

3. Abdomen with segments dark at base, pale across tip; mesonotum with large pale spot in middle, propodeum with large pale spot each side; hind femora dark above.  
*brasiliensis* Banks
3. First and second abdominal segments not plainly banded; mesonotum with two pale lines, united behind; propodeum with an interrupted dark line each side; hind femora not dark above.  
*argentinica* Banks

The type of the genus *A. bequaerti* Banks is the only female known and its male is unknown.

#### LITERATURE REFERENCE

BANKS, N. 1946. Bull. Mus. Comp. Zool. 96, No. 4, pp. 464, 499-503.

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## The Occurrence of Mass Flight Movements in *Hexagenia Occulta* (Ephemeroptera)

By HERMAN G. COOKE, Department of Biology, Hampton  
Institute, Hampton, Virginia

For more than ten years, the writer has been deeply interested in the behavior pattern manifested in the order of mayflies. During this time several flight movements have been observed and the period of their greatest emergence recorded. In a previous investigation<sup>1</sup> a detailed description was presented on the mating flights of *Stenonema vicarium*, with particular reference to the life history of the nymph. In a later study,<sup>2</sup> involving the habits of *Isonychia christina*, it was revealed that a similar tendency toward shyness displayed in the performance of the adults found noteworthy expression in the behavior of the nymphs. Comments were also made with regards to the lofty height to which they frequently ascended which made observation possible only with the greatest degree of difficulty.

<sup>1</sup>COOKE, HERMAN G. 1940. Observation on the mating flight of mayflies, *Stenonema vicarium*. Ent. News 51: 12.

<sup>2</sup>COOKE, HERMAN G. 1942. Mating flights of *Isonychia* mayflies (Ephemeroptera). Ent. News 53: 249.

In a more recent study,<sup>3</sup> involving the influence of weather conditions on the activities of *Hexagenia atrocaudata*, it was found that low temperature served as a limiting factor in both the flight movements of the adults and the emergence of the nymphs. As a result of these findings a desire to seek a further understanding of the behavior of the species and of the underlying phylogenetic relationships prompted the presentation of this paper.

#### METHODS

The methods used in the study were somewhat similar to those employed in the investigation of members of the other genera, the chief difference being occasioned by the environmental habits of the nymph. The most distinguishing characteristics of the immature stage of the genus *Hexagenia* is its tendency to lead an independent aquatic life, confined to a sand or mud-bottom burrow. Species adjusted to situations of this nature afford great difficulty in collecting and can be encountered only by means of dredging. In some locations the method is often time consuming and has other definite limitations.

Subimagos were occasionally seen emerging directly from the surface of the water without ascending on to rocks, stones or debris along the edge, to shed their nymphal skins. Unfortunately for the writer, the sequence of events took place so rapidly that he was unable to gain a sound judgement of the manner by which the transformation was accomplished. Tien-suu,<sup>4</sup> in his description of *Polymitarcys ladogensis*, a closely related European species of the family Ephemeridae, reported a similar incident of emergence.

Bottles of water collected from the Susquehanna River, which harbored the nymphs of *H. occulta*, gave a hydrogen-ion concentration of 7.7, apparently a most favorable medium for the

<sup>3</sup> COOKE, HERMAN G. 1947. Swarm behavior of *Hexagenia atrocaudata* in relation to temperature and relative humidity (Ephemeroptera). Ent. News 58: 221.

<sup>4</sup> TIENSUU, L. 1935. On the Ephemeroptera-fauna of Laatokan Karjala (Karelia Ladogensis). Suomen Hyoteistieteellinen Aikakauskirja 1: 3.

growth and development of the species. The greatest collections of adults were made at twilight. During this time the swarm of insects were so thickly suspended in the air that one could gather a mass of living creatures from three to five centimeters deep in the bottom of a net with a single stroke.

#### OBSERVATION OF FLIGHT MOVEMENTS

On August 28, 1947, at 6:00 P.M., with a temperature of 81° F., three *Hexagenia occulta* males were seen patrolling over the northern bank of the Susquehanna River, about a mile above the Conowingo Dam, near Conowingo, Maryland. At sundown, countless numbers of this species suddenly appeared springing with increasing fury from the shrubbery overhanging the bank of the river. The average height to which they ascended during swarming ranged from five to twenty feet above the ground. One of the most striking features in the performance observed was in the manner by which operations were conducted. Each male maintained its position, flying almost in a single spot, except when attracted by an approaching insect foreign to its group, or a member of the opposite sex. An imaginary zone circumscribed the outer borders of the huge company. Beyond this limit ardent males were seen eagerly returning to resume their places in the midst of the swarm. As the performance reached its peak, the boundaries disappeared and general flight activity became dispersed over the entire area. Both the vertical zigzag-like movements and the deep rhythmic undulations which were so highly characteristic of the behavior of *H. atrocaudata* were absent or inconspicuous in these maneuvers.

Numerous couples of these insects were observed in copulation, and, in some instances, collections were made before they could separate. At times, individuals were seen uniting in a vertical plane. Perhaps this position was due either to a hasty procedure on the part of the male in clutching, or an attempt by the female to elude her attacker.

During the greater part of the day thousands of specimens found shelter by clinging firmly to the under-surface of the leaves of bushes along the shore. They sat closely, side by side,

with their heads directed inward and at right angles to the central axis of the leaf. When disturbed, they immediately took to the air. Some made feeble attempts to mate with any member whom they could reach, while others struck nervously about in a state of disorder and confusion. The incident lasted for about one minute, after which the insects resettled in their former positions on the leaves.

Although weather conditions were recorded at a most favorable level for the last two weeks of August 1948, flight movements were greatly reduced in comparison with those stated for the same period during the previous year. Lyman<sup>5</sup> referred to such variations as cyclic trends in the population of *Hexagenia*. The writer has also reported similar fluctuations for alternating years in this genus.

The following table gives favorable temperature, wind velocity and general weather conditions<sup>6</sup> for certain days during one week when observations were made:

Date	Temperature (Fahrenheit)	Wind Velocity m.p.h.	Weather	Activity
August 26	90°	5.7	Clear	Slight
August 27	88°	4.5	Clear	No Activity
August 28	87°	4.8	Clear	No Activity
August 29	84°	7.0	Clear	Slight

On August 29, 1949 at sundown, with a temperature of 78° F., heavy flight movements again appeared in the same area. In addition to the densely suspended adults, waves of clumsy flying subimagos, mixed among the group, circled briefly above and around the observer before settling upon him in great numbers, and in their escape many of them left their subimaginal skins firmly adhering to his clothes. Heaps of carcasses strewn over the shrubs and rocks served as a reminder of the specimens which had emerged and perished during the current season.

<sup>5</sup> Lyman, Earl F. 1944. Emergence, swarming and mating in *Hexagenia*. Ent. News 55: 207.

<sup>6</sup> Records of temperature, wind velocities and other weather conditions were obtained through the courtesy of the U.S. Weather Bureau at Philadelphia, Pa. All readings are given for 7:30 P.M., Eastern Standard Time.

Attention is called to the fact that during the last week of August and the first week of September 1950, only a few scattered remnants of companies of mayflies were encountered. However, range of temperature and weather conditions recorded was at a most favorable level. For instance, during the week of August stated above the temperature mounted to an all-time high of 96° F., with an average of 85° for the next seven consecutive days. As a comparison, during the same week of the two previous alternating years, flight movements reached a period of their greatest abundance.

#### DISCUSSION

Several incidents of striking interest have been cited to the writer by eye-witnesses with regard to mass flight movement of these insects serving as a hazard to travelers and workers operating in the above area. An article released in an edition of the *Baltimore Sun* newspaper<sup>7</sup> lends added significance to the study. It revealed that on August 26, 1947, at 7:15 P.M., a mass flight of mayflies appeared swarming over the Pennsylvania Railroad along the banks of the Susquehanna River so densely suspended that they resembled a mid-winter snow drift. The report further stated that the fragile creatures hurled their tiny bodies upon the trolley power line (over the track) in such countless numbers that they formed a complete insulation around it. Because of this sudden blockage of the current, an electric train en route through the area was stalled for several hours.

As a compensation for the tendency toward shyness exhibited by *Isonychia* while in flight, *Hexagenia* demonstrated a more highly tolerant disposition toward its environment. Berner,<sup>8</sup> in his recent study of mayflies, remarked; "I have not observed the mating flights of *Isonychia*. As far as I have been able to ascertain there are only a few scattered notes describing

<sup>7</sup> August 27 edition of the *Baltimore Sun*. This news report was confirmed by the Bureau of Information of the Pennsylvania Railroad in Baltimore, Md.

<sup>8</sup> BERNER, L. 1950. *The Mayflies of Florida*, Vol. IV, No. 4.

the mating of some of the species of this genus." According to the experience of the writer, in his study of *Isonychia*, it is reasonable to believe that the paucity of observations recorded on actual mating among different species of this genus is due either to the lofty height to which they frequently ascend, or to their keen sense of detecting disturbances in the surrounding environment. In some instances it appears to be a combination of both factors.

In a former paper involving major families of the order of mayflies, Spieth<sup>9</sup> made a comparative study pointing out the phylogenetic relationship among the different genera of each group. On the one hand, he used the mouthparts and gills of nymphs, while on the other, he employed the wing venation and genitalia of adults. The results in both cases were found to be consistent. The degree of resemblance recorded between the species of *Hexagenia* and those of *Polymitarcus* indicates that they were derived from related stock. By the same token, I should like to call attention to the similarity in the method of emergence between members of these two genera, as described in an earlier paragraph of this paper.

Finally, in addition to the phylogenetic data mentioned, mating flights reveal a technique, which is not only unique for the particular genus, but also, as far as I have been able to observe, species specific for the individuals by which the movements are being performed.

The writer wishes to express his gratitude to Dr. N. Runner of the University of Pennsylvania for contributing an analysis of the river water.

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<sup>9</sup> SPIETH, H. 1933. The Phylogeny of Some Mayfly Genera. Jour. New York Ent. Soc., Vol. XLI, September.