

THE SWARMING OF CULEX PIPIENS.

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It has been the writer's good fortune to observe the swarming and mating of *Culex pipiens* upon four consecutive evenings, October 15-18, 1904. Many notices of the swarming of Culicidae and related forms have appeared, but most of the accounts deal with the swarming simply as a remarkable phenomenon while its significance escaped them. It therefore seems worth while to record my own observations. Following these I shall give the more interesting data of previous writers, and at the end, a bibliography of the subject.

My observations were made at Urbana, Illinois, under exceptionally favorable conditions. Although the country about Urbana is well drained and there is but little water, mosquitoes were remarkably abundant. As far as could be determined all came from one source. On the outskirts of the town is a small stream, known as the Salt Fork, which, during dry weather, becomes practically stagnant. About a mile up the stream the water was polluted by the discharge from an abattoir. The foulness of the water was such that the fish normally present in the stream were all destroyed and thus an ideal breeding-place for mosquitoes was created. Early in October the writer found the larvae of *Culex pipiens* present in immense numbers, and when the shrubbery bordering the stream was disturbed the imagos rose in great clouds. These mosquitoes, however, showed no inclination to leave the water-side and would quickly return to the shelter of the marginal vegetation.

October 15 was a warm autumn day and its close was marked by one of those clear calm evenings when not a leaf stirs and the air appears to be perfectly still. At five o'clock the writer was crossing a corn-field not far from the stream. The sun was already near the horizon and its direct rays were cut off by an intervening line of tall trees. When near the middle of the field a cloud of mosquitoes was noticed directly overhead. The lowest mosquitoes were about the writer's head and shoulders, the topmost ones perhaps five feet higher; the transverse diameter of the swarm was about two feet. The high-keyed piping, vibrating between two notes in constant rapid reiteration, was very distinct. The variations in tone seemed to correspond to the upward and downward movements of the individuals. In the light of the succeeding observations it would seem that this swarm had been forming above the writer's head from the time he entered the field. The swarm was watched for about twenty minutes. The individuals in the swarm flew up and down amongst

each other with a kind of weaving motion — a downward and forward plunge and back again, performed without unison or regularity. The movements were sufficiently slow to allow the plumed antennae of the males to be clearly distinguished and it appeared that the swarm was composed wholly of males. Once a female was seen to dash into the midst of the swarm and emerge on the other side united with a male. The insect-net was swept through the swarm a number of times. At each stroke the mosquitoes would disperse somewhat but returned at once to their former position and continued their dance, and there was no perceptible diminution of their numbers. An examination of the captures showed 897 males and four females. This count includes the female observed passing through the swarm, as narrated above, and it is obvious that the other three females in the capture are not to be considered as members of the swarm. They may have entered the swarm unnoticed in the manner described, or they may even have been hovering about outside of it. The observations of T. H. Taylor (in Miall & Hammond, *The Harlequin Fly*) show a like condition in *Chironomus*. On a still evening his captures from a swarm were 700 males, no females. On a windy evening, when the swarm was thrown more or less into disorder by the breeze, a capture of 4300 specimens included 22 females.

Upon turning to leave the mosquito-swarm another one was discovered close by, hovering over and about a corn-stook. The swarm extended about half way down the side of the stook and kept on the south side of it, the mosquitoes all facing northward. Although there was no perceptible breeze it was thought that the attitude of the mosquitoes was in response to a current of air and subsequent observations confirmed this supposition. It was but seldom that one of the mosquitoes alighted on the corn, and as in the cloud first observed, all appeared to be males. A round of the field showed that each corn-stook had its swarm of mosquitoes, and furthermore, single stalks that remained standing had small swarms dancing over them — sometimes of only six or eight individuals — and the bushes and small trees on the edge of the field had their swarms. In every case the mosquitoes faced northward and the swarm kept on the south side of the object of attraction. Always the mosquitoes gathered over some prominent object such as a tree or a projecting branch, a bush, a corn-stook or a person. In this last case the swarm would move with the person and the only way to get rid of it was by passing under some taller object where the swarm would then remain.

On the following evening at five o'clock the field was again visited. Upon approaching the region of the creek swarms of mosquitoes were noted over every tall object — at the tops of telephone-poles, orchard-trees and shrubbery. On a very tall elm, standing alone in a pasture, a swarm was dancing before a projecting branch

In the corn-field the swarms were found, as on the evening before, over every prominent object and as the writer entered the field a swarm immediately began to form over his head. This time, however, the position of the swarms in relation to the objects was the opposite of the evening before — the mosquitoes were now all facing southward and they kept on the north side of the objects. The trees on the south side of the field, some of them 25 or 30 feet high, had immense clouds on their north sides. As on the evening before, there was no perceptible breeze but the drift of smoke showed that there was a current of air from the south. Station was taken near the row of trees bordering the field and some swarms dancing before projecting limbs kept under observation. Repeatedly females were seen to issue from the foliage, dash into the swarm, and emerge united with a male. When in copula the male and female face in opposite directions, their bodies in a horizontal plane; the female dragging the male after her.* The pair (or rather the female) would fly upward for a while and then slowly drift towards the ground. Once a pair in copula was seen to issue from one swarm and plunge into another swarm close by. The pair made great haste to extricate itself while the swarm was immediately thrown into frantic excitement and the mosquitoes danced up and down at a furious pace for some time, until at last the ordinary measure of speed was regained. With the growing darkness the excitement in the swarms increased and the movements became more rapid. Few successful unions now took place. Females entering the swarm would be pounced upon by two or three males, and together, tumbling over each other, they would fall to the ground and there separate. Towards the last no more females appeared and with the increasing darkness the swarms rapidly diminished, the males flying off into the air.

At five o'clock on the following evening the swarms were found as before, dancing over every object projecting above the general level. Single mosquitoes were seen flying rapidly and straight. These looked larger than the dancing males and when captured proved to be females. The air was again very still with a current from the south and, as before, the dancing males faced towards it and kept on the opposite side of the objects. The west side of the field was bounded by tall trees and high up on these, at least fifty feet from the ground, before projecting branches, clouds of mosquitoes could be distinguished while lower down on these trees there were none. Station was taken at a corn-stook to determine how long the dance would continue. As the darkness grew the numbers began to diminish, and at 5.50, when the darkness

*Goeldi (*Os mosquitos no Pará*, 1905, p. 74, pl. I, fig. 3a) describes and figures the copulation of *Stegomyia calopus*. In that species the male clings to the under side of the female.

was almost complete, the last male flew away. The departing males flew upward and none of them alighted on the stook.

On the fourth evening the field was visited nearly an hour earlier than before. The sun was still shining and there were no mosquitoes present. Later, when the sun had disappeared behind the trees, the swarms were again present just as on the previous evenings. On this evening, however, there was quite a breeze blowing and the mosquitoes could not maintain their position over the projecting objects and swarmed altogether on the leeward side of them. Otherwise their behavior was much the same, only that the freshening wind occasionally threw the swarms into confusion and greater activity. Rain and cold weather followed the next day and put an end to further observations and presumably to the swarming.

There are many records of swarms of Culicidae and related forms, although in many cases there is no exact indication of the identity of the insects in question. I am convinced that all such records, in so far as they refer to swarms of the nature described above, apply to *Nemocera* and probably in every case either to Culicidae or Chironomidae. I believe that these swarms of dancing males, congregated for sexual intercourse, are peculiar to the *Nemocera*. Many of the records from untrained observers, called forth by the appearance of these Diptera in extraordinary numbers, though incomplete, are nevertheless of interest. In nearly all of them the fact that the swarming leads to sexual union has been entirely overlooked.

Moufet, in 1634, already speaks of these swarms and notes how they gather at the gables of houses and over the heads of people passing over bridges. It should be noted that in his chapter "De Culicidum" the Culicidae and Chironomidae are not distinguished, as indeed has been the case with many a writer since.

The oldest record of the copulation of *Culex* appears to be that of the Spaniard Diego Reviglias, communicated to the Leopold-Carolinian Academy in a letter dated 4 March, 1728, but not published until 1737. Reviglias observed under the microscope, and described at considerable length, the sexual union and the copulatory apparatus of the mosquito. He treats his discovery as a very important one, which indeed it was in those days of lingering belief in spontaneous generation. However he does not mention swarming and there is reason to believe that he had before him a species which does not swarm — a matter which I shall take up again farther on. Later the French commander Godeheu de Riville also claimed as the first his observation of the copulation of mosquitoes, made on board his ship. The account is quite detailed and it is evident that in this case likewise copulation took place without swarming. I shall treat of this article more at length in another place.

Perhaps the earliest definite record of mosquitoes swarming is that by Swinton,

published in 1798. Swinton describes some swarms which he, together with a friend, witnessed on August 20, 1766, in a garden at Oxford. The account has been drawn upon by later writers but I quote it here as it brings out very clearly the habit of congregating over prominent objects. There can be little doubt that the swarms in question were Culices as Swinton especially remarks upon the great annoyance caused that season by the bites of the unusually abundant "gnats." He relates that "about half an hour before sunset, such an immense number of gnats filled the atmosphere in which we breathe, as I had never seen before. We both of us also then observed six columns, formed intirely of these insects, ascending from the tops of six boughs of an apple-tree, * * * to the height of at least fifty or sixty feet. Two of these columns seemed perfectly erect and perpendicular, three of them oblique, and one approached somewhat towards a pyramidal form." He further relates that other swarms were seen in the vicinity on the same evening. In conclusion he states: "I have been informed by the Reverend Dr. Wyndham, Warden of Wadham College in this University, that, about thirty years ago, many columns of gnats were perceived to rise from the top of the steeple of the cathedral church at Salisbury, by a considerable number of people. He likewise declared, that these columns were seen both by himself and the Reverend Dr. John Clarke, then Dean of Salisbury; that, at a small distance, they resembled smoke; and that this at first occasioned a sort of alarm, many believing that the church was on fire."

There are a number of accounts of such swarms about church steeples causing alarm of fire. We have them from Germar (1813), Boll, Kirby and Spence, and Hagen. Boll records three such swarms. One of them on the steeple of the Nicolai church in Hamburg took place on a June evening at nine oclock. The discovery of the true nature of the apparent smoke, after the fire-department had been called to the spot, caused great merriment in the crowd of spectators. In 1807, when the St. Mary's church in Neubrandenburg served as a powder magazine, the sudden news that the steeple was on fire caused many of the inhabitants to flee precipitately from the city. As the column of smoke about the steeple did not increase, some courageous men finally ventured onto the tower and discovered that the source of alarm was an immense swarm of gnats. Another swarm was observed about the cross of this same church-steeple, at a height of 300 feet, on the afternoon of August 20, 1859. Hagen relates that dense swarms of gnats about the church-steeple at Fischhausen caused an alarm of fire which has earned for the inhabitants the nickname of "Mückenpeitscher." Koch has reported a swarm from the wings of a windmill, at a height of perhaps a hundred feet from the ground, curled by the breeze and resembling smoke.

Haliday states that *Culex detritus** occurs at Holywood, County Down, "in multitudes, during the day among hedges on the seacoast, in the evening in columns about the tops of trees, appearing like smoke at the distance of a furlong." Weyenbergh records two swarms of *Culex pipiens* from the vicinity of Haarlem, observed in 1857, dancing in perpendicular columns.

Mott gives an interesting account of an unusual gathering of gnats observed by him in 1879. As the article is not generally accessible and describes well the phenomenon, I quote it nearly in full. "On the evening of September 1st, between six and seven, after a fine, sunny day, the sky being clear, and the full moon just rising as the sun went down there was a grand festival among the gnats. Above the tops of the trees and hedge-rows in the low meadows north of Leicester these little Diptera were out in immense numbers. * * They assembled in groups of various shapes, sometimes a vertical column from 6 ft. to 20 ft. high, and 1 ft. to 3 ft. diameter, rose from a tree top like a pillar of smoke. Sometimes a sheet 4 ft. or 5 ft. high and 10 ft. long hung above the hedgerow, but seemed never more than a foot or so in thickness. The following evening, at the same hour, the sky being more clouded, a few gnats only were to be seen; but on the evening of the 6th, with the sky again cloudy, there was a still more remarkable display of gnat life. The little creatures were out again in millions, but this time the vertical column formation was adopted by nearly the whole of them. These columns rose from the hedges on either side of the road, and were visible for half a mile a-head at irregular distances, averaging, perhaps, 21 ft. or 15 ft. They formed an avenue of such a singular and unusual appearance that everyone who passed along the road paused at intervals to watch and wonder at them. This piece of road is about half a mile long, on the top of an embankment which carries it over the low meadows and the river. At the farther end there are a number of trees, and from the top of nearly every tree three or four of the strange, smoke-like columns could be seen standing up in the air, always straight but not always vertical, some of them being inclined at small angles. * * * On watching one of the columns closely, it was apparent that all the gnats had their heads one way, facing the breeze, which, however, was a very light one. It was a calm evening; what air-current there was came from the south-east. It seemed to be sufficient occasionally to press back the column a few inches from its normal position, and whenever this happened the whole body of gnats jerked themselves forward again with one perfectly synchronous impulse."

A picturesque account of a remarkable swarming of Culices, at Lewisham Road

* Haliday's *Culex detritus* greatly resembles the common *Culex pipiens* and most probably the observation should be credited to the latter species.

near London, is given by Douglas. During ten days he observed "the air thick with millions of them, at times charging in close column up the road, like a squadron of cavalry, at other times engaged in dancing up and down, after the manner of their race." These swarms were in evidence only during the hour before dark and it appears were over or near the road, within reach of the riding whips and sticks of the "*profanum vulgus*." Near by "are several tall trees, and round the top of the highest one only, at the same hour of the evening that the periodical saltatory performances are going on in the road, enormous swarms of gnats congregate. At first they appear as a small black cloud curling about the ends of the branches, and soon, when the air is calm, rising in a close column, like smoke from a chimney, for a distance of some 20 or 30 feet, the bulk gradually becoming more grey and attenuated until lost to sight in the upward progress. When a breeze is moving, the insects, always preserving close order, are blown out laterally, and after skirmishing with the wind return to their cover among the top leaves of the tree." This last remark may be an assumption and at such distance from the ground could hardly have been based upon actual observation. Douglas suspects that the species in the tree was "not the same as that of the acrobats of the road," and with right; unfortunately neither form was definitely identified. It further appears from the remarks of Douglas that these swarms are an annual occurrence, only that the number of individuals varies greatly from year to year.

In all the foregoing notes the writers failed to notice the true function of these gatherings of *Nemocera*. However it had not escaped that keen observer Gilbert White. He was evidently uncertain of the identity of the insects concerned, for in his posthumously published notes he calls them "*empedes* or *tipulae*." Speaking of their swarms at evening he says: "At this juncture they sport and copulate; as it grows more dark they retire. All day they hide in the hedges. As they rise in a cloud they appear like smoke." No further mention of copulation in connection with swarming appears until Taschenberg's popular account of *Culex pipiens*, published in 1882. He notes their habit of gathering at the gables of houses and other prominences and describes how the females fly to the swarm of males to effect copulation. In the notes on the swarming of Chironomidae which follow, Taschenberg describes the formation over trees and in tall columns, and we are left to infer that the *Culex* swarms do not assume the columnar form — at least not in the same degree.

Theobald's brief, disjointed notes on the pairing and swarming of mosquitoes would hardly convey the correct impression to the lay mind. He corroborates Taschenberg's statement that in *Culex pipiens* the females fly to the males to copulate but he failed to note that the males congregate about prominent objects. The brief

remarks on the swarming of *Culex cantans*, observed twice by Theobald in the fens, shows a distinct mode of swarming in this species. These swarms, composed of both sexes, formed dense clouds which quite darkened the air. "These insect-clouds were constantly moving up and down about ten to twelve feet above the ground. At times the noise they produced could be heard a quarter of a mile off, then it would suddenly cease for some time and commence again." It is to be supposed that Mr. Theobald is not to be taken literally when he says the insect clouds were constantly moving up and down but that the motion applies to the individuals in the swarms, as in the foregoing observations.

Radl has written two most interesting and suggestive papers on the light-reactions of Arthropods and a great part of his discussion is based on the behavior of swarming insects, particularly of Culicids and Chironomids. It would lead too far to enter into a discussion of these papers, but the fact is brought out that these insects orient themselves towards some definite object which is differentiated from its surroundings either by greater prominence or a difference in color. He not only cites instances of orientation towards trees, bushes, sign-posts, or even heads of grass, but others where the swarms hovered over paths through fields, or spots of different color but not elevated above the surroundings. The swarms over spots on the ground in all probability belong to different species from those attracted to prominent objects. Radl confesses that he made no attempt at close determination of the insects under observation and it is evident that he had no conception of the number of forms of similar but distinct habits that he might have before him. In consequence his statements are far too general and much that might have been used for or against his contention has escaped him.

Little as we yet know of the subject, it will be well to state right here that, even within the Culicidae, there is not only a marked diversity in the mode of swarming of different species, but that there are many forms which do not swarm at all. In the case of the almost exclusively house-inhabiting *Stegomyia calopus*, as Goeldi has shown, there are no such swarms as in *Culex* proper. The males congregate in little groups of 15 or 20, hovering over the corner of a cabinet or other prominent object, and pounce upon the females that come within range. I can add that copulation frequently takes place when there is no evidence of even such weak swarms. It should be noted that in *Stegomyia* copulation takes place during the brightest part of the day. On the other hand I have upon two occasions observed small swarms of *Stegomyia* (presumably males) hovering over the heads of persons, in both cases shortly before sunset. Once this occurred upon the hotel-veranda at Cordoba, Mexico, and again in the street at Acapulco, over the heads of passers and keeping along with them. In this case the meaning of the swarms would be hard to interpret.

Upon a recent trip to the west coast Dr. H. G. Dyar found a pair of *Culiseta consobrinus* in copula, resting on the under side of a board. This observation shows a wide departure from the short copulatory act of *Culex* and *Stegomyia*.

The crab-hole inhabiting *Deinocerites cancer* swarms during the short twilight period just outside the crab-holes and copulation takes place then.

Goeldi has given a vivid account of the swarming of the common house-mosquito of Pará which he designates as *Culex fatigans*. Swarming takes place indoors when it is nearly or quite dark and there are separate swarms of males and of females. Such peculiar mating-habits surely indicate a distinct species. In the case of our *Culex pipiens* the males are never found in houses — unless, indeed, they happen to come from larvae developed indoors.

Mr. E. A. Schwarz has kindly placed at my disposal his observations made on a species of *Culex*, probably the *Culex cubensis* of Bigot, at Cayamas in Cuba. The swarming occurred in the house, always on the side away from the sun, and when it was almost fully dark. The mosquitoes could only be seen against the sky, when between the observer and the open doors and windows and close observation was impossible under the circumstances. However, the swarms in this case were made up of both sexes and copulation freely took place. A capture of 60 specimens from such a swarm contains 44 males and 16 females.

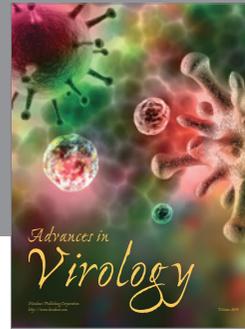
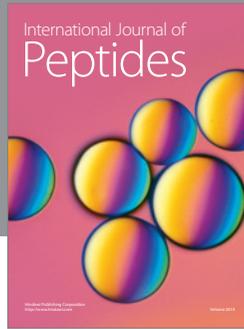
In conclusion the curious reaction of a mosquito swarm to sound, related to Osten Sacken by a Cuban naturalist, seems worthy of notice. While a swarm of mosquitoes was hovering over the head of the observer a band was playing at a distance. Whenever the note A was struck the mosquitoes were all precipitated downward, striking against the face of the observer. A similar and quite independent observation is recorded by Howard.

The bringing together of these notes shows how very meagre our knowledge of this interesting subject is and it is to be hoped that it will stimulate others to further observations. No claim of completeness is made for the following bibliography. The works not seen by the writer are indicated with an *.

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