ART. 29.—*Notes on the Mating-habits and Early Life-history of the Culicid* Opifex fuscus *Hutton.*

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[*Read before the Wellington Philosophical Society, 26th October, 1921; received by Editor, 31st December, 1921; issued separately, 30th April, 1923.*]

THIS particularly interesting mosquito has long been known to observers, and was generally supposed to be undescribed until, in the early part of this year, Mr. David Miller published some notes with regard to certain of its structural peculiarities, when Mr. G. V. Hudson called attention to the fact that Hutton had described it in 1902 (*Trans. N.Z. Inst.*, vol. 34, p. 188), placing it among the Tipulids. It is never found away from the coast, and it breeds in pools a little above high-water mark. These pools contain brackish water, in which there is generally an abundant growth of *Enteromorpha.* The present notes will be confined to the mating-habits, oviposition, and similar features of the insect.

Larvae, and often a few pupae, are to be found in the pools throughout the winter. In mild winters a few emergences may take place. During September pupation takes place somewhat more freely. Mating takes place among the newly-emerged insects; but it is usually not until October that it is in full swing. Although nothing that quite corresponds to the swarming of many other mosquitoes takes place, the surface of the breeding-pools becomes dotted, often quite thickly, with males. They adopt a very alert attitude, peering down into the water and often thrusting the head below the surface to get a clearer view. Their object is to capture the female pupae that are about ready to emerge. If the surface of the water is broken by a rising pupa a few inches away, the male darts at the spot with wonderful quickness. The capture of the pupa is made by means of the anal forceps, the great ungues of the male not being used in these circumstances. The grip is usually secured on the frontal ridge, along which the puparium would split in a case of unaided emergence; but often the grip is to one side of the ridge. In either case the puparium is ruptured a little to one side of the ridge, and the anal forceps of the male rest upon the thorax of the pupa, working backwards and extending the slit. In a few cases the slit is greatly extended, but generally the male ceases active efforts in this direction as soon as the head and part of the thorax are clear. Emergence from this point is generally effected by the gradual straightening of the legs of the young imago, which rises slowly and steadily, without jerky movement, till nearly the whole of the abdomen is clear. The male has kept the forceps in close contact with the body of the imago, two or three segments of his abdomen being inside the puparium. If, as is usually the case, the imago is a female, connection is effected before her abdomen is quite clear, and when emergence is complete copula has already begun.

While it is in progress the two insects rest quietly, in the end-to-end position, on the water or on a rock. Copula usually lasts from three to seven minutes, but it has been observed to last over half an hour.

It is by no means an uncommon thing for a male pupa to be captured, and in this case the captor does not discover his mistake until emergence is about complete. He then darts away, one can fancy, with an expression of disgust, and after a little time resumes his place among the hunting males.

When swarming is active it never happens that a captor is allowed undisputed possession of the captive. Three or four or a dozen other males will have leapt at the same time, and a fierce struggle takes place, the successful captor making for the shore, stabbing with his proboscis and dragging the struggling mass along. The competitors seem to use their ungues in thrusting or dragging each other away, and the proboscis is apparently used freely. But the struggle never lasts long. Apparently it is abandoned as soon as it is recognized that the captor has a sufficient hold with the forceps to prevent loss of the captive. I have never seen a competitor injured in the struggle, or, at all events, so injured that he could not at once return to the occupation of watching for a pupa. Whether the original captor is ever dispossessed during the struggle I cannot say, but probably if the rivalry were never successful it would not exist. One occasionally sees two males with a hold on the same pupa, dragging in opposite directions. In these cases the one that drags the pupa head forward is successful.

From a long series of observations it seems evident that the method of the copula is usually the one just described, and that fully emerged females may be supposed, as a rule, not to copulate a second time. The following extracts from my notes refer to observed departures from this apparent rule and to the sensitiveness of the male to interruption.

27th September, 1921: At 11.45 saw another male holding a pupa as before, but between the spiracles, though close to the left one. I put the couple in a phial half filled with water, and shook it violently till they separated. The male made no further attempt to capture the female, which, in a quarter of an hour, completed her emergence without effort. I drained off the water and kept the couple under observation for an hour. Neither took the least notice of the other.

I repeated these experiments several times on this and subsequent days, and never found that connection was resumed. I have also separated pairs just as copula was about to be established, and others just after it had begun. With two exceptions, one of which is about to be referred to, they have remained indifferent to each other, and the females, removed to a tank containing a large number of hunting males, excited no attention.

One of the two exceptional cases of resumed copula just referred to demonstrates hypertrophy of the sexual instinct in a male. The note is as follows:—

At 10.20 p.m. (3rd October, 1921) noticed in a mating-tank over which an electric light was placed two insects in full copula. I placed them in a phial with some water. They immediately separated. From the appearance of the female I judged that she had emerged some minutes before, and I supposed that copula had about come to an end. At 10.40, the phial having for some five minutes been unobserved, I saw that renewal had taken place. I moved the phial to get it in a better light, and the insects again

separated. Three minutes later the male darted at the female and seized her, using the ungues and the anal forceps. A struggle ensued, during which the female was forced partly under the surface. Copula was again established, and it lasted for seven minutes. After separation had taken place, and within five minutes of it, a fresh connection was established, with the like preliminary struggle. This lasted for five minutes. On both occasions the normal end-to-end position was assumed, both standing on the water. Five minutes after separation the male again seized the female and established connection, which he immediately broke off. I have placed the female in a separate jar to note whether eggs are deposited. (None were deposited). On the next day the male was quite ready to repeat the above performances with another female. After keeping him under observation for a day or two I thought the proper thing to do was to kill him.

Another exceptional case was the following: On the 1st October I saw a male that had been darting about actively in a mating-tank pounce upon a female that was resting on the surface and effect immediate connection, apparently with no great difficulty. He ran straight forward, as if he had seized a pupa. The effect was to turn the female back downwards in the water, and by the time the resting-stone was reached her wings were thoroughly draggled. I removed them to a phial, and they separated five and a half minutes after the capture. The female could not clear her wings. Later I placed her upon a piece of blotting-paper, but she did not recover. During copula the forceps of the male could not, on account of the unusual position, grip the last segment of the abdomen of the female, as in the normal position, but nearly met below it. Yet the dragging of her body through the water, and the subsequent struggle during the isolation of the couple, did not cause separation. During two summers I have often watched the mosquito-pools, and have never witnessed the capture of an imago, and, except for the case last noted, this is the only case I have witnessed in the laboratory.

Although the pupa may be seized by the frontal ridge or crest, the slit is made by the male just to one side of it, usually the left. But when a pupa emerges unaided, whether it be male or female, the puparium opens along the crest.

Males sometimes capture immature pupae, and in that case they seem unable to rupture the puparium. But these cases are rare, partly because the males sometimes discriminate and partly because the immature pupae are more active in avoiding capture. When the pupa is mature, air accumulates between the puparium and the new cuticle, until the only connection is at the spiracles. The pupa then has a silvery-white sheen, and is easily recognizable by the observer. Its vision is impaired, and also its power to struggle. It is therefore easily captured.

Neither male nor female pupa has the least difficulty in quitting the puparium unaided. The following note shows the course of things as frequently observed in the case of pupae that have been isolated: The pupa resting at the surface of the water began emergence from the puparium. The groove along the crest that runs backwards along the dorsum of the head and thorax deepened to a slit, and through this the head of the pupa began to emerge. The limbs and wings could be seen folded close to the body. By the straightening and expansion of the legs as they became more exposed to the air the head and thorax were steadily pushed, as it were, upwards. Presently the first pair of legs

was freed by a single effort. Immediately the insect spread them, and they rested on the surface of the water. The other legs were steadily drawn out, and only the last two or three segments of the abdomen were now within the puparium. The puparium was now seized between the hind legs and thrust backwards, floating away. Within half a minute of clearing itself the imago walked away. The whole process, from the first appearance of the head between the sides of the cleft, occupied just under four minutes. As the insect emerged it was of a whitish colour, turning rapidly greyish-white, the only black being in the form of bands on the legs. Soon these were as wide as the white, and then wider, until the only white on the legs was in the form of the narrow bands at the joints as in the adult insect. Meanwhile dark spots appeared at the spiracles, and these rapidly spread. Within five minutes the whole insect was a greyish-black, and within another five it was practically black. On emergence the wings flattened at once, but did not extend the full length of the abdomen, the last two segments of the abdomen being quite uncovered. Within ten minutes the wings were the full length of the abdomen, and in another five they had extended beyond it to the full length of the adult wing.

The male imago does not commence hunting for pupae immediately on emergence from the puparium, but may do so within ten minutes, and usually does so within twenty.

I have for several summers examined the pools, and the rocks that border them, together with any growth of weeds, in the hope of finding the eggs, but always without success. During the early part of last summer very young larvae made their appearance in a mating-tank, and it was evident that eggs had been deposited. On the 7th March I placed newly emerged insects, male and female, in a large cage resting over a dish of water with a white oyster-shell rising above the surface. On the evening of the 10th, at 9 p.m., a female was observed resting on the shell at the edge of the water. Now and again the abdomen was raised and then lowered to the water and brushed with the femur and tibia of the hind legs. I could not, without withdrawing the dish, which I did not wish to do, see any eggs. In about fifteen minutes she flew up into the cage. Next morning I found attached to the shell at the spot where she had been resting, and just below the surface of the water, a group of five tiny eggs. They were black, and easily seen against the white shell, as I had hoped they would be. At another spot there was a group of seven, and eight others were found singly at different spots. All were very lightly attached. There were also nine eggs floating in the water. These floating eggs looked spherical, though in reality oval, the spherical appearance being due to the fact that one end of the egg, the narrow end, was downward. The attached eggs had short blunt "processes" of the shell in contact with the oyster-shell, and the floating ones had similar "processes" on one side. These "processes"—if indeed they are really processes and not an independent secretion from glands of the female—were colourless. The floating eggs had probably become detached owing to the comparatively smooth oyster-shell not being a suitable surface for attachment. The five eggs of the first group, together with one that was lying on the floor of the dish, were removed to a phial to enable me to watch them. The dish containing the oyster-shell was taken away and the eggs kept under observation, another dish, containing a piece of white sandstone, being substituted.

On the 13th March about a dozen eggs were found attached at the water-edge to the sandstone, and not grouped. Next day about a hundred more were observed. Deposition of eggs on this stone continued until the 19th.

The eggs are oval, broader at one end than at the other, and covered with minute blunt spinous processes. They have also the colourless "processes" of mucilaginous matter already referred to. They vary slightly in size, but the usual length is 0·45 mm. and the greatest breadth is usually 0·3 mm. (Fig. 1.)

With regard to the eggs first deposited on the 11th March: By 10 p.m. on the 18th none had incubated; but at 10 a.m. on the 19th a single larva was found in the phial. This I killed and mounted. These eggs, and those left on the oyster-shell, were kept under observation until the end of the month; but no further incubation took place. The eggs were then thrown away.

The eggs on the sandstone block were observed constantly until 10.30 p.m. on the 24th. On the 25th no observation was made. At 10 a.m. on the 26th two larvae were found in the dish, evidently incubated not more than a very few hours earlier. As none of these eggs were deposited before the evening of the 12th March, the incubation period had been about fourteen days, as against eight days in the first case. Between 4 and 5 o'clock on the same day two more completed incubation, and four more next day. The dish had been removed from under the cage. Up to the middle of April no further incubation took place, and I supposed that there would be no more. On the 15th September, however, I found in the dish about a dozen very young larvae, and others appeared from time to time during the next four weeks. Probably about 10 per cent. in all of the eggs on the sandstone block incubated. None have incubated since the 15th October.

From these observations it is evident that hibernation may take place either in the larval stage or in the egg.

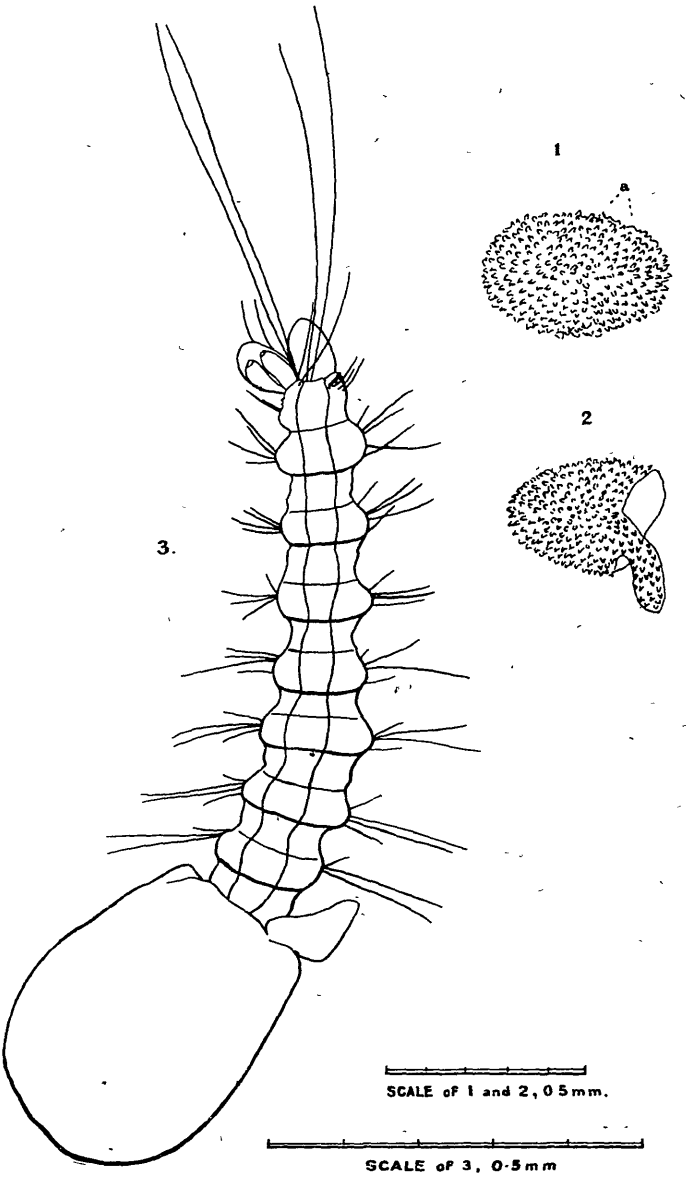
The first moult takes place not earlier than three weeks from the egg. The time varies greatly, but I do not give full notes of dates, as it is probable that the times would not be the same in the open pools. The second moult in hibernating larvae in the laboratory was about the end of August, or a little earlier; pupation began the first week in September, and the first imago appeared on the 17th.

In incubation the egg generally opens at the broad end, and the empty egg-shells have always a flap thrown back, leaving quite a wide opening. I have failed to find in the fresh eggs any indication of the line along which the "dehiscence" takes place. (Fig. 2.)

The larva leaves the egg tail first. This is obviously quite a suitable plan for a mosquito that has the eggs firmly attached. I have not been able to witness the actual opening of the flap, but I have found a larva that had most of the body clear though the head and thorax were still inside the shell. The egg had in this case become detached, and the larva was having some difficulty in getting clear. (Fig. 3.) Presumably he would have succeeded if I had not killed and mounted him.

It is not within the scope of this note to deal with the early stages of embryonic development; but it is of interest to note that six days after copula the eggs in the ovarian sacs are round, and that a thin shell, which is also round, is already formed.

In September of this year I isolated over a dozen females that had emerged in copula, giving them the most favourable conditions I could



Opifex fuscus.

FIG. 1.—Egg: *a*, mucilaginous elevations for attachment.
FIG. 2.—Empty egg-shell.
FIG. 3.—Larva quitting egg, in this case by the narrow end.

devise for the laying of eggs; but altogether without result. It would appear that it is only rarely that eggs are laid in captivity.

Seeing how crowded the pools are with larvae during the greater part of the summer, it is surprising that the number of adults at the different pools remains about the same. Even towards the end of summer, though a pool may be crowded with larvae, there do not seem to be more adults than one sees in November. It is probable that the normal life of the adult is short; nevertheless, I have kept both male and female mosquitoes alive in the laboratory for over three weeks.

Another feature that strikes one as singular is the apparently capricious preference given to certain pools. These favourite pools are always found to be occupied, while others, apparently equally suitable, are either not occupied at all, or are occupied in some years and not in others.

The following extract from my notes does not properly come within the scope of this paper, but it seems to me to be of sufficient interest to warrant publication:—

2nd October, 1921: When watching the mating-tank, observed at 4 p.m., an imago standing completely submerged on the side of the resting-stone, head downwards. I endeavoured to take the insect by means of a pipette; but it immediately walked down the rock till it was 4 in. below the surface, then walking along an almost horizontal surface, back downwards, to a smaller stone that rested on the floor of the tank. It clung so tightly that, even at this depth, it resisted the suction of the pipette for several attempts. At last I secured it, and put it in a phial for examination. It did not stand on the water, but lay on its side with draggled wings. It proved to be a female, newly emerged, the abdomen still greyish. I put the insect on a stone in a jar of brackish water. She immediately walked down into the water, pausing now and again to stroke the head and wings with the legs, as if endeavouring to dislodge the film of air that adhered to them. She remained on the sloping stone about 2 in. below the surface, apparently in comfort. She remained in this position till 4.31, when she loosed her hold and floated to the surface, almost motionless there. I placed her on the stone; but she did not recover. It may be supposed that the larva, making the complete change of bodily structure necessary for aerial life, and making it with apparent success, had failed to make the subtle change of instinct that should have accompanied the change of structure. Next morning, finding that she had not recovered, I fixed with mercury bichloride in 30 per cent. alcohol, hoping that some one that has a more complete knowledge of the histology of the nervous system of mosquitoes may be able to make use of it.