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NOTES ON THE COLORATION OF FISHES.

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While it is well known that the color of fishes of the same species varies more or less it may not be amiss to call especial attention to some of the more marked changes that may be noticed. The color changes in living fishes may be due to various emotions as fright, curiosity, anger, or sexual excitement, or they may be due to environment, as the color of the bottom, the color of the water, distance of the fish from the surface or from bottom, distance from objects attached to the bottom or floating at the surface, presence in the immediate vicinity of grass, sticks, etc.

Many people who are familiar with the fact that the color and color pattern may change in the same species have an idea that this takes place slowly. We hope to show that this does not necessarily follow and will give some illustrations of color changes which we have noted in various species in aquariums, principally that of the Bureau of Fisheries at Washington, D. C.

The Large Mouth Black Bass (*Micropterus salmoides*) when viewed as an ordinarily preserved specimen usually shows more or less traces of a black lateral band. In the large specimens this may be very faint but can usually be discerned. Similar specimens of the Small Mouth Black Bass (*Micropterus dolomieu*) show no traces of this black band but are plain olivaceous in color. There are several living specimens of each species in the aquarium at the Bureau of Fisheries where we have spent some time watching the color changes. One large specimen which showed very strongly the typical black lateral band of the Large

Mouth Black Bass changed in less than two seconds, so that the band was entirely invisible and the fish appeared to be a Small Mouth Black Bass. In preserved specimens of both species the color, except for the black lateral band, is plain; that is, there are no mottlings or marmorations, but in the aquarium, where the fish are so used to seeing visitors that they pay no attention to their presence, the color may be seen to change from plain olivaceous without the black lateral band to plain olivaceous with such a band, or to a mottling of light and dark green with or without the black band. The Large Mouth Black Bass when showing the mottled color usually shows the black band; specimens of the Small Mouth Black Bass usually do not show the black band and the mottlings have a greater tendency to appear as dark cross bars. It is difficult to determine the exciting causes of these changes as fish hiding in crevices of the rocks will show both colorations and fishes swimming show both color patterns. It appears, however, that fish swimming freely or hiding in rather dark holes have a greater tendency to exhibit the plain coloration, while those resting on the bottom or swimming close to the rocks at the side of the aquarium have a greater tendency to show the marbled or mottled color pattern.

Preserved specimens of Tautog (*Tautoga onitis*) are usually nearly plain black but with more or less distinct vertical light and dark bars of about equal width. In the aquarium they show remarkable variations of these two color patterns. When swimming freely the color is usually plain black and when resting on the bottom or at the sides of the aquarium the bright pattern is visible. However, these colors are not constant and swimming fish may be seen showing the bars while those resting on the bottom show the dark color. The color changes are frequently very rapid. We have seen a fish swimming in a vertical circle about two feet in diameter showing the bright coloration only near the bottom of the aquarium and the black color in the upper half of the circle at each turn.

In the New York Aquarium at Battery Park notices are posted in front of certain tanks containing some of the tropical angel fish, calling attention of visitors to rapid changes in color and color pattern of this fish. These changes are truly marvelous. Waves of blue starting at the head pass to the tail and disappear. While one is watching the fish the color will become all

blue or all brownish or half blue and half brown, etc. Indeed the changes are too numerous to mention.

The Pigfish (*Orthopristis chrysopterus*) shows very remarkable changes in color and color pattern. There are three perfectly distinct color patterns which appear to be about equally common. One is a perfectly plain light or dark gray without spots or bars of any kind. Another has this same gray ground with several heavy black cross bars, which sometimes are more or less broken up into dark mottlings. A third shows instead of the cross bars a black line from the end of the snout to the base of the dorsal fin and along each side of this fin. Below this is a narrow light stripe with a heavy black band below it. A second dark band extends from the eye straight to the caudal peduncle. The lower edge of this band is just above the upper lip. Between this and the dark band above it is a light stripe about the same width as either of these dark bands. The upper dark band crosses the front of the head about midway between the lower band and the front of the dorsal fin. There are also a few small black lines across the front of the head which make the markings appear much like a bridle. One of these lines passes from the upper edge of the opercle to the upper edge of orbit and then across front of head. Sometimes the two sets of bars fade out except at points where they cross, giving rise to a series of square black blotches on the side of the fish. Any of these color patterns may appear instantaneously, following any other. Sometimes the change may be likened to the fading of one picture and the appearance of another in a stereopticon.

Specimens of the Pinfish (*Lagodon rhomboides*) in the aquarium show mostly a color pattern made up simply of longitudinal blue stripes of greater or less intensity on a grayish ground. However, at times black cross bars appear. The appearance and disappearance of these bars may be practically instantaneous or it may be quite slow. The ground color between the blue lines often becomes a bright shell pink.

Many of our common fresh-water sunfishes show remarkable changes in their color in life. The Common Sunfish or "Tobacco Box" (*Lepomis gibbosus*) does not show these changes so well as some of the other species. The "Green Sunfish" (*Lepomis cyanellus*), a widely distributed fish in the

Mississippi Valley, which has been introduced into the Potomac River, shows these color changes more than any other sunfish with which we are acquainted, in fact the changes of color and color patterns are almost as numerous and as rapid as in the angelfish. In addition to the normal color changes, an increase or reduction in the intensity of the color, or a change from dark to light color, due to emotions or environment, there are many other changes for which we can only guess at the cause. We shall probably never know why one fish when frightened will turn pale while another in the same aquarium will become very strongly barred. The commonest color, visible in preserved specimens, in dead fish and in fish just taken from the water, is a plain dark olivaceous with more or less dark red in the vertical fins and with two blue lines across the cheek. In the aquarium this may be seen to change to a rich golden brown with or without vertical cross bars or to a plain light color almost silvery. The vertical cross bars are sometimes as pronounced as in the Yellow Perch (*Perca flavescens*), at other times the whole side of the fish is covered with minute shining specks without any apparent regular arrangement. Any of these color patterns may appear practically instantaneously. The change from vertical bars to the plain coloration with light specks may occur apparently in a flash. Where a few specimens of approximately equal size are confined in a small aquarium these color changes may be most readily noted. The intensification in color of the largest specimen when a smaller one happens to stray into forbidden territory and the sudden paling of the latter as he retreats may be seen very frequently, especially when the fish are being fed.

The Long Eared Sunfish (*Lepomis auritus*), known also as Red Breasted Bream, is commonly a more or less yellowish fish with orange spots and mottlings over the entire body, these sometimes showing as more or less indistinct cross bars. There are many specimens of this species in the aquarium at the Bureau of Fisheries where we have watched their color changes. Most of the specimens showed a dark olive color with the vertical fins and the breast dark red. Sometimes faint cross bars show. This coloration is so similar to that of *Lepomis cyanellus* that only the position of some blue lines on the operculum and the shape of the "ear" indicated the specific difference. From

this olive coloration fishes would quickly change to a golden brown with or without dark cross bars or with bars formed of small spots slightly darker than the ground color. One fish which we watched for some time and which, by its actions, appeared to be a male more or less approaching the breeding condition was a bright yellow color mottled over the whole side with dark orange spots each about the size of a scale. The breast was a clear bright orange. The pectoral fins were a clear lemon yellow. There was hardly a trace of cross bars although at times a few could be seen quite indistinctly. This fish was observed several times and seemed to show no color changes except, on one occasion, a slight tendency of the yellow ground color to appear grayish.

The Blue Sunfish (*Lepomis pallidus*) which is known also as Bluegill, Copper Nosed Bream, Blue Bream, Black Sunfish, Roach (Soldus Bay, New York), etc., shows various color patterns. Sometimes the fish will be a plain iron color with no markings at all except the black spot on the opercular flap. At other times it is a plain yellowish green with no markings or it may show either of these colors with faint or dark cross bars, or the light ground color may be almost entirely obscured by heavy dark bars with dark mottlings between them.

In *Enneacanthus gloriosus*, a common sunfish of the vicinity of Washington, color changes may be noted which are very similar to those of *Lepomis cyannellus*. The changes from vertical dark and light bars to the coloration of bright specks is practically the same as in the Green Sunfish except that in *Enneacanthus* the heavy black stripe through the eye never, so far as we know, becomes entirely invisible.

The War Mouth (*Chæuobryttus gulosus*) shows little change in color except that the extent of the dark patches varies considerably so that the same fish may be grayish mottled with black or nearly all black with a few grayish streaks. Fish caught on hook and line near Washington often show much red or dark orange in the ground color.

Some of our common fish, which are frequently seen in aquariums, as the Gar Pike (*Lepidosteus ossens*) and Strawberry Bass or Calico Bass (*Pomoxis sparoides* and *Pomoxis annularis*), apparently show no changes except an increase or reduction in the intensity of the coloration.

Preserved specimens of the Pickerel (*Esox reticulatus*) show very slight differences in color pattern, which is usually more or less of a network of dark lines on a lighter ground, but great differences in its visibility. These differences are probably largely due to the condition of the fish when taken from the water and difference in manipulation in preserving the specimen. Fishes from clear water usually have the color pattern more pronounced, while those from muddy water, particularly water of a distinctly yellow color, frequently show no traces of the color pattern when first taken and if killed in the preservative immediately will show none. However, if these fish are placed for a few minutes in clear water the color pattern becomes visible, and it may appear in cold water even after the fish has died, showing that the color cells may remain active for a time under favorable conditions. Fishes of this species swimming near the surface in the aquarium show a very strongly marked color pattern. In some of them the reticulations extend entirely over the back, while in others the back is more or less plain dark olivaceous. When these fish are resting on a bottom of clear yellow sand the vertical bars of the reticulations tend to disappear and portions of the horizontal bars also become fainter so that the markings resemble wave marks on the bottom. The color of the back becomes plain greenish yellow, except for the presence of scattered black specks resembling, in color and arrangement, black sand grains in the neighborhood. The fish resting near the surface resembles a floating stick covered with spots of light refracted by the small waves. In this species the color changes are not in the nature of a change in color pattern, but simply variations in its intensity.

In the Yellow Perch (*Perca flavescens*) the color pattern does not change, but the intensity of the black cross bars is quite variable. Sometimes they are almost invisible and the fish appears to be a clear yellow color, while at other times they are so broad and intense that the fish appears almost black. The ground color changes with the bands from a light yellow to a dark yellowish gray.

The Sea Robin (*Prionotus evolans*), the Puffer (*Spheroides maculatus*), and the Filefish (*Alutera scripta*) show no change in the color pattern, but considerable changes from golden to grayish in the ground color. Specimens of the Sea Robin

which had buried themselves in the sand were light gray with black markings, while those that were swimming were various shades of yellow and brown marked with darker brown.

Early in the summer of 1908 a small catfish (*Ameiurus* sp.) was taken in a dip net in the Chesapeake and Ohio Canal, at Chain Bridge, near Georgetown, D. C. When first taken it was entirely black. This color persisted for several days and was then replaced by a most unexpected pattern. The body was black, but at the base of dorsal, adipose dorsal, anal and caudal fins was a narrow white band so that each fin appeared cut off from the body, which seemed to be a little piece of black stick with some little pieces of rotted leaves (the black part of the fins) near it. The caudal fin was in reality truncate, but there was a large white patch in it which made it appear that the upper and lower rays were greatly produced. This color in turn, after a few weeks, was replaced by the black color of the adult.

Although many notes on the coloration of fishes have been published they are scattered through the literature of every branch of ichthyology.

We offer the following partial list of the more recent papers:

- 1897—A. E. Verrill—Nocturnal Protective Coloration of Fishes. *Am. Nat.*, Vol. XXXI, Feb., 1897, 99-103. *Am. Journ. Sci.*, Vol. III, 1897, 132-136. Abstract of paper read before *Am. Morph. Soc.*, Dec. 30, 1896.
- 1905—D. S. Jordan—A Guide to the Study of Fishes. New York, 1905. Vol. I, pp. 226 to 236.
- 1907—Raveret-Wattel—"Le Pêcheur" 18 anée No. 421, Sept. 30, 1907, p. 767. "La coloration des Poissons" gives an account of the slow color changes in fishes under the influence of great changes in color of environment.
- 1908—Francis Ward—Markings and colors in fish. How they protect their wearers. *Scientific American*, Supplement No. 1714, p. 297. New York, 1908. A few notes on protective relation of color to surroundings in Stone Loach, Pike and Gudgeon. Experiments on Pike with head in dark and body in light and vice versa. This paper was apparently published or offered for publication in "Country Life," but we have not found it in that magazine.

- 1909—C. Tate Regan—Proc. Zool. Soc. London, Feb. 16. 1909, p. 130. Gives notes on four species and criticises Dr. Evermann's note on species of *Bodianus* based on color in Fishes of Porto Rico, Bull. U. S. F. C., 1900 (1902).
- 1909—Jacob Reighard—An experimental study of warning coloration in coral reef fishes. Carnegie Inst. Pub. 103, pp. 257-325 (1909). Experiments in feeding variously colored baits to wild fishes.
- 1909—C. H. Townsend—13th Ann. Rep. N. Y. Zool. Soc., Jan. 1909. Observations on instantaneous changes in color among tropical fishes.
- 1910—C. H. Townsend—"The Century Magazine," September, 1910. Chameleons of the Sea. Notes instantaneous color changes in many tropical fishes and slower ones in some northern ones. Practically a reprint of 13th Ann. Rept. N. Y. Zool. Soc., Jan., 1909, pp. 1-28.
- 1910—F. B. Sumner—Adaptive color changes among fishes. Bull. Zool. Soc. N. Y., No. 42, p. 699, 1910. Color changes of *Pleuronectidae*. Five photographs of the same fish on different bottoms.
- 1910—R. C. Osburn—Bull. Zool. Soc. N. Y., No. 42, p. 704, 1910. Cichlid fish at the Aquarium. These fresh-water fishes have the power of instantaneous color changes.