International Journal of Zoology Studies
ISSN: 2455-7269; Impact Factor: RJIF 5.14
www.zoologyjournals.com
Volume 1; Issue 6; September 2016; Page No. 18-22

Morphology of scales in three teleost species from Godavari river basin in parts of Maharashtra, India

Sumayya Ansari, * Shivaji Chavan, Sharda Padghane

Fisheries Research Laboratory, Department of Zoology, School of Life Sciences, Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra, India

Abstract
Scale surface morphology provides new and useful information on fish taxonomy. Several characters of scales are established and being used as a taxonomic tool. Scales in three teleosts species were observed and measured from eight regions of fish body that represented different size, shape and characters. From the results, it was concluded that scale morphology and its surface patterns can be valuable tools to investigate systematic relationship among the fish species, scale structure is also useful to recognize food chain in aquatic ecosystem which will be helpful to maintain and conserve different components in freshwater food chain.

Keywords: Fish Scale, Morphology, Teleosts, Godavari river

1. Introduction
Fishes are one of the widely distributed and diverse group of animals in the world. Due to overfishing & habitat destruction this diversity is decreasing. Taxonomic identification of fishes is essential to conserve them and to understand their role in the aquatic ecosystems. Several morphometric and meristic characters are used in fish taxonomic studies but scales morphology in fish taxonomy is one of the important parameter which cannot be ignored. The scale study method is easy to apply, rapid and inexpensive, it does not require killing and dissection of host fishes. Scale shape & scale number have been used for taxonomical investigations since the first half of 19th century when Agassiz (1833-1884) [1] used it in fish taxonomy for the first time. During the late 19th century & first half of 20th century, studies on scale morphology found increased considerably in the field of fish taxonomy (Williamson 1851; Baudelot 1873; Cockerell 1915a,; 1915b; 1955; Chu 1935; Lagler 1947; Kobayasi 1951, 1953, 1955; McCuly 1961) [23, 2, 4, 5, 3, 18, 15, 16, 17, 20]. Fish scale characteristics are very useful in the identification as they tend to change from species to species. Circuli, redii, cternii, structure of lateral line canal opening on the scale, presence and absence of chromatophores & other structures associated with scales have been used authentically for fish classification (Hughes 1981, Hollander 1986, Dicenzo & Sellers 1998, Kaur & Dua 2004)[12, 6, 14] Generally elliptic, oblong, pentagonal, rectangular, square, triangular and cycloid shaped scales are found in bony fishes (Jawad 2005) [13]. Fish species are differentiated with morphometric & meristic characters of scales. Scales are the unique part of fish body, the study showed that scale morphology can be used successfully to distinguish between species even at fry and fingerling stages. The scale morphology of the selected fish species were not investigated earlier hence this research work was planned.

2. Materials and Methods
a) Importance of scale study
The scales in teleost are dermal derivatives and used as an important structures in fish taxonomy and biology. They show clear pattern of dark and light bands related to closely and widely spaced circulii that form annular zones of growth which show the age of fish in years. The impressions and surface pattern of circulii on scale served as a blue print for some physiological studies. Besides this there is role of scales in fish biology having numerous hidden details in their two or three dimensional design that helps effectively to identify and classify the fishes. Scale morphology is an important tool in determining the diet of piscivorous predators or in the paleontological analysis. (Esmaeili, 2001) [7]. Through the scale study in gut content analysis the food preference, feeding habit and habitat of piscivorous animal can be confirmed because in the gut and fecal waste usually the scales remain undigested and little affected by the secretion of digestive system. There are spawning marks on the scales of salmon species. The data on structural details of scales on different parts of the body in several fish species are not available hence this would be an important data base applicable in several ways for ecology, fish biology, ecological conservation, habitat restoration etc in freshwater ecosystem.

b) Study area
Fish samples were collected from four different fish markets in Nanded city, Maharashtra State, India; the fish markets were located at Itwara Sunday market near Mutton Market, Tuesday market Kawtha near new bridge of river Godavari, Stadium road Friday Market and Wednesday Market Taroda Naka Malegaon Road. From all these fish markets during bazaar days the fish samples were collected during Year 2015.The source of fish to these markets was from river Godavari basin.

c) Identification of fishes and sampling of scales for identification
From the selected markets where the fish input was from the nearby water resource like river Godavari, Asna, Purna and Reservoirs near Barul, Sonkhed, Derla, Vishnupuri and also from the nearby streams. Three selected fish species were common in occurrence in the all selected fish markets throughout collection period. International fish Database was used as standard and current reference http://www.fishbase.org. Froes and Pauly (2016) to identify the fish samples to species level. Copllected samples were identified as *Neolissochilus hexastichus* (McClalland, 1839), *Pethia ticto* (Hamilton, 1822)

and *Glossogobius giuris* (Hamilton, 1822). The Scales were removed carefully using forcep from eight different regions of fish body so as to see any possible variation in the surface structure of the scales. Before removal of scales the fish body surface was cleaned and washed using tap water and collected scale samples were fixed in to 4 % formalin. The scales were so small, delicate and flat in form that need not require flattening again to prepare stained micro-preparation. After dehydration in ascending grades of ethanol from 30 % - 100 % the scales were stained in to Acid carmine. Scale sample were cleared in xyline and mounted in canada balasam mountant. Dried slides of the scales were observed under the Carl Zeiss Dissceting (305) and Compound binocular (Primo Star) microscopes and photo images were recorded using TUCSEN eyepiece fixed camera. Scale images were processed for various measurements in mm by using TUCSEN image processing software. All the scale samples collected and fish species are preserved with collection reference number in the Department of Zoology, School of Life Sciences, S. R. T. M. University, Nanded, MS- 431606, India for the further reference.

d) Surface microstructures on the scales

The scale surface has various microstructures such as focus located usually at the centre position of scale, granules, radii, circuli, tubercles and lepidents, and plane circular or wavy margin. The Focus of a scale has various sizes, positions and shapes in various fish species. The focus positions may occur at the centre, below centre or towards the caudal part of the scale. Focus shape may be round, pentagonal, oval, elliptical or sometimes indistinct to explain like diagonal, multiangular or conical etc. In some scales the surface of the focus may be smooth or covered with granules. In some species the scales have only one type of granules or simple pattern, while in others the granules may be mixing of two granule types or complex pattern may found. Radii are of three types as primary secondary and tertiary.

Primary radii rise from the focus or near the focus and grow towards the scale margin. Secondary radii start at the scale margins and end after a short distance from the origin. Tertiary radii position is between the focus and the scale margin. The number of tertiary radii is usually 3-7 in the different species. Tertiary may be absent and the total number of radii is not concern with the age and size of the specimens but their arrangement is species specific. Tubercles are present on the caudal field of a scale, these are tiny, small or large. The shape of tubercles is variable in forms like round, oval or slightly cylindrical. The outer surface of a tubercles may be smooth or rough. Tubercles occur almost in all members fish species having scaly body. In most of species, the tubercles are present on both the circuli and intercircular region. Lepidonts are small denticles present on circuli of the rostral and lateral fields and they are attached firmly. when observed under high magnification they show variation in size like tiny, very tiny, small, prominent etc. their shapes are blunt, pointed, short or truncated. Lepidonts are present in few number sometimes numerous or absent and distributed widely or closely spaced. All characters of lepidonts are varying considerably between populations or fish species. Generally lepidont size, shape, number and distribution are similar on the rostral and lateral fields of the scales, exceptions that have smaller and fewer lepidents on the lateral fields than on the rostral fields.

The lateral line scale is also divided in to anterior (rostral) and posterior (caudal) parts. Focus is absent in the lateral line scales due to the position of lateral line canal at the focus point this route has a canal which characteristically lies along the anterio posterior axis, slightly toward the posterior part with the openings. The anterior part of the lateral line has several mucus pores that opens on the scale. The circuli are densely spaced. The granulation on the posterior portion is similar as in normal scales located below the dorsal fin except that the canal is extended to the granulation area. Hamid (2014) [10] also illustrated the scale surface microstructures and scale size in three Mugilid fishes (Teleosti: Mugilidae) from Iran, and Hollander (1986) [11] studied the microstructures in Poeciliid fishes indicates the importance of scales in fish species identification.

3. Results and Discussions

The permanent micro preparations of scales were observed under the dissecting binocular microscope and compound binocular microscope with phase contrast arrangement and various structural details are recorded for the three different fish species selected under this investigation viz. *Neolissochilus hexastichus* (McClalland, 1839), *Pethia ticto* (Hamilton, 1822) and *Glossogobius giuris* (Hamilton, 1822).

In a fresh water ecosystem especially in the river ecosystem these species are at the base of food chain. *N. hexastichus* and *Pethia ticto* both are from family Cyprinidae, these are the common weed fishes living in a group of 10-50 in the stagnant pools of rivers and shallow area of water bodies. These are important food for the predatory fishes like *Wallago attu*, *Sperata seenghala* and species of snake headed (*Channa species*) fishes. Hence the availability of these fishes determines the assurance of food for predators in the river ecosystem. *Glossogobius giuris* (Gobidae) is another common shallow water species prefer to live in the sand-mixed muddy bottoms and act as main food for the predatory fishes. It is one of the delicious fishes in human diet. Due to food value these are captured by gill nets and cast net in large quantities. The structural details of scales in these three fish species is given in the table 1.

Table 1: The structural details of scales of three teleosts from Godavari river basin MS.

S. No.	Characters	Particulars in three teleosts		
		1. *N. hexastichus*	**2. *P. ticto***	**3. *G. giuris***
1.	Shape of the scale	Pentagonal with wavy anterior margin /Hexagonal with circular anterior margin.	Semispherical with wavy anterior margin	Triangular
2	Focus of the scale	Located nearly in the middle of a scale with 12-15 small outlet openings that communicate with radii	Located at the centre medium to large in size and communicate with radii	absent
3.	Circulii	Many in number	Many in number	Many in number

4.	Tubercles	Present at the caudal field of scale	Absent	Absent
5.	Radii (N= 8)	13-18	12-14	18-22
6.	Shape of anterior margin of scale	Rounded in dorsal scales, Wavy on scales of other body parts	Wavy	Wavy
7.	Chromatophores	Present at the posterior end of the focus	Absent	Absent
8.	Lepidonts (Wavy structures near circulii)	Absent	Absent	Absent
9.	Ctenii (Thorny projections from the scale margin)	Absent	Absent	18-30 (N=8) at lower lateral margin of scales.
10	Length of scale	7.8-7.9 mm	3.6-3.8 mm	1.7-1.8 mm
11.	Width of scale	4.9-5.1.mm	4.5-4.6 mm	2.2-2.3 mm

(N=Total number of scales observed, mm = millimeter)

(Jawad, 2005) [13] Studied the scale surface morphology and squamation patterns to provide new and useful information for the systematics of teleost members from Tripterygiid family. Various types of body scales were observed and found different shapes like elliptic, oblong, pentagonal, rectangular, rounded, square, triangular, cycloid; Where as in the present study the shape of scale (Table 1.) in the selected three fish species was not variable and it remain unchanged in each species in the present study. Comparative study of ctenoid scales with reference to the total body length in different species of the genus *Lutjanus* from Karachi fish harbor in Pakistan was studied by Masood (2011) [21] and concluded that the detailed stricture of fish scales can be helpful in identification of fish up to major group or species levels. (Gholami, 2013) [1] Reported that the species within the tooth-carp *Aphanius sp.* has been recorded from the endorheic drainage system of Iran. The description of this investigation is based on morphological and molecular data. The objective of this study was to test as to whether the scale surface morphology, scale surface microstructure and scale size can be used to differentiate species. The scales of three species of the genus *Aphanius* from endorheic basins in SW Iran have been studied using Scanning Electron Microscope (SEM). In the present study also the scale microstructure are found useful to distinguish the fish species. (Loyd and Dapar, 2012) [19] Examined numerous hidden details of a scale in Indian goatfish *Parupeneus indicus* and concluded that the variations in the microstructures contribute effectively in identification and classification of fishes. Using a stereomicroscope observed some distinguishable characteristics such as the type of scale, shape, size of scale, position of the focus, circuli appearance, and the type of radii. The study was with significant variations in shape of scales observed between male and female of the species. Esmaeili (2012) [7] observed the scales of *Garra rossica* which is one of the most common and poorly known cyprinid fish south-eastern Iran by using SEM. They observed about features on anterior and posterior region of focus. It was found that focus covered by reticulate and honeycomb from structures with few mucous gland pores. In the present study Binocular compound microscope with eyepiece fit camera was used to investigate the details of focus structures (fig. 7a). The scales of *G. rossica* shows the general structure of a cycloid scale. Esmaeili (2012) [7] also recorded the variation in scale structure of species from Family Mugilidae to characterize the variation in relation to habitat difference as fresh water, brackish and marine. Beside these the form of the lateral line canal, position of their anterior and posterior openings and extention of canal were investigated in species. Sheikh-Eldin (1988) [22]; Ghisotti, (1995) [9] examined 1160 scales from 27 specimens of three *Plectorhynchus* species namely: *P. gaterinus, P. pictus and P. schotaf* collected from the Red sea at Jeddah, Saudi Arabia were examined for scale characteristics from the four different region of the body using SEM. Scales in the rostral, lateral and caudal regions represented variations.

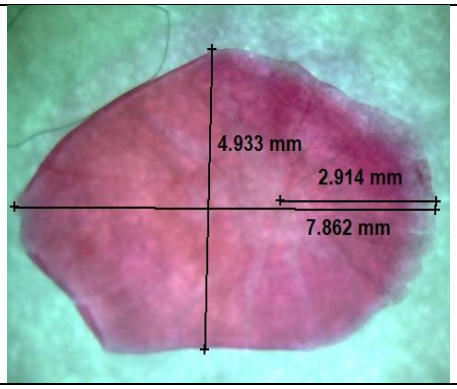

Fig 1: Scale of *Neolissochilus hexastichus* from dorsal body surface.

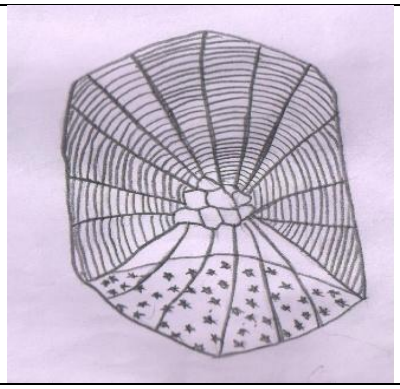

Fig 1: (a) Line diagram of scale *Neolissochilus hexastichus*

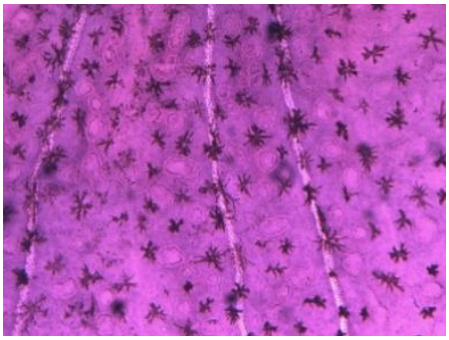

Fig 2: Chromatophores on caudal region of scale in *Neolissochilus hexastichus*

Fig 3: Focus and radii origination from focus in the scale of *Neolissochilus hexastichus*

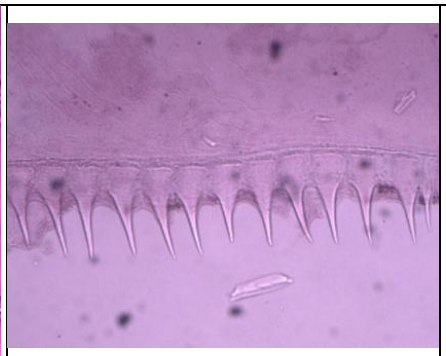

Fig 4: Thorn shaped ctenii on the latero-ventralmargin of scales in *Glossogobius giuris*

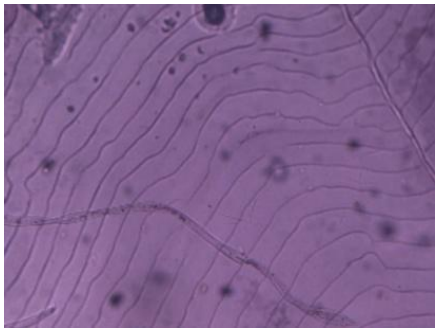

Fig 5: Arrangement of circulii on the scale of *Neolissochilus hexastichus*

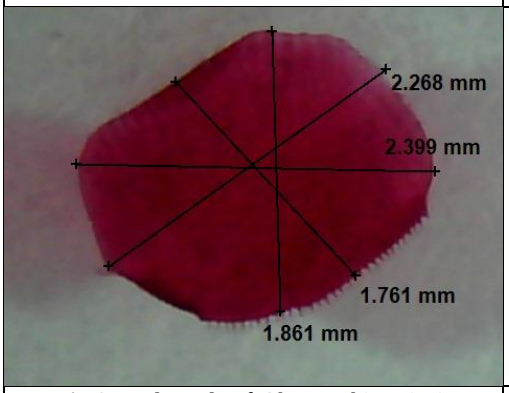

Fig 6: Body scale of *Glassogobius giuris*

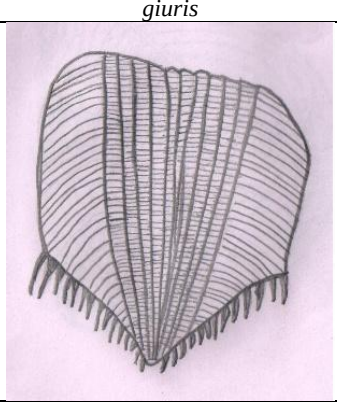

Fig 6 (a): Body scale of *Glassogobius giuris*

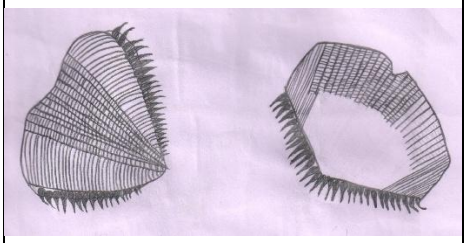

Fig 6 (b): Body scale of *Glassogobius giuris*

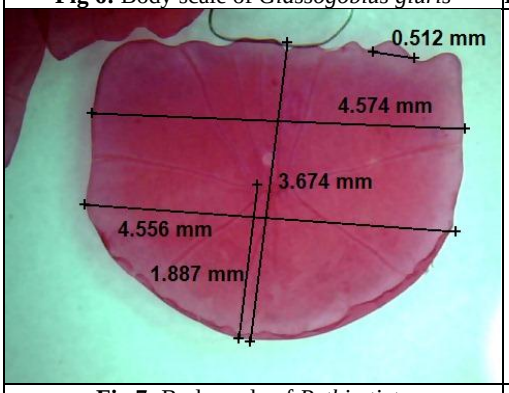

Fig 7: Body scale of *Pethia ticto*

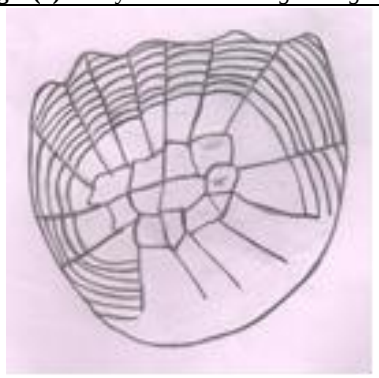

Fig 7 (a): Body scale of Pethia ticto

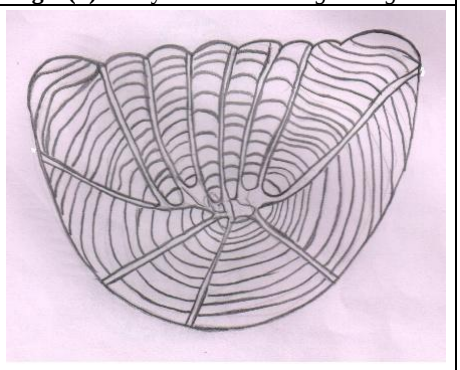

Fig 7 (b): Body scale of *Pethia ticto*

4. Conclusion

After the review of various studies as above it is concluded that the scales have microstructures other than what we think as plane structures, all these structural peculiarities are so important that one can distinguish two fish species just by observing the structural details of scales instead of going for their biochemical and bimolecular analysis by using expensive, sophisticated and inaccessible methods and protocols. In the present study we tried to characterize the scale structures of three fish species in the river ecosystem, also it will add in the basic primary data on this issue which was not investigated earlier.

5. Acknowledgments

The Authors are sincerely thankful for financial support to Maulana Azad National Fellowship for the minorities from University Grants Commission (UGC), New Delhi, India awarded to S. F. (F. No. F-1-17.1/2014-15/MANF-2014-15-MUS-MAH-43439/(SA-III/Website) and Rajiv Gandhi National Fellowship from UGC, New Delhi to S. P. (F. No. F1-17.1 / 2016 - 17 / RGNF - 2015 - 17 - SC - MAH - 21064 / (SA-III / Website). Thanks to RGSTC, Mumbai for equipment grants to S. C. (F. No. APDS/RGSTC/Proposal/ASTA/2014-15/2976. Dt. 20/02/2015). Thanks to local fishermen for cooperation in getting fish and scale samples.

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