FLIGHT AND HOST SEEKING BEHAVIOUR OF ADULT BLACK FLIES IN THE SOURIS RIVER AREA, MANITOBA

BY

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ABSTRACT

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Flight and Host Seeking Behaviour of Adult Black Flies in the Souris River Area, Manitoba. Major Professor; R. A. Brust.

Flight and host-seeking activity of adult black flies were studied in the Souris River area, Manitoba. Six species, Simulium meridionale, Simulium luggeri, Simulium johannseni, Simulium venustum/verecundum complex and Simulium vittatum were potential pest species. These black flies fed on cattle, humans, poultry and horses. Simulium meridionale and Simulium luggeri are potentially the most important black fly pests in this area because they are abundant, they attack a wide range of hosts and they are multivoltine in the Souris River.

Flight and feeding activity occurred between 0600 h and 2200 h, at air temperatures between 17.3^{0}C and 36.7^{0}C, at relative humidities between 7% and 81% at light intensities between 0.6 and 11,250 lux, at winds with gusts up to 15.7 km/h and on days with 0-100% cloud cover. Most host-seeking adults were active between 1900 h and 2100 h, at air temperatures between 25^{0}C and 30^{0}C and at light intensities between 60 and 1,620 lux.

Simulium meridionale, Simulium luggeri, Simulium johannseni Simulium venustum/verecundum complex are anautogenous while Simulium vittatum and Cnephia dacotensis are autogenous.

Cone samplers did not correctly estimate larval populations, and were of little value in predicting adult population size. Cone samplers gave the relative stage of development and the relative proportions of black fly species present.

CHAPTER I

Introduction

Severe black fly outbreaks were first reported in the Hartney-Cameron area of the province of Manitoba in 1949 (Michener unpub. rept. and Bird unpub. rept.). Cattle, horses, poultry and humans were all attacked by simuliids. Due to continuous outbreaks in the early 1950's, the river was treated with DDT to reduce simuliid populations.

More recent black fly outbreaks in the spring and early summer of 1974 and 1975, resulted in the death of numerous domestic chickens and wild birds. Several humans in the area were hospitalized and outdoor activities were curtailed during attacks. These outbreaks prompted the residents of the Hartney-Cameron area to request assistance from the Government of Manitoba. In 1976, high water levels and high black fly numbers led to the use of the larvicide, methoxychlor, to control black fly breeding in the Souris River. Since this treatment, Westwood (1979) studied the biology and ecology of immature simuliids in the Souris River. He found five species, Simulium (Phosterodorus) luggeri Nicholson and Mickel, Simulium (Byssodon) meridionale Riley, Simulium (Simulium) venustum Say, Simulium (Simulium) verecundum Stone and Jamnback and Simulium (Eusimulium) johannseni Hart to be potential pest species. These simuliids were observed feeding on cattle, horses, poultry and humans. Westwood (1979) found that S. johannseni and the

S. venustum/verecundum complex were the first simuliids to emerge in spring, followed 10 to 14 days later by S. luggeri and S. meridionale. He recommended that two larvicide treatments should be undertaken to control simuliid populations: the first aimed at S. johannseni and S. venustum/verecundum; the second at S. luggeri and S. meridionale.

The present study was undertaken during the summers of 1979 and 1980 to study adult flight activity and host-seeking behaviour of simuliids in the Souris-Hartney area. Females were given a choice of domestic fowl (turkeys and chickens) or a bovine host. Flies feeding on equines, humans and a small herd of cattle were sampled on an irregular basis (mainly, as time permitted), and identified to species.

CHAPTER II

Literature Review

Section A - Review of Capture Studies of North American Black Fly Adults Using Carbon Dioxide-Baited Traps and Animal-Baited Traps

Carbon Dioxide-Baited Traps. In the U.S.A., Snoddy and Hays (1966) were the first to report that more simuliids were attracted to humans when a stream of CO_2 was supplied through clothing than without. Using modified New Jersey light traps and CO_2, Snoddy and Hays were able to captured 11 species of simuliids, including Simulium vittatum Zetterstedt, Simulium venustum Say, Simulium tuberosum Lundström and Simulium decorum Walker. The average catch was 45 flies per h while traps without CO_2 collected few flies.

In Ontario, CO_2 was provided from cylinders along with the ether extracts of ducks and loons to study the behaviour of simuliids (Fallis and Smith, 1964). They found that Simulium rugglesi Nicholson and Mickel is attracted in greater numbers to a combination of CO_2 and an ether extract of the uropygial gland of ducks than to the ether extract alone. In Ontario, Canada, Baldwin et al. (1966) caught large numbers of S. venustum females with cylindrical, dark blue sticky traps baited with dry ice.

Upwind orientation to CO_2 by S. venustum was studied in Ontario

by Golini and Davies (1971) confirming the findings of Smith (1966) who first proposed the hypothesis of upwind orientation of simuliids to CO_2 during host seeking.

In Newfoundland, Bradbury and Bennett (1974) reported that the number of simuliids orientating to a CO_2 source decreased with the distance downwind from the source. In Algonquin Park, Ontario, simuliids were numerous in fan traps and on sticky flesh coloured cylinders and mannequins only when CO_2 was released nearby (Fallis et al., 1967). Ninety to 99% of simuliid catches consisted of S. venustum, the remaining being mostly S. decorum. They found that the greater the discharge of CO_2 the higher the number of simuliids caught.

Animal-Baited Traps. Large and small cages or traps, containing animals, were used in the U.S.A. and Canada to study simuliid biting activity (Bennett, 1960; Anderson and Defoliart, 1961; Roberts, 1965; Wright and Defoliart, 1970; Service, 1977; Shemanchuk, 1978).

In Algonquin Park, Ontario, Bennett (1960) exposed birds in 400 or 900 cubic cm boxes having tops and sides made of chicken wire or heavy mesh netting, and bottoms made of 1.2 cm mesh hardware cloth. Cages were placed at heights varying from the ground to 7.6 m in the tree canopy. Flies were given 20-30 min. to feed and cages were then covered with nylon netting. Blood-fed S. venustum were captured, primarily along the lake shore and the ground, around ravens, ruffed grouse, domestic ducks, crows, grackles, robins and saw-whet owls. Blood-fed S. decorum were taken from crows and domestic ducks, at the lake shore and at ground level. Other simuliids, including S. aureum Fries and S. latipes (Meigen) were at greater heights in forest habitats

(Bennett, 1960).

In Wisconsin, Anderson and Defoliart (1961) confined a variety of wild and domestic birds and small mammals to wire mesh cages, 61 x 30.5 x 30.5 cm or 50 x 41 x 30.5 cm. After 30 minutes they were covered with a cardboard box. Flies were allowed to escape from windows cut into the sides of the box. Windows were fitted with sleeves of cheesecloth. A sheet of cheesecloth larger than the bottom of the box was attached to the lower edge of one side of the box. As the box was lifted from the cage, the sheet of cheesecloth was drawn over the open bottom to prevent black flies from escaping. Flies were then aspirated from the box. S. johannseni and S. meridionale fed on domestic turkeys (white and bronze varieties), white Leghorn chickens, ring-necked pheasants, domestic white Pekin ducks, ring-necked doves, and starlings. Blood-fed S. decorum were taken from horses, cattle, and white-tail deer; S. venustum from humans, horses, cattle, white-tail deer and sheep; S. tuberosum from humans, and S. vittatum from horses and cattle.

In Mississippi, Roberts (1965) used a steer-baited trap, 1.5 x 1.8 x 2.1 m having the top and sides covered with a fine mesh screen. An internal stanchion was constructed and extended the full length of the trap. A door was provided at one end of the trap to gain admittance. Flies entered the trap through a series of angled baffles constructed into the sides of the traps. Blood-fed S. vittatum were captured in this trap.

In Wisconsin, Wright and Defoliart (1970) used animal traps, 45 x 50 x 50 cm having a wooden frame, wooden top and bottom and sides covered with saran screen. A 10 cm angled baffle with a 2 cm opening was

positioned 10 cm from the top and along the entire length of each side. Plywood doors were attached to the frame at the front centre of the trap for removal and placement of the caged animal. In these traps, 2 of 41 flies of the S. venustum-tuberosum complex, attracted to racoon, were engorged and 1 fly attracted to a fawn deer was engorged. Although S. johannseni and S. meridionale were attracted to racoon and woodchuck they did not feed. S. meridionale engorged on chickens (1,283 of 1,501 flies attracted to chickens were engorged) and on humans during the summer of this study. On two occasions, it was confirmed that this fly feeds on humans either indoors or in a screened porch (Wright and Defoliart, 1970).

In Alberta, Shemanchuk (1978) used a steer-baited trap which differed from Roberts (1965) in that the sides of the trap were completely removed between collections. In this way flies which were present on the host as it entered the trap could not accidently become trapped in the cage. Several steers were trained to enter the stanchion of the trap, at which time the sides made of fine nylon mesh, were lowered as quickly as possible. The steer was covered for 10 min. to allow flies to complete feeding and settle on the walls and ceiling of the trap. A collector would then enter the trap and aspirate adults into 70% ethanol. Blood-fed and non blood-fed S. venustum, S. vittatum and S. decorum were successfully collected by this method.

Section B - Review of Host Specificity and Site of Attack of Some North American Simuliids

Simulium (Simulium) venustum Say. In Ontario, S. venustum feeds on birds and mammals but prefers mammals (Bennett, 1960). This simuliid

feeds at the back of the neck, behind the ears and on the forearms and ankles of humans (Wolfe and Peterson, 1960). S. venustum was also reported to feed on the eyes, ears and nose of beaver in Ontario (Davies and Peterson, 1956).

In Wisconsin, this simuliid feeds on horses in preference to cattle, humans, dogs, cats or birds (Anderson and Defoliart, 1961). Here, S. venustum feeds on the chest, neck, behind the jaw and on the inner margin of the legs of horses. In Virginia, Teskey (1960) reported that S. venustum fed over the general body surface of cattle. In Manitoba, blood-fed S. verecundum, a species closely related to S. venustum, has been taken from humans and horses (Westwood, 1979). Few other reports of hosts attacked by S. verecundum are available (Golini and Davies, 1975a).

Simulium (Phosterodorus) luggeri Nicholson and Mickel. In Saskatchewan and Manitoba, S. luggeri feeds on horses, cattle and humans (Fredeen, 1977). This fly swarms around the head of cattle and feeds aggressively about the eyes (Fredeen, 1977). This mode of attack makes this simuliid very alarming to cattle and attacks often result in the death or injury to animals through stampeding and trampling.

Simulium (Byssodon) meridionale Riley. In Wisconsin, S. meridionale feeds on a wide variety of bird hosts and is the most common simuliid feeding on turkeys and chickens (Anderson and Defoliart, 1961). Flies feed on the unfeathered head and comb and beneath the feathers of large turkeys. On young poults, this simuliid prefers to attack the feathered body over the head area.

Reports of this simuliid feeding on humans (Anderson and Defoliart,

1961; Defoliart and Rao, 1965; Wright and Defoliart, 1970 and Westwood, 1979) and on cattle (Westwood, 1979) suggest that this fly is not restricted to avian hosts.

S. meridionale is the principal vector of Leucocytozoon in turkeys in Wisconsin (Anderson and Defoliart, 1961) and strong evidence suggests that this simuliid may vector Leucocytozoon to turkeys in Manitoba as well (Fredeen, 1977). In Wisconsin, Eastern Equine Encephalitis has been isolated from this simuliid (Anderson and Defoliart, 1961).

Simulium (Eusimulium) johannseni Hart. In Wisconsin, S. johannseni feeds on a variety of avian hosts but prefers to feed on chickens rather than on pheasants, and on turkeys rather than chickens or pheasants. Reports by Anderson and Defoliart (1961), indicated that greater numbers of this simuliid were taken at the lower forest canopy than at ground height perhaps suggesting a preference for birds over mammals. However, in Manitoba, Westwood (1979) has took blood-fed S. johannseni from humans and cattle. Eastern Equine Encephalitis has been isolated from S. johannseni in Wisconsin (Anderson and Defoliart, 1961).

Simulium (Psilozia) vittatum Zetterstedt. In Utah, Knowlton and Maddock (1944), and in Virginia, Townsend et al. (1977), found that S. vittatum prefers to feed on the ears of horses. In California, Anderson and Voskuil (1963) and in Manitoba, Westwood (1979), took this simuliid from the ears of horses and cattle. However, in Ontario, Teskey (1960) observed this simuliid feeding on cattle only. In Utah, Knowlton and Maddock (1944) found S. vittatum to feed on the head, neck, shoulders, back, front legs, brisket and the underbelly of horses.

Section C - Behaviour of Some North American Simuliids During Various Meteorological Conditions

Host-seeking Activity. Host-seeking behaviour of simuliids during various meteorological conditions, indicate that flight occurs under a wide range of conditions (Underhill, 1940; Davies, 1950; Davies, 1952; Davies, 1953; Davies and Peterson, 1956; Wolfe and Peterson, 1960; Anderson and Defoliart, 1961; Alverson and Noblet, 1976).

Air temperatures below 7^0 to 9^{0}C and above 30^{0}C in Wisconsin inhibit simuliid flight and feeding activity (Anderson and Defoliart, 1961; Alverson and Noblet, 1976). In Ontario, Davies (1952) reported that the highest number of S. venustum adults landed on human skin at air temperatures between 13^{0}C and 18^{0}C. He found no correlation between landing rates and air temperature, but reported that landing rates dropped to ½ and biting rates to ¼ when human skin was exposed to direct sunlight. Davies suggested that some black flies seem very susceptible to dessication under hot, dry conditions. In Virginia, Underhill (1940) reported that maximum simuliid feeding occurred between relative humidities of 65% and 75% and between air temperatures 24^{0}C and 29^{0}C with few flies feeding below 21^{0}C. Simuliids remained active under a greater range of relative humidity than air temperature. Air temperature therefore was the more limiting factor. Unfortunately, Underhill does not indicate which simuliid species he worked with. In Quebec, Wolfe and Peterson (1960) found that S. venustum feeding activity was curtailed at relative humidity extremes below 25% and above 95% and at air temperatures below 7^{0}C and above 30^{0}C.

In Wisconsin, Anderson and Defoliart (1961) reported that hundreds

of S. venustum fed on horses under overcast skies and at an air temperature of 15^{0}C and a relative humidity of 79%. During the initial period of attack flies were present throughout the day but in following days biting activity was greatest in the evening.

Many simuliids have a diurnal feeding pattern with morning and evening peaks (Wolfe and Peterson, 1960; Anderson and Defoliart, 1961). In Quebec, the peak activity of S. venustum occurred 1 to 2 h after dawn and ½ to 1 h before sunset at light intensities of 215 lux and 54 lux respectively (Wolfe and Peterson, 1960). Wolfe and Peterson suggested that greater peak periods of activity in the evening may have been related to higher air temperatures before sunset than after dawn.

Anderson and Defoliart (1961) reported that simuliids, including S. johannseni, S. meridionale, S. decorum, S. luggeri, S. venustum and S. vittatum, fed continually throughout warm overcast or sunny days, with morning and evening peaks of activity. No feeding occurred after dark. They found that morning and evening peaks of activity were correlated with peaks in relative humidity. However, in British Columbia, Wellington (1974) found no such correlation.

In South Carolina, Alverson and Noblet (1976) reported that simuliids, including Simulium slossonae (Dyar and Shannon), were active at light intensities between 17 and 27,500 lux. Feeding activity was reduced between 1000 h and 1600 h or during the time of greatest light intensity. They concluded that simuliid feeding activity was correlated to light intensity, air temperature, relative humidity and time of day. They also reported that significant increases in activity occurred during the presence of cumuliform clouds. The presence of cumuliform clouds was regularly associated with small changes in barometric

pressure throughout this study. In British Columbia, Wellington (1974) correlated the approach of cumulus clouds to small fluctuations in barometric pressure. He reported that in the absence of an indigenous breeding population of simuliids, swarms suddenly appeared as cumulus clouds passed directly overhead, or plus or minus 20 degrees to either side of the zenith.

In Utah, Peterson (1956) reported that simuliids, including S. arcticum, S. tuberosum and S. vittatum, seldom fed on humans below 2,100 m but did so quite readily above this elevation. Peterson (1956) suggested that simuliid feeding activity increases at high elevations where barometric pressure is lower. One record of S. vittatum feeding on humans at 1,300 m may have been due to low barometric pressure. In Virginia, Underhill (1940) found that maximum feeding activity occurred at barometric pressures between 701 and 712 mm Hg at an elevation of 610 m. He also reported that a dropping barometric pressure, as occurs before thunderstorms, increased simuliid feeding activity. In Ontario, Baldwin and Gross (1972) reported that rainfall preceded increases in simuliid activity. However, in Quebec, Wolfe and Peterson (1960) found that black fly activity increased preceding thunderstorms and rain and attributed these increases to changes in light intensity.

Feeding activity of most simuliids is severely reduced at wind speeds greater than 8 km/h (Underhill, 1940; Wolfe and Peterson, 1960). However, Alverson and Noblet (1976) reported simuliid activity at wind speeds of 19 km/h. In Algonquin Park, Davies (1952) reported that the flight activity of S. venustum was reduced at wind speeds greater than 24 km/h.

Alverson and Noblet (1976) concluded that less than 25% of all

changes in simuliid activity could be attributed to changes in relative humidity, barometric pressure, percent cloud cover or hourly light intensity at individual trapping sites. However, light intensity is considered by many to be the singular most important meteorological factor governing black fly activity (Davies, 1952; Wolfe and Peterson, 1960; Anderson and Defoliart, 1961).

Oviposition Activity. Simuliids lay eggs in rivers, creeks and streams or on vegetation, dam faces, rocks or debris found in flowing water. Those simuliids which oviposit directly into the water do so by touching or dipping the abdomen into the water while in flight (Davies, 1950; Hocking and Pickering, 1954; Davies and Peterson, 1956) or land to oviposit on a suitable substrate (Golini and Davies, 1975b). Davies and Peterson (1956) reported that S. decorum and S. vittatum engage in both methods while S. venustum and S. verecundum oviposit on vegetation (Merrit et al., 1978). S. venustum was observed to oviposit frequently on cattail, Typha latifolia Linnaeus and less frequently upon reed meadow grass, Glycera grandis Wats., bur reed, Sparangium sp., eelgrass, Vallisneria spiralis Linnaeus, leaves of alder, Alnus rugosa Spreng. and meadow rue Thalictrum polygamum Muhl. (Davies and Peterson, 1956). In the absence of suitable oviposition substrates, S. venustum has been observed to lay eggs on filamentous green algae floating at the water surface (Davies and Peterson, 1956). Most eggs were laid on days during which thunderstorms occurred, between 1800 h and 2045 h, at light intensities between 0 and 1,145 lux and at air temperatures between 11^0C and 27^0C. S. venustum also oviposited on evenings with little or no wind, on overcast days and on warm sunny days (Davies and Peterson, 1956).

In Ontario and Quebec, Davies and Peterson (1956) and Corbet (1967) reported that oviposition peaks for S. vittatum occurred near sunset and less frequently shortly after sunrise.

CHAPTER III

Materials and Methods

Section A - Sampling and Rearing Methods for Eggs and Immatures

Eggs. Eggs of Simulium vittatum were collected during 1979 and 1980 from various substrates: vegetation, rocks, sticks, moist dam faces, sluice gates, algae, pieces of 1 cm dia. yellow nylon ropes (Fig. 15), expanded polystyrene floats (Fig. 14) and occasionally from a larval cone sampler. Forceps were used to scrape eggs from the substrate. Some eggs were preserved in 70% ethyl alcohol, and some were transported to the laboratory on wet paper towels. Time of day, air temperature, relative humidity, wind velocity and light intensity were recorded when freshly laid eggs were found.

Immatures.

Collection of Immatures. Immatures were collected in 1979 and 1980 from vegetation, sticks, rocks and artifical samplers. Artificial samplers consisted of white polystyrene cones 18.5 cm long x 10 cm maximum dia. (Fig. 2). A cone sampler set consisted of 3 cones, each 1.5 m apart, tied to a 6.3 mm nylon rope. About 5 kg of building bricks were attached to one end of the nylon rope to act as an anchor and a 900 cm^2 expanded polystyrene float, 4 cm in thickness, was tied to the other end of the rope. Cone samplers were placed into the river from bridges at sites 4 and 5, since the water was too deep to navigate at