ECOLOGICAL STUDIES ON THE BLACK FLIES OF THE SOURIS RIVER, MANITOBA

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Arthur Richard Westwood

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of

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BY

ARTHUR RICHARD WESTWOOD

A dissertation submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

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ABSTRACT

Westwood, Arthur Richard. M.Sc., The University of Manitoba, October, 1979.

Ecological Studies of the Black Flies in the Souris River, Manitoba. Major Professor: R. A. Brust

Nine species and one subspecies of black flies were collected in the Souris River. These were Cnephia dacotensis, Simulium johannseni, Simulium johannseni duplex, Simulium venustum, Simulium verecundum, Simulium tuberosum, Simulium vittatum, Simulium decorum, Simulium luggeri and Simulium meridionale. Five species, Simulium luggeri, Simulium meridionale, Simulium venustum, Simulium verecundum and Simulium johannseni are potential pest species. These five were observed to take blood meals from humans, cattle, horses and poultry. Simulium vittatum was the most abundant species. Simulium luggeri, Simulium meridionale and Simulium johannseni were less abundant than Simulium vittatum, but more numerous than Simulium venustum, Simulium verecundum and Simulium decorum. The least common species were Simulium tuberosum, Cnephia dacotensis and Simulium johannseni duplex.

Simulium johannseni, Simulium johannseni duplex, Simulium venustum, Simulium verecundum, Simulium tuberosum and Cnephia dacotensis were univoltine in the Souris River; the remaining species were multivoltine.

In an outbreak year, it appears that two larvicide treatments would be needed to control black flies in the Souris River. The first should be aimed at late instar larvae of Simulium johannseni and the Simulium venustum/ verecundum complex. The second treatment, approximately 10 to 14 days later, should be aimed at late instar larvae of Simulium luggeri and Simulium meridionale.

Four different artificial sampling devices were employed to collect black fly larvae and pupae. Of the four samplers tested; (cones, plates, ropes and wire cages), cone samplers are recommended for future larval population assessment in the Souris River. The characteristics that make cone samplers more desirable than the others tested include ease of handling, versatility and high performance in collecting immature simuliids. Comparison between samplers showed cone and plate samplers to collect significantly more black fly larvae and pupae than wire cage samplers. There was no significant difference in the collection of immature simuliids between cone and plate samplers. Rope samplers were not compared to the others because a true 2.5 cm^2 sample could not be obtained.

CHAPTER I

Introduction

The serious nature of the black fly populations along the Souris River in Manitoba was first noted in 1949 when livestock between Hartney, Deleau and Souris, Manitoba were severely attacked by black flies. At Hartney, Manitoba, A. V. Mitchener (unpublished report) recorded the appearance of "clouds" of black flies which attacked horses, cattle and humans on 18 May, 1949. The black flies were originally identified as Simulium occidentale Townsend, but a recent examination of the specimens showed that they belong to the Simulium venustum/verecundum complex. R. D. Bird (unpublished report) collected black flies several miles north of Hartney, at Deleau, Manitoba, on 16 May, 1949. These simuliids were attacking cattle, horses, humans and poultry. Bird reported that cattle suffered heavily from black fly bites, especially around the head and udders. The flies were identified as Simulium venustum Say, but a later examination showed that only about one-half of them were S. venustum, while the rest were Simulium verecundum Stone and Jamnback.

Continued black fly outbreaks during the early 1950's prompted insecticide treatment of the Souris River with DDT in order to control black fly larvae. Some limited

investigations on the biology of black flies breeding in the Souris River were conducted prior to and following treatment. The black fly levels subsided after 1956 and little attention was paid to black fly activity along the Souris River during the 1960's.

In 1970, serious black fly outbreaks again became prevalent along the Souris River from the Hartney area east to Wawanesa, Manitoba. In 1974, the rural municipality of Cameron petitioned the Manitoba Department of Agriculture to provide assistance to alleviate the black fly outbreaks in the Hartney - Souris area. The problem was especially serious to both humans and livestock in 1975. Several area residents were admitted to hospital for treatment because of black fly bites (Kolach 1977). Black flies were responsible for numerous deaths in chicken flocks in the Hartney area and cattle were noticeably stressed during the outbreak. The Manitoba Department of Agriculture treated the Souris River south of Hartney with methoxychlor (24% emulsifiable concentrate at 0.1 ppm for 15 minutes) on 11 May, 1976.

The present study was undertaken during the summers of 1977 and 1978, to learn more about the biology and ecology of the Simuliidae in the Souris River and to provide background data for future studies. The taxonomy, breeding habits and seasonal and geographical distribution of nine species of black flies were examined. The criteria affecting

the control of pest species were also investigated. Finally, an assessment of larval and pupal sampling techniques was undertaken to determine those best suited for the river, and those which might be used in the future to help monitor and predict black fly outbreaks.

CHAPTER II

Literature Review

Section A - Review of General Biological Studies of North American Black Flies

A large number of studies on black flies have been conducted in North America. In the United States, Malloch (1914), Jobins-Pomeroy (1916), Dyar and Shannon (1927) and Stains and Knowlton (1943) were among the first authors to describe simuliid biology, taxonomy and ecology. Stone and Jamnback (1955) pointed out that while these early contributions were often based on erroneously determined material, they paved the way for a more in-depth study of North American Simuliidae.

Studies initiated after 1950 in the United States to investigate simuliids have had several recurrent themes. Each study was confined to the fauna of distinct areas because of the often restricted habitat of Simuliidae. While emphasizing taxonomic representation of simuliids, these studies have also made an effort to present black fly bionomics. Nicholson and Mickel (1950) dealt extensively with the economic importance and biology of black flies in Minnesota and included keys and species descriptions for the adults collected. Stone (1952) and Sommerman et al.

(1953) followed much the same format as the previous authors in their examination of Alaskan Simuliidae. Unlike Nicholson and Mickel (1950), Stone (1952) and Sommerman et al. (1953) concentrated not only on adults, but also included pupal and larval biology, taxonomy and keys to immature stages. Stone and Jamnback (1955) produced a major work on the black flies of New York State, and combined taxonomic descriptions pertinent to the black fly fauna of this region with limited amounts of biological information. Stone (1964) published a paper, similar in content to that of the previous authors, in which he reported his investigations on the black flies of Connecticut. This publication included important biological and ecological data accompanied by updated taxonomic keys and descriptions of many species not fully dealt with by Nicholson and Mickel (1950) or Stone and Jamnback (1955). Studies by Snow et al. (1958) and Stone and Snoddy (1969) provided taxonomic and biological descriptions of the black flies of the Tennessee River basin, and of Alabama respectively. Anderson and Dicke (1960) investigated the biology and occurrence of the immature stages of Wisconsin black flies in detail and provided information on the life cycles of numerous species. Recently, Merritt et al. (1978) and Pinkovsky and Butler (1978) have added further biological information, taxonomic descriptions and keys to the black flies of lower Michigan and Florida.

Parallel studies on taxonomy and bionomics of Canadian black flies can be divided into two categories. The first includes woodland simuliids, encompassing eastern and northern Canada and the west coast. The second major area of investigation has been the black fly fauna of the Canadian prairies.

Twinn (1936) and Hearle (1932) were among the first to study woodland black fly species in Canada. Wolfe and Peterson (1959) updated Twinn's work (1936) on the black flies of Quebec, and added new biological information. Hocking and Richards (1952) and Hocking and Pickering (1954) examined the taxonomy and bionomics of northern black flies in Labrador and Manitoba. Davies et al. (1962) and Wood et al. (1963) made important contributions to the taxonomy and biology of black flies of Ontario. They revised the descriptions and outlined new life history findings for many species. Recent efforts in Newfoundland by Lewis and Bennett (1973; 1974a) have added to the biology of woodland black flies.

The black fly species inhabiting the Canadian prairies have been the object of several studies. Fredeen (1956) listed black flies of the agricultural areas of Manitoba, Saskatchewan and Alberta and outlined the life cycles of both abundant and important pest species. Fredeen and Shemanchuk (1960) investigated the black fly fauna of irrigation canals in Saskatchewan and Alberta.

Abdelnur (1968) discussed species biology and presented comprehensive keys to all stages of the black flies found in his study on Alberta simuliids. Fredeen (unpublished 1972) revised his earlier checklist of the Simuliidae of Manitoba, Saskatchewan and Alberta and also provided keys to both adult and pupal stages.

Research on black flies in Alberta and Saskatchewan has been far more intensive than in Manitoba. The only published study concerning biology, ecology and seasonal occurrence of Manitoba black flies in that of Hocking and Pickering (1954). These authors reported on simuliids found in Churchill. The study deals with black flies of the boreal forest - tundra ecotone, and therefore adds little to our knowledge of prairie species.

Section B - Sampling Techniques for Adult and Immature Black Flies

Immature stages of black flies (ova, larvae and pupae) can be collected from natural substrates, or by the use of artificial sampling devices. Sampling techniques for adult black flies can be divided into two categories: selective sampling methods which capitalize on behavioral characteristics of Simuliidae (eg. attraction to host via odor, movement or sight) and non-selective sampling techniques that provide a general cross-section of the simuliid population.

Ova. Sampling for black fly eggs is the method least practised for ecological, taxonomic or control purposes. Marr (1962) suspended small flat sticks from a rope onto the surface of the river. These sticks acted as oviposition sites for females of several black fly species, including Simulium damnosum Theo. The sticks were replaced periodically and provided an effective means for sampling eggs of certain simuliids. Golini and Davies (1975a; 1975b) used polyethylene strips suspended on the water surface to sample for eggs laid by gravid black flies. By adding sticky adhesive to the strips, Golini and Davies were also able to trap the adult females when they landed to oviposit. Egg samples have also been collected along the shores of pools, streams and rivers from trailing and standing vegetation and debris (Tarshis 1968a). A third method used by Tarshis (1968a) and Fredeen (personal communication) was to sample the river bottom with an Eckman dredge or equivalent device. Simuliid eggs were then separated using a salt flotation process. The main drawback to this method is the low return in number of eggs relative to the large number of samples that must be taken.

Larvae and Pupae. Sampling for black fly larvae and pupae can be done using either artificial or natural substrates. In regard to the former, a set of guidelines to ensure the effectiveness of artificial substrates was proposed by Lewis

and Bennett (1974b). The samplers (all types) should have nearly equal attractiveness, or their degree of attractiveness should be established in relation to other substrates. Samplers should be easily positioned and retrieved, and should be of uniform dimensions. Samplers should hold a stable position throughout the season under a variety of conditions and the larvae should be easily removed with minimum specimen damage. In addition to this, there should be no significant disturbance to the immediate environment.

An artificial substrate used by Lewis and Bennett (1974b) consisted of fine-textured ceramic tiles (10 cm^2) fixed at various depths to obtain samples of larvae and pupae. Fredeen (in press) utilized 10 cm^2 polyethylene-covered plates or 10 cm^2 aluminium wire mesh squares. Fredeen emphasized that smooth, hard surfaces were best for collecting large numbers of black fly larvae and pupae, while the wire mesh grids acquired higher numbers of Trichoptera and Plecoptera than simuliids. Wolfe and Peterson (1958) utilized 10 cm^2 solid metal plates and Baldwin et al. (1977) used 30 cm^2 floor tiles to evaluate the effect of insecticide treatments on simuliids in streams.

The need for standardized sampling techniques to be used worldwide was emphasized by Lewis and Bennett (1974b). They felt that with the large number of sampler types being used, population comparisons from one study to another were impossible and suggested that the tile method should become a standard black fly sampling technique for ecological and

control studies in small streams or shallow rivers. (Obviously this method would not be suitable for large, deep rivers.)

The use of metal and polystyrene cones for black fly larval sampling has been widespread (Peterson et al. 1955; Wolfe and Peterson 1958; Phelps and Defoliart 1964; Johnson and Pengelly 1966; Abdelnur 1968; Wallace et al. 1973; Depner 1977 personal communication). Cones are suspended at various depths pointing into the water flow. This keeps them relatively stable and allows attachment for larvae and pupae to the outside surface. Peterson et al. (1955) used metal cones (20 cm in height and 10 cm in base diameter and a 30° apex) while Abdelnur (1968) utilized hollow white polystrene cones of the same dimensions. Cones fixed in the current gave very low numbers of black fly larvae at all depths, while cones allowed to move freely with the current collected many more larvae. Abdelnur and Peterson et al. (1955) also found that higher numbers of larvae attach to "brighter" surfaces, with white cones giving the highest catches of larvae. Peterson et al. (1955) listed six types of information that could be obtained using cone samplers. These were: a) determination of the level of infestation at a particular locality, b) estimation of larval growth, c) determination of periods of migration and spread of small larvae throughout a watercourse, d) determination of periods of peak abundance of larvae and pupae, e) indication

of river and stream suitability for larval growth and f) assessment of the effectiveness of larvicidal control procedures.

Nets and polyethylene strip samplers have been used to collect larval samples. Tarshis (1965, 1968b) collected larvae with nets made from organdy nylon mesh and coarse mesh cheesecloth. Nets, 0.6 by 0.9 meters, were anchored to the base of streams and collected up to 3,000 Simulium and Cnephia spp. larvae per screen within days of immersion. Wallace et al. (1973, 1976) used drift nets of varying mesh sizes to sample Simuliidae and other aquatic invertebrates. Boobar and Granett (1978) collected 1,500 to 2,000 black fly larvae per m^2 using polyethylene strip samplers.

Larvae and pupae can also be collected from natural surfaces, eg. rocks, vegetation, stream bottoms and from man-made structures. In fact, whenever artificial substrates are used, sampling from vegetation, rocks and dam faces is nearly always carried out as well (Peterson et al. 1955; Marr 1962; Abdelnur 1968; Boobar and Granett 1978).

Adult Black Flies. Sampling for adults has been attempted using both non-selective and selective techniques. Selective sampling techniques utilize attraction to hosts by visual and olfactory stimuli.

The simplest selective method is the use of humans or animals as bait for blood-seeking female black flies (Dalamat 1950; Muirhead-Thompson 1968; Thompson et al. 1972; Service

1977). Females are either aspirated or netted from or around the host. Black flies can also be captured by constructing traps around mammalian and avian hosts. Anderson and Defoliart (1961) used animal bait traps constructed with dark sides and a bright apex to lure adults inside and upward to be captured. Shemanchuk (1978) suspended a large mammalian host (eg. steer) in an open steel framework. The tops of the framework held netting which was dropped over the sides of the enclosure to capture blood-seeking females attracted to the bait. A very effective method used on African black flies was to surround a host in a fine gauze mesh framework. Blood-seeking females would enter through the mesh, but once their abdomens swelled with blood, they could not leave (Service 1977). Service stated that suction traps placed around bait can also be used to collect black fly adults. The window-type exit trap has also been used successfully to capture adult black flies. These traps are often placed in barns and buildings where animals are housed to capture those flies attracted to hosts for feeding (Service 1977).

Fallis et al. (1967) experimented with odoriferous animal extracts and carbon dioxide gas to attract blood-seeking female black flies. While these studies concentrated on behavior and attraction, they are an effective means of sampling the adult female population. Common loon extract and carbon dioxide gas attracted large numbers of Simulium

euryadminiculum Davies. Peschken and Thorsteinson (1965) and Golini and Davies (1970) also experimented with carbon dioxide, color, shape and movement of artificial samplers to attract black flies. Baits, animal or bird extracts and carbon dioxide have been used as attractants in the sampling of blood-seeking female black flies, but are of no use in examining male or non-blood seeking female populations.

Another selective sampling method employs visual cues used by black fly females to orient toward a host. Fredeen (1961) constructed traps in the form of a) a cow silhouette (a four-legged frame two-thirds covered with dark cloth and the underside open), b) sheep silhouette (smaller version of the cow trap) and c) a small pyramidal trap. Black flies were attracted to the dark undersides mistaking the traps for live animals. The traps effectively provided a cross-section of the female black flies attracted to the silhouettes. Fallis et al. (1967) used Fredeen's idea of visual traps shaped as hosts and constructed colored animal and bird silhouettes of various shapes and sizes and captured black flies attracted to them. The attractiveness of the silhouettes was enhanced by adding carbon dioxide gas and heat. Baldwin et al. (1977) experimented with suspended lard tins (22.5 kg) painted dark blue with white vertical contrasting stripes. A thin layer of clear adhesive was applied to the surface of the tins to catch adult female black flies as they alighted. Carbon dioxide, in the form

of dry ice, was placed within the containers and allowed to leak out as a gas to provide olfactory stimulus for attraction. Females that were attracted by the dark and highly contrasting colors, and the carbon dioxide, were then collected from the adhesive film.

Service (1977) stated that the main drawbacks to using traps which depend upon visual and olfactory stimuli are that only females are sampled and attraction is much dependant on their physiological state. To try to overcome this drawback, devices which attract or sample both sexes have been developed. Bellic (1976) used 1 m^2 by 0.7 cm thick aluminium sheets with a thin film of adhesive applied over the top surface. These sheets were placed flat on the ground beside black fly breeding sites. The black flies, mistaking the mirrors for water, were caught in the adhesive during oviposition or when mating swarms dipped too low to the ground. Davies and Williams (1962) and Service (1977) discussed the use of light traps which attract both sexes of many types of insects including some Diptera. Although black flies are considered to be diurnal, New Jersey and Minnesota type light traps equipped with a light source and suction apparatus captured many species of black flies during the night. Males and females were equally attracted and this method, once considered inapplicable to adult black fly sampling, adds another dimension to population surveys. Other visual attraction techniques to sample adult simuliids

include geometrical figures (squares, cylinders, discs, triangles and glass plates) smeared with resins, adhesive glues or Tanglefoot^{R} and cloths of different colors and reflective types (Service 1977).

Non-selective sampling techniques do not depend on attraction methods for capturing black flies. They simply sample a given area capturing whatever insects may be present. The simplest method of non-selective sampling is using a net to sweep a predetermined area over a specified period of time (Dalamat 1950; Muirhead-Thomson 1968; Service 1977). Fallis et al. (1967) constructed a large fan trap which forced air into a gauze bag. This fan and gauze bag were suspended on 3.6 m arms which circled slowly through the air at various heights. Another non-selective type of sampling device is the aquatic emergence trap (Marr 1962; Service 1977). Aquatic emergence traps are placed over stream beds or sit on the water surface. They are usually square at the bottom extending into a funnel for collection of black flies at the peak. When emerging adult male and female black flies leave the cocoon they are captured in the emergence trap.

As previously outlined, there have been many attempts to collect immature and adult black flies using a wide range of artificial sampling devices. These sampling techniques, combined with the collecting of immature stages from natural substrates, are essential to studies on taxonomy,

ecology or general bionomics of Simuliidae.

Section C - Review of the Bionomics of Nine Black Fly Species Found in the Souris River, Manitoba

Cnephia (Cnephia) dacotensis (Dyar and Shannon).

Cnephia dacotensis occurs throughout North America in a wide variety of aquatic habitats. The eggs of this univoltine species overwinter at the bottom of streams and rivers throughout its range (Stone and Jamnback 1955; Davies et al. 1962; Ezenwa 1974). The overwintering ova usually hatch from late March until the beginning of May depending on geographic location (Stone and Jamnback 1955; Davies et al. 1962; Stone 1964; Abdelnur 1968; Lewis and Bennett 1973; Merritt et al. 1978). Davies et al. (1962) reported that in southern Ontario, eggs occasionally hatch in the late fall, but it is unknown whether the larvae are capable of surviving the winter. These authors found first instar larvae normally hatching when the water temperature reached 5°C.

Ross and Merritt (1978) suggested that C. dacotensis passes through six larval instars. The duration of the larval stage is dependant on water temperature. C. dacotensis larvae took up to six weeks to pupate in Michigan (Merritt et al. 1978). Abdelnur (1968) reported that the peak pupation period in Alberta was the third week in May, while Stone and Jamnback (1955) and Stone (1964) observed pupation

to begin from the first to the third weeks in May in the eastern United States. In Wisconsin, Anderson and Dicke (1960) recorded the larval stage to last from four to five weeks and the pupal stage from five to seven days. These authors noted that C. dacotensis larvae occurred in very high densities, reporting populations as high as 10,000 to 20,000 per 0.30 m^2. Duration of the pupal stage in New York was approximately eight days (Stone and Jamnback 1955).

Adult emergence usually occurs in late May and early June in Ontario (Davies et al. 1962). Adults mate on objects (eg. stones and vegetation) along the edges of the stream. Egg-laying commences soon after copulation and females oviposit by flying low over the breeding site and release eggs with a tap of the abdomen on the water surface (Stone and Jamnback 1955; Davies and Peterson 1956; Fredeen 1959; Davies et al. 1962; Abdelnur 1968). The mouth parts of C. dacotensis are not fitted for piercing and sucking of blood from mammalian or avian hosts, and consequently this black fly is of little economic importance. Eggs are fully developed by the time females emerge (Smith 1970).

Simulium (Eusimulium) johannseni Hart.

Simulium (Eusimulium) johannseni duplex Shewell and Fredeen.

The geographic range of Simulium johannseni has been reported to extend from the eastern United States and south-eastern Canada to the central plains of North America (Stone 1964). S. johannseni duplex has been recorded from

Saskatchewan and its biology is considered to be very similar to that of S. johannseni (Shewell and Fredeen 1958). Anderson and Dicke (1960) collected S. johannseni in southern Wisconsin, finding mature larvae and pupae attached to vegetation in late April. Both stages were found at depths of 10 to 46 cm and current speeds of 0.30 to 0.60 meters per second, at water temperatures of 10 to 12°C. Anderson and Dicke postulated that S. johannseni probably overwinters in the larval stage. These authors considered S. johannseni to have but one generation per year. While the number of larval instars of this species has not been published, Fredeen (personal communication) believes that S. johannseni passes through six instars.

Stone (1964) and Anderson and Defoliart (1961) reported adult females of S. johannseni to feed primarily of gallinaceous birds (eg. domestic turkey, chicken, pheasant and duck), preferring to feed in the lower forest or woodland canopy, rather than on the ground. Anderson and Defoliart (1961) noted that S. johannseni is most likely a specialized ornithophilic feeder. These authors felt that the presence of strongly bifed claws in S. johannseni was an adaption for easy movement through bird feathers.

Simulium (Byssodon) meridionale Riley.

Simulium meridionale overwinters as an egg (Anderson and Dicke 1960). Larvae begin to hatch during mid and late May in Wisconsin and develop at water temperatures of 15 to

23°C. Anderson and Dicke stated that larvae and pupae in woodland and forest watercourses were most often found attached to vegetation 5 to 16 cm beneath the surface in current speeds less than 0.30 meters per second. Fredeen (1959) reported S. meridionale larvae to be abundant in fast flowing prairie streams (0.30 to 0.90 meters per second). Fredeen and Shemanchuk (1960) observed large numbers of S. meridionale larvae and pupae on vegetation in irrigation ditches in Alberta and Saskatchewan. Larvae usually require about three weeks to reach maturity and the pupal stage lasts from three to four days (Anderson and Dicke 1960). Fredeen (1959) found that larvae of midsummer generations could develop to maturity within fourteen days, the pupae lasting no longer than four days. In prairie streams and rivers, the first pupae of S. meridionale appear by the first week in June (Fredeen and Shemanchuk 1960). Fredeen (personal communication) reported that S. meridionale passes through seven larval instars. Anderson and Dicke (1960) stated that this black fly species had at least four generations per year in Wisconsin, while Fredeen (1956) found only one generation per year in Saskatchewan and two to three in Alberta.

Anderson and Defoliart (1961) and Fredeen (1959) considered females of S. meridionale to be of economic importance because of their wide host range. These authors documented S. meridionale to feed upon turkeys, chickens, starlings and pheasants in Nebraska, again stating that like S. johannseni, S. meridionale, is probably a bird feeder because of strongly bifed claws. It is a proven vector of

Leucocytozoon smithi (Laveran and Lucet 1905) in turkeys in Wisconsin (Anderson and Defoliart 1961). Fredeen (1959) and Defoliart and Rao (1965) recorded S. meridionale attacking man and the latter authors implicated this simuliid as a vector of eastern equine encephalitis virus.

Simulium (Psilozia) vittatum Zetterstedt.

Simulium vittatum ranges throughout North America from Alaska to Florida. It is a multivoltine black fly that most often overwinters in the larval stage (Stone and Jamnback 1955; Fredeen 1959; Fredeen and Shemanchuk 1960; Davies et al. 1962; Ezenwa 1974; Merritt et al. 1978). However, Sommerman et al. (1955), Wolfe and Peterson (1959), Anderson and Dicke (1960), Abdelnur (1968) and Lewis and Bennett (1973) observed that S. vittatum also overwintered in the egg stage. In Alberta, Abdelnur (1968) observed overwintering larvae maturing between May 10th and 15th, while mature larvae from overwintering eggs were collected during the last week of May. Anderson and Dicke (1960) suggested that in Wisconsin overwintering eggs hatch in early to mid March. The eggs that give rise to overwintering larvae are laid in autumn and larvae develop slowly through the winter (Davies et al. 1962). Fredeen (1959) found eggs to survive for only a few weeks in the laboratory at 0 to 2°C; at higher temperatures they hatched. Fredeen questioned the ability for eggs to overwinter based on his laboratory findings. Anderson and Dicke (1960) suggested two possible

explanations for the different methods of overwintering: a) S. vittatum in Wisconsin may consist of two distinct subspecies or species that differ biologically from one another or b) the overwintering stage is inherently controlled by the last generation in response to some external stimuli. Development of the immature stages can be very rapid, especially in summer months. Development from the first to the last instar larva ranges from 11 to 21 days during the summer and up to six months during the winter (Fredeen 1959; Anderson and Dicke 1960). Ross and Merritt (1978) stated that larvae of S. vittatum pass through seven larval instars, while Colbo and Porter (1979) reported eight. Stone and Jamnback (1955) reported the pupal stage to last three to four days. Pupae resulting from overwintering larvae appear in streams and rivers from early March onward (Stone and Jamnback 1955; Merritt et al. 1978).

The larvae and pupae of S. vittatum are found in wide-ranging current speeds, temperatures and pH. Larvae have been collected in current speeds from 0.06 to 1.8 meters per second and in temperatures ranging from 1 to 31°C (Fredeen 1959; Fredeen and Shemanchuk 1960). S. vittatum larvae and pupae tolerated a range in oxygen concentrations from 6.5 to over 10 ppm (Jenkins 1948).

Adults begin emerging after the first warm days in April even when ice and snow are still on streams and rivers. In the majority of cases, the spring generation of females

is autogenous (Davies et al. 1962; Davies 1978). Following generations are usually anautogenous. The exact number of generations per year is often difficult to determine because of extensive overlap between successive broods (Anderson and Dicke 1960; Davies 1978). Stone (1964) found three to five generations per year in the eastern United States.

S. vittatum adults mate in swarms beside or over breeding sites and subsequently females produce eggs in long strings joined together in a gelatinous matrix (Davies et al. 1962; Abdelnur 1968). Eggs may be laid on objects in the water or on substrates receiving a continual spray of moisture (Wolfe and Peterson 1959). Females sometimes lay eggs in communal masses and are often caught in the egg masses during oviposition. Davies and Peterson (1959) stated that females of S. vittatum that could not find oviposition substrates dropped eggs freely while flying over the water.

S. vittatum is considered a significant economic pest throughout much of North America. It has been observed feeding on humans, cattle, especially horses and numerous smaller mammals (Stone and Jamnback 1955; Anderson and Defoliart 1961; Davies et al. 1962; Anderson and Voskuil 1963; Stone 1964; Abdelnur 1968; Townsend et al. 1977).

Simulium (Phosterodorus) luggeri Nicholson and Mickel.

Simulium luggeri is prevalent in north central

North America, being common in the central plains and to a lesser extent in more eastern regions. This simuliid overwinters in the egg stage (Fredeen 1959; Anderson and Dicke 1960; Stone 1964). Fredeen (1959) reported the duration of the larval stage in Saskatchewan to be 20 to 25 days, depending on water temperature (usually above 10°C).

In Wisconsin, first generation larvae require 3.5 to 6 weeks to mature (Anderson and Dicke 1960). Larvae and pupae are usually found at a depth of 2.5 to 15 cm and favour vegetation for attachment (Anderson and Dicke 1960). In the absence of vegetation, S. luggeri larvae attached to rocks 45 cm beneath the surface. Larval development in Wisconsin occurred from 12.8 to 22.5°C and Fredeen (personal communication) stated that S. luggeri passes through seven larval instars.

The pupal stage lasts four to seven days. Adults mate in swarms and females oviposit by scattering eggs singly over breeding sites while in flight (Fredeen 1959; Anderson and Defoliart 1961). S. luggeri is multivoltine and cool water temperatures during autumn induce eggs to diapause (Fredeen 1977).

The adults of the first generation usually appear in the first two weeks of June (Abdelnur 1968; Fredeen 1977). Stone (1964) and Fredeen (1977) stated that this anautogenous black fly is a serious economic pest of man, cattle and horses, especially on the prairies. The multivoltine breeding habit of S. luggeri compounds its economic impact.

The Simulium venustum/verecundum complex.

This complex of at least three species of black flies has presented considerable problems in identification of its members. The first described species of the complex was Simulium venustum by Say in 1823. Stone and Jamnback (1955) described Simulium verecundum and coined the word complex for the two species. Stone and Jamnback (1955) and Stone (1964) stated that adult females of S. venustum and S. verecundum were morphologically indistinguishable from one another. Recently, Golini and Davies (1975) suggested that females are distinguishable on the basis of structural differences of the ovipositor lobes. They state that while some variation does occur amongst individuals, this is a reliable diagnostic character. Preserved larvae of these two species are indistinguishable in many cases (Stone and Jamnback 1955; Stone 1964). Wood et al. (1963) and Stone (1964) reported that occasionally in living specimens, S. verecundum larvae will exhibit red scaling on the abdomen and S. venustum will not. A third black fly, Simulium tuberosum (Lundström) is also considered to be a member of the S. venustum/verecundum complex (Stone 1964). While S. tuberosum females are difficult to distinguish from those of S. venustum and S. verecundum; males are fairly easy to identify. The pupae and larvae of S. tuberosum are less difficult to segregate from those of S. venustum and S. verecundum, but variation in morphological makeup does occur, even within larvae from the same location (Stone and Jamnback 1955). When S. venustum

and S. verecundum occur together, there exist identifiable forms of both species. Accompanying these forms, is a wide range of intermediate forms (including larval, pupal and adult stages) that exhibit characteristics of both species, making identification very difficult (Fredeen personal communication). Frequently therefore, when S. venustum and S. verecundum occur together researchers list them as the S. venustum/verecundum complex (Stone 1964; Merritt et al. 1978; Colbo and Thompson 1978).

Simulium (Simulium) venustum Say. Simulium venustum is perhaps the commonest and most serious black fly pest in North America, extending over much of the continent. The overwintering stage throughout its range is the egg (Stone and Jamnback 1955; Wolfe and Peterson 1959; Davies et al. 1962; Fredeen 1973). The larvae of the first generation begin hatching in early to mid-April in Ontario (Davies et al. 1962). The length of the larval stage varies from ten days to six weeks, although summer generations require ten days to three weeks on the average (Fredeen 1959; Lewis and Bennett 1973; Ezenwa 1974). Fredeen (1959) and Ezenwa (1974) reported the pupal stage to last from five to seven days. Mokry (1976) stated that S. venustum passes through six larval instars. The larvae occur in a wide variety of watercourses, preferring larger streams with shallow rapids (Davies et al. 1962; Fredeen 1973).

Abdelnur (1968) noted that the first adults appeared in

mid to late May in Alberta and as many as three generations followed this spring brood. Mating occurs in swarms close to breeding sites and all generations of S. venustum are anautogenous (Peterson 1962; Davies et al. 1962). Davies (1978) and Fredeen (1973) found that the first generation constituted the largest population and was subsequently the most damaging to hosts. Jamnback (1976) concluded that increasing temperature and algal populations combined with decreasing flow rates reduce succeeding generations of S. venustum in many areas in North America. Females lay eggs in mats on vegetation at and below the water surface (Wolfe and Peterson 1959). Wolfe and Peterson found that vegetation, carrying eggs from the last summer generation, decayed in the fall and drifted to the bottom of streams and rivers where the ova overwintered. Golini and Davies (1975) suggested that S. venustum oviposits while flying and that records of this species ovipositing on vegetation are incorrect. They suggest that it was S. verecundum that others had observed laying eggs on vegetation.

S. venustum feeds on a large number of hosts. Cattle, humans, horses, deer, bear and smaller mammals are most severely affected (Anderson and Defoliart 1961; Davies et al. 1962; Stone 1964). Abdelnur (1968) and Davies and Peterson (1956) have also recorded S. venustum feeding on birds, including young sparrows, crows, nestling grackles, ducks and geese.

Simulium (Simulium) verecundum Stone and Jamnback. This species like S. venustum, overwinters in the egg stage. The larval biology of S. verecundum is very similar to that of S. venustum and the two species are often found together in the same habitat (Lewis and Bennett 1973; Merritt et al. 1978).

Golini and Davies (1975) stated that in Ontario S. verecundum adults usually emerge from one to two weeks after those of S. venustum. They considered S. verecundum to be anautogenous for the first ovarian cycle in southern Ontario. S. verecundum like S. venustum is multivoltine (Merritt et al. 1978). S. verecundum females have been recorded to lay eggs on vegetation that is covered by a thin film of water or kept moist by spray. Golini and Davies (1975) found that peak oviposition periods for S. verecundum occurred two hours before sunset and just before sunrise. While the preferred hosts of S. verecundum are not known, it has been recorded to feed on man. It is, however, not considered to be a serious pest on man or animals (Golini and Davies 1975; Merritt et al. 1978).

Simulium (Simulium) tuberosum (Lundström). Simulium tuberosum occurs throughout North America. This species overwinters in the egg stage, with larvae beginning to hatch in early May (usually later than S. venustum). Davies et al. (1962) found in eastern Canada that S. tuberosum larvae occurred in cool,swift streams. Sommerman et al. (1955) reported that in Alaska S. tuberosum larvae predominate

in fast, shallow streams with rocky bottoms. In Alberta, Abdelnur (1968) stated that the larvae occurred on rocks and stones in moderate to swift streams. While the larval stage lasts from two to four weeks, the pupal period extends from four to six days (Lewis and Bennett 1974a). Lewis and Bennett found S. tuberosum larvae in current velocities ranging from 0.27 to 1.34 meters per second. Fredeen (personal communication) considered S. tuberosum to pass through six larval instars.

Females usually oviposit by landing on the water surface and depositing eggs singly or in batches which sink to the bottom (Wolfe and Peterson 1959; Davies et al. 1962). Davies and Peterson (1959) also observed females ovipositing while in flight when the water was rough and no calm areas could be found. There are two to four generations per year, depending on the geographic location (Stone and Jamnback 1955; Lewis and Bennett 1973).

S. tuberosum females are anautogenous and have been recorded feeding on man, horses, cattle, ground squirrels and dogs in North America (Davies et al. 1962; Peterson 1959). In Europe, S. tuberosum is considered a significant pest, especially in England, Scandanavia and northern Asia. S. tuberosum is not considered a serious economic pest in North America.

Simulium (Simulium) decorum Walker.

Simulium decorum has been collected from Alaska to

Newfoundland and southward to the gulf states. The ova of S. decorum overwinter at the bottom of watercourses or attached to submerged substrates and hatch earlier than overwintering eggs of other species (Wolfe and Peterson 1959; Davies et al. 1962; Stone 1964; Merritt et al. 1978). Davies et al. (1962) and Merritt et al. (1978) recorded eggs hatching from the beginning of March. For the first generation, pupation begins in late April until mid-May. Stone and Jamnback (1955) reported that eggs laid in the summer at 21°C hatched within seven days and larvae required twelve to sixteen days to mature. In Quebec, Wolfe and Peterson (1959) found that eggs laid on dam faces hatched within nine days and that first instar larvae moved against the current along the dam to the area of highest current velocity, usually over 0.30 meters per second. Larvae of S. decorum predominate on dams, sluice and head gates, pond and lake outfalls, beaver dams and on man-made debris in aquatic habitats. S. decorum is often less abundant on rocks, vegetation or other natural substrates when man-made substrates are available (Fredeen and Shemanchuk 1960; Stone 1964; Fredeen 1973). On dams and lake outlets, Anderson and Dicke (1960) have recorded populations of 1,000 to 2,000 larvae and pupae per 0.30 m^2. S. decorum probably passes through six larval instars.

Adults have been observed mating soon after emergence, usually on the ground beside breeding sites (Fredeen 1959; Davies et al. 1962; Davies 1978). The first generation is

autogenous, but subsequent generations of females require a blood meal for egg development. Females oviposit on substrates covered with water or surfaces that are kept continually moist. Davies et al. (1962), Fredeen (1959) and Peterson (1956) have observed S. decorum females to oviposit by tapping their abdomens on the water surface while in flight when no substrates were available.

While S. decorum is not considered a serious economic pest, it has been recorded feeding on humans, horses, deer, cattle and occasionally turkeys and geese (Davies and Peterson 1956; Anderson and Defoliart 1961; Davies et al. 1962). Fredeen (1973) stated that S. decorum can be locally annoying to humans and animals, but does not occur in large scale outbreaks as occur with S. luggeri, Simulium arcticum Mall or the S. venustum/verecundum complex.

CHAPTER III

Physiography of the Souris River and the Surrounding Area

The Souris River crosses the Manitoba - United States boundary 6.58 km southwest of Lyleton, Manitoba, 101° 15' W and 49° 00' N. The river flows northeast through southwestern Manitoba, passing through or near the towns of Coulter, Melita, Hartney, Souris, Wawanesa and Treesbank. The Souris River enters the Assiniboine River 4.1 km north of Treesbank at 99° 36' W and 49° 40' N. The total length of the river in Manitoba is 213.8 km with approximately 123.3 km being included in the present study (Weir 1960).

Topography.

The Souris River is located in the southern upland, or "second prairie level" in Manitoba. The elevation of this level ranges from 300 to 450 meters above sea level. The topography of the land surrounding the river is characterized by till plain interspersed with gently undulating to rolling hills with occasional areas of sand plain and sand dunes. The Souris River runs in a valley which is fairly prominent in the northern part of its Manitoban range, but has eroded away along the southern reaches of the river toward the international boundary. The bed of the river lies on top of what was once glacial Lake Souris, which originally drained into the Red

River Valley and glacial Lake Agassiz via what is now the Pembina River drainage system. The riverbed runs over the second prairie level which, at its base, has rock strata from the Mesozoic era. These strata consists mostly of gray shale, green-gray shale and siliceous shale (underneath this rock strata lies a foundation of Palaeozoic rock, laid down before the pre-Pleistocene or Ice-Age). The Palaeozoic foundation rock is seldom exposed despite the eroding action of successive ice sheets during the Pleistocene.

The soil base is made up of lacustrine deposits, clays, silts, sand dunes, some shale and sand. The dominant soil type is black, meadow soil and dry sandy soil of the Regosolic and Chernozemic classification. These soil and rock types are reflected to a large degree in the Souris riverbed. The riverbed consists of few lacustrine deposits, some clays and mostly gray and siliceous shales. Rocky areas are scarce and occur only in localized pockets. This makes for occasional turbulence and small rapids, but for the most part the river follows a characteristic pattern of a meandering prairie river.

Vegetation.

The Souris River runs through open grassland. Mature natural grassland areas are represented by grama-grasses (Bouteloua spp.) and spear grasses (Stipa spp.). On local divergent soil types, these are often replaced by Muhlenbregia spp. and several Poa spp. Overgrazed areas, especially with high run-off along the river, show changes in

vegetative cover, eg. presence of sageworts and dominance of Kentucky bluegrass, Poa pratensis L. Sparsely intermixed with open prairie are tracts of woodland. Shrubs dominating these wooded areas include Saskatoons (Amelanchier spp.), silverberry (Symphoricarpos spp.) and dogwoods (Cornus spp.). Tree species are mainly aspen poplar (Populus tremuloides Michx.), bur oak (Quercus macrocarpa Michx.) and willow (Salix spp.). These woodlands are most prominent north of Lauder and southeast of Oak Lake, Manitoba (Fig. 1).

Wildlife.[†]

A total of 54 species of mammals are found in the Souris River basin. Major mammal species include white-tailed deer, moose, elk and occasionally pronghorn antelope and mule deer. Of the 260 species of birds that occur on a regular basis, approximately 160 species breed in the study area. Waterfowl are the most abundant game birds throughout the basin. About 22 species of raptors (eagles, hawks, falcons and owls) occur in the Souris River basin and 13 species may breed there. Seventeen species of reptiles and amphibians are known in the study area.

A very important white-tailed deer wintering area occurs north of Lauder and densities in late winter and spring can reach as high as 150 deer per 1.6 km^2.

Forty-seven species of fish occur in the Souris River with 20 being considered common. White suckers, fathead minnows, darters, sticklebacks and shiners provide a very

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[†]Souris River Basin Study Board - Canada - Manitoba - Saskatchewan. 1978.

large biomass of forage fish upon which the predaceous fish depend. The predaceous fish include yellow perch, northern pike and walleye.

Climate.

The Souris River lies in a dry subhumid moisture zone. This zone is bordered to the north by a transitional subhumid region and to the south by a dry fringe subhumid moisture zone. Both these ajoining regions are characterized by having lower moisture deficits than the dry subhumid region. Potential yearly evapotranspiration of the land in the dry subhumid region is 500 to 550 mm per year. The average annual precipitation in the area is 400 to 450 mm. The moisture deficit, or actual precipitation minus potential evapotranspiration, equals approximately 100 mm per year.

The average annual June temperature in the northern section of the dry subhumid moisture zone is 13.9°C, and in the south is 15.6°C. The July average in the northern sector is 20.0°C and in the southern sector is 21.1°C. The average January temperature along the northern boundary of the dry subhumid moisture zone is -20.0°C and in the south -16.7°C. The frost free season extends from 100 to 110 days with 2600 - 2700 degree days above 6.1°C.

Land Use.

The majority of the land bordering the Souris River on the second prairie level is agricultural. Approximately

two-thirds of the developed farm land along the Souris River, eg. the Melita, Souris and Wawanesa areas, is used for mixed grain production. The remaining one-third of the land bordering the river, eg. the Grand Clairere, Hartney and Bunclody areas, support varying concentrations of livestock and mixed grains.

River Characteristics.†

The Souris River and its tributaries, being typical prairie waterways derive most of their annual flow from snowmelt and early spring rains. The Souris River is characterized by a fairly slow current following a meandering course and can be classified as an old river (Dalmat 1954; Anderson and Dicke 1960). There has been a great reduction in the number of tributaries with the single stream flow remaining dominant. The water often has a muddy color and there is very little emergent vegetation. The shrub and tree line are often far removed from the bank. The river is characterized by occasional turbulent sections flowing mainly over rounded boulders. Boulders may also be dispersed along the river's edge. The depth of the Souris River varies greatly depending on location and time of year. Normally, depths range anywhere from 30 to 400 cm with an average depth approximately 80 - 100 cm. Width is also quite variable along the river, ranging from 10 to 20 m.

Flow rates on the Souris River are to some degree dictated by the presence of dams along its course. Dams at Melita,

† Souris River Basin Study Board - Canada - Manitoba - Saskatchewan. 1978.

Hartney, Souris and Wawanesa regulate water flow, except in spring when severe flooding can occur and flood waters cover the dams. In 1976, major flooding occurred, and abnormally high peak flows in May reached 285.0 cubic meters per second (cms), while minimum discharge was 0.03 (cms) in October. The flow rates were suprisingly low the following year when the peak flow was 3.75 (cms) in May and the minimum discharge was 0.16 (cms) in November, 1977. Water levels and flow rates were considerably higher in 1978. Peak flow occurred in April (29.20 cms) and minimum discharge took place in December (0.12 cms). It can be seen from these data, and Appendices M-O, that the discharge levels vary greatly in different localities, and from year to year. The flow rate is dependent on precipitation and soil moisture levels which affect runoff. The Souris River is also fed by numerous subterranean springs throughout its length and these too, influence water flow and depth.

The mean concentrations of phosphorus in the Souris River at the International boundary is approximately 0.16 mg/l to 0.27 mg/l. These concentrations are further diluted by tributary streams in Manitoba. Concentrations of nitrogen in the Souris River when entering Manitoba range from 1.0 to 2.0 mg/l.

Dissolved oxygen in the river in Manitoba, ranged from 6.5 to 10 ppm in non-riffle areas. Oxygen concentrations in large riffle areas in spring can reach 13 to 14 ppm. Oxygen

levels usually drop as flow decreases and temperature increases. In Manitoba total dissolved solids in the river range from 280 to 500 ppm.

The density of coliform bacteria in the Souris River ranges from 0 to 200 per 100 mls of water near the international boundary to 200 to 1,000 per 100 mls of water east of Hartney. The only metals that are detectable in significant extractable concentrations are iron (0 to 1 ppm) and manganese (0 to 0.20 ppm). Trace quantities of the insecticide Lindane and the herbicide 2,4-D have also been detected in the Souris River and its tributaries throughout its Manitoba range.

CHAPTER IV

Materials and Methods

Section A - Sampling Methods for Immature and Adult Black Flies

Eggs. Eggs were collected when adult females were observed ovipositing. Ova were removed from vegetation, rocks and from larval and adult samplers (Fig. 2). Eggs were also collected from moist dam faces and sluice-gates. The eggs were scraped from the surface of the oviposition site with a scapel and placed, along with the adult(s), into vials containing 70% ethyl alcohol. In certain cases, pieces of vegetation bearing egg masses and ovipositing females were placed directly into 70% ethyl alcohol. Eggs were collected during 1977 and 1978.

Whenever eggs were collected, water temperature, oxygen concentration, air temperature and relative humidity were measured.

Larvae and Pupae - Portable Artificial Substrate Samplers.

Rope samplers. Rope samplers consisted of yellow nylon cord, 8 mm diameter and 1.5 m long, attached either to 1.5 m metal poles embedded in the river bottom or to the surface of a dam and allowed to trail downstream. Both attachment methods maintained the rope within 5 cm of the water surface. Drifting larvae attached to the rope, often pupating in the same location (Fig. 3).

At each sample period, a 1.3 cm length of nylon cord was cut from the end of the rope sampler. The cut end was lifted slowly and not allowed to touch the water surface in order to minimize the release of larvae. The sample with attached larvae and pupae was placed directly into a labelled vial containing 95% ethyl alcohol, and stored for later examination. Remaining larvae and pupae were removed from the rope to ensure a clean substrate for the next sample period. The rope sampler was used in 1977 but not in 1978.

Wire cages containing smooth stones. This sampler (chicken barbecue basket) was used to collect black fly larvae and pupae at the bottom of the river. The cage was cylindrical, 31 cm long and 16 cm in diameter (Fig. 4). A hinged wire door was located on one side to allow access to the interior. Five stones were selected at random from the riverbed and placed into each cage. All stones had at least one smooth surface from which several 6.5 sq. cm samples could be taken. Samples were collected by using a 25 sq. cm plastic plate containing a 6.5 sq. cm hole. The plate was held over three randomly selected spots on the stones and larvae and pupae were removed from the 6.5 sq. cm area.

The wire cage sampler was secured near the base of a vertical metal pole by a 0.3 m length of 6 mm nylon cord. The pole was 1.5 m long, and was firmly driven into the riverbottom. At the time of sampling, the wire cage was removed from the water and the stones withdrawn. Larvae and

pupae were removed from the 6.5 sq. cm area with forceps and placed in a vial containing 95% ethyl alcohol. After sampling, the stones were scraped clean of remaining simuliids, and other organisms, and returned to the cage. Wire cage samplers were used in 1977 and 1978.

During each sampling period in 1977, the sampler depth, the water temperature and the oxygen concentration of the water were measured. In 1978, in addition to the above, water current speed (meters per second) was recorded at each sampling site.

Plate sampler. The plate sampler was designed to sample at all river depths. The sampler consisted of 225 sq. cm clear plastic plates alternating with 225 sq. cm, 17 guage wire mesh attached to a 1.5 m long steel pole. The two plate types were alternated every 20 cm along the pole, except for 30 cm at the top and 40 cm at the bottom for embedding the rod into the riverbottom (Fig. 5 and 8). When the pole was embedded 40 cm, the first plastic plate touched the river bottom. At the time of sampling, the entire assembly was removed from the river, the specimens were collected from each plate and placed separately in vials of 95% ethyl alcohol. The assembly was replaced in the same position, with plates perpendicular to the water flow. Plate samplers were used in 1977 and 1978.

The depth and type of sampling plate were recorded with every collection of larvae and pupae. The water temperature and oxygen concentration at the site were recorded during

each sampling period at each sampling station in 1977. In 1978, the current speed of the water (meters per second) was measured in addition to the above.

Polystyrene cones. The polystyrene cone samplers were white in color, 20 cm long, with a 10 cm base diameter and a 30° apex[†]. They were anchored with a styrofoam float and an opposing weight at opposite ends of a 6 mm diameter nylon anchor cord. The cones were attached from the apex by a 10 cm length of 2 mm nylon cord to the anchor cord. The cones moved freely with the current but remained pointed upstream (Fig. 6 and 7). The first cone was attached directly above the weight anchoring the assembly to the river bottom. The remaining three cones were evenly spaced along the anchor cord and the last cone rested just beneath the water surface, below the float. The anchor cord was eight to ten times as long as the depth of the river. This arrangement kept the cones spaced equally, regardless of the river depth throughout the summer. The cones were lifted from the water and pupae and larvae were removed from the outside surface with forceps. Immature simuliids were then placed in 95% ethyl alcohol. Cones were then returned to the water for the next sampling period. The cone sampler was used in 1978, as an alternative to the rope sampler used the previous year.

At each sampling, the depth of each cone was recorded,

[†] Manufactured by Spence-Lemare Industries, Edmonton, Alberta.

as well as the oxygen concentration, temperature and current speed of the water.

Natural and Fixed, Man-made Substrates. In addition to the use of artificial samplers to collect black fly larvae and pupae, natural and fixed, man-made substrates were used to sample populations. Natural substrates included vegetation and rocks. Man-made substrates included dams, sluice gates and various types of fixed debris occurring in the river.

Black fly larvae and pupae were sampled from natural and man-made substrates using the plastic plate with the 2.5 cm^2 hole as previously described (Fig. 9). The oxygen concentration, temperature, depth and current speed of the water were recorded at each collection point.

Adults.

Emergence traps. Traps were pyramidal in shape, one m square at the base and 55 cm high at the 18 cm^2 apex (Fig. 10). At the apex, a removable clear glass collecting bottle was fixed over a 5 cm diameter hole. A 3 cm high clear plastic funnel with a 0.5 cm opening was inverted over the hole to prevent adults entering the bottle from returning to the lower section of the trap. Styrofoam floats, 13 cm wide and 15 cm deep, were placed aroung the m^2 base of each trap. The trap was held in place by a 6 mm nylon cord fixed 3 m upstream to a 1.5 m steel pole embedded into the riverbed. This allowed the trap to swing with the river current in an

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approximate 30° arc. Adults were aspirated from the inside of the collection jar, and the inside of the trap by slightly lifting the trap above the water.

Sweep netting. Whenever adults were found, the area was swept with a fine mesh insect net. A single sample consisted of 10 sweeps of the net in a 1.5 m arc. Three samples were taken when adults were encountered.

Attractant trap. A black fly attractant trap was constructed to capture blood-sucking females. The trap consisted of a (4.5 l) paint can, painted dark blue and suspended at a height of 1.2 m beneath a metal tripod (Fig. 11). The surface of the trap was wrapped in clear polyethylene, coated with a fine layer of vaseline petroleum jelly. Two traps were equipped with a carbon dioxide tank from which gas was fed through the top of the paint can into a beaker stuffed with a wet paper towel. The moist carbon dioxide gas was allowed to escape from the bottom of the trap. Carbon dioxide was released daily from traps at regulated amounts of 200 to 300 ml per minute from 1200 to 1900 hours between May 15 and June 15, 1978. A third trap, similar to the two previously described, but not equipped with a carbon dioxide source, was also tested.

Whenever adults were collected from emergence and attractant traps or by sweep net, the air temperature and relative humidity were recorded at the site of sampling.

Collection of associated adult-pupal material. Collection

of pupae was employed to obtain material for taxonomic study and to facilitate adult-pupal associations. Only mature pupae, identifiable by the darker coloration of the cuticle, were collected for adult emergence. Pupae were removed while still attached to substrates (eg. rocks, dead and living vegetation) at collection points along the river. These were kept in cool water and transported to the field laboratory. Pupae were then removed intact from the substrate and placed singly on 1.9 cm diameter filter paper circles moistened with river water. A paper towel was placed beneath the filter paper to absorb excess moisture. Each pupa was covered by an individual adult cage, consisting of a 2cm section of acrylic plastic tubing sealed at one end with a fine mesh screen (Fig. 12). As adults emerged they were placed in 70% ethyl alcohol with associated pupal cases, labelled, and stored for later examination. Whenever pupae were collected, the water temperature and oxygen concentration were recorded.

Section B - Sample Sites

Between May 1977 and October 1978, nine sampling sites were established along the Souris River between Lauder and Wawanesa. Sites were numbered according to the order of discovery and use. The sampling sites were designated as one of two types: a) where portable artificial substrates were used to collect immature (and adult) black flies, or, b) where natural and fixed, man-made substrates were sampled.

Site 1. This site was located on Plum Creek and consisted of two sub-sites approximately 25 m apart. The first area (1a) was located about 15 m west of where Plum Creek enters the Souris River. The site consisted of a combination dam-sluice gate about 5 m across and 1.2 m high (Fig. 13). Water ran over the structure from the beginning of April (ice-breakup) until the creek dried up in July, during both 1977 and 1978. Larvae and pupae were collected from the top and downstream surfaces of the structure (Fig. 14). The second area (1b) consisted of a rocky stretch 7.5 m wide and 3.0 m long. It was located 25 m west of the dam, and approximately 40 m west of the confluence of Plum Creek and the Souris River (Fig. 15). Immature black flies were collected from rocks, vegetation and man-made creek debris (Fig. 16). Adults were collected by sweep netting.

Site 2. This site was located about 0.75 km south of the bridge crossing Provincial Road #348 at Bunclody. The site consisted of a rocky, turbulent section 15 to 20 m wide and about 400 m in length (Fig. 17 and 18). In 1977, the sample design was as follows: six plate samplers were positioned in the river 3 to 4 m apart in two rows of three. One row was positioned at the head of the rapids and a parallel row 8 to 10 m downstream. In 1977, three rope samplers were placed in a line downstream and parallel to the first row of plate samplers. Three wire basket samplers were tied to plate sampler #2, row 1; #4, row 2 and #6, row 2 (Fig. 19).

In 1978 the design was the same as above, except three cone samplers replaced the rope samplers.

Adults were also collected by sweep netting and attractant traps. Two attractant traps were used on the riverbank at site 2. One was used with CO_2 and one without, and placed 10 m apart. A third adult attractant trap with CO_2 was placed in dense woods 75 m west of the previous two traps.

Site 3. This site was located where Provincial Highway #2 crosses the Souris River 4.8 km southwest of Wawanesa (Fig. 1). Immature black flies were collected from rocks, trailing vegetation and man-made debris from an area of riffles and fast eddies, approximately 15 m wide and 30 m long (Fig. 20). Adults were collected by sweep net.

Site 4. This site was located at the Hartney, stoplog-dam, 1.0 km northwest of Hartney. Larvae and pupae were sampled from the dam and adults were collected by sweep netting over the structure. The dam was 15 m across and ranged from 3.0 to 5.0 m high, depending on the need to control the water level (Fig. 21).

Site 5. This site was 9.0 m wide and 5 m long located at a bridge crossing the Souris River about 8.0 km north of Lauder and 5 km east of Provincial Road #254 (Fig. 22). It consisted of a small riffle of stones and rocks located upstream from the bridge. Two plate samplers were placed 3 m apart across

the riffle. In 1977, two rope samplers and two wire cage samplers were situated downstream from the plate samplers. In 1978, rope samplers were replaced with cone samplers.

Site 6. This site was located directly between the bridge on Provincial Road #454 and the Mentieth railroad bridge (Fig. 24). The sample method was similar to that at site 5 during both 1977 and 1978. Adult emergence traps were not used at either site 5 or 6, due to vandalism and subsequent loss of equipment. Site 6 consisted of a stony riffle 10 to 15 m wide and approximately 20 m long.

Site 7. This site was the dam at the town of Souris, including the rocks and vegetation 30 m downstream from the structure (Fig. 25). Immature stages were sampled from the dam, stones and vegetation. The dam was approximately 20 m wide and 3.5 m high.

Site 8. This natural sampling site was located directly behind the Wawanesa dam on the Souris River (Fig. 26). Immature black flies were collected from stones, rocks and vegetation in a riffle approximately 15 m wide and 30 m long.

Site 9. This site was located 0.5 km north of the bridge on Provincial Road #348 at Bunclody and was used only in 1978. The site was approximately 1.25 km upstream from site 2, and consisted of a stony riffle 14 to 16 m wide and 35 m long (Fig. 27). The sample design was as follows: three plate

samplers were placed in a row 3 m apart across the riffle; three cone samplers were positioned downstream from these, and wire cage samplers were attached to the base of plate samplers #1 and #3. Two emergence traps, one attached to plate sampler #2 and the other attached to plate sampler #3 were also used (Fig. 28).

Section C - Statistical Analysis

Analysis of data was divided into two categories. Firstly, individual species (larvae and pupae) were examined as to their preference for sampler type, current speed and depth. Before analysis was carried out, a species had to have two or more sampling dates in which larval and pupal numbers reached a level of 1.0 per 2.5 cm^2 or more, in at least 2 of the 4 sites with artificial samples. Two-way ANOVA and orthogonal contrast were used to examine species preference.

The second category was analysis of the interaction of the location of samplers and physical parameters with each other and/or larval and pupal density of all species present at sites 2 and 9 in 1978. Multilinear regression was used for this examination. The variables entered into the multilinear regression were: a) date (first day of sampling at site 2 considered day zero); b) sample location (position of sampler in river - Fig. 19); c) depth of cone; d) temperature of water; e) oxygen concentration in water; f) current speed of each sampler (not the overall means present in Appendix L) and; g) Y or density of larvae and pupae per cone.

Figure 1. Map of Study Area: 1977 - 1978.

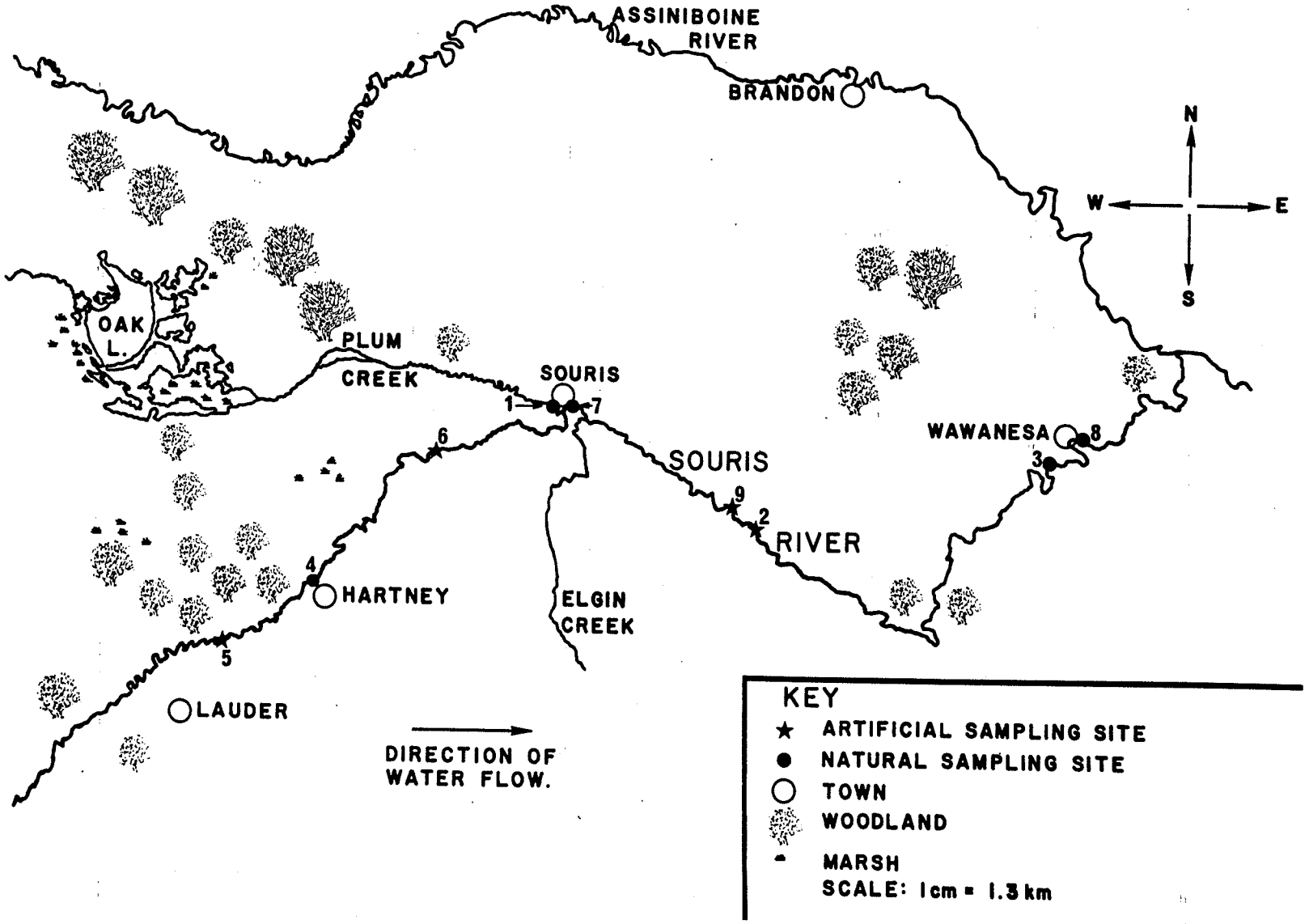

ASSINIBOINE
RIVER
BRANDON
N
W
E
S
OAK
L.
PLUM
CREEK
SOURIS
1
7
6
SOURIS
RIVER
9
2
WAWANESA
8
3
4
HARTNEY
ELGIN
CREEK
5
LAUDER
DIRECTION OF
WATER FLOW.
KEY
ARTIFICIAL SAMPLING SITE
NATURAL SAMPLING SITE
TOWN
WOODLAND
MARSH
SCALE: 1cm = 1.3 km

Figure 2. Adult Simulium vittatum Females Laying Eggs on Vegetation: Site 9 - 1978.

Figure 3. Rope Sampler.





Figure 4. Wire Cage Sampler.

Figure 5. Plate Samplers.





Figure 6. Cone Sampler.

Figure 7. Larvae and Pupae on Cone Sampler.



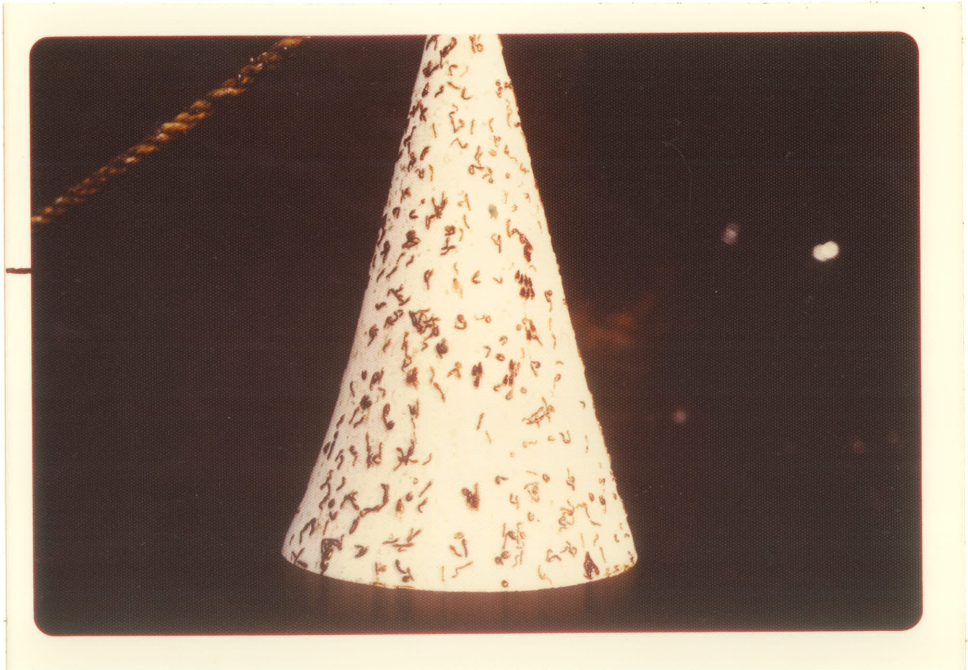


Figure 8. Larvae and Pupae on Plate Sampler.

Figure 9. Larvae on Top of Dam at Site 4.



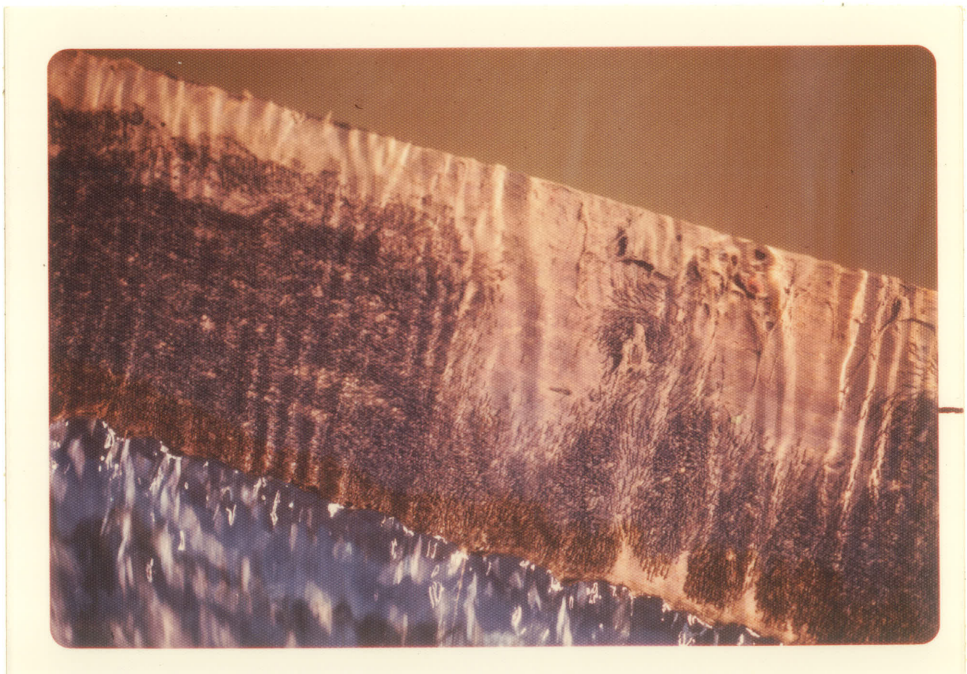


Figure 10. Adult Emergence Trap.

Figure 11. Attractant Trap under Tripod, with Carbon Dioxide Source.

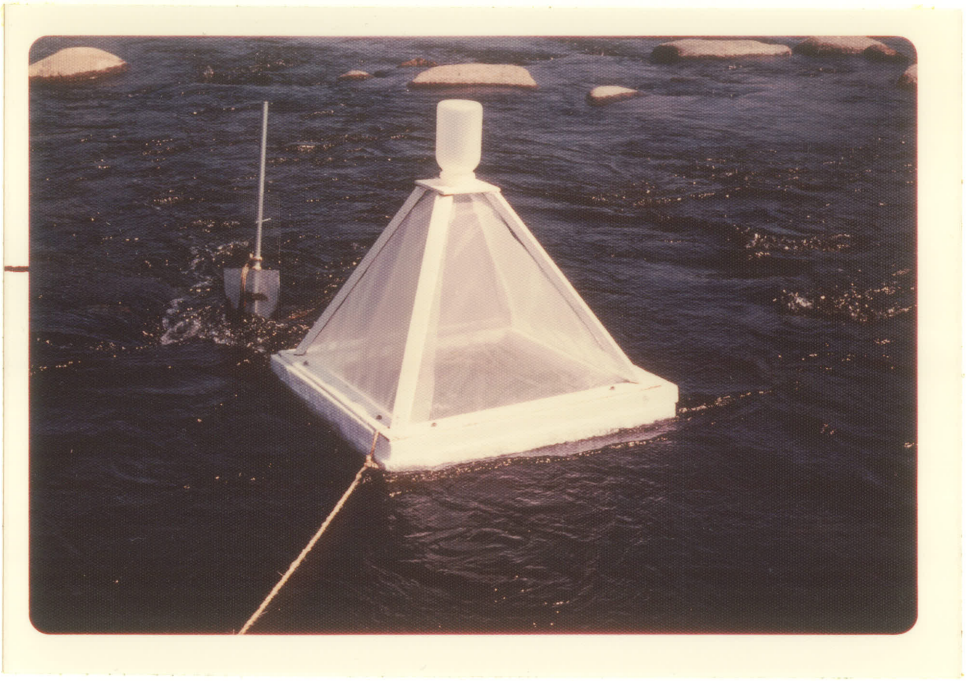
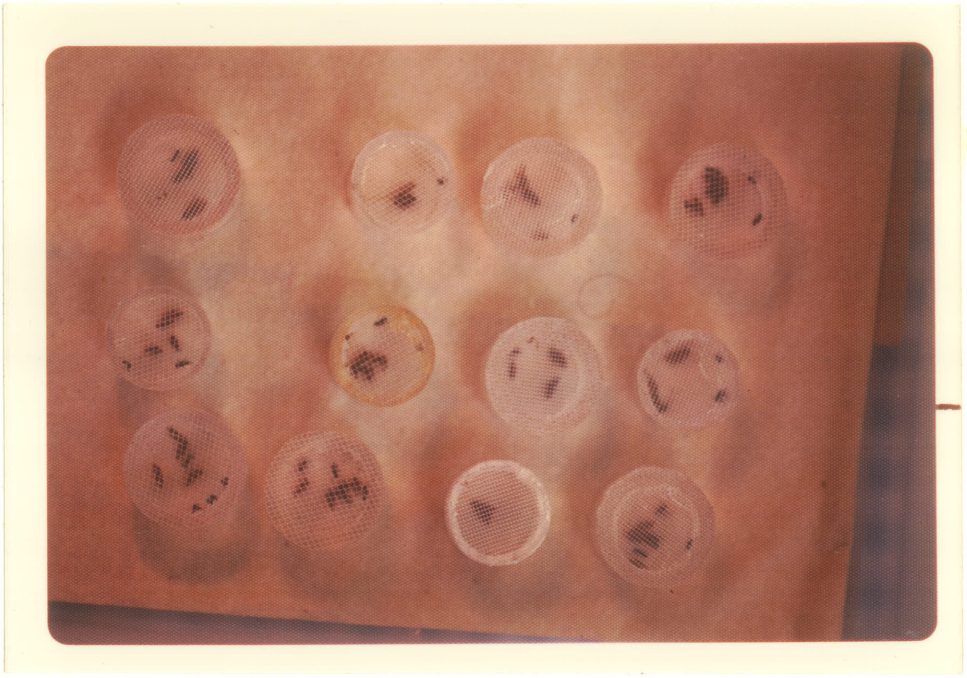




Figure 12. Tubing Cages for Collection of Associated Material.

Figure 13. Site 1a - 20 April, 1978.



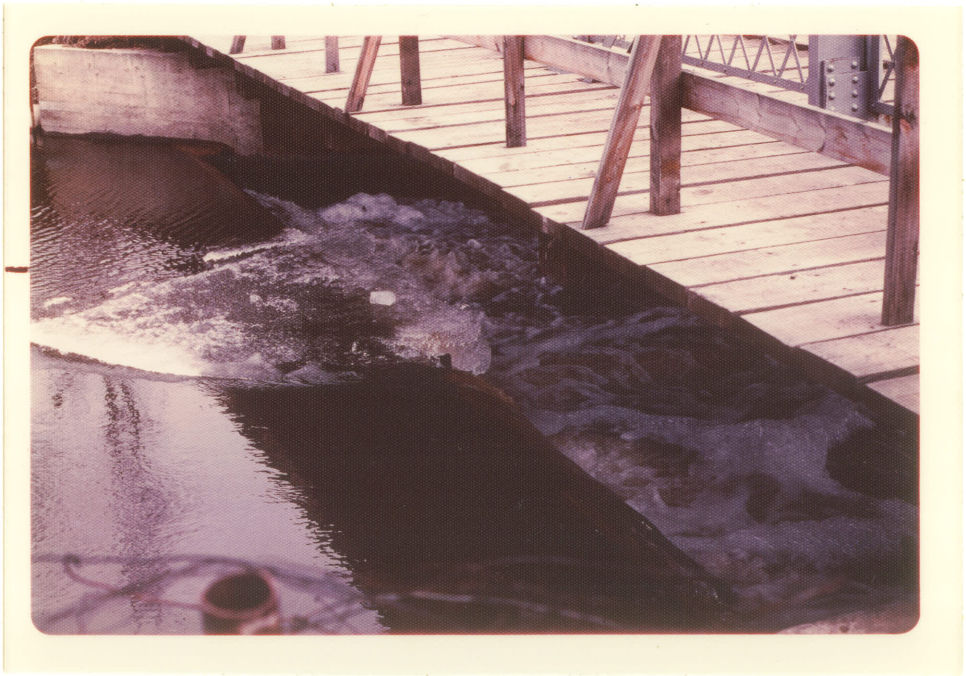
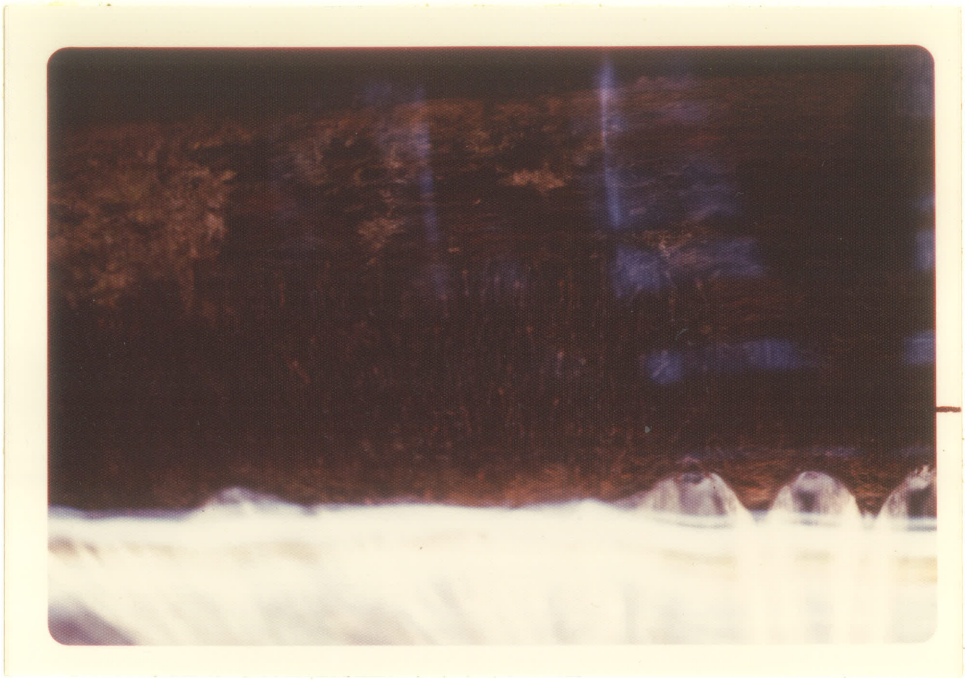


Figure 14. Larvae on Top of Dam Site 1a - 1 May, 1978.

Figure 15. Site 1b - 10 May, 1977.



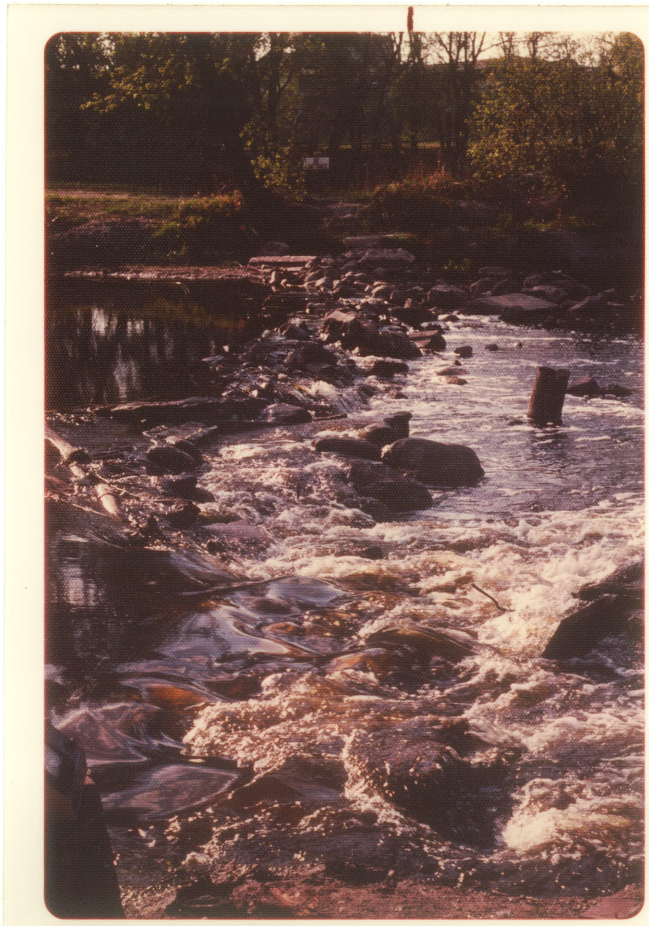


Figure 16. Larvae on Rocks at Site 1b.

Figure 17. Site 2 - 20 April, 1978.



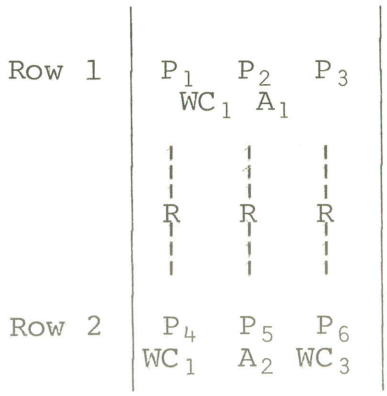


Figure 18. Site 2 - 15 May, 1978.

Figure 19. Sampling Design for Site 2 - 1977.



Legend
P - Plate sampler
---R--- Rope sampler
WC - Wire cage sampler
A - Adult emergence trap





Direction of river flow



N

Figure 20. Site 3 - 20 August, 1977.

Figure 21. Site 4 - 23 July, 1977.



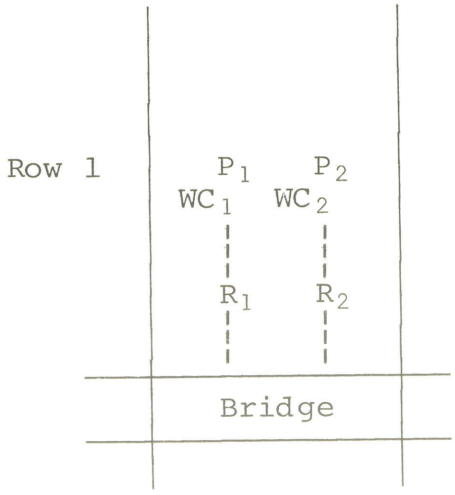


Figure 22. Site 5 - 10 September, 1977.

Figure 23. Sampling Design for Sites 5 and 6 - 1977.



Legend
P - Plate sampler
---R--- Rope sampler
WC - Wire cage sampler



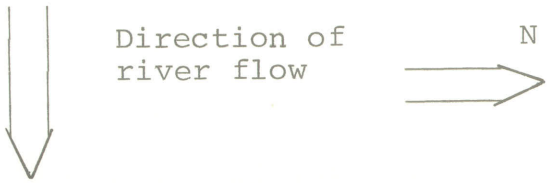


Figure 24. Site 6 - 5 September, 1977.

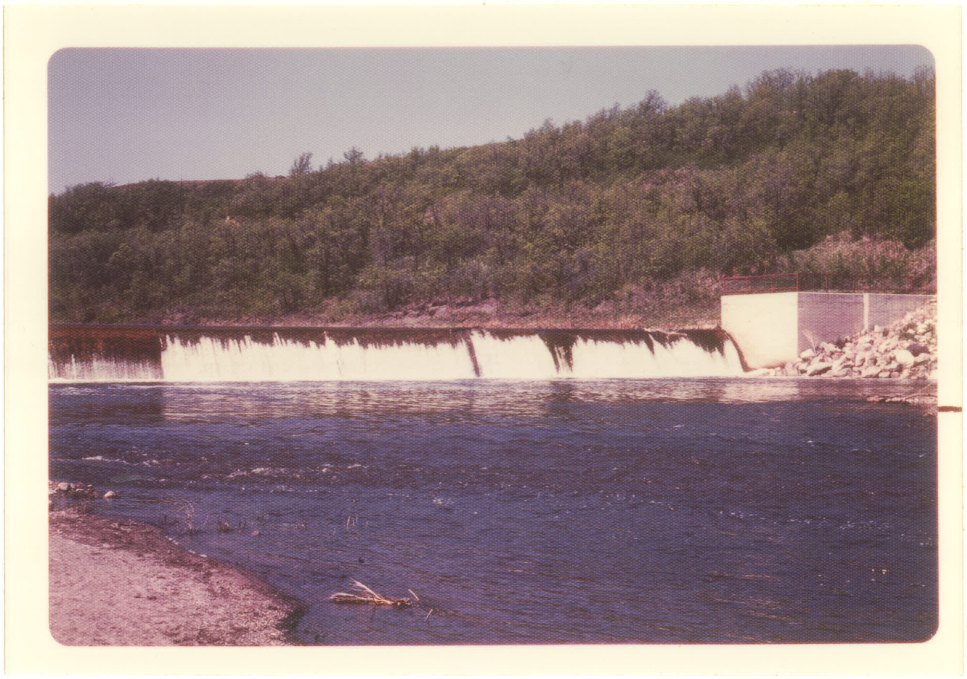
Figure 25. Site 7 - 20 April, 1978.





Figure 26. Site 8 - 15 June, 1978.

Figure 27. Site 9 - 25 April, 1978.





CHAPTER V

Results and Discussion

Section A - Black Fly Species Found in the Souris River

Cnephia dacotensis (Dyar and Shannon).

Geographic distribution in the Souris River. In 1977, *C. dacotensis* was not found in the Souris River nor in Plum Creek. *C. dacotensis* larvae were collected at sites 1, 2, 5 and 9 in 1978 (Fig. 1). Pupae were collected from site 9 and adults from site 2 (Tables 2, 4, 6).

Seasonal distribution. Larvae were collected between 26 April and 16 May (Fig. 38, 42). No instar I (I_1) to instar III (I_3) larvae were collected at any site after 10 May. Pupae were found at site 9 on 10 May.

C dacotensis adults were collected on 16 May at site 2 and consisted solely of males (App. C).

Seasonal abundance. *C. dacotensis* was not abundant at any of the sites from which it was collected. Maximum larval densities were observed during the first ten days of May and dropped quickly afterwards. Site 1 had 1.0 per 6.5 sq. cm, the highest larval density out of 4 sites at which they were collected (Fig. 38, 42). The absence of pupae at all sites except site 9 is difficult to explain. Perhaps mature larvae moved to micro-habitats beyond the range of the sampling equipment for pupation (eg. slow, deep areas

of the river).

Water characteristics. Larvae and pupae experienced a temperature range of 7.2 to 20°C, current speeds of 0.26 to 1.38 meters per second (m/sec) and oxygen concentrations of 7.8 to 13.1 ppm in 1977 and 1978 (App. H, I, J, K, L).

Efficiency of Samplers. Larvae were collected from cone and plate samplers and in wire cage samplers at depths ranging from 2 to 100 cm. C. dacotensis larvae showed no significant ($p \leq 0.05$) preference for any of the sampler types in 1978. Pupae collected at site 9 on 16 May occurred on cone samplers at a depth of 15 to 30 cm. Adults were only collected in emergence traps (App. C).

Voltinism. The seasonal distribution of C. dacotensis is limited in the Souris River. In 1978 larvae and pupae were present for 21 days at four sites in the study area. The absence of larvae and pupae for the rest of the year indicates that C. dacotensis is univoltine in the Souris River, overwintering in the egg stage, with eggs hatching in mid to late April. Stone and Jamnback (1955) and Ezenwa (1974) have also found C. dacotensis to be univoltine and overwinter as an egg. Larval development took 20 to 25 days.

Since only adult males were collected, and these on a single day, longevity, oviposition and mating habits of C. dacotensis were not studied.

Simulium johannseni Hart.

Geographic distribution in the Souris River. In 1977,

immature specimens of S. johannseni and S. johannseni duplex were not found in the study area. Adults of S. johannseni were collected by the sweep net at sites 1 and 2 (App. B).

S. johannseni was more widely distributed and abundant in 1978. Larvae and pupae were found at sites 2, 3, 5, 6, 7 and 9. Adults were collected from sites 2, 5 and 9. S. johannseni duplex was only collected in the pupal stage from site 5 (Tables 2, 4, 5, 6).

Seasonal distribution. S. johannseni larvae occurred from 21 April to 1 June. No I_3 larvae were found after 13 May and I_6 larvae did not appear before 12 May (Fig. 37, 45). Pupae were collected between 5 May and 1 June (Fig. 39, 50). S. johannseni duplex pupae were collected on 10 May. S. johannseni adults were collected between 16 May and 13 June.

Seasonal abundance. S. johannseni was abundant in both east and west halves of the study area. The immature stages proved to be slightly more abundant in the western half, while adults were equally numerous in both. Larval densities west of the town of Souris reached a peak of 28 per 6.5 sq. cm while eastward the peak larval density was only 7.2 per 6.5 sq. cm (Fig. 45, 37). The period of peak larval density throughout the river lasted from 5 May to 12 May (Fig. 37, 45). Pupal densities were lower than larval concentrations. Peak pupal populations occurred between 12 May and 20 May with site 5 having the highest density at 5.0 pupae per 6.5 sq. cm.

Adults were collected by emergence trap, and by sweeping

with a net over breeding sites and around and off hosts. Emergence traps collected the least number of adults, with only a single female being captured (App. C). Sweep net collection over breeding sites captured two females (App. D). Sweep collections around hosts (humans, chickens, geese, horses and cattle) netted a total of 144 females (App. E). Twenty-nine blood-fed females were collected from humans, horses and cattle (App. E). The peak period of adult activity, when the majority of adults were collected, occurred from 17 May to 25 May. Numbers of S. johannseni quickly subsided after 25 May. Four females were caught on attractant traps between 23 May and 13 June (App. F).

Water Characteristics. Larvae and pupae occurred in current speeds ranging from 0.27 to 1.70 m/sec and at depths of 1 to 60 cm (App. L). Oxygen concentrations where S. johannseni was collected ranged from 6.8 to 11.2 ppm in 1977 and 1978 (App. H, I).

Efficiency of Samplers. S. johannseni larvae and pupae were collected on all types of samplers at sites 2, 5, 6 and 9 in 1978. Two sampling dates had larval and pupal collections large enough to permit analysis of preferences for habitat according to sampler type, current speed and depth. No significant difference ($p \leq 0.05$) in larval preference for cones, plate or wire cage samplers was observed. There were no noticeable trends in larval or pupal preference for current speed or depth at artificial sampling sites.

Voltinism. The larvae of S.johannseni required 20 to 30 days to complete development in the Souris River. Overwintering eggs that gave rise to the single yearly generation hatched at water temperatures of 5 to 7°C and by 1 June when temperatures reached 20°C no larvae were found (App. K). Pupae developed within 4 to 6 days and also disappeared by 1 June.

Adults of this univoltine species required a blood meal to lay eggs. Oviposition by adults probably began by 16 May and continued to the end of June. Stone (1964), and Anderson and Defoliart (1961) stated that this species is primarily a bird feeder. The majority of blood-fed S. johannseni adults caught in my study came from mammals (App. E). It is noteworthy that while birds may be attacked, mammals can be considered a significant host for S. johannseni along the Souris River.

Anderson and Dicke (1960) considered S. johannseni to be univoltine and to overwinter as larvae. Evidence presented here supports their finding but suggests the overwintering stage to be the egg rather than the larva. The absence of I_6 larvae at any of the sampling sites before 25 April and the presence of I_1 to I_4 larvae at 7 out of 10 sampling sites during late April and early May supports the hypothesis that in the Souris River S. johannseni overwinters in the egg stage.

Simulium meridionale Riley.

Geographic distribution in the Souris River. In 1977,

larvae and pupae of S. meridionale were collected from site 5 at the western perimeter of the study area (Fig. 1). During 1978, this simuliid was more abundant and widespread. As in 1977, larvae and pupae were more prevalent at sites occurring in the western half of the study area (eg. west of the town of Souris). Larvae and pupae were collected from sites 2, 3, 4, 5, 6, 7 and 9. While no adults were collected in 1977, adults were collected at sites 2, 5 and 9 in 1978 (Tables 1, 2, 3, 4, 6).

Seasonal distribution. In 1977 I_1 to I_5 larvae were collected from vegetation on 10 May at site 5. Larvae then occurred at site 5 on samplers from 16 May to 1 June (Fig. 33). In spite of regular sampling, no larvae were found between 2-9 of June. Larvae appeared again on 10 June until 18 July (Fig. 33). During 1978 larvae were present from 10 May until 5 September (Fig. 36, 44).

In 1977 pupae were collected at site 5 from 16 May until 1 June. None were found between 2 June and 19 June. Pupae appeared again from 20 June to 15 July (Fig. 34). During 1978 pupae were present between 17 May and 15 August (Fig. 51).

Adults were caught in 1978 from 23 May to 14 June (App. C, D, F).

Seasonal abundance. In 1977 peak larval density was 3.7 per 6.5 sq. cm and the peak pupal density reached 1.3 per 6.5 sq. cm (Fig. 33, 34). During 1978 peak larval densities reached 9.8 per 6.5 sq. cm, while pupae proved less abundant than larvae reaching a peak density 0.15 per 6.5 sq. cm (Fig. 44, 51).

In 1978 adults were collected by emergence traps, by sweep netting over breeding sites around and directly from hosts and from attractant traps. The peak period of adult activity lasted from 23 May to 1 June.

Water Characteristics. In 1977, oxygen concentrations ranged from 6.9 to 11.4 ppm (App. H). During 1978, larvae and pupae were collected in current speeds of 0.26 to 1.20 m/sec and oxygen concentrations of 5.0 to 11.3 (App. I, L).

Efficiency of Samplers. In 1977, larvae and pupae were collected from plate and rope samplers at depths of 1 to 40 cm. Statistical analysis revealed no significant ($p \leq 0.05$) preference of S. meridionale larvae and pupae for rope or plate samplers. Immature stages of S. meridionale did not occur on substrates deeper than 40 cm in 1977.

In 1978, S. meridionale larvae and pupae preferred samplers closer to the surface. Collections on three different sampling dates provided enough larvae and pupae to examine possible preferences for sampler type and depth. Statistical analysis showed that on two of the three sampling dates, cone and plate samplers (from depths of 1 to 40 cm) collected significantly ($p \leq 0.05$) more larvae and pupae than wire cage samplers (60 cm deep). There was no significant ($p \leq 0.05$) difference between the collections on cone and plate samplers. Within cone samplers, there was a trend for larvae and pupae to colonize the two cones closest to the surface. On two sampling dates, cones between 0 and 30 cm collected significantly ($p \leq 0.05$) more larvae and pupae than cones below 30 cm.

Comparison within plate samplers revealed a smaller but significant ($p \leq 0.05$) difference in preference of larvae and pupae for depths above 30 to 40 cm.

Voltinism. In 1977, two well separated larval peaks were observed. The first peak (spring generation) disappeared by 1 June (Fig. 33). The presence of a well separated second peak in the latter half of June and the first two weeks of July suggests a second or first summer generation of S. meridionale. Larvae probably began hatching from overwintering eggs in the first and second weeks of May. The spring generation (egg to pupa) lasted 20 to 30 days at water temperatures of 16 to 21°C (App. J). The summer generation (egg to pupa) took 18 to 23 days to mature, at water temperatures of 21 to 23°C.

In 1978, the larval peaks were similar to 1977. At natural sampling sites, I_1 to I_3 larvae were not encountered. This is possibly due to a lack of overwintering eggs at these sites. Later instar larvae probably drifted into the sites from upstream portions of the river with more suitable habitats for overwintering eggs. Larvae disappeared from sites 3, 4 and 7 after the completion of the spring generation, indicating an absence of subsequent generations at these sites (Fig. 36). Site 4 had a first and possible second summer generation (Fig. 44). Two generations of S. meridionale, one spring and one summer, definitely occur in the Souris River, while the presence of I_1 larvae in August may indicate a second summer cohort. The findings presented here agree

with Anderson and Dicke (1960) and Fredeen (1956), who stated that S. meridionale is multivoltine, having up to 4 generations per year.

In 1978, as in 1977, larvae began hatching from overwintering eggs by the second week in May at water temperatures of 14.3 to 18.0°C (App. K). Larvae and pupae were then collected until September at temperatures from 18.0 to 24.0°C (App. K).

Adult females of S. meridionale were collected from several hosts. Nine blood-fed females were collected from humans and one from a yearling heifer (App. E). Another 25 adult females were collected by sweep netting around humans and cattle (App. E). Anderson and Defoliart (1961) and Fredeen (1959) suggested that S. meridionale is primarily a bird feeder. Fredeen mentioned some biting activity on man. Defoliart and Rao (1965) reported that S. meridionale attacks humans. Adults were also caught by attractant traps, both the carbon dioxide and non-carbon dioxide type (App. F).

Simulium vittatum Zetterstedt.

Geographical distribution in the Souris River. Immature stages of this black fly species were found at sites 1a, 1b, 2, 3, 4, 5 and 7 in 1977. During 1978, the only site not colonized by S. vittatum was site 8. In both years this simuliid was the most abundant and widespread black fly species. S. vittatum did not predominate at any one site or prefer the east or west half of the study area in 1977 or 1978, but was prevalent throughout (Tables 1, 2, 3, 4, 5, 6).

Seasonal Distribution. In 1977, larvae and pupae were present at various sites from 10 May until 15 October (Fig. 29, 32, 33, 34). During 1978, immature stages of S. vittatum were collected between 20 April and 15 October at various sites (Fig. 35, 40, 43, 52).

S. vittatum adults were collected from 8 May until 9 July (App. B). In 1978, adults were collected between 10 May and 5 September (App. C, E).

Seasonal Abundance. In 1977 peak larval densities reached 100 per 6.5 sq. cm (Fig. 29, 33). Pupal densities were appreciably smaller with a maximum density of 8.5 per 6.5 sq. cm (Fig. 32, 34). S. vittatum proved to be more abundant in 1978, than 1977, even though maximum densities were smaller. The peak larval density in 1978 was 50 per 6.5 sq. cm (Fig. 35, 43), while the peak pupal density reached 3.0 per 6.5 sq. cm (Fig. 40, 52).

Adults were also very abundant in both years. Adult populations peaked from 25 May to 8 June and again from 27 June to 9 July (App. A, B). In 1978, a total of 1,764 females and 554 males were collected in emergence traps between 10 May and 15 August (App. C). Peak periods for adult catches were 25 May through 31 May, 14 to 15 June and 22 June through 29 June.

Water Characteristics. In 1977, oxygen concentrations ranged from 6.3 to 14.0 ppm, while during 1978 S. vittatum larvae and pupae were collected in oxygen concentrations of 5.0 to 11.2 ppm (App. H, I). Current speeds where S. vittatum

larvae and pupae were found ranged from 0.09 to 1.20 m/sec (App. L).

Efficiency of samplers. In 1977, larvae and pupae occurred on all three types of samplers; rope, plate and wire cage. Analysis showed no significant ($p \leq 0.05$) preference by larvae and pupae for specific sampler type or depth. Immature stages occurred from 1 to 70 cm in depth.

During 1978, collections from 8 different sampling periods had over 1.0 larva and pupa per 6.5 sq. cm. At both natural and artificial sites, S. vittatum showed no significant ($p \leq 0.05$) preference for water depth. Possibly the water level of the Souris River was low enough to prevent immature stages from displaying a depth preference. Analysis showed that larvae and pupae had no significant ($p \leq 0.05$) preference for any of the three sampler types used in 1978.

Voltinism. Data collected in 1977 suggests that S. vittatum may have 3 to 4 generations during a year. The lack of I_7 larvae at sites 1a and 1b on 5 May was probably because overwintering larvae had pupated and ecdysed before sampling began (Fig. 29). At sites 1a and 1b the first summer generation began 20 days after the spring cohort. At site 3 two summer generations were observed (Fig. 29). It is suspected that I_7 larvae collected in mid-October at site 3 pupated and emerged before freeze-up in mid-November. The majority of the larvae in the I_1 to I_4 stages no doubt

passes the winter under the ice, pupating in March or April. Thus, the young instars of this group of larvae that hatched as a second summer generation at site 3, actually became the winter and spring generation of S. vittatum. At site 4, a winter generation, a spring cohort and at least one summer generation were present (Fig. 29). The I_4 to I_7 larvae found at site 4 from 7 June to 1 July were probably a remnant of the spring generation and not a complete generation. The pupal distributions at these sites help in the delineation of the generations (Fig. 32). For instance, at site 3, pupae occurred well into October. The presence of these pupae supports the assumption that late instar larvae pupate in September and October and that adults emerge before freeze-up.

In 1977, similar conditions occurred at sites 2, 5 and 6. At site 2 three well separated groups of I_1 larvae were strongly indicative of the presence of a spring and two summer generations (Fig. 33). At site 5, two widely separated summer generations and the tail-end of a spring cohort were present (Fig. 33). The distribution of pupae at sites 2, 5 and 6 clearly separates generations (Fig. 33, 34). As often happens with S. vittatum, overlap occurs between generations and determining the dates for the beginning and end of generations is often arbitrary. Anderson and Dicke (1960) and Davies (1978) stated that because of this extensive overlap it is often difficult to separate the individual generations (especially summer cohorts), let alone determine dates for the beginning and termination of

a generation.

With respect to the number of generations in the Souris River in 1977, it is interesting to note that at sites 2, 5 and 6 there was a spring generation and two summer generations; overwintering larvae appeared late in the fall (Fig. 33, 34). However, data from sites 1a, 1b, 3, 4 and 7 indicated the presence of a spring generation, one summer cohort and a significant overwintering generation, instead of a second summer generation (Fig. 29). There may therefore have been 3 or 4 generations during the year. The duration of each generation was difficult to estimate. The winter generation was made up of remnants of the second summer generation and hatching eggs laid by adults of this summer cohort. This generation of larvae lived from mid-October to late March or early April. The larval development period of the spring generation began in April and was longer than that of the summer generations, lasting anywhere from 18 to 30 days. Water temperatures during the spring ranged from 17.0 to 22°C, only slightly lower than summer temperatures. Summer generations were shorter in duration, taking as little as 12 to 14 days from egg to pupae. The duration of the pupal stage in the different generations was 4 to 12 days, being longest during the overwintering generation.

In 1978 there was strong evidence of four generations of S. vittatum (Fig. 35, 40, 43, 52). There was also an indication that the overwintering generation consisted of larvae hatching in the fall and larvae hatching in the spring

from overwintering eggs. At site 3, I_7 larvae were collected from 20 April to 10 May (Fig. 35). These larvae could have originated either from overwintering eggs hatching in February or March or as overwintering larvae. The former seems more likely as overwintering S. vittatum larvae usually pupate by late March or early April and adults emerge at the time these I_7 larvae occurred at site 3. At sites 1a and 1b, only the spring generation was encountered. At site 4 a spring generation, a first summer cohort and a combination of a second summer and a winter generation were evident. Site 7 presents a more confused picture because of extensive generation overlap but there were at least a first summer and a combination second summer - winter generation. At sites 2, 5, 6 and 9 at least three generations were recorded. Pupal collections at sites 1, 2, 3, 4, 5, 6, 7 and 9 confirm what was observed in larval distribution.

Duration of generations in 1978 were roughly the same as in 1977. The spring generation lasted up to 30 days and summer generations ranged from 12 to 22 days (egg to pupa). Oxygen concentrations ranged from 5.0 to 11.2 ppm.

Adults were collected by emergence trap and sweep net over breeding areas in 1977, but none were caught either flying about or taking a blood meal from a host (App. A, B). It is noteworthy that adults collected by sweep net on 8 and 10 May undoubtedly arose form overwintering larvae. The absence of adults from 10 May to 19 May separated the spring generation from those of the overwintering larval

generation. The extensive crowding and overlap between generations makes it impossible to pinpoint exact times for the beginning of the spring and end of the winter cohort. This is further compounded by the possibility of overwintering eggs hatching in February or March. Individuals from such a cohort probably should not be considered to belong to either winter or spring generations. They may in fact represent an intermediate generation, bridging these two.

While many more adults were captured in 1978, mostly by emergence traps and sweep netting over breeding areas, only ten S. vittatum females were collected by sweep net around horses and humans (App. C, D, E). Two blood-fed females, one from a human and the other from a horse were collected in 1978 (App. E).

Simulium luggeri Nicholson and Mickel.

Geographic distribution in the Souris River. In 1977 larvae and pupae were collected at sites 1, 2, 3 and 5. S. luggeri was not abundant but was well spread through most of the study area. S. luggeri was absent between Souris Hartney. During 1978 larvae and pupae found at sites 2, 3, 5, 6, 7 and 9, were more abundant than the previous year and did not dominate any specific area (Tables 1, 2, 3, 4, 6).

Seasonal distribution. In 1977 larvae and pupae were collected between 10 May and 1 July (Fig. 30, 31, 33, 34). No adult specimens of S. luggeri were collected in 1977. During 1978 larvae and pupae were collected between 8 May and 15 October, while adults were caught between 25 May and

15 August (Fig. 36, 39, 46, 49; App. C, E).

Seasonal abundance. In 1977 the peak larval density was 12 per 6.5 sq. cm and the highest pupal density was 7.2 per 6.5 sq. cm (Fig. 30, 31, 33, 34). Populations of S. luggeri were higher in 1978, with a peak larval density of 29 per 6.5 sq. cm and a peak pupal density of 5.0 per 6.5 sq. cm (Fig. 36, 39, 46, 49).

While no adults were encountered in 1977, two adult peaks occurred in 1978. The first occurred between 25 May and 14 June and the second lasted from 21 June to 29 June (App. C).

Water characteristics. In 1977, larvae and pupae occurred at oxygen concentrations of 5.8 to 13 ppm and water temperatures of 16.7 to 23.9°C (App. H, J). During 1978, larvae and pupae were collected at 12.8 to 26.4°C and at oxygen concentrations of 6.0 to 9.3 ppm (App. I, K). Larvae and pupae occurred at current speeds of 0.26 to 0.91 m/sec (App. L).

Efficiency of samplers. The very low numbers of larvae and pupae collected in 1977 prevented comparison of sampler types and larval preferences for current speed and depth. The larvae and pupae of S. luggeri were collected at depths of 2 to 60 cm. On three separate dates, larvae and pupae significantly ($p \leq 0.05$) preferred cone and plate samplers over wire cages in 1978. There was no significant ($p \leq 0.05$) difference between plate and cone samplers.

Larvae and pupae collected at both natural and artificial

sites showed no significant ($p \leq 0.05$) preference for depth (range - 1 to 70 cm).

Voltinism. In 1977, at site 1, only larvae of the spring generation were encountered. These hatched from overwintered eggs (Fig. 30, 31). At site 2 the first summer generation was encountered but not the spring generation (Fig. 33, 34). The spring cohort probably began hatching in the first to second week of May, when water temperatures were 12 to 14°C. The first summer generation began hatching in early to mid June and development extended into the first week of July.

During the second year of the study, at least three generations were observed. At site 3 the spring generation lasted well into June, telescoping into the first summer cohort (Fig. 36). The end of the second summer, or even a possible third summer generation was noted in September and October at site 3 (Fig. 36). The presence of I_4 to I_7 larvae in October indicated that adults would emerge before freeze-up and deposit eggs that would go into diapause until the following spring or summer. Pupal peaks corresponded to the larval peaks at site 3 confirming at least three generations (Fig. 36, 39). At sites 2 and 6, larval collections showed the spring generation and the first summer generation of S. luggeri (Fig. 46). Pupal collections revealed the presence of a second summer generation at site 2, not seen in larval distributions (Fig. 49). Site 9

provided perhaps the most informative data showing conclusively at least three generations, one spring and two summer, in both larval and pupal collections (Fig. 46, 49).

The finding that S. luggeri has a minimum of three generations in the Souris River agrees with Fredeen (1977), who reported up to four generations per year for S. luggeri in the Saskatchewan River. The spring generation began during the first two weeks of May with the hatch of overwintering eggs. The first summer generation began in mid-June and ended in mid-July. A second summer generation began in late July and matured in mid to late August. A third summer generation extended from late August to October. In the Souris River, larvae found in October either belonged to a third summer generation or else were the remnant of the second summer generation.

Adults were collected by emergence trap, sweep net, attractant traps and around and off hosts (App. C, D, E, F). Between 23 May and 13 June, 122 adult females of S. luggeri were collected about horses, cattle and humans (App. E). Six blood-fed females were aspirated from cattle and 18 blood-fed females were collected from humans (App. E). Stone (1964) and Fredeen (1977) have reported S. luggeri to attack man, cattle and horses.

Simulium venustum Say. Simulium verecundum Stone and Jamnback.

Geographical distribution in the Souris River. In 1977, S. venustum/verecundum larvae, pupae and adults were collected from site 1a and 1b. Immature stages could not be identified to species with 100% accuracy, so they are here referred to as the S. venustum/verecundum complex. Adults, on the other hand, could be identified and are presented separately. Duting 1978 S. venustum/verecundum larvae and pupae were collected from sites 1a, 1b, 2, 3, 5, 6 and 9.

Seasonal distribution. During 1977 larvae and pupae occurred from 5 May to 1 June (Fig. 30, 32). Adults were encountered on 7 through 8 May. In 1978 larvae and pupae were present from 20 April to 1 June (Fig. 37, 48). Adults were present from 10 May to 25 May (App. C, D, E, F).

Seasonal abundance. Larval and pupal densities were low in 1977, reaching 1.8 per 6.5 sq. cm for larvae and 7.2 per 6.5 sq. cm for pupae (Fig. 30, 32). In 1978 peak larval density was 30 per 6.5 sq. cm and the peak pupal density was 4.0 per 6.5 sq. cm (Fig. 37, 39). The peak period of adult activity occurred between 16 May and 25 May in which specimens were collected by emergence trap, sweep net, around and off hosts and attractant trap.

Water characteristics. In 1977 S. venustum/verecundum larvae and pupae were collected at oxygen concentrations of 8.0 to 14.1 ppm (App. H). During 1978 larvae and pupae were collected in current speeds of 0.12 to 13.8 m/sec and oxygen concentrations of 6.8 to 13.0 ppm (App. I, L).

Efficiency of samplers. As no S. venustum/verecundum larvae were collected on artificial sampling equipment in 1977, no preference for sampler type, depth or current speed could be examined. Analysis to test for larval and pupal preferences in 1978 for the various samplers on three dates with sufficient populations proved inconclusive. No significant preference ($p \leq 0.05$) was exhibited for any of the three sampler types, depth or current speed in 1978. Immature stages were collected at depths of 1 to 60 cm. In 1977 larvae and pupae were found at depths of 0 to 40 cm.

Voltinism. This is a single generation species and during 1977 overwintering eggs hatched in mid to late April. Water temperatures during the collection period, 5 May to 1 June, ranged from 17.8 to 21.8°C (App. K). First instar larvae would have hatched in water temperatures of 2 to 7°C in 1977.

In 1978 water temperatures during late April and early May, when I_1 to I_3 larvae were developing, ranged from 5.1 to 14.3°C. Overwintering eggs began hatching prior to 1 May, as in 1977, in 2 to 6°C water. Duration of the larval stage was approximately 20 to 30 days and the pupal stage as short as four days at the warmer water temperatures in late May. In 1978 larvae and pupae were collected at water temperatures from 5.1 to 22.3°C (App. K).

Abdelnur (1968) and Merritt et al. (1978) considered S. venustum and S. verecundum as multivoltine species, having up to four generations per year. However, Jamnback (1976) stated that increasing temperatures and algal populations

combined with decreasing flow rates reduce generations succeeding the spring one in North America. The Souris River warms up very rapidly (App. J, K) in the spring and algal content often increases dramatically by mid-June. Flow rates often decrease substantially. These conditions, similar to those outlined by Jamnback, may prevent eggs laid by the spring generation from hatching, instead forcing them into diapause until more favourable conditions occur in the following spring.

Adults were collected about hosts and during blood feeding. Five S. verecundum females were caught while flying about humans, chickens, geese and a horse (App. E). Two adult S. venustum females were collected around a two year old heifer and a flock of chickens. No blood-fed S. venustum females were collected but four such females of S. verecundum were caught, two from a human and two from a horse (App. E). S. venustum has been found to feed on cattle, humans, horses, deer and many bird species (Anderson and Defoliart 1961; Stone 1964; Abdelnur 1968). S. verecundum has previously been recorded feeding on man only (Golini and Davies 1975).

Simulium tuberosum (Lundström).

Geographical distribution in the Souris River. S. tuberosum was not collected in 1977. In 1978 larvae, pupae and adults were collected from sites 2, 3, 6 and 9.

Seasonal distribution. Larvae and pupae of S. tuberosum were collected between 1 May and 15 June (Fig. 42). The only

adult found was on 15 June (Tables 2, 4, 6).

Seasonal abundance. After S. johannseni duplex, S. tuberosum was the least abundant species found in the Souris River. The peak larval density was only 0.10 per 6.5 sq. cm and 0.05 per 6.5 sq. cm for the peak pupal concentration (Fig. 42).

Water characteristics. In 1978, S. tuberosum larvae and pupae were collected at currents speeds of 0.34 to 1.38 m/sec and oxygen concentrations of 6.8 to 10.1 ppm (App. I, L).

Efficiency of samplers. Too few S. tuberosum larvae and pupae were found to examine possible preferences for sampler types, depth or current speed. Immature stages were found at depths of 3 to 50 cm.

Voltinism. Only one generation of S. tuberosum was observed in the Souris River, possibly because of the low population. Stone and Jamnback (1955) and Lewis and Bennett (1973) have demonstrated up to four generations elsewhere. In the Souris River larvae and pupae were found in water temperatures of 13.9 to 20.6°C (App. K).

Simulium decorum Walker.

Geographical distribution in the Souris River. In 1977 S. decorum larvae and pupae were collected at sites 1a, 1b and 4. During 1978 this simuliid proved to be more abundant and widespread, being found at sites 1a, 1b, 2, 3, 4, 5 and 9.

Seasonal distribution. S. decorum larvae and pupae were collected from 3 June to 15 October in 1977 (Fig. 30, 31).

No adults were collected in 1977. In 1978, S. decorum larvae were encountered much earlier in the year, on 25 April, and the last larvae were collected on 15 October (Fig. 38, 40, 47). Adults were collected between 11 July and 5 September (App. D).

Seasonal abundance. While S. decorum was fairly limited in its geographical distribution in 1977, it was abundant at the few sites where it was collected. The peak larval density was 60 per 6.5 sq. cm and the peak pupal density encountered was 3 per 6.5 sq. cm (Fig. 30, 31). In 1978, larval and pupal populations were larger at natural sampling sites than those with artificial sampling equipment. For example, the peak larval density at natural sites was 75 per 6.5 sq. cm, while artificial sampling sites had a maximum of 0.02 larvae per 6.5 sq. cm (Fig. 38). Peak pupal densities encountered were 4.0 per 6.5 sq. cm (Fig. 40). Wolfe and Peterson (1959), Fredeen and Shemanchuk (1960) and Stone (1964) noted that the immature stages of S. decorum favour dams, sluice and head gates, pond and lake outfalls and beaver dams for colonization. This may explain why in the Souris River large populations of S. decorum occur at those sites where dams and other large man-made structures occur and not at the artificial sampling sites. In 1978, a total of 178 S. decorum adults were collected by sweep net with no noticeable peaks of abundance (App. D).

Water characteristics. In 1977 larvae and pupae were collected at water temperatures of 19.0 to 22.7°C, oxygen

concentrations of 6.8 to 11.2 ppm (App. H, J). During 1978, larvae and pupae were found in oxygen concentrations of 5.0 to 11.2 ppm, current speeds 0.07 to 1.38 m/sec and water temperatures of 7.2 to 26.0°C (App. I, K, L).

Efficiency of samplers. In 1977 S. decorum was not collected from sites with artificial sampling equipment. S. decorum larvae and pupae were collected at natural sites at depths of 1 to 30 cm and at sites 2, 5 and 9 from 1 to 40 cm in 1978. Larvae and pupae were not numerous enough on artificial substrates to analyze for sampler preference.

Voltinism. In 1977, four generations were observed in S. decorum. A spring generation and three summer generations occurred; the last ended in mid-October. At site 4, the presence of three well separated groups of I_1 larvae suggest three generations, but the continued presence of pupae from late June until mid-October masked the number of generations present (Fig. 30, 31). By matching the pupal peaks (Fig. 31) to the larval peaks (Fig. 30) at site 4, the three generations can be observed in the distribution. Site 1 showed the presence of the spring generation very clearly (Fig. 30).

During 1978 the spring generation occurred from mid to late April until the last week in May. The first summer generation began in late May and early June and terminated in the first and second weeks of July. As in 1977, large increases in pupal populations and cohorts of late instar larvae in September and October indicate that S. decorum

adults emerged before freeze-up. Members of the pupal and larval population groups observed in September and October probably belong to the third summer generation (beginning in early August) and included stragglers from the second summer generation (beginning in the second to the third week of July). In 1978, just as in the previous year of the study, overwintering eggs began hatching in mid-April at water temperatures of 1.4 to 7.0°C and larvae reached the I_6 and pupal stages by mid-May. The duration of the spring generation was 25 to 40 days, and most likely in the 25 to 35 day range if eggs hatched around 15 April. Summer generations were shorter, probably a maximum of 25 days and at sites that provided optimum conditions for development the length of time from egg to adult eclosion was as short as 18 to 20 days (Fig. 38, 40).

Along the Souris River S. decorum adults were not recorded attacking hosts. This agrees with observations made by Davies and Peterson (1956) and Davies et al. (1962) that this simuliid is not normally of economic importance in North America.

Section B - Sampler Performance and Physical Parameters

The nine species collected in the study area showed little preference for sampler type. However, on several occasions and for different species, the wire cage samplers were significantly inferior to plate or cone samplers in collecting black fly larvae and pupae.

In 1977 analysis of the performance of the samplers used was minimal because of the abnormally low populations of black flies that inhabited the river.

Rope samplers were excluded in the sampler comparison because of the difficulty of obtaining a true 6.5 sq. cm sample from them. This left plate and wire cage samplers. As already stated, plate samplers seemed more efficient at collecting larvae and pupae. Consequently, figures presenting collections at sampling sites with artificial sampling devices in 1977 are based on plate sampler catches.

In 1978, while wire cage samplers were significantly ($p \leq 0.05$) poorer than cone and plate samplers in collecting larvae and pupae, the cone and plate samplers were very similar in performance. As one aim of this study was to choose a sampler which best reflected black fly population changes and numbers in the Souris River, a decision had to be made as to which sampling device should be used in the future. A sampler must be easy to handle in the river under a variety of environmental conditions. The cone sampler has several physical advantages over the plate sampler, and these are presented below.

The first advantage of the cone sampler is its versatility in conjunction with water depth. At water depths over 130 cm, plate samplers become impractical and must be made increasingly longer to facilitate retrieval. Whereas, cone samplers can be employed even at flood stage (eg. water depths in excess of 400 cm) and are easily

retrieved. Cone samplers can also be employed in deep water without the use of a boat or drag pole or hook for retrieval by attaching samplers to bridges etc. and reversing the order of descent. The cones closer to the point of attachment (eg. bridge) remain near the surface and weights at the opposite end keep cones further down the rope near the river bottom.

A second advantage to cone samplers is the ease of removing larvae and pupae from cones and speed in returning cones to the water. Where plate samplers must be completely removed from the water for sampling and replaced into the riverbed, cone samplers do not have to be completely removed from the water.

A third desirable characteristic of the cone sampler is that cone depth can be regulated to give the desired position relative to the riverbed. Plate samplers, on the other hand, are immovable and must be checked constantly if a desired level of the river is to be properly sampled. For example, fluctuations in water levels of 5 to 30 cm within several days in waterways such as the Souris River are not uncommon. If water levels were to rise 15 cm between sampling periods, plate samplers would not sample this new 15 cm of water above them as they are stationary. The cone sampler, due to the float, would rise 15 cm and the top cone would still sample the new 15 cm of water, with remaining cones sampling the other depths (depending on the number and position of cones).

For these reasons cone samplers are recommended for use on the Souris River and figures representing collections at sites 2, 5, 6 and 9 in 1978 are based on their total catches.

As black fly outbreaks did not occur in 1977 or in 1978, the number of larvae or pupae per cone in the Souris River which constitute an outbreak is unknown. Each cone had an area of 314 sq. cm. In 1978, S. venustum/verecundum reached a maximum density of 9 larvae per 6.5 sq. cm or 1,130.4 larvae per cone at site 2 (Fig. 41). S. johannseni reached a maximum density of 3,516.8 larvae per cone at site 5 in 1978 (Fig. 45). S. vittatum had a maximum of 18.8 larvae per 6.5 sq. cm or 2,361.3 larvae per cone at site 9 and S. meridionale reached a peak density of 1,125.0 larvae per cone at site 6 (Fig. 43, 44). While some of the numbers on cones seem high, they were never consistently numerous throughout the study area. For a serious outbreak to occur, populations on cones placed several miles apart would probably have to be over 500 per cone.

It is difficult to relate the densities of larvae and pupae collected on cones to those on natural substrates. In the majority of cases, natural substrates had higher densities of immature simuliids than cone or plate samplers. As no comparison was made to determine the degree of attractiveness of natural versus artificial devices it is unfair to equate the two. At certain sites cone samplers were placed in micro-environments where few natural substrates could be

utilized as attachment sites for larvae and pupae (eg. deep slow moving water sections between and in front of riffles at sites 5 and 6). In such areas cones would collect higher numbers of immature black flies than surrounding less favourable substrates because of depth or position in respect to the current. Yet, because natural substrates are devoid of larvae in such areas does not mean that artificial samplers are superior in collecting larvae or give a biased reflection of larval densities present in the river. The opposite conditions exist where natural substrates provide good attachment sites and artificial samplers at such sites may not collect as many individuals due to competition for optimum areas for colonization. For these reasons the seasonal distribution and abundance of immature black flies have been presented on natural as well as artificial substrates. Although a standard measurement (No. per 2.5 cm^2) of density has been used for simplicity, it does not mean that densities at natural and artificial sampling sites should be directly compared. Rather, in comparing sites, densities presented are a guideline to measure future black fly populations at these sites.

The second category of population measurement was the examination of the influence that sampler location and physical parameters had on each other and on density of larvae.

The most numerous species, S. vittatum was chosen for preliminary investigation. Sites 2 and 9 were chosen for

the analysis because of a larger number of cone samplers.

Analysis of each component is presented in a matrix of correlation coefficients (Table 7).

A number of expected trends were found (Table 7). These included a positive correlation between date and water temperature (0.28), a negative correlation between date and oxygen concentration (-0.54) and a negative correlation between date and larval density (-0.32). A positive correlation between date and current speed (0.28) meant water velocity increased overall from May through July. Heavy rains in June and July could be partially responsible for this. Although current speed stayed the same or increased through April to July, density of larvae still decreased when all cone samplers were considered, irrespective of position in the river.

Sampler location within sites (eg. position across the river) strongly correlated with current speed (0.54). This large positive correlation means that samplers in the highest current speeds (those in the middle of the river channel) collected the most larvae. This in turn meant that sampler location would have a positive correlation with density (0.17); those samplers in mid-channel had the highest larval density. While current speed did not influence the overall density of larvae in the river, it did influence which sampler collected the most larvae.

Depth had no positive or negative correlation with either physical parameters of larval density in 1978. It

obviously had no apparent effect on the distribution of S. vittatum larvae in the Souris River.

Other relationships included a negative correlation between water temperature and oxygen concentration (-0.59), positive correlation between density and oxygen concentration (0.14) and a negative correlation between density and current speed (-0.13).

The matrix of correlation coefficients showed many expected relationships between physical parameters and density of larvae. What it did not show was the actual importance each parameter had in governing the rest. Depth and current speed were the least significant factors in determining larval density while temperature, oxygen concentration and date were more important in determining larval density. Analysis of the most numerous species (providing the largest sample size) did not indicate any unusual trends between density and physical parameters. Multiple correlations among other species and physical variables were not carried out.

Section C - Pest Species - Implications for Control

Of the nine black fly species collected from the Souris River, five can be considered economic pests to the surrounding area: S. johannseni, S. venustum/verecundum, S. luggeri and S. meridionale. S. vittatum, although numerous, was seldom observed to attack man or livestock in 1977 or 1978. S. decorum adults were not found around any

mammals. C. dacotensis is autogenous, and S. johannseni duplex and S. tuberosum were not numerous enough to be an economic threat.

The five pest species can be lumped into two groups. S. johannseni, S. venustum and S. verecundum developed earlier than S. luggeri and S. meridionale. The former three species were most abundant in spring, arising from overwintering eggs which hatched at temperatures of 5 to 7°C. In a year of average or above average water flow and normal water temperatures, eggs begin hatching in mid to late April and larvae begin to pupate by the second week of May. Adults of S. johannseni, and the S. venustum/verecundum complex begin emerging by late May and continue to the end of May or the first week of June. Conventional larvicide treatment to control these two species would have to be timed for late instar larvae eg, I_4 to I_6. In 1977 and 1978 the second week of May was the peak period for these instars.

Compounding the problem of control is the presence of the two warm water species, S. luggeri and S. meridionale. Overwintering eggs of these species begin hatching in the first week of May and most likely continue over a two week period. Water temperatures of 12 to 14°C initiate egg hatch. Mature larvae and pupae occur by the end of May and the beginning of June, with the majority of adults emerging usually from 1 June onward. Thus the larvicide treatment aimed at S. johannseni and the S. venustum/verecundum

complex in early May would have little effect on S. luggeri and S. meridionale, which are in the egg stage (resistant to conventional larvicidal treatment). The optimum time interval for control of S. luggeri and S. meridionale would be late May dependant upon immature development rate.

The black fly situation in 1976 reflected to a large degree the importance of correct timing for larviciding and the need to predict developmental rates for these species. In 1976, the larvicide treatment in early May probably suppressed adult S. johannseni and the S. venustum/verecundum complex activity for the month of May. From post facto examination of pupal cases found on a bridge, it appeared that S. luggeri and S. meridionale were the pest species in 1976. These probably hatched after the May 11 application, and escaped the effects of the larvicide treatment.

A rather unique situation occurs in relation to black flies and their pest status in the Souris River. Unlike many areas of North America which have one or at most two serious pest species at any one time, the Souris River produces five pest species. It may be the combination of the five pest species that results in an economic problem on livestock.

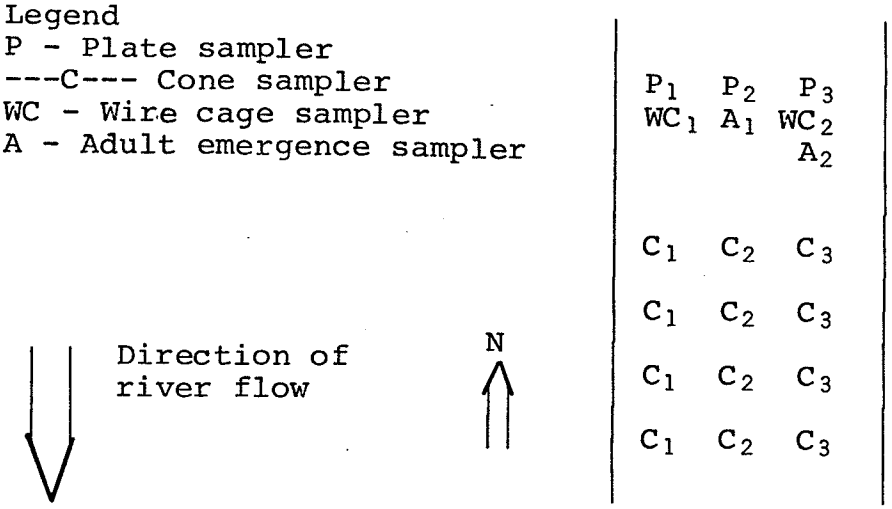
In 1977 and 1978, peak adult populations of S. johannseni and S. venustum/verecundum complex occurred during the last two weeks of May. These overlapped with populations of S. luggeri and S. meridionale that peaked during the first two weeks of June. Control of these five species in an outbreak year may be possible with two separate and well timed larvicide treatments.

A second very important factor that influences the degree of seriousness of an outbreak by the five pest species is water level and flow of the Souris River. It seems that serious black fly outbreaks only occur in the Souris River when it undergoes moderate to heavy flooding in the spring. Under normal conditions this river, with its mud and shale bed, has very few stretches of rapids causing turbulent water which is needed by black fly larvae and ovipositing adults. In the spring, when the river exceeds its banks and spreads into the surrounding vegetation, black flies are provided with egg and larval attachment sites along its entire length. The degree of flooding by the swiftly moving river in the spring dictates the intensity of the black fly outbreak. In the spring of 1976, severe flooding occurred along much of the river with peak flows reaching as high as 24,000 cfs (480 m^3/sec). The river bank vegetation, bridges, debris, etc. provided excellent substrates to produce large populations of black flies. In 1977, river levels were at record lows, not seen since parts of it dried up in 1933. Water flows were between 20 - 200 cfs (0.40 to 4.0 m^3/sec) and black fly production was negligible. In 1978, while flows increased somewhat (peaking at 22.2 m^3/sec at Hartney), there was still no flooding and populations of black flies remained relatively small. Thus, river flow prior to the beginning of black fly breeding often gives a good indication as to the potential of an outbreak.

Figure 28. Sampling Design for Site 9 - 1978.

Figure 29. Larvae Collected on Natural Substrates in 1977. Simulium vittatum; A - Site 3, B - Site 7, C - Site 1a, D - Site 1b and E - Site 4. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.

Legend
P - Plate sampler
---C--- Cone sampler
WC - Wire cage sampler
A - Adult emergence sampler



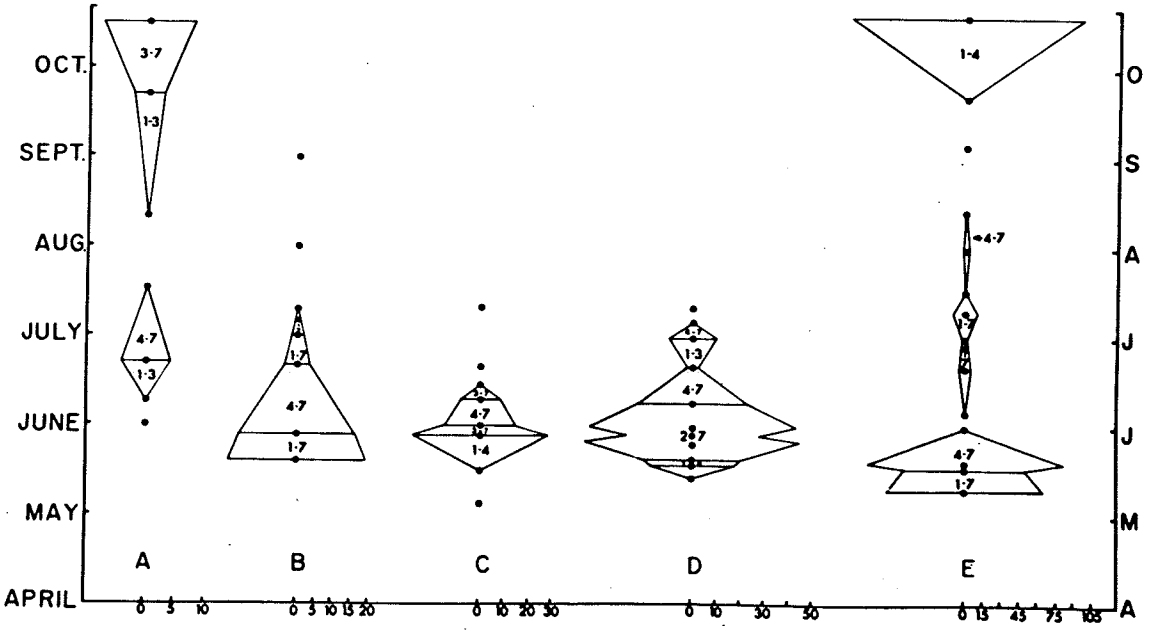
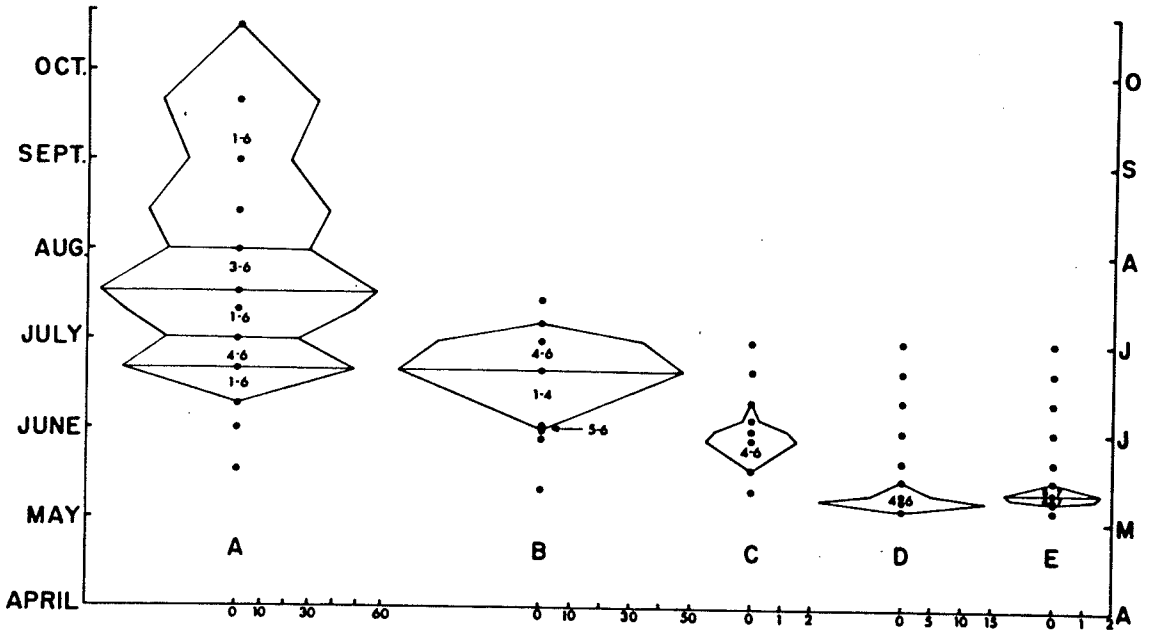


Figure 30. Larvae Collected on Natural Substrates in 1977. Simulium decorum; A - Site 4, B - Site 1b and C - Site 1a. Simulium venustum/verecundum complex; D - Site 1a and 1b. Simulium luggeri; E - Site 1a and 1b. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.

Figure 31. Pupae Collected on Natural Substrates in 1977. Simulium luggeri; B - Site 3. Simulium decorum; C - Site 4 and D - Site 1a and 1b. Larvae Collected on Natural Substrates in 1977. Simulium luggeri; A - Site 3. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution



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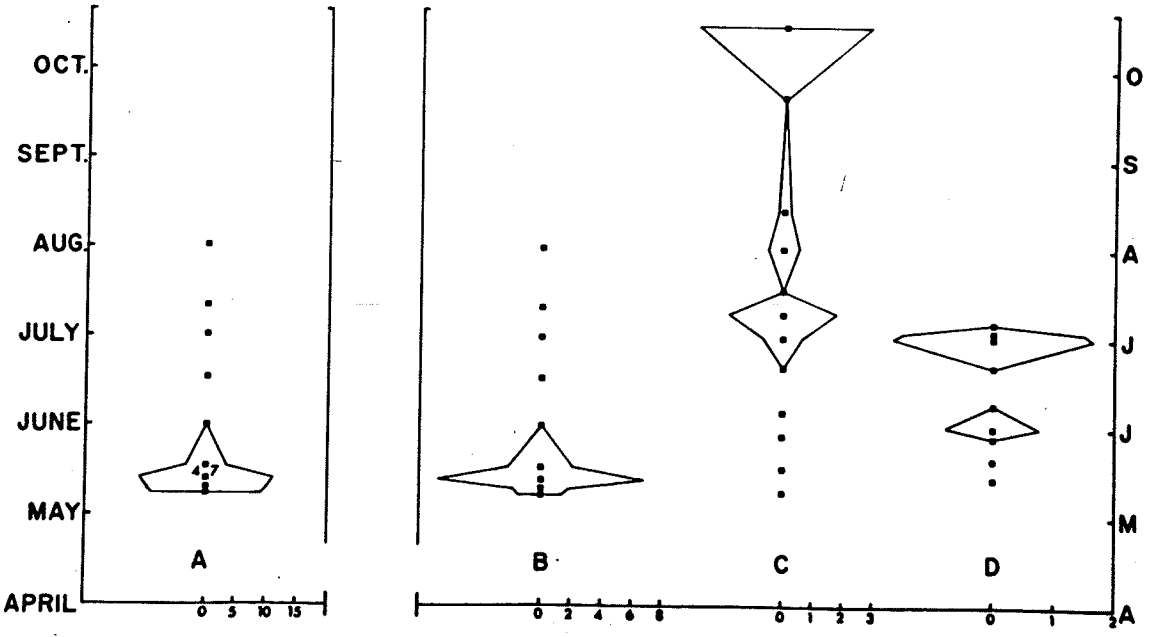

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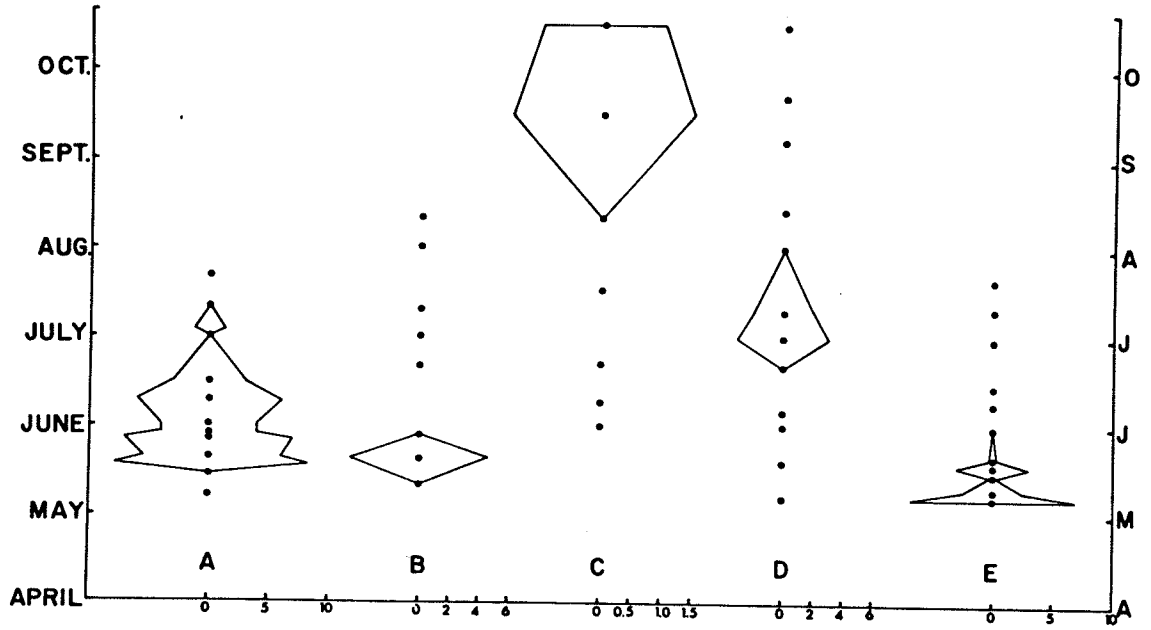
Figure 32. Pupae Collected on Natural Substrates in 1977. Simulium vittatum; A - Site 1a and 1b, B - Site 7, C - Site 3 and D - Site 4. Simulium venustum/verecundum complex; E - Site 1a and 1b. Dot Represents Sampling Point.

Figure 33. Larvae Collected on Plate Samplers in 1977. Simulium vittatum; A - Site 2, B - Site 5, C - Site 6. Simulium luggeri; D - Site 2 and E - Site 5. Simulium meridionale; F - Site 5. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.



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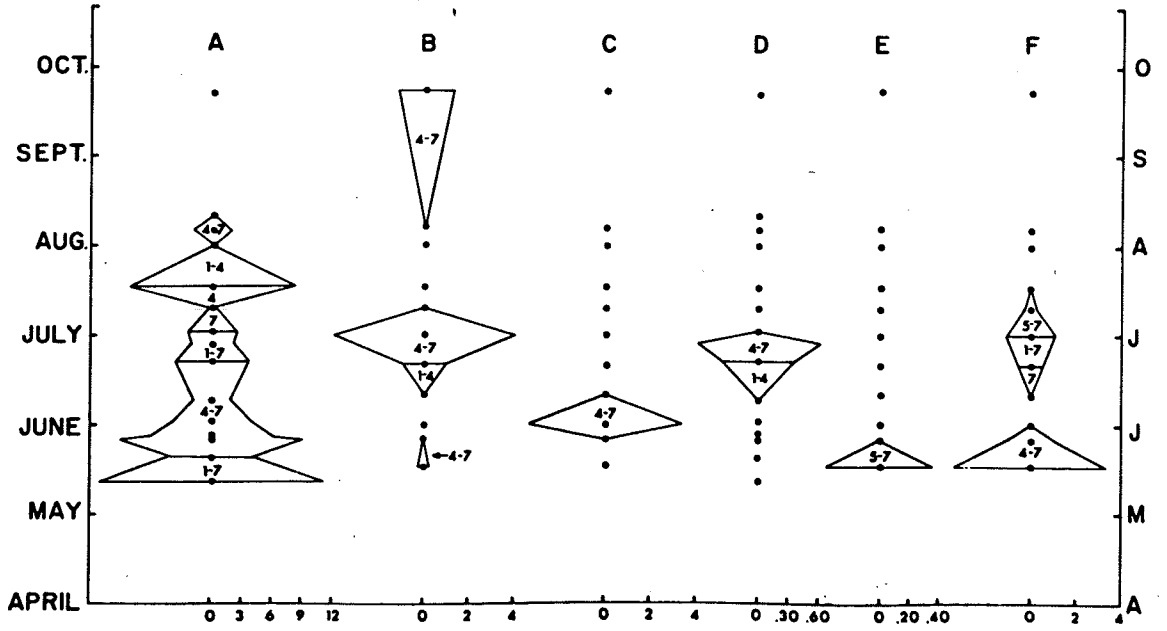

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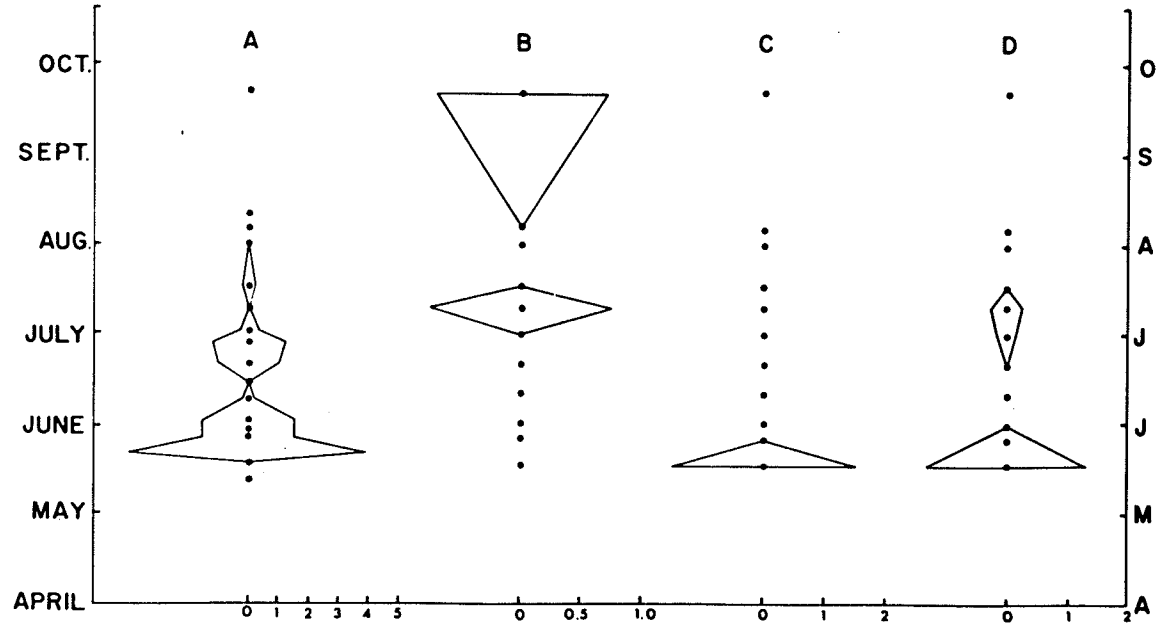
Figure 34. Pupae Collected on Plate Sampler in 1977. Simulium vittatum; A - Site 2 and B - Site 5. Simulium luggeri; C - Site 5. Simulium meridionale; D - Site 5. Dot Represents Sampling Point.

Figure 35. Larvae Collected on Natural Substrates in 1978. Simulium vittatum; A - Site 1b, B - Site 1a, C - Site 3, D - Site 4 and E - Site 7. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.



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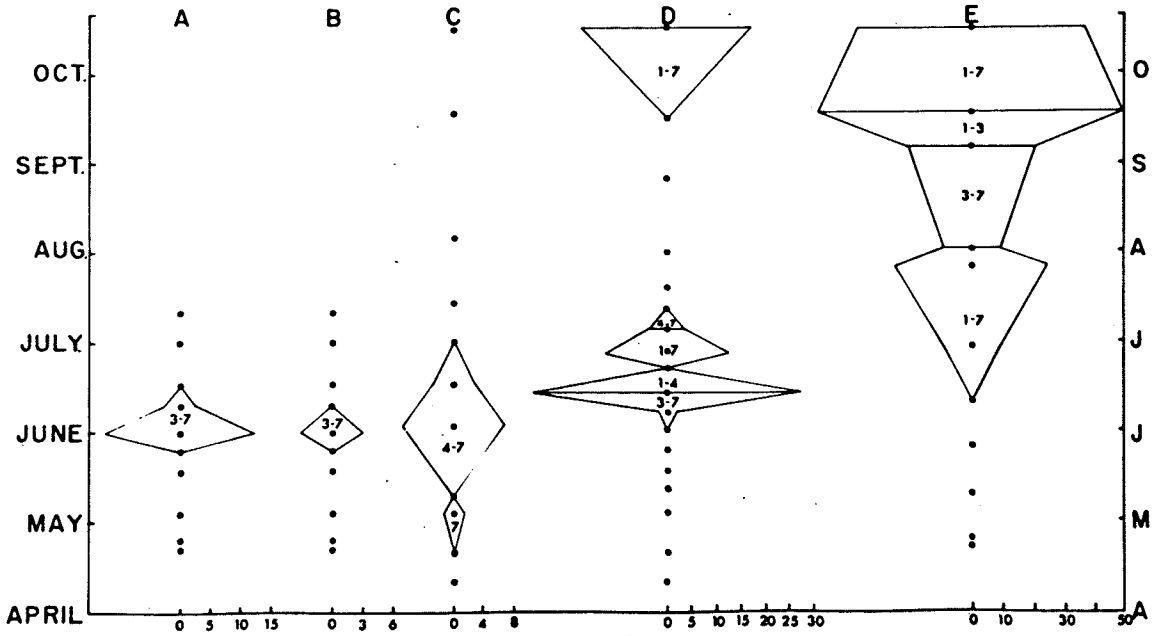

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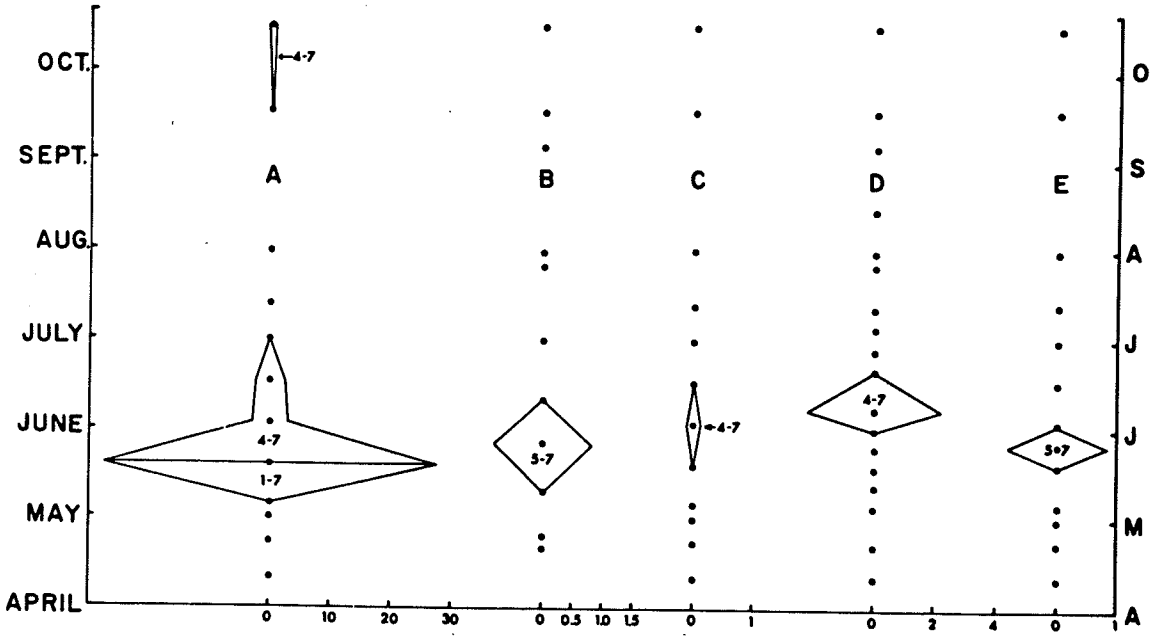
Figure 36. Larvae Collected on Natural Substrates in 1978. Simulium luggeri; A - Site 3 and B - Site 7. Simulium meridionale; C - Site 3, D - Site 4 and E - Site 7. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.

Figure 37. Larvae Collected on Natural Substrates in 1978. Simulium venustum/verecundum complex; A - Site 1b, B - Site 1a and C - Site 3. Simulium johannseni; D - Site 3 and E - Site 7. Square Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.



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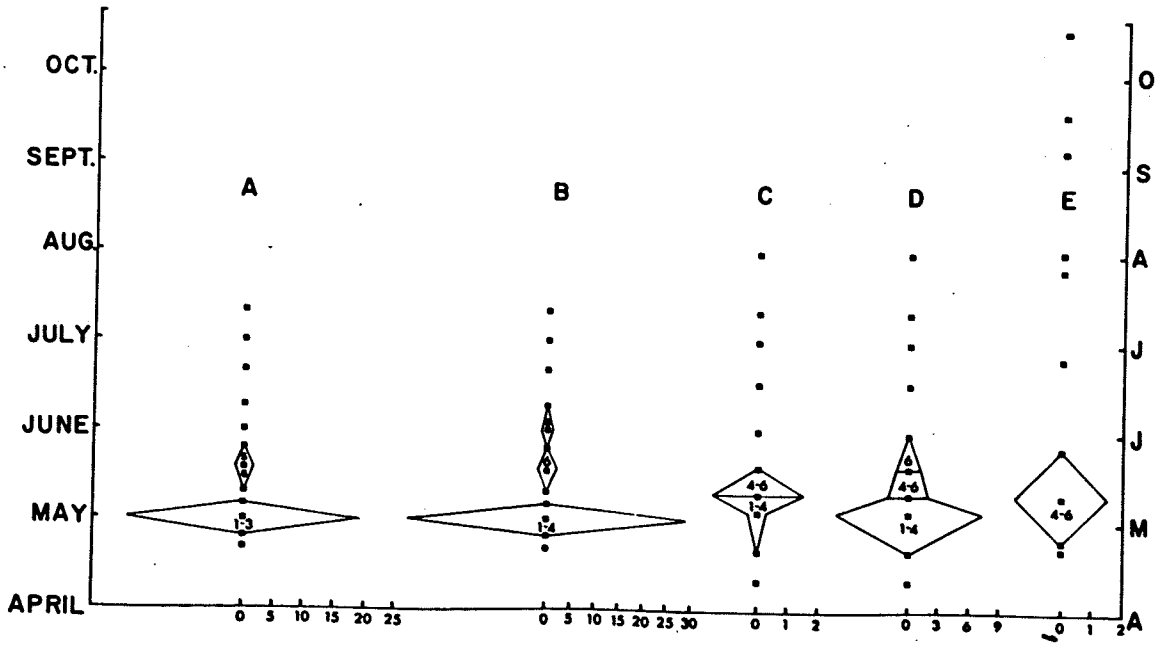

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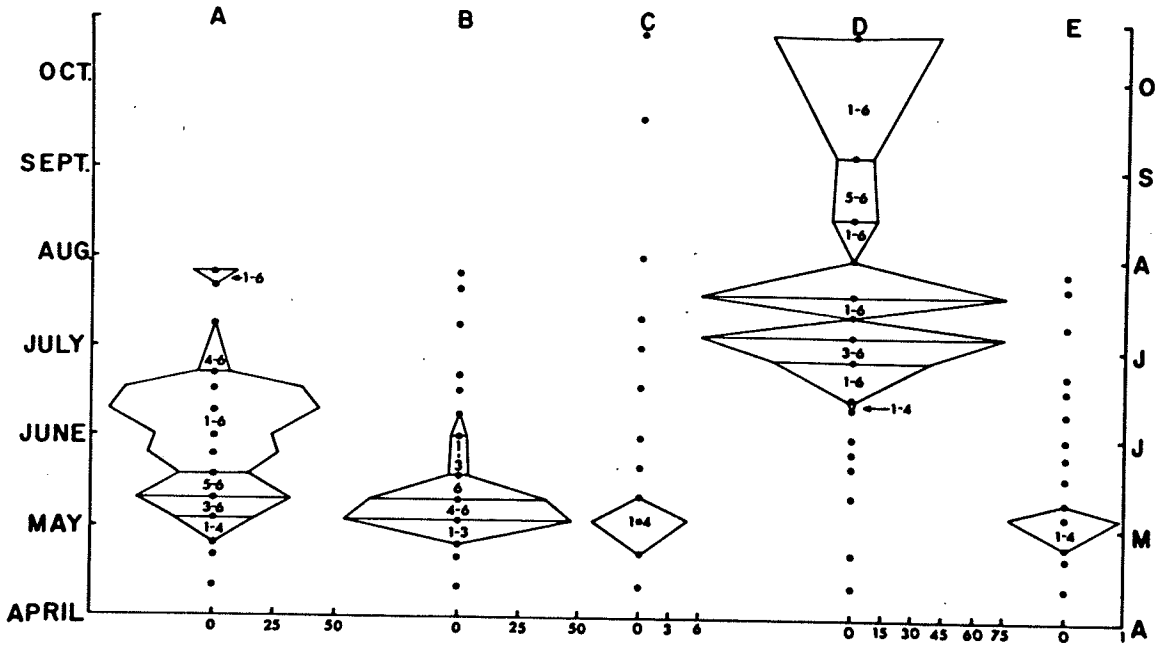
Figure 38. Larvae Collected on Natural Substrates in 1978. Simulium decorum; A - Site 1b, B - Site 1a, C - Site 3 and D - Site 4. Cnephia dacotensis; E - Site 1a and 1b. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.

Figure 39. Pupae Collected on Natural Stubstrates in 1978. Simulium venustum/verecundum complex; A - Site 1a and 1b and B - Site 3. Simulium tuberosum; C - Site 3. Simulium johannseni; D - Site 3. Simulium luggeri; E - Site 3. Dot Represents Sampling Point.



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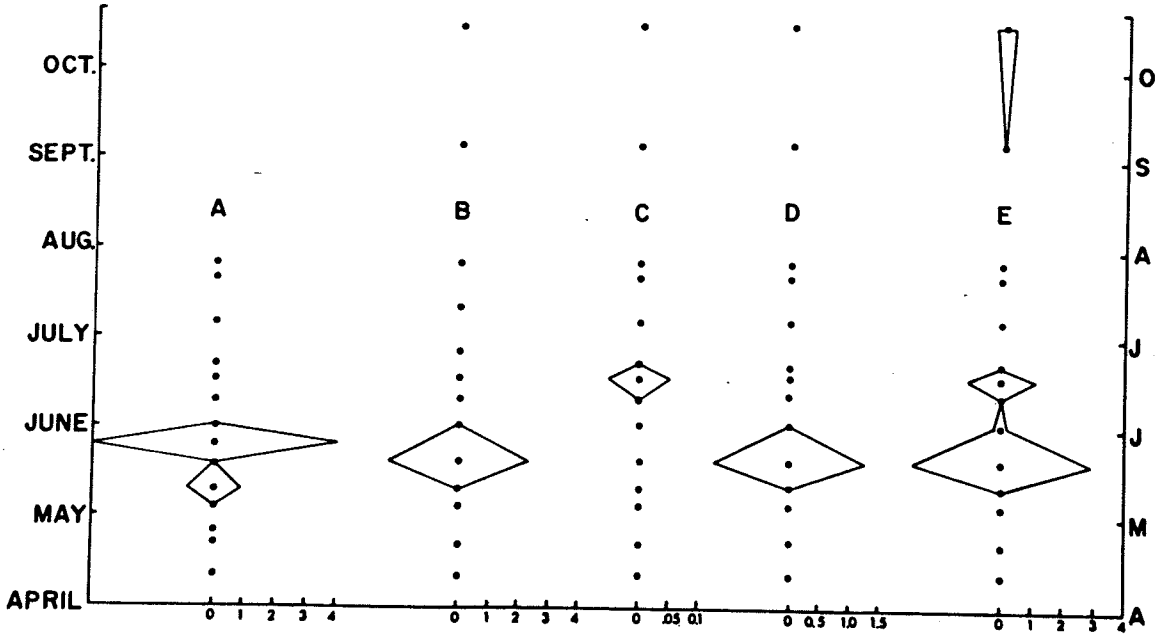

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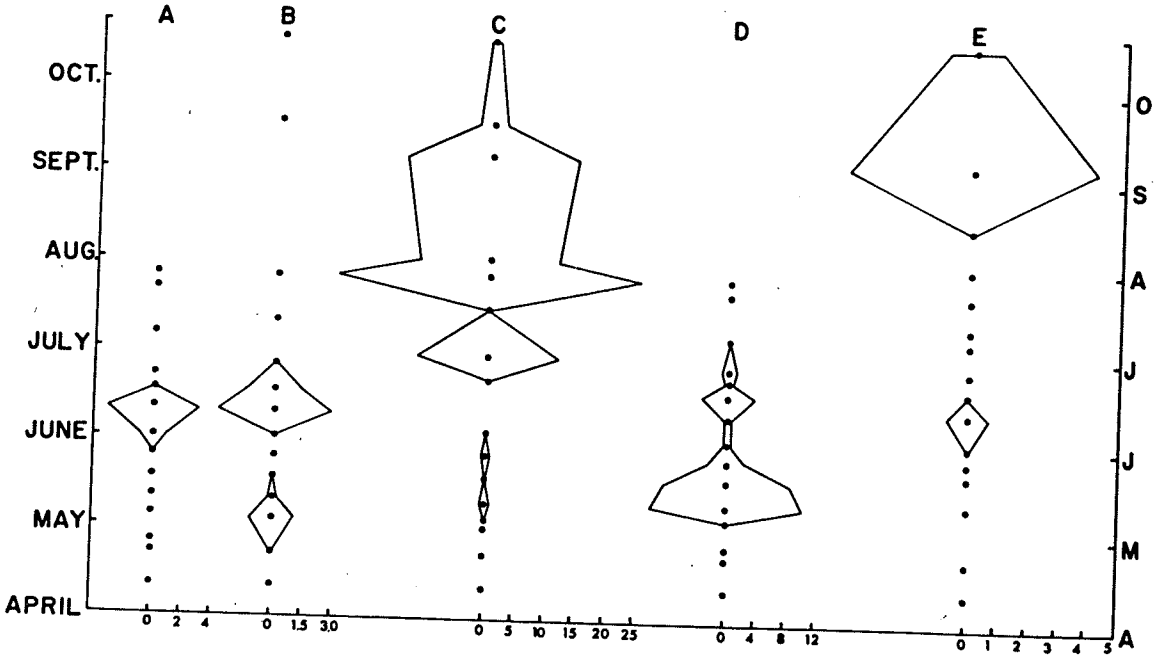
Figure 40. Pupae Collected on Natural Substrates in 1978. Simulium vittatum; A - Site 1a and 1b, B - Site 3 and C - Site 7. Simulium decorum; D - Site 1a and 1b and E - Site 4. Dot Represents Sampling Point.

Figure 41. Larvae Collected on Cone Samplers in 1978. Simulium venustum/verecundum complex; A - Site 9, B - Site 6, C - Site 5 and D - Site 2. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.



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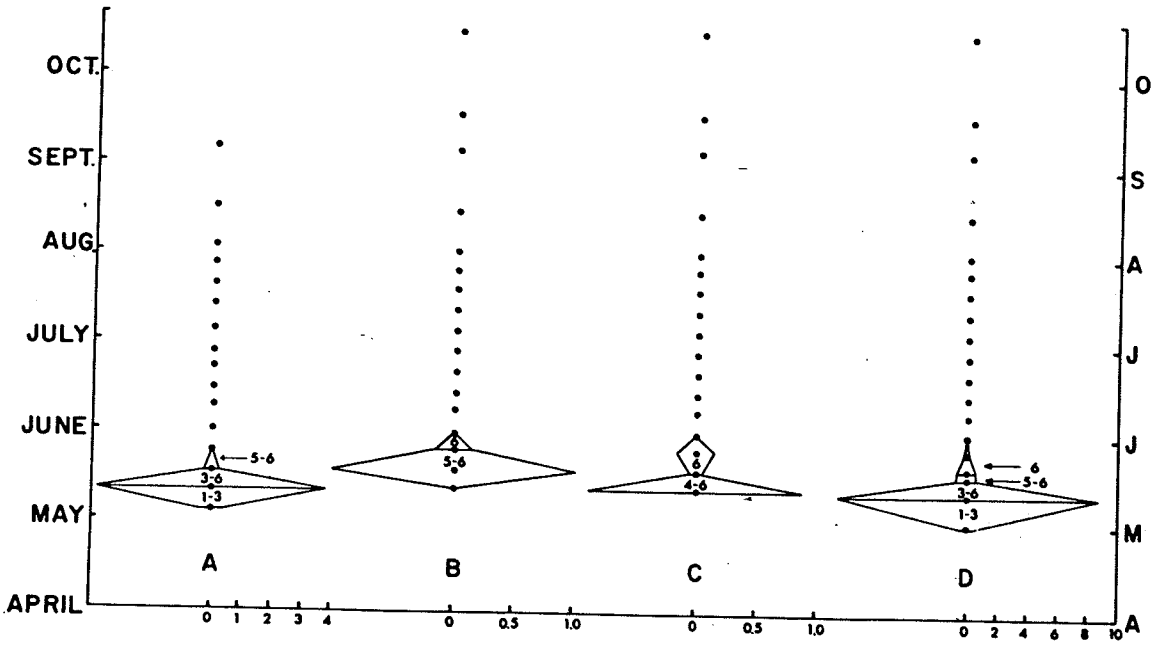

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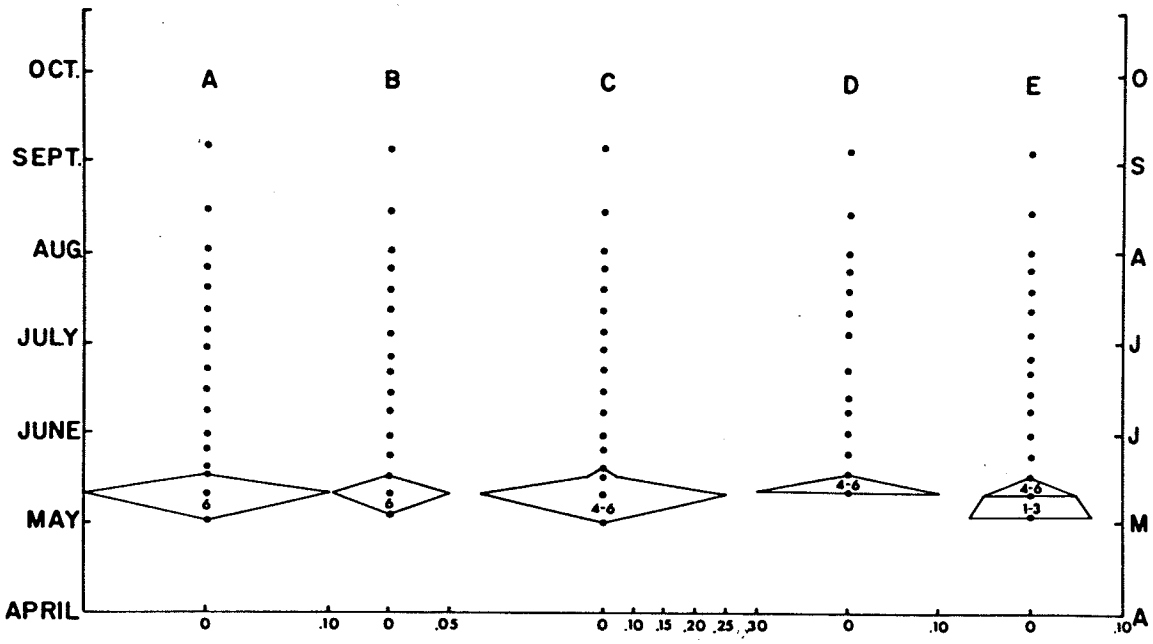
Figure 42. Larvae Collected on Cone Samplers in 1978. Simulium tuberosum; A - Site 2 and B - Site 9. Cnephia dacotensis; C - Site 2, D - Site 5 and E - Site 9. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.

Figure 43. Larvae Collected on Cone Samplers in 1978. Simulium vittatum; A - Site 9, B - Site 6, C - Site 5 and D - Site 2. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.



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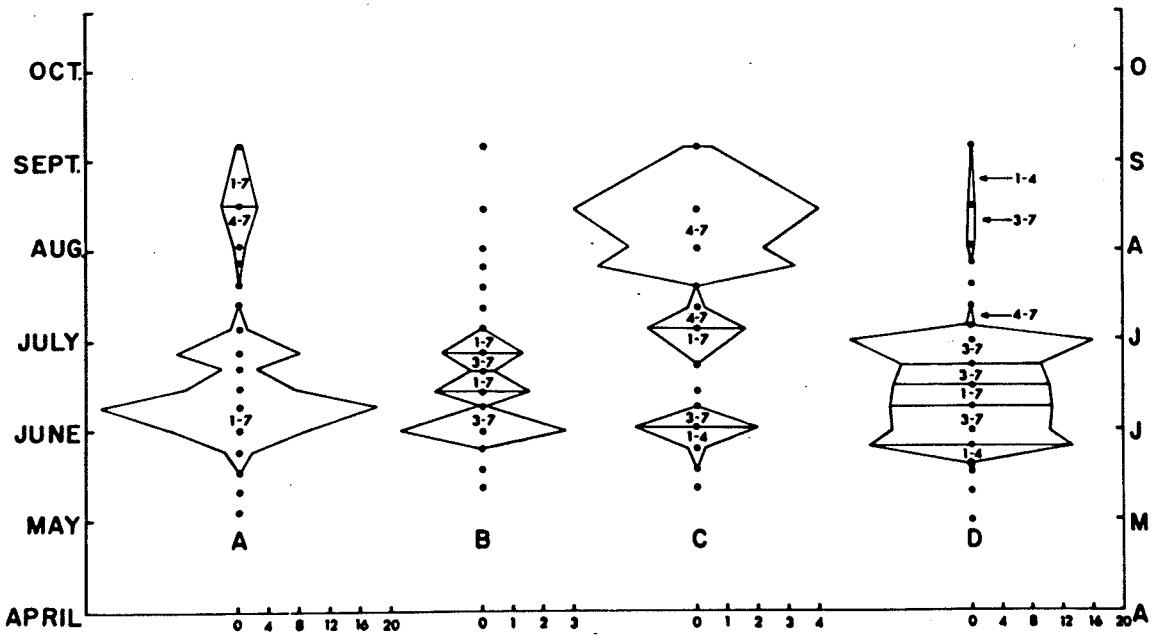

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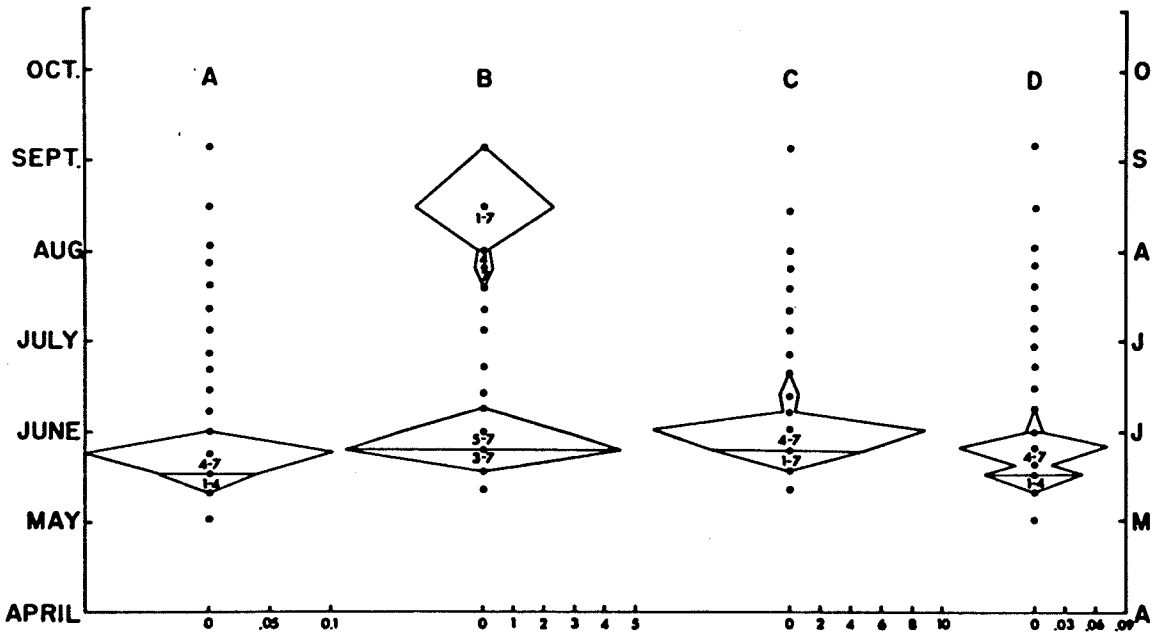
Figure 44. Larvae Collected on Cone Samplers in 1978. Simulium meridionale; A - Site 9, B - Site 5, C - Site 6 and D - Site 2. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.

Figure 45. Larvae Collected on Cone Samplers in 1978. Simulium johannseni; A - Site 9, B - Site 6, C - Site 5 and D - Site 2. Dot Represents Sampling Point and Numerals Within Figures Denote Instar Distribution.



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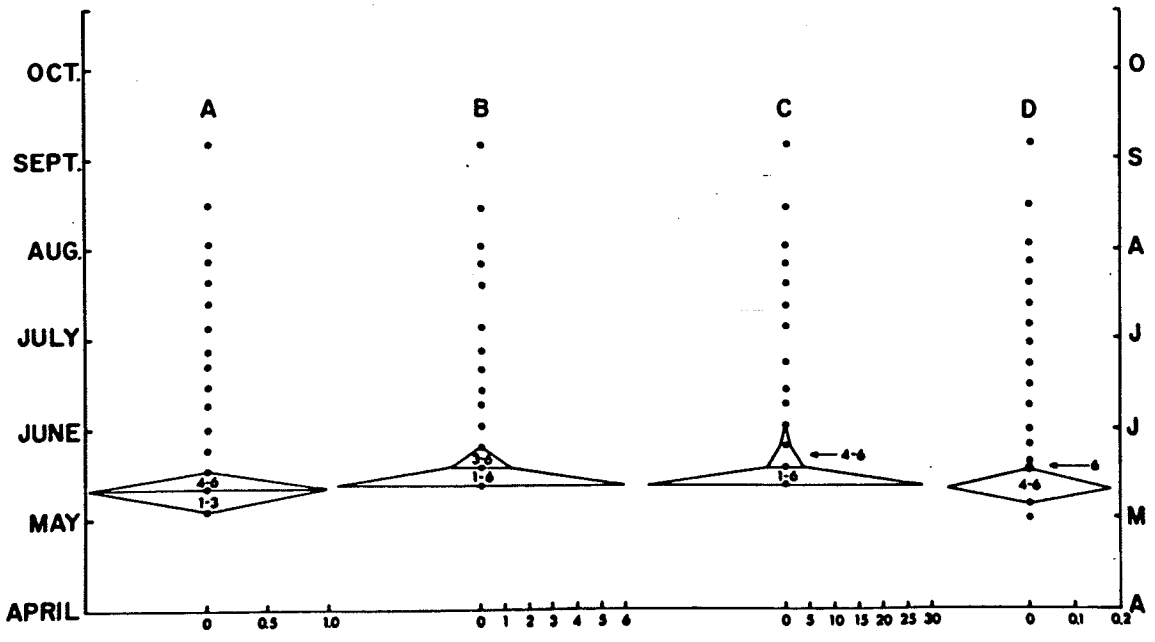

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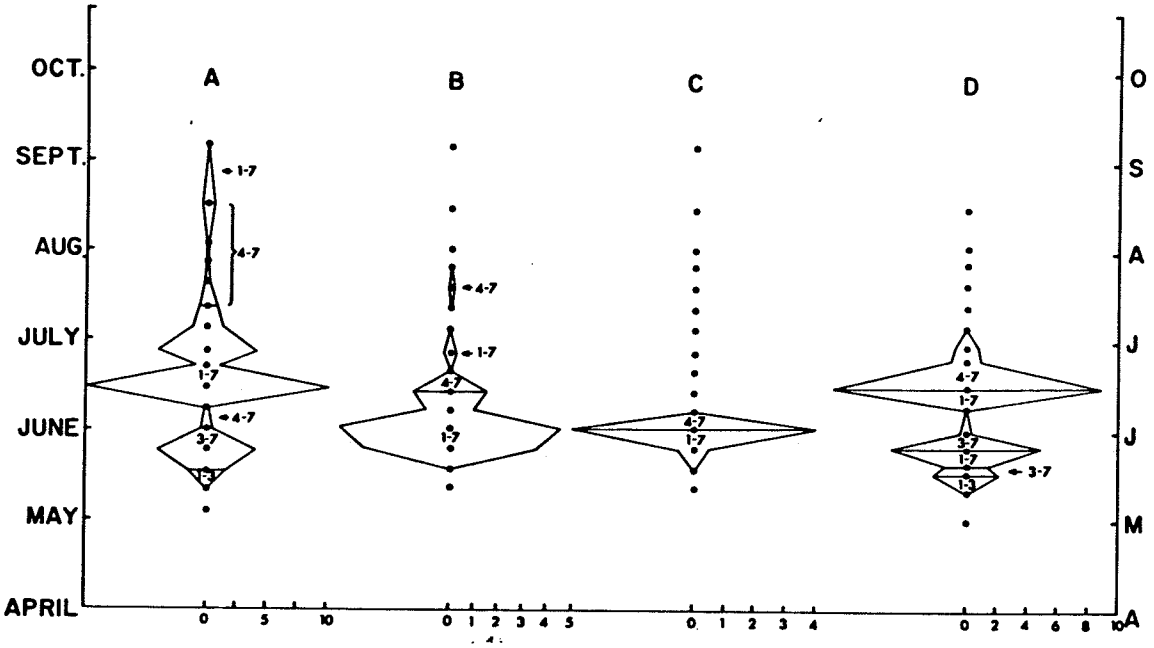
Figure 46. Larvae Collected on Cone Samplers in 1978. Simulium luggeri; A - Site 9, B - Site 6, C - Site 5 and D - Site 2. Dot Represents Sampling Point and Numeral Within Figures Denote Instar Distribution.

Figure 47. Larvae and Pupae Collected on Cone Samplers in 1978. Simulium decorum; larvae: A - Site 2, B - Site 5 and C - Site 9. Pupae: D - Site 9. Dot Represents Sampling Point.



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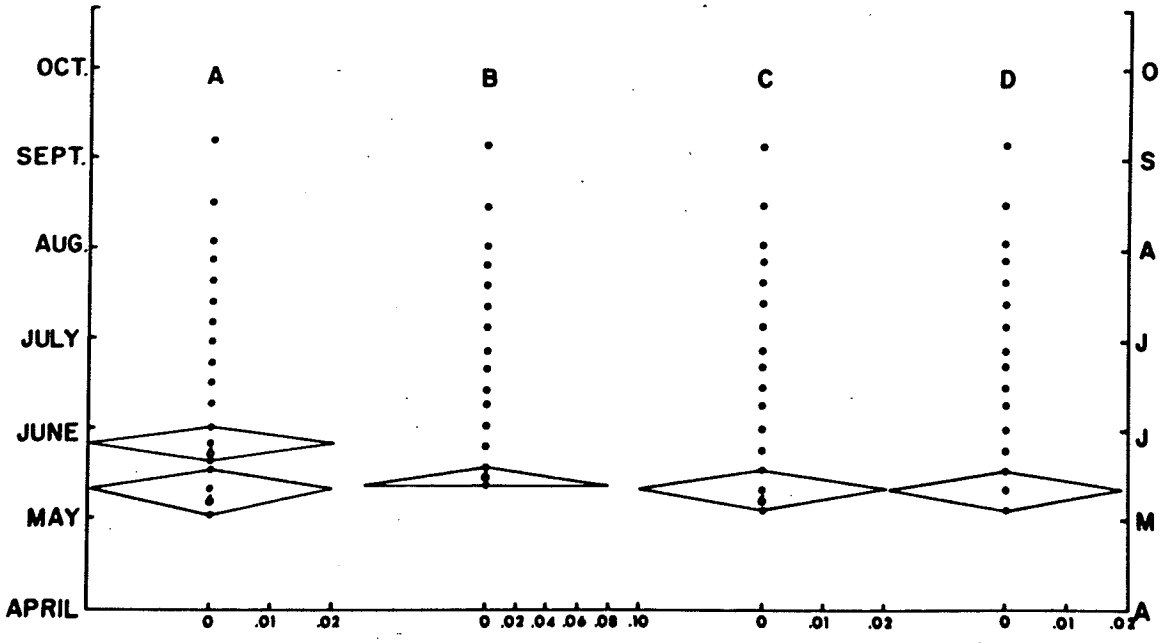

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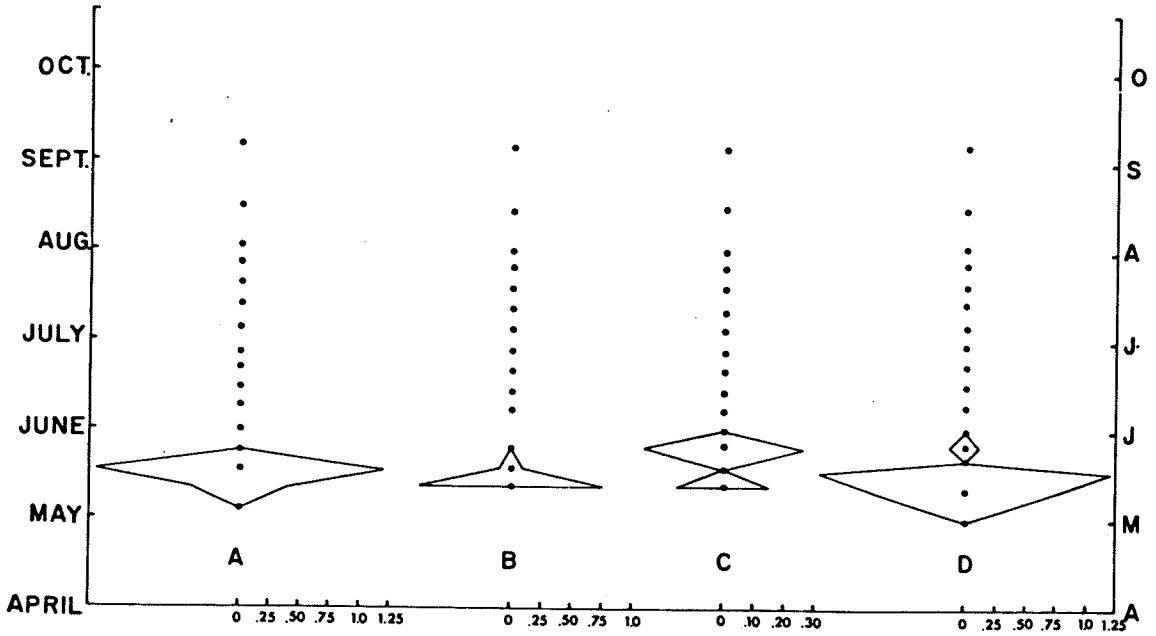
Figure 48. Pupae Collected on Cone Samplers in 1978. Simulium venustum/verecundum complex; A - Site 9, B - Site 6, C - Site 5 and D - Site 2. Dot Represents Sampling Point.

Figure 49. Pupae Collected on Cone Samplers in 1978. Simulium luggeri; A - Site 9, B - Site 6, C - Site 5 and D - Site 2. Dot Represents Sampling Point.



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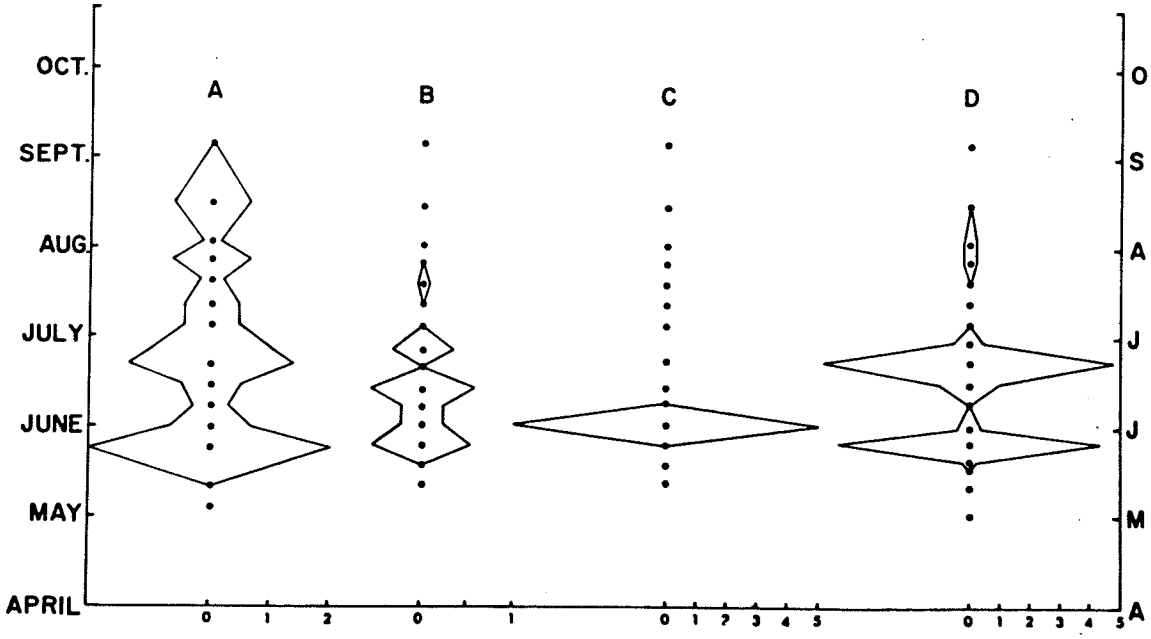

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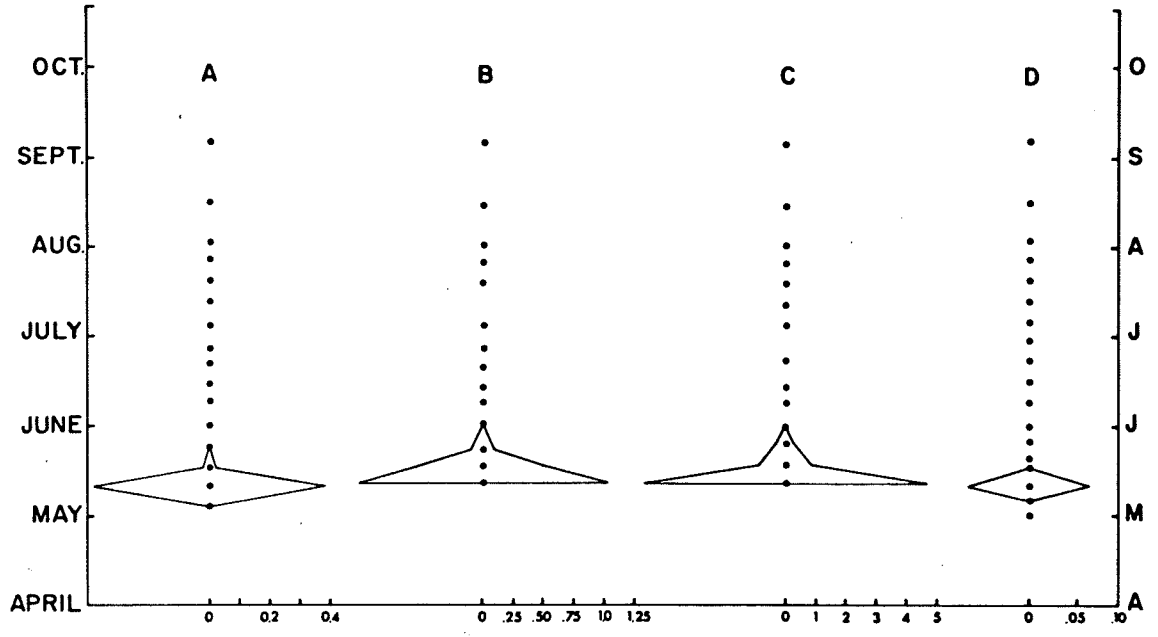
Figure 50. Pupae Collected on Cone Samplers in 1978. *Simulium johannseni*; A - Site 9, E - Site 6, C - Site 5 and D - Site 2. Dot Represents Sampling Point.

Figure 51. Pupae Collected on Cone Samplers in 1978. *Simulium meridionale*; A - Site 9, B - Site 6, C - Site 5 and D - Site 2. Dot Represents Sampling Point.



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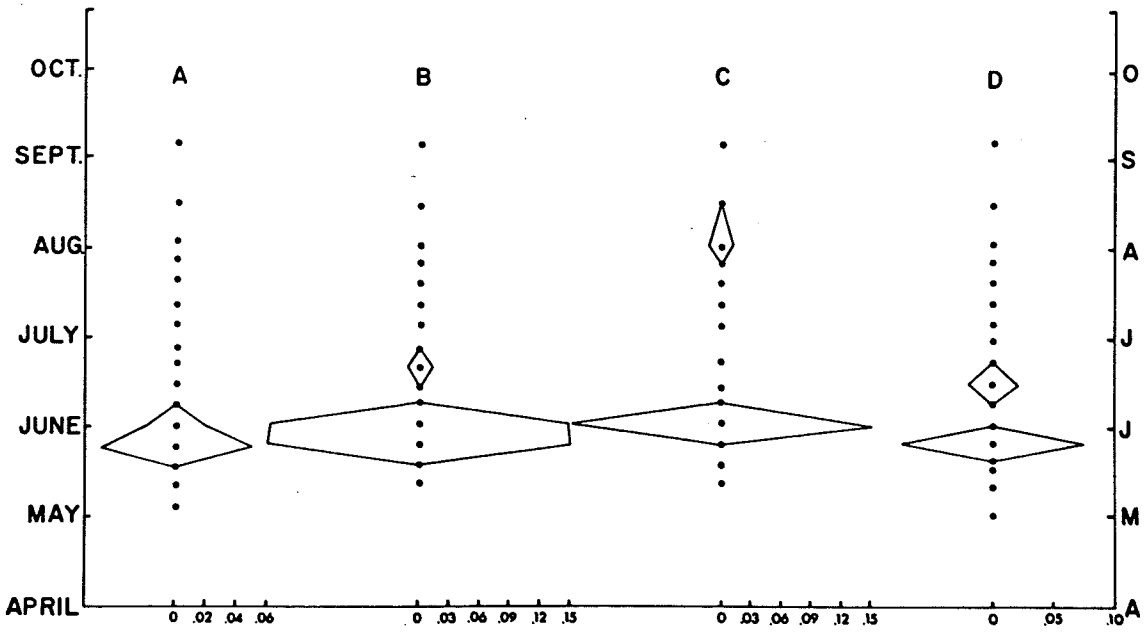

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Figure 52. Pupae Collected on Cone Samplers in 1978. Simulium vittatum; A - Site 9, B - Site 6, C - Site 5 and D - Site 2. Dot Represents Sampling Point.

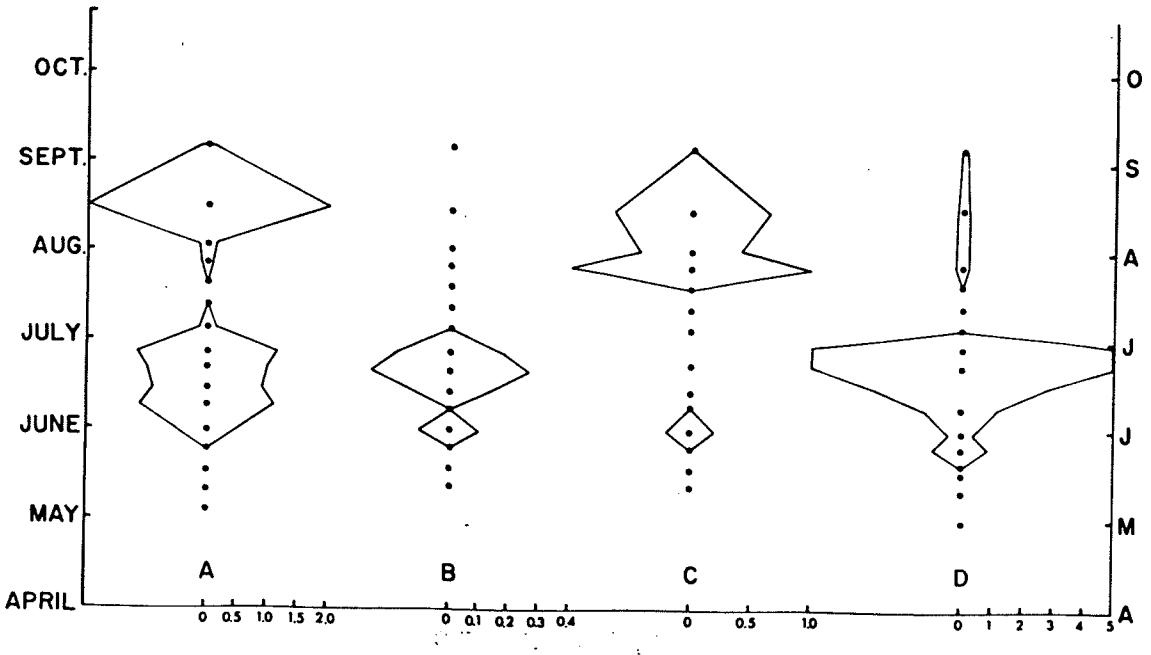

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TABLE 1. Black Fly Species - Site Associations; 1977 - Larvae.

Species	Site								
	1	2	3	4	5	6	7	8	9
Cnephia dacotensis									NOT SAMPLED
Simulium vittatum	X	X	X	X	X	X	X		
Simulium decorum	X			X					
Simulium luggeri	X	X	X		X				
Simulium johannseni									
Simulium meridionale					X				
Simulium tuberosum									
Simulium venustum/verecundum complex	X								

TABLE 2. Black Fly Species - Site Associations; 1978 - Larvae.

Species	Site								
	1	2	3	4	5	6	7	8	9
Cnephia dacotensis	X	X			X				X
Simulium vittatum	X	X	X	X	X	X	X	X	X
Simulium decorum	X	X	X	X	X	X			X
Simulium luggeri		X	X		X	X	X	X	X
Simulium johannseni		X	X		X	X	X		X
Simulium meridionale		X	X	X	X	X	X		X
Simulium tuberosum		X				X			X
Simulium venustum/verecundum complex	X	X	X		X	X			X

TABLE 3. Black Fly Species - Site Associations; 1977 - Pupae.

Species	Site								
	1	2	3	4	5	6	7	8	9
Cnephia dacotensis									
Simulium vittatum	X	X	X	X	X		X		NOT
Simulium decorum	X			X					
Simulium luggeri			X		X				SAMPLED
Simulium johannseni									
Simulium meridionale					X				
Simulium tuberosum									
Simulium venustum/verecundum complex	X	X							

TABLE 4. Black Fly Species - Site Associations; 1978 - Pupae.

Species	Site								
	1	2	3	4	5	6	7	8	9
Cnephia dacotensis		X							
Simulium vittatum	X	X	X	X	X	X	X	X	X
Simulium decorum	X	X		X					X
Simulium luggeri		X	X		X	X	X		X
Simulium johannseni	X	X	X		X	X	X		
Simulium johannseni duplex					X				
Simulium meridionale		X			X	X	X		X
Simulium tuberosum		X	X						X
Simulium venustum/verecundum complex	X	X	X		X	X			X

TABLE 5. Black Fly Species - Site Associations; 1977 - Adults.

Species	Site								
	1	2	3	4	5	6	7	8	9
Cnephia dacotensis									
Simulium vittatum	X	X	X						NOT
Simulium decorum									
Simulium luggeri									SAMPLED
Simulium johannseni	X	X							
Simulium meridionale									
Simulium tuberosum									
Simulium venustum/verecundum complex	X	X							

TABLE 6. Black Fly Species - Site Associations; 1978 - Adults.

Species	Site								
	1	2	3	4	5	6	7	8	9
Cnephia dacotensis		X							
Simulium vittatum	X	X		X	X	X	X	X	X
Simulium decorum	X			X					
Simulium luggeri		X			X				
Simulium johannseni		X	X	X				X	X
Simulium meridionale		X			X				X
Simulium tuberosum		X							
Simulium venustum/verecundum complex	X	X							X

TABLE 7. Matrix of Correlation Coefficients for Comparison of the Influence of Cone Sampler Location and Physical Parameters on One Another and Black Fly Larval Density in the Souris River (*S. vittatum*).

	1 Date	2 Sampler Location	3 Depth	4 Water Temperature	5 Oxygen Concentration	6 Current Speed	Y Larval Density
1							
2	0.0						
3	0.0	0.0					
4	0.28	0.0	0.0				
5	-0.54	0.0	0.0	-0.59			
6	0.28	0.54	-0.01	0.01	-0.01		
Y	-0.32	0.17	0.0	-0.01	0.14	-0.13	

CHAPTER VI

Conclusions

As a result of the study described herein, the following conclusions were made concerning black fly biology, pest status and sampling techniques used in the Souris River, Manitoba.

1. Nine species and one subspecies of black flies were collected in this study: Cnephia dacotensis, Simulium johannseni, Simulium johannseni duplex, Simulium venustum, Simulium verecundum, Simulium tuberosum, Simulium vittatum, Simulium decorum, Simulium luggeri and Simulium meridionale.

2. Five species, Simulium luggeri, Simulium meridionale, Simulium venustum, Simulium verecundum and Simulium johannseni have the potential of being pest species. These five species were observed to gather around, and take blood meals, from humans, cattle, horses and poultry.

3. The most numerous species in the river in 1977 and 1978 was Simulium vittatum. Simulium luggeri, Simulium meridionale and Simulium johannseni were less abundant than Simulium vittatum, but more abundant than Simulium venustum, Simulium verecundum and Simulium decorum. The least common species were Simulium tuberosum, Cnephia dacotensis and Simulium johannseni duplex.

4. Simulium johannseni, Simulium johannseni duplex, Simulium verecundum, Simulium tuberosum and Cnephia dacotensis are univoltine in the Souris River. Multivoltine species include Simulium vittatum, Simulium decorum, Simulium luggeri and Simulium meridionale.

5. In an outbreak year, two larvicide treatments would be needed to control black flies in the Souris River. The first treatment should be aimed at the suppression of Simulium johannseni and the Simulium venustum/verecundum complex, and timed to control the last larval instars. The second treatment, approximately 10 to 14 days later, should be aimed at late instar larvae of Simulium luggeri and Simulium meridionale.

6. Cone samplers are recommended for future larval population assessment in the Souris River. The characteristics that make the cone sampler more desirable than the others tested include ease of handling, versatility and high performance in collecting immature simuliids.

7. Of the larval and pupal samplers used, plate and cone samplers collected signficantly ($p \leq 0.05$) more specimens than wire cage samplers. There existed no significant ($p \leq 0.05$) difference in the collection of larvae and pupae between cone and plate samplers. Rope samplers were not compared to the other samplers because a true 6.5 sq. cm sample could not be obtained.

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APPENDIX A. Adult Black Flies Collected from Aquatic Emergence Traps at Site 2 in 1977.

Date	Trap No.	Female	Male	Species
May 19	A_1	16	3	Simulium vittatum
	A_2	0	0	Simulium vittatum
May 25	A_1	26	61	Simulium vittatum
	A_2	101	44	Simulium vittatum
June 1	A_1	31	37	Simulium vittatum
	A_2	98	161	Simulium vittatum
June 8	A_1	50	69	Simulium vittatum
	A_2	5	3	Simulium vittatum
June 27	A_1	50	68	Simulium vittatum
	A_2	0	0	Simulium vittatum
July 1	A_1	22	20	Simulium vittatum
	A_2	7	2	Simulium vittatum
July 9	A_1	11	12	Simulium vittatum
	A_2	0	0	Simulium vittatum

APPENDIX B. Adult Black Flies Collected by Sweepnet Over Breeding Sites in 1977. (Three samples of 10 sweeps x 1.50 m each.)

Date	Site No.	Female	Male	Species
May 7	1	2	0	Simulium venustum
May 8	1	5	0	Simulium verecundum
May 9	1	58	0	Simulium vittatum
	4	24	0	Simulium vittatum
May 10	4	41	0	Simulium vittatum
May 19	1	55	0	Simulium vittatum
	1	2	0	Simulium johannseni
	2	23	0	Simulium vittatum
May 20	2	1	0	Simulium johannseni
May 27	2	11	11	Simulium vittatum
May 31	1a	6	1	Simulium vittatum

APPENDIX C. Adult Black Flies Collected from Aquatic Emergence Traps at Site 2 and Site 9 in 1978.

Date	Site No.	Trap No.	Female	Male	Species
May 10	2	A_1	3	0	Simulium vittatum
			1	0	Simulium venustum
May 16	2	A_1	89	0	Simulium vittatum
			0	11	Cnephia dacotensis
			1	0	Simulium verecundum
		A_2	0	12	Cnephia dacotensis
			1	0	Simulium johannseni
			4	1	Simulium vittatum
May 19	2	A_1	28	0	Simulium vittatum
			9	9	Simulium verecundum
			1	1	Simulium venustum
		A_2	21	12	Simulium verecundum
			1	0	Simulium vittatum
May 25	2	A_1	8	0	Simulium vittatum
			3	1	Simulium meridionale
			11	5	Simulium luggeri
		A_2	92	0	Simulium vittatum
May 30	9	A_1	6	4	Simulium luggeri
			1	0	Simulium meridionale
			14	10	Simulium vittatum
		A_2	12	4	Simulium vittatum
May 31	2	A_1	4	2	Simulium luggeri
			22	36	Simulium vittatum

APPENDIX C concluded.

Date	Site No.	Trap No.	Female	Male	Species
May 31	2	A_2	8	3	Simulium vittatum
			2	4	Simulium luggeri
June 8	2	A_1	21	19	Simulium vittatum
			6	3	Simulium luggeri
		A_2	22	9	Simulium vittatum
			5	5	Simulium luggeri
June 14	9	A_1	50	36	Simulium vittatum
			2	0	Simulium luggeri
		A_2	19	22	Simulium vittatum
			6	1	Simulium luggeri
June 15	2	A_1	26	24	Simulium vittatum
			0	1	Simulium tuberosum
		A_2	1	0	Simulium venustum
			1	1	Simulium luggeri
			294	26	Simulium vittatum

APPENDIX D. Adult Black Flies Collected by Sweepnet Over Breeding Sites in 1978. (Three samples of 10 sweeps x 1.5 m each.)

Date	Site No.	Female	Male	Species
May 11	4	1	0	Simulium vittatum
May 16	1	10	1	Simulium vittatum
		2	0	Simulium venustum
		1	0	Simulium verecundum
May 25	2	25	4	Simulium vittatum
		2	0	Simulium johannseni
		1	0	Simulium venustum
June 8	2	18	6	Simulium vittatum
		4	0	Simulium luggeri
		1	0	Simulium meridionale
July 11	4	72	2	Simulium decorum
		18	0	Simulium vittatum
July 18	4	9	0	Simulium vittatum
		26	2	Simulium decorum
Aug. 1	4	44	2	Simulium decorum
		6	0	Simulium vittatum
Sept. 5	4	40	0	Simulium vittatum
		30	0	Simulium decorum

APPENDIX E. Adult Female Black Flies Collected while Feeding On and Flying About Hosts in 1978.

Date	Host	Site No.	No. Females Collected Around Host†	No. Blood Fed Females‡	Species
May 17	Human	2	9	2	Simulium johannseni
			1	1	Simulium verecundum
May 18	Domestic chickens and geese	2	12	Not sampled	Simulium johannseni
			2	Not sampled	Simulium verecundum
			1	Not sampled	Simulium venustum
May 23	Horse	2	20	10	Simulium luggeri
			1	1	Simulium vittatum
			1	1	Simulium johannseni
			2	2	Simulium verecundum
	Cattle	2	37	5	Simulium johannseni
			13	3	Simulium luggeri
			1	0	Simulium meridionale
			1	0	Simulium venustum

†Sweepnet (3 sweeps 10 x 1.5 m wide).

‡Aspirated from 10 cm^2 area of skin.

APPENDIX E continued.

Date	Host	Site No.	No. Females Collected Around Host†	No. Blood Fed Females‡	Species
May 23	Human	2	65	8	Simulium luggeri
			1	0	Simulium vittatum
			1	1	Simulium verecundum
			2	1	Simulium johannseni
May 23	Human	9	16	3	Simulium johannseni
			8	5	Simulium meridionale
			1	0	Simulium luggeri
May 24	Human	2	14	2	Simulium johannseni
			5	3	Simulium meridionale
			1	0	Simulium luggeri
May 24	Cattle	5	25	8	Simulium johannseni
			1	0	Simulium luggeri
	Human	5	15	4	Simulium johannseni

†Sweepnet (3 sweeps 10 x 1.5 m wide).

‡Aspirated from 10 cm^2 area of skin.

APPENDIX E continued.

Date	Host	Site No.	No. Females Collected Around Host†	No. Blood Fed Females‡	Species
May 25	Cattle	2	7	1	Simulium johannseni
			2	1	Simulium luggeri
			1	0	Simulium meridionale
May 30	Cattle	4	2	0	Simulium johannseni
June 1	Human	2	22	8	Simulium luggeri
			3	1	Simulium meridionale
			1	0	Simulium johannseni
June 7	Human	2	11	2	Simulium luggeri
			1	0	Simulium johannseni
June 13	Cattle	5	6	1	Simulium meridionale
June 13	Cattle	2	6	2	Simulium luggeri
			2	0	Simulium meridionale
			2	0	Simulium johannseni

†Sweepnet (3 sweeps 10 x 1.5 m wide).

‡Aspirated from 10 cm^2 area of skin.

APPENDIX E concluded.

Date	Host	Site No.	No. Females Collected Around Host†	No. Blood Fed Females‡	Species
June 15	Human	5	3	1	Simulium vittatum
Aug. 14	Human	6	5	0	Simulium vittatum

†Sweepnet (3 sweeps 10 x 1.5 m wide).

‡Aspirated from 10 cm^2 area of skin.

APPENDIX F. Adult Black Flies Collected from Carbon Dioxide† and Non-Carbon Dioxide Attractant Traps at Site 2 in 1978.

Date	Trap Type	Carbon Dioxide Output	Female	Male	Species
May 18	CO_2 - 1	300 ml/min	7	1	Simulium verecundum
			1	0	Simulium venustum
May 23	CO_2 - 1	300 ml/min	1	0	Simulium johannseni
May 25	CO_2 - 1	200 ml/min	2	0	Simulium johannseni
			0	1	Simulium luggeri
			1	0	Simulium verecundum
	Non-CO_2	--	1	0	Simulium verecundum
May 30	CO_2 - 1	200 ml/min	2	1	Simulium luggeri
			1	0	Simulium meridionale
			1	0	Simulium johannseni
	Non-CO_2	--	1	0	Simulium luggeri
			1	0	Simulium meridionale
June 6	CO_2 - 1	200 ml/min	3	0	Simulium luggeri
	Non-CO_2	--	1	0	Simulium luggeri

†Carbon dioxide traps were operated between 1200 and 1800 hours daily.

APPENDIX F concluded.

Date	Trap Type	Carbon Dioxide Output	Female	Male	Species
June 8	CO_2 - 1	200 ml/min	1	0	Simulium luggeri
June 13	CO_2 - 1	200 ml/min	9	1	Simulium luggeri
			1	0	Simulium johannseni
	CO_2 - 2	300 ml/min	9	0	Simulium luggeri
	Non-CO_2	--	1	1	Simulium vittatum
June 14	CO_2 - 1	200 ml/min	2	0	Simulium meridionale
			1	0	Simulium luggeri
	Non-CO_2	--	0	1	Simulium vittatum

APPENDIX G. Egg Masses Collected with Ovipositing Female Black Flies in 1978.

Date	Site No.	Substrate	No. of Females	No. of Individual Egg Masses	Species
May 23	9	Floating vegetation	6	7 - 10	Simulium vittatum
		Cone sampler	12	> 15	Simulium vittatum
May 24	5	Floating vegetation	2	4	Simulium vittatum
May 30	9	Cone sampler	5	> 20	Simulium vittatum
June 13	6	Plate sampler	5	> 15	Simulium vittatum
June 14	9	Plate sampler	6	> 25	Simulium vittatum
June 21	2	Cone sampler	7	> 10	Simulium vittatum
June 28	2	Base of adult emergence trap	15	> 30	Simulium vittatum
July 11	4	Dam face	2	3	Simulium decorum
July 30	4	Dam face	5	7	Simulium decorum
Aug. 15	2	Floating vegetation	3	5	Simulium vittatum

APPENDIX H. Oxygen Concentration (ppm) in 1977.
(Measured in riffle areas at a depth of 30 cm.)

Date	Site								
	1	2	3	4	5	6	7	8	9
May 8	14.1	--	--	--	--	--	13.2	--	
May 9	14.0	7.2	12.9	--	--	--	--	--	
May 10	--	--	--	12.0	11.4	10.6	12.7	--	
May 16	--	--	10.1	9.1	9.3	8.7	--	--	NOT
May 25	--	6.9	8.2	--	--	--	--	--	
May 31	8.0	8.2	--	11.2	--	--	--	--	SAMPLED
June 8	6.5	7.0	--	--	5.8	--	--	--	
June 20	9.3	8.6	7.4	9.0	6.9	6.1	6.2	--	
June 30	--	9.3	--	10.1	9.4	8.0	--	--	
July 9	--	9.0	--	9.0	--	10.1	--	--	
July 16	--	9.6	--	7.4	--	--	--	--	
July 30	6.3	8.5	--	6.8	--	--	--	--	

APPENDIX I. Oxygen concentration (ppm) in 1978.
(Measured in riffle areas at a depth of 30 cm.)

Date	Site								
	1	2	3	4	5	6	7	8	9
April 20	13.0	14.1	--	13.6	--	--	--	--	--
April 24	13.1	--	--	13.4	--	--	--	--	13.0
May 1	10.2	9.9	11.2	--	--	--	--	--	9.2
May 4	10.1	--	--	--	9.0	10.6	--	--	--
May 9	8.6	9.1	9.3	--	11.1	10.7	10.0	9.6	10.1
May 16	7.8	9.0	9.1	--	8.7	8.9	--	8.1	--
May 23	6.9	8.8	--	10.2	9.3	9.0	--	--	7.8
May 25	--	9.2	--	--	--	--	7.4	--	--
May 31	7.1	8.7	--	11.3	10.0	10.4	--	--	6.8
June 7	--	7.1	--	8.5	8.5	9.0	--	--	6.8
June 20	--	7.2	--	--	9.3	8.7	7.0	7.4	7.0
June 27	--	9.0	--	--	8.9	7.1	--	--	--
July 4	--	8.0	8.2	8.4	9.0	8.1	--	--	8.6
July 11	--	9.8	8.0	--	7.5	7.2	--	--	7.5
July 18	7.0	8.0	--	--	5.0	6.0	8.1	--	7.5
Aug. 1	--	8.9	--	7.1	5.4	6.9	7.9	7.3	8.5
Aug. 14	--	--	--	--	7.3	8.0	--	--	--

APPENDIX J. Water Temperature (°C) in 1977.
(Measured at a depth of 30 cm.)

Date	Site								
	1	2	3	4	5	6	7	8	9
May 8	18.9	17.0	17.2	17.4	--	--	--	--	
May 10	--	--	21.0	18.1	22.0	--	--	--	
May 16	19.8	18.4	18.9	18.3	21.0	--	--	--	
May 19	17.8	16.7	--	--	19.1	18.7	18.4	18.7	
May 25	--	18.8	--	--	18.3	21.7	--	--	NOT
May 31	21.8	20.0	--	21.2	23.9	24.0	--	--	
June 8	22.6	21.2	--	--	23.4	23.8	--	--	SAMPLED
June 20	22.0	23.1	22.4	19.0	21.5	22.1	22.8	21.3	
June 30	21.8	--	--	--	21.6	22.6	--	--	
July 9	22.6	21.3	--	22.3	21.2	20.9	21.0	--	
July 16	--	21.9	--	21.8	23.6	--	--	22.1	
July 30	22.7	25.0	--	22.4	20.1	21.2	--	--	
Aug. 6	--	21.8	19.8	20.0	19.8	--	20.2	21.0	
Sept. 5	--	18.0	19.0	19.7	18.8	19.2	19.7	20.0	
Oct. 19	--	8.4	8.2	10.2	10.1	9.8	--	--	

APPENDIX K. Water Temperature (°C) in 1978.
(Measured at a depth of 30 cm.)

Date	Site								
	1	2	3	4	5	6	7	8	9
Feb. 11	1.0	1.3	0.9	1.1	0.8	0.9	1.2	1.3	0.9
April 10	--	1.4	1.0	0.9	1.2	--	--	--	--
April 20	5.1	7.0	--	6.9	5.6	5.9	--	--	--
April 24	7.2	--	--	--	--	--	8.3	7.1	8.9
May 1	12.8	13.9	15.0	--	--	--	--	--	14.9
May 4	16.1	--	--	--	14.9	15.2	--	--	--
May 9	14.3	15.2	14.8	15.0	15.1	14.8	14.3	14.7	14.8
May 16	20.1	17.2	20.7	--	19.1	20.0	--	--	18.0
May 23	21.8	20.1	--	20.6	20.5	22.3	--	--	22.9
May 25	--	20.3	--	--	--	--	20.8	--	--
May 31	15.6	17.8	--	--	15.9	16.2	--	--	20.0
June 7	16.8	17.9	--	--	18.6	18.3	--	--	17.8
June 13	--	--	20.6	21.2	20.0	--	20.6	19.9	23.0
June 16	21.3	24.0	--	--	--	--	--	--	--
June 20	24.6	23.8	--	18.0	18.3	17.7	--	--	20.1
June 27	26.0	25.2	23.8	24.6	24.1	23.3	24.8	22.9	25.0
July 4	--	26.8	--	--	26.8	27.0	--	--	26.4
July 11	--	21.4	21.5	21.0	21.3	21.3	--	--	22.7
July 18	25.8	25.2	--	--	23.8	24.0	--	--	25.1
July 25	26.2	22.3	21.9	22.9	24.0	23.7	24.3	22.8	22.2
Aug. 1	--	19.5	--	20.8	20.7	20.2	20.9	--	19.8

APPENDIX K concluded.

Date	Site								
	1	2	3	4	5	6	7	8	9
Aug. 14	--	22.4	--	22.8	22.1	22.3	--	--	22.0
Sept. 5	--	23.0	--	23.3	22.9	23.1	23.8	--	22.8
Sept. 17	--	12.5	15.3	15.1	14.4	14.0	14.5	13.8	12.7
Oct. 15	--	7.0	5.1	7.5	7.3	7.8	8.1	5.3	6.9

APPENDIX L. Current Speed (m/sec) in 1978.
(Measured in mid-channel at a depth of 40 cm.)

Date	Site								
	1	2	3	4	5	6	7	8	9
April 10	--	0.62	0.58	0.61	--	--	--	--	--
April 20	0.34	1.00	--	--	--	--	--	--	--
April 24	0.36	1.20	0.61	--	--	--	--	0.59	1.09
May 1	0.30	1.38	1.10	1.20	1.10	1.00	1.70	1.08	0.75
May 4	0.42	--	--	--	0.68	0.54	--	--	--
May 9	0.26	0.75	0.52	--	0.30	0.39	0.49	0.60	0.64
May 16	0.12	0.50	1.20	0.50	0.34	0.39	0.51	--	0.34
May 23	0.11	0.49	--	0.41	0.27	0.38	--	--	0.75
May 25	--	0.81	--	--	--	--	0.55	--	--
May 31	0.09	0.80	--	--	0.30	0.37	--	--	0.70
June 7	--	0.49	--	--	0.29	0.25	--	--	0.48
June 13	--	--	0.26	0.30	0.24	0.28	0.28	0.35	0.53
June 16	0.07	0.54	--	--	--	--	--	--	--
June 20	--	0.68	--	0.41	0.39	0.37	--	--	0.56
June 27	--	0.66	0.54	0.33	0.28	0.42	0.56	0.30	0.68
July 4	--	0.63	--	0.48	0.32	0.38	--	--	0.67
July 11	--	0.70	--	0.45	0.34	--	--	--	0.87
July 18	--	0.73	--	--	0.38	0.42	--	--	0.91
July 25	--	0.92	0.43	0.42	0.37	0.46	0.68	0.48	0.86
Aug. 1	--	0.68	--	0.50	0.48	0.42	0.67	--	0.76
Aug. 14	--	0.64	--	0.70	0.42	0.43	--	--	0.70

APPENDIX L concluded.

Date	Site								
	1	2	3	4	5	6	7	8	9
Sept. 5	--	0.38	--	0.61	0.38	0.35	0.59	--	0.67
Sept. 17	--	0.29	0.26	0.50	0.25	0.30	0.50	0.29	0.68
Oct. 15	--	0.24	0.28	0.31	0.22	0.25	0.35	0.28	0.52

APPENDIX M. Souris River Monthly Water Discharge (cubic meters per second) in 1976.

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Wawanesa												
Maximum												
Minimum				N O T	A V A I L A B L E							
Mean												
Souris												
Maximum	--	--	34.6	360.0	236.0	84.6	27.8	12.6	10.8	3.8	--	--
Minimum	--	--	4.0	41.4	88.0	28.2	11.9	10.5	1.7	0.1	--	--
Mean	--	--	8.8	252.0	149.6	52.0	18.0	11.8	6.2	1.3	--	--
Hartney												
Maximum	--	--	--	480.0	285.0	76.9	22.1	--	--	--	--	--
Minimum	--	--	--	90.0	96.7	37.8	10.0	--	--	--	--	--
Mean	--	--	--	362.4	209.0	54.8	16.5	--	--	--	--	--

APPENDIX M concluded.

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Melita												
Maximum	3.9	3.8	30.0	248.0	199.8	70.0	21.6	11.7	9.8	2.5	0.9	1.3
Minimum	3.8	3.8	3.8	38.0	72.4	22.0	10.9	8.5	1.3	0.4	0.3	0.8
Mean	3.8	3.8	8.8	177.0	119.4	44.4	15.6	10.5	4.5	0.7	0.7	1.0
Coulter												
Maximum	--	--	--	247.7	220.2	--	--	--	--	--	--	--
Minimum	--	--	--	154.3	79.6	--	--	--	--	--	--	--
Mean	--	--	--	201.0	149.9	--	--	--	--	--	--	--

APPENDIX N. Souris River Monthly Water Discharge (cubic meters per second) in 1977.

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Wawanesa												
Maximum	1.9	1.2	3.1	3.3	3.4	2.4	3.2	1.4	2.0	1.2	1.0	0.8
Minimum	1.3	1.1	1.0	1.5	0.8	0.4	0.5	0.3	0.6	0.7	0.2	0.5
Mean	1.6	1.2	1.8	2.3	2.0	1.1	1.2	0.5	1.0	0.9	0.6	0.6
Souris												
Maximum	--	--	2.2	2.6	3.7	2.1	1.6	0.5	1.0	0.7	--	--
Minimum	--	--	1.0	1.0	0.6	0.3	0.3	0.3	0.2	0.6	--	--
Mean	--	--	1.7	1.7	1.6	1.1	0.8	0.4	0.6	0.6	--	--
Hartney												
Maximum	--	--	--	--	--	--	--	--	--	--	--	--
Minimum	--	--	--	--	--	--	--	--	--	--	--	--
Mean	--	--	--	1.2	1.0	6.8	0.8	0.5	--	--	--	--

APPENDIX N concluded.

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Melita												
Maximum	--	--	1.7	0.5	0.2	0.7	0.9	1.4	0.9	1.4	--	--
Minimum	--	--	0.4	0.2	0.1	0.2	0.3	0.3	0.4	0.2	--	--
Mean	--	--	0.9	0.2	0.1	0.5	0.6	0.5	0.6	0.5	--	--
Coulter												
Maximum	--	--	1.7	0.2	0.3	0.6	0.5	0.6	0.6	0.5	0.7	0.7
Minimum	--	--	0.1	0.1	0.1	0.1	0.3	0.4	0.4	0.4	0.6	0.6
Mean	--	--	0.7	0.1	0.1	0.4	0.4	0.5	0.5	0.4	0.5	0.7

APPENDIX O. Souris River Monthly Water Discharge (cubic meters per second) in 1978.

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Wawanesa												
Maximum	0.5	0.5	6.2	29.2	16.7	6.9	6.5	4.7	4.1	0.6	1.1	0.8
Minimum	0.4	0.5	0.3	13.4	5.9	0.4	0.7	3.5	0.5	0.2	0.1	0.1
Mean	0.5	0.5	0.6	18.2	9.1	1.8	3.1	4.3	2.9	0.3	0.5	0.3
Souris												
Maximum	--	--	2.3	19.0	16.9	7.1	6.3	5.6	4.5	0.6	--	--
Minimum	--	--	0.2	2.7	4.0	0.3	0.1	4.5	0.8	0.3	--	--
Mean	--	--	0.5	11.3	8.2	1.5	3.0	4.8	3.1	0.4	--	--
Hartney												
Maximum												
Minimum					N O T A V A I L A B L E							
Mean												

APPENDIX O concluded.

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Melita												
Maximum	--	--	0.4	18.5	15.2	3.4	6.6	5.6	3.7	0.6	--	--
Minimum	--	--	0.2	0.5	4.0	0.3	1.7	3.4	0.5	0.3	--	--
Mean	--	--	0.3	11.9	5.8	1.1	4.2	4.5	2.5	0.5	--	--
Coulter												
Maximum	0.4	0.4	0.4	22.2	18.4	2.5	6.9	5.7	5.4	0.4	0.5	0.5
Minimum	0.4	0.3	0.1	0.6	2.7	0.5	1.7	4.1	0.3	0.3	0.3	0.3
Mean	0.4	0.3	0.2	12.6	5.4	1.1	4.3	5.0	3.1	0.4	0.4	0.3

APPENDIX P. Keys to the Larval, Pupal and Adult Stages of Black Flies of the Souris River.

Adults - Genera

1. Basal cell usually present; calcipala on hind basitarsus sometimes reduced; pedisulcus on second hind tarsal segment absent or very shallow; length of basal portion of vein R usually more than one-third the remaining distance to the wing tip; vein R covered with hair dorsally.....Cnephia

   Basal cell never present [except in a few Eusimulium spp.]; hind basitarsus usually with a well developed calcipala; second hind tarsal segment with deep pedisulcus [except in a few Eusimulium spp.]; basal portion of vein R usually distinctly less than one-third as long as the remaining distance to the wing tip; vein R may be covered with hair dorsally [Eusimulium subgenus] or bare [other subgenera].....Simulium

Cnephia - Adult male and female

1. Female - Tarsal claw of female with minute basal tooth; frons moderately broad, distinctly widened above; ninth tergite produced posteriorly, snout like; precoxal bridge complete, slender; sternites 2 to 7 sclerotized; general color brown.....Cnephia [Cnephia] dacotensis

   Male - Length of basistyle of male about twice that of the width; dististyle [distimere] with only one tooth at apex; mesonotum shining brown with three vittae faintly visible.....Cnephia [Cnephia] dacotensis

Simulium - Females

1. Basal portion of vein R with hair dorsally; claws bifed, base produced as a large lobe or thumb-like basal projection; stem vein with light yellow hair; katepisternum bare; genital fork with external tooth weak or absent, internal tooth of genital fork large, nearly touching one from opposite side; frons at narrowest, narrower than pedicel in dorsal view.....
   .....Simulium [Eusimulium] johannseni

   - Hair of abdomen silvery-white, dense laterally and obscuring the integument but absent on the black, dorsolateral areas of segments 3 and 4; median and two lateral vittae on scutum narrow, black....Simulium [Eusimulium] johannseni duplex

   Basal portion of vein R without hair dorsally.....2

APPENDIX P continued.

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2. Claw with a large thumb-like basal projection; fore leg entirely dark; width of frons at narrowest point about one-quarter the length of the frons; frons and terminal abdominal tergites grey-pollinose; scutum densely grey-pollinose with three narrow, brown vittae.....
.....Simulium [Byssodon] meridionale

Claw simple or with minute sub-basal tooth.....3

3. Pale grey species, abdomen pale grey or with distinct black and grey pattern; fore coxa dark; scutum distinctly striped with a light and dark pattern; claw simple; median line on scutum broader than antenna, edge diffuse; abdomen with a distinct black and grey pattern; subcosta bare ventrally, occassionally with one to three hairs; fore tibia with a conspicuous, broad white patch anteriorly, extending two-thirds the length of the tibia; precoxal bridge absent.....
.....Simulium [Psilozia] vittatum

Blackish or brownish species without conspicuous vittae on dorsum of scutum; if paler or with indication of thoracic strips, abdomen never pale grey and without a distinct black and light grey pattern; fore coxa variable.....4

4. Wing generally without hairs on ventral surface of subcosta [a few hairs on occassional specimens]; hairs of stem vein mostly yellow.....
.....Simulium [Phosterodorus] luggeri

Wing with a row of 10 or more hairs on ventral surface of the subcosta.....5

5. Frons and terminal abdominal tergites distinctly greyish and pollinose; anal lobe large, subquadrate, narrow dorsally, greatly broadened ventrally, anteroventral margin rounded with a short posteroventral projection under cercus.....Simulium [Simulium] decorum

Frobs and terminal abdominal tergites shining black or brown with a thin pollinosity; anal lobe not as above..6

6. Fore tibia with at most a narrow, greyish-white streak on the anterior surface covering not more than one-third of tibia; fore coxa, trochanter and entire femura as dark as the basitarsus; hairs on stem vein and base of costa dark; entire antenna dark; small dark species with a wing length of about 2mm.....
.....Simulium [Simulium] tuberosum

APPENDIX P continued.

Fore tibia with a conspicuous, bright yellowish-white patch on anterior surface covering at least one-half the width of the tibia; fore coxa, trochanter and proximal portion of femora distinctly paler than basitarsus; hairs of stem vein and base of costa relatively pale; pedicel of antenna paler than remainder; size and color variable but abdomen pale ventrally.....7

7. Inner margins of ovipositor lobes [flaps] straight and slightly diverging distally; anterior margin of anal lobe not noticably more sclerotized than rest of lobe.... .....Simulium [Simulium] venustum

Inner margins of ovipositor flaps concave, with an oval space between them; anterior margin of anal lobe noticably more sclerotized than rest of lobe..... .....Simulium [Simulium] verecundum

Simulium - Males

1. Basal portion of vein R with hairs dorsally; postnotum without scales; ventral plate tongue-shaped; distimere tapered and curved rather uniformily to a rounded tip with an apical tooth; pedisulcus a deep notch; parameral hooks long and strong; pleural tuft dark..... .....Simulium [Simulium] johannseni

- Ventral plate conical, about same width as base of of distimere; ventral surface clothed in long pale bristles and strongly convex; parameal hooks shorter and weak; pleural tuft pale..... .....Simulium [Eusimulium] johannseni duplex

Basal portion of vein R without hairs dorsally.....2

2. Distimere short and stout, with three or more teeth; ventral plate tongue-shaped; postnotum with two silvery-pollinose vittae.....Simulium [Psilozia] vittatum

Distimere with one or no teeth; ventral plate variously shaped, postnotum usually without distinct vittae.....3

3. Scutum without prominent, anterior shining, white spots or bars, but with three indistinct vittae; scutum densely covered with golden hairs; distimere lacking prominent basal lobe.....Simulium [Byssodon] meridionale

Ventral plate exclusive of ventral arms, spike or tooth shaped, generally longer than wide; scutum not as above.4

APPENDIX P continued.

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4. Arms of ventral plate each with a prominent lateral projection; distimere lacking a hairy lobe at base; posterior quarter of scutum with only a few hairs; femora distinctly browned except at base; large silvery patches on sides of tergites 2, 6 and 7, that on 5 greatly reduced.....*Simulium* [*Phosterodorus*] *luggeri*

   Arms of ventral plate lacking prominent lateral projections; base of distimere generally with a hairy or spiny lobe on the medial surface; posterior quarter of scutum with strong erect hairs 5

5. Basal lobe of distimere armed with stout spines; wing generally less than 2mm....*Simulium* [*Simulium*] *tuberosum*

   Basal lobe of distimere, if any, armed with fine hairs; wings longer than 2mm.....6

6. Ventral plate relatively broad, with the approximate outline of a molar tooth or appearing trilobed when viewed on end.....*Simulium* [*Simulium*] *venustum*

   Ventral plate laterally compressed into a narrow keel..7

7. Scutum with two large grey-brown pollinose areas occupying most of the anterior when viewed from the anterior; ventral keel of ventral plate setose, strongly compressed laterally, rather square in profile, forming an angle before the apex of the ventral keel of the median portion of the ventral plate, with at most a short bare projection beyond the dentate portion.....
   .....*Simulium* [*Simulium*] *decorum*

   Scutum velvety black with two white bars or triangular spots extending posteromedially from the anterior edge when viewed from the anterior; ventral keel of the ventral plate less strongly compressed laterally, not square in profile, the angle being at the apex and forming a conspicuous bare projection beyond the dentate portion; dentate lateral margins of ventral plate somewhat separated but turned inward toward each other concealing the central region; ventral keel in profile, triangular in shape and inner margins straight; distimere with a pronounced broad medial lobe near base clothed thickly in fine hairs.....
   .....*Simulium* [*Simulium*] *verecundum*

APPENDIX P continued

Pupae - Genera

1. Cocoon either loosely woven with a ragged margin around the anterior opening or a thin, semi-transparent shealth with visible individual threads, if the latter then boot-shaped eg. with a broad, elevated anterior collar and with a well defined anterior rim; respiratory tree either with 12 branches or with 30 to 40 branches arising from a rounded base; terminal spines on abdomen may or may not be present.....Cnephia

   Cocoon either loosely woven or tightly woven, but always with individual threads visible and a well defined anterior rim; either slipper-shaped eg. without an elevated anterior collar, or boot-shaped.....Simulium

Cnephia

1. Cocoon slipper-shaped; terminal hooks on abdomen large and strong; respiratory filaments 27 to 40, average 30 .....Cnephia [Cnephia] dacotensis

Simulium

1. Respiratory filaments 4, rather stout basally, all arising close to the base.....
   .....Simulium [Simulium] johannseni

   - Respiratory filaments generally 2 but one or both filaments occassionally dividing once at some distance beyond the base, filaments swollen beyond base.....
     .....Simulium [Eusimulium] johannseni duplex

   Respiratory filaments more than 4.....2

2. Respiratory filaments 6.....3

   Respiratory filamets more than 6.....5

3. Pupae and cocoon relatively dark and small [generally less than 3.5mm]; respiratory filaments less than one-half as long as the cocoon, fine spreading scarcely more than 90° near the base; dorsum of head and thorax smooth.....Simulium [Simulium] tuberosum

   Pupae and cocoon relatively pale and large [cocoon generally longer than 3.5mm]; respiratory filaments more than one-half as long as the cocoon and spreading more than 90° near the base.....4

APPENDIX P continued.

4. Respiratory filaments spreading out about 90° or a little more from base, relatively fine.....Simulium [Simulium] venustum

   Respiratory filaments spreading out to as much as 180° from the base, relatively coarse.....Simulium [Simulium] verecundum

5. Respiratory filaments 8; filaments in four short-petoilate pairs [two pairs often arising singly], coarse cocoon coarsely woven.....Simulium [Simulium] decorum

   Respiratory filaments more than 8.....6

6. Respiratory filaments 12; cocoon with two conspicuous anterolateral openings or windows.....Simulium [Phosterodorus] luggeri

   Respiratory filaments more than 12; cocoon without large anterolateral openings or windows.....7

7. Respiratory filaments 16.....Simulium [Psilozia] vittatum

   Respiratory filaments 22 to 26.....Simulium [Byssodon] meridionale

Larvae - Genera

1. Rectal gill with three simple lobes; respiratory histoblast variable but never containing 4 or 16 filaments; hypostomal teeth uniformly small.....Cnephia

   Rectal gill with three lobes, generally compound [simple in S. vittatum]; hypostomium with median tooth and outer lateral [corner] teeth moderately large and subequal in height and with 3 variably smaller but nearly equal sublateral [intermediate] teeth on each side.....Simulium

Cnephia

1. Hypostomial teeth short, not well developed; second segment of antenna nearly uniformly pale yellow, without a white band near tip; antero-lateral head spots separated; abdomen gradually expanding posteriorly.....Cnephia [Cnephia] dacotensis

APPENDIX P continued.

Simulium

1. Ventral papillae absent or small, rounded and inconspicuous; usually postgenal cleft pointed anteriorly or suboesphageal ganglion and/or epidermis of postgenal cleft distinctly black, or both; spots of cephalic apotome light or dark.....2

   Ventral papillae conspicuous, conical; postgenal cleft not usually pointed anteriorly; suboesophageal ganglion and epidermis in postgenal cleft usually not distinctly black; spots of cephalic apotome black.....7

2. Suboesophageal ganglion and epidermis in postgenal cleft not distinctly black; abdomen not black.....3

   Suboesophageal ganglion and epidermis in postgenal cleft distinctly black; abdomen mostly dark.....6

3. Spots of cephalic apotome dark; abdomen pale yellowish-brown; suboesophageal ganglion pale; respiratory histoblast with 12 filaments; antenna short, scarcely longer than cephalic fan stem; spots of cephalic apotome pale yellowish-brown.....Simulium [Phosterodorus] luggeri

   Spots of cephalic apotome light.....4

4. Infusication around spots of cephalic apotome not extending beyond inner edge of antero-lateral spots; pale, yellow area present just anterior to apex of postgenal cleft on epicranial plate; anal sclerite narrowly fused medially; antenna not longer than cephalic fan stem.....Simulium [Simulium] decorum

   Infusication around head spots wider, extending beyond outer edge of antero-lateral spots; antenna slighty longer than cephalic fan stem; arms of anal sclerite broadly fused medially.....5

5. Lateral plate of proleg lighty sclerotized, faintly visible; head fan with over 52 rays; anal ring with about 66 rows of hooks; postgenal cleft not bordered by a fulvous band.....Simulium [Simulium] verecundum

   Lateral leg of proleg heavily sclerotized, conspicuous; head fan under 48 rays; anal ring over 70 rows of hooks; postgenal cleft bordered by a narrow fulvous band.....Simulium [Simulium] venustum

APPENDIX P concluded.

6. Postgenal cleft a bowed V; full grown larvae 5 to 7mm long; anal hooks 11 to 15 per row; anal gill with digitally compound lobes; postgenal cleft extending less than one-half the distance to teeth of hypostomium, without a narrow apical extension; subeosphageal ganglion distinctly black; epidermis in postgenal cleft usually pale; cephalic apotome with obscure dark spots, fulvous area broad, extending one-half or more the length of head.....Simulium [Simulium] tuberosum

   Postgenal cleft subquadrate, apical margin straight or rounded; full grown larvae 9 to 11mm long; anal hooks 18 to 27 per row; anal gill with three simple lobes; hypostomial teeth long, well developed; second segment of antenna with a whitish band near tip; abdomen abruptly expanding at segment 5; postgenal cleft extending slightly more than one-fourth distance toward apex of hypostomium.....Simulium [Psilozia] vittatum

7. Postgenal cleft extending one-half to two-thirds the distance to the base of the hypostome; spots of cephalic apotome rather sharply defined, consisting of antero and postero-median spots and a pair of well defined, oblique postero-lateral spots; median and corner teeth of hypostomium noticably larger than intermediate teeth; respiratory histoblast with 4 filaments.....Simulium [Eusimulium] johannseni

   Postgenal cleft extending to the base of hypostome; spots of cephalic apotome consisting of merging and rather indistinct infusication from antero to postero-median positions and a pair of poorly defined postero-lateral spots; area around postgenal cleft heavily infusicated; antenna slightly longer than cephalic head fan stalk; integument of thorax and abdomen embedded with fine black granular particles or specks; body abruptly expanding after segment 5; anal gills digitally compound.....Simulium [Byssodon] meridionale†

†Previously undescribed.

Keys to the larval, pupal and adult stages of black flies of the Souris River are based on the following references:

Stone 1964
Davies, Peterson and Wood 1962
Wood, Peterson, Davies and Gyorkos 1963
Nicholson and Mickel 1950
Peterson 1978
Fredeen 1972 unpublished

APPENDIX Q. Instruments Used for Measurement of Physical Parameters.

Temperature	- Standard glass pocket thermometer. YSI Oxygen - Temperature meter, model 51.
Current speed	- Teledyne Gurley Current meter, model 622.
Oxygen concentration	- YSI Oxygen - Temperature meter, model 51.
Depth measurement	- Graduated 1.5m steel pole.