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H. Page Nicholson[1] and Clarence E. Mickel[2]

PART I. INTRODUCTION

THE SIMULIIDAE are known throughout the world as biting pests of man and animals and as transmitters of several disease producing agents. Important contributions to our taxonomic knowledge of the group in North America have been made by Malloch *(21)*, Dyar and Shannon *(8)*, Twinn *(39)*, Stains and Knowlton *(32)*, and Vargas, *et al. (42) (43)*. Yet the Simuliidae of Minnesota and the regions immediately adjacent to the State remained relatively unworked. It was, therefore, the purpose of this study to determine, insofar as possible, the species present in Minnesota and to obtain information concerning the distribution and relative abundance of the group as a basis for possible future biological studies or control activities. During the course of the study every effort was made to obtain supplementary data of a biological nature.

The Simuliidae have been known by various common names such as "sand flies," "turkey gnats," "buffalo gnats," and "cholera gnats," but most commonly as "black flies." Lugger *(20)* in his report of 1896 listed four species as occurring in Minnesota. Washburn *(45) (46)* reduced this number to three in 1905 through 1906. The writers in this paper record eighteen species and two subspecies of which two species and one subspecies are new to science.

Economic Importance

Although early references to the depredations of this group of insects in Minnesota are scarce, black flies must have presented a problem of considerable magnitude to the early inhabitants if one may judge from the writings of Professor Otto Lugger, the first Entomologist of the Minnesota Agricultural Experiment Station. In his report of 1896 *(20)* he

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[2] The writers wish to express their sincere appreciation to Dr. Alan Stone, Bureau of Entomology and Plant Quarantine, U. S. National Museum, Washington, D. C., for checking the identification of the writers' material, for comparing it with the types, and for his advice and comments concerning the synonymy of species; to Dr. S. W. Simmons, Chief of the Technical Development Division, Communicable Disease Center, U. S. Public Health Service, Savannah, Georgia, for use of facilities of the Division and for encouragement in the preparation of this manuscript.

wrote, "These small flies breed in rapidly flowing water, hence are very numerous in the northern part of our state where streams abound. The adult flies are well-known tormentors, and occur sometimes in such numbers as to prevent travel. Prospectors and surveyors, though usually thick-skinned by living constantly out of doors, have been repeatedly forced to leave a region thus infested. . . . Such tormentors are exceedingly annoying in the northern part of Minnesota, and especially near Lake Superior."

He quotes Louis Agassiz's "Lake Superior" (1850) as follows: "Neither the love of the picturesque, however, nor the interests of science, could tempt us into the woods, so terrible were the black flies. This pest of flies which all the way hither had confined our ramblings on shore pretty closely to the rocks and the beach, and had been growing constantly worse and worse, here reached its climax. Although detained nearly two days, yet we could only sit with folded hands, or employ ourselves in arranging specimens, and such other occupations as could be pursued in camp, and under protection of a 'smudge.' One, whom scientific ardor tempted a little way up the river in a canoe, after water plants, came back a frightful spectacle, with blood-red rings around his eyes, his face bloody and covered with punctures. The next morning his head and neck were swollen as if from an attack of erysipelas." Lugger stated that the above quotation applied as well in 1896 as at the time of Agassiz's writing.

The bite of the adult female (the male is not capable of biting) is notoriously severe, due probably to the presence of a toxic protein in the saliva. In some parts of the world losses among livestock have been heavy because of mass attacks of certain species. The vicinity of the town of Kolumbacz, Hungary, has been particularly plagued periodically for over 200 years with hundreds of head of livestock succumbing to the attacks of the flies. Riley *(27)* quotes Schönbauer, 1795, as witnessing the postmortem of a horse in which the arms, genital orifices, nasal passages and bronchial tubes were filled with black flies. Schmidt *(28)* describes the effects of the bites of these "Kolumbacser Mücken" upon animals as causing labored breathing, stumbling gait, rapid pulse, and painful swellings. Animals attacked by large numbers died in from one to two hours. He wrote that less severe cases are characterized by loss of appetite, abortion, marked depression, and blindness.

Farmers in North America also have suffered periodic losses from the attacks of various species of Simuliidae. Bradley *(3)* wrote that during the Civil War and for a period thereafter extending up until 1887, *Cnephia pecuarum* (Riley) caused enormous losses of livestock, chiefly mules, in the lower Mississippi Valley. In 1927 about 100 farm animals were killed near Yazoo City, Mississippi, and a year later many mules were killed near Charleston, Mississippi. In 1931 more than a thousand mules were killed in Coahoma County, Mississippi, and in eastern Arkansas. He reported that again in 1934 during April 500 mules were killed in eastern Arkansas.

Rempel and Arnason *(26)* reported severe outbreaks of *Simulium arcticum* Mall. in central Saskatchewan occurring in late May and June of 1944, 1945, and 1946 which in the last named year alone, resulted in the death of 600 farm animals, mostly cattle, and in brief but serious illness to many more. Cameron *(6)*, writing about the attacks of this species,

suggested that the direct cause of death might be suffocation following the entrance of large numbers of flies into the respiratory passages through the nostrils, but Rempel and Arnason believed that death is due to shock caused by an increase in the permeability of the capillaries with a consequent great loss of fluid into tissue spaces and body cavities.

Stokes *(34)* gave a detailed description of the bite of *Simulium venustum* Say and its effects upon man. He stated that the puncture is absolutely painless, not only at the time, but for some hours after. He believed that the saliva is anesthetic and also causes an increase in the flow of blood, perhaps by dilating the capillaries. "With the withdrawal of the proboscis the bite oozes out a small drop of lymph, followed at once by a hemorrhage which is often remarkably profuse.

"The writer has noted an actual trickle of blood for nearly 10 minutes from an arm bite. This hemorrhage occurs beneath the skin as well as through the puncture, giving rise to an ecchymosis varying in size from a pin point to several millimeters in diameter." He mentioned that persons residing in areas where they are subject to repeated attacks by black flies develop an immunity to the bites, and described a condition known as "black fly stiff neck" accompanied by swelling of the lymph nodes of the neck which affects non-immune individuals bitten about the face and neck.

The present writer has observed that black flies very definitely attack some individuals in preference to others. On one occasion, while he and two other entomologists were on a collecting trip, one of the men was suddenly attacked by a horde of *Simulium venustum* Say which had been flying around the heads of all three for several hours. The individual favored by the attention of the flies patiently stood while his two companions aspirated the flies from his head and neck as rapidly as possible. So vicious was the attack that the efforts of two men could not prevent the third from being severely bitten. During this period and later, the writer received not a single bite and the second man, only a few. The reasons for this seemingly natural repellency or special selectivity are not known.

The Simuliidae are not only prominent as tormentors of man and beast but also as vectors of disease. Several species are known to be transmitters of Onchocerciasis to man in equatorial Africa *(2)*, Central America, and southern Mexico *(16) (36)*, and to cattle in England *(33)*. Parker *(24)* in 1933 indicated *Simulium decorum katmai* D. and S. as a possible vector of tularemia in western United States. Skidmore *(29)* in 1932 demonstrated that *S. occidentale* Townsend was responsible for the transmission of a malaria-like disease of poultry in Nebraska caused by *Leucocytozoon smithi* (Lavern and Lucet). In 1934 O'Roke *(23)* described a similar disease of ducks caused by *L. simondi* Mathis and Leger (= *anatis* Wickware) which is transmitted in Michigan by *S. venustum* Say.

This latter disease is reported to cause from 10 per cent to 100 per cent mortality among ducklings, but adults are able to resist it more effectively. Leucocytozoon disease has been reported by Twinn *(38)* to be common among ducks in eastern Canada, and by Johnson, *et al. (18)* to occur in Virginia where it is transmitted to turkeys by *S. jenningsi* Mall. (= *nigroparvum* Twinn).

Leucocytozoon disease was first reported from Minnesota[3] about 1935 and since then has occurred at such widely scattered points as Albertsville in Wright County and Waseca in Waseca County (July, 1937); Ramsey County (July, 1938); Lindstrom in Chisago County (July, 1941); Duluth in St. Louis County (July, 1942); Berup in Norman County (August, 1944); Minneapolis in Hennepin County, and Lakeville in Dakota County (August, 1947). All occurrences were in ducks except at Lakeville, which was in turkeys. The record from Duluth was from a wild duck.

The disease also has been reported in southeastern North Dakota near Davenport in bronze turkeys (August 8, 1944), and in ducks from Lisbon (July 24, 1946). The records unfortunately are incomplete from this state.

The existence of Leucocytozoon disease in Minnesota presents a problem, as yet minor, but of potentially serious proportions because of the State's large and still growing poultry industry, particularly the turkey producing industry. The three proved vectors of the disease (*S. venustum* Say, *S. occidentale* Townsend, and *S. jenningsi* Mall. (= *nigroparvum* Twinn) occur in the State and the first of these, at least, is widely distributed and common. O'Roke *(23)* has indicated that wild duck carriers may be a factor in the spread of *L. simondi* and it is known that ruffed grouse *(11)*, and other wild birds, are infected with *Leucocytozoon* spp. some of which might conceivably be transmissible to domestic fowl. If such a reservoir exists in nature and the parasites are infectious to poultry, the proper combination of circumstances might bring forth the disease in outbreak proportions.

There has never occurred in Minnesota, to the writers' knowledge, an instance where black flies have caused such dramatic loss of life among livestock as reported from certain other regions of the world. Nevertheless, these insects are an economic liability to the State ranking, among blood sucking insects, probably after the Culicidae and the Tabanidae. Possibly the most severe losses occur in the dairy and tourist industries of the State, particularly to those in the northern sections. In localities where black flies are abundant cattle definitely lose weight during the season of greatest fly prevalence, and milk production drops. The writers have been told of instances in which cattle have returned from the pasture with bloody ears and udders resulting from the attacks of black flies.

PART II. BIOLOGY

The immature stages of the Simuliidae are aquatic and are found clinging to submerged grasses, branches, or stones in fresh water streams or ditches in which there is a definite current. Most species require rapidly flowing water, but others have been taken in streams which are rather sluggish. It has been shown by Wu *(47)* that the affinity of these insects for flowing water is determined, at least in part, by their demand for oxygen. Tonnoir *(37)* suggested that a second function of current is

[3] This information was kindly supplied by Dr. B. S. Pomeroy, Poultry Division, Department of Veterinary Medicine, University of Minnesota, and by Dr. D. F. Eveleth, Head of the Department of Veterinary Science, North Dakota Agricultural College, Fargo, North Dakota.

to keep open the mouth brushes of the larvae. It follows then that a third function is to carry food to the larvae since they subsist largely on animalcules and algae strained from the water by the filaments of the mouth brushes.

The eggs of black flies are deposited on the leaves of aquatic vegetation such as grass, and on emergent branches and stones in the stream. Wu *(47)* stated that the eggs of *Simulium venustum* Say are placed irregularly in a compact mass, while those of *S. vittatum* Zett. are deposited in a string which curves and twists over itself. He added that when oviposition is heavy the egg masses may become extensive and several layered. Bradley *(3)* was able to obtain oviposition by *Cnephia pecuarum* (Riley) in captivity. The eggs were found loose at the bottom of a jar in which the female was confined over water, or stuck to the side just above or below the water line. He observed one female resting on the water with the tip of the abdomen below the surface dropping eggs two or three at a time. He did not believe that this species lays eggs directly in rivers, as he was able to find only a few in plankton collections. Britten *(5)* observed *Simulium maculatum* Mg. creep, encased in a bubble of air, nine inches to one foot underwater down the stems of grass to oviposit.

The writers repeatedly have obtained mating and oviposition of *Cnephia dacotense* (D. and S.) on moist cotton in emergence vials from adults less than a day old. Several females of the species were confined over water for observation, and oviposition was obtained. In this instance five eggs were stuck to the side of the container just above the water line, a group of 30 were strung from these down into the water, and 60 eggs were scattered on the bottom. The eggs were not laid in any definite order but in patches. Where most numerous they were piled several deep. It must be remembered, however, that the above observation was made under highly unnatural conditions.

All attempts to hatch the eggs of *C. dacotense* (D. and S.) collected in the above described manner failed. Bradley *(4)*, who obtained the eggs of *C. pecuarum* (Riley) in a similar manner during the month of April, found that they hatched the following December after being kept in either still or moving water. This suggested the possibility that the species may go through the summer in the egg stage, an occurrence which is stated by Baranov *(1)* to be true of the eggs of *Simulium columbaczense* Schönb.

Smart *(30)* determined, under laboratory conditions, that the incubation period of the eggs of *Simulium pictipes* Hagen was two and one half days at 25 degrees C. He also showed that the eggs cannot withstand desiccation, but can be frozen in ice for at least two days without injury. Wu *(47)* showed that the eggs of *Simulium vittatum* Zett. hatched in four to five days under natural conditions when the water temperature was 20 degrees to 22 degrees C. In standing water incubation varied from 5 to 55 days. He found that a small number of eggs could withstand exposure to air 10 to 14 hours.

The larvae of the Simuliidae vary in color from gray to brown or black. They are elongated and round in cross section. The thorax is greater in diameter than the mid-abdominal segments and the terminal third of the body is definitely swollen. The head is strongly sclerotized,

but the remainder of the body is membranous. The larvae are characterized by the large, fan-like feeding brushes, a single thoracic proleg, and the anal disk.

The larvae may be found attached to submerged leaves, grasses, pieces of wood and stones where there is a flow of water. They prefer places of attachment which are clean, and are usually not found where the substratum is covered by slimy deposits of algae and sediment. Some larvae, such as those of *Simulium jenningsi luggeri* and *S. venustum* Say, when attached to stones are frequently found under the down stream edges where they are protected from debris carried by the current. Other species seem to prefer exposed situations. Feeding is accomplished with the aid of the mouth brushes which strain diatoms and other minute particles of animal and plant food from the water.

The larvae are incapable of swimming, but loop along on submerged objects much in the same manner as do Geometrid caterpillars. Puri *(25)* gives an account of their mode of traveling which agrees with the writers' observations. A patch of silk is first applied to a spot with the mouth parts, the proleg is attached to this spot, and the anal disk is brought forward and is attached either to the left or the right and a little in front of the proleg. The proleg is then released, the body is extended and the process is repeated. If disturbed, the larvae releases its grasp and is carried off a short distance by the current, secreting a strand of silk behind it from the mouth parts. The larva may return to its point of attachment by climbing back up this silken strand using the proleg and mouth parts, or it may sever the strand and be carried away.

The length of the larval period apparently varies with the species, the temperature of the water, and the availability of food. Smart *(30)* found that the larval stage of *Simulium pictipes* Hagen was passed in four to six weeks during the summer. Wu *(47)* stated that *S. vittatum* Zett. required 13 to 17 days when the water temperature varied from 16 degrees to 18 degrees C. Wanson and Henrard *(44)* indicated that *S. damnosum* Theob. took only five days to pass through the larval stage under tropical conditions. The larva undergoes six moults during development *(6) (25) (9)*.

The method of overwintering of most species of the Simuliidae is not known. It is fairly certain, however, that the species in northern latitudes do not overwinter in the pupal or adult stages. Several species are known to overwinter as developing larvae. The writers have collected the larvae of *Simulium vittatum* Zett. in streams from which the ice had not yet entirely cleared as early as February 10 when the water temperature was only a few degrees above freezing. Grenier *(14)* found that *Simulium costatum* Fried., a European species, passed the winter in the larval stage. He found that larval growth continued slowly at water temperatures of 6 degrees to 8 degrees C. It is suspected that some species may pass the winter in the egg stage. Cameron *(6)* in writing of *Simulium arcticum* Mall. in Canada stated that it is practically certain that no larvae or pupae remain in the river during the winter as the species reappears in the summer as a first stage larva.

The writers were unable to discover either the oversummering or overwintering stages of the apparently single generation species *Cnephia dacotense* (D. and S.). This species appears in both permanent and temporary streams as first instar larvae during the month of April, and the

adults emerge in May. Search for this species during the summer has been fruitless. The experience of Bradley *(4)* in holding viable eggs of *Cnephia pecuarum* (Riley) unhatched from April until December suggests the possibility that *C. dacotense* may survive the summer and winter in the egg stage.

The spring season is undoubtedly a difficult period for the immature stages in those streams subject to spring floods. Many larvae and pupae must be torn from their places of attachment to be carried away by the force of the current, or be crushed by debris. It has been observed that the lower portions of streams flowing into Lake Superior between Duluth and the Canadian border are unusually barren of black flies during the spring until early June. These same streams near their headwaters, however, before the volume of water increases to a roaring torrent, are found to bear the normal Simuliid fauna. These clear, cold, rock bottomed streams drop rather abruptly several hundred feet over a series of falls and rapids into Lake Superior after winding rather aimlessly over relatively level beds near their headwaters. The force of the water during the spring months and the degree of fall are so great that boulders as large as one's head may be seen and heard rolling along in the river beds. These stream beds are also subject to scouring by ice and debris during the early spring, as may be seen in figures 1 and 2, and to sudden fluctuations in water level, all of which is detrimental to the developmental stages of the black fly.

The pupae are characterized by a conspicuous pair of respiratory organs, which are located on the antero-lateral angles of the thorax, and by the cocoon (figure 4). In most species the respiratory organs consist of a pair of branching thread-like filaments; but about a dozen species, according to Hearle *(15)*, have breathing organs of bizarre forms. The co-

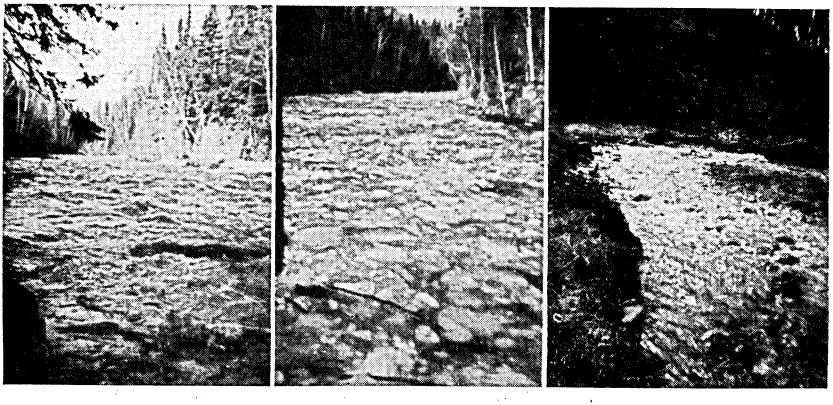


FIG. 1. Arrow Head River, Cook County, April 12, 1941. This is typical of the many streams which flow into Lake Superior between Duluth and the Canadian border. FIG. 2. The same scene taken 10 minutes later. An ice jam upstream had broken filling the river with ice and debris. Such conditions are detrimental to the immature stages of black flies. FIG. 3. A temporary stream near the Isaac Walton Bass Pond, Hennepin County, April 1939. The larvae of *Simulium vittatum* Zett. were abundant here.

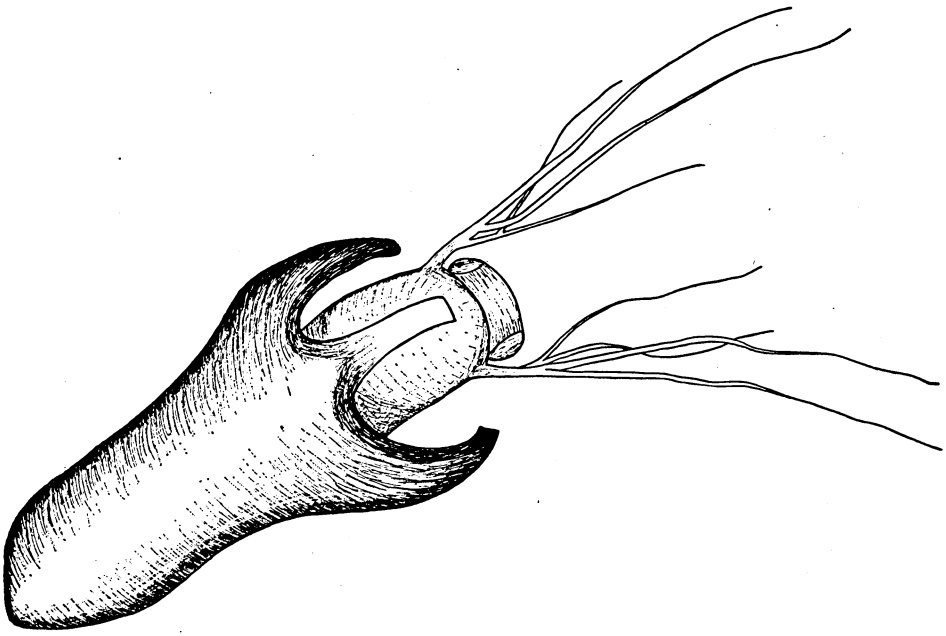


FIG. 4

FIG. 4. Cocoon and pupa of *Simulium latipes* Meigen.

coon is either an unorganized mass of silk filaments in which the pupa is embedded, or a delicately woven case, open at the anterior end, which has been described as resembling a slipper or a wall vase. The latter type may bear spatulate antero-dorsal projections, or antero-lateral "windows," or an anterior lattice-like fringe. Pupation occurs in the same situations as does larval development, and both stages of development frequently are found together.

The pupal stage is usually quite short. *Cnephia dacotense* (D. and S.) requires less than eight days to develop and emerge in nature. In rearing experiments with *Simulium jenningsi luggeri,* in which four larvae were allowed to pupate under laboratory conditions, two to four days were required for the pupal stage to pass when the water temperature was unregulated, but about 25 degrees C. With the water temperature varying from 14 degrees to 22 degrees C. but averaging 17.2 degrees C., pupal development of nine individuals required one to ten days, but averaged 5.4 days. Puri *(25)* stated that the time required for pupal development varies with the water temperature. He placed two lots of *Simulium nölleri* at different temperatures, one at 16 degrees C. and the other at 3.8 degrees C. The pupae in the first lot emerged after five days, but those in the second required 13 to 15 days.

The adult black fly is relatively short-lived. The life span of *Simulium neavei* Roubaud has been estimated by Garnham and McMahon *(13)* to

be not over two months, but this probably approaches the extreme. The writers were not able to keep adult *Cnephia dacotense* (D. and S.) alive longer than two days. All attempts to feed them on water soaked raisins failed. Wu *(47)* working with *Simulium vittatum* Zett. was able to keep one female alive for six days and five of each sex for five days, but the majority died within three days. When he provided sugar solution or soaked raisins both sexes fed and the life span was increased, the majority dying within eight days, but several living 17 days and one for 18 days. Baranov *(1)* stated that the adults live under natural conditions probably considerably longer than a month. He was able to keep them alive in the laboratory for 20 to 30 days if the relative humidity was about 90 per cent.

The mouth parts of the males of this family are not developed for piercing. This sex therefore does not bite but feeds on plant sap and the nectar of flowers *(1)*. A blood meal for the females of at least some species appears to be essential for the maturation of the ova *(6);* but the females of *Cnephia dacotense* (D. and S.) *(22) (19)* and *Prosimulium alpestre* D., R. and V. *(7)* have been shown to be incapable of piercing the skin and must, therefore, produce viable ova without a blood meal.

Most of the observations which have been made concerning mating indicate that this phenomenon occurs in the air during swarming. Bradley *(3)* stated that mating of *Cnephia pecuarum* (Riley) has been observed most frequently on bright sunny afternoons and takes place commonly over open fields. He wrote that a female entering a group of swarming males is immediately pounced upon and the pair fly to the ground or some adjacent bush. Smart *(30)* stated that copulation of *Simulium pictipes* Hagen apparently takes place in the air.

The writers have witnessed an emergence and the mating of *Cnephia dacotense* (D. and S.) on the ground. The males occurred in great numbers at the edge of the water of a small stream (figure 8), on the water itself, on the banks of the stream in sunny spots clinging to sticks and grass, and on the ground. A definite preference was shown for moist surfaces, and it was there that most of the mating occurred. As the females appeared they were pounced upon by as many as four males simultaneously in attempts to copulate. The males in wandering around frequently came in contact with each other and attempted copulation,

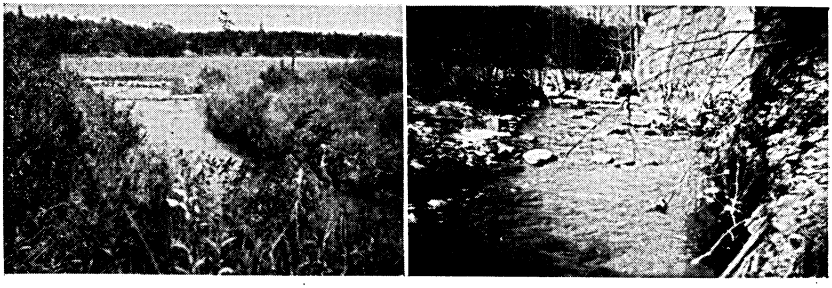


FIG. 5. The source of the Mississippi River with Lake Itasca in the background, July, 1941. *Simulium venustum* Say were found breeding here. FIG. 6. Battle Creek, St. Paul, April, 1939. A breeding place of *Simulium vittatum* Zett. The immature stages of *S. aureum* Fries were collected at this site from July through September.

but soon separated. Observations were continued from 9:30 a.m. until noon without any indication of a decrease in activity. Two days later the flies were still abundant at this site, but had decreased in numbers and mating was still continuing. On the fifth and ninth days a few males were still present at the stream. The writers also have witnessed the copulation of adults of this species, which had emerged from the pupal exuviae in rearing vials less than five minutes previously.

Swarming occurs on warm, relatively windless days, usually in the afternoon. The writers witnessed a swarm, predominantly of males of an unidentified species, on June 11 in Anoka County. The swarming occurred from 5 to 25 feet above the ground in the protection of a steep hill about 5:30 p.m. with the air temperature 60 degrees to 65 degrees F. Another swarm, probably of *Simulium venustum* Say, was observed on May 23 in Kittson County, dancing about six to ten feet from the ground. The flies remained momentarily stationary in the air with heads into the wind, and then dashed off. This dance was made repeatedly. A collection from this loose swarm yielded 21 males and 6 females. Of the latter four had fed on blood, one had not fed, and the condition of the sixth was doubtful.

The factors which determine when the female will bite are not well understood. Baranov *(1)* stated that all attacks are associated with a weather change and very frequently with a thunderstorm. Underhill *(41)* indicated that the feeding activity of *Simulium jenningsi* Mall. (= *nigroparvum* Twinn) was not greatly influenced by temperature except when below 65 degrees F., that relative humidity did not influence feeding activity appreciably, that strong winds (28 m.p.h. or over) slowed down feeding or stopped it altogether, and that the most pronounced influence was a change in atmospheric pressure, a drop being accompanied by an increase in activity and a rise by a decrease in feeding.

These insects are considered to be weak fliers but the females frequently may migrate long distances, probably with a wind. Wanson and Henrard *(44)* stated that *Simulium damnosum* Theob. migrates nine to twelve miles regularly. Underhill *(40)* took adults of *Simulium jenningsi* Mall. (= *nigroparvum* Twinn) in fairly large numbers 10 miles, and in small numbers 15 miles, from any known breeding place. Rempel and Arnason *(26)* reported a severe outbreak of *S. arcticum* in two areas

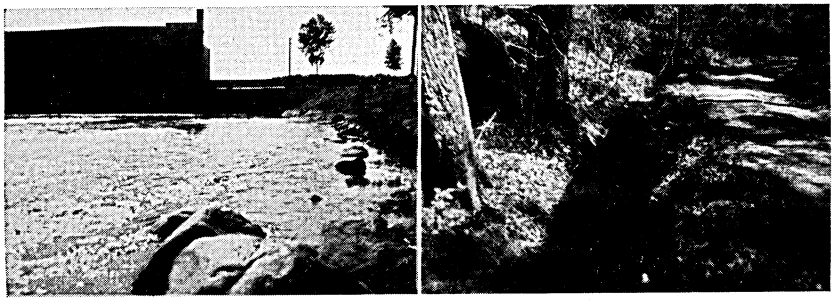


FIG. 7. Coon Rapids of the Mississippi River, Anoka County, July 1, 1939—the breeding place of *Simulium jenningsi luggeri* n. subsp. FIG. 8. A temporary stream between Schultz Lake and Lake Minnetonka, Carver County, May 1939—the breeding place of *Cnephia dacotense* (D. and S.).

whose centers were 50 miles from the breeding places, and indicated maximum range flights of 80 to 90 miles.

The writers have observed that the adults of *Simulium occidentale* Townsend, when on the wing, are attracted by movement. The violent swinging of a net around one's head will attract swarms of them.

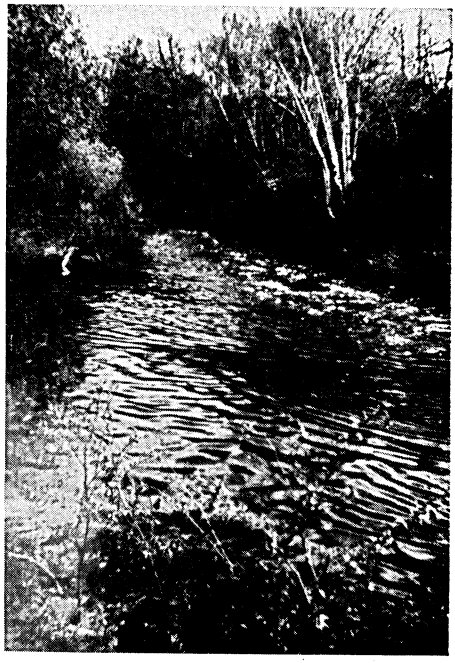


FIG. 9. North Branch of Two Rivers near Lancaster, Kittson County, May 8, 1941. This is a breeding place of *C. dacotense* (D. and S.). The water becomes stagnant during the summer.

PART III. SYSTEMATIC TREATISE

Methods of Collection

Insects of the family Simuliidae are usually rare in general insect collections or, at best, represented by many specimens of a few species. A variety of species is seldom obtained by general collecting methods. In order to adequately sample the fauna existing in a given region, the collector must obtain the pupae and hold them for the emergence of the adults. This method of collecting has the distinct advantage of usually yielding both sexes of a given species, and enabling the two sexes to be associated. In addition the pupae and cocoons have characters of definite taxonomic value, which, in some cases, are nearly indispensable.

The method of rearing employed during this study is one generally in use among taxonomists in this group. The pupae were carefully removed from their objects of attachment with forceps and were placed on moist strips of absorbent cotton laid lengthwise in glass vials approximately 4 inches by 1 inch in size. A second vial containing a dry strip of paper toweling was placed lip to lip with each of the first, and the two were wrapped in a sheet of paper leaving about an inch of the empty vial uncovered. The paper was fastened with a rubber band. The flies, being phototropic, entered the dry vial upon emerging where the cuticula was permitted to harden. The pupal exuviae were preserved in fluid, or were placed in genitalia vials and were pinned along with the adult specimens.

Classification

The classification used by the writers is that proposed by Smart *(31)* in 1945 in his outstanding and much needed review of the family Simuliidae. Smart divided the family into two subfamilies, *Parasimuliinae* and *Simuliinae*. The first of these contains the genus *Parasimulium* Malloch which is known only from a single specimen taken in California. The latter contains the genera *Prosimulium* Roubaud, *Cnephia* Enderlein, *Austrosimulium* Tonnoir, *Gigantodax* Enderlein and *Simulium* Latreille (restricted and comprising the sub-genera *Simulium, Eusimulium,* and *Morops* of Edwards *(10)*. Of the genera he recognizes, only *Prosimulium, Cnephia,* and *Simulium* are known to occur in Minnesota. He recognizes no sub-genera.

The important taxonomic characters used in this study are illustrated in figures 10 through 15.

KEY TO THE GENERA OF SIMULIIDAE (AFTER SMART)

1. The radius (R) joining the costa about the middle of the front edge of the wing.
   Radial sector (Rs) forked, the posterior branch of the fork joining the costa some distance before the termination of the latter towards the wing tip; macrotrichia of the anterior wing veins hair-like. *(Parasimuliinae)* ..... *Parasimulium*

—. The radius (R) joining the costa well beyond the middle of the front edge of the wing.
   The tip of the radial sector (Rs), if this is simple, or the tip of the posterior branch, if it is forked, joining the costa practically at the termination of the latter toward the wing tip; macrotrichia of the anterior wing veins shorter and more bristle-like and in some genera with an admixture of spiniform microtrichia on the costa at least *(Simuliinae)* 2

2. Radial sector (Rs) forked; macrotrichia of the anterior wing veins bristle-like only (no spiniform ones present).
   Basal section of the radius with macrotrichia above; basal cell present; Cu_2 sinuous; no pedisulcus; no calcipala ..... *Prosimulium*

—. Radial sector (Rs) simple, not forked (in a few species the tip of the simple radial sector may be swollen, giving the semblance of a slight furcation); spiniform macrotrichia amongst the bristle-like ones on the costa at least 3

3. Cu_2 straight; An straight.
   Basal section of the radius with macrotrichia above; no basal cell; distal section of the simple radial sector with a single row of macrotrichia above; no pedisulcus; calcipala exceptionally strongly developed. A Neotropical and Australian genus with the exception of one species occurring in Mexico ..... *Gigantodax*

—. Cu_2 sinuous; An sinuous 4

4. Antennae with ten segments (or fewer) and with the basal section of the radius and the distal section of the radial sector with macrotrichia above.

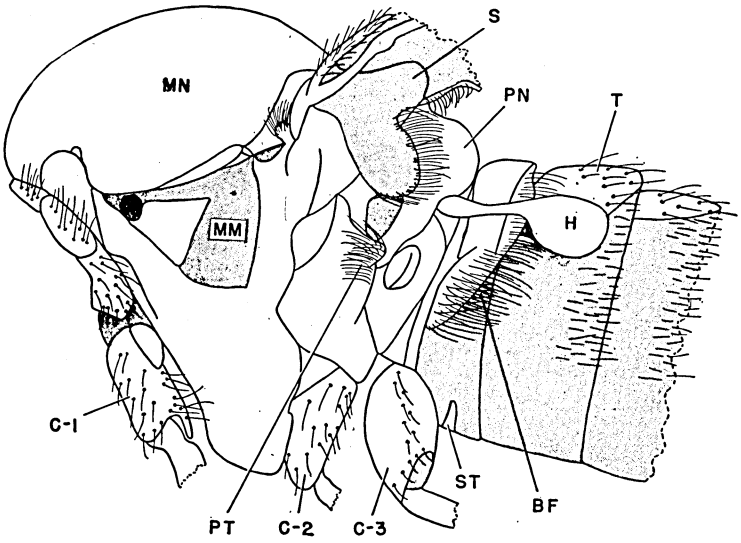


FIG. 10

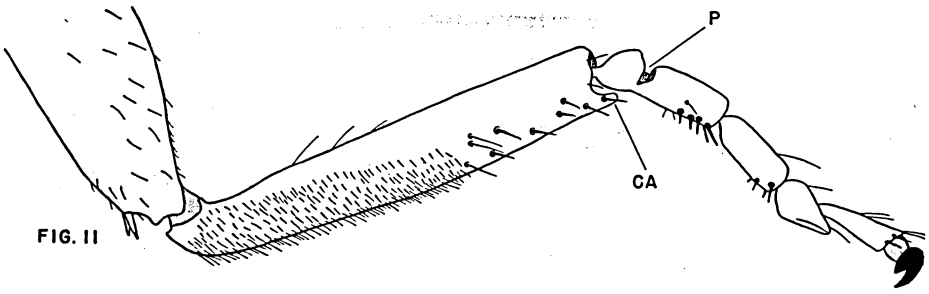


FIG. 11

FIG. 10. Lateral view of the thorax and part of the abdomen of a female *Prosimulium hirtipes* (Fries) showing the characters of taxonomic interest. BF—basal fringe; C—1, 2, 3—Coxa 1, 2, and 3; H—halteres; MM—mesopleural membrane; MM—mesonotum; PN—postnotum; PT—pleural tuft; S—scutellum; ST—sternite of the first abdominal segment; T—tergite of the second abdominal segment. FIG. 11. Hind leg of *Simulium johannseni* Hart., CA—calcipala on the first tarsal segment or basitarsus and P—pedisulcus in the second tarsal segment.

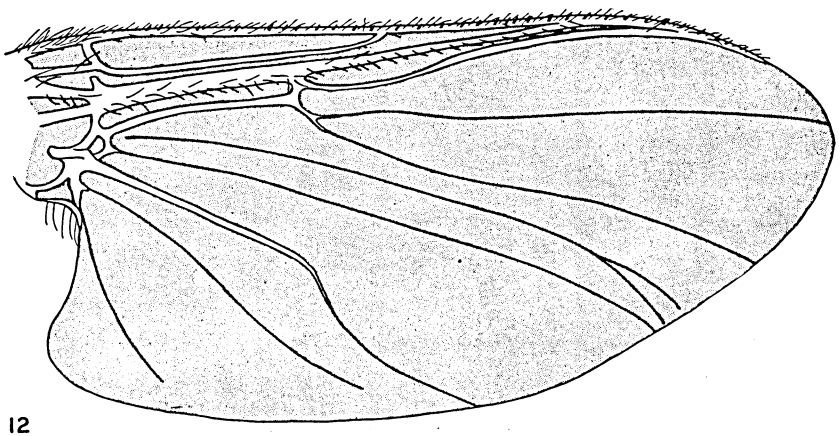


FIG. 12

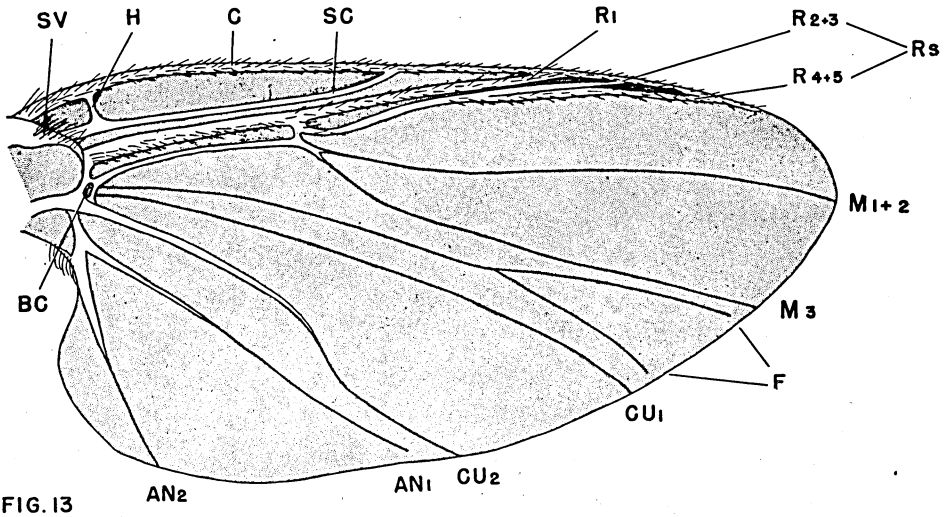


FIG. 13

FIG. 12. Wing of a male *Cnephia dacotense* (D. and S.) FIG. 13. Wing of a female *Prosimulium hirtipes* (Fries). AN—anal veins, BC—basal cell, C—costa, Cu—cubitus, F—folds, H—humeral cross vein, M—medius, R—radius, Rs—radial sector, SC—subcosta, SV—stem vein.

Basal cell poorly developed or absent; calcipala and pedisulcus present. Known to occur only in the Neotropical and Australian Regions ..... *Austrosimulium*

—. Antennae with ten segments but the basal section of the radius and the distal section of the radial sector naked above 5b

—. Antennae with eleven segments; basal section of the radius with or without macrotrichia above 5a

5a. Pedisulcus absent or very indistinct, basal cell usually distinguishable.

Basal section of the radius with macrotrichia above; distal section of the radial sector with a single row of macrotrichia above; calcipala present though in some species extremely small.....*Cnephia*

5b. Pedisulcus present; basal cell absent (except in *johannseni* in which a small sometimes indistinct basal cell may be found, but the pedisulcus is deep).

Basal section of the radius with or without macrotrichia above; distal section of the radial sector with or without macrotrichia above; calcipala present.....*Simulium*

Genus *Prosimulium* Roubaud

Prosimulium Roubaud, C. R. Acad. Sci. **143**:521. 1906 (in part). Genotype: *Simulium hirtipes* Fries.

Prosimulium Roubaud of Surcouf and Gonzales—Rincones, Dipt. vul. Venezuela **1**:277. 1911.

Prosimulium Roubaud of Malloch, U. S. Dept. Agr., Bur. Ent., Tech. Ser. **26**:15. 1914 (in part).

Prosimulium Roubaud of Dyar and Shannon, Proc. U. S. Nat. Mus. **69** (Art. 10):3. 1927.

Prosimulium Roubaud of Edwards, Dipt. Pat. S. Chile **2**:(4):127. 1931

Prosimulium Roubaud of Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921 and Arch. Klassif. phylog. Ent. **1**:87. 1930.

Heledon Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Simulium ferrugineus* Wahlberg.

Taeniopterna Enderlein, Zool. Anz. **62**:203. 1925. Genotype: *Simulium macropyga* Lundström.

KEY TO THE SPECIES OF *PROSIMULIUM*

Antennae 11-segmented; claws of the female simple; clasper of the male with two or three stout teeth.....*hirtipes* (Fries)

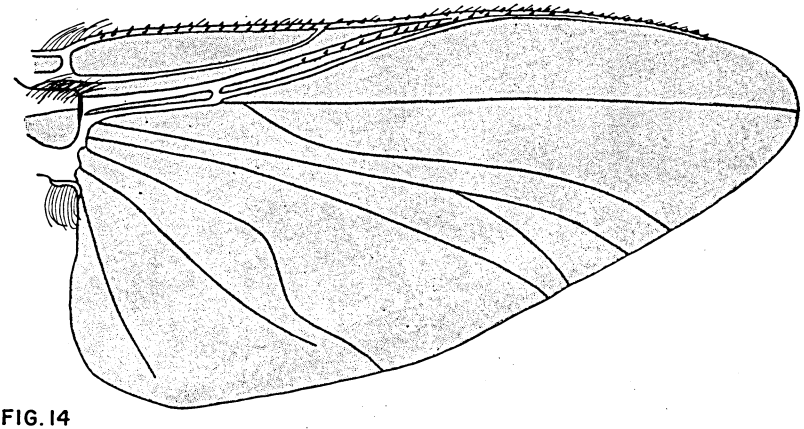


FIG. 14

FIG. 14. Wing of a male *Simulium vittatum* Zett.

Antennae 9-segmented; claws of the female with a basal tooth; clasper of the male with a single tooth..... *gibsoni* (Twinn)

Prosimulium gibsoni (Twinn)

Simulium (Prosimulium) gibsoni Twinn, Can. Jour. Res. **14**:108-110. 1936.

Female: A brown species. Length 1.8 to 2 millimeters. Twinn *(39)* reports the length to be as short as 1.6 millimeters. Vertex moderately broad, not extremely narrowed at the antennae; vertex and clypeus with scattered pale setae. Antennae 9-segmented, brown, basal two segments and basal half of the third segment light brown. Palpi dark brown. Mesonotum brown, moderately covered with pale pile, unmarked. Scutellum with numerous upright pale setae; postnotum bare. Pleurae brown; tuft pale. Halteres brown. Wings smoky brown; hair-like setae on the stem vein and base of costa pale. Legs light brown; tarsal segments four and five darker; the ventral edges of the hind basitarsi dark brown; second hind tarsus elongate, almost half as long as basitarsus; calcipala and pedisulcus absent; claws with a basal tooth. Abdomen brown; pilosity pale; dorsal fringe pale, sparse.

Genitalia (figure 15, B and C): Anal lobe wider than long, rounded anteriorly and ventrally, deeply indented posteriorly; evenly setose. Cerci rounded distally, not quite half as long as wide. Arms of the genital rod with ridged apical membranous expansion, the distal margin crenulate. Arms terminating in what appears to be broad-based hooks, this appearance resulting from a folding under of the lateral margins of the ninth sternite. Stem of the genital rod darkly pigmented, expanding gradually at the tip.

Male: Similar to the female in general appearance. Mesonotum, legs, halteres, and abdomen darker. Basal fringe dense and long. Hind basitarsi swollen, as wide as tibia, slightly over one half as long as the tibia.

Genitalia (figure 15, A): Side pieces about as long as broad, more or less ovoid. Claspers slightly longer than the side pieces, pointed, with a single terminal tooth. Adminiculum flat, lightly sclerotized, about as long as broad, rounded distally, basal processes heavily sclerotized, slender. A prominent, very heavily sclerotized, bifurcate prong overlies the adminiculum dorsally. This prong is attached to the adminiculum by a strap-like process extending ventrally from its proximal end to the proximal end of the adminiculum midway between the basal processes.

This species can be separated from *P. hirtipes* (Fries) by the nine-segmented antennae, generally smaller size, the possession of a basal tooth on the claws of the female, and details of the genitalia of both sexes.

Pupa: The writers' specimens are damaged but agree in essential details with the description given by Twinn *(39)* who writes as follows:

FIG. 15. Genitalia of *Prosimulium gibsoni* (Twinn). A. Male assembled, B. Genital rod of the female, C. Lateral view of the terminal end of the female abdomen showing the ninth tergite (T), a lateral view of the genital rod (GR), the anal lobe (AL), and the cercus (CE). FIG. 16. Genitalia of *Prosimulium hirtipes* (Fries). A. Male assembled, B. Lateral view of the adminiculum (male), C. Dorsal view of same, D. Female assembled, E. Genital rod (female).

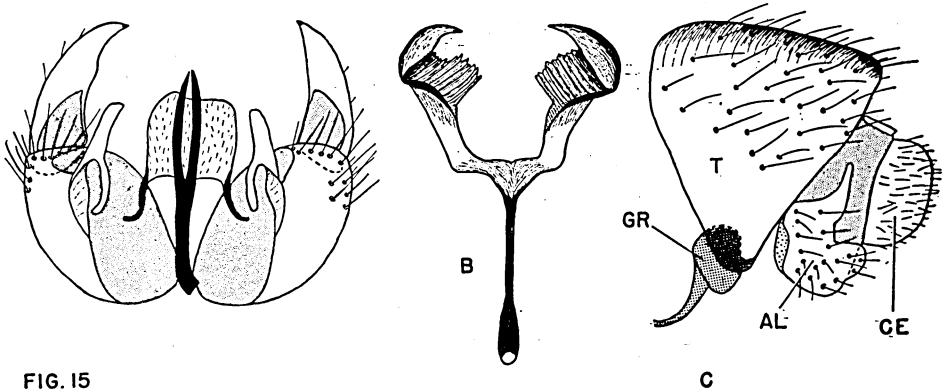
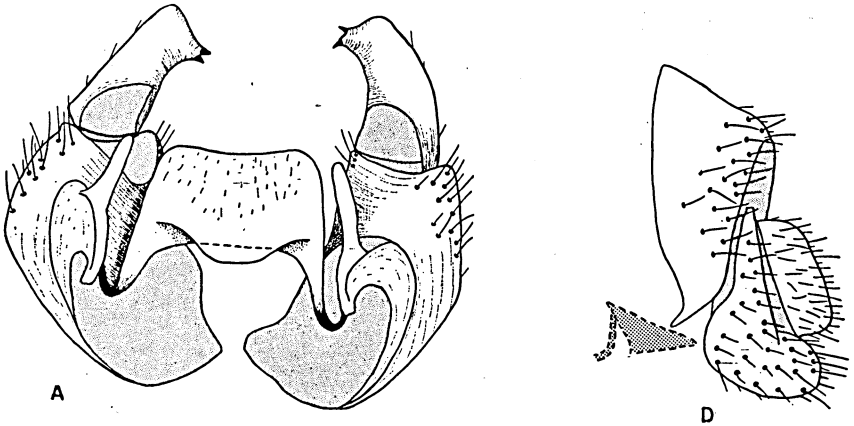


FIG. 15



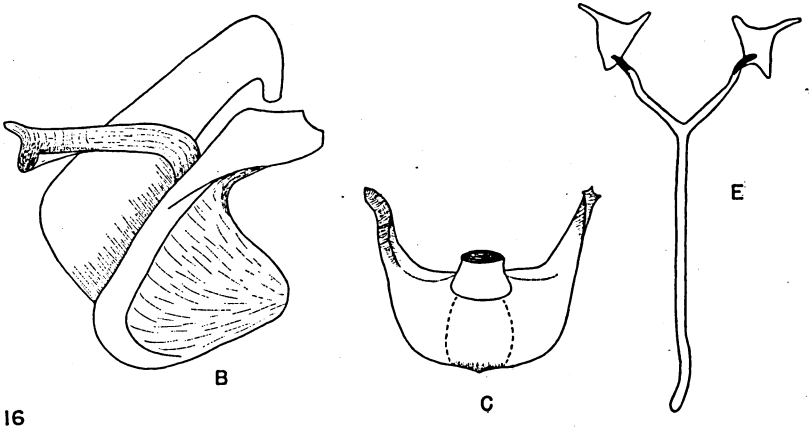


FIG. 16

"Length about 3.8 millimeters. Respiratory tuft about two-thirds the length of pupa and comprised of 14 filaments, which divide from three branches, one dorsal and two ventral, arising from the main trunk. The dorsal branch divides into two, each part bearing three filaments, a single one and a short-stalked pair, thus forming six filaments; the ventral branches each bifurcate twice making eight filaments; or 14 in all." The cocoon is shapeless and is encrusted with coarse particles of sand similar to that of *C. mutatum* (Malloch). The immature stages of the two species were collected together.

Distribution: Twinn *(39)* collected this species near Carleton Place, Ontario, and Hull, Quebec in 1935. The writers collected pupae near McGrath in Aitkin County, Minnesota on May 9 through 10, 1939 from which 12 adults were reared.

Prosimulium hirtipes (Fries)

Simulia hirtipes Fries, Mono. Simul. Suec., p. 17, 1824.
Simulium picipes Stephens, Sys. Cat. British Insects, **2**:254. 1829 *(apud* Edwards 1915) *(31)*.
Prosimulium nigripes Enderlein, Zool. Anz., **62**:202. 1925. *(apud* Edwards 1915) *(31)*.
Simulium pseudohirtipes Smart, Proc. R. Ent. Soc. London (B) **13**:132. 1944 *(apud* Smart *31)*.

Female: A moderately large brown species with yellowish-brown legs. Length, 2 to 3 millimeters. Vertex moderately broad, not extremely narrowed at the antennae; clypeus and vertex with scattered pale yellow setae. Antennae 11-segmented, dark brown with the basal two segments somewhat lighter. Mesonotum dark brown, rather densely covered with coarse yellow pile; scutellum lighter with numerous long upright pale yellow setae; postnotum bare. Pleural area brown; tuft pale, covering an area larger than usual. Halteres pale brown. Wings somewhat smoky; stem vein with pale yellow setae, other veins with brown setae. Legs yellowish-brown, coxae and tarsi darker; hind basitarsus about two thirds as long as the tibia; calcipala small; pedisulcus absent; claws simple. Abdomen brown with scattered pale pile; basal fringe pale yellow, sparse.

Genitalia (figure 16, D and E): Ovipositor valves large; produced posteriorly between the anal lobes; largely membranous, but somewhat sclerotized along the basal two thirds of the inner margins; finely spiculate. Anal lobe produced beneath the cercus; L-shaped; evenly setose. Cercus rectangular, about twice as wide as long. Forks of the genital rod with broadly expanded triangular tips; arms and stem narrow, moderately pigmented; stem not expanded at the tip.

Male: Similar to the female, but darker. Antennae entirely brown. Halteres dark brown. Basal fringe brown, longer and denser than in the female. Legs brown; hind basitarsus as wide as tibia, not quite two thirds as long; claws bifid.

Genitalia (figure 16, A, B, and C): Side piece conical, slightly longer than broad; claspers half as long as the sidepieces, terminating in two or three strong teeth. Twinn *(39)*, in discussing this species, stated that two teeth may be present on one clasper and three on the other. Adminiculum

wide, semi-membranous, broadly rounded terminally; concave dorsally; basal arms broad when viewed laterally and semi-membranous; ventrally produced into a large triangular lobe best seen from the lateral aspect. A semi-membranous, strap-like process extends dorsally from a point midway between the basal arms.

This species can be distinguished from *P. gibsoni* (Twinn) by the 11-segmented antennae, generally larger size, the simple claws of the female, and the details of the genitalia of both sexes.

Pupa: The writers have not seen the pupae of *P. hirtipes* (Fries). The following description is taken from Twinn's paper on the black flies of Eastern Canada *(39)*: "Length about 5 millimeters; the respiratory tuft one half as long as the pupa, consisting of 16 filaments. This character is constant for all the numerous pupae taken from streams in the Gatineau hills, Quebec, north of Ottawa, from which adult flies were reared. Various authors: Johannsen, (See p. 105, Twinn for ref.), Malloch, and others have indicated up to 60 or more respiratory filaments for this species in the United States. Puri states that pupae from France attain a total number of 50 to 60 filaments. He found, however, that pupae from Norway have only 16, and that as the species was originally described from Scandinavia the specimens must be regarded as typical. Puri's description of the filaments of the Norwegian species is in perfect agreement with my (Twinn's) material and I cannot do better than quote him: 'The first division is near the base into three short stems, each of the two ventral stems dividing almost immediately into two branches, each of which bifurcates again. The upper stem again divides into three branches, the two lower ones dividing into three each and the upper into two. All the filaments are more or less of equal thickness and length.' The cocoon consists of a mat of silk of indefinite shape which sometimes only partially covers the pupa, and to which extraneous matter, such as sand and tiny pebbles and fragments of stone is often attached."

Distribution: The species is Holarctic *(31)*. It is reported to be particularly abundant and troublesome in the eastern parts of the United States and Canada. In Minnesota it has been collected at:

Clearwater County, Itasca State Park, May 26, 1937.
Cook County, near Grand Marais, June 17-18, 1940, and May 30, 1941.
Lake County, 10 miles north of Finland, July 5, 1935.
Pine County, junction of the Snake and St. Croix Rivers, May 16, 1942.
Number of specimens examined: 48, all females.

GENUS *CNEPHIA* ENDERLEIN

Cnephia Enderlein, Deut. Tierärztl. Woch. **29:**199. 1921. Genotype: *Simulium pecuarum* Riley.

Hellichia Enderlein, Zool. Anz. **62:**203. 1925. Genotype: *Hellichia latifrons* Enderlein.

Astega Enderlein, Arch. Klassif. phylog. Ent. **1:**88. 1930. Genotype: *Cnetha lapponica* Enderlein.

Ectemnia Enderlein, Arch. Klassif. phylog. Ent. **1:**88. 1930. Genotype: *Ectemnia taeniatifrons* Enderlein.

Stegopterna Enderlein, Arch. Klassif. phylog. Ent. **1:**89. 1930. Genotype: *Stegopterna richteri* Enderlein.

Mallochella Enderlein, Arch. Klassif. phylog. Ent. **1**:91. 1930. Genotype: *Mallochella sibirica* Enderlein. Preoc. by *Mallochella* Duda, 1925 (Borboridae).

Cnesia Enderlein, Deut. Ent. Zeit. **1933**:273. 1934. Genotype: *Simulium (Cnephia) gynandra* Edwards.

Prosimulium Roubaud, C. R. Acad. Sci. **143**:521. 1906 (in part).

Prosimulium Roubaud of Malloch, U. S. Dept. Agr., Bur. Ent., Tech. Ser. **26**:15. 1914. (in part).

Eusimulium Roubaud of Surcouf and Gonzales-Rincones, Dipt. vul. Venezuela **1**:277. 1911 (in part).

Eusimulium Roubaud of Dyar and Shannon, Proc. U. S. Nat. Mus. **69** (Art.10):12. 1927 (in part).

Not *Eusimulium* Roubaud, C. R. Acad. Sci. **143**:521. 1906.

Not *Eusimulium* Roubaud of Edwards, Dipt. Pat. S. Chile **2**(4):149. 1931.

Key to the Females of *Cnephia*

1. Mesonotum with evidence of vittae 2
—. Mesonotum without vittae 3
2. Ninth tergite produced posteriorly as a narrow snout-like projection beyond the cerci; claws with a small sub-basal tooth; general color, brown ..... *dacotense* (D. and S.)
—. Ninth tergite not produced snout-like posteriorly; claws with a large sub-basal tooth; a large gray species with three pale vittae ..... *invenustum* (Walker)
3. Claws simple; general color, brown ..... *mutatum* (Mall.)
—. Claws with a large basal tooth; general color, gray ..... *Cnephia* sp. unid.

Key to the Males of *Cnephia*

1. Pleural tuft dark; hair-like setae on the stem vein and the base of the costa dark; general color dark brown to black 2
—. Pleural tuft white; hair-like setae on the stem vein and base of the costa pale; general color gray; clasper terminating in two closely placed teeth ..... *invenustum* (Walker)
2. Mesonotum velvety black without vittae; clasper terminating in two closely placed teeth ..... *mutatum* (Mall.)
—. Mesonotum shining brown with three vittae faintly visible; clasper terminating in a single tooth ..... *dacotense* (D. and S.)

Cnephia dacotense (Dyar and Shannon)

Eusimulium dacotense Dyar and Shannon. Proc. U. S. Nat. Mus. **69**(Art 10):20-21. 1927.

Simulium (Eusimulium) lascivum Twinn, Can. Journ. Res. **14**:127-128. 1936. *(apud* Nicholson *22)*.

Female: A brown species with smoky wings. Length 3 to 4 millimeters. Vertex moderately broad, not extremely narrowed above the antennae; about twice as wide at crown as at the antennae, sparsely covered with brown setae. Antennae 11-segmented, brown, the basal two segments lighter. Clypeus brown, convex, longer than wide, sparsely covered with

brown setae. Mesonotum shining brown with a sprinkling of fine, pale, recumbent setae anteriorly and laterally; posterior portion with heavier, more upright, anteriorly directed, dark setae; disk bare, but with faint evidence of three mesonotal vittae, a narrow medium one and a pair of broad, light brown, lateral ones with rather indefinite lateral limits. Scutellum light brown, thinly covered by upright brown setae. Postnotum dark brown, bare. Pleural area brown; pleural tuft brown. Halteres light brown. Wings smoky brown; setae on the veins, black. Legs light brown except the coxae and the tarsi which are darker; calcipala minute; pedisulcus indistinct; claws with a small sub-basal tooth. Abdomen opaque brown; the ninth tergite produced posteriorly beyond the anal lobes and cerci as a snout-like projection. This projection is clearly visible in dried specimens. Basal fringe thin, short, light brown. Tergal and sternal sclerites well developed.

Genitalia (figure 17, B and C): Anal lobe quadrangular, longer than wide, broadly lobed disto-ventrally and that portion setose; remainder bare. Cercus quadrangular, twice as wide as long. Ovipositor valves moderately large, as wide at the base as long, setose. Arms of the genital rod broad, irregularly shaped; the expanded portions each with a heavily sclerotized central area; stem heavily sclerotized, not expanded at the tip.

Male: Very similar to the female except as follows: Basal segments of the antennae dark; mesonotal vittae less distinct; basal fringe well developed; ninth tergite not produced distally.

Genitalia (figure 17, A, D, and E): Side piece conic-quadrate, slightly longer than broad, clasper tapering to a point, about two thirds as long as the side piece; a single tooth present at the tip. Adminiculum about twice as wide as long, moderately sclerotized, finely spiculate, broadly rounded distally, and arched tent-like mesally; the basal arms long and well developed. Adminiculum arms small, with a row of small teeth.

The females of this species may be separated readily from other known Minnesota species by the snout-like posterior development of the ninth tergite. The males may be distinguished from *C. mutatum* (Malloch) by the presence of a single terminal tooth on the clasper and three mesonotal vittae.

Pupa: Length 4 to 6 millimeters. Respiratory filaments 30 to 40 in number arising from a short swollen stalk in 6 to 7 branches which in turn branch close to their bases. Some branching occurs, however, more distally on the filaments. The length of the filaments is less than half that of the pupa. The cocoon consists of a shapeless mass of silk.

Distribution: This species has been reported from Idaho *(32)*, Massachusetts (identified by the writers), New York, Ontario *(39)*, and South Dakota *(8)*. In Minnesota the species is widely distributed, but by no means common. It has been taken as follows:

Aitkin County, May 29, 1941.
Carver County, May 5, 6, 9, 1939; May 26, 1940; May 6, 1941.
Kittson County, May 6 to 16, 1941.
Mille Lacs County, June 2, 1937; May 14, 1938.
Murray County, May 2 to 3, 1941.
Pine County, May 28, 1938.
Pipestone County, May 3, 1941.
Number of specimens examined: 566.

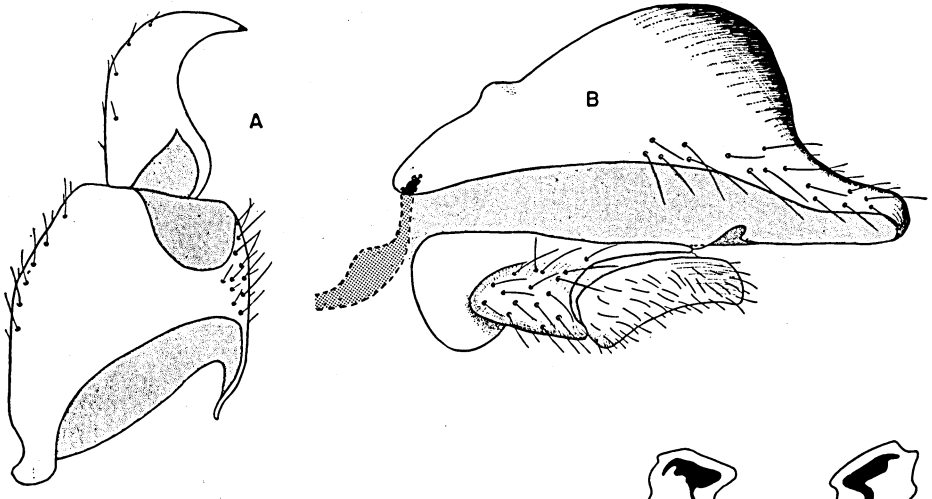


FIG. 17

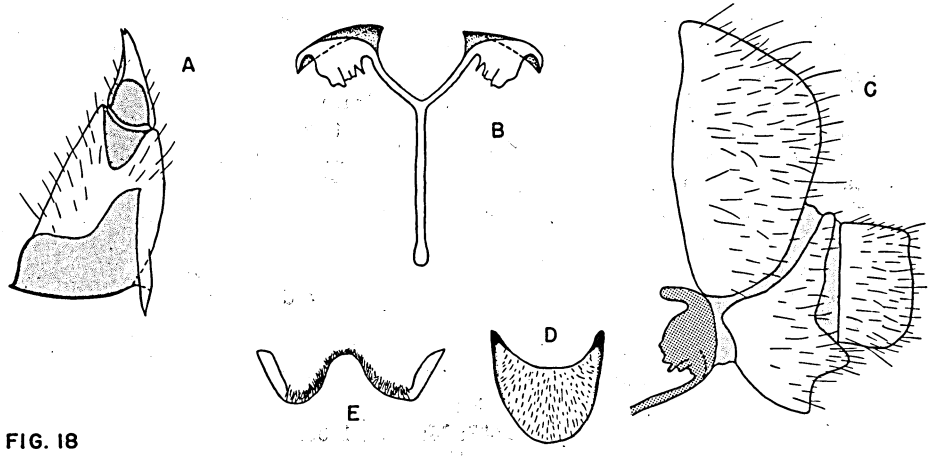


FIG. 18

FIG. 17. Genitalia of *Cnephis dacotense* (D. and S.) A. Clasper and side piece, B. Female assembled, C. Genital rod, D. Adminiculum, E. Adminiculum arms.
FIG. 18. Genitalia of *Cnephia mutatum* (Malloch) A. Clasper and side piece, B. Genital rod, C. Female assembled, D. Adminiculum, E. Adminiculum arms.

Cnephia mutatum (Malloch)

Prosimulium mutatum Malloch, U. S. Dept. Agr., Bur. Ent., Tech. Ser. No. 26, pp. 20-21. 1914.

Female: A brown species apparently quite variable in size. Specimens in the writers' possession taken in Minnesota vary in length from 1.5 to 2 millimeters, while material from the New England States is somewhat larger. Twinn *(39)* reports the length as 2.5 to 3.5 millimeters. Vertex narrow; a short median groove present above the antennae; sparsely covered with pale setae. Clypeus longer than broad, sparsely setose. Antennae 11-segmented, brown; the basal two segments lighter in some specimens. Mesonotum brown, moderately covered with pale hair-like pile; scutellum with dark upright setae, mixed with pale setae on some specimens; postnotum bare, shining. Pleural area brown; tuft mixed dark and light. Halteres brown. Wings smoky brown, hair-like setae on the stem vein and base of costa dark. Legs brown; hind tibial spurs elongate; calcipala large; pedisulcus absent; claws simple. Abdomen brown; pilosity pale, sparse, confined mostly to the terminal segments; basal fringe pale, sparse.

Genitalia (figure 18, B and C): Ovipositor valves small. Anal lobe narrow behind the cercus, expanded ventrally and produced posteriorly beneath the cercus; postero-ventral portion broadly notched. Cercus about twice as broad as long, quadrate. Genital rod narrow; stem dark, slightly expanded at the tip; arms quadrately expanded, terminating in a large tooth-like lobe; lower margin dentate, rounded.

Male: Darker than the female. Mesonotum velvety black, sprinkled generously with fine pale hair-like pile; those on the posterior margin upright and black. Scutellum brown with upright black setae. Postnotum bare, brown, shining. Pleural area brown, shining; tuft dark. Halteres brown. Wings clearer than in the female; hair-like setae dark. Legs brown, somewhat darker than in the female; hind basitarsi swollen; hind tibial spurs prominent; claws bifid. Abdomen velvety black, apical margins of the segments narrowly pale; pubescence short; basal fringe dense, long, black.

Genitalia (figure 18, A, D, and E): Side piece conic-quadrate, two thirds as wide as long. Clasper short, about half as long as side piece; narrow when viewed dorsally, but broad and abruptly pointed from a lateral aspect; terminating in two closely placed teeth. Adminiculum as broad as long, moderately sclerotized, broadly rounded, hirsute; basal prongs strong but small. Adminiculum arms band-like, joined medially, and bearing numerous small irregular teeth.

C. mutatum most resembles *C. dacotense* (D. and S.) of any of the Minnesota species. The females may be distinguished from it by the unproduced ninth tergite; and from other species by the brown color, narrow vertex, and the simple claws. Two males are distinguishable from other known forms by the genitalia and the velvety black mesonotum which lacks vittae.

Pupa: Length 3 to 3.5 millimeters. Respiratory tuft widely branching, about two thirds the length of the pupa. Filaments 12 in number divided from a short main trunk which breaks into three branches from a common point—two dorsal and one ventral. The laterad of the two dorsal

branches breaks into three filaments; the mesad into four. Five filaments are borne on the ventral branch. In some specimens the latero-dorsal branch emerges a short way up the stem of the meso-dorsal branch, thus fitting the description of the gill filaments as given by Twinn *(39)*, who stated that the main trunk divides close to the base into two branches held in the vertical plane. He also stated that the unpaired filament of the ventral branch sometimes divides into two near the apex, or one of the paired filaments gives rise to a short branch, or a weak filament arises from the main stem of the upper group causing the number of filaments to be 12 to 14, with the usual number, 13. The cocoon is of indefinite shape and may be encrusted with large particles of sand. Twinn stated that the cocoon is similar to that of *Prosimulium gibsoni* (Twinn). The writers have collected the two species together.

Distribution: This species is widely distributed over North America. Dyar and Shannon *(8)* reported it from Illinois, Indiana, Maryland, Missouri, New Jersey, and Virginia. Twinn *(39)* took it in Ontario and Quebec. Jenkins *(17)* collected a single female in Alaska. The writers have specimens from Rhode Island and Massachusetts. In Minnesota *C. mutatum* has been recorded from the following localities:

Grand Marais, Cook County, June 17, 1940 (1 specimen)

McGrath, Aitkin County, May 10 to 11, 1939 (13 specimens, reared).

Cnephia invenustum (Walker)

Simulium invenustum Walker, List Dipt. Brit. Mus. 1:112. 1848.

Female: A large gray species with three mesonotal vittae. Length 2 to 3.8 millimeters; wing 3.5 to 4.2 millimeters. Vertex narrow with a distinct median groove extending from the antennae to the crown, gray pollinose, moderately covered with white hair-like setae. Clypeus round-quadrate, gray pollinose, moderately covered with white hair-like setae. Palpi black, moderately setose. Antennae 11-segmented, black, densely covered with fine white setae; basal two segments shining gray pollinose, bare except for a few white setae; third segment as large as the second. Mesonotum with the integument black covered with brownish-gray pollinosity, and moderately with fine white pile.

Three light colored mesonotal vittae are present, the median one narrow and rather indistinct, the lateral two more easily discerned and converging anteriorly toward the center. Scutellum opaque gray pollinose, it and the posterior portion of the mesonotum bearing upright hair-like white setae. Postnotum black with shining silvery-gray pollinosity. Pleural area gray pollinose; tuft wide, covering an area greater than usual with a few setae extending down the meso-thoracic epimeron toward the middle coxa. Halteres varying in color from pale yellow, to reddish-brown to gray; bases darker. Wings clear with brown to reddish-brown bases; hair-like setae on the stem vein and base of the costa white; other setae light and dark mixed; subcosta with dark setae ventrally. In

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FIG. 19. Genitalia of *Cnephia invenustum* (Walker). A. Female assembled, B. Genital rod, C. Clasper and side piece, D. Adminiculum, lateral, E. Adminiculum, dorsal, F. Adminiculum arms. FIG. 20. Genitalia of *Simulium croxtoni* n. sp. A. Female assembled, B. Genital rod. FIG. 21. Genitalia of *Cnephia* sp. A. Genital rod B. Female assembled.

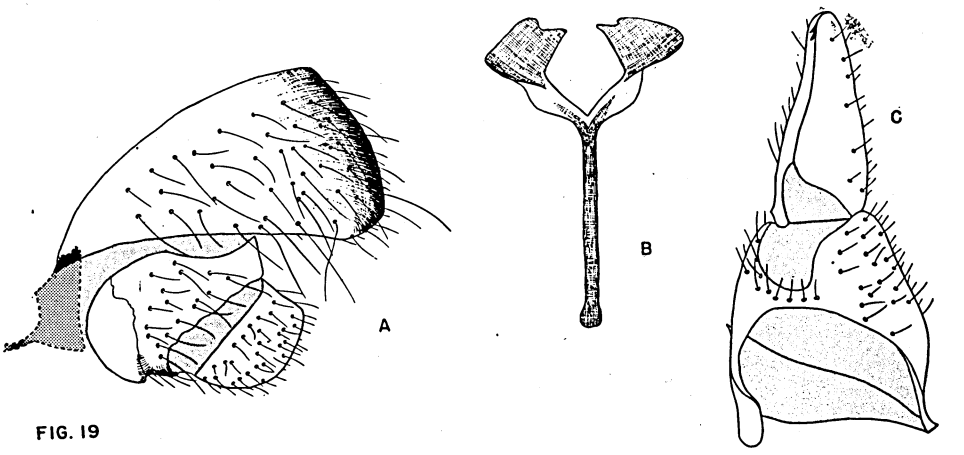
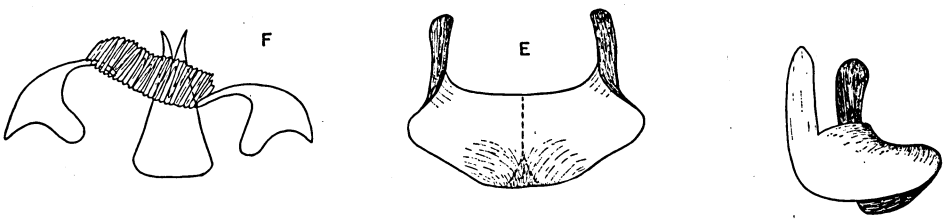


FIG. 19



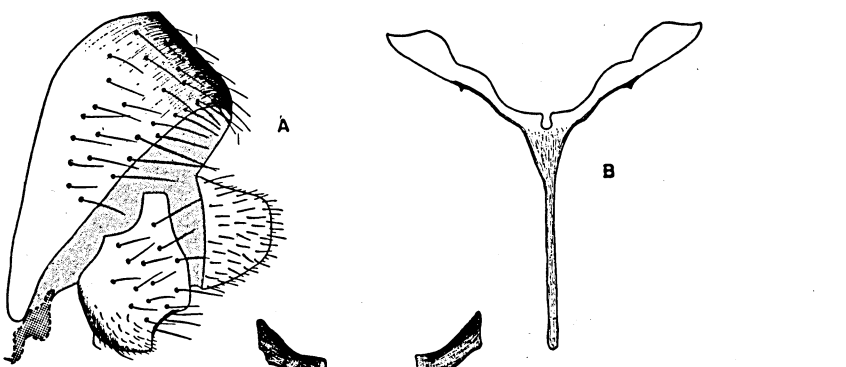


FIG. 20

FIG. 21

some specimens a few of the setae of the stem vein and base of the costa are dark, and the other vein setae are mostly dark. Legs dark gray, pollinose, with white pilosity; anterior aspects of the coxae densely clothed with long white pile; pile on the front femora and dorsal margin of the hind tibiae long, other pile relatively short; hind basitarsus not greatly expanded, about five eights as wide as tibia and four fifths as long; calcipala small; pedisulcus absent; claws with a large sub-basal tooth. Abdomen opaque gray with the dorsal area sparsely pale setose; setae most noticeable terminally; pleural area densely covered by long pale setae; basal fringe long and white.

Genitalia (figure 19, A and B): Ovipositor valves large, but not produced terminally; membranous, except the inner margins which are partially sclerotized. Anal lobe longer than broad, membranous anteriorly; setae confined to the posterior sclerotized portion. Cerci over half as wide as tall, broadly rounded posteriorly. Genital rod narrow, sclerotized, slightly expanded at the tip; arms broad. more membranous, expanded into roughly rectangular plates without teeth.

Male: Similar to the female in color. Antennae dark brown; basal two segments slightly lighter and with brown setae. Clypeus brown, densely clothed with long brown setae. Palpi dark brown to black. Mesonotum shining dark gray pollinose with a slight indication of three mesonotal vittae; pilosity hair-like, pale, most noticeable around the margins; posterior part densely clothed with long pale hair-like setae. Scutellum dark brown to black with pale upright hair-like setae. Postnotum bare with silvery pollinose reflections. Pleural area brown to gray pollinose; tuft as in the female. Halteres brown. Wings clear; hair-like setae of the stem vein and base of the costa pale; other setae mixed light and dark. Legs dark brown somewhat darker terminally, hairy; hind basitarsus about three fourths as wide as the tibia and about two thirds as long; calcipala small; pedisulcus absent. Abdomen opaque black, densely clothed with long pale hair-like setae except terminally where they are less dense and shorter; basal fringe pale, dense, and long.

Genitalia (figure 19, C, D, E, and F): Side piece conical, three fourths as wide as long. Clasper as long as side piece, laterally compressed, and terminating in a pair of stout teeth. Adminiculum moderately sclerotized, broad, roughly triangular when viewed dorsally, protruding laterally, distally curved ventrad; basal arms heavily sclerotized. Arms of the adminiculum triangular with narrow recurved extensions mesoproximally; widely separated with a darkly striate membrane between. Underlying the membrane and attached to the adminiculum between its basal arms is a moderately sclerotized plate, broad at the base, narrowed distally and terminating as a bi-pronged fork.

This large gray species is readily distinguished from other known Minnesota *Cnephia* by its large size and the presence of three light colored mesonotal vittae. The males are much like the females in general appearance.

Pupa: The immature stages are unknown to the writer.

Distribution: The type locality for this species is given as St. Martins Falls, Albany River, Hudson Bay, Canada. The writers have one male

from Fridley, Anoka County, Minnesota, collected April 26, 1941, and females from the following locations:

Minnesota:

Aitkin County, McGrath, May 7, 1939: 1 specimen.
Anoka County, April 1941 to 1942, May 1939 to 1940: 35 specimens.
Crow Wing County, Mille Lacs, May 18, 1940: 1 specimen.
Hennepin County, April and May, 1939, 4 specimens.
Houston County, May 22, 1937: 1 specimen.
Pine County, May, 1939 to 1941: 49 specimens.
Ramsey County, St. Paul, May 4, 1923: 1 specimen.
Washington County, April 22, 1939: 1 specimen.

Notes: *Cnephia invenustum* is an early spring species probably having only one generation a year. It has been collected most abundantly near large, swiftly flowing rivers such as the Mississippi, St. Croix, and Snake in which it probably breeds. The writers have not been successful in locating the immature stages. Thorough search in the above mentioned rivers has been prevented by the existence of flood conditions during the period when one would expect to find the immature stages. The writers have no record of this species biting.

Malloch *(21)* in 1914 listed this species as unrecognizable because he was unable to distinguish it from several others on the basis of Walker's description. Dr. Alan Stone of the U. S. National Museum who has examined the writers' specimens, has informed the writers that he has had specimens of this species compared with the types by Dr. Paul Freeman of the British Natural History Museum. He states that they agreed in every particular with *invenustum*.

Cnephia sp.

The writers possess only five specimens (all females) of this species and do not have the immature stages. Although it probably is a new species, the female does not offer characters sufficiently distinctive to warrant describing it as such. A formal description must, therefore, await the discovery of the male or pupa or both. Dr. Stone, of the U. S. National Museum, who has examined these specimens, states that they appear to be close to *Cnephia minus* (D. and S.) and *C. subexcisum* (Twinn).

Female: A dark gray species with brown legs and smoky wings. Length approximately 2 millimeters. Vertex at the crown as wide as the clypeus, moderately narrowed to about half as wide above the antennae; shining dark gray pollinose; moderately covered with white setae. Clypeus quadrate, as broad as long; dark gray pollinose; moderately covered with white setae. Palpi black. Antennae 11-segmented, dark brown to black, the two basal segments very slightly lighter. Mesonotum dark gray pollinose, sub-opaque; pilosity moderately long and dense, pale. Scutellum dark gray, sub-opaque; upright setae dark and light mixed, recumbent setae, pale. Pleurae gray pollinose, shining; tuft pale. Halteres yellow, bases dusky and setose. Wings somewhat smoky; hair-like setae on the stem vein and base of costa black; a row of dark setae ventrally on the subcosta. Legs brown; coxae dark gray; tarsi dark brown; hind basitarsus about one-half the width of the tibia; calcipala and pedisulcus small; claws with a large thumb-like basal tooth. Abdominal fringe pale.

Genitalia (figure 21, A and B): Ovipositor valves short, membranous setulose basally. Anal lobe about as long as wide, the anterior margin produced ventrally as a rounded lobe. Cercus as wide as the anal lobe, three fourths as long as wide, roughly triangulate. Stem of the genital rod sclerotized, expanded at the tip; arms membranous, the inner margins of the sclerotized tips produced angularly; not toothed.

This species differs from the females of other members of the genus known to occur in the State by its gray color, the relatively broad vertex above the antennae, the dark and light mixed setae on the scutellum, the black setae on the wing bases, and the large basal tooth on the claws.

Distribution: Cannon Falls, Goodhue County, Minnesota, May 1, 1941 (1 female).

Middle branch of Two Rivers eight miles east of Hallock, Kittson County, Minnesota, May 11, 1941 (1 female).

Lancaster, Kittson County, Minnesota, May 9, 1941 (1 female).

Mouth of Snake River, Pine County, Minnesota, May 3, 1941 (1 female).

Hennepin County, Minnesota, no date, collected by O. W. Oestlund (1 female).

Genus *Simulium* Latreille (restricted)

Simulium Latreille, Hist. nat. gen. part. Crus. Ins. **3**:426. 1802. Genotype: *Rhagio colombaschensis* Fabricius (in part).

Melusina Meigen, Nouv. Class: 19, 1800 (in part).

Atractocera Meigen, Illiger's Magazine **2**:263. 1803 (in part).

Simulium Latreille of authors (in part).

Eusimulium Roubaud, C. R. Acad. Sci. Paris **143**:521. 1906 (in part). Genotype: *Simulium aureum* Fries.

Eusimulium Roubaud of authors (in part).

Cnetha Enderlein Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Simulium lactipes* Meigen.

Nevermannia Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Simulium annulipes* Becker.

Schönbaueria Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Schönbaueria* matthiecseni Enderlein.

Boophthora Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Simulium argyreata* Meigen.

Chirostilbia Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Chirostilbia flavifemur* Enderlein.

Edwardsellum Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Simulium damnosum* Theobald.

Odagmia Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Simulium ornatum* Meigen.

Wilhelmia Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Simulium lineata* Meigen.

Gomphostilbia Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Gomphostilbia ceylonica* Enderlein.

Stilboplax Enderlein, Deut. Tierärztl. Woch. **29**:199. 1921. Genotype: *Simulium speculiventre* Enderlein.

Friesia Enderlein, Konowia **1**:69. 1922. Genotype: *Nevermannia tristigata* Enderlein.

Discosphyria Enderlein, Konowia, **1**:72. 1922. Genotype: *Discosphyria odagmiina* Enderlein.

Gynonychodon Enderlein, Zool. Anz. **62**:208. 1925. Genotype: *Simulium nobilis* Meijere.

Byssodon Enderlein, Zool. Anz. **62**:209. 1925. Genotype: *Simulium forbesi* Malloch.

Pseudodagmia Baranov, Neue Beitr. syst. Ins. **3**:164. 1926. Genotype: *Odagmia kondici* Baranov (= *Simulium variegatum* Meigen).

Pseudosimulium Baranov (not Handlirsch), Neue Beitr. syst. Ins. **3**:164. 1926. Genotype: *Simulium argyreatum* Meigen.

Pseudonevermannia Baranov, Neue Beitr. syst. Ins. **3**:154. 1926. Genotype: *Simulium latipes* Meigen.

Pternaspatha Enderlein, Arch. Klassif. phylog. Ent. **1**:88. 1930. Genotype: *Pternaspatha nigristrigata* Enderlein.

Anasolen Enderlein, Arch. Klassif, phylog. Ent. **1**:94. 1930. Genotype: *Anasolen adolf-friedericianus* Enderlein.

Notolepria Enderlein, Arch. Klassif. phylog. Ent. **1**:95. 1930. Genotype: *Simulium exiguum* Roubaud.

Morops Enderlein, Arch. Klassif. phylog. Ent. **1**:93. 1930. Genotype: *Wilhelmia pygmaea* Enderlein.

Dasypelmoza Enderlein, Deut. ent. Zeit. **1933**:275. 1934. Genotype: *Simulium varipes* Philippi.

Acropogon Enderlein, Deut. ent. Zeit. **1933**:276. 1934. Genotype: *Acropogon barbatipes* Enderlein.

Ectemnaspis Enderlein, Deut. ent. Zeit. **1933**:281. 1934. Genotype: *Ectemnaspis macca* Enderlein.

Psilopelmia Enderlein, Deut. ent. Zeit. **1933**:283. 1934. Genotype: *Psilopelmia rufidorsum* Enderlein.

Thyrsopelma Enderlein, Deut. ent. Zeit. **1933**:284. 1934. Genotype: *Thyrsopelma brasiliense* Enderlein.

Trichodagmia Enderlein, Deut. ent. Zeit. **1933**:288. 1934. Genotype: *Trichodagmia latitarsis* Enderlein.

Hemicnetha Enderlein, Sitz. Ges. naturf. Freunde **1934**:190. 1934. Genotype: *Hemicnetha mexicana* Enderlein.

Psaroniocompsa Enderlein, Sitz. Ges. naturf. Freunde **1934**:192. 1934. Genotype: *Psaroniocompsa opalinifrons* Enderlein.

Aspathia Enderlein, Sitz. Ges. naturf. Freunde **1935**:359. 1935. Genotype: *Simulium hunteri* Malloch.

Psilocnetha Enderlein, Sitz. Ges. naturf. Freunde **1935**:359. 1935. Genotype: *Psilocnetha scapulata* Enderlein.

Titanopteryx Enderlein, Sitz. Ges. naturf. Freunde **1935**:360. 1935. Genotype: *Simulium maculata* Meigen.

Metomphalus Enderlein, Sitz. Ges, naturf. Freunde **1935**:361. 1935. Genotype: *Metomphalus caffer* Enderlein.

Danubeosimulium Baranov, Arb. morph. taxon. Ent. Ber. **2,3**:156-158. 1935. Genotype: *Simulium columbaczenae* (Schönbauer).

Cleitosimulium Seguy and Dorier, Trav. Lab. Hydrobiol. Pisciculture, Grenoble, **27**:9. 1936. Genotype: *Simulium (Cleitosimulium) rupicolum* Seguy and Dorier.

Psilozia Enderlein, Sitz. Ges, naturf. Freunde **1936:**113. 1936. Genotype: *Psilozia greenlandica* Enderlein.

Cryptectemnia Enderlein, Sitz. Ges. naturf. Freunde **1936:**114. 1936. Genotype: *Cryptectemnia laticalx* Enderlein.

Chelocnetha Enderlein, Sitz. Ges. naturf. Freunde **1936:**117. 1936. Genotype: *Chelocnetha biroi* Enderlein.

Pselaphochir Enderlein, Sitz. Ges. naturf. Freunde **1936:**120. 1936. Genotype: *Pselaphochir oculata* Enderlein.

Pliodasina Enderlein, Sitz. Ges. naturf. Freunde **1936:**124. 1936. Genotype: *Pliodasina guttata* Enderlein.

Miodasia Enderlein, Tierwelt Mitteleurop. **6,** 1f. ii (xvi):39. 1926. Genotype: *Miodasia opalinipennis* Enderlein.

Echinosimulium Baranov, Vet. Arkiv. **8:**313. 1938. Genotype: *Echinosimulium echinatum* Baranov.

Gnus Rubtzov, Bull. Acad. Sci. U.S.S.R. **1937:**1290 and Faune de l'U.S.S.R., Insectes Dipteres **6**(6):116. 363. 1940. Genotype: *Simulium decimatum* Dorogostajskij, Rubtzov and Vlasenke.

Hearlea Rubtzov, Faune de l'U.S.S.R., Insectes Dipteres **6**(6):116. 1940. Genotype: *Simulium canadense* Hearle.

Neosimulium Rubtzov, Faune de l'U.S.S.R., Insectes Dipteres **6**(6):116. 1940. Genotype: *Simulium vittatum* Zetterstedt.

KEY TO THE FEMALES OF *SIMULIUM* LATREILLE

1. Radius setose between the stem vein and the radial sector 2
—. Radius bare between the stem vein and the radial sector 5
2. Mesonotum with three dark vittae; subcosta bare ventrally; general appearance gray ..... *johannseni* Hart
—. Mesonotum without vittae; subcosta setose ventrally 3
3. Postnotum with a patch of yellow recumbent setae; mesonotum densely clothed with golden pile (occasionally silvery); legs bicolored ..... *aureum* Fries
—. Postnotum bare; mesonotum not as above; legs not bicolored 4
4. Ventral side of the costa basad of the humeral cross vein with pale setae, those on the dorsal side and the base of the stem vein dark; antennae entirely dark; wings clear ..... *croxtoni* n. sp.
—. Setae on the base of the costa and the stem vein entirely dark; antennae with the basal two segments distinctly lighter than the others; wings somewhat smoky ..... *latipes* Meigen.
5. Mesonotum with vittae 6
—. Mesonotum without vittae 9
6. Mesonotum with 5 vittae ..... *vittatum* Zett.
—. Mesonotum with 3 vittae 7
7. Claws simple; subcosta setose ventrally; a relatively large species ..... *pictipes* Hagen
—. Claws with thumb-like basal teeth; subcosta bare ventrally; relatively small species ..... 8.
8. Antennae with basal two segments distinctly paler; subcosta bare ventrally; abdomen with tergites 2 to 5 black ..... *occidentale* Towns.
—. Antennae entirely dark, basal two segments very slightly paler, if at all; abdomen with tergites of segments 2 to 5 no darker than the others; subcosta bare ventrally ..... *johannseni* Hart

9. Claws simple 10
—. Claws with basal or sub-basal teeth 13
10. Subcosta with a row of setae ventrally 12
—. Subcosta bare ventrally (*jenningsi* Malloch) 11
11. Each pupal respiratory tuft with 10 filaments ..... *jenningsi* subsp. *jenningsi* Malloch.
—. Each pupal respiratory tuft with 12 filaments ..... *jenningsi luggeri* n. subsp.
12. Terminal abdominal segments shining brown to black; upright setae on the scutellum black, recumbent setae pale; hair-like setae on the base of the wings pale ..... *venustum* Say
—. Terminal abdominal segments sub-opaque, rather bluish-gray pollinose; all segments except the first rather bluish-gray laterally and ventrally; upright and recumbent setae on the scutellum pale yellow and dark mixed; hair-like setae on the base of the wings usually pale with an occasional dark setae, sometimes entirely dark ..... *decorum* Walker
13. Claws with small, but distinct sub-basal teeth; subcosta setose ventrally ..... *corbis* Twinn
—. Claws with large basal teeth; subcosta without setae ventrally ..... *rugglesi* n. sp.

KEY TO THE MALES OF *SIMULIUM* LATREILLE[4]

(Based on external characters and the genitalia)

1. Radius setose between the stem vein and the radial sector 2
—. Radius bare between the stem vein and the radial sector 3
2. A few recumbent golden setae on the postnotum; setae on the scutellum golden; pleural tuft pale; legs bicolored ..... *aureum* Fries.
—. Postnotum bare; setae on the scutellum black; pleural tuft black; legs dark brown with hind basitarsus as wide as the tibia ..... *latipes* Meigen
3. Clasper with three to four or no terminal teeth 4
—. Clasper with a single terminal tooth 5
4. Clasper with three to four terminal teeth; adminiculum broad, convex above, not cleft medially ..... *vittatum* Zett.
—. Clasper without a terminal tooth; adminiculum broad and deeply cleft mesially ..... *pictipes* Hagen
5. Clasper tapered to a point and bearing a single terminal tooth; adminiculum broader than long, plate-like, thin from a lateral aspect, semi-membranous; mesonotum black without white patches ..... *occidentale Towns.*
—. Clasper bluntly rounded terminally and bearing a single tooth; adminiculum not as described above, heavily sclerotized; mesonotum with or without white pollinose markings 6
6. Adminiculum Y-shaped from the dorsal aspect 7
—. Adminiculum not Y-shaped from the dorsal aspect 8
7. Mesonotum velvety black, unmarked by white pollinose patches; legs dark but with dusky yellow markings visible; hind basitarsus about three fourths as wide as the tibia ..... *decorum* Walker

[4] Males of *S. croxtoni, S. rugglesi,* and *S. johannseni* unknown to the writers.

—. Mesonotum velvety black with white pollinose markings; legs practically all black except the front coxae and the pearlaceous spots on the front and middle tibiae; hind basitarsus almost as wide as the tibiae ..... *corbis* Twinn

8. Adminiculum with the basal arms each bearing a posteriorly directed sub-basal arm; hind basitarsus about half as wide as the tibia (*jenningsi* Malloch) 9

—. Adminiculum with the basal arms simple; adminiculum either stout and broad, or with the sides laterally compressed; with a large, smooth ventral projection best seen from the lateral aspect. Hind basitarsus about two thirds as wide as the tibia ..... *venustum* Say

9. Each pupal respiratory tuft with 10 filaments ..... *jenningsi* subsp. *jenningsi* Malloch

—. Each pupal respiratory tuft with 12 filaments ..... *jenningsi luggeri* n. subsp.

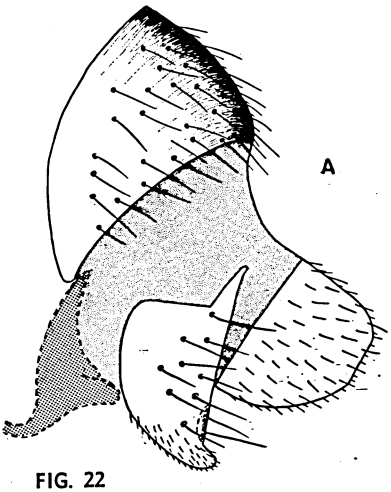
Simulium johannseni Hart

Simulium johannseni Hart, 27th Rept. State Ent. Ill. p. 32. 1912.
Simulium meridionale Malloch (part), U. S. Dept. Agr., Bur. Ent., Tech. Ser. No. 26, p. 49. 1914 *(apud* Dyar and Shannon *8)*.

Female: A small gray species with dark legs and three mesonotal vittae. Length 1.5 to 2 millimeters. Vertex gray pollinose with scattered pale setae; slightly narrower at the crown than the clypeus, sharply converging above the antennae. Clypeus gray pollinose, slightly longer than broad; sparsely covered with pale setae. Palpi dark brown to black. Antennae 11-segmented, dark brown to black, occasionally the basal two segments slightly paler. Mesonotum gray pollinose, moderately covered with short, white, hair-like pile; three longitudinal black to brown vittae present but sometimes rather indistinct, the two lateral ones converging somewhat anteriorly but ending before reaching the margin. Scutellum dark gray to black with upright pale setae; recumbent setae lacking. Postnotum black with shining pollinose reflections; bare. Pleurae gray pollinose; tuft white. Halteres yellow; bases dark, setose. Wings clear; a small basal cell present, but sometimes indistinct; hair-like setae on the stem vein and radial sector, but the setae are apparently easily lost and may be missing in many specimens; radial sector not enlarged at the tip; subcosta bare ventrally. Legs dark brown to black; coxae gray pollinose; tarsi black; calcipala small; pedisulcus deep and distinct, but often obscured by setae; claws with a large thumb-like basal tooth. Abdomen dark gray, sub-opaque, somewhat pollinose; tergites of segments 2 to 5 not noticeably blacker than the others; fringe thin, white.

Genitalia (figure 22, A and B): Ovipositor valves short, membranous, dark on the margins, setulose basally. Anal lobe about twice as broad as long; narrowed dorsally; produced slightly ventro-posteriorly with a

FIG. 22. Genitalia of *Simulium johanseni* Hart. A. Female assembled, B. Genital rod.
FIG. 23. Genitalia of *Simulium rugglesi* n. sp. A. Genital rod, B. Female assembled.
FIG. 24. Genitalia of *Simulium occidentale* Townsend. A. Clasper and side piece B. Genital rod, C. Female assembled, D. Adminiculum, E. Adminiculum arms.



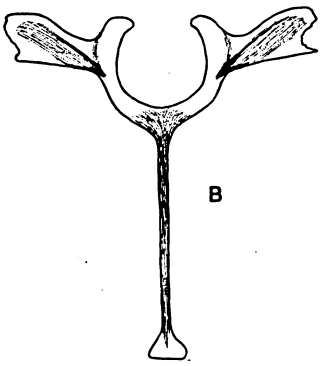
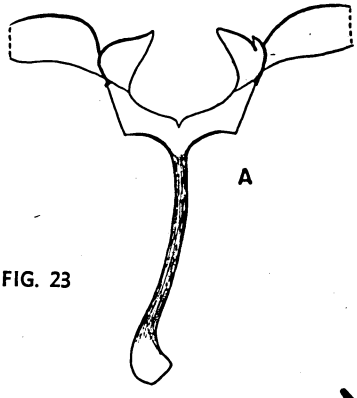


FIG. 22



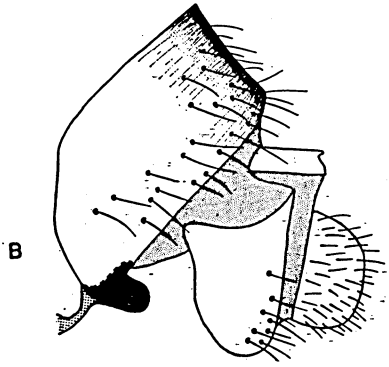
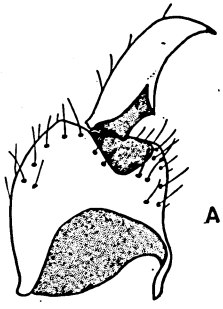
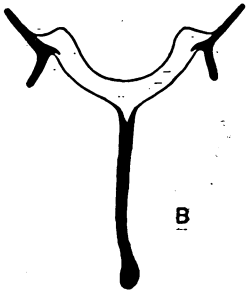
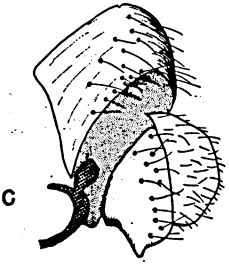
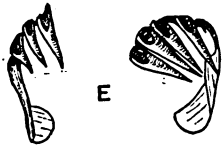


FIG. 23









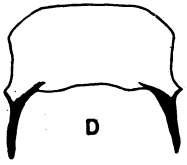


FIG. 24

small darkened indentation just dorsad of the projection. Cercus almost as wide as the anal lobe; two thirds as long as wide; rounded posteriorly. Stem of the genital rod heavily sclerotized, expanded at the tip; arms with a rounded, incurved appearance resulting from the presence of broad mesally directed basal flanges; distally directed flanges broad and flat, more or less sclerotized.

S. johannseni may be confused with *S. occidentale* Townsend which it superficially resembles. This is particularly true of specimens in which the setae have been rubbed from the radius between the stem vein and the radial sector. The following characters, other than the genitalia will distinguish it without difficulty: Radius between the stem vein and the radial sector setose; the presence of a small, rather indistinct basal cell in the wing; the antennae usually entirely dark, the basal two segments being slightly lighter only occasionally; the abdomen gray, rather than bluish-gray, and the tergites of segments two to five being no darker than the others (abdominal pleurae may be black on the basal segments).

Male: The writers have not seen the male of this species, but the following is quoted from the original description by C. A. Hart *(12):* "Slaty-black, invested with silvery white hair, rather long on the abdomen, becoming blackish on the anterior coxae, the second palpal joint, and the posterior face of the fore femora, moderately dense on the mesonotum and legs. Eyes contiguous, lower halves sharply differentiated as usual, their facets hardly one third diameter of those of the upper halves. Antennae and palpi black, antennae with minute silvery pubescence.

"Mesonotum with rather dense short silvery pubescence, that on disk with a faint golden tint. In certain lights three longitudinal dark lines are traceable—a pair distant about one-third the width of the mesonotum, curved broadly outward near middle and a median line between them. Scutellum with longer hairs directed medially; metanotum lustrous, slightly brownish, with microscopic pubescence.

"Abdomen with somewhat sparse silvery pubescence, longer anteriorly, especially on the sides of the first segment. Legs with silvery white pubescence arising from minute black points, the hairs in some lights slightly fuscous, and distinctly blackish on the posterior side of the fore femora. Surface beneath the pubescence yellowish fuscous; coxae mostly black; tips of femora, basal and apical thirds of fore tibiae and basal and apical fourths of middle and hind tibiae black, the lines of the separation sharply defined, the dark ends on the tibiae connected by a dark line along the extensor surface; tarsi black, the base of the fore metatarsus, sometimes, the basal half of the middle metatarsus, all but the extreme base and apex of the hind metatarsus, and often more or less of the second segment of the hind tarsus, yellowish; under side of fourth tarsal segment more or less yellowish. Hind metatarsus elongate, parallel-sided, about six times as long as broad, one half broader than the remaining tarsal segments, one third longer than the remaining segments together. Tarsal claws trifid. Halteres fuscous, wing veins yellowish, the costa and radius with black spines.

"Length, 2½ millimeters (alcohol specimens, about 4 millimeters): wing, about 3 millimeters."

Dyar and Shannon *(8)* describe the genitalia of the male as follows: "Side piece conical quadrate, as broad as long, ridge nearly central, reën-

rant angle of margin long. Clasper stout, smooth, tip obliquely truncate with rudimentary but large tooth on the angle, not so long as side piece, nearly half as thick. Adminiculum arcuate, somewhat truncate-tipped, hirsute, the basal prongs large, curved, thick, forming an arc wider than the adminiculum. Adminiculum arms with a small group of very long teeth at each outer fold, the conjoined portion inconspicuous. Lateral plates large, grooved on the margin."

Stains and Knowlton *(32)* give the following description: "Male with integument and antennae black; legs paler in color (than in the female); scutum with sparse pale pile; adminiculum truncate, with a small triangular notch on the dorsum, prongs divergent; adminiculum arms with four or five large teeth."

Pupa: Unknown to the writers. Hart described the pupal respiratory tufts as dividing close to the base and almost immediately again dividing to form four filaments on each side. He states that the cocoon is of the "wall pocket" type.

Distribution: *S. johannseni* Hart has been taken in Illinois (type locality, Havana, Ill.) Idaho, Massachusetts, Montana, and Ontario *(8)*. In Minnesota it has been collected in the following counties:

Kittson, May 15 through 23, 1941: 96 females.

Houston, May 21 through 23, 1937: 8 females.

Simulium aureum Fries

Simulia aureus Fries, Monogr. Simul. Suec., p. 16. 1824.

Simulium flavipes Stephens, Syst. Cat. British Ins., **2**:254. 1829. *(apud* Edwards 1915) *(31)*.

Simulium bracteatum Coquillet, U.S.D.A. Div. Ent. Bul. 10N.S., p. 69. 1898 *(apud* Twinn *39)*.

Simulium angustipes Edwards, Bul. Ent. Res. **6**:40. 1915 *(apud* Edwards 1920) *(31)*.

Eusimulium pilosum Knowlton and Rowe, Ann. Ent. Soc. Amer., **27**:580-81. 1934. *(apud* Stains and Knowlton *32)*.

Eusimulium utahense Knowlton and Rowe, Ann. Ent. Soc. Amer., **27**:582. 1934. *(apud* Stains and Knowlton *32)*.

Female: General appearance golden. Length, 2 to 3 millimeters. Integument brown to black. Head and mesonotum densely clothed with golden pubescence; occasionally silvery. Vertex of the head narrowed sharply to the antennae; clypeus gray with dense pile. Antennae 11-segmented dark brown, with the basal two segments light brown. Pleural area brown; pleural tuft pale. Scutellum brown, densely clothed with pale yellow upright and recumbent setae. Postnotum bare except for a few recumbent yellow setae posteriorly. Halteres pale; brown at their bases. Wings clear; hair-like setae on the stem vein and base of the costa, pale; other setae dark, those on the costa and basal two thirds of the radius mixed with spinules; subcosta with a row of setae on the lower surface; radius setulose dorsally on its entire length. Legs yellow, except the middle and hind coxae, the apices of the femora, tibiae and hind basitarsi, which are black; calcipala prominent and pedisulcus distinct; claws bifid. Abdomen densely clothed with golden to silvery pile; basal fringe pale yellow.

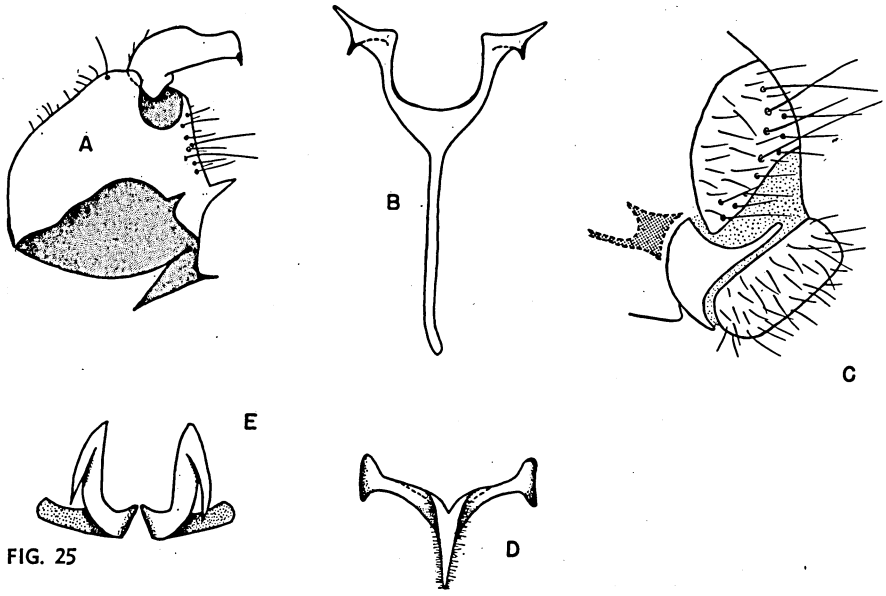


FIG. 25

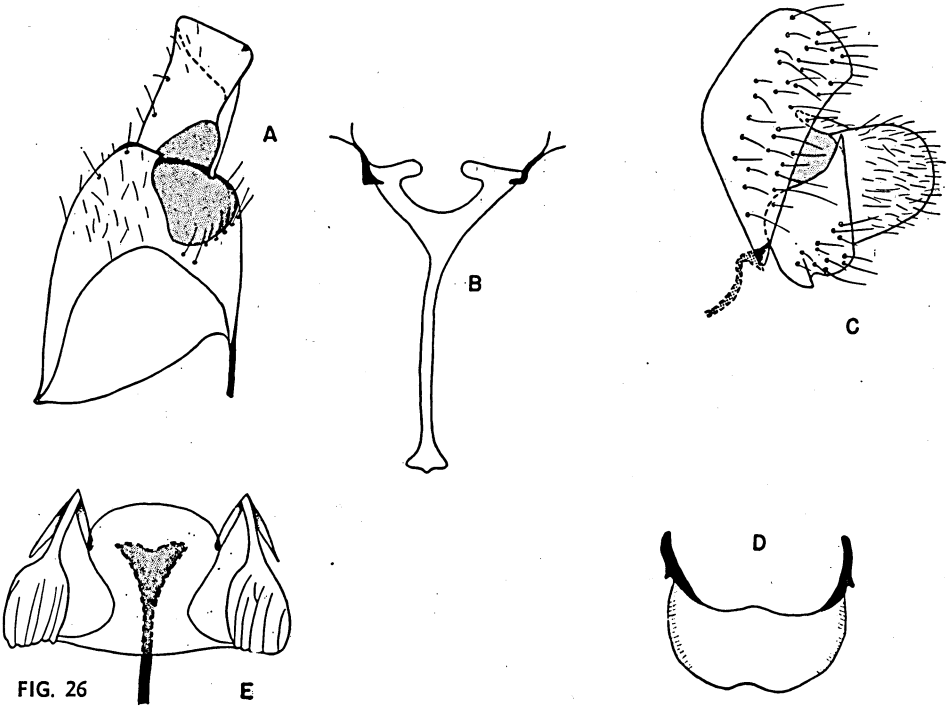


FIG. 26

Genitalia (figure 25, B and C): Ovipositor valves weakly sclerotized, conical, spicular; anal lobe shorter than cercus, curved beneath; setose only ventrally. Cercus quadrate, about twice as wide as long. Arms of the genital rod with a heavily sclerotized tooth ventro-distally; stem darkened, not expanded at the tip.

Male: General appearance velvety black. Antennae brown; basal two segments only slightly lighter. Mesonotum velvety black; in unrubbed specimens bearing golden pile, particularly on the antero-lateral and posterior margins. White pollinose spots absent. Scutellum dark with upright golden setae. Postnotum in unrubbed specimens bearing a few golden scales posteriorly. Pleurae brown; pleural tuft pale. Halteres brown to reddish-brown, pilose at the base. Wings with dark and light setae intermixed on the stem vein and base of costa; other setae dark; a few setae on the lower side of the subcosta. Legs as in the female, but somewhat darker, except that the hind basitarsi are entirely black. Abdomen velvety black with a few scattered golden setae; basal fringe black to dark brown.

Genitalia (figure 25, A, D, and E): Side pieces conical, quadrate. Clasper small with a single tooth. Adminiculum narrow, hirsute, the basal arms widely divaricate and expanded terminally. Adminiculum arms consisting of broad sclerotized plates and a single pair of large heavily sclerotized spines.

This species resembles somewhat *S. latipes* Meigen. The females may be separated from this and other species known to occur in Minnesota on the basis of the dense golden pilosity of the mesonotum, the possession of a few yellow recumbent setae on the postnotum, the pale hair-like setae on the stem vein and base of the costa, and the possession of bicolored legs. The males may be distinguished by the possession of golden hair-like setae on the scutellum, a few recumbent golden setae on the postnotum, the pale pleural tuft, and the bicolored legs.

Pupa: Gill filaments about as long as the pupa, four in each tuft arising from a short trunk as follows: Two, slightly smaller than the others, branching off together ventrally from the base of the trunk; the dorsal trunk extending on for about one tenth millimeter before branching into the remaining two filaments. The cocoon is of the typical wall vase type, tightly woven, with the ventro-lateral edges extended well forward and the anterior lip thickened. The "slightly median salient" at the anterior margin mentioned by Twinn *(39)* is not evident in the writers' specimens.

Distribution: This species occurs widely over North America *(32)*, *(39)*, *(8)*, *(17)*, and is, in fact, Holarctic in distribution, (31). It is not abundant in Minnesota and to date has been taken only from the eastern part of the State. Minnesota records are as follows:

Chisago County, Taylors Falls, September 15, 1940.

Pine County, May 28, 1938.

Ramsey County, St. Paul, Battle Creek State Park, July 2, 5, 24 through 28; August 7 through 10; September 19, 1939 (reared).

FIG. 25. Genitalia of *Simulium aureum* Fries. A. Clasper and side piece, B. Genital rod, C. Female assembled, D. Adminiculum, E. Adminiculum arms. FIG. 26. Genitalia of *Simulium latipes* Meigen. A. Clasper and side piece, B. Genital rod, C. Female assembled, D. Adminiculum, E. Adminiculum arms.

St. Louis County, October 4, 1941.
Wabasha County, Wabasha, October 9, 21 through 23, 1941 (light trap).
Number of specimens examined: 53.

Simulium latipes Meigen

Simulium latipes Meigen, Klass. 1, 96.5. 1804; Syst. Beschr. 1, 297.11. 1818.

Female: Length 1.5 to 2.5 millimeters. General appearance brown with the mesonotum moderately covered with golden pile. Vertex and the clypeus brown, slightly gray-pollinose; sparsely setulose. Vertex narrow toward the crown, abruptly narrowed at the antennae. Clypeus one to one third times as long as broad. Antennae 11-segmented, brown with the basal two segments somewhat paler. Palpi brown. Mesonotum brown, moderately covered with recumbent, short, golden pile. Scutellum lighter brown bearing numerous upright and recumbent yellow hair-like setae. Postnotum brown, bare. Pleural area brown, with gray pollinosity; pleural tuft pale. Halteres pale; bases brown. Wings somewhat smoky, setae on the stem vein and base of costa brown to black; other setae dark, those on the costa and distal two thirds of the radius mixed with spinules; radius setose dorsally on its entire length; subcosta and radial sector strongly setose beneath. Legs brown; calcipala prominent; pedisulcus distinct; claws with a large, thumb-like sub-basal projection. Abdomen brown, unmarked; basal fringe pale.

Genitalia (figure 26, B and C): Ovipositor valves small, conical, membranous, slightly sclerotized on the inner margins. Anal lobe semi-quadrate, setose on the ventral half; with a short antero-ventral projection. Cercus rounded posteriorly, as long as wide. Arms of the genital rod broad, lightly sclerotized, each bearing a rounded mesally directed lobe and a small, blunt, heavily sclerotized tooth; stem somewhat darker with an expanded base.

Male: General appearance velvety black. Antennae, clypeus and palpi black. Mesonotum velvety black with scattered recumbent golden setae, especially at the anterior margin, laterally and posteriorly; without markings. Scutellum dark brown with upright black setae; postnotum bare. Pleural area dark brown; tuft black. Wings the same as in the female except that the lower surface of the subcosta may have a few setae or none and those on the lower surface of the radial sector are not so numerous. Halteres black to dark brown setose on the base. Legs dark brown, tarsi darker; hind basitarsus greatly inflated, almost one third as wide as long, as wide as the tibia; calcipala prominent; pedisulcus distinct. Abdomen velvety black, unmarked; basal fringe black.

Genitalia (figure 26, A, D, and E): Side piece quadrate, longer than broad. Clasper angular about two thirds length of side piece, with single spine at tip. Adminiculum moderately sclerotized, twice as wide as long, broadly rounded distally and arched tent-like mesally; basal prongs prominent and heavily sclerotized. Adminiculum arms heavily sclerotized, broadly rounded; tips with two large posteriorly directed spines arranged to resemble arrow heads; the arms connected by large heavily sclerotized, rounded plate, somewhat constricted toward base.

This species resembles *S. aureum* Fries, but may be separated from it by the following characteristics. In the females the golden pile of the

mesonotum is not so heavy, the postnotum is bare, the setae on the stem vein and base of the costa are brown to black, and the legs are entirely brown. The males are easily separated by the possession of a bare postnotum, black setae on the scutellum, a black pleural tuft, dark brown legs with darker tarsi, and inflated hind basitarsi.

Pupa (figure 4): Length 3.2 millimeters to 3.8 millimeters with filaments 4 millimeters in length, the ventral pair being shorter than those dorsal to them. Four filaments to each tuft arising from a short main trunk in two distinctly stalked pairs held in the vertical plane. The cocoon is the wall vase type, densely woven, with the anterior margin thickened. The dorso-anterior margin is extended forward as a flat projection 5 millimeters to 1.2 millimeters long.

Distribution: Alaska *(17)*, Eastern Canada, Europe *(35)*, and Eastern Siberia *(7)*. The species is apparently not abundant in Minnesota. It has been collected in the state as follows:

Lake County, near Isabella, May 31, 1941 (reared).

Koochiching County, west of International Falls, June 2, 1941 (1 pupa).

Number of specimens examined: 11.

Simulium croxtoni n. sp.

Female: Length about 2 millimeters. Vertex as broad as the clypeus, narrow above the antennae, light gray pollinose, moderate to densely covered with white hair-like setae. Clypeus bluish-gray pollinose, longer than broad, moderately white setose. Antennae 11-segmented, dark brown with the basal two segments very slightly paler on some specimens. Palpi dark brown. Mesonotum dark brown to black, somewhat gray pollinose; moderately covered by hair-like setae, those on the margins white, while those on the disk are brassy yellow. (On paratype specimens the pile is entirely white.) Scutellum dark brown with upright and recumbent pale setae. Postnotum dark brown, shining pollinose. Pleural area bluish-gray pollinose; membranous areas brown; tuft white. Halteres pale; bases dusky, setose. Wings clear; hair-like setae on the costa between the humeral cross vein and the base of the wing white ventrally and dark dorsally; those on the vein long and rusty brown in color; setae on other veins dark; subcosta with a row of setae ventrally; radius setose dorsally on its entire length. Legs mostly brown; front coxae gray pollinose, coxae, femora and tibiae densely covered by white setae; tarsi black, dark setose; calcipala and pedisulcus present; claws with large basal and sub-basal teeth, the sub-basal tooth being the longer. Abdomen with the basal scale pale dorsally; fringe long and white; remaining segments dark brown, sub-opaque; pilosity hair-like, most dense laterally and terminally; white except on the terminal segments where a few dark setae may be found.

Genitalia (figure 20, A and B): Ovipositor valves short and membranous, darkened at the inner margins. Anal lobe broader than long, narrow dorsally, expanded mesally; the antero-ventral margin produced as a broad lobe; the postero-ventral margin indented; setose on the posterior half. Cercus broadly rounded. Stem of the genital rod sclerotized; crotch with an indentation caused by mesal expansions of the bases of

the arms; arms membranous, gradually expanded at the tips, the ventral margins sclerotized narrowly; a small tooth present about midway from the crotch to the tip of the arms.

This species somewhat resembles the females of *S. latipes* Meigen, but may be separated from it by the genitalia, the possession of clear wings, pale setae on the ventral side of the costa basad to the humeral cross vein and dark setae dorsally, and the dark antennae.

Pupa: Respiratory filaments of about equal length and thickness, and approximately five eighths the length of the pupa. Each tuft with eight filaments arising from a short trunk as follows: a pair of filaments arising from a short-stemmed dorsal branch; a shorter stalked lateral branch which produces a single filament ventrally near its base and a relatively long-stemmed dorsal pair; and a ventral branch which divides into a single dorsal filament and a short-stemmed ventral pair. The stem of the main lateral branch is about one half the length of that of the main dorsal branch which is, in turn, about one half the length of the stem of the main ventral branch.

The cocoon is of the wall vase type and is rather loosely woven. The anterior margin is thickened and protruded dorso-medially as a short, flat projection similar to that which occurs on the cocoon of *S. latipes* Meigen. The pupae were collected in association with *S. latipes*.

Holotype: Female, Koochiching County, Minnesota, west of International Falls, June 2, 1941 (reared). University of Minnesota collection.

Paratypes: Same place data (1 female). Same place data, June 11, 1941 (reared) (1 female). International Falls, Koochiching County, Minnesota, July 10, 1941 (1 female).

Males unknown.

This species is named in honor of Dr. W. C. Croxton, Head of the Science Department, St. Cloud State Teachers College, St. Cloud, Minnesota, a friend and former teacher of the senior author.

Simulium vittatum Zetterstedt

Simulium vittatum Zetterstedt, Ins. Lappan. Dipt., p. 803. 1838.

Simulium tribulatum Lugger, Insects Injurious in 1896 (2nd report of State Entomologist), U. Minn. Agr. Expt. Sta. Bul. 48, p. 205. 1897. *(apud* Washburn *45)*.

Simulium glaucum Coquillett Proc. U.S. Nat. Mus. **25**:97. 1903. *(apud* Dyar and Shannon *8)*.

Simulium dahlgrüni Enderlein, Deut. Tierärztl. Woch. Hanover, p. 43. 1921; Zool. Anz. **53**:45. *(apud* Dyar and Shannon *8)*.

Female: Length 2 to 3 millimeters. Head gray, sparsely covered with white setae; vertex broad, not narrowly constricted above the antennae; clypeus about as broad as long with numerous white setae; palpi black to brown with pale setae; antennae 11-segmented, black with pale pilosity, basal two segments on some specimens brownish. Mesonotum gray with sparse white pilosity; five black to brown longitudinally occurring mesonotal vittae present, the median one longest and most prominent, traversing the length of the disk; the pair on each side of the median vitta shorter and situated on the posterior half of the mesonotum; and the

lateral pair sometimes indefinite and elongate spot-like occurring mesally from anterior to posterior on the disk. Scutellum black to dark brown with some gray pollinosity; clothed with long white setae. Postnotum dark with gray pollinosity, smooth, velvety. Pleural region gray; pleural tuft white. Halteres pale, the bases darkened. Wings clear; veins pale; the veins at the base of the wings slightly yellowed; hair-like setae on the stem vein and base of the costa white; radius bare between the stem and the radial sector; radial sector with a single row of setae ventrally; subcosta bare ventrally. Legs yellow and black with gray pollinosity; coxae gray pollinose; trochanters and femora varying from yellowish-brown to black; front tibiae of all legs yellow on the basal half to two thirds, but remainder black; front surfaces of anterior pair of tibiae bearing a rather indefinite white pollinose area; front tarsi entirely black; basal half of middle and hind basitarsi and basal half of the second tarsal segment of the hind legs yellow; remainder of tarsi black; calcipala small; pedisulcus distinct; claws simple. Abdomen gray; dorsum of the second segment with a median black spot; segments 3 to 7 with a posteriorly tridentate black cross band dorsally, remaining segments darkened; segments 3 to 7 with small black spots in the pleural region and paired black spots ventrally in some specimens, although the latter may be indefinite; eighth sternite heavily sclerotized and bearing a fringe of heavy setae along the posterior margin; remaining tergites membranous and relatively hairless.

Genitalia (figure 28, A and B): Valves of the ovipositor membranous. Anal lobe about twice as broad as long, evenly setose; produced ventrally as a finely setose conical lobe. Cercus setose and rounded distally. Expanded portions of the genital rod quadrate; inner margins produced; stem heavily sclerotized and slightly expanded at the tip.

Male: Opaque, velvety black. Mesonotal markings extremely variable; sometimes black with the mere hint of two white pollinose spots on the anterior margin; frequently with two short, rather indefinite pale stripes extending posteriorly from two well-defined white spots; occasionally having the disk largely pollinose gray with darker margins and three black vittae in addition to two lateral dark patches and two large white pollinose spots on the anterior margin. Margins of the mesonotum usually pearlaceous gray; pilosity hair-like, moderate; yellow. Pleural area brown with gray pollinosity; pleural tuft pale. Legs as in female, but darker. Setae on stem vein of wings and base of costa variable in color. Halteres yellow to reddish-yellow. Abdomen velvety black with silvery pollinose area laterally on segments 2, 5, 6, 7, and 8. In some specimens this silvered area is restricted to segment 2. Basal fringe brown.

Genitalia (figure 28, C, D, and E): Side piece longer than broad, conical. Clasper shorter than side piece, with three to four terminal teeth. Adminiculum broad, convex above; rather weakly sclerotized, hirsute on the terminal margin; basal prongs short. Adminiculum arms bearing a few elongate teeth.

This species is very close to *S. pictipes* Hagen, but is somewhat smaller. The females may be readily separated on the difference in the number of mesonotal vittae, the genitalia, and the absence of a dense fringe on the tergite of the seventh abdominal segment. The males are more difficult to distinguish, except by means of the genitalia, but can be separated by the presence of a white pollinose area on the dorsal face of the front tibiae.

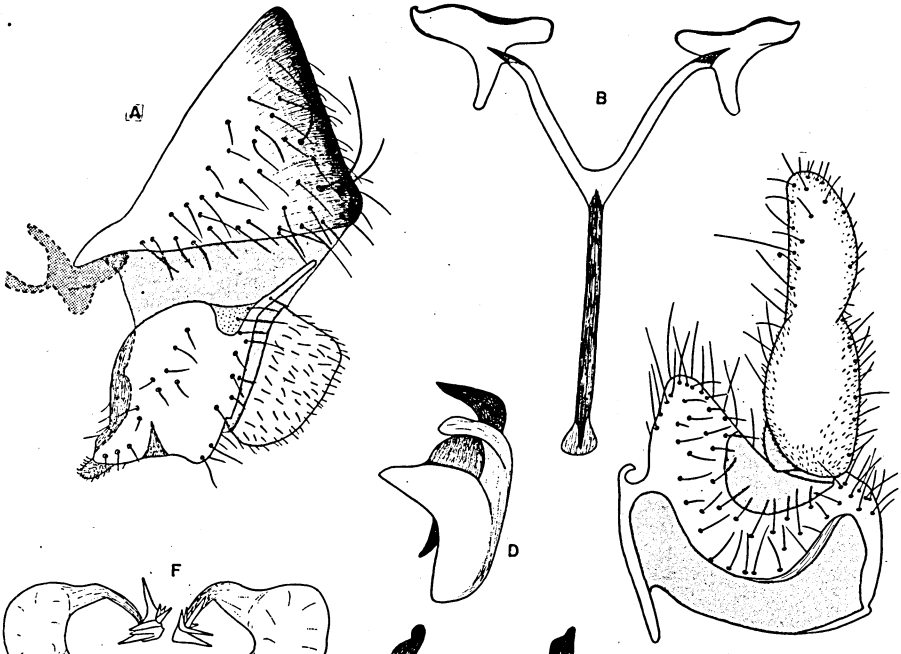


FIG. 27

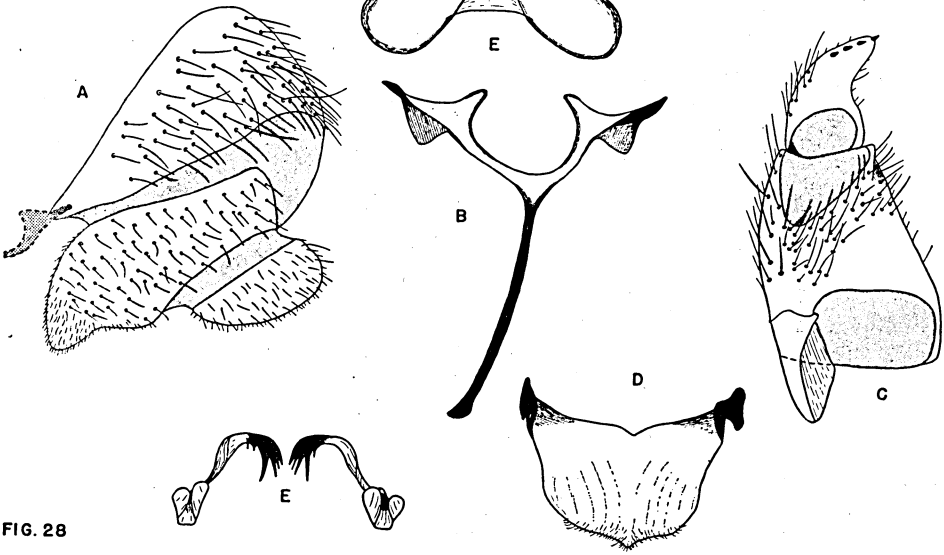


FIG. 28

Pupa: The cocoon is wall vase shaped, densely woven and with the tip thickened. Pupal gill filaments usually 16 in number, but occasionally having as few as 14 or 15. The tuft consists of a short main trunk which branches typically as follows: A dorsal branch which divides near its base into two; the ventral of these divides again into two filaments, the dorsal divides into two, which may again divide making a total of six filaments. A short-based ventral branch emerging from the trunk opposite the main dorsal branch which divides and subdivides into four filaments. A short-based terminal branch which divides into six filaments in the same manner as the dorsal branch.

Distribution: This is a species which is widely distributed over North America from Mexico to the Arctic, and is common in Europe *(39)*. It is probably the most abundant and widely distributed species in Minnesota, having been taken in the following counties:

Aitkin: May 1939, 1940.
Anoka: April 1939, 1942; May 1939, 1940, 1941; June 1938, 1939; July 1939; September 1938.
Big Stone: May 1938.
Carlton: July 1935, 1939.
Carver: June 1939.
Cass: May 1939; September 1941.
Clearwater: June 1938, 1941; July 1938.
Crow Wing: May 1939; June 1939; August 1938; September 1939; October 1938, 1939.
Goodhue: May and June 1939.
Hennepin: April 1939; May 1939, 1940; June 1939; July 1925; September 1938.
Isanti: May 1939.
Itasca: July 1939; August 1896.
Kittson: May 1941; June 1941; July 1937, 1940.
Lake: July 1935.
Lake of the Woods: May 1941; July 1941.
Lincoln: June 1938.
Marshall: May 1941; July 1941.
Mille Lacs: June 1939; August 1938.
Morrison: June 1939.
Olmsted: No date given.
Pine: May 1938, 1940, 1941.
Polk: June 1937, 1940, 1941; July 1935, 1937.
Ramsey: April 1940; May 1932, 1939, 1941, 1948; June 1938, 1939; July 1939; August 1938; September 1938; October 1938.
Redwood: June 1938.
Scott: April 1939; August 1938.
Sherburne: August 1938.
Wabasha: May 1939; July 1941; October 1941.

FIG. 27. Genitalia of *Simulium pictipes* Hagen. A. Female assembled, B. Genital rod, C. Clasper and side piece, D. Adminiculum, lateral, E. Adminiculum, dorsal, F. Adminiculum arms. FIG. 28. Genitalia of *Simulium vittatum* Zett. A. Female assembled, B. Genital rod, C. Clasper and side piece, D. Adminiculum, E. Adminiculum arms

Wadena: June 1938.
Winona: May and June 1939.
Wright: July 1940.
Number of specimens examined: 664.

Simulium pictipes Hagen

Simulium pictipes Hagen, Proc. Bos. Soc. Nat. Hist., **20**:305. 1879.
Simulium innoxium Comstock, Manual for the Study of Insects, p. 453. 1895. *(apud* Malloch *21).*

Female: Length, 3 to 4 millimeters. Vertex and clypeus grayish; antennae 11-segmented brown with basal two segments reddish-brown; palpi brown to black. Mesonotum opaque gray, finely clothed with white pilosity and bearing three longitudinal black vittae, the lateral two expanded anteriorly and converging toward the center anteriorly. When viewed from the rear these expanded areas appear as two white pollinose spots. Scutellum dark gray to brownish. Postnotum smooth, hairless, velvety gray, opaque. Pleural tuft white. Veins at base of wings and halteres orange-yellow to reddish-brown. Hair-like setae on the stem vein white and black mixed; those on the costa basad of the humeral cross vein entirely black; subcosta and radial sector with a single row of hairs ventrally; radius bare between the stem vein and the radial sector. Abdomen gray with tergites of segments 3 to 5 opaque black, the markings undivided; basal scale brown with a pale fringe; seventh sternite lightly pigmented, possessing a dense fringe of heavy black setae posterior to the middle; distal margin smooth and hairless; eighth sternite heavily sclerotized and bearing a fringe of shorter setae along the posterior margin. Legs grayish brown with only the bases of the tibiae and basal half of the first tarsal segments of the middle and hind legs yellow; other tarsal segments brown to black; claws simple; calcipala and pedisulcus prominent.

Genitalia (figure 27, A and B): Ovipositor valves narrow, thin, membranous. Anal lobe more or less quadrate, rather sparsely clothed with setae and with a partly membranous projection, which is densely spiculate, extending antero-ventrally. Cercus rounded quadrangular; twice as wide as long; setose. The expanded parts of the arms of the genital rod triangular when viewed ventrally, each possessing a single tooth; stem heavily sclerotized and with the tip expanded.

Male: General appearance opaque velvety black. Antennae brownish with basal two segments slightly paler. Mesonotum velvety black with margins gray; two white pollinose antero-dorsal spots visible when viewed from the posterior; pilosity fine, sparse and golden. Mesonotal markings somewhat variable according to Malloch *(21)*. Scutellum densely clothed with long golden-brown setae. Pleurae grayish with pleural tuft pale. Veins at the bases of the wings brown; halteres orange to reddish brown; subcosta bare. Legs brown paling toward yellow at the bases of the hind tibiae and basitarsi. Abdomen velvety black dorsally with segments 2, 5, and 6 silvered laterally, basal fringe golden brown shading to pale at the tips of the setae.

Genitalia (figure 27, C, D, E, and F): Side piece quadrate, outer angle produced. Clasper longer than side piece, constricted in the middle, and

without a terminal tooth. Adminiculum broad, weakly sclerotized, minutely hirsute, and deeply cleft mesally. Viewed laterally the basal prongs are seen to be recurved and the body is produced triangularly corresponding to the mesal cleft. Adminiculum arms with a few strong teeth and the lateral plates broad.

This species is very close to *S. vittatum* Zett., but may be separated readily in the female sex on the basis of the difference in the number of mesonotal vittae, the possession of a dense fringe of heavy setae on the sternite of the seventh abdominal segment, and the genitalia. The males are more difficult to distinguish, but may be separated on the basis of differences in the genitalia and the absence of a white pollinose area on the dorsal face of the front tibiae.

Pupa: The writers have not seen the pupa of this species. The description as given by Twinn *(39)* is as follows: "Length 3.5 to 5 millimeters. The respiratory tuft is about two fifths as long as the pupa, and consists of nine rather stout filaments, eight of them arranged in pairs on very short stalks and the ninth arising directly from the short main trunk. The cocoons are boot-shaped, with open weave, and the anterior margin not thickened. The pupa and its respiratory filaments lie concealed within the cocoon."

Distribution: This species has been taken from New York, Maryland, District of Columbia, Virginia, South Carolina, Indiana, and from Ontario and Quebec in the vicinity of Ottawa *(39)*, *(8)*, *(21)*. In Minnesota it is rare, having been collected as follows:

Cook County, October 11, 1933: 1 female from the ear of a moose.

Ramsey County, St. Paul, July 22 through August 15, 1901 (O. A. Johannsen). Reported by Dyar and Shannon *(8)*.

Simulium occidentale Townsend

Simulium occidentale Townsend, Psyche **6**:107. 1891.

Simulium tamaulipense Townsend, Journ. N. Y. Ent. Soc. **5**:171. 1897 *(apud* Dyar and Shannon *8)*.

Simulium forbesi Malloch, U. S. Dept. Agr., Bur. Ent., Tech. Ser. No. 26, p. 63. 1914 *(apud* Dyar and Shannon *8)*.

Female: A small gray species with dark legs and three mesonotal vittae. Length 1.7 to 2 millimeters. Vertex gray pollinose with scattered pale setae; sharply converging above the antennae. Clypeus gray pollinose; slightly longer than broad; sparsely covered with pale setae. Palpi dark brown to black. Antennae 11-segmented, dark brown with the basal two segments paler. Mesonotum gray pollinose, moderately covered with short white hair-like pile; three longitudinal black vittae present but rather indistinct in some specimens, the two lateral ones converging somewhat anteriorly but ending before reaching the margin. Scutellum black with upright and a few recumbent pale setae. Postnotum dark brown, shining, bare. Pleurae bluish-gray pollinose, shining; tuft pale. Halteres pale; bases dusky, setose. Wings clear, hair-like setae on the stem vein and base of costa white; radius bare dorsally between the stem vein and the radial sector. Legs dark brown; coxae gray pollinose; tarsi black; calcipala and pedisulcus present; claws with a large thumb-like

basal tooth. Abdomen bluish-gray; tergites of segments 2 to 5 black; fringe white.

Genitalia (figure 26, B and C): Ovipositor valves membranous, angular but with the tips rounded; without setae. Anal lobe broader than long, produced ventrally to an acutely angled point. Cercus more or less triangularly rounded. Stem of the genital rod heavily sclerotized, expanded at tip; arms heavily sclerotized at tips, pointed, with long ventral tooth.

Male: Antennae dark brown to black, the basal two segments usually slightly lighter. Clypeus black, gray pollinose. Palpi dark brown to black. Mesonotum velvety black, opaque; appearing white frosted when viewed from the anterior aspect with one to three narrow black vittae visible in some specimens; pilosity sparse, pale to yellow, most apparent at the antero-lateral angles. Scutellum dark brown, with upright brown setae. Postnotum brown to black with shining pollinose reflections. Pleurae gray pollinose with the membranous areas brown; tuft dark. Legs entirely black. Wings clear; hair-like setae black. Halteres dark. Abdomen velvety black, lighter ventrally; without lateral pollinose spots; fringe long and black.

Genitalia (figure 26, A, D, and E): Side piece longer than broad. Clasper about as long as the side piece, tapered and bearing a single terminal tooth. Adminiculum semi-membranous, broader than long; narrow from the lateral aspect; basal arms heavily sclerotized, short. Adminiculum arms with small basal plates; bearing three to four stout teeth.

The females of *S. occidentale* may be confused with those of *S. johannseni* because setae on the radius between stem vein and radial sector on the latter are easily lost. It may be distinguished from this species, however, by two basal segments of the antennae usually being paler than the more distal segments, the blue-gray abdomen with tergites 2 to 5 black, and differences in genitalia, especially of the genital rod.

Pupa: Unknown to the writers.

Distribution: *S. occidentale* has been recorded from the midwestern section of the United States westward and southward. In addition, it has been taken from District of Columbia, Manitoba, and Alaska (Dyar and Shannon *8)*. In Minnesota, it has been collected in these counties:

Dakota: June and July 1938.
Hennepin: July (year not indicated).
Houston: May 1936, 1937, 1939, 1941.
Kittson: June 1941.
Lac Qui Parle: June 1921.
Olmsted: No date given.
Polk: June 1940.
Ramsey: June 1920, 1921.
Wabasha: May 1939, October 1941.
Winona: May 1936.
Number of specimens examined: 191.

Simulium venustum Say

Simulium venustum Say, Journ. Acad. Sci. Phila. **3**:28. 1823.
Simulium molestum Harris, Ins. Injur. to Veg., ad. **3**:601. 1862 *(apud* Coquillett) *(31)*.

Simulium piscidium Riley, Amer. Ent. 2:367. 1870 *(apud* Coquillett) *(31).*
Simulium minutum Lugger, Ins. Injur. in 1896 (2nd report State Entomologist), U. Minn. Agr. Expt. Sta. Bul. 38, p. 201. 1897 *(apud* Washburn *45).*
Simulium irritatum Lugger, *ibid.* pp. 203-204. *(apud* Washburn *45).*
Simulium austeni Edwards, Bul. Ent. Res. 6:33. 1915. *(apud* Edwards 1920) *(31).*
Simulium arakawae Matsumura, Dia Nippon Gaichu Zensho (ed. 3) 2:85. 1921 *(apud* Kono and Takahasi) *(31).*
Simulium rileyana Enderlein, Konowia, 1:75. 1922 *(apud* Dyar and Shannon *8).*

Female: A gray to black species extremely difficult to differentiate from closely related species. Length, 1.5 to 2.6 millimeters. Vertex glossy brown to black with light pollinosity; as wide at the crown as the clypeus; moderately narrowed at the antennae; a short remnant of the epicranial suture visible immediately dorsad of the antennae, setae pale and sparse. Clypeus light gray pollinose, opaque; quadrangular, as broad as long; sparsely white setose. Antennae 11-segmented, dark brown, the basal two segments and the proximal half of the third pale brown. Mesonotum shining dark brown or black; in undamaged specimens with gray pollinosity, lightest at the antero-lateral and lateral margins; pubescence, pale, minute, moderately dense. Scutellum dark brown with upright black setae and numerous recumbent pale hair-like setae. Postnotum bare, shining brown with silvery pollinose reflections. Pleurae gray pollinose, shining with the membranous areas brown; tuft mostly pale, but with a few dark setae present in some specimens, the color hard to determine from some angles. Halteres pale yellow, the bases brown. Wings with hair-like setae on the stem vein and base of the costa pale, others mostly pale; a row of setae present on the underside of the subcosta; the radius bare dorsally between the stem vein and the radial sector. Legs mostly yellow but darkened on the middle and hind coxae, the femora and tibiae apically, the tarsi except the basal half of the middle and hind basitarsi and the second hind tarsus basad of the pedisulcus; pollinose areas dorsally on the tibiae, but this is more prominent in some specimens than others; calcipala and pedisulcus prominent; claws simple. Abdomen with basal fringe pale; second segment silvery pollinose laterally; segments 3 to 5 velvety black, opaque; remaining segments shining brown to black.

Genitalia (figure 30, A and B): Ovipositor valves small membranous, but darkened along the edges; with a number of setae. Anal lobes acutely triangular, narrowly tapered dorsally; broader than long; evenly setose. Cercus about two thirds as broad as the anal lobe; evenly rounded distally. Stem and arms of the genital rod moderately to heavily sclerotized, not swollen at the tip; arms terminating in heavily sclerotized expansions, each with a long blunt tooth; crotch usually without a crescent-shaped darkened membrane.

Male: Antennae brown, basal two segments lighter. Clypeus dark brown with pollinose reflections. Mesonotum opaque velvety black with somewhat variable pearlaceous pollinose markings. These markings are most apparent at the anterior and posterior of the mesonotum. Anteriorly they may appear as two triangular spots as broad at the base as long, or as a pair of very small spots at the antero-lateral margins. A compromise

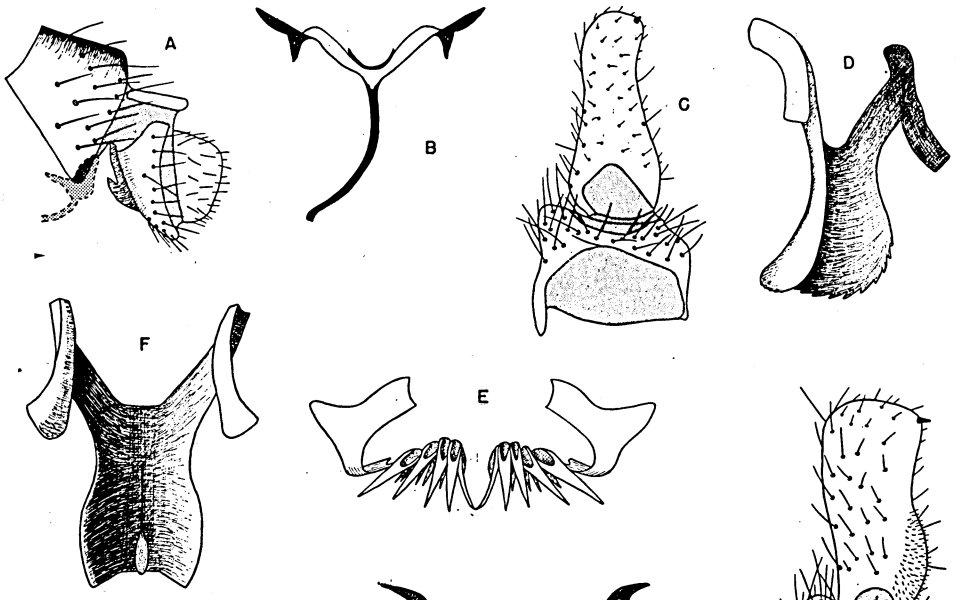
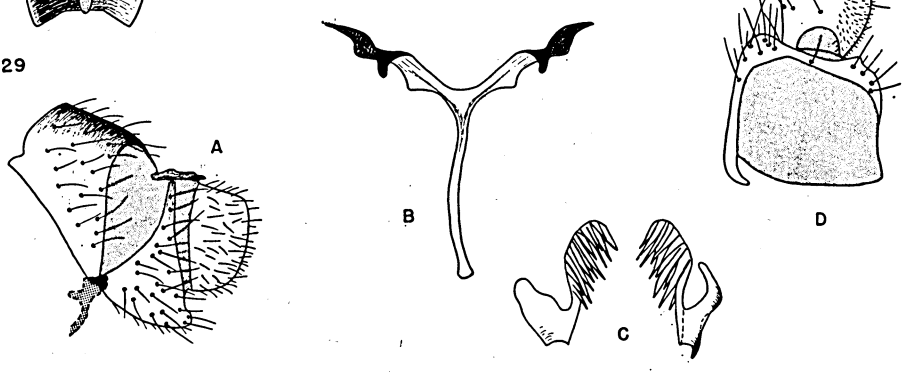


FIG. 29



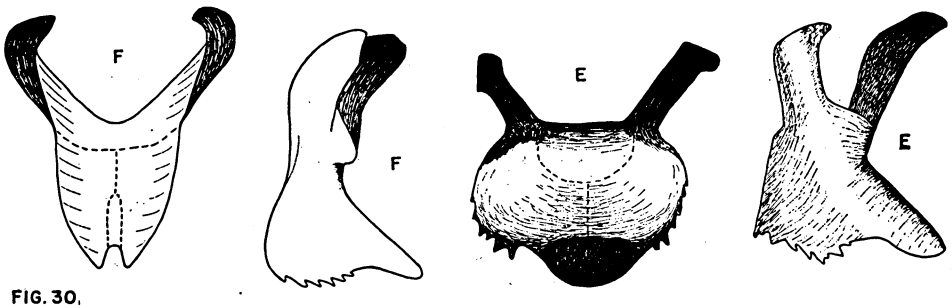


FIG. 30.

between these two extremes is probably most common when the pearlaceous areas appear as backward and inwardly directed stripes. The pubescence of the mesonotum is golden-brown to yellow, most conspicuous around the margins. Scutellum brown with dark upright setae; recumbent pale setae present or absent. Postnotum black, shining with pollinose reflections. Pleurae gray pollinose; tuft black. Halteres pale yellow with bases dark and setose. Wings clear; hair-like setae on the veins black; subcosta bare. Legs mostly dark except the following which are yellow: fore coxae, femora and tibiae narrowly basally, proximal halves of middle and hind basitarsi and second hind tarsus. Dorsal surfaces of front and middle tibiae with a silvery pollinose area, hind tibiae with a short silvered spot basally; hind tibiae and basitarsi somewhat inflated; hind basitarsus about two thirds as wide as tibiae. Abdomen opaque black, with conspicuous lateral pearlaceous markings on segments 2, 6, and 7; basal fringe black.

Genitalia (figure 30, C, D, E, and F): Side piece quadrate wider than long. Clasper nearly twice as long as the side piece, blunt, with a single tooth at the tip. Shape of the adminiculum of two types: in one (F) the sides are laterally compressed with the terminal teeth not visible when viewed dorsally; in the other (E), the adminiculum is broad with the terminal teeth and the large ventral projection visible from the dorsal aspect. From the lateral aspect both types are roughly plow-shaped with a large, smooth ventral projection and with the disto-lateral edges coarsely serrate. Adminiculum arms with numerous long, coarse teeth.

The females of *S. venustum* may be distinguished from similar Minnesota species by the unmarked mesonotum, bicolored legs, simple claws, the presence of setae on the ventral side of the subcosta, the upright black setae on the scutellum, and the shining brown to black terminal segments of the abdomen. The males are most similar to those of *S. jenningsi* Malloch, but the hind basitarsus is about two thirds as wide as the hind tibiae and the genitalia are characteristic.

Pupa: Respiratory tuft about half as long as the pupa, the filaments six in number branching in short stalked pairs, from a short main trunk. The main branching occurs vertically. The cocoon is of the wall vase type, closely woven with the anterior margin thickened.

Distribution: Holarctic *(31)*. *S. venustum* occurs widely throughout Minnesota. Considering the State as a whole, it is probably the second most abundant species, being out-ranked only by *S. vittatum* Zett. In the forested regions of northern and northeastern Minnesota, however, it undoubtedly is the most common species as well as the one of greatest economic importance. Collections have been made in the following counties:

Aitkin: August 1938.
Anoka: May 1940; June 1939.
Beltrami: June 1940.
Carlton: May 1911; June 1935.

FIG. 29. Genitalia of *Simulium jenningsi jenningsi* Mall. (Same for *S. jenningsi luggeri* n. subsp.) A. Female assembled, B. Genital rod, C. Clasper and side piece, D. Adminiculum, lateral, E. Adminiculum arms, F. Adminiculum, dorsal. FIG. 30. Genitalia of *Simulium venustum* Say. A. Female assembled, B. Genital rod, C. Adminiculum arms, D. Clasper and side piece, E. Adminiculum, lateral and dorsal (type 1), F. Adminiculum, lateral and dorsal (type 2).

Cass: May 1939; September 1941.
Clearwater: May 1937; 1939; June 1937.
Cook: May 1941; June 1940; July 1939; October 1933.
Crow Wing: May 1939; June 1939.
Dodge: May 1941.
Goodhue: May 1939, 1941.
Hennepin: May 1939, 1940.
Kittson: May 1941; June 1938.
Lake: July 1935, 1939; August 1939.
Lake of the Woods: May 1941.
Lincoln: May 1941.
Marshall: May 1941.
Mille Lacs: June 1939.
Morrison: June 1939.
Murray: May, 1941.
Norman: May 1937.
Pine: May 1938, 1940.
Pipestone: May 1941.
Polk: June 1940.
Ramsey: May 1939, 1941; June 1932, 1937, 1938; August 1938.
St. Louis: June 1936, 1938, 1941.
Sherburne: August 1938.
Wabasha: October 1941.
Washington: July 1940.
Watowan: May 1941.
Yellow Medicine: May 1940.
Number of specimens examined: 1,014.

Simulium jenningsi subsp. *jenningsi* Malloch

Simulium jenningsi Malloch, U. S. Dept. Agr., Bur. Ent., Tech. Ser. No. 26, p. 41. 1914.

Simulium venustum var. *jenningsi* Twinn, Can. Ent. **65**:3. 1933 *(apud* Twinn *39)*.

Simulium (Simulium) nigroparvum Twinn. Can. Journ. Res. **14**:142-145. 1936. (See notes on page 54).

Female: A glossy dark gray to black species. Length 1.5 to 2 millimeters. Vertex glossy chocolate-brown; wide, only slightly narrower at the antennae; with a few pale setae, but mostly bare. Clypeus quadrate sub-opaque, gray pollinose, with a few scattered pale setae. Antennae 11-segmented, dark brown; the proximal two segments and the base of the third, light brown. Mesonotum glossy dark gray to black, slightly grayish pollinose anteriorly and laterally; pubescence sparse, pale yellow, fine. Scutellum dark brown, shining; upright setae black; recumbent pale yellow scales absent. Postnotum shining black; somewhat silvery pollinose. Pleurae dark brown, pollinose; tuft short, dark or light. Halteres yellow with bases dusky. Wings clear; hair-like setae on stem vein and base of costa usually pale, but mixed dark and light in some specimens; subcosta bare ventrally; radius bare dorsally between the stem vein and the radial sector. Legs mostly yellow with the middle and hind coxae dark; the femora somewhat darkened distally, especially the hind pair; the front and middle tibiae definitely blackened distally with the hind pair

dark except at the bases; front tarsi and terminal two segments of the other tarsi black, remaining tarsal segments black distally; calcipala and pedisulcus prominent; claws simple. A prominent silvery-white pollinose patch present dorsally on all tibiae, those on the hind pair confined to the basal half. Abdomen with basal fringe pale and sparse; second segment dark brown with gray pollinose reflections laterally; segments 3 to 5 opaque velvety black dorsally; terminal segments dark brown to black, shining.

Genitalia (figure 29, A and B): Anal lobe triangular, anterior margin recurved. Cercus roughly triangular, wider dorsally than ventrally. Genital rod narrow, the stem darkened, the tip not expanded; the arms widely divaricate, heavily sclerotized distally and bearing a long sharp ventral tooth; crotch with a dark crescent-shaped thickening of the membrane.

Male: Antennae brown, basal two segments lighter. Clypeus dark brown with pollinose reflections. Mesonotum velvety, black, pearlaceous gray laterally and basally; antero-lateral margins with a pair of shining pearlaceous spots, triangular in shape, extending posteriorly to the center of the disk. These spots are frequently as wide at the base as long, but the size and shape is by no means uniform. On some specimens the spots are bar like, extending dorso-mesally on the disk. Scutellum chocolate brown with upright black setae; without scales. Postnotum black, shining. Pleurae gray pollinose; tuft black. Halteres yellow with black bases; bases setose. Wings clear; hair-like setae black; subcosta bare. Legs with fore coxae yellow, others dark; fore femora dusky yellow beneath, darker dorsally; other femora dark with yellow bases; tibiae and front tarsal segments black; basal half of middle and hind basitarsi and hind second tarsi yellow, occasionally yellow on second tarsal segment of middle legs; all tibiae with silvery-pollinose areas dorsally, those on the front tibiae large while those on the middle and hind tibiae are small and are restricted to the basal fifth; hind basitarsus about one half as wide as the tibiae. Abdomen velvety black; the second, sixth, and seventh segments with conspicuous lateral pearlaceous spots; fringe dense, black.

Genitalia (figure 29, C, D, E, and F): Side piece quadrate, wider than long. Clasper about twice as long as the side piece, with a terminal tooth. Adminiculum, usually about twice as long as wide, heavily sclerotized, trough like, the disto-lateral margins serrate; basal arms heavy, each with a posteriorly directed sub-basal arm. Adminiculum arms with heavy teeth mixed with finer spine-like processes.

The female of this species is characterized by the unmarked mesonotum, bicolored legs, simple claws, the absence of setae on the ventral side of the subcosta, and the upright black setae on the scutellum. The males are most similar to those of *S. venustum* and most readily separated on the basis of the genitalia and width of the hind basitarsus in proportion to that of the hind tibiae. In this species the hind basitarsus is about one half as wide as the hind tibia while in *S. venustum* the width is about two thirds.

Pupa: Respiratory filaments 10 in each pair arising as follows: two short stemmed main trunks occurring from a short base; the upper breaks into two equally short stemmed branches which divide once to make four; the lower branch divides once, each of these branches pro-

ducing three filaments. All branching occurs in the vertical plane. The cocoon is of the wall vase type, densely woven with an undivided "window" occurring antero-laterally on each side.

Distribution: Reported by Twinn *(39)* from Ottawa, Ontario, and Perkins Mills, Quebec, and by Underhill *(41)* from Virginia. In Minnesota the subspecies has been collected and reared from Houston County, Winnebago Creek, May 30 through 31, 1939 (three females and four males).

Notes: The synonymy of *S. jenningsi* Mall. with *S. nigroparvus* Twinn was pointed out to the writers by Dr. Alan Stone, U. S. National Museum, who based his conclusion on a comparison of the type material *(35)*.

Simulium jenningsi subsp. *luggeri* n. subsp.

Similar to *S. jenningsi jenningsi* Malloch as described above except in the pupal stage in which 12 respiratory filaments are present rather than the typical 10. The manner of branching of the filaments is similar to that occurring in *S. jenningsi jenningsi* except in the main dorsal branch where an additional pair occurs. This condition appears to be constant. Intergradation between the pupae of the two varieties has not been observed by the writers, and neither have they collected the two varieties together from the same stream.

The cocoon is of the wall vase type and is densely woven with two antero-lateral windows, each of which may be divided into two parts by several coarse strands of silk. Some cocoons are provided with an antero-ventral lip raised vertically above the object to which it is attached.

No dependable characters have been found to separate this subspecies from *S. jenningsi jenningsi* Malloch in the adult stage.

Holotype: Male, Coon Rapids, Anoka County, Minnesota, July 2, 1939 (reared). University of Minnesota Collection.

Allotype: Female, Coon Rapids, Anoka County, Minnesota, August 25, 1939 (reared). University of Minnesota Collection.

Paratypes: Zumbro River, Wabasha County, Minnesota, May 30, 1939, two females and three males (reared).

Coon Rapids, Anoka County, Minnesota (reared) as follows: three males, June 12, 1939; three males, June 13, 1939; one female, two males, June 14, 1939; seven females, three males, July 2, 1939; three females, one male, July 5, 1939; one male (reared from larva) July 16, 1939; two females, one male (reared from larvae), July 17, 1939; one male, July 22, 1939; three females, one male, July 24, 1939; two females, July 25, 1939; five females, two males, August 25, 1939; five females, one male, August 26, 1939.

Notes: Twinn *(39)* in his description of the typical *S. nigroparvum* (= *jenningsi* Mall.) stated that the scutellum of the female lacks pale recumbent scales. This is also true of the limited number (two) of the undamaged females of the subspecies *jenningsi* in the writers' possession. The females of the subspecies *luggeri*, however, possess a few recumbent pale yellow scales on the scutellum. Further comparison of reared specimens might prove this to be a reliable character for separating the adults of the two varieties.

Simulium jenningsi luggeri is named in honor of Professor Otto Lugger, first Entomologist of the Minnesota Agricultural Experiment

Station. It is possible, even probable, that this variety is Lugger's *S. minutum* or/and *S. irritatum* which are considered by most writers to be synonymous with *S. venustum* Say. Lugger *(20)* wrote concerning *S. minutum,* "It is a very small species. . . . This species flies from May 15 to June 1 and very likely breeds in the Mississippi River near Minneapolis. . . ." He also indicated that it apparently did not bite humans, but was a pest of horses. His *S. irritatum* also occurred in the central part of the State.

We may also conjecture as to what species Lugger figured in his report of 1896 since his types and all specimens determined by him as *S. minutum* and *S. irritatum* apparently have been lost. Circumstantial evidence, however, is not lacking in support of the contention that at least one of his species may have been new. This evidence may be summarized as follows:

a. *S. jenningsi luggeri* has been found breeding in the Mississippi River at Coon Rapids about nine miles north of Minneapolis. This river flows through both Minneapolis and St. Paul.

b. This subspecies, or subspecies *jenningsi,* has been taken abundantly in light traps at University Farm, St. Paul, where Lugger did much collecting.

c. Although abundant in the vicinity of Minneapolis and St. Paul, it is apparently not a pest of humans.

d. *Simulium jenningsi* is closely related to and difficult to distinguish from *S. venustum* except by examination of the genitalia or the immature stages.

Distribution records of *Simulium jenningsi* Malloch, of undetermined subspecies:

Wisconsin: Sawyer County: August 1937.
Rib Mountain State Park: August 1937.
Minnesota: Anoka County: June 1922.
Crow Wing County: June, September, and October, 1939.
Lake County, August, 1938.
Hennepin County: June, 1935.
Pine County: May 1938-39, 1942; October 1940.
Polk County: June, 1940.
Ramsey County: May 1911, 1928, 1936, 1939; June 1921-23, 1932, 1935, 1937, 1939-40; July 1925, 1932, 1939; August 1938-39.
Sherburne County: June 1938.
Wabasha County: October 1941.
Number of specimens examined: 300.

Simulium decorum Walker

Simulium decorum Walker, Cat. Brit. Mus. Dipt. 1:112. 1848.
Simulium venustoides Hart, 27th Rept. State Ent. Ill., p. 42. 1912. *(apud* Dyar and Shannon *8).*
Simulium piscidium Malloch (not Riley), U. S. Dept. Agr., Bur. Ent., Tech. Ser. No. 26 p. 45. 1914 *(apud* Dyar and Shannon *8).*

Female: A moderately large gray species with legs mostly yellow. Length 3 to 4 millimeters. Vertex moderately wide, only slightly narrowed above the antennae; shining dark gray with light pollinosity.

Clypeus slightly wider than the vertex, quadrate, silvery pollinose with a few scattered setae. Palpi dark brown to black. Antennae 11-segmented dark brown with the proximal two segments and the basal half of the third, light brown. Mesonotum black, shining, lightly gray pollinose; pilosity fine, scattered, pale, longer posteriorly. Scutellum dark brown to black with upright and recumbent hair-like setae pale yellow and dark mixed. Postnotum bare, dark brown to black with light reflections. Plurae dark gray, pollinose with membranous areas brown; tuft dark or light, sometimes mixed. Halteres yellow, the bases yellowish-brown. Base of wings yellow to yellowish-brown; hair-like setae on stem vein and base of costa in most specimens pale with an occasional dark hair present, in a few specimens mostly dark; the subcosta with a row of setae ventrally; the radius bare between the stem vein and the radial sector. Legs bright yellow or light brown except the following, which are black; the middle and hind coxae, terminally on the femora and tibiae, the entire front tarsi, terminally on the basitarsi of the middle and hind legs and the terminal half of the second tarsal segment of the hind legs. The tibiae of all legs bear silvery pollinose areas dorsally. These are most prominent on the anterior legs. Calcipala and pedisulcus prominent and the claws simple. Abdomen with a pale basal fringe; second segment somewhat pollinose laterally; segments three and four black dorsally; remaining segments sub-opaque, rather bluish-gray pollinose; all segments except the first rather bluish-gray laterally and ventrally; pilosity short, sparse, pale.

Genitalia (figure 31, A and B): Ovipositor valves small, membranous with the inner margins lightly sclerotized; coarsely setose. Anal lobe longer than wide, bare anteriorly. Cercus evenly rounded, not as long as broad. Stem of genital rod heavily sclerotized, not expanded at tip; arms membranous except terminally where they are heavily sclerotized and each possesses a long blunt ventral tooth.

Male: Antennae, clypeus, and palpi as in the female. Mesonotum velvety black, unmarked by pearlaceous spots; gray pollinose around the margins; sparsely covered with fine golden pile. Scutellum brown to black with upright dark setae and pale yellow recumbent setae. Postnotum bare, brown to black, shining. Pleurae gray to brown, pollinose; tuft black. Halteres yellow with dusky setose bases. Wings clear, the hair-like setae of the veins black; subcosta bare ventrally. Legs darker than in the female but marked similarly; the hind legs in some specimens almost entirely dark; hind basitarsus about three fourths as wide as tibia. Abdomen velvety black; fringe long and black; segments 2, 5, 6, and 7 indistinctly pearlaceous laterally; general pilosity short and sparse.

Genitalia (figure 31, C, D, E, and F): Side piece wider than long, quadrate. Clasper one and one half times as long as the side piece, bluntly rounded terminally with a single tooth. Adminiculum Y-shaped when viewed dorsally; the two sides appressed distally but with a cavity remaining at the base of the arms extending completely through to the

FIG. 31. Genitalia of *Simulium decorum* Walker. A. Female assembled, B. Genital rod, C. Adminiculum, lateral, D. Adminiculum, dorsal, E. Clasper and side piece, F. Adminiculum arms. FIG. 32. Genitalia of *Simulium corbis* Twinn. A. Female assembled, B. Clasper and side pieces, C. Adminiculum, lateral, D. Genital rod, E. Adminiculum arms.

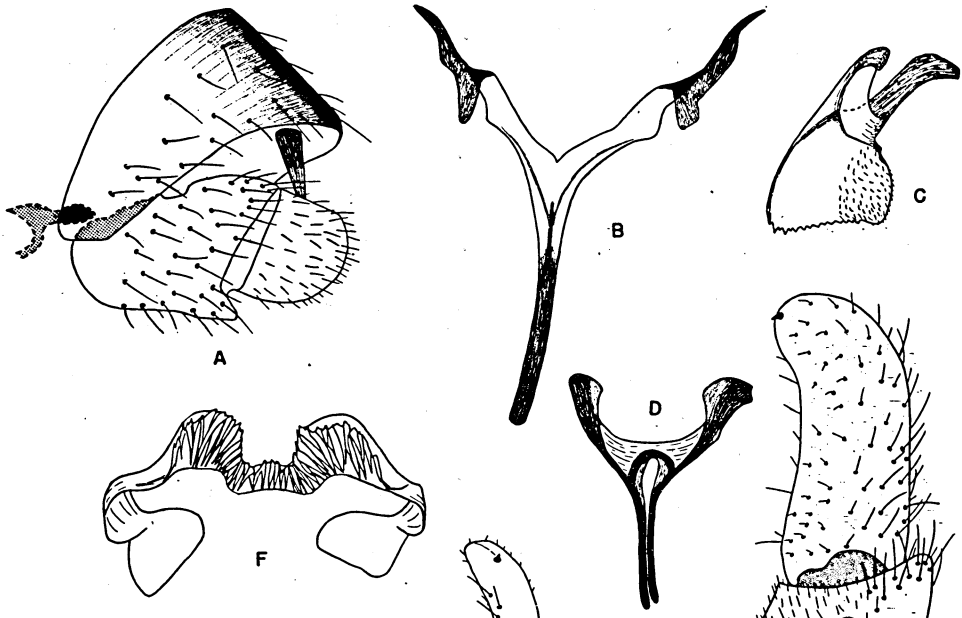


FIG. 31

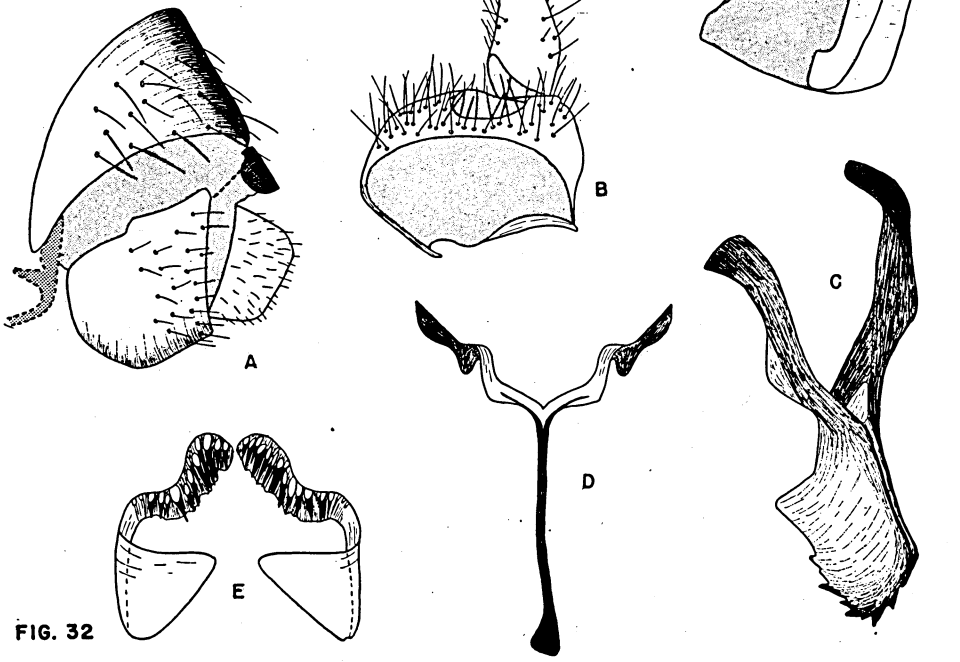


FIG. 32

other side. Adminiculum plow-shaped when viewed from the lateral aspect; distally with serrate edges; ventrally hirsute. Adminiculum arms with numerous stout teeth.

The description of the male genitalia given above does not agree with that given for this species by Dyar and Shannon *(8)* who state, "Male hypopygium as in *vittatum,* rather darker, the claspers with four teeth." The writers' males and females were associated through rearing from the same type of pupae. Dr. Alan Stone of the U. S. National Museum has kindly identified them for the writers as *S. decorum* Walker.

S. decorum may usually be distinguished from other similar species by its large size and reddish brown wing bases. The females are further differentiated by the simple claws, light and dark mixed setae on the scutellum, the setae ventrally on the subcosta, and the sub-opaque, rather bluish-gray pollinose appearance of the terminal abdominal segments. The genitalia and the velvety black, unmarked mesonotum serve to distinguish the male.

Pupa: With eight respiratory filaments as follows: A short main trunk which divides into two branches, the ventrad of which divides almost immediately in the horizontal plane and re-divides to form two short stalked pairs; the upper branch bears two filaments emerging singly from near its base and a short stalked dorsal pair. The filaments are about half as long as the pupa. The cocoon is the wall vase type and rather loosely woven, especially anteriorly.

Distribution: Records concerning the distribution of this species are confused as a result of the error obviously made by Dyar and Shannon *(8)* in describing the male of the species. Records of probable validity are:

Martin Falls, Ontario (type locality).
Boulder, Colorado (Stains and Knowlton *32).*
Alaska (Jenkins *17).*
Shawanow, Wisconsin (biting man): U. Minn. Collection.
Winnipeg, Manitoba: U. Minn. Collection.
Lake Wyoza, Massachusetts: U. Minn. Collection.

In Minnesota it is a well distributed but uncommon species. Collection records by county are as follows:

Cook: June 1940, October 1939.
Goodhue: May 1941.
Lake: July 1935, 1939.
Olmsted: No date.
Pine: May 1942.
Pipestone: May 1941.
Polk: July 1937.
Pope: September 1939.
Ramsey: May 1930, June 1939, October 1921.
St. Louis: October 1941.
Number of specimens examined: 53.

Simulium corbis Twinn

Simulium (Simulium) corbis Twinn, Can. Journ. Res. 14:147-148. 1936.

Female: A dark gray species superficially resembling *S. venustum* Say. Length about 2 millimeters. Twinn *(39)* reports specimens as long

as 3.4 millimeters. Vertex shining black, narrowed moderately above the antennae. Clypeus slight gray pollinose; one and one third times as wide as the vertex at the crown; setae sparse, pale. Palpi dark brown to black. Antennae 11-segmented, dark brown to black, basal two segments lighter but in some specimens the difference is hardly noticeable. Mesonotum shining dark brown to black, gray pollinose antero-laterally; pubescence yellow, sparse, longer posteriorly. Scutellum dark brown with yellow upright and recumbent setae, mixed with black setae, occasionally. Postnotum brown, shining. Pleurae brown, pollinose; tuft pale. Halteres yellow with brown bases. Wings clear; hair-like setae of the stem vein pale, those on the costa mixed pale and dark at the base, dark on the remainder; subcosta with a row of dark setae ventrally; radius bare between the stem vein and the radial sector. Legs bicolored; front coxae yellow, middle and hind coxae dark; femora and tibiae yellow basally, remainder darkened; all tarsi black except the basal half of the first of the middle legs and the first and second on the hind legs; dorsal surfaces of all tibiae with white pollinose patches; calcipala and pedisulcus prominent; claws with a small but distinct sub-basal tooth. Abdomen with a pale fringe; segments 3 to 6 opaque brown to black dorsally, remaining segments shining black to brown.

Genitalia (figure 32, A and D): Ovipositor valves short, broad, rounded terminally, membranous, darkened somewhat on the inner margins, and sparsely setulose. Anal lobe longer than broad when viewed laterally, setose on the posterior half; almost as broad as long from the latero-ventral aspect, rounded anteriorly and truncate posteriorly. Cercus broadly rounded. Stem of the genital rod heavily sclerotized, expanded at the tip; arms angled on the ventral margins, tips heavily sclerotized and bearing a large blunt tooth ventrally.

Male: Mesonotum velvety black with sparse golden pilosity; bearing a pair of pearlaceous spots on the antero-lateral margins as in *S. venustum*. The size of these spots appears to be as variable as in *S. venustum*. On most of the writers' specimens, however, they are much reduced; on some being barely discernable. Pleurae brown with gray pollinosity; tuft black. Halteres yellow, the bases dark. Wings clear; hair-like setae black; subcosta bare ventrally. Legs practically all black except the front coxae and white pollinose areas on the front and middle tibiae; other yellow areas more or less obscured by an abundance of black setae; hind basitarsus almost as wide as tibia. Abdomen velvety black; fringe black; lateral pearlaceous spots on segments 2, 6, and 7.

Genitalia (figure 32, B, C, and E): Side pieces quadrate, rounded terminally, about three fourths as long as wide, a reinforced bar present as noted by Twinn *(39)*. Clasper about one and one-half times as long as the side piece, constricted at the middle, blunt, with a single terminal tooth. Adminiculum narrow, Y-shaped, strongly sclerotized; plow-shaped from the lateral aspect; dentate along the terminal margins, the teeth directed backward. Arms of the adminiculum with triangular bases and a series of stout teeth on a median membrane.

The females of *S. corbis* are very similar to those of *S. venustum* but may be readily segregated from this species and others by the presence of a small but distinct sub-basal tooth on the claws, and the presence of setae ventrally on the subcosta. The males are similar externally to those

of *S. venustum* except that the legs are almost entirely black with pearlaceous spots only on the front and middle tibiae. The hind basitarsus is almost as wide as the tibiae.

Pupa: Possessing 10 respiratory filaments in each tuft arising in short stalked pairs from a common point on a short trunk. The cocoon is wall vase shaped, the posterior two thirds closely woven and the anterior third consisting of a loosely and uniformly woven series of filaments described by Twinn *(39)* as resembling the ornamental rim of a basket. This forms a trim around the ventral and lateral sides of the cocoon. The pupa lies deeply in the cocoon with the rim extending almost to the ends of the rather short filaments. The writers have collected the immature stages of this species from cold streams in association with *S. latipes* Meigen.

Distribution: This species has been reported from Perkins Mills, Quebec, by Twinn *(39)*, and from Alaska by Jenkins *(17)*. In Minnesota it has been taken from the Devil's Track River north of Grand Marais in Cook County (68 specimens, May 31, 1941, reared), and from a small stream near Isabella in Lake County (1 specimen, May 31, 1941, reared).

Simulium rugglesi n. sp.

Female: A small dark gray species with bicolored legs closely resembling *S. venustum* Say. Vertex shining black or dark brown, lightly pollinose, sparsely setose, moderately broad, not extremely narrowed above the antennae; as wide at the crown as the clypeus. Clypeus quadrate, about as broad as long, shining black with moderate gray pollinosity and a few scattered pale setae. Palpi brown. Antennae 11-segmented, dark brown with the basal two segments and the proximal half of the third light brown. Mesonotum dark gray, shining, somewhat pollinose; pilosity pale, minute, moderately dense. Scutellum dark brown with upright setae mostly light, but with a few dark ones present; recumbent setae absent. Postnotum bare, dark brown, shining. Pleurae black, pollinose, shining; tuft pale. Halteres yellow, bases dusky, setose. Wings clear; hair-like setae on the stem vein and base of costa pale; lower surface of subcosta bare; radius bare between the stem vein and the radial sector. Legs bicolored; front coxae yellow, others black; femora largely dark except at the bases; front tibiae largely yellow, terminal third black, white pollinose patches on the dorsal surfaces; basal half of the middle and hind tibiae yellow, remainder black; tarsi black except the basal half of the basitarsus on the middle and hind legs, and the basal half of the second tarsus on the hind legs which are yellow; hind basitarsus not inflated, about two-thirds the width of the tibia; calcipala and pedisulcus present; claws with a large basal tooth. Abdomen with the basal fringe pale and short; segments 6 to 9 dark brown, shining.

Genitalia (figure 25, A and B): Ovipositor valves short, membranous, darkened along the inner margins; obtusely angled terminally; without setae. Anal lobe broader than long; rounded ventrally. Cercus two-thirds as long as the anal lobe; rounded posteriorly. Stem of the genital rod heavily sclerotized; arms broad and membranous, angulate ventrally; tips of arms each with a disto-medial lobe, this lobe appearing roundly triangular when viewed laterally (B); arms expanded laterally from the

lobes as broad plates; a small, sharp, heavily sclerotized ventral tooth present.

The females of *S. rugglesi* may be separated from other Minnesota species by the large basal tooth on the claws and the absence of setae on the ventral surface of the subcosta.

The males and pupae of this species are unknown to the writers.

Holotype: Female, Todd County, Minnesota, June 24, 1937 (on geese). University of Minnesota collection.

Paratypes: Same data. Seven females.

This species is named in honor of the late Professor A. G. Ruggles, State Entomologist of Minnesota from 1918 to 1943.

SUMMARY

Part I presents a review of the economic importance of the Simuliidae throughout the world and in Minnesota. Early accounts of the depredations of these insects in the State are given. At the present time these flies remain an economic liability to the State, ranking perhaps third among the blood sucking insects, with the most severe losses occurring chiefly to the dairy and tourist industries. The incidence of Leucocytozoon disease of poultry in Minnesota is also presented.

Part II contains a discussion of the general biology of the group supplemented by personal observations by the writer.

Part III includes keys to the taxonomic descriptions of eighteen species and two subspecies which occur in Minnesota. *Simulium croxtoni* and *S. rugglesi* are described as new species and *S. jenningsi luggeri,* as a new subspecies.

LITERATURE CITED

1. BARANOV, N. Stand der Kolumbatscher mückenforschung in Jugoslawien. Ztschr. f. Parasitenk **11**:215-234. 1939.
2. BLACKLOCK, D. B. The development of *Onchocerca volvulus* in *Simulium damno sum.* Ann. Trop. Med. and Parasitol. **20**:1-48. 1926.
3. BRADLEY, G. H. Notes on the southern buffalo gnat, *Eusimulium pecuarum* (Riley) (Diptera, Simuliidae). Proc. Ent. Soc. Wash. **37**:60-64. 1935.
4. ———— The hatching of eggs of the southern buffalo gnat. Science **82**:277-278. 1935.
5. BRITTEN, H. A note on the oviposition of *Simulium maculatum* Mg. Ent. Monthly Mag. **51**:170-171. 1915.
6. CAMERON, A. E. The morphology and biology of a Canadian cattle-infesting black fly, *Simulium simile* Mall. (Diptera, Simuliidae) Canada Dept. Agr. Bul. 5 (Ent. Bul. 20), 26 pp. 1922.
7. DOROGOSTAJAKIJ, V., RUBZOV, I., and VLASENKO, N. Notes on the taxonomy, biology and geographical distribution of black flies in East Siberia. Mag. de Parasit. de l'Inst. Zool. de l'Acad. des Sci. de l'U.S.S.R. **5**:107-204. 1935. (In Russian with English Summary).
8. DYAR, HARRISON G. and SHANNON, RAYMOND C. The North American two-winged flies of the family Simuliidae. Proc. U. S. Natl. Mus. **69**(10):1-54. 1927.
9. EDWARDS, F. W. On the British species of Simulium. II. The early stages; with corrections and additions to Part I. Bul. Ent. Res. **11**:211-246. 1921.
10. ———— Diptera of Patagonia and South Chile. Brit. Mus. Nat. Hist. 2(4):121-154. 1931.
11. FALLIS, A. MURRAY and DAVIES, DOUGLAS, M. *Leucocytozoon bonasae* Clark in the ruffed grouse and its development in the black fly, *Simulium venustum* Say. Jour. Parasitol. Suppl. Vol. **32**, p. 20. Dec. 1946.
12. FORBES, S. A. On the black flies and buffalo gnats as possible carriers of pellegra in Illinois. 27th Rept. State Entomologist Ill. pp. 21-55. 1912.
13. GARNHAM, P. C. C. and MCMAHON, J. P. The eradication of *Simulium Neavei,* Roubaud, from an Onchocerciasis area in Kenya Colony. Bul. Ent. Res. **37**:619-628. 1947.
14. GRENIER, P. Observations biologiques sur *Simulium costatum* Fried. (Dipt.) I. L'hibernation. Bul. Soc. Path. exot. 37(1944):363-374. 1945.
15. HEARLE, ERIC. Notes on *Simulium canadense* Hearle and *Simulium virgatum* Coquillett and its varieties. Canad. Ent. **67**:15-18. 1935.
16. HOFFMANN, CARLOS C. Über *Onchocerca* in süden von Mexikco und die weiterentwicklung ihrer mikrofilarien in *Eusimulium mooseri.* Arch. f. Schiffs u. Tropen Hyg. **34**:461-472. 1930.

17. JENKINS, DALE W. Ecological observations on the blackflies and punkies of Central Alaska. Mosq. News **8**:148-154. 1948.
18. JOHNSON, E. P., UNDERHILL, G. W., COX, J. A., and THRELKELD, W. L. A blood protozoon of turkeys transmitted by *Simulium nigroparvum* (Twinn) Amer. Jour. Hyg. **27**:649-665. 1938.
19. KRAFCHICK, BERNARD. The mouthparts of blackflies with special reference to *Eusimulium lascivum* Twinn. Ann. Ent. Soc. Amer. **35**:426-434. 1942.
20. LUGGER, OTTO. Insects injurious in 1896. (Second annual report of State Entomologist). Minn. Agr. Expt. Sta. Bul. No. 48. 1896.
21. MALLOCH, J. R. American black flies or buffalo gnats. U. S. D. A., Bur. Ent., Tech. Ser. No. 26, pp. 1-71. 1914.
22. NICHOLSON, H. P. The morphology of the mouthparts of the nonbiting blackfly, *Eusimulium dacotense* D. & S., as compared with those of the biting species, *Simulium venustum* Say. Ann. Ent. Soc. Amer. **38**:281-297. 1945.
23. O'ROKE, EARL C. A malaria-like disease of ducks caused by *Leucocytozoon Anatis* Wickware. Mich. Univ. School Forestry and Conserv. Bul. 4. 1934.
24. PARKER, R. R. Recent studies of tick-borne diseases made at the U. S. Public Health Service at Hamilton, Montana. Proc. Pan-Pac. Sci. Congress **5**:3367-3374, 1933. Toronto. 1934.
25. PURI, I. M. On the life-history and structure of the early stages of Simuliidae (Diptera, Nematocera). Part I. Parasitology **17**:295-369. 1925.
26. REMPEL, J. G. and ARNASON, A. P. An account of three successive outbreaks of the black fly, *Simulium arcticum*, a serious livestock pest in Saskatchewan. Sci. Agr. **27** (9):428-445. 1947.
27. RILEY, CHARLES V. The southern buffalo gnat. Rept. Entomologist, U.S.D.A., for 1884. pp. 340-345.
28. SCHMIDT, M. Durch die Kolumbacser mücken hervorgerufene er krangungen. Deut. Tierärztl. Wchnschr. **24**:247-248. 1916.
29. SKIDMORE, L. V. *Leucocytozoon smithi* infection in turkeys and its transmission by *Simulium occidentale* Townsend. Zentbl. f. Bakt., Abt. I., **125**:329-335. 1932.
30. SMART, JOHN. Notes on the biology of *Simulium pictipes* Hagen. Canad. Ent. **66**:62-66. 1934.
31. ———— The classification of the Simuliidae (Diptera). Trans. R. Ent. Soc. of London **95**:463-532. 1945.
32. STAINS, G. S. and KNOWLTON, G. F. A taxonomic distributional study of Simuliidae of western United States. Ann. Ent. Soc. Amer. **36**:259-280. 1943.
33. STEWARD, J. S. The occurrence of *Onchocerca gutturosa* Neumann in cattle in England with an account of its life history and development in *Simulium ornatum* Mg. Parasitology **29**:212-218. 1937.
34. STOKES, JOHN HINCHMAN. A clinical, pathological and experimental study of the lesions produced by the "black fly" *(Simulium venustum)*. Jour. Cutaneous Dis. **32**:751-769. 1914.
35. STONE, ALAN. In press. Brooklyn Ent. Soc.

36. STRONG, R. P., SANDERGROUND, J. H., BEQUAERT, J. C., and MUNOZ OCHOA, M. Onchocerciasis with special reference to the Central American form of the disease. Contr. from Dept. Trop. Med. & Inst. Trop. Biol. Med., Harvard U. Vol. 14, No. 6, 234 pp. 1934.

37. TONNOIR, A. L. Australasian Simuliidae. Bul. Ent. Res. **15**:213-255. 1925.

38. TWINN, C. R. The blackfly, *Simulium venustum* Say, and a protozoon disease of ducks. Canad. Ent. **65**:1-3. 1933.

39. ———— The blackflies of Eastern Canada (Simuliidae, Diptera). Part I. Canad. Jour. Res. **14**:97-120. 1936.

40. UNDERHILL, G. W. Two simuliids found feeding on turkeys in Virginia. Jour. Econ. Ent. **32**:765-768. 1939.

41. ———— Blackflies found feeding on turkeys in Virginia. *Simulium nigroparvum* Twinn and *Simulium slossonae* (Dyar and Shannon). Va. Agr. Expt. Sta. Tech. Bul. 94, 32 pp. 1944.

42. VARGAS, L. Simulides del nuevo mundo. Monog. I., del Inst. de Salubridad y. Enfermedades Tropicales. 241 pp. 1945.

43. VARGAS, L., MARTINEZ PALACIOS, A., and DIAZ NÁJERA, A. Simulidos de Mexico. Rev. del Inst. de Salubridad y Enfermedades Tropicales **7**:101-192. 1946.

44. WANSON, M. and HENRARD, C. Habitat et comportement larvaire du *Simulium damnosum* Theobald. Rec. Trav. Sci. méd. Congo belge no. 4, pp. 113-121. 1945. (Rev. Appl. Ent. **36**:146-148. 1948. Series B.)

45. WASHBURN, F. L. Diptera of Minnesota (10th Ann. Rept. State Ent. Minn.) Agr. Expt. Sta., St. Anthony Park, 1905.

46. ———— Minnesota Diptera (additional species collected since 1905). Agr. Expt. Sta., St. Anthony Park, May 1906.

47. WU, YI FANG. A contribution to the biology of *Simulium*. Papers Mich. Acad. Sci., Arts & Letters **13**:543-599. 1930.