observations with figures, and thus to supply good evidence that my original statements were correct in every particular, though necessarily somewhat incomplete.

5. An Experiment concerning the Absence of Color from the lower Sides of Flat-fishes.

By J. T. Cunningham, M.A., Naturalist to the Marine Biological Association.

eingeg. 1. December 1890.

One of the most interesting questions which biological research has still to decide is whether adaptations in organisms are due to the natural selection of indefinite variations or to the definite influence of the conditions of life. One school of evolutionists, that of which Weismann is one of the most eminent leaders, maintains that every character in animals is an adaptation and every adaptation is sufficiently explained by indefinite variation and natural selection. Another school believes that many things are not adaptations and that those characters which are adapted are due to the definite influence of conditions. The former school would I suppose maintain that the whiteness of the lower sides of flat-fishes was an adaptation, and was due to selection. What is the especial advantage of this character to flat-fishes I am unable to perceive. But it seems to me more probable that it is due in some way to the fact that little or no light can fall on the lower sides of these fishes, because these sides are generally in contact with the ground.

The following experiment seems to me to support very strongly the latter views; it was carried out in the Plymouth Laboratory of the Marine Biological Association.

At the beginning of last May I received from Mevagissey in Cornwall a large number of young flounders (*Pleuronectes flesus*) in process of metamorphosis. They were very transparent and measured 11·5 to 12·7 mm in length. In a few the metamorphosis was almost complete the left eye having reached the edge of the head but in the majority the left eye though it had commenced its »migration« was still on the lower side. The little fish had already developed the habit of lying on the bottom on the left side. Nearly all the pigment, i. e. the chromatophores had disappeared from the lower side, where only a few scattered black and yellow cells remained: on the upper side the pigmentation was considerable, but not so fully developed as in the adult.

On May 8th I took about 15 or 16 of these small flounders and placed them in a glass vessel without sand. This vessel I placed on a plate of glass supported at the ends by two supports. Beneath the glass plate I arranged a mirror about 15 inches by 12, sloping it at an angle

of 45°. The top and sides of the vessel containing the fish were covered with opaque material, and through the cover were passed a jet delivering water and an outflow pipe connected with an overflowing bottle a little distance off, so that a constant circulation of sea water was maintained in the vessel while the level of the water in it remained constant. The whole apparatus was placed in front of a south window from which the light fell on the mirror and was reflected vertically upwards on to the bottom of the vessel containing the fish: as the fish were usually resting on this bottom their lower sides were illuminated while their upper sides were in the dark.

At the same time I kept a large number of the same young flounders living under ordinary conditions in table-tanks at the bottom of which was a layer of fine sand.

I fed these young flounders first with minute crustacea sifted out from weeds gathered on the shore, and afterwards with minced worm, and they all throve well and grew rapidly.

On June 21st I took out one of the specimens from the mirror-apparatus and examined it. It was 2·7 cm in length. Another specimen taken from an ordinary tank for comparison was 2·6 cm long. The difference between the lower sides of these two was as follows: In the mirror-specimen there was an opaque white layer all over the wall of the abdominal cavity, the rest of the skin being translucent. In the normal specimen this coating was confined to the edges of the same area. There were a few scattered black chromatophores on the lower side of the head in each specimen, but rather more in the mirror specimen than in the other.

It is evident that these differences are not very important, and I think it is reasonable to conclude that at this time, one month and a half after the commencement of the experiment, the lower sides of the mirror-specimens had become, by inherited tendency, as destitute of pigment as those of the specimens under the ordinary conditions.

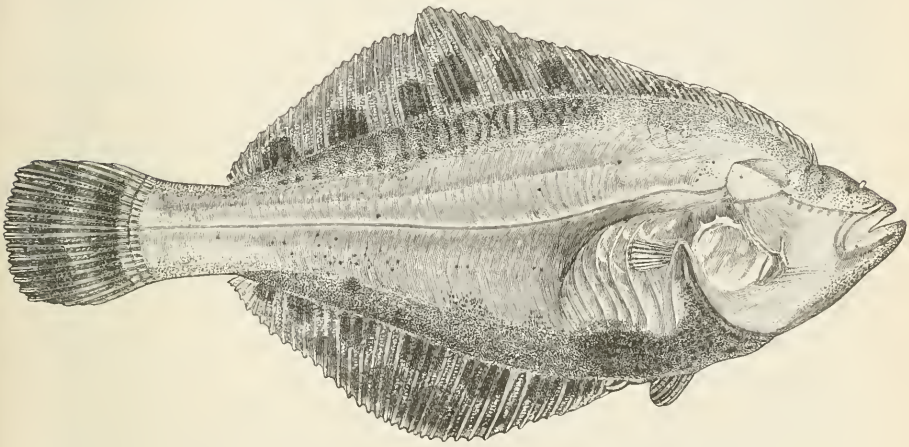
But two months afterwards namely on August 27th all the flounders in the mirror apparatus died. The cause of death was this. After my return from Norway on August 13th I noticed that the fish in the apparatus very frequently clung to the sides of the vessel instead of lying on the bottom, and as the sides were darkened, while they were in this position their upper sides only were exposed to the light from the mirror. In order to prevent this I introduced a horizontal partition of network so as to keep the fish on the bottom of the vessel; but the netting soon got obstructed with remains of the food, and the water below the partition was thus cut off from the circulation so that the fish were asphyxiated.

The following are the notes I made from my examination of the fish immediately after their death: —

1) 3·2 cm in length: black and yellow chromatophores on the lower surface of the longitudinal fins and in a broad band on each side of the lower surface of the body; also on the edges of the lower side of the head. The accompanying woodcut, made from a drawing of the recently dead fish as seen under a lens shows the amount and the distribution of the pigment.

2) 3·7 cm in length. Normal pigment all over the same band at the edges of the body on the lower side: also in the angle behind the operculum and on the lower pectoral.

3) 3·2·cm in length. Pigmentation on the lower side as in 1) and 2) but not quite so much of it.



Drawn on the wood without mirror and therefore representing the left side reversed.

4) 6·3 cm in length. A small patch of chromatophores both black and yellow in the area covered by the lower pectoral, and extending beyond that area.

5) 4·2 cm in length. Little pigment on the lower side; a little on the pectoral, on the edges of the head, and near the ventral edge behind the operculum.

6) 5·7 cm in length. Pigment on the rays of the lower pectoral, and on the dorsal edge of the head.

7) 5·3 cm in length. Pigment on lower side of head near edges: on lower branchiostegal membrane a good deal.

8) 4·3 cm in length. Scattered black chromatophores behind body cavity.

9) 5·8 cm in length. A few black chromatophores near dorsal edge of lower side of the head.

10) 5·5 cm in length. A few scattered black chromatophores over the lower side, especially behind the body cavity on the ventral half.

11) 5·3 cm in length. No pigment on lower side except on lower surface of the tail.

12) 5·8 cm in length. No pigment on lower side.

13) 3·3 cm in length. No pigment on the under side.

At the same time I examined 4 of the specimens which had been kept during the same time on a sandy bottom in the aquarium and found no pigment on the lower sides of either. I have also frequently had occasion to examine other of these specimens of the young flounders of the same age kept in the tanks since last May, and have never seen any pigment on the lower sides of any.

To show the significance of this experiment it must be mentioned that the colors of flat-fishes always depend on three and only three kinds of cellular elements, namely the black chromatophores, yellow or orange-yellow chromatophores, both of which are capable of expansion and contraction, and thirdly the iridocytes which are strongly reflecting and white or slightly iridescent, and which are fixed in shape and size. The iridocytes are alone present on the lower sides of normal flat-fishes, and give them their opaque white appearance.

Of the above 13 specimens whose lower sides had been exposed to light for less than 4 months only three had failed to develope black and yellow chromatophores in the skin of those sides. Three showed very well developed bands of pigment quite similar to that of the upper side over the area occupied by the muscles of the longitudinal fins. The other 7 specimens possessed a less quantity of pigment on the lower it is true, but chromatophores were present in one part or another where they are not present in the specimens living in the ordinary way on sand.

The question of course arises, how are these pigment cells developed, by migration from the upper side? from wandering lymphatic cells? or from unpigmented cells already present in the same position before? These questions I cannot at present answer, but am now endeavouring to find replies to them. I think the third suggestion the most probable. The chromatophores in flat-fishes are situated in the derma between the surface of the scales and the epidermis.

Of course I am well aware that specimens of flounders and other flat-fishes are occasionally taken from the sea in which both sides are colored, or in which there are colored spots on the lower side. But I scarcely think any one will maintain that the condition of the specimens in my experiment can be supposed to be a case of accidental variation. On the other hand it is always possible that abnormal pigmentation on the lower sides of free-living specimens is due to peculiarities of environment or of habit.

I have other experiments in progress which I hope will further elucidate the relation of the pigmentation of the flat-fishes to the action of light. For the present I will conclude with a brief summary of what previous writers have said as to the causes of the absence of chromatophores from the lower side. Prof. Alexander Agassiz in his paper on the »Development of the Flounders«[1] published in 1878, says that the attempt which he made of placing the glass dish containing young flat-fishes at a height over a table, and thus allowing the light to come from below as well as from all other sides, failed in arresting the transfer of the eye, and also produced no effect in retaining the pigment spots of the blind side longer than in specimens struck by the light only normally from above. Prof. Agassiz in the first place did not use a mirror, and in the second place he evidently expected that the effect if any would be to arrest the metamorphosis. The idea on which I found my experiments is that the inherited tendency will cause the metamorphosis to take place even when the conditions are reversed, but that when the reversed conditions are kept up long enough a new metamorphosis will be induced in the opposite direction to the first.

Prof. Agassiz refers in the same paper to Pouchet's researches on chromatophores[2] saying that they point most plainly to the partial atrophy of the great sympathetic nerve, effected during the passage of the eye from the right to the left or vice versa, as the cause of the absence of chromatophores from the lower sides of flat-fishes. I have read Pouchet's paper referred to below and can find no mention whatever of any suggested cause of the absence of color on the lower sides of flat-fishes. Pouchet found that section of the great sympathetic put an end to the changes of color under the influence of light, but he distinctly says that it made no difference whether the left or the right eye was extirpated in the turbot. In either case the changes of color

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[1] Proceedings Amer. Acad. Arts and Sc. Vol. XIV.

[2] G. Pouchet, Des Changements de Coloration sous l'Influence des Nerfs. Arch. de Physiol. et d'Anat. 1876.

went on as before when the fish was changed from one bottom to another, but when both eyes were extirpated the changes ceased.

Finally I must refer to the remarks of Prof. Semper in his »Animal Life«[3] who says that the absence of color in animals is certainly not to be ascribed to the absence of light, since we know that animal pigment like vegetable pigment can be developed in total darkness, and in fact is so developed normally in many animals (op. cit. 2. edit. p. 90).

III. Personal-Notizen.

Stuttgart. Die durch den Tod des Director Dr. F. v. Krauß erledigte Stelle des I. Conservator am k. Naturaliencabinett erhielt der seitherige II. Conservator, Professor Dr. Oscar Fraas unter Verleihung des Titels und Ranges eines Oberstudienrathes. Die Stelle des II. Conservator mit der Aufsicht über die zoologisch-botanische Abtheilung der Sammlung, sowie der administrativen und öconomischen Verwaltung wurde dem seitherigen Assistenten Dr. Kurt Lampert unter Ernennung desselben zum Professor verliehen. Der Assistent an gedachter Anstalt, Custos Dr. Ernst Hofmann, wurde zum Professor ernannt.

Paris. La Société Zoologique de France vient de procédes au renouvellement annuel du Bureau et d'un tiers du Conseil. Ont été élus:

Président: M. le professeur Railliet (d'Alfort).

Vice-présidents: MM. Ph. Dautzenberg, E. Oustalet.

Secrétaire général: M. le professeur R. Blanchard.

Secrétaires: Melle F. Bignon, Dr. ès-sciences, MM. J. Richard, L.-B. de Kerhervé.

Trésorier: M. Ch. Schlumberger.

Archiviste-bibliothécaire: M. H. Pierson.

Members du Conseil: MM. le professeur L. Bureau (de Nantes), le Dr. F. Jousseaume, le Dr. J. G. de Man (de Middelbourg), P. Mégnin.

Necrolog.

Am 1. Januar 1891 starb in Mailand der Abate Antonio Stoppani, Professor der Geologie am R. Istituto Tecnico Superiore und Präsident der Società Italiana di Scienze Naturali in Mailand.

[3] Natural Conditions of Existence as they affect Animal Life. Internat. Sc. Series. London, Kegan Paul & Co., 1881.

Druck von Breitkopf & Härtel in Leipzig.