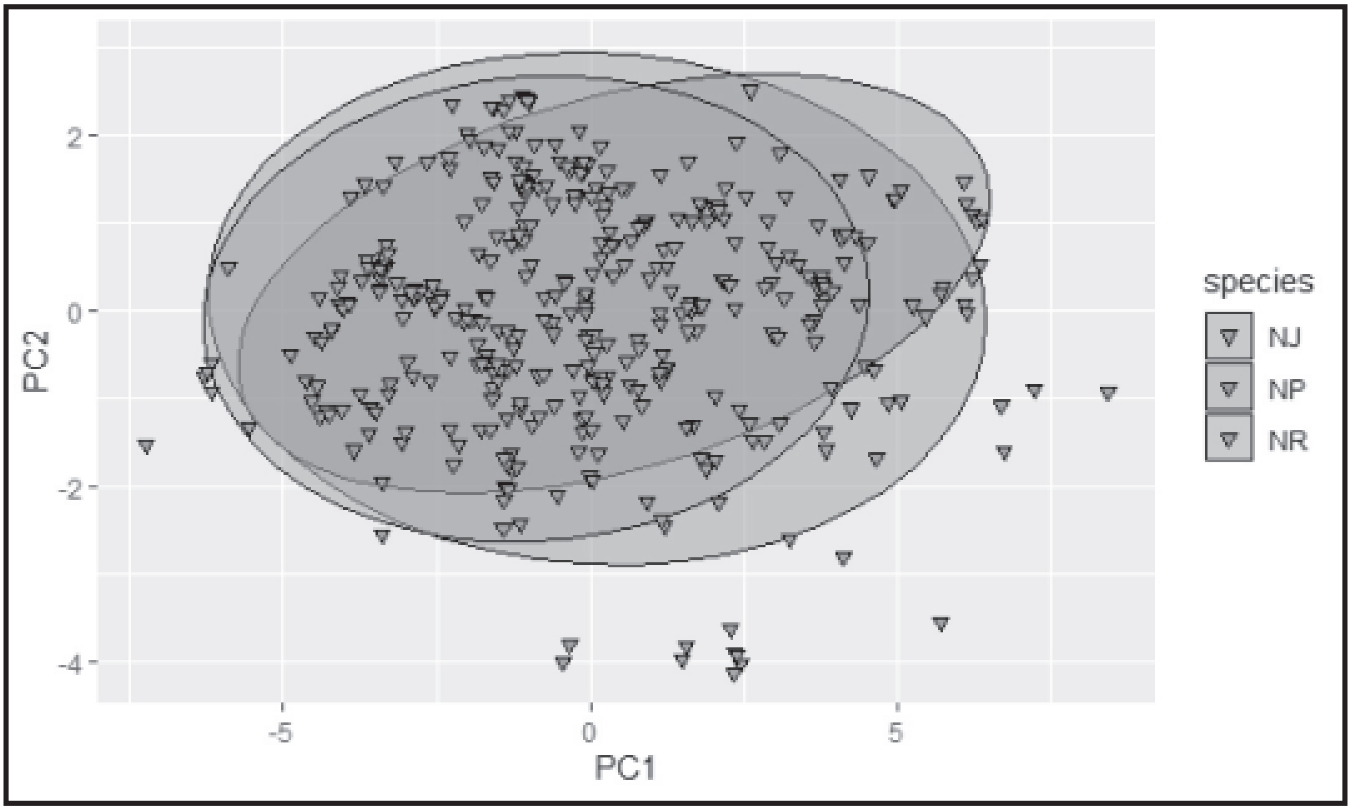

Fig. 4 : Scatter plot with sheared PC scores of morphometric parameters of different fishes (NJ is *N. japonicus*, NP is *N. bipunctatus* and NR is *N. randali*).

sexes of the fish with help of scale morphology and it can provide useful taxonomic information on the morphological differences between sexes of *P. binotatus.* The distinctive morphological character that distinguished it from other Cyprinidae species is having clearly formed scales[7]. Workers[30] studied the scale morphology and reported significant morphological difference in tilapia fish population of different water bodies of western India. The observed morphological differentiation in *N. japonicus*, *N. bipunctatus*and *N. randalli* may be attributed to environmental, geographical and biological variations among the studied fish. Similar findings were also reported by others[23,27].

References

1. Baranes A, Golani D. An annotated list of deep-sea fishes collected in the northern Red Sea, Gulf of Aqaba. *Israeli J. Zool*. 1993; **39** : 299–336.
2. Bookstein FL, Chernoff B, Elder R, Humphrier J, Smith G, Strauss R. Morphometric in evolutionary biology. Spl. Pub. 15. The Academy of Natural Science of Philadelphia, Philadelphia, 1993.
3. Campbell, NA, Atchley WR, The geometry of canonical variant analysis. *Syst. Zool.* 1981; **30** : 268–280.
4. Chen J, Jayachandran M, Bai W, Xu B. A critical review on the health benefits of fish consumption and its bioactive constituents. *Food Chem.*, 2022; Article No. 130874, DOI: 10.1016/j.foodchem.2021.130874.
5. DiCenzo VJ, Sellers KK. Proceeding of the Annual Conference of Southeast Association of Fisheries and Wildlife Agencies. 1998; **52**: 104-110.
6. DOF. Handbook of Fisheries Statistics, Compiled by Fisheries Statistics Division, Department of Fisheries (Ministry of Fisheries, Animal Husbandry and Dairying) Govt. of India, New Delhi, 2023; p 18.
7. Farah-Ayuni F, Muse AO, Samat A, Shukor MN. Comparative Scale Morphologies in Common Freshwater Fishes of Peninsular Malaysia – A Case Study. UKM FST Postgraduate Colloquium AIP *Conf. Proc. Published by AIP Publishing.* 2016; 978-0-7354-1446-4 doi: 10.1063/1.4966850.
8. Ganzon, Mary Ann M, Mark Anthony J Torres, Jessie J Gorospe, Cesar G. Demayo. Variations in Scale Morphology between Sexes of the Spotted Barb, *PuntiusBinotatus* (Valenciennes, 1842) (Actinopterygii: Cyprinidae). *Proceedings of 2nd International Conference on Environment and Bio-Science IPCBEE,* 2012; **44**

IACSIT Press, Singapore.

9. Green PE. Mathematical tools for applied multivariate analysis. Academic Press, 1976; N.Y., p. 376.
10. Hanski I, Simberloff D. The metapopulation approach, its history, conceptual domain, and application to conservation. In: Hanski, I. and M.E. Gilpin, eds. Metapopulation biology, Ecology, Genetics, and Evolution. Academic press, San Diego, 1997; pp. 5–26.
11. Hollander RR. Microanalysis of scales of Poecilid fishes. *Copeia.* 1986; **1**: 86-91.
12. Hughes DR. Development and organization of the posterior field of ctenoid scales in the Platycephalidae. *Copeia.* 1981; **3**: 596-606.
13. Jawad LA, Al-Jufaili SM. Scale morphology of greater lizardfish Sauridatumbil (Bloch, 1795) (Pisces: Synodontidae). *J. Fish Biol*. 2007; **70**: 1185-1212.
14. Jawad LA. Comparative morphology of scales of four teleost fishes from Sudan and Yemen. *J. Nat. His.* 2005; **39**(28): 2643–2660.
15. Johal MS, Esmaeili HR, Tandon KK. A comparison of back–calculated lengths of silver carp derived from bony structures. *J. Fish. Biol*. 2001; **59**: 1483-1493.
16. Kaur N, Dua A. Species specificity as evidenced by scanning electron microscopy of fish scales. *Current Science*. 2004; **87**: 692-696.
17. Kuusipalo L. Evolutionary inferences from the scale morphology of Malawian cichlid fishes. *Adv. Ecol. Res.* 2000; **31**: 377-397.
18. Lippitsch E. Scale morphology and squamation pattern in cichlids (Teleostei, Perciformes): A comparative study. *J. Fish. Biol*. 1990; **37**:265–291.
19. Lippitsch E. Scale surface morphology in African cichlids (Pisces, Perciformes), *Annales du Muse´e Royal de l'AfriqueCentrale Sciences Zoologiques*. 1989; **257**:105–108.
20. Lippitsch E. Squamation and scale character stability in cichlids, examined in *Sarotherodon galilaeus* (Linnaeus, 1758) (Perciformes, Cichlidae). *J. Fish. Biol*. 1992; **41**:355–362.
21. Miranda Rafael, Escala Ma Carmen. Morphological and biometric comparison of the scales of the barbels (Barbus Cuvier) of Spain. *J. Morph.* 2000; **245**(3):196-205.
22. Poulet N, Yorick R, Hélène C, Sovan L. Does fish scale morphology allow the identification of populations at a local scale? A case study for rostrum dace *Leuciscus leuciscus burdigalensis* in River Viaur (SW France). *Aquat. Sci*. 2005; **67**: 122–127.
23. Radkhah AR, Poorbagher H, Eagderi S. Habitat effects on morphological plasticity of Sawbelly (*Hemiculter leucisculus*) in the Zarrineh river (Urmia Lake basin, Iran). *J. BioSci. Biotech.* 2017; **6:** 37–41.
24. Reza EH, Somayeh B, Halimeh Z, Fatemeh S. Scale morphology of tank goby *Glossogobius giuris* (Hamilton-Buchanan, 1822) (Perciformes: Goblidae) using scanning electron microscope. *J. Biol. Sci.* 2009; **9**: 899-903.
25. Russell BC. FAO species catalogue. Nemipterid fishes of the world. (Threadfin breams, Whiptail breams, Monocle breams, Dwarf monocle breams, and Coral breams). Family Nemipteridae. An annotated and illustrated catalogue of nemipterid species known to date. *FAO Fisheries Synopsis.* 1990; 125.
26. Russell BC. Review of the western Indian Ocean species of *NemipterusSwainson* 1839, with description of a new species (Pisces: Nemipteridae). *Sencken bergiana biologia*. 1986; **67**: 19–35.
27. Shukla R, Bhat A. Morphological divergences and ecological correlates among wild populations of zebrafish (*Daniorerio*). *Envl. Biol. Fishes*, 2017; **100**: 251–264.
28. Sire JY, Arnulf I. Structure and development of the ctenial spines on the scales of a teleost fish, the cichlid *Cichlasoma nigrofasciatum*. *Acta Zoologica*, 2000; **81** : 139–158.
29. Ujjania NC, Nandita S. Use of scale for the growth study of Indian major carp (*Cirrhinus mrigala*Ham., 1822) in tropical freshwater. *Ind. J. Expl. Biol.* 2018; **56**: 202–206.
30. Ujjania NC, Sharma LL, Sanchita Rose, Prajapati SD. Scale Morphology and Population Differentiation in Exotic Fish Tilapia (*Oreochromis mossambicus* P. 1852) from Some Major Water Bodies of Western India. *Inte. J. Bio-res. Stre. Mangt.* 2023; **14**(10):1370-1377 DOI.ORG/10.23910/1.2023.4798a
31. Ujjania NC, Soni Nandita, Sharma LL. Determination of Age and Growth of Cyprinid Fish of tropical Environment using Scale- A Protocol. *Fish. Chim.* 2014; **34**(4) : 51–56.
32. Varma KBR. Morphology and dielectric properties of fish scale. *Current Science*. 1990; **59**(8): 420–422.