SOME NEW MORPHOLOGICAL FINDINGS IN EPHEMEROPTERA

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In working on the morphology, habits, gill development, and taxonomy of Mayfly genus, *Stanonema,* of North America in the Entomological Laboratory of Cornell University, Ithaca, N. Y., U. S. A. under the direction of Professor James G. NEEDHAM, several new morphological structures and mode of gill development in Ephemeroptera were found.

1. Palmen Bodies in Abdomen (Plate XVIII, figs. 1 to 3).

The presence of a chitinous structure, the Palmen Body, in the head of most Ephemeroptera was first noted by Dr. J. A. PALMEN in the year 1877, after whom the organ was named. The workers in the past have all found the organ in the head only and evidently the presence of two small similar bodies in the eigth and ninth abdominal segments apparently escaped their observations.

On the ventral side of the eighth and ninth abdominal segments above the sternum there are two small oval-shaped chitinous bodies, which lie along the median line at the middle of the segment. These are evidently overlooked by the previous workers.

Each of these organs is about one-fourth the size of the one in the head and is formed by the union of the inner ends of the two transverse tracheal branches from the two longitudinal trunks. The organ is also composed of a series of concentric chitinous layers or rings, which were left in it at successive molts, and is surrounded on the outside by a layer of larger hypodermal cells.

2. **The Ilial Valve** (Plate XVIII, figs. 3 and 4).

The alimentary canal is almost a straight tube. The divisions of the digestive tract and their histological structures are very similar to the conditions found in generalized insects. One interesting new structure, however, was found in between the ileum and colon, where the wall of the alimentary canal forms a distinct valve-like structure, the ilial valve, which is very similar to the oesophageal valve found between oesophagus and mesenteron.

The posterior end of the ileum like in the case of oesophageal valve, constricts and sinks slightly into the colon to form the ilial valve, which is also formed by a complete circular fold of the epithelial layer and intima of the ileum. The inner part of the fold is composed of columnar cells, while the outer part of the fold the cells begin with columnar cells and gradually decrease in thickness to merge into a homogenous epithelial layer of the colon. The muscular layer continues into the fold of the ilial valve, and is continuous with the very thin muscular layer of the colon.

3. **The Johnston's Organ** (Plate XVIII, fig. 6).

The Johnston's organ is known to occur in Odonata, Orthoptera, Hemiptera, Anoplura, Neuroptera, Coleoptera, Trichoptera, Lepidoptera, Diptera, and Hymenoptera (Snodgrass '26). This is the first time that this organ was found in Ephemeroptera.

The Johnston's organ is only a simplified chordotonal organ. Some writers say that the organ of Johnston is an auditory organ, but there is little evidence to support this view. According to Snodgrass its function may be perceptive to slight air motions, but whether to waves of sound or not is still to be questioned.

It consists essentially of a ring of large bipolar nerve cells, whose fibers run back and continue with the fibers of the antennary nerve. Their distal extremities are attached to the conjunctiva between the second and third joints of the antenna.

4. **The Mating Gland** (Plate XVIII, fig. 5).

The mating glands are minute unicellular glands distributed all over on the inner surface of the male forceps extending from the base of the second segment to the tip of the distal segment. Externally they appear as very minute club-shaped protuberances which are the terminal parts of the glands.

The forceps are lined on the outside by a thick layer of cuticle. A layer of columnar hypodermal cells is situated inside the cuticle with large oval nuclei. The hypodermis is twice as thick as the cuticle. The cell walls are not well defined.

A mating gland is a large unicellular globular gland embedded in the hypodermal layer, and is derived from the hypodermal cells. The nucleus of the gland is eccentric. The cytoplasm forms a dense ring around the center. The globular cell elongates into a very slender capillary tube penetrating through the cuticle. At the tip of the tube, it swells into a round reservoir, where the mating fluid is temporarily stored. The cuticle of the wall of the forceps projects out and encloses the reservoir forming a club-shaped protuberance, which is visible on the inner surface of the male forceps. At the time of mating the thin cuticle surrounding the reservoir evidently bursts open, thus liberating the mating fluid.

5. **The Mating Spines** (Plate XVIII, figs. 7 and 8).

The mating spines are minute cuticular outgrowths on the ventral side of the egg valve in the female. They are conical spines of the cuticle beset with numerous small spines. They are evidently used to hold the male genitalia in place at the time of mating.

6. Mode of Gill development in Stanonema interpunctata Say.

A study of the eleven early stages of the nymph of *Stanonema interpunctata* shows very interesting mode of the development of respiratory gill plates on the sides of the first seven abdominal segments, and other changes of the external body structures.

a. **The First Stage** (Plate XIX, fig. 1).

The newly hatched nymph measures : 5 mm. in length, not including the antennae and tails. The head is alomost quadrangular in shape, except that its anterior margin is more or less rounded off. From the anterior border of the head between the antennae arises a small rounded projection, which is called by LESTAGE the clypeo-cephalic prolongment. The dorsal surface of the head bears five ocelli; an anterior pair, a posterior pair, and one unpaired median ocellus at the base of the clypeo-cephalic prolongment in front and between the anterior pair. The anterior three are ocelli proper and the posterior two will develop into the two compound eyes. These latter are now each composed only of a single ommatidium, so their size is exactly the same as that of the true ocelli, and they are situated at the postero-lateral angles of the head.

Each antenna is composed of five segments. The first or the proximal segment is the shortest and narrow basally and wider distally. The second segment is about twice as long as the first and increases in thickness towards the apex. The third segment is a little shorter than the second and a little longer than the first, and of uniform thickness throughout. It bears a long

bristle on its inner margin at the distal end. The fourth and the fifth segments are approximately equal in length and each about two and half times longer than the first one. The fourth segment bears three bristles at its distal end and the fifth segment terminates into two long bristles at its apex.

The three pairs of legs are all similar and have not become flattened yet. Each of the fore and middle femora bears a bristle, and the hind femur bears two bristles. All tibiae bear two bristles.

There is no sign of the development of gills on the sides of the abdomen. They are entirely wanting during this stage.

The lateral tails are each composed of five segments. The first segment is the shortest; second, third, and fourth segments equal in length; and the fifth segment the longest. The second, third, and fourth segments each bears a bristle and the fifth segment terminates into two bristles at its apex. The median tail is composed of six segments. The first and the sixth segments are equal in length and shorter than the others, and do not bear any bristles. The remaining four segments are each longer than the first or the last segment and are equal in length. Each of them bears one or two bristles.

2. The Second Stage (Plate XIX, fig. 2).

The nymphs of this stage measure .8 mm. in length, and look much more like the later nymphs in appearance than the first stage. The head is more or less rounded in outline. The five ocelli are still in the same condition as in the first stage. The antennae have increased in length and in the number of segments, and have lost their bristles. The legs are modified for their habitat and are flattened, especially the femora which are strongly developed and armed with spines along the hind margin.

The most important change has taken place in the abdomen, and this is the beginning of the development of gills. There are two ways by which the seven pairs of gills on the sides of the first seven abdominal segments are developed, one is called « filament to plate » method, and the other is « bud to plate » method. The first four pairs of gills are developed by the latter method and the last three pairs are by the former method.

Arising from the postero-lateral angles of segments five and six there developed a pair of thread-like gills, each with a single tracheal tube inside. They are developed by the « filament to plate » method.

The three tails increase in length and in the number of segments. Each tail has two whorls of bristles.

3. The Third Stage (Plate XIX, fig. 3).

The length of the body of this stage is 1 mm. The five ocelli have differentiated into the posterior two compound eyes and the anterior three true ocelli. Beginning with this stage the compound eyes increase rapidly in

size and in the number of ommatidia. Each eye of this stage is composed of more than ten ommatidia. Each is about one-fourth larger than the ocelli.

The fifth and the sixth pair of thread-like gills, developed in the previous stage, have increased their length.

The most important event in this stage is the development of the seventh or the last pair of gills which appears as a pair of little thread-like stubs arising from the postero-lateral angles of the seventh abdominal segment.

4. The Fourth Stage (Plate XIX, fig. 4).

The length of the body of this stage is 1.2 mm. The compound eyes have increased in size and in the number of ommatidia. Each is about one-third larger than the ocelli.

The most important change in this stage is the increase in length of the last three pairs of thread-like gills. The first four pairs of gills are still undeveloped yet.

5. The Fifth Stage (Plate XIX, fig. 5).

The fifth stage is a very important stage which marks the first appearance of all seven pairs of gills. The nymph of this stage measures 1.25 mm. in length. The compound eyes increase in size and are little more than one-third larger than the ocelli.

The most important changes in this stage are the simultaneous appearance of the first four pair of gills and the maximum increase of the length of the fifth and the sixth pairs of gills. Arising from the postero-lateral angles of each of the first four abdominal segments there developed a pair of very short bud-like out-pockets of the body wall. They do not contain tracheal tubes. They represent the beginnings of the first four pairs of gills. Their development is different from that of the last three pairs in being developed by the « bud to plate » method.

6. The Sixth Stage (Plate XIX, fig. 6).

The length of the body of this stage measures 1.4 mm. The compound eyes keep on increasing in size and in the number of ommatidia.

The most important thing to be noticed in this stage is the beginning of the reduction of the length of the fifth and the sixth pair, of gills. The seventh pair still increases in length. The first four pairs of bud-like gills also increase in length.

7. **The Seventh Stage** (Plate XIX, fig. 7).

In this stage the body of the nymph measures 1.5 mm. in length. The size of the compound eyes increasesto about twice larger than the ocelli.

The first four pairs of gills still increase in length. The fifth and the sixth pair of gills keep on reducing their length. The seventh pair increases in length.

8. **The Eighth Stage** (Plate XIX, fig. 8).

The eighth stage is a very important one which marks the beginning of the development of the first four pairs of gills from bud-like structures into plate-like organs. Hence they are said to be developed by the « bud to plate » method. The body measures 1.6 mm. in length.

The most important events in this stage are the beginning of the development of the first four pairs of gills into small plate-like organs and the attainment of the maximum length of the last pair of thread-like gills. The first four pairs of of plate-like organs are not yet penetrated with tracheal branches. Each plate is a small oval structure. The fifth and the sixth pairs of gills keep on reducing in length.

9. **The Ninth Stage** (Plate XIX, fig. 9).

The ninth stage is another very important one in the development of gills. It marks the beginning of the development of the last three pairs of gills from thread-like filaments into plate-like organs. The length of the body is 1.95 mm.

The first four pairs of gills have become entirely flat and leaf-like with tracheal ramifications inside. They are pointed at the tip. The length of the last three pairs of thread-like gills keep on reducing. The fifth pair reduces trememdously in length and begins to expand at its base to form plate-like organ with the distal half still in thread-like form. The sixth and the seventh pairs remain thread-like.

10. **The Tenth Stage** (Plate XIX, fig. 10).

The length of the body measures 2.1 mm. The compound eyes are much larger now.

The most important changes in this stage are the completion of the modification of the fifth pair of gills from thread-like filaments to leaf-like plates similar to the first four pairs of gills, and the beginning of the sixth pair of filamentous gills to expand at its base, as the fifth one, to form plate-like organs with the distal half still in filamentous form. The last or the seventh pair still remains filamentous. All last three pairs of

gills reduce in length. The first four pairs and the fifth pair are all well developed by this time into plate-like gills.

11. **The Eleventh Stage** (Plate XIX, fig. 11).

This marks the final stage of the development of gills to plate-like form. The body measures 2.6 mm. in length.

The most important change in this stage is the completion of the sixth pair of filamentous gills into leaf-like plates similar to the first five pairs, except for smaller size. The seventh or the last pair of gills always remains filamentous in this genus. It is one of the important characters, which separate this genus from the rest.

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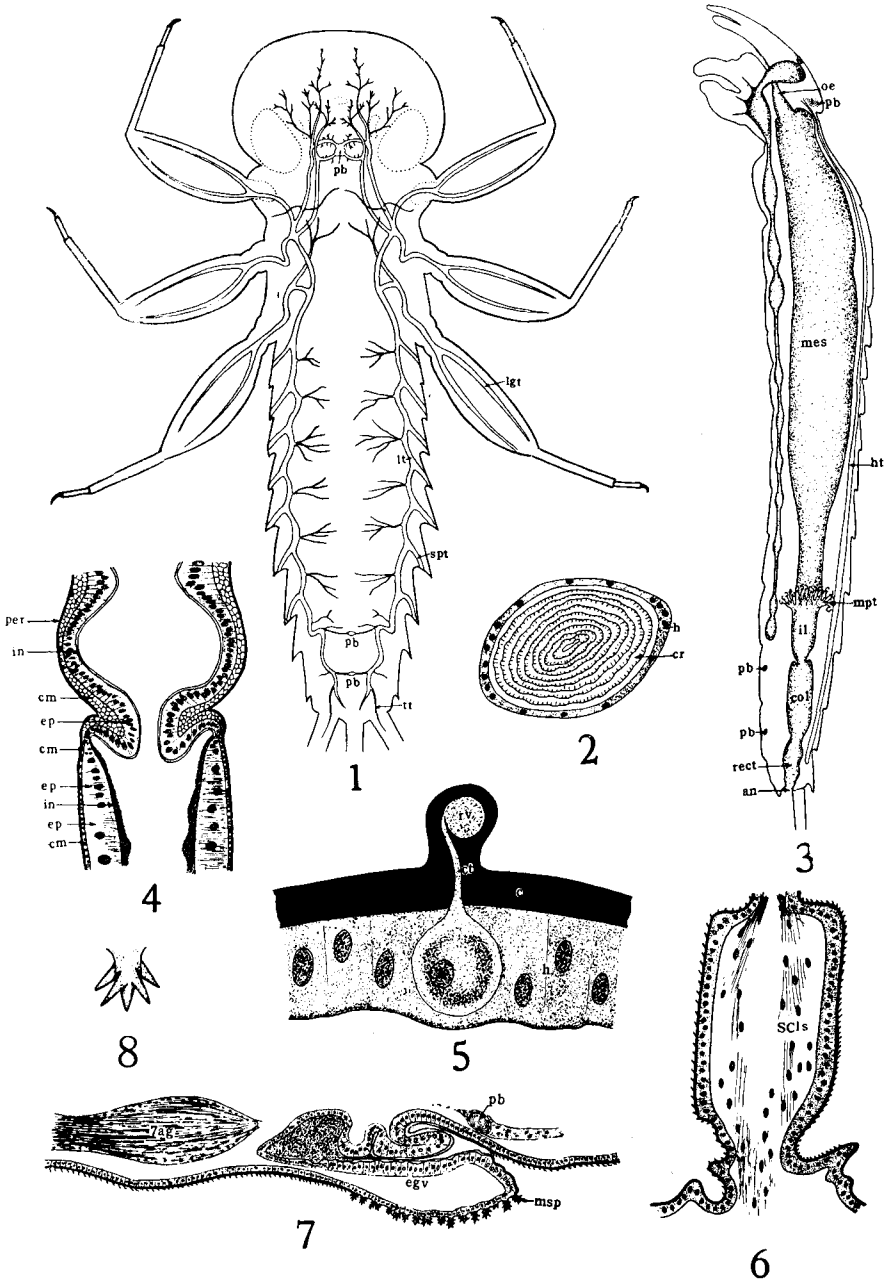
Explanation of Abbreviations.

an...	anus	in...	intima
cm...	circular muscle	lt...	longitudinal tracheal trunk
cr...	concentric rings	oe...	oesophagus
egv...	egg valve	pb...	Palmen body
h...	hypodermis	rv...	reservoir
il...	ileum	spt...	spiracular tracheal trunk
lgt...	leg tracheae	mes...	mesenteron
mpt...	Malpighian tubule	rect...	rectum
msp...	mating spine	Scls...	sense cells
c...	cuticle	tt...	tail treachea
col...	colon	per...	peritoneum
ct...	capillary tube	7ag...	7th abdominal ganglion
ep...	epithelium		
ht...	heart		

Explanation of Plates XVIII and XIX

Plate XVIII. — Morphological Structures.
Fig. 1. — Dorsal view of the nymph showing the tracheal system and the Palmen bodies in head and abdomen.
Fig. 2. — Transverse section of the Palmen body in abdomen.
Fig. 3. — Lateral view of the nymph showing the internal systems and the Palmen bodies in head and abdomen.
Fig. 4. — Longitudinal section between ileum and colon showing the ilial valve.
Figt 5. — The mating gland.
Fig. 6. — Longitudinal section of the pedicel of the antennae showing the Johnston's organ.
Fig. 7. — Sagittal section between seventh and eighth abdominal segment showing the mating spines.
Fig. 8. — A mating spine, much enlarged.

Plate XIX. — Mode of Gill Development in Stanonema interpunctata.
Fig. 1. — First Stage.
Fig. 2. — Second Stage.
Fig. 3. — Third Stage.
Fig. 4. — Fourth Stage.
Fig. 5. — Fifth Stage.
Fig. 6. — Sixth Stage.
Fig. 7. — Seventh Stage.
Fig. 8. — Eighth Stage.
Fig. 9. — Ninth Stage.
Fig. 10. — Tenth Stage.
Fig. 11. — Eleventh Stage.



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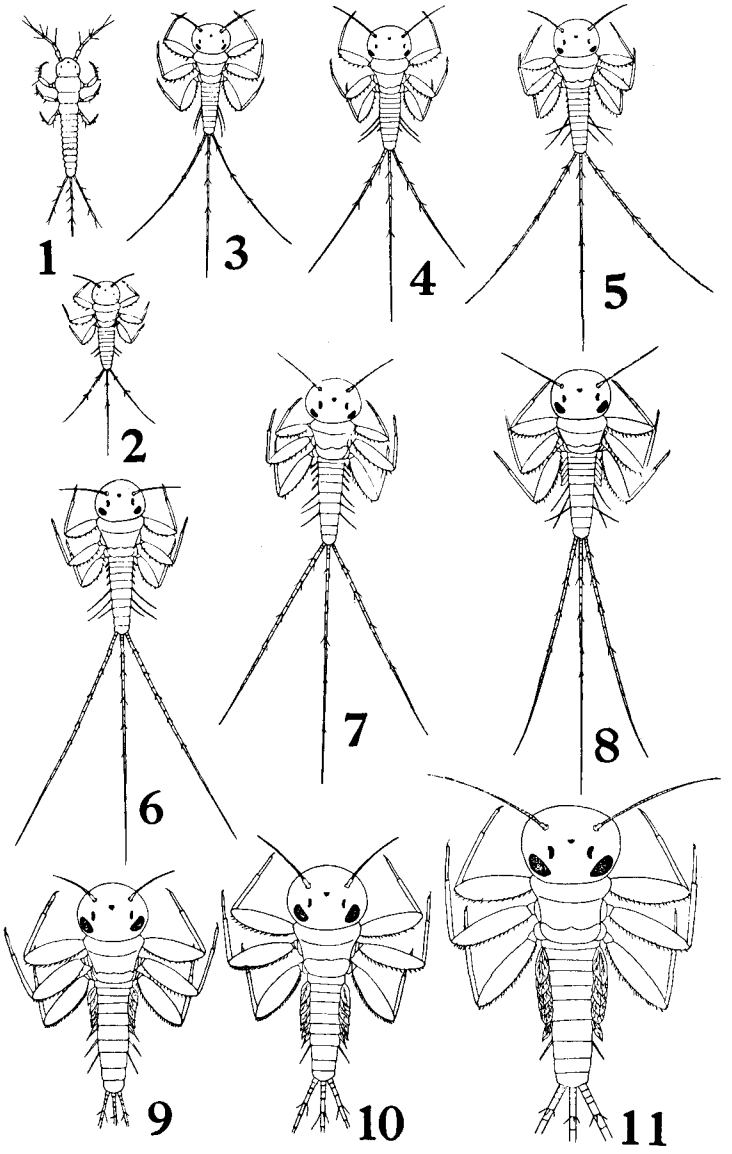

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