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EVALUATION OF SCALE MORPHOLOGICAL VARIATIONS AND FEATURES IN FRESHWATER AQUARIUM FISHES

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The integumentary system plays a significant role in the interactions with the environment in vertebrates. The integument part acts as the body envelope that protects and separates the individual from its environment and is an essential organ in communicating and sensing the outer atmosphere in fishes. The fish integument is a large organ covering all the body surfaces and lines the body openings. Thus they play a wide range of functions like protection, communication, sensory perception, respiration, locomotion, excretion, ion balance, and thermal regulation. For the present study, freshwater aquarium teleost fishes were collected from the local freshwater aquarium shops in and around Thiruvananthapuram. Our researchers collected eight teleost freshwater aquarium fishes from three different families (*Cyprinidae, Osphronemidae*, *Poeciliidae*) and qualitatively compared the morphology based on the observations and images captured using stereomicroscope and research microscope. The parameters used for comparison include scale shape and size, focus location, anterior margin shape, presence of lepidonts, tubercles, and ctenii. The relative size is also calculated to know the arrangement. The essential scales showing all the peculiar characteristics of scales such as caudal scale, dorsal scale, and median scales are analysed. This preliminary work might be helpful for further understanding the qualitative characters of different fishes.The qualitatively analyzed characteristics can be used in taxonomy and in studying more about the integumentary system of fish as well as in comparative studies with other vertebrate integumentary systems.

Keywords: Lepidonts; ctenii; actinopterygians; placoid; cosmoid.

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ABBREVIATIONS

IRC: Interradialcirculli

1. INTRODUCTION

The scale is an essential part of the integumentary system of fishes that helps the organism's smooth movement in the water. It also helps protect body parts from getting wounded and prevents bacterial infection. The integumentary system plays a significant role in interacting with the environment, similar to other vertebrates. In fishes, the integument acts as the body envelope that protects and separates the individual from its environment and is essential in communicating and sensing the outer environment. The fish integument is a large organ covering all the body surfaces and lines the body openings. The aggregation chromatophore provides definite coloration in the epidermis. The integumentary system of fish, as in other vertebrates, is well developed and evolved in such a way to carry out multiple functions [1]. Like all other vertebrates, they have two layers of integument; an outer epidermis and an inner dermis or corium. These layers differ in their origin, structure, and function. The epidermis has a multi-layered epithelium from the embryonic ectoderm [2]. In contrast, the dermis has a fibrous structure with relatively fewer cells and is derived from embryonic mesenchyme of mesodermal origin. Placoid scales are also called dermal denticles, which contain dermal denticles, containing dermal and epidermal portions, same as in mammalian tooth.

The epidermis of fish shows variation in thickness depending on species, age, environmental conditions, and region of the body. Generally, the dermis is thicker than the epidermis in most fish species. Scale morphology is an indicator of pollution and waste toxicity [3]. The thickness, structure, and arrangement of the epidermis and the types of cells present can also be significantly influenced by the size, sex, condition, and degree of sexual maturation of a fish. Epidermal scale derivatives are the tough, horny extensions of the stratum corneum. They differ from the dermal scales in that epidermal scales shed off periodically after attaining the specific growth phase. Epidermal scales are absent in the fishes, and they have dermal scales that cover their body surface.

Integumentary adaptations for protecting fishes in an aquatic environment show a wide range of variation and transformation based on their path of evolution. The mucus secretion on the body surface helps keep the organism free of pathogens by sloughing, renewal, and presence of antimicrobial components such as fatty acid, immunoglobins, lysozyme, lectin, antimicrobial peptides, and proteolytic enzymes. Moreover, scales are the regions where chromatophores aggregate, providing epidermis and dermis definite colorations. Fishes are divided into four groups based on scale morphology: placoidei, ganoidei, ctenodei, and cycloidei [4]. Since then, the fish scale has been considered an essential character in systematics and phylogenetics. The cosmoid scales are ancient scale types found in the extinct coelocanths and lungfishes. They are similar to the placoid scales and may have arisen from the fusion of placoid scales. The cosmoid scales are made up of a basal dense lamellar layer known as the isopedine and a cancellous or spongy bone with the supply of blood capillaries. The ganoid scales are modified cosmoid scales with ganoine, secreted by the dermis replacing the surface *in vitro* dentine and cosmine replacing dentine inside. These are entirely dermal scales as compared to the other types of scales. Cycloid and ctenoid scales are devoid of enamel layer except in some parts like the ctenii, posterior and superficial edges of scales, etc. These scales evolved by loss of ganoine and dermal plate thinning in the ganoid scales. The scale contains a bony surface layer of salts like calcium phosphate and calcium carbonate and a deeper fibrillary plate containing most collagenous substances. The chromatophores can be seen in both scales and the underlying dermis. According to the situation, the dispersion and aggregation of chromatophores are controlled by nervous and endocrine systems.

Actinopterygians are called “ray-finned” fishes because of their distinctive fins,internally supported by numerous slender, endoskeletal lepidotrichia. Fish biologists divide actinopterygians into chondrosteans, holosteans, and teleosts, each intended to represent primitive, intermediate, and advanced groups of finned fishes.

The current study analyzes the qualitative morphological characters of different scales from the common freshwater aquarium teleost fishes. The scales selected for the study are key scales present in specific locations of fish bodies with all the characteristic features that can be observed from all scales present in a specimen. These include (a) Middle scales just below the dorsal fin, (b) dorsal head scales, and (c) caudal or tail region scales. The qualitative morphological parameters of key scales used in the present study include the scale type, number and type of radii, presence or absence of lepidonts, tubercles, ctenii, shape lepidonts, and focus position, the shape of the scale. The mentioned parameters are compared based on the data collected from the microscopical view. This is a preliminary study to understand the different scales' differences and their characteristics in the teleost fishes. In the future, documenting the scale characters of more species can develop taxonomic keys and help taxonomic identification in a relatively simple way.

2. MATERIALS AND METHODS

For the present study, freshwater aquarium teleost fishes were collected from the local freshwater aquarium shops in and around Thiruvananthapuram, Kerala.The fishes were suitably selected based on age calculated from the hatching time. The health of the fish was also evaluated through observation on body surfaces like scales and fin and by checking the overall activity of the fish[5]. The fishes were then acclimatized to laboratory conditions before taking scale samples from the live specimen. A total of 8 fishes from three different families were taken for the study. The scales were taken for microscopic observations. The key scales for observation are collected from the mother part of the body [6]. These scales were collected using sterilized forceps from the left side of all the specimens to make the procedure uniform. The carefully taken fish scales were gently washed in water using a fine brush to remove loose skin and slime layers.

The scales were then wet mounted on a clean, dry glass slide, and a coverslip was put on for getting a focused plane image.Labomed Luxeo 6z stereo microscope (Labo America Inc. 920 Auburn Court, America) and LabomedLx 500 (Labo America Inc. 920 Auburn Court, America) research microscope with magnification ranging 100x were used for the qualitative morphological analysis of scales. The main parameters measured during the study is; the size of the fish, length and width of the scale, type of scale, number of circulli presents, number and variety of radii present, presence and absence of lepidonts, presence, and lack of tubercles,Chromatophores, Anterior field margin shape, Overall shape of the scale, Location of focus, Presence or absence of Ctenii.

Using the measured length of the scale and the total fish length, a relative measurement in percentage is formulated to compare the size of scale to the total length of the individual, known as the J – indices[3]. The relative scale length and scale width were calculated as follows;

J = length of scale (mm)/ fish length (mm) *100.22

Family	Fishes Selected for the Study	Characteristics
Cyprinidae	*Cyprinusrubrofuscus* (Koi carp)	Native to central Asia and Europe Able to withstand different climates and water conditions They are slow-moving and live in calm waters
	Carassiusauratus	Native to East Asia and were selectively bred in china Slow-moving and living in a calm environment hey have large scales all over the body, with anterior margins visible
	Barbonumusschwanenfeldii	Found in the South-East Asian freshwaters Red dorsal fin with a black spot at the tip, red pelvic, pectoral, anal fins, with red caudal with white bordering.Fast-moving nature
	Puntigrustetrazona (Tiger barbs)	Tropical cyprinids with their natural geographic location range in the Malay Peninsula, Sumatra, and Borneo in Indonesia They are active fishes showing aggressive behavior and prefer flowing waters compared to stagnant waters
Osphronemidae	*Trichopodus trichpterus(Three spot Gourami)*	Native to South-East Asian countries Hardy species with labyrinthorgans present Blue Gourami is comparatively a medium paced shows aggressive behavior
	Trichopodus trichpterus	An active colour morph and have similar behavior to the parent fish
	Bettaspledans(Yellow Gourami)	Shows high territorial behavior, and they have different colormorphs Relatively large fins compared to their body size
Poecillidae	*Poeciliasphenops*	Native to Mexico regions Scales are easily visible and have a white iridescence Appers in different colour morphs and selected species are in white molly type

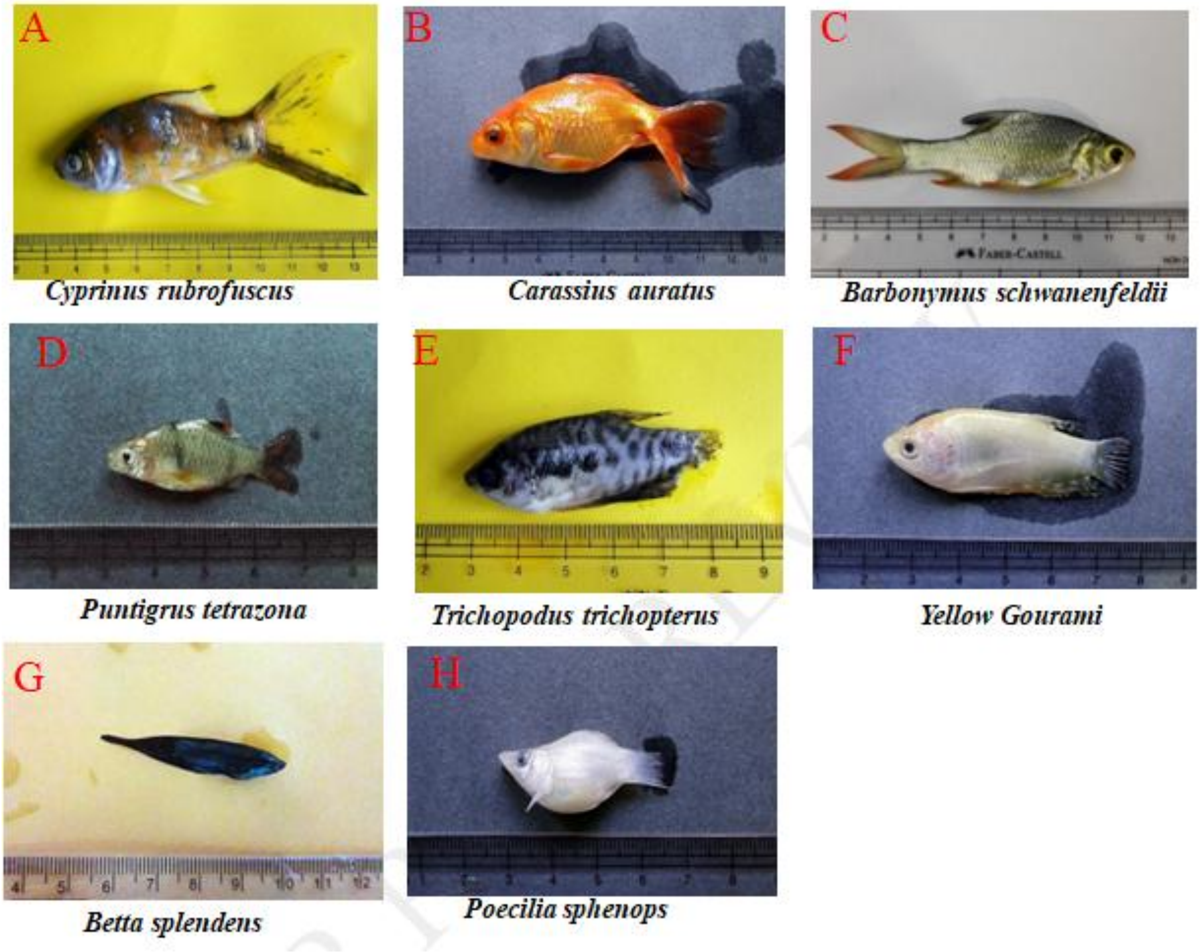

Fig. 1. (A-H) – Fishes selected for the study

3. RESULT

Observable morphological characteristics of different key scales of fishes belonging to different families:

Ⅰ. Cyprinidae family

ⅰ. ***Cyprinusrubrofuscus* (koicarp):** The Carp was observed with cycloid scales on its body. The following characteristics were observed in the key scales of Carp

Caudal Scale: The caudal scale observed was oval with a wavy anterior margin, and the focus was located at the center of the scale (Fig. 2 A). There were fifteen primary radii and five secondary radii from all sides of the scale (Table 1). The primary radii conjoined together at the focus in a different pattern. The lepidonts were absent on the scale, whereas the tubercles were present.

Dorsal Scale: The observed shape of the scale was oval with a focus located at the center (Fig. 3 A). The primary radii were more numerous, with seven against only one secondary radius, located from all sides. Tubercles were present, and lepidonts were absent in the scale (Fig. 6).

Median Scale: The median scale observed was square-shaped, focusing at the center (Fig. 4 A). The anterior margin was wavy and prominent, and the scale contained eight primary radii and one secondary radius. The tubercles were present, and the Lepidonts were absent on the scale.

ⅱ. ***Carassiusauratus* (Gold Fish)**: The observed scales showed characteristics of Cycloid scale in Gold Fish. The following features were observed in the key scales:

Caudal Scale: The caudal scale observed was circular, focusing at the center (Fig. 2 B). The anterior margin teeth were wavy in appearance and had primary and secondary radii present at all the sides of the scale (Fig. 5). The lepidonts were present in the circulli.

Dorsal Scale: The dorsal scale observed was circular, focusing at the center (Fig. 3 B). Two types of radii were present, with six primary radii and one secondary radius at all sides. The anterior margin teeth were wavy, and lepidonts were present in the circulli.

Median Scale: The median scale observed overall shape was a circle focused at the center (Fig. 4 B). The anterior margin teeth were wavy with only six primary radii present in the scale, and the circulli contained lepidonts.

ⅲ. ***Barbonymusschwanenfeldii*** ***(*****Tinfoil Barb*****)***: The scales observed in the Tinfoil Barb were of cycloid type. The following characteristics of key scales were observed in Tinfoil Barb;

Caudal Scale: The caudal scale was elongated with the focus located towards the posterior field (Fig. 2 C). The focus was free without primary radii joining together. The anterior margin of the scale was comparatively less wavy than others, and the scale contained ten primary radii, six secondary radii, and two tertiary radii (Fig. 5). Both the lepidonts and the tubercles were absent in the scale (Table 1).

Dorsal Scale: The dorsal scale observed was elongated, focusing on the posterior field (Fig 3 C). The anterior margin was less wavy, and the scale contained twelve primary radii, ten secondary radii, and two tertiary radii. Both lepidonts and tubercles are absent on the scale. The interradial circulli (IRC) shows a different pattern (Table 1).

Median Scale: The median scale observed was oval, with the focus located at the center and was devoid of joined primary radii structures (Fig. 4 C). The scale contained eight primary radii, four secondary radii, and four tertiary radii. Both lepidonts and tubercles were absent in the scale (Table 1).

ⅵ. ***Puntigrustetrazona*** ***(*****Tiger Barb*****)***: The observed scales were cycloid type, and the characteristics were found in the key scales of Tiger Barb;

Caudal Scale: The caudal scale observed was elongated, focusing on the anterior field (Fig. 2 D). The anterior margin of the scale was smooth, and the scale contained nine primary radii and one secondary radius. Lepidonts were present with a small dome-like shape, and the tubercles were absent (Fig. 6).

Dorsal Scale: The dorsal scale observed was oval in appearance, focusing on the anterior end (Fig. 3 D). Only seven primary radii were present on the scale. The anterior margin of the scale was found wavy (Fig. 5). The lepidonts were dome-shaped, while the tubercles were absent (Table 1).

Median Scale: The median scale observed was rectangular, focusing at the center and containing eight primary radii (Fig. 4 D). The lepidonts were less prominent in this scale (Fig. 6). The tubercles were absent similar to other scales in the fishes. The anterior margin observed with a wavy appearance (Fig. 5).

Ⅱ. Osphronemidaefamily

ⅴ. ***Trichopodustrichopterus*** ***(*****Blue Gourami*****)***: The observed scales of Blue Gourami showed characteristics of ctenoid scale. The features of the key scales were describe below

Caudal Scale: The caudal scale observed was an inverted dome shape with a focus located towards the posterior (Fig. 2 E). The ctenii were present in considerable numbers. Spine-like lepidont was observed in the circulli. The tubercles were found absent in the scale (Fig. 6). The anterior margin of the scale was wavy in appearance, and the scale consisted of five primary radii and two secondary radii (Fig. 5).

Dorsal Scale: The dorsal scale observed was circular with focus at the centre (Fig. 3 E). The dorsal scale was found devoid of any projecting ctenii, but the surface of the scale at the posterior field was observed with small outgrowths. The anterior margin was wavy in appearance, and the scale consisted of only four primary radii (Fig. 5). The lepidonts were found present, and the tubercle was absent in the scale (Fig. 6).

Median Scale: The median scale observed has an inverted dome shape with a focus located at the centre (Fig. 4 E). The anterior margin was wavy, and the scale consisted of six primary radii, five secondary radii, and one tertiary radius. The ctenii was present, and the lepidonts were absent in the scale (Fig. 6).

ⅵ. ***Trichopodustrichopterus*** ***(*****Yellow Gourami*****)***: The observed scales in the fish yellow Gourami showed characteristics of ctenoid scale. The following attributes of key scales were observed in the Yellowfish Gourami;

Caudal Scale: The caudal scale observed showed an inverted dome shape focusing on the posterior field (Fig. 2 F). The ctenii was numerous found on the rear field of the scale. The scale consisted of six primary radii and two secondary radii, and the anterior margin was wavy in appearance. The lepidonts were present with a soft edge, and the tubercle was absent in the scale.

Median Scale: The median scale observed showed an inverted dome shape with a focus located towards the posterior (Fig. 4 F). The ctenni was numerous in number present on the posterior field of the scale. The anterior margin was wavy in appearance, and the scale consisted of six primary radii, four secondary radii, and two tertiary radii (Fig. 5). The Lepidonts were found present in the scale with soft edges (Table 1).

Dorsal Scale: The dorsal scale observed was oval with a focus located at the center. Only four primary radii were present on the scale (Fig. 3 F). The ctenii was absent in the posterior field, but small projections on the surface of the posterior field of the scales were observed. The lepidonts with soft edges bordered the circulli of the dorsal scale, whereas the tubercle was completely absent. The anterior margin of the scale was wavy in appearance (Fig. 5).

ⅶ. ***Bettasplendens*** ***(*****Siamese Fighter Fish*****)***: The scales observed in the fighter fish showed characteristics of ctenoid scale. The following attributes of key scales were observed in the Siamese Fighter Fish;

Caudal Scale: The caudal scale observed has an inverted dome shape with unequal sides (Fig. 2 G). The focus was located towards the posterior field, and the scale consisted of four primary radii, four secondary radii, and two tertiary radii. The anterior margin was wavy in appearance (Fig. 5). The lepidonts were present in the circulli, whereas the tubercle was absent in the scale.The ctenii was present in the posterior field of the scale.

Dorsal Scale: The dorsal scale observed showed an inverted dome shape focusing on the posterior (Fig. 3 G). The anterior margin was wavy in appearance, and the scale consisted of six primary radii, two secondary radii, and two tertiary radii (Fig. 5). The ctenii and the lepidonts were present on the scale, whereas the tubercle was absent.

Median Scale: The median scale observed has an inverted dome shape with a focus located at the posterior field (Fig. 4 G). The anterior margin was wavy in appearance, and the circulli was observed with lepidonts. The tubercle was found absent, and it consisted of eight primary radii and four secondary radii (Fig. 6).

Ⅲ. Poecilidaefamily

ⅷ. *Poeciliasphenops* (White Molly): The observed scales in White Molly showed the characteristic of cycloid scale. The following characteristics of key scales were observed in the fish White Molly.

Caudal Scale: The caudal scale observed showed an inverted dome shape with a focus located at the center (Fig. 2 H). The lepidonts were found spine-like in the circulli, and the tubercle was absent in the scale (Fig. 5). The scale consisted of numerous radii, including ten primary radii, four secondary radii, and three tertiary radii. The scales showed the presence of calcium or white crystal-like depositions.

Dorsal Scale: The dorsal scale observed was oval with a large focus located at the scale center (Fig 3 H). The overall shape and circulli arrangement were different from other key scales. The lepidonts were spine-like in the circulli, and the tubercles were present in the scale (Fig. 6). The scale showed only secondary radii originating from the margin, and the anterior margin of the scale was wave-like in appearance. Melanophore was found present in the scale (Fig. 7G).

Median Scale: The median scale observed showed an inverted dome shape with a focus located at the center (Fig 4 H). Spiny lepidonts were present on the circulli, and the tubercles were present in the scale. The scale consisted of eight primary radii, four secondary radii, and two tertiary radii. The anterior margin of the scale was wave-like in appearance (Fig. 5). The presence of melanophores can be observed on the scales (Fig. 7G).

Chromatophores in the Common Teleost Freshwater Aquarium Fishes

The chromatophores present in the observed fishes include melanophores, xanthophores, erythrophores, iridophores, and leucophores. Melanophores were the highest sighted chromatophore in the observed fishes. The leucophores were present in the fishes of the family *Poecilidae* (Fig. 7). The iridophores were observed in almost all fishes giving them an iridescent appearance. The rapid dispersion of chromatophores was evident in the *Trichopodustrichopterus* compared to other observed fishes.

4. DISCUSSION

The different key scales of the freshwater aquarium teleost fishes have been described qualitatively based on morphological characteristics of scales like the shape of the scale, location of focus, lepidont, and tubercle. The scales are usually reduced to a thin transparent structure with (a) a basal plate which is the thickest layer composed of elasmodine and several layers of collagen fibers, (b) the external thin layer made up of collagen fibers, and (c) the limiting layer, a hyper mineralized layer without collagen fibers found on the surface of the scale in regions close to the epidermis [7]. The elasmoid scales consisting of both cycloid scale and ctenoid scale lacks ganoine and dentine [7].

The shape of the scale is one of the easily observable characters that showed variation between species and between different scales. The various scale forms include oval, circle, rectangle, square, and elongated shapes. The different key scales observed various shapes. The caudal scale and median scale of *Trichopodus trichopterus* (yellow gourami) display an inverted dome shape. In contrast, the dorsal scale is oval in appearance, and variations in scale shape can be observed in other varieties. Cycloid scales also show variations in the case of *Carassius auratus,* and the median scale is circular in contrast to the median scale of *Poecilia sphenops*, which shows an inverted dome shape. The key scales within these species are also different; for example, the median scale, the dorsal scale, and the caudal scale showed circular shape while the lateral scale was rectangular. The caudal scale and median scale in *Trichopodustri chopterus* (yellow gourami) are inverted dome shapes. Cycloid scales also show variations in the case of *Carassiusauratus*, and the median scale is circular.The elasmoid scales also showed calcified concentric ridges (bony ridges) called circulli. *Carassiusauratus* are examples of fish species having circulli with concentric circles.

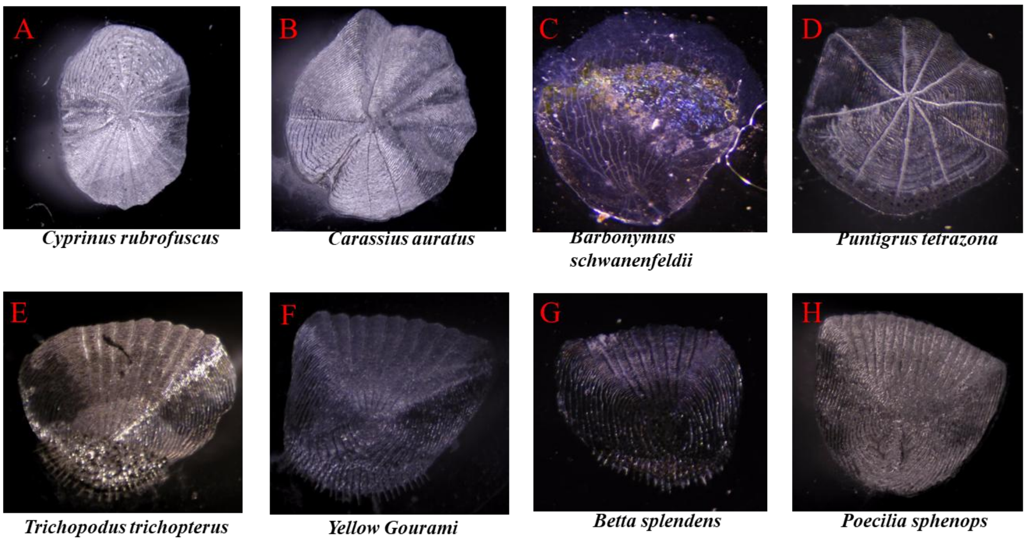

Fig. 2. (A-H). Stereo microscope image of caudal scale

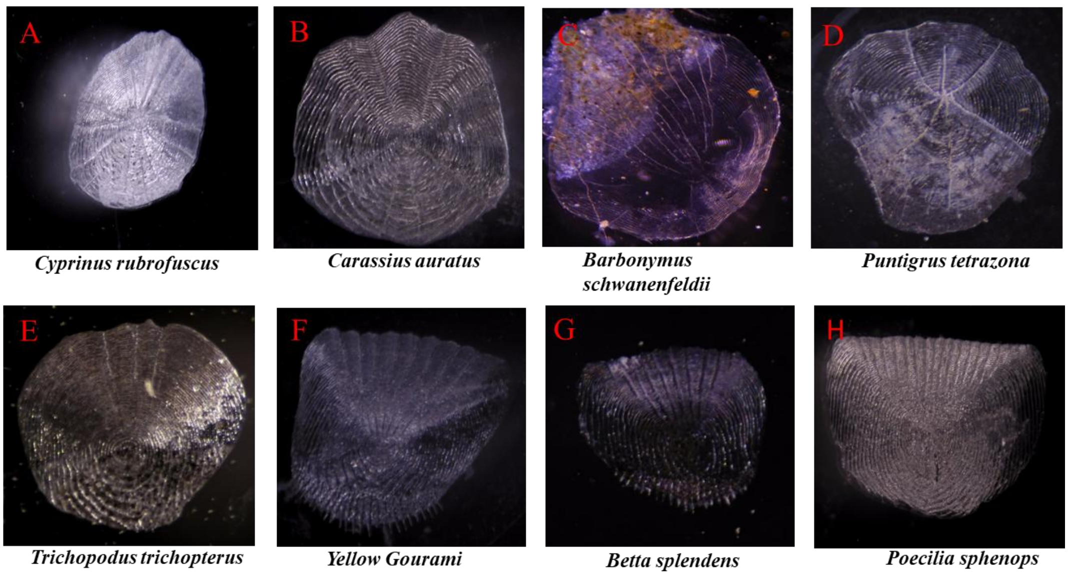

Fig. 3. (A-H). Stereo microscope image of dorsal scale

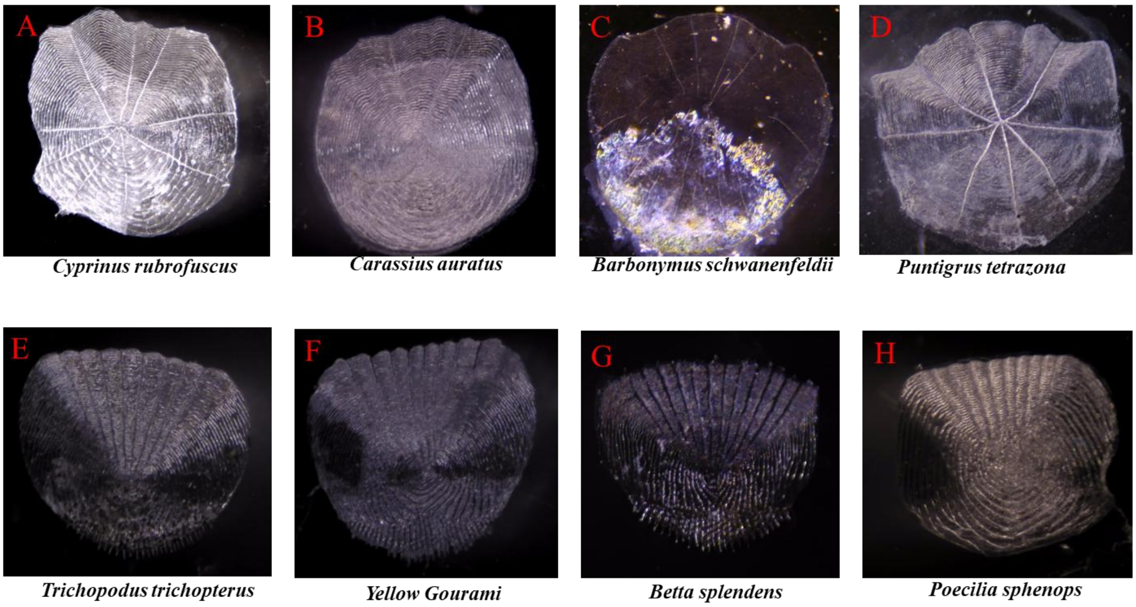

Fig. 4. (A-H). Stereo microscope image of median scale

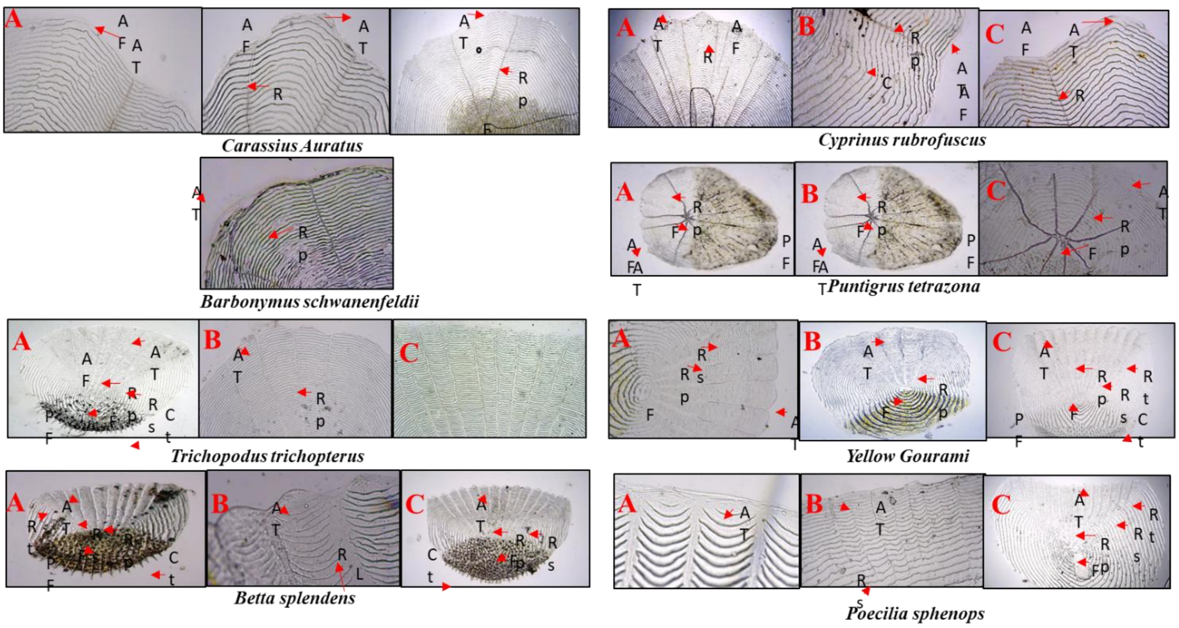

Fig. 5. Anterior margin shape (A) Caudal scale (B) Dorsal scale (C) Median Scale

R-Radil, AT- Anterior field, ct- ctenii, F- focus

The scales' circulli provide mechanical strength and flexural stability in movement [6]. At the same time, the radii help more anchorage to the scale in the dermis.The number and type of radii vary according to the specimen and are not concerned with the age and size of the sample. But the arrangement is always species-specific [7]. The dorsal scale of *Poeciliasphenops* contains only primary radii, whereas the dorsal scale of *Trichopodustrichopterus* (Blue Gourami) has only secondary radii. The uncalcified grooves, also known as the radii are seen in almost all the key scales of the observed specimen. The anterior margin of the scales also showed variation in shape in the form of wave-like (teeth) and soft edges The *Barbonymus schwanenfeldii*are example for fish showed a smooth anterior margin of the scale.

Usually, the arrangement of radii in scales is in the order of primary radii in the center, and adjacent to the last primary radii follows the secondary radii. Then the tertiary radii follow the last secondary radii [8]. The scales in *Carassiusauratus*, the radii are distributed from the focus towards all sides of the scale. At the same time, the fishes observed from the Family *Osphronemidaehas* radii distributed only in the anterior field of the scale. The uncalcified ridges may also help provide more grip to attach the scales to the dermis and the overlapping of scales. The total number of radii, ctenii, and circulli increases with fish age [9]. This arrangement and shape of the anterior end of scales help firm attachment space for overlapping scales. The focus on the scale is the first part growing on a new scale. The position of the focus can be seen at the center, caudal end, or towards the anterior end of the scale in the observed specimens. *Carassiusauratus* and *Cyprinusrubrofuscus* have their focus situated in the center of the scale. Thus, the overall flexural stability may depend on the growth of the focus [10]. The development of other structures like the radii and circulliis related to the location and growth of the focus. The lepidonts are calcified projections on the edge of the circulli [11]. The lepidonts show the difference in shape and arrangement in the circulli. The lepidonts are considered functions like acting as a friction pad between overlapping scales. The space in between two scales provided by the lepidont may help in water circulation, thereby exchanging ions, gases, and nitrogenous waste can take place [12].

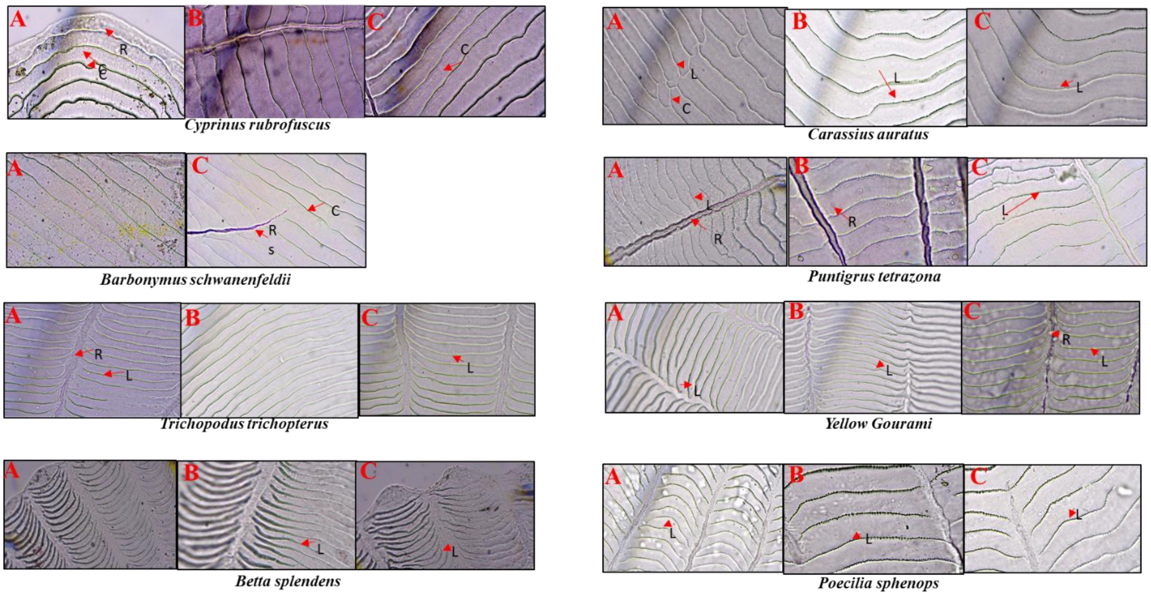

Fig. 6. Scale with Lepidonts (40x). (A) Caudal scale (B) Dorsal scale (C) Median Scale
L- Lepidonts, R-Radil, C-Circulii

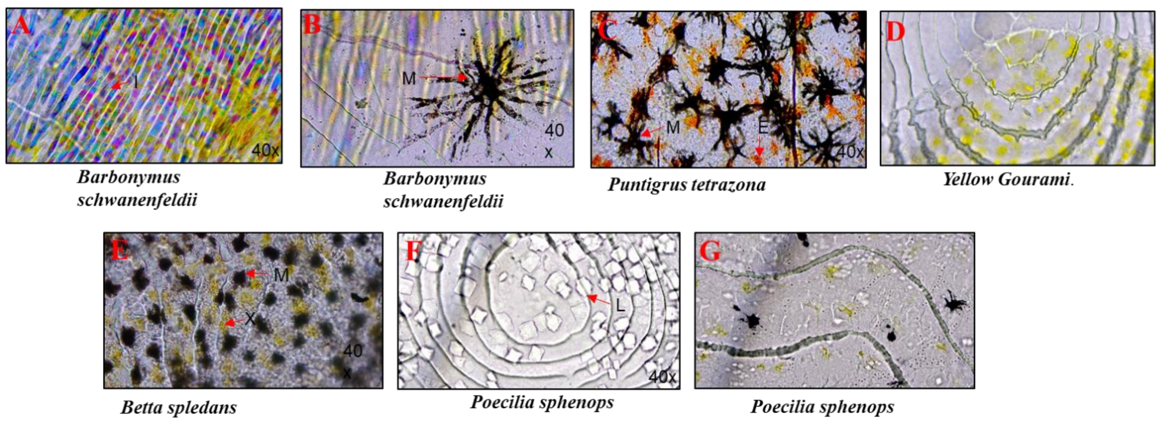

Fig. 7. (A-G). Chromatophored (40x). X-Xanthophore, M-Melanophore, M-Melanophore, I-Iridiophores, E-Erythophores, L-Leucophores

Table 1. Morphological parameters of different scales

Scientific Name	Length (mm)	Body region	Scale type	Lenth of scale	Relative size of scale	Tubercles	Radii	Anterior margin	Lepidonts	Ctenii	Position of focus	Scale shape
Cyprinusrubrofuscus	80	ML	cycloid	2.80	3.55	P	p8 s1	wavy	A	A	C	circle
		L	cycloid	4.20	5.25	P	p11 s1	wavy	P	A	C	rectanglee
		AD	cycloid	2.35	2.90	P	p8 s1	wavy	P	A	C	circle
		CL	cycloid	3.71	4..63	P	p15 s5	wavy	A	A	C	circle
Carassiusauratus	75	ML	cycloid	2.80	3.73	A	p6	wavy	P	A	C	square
		L	cycloid	3.85	5.13	A	p6 s1	wavy	P	A	C	rectangle
		AD	cycloid	2.50	3.30	A	p6 s1	wavy	P	A	C	oval
		CL	cycloid	3.60	4.80	A	p5 s2	wavy	P	A	C	oval
Barbonymusschwanenfeldii	100	ML	cycloid	3.45	3.45	A	p8 s4 t2	smooth	A	A	C	oval
		L	cycloid	4.25	4..25	A	p9 s4 t6	smooth	A	A	C	elongated
		AD	cycloid	2.95	2.95	A	p12 s10t2	smooth	A	A	TP	elongated
		CL	cycloid	2.84	2.84	A	p10 s6 t2	wavy	A	A	TP	elongated
Puntigrustetrazona	38	ML	cycloid	1.68	4.42	A	p8	wavy	P	A	C	rectangle
		DL	cycloid	1.58	4.15	A	p7	wavy	P	A	TA	oval
		AD	cycloid	-	-	-	-	-	-	-	-	-
		CL	cycloid	1.68	4.42	A	p9 s1	smooth	P	A	TA	elongated
Tripodustrichopterus	55	ML	ctenoid	2.16	3.90	A	p6 s2 t3	wavy	A	P	C	Inverted dome
		L	-	-	-	-	-	-	-	-	-	-
		AD	ctenoid	1.50	2.72	A	p4	wavy	P	UI	C	circle
		CL	ctenoid	1.37	2.49	A	p5 s2	wavy	P	P	TP	Inverted dome
Tripodustrichopterus	53	ML	ctenoid	2.12	4	A	p6 s4 t2	wavy	P	P	TP	-
		L	ctenoid	-	-	-	-	-	-	-	-	oval
		AD	ctenoid	1.62	3.05	A	p4	wavy	P	UI	C	Inverted dome
		CL	ctenoid	1.50	2.83	A	p6 s2	wavy	P	P	TP	Inverted dome
Bettaspledans	45	ML	ctenoid	1.41	3.13	A	p8 s4	wavy	P	P	TP	-
		L	ctenoid	-	-	-	-	-	-	-	-	Inverted dome
		AD	ctenoid	1.58	3.51	A	p6 s2 t2	wavy	P	P	TP	Inverted dome
		CL	ctenoid	0.98	2.17	A	p4 s4 t2	wavy	P	P	TP	Inverted dome

Scientific Name	Length (mm)	Body region	Scale type	Lenth of scale	Relative size of scale	Tubercles	Radii	Anterior margin	Lepidonts	Ctenii	Position of focus	Scale shape
Poeciliaspenops	43	ML	cycloid	1.94	4.50	P	p8 s4 t2	wavy	P	A	C	Inverted dome
		L	cycloid	1.85	4.30	P	p8 s4 t4	wavy	P	A	C	Inverted dome
		AD	cycloid	1.94	4.51	P	s8	wavy	P	A	C	oval
		CL	cycloid	1.94	4.51	A	p10 s4 t3	wavy	P	A	C	Inverted dome

ML-middle scale, L- lateral scale,AD- dorsal scale,CL- caudal scale,P-present,A- absent,Centre,TP-towards posterior,TA- towards anterior, p-primary radii, s- secondary radii, t- tertiary radii,UI- unidentified

Tubercles are also calcified projections in the posterior field of the scales, which may have the anchorage function to the dermis[13]. *Cyprinusrubrofuscus* scales showed tubercles in the posterior end. All the other species of fishes observed do not contain tubercles in their anterior end. The reason for this variation in tubercles is unknown.

The posterior end of the ctenoid scales contain ctenni and can be observed in fishes *Trichopodustrichopterus*. One exception for this is the absence of protruding ctenii in the dorsal scales of *Trichopodustrichopterus* (Blue Gourami). The scale and associated integumentary system also contain different chromatophores like xanthophores, melanophores, iridiophores, leucophores and erythrophores [14]. But these structures cannot be included in the scale characters as the chromatophores are found in the dermis in stratum spongiosum and hypodermis.

Similarly, fishes included in the family Osphronemidae have ctenoid scales with ctenii present in the posterior. The tubercle is completely absent in the collected fishes of *Osphronemidae.* The fishes from 3 different families showed a difference in morphological characters of scale. As discussed, the variation starts from the overall shape of scales to the ultrastructural variations like tubercles and lepidonts. These differences in morphological characters of scales can be used for taxonomic studies of fishes.

5. CONCLUSION

The scale characteristics are different for various species and differ in the key scales within an individual. The scales that show all the peculiar features of the entire scales in a fish are known as key scales. The shape of the scale is one of the easily observable characters that showed variation between species and between different types of scales. The different key scales used in the study are median, lateral line, dorsal, and caudal. The parameters used for comparison include scale shape and size, focus location, anterior margin shape, presence of lepidonts, tubercles, and ctenii.

The focus of the scales is located at various locations like center, towards posterior, or towards anterior. The anterior margin of most of the scales observed is wave-like in appearance, with some exceptions. The ultrastructure of scale-like ctenii is present in the observed fishes from the family *Osphronemidae* and not observed in the dorsal scale of *Trichopodustrichopterus* variety. Cycloid scales are kept in the fishes from the families *Poecilidae* and c*yprinidae*. The uncalcified radials and calcified circulli also showed differences among species. The lepidont and tubercle are also present in some species, while some are absent and thus functional parameters for taxonomic differentiation. According to the species, the lepidont morphology also shows variations like the spine and soft-edged lepidont. Certain species in the same family also indicate the presence and absence of Lepidonts. The relative size of the scales to that of the fish is also calculated to know the arrangement.The qualitatively analysed characteristics can be used in taxonomy and in studying more about the integumentary system of fish as well as in comparative studies with other vertebrate integumentary systems. This work might be helpful for further understanding the qualitative characters of different fishes.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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