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The Effect of Abundant Food on the Growth of Young Ciona intestinalis.

By H. M. Fuchs.

(Mit 9 Figuren.)

During the spring of 1913 a considerable number of experiments were made to discover the optimum conditions for rearing *Ciona intestinalis.* The work was done at the Zoological Station, Naples, and was a preliminary to the breeding of the animals for certain heredity investigations. In the course of the work an interesting effect of the amount of the food supply on the growth of the young *Ciona* was brought to light, and it is thought that the results are worth recording now.

For each rearing experiment the eggs of one individual were artificially cross-fertilized by the sperm of another. The exact methods employed, ensuring the absence of spermatozoa of any other individual, and the consequent purity of the separate families, will be described in full in a later paper dealing with the relative effects and conditions of self- and cross-fertilization in *Ciona intestinalis.* It is unnecessary to go into the methods and precautions here, since the purity of the different families reared does not affect the point under discussion. The larvae were allowed to settle on the walls of the bowls in which they hatched out of the eggs, and these bowls were then immersed in an aquarium tank, through which a continual stream of water was flowing. Here they under-went their early growth and development, all exposed to more or less the same conditions of light, temperature and food supply.

In such aquarium tanks at Naples, besides the cultures introduced, young individuals of *Ciona* appear sporadically on the walls. These must come in as larvae through the sea water circulation, and their apperaance is unavoidable unless the incoming water be specially filtered. The latter precaution was, of course, taken when different pure families were being raised, but in the preliminary investigations of which the following are a part it was unnecessary. The growth of some such accidentally introduced individuals is discussed below.

Figs. 1 and 2, forming Series I, are from photographs (3/4 natural size) of typical living individuals, nearly $3^1/_2$ months old, from an aquarium culture. The only important point to notice in them for our present purpose is the relative length of the oral siphon to that of the rest of the body.

In Series II[1]), illustrated by Figs. 3—6, some of the animals growing in the aquarium were removed to water containing a much more abundant food supply, and the growth of these was compared with that of the remainder of the animals, still in the aquarium. Fig. 3 (9/11 nat. size) shows a typical animal from the aquarium. It was taken on Mar. 5, and like all the other photographs, exhibits the living animal in the expanded condition under water. The feature to observe in Fig. 3 is the relative shortness of the oral siphon as compared with the length of the remainder of the body. The ratio between the two was more or less constant in all the aquarium-grown animals.

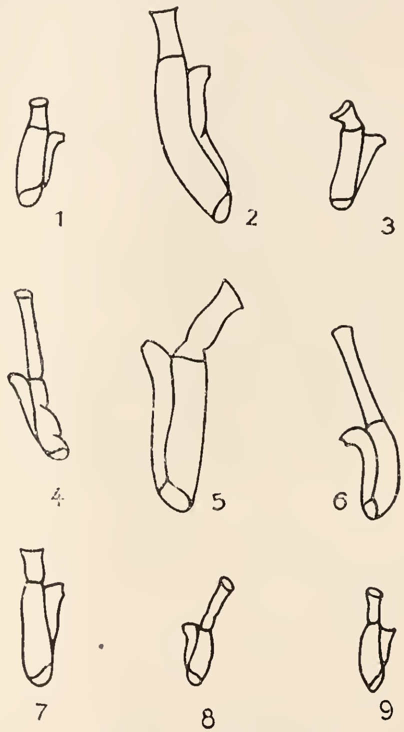
The aquarium contained only a meagre growth of algae on its walls, and the transparent tissues of the young animals showed that, although the gut always contained some food, it was never full. On Mar. 5th., immediately after the photograph had been taken, some of the animals were removed from the aquarium into a jar of about 2 litres capacity, the walls of which were covered by a thick and abundant growth of green algae. The other individuals were left in the aquarium.

On Mar. 18th., that is 13 days after the transfer, the animals in the jar of food culture were found to have completely altered in appearance. The oral siphon had become relatively enormously long. Fig. 4 (3/4 nat. size) is a typical individual from the food jar. The oral siphon approaches in length that of the rest of the body, and is an extreme contrast to the aquarium-

1) All the individuals of Series II were ones which had come through with the circulation water & settled and grown on the walls of the tank.

grown individuals such as those shown in Fig. 3. In the remaining animals left in the aquarium the ratio of siphon to body length was unchanged on Mar. 18th., as indeed it remained in later growth under the same conditions.

Moreover, although there was considerable variation in different individuals, the animals in the food culture showed a much more rapid rate of total growth than those remaining in the aquarium. This is not to be wondered at, since the former could always be seen to have their gut crammed with green algae and other foodstuffs. One individual, for example, taken from the aquarium on Mar. 5th. measured 1,5 cm extended. On that date it was placed in a jar with weed growths, and on Mar. 18th. it measured 4,5 cm, i. e. its length had increased by 3 cm. In contrast to this, the greatest growth of any individual in the aquarium during the period Mar. 5—18th. was ·5—1 cm.



After having been photographed on Mar. 18th., the animal shown in Fig. 4 was placed back in the aquarium again. Fig. 5 (3/4 nat. size) shown this same individual on Mar. 27th., i. e. 9 days later. Its absolute size had increased considerably, but the oral siphon was relatively shorter again as compared with the rest of the body, tending to resume the ratio characteristic of animals grown throughout in the aquarium. With this should be compared Fig. 6 (3/4 nat. size) which shows one of the animals left in the food jar as it appeared on Mar. 27th., the date on which Fig. 5 was photographed.

The essential points, then, are that removal of aquarium-grown animals to a jar containing an abundant growth of algae produces a great increase of the oral siphon length as compared with the length of the rest of the body. Replacement into the aquarium brings about a relative shortening of the siphon again as further growth proceeds. It should be further mentioned that the same effects were obtained repeatedly. Series II of experiments is alone given in detail here, as an illustration of the general result.

Now there were several factors which were different in the food jar and in the aquarium and which might account for the difference in growth. The temperature and lighting were the same in both, as was also the salinity of the water. The three points in which the conditions in the food culture differed from those in the aquarium were as follows:

(1) Abundance of food (algae).

(2) Volume and lack of motion of water.

(3) H-ion concentration of water.

Further experiments were accordingly made to decide to which of these factors the observed effects were due.

The third factor mentioned requires a word of explanation. It was found by employing Sörensens colorimetric tests[2]) that the H-ion concentration of the water in the jar containing abundant growths of green algae (used in Series II) was considerably less than that of the water circulating through the aquarium. The former gave green with α-Naphtholphthalein and the latter faint green. Again, the former gave rose with Phenolphthalein and the latter no colour. It was then found by tests with both these indicators that the addition of I drop N/10 NaOH to 10 ccm aquarium water gave a solution less alkaline than the weed water, while the addition of 2 drops gave slightly more alkalinity than the latter.

In the experiments illustrated by the photographs of Series III, aquarium-grown animals, of which Fig. 7 (9/11 nat. size) is typical, were employed. The photograph was taken on Mar. 19th., when the animals were about three months old. On this date some of the animals were removed to each of three jars containing equal volumes of,

(1) aquarium water, the sides of the jar being coated with abundant growths of green algae;

(2) aquarium water, containing no additional food material;

(3) aquarium water + 2 drops N/10 NaOH per 10 ccm water, also with no additonal food material.

Jar (2) tested the factors of volume and stillness of the water, and jar (3) the H-ion concentration of the water, without the extra food.

It was found on Mar. 27th. (8, days later) that the animals in jars (2) and (3) were absolutely unchanged as regards the ratio of oral siphon to body length, being exactly similar to the individuals left in the aquarium. Those in jar (1), however, showed the typical siphon elongation of the food culture forms. A typical example from this jar is shown in Fig. 8 (11/14 nat. size.) (After having been photographed, this animal was replaced in the aquarium,

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2) Compt. Rend. du Lab. de Carlsberg, 1909.

and on April IIth. a marked shortening of the siphon was again apparent — see Fig. 9 (3/4 nat. size.)

This series consequently proves that the siphon elongation in the food cultures is due to the abundant food itself, and not to the other conditions which are different from those prevalent in the aquarium.

This effect of feeding on the growth of *Ciona* gains additional interest when the condition of mature individuals in their natural habitat is considered. Animals collected from different localities in the Bay of Naples are found to have the oral siphon of different lengths relative to that of the body. Individuals from any given spot, however, agree more or less among themselves in having the siphon longer or shorter. Some have the ratio of the siphon to the body length similar to the aquarium-grown young animals, others have a proportion intermediate between that of aquarium and food culture specimens. None, however, have the excessively long siphons of the last mentioned. That some localities should offer a richer food supply than others is extremely likely, and the laboratory experiments indicate that the variations in relative siphon lengths found in nature are attributable to this cause. The absence of animals with extremely elongated siphons is not surprising, since the food supply in the sea could scarcely ever be as abundant as in the culture jars ot the experiments.

Description of Figures.

The photographs were taken of the animals in the fully extended condition under water. Owing to the weakness of the negatives, the actual photographs could not be reproduced. The figures are accurate outline tracings taken from the photographic prints. In each figure the cross line at the base of the oral siphon is the peripharyngeal band.

Series I.

Figs. 1 & 2. Photographed Mar. 27, × 3/4. Typical aquarium-grown animals, from eggs fertilized Dec. 14.

Series II.

Fig. 3. Photographed Mar. 5, × 9/11. One of a number of animals which came through the circulation and grew in the aquarium. After being photographed these were placed in Jar A, with abundant weed growths.

Fig. 4. Photographed Mar. 18, × 3/4. Typical animal from Jar A. After being photographed it was replaced in the aquarium.

Fig. 5. Photographed Mar. 27, × 3/4. Same animal as Fig. 4, after having been back in the aquarium since Mar. 18.

Fig. 6. Photographed Mar. 27, × 3/4. Typical animal remaining in Jar A.

Series III.

Fig. 7. Photographed Mar. 19, × 9/11. Typical example of aquarium-grown animals (about 3 months old) which were placed on Mar. 19:

I. In jar of aquarium water containing abundant growths of weed.

II. In jar of aquarium water + 2 drops of N/10 NaOH per 10 ccm water. No weed growths.

III. In jar of normal aquarium water without weed growths

Fig 8. Photographed Mar. 27, × 11/14. Typical animal from Jar I.
After being photographed this individual was replaced in the aquarium. The animals in Jars II and III were unchanged on Mar. 27.

Fig. 9. Photographed April 11, × 3/4. Animal which had been removed from Jar I to aquarium on Mar. 27.

L. J. Henderson on "The Fitness of the Environment"[1]).

By S. O. Mast.

(From the Zoological Laboratory of The Johns Hopkins University.)

In earlier days when design and special creation were topics of the hour it was generally assumed that the environment had been especially created for the needs of the organism, and the foundation for many an argument favoring the existence and omnipotence of an all-wise Creator was based on statements concerning the fitness of its various factors. But with the appearance of "The Origin of Species" in 1859 this attitude changed and it came to be quite generally held that the organism had been gradually so molded as to fit that part of the world in which it was destined to live. Since that time this assumed molding process has dominated practically all investigation bearing on the relation between animate beings and their surroundings. Thus interest in fitness and adaptation from the point of view of the environment itself was all but lost. In the opinion of the reviewer the greatest value of Henderson's stimulating book lies in the bearing it has on again directing attention to the problem from this point of view.

The book may be divided into three parts. The first part, covering 72 pages, is devoted largely to a characterization of the organism and its environment and a statement of the fundamental problems concerning fitness. Our author recognizes that life has various aspects. In his argument however he aims to consider it only from the mechanical or physico-chemical aspect. He says (p. 31), Life as we know it is a physico-chemical mechanism[2]), and it is probably inconceivable that it should be otherwise. ‘As such, it possesses, and, we may well conclude, must ever possess, a high degree of complexity."

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1) Published by The Macmillan Company, New York 1913, 317 pages.

2) The term mechanism is frequently used to designate merely the material parts of a machine. I assume, however, that Henderson uses the term in a broader sense, that he intends to include in his statement, that life is a mechanism, not merely the idea that it is a complex system of material parts, but that it is such a system in action. If this assumption is valid his definition of life is somewhat broader than that of Aristotle, Spencer and Brooks, in which they state that the essence of life is adjustment.

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