NOTES ON PUERTO RICAN BLACK FLIES

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Up to the present, three species of the dipterous family Simuliidae have been reported from Puerto Rico, namely: *Simulium minusculum* LUTZ, *S. haematopotum* MALLOCH, and *S. quadrivittatum* LOEW. The first of these species has hitherto been reported only from Brazil and Costa Rica; the second, from Mexico, Guatemala, and Cuba; the third, known previously from Cuba, may be an exclusively Antillean form.* Owing to the painful attacks of adults of the last named species, the writer became interested in working out its life history with the ultimate end of control in mind. Such notes as lead to these objectives are here presented, although lack of time prevented complete attainment of the end in view.

The following account represents the more pertinent of a series of observations noted during the period from the middle of March to the middle of May, 1932. Trips were made to, and material collected at, Lares, San Sebastián, Las Marías, and Barranquitas, all inland and elevated localities. Most of the field work was attempted in a small stream at Guaynabo, near San Juan, where only *S. quadrivittatum* was found. With this species the major part of the study deals.

OBSERVATIONS ON ADULTS

Sufficient data have not been amassed in order to decide whether simuliids in Puerto Rico tend to be prevalent at certain seasons. In the Guaynabo district adults have been reported to cause annoyance during the months of January, February and March. Their presence, however, has been noted during the two succeeding months as well. In the Lares region they are supposed to cause more annoyance during the winter months.

* Dr. Alfonso Dampf, chief entomologist of the Mexican Entomological Service in a recent personal communication, states that *S. quadrivittatum* also occurs in Mexico and Panama.

The flies bite through the daylight hours, but more noticeably in the afternoon. High humidity seems to offer conditions favorable for their activities since they are frequently encountered in abundance after rains. Along stream courses flies bite intermittently even during heavy rains. On such occasions they alight only on surfaces not exposed to the direct impact of the drops. There is a belief among the country people of some parts of the island that "majes", or black flies, are killed by the sun. However, the sharp contrast of atmospheric conditions that occurred during an afternoon late in March serves as an excellent illustration of their indifference to atmospheric changes. The sun was strong, there was no breeze, and the flies bit viciously. At four o'clock the sun disappeared under a heavy bank of "thunderheads", and a strong breeze arose; but biting in no wise decreased.

The stream near which most of the observations were made has its source in the south, runs in a northerly direction, and then turns east. The prevailing south-east winds tend to carry the black flies from the last named part of the stream to the insane asylum, which is about a kilometer and a half away. The wind is then deflected south down a shallow valley, and carries the flies before it along a north to south portion of the brook until a barrier formed by a bridge and bamboo trees is reached. It is reasonable to assume that the bamboos act as a barrier, because on windy days few flies are found along the brook though they are present in abundance in the shelter of the trees. From the bamboos they work up the low hills on either side of the brook using cane, low brush, and banana trees as a windbreak. This possibly explains why the female *S. quadrivittatum* is often found on elevations some hundreds of yards distant from any stream.

Flies were repeatedly encountered in small swarms not higher than a foot or six inches above the ground. They appeared to be males, because they made no attempt to bite on the ankles; yet, when the bare hand was exposed to that area, two or three flies would always follow the movement of the hand to the head, biting the hand when cessation of motion would allow them to. One fly even followed to the top of a fifteen foot water tower and engorged. When we squatted at the water's edge, and rose slowly, our move-

ments were followed by the flies as far as ten meters parallel to the brook, and not more than five meters at right angles to it.

Adult females of *S. quadrivittatum* occasionally enter houses. Darkening the rooms causes them to depart within a short time.

S. quadrivittatum is very quick. Before the hand can brush it away, one may land and insert its stylets and leave a puncture from which the irritation often persists for at least two days.

The flies show no preference for wet, or dry, or sunny, or shaded portions of the skin when attempting to bite. After puncturing the skin the female is usually reluctant to leave until engorgement has taken place. One individual blown at from a point four inches away, though compelled to pivot almost 180 degrees, remained until feeding had been completed.

On two occasions, the arm on which females were biting was immersed in water. It was interesting to note that contrary to Blacklock's observations on *S. damnosum* in Africa, which record the continued biting of the insects when submerged, our flies immediately crawled to the surface along the hairs of the arm. One was partially engorged; the other had just begun to feed. Females caught in test tubes while engorging died within a short time, apparently having exhausted themselves in frantic efforts to escape.

Bred females were given opportunity to feed. Where specimens of each sex were together in the same tube, the male almost invariably disturbed the female when the latter seemed on the point of inserting her proboscis. When isolated, the females evinced no interest in biting, even though given ample chance to do so.

Only one female was induced to bite under laboratory conditions. In this instance a male and a female had emerged about twelve hours before opportunity to feed was offered. The latter engorged completely. On the following day she twice refused to feed. Both died about forty-eight hours later. Both came in contact with each other before the blood meal, but not after, though whether copulation actually took place could not be ascertained. This, coupled with the fact that virgin females took no interest in blood-sucking

activities, suggests the possibility that copulation might have occurred before the female ingested blood.

The act of feeding requires three to five minutes. Two distinct sensations are felt by the person bitten; the first shortly after the fly alights, the other, near the end of engorgement; some people notice the last only. These sensations are best described, not as a painful, but rather as a pronounced itching. If the fly is permitted to engorge and depart unmolested, less swelling (if any), and less irritation result, than if it be disturbed. A bite, in most cases, after satisfied engorgement, appears as a pinprick. In other instances the swelling, from a sixteenth to an eighth of an inch in height and covering an area from one half to a square inch, persists for at least twenty-four hours, and sometimes as long as three days. It is not uncommon for the scab to remain for a week. A small quantity of blood usually exudes from the wound immediately after the bite. Individuals differ greatly as to susceptibility; natives, for instance, suffer little irritation and no swelling.

The writer has frequently observed ninety-two head of cattle that graze near the brook at Guaynabo and during various field trips cows and oxen were examined, but at none of the localities visited were blackflies observed upon them. Dr. Hoffman has seen an unidentified blackfly in the ears and on the ventral surface of a horse, half way up el Yunque, a mountain some 3,500 feet high. At 6.30 p. m., June 2nd., the writer collected twenty-six females of *S. quadrivittatum* engorging on the belly of his horse. The horse was led through a small patch of half-grown sugar-cane, eighty meters in length. Most of the flies remained nearby flying in small circles close to the belly. When the horse was led twice the distance over open ground, the flies disappeared.

OBSERVATIONS ON LARVAE

Heavy rains had three effects on larvae: first, they tended to transplant them further down stream; second, many larvae were crushed by shifting stones if the stream happened to be of the mountain type; third, flooded streams washed larvae high up along the banks, leaving them to perish.

Usually larvae have been found to establish themselves on plants. In the lowlands they prefer sugar-cane débris,

and such plants as are represented by the genera *Comelina* and *Paspalum*. In one stream at Barranquitas numerous larvae were found adhering to rocks and stones.

On several occasions when mayfly nymphs have been placed in containers with *Simulium*, it has been noticed that the *Simulium* lash round excitedly. The lashing is caused by the larvae binding the nymph with fine threads. At first the mayfly struggles and succeeds in breaking these threads, but soon it is exhausted and is then completely enveloped and secured. Twelve hours later the specimens are found dead already subject to decomposition. *Simulium* hold no interest in their victim once it is overwhelmed.

A dragonfly nymph from the same environment as that of the black-fly larvae was placed in a vial containing eleven *Simulium* larvae. Within thirty seconds the dragonfly had consumed four of them. Here again the remaining larvae attempted to duplicate the procedure so fatal to the mayfly nymphs, but the dragonfly was too strong, and never allowed more than two legs to be confined at the same time. Twenty-four hours later the nymph was still alive, having eaten two more larvae; the rest were dead.

When combating alien aquatic organisms, *Simulium* larvae work in an unorganized manner, some attaching themselves to the body and weaving aimlessly, while others on the surface of the vial deposit a glutinous substance to which they anchor their threads in the attempt to bind their victim to the glass.

SPEED OF CURRENT

Current rates were measured to determine the speed most favorable to larval propagation and to determine the extreme speeds in which larvae had established themselves. The method employed was not unlike the system used by Yi Fang Wu in Michigan. After a careful study of current rates in the stream at Guaynabo, the following formula was worked out and checked: $V = 0.023 \times \sqrt{2gh}$. V = velocity, in terms of kilometers per hour; g = gravity, 980 centimeters per second; and h = height of water column in the upright arm of the tube in centimeters when the other arm is set in water against the current at six-tenths the depth of the stream. Readings for h were taken from a calibrated

glass tube of 1.27 centimeters diameter bent at right angles. The following results were obtained:

The minimum rate below which no larvae were found, was 1.1 + 1 kilometers per hour. In the sluice of a small dam, the maximum measurable rate where larvae were established was estimated at 30.0 + 1 kilometers per hour. The speed of flow most suitable to larval propagation, if abundance may be used as an indication of favorable conditions, was 4.5 + 1 kilometers per hour.

The data mentioned above were obtained toward the end of this study. Possibly different values would have resulted if current determinations had been made at various intervals.

CULTIVATION OF LARVAE

Experiments in keeping larvae alive in the laboratory were in the main unsuccessful. An aeration system was devised whereby a partial vacuum caused air to be exhausted from a tightly stoppered vial by means of an aspirator. Air was admitted through an intake tube, the opening of which larvae enjoyed a steady stream of air bubbles, they nevertheless were subject to a slight negative difference in atmospheric pressure. These vials or containers in which the larvae were placed had a 500 cc. capacity and were usually kept two thirds full; the water averaged 28.2°C, or 1.4° C warmer than the water in the stream from which the larvae were taken. Various types of food were tried, including green Algae, Klim, powdered yeast and Vegex—a concentrated yeast product. In these experiments over four hundred larvae were used, of which 15 per cent pupated, the remaining majority dying within a few days after being introduced into the containers. The following observations were made over a period of nine weeks:

1. One larva lived ninety hours without food in aerated distilled water.
2. Two larvae remained alive twelve days in two changes of aerated brook water taken from the stream at Guaynabo.
3. One larva fed a few grains of Klim and powdered yeast once a day was kept alive two weeks in aerated distilled water.

4. In the aeration jars larvae invariably affixed themselves to the intake tube on that side which was in the direct patch of rising air bubbles, but the system used proved unsuitable, because it owed its efficiency directly to the pressure of the tap water, which fluctuated considerably.
5. Larvae disintegrated within three hours after death.
6. Chlorinated city water had no noticeable effect on larvae.
7. At an average temperature of 28.8°C. the periods between moults lasted approximately three and a half days. The writer was never able to observe the duration of the entire larval period, but it was estimated from a large number of specimens of various sizes observed to moult, that the time between egg and pupa was from seventeen to twenty-one days.
8. The pupal stage at 30°C. on damp gauze was from eighty-four to one hundred and twenty-one hours. In rearing pupae the best results were obtained when they were placed on gauze in small vials with just enough moisture to keep the cocoons damp.

Martini's method of clearing culicid larvae and pupae was found most satisfactory for mounting immature stages. The specimens to be cleared are taken from water or alcohol, placed in a watch glass and covered with 5 cc. of a mixture of one part unthickened cedar oil and nine parts absolute alcohol heated to 70°C. (158°F.) After cooling, the watch glass is placed with a receptacle containing H_2SO_4 in a closed container. After twenty-four hours the mixture is replaced by pure cedar oil, and the H_2SO_4 removed. A few hours later the larvae can be mounted in balsam. Even larvae kept in alcohol a long time can, in most cases, be satisfactorily dealt with in this manner.

The mortality of larvae kept in large numbers in small vials during transportation was high. It remained at zero during the first four hours, then rose sharply to 100 per cent at the six and a half hour mark. However, the mortality curve of larvae kept between layers of damp gauze started at six hours, rose gradually to 35 per cent at twenty-three hours, then ascended irregularly until all died after thirty-six hours.

On field trips where larvae and pupae were collected, it was found that by placing almost mature pupae in damp gauze, a high percentage of the imagos emerged therefrom.

Descriptions of the larva and pupa of *S. quadrivittatum* have not been included. It is believed, however, that illustrations of the head, antenna, labial plate, anal gills, and the pupa, will serve to identify the larval and pupal stages. Egg masses were collected on several occasions, but their failure to hatch made it impossible to link this stage with the species.

CONTROL

The species of *Simulium* encountered in Puerto Rico in their larval stage, as has been said before, prefer to attach themselves to plant matter rather than to stones. Therefore, it is suggested as a preliminary step towards control, that where the nature of the stream permits, plant matter and all other refuse should be removed. The cleaning of the stream should be followed by at least two applications of a suitable emulsified larvicide at intervals of ten days.

Various experimenters have worked on emulsions suitable for destroying black flies. In 1904 Weed found that Phinotas Oil was effective. The results of his experiments with his oil were verified by Cameron, O'Kane, and others. As Phinotas Oil was not procurable in Puerto Rico at the time, we tried other emulsions in its stead.

Among those solutions tested in the laboratory, carbon disulfide was the most satisfactory. An emulsified solution diluted to one part in three thousand caused death to larvae in a short time.

A litre of this emulsion was dumped into the brook at Guaynabo, which has an approximate capacity in the dry season of seven tenths of a cubic meter per second. Forty meters below the point of dumping a net was set up. No dead larvae were collected in the net in half an hour's time. Apparently not enough carbon disulfide had been used. Nevertheless, the next day the forty meter stretch of brook was found to be 80 per cent denuded of larval life of any description. This can possibly be explained by the fact, as observed in the laboratory, that larvae after death frequently remain attached until decomposition sets in.

The ingredients of the emulsion consisted of ten parts by volume of carbon disulfide, one part by volume of cold water soluble rosin fish-oil soap, and three parts by volume of water.

RECORDS OF *simulium* IN PUERTO RICO

The following notes concerning simuliids were compiled from Wolcott's list, and the files of the Experiment Station correspondence:

S. haematopotum Malloch.

Four specimens collected January 24th, 1912, by T. H. Jones at Río Piedras: determined by Malloch. "These flies were abundant and persistant, attacking hands, forearms, neck and face; the bite was painful and felt immediately after alighting, although only a slight swelling followed". One specimen collected June 25th, 1913, by R. T. Cotton at Río Piedras and determined by him, was caught while feeding on his arm in a room. .

S. minusculum Lutz.

Seven specimens collected May 2nd, 1922, by F. Seín at Río Piedras and determined by Aldrich. The flies seemed to be abundant only in the spring; their host was man. To quote Dr. Aldrich concerning *S. minusculum* in Puerto Rico: "Described from Brazil, not heretofore reported from North America, but we have it also in Costa Rica."

S. quadrivittatum Loew.

Nine specimens collected March 16th, 1913, by D. S. Van Dine at Río Piedras, and determined by Malloch. To quote D. S. Van Dine: "Collected in forest back of the Experiment Station land; abundant in clearing and very troublesome; bite painful and followed by swelling; irritation from bite persists for two or three days; wound indicated by a bright red spot and following subsidence of inflammation by a small area similar to a slight burn."

Specimens were also collected in a coffee grove by G. N. Wolcott and determined by Johannsen.

One specimen of *S. quadrivittatum* was identified out of eighty-nine stomachs of *Todus mexicanus* examined by Wetmore. "Though remains of *Diptera* figure as 30.88 per cent (of stomach contents) and were eaten by sixty-five birds, they were so broken and ground up that further identification

was impossible." *Todus mexicanus* is common over the entire island of Puerto Rico, with the exception of the coast which it never reaches, and of the lowlands where it is found in scanty numbers.

A few specimens of *S. quadrivittatum* collected at Utuado by C. W. Richmond are in the U. S. National Museum. They are labeled "Biting Flies." (See Malloch).

The writer worked under the direction of Dr. W. A. Hoffman of the School of Tropical Medicine, at which institution laboratory observations were carried out with material collected at Guaynabo. Dr. M. D. Leonard and Mr. Francisco Seín of the Insular Experiment Station at Río Piedras, and Dr. Cook of the School of Tropical Medicine, also gave valuable aid.

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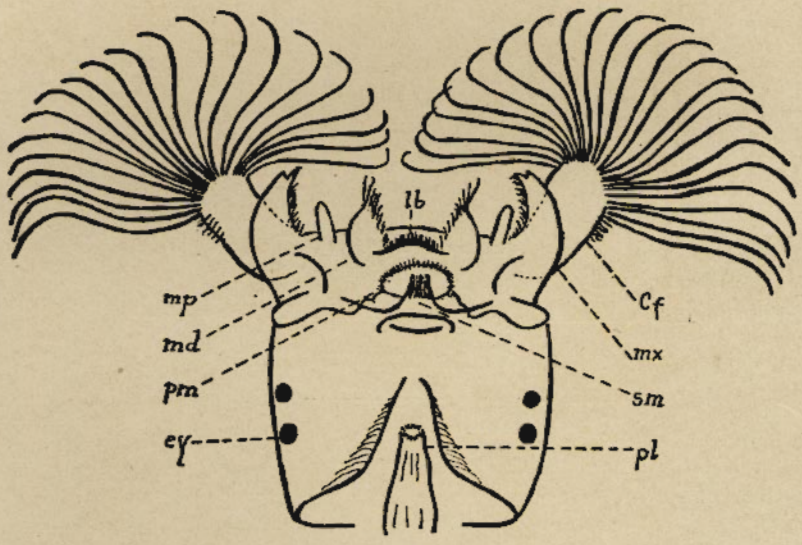
ILLUSTRATIONS (*Simulium quadrivittatum*)

1. Head of larva, ventral view.
2. Labial plate of larva.
3. Antenna of larva.
4. Anal gills of larva.
5. Pupa of male, dorsal view.

EXPLANATION OF ABBREVIATIONS

cf	Cephalic fan.
ey	Eye.
lb	Labium.
md	Mandible.
mp	Maxillary pulpus.
mx	Maxilla.
pl	Proleg.
pm	Prementum.
sm	Submentum.



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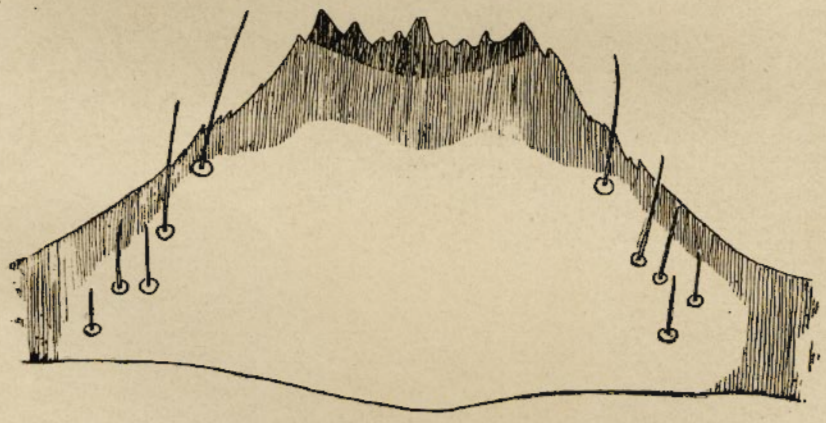

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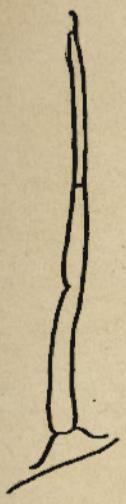

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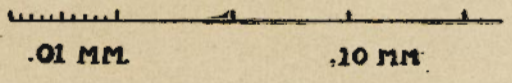

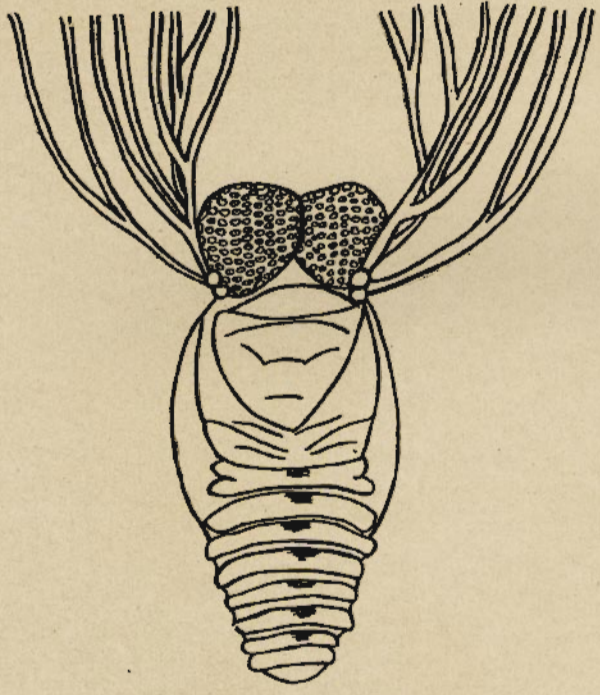

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