ON THE MODE OF FIXATION OF THE FRY OF THE OYSTER.

By JOHN A. RYDER.

During the past season five American investigators have been engaged in the investigation of the question of the feasibility of rearing *Ostrea virginica* from its eggs. Of these, Dr. Brooks, Lieut. Francis Winslow, and Henry J. Rice, have not yet, as far as I am aware, published anything upon what they have done. Col. Marshall McDonald and the writer were engaged, during a part of the months of July and August last, with the investigation, in the United States Fish Commission station at Saint Jerome's Creek, Maryland. The most remarkable result which Colonel McDonald and myself obtained, with an apparatus devised by the former, was the apparent fixation of the fry to the sides of the glass hatching-vessels twenty-four hours after impregnation. We found in a temperature of 73° to 80° Fahr., that they would develop a larval shell in this short space of time, but were surprised to find the young apparently fixed in such numbers to the sides of the glass hatching-vessels. How they were attached we failed to learn; whether by means of a byssus or not could not certainly be determined. They were found fixed so firmly, however, that they could be removed only by force, such as scraping the clean, dead oyster shells upon which they had lodged in the apparatus. Holding the shells upon which the fry had caught under a strong stream of water from a faucet failed to dislodge them. Our conclusion was, in view of the foregoing facts, that these young embryos had voluntarily attached themselves. It was noticed that this young fry had a disposition to lie upon the side, with the border of the rudimentary mantle projecting over the border of the shell. Many were noticed in other positions, but I am inclined to believe that these were not normal, as will appear further on. The projecting border of the mantle, as it appeared to the writer, is probably the organ by which the adhesion of the embryo is effected—in fact, we will learn further on that this flatwise position of the fry is assumed at the time of fixation. Unfortunately for us, our endeavors to repeat our first successful experiment, which had given us such a remarkable result, invariably ended in failure, although we had taken the precaution to vary again and again the character of the apparatus to meet what were supposed to be unfavorable and fatal conditions. Several other forms of apparatus were used, which worked so unsuccessfully that their use was discontinued, including the air-blast playing upon the surface of the water in the hatching-vessels, upon which I had largely built my hopes last year.

The fixed embryos or fry alluded to above did not grow any during the three days which we were permitted to observe them, both in a

continuous current and in a closed or interrupted circulation of water. Putrescence or the development of deleterious organisms did not, I believe, interfere with our experiments. At all events, they remained of about the same size as the eggs with which we started, although food was already perceptible in the stomach rotating under the impulse of the cilia which lined the gastric cavity. They had the power to retract the velum and mantle, but not wholly. The pallial and velar muscles were therefore developed as well as the adductor, which could be seen to actuate the valves. That these embryos were developed from the eggs put into our apparatus there could not be the slightest doubt, since the sea-water used was first carefully filtered through a large dense mass of cotton wool to remove impurities and small, hurtful organisms, and no additional water from the open bay was afterwards introduced.

The deflected border of the mantle in this fry seems to me an important fact in its bearing upon the manner in which the fixation of the young animal is accomplished. Though it is true there was as yet no umbo developed upon the shells of these larvæ, such as may be seen when the larval shell measures from an eightieth to a ninetieth of an inch in diameter, yet the hinge-line was straight as if the shell at this point was truncated. In the last stage of development of the larval shell, which I shall call the *umbo stage*, this apparent truncation disappears, the umbos projecting somewhat past the level of the hinge, which is still approximately straight and without teeth, contrary to the statement of Lacaze-Duthiers. Immediately following the umbo stage, the larval shell is converted into the spat, the valves of the latter growing outwards from the borders of the valves of the fry shell, or, rather, speaking more correctly, the calcareous deposits which are laid down by the young developing bivalve project past the free edges of the valves more and more, and immediately thereupon exhibit a prismatic arrangement of the shelly substance wholly different from that seen in the fry, which is laminar, homogeneous, and not prismatic. The fry shell is perfectly symmetrical and very convex up to the time when it is converted into that of the spat, which is at once developed in an unsymmetrical manner, but at first tends to simulate the rounded outline of the fry, except at the hinge, where no lateral growth of shelly matter takes place. As growth of the spat goes on, and in fact from the very first, the hinge of the fry shell is inclined slightly upward, the fixation evidently having taken place at its edge.

This I regard as the most important step which I have made in developing the history of the shell, and it is probable that in it we have a clew to the manner in which the young oyster becomes fixed to stationary objects. It is important to note in this connection that the whole of the lower surface of the under valve of the young oyster is at first firmly attached by an organic cement. So firm is this substance that the young shell can rarely be removed from its attachment without

breaking the lower valve. The substance which effects this attachment is without doubt the organic matrix of the shell, viz, the so-called conchioline of the external horny covering, epidermis, or periostracum. The lower valve of the spat when growing on a flat surface may continue to adhere throughout the whole extent of its under surface, until it is nearly 2 inches in diameter, before its edge, together with that of the upper valve begins to bend upwards and become free. This attachment is effected very early, as I have met with it in spat a little over an eightieth of an inch in diameter. When it is twice this size it is scarcely possible to remove the young oyster entire from its attachment without first breaking loose with it a little flake of the object upon which it rests. When the lower valve of the fry shell is examined under a microscope it is found that a faint groove runs around its border, beyond which it is abruptly continued into the shell of the spat. This groove is perhaps more pronounced on the lower valve than on the upper, and marks the point of transition from the very convex ventricose valves of the fry to the depressed or flattened valves of the spat or fixed stage of development. These facts indicate most conclusively the means by which the final fixation is effected, viz, by cementing itself to some stationary object by means of a deposit of conchioline from the mantle border upon which the animal continued to deposit layers of calcic carbonate. This does not, it may be remarked, dispose of the possible existence of a temporary or larval byssus and byssal gland, which, by the way, no embryologist appears to have observed up to the present time at least; but, as already remarked, our failure to find such a structure with special adaptations of the microscope, in the apparently attached fry in our aquaria now renders its existence somewhat doubtful. We have already alluded to the fact that the mantle border of the fry is deflected outwards over the edge of the lower valve before the formation of any trace of the spat shell. This is shown in Fig. 1 in the plate appended to this article. It may be that a byssal organ is developed to effect the first stage of adhesion prior to the deposition of the horny cementing material which ministers to the permanent fixation of the spat.

The further development of the spat shell is interesting in that the deposit of lime is continued mainly from the free borders of the valves and not from the hinge margin, as may be gathered from Figs. 4, 5, 6, 7, 8 and 9 of the accompanying plate. It will also be noticed that the beak or umbo of the fry shell has a constant direction in all of the figures, showing that the dorsal and ventral margins of the animal, even at this stage, are constant in position; that the lower fry shell very uniformly represents the rudiment of the left valve of the adult. At the hinge margin the development of shelly matter is interrupted, as shown by the figures. In fact, the valves of the spat are at first truncated on a line with the hinge of the fry shell, and as the shelly deposit is continued outwards alæ are developed, as shown in the figures, which

remind one of the lateral hinge processes in *Pecten* or the scallop. The hinge border of the spat is at first somewhat bent upwards, as may be seen in Fig. 9, which is a side view of Fig. 8. This is also shown in Figs. 5, 6 and 7, and is in conformity with the slightly upward inclination of the hinge end of the fry shell. It results from this that the hinge border of the newly fixed fry is at first free. To sum up, we find that the fry of the oyster is at first permanently fixed by a pallial secretion, probably conchioline, at the border of its valves, with the hinge end inclined upwards, and the free border of the lower valve in fixed contact with some foreign object, as shown in the annexed figures, and that the hinge end of the spat is free for some time, the whole of the rest of the under surface of the lower valve being cemented fast with conchioline. This marginal adhesion of the lower valves is well shown in Figs. 5, 6, and 7. The material from which I have obtained my figures was mainly obtained in August last, adherent to old oysters in the vicinity of Saint Jerome's Creek, Maryland. Most of the specimens, even the oldest, which I have figured, had probably not been attached quite a week; in fact, some of them had evidently only just begun to develop the spat shell. Fig. 2 is taken from a preparation of the brood *Ostrea edulis*, which was presented to me by Mr. W. H. Walmsley.

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EXPLANATION OF PLATE.

FIG. 1. Young American oyster, two days old, adherent to side of the McDonald apparatus, June 24, 1882. Viewed from the side, showing the projecting velum *v* and mantle border *m* magnified 183 times.

FIG. 2. Four shells of the fry of *Ostrea edulis*, showing their form and variable size when taken from the beard of the parent. Magnified 96 times.

FIG. 3. Young American oyster on the eve of becoming converted into the spat, having just become firmly attached during the last larval or umbo stage. Magnified 96 times.

FIG. 4. Young spat of the American oyster shortly after its transformation into the spat, viewed as a transparent object, showing the fry shells in the umbo stage and the prismatic structure of the spat shell growing from the edges of the former. The upper and lower valves are shown slightly displaced. Magnified 96 times.

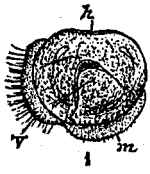
FIG. 5. Young spat of the American oyster showing the manner of the attachment of its lower valve with the downwardly bent lateral alæ of the hinge and margin of the lower valve. Magnified 35 times.

FIG. 6. Young spat of the American oyster a little older than the preceding, magnified to the same extent.

FIG. 7. Lower valve of another specimen of the young spat of the American oyster, to show the great convexity of the lower valve of the fry shell and its abrupt transition into that of the spat shell. Like Figs. 5 and 6 this specimen was drawn *in situ* from the old shell to which it was attached. Magnified 35 times.

FIG. 8. Much older spat of American oyster detached and viewed from the lower side to show the groove of the margin of the fry shell where that of the spat begins to be formed. Magnified 35 times.

FIG. 9. The preceding viewed from the edge to show the depressed form of the spat shell, its flat under valve, the inclined hinge border, the inclined and convex fry shells and slightly convex upper valve of the spat. Magnified 35 times.



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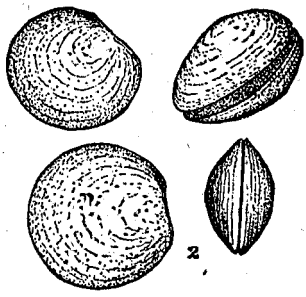

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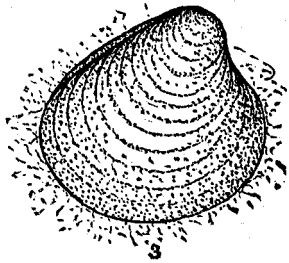

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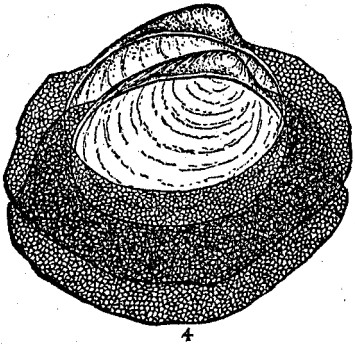

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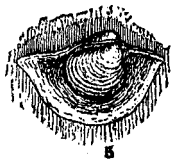

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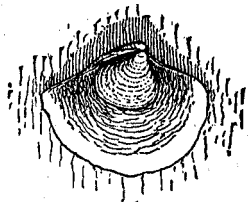

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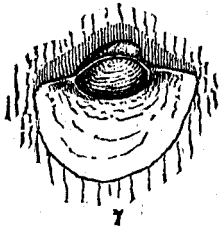

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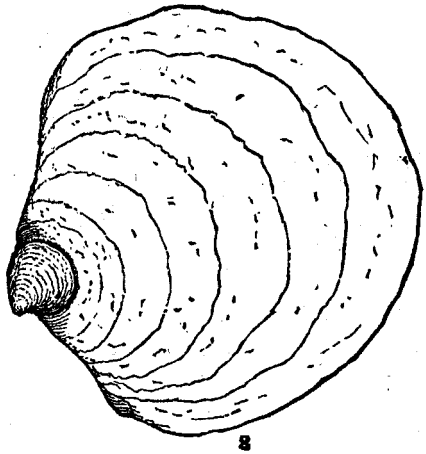

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