2. The Development of the American Lobster.

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(Schluß.)

Table II.

No.	Date	Hour	Temp. surface water.	Age of Egg.	Stage.	Remarks.
	1890		Fah.			
1(1)	Jl. 30	1.45 p. m.	72°	8 hrs. (?)	Yolk unsegmented.	2—4, possibly fewer nuclei.
1(2)	do.	6.00 p. m.	72	12¼ hrs.	do.	
1(3)	do.	10.00 p. m.	72	16¼ hrs.	do.	
1(4)	Jl. 31	10.00 a. m.	72	28¼ hrs.	Segmentation of Yolk	Only a few eggs with yolk segmented.
1(5)	do.	2.00 p. m.	72	32¼ hrs.	do.	Only a few with unsegmented yolk.
1(6)	do.	6.00 p. m.	72	36¼ hrs.	do.	30 or more segments: a few eggs unsegmented.
1(7)	Aug. 1	9.30 a. m.	72	51¼ hrs.	do.	160 segments: some eggs unsegmented.
1(8)	Aug. 2	12.00 m.	72	77¾ hrs.	do.	Superficial layer of very small cells: very few eggs with yolk unsegmented.
1(9)	Aug. 3	11.00 a. m.	72	100¾ hrs.	Invagination	
1(10)	Aug. 4	9.00 a. m.	72	122¾ hrs.	do.	
	1889					
2(1)	Jl. 11	5.30 p. m.	68		Yolk segmentation	Late stage. About equivalent to 1(7) above. Cell protoplasm not quite at surface.
2(2)	Jl. 12	9.30 a. m.	68	16 hrs. +	do.	Protoplasm generally at surface, and cells most numerous on one side of egg.
2(3)	Jl. 13	1.00 p. m.	69	43½ hrs. +	Invagination	
2(4)	Jl. 14	5.45 p. m.	69	72¼ hrs. +	do.	Depression at surface slight. Keel forming.
2(5)	Jl. 18	9.50 a. m.	68	160¼ hrs. +	Keel	Depression larger (Fig. 4).
2(6)	Jl. 19	12.20 p. m.	68	174¾ hrs. +	do.	Nauplius not yet outlined.
3(1)	Jl. 10	11.00 a. m.	68		Keel	1st. antennae and mandibles outlined.
3(2)	Jl. 11	12.45 a. m.	68	24¾ hrs. +	Egg-Nauplius	2d. antennae not budded.

The lobster numbered one — 1 (1 – 10) — in Table II was taken directly from the pot in which it was caught, and the eggs are assumed to have been laid eight hours. It is probable that they had not been laid longer than this, and possibly a much shorter time. In number two — 2 ($^{1-6}$) — about 50 hours should be added after each plus sign in the column which shows the age of the egg.

Table III.

No.	Date	Hour	Temp. surface water.	Age of Egg.	Stage	Remark.
	1890		Fah.			
4(1)	Jl. 9.	3.45 p. m.	71°	8d. 3 hrs.(?)	Keel	Depression in midst of keel very marked.
4(2)	Jl. 11.	12.45 p. m.	69	10d.	Egg-Nauplius	2d. antennae not budded or just budding.
4(3)	Jl. 15.	10.30 a. m.	69	14d. $2^1/_4$ hrs.	do.	2d. antennae biramous. Thoracic - abdominal fold forming.
4(4)	Jl. 17.	12 m.	70	16d. $3^3/_4$ hrs.	do.	Late Egg-Nauplius.
4(5)	Jl. 22.	12 m.	70	21d. $3^3/_4$ hrs.	Post-Nauplius	4—5 Pairs post-mandibular appendages; tip of abdomen conspicuous forked; optic-discs lobular.
4(6)	Jl. 25.	10.30 a. m.	69	24d. $2^1/_4$ hrs.		Optic lobes very large: telson overlaps brain: 6—7 Pairs post-mandibular appendages: antennae and telson-plate tipped with rudimentary setae.
4(7)	Jl. 27.	—	70	26d. $2^1/_4$ hrs.		Tip of telson opposite roots of optic-lobes.
4(8)	Jl. 29.	5 p. m.	71	28d. $8^3/_4$ hrs.	Eye-pigment	Eye-pigment appears at about 27th. day.
4(9)	Aug.3.	10.30 a. m.	72	33d. $2^1/_4$ hrs.		Eye-spots crescentic or semicircular in shape. Telson extends over optic-lobes.
4(10)	Ag. 12.	12.30 p. m.	72	42d. $16^1/_4$ hrs.		Eye spots oral. Extremity of abdomen considerably in front of optic-lobes.
4(11)	Sept.1.	—	—	61d.		
4(12)	Oct. 1.	—	—	91d.		
4(13)	Nov.1.	—	—	122d.		
4(14)	Dec. 1.	—	—	152d.		
4(15)	Jan. 1	—	—	183d.		Eye-spots nearly circular. Red pigment developed on abdomen.

Table III shows the progressive stages of development of eggs from the same lobster, which was taken in summer at the very beginning of the spawning season, and kept confined in a latticed box in the water off the First Commission's wharf at Wood's Holl during the fall, winter and spring. Development slows up in full, but does not come to a standstill even in winter. Sections of eggs taken December 1st. and January 1st. do not exhibit marked changes, but surface views of the embryos, and the relative size of the black eye-spots (which serve as a good measuring gauge), prove that considerable progress is made by the growing embryo, during this month. This is also seen in the gradual absorption of food yolk.

The period of incubation at Woods Holl is 10—11 months or about 300 days[2].

In an egg with the segmentation of the superficial yolk completed, 34 cells or yolk pyramids are present. The constrictions of the yolk are not simply superficial, but cleavage planes often reach down half way to the centre of the egg. The nucleus with its rayed protoplasm lies near the centre of the convex face of each segment, but it is still separated from the surface of the egg by a considerable layer of yolk. The entire amount of protoplasm is thus distributed among the yolk segments, none of it remaining in the undivided yolk below. Nuclear division is now radial, but at a later period after a large number of small segments have been formed, some of the nuclei begin to divide tangentially, that is to delaminate (Fig. 5), and their products pass into the yolk below the superficial cells. Yolk cells are

Fig. 5.

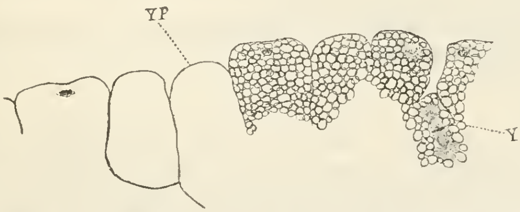

Fig. 5. Part of section of egg in a stage later than Fig. 3, in which the surface consists of a pavement of very small, polygonal segments. This shows a single nucleus which is delaminating. This egg contains several yolk cells. Y = yolk sphere. YP = yolk segment. Yolk somewhat diagramatic.

formed at a similar stage in *Alpheus* by migration and possibly also by delamination.

[2] An earlier statement to the effect that incubation lasted for a much shorter period was based upon an erroneous assumption (v. Johns Hopkins University Circulars, No. 80).

The invagination stage in marked by the presence at the surface of a small circular pit. On one side of the pit, the anterior side, and over a considerable surface of the egg, the cells multiply rapidly, and thus mark off the embryonic area. The invaginate cells proliferate and form a solid wedge-shaped mass which will be spoken of as the »Keel« (Fig. 6). For fuller account see No. 80 of Johns Hopkins

Fig. 6.

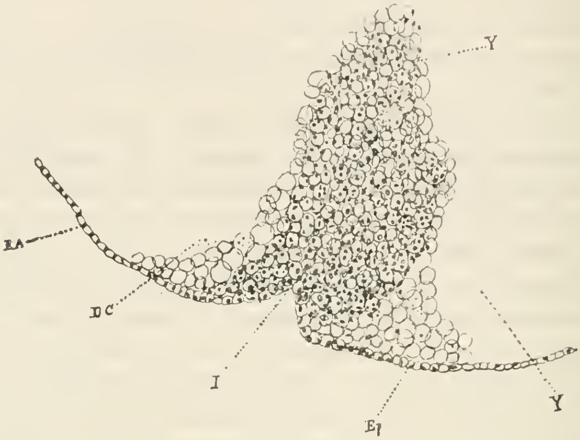

Fig. 6. Longitudinal median section through embryonic area (*EA*), invaginate cavity (*I*) and cell mass of keel. The cells forming the keel are very small. They are rapidly dividing, and are very intimately associated with spherules of yolk, as is indicated in the drawing.

DC = Traces of degenerating nuclei.

Ep = superficial cell-layer; the peripheral nuclei closely associated with a peripheral tier of yolk spheres.

Y = yolk.

University Circulars). The pit, at first very slight becomes deeper and broader, and is easily seen with the naked eye (Fig. 4). Eventually this depression entirely disappears and in its place, we have a plug or core of cells extruding downward into the yolk, and backward in a conspicuous train.

By the time the naupliar appendages are outlined, the keel has undergone remarkable changes, and is no longer visible as a prominent object at the surface. Some of its cells pass forward under the embryonic area; some take part in the thoracic-abdominal process, while a very large number pass to various parts of the egg in a way already described in an earlier paper already referred to.

Some remarkable variations and irregularities occur in the keel and egg-nauplius stages. There is frequently formed in connection with the keel an oval, circular, or irregular shaped disc of cells, of from one to two thirds the diameter of the egg. The edges of the disc grow down into the yolk so that they are sharply defined all around. Either wholly or partly within this area, or upon its edges the embryo is formed. Sections through the disc show that it consists of, for the most part, a single layer of large columnar or cubical cells, gorged with yolk. The edges bend down and grow into the yolk, entirely independent of the general epithelium which covers the rest of the egg. The edges of each side unite in front and behind, so as to form a cul-de-sac at each end of the disc, and the whole structure represents a flattened bug, partly buried in the yolk, and in communication with the latter by an opening below. Sometimes the whole disc sinks into the yolk, so that the nauplius embryo is nearly covered by yolk material. This recalls the condition of the insect embryo after the amnion and serosa are formed. Throughout the whole extent of the embryo there is a meteoric cloud of spore-like fragments, the degenerating nuclei, which pass into the yolk and are absorbed.

Degenerating nuclei occur in the fully formed egg-nauplius in various parts, but are most noticeable perhaps in the region of the stomadaeum and optic discs. I believe it will be found that the fragmentation and dissolution of cells is a common phenomenon among the Crustacea and other Arthropods. I have already observed it in several Decapods, and it seems to me quite possible that »secondary mesoderm cells« which have been described in the Crayfish, may be explained, in part at least, as cases of cell-degeneration. In the peculiar »dorsal organ« of the lobster which I have described in a former paper, many of the cells proliferate and then break up into degenerating products precisely as in *Alpheus Saulcyi*. The history of the degenerating cells is very similar in the two forms.

3. Die Entwicklung der Daphnia aus dem Sommereie.

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eingeg. 28. März 1891.

Der Arbeiten, welche über die Cladocerenentwicklung handeln, sind sehr wenige. Einige von ihnen haben nur ein historisches Interesse[1]; die anderen betrachten nichts mehr als die äußere Gestalt des Embryo in verschiedenen Stadien, ohne etwas Weiteres über die inneren Entwicklungsvorgänge zu geben[2]. Die beste Abhandlung in Be-

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[1] Jurine, Histoire des Monocles. 1820.

[2] Zaddach 1854; Leydig 1860; Metschnikoff 1866; P. E. Müller 1868; Dohrn 1870; Claus 1876.

Zeitschrift/Journal: Zoologischer Anzeiger

Jahr/Year: 1891

Band/Volume: 14

Autor(en)/Author(s): Herrick F. H.

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