

and I see his "Essay" handled so tenderly, and treated with so much respect, that I flatter myself these observations will not altogether escape his notice, and I may reasonably expect that I shall draw on myself his angry reply. I wish now most positively to state, that I shall decline a controversy; and to all who may desire to commence one, I merely say, reperuse *this*.

It is scarcely allowable thus to point out the *errors*, without making any allusions to the *merits* of a work: permit me, therefore, to add, that I have never seen any summary of the characters of the different classes of insects given in so clear, concise, and unexceptionable a manner, as in Mr. Newman's table; neither did I ever read a work on natural history containing such profound ideas, and displaying such varied and great talent, as the one, the main theory of which it has been my endeavour to point out as being completely imaginary. How often is this the case! how often does talent, like the "ignis fatuus," dazzle to mislead.

I am, Sir,

Your subscriber, and generally your admirer,

CLERICUS.

October 1, 1832.

ART. XXV.—*Observations on the Circulation of the Blood in Insects.* By JAMES BOWERBANK, ESQ., F. G. & Z. S.

THE larva of the *Ephemera marginata*^a is the insect which best exhibits the general circulation of the blood, and is the one which has been the principal subject of the following observations. It is figured and described in Dr. Goring and Mr. Pritchard's "Microscopic Illustrations;" but, for my first introduction to the living larva, I am indebted to my friend, Mr. Tulley, with one of whose splendid instruments my observations have been made. These larvæ may be found

^a It does not appear quite certain of what particular species of ephemera the insect described here is the larva.—ED.

in considerable numbers in small pools of water in boggy or marshy places; mine were procured from similar situations on Hampstead Heath. They may be preserved for many months in glass jars, or other vessels, with a little duck-weed floating upon the surface of the water. In selecting them for the purpose of exhibiting the circulation of the blood, care should be taken to choose such as have not yet attained a greater length of body than about one-eighth of an inch, as the whole insect may then be subjected to examination, with a reasonable expectation of seeing the full extent of the great dorsal vessel; particularly if one be selected which has the intestinal canal free, or nearly free, from food, as the success of the observation will greatly depend upon this circumstance. In fixing the larva for observation, which of course must be in water, great care must be taken not to compress the body, as, although the central circulation may be seen proceeding with considerable vigour, that through the lateral vessels, and those of the tail, legs, and antennæ, will either be much impeded or entirely stopped. Having fixed the insect, with the above precautions, and with its back towards you, a truly beautiful and astonishing sight presents itself. The blood, abounding in flattened oat-shaped particles, will be seen circulating in every part of the body, not in a continuous stream, but at regular periods, agreeing in its motion with the pulsations of the great dorsal vessel. This vessel (Fig. 1, *a, a, a, a*), extends nearly the whole length of the body, and is of great comparative magnitude. It is furnished, at regular intervals, with double valves, about equal in number to the sections of the body. Both above and below each of these sets of valves is a pair of singular looking appendages, (Fig. 2, *a*.) They are, probably, nervous ganglions, auxiliary to the motions of the vessel, but so exceedingly pellucid as scarcely to be defined with the highest power which can be applied to them. The action of the valves is a most interesting and beautiful sight. While in their greatest state of collapse, the point of the lower valve is seen closely compressed within the upper one, (Fig. 3, *a*.) At the commencement of the expansion of the artery, the blood is seen flowing in from the lateral apertures, (Fig. 2, *b*); and, at the same time, the stream in the artery commences its ascent. When it has nearly attained its greatest state of expansion, the sides of the lower valve are forced

upwards by the increased flow of the blood from the section below the valve, the lateral openings are closed, and the main current of the blood is projected through the two valves, as shewn in Fig. 4, *a*.

It is not easy to see this beautiful structure of the valves of the great dorsal vessel, for it is only when the insect is in a state of great exhaustion, or has been just so much compressed as to destroy voluntary motion without entirely depriving it of life, that it is possible to subject it to a power sufficiently high to discern these extremely delicate and transparent tissues; and even then, to see them to the greatest advantage, recourse should be had only to such as are in the last three or four sections of the body.

The structure of the upper valve appears to be a reflecting inwards and upwards of the inner coat or coats of the artery; and of the under one, to be a contraction and projection of the like parts of a portion of the artery beneath, so as to come within the grasp of the lower part of the valve above it. The exterior portion of the artery may be seen as an exceedingly fine line, connecting the parts above and below the valves, as represented at *c*, Figs. 2, 3, and 4.

The blood does not appear to be confined within any specific vessels, previously to its entering the lateral openings before-mentioned, as, when they open, the particles are seen converging towards them, as shewn by the curved and straight arrows, Fig. 2.

The whole of the blood received throughout the course of this vessel is conveyed to the extremity of the anterior part of the body, where the vessel makes a curve inwardly, and is lost to view at *b*, Fig. 1. To all appearance, the main current of the blood is now discharged into the cavity of the body, as it is seen pursuing its course downwards, in a wide spreading stream, on each side and beneath the great dorsal vessel. As it descends, portions are again absorbed by the valves of the dorsal vessel, and, at the same time, vessels passing down each side of the body convey another portion of the blood to its lower extremity. These are decidedly vessels, not portions of the great abdominal cavity, their boundaries being clearly definable. They communicate at each junction of the sections of the body with the great abdominal cavity, as a part of the blood they convey is discharged at these points, to supply

the place of that absorbed by the valves of the great dorsal vessel; *c*, Fig. 1, shews the course of these vessels, and *d*, Fig. 1, the points at which they communicate with the abdominal cavity. These vessels terminate at *e*, Fig. 1, by discharging their contents into the lower end of the great dorsal vessel.

The circulation is also strikingly and beautifully exhibited in the tail. Here the ascending and descending vessels, like vein and artery, accompany each other; and, at the same instant that the blood is seen to pass up the one, with the usual pulsatory motion, it descends in the other in a similar manner. This is the more apparent, as the sides of the vessels are well defined, and each perfectly distinct from the other.

Although the blood passes with the same pulsatory motion through these minute vessels as it does in other parts of the body, yet no pulsation of either the ascending or descending vessels themselves can be detected. The motion, therefore, seems to be entirely dependent on the action of the great dorsal vessel, which evidently performs in the insect the same functions that the heart does in vertebrated animals.

Supplying and returning vessels may also be seen in the legs, although they cannot be so clearly defined as in the tail; and in the antennæ they pass up on the one side of the first joint, and, turning round at the extremity, they again descend into the head.

Upon fixing the insect so as to obtain a side-view, the great dorsal vessel presents a very interesting appearance. It is seen continually and regularly oscillating backwards and forwards, upwards and downwards, and at the same time the main current of the blood in the great abdominal cavity winds its way in all directions towards the hinder extremity of the insect. Scarcely any larvæ exhibit the circulation of the blood in so beautiful a manner as the one described, although there are few in which it is not more or less to be seen, as I have been able to detect the great dorsal vessel in almost all I have examined. In one, figured in the work before quoted of Dr. Goring and Mr. Pritchard, and said to be the larvæ of a *Culex*, no particles are visible in the blood; but the great dorsal vessel, its valves, and their singular appendages, are distinctly and beautifully apparent.

Next to the larvæ of the *Ephemera marginata*, the larvæ of *Agrion* affords the best view of the blood and its circulation.

In all the species of these larvæ I have yet examined, I have found it as nearly similar as possible in appearance to that which we observe in the Ephemera, and in some instances it has afforded even more satisfactory results. The head of this larva is much more transparent than that of the larva of the Ephemera; we therefore had a better view of the circulation of the blood in the head of this insect than can possibly be obtained in the other. In this object the blood is seen rushing like a beautiful intermittent fountain towards the mouth, and dividing, right and left, into two jets, a portion of each of which flows within a given boundary past the back of the eye, whilst the remainder winds its way through other channels, deep in the side of the head, and returns again into the body.

The antennæ of this insect also afford another beautiful instance of the circulation being carried forward within well-defined vessels. They are each composed of six joints, up four of which the blood is seen to take its course, and turning round the extremity of the fourth joint, it returns by a distinct vessel into the head.

In the leg, likewise, the circulating fluid and its vessels are clearly and distinctly to be traced, even to the very extremity of the tarsus, where, as in the antennæ, the particles of the blood are seen to descend on the one side of the leg, and, turning the extreme point, to return up the contrary side to the one by which they came down.

I regret much that I have not yet had an opportunity of examining the Ephemera in its perfect state; but in two species of *Culex*, one of which was first observed and brought to me by my friend, Mr. Tulley, I have seen the great dorsal vessel performing its functions in a manner similar in every respect to its appearance in the larvæ of Ephemera, Agrion, &c. &c.; but, from the body of the fly being more opaque than that of the larvæ, and nearly covered with its striated scales, neither the valves nor the particles of the blood could be detected. On another occasion, after having carefully cleared the wings of *Phlogophora meticulosa* of their coloured scales, both Mr. Samouelle and myself clearly saw a fluid pass down the side of one of the principal ribs of the wing. We may therefore, I think, fairly conclude, that the circulation is carried forward in the perfect insect as well as in the larva, although, perhaps, not with so much vigour as when young and growing.

In describing what I have seen, I have abstained from using the word vessel, except where the margins were distinctly to be defined, although I am inclined, from what I have seen, to be of opinion, that a much greater portion of the circulation than we can clearly define is carried on within given vessels, as the blood may frequently be seen flowing in curved and other lines, and confined within very narrow limits, but so deeply seated amidst the muscles and intestines as totally to prevent the boundaries of the current from being clearly observed. This is strikingly the case in the side-view of this insect, where currents are seen winding about in many different directions, but, from the intervening muscles and intestines their boundaries are not visible; nor can it be expected under such circumstances, when we consider that the blood is a perfectly colourless and transparent fluid, visible only from its containing a number of particles of a somewhat flattened oat-shape; and that the great dorsal vessel itself is only to be seen distinctly with a very high power, and even then can only be defined with certainty whilst it is in motion.

I cannot omit observing a singular coincidence between the flattened oat-shaped particles of the blood in the insect, and of the circular double concave plates in the human blood, which is, that the particles of the former, like those of the latter, assume a globular form immediately on coming in contact with water.

ART. XXVI. — *Observations on the British Species of Sepsidæ.* By FRANCIS WALKER, ESQ. F. L. S.

Micropeza was the generic name given by Meigen to *Musca corrigiolata*, of Linnæus; or, *Calobata corrigiolata*, of Fabricius, who has placed in the latter genus some Dipterous insects, having not the slightest affinity to each other; one species being a *Sepsis*; another, a *Tachydromia*; a third, a *Borborus*; their only mutual resemblance consisting in the rapidity of their movements. Latreille, in his *Genera Crust. et Insect.*, has placed *Musca cynipsea*, of Linnæus, and *Tephritis macula*, of Fabricius (both belonging to *Sepsis*,

