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Identification of Scales in Fresh Water Fishes in Indian Major Carps observed under the compound microscope to determine age growth

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Abstract

Sustainable fisheries management is critical in supporting both the planet's economy and ecosystems The shape of fish scales is to a considerable extent species-specific and is also useful in the determination of stock membership. Size is also important in distinguishing fish scales, both in absolute terms and potentially through allometric effects on scale shape. The present study uses landmarks and geometric morphometric statistical approaches to address two specific questions: (1) if and how fish scale shape varies with a general measure of size: fish fork length. This is assessed by regressing shape on fork length and (2) To what extent size, expressed as fish fork length (FL), is an important factor that has to be taken into account in the identification of species. The analysis is conducted with fish scales taken from particular body regions from the longitudinal and transverse axis. Cross-validated discriminant analyses are carried out on shape, form (shape plus size) and allometrically standardised data (i.e. allometrically adjusting scale shape according to FL). Using only shape (without size), identification rates are much better than chance, and by taking size into account, but not allometrically adjusting shape, classification is improved somewhat.

Keywords:- Cycloid Scale, Ganoid Scale ,Cosmoid scale, Ctenoid Scale

Introduction.

Sustainable fisheries management is critical in supporting both the planet's economy and ecosystems. Fisheries provide massive economic support to countries around the globe, supporting an estimated 260 million jobs worldwide in 2011 (Teh & Sumaila, 2011). In the United States, the fishing industry alone contributed 100 billion dollars to the Gross Domestic Product (NOAA, 2020). Perhaps more important than the face-value economic support fisheries offer is the fact that organisms comprising fisheries are the stabilizing consumers of nearly every aquatic food web (NOAA, 2019). Structure of teleost fish skin The skin of teleost fish can be though of a soft asymmetric shell that comprises a highly elastic dermis on one side and a population of thin, but stiff scale on the other. The scale structure typically displays a quasi-periodic pattern comprised of alternate rows of overlapping scales running over the length of the fish (Fig. 1a and c). In the simplest description the scales can be characterized by their shape, size and overlapping distance (Fig. 1b and d) (Browning et al., 2013).

Although size can significantly vary among species, we found that the normalized overlapping distance within a single row of scale is remarkably consistent. For instance, for the four fish considered in this study, the ratio r of the scale spacing to the length of a single scale was comprised between r¼0.2 for the milkfish and r¼0.3 for the mullet (Fig. 1c and d). Striped bass and the white perch displayed intermediate configurations with r¼0.25. Individual scales are attached to the underlying dermis by small pockets of skin, which overlap approximately half of the scale length (Fig. 1d). These pockets are characterized by an intricate net-like structure supported by a soft elastic film (the dermis) that gives the skin its high deformability. More importantly, these pockets function as elastic sleeves for individual scales (Fig. 1d) providing resistance to their out-of-plane rotation as the overall skin bends. The scales themselves are characterized by an elastic modulus that is several orders of magnitude larger than the dermis (Zhu et al., 2013). Meanwhile, their small thickness ensures a finite bending rigidity and low weight. Overall, the interactions between the scales and the underlying dermis offer a variety of mechanical functions that are essential to fish survivability, such as freedom of motion, swimming efficiency, lightweight, robustness, protection and escape mechanism. For instance, recent studies on artificial (Browning et al., 2013) and natural scale (Zhu et al., 2013) have shown that the interaction between scales plays a significant role to resist sharp puncture. To first investigate the role of scales on skin bending, we first designed a simple pinching test in which a skin specimen (with scales) is removed from the fish body and immediately subjected to a force-couple (with forceps) which induced large skin curvature (Fig. 2a). This strategy ensured that the skin remained fully hydrated during the test but did not allow a direct measurement of the force–displacement relation. This test was however particularly useful to understand the synergy F.J. Vernerey, F. Barthelat / J. Mech. Phys. Solids 68 (2014) 66–76 67 between scale and dermis deformation during bending, as shown in Fig. 2. For concave bending (scales are on the inside of the curve), Fig. 2b clearly shows that skin bending involves a significant rotation of individual scales, a feature that is associated with a rise on the skin's bending resistance with curvature. On the other hand, for convex bending the scales play no role in the skin mechanics and the structure remains extremely soft.

Fish are biochemical keystones, providing a critical mass of nutrients necessary for primary producers to grow and develop (Allgeier et al., 2013). In order to mitigate the threat of overfishing, proper fisheries management is needed. Fisheries management sets fishing regulations and quotas, aiming to protect and sustain marine ecosystems (NOAA Fisheries). Through the use of stock assessments and other scientific observations, fisheries management organizations such as the National Oceanic and Atmospheric Administration seek to balance stock harvest and stock size, striving to create a sustainable harvest of global fish populations (NOAA Fisheries) Background on Fish Scales The presence of scales on fish is mainly for protection. In fact, early forms of extant fish had scales of such size and multitude that, while they provided protection, they hindered the ability for the fish to move efficiently (Burdak, 1986). As fish evolved, the reduction in the integumental skeleton (the “outside” of the fish body) led to scales taking on different forms in order for the fish to achieve efficient locomotion. There are four types of fish scales, each with their own distinct shape. Those scale groups are cycloid, ctenoid, ganoid, and placoid (Rawat, 2021; Figure 2). Placoid scales are spiny projections characteristic of cartilaginous fish. As fish will regenerate lost scales in locations of injury, identifying sites of frequent injury and scale shedding will help researchers lower the frequency of sampling non-representative, regenerated scales. Identifying such hot spots will need to be species-specific and must take into consideration the functional community dynamics at play. Generally, it is recommended that scales be selected from the body region where they first form, as they will contribute the most accurate age data (Longo et al., 2020). In some fast-growing species, however, the risk of obtaining a regenerated scale discourages sampling from an “old” scale region on the fish body. For instance, it has been observed in the striped bass that scales nearest to the lateral line form earliest, but these scales have only an approximate 30- day head start when compared to scales from other candidate sampling sites (Galbraith et al.). Scales are aged by seasons, not days. Therefore, it may be more efficient to focus on avoiding regenerated scales, as opposed to selecting scales from regions that form earliest, given that formation times are relatively similar across the fish body. An example of the importance of understanding fish scale regeneration when evaluating fish age can be found when fish eyespots are examined. There is evidence that piscine predators hunt by honing in on the eyes of their prey (Kjernsmo & Merilaita, 2013). Fish with noticeable or larger eyes would logically be more commonly attacked at their head. Conversely, fish with eyespots ("fake" eyes designed to deter predators from vital organs) might have a higher rate of injury – and consequently a higher rate of regeneration – in areas where eyespots are present. Additionally, abiotic loss of scales related to fish habits such as rock scraping, bottom feeding, or hole burrowing, must also be taken into account. These mechanisms of scale loss are a consequence of body size and swimming habits in different environments. Common locations of scale loss must be investigated in individual fish species before extensive scale analysis is used in fisheries management, in order to avoid a high occurrence of regenerated scales. In order to determine areas of high regeneration on fish bodies, a study could be conducted analyzing photos of caught fish to visually identify sites of injury. Scales could be sampled from injured fish to compare the occurrence of regenerated scales in the injury site with scales from healthy fish used as a control variable. This would be most successful through the use of citizen science, with anglers submitting pictures of their caught fish to a central organization for analysis, similar in process to the Snap-a-Striper project conducted by the Gulf of Maine Research Institute, where fishermen are encouraged to submit photos of their catch next to a standardized data card for morphometric analysis. While the goals of the proposed study would be different from those of the Snap-a-Striper program, the concept of citizen science and photo collection could still be utilized effectively ("Snap-a-Striper."). Photos of fish deemed healthy and injury-free by researchers could be compared to submitted photos, and a machine-learning algorithm might be used to discriminate pictures of injured fish from pictures of healthy fish, increasing the efficiency of such a research

MATERIAL AND METHODS

Method for counting annuli Scales from, fresh specimens preserved in the freezer were collected from about the middle flank of the fish just under the dorsal fin and above the lateral line. Key scales were regarded as those lying directly below the posterior end of the dorsal fin and on the first row of scales above the lateral line. The scales were cleaned with cold water (as warm water disintegrates them) and will be observed under a binocular microscope. The number of growth rings on scales was counted. When inspection is not made on same day, the scales were fixed in-between two slides held with cello tape for observation later.

Cosmoid scales

Cosmoid scales are found only on ancient lobe-finned fishes, including some of the earliest lungfishes (subclass Dipnoi), and in Crossopterygii, including the living coelacanth in a modified form (see elasmoid scales, below). They were probably derived from a fusion of placoid-ganoid scales. The inner part of the scales is made of dense lamellar bone called isopedine. On top of this lies a layer of spongy or vascular bone supplied with blood vessels, followed by a complex dentine-like layer called cosmine with a superficial outer coating of vitrodentine. The upper surface is keratin. Cosmoid scales increase in size through the growth of the lamellar bone layer.

Ganoid scales

Ganoid scales are found in the sturgeons, paddlefishes, gars, bowfin, and bichirs. They are derived from cosmoid scales and often have serrated edges. They are covered with a layer of hard enamel-like dentine in the place of cosmine, and a layer of inorganic bone salt called *ganoine* in place of vitrodentine

Cycloid (circular) scales

Cycloid (circular) scales have a smooth texture and are uniform, with a smooth outer edge or margin. They are most common on fish with soft fin rays, such as salmon and carp

Ctenoid scales

Ctenoid (toothed) scales are like cycloid scales, except they have small teeth or spinules called ctenii along their outer or posterior edges. Because of these teeth, the scales have a rough texture. They are usually found on fishes with spiny fin rays, such as the perch-like fishes. These scales contain almost no bone, being composed of a surface layer containing hydroxyapatite and calcium carbonate and a deeper layer composed mostly of collagen. The enamel of the other scale types is reduced to superficial ridges and ctenii.

Fish without scales

Fish without scales usually evolve alternatives to the protection scales can provide, such as tough leathery skin or bony plates.

- Most eels are scaleless, though some species are covered with tiny smooth cycloid scales.
- Most catfish lack scales, though several families have body armour in the form of dermal plates or

USES AND FUNCTIONS OF SCALES

Scales serve as external structures with defensive capabilities and have a wide range of functions and uses. The following points outline their roles and applications: 1. Fish Classification: Scales are of utmost importance in classifying fish. The quantity of scales varies among different species, and the arrangement of scales above and below the lateral line is crucial for determining the fish's position in the hierarchy of family, genus, and species. 2. Life History of Fish: Scales grow as fish mature, leading to the formation of concentric circular lines known as growth rings. These rings document physical changes in the fish across seasons. The annual formation of a distinct line called the annulus reflects winter slowdown in fish development, providing insights into breeding, seasonal growth, and yearly changes. Atlantic salmon scales also bear spawning marks, revealing the number of times a fish has spawned.

RESULTS AND DISCUSSION

Scales play a significant role in the categorization of fish species, making them extremely valuable for ichthyologists. Lampreys and hagfishes do not have scales, while sharks are characterized by placoid scales, primitive bony fishes have ganoid scales, and more advanced bony fishes possess ctenoid or cycloid scales. The number of scales on a fish is crucial for taxonomy, and the specific count of scales along the lateral lines and around the body is unique to each species. Fish age can be determined by measuring the spacing in the annual growth rings of their scales. In certain species, such as Atlantic Salmon, scales display marks related to spawning events, indicating the number of times the fish has spawned and the timing of its first spawning. Most fish have scales, with the exceptions being Agnatha and catfish, which lack scales on their bodies. Some fish, like paddlefish (Polyodon) and mirror carp (Cyprinus carpio), have partial scales, while others, like trout and freshwater eel, have small scales that primarily cover their bodies, providing protection against injuries. It's important to note that larger scales offer better protection but can limit a fish's mobility, whereas smaller and lighter scales, while offering less protection, allow for greater maneuverability. Fish scales contain a diverse range of pigments that contribute to their various colors. These scales collectively form a lateral line along the fish's body, running along its side, and play a crucial role in sensing water vibrations, serving as sensory receptors.

CONCLUSION

The overall results indicate that Labeo rohita showed an almost isometric pattern of growth in the present habitat and the condition factor values showed that it is in good condition or health and the present condition existing in the collection site is conducible for the feeding and optimum growth of fish. This study will help biologists to know the status of this fish and develop culture technology in natural waters and will be useful for the fishery biologists and conservation biologist, for successful development, management, production and ultimate conservation of the most preferred food fishes of the states.

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