THE BITING FLIES OF THE NOVA SCOTIA-NEW BRUNSWICK BORDER REGION

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by

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ABSTRACT

During the last decade, federal and provincial government departments acquired about 4,000 hectares of land in the Tantramar Marshes in the Nova Scotia-New Brunswick border region. Some 440 hectares have been dyked and flooded to constant water levels to provide habitat for breeding and migratory waterfowl. This study prepared an inventory of the biting flies of the Nova Scotia-New Brunswick border region, studied aspects of the population dynamics of these flies, and determined how the species composition and population dynamics of biting flies are influenced by environmental modification and marsh management.

One hundred and eight species of biting flies (32 Culicidae, 20 Simuliidae, and 56 Tabanidae) are now recorded from the Maritime Provinces. A total of 59 species (19 culicids, 9 simuliids, and 31 tabanids) were collected in the Nova Scotia-New Brunswick border region during the period 1 May to 31 August, 1973-1975. With the exceptions of *Simulium latipes auct. nec.* Meigen, *Chrysops calvus* Pechuman and Teskey, *Hybomitra illota* (Osten Sacken), *H. itasca* (Philip), and *H. typhus* Whitney Form B, all species collected in this area were previously recorded in the literature or contained in the Biosystematics Research Institute, Ottawa. Taxonomic keys were constructed for the females of Culicidae, Simuliidae, and Tabanidae of maritime Canada.

Seven species of mosquitoes were found in temporary pools of snowmelt origin and three were taken in temporary floodwater pools. *Aedes punctor* (Kirby) was the most abundant culicid taken in the snowmelt pools, and *A. cantator* (Coquillett) was the most abundant in floodwater pools. One species of each of five genera of mosquitoes were found in permanent marshes. *Mansonia perturbans* (Walker) was the most abundant mosquito of

this group, and was the most serious pest encountered in the Tantramar Marshes and neighboring towns of Sackville, New Brunswick and Amherst, Nova Scotia.

Nine species of simuliids were found in temporary and permanent streams in the Nova Scotia-New Brunswick border region. Larvae of a complex of species, consisting of *S. venustum* Say and *S. verecundum* Stone and Jamnback, were found in all streams which contained larval simuliids. While adult simuliids were relatively uncommon in the study area, this species complex comprised over two-thirds of the adults collected.

Ten species of culicids, six species of simuliids, and 15 species of tabanids were taken feeding on man. The principal pest within each group was *M. perturbans*, *S. venustum-verecundum* and *H. frontalis* (Walker). Nine species of tabanids were found feeding on cattle, the most abundant of which was *H. typhus* Form A.

The seasonal succession of culicids, simuliids, and tabanids, as determined by aerial net sweeps in the Nova Scotia-New Brunswick border region, very closely follows the seasonal succession of the same species in other regions of eastern North America.

A two-year study of natural and man-made marshes of various ages has indicated that mosquito productivity was greatest in marshes of 3.5 years of age. On the average, the man-made marshes produced over 2.5 times as many mosquitoes as the natural marsh, the majority of which were *M. perturbans*.

A system of shoreline modification, constant water levels, and periods of water drawdown in the man-made waterfowl marshes is recommended for control of pest mosquitoes, especially *M. perturbans*.

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INTRODUCTION

The Tantramar Marshes constitute the largest body of marshland in the Maritime Provinces and have an agricultural history that dates back over two hundred years. Before these marshes could be adapted for agriculture they had to be protected from further inundation of the tides. In the seventeenth century, the Acadians constructed dykes and built tidal dams, and succeeded in preventing tidal penetration while allowing freshwater runoff. This was maintained and continued by the New Englanders and British who replaced the French in the eighteenth century.

During the late 1950's and early 1960's, a drainage of natural wetlands for agriculture resulted in extensive loss of and damage to waterfowl production areas in eastern Canada. Within the last decade, about 4,000 hectares of potential waterfowl habitat have been acquired by federal and provincial government wildlife agencies in the Nova Scotia-New Brunswick border area. Several waterfowl marshes have been restored or improved with funds and engineering advice by Ducks Unlimited (Canada). These marshes include the Tintamarre National Wildlife Area, owned and managed by the Canadian Wildlife Service, and the Missaquash Marsh, owned and operated by the Province of Nova Scotia. These marshes have been under intensive management programs for several years. As a result, there is a series of impoundments of different ages which, together with adjacent natural marshes, represent stages of community succession. There are numerous farms and farming communities situated among these marshlands.

No studies have been conducted to determine the effect of such large-scale, continuous, environmental modification on the populations of biting flies in eastern North America, nor have detailed studies been carried out to determine how the creation of man-made freshwater waterfowl habitats affects the biting fly community. The present study is an attempt to make a species inventory of the biting flies (mosquitoes, blackflies, horse flies and deer flies) of the Nova Scotia - New Brunswick border region; to study aspects of the population dynamics of these biting flies, with emphasis on mosquitoes and other potential vectors of diseases of man, livestock, and waterfowl; and to determine how the species composition and population dynamics of biting flies are influenced by environmental modification and marsh management. Baseline information acquired in this study should provide data for future marsh impounding and recommendations for controlling biting fly pests of the managed wetlands.

REVIEW OF LITERATURE

The purpose of the literature review is to determine what information is available on biting flies (mosquitoes, blackflies, horse flies and deer flies) of eastern North America, particularly maritime Canada. Specific information sought, related to this study, includes taxonomic keys, distributional studies, studies on the biology of the various species of biting flies, sampling procedures and vector potential.

The present study area is in many places just a few meters above sea level, and it was anticipated that the literature review would include information on biting flies and freshwater marsh systems of environmentally similar areas. This suggests that reference would be made only to the low-lying land of the Atlantic coast. The Appalachian Mountain range forms a convenient barrier, running from northern Alabama to the Gaspe Peninsula, Quebec. This effectively isolates the New England States and the Maritime Provinces from the rest of North America. However, relatively little biting fly work has been done in this region, particularly in the Maritime Provinces. Since most biting fly work done on the Atlantic coast pertains to salt marsh studies, very little pertinent literature is available. A geographical area, which includes the Province of Ontario and the States of New York and New Jersey, and all states and provinces east of those, was chosen for the literature review. Reference will be made to studies outside the area when deemed necessary.

Culicidae

Keys to the species of culicines for larger geographical areas include those of Carpenter and LaCasse (1955) and Matheson (1944) for

North America, Dyar (1921) for Canada, Dyar (1922) for the United States, Darsie (1951) for the northeastern United States and Smith (1958, 1969) and Tulloch (1930) for the New England States. Similar studies, but on a smaller scale, are presented by Lowry (1929) for New Hampshire, Steward and McWade (1961) for Ontario, and Tulloch (1939) for Massachusetts. A key to the anopheline mosquitoes of northeastern America was presented by Matheson and Shannon (1923).

Lists and annotated lists of mosquitoes are available for the New England States (Fellton *et al.*, 1950), Maine (Bean, 1946; Lathrop, 1939; McDaniel, 1975; Shaw, 1959), New Hampshire (Blickle, 1952; Dyar, 1909), New Jersey (Schmitt, 1942), Rhode Island (Bartosewitz, 1945), New York (Barnes *et al.*, 1950; Jamnback, 1969*b*), southeastern Ontario (James *et al.*, 1969), and Quebec (Harrison et Cousineau, 1973).

Distributional studies for a single species or several species of Culicidae have been considered by numerous workers, including Knight (1967) for the United States, Carpenter (1950) for the eastern United States, Miles and Rings (1946) for the southeastern States, Fellton *et al.* (1950) for the New England States, Shaw (1959) for Mt. Desert Island, Maine, Barnes (1946) for Vermont, Coyne and Hagmann (1970) and Lake (1953) for New Jersey, Ozburn (1944) for Canada, and Smith and Trimble (1973) for Point Pelee National Park, Ontario.

Carpenter and LaCasse (1955) and Twinn (1949) considered the biology of the various species of culicids in North America and Canada respectively. Much of the biology contained within these works applies to the mosquitoes of maritime Canada. Biological studies of mosquitoes specifically in areas of eastern North America include those by King *et al.* (1944) for the southeastern States; McDaniel and Horsfall (1963) and

McDaniel and Webb (1974) for Maine; Blickle (1952) and Dyar (1903, 1909) for New Hampshire; Scott (1948, 1949, 1950) for Vermont; Barnes (1945), Berg and Lang (1948), Hayes (1962), Lounibos and Bradshaw (1975) and Main *et al.* (1968) for Massachusetts; Knutson (1943) for Rhode Island; Anderson (1970), Wallis (1959, 1960) and Wallis and Frempong-Boadu (1967) for Connecticut; Dyar (1902) for Long Island; Butts (1974), Felt (1904), Jamnback (1969*b*), Matheson and Belkin (1943), Matheson and Hurlburt (1937) and Mullen (1971*b*) for New York; Bast and Rehn (1963), Benach (1970), Hagmann (1952, 1953), Headlee (1921, 1931, 1945), Smith (1904), and Vannote (1970) for New Jersey; Twinn (1931) for eastern Canada; Baldwin and Chant (1975), Beckel and Atwood (1959), Belton (1967), Belton and Galloway (1966), Bennett (1960), James (1960, 1962), Judd (1950, 1954*a*, 1954*b*), McIver (1969), Smith and Brust (1971), Twinn (1926), and West and Hudson (1960) for regions of Ontario; Jenkins and Knight (1950) for Quebec; Twinn (1953) for Prince Edward Island; Haufe (1952) for Labrador; and Pickavance *et al.* (1970) for Newfoundland. Bourassa and Aubin (1974) considered the physical and chemical characteristics of some mosquito breeding sites in Quebec, and Chant and Baldwin (1972) studied dispersal and longevity of mosquitoes tagged with radioactive phosphorus in Ontario.

Sampling methods used for estimation of the size of mosquito populations are numerous, varied, and apparently all have some sort of bias. Quantitative methods for sampling mosquito larvae have been described by Bidlingmayer (1954), Roberts and Scanlon (1974), and Welch and James (1960). Knight (1964) evaluated quantitative methods for mosquito larval surveys. The more common methods of sampling adult mosquitoes include versions of the New Jersey light trap as described by Mulhern (1942), modifications of the Malaise trap designed by Malaise (1937) and initially modified by Townes (1962), sweep netting (Mullen, 1971*a*), and dry ice-baited traps (DeFoliart and Morris, 1967). Other traps include the rotary-type trap (Stage and Chamberlin, 1945), the truck trap (Bidlingmayer, 1966), the animal trap (Easton *et al.*, 1968), and ultra-violet light traps (Morgan and Uebel, 1974). Aubin *et al.* (1973) constructed an emergence trap for the collection of mosquitoes in Quebec. Bidlingmayer (1967), Gojmerac and Porter (1969), Graham (1969), Hayes *et al.* (1958), Minson *et al.* (1970), and Service (1969) have compared several trapping methods for adult mosquitoes. Bidlingmayer (1974) considered the influence of environmental factors and physiological stage on flight patterns of mosquitoes taken in a variety of traps in Florida. Gillies (1974) reviewed methods for assessing the density of blood-sucking Diptera.

Studies on feeding and host preferences of mosquitoes in eastern North America have been carried out in Massachusetts (Hayes, 1961), New York (Means, 1965, 1968), New Jersey (Crans, 1964, 1970; Crans and Rockel, 1968) and Ontario (Downe, 1962; Teskey, 1960).

Very little arbovirus work has been done in maritime Canada. Beaudette (1946) considered mosquito borne diseases of birds in New Jersey, while Hayes *et al.* (1960), also in New Jersey, isolated eastern encephalitis from mosquitoes. Wallis and Main (1974) indicated that eastern equine encephalitis has long been recognized as a potential public health problem in Connecticut, and reported on problems in the ecology and transmission of this disease and progress made in solving some of these problems. Bellavance *et al.* (1972) and Le Maître (1972) reported eastern equine encephalitis for the first time in Canada.

Gibson (1934, 1938, 1939, 1940, 1941) considered mosquito suppression work in Canada, and referred to mosquito problems and control in the Maritime Provinces. Other studies specifically on control, or including control, include those by Botsford (1936) in Connecticut; Lowry (1929) in New Hampshire; Headlee (1921, 1945), Headlee and Miller (1927), and Vannote (1970) in New Jersey; Twinn (1949) in Canada; Twinn (1953) in Prince Edward Island; and Brown *et al.* (1951) in Labrador.

While there is a great deal of information available on the mosquitoes which occur in eastern North America, very little work has been done in maritime Canada. Meyer (1974) and Meyer and Bennett (1976) recorded 14 and 13 species of mosquitoes respectively from the Tantramar Marshes. McIntosh (1903) recorded two species of mosquitoes and Dyar (1921) recorded three species from New Brunswick. Twinn (1931) reported on the biology of 25 species of mosquitoes from eastern Canada, but did not refer to specific geographic localities. Gibson (1934, 1938, 1939, 1940, 1941), considering mosquito suppression work in Canada, reported 14 species of mosquitoes from Nova Scotia and 10 from Prince Edward Island. Gibson (1939) indicated that mosquitoes were so annoying in Sackville, New Brunswick that haying operations were disrupted. He later (Gibson, 1941) reported that the Tantramar Marshes were an ideal habitat for several mosquito species. Ozburn (1944), surveying mosquitoes of Canada, recorded eight species from Nova Scotia and seven from New Brunswick. Twinn (1949) recorded 23 species from Nova Scotia, 18 from New Brunswick, and 10 from Prince Edward Island. Twinn (1953) reported 14 species of mosquitoes from Prince Edward Island; this is the only study specifically of culicids confined to maritime Canada. Stone *et al.* (1965) recorded 16 species of mosquitoes from the Maritime Provinces. A total of 32 species of mosquitoes are recorded from the Maritime Provinces of Canada.

Twinn (1931) reported that knowledge on the biology of mosquitoes in eastern Canada was very incomplete. It appears that this has not changed substantially since then.

Simuliidae

Keys to the simuliids of eastern North America are relatively few and include those by Malloch (1914) for the United States, Holbrook (1967) for Massachusetts, Stone (1964) for Connecticut, Jamnback (1956) and Stone and Jamnback (1955) for New York, Twinn (1936*a*,*b*) for eastern Canada, Davies *et al.* (1962) and Wood *et al.* (1963) for Ontario, and Lewis (1973) for Newfoundland. Peterson (1970) presented a taxonomic study of the species of *Prosimulium* of Canada and Alaska.

The published biology of blackflies, generally and specifically, is available for many geographic locations in eastern North America, including Rhode Island (Dimond and Hart, 1953), New Hampshire (O'Kane, 1926), Connecticut (Stone, 1964), New York (Jamnback, 1969*b*; Metcalf, 1932; Stone and Jamnback, 1955; Travis, 1966, 1967), Canada (Peterson and Wolfe, 1958), Ontario (Bennett, 1960; Chutter, 1970; Davies, 1950, 1952, 1953; Davies and Peterson, 1956; Davies *et al.*, 1962; Davies and Syme, 1958; L. Davies, 1961, 1963; Peterson, 1962), Quebec (Wolfe and Peterson, 1959, 1960), Labrador (Hocking and Richards, 1952), and Newfoundland (Davis, 1971; Ezenwa, 1974; Lewis and Bennett, 1973, 1974*b*, 1975; Pickavance *et al.*, 1970). Peterson (1970) recorded notes on the biology of the species of *Prosimulium* of Canada and Alaska.

Shaw (1959) recorded the distribution of simuliids in Maine and Shewell (1957) presented a distributional study of simuliids in Canada and recorded notes on their biting habits. Peterson (1970) presented the distribution of the species of *Prosimulium* of Canada and Alaska.

Studies on feeding and related behavior include those by Davies (1952), Davies and Peterson (1956) and Teskey (1960) in Ontario, and Wolfe and Peterson (1960) and Downe and Morrison (1957) in Quebec. Downes *et al.* (1962) and Fallis (1964) reported on feeding of simuliids on a broader scale.

There have been numerous sampling techniques for collection of larval simuliids. Metal cones have been used by Peterson and Wolfe (1958) and Wolfe and Peterson (1958) in Quebec, and Johnson and Pengelly (1966) in Ontario. White plates were used by Wolfe and Peterson (1958) in Quebec, while Curtis (1968) used white hard board strips in streams in British Columbia. Holbrook (1967) used a plasterer's lath in Massachusetts, Lewis and Bennett (1974*a*) used ceramic tiles in Newfoundland, and Tarshis (1965, 1968) used lengths of fabric for collection of larval simuliids. Various methods are used to study adult populations. Emergence traps have been used in Ontario (Davies, 1950; Davies and Syme, 1958) and Labrador (Hocking and Richards, 1952). Light traps were used by Abdelnur (1968) in Alberta and Fredeen (1961) in Saskatchewan. Baited traps were used in Ontario by Bennett (1960) and in Wisconsin by Anderson and DeFoliart (1961), while Fredeen (1961) used silhouette traps in Saskatchewan. Adult simuliids were sweep-netted in Ontario (L. Davies, 1961, 1963) and Labrador (Hocking and Richards, 1952).

Studies of simuliid control in eastern North America have been presented by Peterson and Wolfe (1958) in Canada; Brown *et al.* (1951) and Hocking and Richards (1952) in Labrador; Jamnback and West (1970) and West *et al.* (1960) in eastern Canada; Conradi (1905) and Weed (1904*a*,*b*) in New Hampshire; Jamnback (1952, 1969*a*), Jamnback and Collins (1955), Jamnback and Frempong-Boadu (1966), Jamnback and Means (1966, 1968), Jamnback and West (1970), Metcalf and Sanderson (1932), Travis (1966,1967, 1968), Travis and Guttman (1966), Travis and Schuchman (1968), Travis and Wilton (1965), and Travis *et al.* (1951, 1967, 1970) in New York. These papers referred basically to chemical control procedures. Gross *et al.* (1972) carried out studies on radiation of simuliids in Ontario to develop methods of control based on the sterile-male technique.

The Simuliidae of eastern North America are relatively well known, although there are no specific studies on blackflies of the Maritime Provinces. Twinn (1936*a,b*) reported two species of simuliids from both Nova Scotia and New Brunswick. Stone (1964) recorded eight species of blackflies from Nova Scotia, seven from New Brunswick, and five from Prince Edward Island. Stone *et al.* (1965), considering the distribution of simuliids, recorded 13 species from Nova Scotia, 10 from New Brunswick, and nine from Prince Edward Island. Seventeen species of blackflies are recorded in the literature from the Maritime Provinces. Twinn (1936*a*) indicated that published information on the blackflies of eastern Canada was very meagre. With reference to the Maritime Provinces, this has apparently not changed.

Tabanidae

The tabanids of eastern North America have not been given as much consideration as the mosquitoes and blackflies. Major taxonomic studies of tabanids include those by Teskey (1969) for larvae and pupae of eastern North America, Jamnback and Wall (1959) for the species of Rhode Island, Pechuman (1972) for the species of New York, and Pechuman *et al.* (1961) for the species of Ontario.

Annotated lists of horse flies and deer flies are available for Maine (Shaw, 1959), New York (Jamnback, 1969*b*; Leonard, 1928; Pechuman, 1938, 1964), Quebec (Robert, 1958), New Brunswick (McIntosh, 1903), and Newfoundland and Labrador (Philip, 1962). Pechuman (1957*a*) recorded new distribution records for Canada and Pechuman (1957*b*) presented a distributional study of the Tabanidae of New York. McAlpine (1961) considered the North American distribution of a complex of horse flies. Stone *et al*. (1965) provided distributional records for the Tabanidae of North America.

Studies on the biology of tabanids have been presented by Robert (1958) in Quebec; Davies (1959), James (1963), Pechuman *et al*. (1961), Teskey (1960), Troubridge and Davies (1975), and Smith *et al*. (1970) in Ontario; Wallis (1962) in Connecticut; Thompson (1969*b*) and Thompson and Pechuman (1970) in New Jersey; Bequaert and Davis (1923) and Jamnback and Wall (1959) in Long Island; Bequaert and Davis (1923) in Staten Island, N.Y.; Jamnback (1969*b*), Matthysse *et al*. (1974), Pechuman (1972), Pechuman and Burton (1969), Tashiro and Schwardt (1949, 1953*a,b,c*) and Travis (1967) in New York; and Pechuman (1949) and Philip *et al*. (1973) in eastern North America. Bennett and Smith (1968) marked tabanids with radioactive phosphorus.

Specific studies on the biology of salt marsh tabanids have been done by Anderson (1971) in Connecticut; Wall and Doane (1960) in Massachusetts; Freeman and Hansens (1972), Hansens and Robinson (1972), Joyce and Hansens (1968), Rockel (1969), and Rockel and Hansens (1970) in New Jersey.

Feeding and related behavior of tabanids have been discussed in varying degrees by Bennett (1960), Smith *et al*. (1970), and Teskey (1960) in Ontario, and Anderson (1973) in Connecticut.

There are three basic trapping techniques for qualitative and/or quantitative sampling of adult tabanid populations. These are the Manitoba trap (Thorsteinson, 1958), the Malaise trap (Malaise, 1937) as modified by Townes (1962), and the traps used by DeFoliart and Morris (1967). Catts (1970) developed a trap which was an attempt to combine features of these three traps. Other types of traps include modifications of the animal trap originally designed by Morris and Morris (1948), sticky traps (Wilson, 1968), and ultraviolet light traps (Anthony, 1960). Thompson (1969*a*) considered several methods of collecting tabanids in Maryland and New Jersey and indicated that each of the methods showed selectivity.

Travis (1967) has considered the control of tabanids in New York, and Anderson and Kneen (1969) studied the impoundment of salt marshes in the control of coastal deer flies in Connecticut.

Published information on the tabanids of maritime Canada is uncommon. McIntosh (1903) recorded 11 species of tabanids from New Brunswick. Stone *et al.* (1965) reported that the known distribution of tabanids includes 44 species from the Maritime Provinces. Pechuman and Teskey (1967) and Pechuman (1972) recorded one species from Nova Scotia and one from New Brunswick, and Philip *et al.* (1973) recorded one species from Nova Scotia. The literature records 49 species of tabanids from maritime Canada; however, there is very little published information on their biology in this region.

Biting Flies of Impounded Waters

To the author's knowledge, no detailed studies are available pertaining to biting flies of freshwater marshes or of the effects on biting flies of the creation of waterfowl marshes anywhere in North

America, although Whitman (1976) indicated that the creation of waterfowl impoundments provides favorable habitat for mosquitoes and black flies. Bennett *et al.* (1975) indicated that introduction of water level control systems to maintain constant water levels in the managed wetlands of the Tantramar Marshes has created streams where streams did not previously exist. Mosquitoes have long been associated with the development of waterfowl marshes, particularly salt marshes, in New Jersey (Ferrigno, 1961), California (Fraser, 1961; Kozlik, 1969), and Utah (Andersen and Rees, 1963; Rees, 1969; Rees *et al.*, 1966; Smith, 1961), and other developed water resources in Utah (Rees, 1961, 1968), Virginia (Gladney and Turner, 1968) and Tennessee (Gartrell *et al.*, 1972). Proper water management has been found to be an effective mechanism for the control of mosquitoes in developed water resources in Massachusetts (Bodola, 1968), New Jersey (Chapman and Ferrigno, 1956; Sutherland *et al.*, 1967; Hagmann, 1953), Virginia (Dorer *et al.*, 1950), Delaware (Darsie and Springer, 1957), Florida (Provost, 1968), and Utah (Andersen and Rees, 1968; Collett and Rees, 1972; Nagel, 1967; Rees, 1961, 1965; Rees *et al.*, 1966).

Summary of Information Available on Biting Flies of Maritime Canada

One hundred and eight species of biting flies of the families Culicidae, Simuliidae and Tabanidae are presently recorded in the literature from the Maritime Provinces. For the most part, these represent isolated collections and thus distribution records. Very little information is available on the biology of any of these species in maritime Canada. It appears that studies of the effects of the creation of freshwater waterfowl marshes on populations of biting flies are either lacking or not available.

MATERIALS AND METHODS

Location

The study area consisted mainly of the Tintamarre National Wildlife Area and the Missaquash Marsh, which are located in the Tantramar Marshes at the head of the Bay of Fundy in the Nova Scotia-New Brunswick border region (Fig. 1). This area has a number of different habitats which include bogs, marshes, spruce and larch forests, upland fields, and previously drained or semi-drained marshland, some of which was once used for agriculture.

The Tintamarre National Wildlife Area is approximately 11.3 km northeast of the town of Sackville, New Brunswick and contains six man-made marshes and three natural lakes. The Missaquash Marsh is approximately 4.8 km east of the Tintamarre National Wildlife Area and contains three man-made marshes.

Size and Age of Marshes

Within the study area, nine marshes varying in size and age were studied. Six of these are located in the Tintamarre National Wildlife Area, four of which are man-made and here designated as Impoundment I, II, III and IV (Fig. 2). The natural marsh consists of Front Lake and marginal areas of Long Lake (Fig. 2). The remaining three areas are man-made and are located in the Missaquash Marsh. These are designated Missaquash O, A and B (Fig. 2).

The predominant vegetation is similar in these marshes and includes cattail (*Typha* spp.), sedges (*Carex* spp.), burreed (*Sparganium eurycarpum* Engelm.), and sweetflag (*Acorus calamus* L.). A detailed description of the vegetation of these marshes and changes in type of

Fig. 1

Location of the Tintamarre National Wildlife Area

and the Missaquash Marsh

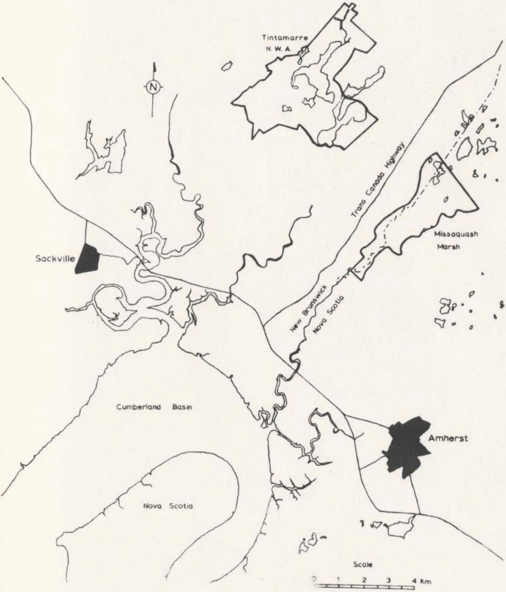

Tintamarre
N. W. A.
N
Trans Canada Highway
Missaquash
Marsh
Sackville
New Brunswick
Nova Scotia
Cumberland Basin
Amherst
Nova Scotia
Scale
0 1 2 3 4 km

Fig. 2

Aerial photograph of the Tintamarre National Wildlife Area

and the Missaquash Marsh


MISSAGUASH MARSH
MISSAGUASH D
MISSAGUASH A
MISSAGUASH B IMPOUNDMENT
MISSAGUASH B
AERIAL NET SWEEP SITES
SCALE
(APPROX.)
m 300 0 300 600 900 m
FRONT LAKE OUTFLOW
FRONT LAKE EXT. OUTFLOW
FRONT LAKE
LONG LAKE
LARGE LAKE
TINTAMARRE N.W.A.
LARGE LAKE OUTFLOW
IMPOUNDMENT III
IMPOUNDMENT II
IMPOUNDMENT I
IMPOUNDMENT IV

vegetation prior and subsequent to initial flooding are recorded by Whitman (1974).

The dates of flooding of the marshes and the area of each are recorded in Table 1.

History

The Tintamarre National Wildlife Area and the Missaquash Marsh were formed by the same geological processes. According to Whitman (1974), the most widely accepted theory of the formation of these areas was recorded by Ganong (1903), who indicated that the marsh areas were originally situated above their current elevation and were probably part of an extensive shallow freshwater lake that formed the Cumberland Basin. As the land settled, the lake was inundated by the sea, became a brackish lagoon and then a saltwater bay which restricted tidal movements in the narrow boundaries of the Cumberland Basin of the Bay of Fundy. As a result, strong tidal currents rapidly eroded the soft Permo-carboniferous sandstone. The eroded sand was carried inland and was deposited over the land as the tidal current lost velocity. Core sampling has located peat bogs and entire forests covered by as much as 24.4 m of alluvial deposits. Radio-carbon dating of submerged stumps have been estimated to be 3,300 to 3,700 years old (Ramsay, 1963).

The original marshes were altered greatly by man in his attempts at reclamation for agriculture. According to Ganong (1903) and Jackson and Maxwell (1971) the first dykes and sluice gates were probably made by the French Acadians in the late seventeenth century. Some of the reclaimed marsh was farmed by the French until they were expelled by the English about 1760. Reclamation and farming projects are still being

Table 1

Canadian Wildlife Service habitat management study areas

Area	Date of initial flooding	Area (hectares)	Age (years)	
			1974	1975
Impoundment I	1 January 1972	16	2.5	0*
Impoundment II	1 September 1969	10	5.0	6.0
Impoundment III	1 April 1970	10	0	0.5*
Impoundment IV	1 April 1970	18	3.5	4.5
Front Lake	Natural	320	Natural	Natural
Long Lake	Natural	200	Natural	Natural
Missaquash O	1 September 1965	320	8.0	9.0
Missaquash A	1 April 1974	36	0.5	1.5
Missaquash B	1 April 1974	60	0.5	1.5

*These marshes have been drained, plowed, fertilized, and reflooded since initial flooding.

continued. Complete exclusion of the tidal influence over most of the Cumberland Basin has occurred during the last 20 years although most land comprising the present study areas has probably not been influenced by the sea for over 100 years.

The Missaquash Marsh and the Tintamarre National Wildlife Area formerly contained land that was rendered extremely low in quality for both waterfowl and agriculture because of unsuccessful drainage attempts. During the early 1960's, the Department of Lands and Forests of Nova Scotia acquired about 2,400 hectares within the Missaquash Marsh. With funds supplied by Ducks Unlimited, constant water levels were restored to 320 hectares previously serving as marginal pasture land. This was completed in 1965 and represented the first waterfowl management project of its kind in the Maritime Provinces. Another 96 hectares were flooded in the spring of 1974.

The Canadian Wildlife Service began acquisition of a 1,600 hectare tract of marshland in the Tantramar Marshes in 1967. This area includes five natural lake basins, upland forests and fields, and semi-drained and drained marshland, which was originally agricultural. Between 1967 and 1971, six impounded areas were created in the drained marshlands with development funds provided by Ducks Unlimited.

Field and Laboratory Procedures

The field work portion of this study was conducted from 1 May through 31 August during 1973-1975.

1973

The first year of the study was used to gather the necessary baseline data including the determination of the species of biting flies inhabiting this area. This involved a survey which included sampling of larval habitats, and aerial net sweeps to determine the seasonal abundance of the adults in the area surrounding Sackville, New Brunswick and Amherst, Nova Scotia. All adult biting flies were either killed in ethyl acetate vapor and pinned, or preserved in 70% ethanol.

Mosquito larvae were collected from 30 different localities with dippers, fine gauze nets, and rubber syringes. Habitats sampled included pitcher plants (*Sarracenia purpurea* L.), temporary and permanent freshwater and saltwater marshes and pools, as well as naturally and artificially impounded areas used for waterfowl production. Water temperatures (°C) were recorded for each collection. About half of each larval sample was placed in 70% ethanol and the remainder was placed in a plastic container and returned to the laboratory at Mount Allison University, where the larvae were reared to adults. The larvae were placed in small covered containers, from which emerging adults were removed by lifting the cover and inserting an aspirator.

Blackfly larvae were collected from 21 streams, including temporary and permanent streams, drainage ditches, and water control structures associated with the managed wetlands. For each collection the following measurements were recorded: water temperature (°C), stream width (m), stream depth (mm), substrate, and depth (mm) at which larvae were taken. Ceramic fireplace tiles, as described by Lewis and Bennett (1974*a*) were the usual experimental substrate. These tiles were easily positioned on stream bottoms and provided a convenient uniform area (.01 m^2) for determination and comparison of population densities. Immature stages of blackflies were collected from a variety of substrates, including tiles, rocks, and trailing vegetation. Larvae and pupae were removed from the substrate with forceps. Immature simuliids were preserved in 95% ethanol in the field and species identifications were later determined in the laboratory.

Sampling of immature mosquitoes and blackflies was usually on a weekly basis. Collection of larvae provided data on specific larval habitats, and the rearing of mosquito larvae to adults provided good taxonomic material.

Adults of Culicidae, Simuliidae, and Tabanidae attracted to man were sampled by regular aerial net sweeps in 15 areas. Five of these areas were not used in 1974-1975 and, therefore, are not illustrated in Fig. 2 (pp. 17-18). On each occasion and site sampled, a standard procedure of 40 figure-eight sweeps were made about the collector, similar to the sweep netting described by Gjullin *et al.* (1961). Hereafter a sweep will be considered to consist of 40 figure-eight sweeps. Sweeps were done with a standard entomological aerial sweep net once during the day and once at dusk or dark at each site. During each sweep, the following observations were made: time (hrs), temperature (^{o}C), wind estimation (nil, slight or brisk), and cloud cover (%). Adult mosquitoes, blackflies, horse flies and deer flies were also netted in flight activity about man and feeding on man.

1974-75

During 1974 and 1975 the study focused specifically on the species composition and population dynamics of biting flies of the managed wetlands.

Adult mosquitoes were collected in emergence cages. Sixty cages (0.6 x 0.6 x 0.3 m) were placed in permanent man-made and natural marsh environments. Table 2 indicates the distribution of the 60

Table 2

Location of emergence cages, 1974-1975*

Area	Number of cages	
	1974	1975
Front Lake	5	5
Long Lake	10	10
Impoundment I	10	0
Impoundment II	10	10
Impoundment III	0	10
Impoundment IV	10	10
Missaquash O	7	7
Missaquash A	2	2
Missaquash B	6	6

*Reference should be made to Figure 2 (pp. 17-18).

emergence cages. Usually these cages were positioned in transects across the marshes or along the margins. Each cage was made of spruce frames (25 x 25 mm), covered on the top and four sides with fibreglass screen, and was positioned in the vicinity of emergent vegetation; usually the cages were sunk into the water about 100 mm. Each cage was anchored to the substrate by three legs attached to the sides of the cage. Mosquitoes were collected using an extra long aspirator which was inserted through the side of the cage. Following removal of the mosquitoes, the other insects were enumerated and classified, and released by lifting the cage out of the water. Before replacing the cage, the emergent vegetation was cut above the water level with a knife; this was necessary since the vegetation grew 150–200 mm each week. Table 3 indicates the species of plants contained within the emergence cages.

These cages were used to determine (i) the species of mosquitoes found in the marsh; (ii) the seasonal succession and abundance of these mosquitoes; (iii) the number of such mosquitoes produced per square meter of marsh; and (iv) the vegetation types associated with the immatures of *Mansonia perturbans* (Walker), the most abundant pest mosquito of this region.

Since predation was suspected to occur in the emergence cages, an experiment was devised to determine whether odonates would prey on mosquitoes in small cages. The cages used were in the form of a cube approximately 200 mm high. They were constructed of 10 mm plywood, one side being of thin plexiglass, one side covered with a thin cloth screen, and another side with a sleeve attached to enable access to the cage. A known number of mosquitoes and dragon flies and/or damsel flies were placed in a cage. Observations were made at intervals of several hours,

Table 3

Plants contained within emergence cages in the Tantramar Marshes, 1974-1975

Species
Acorus calamus L.
Calamagrostis canadensis (Michx.) Nutt.
Carex lasiocarpa Ehrh.
Carex limosa L.
Carex rostrata Stokes
Equisetum fluviatile L.
Iris versicolor L.
Lemna minor L.
Lysimachia terrestris (L.) BSP.
Phragmites communis Trin.
Potentilla palustris (L.) Scop.
Sagittaria latifolia Willd.
Scirpus validus Vahl.
Sium suave Walt.
Sparganium eurycarpum Engelm.
Spartina pectinata Link.
Typha glauca Godr.
Typha latifolia L.
Utricularia vulgaris L.
Zizania aquatica L.

at which time the numbers of mosquitoes and odonates were recorded.

Aerial net sweeps were again carried out; however, only 10 areas were sampled (Fig. 2, pp. 17-18), most of which were the same as in 1973. Since this area is often very windy, all areas were chosen so that some shelter was available. More emphasis was placed on the net sweeps and less on larval collections, although there was some larval sampling. Again adults were collected flying about and feeding on man. Biting flies were occasionally collected from sentinel duck cages as described by Herman and Bennett (1976).

Tabanids were also collected in tabanid traps. During 1974 five traps were situated in a variety of habitats which included open pasture, forest clearings, and in the marsh. The traps were similar to those used by Bennett and Smith (1968), although they were not baited with carbon dioxide. This type of trap proved unsuccessful in the Tantramar Marshes and a canopy trap, based on the design of Catts (1970) and similar to those used by Neys *et al.* (1971) and Pechuman (1972), was used in 1975. Neys *et al.* (1971) and Pechuman (1972) used plastic for the canopy of the trap whereas, in the Tantramar Marshes, the canopy consisted of cloth. The bottom of the canopy was sprayed with black paint. This trap was baited with carbon dioxide gas released from a cylinder at approximately 200 cc/min through a flow meter. Only one trap was utilized in 1975 and, therefore, it had to be transported to various areas for collection. Tabanids were also netted in flight above cattle in pastures, feeding on cattle, and in the windows of two barns, one of which was a dairy barn.

Several taxonomic keys were used to identify the biting flies obtained in this study. The species of the various stages of mosquitoes were identified using the keys of Carpenter and LaCasse (1955) for the

North American species and Steward and McWade (1961) for the Ontario species. Larval blackflies were identified with the keys of Wood *et al.* (1963) for the Ontario species and the adults were identified with the keys of Davies *et al.* (1962), also for the Ontario species. The key of Peterson (1970) for the *Prosimulium* of Canada and Alaska was used for specimens of this genus. Species of adult horse flies and deer flies were determined using the keys of Pechuman (1972) and Pechuman *et al.* (1961) for the species of New York and Ontario respectively.

During a two-week visit to Ottawa the author was provided with confirmation of identification of some of the species of biting flies of the Maritime Provinces by members of the Diptera Section of the Biosystematics Research Institute, Agriculture Canada. At this time, an inventory of the biting flies of the Maritime Provinces was prepared and some of the taxonomic problems encountered during this study were resolved through discussion with personnel of the Diptera Section.

RESULTS

ENVIRONMENTAL OBSERVATIONS

Climatological

The following climatological data are based on daily measurements in Sackville, New Brunswick. While there may be some differences in climate between Sackville and the research area, it is nevertheless the nearest Atmospheric Environment Service Climatological Station and will certainly show trends from year to year.

Figure 3 presents the weekly maximum, minimum, and mean air temperatures for May through August, 1973-1975. Table 4 summarizes the maximum and minimum temperatures for the three-year period. The year 1973 had the highest mean weekly temperature. The lowest minimum temperature, the lowest maximum temperature, and the lowest mean weekly temperatures were recorded in 1974. In 1975 the highest maximum temperature was recorded, and the lowest minimum temperature was the same as that for 1974.

Figure 4 presents the amount of precipitation for the period May through August, 1973-1975. These figures are also obtained from daily measurements taken in Sackville. Table 5 summarizes the amount of precipitation over the three-year period. The first year had the greatest rainfall and, subsequently, precipitation decreased each year. Much of the precipitation during the first week of May, 1974 was in the form of snow.

Marsh Management

This study is, in part, based on man's modification of the environment, in particular the impounding of water to create waterfowl marshes from existing agricultural land. During the study period the

Figure 3

Weekly maximum, minimum, and mean air temperatures at Sackville, New Brunswick, May - August, 1973-1975

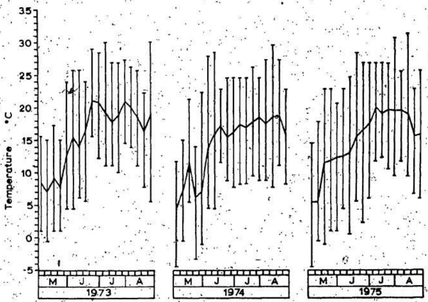

35
30
25
20
15
10
5
0
-5
Temperature °C
M
J
J
A
1973
M
J
J
A
1974
M
J
J
A
1975

Table 4

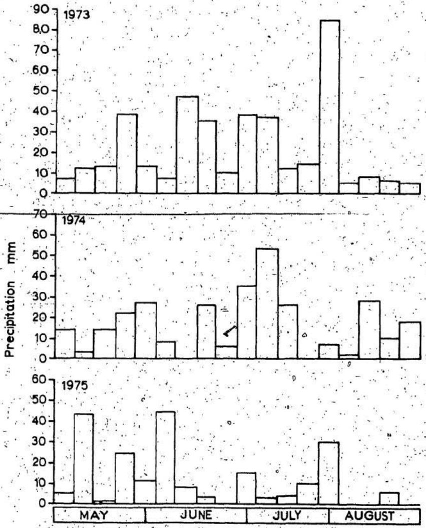
Temperatures recorded at Sackville, New Brunswick, May - August, 1973-1975

Weekly measurements	Temperature (°C)		
	1973	1974	1975
Highest maximum	30.0	29.4	31.1
Lowest maximum	15.0	11.7	14.4
Mean	15.7	14.2	15.0
Highest minimum	15.6	11.7	12.2
Lowest minimum	-0.6	-4.4	-4.4

Figure 4

Weekly precipitation at Sackville, New Brunswick,

May - August, 1973-1975



1973
90
80
70
60
50
40
30
20
10
0
1974
70
60
50
40
30
20
10
0
1975
60
50
40
30
20
10
0
Precipitation mm
MAY
JUNE
JULY
AUGUST

Table 5

Precipitation recorded at Sackville, New Brunswick, May - August, 1973-1975

Month	Precipitation (mm)		
	1973	1974	1975
May	83	80	83
June	99	40	55
July	111	114	58
August	108	65	9
Total	401	299	205
Weekly mean	22	17	12

environment was further modified, as marshes were created while others were drained and tilled to decrease the rate of succession. Tilling, which was done with a tractor when the marshes had drained completely, allowed organic and soil mineral components to become thoroughly mixed to provide a suitable substrate for terrestrial vegetation. Upon reflooding these plants die and decay and provide nutrients and detritus for invertebrates.

Reference should be made to Fig. 2 (pp. 17-18) for the following observations. In the fall of 1973 the Missaquash O was drained and reflooded in the spring of 1974. At the time of reflooding, Missaquash A and B were flooded for the first time. This flooding eliminated two simuliid habitats which had been sampled regularly in 1973. One of these was a small temporary bog-fed stream which flowed through what is now Missaquash B. The second was that portion of the Missaquash River which flows between Missaquash A and Missaquash B.

Impoundment III was drained early in the summer of 1974. It was then tilled, and reflooded in the fall of that year.

Front Lake has two outflows - Front Lake outflow and Front Lake Extension outflow. A regular control structure does not exist at Front Lake Extension outflow and to maintain a reasonable water level in Front Lake in 1974, this area was modified by a bulldozer to decrease water loss. This was done simply by bulldozing earth into the stream, thus elevating the stream bottom and decreasing the volume of water flowing out of Front Lake.

In 1975 Impoundment I was drained in June and tilled in August. It was to be reflooded in the fall of 1975 or spring of 1976. This impoundment did not drain as quickly as was planned since a muskrat channel in one of the dykes kept water flowing into that impoundment from Impoundment IV. Due to the low water level in Front Lake in 1975, the control structure at the outflow of Front Lake was shut completely so that only a trickle of water was passing through the structure. In addition, the water level of the small impoundment contained in the Missaquash B was raised by approximately 400 mm.

CULICIDAE

Thirty-two species of mosquitoes are now recorded from the Maritime Provinces of Canada (Table 6), of which only 19 were collected during this study (Tables 6,7). All of these have been previously recorded in the literature from maritime Canada, although specimens of only 21 species are deposited in the Biosystematics Research Institute, Ottawa (Table 6). Table 7 records how the various species were obtained in the Nova Scotia-New Brunswick border area. The generic abbreviations of the Culicidae used in this study have been used by some other workers. They are: *A.* for *Aedes*, *An.* for *Anopheles*, *C.* for *Culex*, *Cs.* for *Culiseta*, *W.* for *Wyeomyia*, and *M.* for *Mansonia*.

A key to the female mosquitoes of maritime Canada is presented in Appendix A.

Larval Habitats

A system of classifying mosquito larval habitats was developed for the Tantramar Marshes. Freshwater habitats may be identified as temporary, semipermanent, and permanent. Other habitats in the Nova Scotia-New Brunswick border region include specialized breeding places (pitcher plants) and salt marshes. Table 8 indicates the times at which the various species of culicid larvae were collected in the Nova Scotia-

Table 6

Culicidae of maritime Canada

Species	Nova Scotia	New Brunswick	Prince Edward Island
Aedes abserratus (Felt and Young)	1,2,3	3	1,2
Aedes aurifer (Coquillett)		2	
Aedes canadensis (Theobald)	1,2,3	1,2,3	1,2
Aedes cantator (Coquillett)	1,2,3	1,2,3	1,2,3
Aedes cinereus Meigen	1,2,3	2,3	1,2
Aedes communis (DeGeer)	2,3	2,3	1,2
Aedes diantaeus Howard, Dyar, and Knab	2		
Aedes dorsalis (Meigen)		2	
Aedes excrucians (Walker)	2,3	2,3	1,2
Aedes fitchii (Felt and Young)	3	2	2
Aedes impiger (Walker)		2	
Aedes implicatus Vockeroth			2
Aedes intrudens Dyar	2	1,2	1,2
Aedes punctor (Kirby)	1,3	1,2,3	2,3
Aedes sollicitans (Walker)	1,2,3	1,2,3	2,3
Aedes sticticus (Meigen)		1,2	
Aedes stimulans (Walker)	1,2,3	2	1,2
Aedes trichurus (Dyar)			2
Aedes trivittatus (Coquillett)	2		
Aedes vexans (Meigen)	1,2,3	2,3	1,2
Anopheles earlei Vargas	2,3	1,2,3	
Anopheles punctipennis (Say)	1,2	1,2	
Anopheles walkeri Theobald	2,3	2,3	
Culex pipiens Linnaeus	2	2	
Culex restuans Theobald	1,3	2,3	
Culex salinarius Coquillett	1,2		
Culex territans Walker	1	2,3	
Culiseta impatiens (Walker)	2,3	1,2	
Culiseta incidens (Thomson)	2		
Culiseta morsitans (Theobald)	1,2,3	2,3	2
Mansonia perturbans (Walker)	1,2,3	1,2,3	1,2
Wyeomyia smithii (Coquillett)	1,2	3	

1 Biosystematics Research Institute (Canadian National Collection), Ottawa
2 In literature
3 Collected by author

Table 7

Mosquitoes of the Nova Scotia-New Brunswick border region

	Emergence Cages	Larval Collections	Net Sweeps	Flight Activity	Biting Man	Barns	Tabanid Traps
Aedes abserratus		+					
Aedes canadensis		+	+	+	+		
Aedes cantator		+	+	+	+	+	+
Aedes cinereus		+	+	+	+	+	
Aedes communis		+					
Aedes excrucians	+	+	+	+	+		
Aedes fitchii		+					
Aedes punctor		+	+	+	+	+	+
Aedes sollicitans				+	+		
Aedes stimulans				+			
Aedes vexans		+	+	+	+		
Anopheles earlei			+	+	+		
Anopheles walkeri	+		+	+	+	+	+
Culex restuans		+					
Culex territans	+	+					
Culiseta impatiens			+				
Culiseta morsitans	+	+	+				
Mansonia perturbans	+		+	+	+	+	
Wyeomyia smithii		+					

Table 8

Seasonal distribution of mosquito larvae in the Nova Scotia-New Brunswick border area

Species	Month and Week																
	May					June				July				August			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Aedes abserratus	+	+	+	+	+												
Aedes canadensis		+	+	+	+				+			+			+		
Aedes cantator		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Aedes communis	+	+	+	+	+												
Aedes excrucians	+	+	+	+	+	+											
Aedes fitchii					+												
Aedes punctor	+	+	+	+	+												
Aedes sollicitans																+	
Aedes vexans														+	+	+	+
Culex restuans															+	+	+
Culex territans													+	+	+	+	+
Culiseta morsitans					+	+	+										
Wyeomyia smithii	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

New Brunswick border region. The number of generations of a particular species was determined in part by the abundance of larvae and the times at which they were collected, and in part by the abundance and timing of adults taken in emergence cages.

Temporary pools. Temporary pools are of two types - those formed by snowmelt, and those formed as a result of heavy rainfall and/or flooding. These pools of snowmelt origin are normally dry by mid to late June, and are found in a variety of locations including forests, meadows, pastures, roadside ditches, and *Sphagnum* bogs. Species which occur in snowmelt pools include *A. abserratus*, *A. canadensis*, *A. cinereus*, *A. communis*, *A. excrucians*, *A. fitchii*, and *A. punctor*. All of the snowmelt pool species are univoltine and probably overwinter in the egg stage. The floodwater species in the Tantramar Marshes include *A. cantator*, *A. vexans*, and *C. restuans*. *Aedes cantator* and *A. vexans* are apparently multivoltine while *C. restuans* is probably univoltine. All three species are thought to overwinter in the egg stage.

Semipermanent pools. These pools that are formed from snowmelt are maintained to some extent by seepage, a high water table, or rainfall. They may be permanent in some years but temporary in others. *Aedes cantator* usually is the only mosquito which utilizes this type of habitat. It is multivoltine and probably overwinters in the egg stage.

Permanent waters. These pools, ponds, lakes, or marshes contain water throughout the year and often have varying degrees of emergent vegetation. Larvae of *An. walkeri*, *Ca. morsitans*, *A. excrucians*, *C. territans*, and *M. perturbans* are found in permanent waters. *Mansonia perturbans* is unique in that the larvae and pupae attach to the stems and roots of aquatic plants. The other species, however, are found either in pools within the marshes or in water where there is an abundance of emergent vegetation. *Anopheles walkeri* and *Ca. morsitans* are bivoltine; *A. excrucians*, *C. territans*, and *M. perturbans* are univoltine. With the exception of *M. perturbans*, which overwinters in the larval stage, all these permanent water species overwinter in the egg stage. *Aedes cinereus*, while mainly a snowpool species, was also found in pools formed in floating mats of vegetation in permanent marshes.

<u>Salt marshes</u>. Two species of mosquitoes have been collected from salt marshes in coastal areas of the Bay of Fundy in New Brunswick and Nova Scotia. *Aedes sollicitans* is apparently restricted to salt marshes, while *A. cantator* is also found in brackish and freshwater habitats. Both of these mosquitoes are multivoltine and are thought to overwinter in the egg stage.

<u>Pitcher plants</u>. In the Nova Scotia-New Brunswick border region, this type of habitat is utilized by one species. Larvae and pupae of *Wyeomyia smithii* are found only in the pitcher of the pitcher plant *Sarracenia purpurea*. It is thought to be univoltine and, since larvae may be collected from May through August, it is thought that the larvae also overwinter. On one occasion larvae were collected from a pitcher which had a water temperature of 33°C.

<u>Adult Feeding Habits</u>

Feeding habits are known for only 10 of 19 species of mosquitoes collected in the Tantramar Marshes (Table 7, p. 39), all of which have been taken feeding on man. Since "rubbed" specimens of *A. abserratus* and *A. communis* are often confused with *A. punctor*, it is possible that these two species have also been taken feeding on man. Numerous bloodfed females of *A. punctor*, *A. cantator*, *A. cinereus*, *An. walkeri*, and *M. perturbans* have also been taken from the windows and walls of a dairy barn. While no identification of the blood was made, it is thought that these specimens fed on cattle. Bloodfed females of *A. cantator* and *M. perturbans* were also collected from domestic pekin ducks (*Anas platyrhynchos* Linnaeus).

With the exception of *A. sollicitans*, all species which had fed on man (Table 7, p. 39) may be encountered almost anywhere in the Tantramar Marshes. *Aedes sollicitans* is fairly uncommon inland, but is abundant along at least some of the coasts of the three Maritime Provinces. Females have been collected feeding on man approximately 8.0 km inland from their nearest known larval habitat. All of the other species apparently seek out a blood meal in the vicinity of their larval habitats.

All species of mosquitoes which have fed on man will bite during the day and in the evening, but several species are mainly crepuscular. These are *A. cantator*, *A. excrucians*, *A. punctor*, and *M. perturbans*. *Aedes abserratus* and *A. communis* are also thought to be primarily crepuscular. *Aedes cinereus*, *A. sollicitans*, and *An. walkeri* show no preference; biting females are commonly collected both day and night. This is also true for *A. canadensis*, *A. vexans*, and *An. earlei*, although these species were infrequently collected biting man.

Aedes punctor, *A. excrucians*, and probably *A. abserratus* and *A. communis* are the first species of the season to emerge and seek a blood meal. After mid June their numbers steadily decline. Larvae of these species are rarely collected after early June (Table 8, p. 40). *Aedes cantator*, *A. canadensis*, *A. cinereus*, *A. vexans*, and *An. walkeri* may be taken in varying numbers throughout the summer; larvae of most of these species may also be collected through the summer (Table 8, p. 40).

Mansonia perturbans is taken from late June through the end of August, although its abundance rapidly decreases after the end of July. Females of *A. sollicitans* may be taken throughout the summer in salt marsh areas. *Anopheles earlei* appears early in May and during early August.

The more pesteriferous culicids in the Tantramar Marshes include the *A. punctor* group, *A. cantator*, and *M. perturbans*. These species are commonly collected throughout the Tantramar Marshes. *Aedes cantator* and *M. perturbans* are frequent pests in the towns of Sackville, New Brunswick and Amherst, Nova Scotia. *Aedes sollicitans* is a pest in many coastal areas of New Brunswick, Nova Scotia, and Prince Edward Island.

Abundance

Seasonal

The data on seasonal succession and abundance of mosquitoes presented here are based on aerial net sweeps, and the species obtained are recorded in Table 7 (p. 39). The seasonal succession and abundance for 1973, 1974, and 1975 are presented in Figures 5, 6, and 7, respectively. These graphs are generally similar to each other and are based on the average number of mosquitoes per aerial net sweep per week. Aerial net sweeps were started during the second week of June. The first mosquitoes to emerge and seek a blood meal are the *Aedes* species which undergo larval development in pools filled by melting snow. *Aedes punctor*, *A. abserratus*, and *A. communis* are included in this group. Because "rubbed" specimens of *A. abserratus* and *A. communis* appear very similar to *A. punctor*, they are included with *A. punctor*. The next group of mosquitoes to emerge and feed are the "summer" *Aedes*, which also breed in snowmelt pools or in small temporary and/or permanent pools. Most of

Figure 5

Seasonal succession and abundance of mosquitoes obtained in aerial net sweeps, 1973

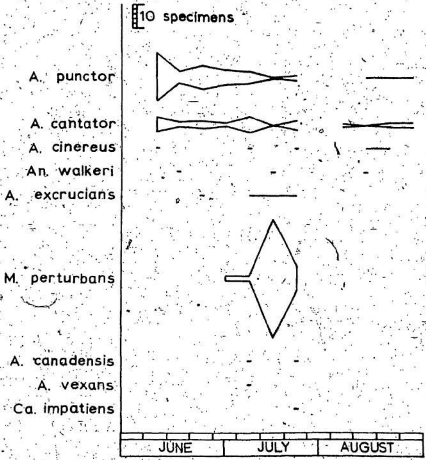

10 specimens
A. punctor
A. cantator
A. cinereus
An. walkeri
A. excrucians
M. perturbans
A. canadensis
A. vexans
Ca. impatiens
JUNE
JULY
AUGUST

Figure 6

Seasonal succession and abundance of mosquitoes obtained in aerial net sweeps, 1974

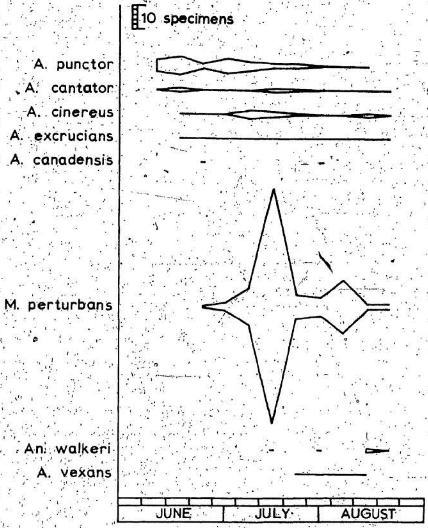
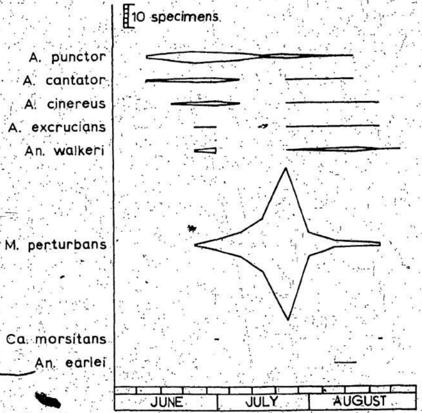

10 specimens
A. punctor
A. cantator
A. cinereus
A. excrucians
A. canadensis
M. perturbans
An. walkeri
A. vexans
JUNE
JULY
AUGUST

Figure 7

Seasonal succession and abundance of mosquitoes obtained in aerial net sweeps, 1975


10 specimens
A. punctor
A. cantator
A. cinereus
A. excrucians
An. walkeri
M. perturbans
Ca. morsitans
An. earlei
JUNE
JULY
AUGUST

these species, which include *A. cantator*, *A. cinereus*, *A. canadensis*, *A. excrucians*, and *A. vexans* are at least bivoltine. Shortly after these species have made their appearance, permanent water species, such as *An. walkeri* and *M. perturbans* emerge. *Anopheles walkeri* is bivoltine and *M. perturbans* is univoltine.

During the second week of June, *A. punctor* and, in smaller numbers, *A. cantator* are collected in net sweeps. *Aedes punctor* was the most abundant mosquito for the first three or four weeks of the mosquito season, and may persist until the end of August, although its numbers decrease through the season. *Aedes cantator* was usually collected throughout the summer. *Aedes cinereus* is usually collected about the third week of June and, although not usually very abundant, it was in 1974. Adults may be taken until mid August. Univoltine *A. excrucians* usually appears in aerial net sweeps during late June; in relation to the total mosquito population, it is not very abundant. *Anopheles walkeri* is another permanent-marsh mosquito and is bivoltine. It is usually collected during late June and persists in small numbers throughout the summer. *Aedes canadensis* appears in net collections during late June or early July until late August. It is thought to be univoltine and is not an abundant species. Emergence of *M. perturbans* commences during late June and early July. By mid July this mosquito has become the most abundant mosquito of the area, persisting until at least the end of August. *Mansonia perturbans* is univoltine and occurs only in permanent bodies of water where there is appropriate emergent vegetation. Its numbers decreased rapidly in 1973. During late July and in August, aerial net sweep catches often consisted entirely of *M. perturbans*, and regular net sweeps yielded as many as 715 specimens. *Aedes vexans* appears in aerial-net sweeps about the middle of July. It is not usually very abundant in the Tantramar Marshes and in 1975 it did not occur in net sweeps at all. *Culiseta morsitans* was collected in aerial net sweeps infrequently and only in 1975. *Culiseta impatiens* is a very uncommon species in this area; it was collected in net sweeps only in late July, 1973. *Anopheles earlei* is another uncommon species, it was collected during the first half of August in 1975, and was not collected in net sweeps at all during 1973 or 1974.

Annual

The species composition of the regular aerial net sweeps during 1973–1975 is presented in Table 9. Fewer net sweeps were made and fewer mosquitoes taken in 1973 than in the subsequent two years. More sweeps were made in 1975 than in 1974 but fewer mosquitoes were obtained. In these two years the species relative abundance was similar, with the exception of *An. walkeri* which rose from 1.0% to 3.5%. There are biologically significant changes in species relative abundance from 1973 to 1974, particularly with *A. cantator*, *A. punctor*, and *M. perturbans*.

The seasonal abundance of the total mosquito population for the three-year period presented in Fig. 8 is based on the average number of mosquitoes per aerial net sweep per week. Most of the mosquitoes collected throughout each of these years were pests. During June, most of the mosquitoes obtained were *A. punctor*, while *M. perturbans* was the most abundant mosquito taken during July and August (Fig. 5, pp. 45-46; Fig. 6, pp. 47-48; Fig. 7, pp. 49-50). In 1973 the population was much larger in June than it was in the same month during 1974 and 1975. The major peak of abundance in 1975 was a week later than in the two preceding years, and, in 1974 there was a peak in early August which did not occur

Table 9

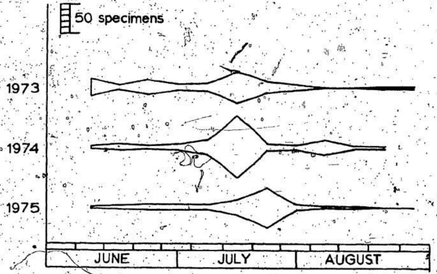
Species composition of mosquitoes collected in regular aerial net sweeps, 1973-1975

Species	Percentage			
	1973	1974	1975	Average
Aedes canadensis	0.2	0.1	0.0	0.1
Aedes cantator	21.3	1.9	2.1	8.4
Aedes cinereus	1.3	4.0	2.2	2.5
Aedes excrucians	0.5	0.6	0.3	0.5
Aedes punctor	37.4	10.6	10.9	19.6
Aedes vexans	0.1	0.3	0.0	0.1
Anopheles earlei	0.0	0.0	0.1	<0.1
Anopheles walkeri	0.6	1.0	3.5	1.7
Culiseta impatiens	0.1	0.0	0.0	<0.1
Culiseta morsitans	0.0	0.0	0.1	<0.1
Mansonia perturbans	38.5	81.5	80.8	66.9
Total mosquitoes	1229	3842	3015	8086
Total net sweeps	83	194	230	507
Average per net sweep	14.8	19.8	13.1	16.0

Figure 8

Seasonal abundance of mosquitoes obtained

in aerial net sweeps, 1973-1975


50 specimens
1973
1974
1975
JUNE
JULY
AUGUST

in 1973 or 1975. Aerial net sweep collections suggest that the mosquito population was greatest in 1974.

Swarming

In 1974 and 1975, 17 aerial net sweeps were taken outside the regular net sweep areas, either at some location en route from one sweep area to another, or when a swarm of mosquitoes was encountered.

Eight sweeps in 1974 yielded 4096 mosquitoes for an average of 512 mosquitoes per net sweep. Nine sweeps in 1975 collected 3064 mosquitoes for an average of 340.4 mosquitoes per sweep. The largest net sweeps during 1974 and 1975 consisted of 2424 and 2141 mosquitoes respectively. The species and sex compositions of these two sweeps are recorded in Table 10. Both of these sweeps were made in swarms and taken in the same location. The swarms were about 2 m above the surface of the dyke around Impoundment V, which is directly east of Impoundments II and III (Fig. 2, pp. 17-18). The exact location was the northern corner of the dyke, the corner forming a right angle, opposite the northeast corner of Impoundment III. The diameters of the swarms were about 3 m. In the 1974 sweep, males accounted for 71.2% of the specimens of *M. perturbans*. Nine other net sweeps were made in the same location. Three sweeps during 1974 yielded an average of 917 mosquitoes per sweep while six sweeps during 1975 contained an average of 460.5 mosquitoes per sweep.

In 1975 a series of net sweeps were taken every half hour on several consecutive nights. Sweeps were started at 1705 hrs and continued until at least 2135 hrs. *Mansonia perturbans* comprised 98.8% of the specimens collected. The results are recorded in Table 11. On each date and in each site, *M. perturbans* was most abundant at 2135 hrs.

Table 10

Mosquitoes obtained in some irregular aerial net sweeps, 1974-1975

Date	Time (hrs)	Temperature (^oC)	Wind	Cloud cover (%)	Species	Number of specimens		
						Females	Males	Total
2-VIII-74	2125	17.0	slight	20	*M. perturbans*	696	1721	2417
					A. punctor	4		4
					A. cantator	3		3
					Total	703	1721	2424
22-VII-75	2125	15.5	nil	5	*M. perturbans*	2018	105	2123
					A. punctor	13		13
					A. cantator	4		4
					An. walkeri	1		1
					Total	2036	105	2141

Table 11

Numbers of *M. perturbans* obtained in aerial net sweeps at half-hour intervals[1]

Time (hrs)	21-VII-75[2]		22-VII-75[3]		23-VII-75[4]		24-VII-75[3]	
	Temperature °C	Number of Specimens	Temperature °C	Number of Specimens	Temperature °C	Number of Specimens	Temperature °C	Number of Specimens
1705	23.0	3	23.0	72(3)	21.5	0	25.5	2(1)
1735	23.0	3	21.0	65(4)	21.5	0	25.5	1
1805	22.0	1	22.0	42(3)	21.5	0	25.0	3
1835	22.0	3	21.5	79(4)	20.0	1	25.0	2
1905	21.0	3	20.5	49(1)	21.0	0	23.5	4
1935	21.0	3	20.5	76(5)	20.0	0	23.5	1
2005	19.5	4(2)	19.5	54(4)	20.0	1	21.5	4
2035	20.5	8(2)	16.0	81(14)	18.0	1	20.5	6(3)
2105	20.5	8(3)	17.5	136(48)	17.5	3	20.0	39(26)
2135	20.5	130(7)	15.5	715(80)	17.0	26	19.5	523(244)
2150							19.0	442(51)

[1]Numbers in parentheses indicate the number of males included in the totals

[2]Tintamarre National Wildlife Area, near Large Lake

[3]Tintamarre National Wildlife Area, near Impoundment V (east of Impoundment III)

[4]Missaquash Marsh

Mosquitoes of the Managed Wetlands

Direct estimates of the number of adult mosquitoes produced per unit area might best to obtained by the use of emergence cages. Sixty emergence cages were positioned in various areas of man-made and natural marshes to determine: (i) the species of mosquitoes found in the marsh; (ii) the seasonal succession and abundance of these species; (iii) the number of such mosquitoes produced per square meter of marsh; and (iv) the vegetation types associated with immatures of *M. perturbans*, the dominant pest mosquito of this region. The location of the emergence cages is contained in Table 2 (p. 24). In both years, 1974 and 1975, the cages were positioned in the marsh during late May, so that sampling could be carried out for the 13 week period of June through August. Due to the large area over which the emergence cages were distributed, collections were made weekly. As a result, the numbers of mosquitoes collected are thought to be minima, since many may have fallen prey to predators such as damsel flies and dragon flies (Odonata).

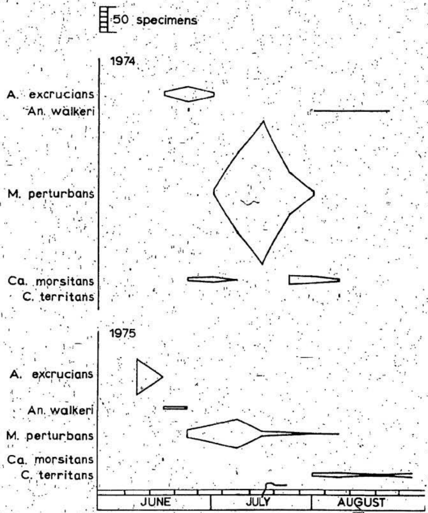
Most of the emergence cages were positioned in approximately the same location in both years. Due to the marsh management program of the Canadian Wildlife Service, Impoundment I could not be used in 1975, so Impoundment III was used instead.

One species of each of five genera were found in the permanent marshes and collected in the emergence cages (Table 7, p. 39): *A. excrucians*, *M. walkeri*, *C. territans*, *Ca. morsitans*, and *M. perturbans*.

The seasonal succession and abundance of mosquitoes in emergence cages, regardless of marsh area, is presented in Fig. 9. *Aedes excrucians* is the first to emerge, usually in early to mid June; emergence is normally completed by the end of June or early July. It is univoltine.

Figure 9

Seasonal succession and abundance of mosquitoes collected in emergence cages, 1974–1975


50 specimens
1974
A. excrucians
An. walkeri
M. perturbans
Ca. morsitans
C. territans
1975
A. excrucians
An. walkeri
M. perturbans
Ca. morsitans
C. territans
JUNE
JULY
AUGUST

The first generation of *An. walkeri* and *Ca. morsitans* begin emergence at about the same time, usually during the latter half of June. The second generation of *An. walkeri*, which begins to emerge in late July or early August, was larger than the first in 1974, while in 1975 it was not recorded by emergence cages. The above is also true for *Ca. morsitans* which begins its second generation emergence in late July. Emergence of univoltine *M. perturbans*, the most abundant mosquito in the area, commences in late June or early July and is usually completed by the end of July. Finally, *C. territans* emerges near the end of July or early August and continues to emerge throughout August.

Adults of all five species emerged exactly one week earlier in 1975 than in 1974. *Mansonia perturbans* and *Ca. morsitans* decreased in numbers from 1974 to 1975 while *A. excrucians*, *An. walkeri*, and *C. territans* increased.

Water temperatures of the various marshes during the period of sampling of emergence cages are presented in Fig. 10.

The emergence cage mosquitoes, according to species and percentages for 1974 and 1975, are contained in Table 12. While there was a considerable drop in numbers from 1974 to 1975, *M. perturbans* was still the most abundant. The two year overall percentages probably provide reasonable figures for percentage composition at any given time.

The mosquito species and the numbers of each collected in emergence cages in the various marshes are shown in Table 13. Each marsh will be considered individually and then the overall succession and abundance will be presented. Reference should be made to Fig. 2 (pp. 17-18) and Table 13.

Figure 10

Water temperatures of marshes sampled with emergence cages, 1974-1975

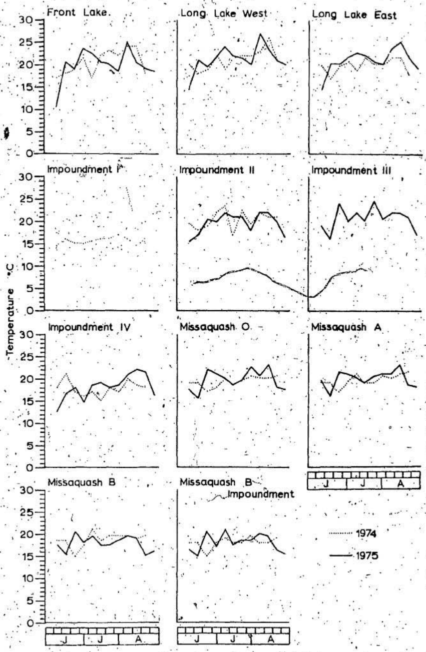

Front Lake
Long Lake West
Long Lake East
Impoundment I
Impoundment II
Impoundment III
Impoundment IV
Missaquash O.
Missaquash A
Missaquash B
Missaquash B Impoundment
Temperature °C
0
5
10
15
20
25
30
J
J
A
1974
1975

Table 12

Mosquitoes obtained in emergence cages, 1974-1975

Species	Number of specimens			Percentage		
	1974	1975	Total	1974	1975	Total
Mansonia perturbans	537	115	652	85.5	51.8	76.7
Culiseta morsitans	48	5	53	7.6	2.2	6.2
Aedes excrucians	38	69	107	6.1	31.1	12.6
Anopheles walkeri	4	8	12	0.6	3.6	1.4
Culex territans	1	25	26	0.2	11.3	3.1
Total	628	222	850	100.0	100.0	100.0

Table 13

Species composition of the mosquitoes collected in emergence cages positioned in marshes of various ages

Location	Species	Number of Specimens		Percentage	
		1974	1975	1974	1975
Front Lake	*M. perturbans*	44	57	100.0	76.0
	C. territans	0	18	0.0	24.0
Long Lake	*M. perturbans*	12	0	100.0	0.0
	An. walkeri	0	1	0.0	12.5
	C. territans	0	7	0.0	87.5
Impoundment I	*M. perturbans*	53	ND	44.9	ND
	A. excrucians	28		23.7	
	Ca. morsitans	35		29.7	
	C. territans	1		0.9	
	An. walkeri	1		0.9	
Impoundment II	*A. excrucians*	0	2	0.0	33.3
	An. walkeri	0	4	0.0	66.7
Impoundment III	*A. excrucians*	ND	61	ND	96.8
	Ca. morsitans		2		3.2
Impoundment IV	*M. perturbans*	428	54	96.2	81.8
	A. excrucians	5	6	1.1	9.0
	Ca. morsitans	12	3	2.7	4.6
	An. walkeri	0	3	0.0	4.6
Missaquash O	*M. perturbans*	0	4	0.0	100.0
	An. walkeri	3	0	75.0	0.0
	Ca. morsitans	1	0	25.0	0.0
Missaquash A	*A. excrucians*	5	0	100.0	0.0
Missaquash B	Nil				

ND = No data

Front Lake

Front Lake is a natural lake; it completely fills in with emergent vegetation and in many areas the vegetation is mat-like. While the water level was a little lower in 1975 than in 1974, it is interesting to note that *M. perturbans* increased in numbers, but decreased in percentage. *Culex territans* immigrated into this area during 1975 or was present in small numbers in 1974.

Long Lake

Long Lake is also a natural lake but unlike Front Lake, emergent vegetation is restricted to the shoreline, so availability of larval habitat suitable for culicids is somewhat restricted. *Mansonia perturbans* was collected from this area in 1974; however, only *An. walkeri* and *C. territans* were taken in 1975. *Anopheles walkeri* larvae were collected in this area in 1973 but were not observed in 1974.

Impoundment I

This impoundment was the youngest man-made marsh sampled in the Tintamarre National Wildlife Area during 1974 (Table 1, p. 20), and was the most diverse in mosquito species, being the only marsh in which all five species were found. Due to the Canadian Wildlife Service water drawdown program, it could not be sampled in 1975. It is interesting to note that this marsh produced more *Ca. morsitans* than any other marsh.

Impoundment II

Impoundment II is the oldest of the Tintamarre National Wildlife Impoundments (Table 1, p. 20). This may have some significance since no mosquitoes were collected in 1974 and only six in 1975.

Impoundment III

In 1974 this impoundment was a "middle-aged" marsh in the

Tintamarre National Wildlife Area, although at the time of sampling it was 0.5 years of age (Table 1, p. 20). Emergence cages positioned in Impoundment I during 1974 were placed in this impoundment in 1975. There is no information regarding mosquito species or abundance in this marsh prior to 1975. In the early summer of 1975 there was a large emergence of *A. excrucians*, but *M. perturbans* was not collected.

Impoundment IV

Impoundment IV is also a "middle-aged" impoundment (Table 1, p. 20). There was a considerable decrease in total mosquito numbers from 1974 to 1975. *Mansonia perturbans* decreased from 96.2% to 81.8%, while *A. excrucians* and *Ca. morsitans* increased. *Anopheles walkeri* immigrated into this marsh in 1975 or was present in small numbers during the previous year.

Missaquash O

This was the largest man-made marsh studied (Table 1, p. 20). During the period of sampling in 1974 and 1975, the total mosquito emergence was the same, but the species composition was quite different.

Missaquash A

This area was flooded in the fall of 1973. Prior to flooding the following mosquitoes were found in temporary pools in this area: *A. cinereus*, *A. excrucians*, *A. fitchii* and *A. canadensis*. Specimens of *A. excrucians* were collected in emergence cages in 1974, but none were obtained in 1975.

Missaquash B

This area was also flooded in the fall of 1973. No mosquitoes have been collected in emergence cages, although larvae of *Ca. morsitans* were collected and reared to adults in June, 1974. Prior to initial flooding of this area, the following species of mosquitoes were found in scattered temporary pools: *A. abserratus*, *A. punctor*, *A. excrucians*, *A. canadensis*, *A. cantator*, *A. cinereus*, *A. communis*, and *A. vexans*.

Productivity of Culicidae of Natural and Impounded Marshes

Table 14 presents the average number of mosquitoes per square meter for each of the marshes studied. During 1974 Impoundment IV was the most productive whereas in 1975 Front Lake was most productive. If these values are determined for natural marshes as opposed to man-made marshes (Table 15), the man-made marshes produced over five times as many mosquitoes as did the natural marsh in the Tintamarre National Wildlife Area in 1974. During 1975 the natural marsh produced more, but the two-year average shows that the impoundments produced 2.5 times as many mosquitoes as the natural marsh. The values for the Missaquash were not included in these figures, since figures for this area are thought to be low due to water management procedures.

The ages of the marshes sampled with emergence cages are recorded in Table 1 (p. 20). For the most part, the same study areas were sampled in both years. However, in 1975 each area became one year older, thereby creating an overlap in age classes between the two years, i.e. an area 2.5 years old in 1974 was considered 3.5 years of age in 1975. Corresponding age classes in both years were averaged to present one value for each class. Table 16 presents the total number of mosquitoes collected in each marsh age class. There is an initial mosquito population which apparently declines in the second year. Most of the mosquitoes collected from the 0.5 age class were *A. excrucians*. In all marshes 2.5 years of age or older, the majority of the mosquitoes collected were *M. perturbans*. The most productive appears to be the 3.5 year old marsh. After this the numbers decline, but the emergence cages show an increase

Table 14

Mosquito productivity in marshes of the Nova Scotia-New Brunswick border region

Area	Average number of mosquitoes per m^2	
	1974	1975
Front Lake	23.7	40.9
Long Lake	3.2	2.2
Impoundment I	32.3	ND
Impoundment II	0	2.2
Impoundment III	ND	17.2
Impoundment IV	119.5	18.3
Missaquash O	1.1	1.1
Missaquash A	6.5	0
Missaquash B	0	0
Average	28.0	9.7

ND = No data

Table 15

Mosquito productivity in man-made and natural marshes in the Nova Scotia-New Brunswick border region

Area	Average number of mosquitoes per m^2		
	1974	1975	Average
Natural marsh (Tintamarre N.W.A.)	9.7	15.1	12.9
Impoundments (Tintamarre N.W.A.)	50.6	11.8	31.2
Impoundments (Missaquash Marsh)	2.2	1.1	1.1

Table 16

Mosquito productivity in marshes of various ages in the Nova Scotia–New Brunswick border region

Marsh age (years)	Average number of mosquitoes per emergence cage					
	A. excrucians	*Ca. morsitans*	*C. territans*	*An. walkeri*	*M. perturbans*	Total
0.5	3.7	0.1	–	–	–	3.8
1.5	–	–	–	–	–	–
2.5	2.8	3.5	0.1	0.1	5.3	11.8
3.5	0.5	1.2	–	–	42.8	44.5
4.5	0.[illegible]	0.3	–	0.3	5.4	6.6
5.0	–	–	–	–	–	–
6.0	0.2	–	–	0.4	–	0.6
8.0	–	0.1	–	0.3	–	0.4
9.0	–	–	–	–	0.4	0.4
Natural	–	–	0.8	0.1	3.8	4.6

again in mosquito production in the natural marshes.

It is interesting that *C. territans* has been collected primarily in natural marshes, whereas *A. excrucians* and *Ca. morsitans* have been collected only in man-made marshes. *Anopheles walkeri* and *M. perturbans* have been found in both situations.

Vegetation Associated with the Aquatic Stages of *M. perturbans*

To determine the vegetation types associated with the larvae of *M. perturbans*, the emergence cages were placed over a variety of aquatic plant species (Table 3, p. 26). Specimens of *M. perturbans* were collected from cages which were placed over a single plant species as well as cages which had several plant species within the area covered by the cage. While many of the plants in Table 3 (p. 26) may be suitable attachment sites for immatures of *M. perturbans*, only the following species have been confirmed in this area: *Acorus calamus*, *Carex lasiocarpa*, *C. limosa*, *C. rostrata*, *Sparganium eurycarpum*, *Typha glauca*, and *T. latifolia*. These species are the most abundant plants in both the natural and impounded marshes in the Nova Scotia-New Brunswick border region.

Predation

Since predation was suspected to occur in the emergence cages, an experiment was devised to determine whether odonates will feed on mosquitoes in small cages.

Table 17 records the results of experiments in which mosquitoes and odonates were put into the same cage on different occasions. All the mosquitoes were *M. perturbans*. Predation obviously occurred in these small cages, therefore, it is quite likely that the mosquito population in any given emergence cage is subject to such predation, especially when cages are sampled only weekly and when there may be as many as 73

Table 17

Experimental predation of Culicidae by Odonata

Date	Time (hrs)	Initial population of cage		Date	Time (hrs)	Final population of cage	
		Culicidae*	Odonata			Culicidae*	Odonata
14-VII-75	2200	12	4A	15-VII-75	0800	0	4A
29-VII-75	1430	10	6Z	30-VII-75	0800	1 (dead)	6Z
6-VIII-75	1400	10	13Z	6-VIII-75	1900	4 (dead)	13Z
12-VIII-75	1230	7	3Z	13-VIII-75	0800	1	3Z (dead)

*All Culicidae were *M. perturbans*

A = Anisoptera (Odonata)

Z = Zygoptera (Odonata)

odonates per cage as was found in Impoundment II. Therefore all mosquito counts per emergence cage and per square meter are minima.

Sex Ratios

The use of emergence cages also permitted observations on adult sex ratios of the emerging mosquitoes. Males usually emerged prior to females; in the case of *M. perturbans* only males were collected in the first week of emergence. The other species consisted mainly of males during the first week of emergence, but not entirely. Obviously, the sex ratios change through the emergence period. Table 18 indicates the sex ratios of the five permanent marsh mosquitoes collected in emergence cages during 1974 and 1975. In all cases where there were large numbers of specimens, there was a predominance of females.

SIMULIIDAE

Twenty species of blackflies have been recorded from the Maritime Provinces of Canada (Table 19). Seventeen of these have been previously recorded from the Maritime Provinces in the literature, although specimens of only 15 species are deposited in the Biosystematics Research Institute, Ottawa (Table 19). Nine species were collected in the Nova Scotia-New Brunswick border region (Tables 19,20). Table 20 indicates how the various species of simuliids were collected in the Nova Scotia-New Brunswick border region.

A key to the female simuliids of maritime Canada is presented in Appendix B.

Larval Habitats

All simuliid species encountered in this study (Tables 19,20) have been taken in larval collections (Table 20). Figure 11 indicates

Table 18

Sex ratios of mosquitoes collected in emergence cages, 1974-1975

Species	Number of mosquitoes		Percentage			
			1974		1975	
	1974	1975	Females	Males	Females	Males
Aedes excrucians	38	69	60.5	39.5	71.0	29.0
Anopheles walkeri	4	4	75.0	25.0	50.0	50.0
Culex territans	1	25	0	100.0	72.0	28.0
Culiseta morsitans	48	5	54.2	45.8	0	100.0
Mansonia perturbans	537	115	58.5	41.5	60.9	39.1
Total	628	222	58.3	41.7	63.5	36.5

Table 19

Simuliidae of maritime Canada

Species	Nova Scotia	New Brunswick	Prince Edward Island
Prosimulium approximatum Peterson		1,2	
Prosimulium fontanum Syme and Davies		1,2	
Prosimulium fuscum Syme and Davies	1,2	1,2	
Prosimulium mixtum Syme and Davies	1,2,3	1,2,3	1,3
Prosimulium multidentatum (Twinn)		1	
Cnephia dacotensis (Dyar and Shannon)	2	2	2
Cnephia mutata (Malloch)	2,3	1,2,3	2
Simulium aureum Fries	2,3	2,3	2
Simulium corbis Twinn	2	1,2	
Simulium croxtoni Nicholson and Mickel	2	2	2
Simulium decorum Walker	1,2,3	1,2,3	
Simulium furculatum (Shewell)	2	2	2
Simulium jenningsi Malloch		1	
Simulium latipes auct. nec. Meigen	3	3	
Simulium parnassum Malloch	2	1	
Simulium rugglesi Nicholson and Mickel		1,2	
Simulium tuberosum (Lundström)	2,3	1,2,3	2
Simulium venustum Say	1,2,3	1,2,3	2
Simulium verecundum Stone and Jamnback	1,2,3	1,2,3	2
Simulium vittatum Zetterstedt	1,2,3	2,3	2

1 Biosystematics Research Institute (Canadian National Collection), Ottawa
2 In literature
3 Collected by author

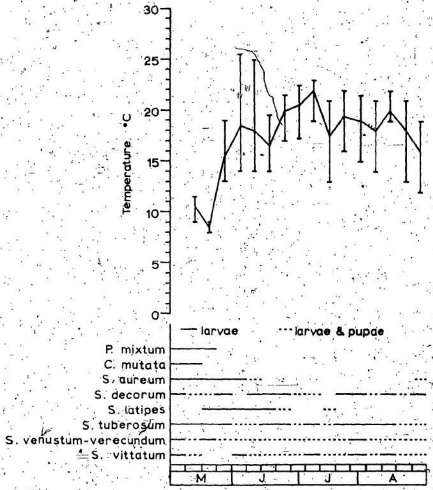
Table 20

Blackflies of the Nova Scotia-New Brunswick border region

Species	Larval Collections	Net Sweeps	Biting Man
Prosimulium mixtum	+	+	+
Cnephia mutata	+	+	+
Simulium aureum	+		
Simulium decorum	+		
Simulium latipes	+		
Simulium tuberosum	+	+	+
Simulium venustum-verecundum	+	+	+
Simulium vittatum	+	+	+

Figure 11

Seasonal succession of blackflies in streams of the Nova Scotia-New Brunswick border region, 1973, and weekly maximum, minimum and mean water temperatures of these streams



30
25
20
15
10
5
0
Temperature °C
larvae
larvae & pupae
P. mixtum
C. mutata
S. aureum
S. decorum
S. latipes
S. tuberosum
S. venustum-verecundum
S. vittatum
M
J
J
A

when the larvae and pupae of these species were collected. This figure is a composite of weekly sampling of 21 streams in 1973. Not all species occurred in all streams. *Simulium venustum* and *S. verecundum* have been considered together; while it is thought that both species occur in this area, the two have been placed together due to taxonomic difficulties.

Streams may be considered temporary or permanent. Both terms apply to natural streams, drainage ditches, water control structures, and streams associated with the managed wetlands. All species collected in this study were taken from permanent streams and, with the exception of *C. mutata* and *S. decorum*, all were also found in temporary streams. All species were found on substrates including ceramic tiles, rocks, and trailing vegetation. *Simulium venustum-verecundum* and *S. vittatum* were also found on other debris such as logs. Immatures of all species were collected in water depths of 5 to 200 mm, while *S. venustum-verecundum*, *S. vittatum*, and *S. decorum* were also taken in depths of up to 300 mm. The stream temperatures at the time of collection are also shown in Fig. 11 (pp. 79–80) as the weekly maximum, minimum, and mean water temperatures of the 21 streams sampled.

Simulium venustum-verecundum and *S. vittatum* were the most widespread species. *Simulium venustum-verecundum* was found in all 21 streams, while *S. vittatum* occurred in 16. These streams were 0.3 to 4.0 m wide. *Simulium tuberosum* was found in nine streams, ranging in width from 0.3 to 3.0 m, and *S. decorum* occurred in six streams which were 1.0 to 3.0 m wide. *Simulium latipes*, *S. aureum*, *P. mixtum*, and *C. mutata* were found in four, three, two, and one stream respectively, respective stream widths being 0.3–2.5, 0.5–3.0, 0.3–2.0, and 2.0 m.

The *Simulium* species are thought to overwinter in the egg stage, while *P. mixtum* and *C. mutata* are thought to overwinter as larvae. *Prosimulium mixtum* and *C. mutata* are univoltine, and data in Fig. 11 (pp. 79-80) suggest that *S. aureum* and *S. latipes* are bivoltine. *Simulium decorum*, *S. venustum-verecundum*, *S. vittatum*, and *S. tuberosum* are multivoltine.

Adult Feeding Habits

Simuliids are not usually bothersome to man in the Tantramar Marshes. With the exceptions of *S. decorum*, *S. aureum*, and *S. latipes*, all species encountered have been collected feeding on man (Table 20, p. 78). Females of *S. decorum* have been taken flying about and landing on man, but *S. aureum* and *S. latipes* were never observed in the vicinity of man.

During the day, the mammalophilic simuliids are often encountered in wooded areas, especially if streams flow through these areas. Biting females are rarely encountered in the marsh areas during the day. In the early evening, however, adults may be taken in marsh areas as well as in the woods.

Adults of *P. mixtum* and *C. mutata* are rarely taken after the end of June, but, because of continuous breeding of *S. venustum-verecundum*, *S. vittatum*, *S. tuberosum*, and *S. decorum* (Fig. 11, pp. 79-80), adults may be collected throughout the summer.

While immature simuliids are obviously restricted to streams, the adults of at least the mammalophilic species may be encountered almost anywhere in the Nova Scotia-New Brunswick border region. They do not appear to be restricted to any specific areas, but are noticeably absent on the salt marshes.

Abundance

Seasonal

Figure 11 (pp. 79-80) illustrates the seasonal succession and seasonal range of larval simuliids in the Nova Scotia-New Brunswick border region. This is a composite of weekly sampling of 21 streams during 1973. A few specimens of *P. mixtum* and *C. mutata* were collected in early May; these were probably from late-hatching eggs since pupal cases were observed on a variety of substrates. Larvae of *S. decorum*, *S. venustum-verecundum*, *S. vittatum*, *S. tuberosum*, and *S. aureum* may also be collected in May. Larvae of *S. decorum* may be collected virtually throughout the summer. *S. decorum* pupae appear during mid May, late June and early July until about mid August. It is multivoltine and the times of pupation and times at which no larvae were collected would suggest that it could have as many as three generations annually. Larvae of *S. venustum-verecundum* may be collected throughout the summer, and commence pupation about mid May. Pupae may be found throughout most of the summer. This complex is multivoltine; the exact number of generations is difficult to determine due to variability in times of egg hatching and duration of larval and pupal development. *Simulium vittatum* is also multivoltine, but the first generation is distinct from subsequent generations. Larvae were collected in early May with pupation occurring about mid May. Larvae of the second generation appear in early June and pupation commences about mid June. Larvae may be collected throughout the summer and pupae may be found during most of this time. Larvae of *S. tuberosum* may be found throughout the summer; pupation occurs in early June, early July, and late August. This would suggest that *S. tuberosum* may be trivoltine. *Simulium aureum* is apparently bivoltine; larvae of the first generation occur from early May through early June at which time pupation occurs. The second generation appears to be of a much shorter duration since larvae and pupae were collected for a very short period late in August. *Simulium latipes* is also bivoltine. Larvae hatch about mid May and pupation occurs near the end of June. Larvae and pupae of the second generation are found during mid July.

During the summers of 1974 and 1975, only streams associated with managed wetlands were sampled regularly. These were Large Lake outflow, Front Lake outflow and Front Lake Extension outflow, which are all situated in the Tintamarre National Wildlife Area (Fig. 2, pp. 17-18).

Simulium venustum-verecundum, *S. vittatum*, *S. decorum*, and *Eusimulium sp.* were found in these areas. The seasonal succession and abundance of simuliids in the outflow of Large Lake, Front Lake, and Front Lake Extension for 1974 and 1975 are presented in Fig. 12 and Fig. 13 respectively. The water temperatures for these areas during the same period are recorded in Fig. 14. Unfortunately, sampling was not started until early June, as road conditions during April and May made access to these areas via normal means impossible. *Simulium venustum-verecundum* and *S. vittatum* were found in all three areas during both years. *Simulium decorum* occurred in all areas except Large Lake outflow in 1975. *Simulium venustum-verecundum*, *S. vittatum*, and *S. decorum* were collected throughout the summer. *Simulium venustum-verecundum* were the most abundant species in Front Lake outflow, while *S. vittatum* was the most abundant in Large Lake outflow and Front Lake Extension. It appears that *S. venustum-verecundum* had at least two generations in this area, especially in Front Lake and Front Lake Extension; however, evidence from Fig. 11 (pp. 79-80) suggests that at least one generation was completed during May. *Simulium*

Figure 12

Seasonal succession and abundance of larval simuliids, 1974

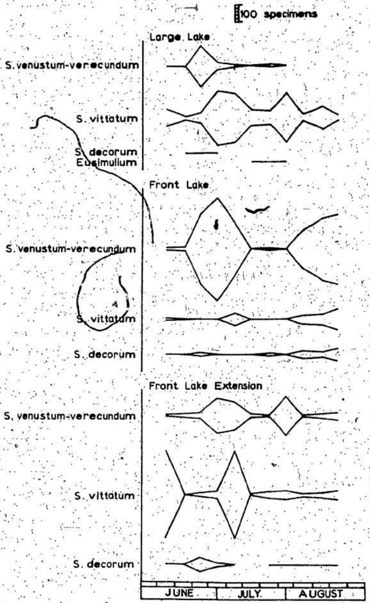

100 specimens
Large Lake
S. venustum-verecundum
S. vittatum
S. decorum
Eusimulium
Front Lake
S. venustum-verecundum
S. vittatum
S. decorum
Front Lake Extension
S. venustum-verecundum
S. vittatum
S. decorum
JUNE
JULY
AUGUST

Figure 13

Seasonal succession and abundance of larval simuliids, 1975

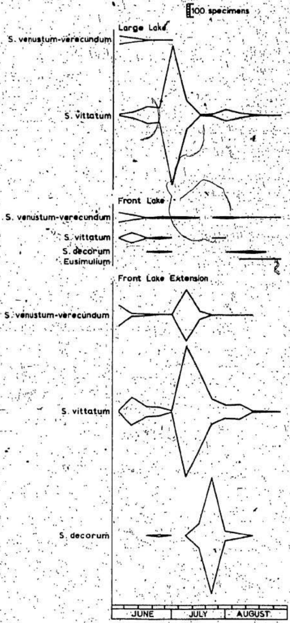
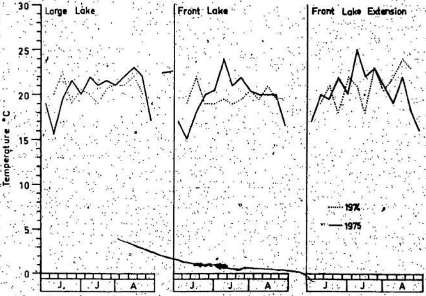

100 specimens
Large Lake
S. venustum-verecundum
S. vittatum
Front Lake
S. venustum-verecundum
S. vittatum
S. decorum
Eusimulium
Front Lake Extension
S. venustum-verecundum
S. vittatum
S. decorum
JUNE
JULY
AUGUST

Figure 14

Stream temperatures, 1974-1975


Large Lake
Front Lake
Front Lake Extension
Temperature °C
30
25
20
15
10
5
0
J
J
A
1974
1975

venustum-verecundum completed its aquatic life history much earlier in Large Lake than in Front Lake and Front Lake Extension. *Simulium vittatum* apparently had two generations during June through August in Front Lake during 1974 and 1975, and Front Lake Extension in 1975. Three generations may have occurred in Large Lake in 1974 and 1975, and Front Lake Extension in 1974. Examination of Fig. 11 (pp. 79-80) would add at least one generation to this.

Simulium decorum was not very abundant in any of the areas except in Front Lake Extension in 1975; immatures were collected throughout most of the summer. In the period June through August, two distinct and separate generations occurred, particularly in Front Lake in 1975 and in Front Lake Extension during 1974 and 1975. The second generation in Front Lake Extension in 1975 was much larger than the first. *Simulium decorum* apparently had just one generation in Large Lake in 1974; however, larvae were not numerous and may have been absent from collections later in the summer, rather than absent from the stream. The minor importance of this species in Large Lake is also reflected in 1975, when no specimens were collected. Figure 11 (pp. 79-80) indicates that an additional generation may have occurred in May. A species of *Simulium (Eusimulium)* occurred in Large Lake in June, 1974, and Front Lake in August, 1975. No further identifications could be made since only very small larvae were collected. Based on information contained in Fig. 11 (pp. 79-80), the *Simulium (Eusimulium)* in Large Lake may have been *S. latipes*, while *S. aureum* may have been the species collected in Front Lake.

Blackfly larvae and pupae were collected from the Missaquash River in 1973, but due to flooding of the lower Missaquash in the spring of 1974 this simuliid larval habitat was eliminated. The control structure at the outflow of the lower Missaquash was examined regularly during 1974 and 1975, but no simuliids were found. It is thought that simuliids were present further down the Missaquash River. A small bog-fed stream flowing in the lower Missaquash area yielded four species of simuliids in 1973 prior to mid June when it stopped flowing. These species were *P. mixtum*, *S. venustum-verecundum*, *S. tuberosum*, and *S. latipes*. Again, due to flooding of this area in the spring of 1974, this area was eliminated for larval simuliids.

Annual.

Figure 15 indicates the total seasonal abundance of adult simuliids obtained in aerial net sweeps from 1973 to 1975. The graph is based on the average number of simuliids collected per net sweep per week. *Simulium decorum*, *S. aureum*, and *S. latipes* were the only species collected during the study which did not appear in the sweeps.

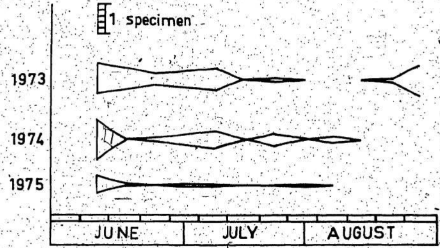
The three years (Fig. 15) are very different, even though simuliids collected in aerial net sweeps were never very numerous. The simuliids collected during June were mostly *P. mixtum* and *C. mutata*, while those taken throughout July and August were mainly *S. venustum-verecundum*, *S. tuberosum* and *S. vittatum*. The first year, 1973, was unique in that there was a period in late July and early August in which no simuliids were collected, but in late August they became as abundant as they were early in June.

More specimens were taken in 1974 than in 1973 and 1975. Several population peaks were obtained that year which were absent from the others, particularly 1975. In 1975, fewer simuliids were collected than in the preceding two years and none were collected after early August.

During the course of this study, less than 200 adult simuliids

Figure 15

Seasonal abundance of blackflies obtained in aerial net sweeps, 1973-1975


1 specimen
1973
1974
1975
JUNE
JULY
AUGUST

were collected. All of these were taken in the vicinity of man. The percentage composition is as follows: *P. mixtum* 10.2, *C. mutata* 17.1, *S. venustum-verecundum* 69.4, and *S. vittatum*, *S. tuberosum*, and *S. decorum* each 1.1.

TABANIDAE

The Tabanidae of eastern Canada have not been studied extensively, probably because most species are not of great economic importance and many are not abundant. The present study is an attempt to determine, in part, the species composition of the Tabanidae of maritime Canada and to present some information on the biology of these species.

Fifty-six species of tabanids have been recorded from maritime Canada (Table 21). Forty-nine of these have been previously recorded in the literature from maritime Canada and specimens of 35 species are deposited in the Biosystematics Research Institute, Ottawa (Table 21). Thirty-one species have been collected in the Nova Scotia-New Brunswick border region (Tables 21,22). Table 22 also records how the tabanids were collected, and the numbers obtained, during the summers of 1973, 1974, and 1975.

A key to the female tabanids of maritime Canada is presented in Appendix C.

Larval Habitats

Larval habitats of tabanids were not determined in this study, but two males of *H. epistates* were taken in emergence cages in Impoundment II, suggesting that larvae of this species are found in freshwater marshes.

Numerous horse fly egg masses were found on a variety of plants, including timothy (*Phleum pratense* L.), cattail (*Typha* spp.), iris (*Iris*

Table 21

Tabanidae of maritime Canada

Species	Nova Scotia	New Brunswick	Prince Edward Island
Chrysops aberrans Philip		2	
Chrysops aestuans van der Wulp	2,3	3	
Chrysops ater Macquart	1,3	1,3	1
Chrysops calvus Pechuman and Teskey	3	3	
Chrysops carbonarius Walker	2,3	1,2,3	
Chrysops cincticornis Walker	1,2	1	
Chrysops cuclux Whitney	2,3	1,3	
Chrysops delicatulus Osten Sacken		2	
Chrysops excitans Walker	1,2,3	1,2,3	1
Chrysops frigidus Osten Sacken	1,3	1,2,3	
Chrysops fuliginosus Wiedemann			1
Chrysops furcatus Walker	1,2,3	1,3	
Chrysops lateralis Wiedemann	1,2,3	1,2,3	
Chrysops mitis Osten Sacken	3	1,2,3	
Chrysops montanus Osten Sacken		2	
Chrysops niger Macquart	1,2,3	1,3	
Chrysops proclivis Osten Sacken		2	
Chrysops shermani Hine		2,3	
Chrysops sordidus Osten Sacken	1	1,2,3	
Chrysops striatus Osten Sacken		2	
Chrysops univittatus Macquart	2	2	
Chrysops vittatus Wiedemann	1,2	1	
Chrysops zinzalus Philip	2	2,3	
Stonemyia rasa (Loew)		2	
Stonemyia tranquilla (Osten Sacken)		2	
Atylotus bicolor (Wiedemann)	1		
Atylotus ohioensis (Hine)		2	
Atylotus pemeticus (Johnson)	1,2	1,2	2
Atylotus thoracicus (Hine)	1,2		

Table 21--Continued

Species	Nova Scotia	New Brunswick	Prince Edward Island
Hybomitra affinis (Kirby)	2,3	1,2,3	2
Hybomitra astuta (Osten Sacken)	1	1,2	
Hybomitra aurilimba (Stone)	2	2	2
Hybomitra epistates (Osten Sacken)	2,3	1,3	
Hybomitra frontalis (Walker)	1,2,3	1,2,3	1
Hybomitra frosti Pechuman	1,2	1,2	
Hybomitra illota (Osten Sacken)	3	3	
Hybomitra itasca (Philip)	3	3	
Hybomitra lasiophthalma (Macquart)	1,2,3	1,2,3	
Hybomitra liorhina (Philip)	1,3	1,3	
Hybomitra longiglossa (Philip)	2	2,3	2
Hybomitra lurida (Fallen)	3	1,2,3	
Hybomitra microcephala (Osten Sacken)	1,2		
Hybomitra minuscula (Hine)	1	2	
Hybomitra nuda (McDunnough)	3	1,2,3	1
Hybomitra sodalis (Williston)		1	
Hybomitra trepida (McDunnough)	1,2,3	1,3	
Hybomitra typhus Whitney Form A	1,2,3	1,3	
Hybomitra typhus Whitney Form B		3	
Hybomitra zonalis (Kirby)	1,2,3	1,2,3	2
Tabanus catenatus Walker	2	1	
Tabanus fairchildi Stone	2		
Tabanus marginalis Fabricius	1,2	1	
Tabanus nigrovittatus Macquart	1,2,3	1,3	1,2,3
Tabanus novaescotiae Macquart	2,3	2,3	
Tabanus quinquevittatus Wiedemann	2		
Tabanus reinwardtii Wiedemann	1,2		
Tabanus similis Macquart	2,3		

1 Biosystematics Research Institute (Canadian National Collection), Ottawa
2 In literature
3 Collected by author

Table 22

Tabanids collected in the Tantramar Marshes, 1973–1975

Species	Numbers of specimens						
	Man	Cattle	Barns	Traps	Truck	Other*	Total
Chrysops aestuans	11		1			1	13
Chrysops ater	18		1		1		20
Chrysops calvus	22	1	11	2	3		39
Chrysops carbonarius	5						5
Chrysops cuclux	20		3		2		25
Chrysops excitans	24	2	3		4		33
Chrysops frigidus	85	12	43	6	36		182
Chrysops fuliginosus	4						4
Chrysops furcatus	23	1	16			1	41
Chrysops lateralis	66		10		2		78
Chrysops mitis	232	4	19	14	37	4	310
Chrysops nigen	5	1	3	1	7		17
Chrysops shermani	1						1
Chrysops sordidus	1						1
Chrysops zinzalus	4				1		5
Hybomitra affinis	21	12	145	1	32	1	212
Hybomitra epistates	72	10	307	33	21	4	447
Hybomitra frontalis	35	4	26	2	6		73
Hybomitra illota	21	1	2	46	19		89
Hybomitra itasca	3	1	5				9
Hybomitra lasiophthalma	48	17	129	3	42		239
Hybomitra liorhina	2		1		1		4
Hybomitra longiglossa	1						1
Hybomitra lurida	4	1	17	1	15		38
Hybomitra nuda	35		70	3	38	1	147
Hybomitra trepida	13	1	20		6		40
Hybomitra typhus Form A	7	8	4		1	1	21
Hybomitra typhus Form B			2				2
Hybomitra zonalis	7	1	14			1	23
Tabanus nigrovittatus	4						4
Tabanus novaescotiae					1		1
Tabanus similis		4					4
Total	794	81	852	112	275	14	2128

*Described in text.

versicolor), and sweetflag (*Acorus calamus*). These eggs usually hatched within three to four days, but no attempt was made to rear the larvae.

Adult Feeding Habits

The feeding habits of 20 species of tabanids are known in the Nova Scotia-New Brunswick border region (Table 23). Fifteen species of tabanids were taken feeding on man and nine species were feeding on cattle. *Chrysops mitis* was the most abundant deer fly collected feeding on man; it comprised 52.6% of the man-feeding deer flies. *Hybomitra frontalis* was the most abundant horse fly feeding on man. It accounted for 74.2% of this group. *Chrysops frigidus* comprised 42.9% of the deer flies taken feeding on cattle, while *H. typhus* Form A accounted for 50% of the horse flies feeding on cattle. Only four species, *C. calvus*, *C. furcatus*, *C. mitis*, and *H. frontalis*, were taken from both man and cattle.

One blood-fed specimen of *C. excitans* was found in a pasture just a couple of meters from a cattle herd. It was attempting to fly and is thought to have fed on cattle.

Deer flies were taken in the vicinity of cattle, in barns, traps, and trucks, but a greater number of each species was taken in the vicinity of man (Table 22, p. 98). *Chrysops mitis* was the most abundant deer fly in the Tantramar Marshes and accounted for 14.6% of the tabanid population, and 40.1% of the total deer flies collected. It accounted for 44.5% of the deer flies taken in the vicinity of man.

Specimens of *C. aestuans* and *C. mitis* have been collected from cages containing mallards (*Anas platyrhynchos* Linnaeus), black ducks (*A. rubripes* Brewster), and domestic pekin ducks (*A. platyrhynchos*).

Table 23

Feeding records of Tabanidae in the Nova Scotia-New Brunswick border region, 1973-1975

Species	Source of blood meal	
	Man	Cattle
Chrysops aestuans	+	
Chrysops ater	+	
Chrysops calvus	+	+
Chrysops cuclux	+	
Chrysops excitans	+	
Chrysops frigidus		+
Chrysops furcatus	+	+
Chrysops lateralis	+	
Chrysops mitis	+	+
Chrysops niger	+	
Hybomitra affinis		+
Hybomitra epistates	+	
Hybomitra frontalis	+	+
Hybomitra itasca	+	
Hybomitra lasiophthalma		+
Hybomitra liorhina	+	
Hybomitra lurida	+	
Hybomitra typhus Form A		+
Hybomitra zonalis		+
Tabanus nigrovittatus	+	

Also, a specimen of *C. furcatus* was taken from an *Empidonax* fly catcher (probably *E. traillii* Audubon), which was entangled in a mist net.

A greater number of adults of 10 species of *Hybomitra* were collected in barns (Table 22, p. 98) than from any other source. It is thought that the adults followed cattle into the barns and, being positively phototropic, flew to the windows where they were collected. Ten of the 14 species of *Hybomitra* have been collected flying over or feeding on cattle. *Hybomitra typhus* Form A was the only tabanid of which more specimens were collected in the vicinity of cattle than anywhere else.

Hybomitra frontalis, H. illota, H. liorhina, and *H. longiglossa* were taken more often from other sources than from cattle or barns.

Hybomitra frontalis was not the only species of horse fly annoying to man, but it was more commonly collected from man than any other source. Of the 35 specimens collected in the vicinity of man, 23 had fed on man; this is more than three times the number of bites from the next most abundant horse fly that had fed on man.

Hybomitra illota was the most abundant tabanid collected in the tabanid traps, and accounted for 41.1% of the total.

Two specimens of *H. liorhina* were collected, one in the vicinity of man and one in a barn. Little is known about the biology of this horse fly in the Tantramar Marshes.

Only one specimen of *H. longiglossa* was collected and, while it was found in the vicinity of man, it is impossible to elaborate on its host preference or other habits.

Species of *Tabanus* were generally uncommon. *Tabanus novaescotiae* was collected only twice. One was collected while flying about a pickup truck and the other was collected while flying about man.

All four specimens of *T. nigrovittatus* which were collected in the study area were collected in the vicinity of man. Also, specimens were frequently collected attempting to feed on man in coastal areas of New Brunswick, Nova Scotia, and Prince Edward Island.

Only four specimens of *T. similis* were collected in the Tantramar Marshes, and these were all taken flying about cattle.

In addition to the two males of *H. epistates* taken from emergence cages, three were collected during the study period. One male of *H. affinis* was taken in the cab of a truck at Jolicure, New Brunswick, one male of *H. nuda* was taken from a car in Sackville, New Brunswick, and one male of *H. typhus* Form A was collected from a branch of a coniferous tree.

Generally, all species of tabanids which were collected in larger numbers may be encountered anywhere in the Tantramar Marshes. *Tabanus nigrovittatus* and *C. fuliginosus* are frequently pests on coastal salt marshes of the Maritime Provinces, but are seldom encountered very far inland. Similarly, most species of *Chrysops* and *Hybomitra* are uncommon in coastal areas.

Horse flies are important pests of cattle. Deer flies annoy cattle to some extent, but are less important than the horse flies. Cattle were frequently observed to huddle together and instead of feeding or resting, they would spend hours fighting the flies. When a cow, or bull, felt the painful bite of a tabanid, it would attempt to rid itself of the fly by brushing with the tail, scratching with a hoof, or licking with the tongue. Since most tabanids are usually active only on very bright warm days, these are the times when cattle are likely to be annoyed. Therefore, prolonged periods of sunny, warm weather causes prolonged annoyance and irritation of the cattle by the tabanids. Since cattle would decrease or stop feeding completely during this time, decrease of body weight and/or milk production is inevitable.

Abundance

Seasonal

The seasonal succession of the Tabanidae in the Nova Scotia-New Brunswick border region is recorded in Fig. 16. This represents the succession of all tabanid species collected during 1973-1975, regardless of sampling technique. Figures 17, 18, and 19 represent the seasonal succession and abundance of tabanids collected in aerial net sweeps during 1973, 1974, and 1975 respectively. Reference should be made to these figures for the following discussion. *Hybomitra nuda* was one of the first tabanids to emerge. It was collected during the first week of June, 1975, but did not occur in the aerial net sweeps until a week later. This species did not appear in net sweeps at all in 1973 and not until the end of June in 1974. Adults were not normally collected after mid-July. *Chrysops mitis* usually appears during the third week of June, but it was collected a week earlier in 1975. Adults are common until the end of July or early August. *Chrysops ater* was collected in net sweeps only in 1974, when it appeared during the third week of June. It was abundant for about a month, although adults were taken during the second week of June in 1973 and the third week of July, 1974.

Hybomitra illota normally occurs in net sweeps from the third week of June until the end of July. Net sweeps in 1973 did not yield specimens of *H. illota*. *Chrysops cuclux* did not occur in net sweeps in 1973 but was collected in net sweeps in the third week of June in 1975.

Figure 16

Seasonal succession of Tabanidae in the

Tantramar Marshes, 1973-1975

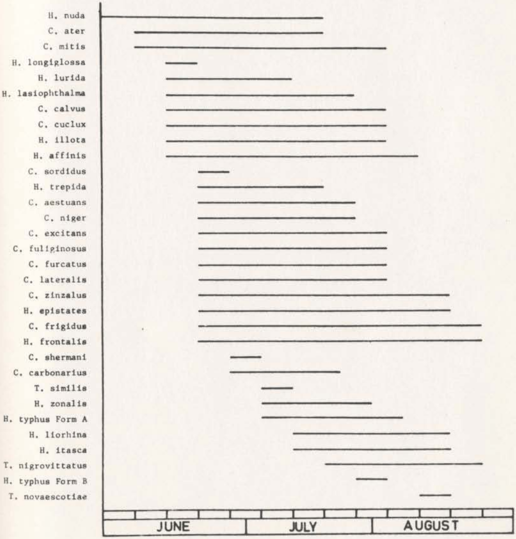
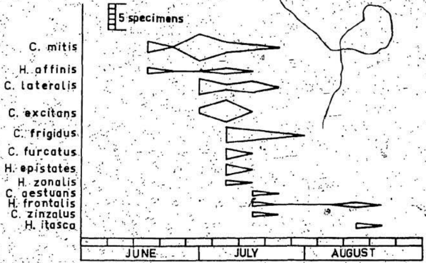

H. nuda
C. ater
C. mitis
H. longiglossa
H. lurida
H. lasiophthalma
C. calvus
C. cuclux
H. illota
H. affinis
C. sordidus
H. trepida
C. aestuans
C. niger
C. excitans
C. fuliginosus
C. furcatus
C. lateralis
C. zinzalus
H. epistates
C. frigidus
H. frontalis
C. shermani
C. carbonarius
T. similis
H. zonalis
H. typhus Form A
H. liorhina
H. itasca
T. nigrovittatus
H. typhus Form B
T. novaescotiae
JUNE
JULY
AUGUST

Figure 17

Seasonal succession and abundance of tabanids

obtained in aerial net sweeps, 1973



5 specimens
C. mitis
H. affinis
C. lateralis
C. excitans
C. frigidus
C. furcatus
H. epistates
H. zonalis
C. aestuans
H. frontalis
C. zinzalus
H. itasca
JUNE
JULY
AUGUST

Figure 18

Seasonal succession and abundance of tabanids obtained in aerial net sweeps, 1974

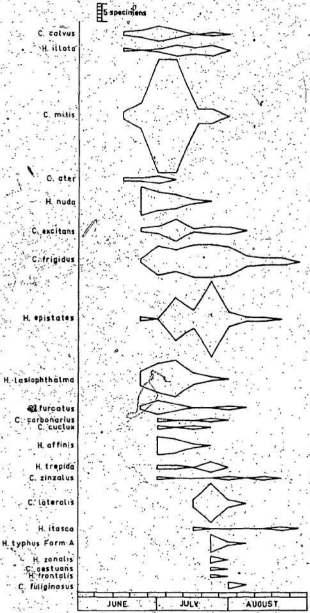
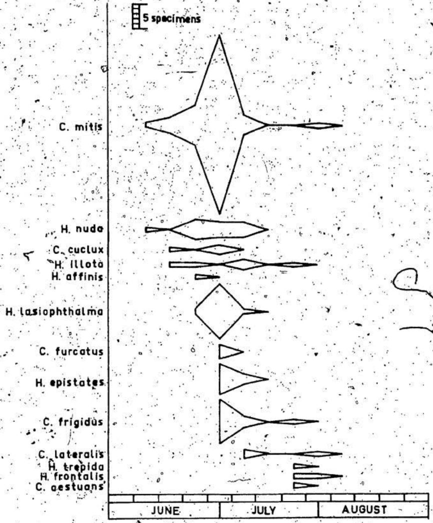

5 specimens
C. calvus
H. illota
C. mitis
C. ater
H. nuda
C. excitans
C. frigidus
H. epistates
H. lasiophthalma
furcatus
C. carbonarius
C. cuclux
H. affinis
H. trepida
C. zinzalus
C. lateralis
H. itasca
H. typhus Form A
H. zonalis
C. aestuans
H. frontalis
C. fuliginosus
JUNE
JULY
AUGUST

Figure 19

Seasonal succession and abundance of tabanids obtained in aerial net sweeps, 1975


5 specimens
C. mitis
H. nuda
C. cuclux
H. illota
H. affinis
H. lasiophthalma
C. furcatus
H. epistates
C. frigidus
C. lateralis
H. trepida
H. frontalis
C. aestuans
JUNE
JULY
AUGUST

It did not appear until the end of June or early July in 1974. In both years adults were collected for about a three-week period in net sweeps although during 1974 other specimens were collected until early August. *Chrysops calvus* also appears about the third week of June; it was collected in net sweeps in 1974 only. Adults are usually found until late July or early August. *Hybomitra affinis* was collected from the third week of June to the second week of August. Net sweeps yielded specimens from the third week of June to mid July in 1973, late June to near the end of July in 1974, and late June to early July in 1975. *Chrysops excitans* appeared in net sweeps during late June and early July, 1973-1974; it was not collected after mid July in 1973 or after early August in 1974. It was not collected in net sweeps during 1975. *Chrysops frigidus* first appeared in net sweeps during the fourth week of June, 1974, a week later in 1975, and even a week later in 1973. *Chrysops frigidus* was fairly abundant in 1974 and was collected until near the end of August. In 1973 and 1975 net sweeps did not yield *C. frigidus* after the end of July or early August. *Chrysops furcatus* followed a similar pattern. During 1973 and 1975 it was collected for two weeks only in net sweeps, whereas in 1974 adults were collected over a six-week period. It, too, was more abundant in 1974 than in 1973 or 1975. *Hybomitra epistates* appears during late June or early July at the same time as *C. furcatus* and *C. frigidus*. In 1974 it was collected until mid August whereas in 1973 and 1975, when the populations were not as large, adults were not collected after mid July. *Hybomitra lasiophthalma* was not collected in net sweeps during 1973, but adults were collected during the third week of June. In 1974 and 1975 adults appeared in net sweeps during late June and were common until mid to late July. *Chrysops carbonarius* was collected in net sweeps only from late June through late July in 1974. *Chrysops lateralis* was collected in net sweeps in all three years, but was a week later in each year, beginning with 1973, then 1975, and 1974. Adults were also collected during the fourth week of June in 1975. Usually *C. lateralis* was collected for a period of four or five weeks, but it was not found after early August. *Chrysops zinzalus* is an uncommon species and may be collected from mid June through mid August. Net sweeps yielded adults from late June through mid August in 1974, whereas in 1973, *C. zinzalus* occurred only during the last half of July. No specimens of *C. zinzalus* were collected in net sweeps in 1975. *Hybomitra trepida* was most abundant in 1974 when adults were collected in net sweeps from late June until late July. Specimens were collected in net sweeps during the last half of July in 1975, but not at all in 1973. *Hybomitra zonalis* occurred for about a month commencing in early July. It was not taken in net sweeps in 1975, but was taken for two weeks in mid July, 1973 and for three weeks near the end of July and early August, 1974. *Hybomitra itasca* usually appeared about mid July and was collected in aerial net sweeps until near the end of August, although it was not collected after late July in 1973. Specimens of *H. itasca* were not collected in net sweeps during 1975. *Chrysops aestuans* was collected in net sweeps for a two-week period in late July, however, specimens were also collected as early as the latter part of June. *Hybomitra frontalis* also appeared about mid July in net sweeps and, while adults were collected until near the end of August, it was rarely encountered after early August. Specimens of *H. frontalis* were collected as early as late June in 1973. *Hybomitra typhus* Form A was found in early July in 1975 and collected as late as mid August in 1974, but adults were usually taken in net sweeps during late July and early August. *Hybomitra typhus* Form A did not appear in net sweeps in 1973 or 1975. *Chrysops fuliginosus* was collected during late June, 1973, but did not occur in net sweeps until late July and early August in 1974. Net sweeps during 1973 and 1975 did not yield specimens of *C. fuliginosus*.

Chrysops niger, *C. shermani*, *C. sordidus*, *H. typhus* Form B, *H. liorhina*, *H. longiglossa*, *H. lurida*, *T. novaescotiae*, *T. similis*, and *T. nigrovittatus* were not collected in net sweeps. *Chrysops niger* usually appears during mid to late June and may be found until late July. Only one specimen each of *C. shermani* and *C. sordidus* were collected in the course of this study - during the first week of July, 1973 and late June, 1975, respectively. Two specimens of *H. typhus* Form B were collected in a barn during the first week of August, 1974. *Hybomitra liorhina* was uncommon; adults were collected from late July to mid August. A single specimen of *H. longiglossa* was collected in mid June, 1973. *Hybomitra lurida* was collected from mid June to mid July. Species of *Tabanus* were uncommon inland, although they may be troublesome in some areas, particularly along the coasts. Two specimens only of *T. novaescotiae* were collected, one in 1974 and one in 1975. While both were collected in mid August, only one was found in the research area. *Tabanus similis* was collected in early June and *T. nigrovittatus* was encountered from mid July to late August.

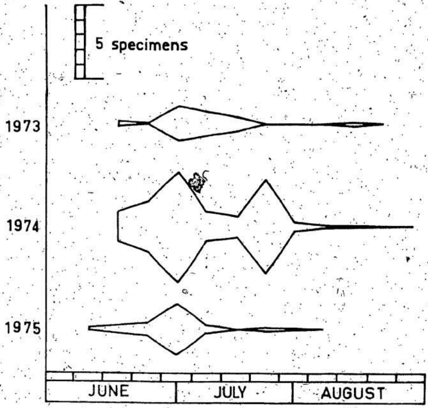
Annual

The seasonal abundance of the total tabanids obtained in aerial net sweeps during 1973-1975 is presented in Fig. 20. This graph is based on the average number of specimens per net sweep per week. The largest population occurred in 1974, and the smallest in 1973. Even though tabanids occurred a week earlier in 1975 than in 1973 and 1974,

Figure 20

Seasonal abundance of tabanids obtained in aerial net sweeps, 1973-1975

α


5 specimens
1973
1974
1975
JUNE
JULY
AUGUST

the population peaks occurred at the same time in each year. Tabanids were not collected in net sweeps after early August in 1975, two weeks earlier than in 1973 and three weeks earlier than in 1974. During 1974 there was apparently a second peak, but this was thought to follow a suppression of tabanid activity as a result of weather conditions, rather than an actual decrease in the population.

DISCUSSION

During the study period (1973-1975) the Culicidae were examined in greater depth than were the Simuliidae and the Tabanidae. Although literature is readily available on the taxonomy and bionomics of the biting flies encountered in this study, there is very little published information on the taxonomy and bionomics of these flies in the Nova Scotia-New Brunswick border region. Compilation of the results obtained by other workers in contiguous areas provides a basis for comparison.

CULICIDAE

Aedes abserratus

Aedes abserratus is univoltine in the Tantramar Marshes and overwinters in the egg stage. Carpenter and LaCasse (1955) reported that it is univoltine throughout its range in North America. Immatures of *A. abserratus* occur in a variety of temporary and semipermanent pools, confirming observations by Beckel and Atwood (1959), James *et al.* (1969), and Steward and McWade (1961) in Ontario; Gibson (1941) in Prince Edward Island; Pickavance *et al.* (1970) in Newfoundland; Jamnback (1969) in New York; Twinn (1931) in eastern Canada; and Carpenter and LaCasse (1955) in North America. This species is mainly crepuscular but also bites during the day in the Tantramar Marshes, where it may be a pest of man during June. Beckel and Atwood (1959) and Pickavance *et al.* (1970) reported that females bite man in Ontario and Newfoundland respectively, and Carpenter and LaCasse (1955) and Hayes (1962) found it to be mainly crepuscular in North America and Massachusetts respectively. It may be a pest in areas of New York (Jamnback, 1969*b*) and Maine (McDaniel, 1975). McDaniel (1975) reported that this species is migratory and frequently invades towns. Bennett (1960) collected blooded specimens from birds in Ontario.

Observations of *A. abserratus* in the Tantramar Marshes agree very closely with observations of this species elsewhere in eastern North America. Due to the similarity of "rubbed" females of *A. abserratus* with *A. punctor*, its actual abundance is uncertain.

Aedes canadensis

Aedes canadensis overwinters in the egg stage in the Nova Scotia-New Brunswick border region, as it does in New Hampshire (Lowry, 1929) and throughout its range in North America (Carpenter and LaCasse, 1955). Dyar (1921) earlier reported this species to overwinter in the egg stage in Canada. It is thought to be univoltine in the Tantramar Marshes although larvae may be taken throughout the summer (Table 8, p. 40). This agrees with Dyar (1921), who reported it to be univoltine in New Brunswick. Twinn (1931, 1953) reported it to be univoltine in eastern Canada. Larvae of *A. canadensis* occur in temporary and semipermanent pools, roadside ditches, and *Sphagnum* bogs. This agrees with observations by Beckel and Atwood (1959), James *et al.* (1969), and Steward and McWade (1961) in Ontario; Twinn (1931, 1953) in eastern Canada; Pickavance *et al.* (1970) in Newfoundland; Lowry (1929) in New Hampshire; Jamnback (1969*b*) in New York; Dyar (1903) in New Hampshire; and Carpenter and LaCasse (1955) for North America. In the Tantramar Marshes, *A. canadensis* feeds on man during the day and in the evening but it is not usually abundant. Steward and McWade (1961) and Beckel and Atwood (1959) reported that *A. canadensis* is active during the day in Ontario, but Hayes (1962) found it to be most active at sunrise or sunset in Massachusetts. Dyar (1921) reported females of this species to be persistent biters in New Brunswick, and it may be an important pest in areas of New England (Jamnback, 1969*b*; Barnes *et al.*, 1950; Fellton *et al.*, 1950). Pickavance *et al.* (1970) found *A. canadensis* biting man in Newfoundland. This species feeds on mammals (Steward and McWade, 1961; Teskey, 1960) and birds (Bennett, 1960) in Ontario; mammals, reptiles, amphibians, and birds in New York (Means, 1968) and Massachusetts (Hayes, 1961, 1962); reptiles in New Jersey (Crans and Rockel, 1968); and mammals throughout its range in North America (Carpenter and LaCasse, 1955). Meyer and Bennett (1976) and Meyer *et al.* (1974) collected specimens in duck baited traps in the Tantramar Marshes. California encephalitis virus has been isolated from *A. canadensis* in Wisconsin (Watts *et al.*, 1973) and in the Yukon Territory (McLean *et al.*, 1974).

The literature indicates that *A. canadensis* is pestiferous in some areas of its range; however, it is neither a pest nor a serious potential vector in the Nova Scotia–New Brunswick border region.

Aedes cantator

Aedes cantator is multivoltine in maritime Canada and overwinters in the egg stage. Lowry (1929) reported it to be multivoltine in New Hampshire, Carpenter and LaCasse (1955) indicated it is also multivoltine in New Jersey, and Dyar (1921) reported it to be multivoltine in Canada. Larvae of *A. cantator* are found in salt, brackish, and freshwater habitats in the Nova Scotia–New Brunswick border region, and throughout eastern North America (Carpenter and LaCasse, 1955), including New Hampshire (Lowry, 1929), New York (Jamnback, 1969*b*; Barnes *et al.*, 1950), areas of New England (Fellton *et al.*, 1950), Canada (Dyar, 1921), Prince Edward Island (Gibson, 1941; Twinn, 1953), and Nova Scotia (Gibson, 1939). *Aedes cantator* is mainly crepuscular in the Tantramar

Marshes, but also feeds during the day. This agrees with observations by Hayes (1962) in Massachusetts and Carpenter and LaCasse (1955) in eastern North America. This species is often a pest in coastal areas of New Brunswick, Nova Scotia, and Prince Edward Island, as it is in coastal regions of New England (Barnes *et al.*, 1950; Fellton *et al.*, 1950; Jamnback, 1969*b*; McDaniel, 1975). Dyar (1921) reported that this species may travel considerable distances inland from its larval habitats in Canada. Crans and Rockel (1968) indicated that *A. cantator* may feed on turtles in New Jersey and Meyer and Bennett (1976) and Meyer *et al.* (1974) collected this species in duck baited traps in the Tantramar Marshes.

Aedes cantator appears to be a serious pest throughout its range in eastern North America. Since larval habitats are frequently salt and brackish water, it is not usually found breeding very far inland.

Aedes cinereus

Aedes cinereus is thought to be univoltine and overwinters in the egg stage in the Nova Scotia-New Brunswick border region, where larvae may be collected until mid August (Table 8, p. 40). Carpenter and LaCasse (1955) indicated that *A. cinereus* is probably univoltine and overwinters in the egg stage throughout its range in North America. Dyar (1921) reported it to overwinter in the egg stage in Canada, Twinn (1953) found it to be univoltine in Prince Edward Island, and Lowry (1929) reported it overwintering in the egg stage in New Hampshire. In the Tantramar Marshes, *A. cinereus* has been found in temporary and semipermanent pools, roadside ditches, and in pools of water formed by mats or floating vegetation in permanent marshes. This variability of larval habitats has also been recorded by Dyar (1921) in Canada; Beckel and Atwood (1959), James *et al.* (1969), Judd (1954*a*), and Steward and McWade (1961) in Ontario; Haufe (1952) in Labrador; Jamnback (1969*b*) and Barnes *et al.* (1950) in New York; Lowry (1929) in New Hampshire; Twinn (1931) in eastern Canada; Gibson (1941) and Twinn (1953) in Prince Edward Island; and Carpenter and LaCasse (1955) in North America. Females have been taken biting man during the day and in the evening in the study area; Twinn (1931) earlier reported this for eastern Canada. This species is not usually a pest in the Tantramar Marshes, but it is a troublesome biter in Ontario (Steward and McWade, 1961) and areas of New England (Fellton *et al.*, 1950). Jamnback (1969*b*) reported that it may be a pest in some New York localities. Teskey (1960) collected adults from cattle in Ontario and Meyer *et al.* (1974) collected females of *A. cinereus* in duck baited traps in the Tantramar Marshes, as did Meyer and Bennett (1976). McLean *et al.* (1974) isolated California encephalitis virus from *A. cinereus* in the Yukon Territory.

Observations of *A. cinereus* in the Tantramar Marshes agree closely with those made by other workers in eastern North America. While this species is pestiferous in some areas of its range, it is not an abundant pest or serious potential vector in the Tantramar Marshes.

Aedes communis

This species is univoltine in the Nova Scotia-New Brunswick border area and overwinters in the egg stage. Carpenter and LaCasse (1955) reported that it is probably univoltine throughout its range in North America. Immatures of *A. communis* breed in almost all types of pools in the Tantramar Marshes and throughout its range in North America (Carpenter and LaCasse, 1955), including the eastern United States (Carpenter, 1950), Ontario (Beckel and Atwood, 1959; James *et al.*, 1969; Steward and McWade, 1961), New Hampshire (Lowry, 1929), New York (Jamnback, 1969*b*), Quebec (Jenkins and Knight, 1950), Prince Edward Island (Gibson, 1941; Twinn, 1953), and Labrador (Haufe, 1952). *Aedes communis* is primarily crepuscular in maritime Canada and may be a pest early in the spring. Beckel and Atwood (1959) reported that females will bite during the day or night. It may be a serious pest early in the spring in New York (Jamnback, 1969*b*), Maine (McDaniel, 1975), Quebec (Jenkins and Knight, 1950), and throughout its range in North America (Carpenter and LaCasse, 1955). California encephalitis virus has been isolated from this species in the Yukon Territory (McLean *et al.*, 1974).

Aedes communis appears to be a troublesome pest early in the spring throughout much of its eastern North American range. Since "rubbed" females of this species are morphologically similar to females of *A. punctor*, its relative abundance is uncertain.

Aedes excrucians

This study has indicated that *A. excrucians* is univoltine and overwinters in the egg stage. This was earlier reported for Canada by Dyar (1921) and for North America by Carpenter and LaCasse (1955). *Aedes excrucians* occurs in a variety of temporary and permanent aquatic habitats in the Nova Scotia-New Brunswick border area, as it does throughout its range in North America (Carpenter and LaCasse, 1955), including Canada (Dyar, 1921), Ontario (Beckel and Atwood, 1959; Steward and McWade, 1961; James *et al.*, 1969), Quebec (Jenkins and Knight, 1950), Nova Scotia (Gibson, 1941), Prince Edward Island (Gibson, 1941; Twinn, 1953), Newfoundland (Pickavance *et al.*, 1970), New Hampshire (Lowry, 1929), and New York (Jamnback, 1969*b*). Females bite man in the Tantramar Marshes where they are primarily crepuscular and not very abundant. Throughout North America (Carpenter and LaCasse, 1955), including Ontario (Steward and McWade, 1961), this species will bite during the day and is most active during the evening. McDaniel (1975) reported that *A. excrucians* only occasionally attacks man in Maine, while Jamback (1969*b*) reported it to be a serious pest in some areas of New York. Pickavance *et al.* (1970) collected this species biting man in Newfoundland. Meyer and Bennett (1976) and Meyer *et al.* (1974) collected specimens in duck baited traps in the Tantramar Marshes. California encephalitis virus has been isolated from *A. excrucians* in Saskatchewan (Iversen *et al.*, 1973).

The literature indicates that this species is rarely a pest in eastern North America. It is not abundant and therefore not a pest in the Tantramar Marshes and is unlikely to be a serious potential vector.

Aedes fitchii

Aedes fitchii is univoltine and overwinters in the egg stage in the Tantramar Marshes, where larvae were found in permanent pools in wooded areas. Dyar (1921) indicated that *A. fitchii* overwinters in the egg stage in Canada. Nothing more is known of the biology of this species in maritime Canada, except that Meyer and Bennett (1976) and Meyer *et al.* (1974) collected females in duck baited traps. Elsewhere, larvae have been taken in temporary and permanent pools in woods, meadows, bogs, and marshes in Canada (Dyar, 1921), Ontario (Beckel and Atwood, 1959; James *et al.*, 1969; Judd, 1954*a*; Steward and McWade, 1961), eastern Canada (Twinn, 1931), Prince Edward Island (Gibson, 1941; Twinn, 1953), Labrador (Haufe, 1952), Newfoundland (Pickavance *et al.*, 1970), eastern United States (Carpenter, 1950), New Hampshire (Lowry, 1929), and

New York (Barnes *et al.*, 1950; Jamnback, 1969*b*). Females bite man in New York (Jamnback, 1969*b*), Ontario (Beckel and Atwood, 1959; Steward and McWade, 1961), Labrador (Haufe, 1952), and Newfoundland (Pickavance *et al.*, 1970). Steward and McWade (1961) also reported that females feed on cattle in Ontario. Teskey (1960) also collected this species from cattle in Ontario. McDaniel (1975) reported that *A. fitchii* only occasionally attacks man in Maine. California encephalitis virus has been isolated from *A. fitchii* in Saskatchewan (Iversen *et al.*, 1973) and the Yukon Territory (McLean *et al.*, 1974).

Although this species has been taken feeding on cattle and in duck baited traps, man appears to be the preferred host throughout its range in eastern North America. It is not pestiferous in the Tantramar Marshes. The reasons for this are not known since there are ample and, according to the literature, suitable, larval habitats.

Aedes punctor

Aedes punctor is univoltine in the Tantramar Marshes, as it is in New Brunswick (Dyar, 1921) and Prince Edward Island (Twinn, 1953), and overwinters in the egg stage in the Tantramar Marshes (author's data) and New Brunswick (Dyar, 1921). Larvae of this species are found in a variety of temporary and semipermanent pools in the study area; this has also been observed throughout its range in North America (Carpenter and LaCasse, 1955), including Ontario (Beckel and Atwood, 1959; James *et al.*, 1969; Steward and McWade, 1961), Quebec (Jenkins and Knight, 1950), eastern Canada (Twinn, 1931), New Brunswick (Dyar, 1921), Prince Edward Island (Gibson, 1941; Twinn, 1953), Labrador (Haufe, 1952), Newfoundland (Pickavance *et al.*, 1970), New Jersey (Lake, 1953), New Hampshire (Lowry, 1929), and New York (Jamnback, 1969*b*). This species is primarily crepuscular in the Nova Scotia-New Brunswick border region where it is a pest in late May or early June. It is a severe biter in New Brunswick (Dyar, 1921) and persistent biter in Ontario (Steward and McWade, 1961), where it feeds during the day and at night (Beckel and Atwood, 1959). It is abundant in Ontario (Beckel and Atwood, 1959; Steward and McWade, 1961) and Newfoundland (Pickavance *et al.*, 1970), while it is uncommon in Maine (McDaniel, 1975) and Quebec (Jenkins and Knight, 1950). It is abundant in some areas of New York (Butts, 1974) but relatively uncommon in others (Jamnback, 1969*b*). Teskey (1960) collected adults from cattle in Ontario. Specimens of *A. punctor* have been taken in duck baited traps in the Tantramar Marshes (Meyer and Bennett, 1976; Meyer *et al.*, 1974) and Newfoundland (Bennett and Coombs, 1975). Bennett and Coombs (1975) indicated that this species may be a vector of *Plasmodium vaughani* Novy and MacNeal in Newfoundland. Iversen *et al.* (1973) isolated California encephalitis virus from the *A. punctor* group of mosquitoes in Saskatchewan.

This species is an early spring pest throughout its range in eastern North America, and is a potential vector of viral and blood diseases. The known ecology of this species in maritime Canada is very similar to its ecology elsewhere in eastern North America.

Aedes sollicitans

Aedes sollicitans is multivoltine and is thought to overwinter in the egg stage in maritime Canada, where larvae are found in coastal salt marshes. Dyar (1921) reported that *A. sollicitans* overwinters in the egg stage in Canada. It is also multivoltine and found in salt marshes in coastal Canada (Dyar, 1921), Connecticut (Anderson, 1970), and New Hampshire (Lowry, 1929). This species has also been reported from salt marshes throughout its range in North America (Carpenter and LaCasse, 1955), including Nova Scotia (Gibson, 1934), Prince Edward Island (Twinn, 1953) and New England (Barnes *et al.*, 1950; Fellton *et al.*, 1950). During this study females were collected feeding on man during the day and in the evening in salt marsh areas of New Brunswick, Nova Scotia and Prince Edward Island, and in the Tintamarre National Wildlife Area which is about 8.0 km inland. Carpenter and LaCasse (1955) reported that adults are strong fliers and often migrate in large numbers to areas of human population many kilometers from their breeding sites. They also reported that females are persistent biters and will attack at any time of the day or night. Gibson (1934) indicated that this species is also found considerable distances inland in Nova Scotia. *Aedes sollicitans* is a pest in much of New England (Barnes *et al.*, 1950; Jamnback, 1969*b*; McDaniel, 1975). Crans and Rockel (1968) reported *A. sollicitans* feeding on turtles in New Jersey. The Cache Valley virus has been isolated from *A. sollicitans* on islands off the Virginia coast (Buescher *et al.*, 1970).

Observations of this species in maritime Canada agree with those by other workers in other regions of eastern North America. It is apparently abundant in most coastal areas and is a potential vector of viral diseases.

Aedes stimulans

Females of this species were netted about man, but nothing more is known on the biology of this species in the Tantramar Marshes. *Aedes stimulans* is univoltine in Canada (Dyar, 1921) and eastern Canada (Twinn, 1931), and occurs in a variety of pools, marshes, and swamps throughout its range in North America (Carpenter and LaCasse, 1955), including Canada (Dyar, 1921), Ontario (James *et al.*, 1969; Judd, 1954*a*; Steward and McWade, 1961), Newfoundland (Pickavance *et al.*, 1970), Prince Edward Island (Gibson, 1941; Twinn, 1953), eastern Canada (Twinn, 1931), New Hampshire (Lowry, 1929), and New York (Jamnback, 1969*b*). Females are persistent biters and their bite is very annoying in Ontario (Steward and McWade, 1961) and much of its North America range (Carpenter and LaCasse, 1955). *Aedes stimulans* is one of the most abundant and annoying woodland mosquitoes of northeastern North America (Barnes *et al.*, 1950; Butts, 1974; Carpenter and LaCasse, 1955; Jamnback, 1969*b*; McDaniel, 1975; Twinn, 1931). Teskey (1960) collected specimens from cattle in Ontario. McDaniel (1975) reported that females attack man readily and seldom move far from their breeding areas in Maine.

Reports in the literature indicate this species to be a serious pest of man in eastern North America; however, it is not pestiferous in the Tantramar Marshes. It is not known why this species is uncommon in this area since there appears to be numerous suitable larval habitats.

Aedes vexans

Aedes vexans is apparently multivoltine in the Tantramar Marshes where it overwinters in the egg stage. It is also multivoltine in Ontario (Steward and McWade, 1961) and New Brunswick (Dyar, 1921) and overwinters in the egg stage throughout its range in North America (Carpenter and LaCasse, 1955), including New Hampshire (Lowry, 1929). This species occurs in a variety of pools, especially those created by rainfall or flooding in maritime Canada, as it does in much of its North American range (Carpenter and LaCasse, 1955) including Ontario (James *et al.*, 1969; Judd, 1954*a*; Steward and McWade, 1961), eastern Canada (Twinn, 1931), Prince Edward Island (Twinn, 1953), New Brunswick (Dyar, 1921), New York (Jamnback, 1969*b*; Barnes *et al.*, 1950), New Hampshire (Lowry, 1929) and New Jersey (Vannote, 1970). In the Tantramar Marshes, *A. vexans* feeds on man during the day and in the evening, but is not usually a pest. Carpenter and LaCasse (1955) reported that this species is a troublesome biter throughout its range in North America, and this was confirmed by Dyar (1921) in Canada, Steward and McWade (1961) in Ontario, and Barnes *et al.* (1950) in New York. Females feed on man (Beckel and Atwood, 1959) and cattle (Teskey, 1960) in Ontario, and man and domestic animals in eastern Canada (Twinn, 1931). Females feed during the day and in the evening throughout their range in North America (Carpenter and LaCasse, 1955) including Ontario (Beckel and Atwood, 1959). Vannote (1970) reported that maximum periods of annoyance are early in the morning and at dusk in New Jersey. Watts *et al.* (1973) indicated that *A. vexans* is capable of transmitting LaCrosse encephalitis virus in the laboratory, and Larson *et al.* (1971) isolated the Cache Valley virus from this species in South Dakota. McLintock *et al.* (1970) isolated western encephalitis from *A. vexans* in Saskatchewan.

This species is apparently a very serious pest in much of its range in eastern North America; however, in the Tantramar Marshes this species is one of the least common. Observations on the biology of this mosquito in the Tantramar Marshes, however, agree with observations by other workers in other regions of eastern North America.

Anopheles earlei

Anopheles earlei was collected feeding on man in early May and probably overwintered as adults. It was also taken flying about man in late July and early August. It is uncommon and further information on the biology of this species in the Tantramar Marshes is lacking, although Meyer and Bennett (1976) and Meyer *et al.* (1974) collected specimens in duck baited traps. The immatures of *An. earlei* occur in temporary and permanent habitats such as woodland pools, roadside ditches, bogs and marshes throughout the range of this species in North America (Carpenter and LaCasse, 1955). This has also been reported by Beckel and Atwood (1959) and Steward and McWade (1961) in Ontario, and Jamnback (1969*b*) in New York. Females are the overwintering stage in Ontario (Steward and McWade, 1961), Labrador (Haufe, 1952), and throughout North America (Carpenter and LaCasse, 1955). Females feed on man in Ontario (Beckel and Atwood, 1959) but are apparently only a minor pest in Maine (McDaniel, 1975).

Observations of *An. earlei* in the Tantramar Marshes agree with those made by other workers for this species in its known range in eastern North America. It does not appear to be a serious pest in any of these areas.

Anopheles walkeri

Anopheles walkeri is bivoltine and larvae are found in fresh-water marshes in the Nova Scotia-New Brunswick border region. Freshwater marshes are also the preferred larval habitat throughout North America (Carpenter and LaCasse, 1955) including Ontario (James *et al.*, 1969; Steward and McWade, 1961; Wishart and James, 1945) and New York (Jamnback, 1969*b*). Dyar (1921) reported larvae of *An. walkeri* in floodpools of rivers in Canada. In the Tantramar Marshes females of *An. walkeri* feed on man during the day and at dusk and may be troublesome near their larval sites. Females attack man during the day and in the evening in eastern Canada (Twinn, 1931), and in the evening in Ontario (Beckel and Atwood, 1959; Steward and McWade, 1961) and throughout its range in North America (Carpenter and LaCasse, 1955). *Anopheles walkeri* has been collected from birds in Ontario (Bennett, 1960) and in the Tantramar Marshes (Meyer and Bennett, 1976; Meyer *et al.*, 1974). It is apparently an uncommon species in some areas of New England (Fellton *et al.*, 1950; Jamnback, 1969*b*; McDaniel, 1975).

Although *An. walkeri* has been taken from birds in some areas, it is probably chiefly mammalophilic in the Tantramar Marshes. The biology of this species in maritime Canada is similar to the biology of this species in other areas of eastern North America.

Culex restuans

Immatures of *C. restuans* were found in temporary pools in the Tantramar Marshes. No further information on the biology of this species in the Nova Scotia-New Brunswick border region is known, except that Meyer and Bennett (1976) and Meyer *et al.* (1974) collected specimens from duck baited traps. The larvae of *C. restuans* are found in a wide variety of aquatic habitats throughout its range in North America (Carpenter and LaCasse, 1955), including Ontario (Beckel and Atwood, 1959; James *et al.*, 1969; Judd, 1954*a*; Steward and McWade, 1961) and New York (Jamnback, 1969*b*). Adults are the overwintering stage in Connecticut (Wallis, 1959; Wallis and Main, 1974). Females of *C. restuans* feed on mammals, reptiles, amphibians, and birds in New York (Means, 1968), Massachusetts (Hayes, 1961), and Connecticut (Wallis, 1959). This species is common in many areas of New England (Barnes *et al.*, 1950; Fellton *et al.*, 1950; Jamnback, 1969*b*), although McDaniel (1975) reported that it rarely or never bites man. This species is known to harbor eastern equine encephalitis (Hayes, 1961; Hayes *et al.*, 1960; McDaniel, 1975). Western equine encephalitis has also been isolated from *C. restuans* in Manitoba (Norris, 1946).

While this species may be capable of transmission of viral diseases, it is not a large component of the mosquito community in the Tantramar Marshes and, therefore, may not be a serious potential vector.

Culex territans

Larvae were collected from freshwater marshes and Meyer and Bennett (1976) and Meyer *et al.* (1974) collected specimens from duck bait. No further information on the biology of this species in the Tantramar Marshes is available. *Culex territans* occurs in temporary and permanent pools and ditches and in swamps and bogs throughout its range in North America (Carpenter and LaCasse, 1955), Canada (Dyar, 1921), Ontario (Beckel and Atwood, 1959; James *et al.*, 1969; McIver, 1969; Steward and McWade, 1961), New Hampshire (Lowry, 1929) and New York (Jamnback, 1969*b*). Females are the overwintering stage in eastern Canada (Twinn, 1931) and elsewhere in North America (Carpenter and LaCasse, 1955). Females feed on man, reptiles, birds, and amphibians in Ontario (Steward and McWade, 1961; McIver, 1969) and New York (Means, 1968; Jamnback, 1969*b*), but cold-blooded animals are preferred in New York (Means, 1968; Jamnback, 1969*b*), New Jersey (Benach, 1970; Crans, 1970), and throughout the range of this species in North America (Carpenter and LaCasse, 1955). West and Hudson (1960) also reported females of *C. territans* biting man in Ontario.

McIver (1969) reported that *C. territans* was most active at the end of dusk and at the beginning of dawn in Ontario.

Reports in the literature indicate that females of *C. territans* feed on man; however, they have not been collected near man in maritime Canada. It appears from the literature that this species prefers amphibians, particularly frogs, as a source of blood.

Culiseta impatiens

Information on the biology of this species in the Tantramar Marshes is lacking. Females were taken in net sweeps in 1973, but have not been collected since. Females of *Ca. impatiens* are thought to overwinter throughout North America (Carpenter and LaCasse, 1955), including Canada (Dyar, 1921), Ontario (Steward and McWade, 1961), Labrador (Haufe, 1952), Newfoundland (Pickavance *et al.*, 1970), and New York (Jamnback, 1969*b*). Immatures are found in a variety of pools, ponds, and puddles in Canada (Dyar, 1921), Ontario (Beckel and Atwood, 1959; James *et al.*, 1969; Steward and McWade, 1961), and New Hampshire (Lowry, 1929). Females bite readily at any time of the day in Ontario (Steward and McWade, 1961) and feed on man throughout much of its range in North America (Carpenter and LaCasse, 1955), including Quebec (Jenkins and Knight, 1950). McDaniel (1975) reported that this species rarely or never bites man in Maine. *Culiseta impatiens* is apparently uncommon in New England (Barnes *et al.*, 1950; Fellton *et al.*, 1950; Jamnback, 1969*b*).

The literature indicates that this species is not a serious pest anywhere in eastern North America.

Culiseta morsitans

This species overwinters in the egg stage and is bivoltine, although Twinn (1931) earlier reported it to be univoltine in eastern Canada. In the Nova Scotia-New Brunswick border region, immatures of this species are apparently restricted to permanent marshes. Meyer (1974) collected larvae in permanent water along the shore of Front Lake (Fig. 2, pp. 17-18). Carpenter and LaCasse (1955) reported that larvae of *Ca. morsitans* are found in marshes, bogs, and pools throughout much of its range. This has been confirmed by Twinn (1931, 1953) in eastern Canada, Pickavance *et al.* (1970) in Newfoundland, Beckel and Atwood (1959) James *et al.* (1969) and Steward and McWade (1961) in Ontario. Concurrent studies in the Tantramar Marshes indicated that *Ca. morsitans* was one of the most abundant culicids taken in duck baited traps and is a natural vector of *Plasmodium circumflexum* Kikuth (Meyer and Bennett, 1976; Meyer *et al.*, 1974). This species has fed on birds, mammals, reptiles, and amphibians in Massachusetts (Hayes, 1961) but rarely feeds on man in New York (Jamnback, 1969*b*), Ontario (Steward and McWade, 1961), and Labrador (Haufe, 1952). Fellton *et al.* (1950) reported that *Ca. morsitans* is relatively uncommon in New England. Haufe (1952) indicated that females of this species are the overwintering stage in Labrador.

Although females of *Ca. morsitans* have been reported to feed on a variety of animals in other regions of eastern North America, they are apparently entirely ornithophilic in the Tantramar Marshes. This species could be important in viral disease transmission.

Mansonia perturbans

Mansonia perturbans overwinters in the larval stage in the Nova Scotia-New Brunswick border region (R. Hall, 1974-pers. comm.). This has been observed by Carpenter and LaCasse (1955) throughout North

America, Dyar (1921) in Canada, Jamnback (1969*b*) in New York, Steward and McWade (1961) in Ontario, and Lowry (1929) in New Hampshire. It is univoltine in maritime Canada, as it is in New York (Jamnback, 1969*b*). In the Tantramar Marshes, larval habitats were found to be restricted to marshes or lakes with emergent vegetation. Similar larval habitats were found in Prince Edward Island (Twinn, 1953) and New Hampshire (Lowry, 1929).

Mansonia perturbans is mainly crepuscular in the Maritime Provinces (Table 11, p. 58) but will also feed during the day. It is the most abundant culicid in the Tantramar Marshes (Table 9, p. 53) and its abundance is apparently related to the increasing amount of suitable larval habitat which has been provided by the creation of waterfowl marshes. Carpenter and LaCasse (1955) reported that *M. perturbans* will bite during the day but is most active at night throughout its North American range. This has also been observed by Hayes (1962) in Massachusetts, Dyar (1909) in New Hampshire, Beckel and Atwood (1959) in Ontario, and Twinn (1931) in eastern Canada. It may be a serious pest throughout its North American range (Carpenter and LaCasse, 1955), particularly in areas of New England (Barnes *et al.*, 1950; Fellton *et al.*, 1950; McDaniel, 1975). Dyar (1921) reported *M. perturbans* to be a severe biter and indicated that it may fly several kilometers from its larval habitat. During the present study, bloodfed females were taken from man and domestic pekin ducks (*A. platyrhynchos*) and, since blooded females were frequently collected in dairy barns, it is suggested that they also feed on cattle. Females feed on birds, mammals, reptiles, and amphibians in New York (Means, 1968) while Hayes (1962) reported that they feed on birds, mammals, and reptiles and that they are attracted to amphibians in Massachusetts. Bennett (1960) reported that *M. perturbans* fed on birds in Ontario and Carpenter and

LaCasse (1955) indicated that it is mammalophilic throughout much of its North American range. Downe (1962) found that in Ontario *M. perturbans* had fed on a variety of animals, including cattle, dogs, deer, birds, horses, pigs, rodents, rabbits, raccoons, and man, and that 15% of all specimens of *M. perturbans* contained more than one kind of blood. Downe (1962) also reported that a considerable number of *M. perturbans* attracted to mammals in baited traps did not actually feed, whereas the great majority of specimens attracted to chickens and ducks obtained blood from these birds. About 10% of the specimens attracted to birds had previously obtained at least a partial blood meal from mammals. Meyer and Bennett (1976) and Meyer *et al.* (1974) reported this species to be the most abundant mosquito collected in duck baited traps in the Tantramar Marshes. *Mansonia perturbans* is known to harbor eastern equine encephalitis virus (Hayes, 1961; Howitt *et al.*, 1948; McDaniel, 1975).

Observations on the biology of this species agree with those made by other workers in eastern North America. It is a widespread species but is apparently only a pest in certain areas, probably where there are abundant and suitable larval habitats. Since this species is the most abundant and annoying mosquito of mammals, particularly man, in the Tantramar Marshes and, because it has been incriminated as a vector of eastern equine encephalitis, it offers tremendous potential for the transmission of viral diseases in this area of maritime Canada.

Wyeomyia smithii

Little is known of the biology of this mosquito in the Tantramar Marshes. Immatures were found only in the pitchers of the pitcher plant (*Sarracenia purpurea*). Larvae are probably the overwintering stage.

Wyeomyia smithii is multivoltine in New Hampshire (Lowry, 1929) and overwinters in the larval stage in New Hampshire (Lowry, 1929), Ontario (Smith and Brust, 1971; Steward and McWade, 1961), Labrador (Haufe, 1952), and probably throughout its range in North America (Carpenter and LaCasse, 1955). Immatures have been found only in the pitcher plant *(Sarracenia purpurea)* throughout its North American range (Carpenter and LaCasse, 1955) including Canada (Dyar, 1921), Ontario (Smith and Brust, 1971; Steward and McWade, 1961), Newfoundland (Pickavance *et al.*, 1970), Massachusetts (Lounibos and Bradshaw, 1975), New Hampshire (Lowry, 1929), Connecticut (Wallis and Frempong-Boadu, 1967), New Jersey (Coyne and Hagmann, 1970), and New York (Butts, 1974; Jamnback, 1969*b*; Barnes *et al.*, 1950). Females are autogenous in Ontario (Smith and Brust, 1971) and Connecticut (Wallis and Frempong-Boadu, 1967) and are not known to feed on man throughout North America (Carpenter and LaCassé, 1955) including Canada (Dyar, 1921), Ontario (Steward and McWade, 1961), New York (Jamnback, 1969*b*), New Hampshire (Lowry, 1929), Connecticut (Wallis and Frempong-Boadu, 1967) and Maine (McDaniel, 1975).

On the basis of available evidence, this species probably never feeds on blood; adults were not encountered in nature in maritime Canada.

SIMULIIDAE

Prosimulium mixtum

Prosimulium mixtum is univoltine and overwinters in the larval stage in maritime Canada, as it does in Ontario (Davies *et al.*, 1962; Davies and Syme, 1958), New York (Jamnback, 1969*b*), and Newfoundland (Ezenwa, 1974; Lewis and Bennett, 1973). Immatures have been collected from two streams in the Nova Scotia-New Brunswick border region, but this species probably occurs in all simuliid streams in this area. Peterson (1970) reported immatures from a wide variety of streams throughout Canada. This has been confirmed by Davies and Syme (1958) in Ontario and Lewis and Bennett (1973) in Newfoundland. *Prosimulium mixtum* is usually found in smaller, slower streams than closely related *P. fuscum* across Canada (Peterson, 1970), Ontario (Davies *et al.*, 1962) and Connecticut (Stone, 1964). Females feed on man in the Maritime Provinces and may be a pest during June in wooded areas. Stone (1964) reported that females feed on man and horses in Connecticut. Females are largely or entirely anautogenous and seek a blood meal from man and perhaps other animals soon after emergence in Ontario (L. Davies, 1961; Davies *et al.*, 1962). Lewis and Bennett (1973) indicated that *P. mixtum* may be autogenous in Newfoundland.

Little is known of the biology of this species in maritme Canada, but observations made in this area agree with those made in other regions of eastern North America.

Cnephia mutata

Cnephia mutata is univoltine and probably overwinters in the larval stage in maritime Canada. It is also univoltine and overwinters in the larval stage in Ontario (Davies, 1950), Newfoundland (Ezenwa, 1974; Lewis and Bennett, 1973, 1974*b*), and New York (Stone and Jamnback, 1955). *Cnephia mutata* is also univoltine in Quebec (Wolfe and Peterson, 1959) and Connecticut (Stone, 1964), and Jamnback (1969*b*) also reported it to be univoltine in New York. Larvae also overwinter in Quebec (Mackay, 1969). In the Tantramar Marshes, larvae were taken from one permanent stream, but it is thought that they occur in most of the streams in this area. Immatures have been taken in a variety of temporary and permanent streams in eastern Canada (Twinn, 1936*a*), Quebec (Wolfe and Peterson, 1959), Newfoundland (Lewis and Bennett, 1973, 1974*b*), Connecticut (Stone, 1964), and New York (Stone and Jamnback, 1955). Emerging adults have much stored nutrient and eggs which are approximately half mature in Ontario (Davies and Peterson, 1956; Davies *et al.*, 1962), and while they have been taken feeding on man in maritime Canada, they are rarely annoying to man in Ontario (Davies, 1950) and New York (Jamnback, 1969*b*; Stone and Jamnback, 1955). Adults were taken feeding on deer (Davies and Peterson, 1956) and horses (Davies *et al.*, 1962) in Ontario, and on horses and cattle in Connecticut (Stone, 1964). Pickavance *et al.* (1970) collected a single female from duck bait in Newfoundland.

The biology of this species in the Tantramar Marshes is not well known, but observations which have been made agree with those recorded in the literature from other areas of eastern North America.

Simulium aureum

Simulium aureum is bivoltine in the Nova Scotia–New Brunswick border region, as it is in New York (Stone and Jamnback, 1955), Connecticut (Stone, 1964), Quebec (Wolfe and Peterson, 1959), Newfoundland (Lewis and Bennett, 1973) and Ontario (Davies, 1950; Davies *et al.*, 1962). Ezenwa (1974) reported only one generation in Newfoundland and Twinn (1936*a*) indicated that there may be three generations in eastern Canada. This species overwinters in the egg stage in the Tantramar Marshes, where it occurs in temporary and permanent streams. Eggs also overwinter in Ontario (Davies, 1950; Dunbar, 1958), Quebec (Wolfe and Peterson, 1959), Newfoundland (Lewis and Bennett, 1973), eastern Canada (Twinn, 1936*a*), Connecticut (Stone, 1964), and New York (Stone and Jamnback, 1955).

Immatures of *S. aureum* are found in a variety of small temporary or permanent streams in Ontario (Davies *et al.*, 1962; Dunbar, 1958), Quebec (Mackay, 1969; Wolfe and Peterson, 1959), Newfoundland (Lewis and Bennett, 1974*b*), eastern Canada (Twinn, 1936*a*), Connecticut (Stone, 1964), and New York (Stone and Jamnback, 1955). Females were not taken in the vicinity of man in the Tantramar Marshes, where they are thought to be ornithophilic. Hocking and Richards (1952) reported that females are only rarely attracted to man in Labrador, and Bennett (1960) and Davies *et al.* (1962) reported that *S. aureum* feeds on birds in Ontario (usually in trees) about 6.6 m above ground. It has also been reported to be ornithophilic and a vector of *Leucocytozoon* and *Trypanosoma* in Ontario (Bennett and Fallis, 1960; Fallis and Bennett, 1958, 1962), New York (Jamnback, 1969*b*), and Connecticut (Stone, 1964).

According to the literature, this species is primarily ornithophilic. It has been shown to be a vector of avian haematozoa in many areas of eastern North America and may be a vector in the Tantramar Marshes.

Simulium decorum

This species is multivoltine in maritime Canada; this agrees with observations in Ontario (Davies, 1950; Davies *et al.*, 1962), Quebec (Wolfe and Peterson, 1959), Newfoundland (Ezenwa, 1974; Lewis and Bennett, 1973), Connecticut (Stone, 1964), and New York (Jamnback, 1969*b*). Overwintering is thought to occur in the egg stage in the study area, and it has been demonstrated to do this in Ontario (Davies *et al.*, 1962), Quebec (Wolfe and Peterson, 1959), and Connecticut (Stone, 1964). In the Tantramar Marshes, immatures of *S. decorum* were found in a variety of permanent streams, including outflows from naturally or artificially impounded waters. Similar observations have been reported by Davies *et al.* (1962) in Ontario, Peterson and Wolfe (1958) and Wolfe and Peterson (1959) in Quebec, Hocking and Richards (1952) in Labrador, Lewis and Bennett (1973) in Newfoundland, Stone (1964) in Connecticut, and Jamnback (1969*b*) and Stone and Jamnback (1955) in New York. Adults have been taken flying about and feeding on man in the Tantramar Marshes. Females of *S. decorum* feed on man, deer, and horses in Ontario (Davies *et al.*, 1962) as well as birds (Davies and Peterson, 1956). Jamnback (1969*b*) reported that females are mammalophilic in New York and rarely attack man. *Simulium decorum* feeds on horses, cattle, deer, and birds in Connecticut (Stone, 1964), livestock in Quebec (Downe and Morrison, 1957) and livestock and occasionally man throughout its range in Canada (Shewell, 1957).

Simulium decorum is relatively abundant in streams of the Tantramar Marshes, but adults are rarely encountered flying about man. It would appear from the literature that livestock are the preferred sources of blood for this species in much of eastern North America, and this is probably true in maritime Canada as well.

Simulium latipes

Simulium latipes is bivoltine in maritime Canada and overwinters in the egg stage. It is apparently univoltine in Connecticut (Stone, 1964) and New York (Stone and Jamnback, 1955), but it is bivoltine in Quebec (Peterson and Wolfe, 1958; Wolfe and Peterson, 1959) and Newfoundland (Lewis and Bennett, 1973, 1974*b*). Wolfe and Peterson (1959) reported the larvae of *S. latipes* overwintering in Quebec, but the egg has been shown to be the overwintering stage in Ontario (Davies *et al.*, 1962), Connecticut (Stone, 1964), New York (Stone and Jamnback, 1955), and

Newfoundland (Lewis and Bennett, 1973, 1974*b*). In the Nova Scotia-New Brunswick border area, immatures of *S. latipes* were collected in small temporary and permanent streams. This agrees with observations by Davies *et al.* (1962) in Ontario, Hocking and Richards (1952) in Labrador, Wolfe and Peterson (1959) in Quebec, Lewis and Bennett (1974*b*) in Newfoundland, Twinn (1936*a*) in eastern Canada, Stone (1964) in Connecticut, and Stone and Jamnback (1955) in New York. No adults have been taken near man in the Tantramar Marshes, where it is thought to be ornithophilic. Downes *et al.* (1962) reported that although *S. latipes* usually feeds on birds in Ontario it will attack several mammals, including man. Pickavance *et al.* (1970) collected *S. latipes* from birds in Newfoundland. Wolfe and Peterson (1959) reported that it made no attempt to feed on man in Quebec. Other workers including Anderson (1956), Bennett (1960), Bennett and Fallis (1960), Davies and Peterson (1956), Davies *et al.* (1962), Fallis and Bennett (1958, 1962) in Ontario, and Jamnback (1969*b*) in New York, have indicated that *S. latipes* feeds on birds and demonstrated its vector potential.

Although this species will attack mammals, it is essentially ornithophilic. Its vector potential is well documented in the literature and it may be shown to be a vector of avian haematozoa in the Tantramar Marshes.

Simulium tuberosum

Simulium tuberosum is multivoltine in maritime Canada and probably overwinters in the egg stage. Ezenwa (1974) and Lewis and Bennett (1973, 1974*b*) reported that it is bivoltine in Newfoundland. Jamnback *et al.* (1971) indicated that it is multivoltine throughout its range in North America. This has been confirmed in Ontario (Davies *et al.*, 1962), New York (Stone and Jamnback, 1955), Connecticut (Stone, 1964), and Quebec (Wolfe and Peterson, 1959). Eggs are the overwintering stage in Newfoundland (Lewis and Bennett, 1973, 1974*b*), Ontario (Davies *et al.*, 1962), Connecticut (Stone, 1964), and New York (Jamnback, 1952; Stone and Jamnback, 1955). Immatures have been collected from a variety of streams in the Nova Scotia-New Brunswick border region and in Ontario (Davies *et al.*, 1962), Labrador (Hocking and Richards, 1952), Newfoundland (Lewis and Bennett, 1973, 1974*b*) and Connecticut (Stone, 1964). Females are not usually very abundant in the Tantramar Marshes, but have been taken flying about man and feeding on man. *Simulium tuberosum* is primarily mammalophilic, feeding on man in Labrador (Hocking and Richards, 1952), Quebec (Wolfe and Peterson, 1959), Newfoundland (Lewis and Bennett, 1973), New York (Jamnback, 1969*b*; Stone and Jamnback, 1955) and Connecticut (Stone, 1964), and on livestock in Quebec (Downe and Morrison, 1957).

Observations on the biology of this species in the Tantramar Marshes generally agree with those made by other workers in eastern North America. It appears to be multivoltine throughout North America but it is bivoltine in Newfoundland.

Simulium venustum and *Simulium verecundum*

The *S. venustum-verecundum* complex is multivoltine in maritime Canada and overwinters in the egg stage. These observations are in agreement with those of Davies *et al.* (1962) in Ontario, Ezenwa (1974) and Lewis and Bennett (1973, 1974*b*) in Newfoundland, Jamnback (1969*b*) in New York, and Jamnback *et al.* (1971) throughout North America. Davies (1950) also reported these species to be multivoltine in Ontario, as did Peterson and Wolfe (1958) and Wolfe and Peterson (1959) in Quebec, Twinn (1930*b*) in eastern Canada, and Stone and Jamnback (1955) in New York.

This species complex has been found in all streams which support simuliid populations in the Nova Scotia-New Brunswick border region. Immatures of *S. venustum-verecundum* have been found in a variety of small and large temporary and permanent streams throughout its range, including Ontario (Davies *et al.*, 1962), Labrador (Hocking and Richards, 1952), Quebec (Peterson and Wolfe, 1958; Wolfe and Peterson, 1959), Newfoundland (Lewis and Bennett, 1973, 1974*b*), eastern Canada (Twinn, 1936*b*), and Connecticut (Stone, 1964). In the Tantramar Marshes, females of this complex may be taken throughout the summer flying about man and feeding on man. The *S. venustum-verecundum* complex accounts for about 69% of the simuliids attracted to man in the Maritime Provinces, and they are major pests of man and livestock throughout much of their ranges in Canada (Shewell, 1957), Ontario (Davies *et al.*, 1962 ; Teskey, 1960), Quebec (Downe and Morrison, 1957; Peterson and Wolfe, 1958; Wolfe and Peterson, 1959), Newfoundland (Lewis and Bennett, 1973, Pickavance *et al.*, 1970), eastern Canada (Twinn, 1936*b*), Connecticut (Stone, 1964), and New York (Jamnback, 1969*b*; Stone and Jamnback, 1955). Adults have also been taken from birds in Ontario (Davies and Peterson, 1956), Quebec (Peterson and Wolfe, 1958), Newfoundland (Pickavance *et al.*, 1970), and Connecticut (Stone, 1964).

Observations of this species complex in the Tantramar Marshes agree with those made in other regions in eastern North America. Due to the taxonomic problems involved with *S. venustum* and *S. verecundum*, these species may be behaviorally quite different and much of the literature to date may contain misleading information on the biology of these species.

Simulium vittatum

Simulium vittatum is multivoltine in the Nova Scotia-New Brunswick border area, and probably overwinters in the egg stage. It is also multivoltine in Ontario (Chutter, 1970; Davies, 1950; Davies *et al.*, 1962), Quebec (Peterson and Wolfe, 1958; Wolfe and Peterson, 1959), Newfoundland (Ezenwa, 1974; Lewis and Bennett, 1973), eastern Canada (Twinn, 1936*b*), Connecticut (Stone, 1964), and New York (Stone and Jamnback, 1955). Overwintering may occur in the larval stage in Ontario (Chutter, 1970; Davies *et al.*, 1962), eastern Canada (Twinn, 1936*b*), and New York (Stone and Jamnback, 1955), or in the egg stage as in Quebec (Wolfe and Peterson, 1959), Newfoundland (Lewis and Bennett, 1973), and Connecticut (Stone, 1964). Immatures of this species have been found in a variety of temporary and permanent streams in the Tantramar Marshes, confirming observations by Davies *et al.* (1962) in Ontario, Peterson and Wolfe (1958) in Quebec, Lewis and Bennett (1973) in Newfoundland, and Twinn (1936*b*) in eastern Canada. Females of *S. vittatum* have been taken feeding on man in the Maritime Provinces, but it is thought to be more of a pest of cattle. This species apparently varies in its feeding habits throughout its range, but man, horses, and domestic animals are the preferred sources of blood throughout Canada (Shewell, 1957), Ontario (Davies *et al.*, 1962; Teskey, 1960), Quebec (Downe and Morrison, 1957), Labrador (Hocking and Richards, 1952), Newfoundland (Lewis and Bennett, 1973; Pickavance *et al.*, 1970), eastern Canada (Twinn, 1936*b*), New York (Jamnback, 1969*b*; Stone and Jamnback, 1955), and Connecticut (Stone, 1964).

Although this species is widely mammalophilic throughout eastern North America, it is thought that cattle are the chief source of blood for this species in the Nova Scotia-New Brunswick border region.

Generally, the known biology of *S. vittatum* is similar throughout its eastern North American range.

TABANIDAE

Chrysops aestuans

This deer fly is uncommon in the Nova Scotia-New Brunswick border area, as it is in New York (Pechuman, 1972). Adults were collected from late June until late July in the Tantramar Marshes, and from early June to late August in New York (Pechuman, 1972). James (1963) reported that adult emergence occurs from early June until early August in Ontario, and Pechuman *et al.* (1961) reported that adults were collected from early June to late August. Pechuman (1964) recorded this species from Quebec. This species feeds on man in the Tantramar Marshes, and has also been taken in cages containing domestic pekin ducks (*A. platyrhynchos*). The feeding habits of this species in other regions of eastern North America have not been recorded. Larval habitats border large bodies such as cattail marshes and muddy banks of streams in Ontario (James, 1963; Teskey, 1969), and New York (Pechuman, 1972).

The literature contains very little information on the biology of this species in eastern North America. Longevity of this species in the Tantramar Marshes is much shorter than in Ontario or New York.

Chrysops ater

This deer fly is uncommon in the Tantramar Marshes, but is rather abundant in New York (Matthysse *et al.*, 1974; Pechuman, 1972; Pechuman and Burton, 1969). Adults are encountered from early June through mid July in the Nova Scotia-New Brunswick border area, and from late May or early June until mid or late June in New York (Matthysse *et al.*, 1974; Pechuman and Burton, 1969). *Chrysops ater* is uncommon in Ontario where specimens were collected in early July (Smith *et al.*, 1970). This species feeds on man in the Tantramar Marshes, and may be annoying to man in New York (Pechuman and Burton, 1969). Pechuman (1972) indicated that larvae were found in mud and organic matter along streams in New York.

Observations, although few, of *C. ater* in the Tantramar Marshes agree with those made by other workers in eastern North America.

Chrysops calvus

Chrysops calvus is relatively uncommon in the Nova Scotia-New Brunswick border region. This agrees with observations in Ontario (Smith *et al.*, 1970), New Jersey (Thompson, 1969*b*), and areas of New York (Matthysse *et al.*, 1974). Pechuman and Teskey (1967) reported *C. calvus* from four provinces, including Nova Scotia and New Brunswick, and 15 states. Adults may be taken from mid June until early August in the Tantramar Marshes and feed on man and cattle during this time. Smith *et al.* (1970) recorded females of *C. calvus* feeding on man and moose, and Pechuman (1972) and Pechuman and Burton (1969) indicated that it may be a pest in some areas of New York. Larvae were taken from saturated clay soil on the banks of a pool in a flood channel of a brook in New York (Teskey, 1969).

Generally, *C. calvus* is relatively uncommon throughout eastern North America, including the Nova Scotia-New Brunswick border region.

Chrysops carbonarius

Chrysops carbonarius is uncommon in the Nova Scotia-New Brunswick border area although McIntosh (1903) reported that it was quite common during June and July in New Brunswick. It is also uncommon in Ontario (Davies, 1959; Smith *et al.*, 1970) and New York (Matthysse *et al.*, 1974; Pechuman and Burton, 1969). Adults may be collected throughout July in the Tantramar Marshes, while in Ontario they may be encountered from late May (Pechuman *et al.*, 1961) until mid July (Davies, 1959; Smith *et al.*, 1970), and from May through August in New York (Pechuman, 1972). James (1963) indicated that adult emergence occurred from late May until early June in Ontario. Robert (1958) reported that *C. carbonarius* may be very abundant from late May to late July in Quebec. Philip (1962) recorded this species from Newfoundland and Labrador. In the Tantramar Marshes, this species has been collected only in the vicinity of man. Smith *et al.* (1970) reported that *C. carbonarius* is exclusively sylvan, and indicated that it feeds on man and deer. Bennett (1960) reported that *C. carbonarius* fed naturally on a crow. Larvae have been found in sandy soil and saturated habitats on the banks of streams and ponds in New York (Pechuman, 1972; Teskey, 1969), Ontario and Vermont (Teskey, 1969).

The known biology of this species in maritime Canada agrees closely with observations made by other workers in eastern North America. Longevity of this species in the Tantramar Marshes is much shorter than in Ontario, Quebec, and New York.

Chrysops dacilux

This species is uncommon in the Tantramar Marshes and in New York (Matthysse *et al.*, 1974), although it is apparently abundant in Quebec (Robert, 1958). Adults may be taken from mid June until the end of July in the Nova Scotia-New Brunswick border region, from June through late July in Quebec (Robert, 1958), from mid May (Jamnback, 1969*b*) to July (Pechuman, 1972) in New York, and mid May to late July in Ontario

(Pechuman *et al.*, 1961). Females feed on man in the Tantramar Marshes, Ontario (Smith *et al.*, 1970), and New York (Jamnback, 1969*b*). Smith *et al.* (1970) reported that adults are exclusively sylvan in Ontario and also feed on deer and moose. Davies (1959) found *C. cuclux* feeding on a recently killed deer in Ontario, and Jamnback (1969*b*) reported this species feeding on livestock in New York. It is thought to be capable of facultative autogeny in Ontario (Troubridge and Davies, 1975). Larvae are found in wet mud along streams and occasionally from pond margins in Ontario (Teskey, 1969) and New York (Pechuman, 1972; Teskey, 1969).

Observations of *C. cuclux* in the Tantramar Marshes are similar to those made by other workers in various regions of eastern North America.

Chrysops excitans

Chrysops excitans is not usually very abundant in the Tantramar Marshes, although McIntosh (1903) reported that it was a very common deer fly in New Brunswick. It is not abundant in New York (Pechuman, 1972) but it is relatively abundant in Quebec (Robert, 1958), Ontario (Bennett and Smith, 1968; Davies, 1959; Smith *et al.*, 1970), and Newfoundland, where females are encountered in large numbers flying over *Sphagnum* bogs (author's data). Adults may be taken from late June until early August in the Nova Scotia-New Brunswick border area, from early June until late August in Quebec (Robert, 1958), from late May (Pechuman *et al.*, 1961; Davies, 1959) until mid August (Smith *et al.*, 1970) in Ontario, and during June through August in New York (Pechuman, 1972). Females feed on man and cattle in the Tantramar Marshes, and is a pest of man in Ontario (Smith *et al.*, 1970) and New York (Jamnback, 1969*b*; Pechuman, 1972). Smith *et al.* (1970) indicated that *C. excitans* is a pest of deer and moose in Ontario and collected specimens from a captive robin. Also in Ontario, Bennett (1960) collected *C. excitans* which had fed naturally on a raven. Larvae are found in mud and organic detritus along the edges of pools, ponds, and lakes in Ontario (Teskey, 1969) and New York (Pechuman, 1972; Teskey, 1969).

According to the literature, *C. excitans* does not appear to vary substantially in its life history throughout its eastern North American range.

Chrysops frigidus

Chrysops frigidus is the second most abundant deer fly in the Nova Scotia–New Brunswick border region. It accounted for 23.5% of the *Chrysops* collected, and 8.6% of the total tabanid population. It is also abundant in Ontario (Smith *et al.*, 1970) and New Jersey (Thompson, 1969*b*), but it is relatively uncommon in areas of New York (Matthysse *et al.*, 1974; Pechuman, 1972). Philip (1962) recorded this species in Labrador and Pechuman (1964) recorded it from Quebec. Adults may be collected from late June until late August in the Tantramar Marshes, mid June until late August in Ontario (Smith *et al.*, 1970), from early June until mid September in New Jersey (Thompson, 1969*b*), and from May until September in New York (Pechuman, 1972). James (1963) found adults emerging during late July in Ontario where they may be taken from early May until late August (Pechuman *et al.*, 1961). Most of the adults encountered in the Tantramar Marshes were taken while flying about man; however, this species was the most abundant deer fly taken feeding on cattle. Smith *et al.* (1970) reported *C. frigidus* feeding on man, deer, moose, and captive elk in Ontario. Larval habitats are usually mossy substrates in bogs, swamps, and along margins of streams and ponds in Ontario (James, 1963; Teskey, 1969), New York (Pechuman, 1972), and Vermont (Teskey, 1969).

According to the literature, *C. frigidus* is a relatively abundant deer fly throughout most areas of eastern North America; however, it is collected during a slightly shorter period during the summer in the Tantramar Marshes than in Ontario, New York, and New Jersey.

Chrysops fuliginosus

This species is very uncommon in the Tantramar Marshes; only four specimens were collected and these were all taken in the vicinity of man. *Chrysops fuliginosus* is usually found in the vicinity of salt marshes along the coast of New York (Jamnback, 1969*b*; Pechuman, 1972). Jamnback and Wall (1959) indicated that this species may be abundant in some areas of that state and Anderson (1973) reported that it is abundant in Connecticut. Adults were taken from late June until early August in the Tantramar Marshes, from late May to late June in New Jersey (Hansens and Robinson, 1973), and May to September in New York (Pechuman, 1972). Rockel and Hansens (1970) reported that adult emergence occurs from late May to late June in New Jersey. Jamnback (1969*b*) indicated that adults are annoying for about a month in New York, and Anderson (1973) reported that females of *C. fuliginosus* land mainly on the head and the back of the neck. Rockel (1969) reported autogeny in females of *C. fuliginosus* in New Jersey. Larvae of this species are found in salt marshes in New York (Jamnback, 1969*b*; Pechuman, 1972), and New Jersey (Freeman and Hansens, 1972; Rockel and Hansens, 1970). Rockel and Hansens (1970) also indicated that larval populations of *C. fuliginosus* were highest below mean high water level on sloping banks where cord grass, *Spartina alterniflora* Loisel, was about 0.6 m tall.

Chrysops fuliginosus is apparently restricted to salt marshes in eastern North America and, for this reason, is uncommon inland. Published information on the biology of this deer fly in eastern North America is based on studies carried out in coastal areas.

Chrysops furcatus

Chrysops furcatus is the fourth most abundant deer fly in the Nova Scotia-New Brunswick border region, yet it accounted for only 5.3% of the deer flies collected. This species is uncommon in Quebec (Robert, 1958) and has been recorded from Newfoundland and Labrador (Philip, 1962). Adults may be taken from late June until early August in the Tantramar Marshes, from late June until late July in Quebec (Robert, 1958), and from late June until mid August in Ontario (Pechuman *et al.*, 1961). Females have been taken feeding on man and cattle in the Tantramar Marshes and one specimen was taken from a bird. Feeding habits of this species in other areas of eastern North America are not recorded. Larvae were taken from a saturated peaty-clay soil beside a water-filled man-made excavation in Ontario (Teskey, 1969).

Very little information is available on the biology of this deer fly in eastern North America. *Chrysops furcatus* feeds on man and cattle in the Tantramar Marshes, and this probably occurs in other areas of eastern North America.

Chrysops lateralis

Chrysops lateralis is the third most abundant deer fly in the Nova Scotia-New Brunswick border area and accounted for 10.1% of the deer flies collected. McIntosh (1903) reported taking this species in limited numbers during July in New Brunswick. *Chrysops lateralis* is rare in New Jersey (Thompson, 1969*b*) and uncommon in Ontario (Smith *et al.*, 1970) and New York (Pechuman, 1972; Pechuman and Burton, 1969; Matthysse *et al.*, 1974) although it is abundant in the Adirondacks (Pechuman, 1972). Adults may be taken from late June until early August in the Tantramar Marshes, from late June until late July in New York (Pechuman and Burton, 1969), and from early June (Pechuman *et al.*, 1961) until late August (Smith *et al.*, 1970) in Ontario. James (1963) reported that adult emergence occurs from late June until early July in Ontario. This species is often taken flying about man and feeding on man in Ontario (Smith *et al.*, 1970) and New Jersey (Thompson, 1969*b*), and also on deer and moose in Ontario (Smith *et al.*, 1970). Jamnback (1969*b*) reported that *C. lateralis* is an occasional pest of man and/or livestock in New York. Smith *et al.* (1970) indicated that this deer fly is exclusively sylvan. Larvae have been found in the muddy banks of streams in Ontario (James, 1963).

Observations of *C. lateralis* in the Tantramar Marshes are very similar to those made by other workers in eastern North America; however, unlike other regions of eastern North America, this deer fly is relatively abundant in the Tantramar Marshes.

Chrysops mitis

Chrysops mitis is the most abundant deer fly in the Nova Scotia-New Brunswick border area. It accounts for 40.1% of the *Chrysops* population and 14.6% of the tabanid population. This species is widely distributed in Quebec (Robert, 1958) and abundant in Ontario (Smith *et al.*, 1970). Philip (1962) recorded it from Newfoundland and Labrador. Adults may be collected from early June until early August in the Tantramar Marshes and in Quebec (Robert, 1958), from late May until early August in Ontario (Pechuman *et al.*, 1961), and from mid May until late July in

New York (Jamnback, 1969*b*; Pechuman, 1972). *Chrysops mitis* was the most abundant deer fly feeding on man in the Tantramar Marshes, and females have also been taken feeding on cattle and found in cages containing domestic pekin ducks *(A. platyrhynchos)*. Pechuman (1972) indicated that *C. mitis* is an early season pest in New York, while Smith *et al.* (1970) collected specimens feeding on man, deer, and moose. Davies (1959) obtained specimens feeding on a recently killed deer in Ontario. Larvae have been found in highly organic substrates on the edges of ponds, streams, swamps, and marshes in Ontario (Teskey, 1969) and New York (Pechuman, 1972; Teskey, 1969).

Observations of *C. mitis* in the Tantramar Marshes are similar to those made by other workers in eastern North America. According to the literature, larvae of this deer fly are found in highly organic substrates; this probably accounts for its abundance in the Tantramar Marshes.

Chrysops niger

This species is relatively uncommon in the Nova Scotia-New Brunswick border region. It is widely distributed in New York (Pechuman, 1972), but it is uncommon in New Jersey (Thompson, 1969*b*), Ontario (Davies, 1959; Smith *et al.*, 1970), and Quebec (Robert, 1958). Adults may be taken from late June until late July in the Tantramar Marshes, from late May until late July in Quebec (Robert, 1958), and May through September in New York (Pechuman, 1972). James (1963) reported adult emergence occurring from mid June until early July in Ontario, while Smith *et al.* (1970) reported that adults may be taken from early June until early August. Adults feed on man and have been taken flying about cattle in the Tantramar Marshes. *Chrysops niger* can be a pest of man in New York (Pechuman, 1972; Pechuman and Burton, 1969) and Ontario (Smith *et al.*, 1970). Smith *et al.* (1970) indicated that this species is preferentially sylvan in Ontario and collected specimens feeding on deer, moose, and captive mule deer. It is apparently autogenous in Ontario (Troubridge and Davies, 1975). Larvae are found in a variety of semi-aquatic habitats along streams, pools, lakes, swamps, and bogs in Ontario, Vermont, New Jersey (Teskey, 1969) and New York (Pechuman, 1972; Teskey, 1969).

Chrysops niger is pestiferous in Ontario and New York, but it is not a serious pest in the Tantramar Marshes. Longevity of this species is of a shorter duration in the Tantramar Marshes than in other regions of eastern North America.

Chrysops shermani

Only one specimen of *C. shermani* was collected in the Nova Scotia-New Brunswick border area; it was netted while flying about man in early July, 1973. This species is uncommon in Ontario (Davies, 1959; Smith *et al.*, 1970) and may be abundant in mountainous areas of New York (Jamnback, 1969*b*; Pechuman, 1972). Pechuman (1964) recorded it from Quebec. Adults may be taken from June through August in New York (Pechuman, 1972; Pechuman and Burton, 1969), and from early June (Davies, 1959; Pechuman *et al.*, 1961) until mid September (Smith *et al.*, 1970) in Ontario. Pechuman (1972) and Jamnback (1969*b*) reported that *C. shermani* may be very annoying late in the season in New York. Smith *et al.* (1970) reported that this species is primarily sylvan and that females were taken feeding on man, deer, and a dead black bear. Pechuman (1972) indicated that *C. shermani* is an aggressive species and observed it attempting to bite during heavy rain. Teskey (1969) found larvae in a small denuded sand bar in a Vermont river.

This species is rare in the Nova Scotia-New Brunswick border region; its larval habitats may be uncommon in this area.

Chrysops sordidus

This species is also very uncommon in the Nova Scotia-New Brunswick border region. One specimen was collected flying about man in late June, 1975. *Chrysops sordidus* is uncommon in Quebec (Robert, 1958), Ontario (Smith *et al.*, 1970) and New York, where it is restricted to the Adirondacks (Jamnback, 1969*b*; Pechuman, 1972). Philip (1962) recorded this species from Newfoundland and Labrador. Adults have been taken during June and July in Quebec (Robert, 1958), early June until early July in Ontario (Pechuman *et al.*, 1961) and from June until August in New York (Pechuman, 1972). This deer fly is apparently uncommon throughout eastern North America and very little is known of its biology.

Chrysops zinzalus

Chrysops zinzalus is an uncommon deer fly in maritime Canada. Only five specimens were collected between late June and mid August, and most of these were netted about man. This species is uncommon in New Brunswick, Nova Scotia, Maine, Vermont and New York (Pechuman, 1972). Philip *et al.* (1973) reported that this species also occurs in New Hampshire. Adults may be taken in mixed spruce hardwood forests and sphagnum bogs (Philip *et al.*, 1973).

This deer fly is also uncommon in eastern North America and little of its biology is known.

Hybomitra affinis

Hybomitra affinis is the third most abundant horse fly in the Nova Scotia-New Brunswick border area. It is widely distributed in Quebec (Robert, 1958), relatively uncommon in New York (Jamnback, 1969*b*; Pechuman, 1972), and fairly abundant in Ontario (Smith *et al.*, 1970). Philip (1962) recorded *H. affinis* from Newfoundland and Labrador. Adults may be taken from mid June until early August in maritime Canada, during June and early July in New York (Jamnback, 1969*b*; Pechuman, 1972), early June until mid July in Quebec (Robert, 1958), and from late May until August in Ontario (Pechuman *et al.*, 1961). James (1963) reported that adult emergence occurred during mid June in Ontario. Adults have been collected flying about man and cattle and feeding on cattle in the Tantramar Marshes. Smith *et al.* (1970) reported that *H. affinis* is mainly sylvan and indicated that it almost never approached man, and rarely deer, but was the most severe pest of moose in Ontario. They also reported taking a single specimen from captive elk. Larvae are found in moss and muck around pools and ponds, in swamps and in sphagnum bogs in Ontario (James, 1963; Teskey, 1969) and New York (Pechuman, 1972).

Observations of *H. affinis* in the Tantramar Marshes agree with those made by other workers in eastern North America. It is apparently abundant in eastern Canada, but uncommon in the eastern United States.

Hybomitra epistates

Hybomitra epistates is the most abundant tabanid of the Nova Scotia-New Brunswick border region. It accounts for 32.9% of the *Hybomitra* population and 20.9% of the total tabanid population. This species is common in Ontario (Davies, 1959) where it is the most abundant tabanid in certain areas (Bennett and Smith, 1968; Smith *et al.*, 1970). It is also a common tabanid in New York (Jamnback, 1969*b*; Pechuman, 1972), but uncommon in New Jersey (Thompson, 1969*b*) and Quebec (Robert, 1958). Adults may be taken from late June until mid August in the Tantramar Marshes, May to September in New York (Pechuman, 1972), and from mid June to mid September in New Jersey (Thompson, 1969*b*). Adult emergence occurs during late June in Ontario (James, 1963), where adults may be taken until late August (Pechuman *et al.*, 1961; Smith *et al.*, 1970). Adults have been taken feeding on man and flying about cattle in the Tantramar Marshes. Specimens were also taken in cages containing domestic pekin (*A. platyrhynchos*), black (*A. rubripes*), and mallard ducks (*A. platyrhynchos*). Adults have been collected feeding on man in New Jersey (Thompson, 1969*b*) and man, deer, and moose in Ontario (Smith *et al.*, 1970). Adults were collected in emergence cages in cattail marshes in the Tantramar Marshes, suggesting these marshes as probable larval habitats. Larvae are usually collected in swamps and marshes in Ontario, New Jersey (Teskey, 1969) and New York (Pechuman, 1972; Teskey, 1969). James (1963) also reported larvae from banks of slow-moving streams in Ontario.

It appears that *H. epistates* is relatively abundant throughout much of its range in eastern North America. Longevity of this horse fly in the Tantramar Marshes is of a shorter duration than in the eastern United States.

Hybomitra frontalis

Hybomitra frontalis is a fairly abundant horse fly in maritime Canada, although McIntosh (1903) reported that it was rare in New Brunswick, and indicated that it could be collected during August.

Jamnback (1969*b*) recorded *H. frontalis* from New York, Philip (1962) recorded it from Newfoundland and Labrador, and Pechuman (1964) recorded this species from Quebec. Adults may be taken from late June until late August in the Tantramar Marshes, from late June until early August in New York (Pechuman, 1972), and from late June until mid August in Ontario (Pechuman *et al.*, 1961). Adults have been taken feeding on man and cattle in maritime Canada. In New York, Pechuman (1972) found that adults are most common in or near open marshlands, and Jamnback (1969*b*) reported that *H. frontalis* may be an occasional pest of man and/or livestock. Teskey (1969) found larvae in wet moss in swamps in Ontario.

Results of this study indicate that the known life history of *H. frontalis* in the Tantramar Marshes is nearly identical with that recorded for other areas of eastern North America.

Hybomitra illota

Hybomitra illota is a relatively common horse fly in the Nova Scotia-New Brunswick border region. Pechuman (1972) reported that *H. illota* may be abundant in New York, but Matthysse *et al.* (1974) found it to be uncommon. It is abundant in Ontario according to Smith *et al.* (1970) but rare according to Davies (1959). It is also uncommon in New Jersey (Thompson, 19[illegible]). Adults may be taken from mid June until late July in the Tantramar Marshes, May to July in New York (Pechuman, 1972), late May to early August in Ontario (Pechuman *et al.*, 1961), and from early June until early August in Quebec (Robert, 1958). Adults were collected flying about man and cattle in maritime Canada, but feeding records were not established. Females of *H. illota* feed on man and livestock in New York (Jamnback, 1969*b*; Pechuman, 1972), and man, livestock, and moose in Ontario (Smith *et al.*, 1970). Smith *et al.* (1970)

reported that *H. illota* is a riparian species in Ontario and captured specimens from a captive robin and the head of a feral snapping turtle. Larvae may be collected in organic debris and moss on edges of ponds, swamps, and in sphagnum bogs in Ontario (Teskey, 1969) and New York (Pechuman, 1972).

Observations of this species in the Tantramar Marshes are similar to those made by other workers in eastern North America.

Hybomitra itasca

Hybomitra itasca is uncommon in the Nova Scotia–New Brunswick border region. Adults were taken from mid July until mid August in the Tantramar Marshes. Females were taken flying about cattle and man, and feeding on man. Stone *et al.* (1965) indicated that the range of *H. itasca* is Alaska and Saskatchewan to Labrador. Teskey (1969) found larvae from wet sphagnum moss growing in drainage ditches in Ontario. The author is unaware of any other published information on this species in eastern North America. Pechuman (1976-pers. comm.) indicated that he had seen *H. itasca* from Labrador, but had not seen it from Ontario, Quebec, New Brunswick, Nova Scotia, or Prince Edward Island.

Hybomitra itasca has not frequently appeared in tabanid literature of eastern North America. It is presumably uncommon and is apparently recorded here from maritime Canada for the first time.

Hybomitra lasiophthalma

Hybomitra lasiophthalma is the third most abundant tabanid in the Nova Scotia–New Brunswick border region, and accounts for 11.2% of the population. McIntosh (1903) reported that this species was quite abundant during June in New Brunswick. Thompson (1969*b*) found

H. lasiophthalma to be one of the more abundant tabanids in New Jersey and, while Pechuman (1972) recorded it as widely distributed in New York, it is apparently abundant in some areas of that state (Matthysse *et al.*, 1974; Tashiro and Schwardt, 1949). This species is not very abundant in Quebec (Robert, 1958) or Ontario (Davies, 1959; Smith *et al.*, 1970). In the Tantramar Marshes, adults may be taken from mid June until late July. James (1963) reported that adult emergence occurs during late June in Ontario. Adults may be encountered from late May until August in Ontario (Pechuman *et al.*, 1961) and New York (Jamnback, 1969*b*; Pechuman, 1972). In the Tantramar Marshes, *H. lasiophthalma* feeds on cattle and is the most abundant tabanid taken flying about cattle. Adults were also collected while flying about man. This species is preferentially sylvan in Ontario, where it feeds on man, deer, and moose (Smith *et al.*, 1970). It may also be a pest of livestock in Ontario (Teskey, 1960) and New York (Jamnback, 1969*b*; Pechuman, 1972; Tashiro and Schwardt, 1953*c*). Pechuman (1972) reported that it is not unusual to see cattle streaming with blood from the attacks of *H. lasiophthalma* in New York. Troubridge and Davies (1975) suggested that this horse fly may be capable of facultative autogeny in Ontario. Pechuman (1972) also reported that eggs are laid in various plants over moist ground in New York, and Teskey (1969) observed jet-black egg masses on leaves of shrubs and cattails in Ontario. Larvae are most often found in moist or wet soil, but have also been found in pools, bogs, partially dried swamps, marshes, and rotting logs in Ontario (James, 1963; Teskey, 1969), New Jersey (Teskey, 1969), and New York (Pechuman, 1972; Tashiro and Schwardt, 1953*c*; Teskey, 1969).

It appears that cattle are the preferred source of blood for this horse fly throughout much of its range in eastern North America.

Hybomitra liorhina

Hybomitra liorhina is uncommon in the Tantramar Marshes. Only four specimens were collected, one of which was feeding on man. Adults were taken from mid July until mid August. This species may be collected in Ontario from late June until mid August (Pechuman *et al.*, 1961). Pechuman (1964) recorded it from Quebec and Philip (1962) reported it from Labrador.

Hybomitra liorhina does not appear to be very abundant anywhere in eastern North America and very little information on the biology of this species is available.

Hybomitra longiglossa

Only one specimen of *H. longiglossa* was collected in the Nova Scotia-New Brunswick border area. It was netted while flying about man during mid June, 1973. Adults may be taken from early to late June in Ontario (Pechuman *et al.*, 1961). It has also been recorded from Quebec (Pechuman, 1964) and Newfoundland (Philip, 1962).

This is another horse fly which is uncommon in eastern North America and for which very little information is available.

Hybomitra lurida

Hybomitra lurida is an uncommon tabanid in the Nova Scotia-New Brunswick border region. It is also uncommon in Ontario (Smith *et al.*, 1970), Quebec (Robert, 1958) and New York (Jamnback, 1969*b*; Pechuman, 1972). Philip (1962) reported this species from Newfoundland and Labrador. Adults may be taken from mid June until early July in the Tantramar Marshes, late May until late June in New York (Pechuman, 1972), late May until late July in Ontario (Pechuman *et al.*, 1961), and during

June in Quebec (Robert, 1958). Females were collected feeding on man and flying about cattle in maritime Canada, and Smith *et al.* (1970) collected adults from deer and moose in Ontario. Larvae are usually found in sphagnum bogs, but have also been taken in moss in swamps, marshes, and ditches in Ontario, Vermont, and New York (Teskey, 1969).

Hybomitra lurida is a widespread but relatively uncommon horse fly in eastern North America. Observations of this species in the Tantramar Marshes agree with those made by workers in other regions of eastern North America.

Hybomitra nuda

Hybomitra nuda is relatively abundant in the Tantramar Marshes and is one of the most abundant horse flies in Quebec (Robert, 1958). It is apparently uncommon in Ontario (Davies, 1959; Smith *et al.*, 1970) and New York (Pechuman, 1972). Adults were taken from early June until mid July in maritime Canada, early June until mid August in Quebec (Robert, 1958), and May through July in New York (Pechuman, 1972). James (1963) reported that adult emergence occurs during mid June in Ontario, where adults may be taken from late May until late July (Pechuman *et al.*, 1961). Females of *H. nuda* were most numerous in barns in the Tantramar Marshes, but were frequently netted about man. Smith *et al.* (1970) reported that this species is exclusively sylvan in Ontario, and collected adults feeding on man, deer, and moose. Pechuman (1972) and Jamnback (1969*b*) indicated that males have been found hovering on mountain tops and in forest clearings. Larvae are most commonly found in wet moss in swamps and in leaf debris at the margin of a pool, and have been taken in Ontario (James, 1963; Teskey, 1969) and New York (Pechuman, 1972).

Observations of *H. nuda* in the Tantramar Marshes do not differ significantly from those made by workers in other regions of eastern North America.

Hybomitra trepida

Hybomitra trepida is an uncommon horse fly in the Nova Scotia-New Brunswick border area. It is also uncommon in New York (Matthysse *et al.*, 1974), but it is apparently common in the Adirondacks (Jamnback, 1969*b*; Pechuman, 1972). Smith *et al.* (1970) reported that *H. trepida* is common in Ontario, where Davies (1959) reported that it was abundant. Adults may be collected from late June until late July in maritime Canada and during June and July in New York (Pechuman, 1972). James (1963) reported that adult emergence occurs during mid July in Ontario where adults may be taken from June until late August (Pechuman *et al.*, 1972). Adults have been taken flying about man and cattle in the Tantramar Marshes. Man is a good host for *H. trepida* in Ontario, but adults have also been taken from deer, moose, and captive elk (Smith *et al.*, 1970). This species is mainly sylvan in Ontario (Smith *et al.*, 1970) and is commonly collected in the vicinity of sphagnum bogs in New York (Pechuman, 1972). Larvae have been found in moss in sphagnum bogs, swamps, and in the banks of slow-moving streams in Ontario (James, 1963; Teskey, 1969) and New York (Pechuman, 1972).

This horse fly is relatively uncommon in the Tantramar Marshes, whereas the literature indicates that it is abundant in many areas of eastern North America. It is unknown why this species is uncommon in the Nova Scotia-New Brunswick border region.

Hybomitra typhus

Two forms of *H. typhus*, both uncommon, have been collected in the

Nova Scotia-New Brunswick border region. Pechuman (1972) has observed variability within this species in New York, and Pechuman *et al.* (1961) indicated that two forms of *H. typhus* occur in Ontario. *Hybomitra typhus* is widely distributed in New York (Pechuman, 1972) but is common only in the mountainous areas of that state (Jamnback, 1969*b*; Pechuman, 1972). Matthysse *et al.* (1974) also found it to be abundant in New York. It is common (Davies, 1959) or relatively abundant (Smith *et al.*, 1970) in Ontario, while it is uncommon in Quebec (Robert, 1958) and New Jersey (Thompson, 1969*b*). Philip (1962) recorded *H. typhus* from Newfoundland. Adults were taken from early July to late August in the Tantramar Marshes and from late June until early August in New York (Pechuman, 1972; Pechuman and Burton, 1969). James (1963) reported that adult emergence occurs during mid July in Ontario, where adults may be taken from early July until late August (Smith *et al.*, 1970). Females of *H. typhus* Form A were taken flying about man and cattle and feeding on cattle in the Tantramar Marshes while *H. typhus* Form B was taken only in barns. Smith *et al.* (1970) reported that *H. typhus* was preferentially sylvan in Ontario and collected specimens feeding on man, deer, and moose. Jamnback (1969*b*) and Pechuman (1972) reported that this species will attack man and livestock in New York. Larvae have been found in wet moss in sphagnum bogs, in swamps, and at the edges of ponds, lakes, and streams in Ontario (James, 1963; Teskey, 1969) and New York (Pechuman, 1972).

Hybomitra typhus apparently occurs in two forms in eastern North America. When more information is known, the two forms of this species may be shown to be quite different ecologically.

Hybomitra zonalis

Hybomitra zonalis is an uncommon horse fly in the Nova Scotia-

New Brunswick border region. It is also uncommon in Quebec (Robert, 1958), Ontario (Smith *et al.*, 1970) and New York (Jamnback, 1969*b*; Pechuman, 1972). Pechuman (1972) reported examining a specimen from New Jersey and Philip (1962) reported *H. zonalis* from Newfoundland and Labrador. In the Tantramar Marshes adults may be collected for a month beginning in early July. Adults may be taken from early June until late July in Ontario (Pechuman *et al.*, 1961) and during June and July in New York (Pechuman, 1972). Females were taken flying about man and feeding on cattle in the Tantramar Marshes. Smith *et al.* (1970) collected adults in Ontario from man, deer, and moose. Davies (1959) reported that *H. zonalis* had the tendency to fly low and dwell near water in Ontario. Teskey (1969) reported the larvae from sphagnum bogs.

This horse fly is apparently uncommon throughout eastern North America, and the reported biology of this species within this area does not differ significantly from one region to another.

Tabanus nigrovittatus

This is an abundant horse fly in many of the coastal areas of the Maritime Provinces, although it is rarely encountered very far inland. Only four specimens were taken in the research area which is approximately 8.0 km from the nearest salt marsh where larvae of *T. nigrovittatus* probably occur. This horse fly is commonly referred to as the "saltmarsh greenhead" in New York (Jamnback, 1969*b*; Jamnback and Wall, 1959; Pechuman, 1972) and New Jersey (Hansens, 1952). It is common, and at times abundant, in coastal areas of Connecticut (Wallis, 1962), New Jersey (Joyce and Hansens, 1968), and New York (Jamnback, 1969*b*; Jamnback and Wall, 1959; Pechuman, 1972). Adults may be taken from mid July until the end of August in maritime Canada, and from June to September in New York

(Pechuman, 1972). Adult emergence occurs from late June through late August in New Jersey (Rockel and Hansens, 1970). Females taken in the study area were flying about man and feeding on man, as were specimens in coastal areas of all three Maritime Provinces. This species is a frequent and annoying visitor to the towns of Amherst, Nova Scotia and Sackville, New Brunswick. This horse fly does not seek to travel inland any appreciable distance in New York (Jamnback, 1969*b*), and is especially attracted to bathers (Pechuman, 1972). Jamnback and Wall (1959) also reported that *T. nigrovittatus* is a serious pest of man in New York, and Pechuman (1972) indicated that domestic animals may also be bothered by this tabanid. Larvae have been found in level ditched salt marshes in New York (Jamnback, 1969*b*; Jamnback and Wall, 1959; Pechuman, 1972), and New Jersey (Freeman and Hansens, 1972; Rockel and Hansens, 1970; Teskey, 1969). Jamnback and Wall (1959) found larvae to be most abundant in areas of coastal New York where *Spartina alterniflora* was the dominant vegetation. Rockel and Hansens (1970) indicated that larval populations in New Jersey were highest on sloping banks where cord grass (*S. alterniflora*) was about 0.6 m tall.

The literature indicates that *T. nigrovittatus* is a serious pest in most coastal areas of maritime Canada and the New England States. It does not usually fly very far inland.

Tabanus novaescotiae

Tabanus novaescotiae appears to be a rare tabanid in the Nova Scotia-New Brunswick border area. One specimen was taken while flying about a truck in the Tintamarre National Wildlife Area and one specimen was collected while flying about man in Tidnish, Nova Scotia. Both were collected in mid August of different years. McIntosh (1903) collected several specimens in New Brunswick during July and August. *Tabanus novaescotiae* is widely distributed in New York (Pechuman, 1972) but it is uncommon (Jamnback, 1969*b*; Matthysse *et al.*, 1974; Pechuman, 1972; Pechuman and Burton, 1969). Pechuman (1964) recorded this species from Quebec, and it is also found in Ontario (Pechuman *et al.*, 1961). The larva of *T. novaescotiae* has not been recorded but Pechuman (1972) found a freshly emerged adult in an overgrown sphagnum bog in New York.

This horse fly is uncommon throughout its reported eastern North American range, and very little information on the biology of this species is available.

Tabanus similis

Tabanus similis is uncommon in the Nova Scotia-New Brunswick border area. It is also uncommon in New Jersey (Thompson, 1969*b*) although it is abundant in areas of New York (Matthysse *et al.*, 1974). Pechuman (1964) recorded *T. similis* from Quebec. Adults have been taken only during early June in the Tantramar Marshes. James (1963) reported that adults emerge during early July in Ontario, where they may be collected from June through August (Pechuman *et al.*, 1961). Adults have also been taken from June through August in New York (Pechuman, 1972; Pechuman and Burton, 1969). All specimens of *T. similis* collected in the Tantramar Marshes were taken while flying about cattle, although a specimen taken at Murray Corner, New Brunswick, was feeding on man. This horse fly is a pest of livestock in New York (Jamnback, 1969*b*; Pechuman, 1972). Pechuman (1972) also reported that cattle may be seen streaming with blood from the attacks of *T. similis*. Larvae have been found in Ontario (Teskey, 1969) and New York (Pechuman, 1972) in a variety of semi-aquatic habitats along streams, ponds, marshes, and bogs.

Although this tabanid is apparently rare in the Nova Scotia-New Brunswick border region, it is abundant in other regions of eastern North America. Livestock may well be the preferred source of blood for this species.

In the preceding discussion of biting flies on the specific level, it is apparent that the known biology of biting flies of the Tantramar Marshes agrees very closely with the biology of these species in other regions of eastern North America. Abundance of these species will obviously differ from area to area, since the abundance of biting flies is related to availability and amount of suitable larval habitat. For example, *A. cantator* is a common mosquito in the Tantramar Marshes (author's data) and in coastal areas of New England (Barnes *et al.*, 1950; Fellton *et al.*, 1950; Jamnback, 1969*b*; McDaniel, 1975), because it breeds in salt, brackish, and freshwater pools. For this reason, it is absent or uncommon in areas such as Ontario. *Aedes sollicitans*, *C. fuliginosus*, and *T. nigrovittatus* are other biting flies which may be abundant in coastal areas of the Maritime Provinces and the New England States, but because their larvae are restricted to salt marshes, they do not normally occur very far inland.

One peculiar difference in the biology of the biting flies of maritime Canada may be found in *Ca. morsitans*. This mosquito apparently has two generations in the Tantramar Marshes (Fig. 9, pp. 60-61), but Twinn (1931) reported that it was univoltine in eastern Canada. According to D. M. Wood (1975-pers. comm.), *Ca. morsitans* has only one generation throughout its known range in Canada.

Since sampling of larval simuliids was usually started in May of each year (Fig. 11, pp. 79-80), only a few larvae of *C. mutata* and *P. mixtum* were collected. Numerous pupal cases were obtained and it is thought that these species and possibly others occurred in many of the streams in the Nova Scotia-New Brunswick border area, but had emerged by the end of April.

Biting flies recorded from the Tantramar Marshes represent 54.6% of the 108 species recorded from the Maritime Provinces. Thirty-two species of culicids are reported from these provinces (Table 6, p. 38) and 19 of these have been taken in the Tantramar Marshes (Tables 6-7, pp. 38-39). Some of these appear to be new provincial records but none are new to the Maritimes. Twenty species of simuliids are recorded from maritime Canada (Table 19, p. 77), of which nine have been found in the Tantramar Marshes (Tables 19-20, pp. 77-78). Again, these are apparently new provincial records and *S. latipes* is recorded from the Maritime Provinces for the first time. Fifty-six species of tabanids are now known from maritime Canada (Table 21, pp. 96-97), of which 31 have been taken in the Nova Scotia-New Brunswick border region (Tables 21-22, pp. 96-98). Several are provincial records, but *C. calvus*, *H. illota*, *H. itasca*, and *H. typhus* Form B are recorded from the Maritime Provinces for the first time.

ABUNDANCE

The species composition and abundance of biting flies in this study are influenced by climate and environmental modification and marsh management.

Effects of Climate

Temperature and rainfall interact to determine not only when biting flies are active but also their abundance. All the biting flies considered in this study have aquatic or semi-aquatic larvae and pupae. Consistently high temperatures and little or no rain would obviously be detrimental to the larval and pupal populations. Extended periods of precipitation, while probably beneficial to the immatures, would obviously decrease the amount of time available for mating, feeding, and oviposition of adults.

Annual Abundance

Figures 8 (pp. 54-55), 15 (pp. 93-94), and 20 (pp. 115-116) present the weekly average of total culicids, simuliids and tabanids in aerial net sweeps during 1973-1975. Weather conditions are reflected in the fluctuations in numbers of the various groups of biting flies during this period.

The second year of this study, 1974, was probably the best of the three for the culicids. During 1974 there was sufficient rainfall (Fig. 4, pp. 33-34) to prevent many of the small temporary and/or permanent pools from drying up and to maintain fairly high water levels in permanent marshes. Also, since the rainfall was not continuous, and at times slight, it allowed adults to follow their usual behavior patterns.

The second peak in mosquito abundance during 1974 (Fig. 8, pp. 54-55) follows a heavy rainfall two to three weeks earlier (Fig. 4, pp. 33-34). This precipitation provided suitable habitats for temporary pool mosquitoes and subsequently another brood. The decline in numbers between the two peaks (Fig. 8, pp. 54-55) could be related to the heavy rainfall (Fig. 4, pp. 33-34) just prior to that decline. Heavy rainfall would not only suppress mosquito activity, but it may have also contributed directly to adult mortality. It would seem likely that mosquitoes could be washed to the ground from their resting places by heavy rain accompanied by strong winds, both of which are so common in the Tantramar Marshes.

The weather conditions during 1974 were also beneficial to the simuliids (Fig. 15, pp. 93-94) and the tabanids (Fig. 20, pp. 115-116). Again, rainfall prevented streams from becoming too shallow and thus decreasing available larval habitat. The various habitats of the tabanids, whether streams, marshes, pastures, or forests, would also remain at least damp, thus ensuring regular larval and pupal development.

The second peak in the tabanid population in late July, 1974 (Fig. 20, pp. 115-116) was due partly to emergence of late summer species. This peak may not be a true increase, rather the continuation of a long peak from late June and early July. The decrease in numbers between the two peaks of abundance (Fig. 20, pp. 115-116) correspond to a period of heavy rainfall (Fig. 4, pp. 33-34) and generally dull weather conditions. Since tabanids are usually only active in bright, sunny weather the dull conditions probably suppressed tabanid activity.

In 1973, although the temperatures were quite seasonable (Fig. 3, pp. 30-31), there was so much precipitation (Fig. 4, pp. 33-34) that water levels in pools, marshes, and streams were maintained at quite high levels. This continuous precipitation restricted adult biting fly activity and this is indicated not only in the tabanids (Fig. 20, pp. 115-116) but also in the culicids (Fig. 8, pp. 54-55). The relatively large numbers of mosquitoes in the first three or four weeks of catches is due to the success of snowpool mosquitoes, as well as to the first generation of the summer, warmer-water species.

In 1975 all biting flies were adversely affected by the high temperatures and low precipitation. Generally, mosquito numbers were reduced and this was apparent in all species. The development of the immatures of the temporary pool species was inhibited by drought. Even when there was significant rainfall, it was enough only to moisten the ground. The water levels in the permanent marshes were also lower than usual, thus affecting, at least to some degree, the species found in this type of habitat. In certain areas of these marshes, portions of dry land were obvious which normally might be under as much as 400 mm of water. With reduced precipitation, the larval simuliids had less available habitat. Streams would either become shallow, often leaving portions of the bed exposed, and/or the streams would become narrower, again decreasing the amount of available, suitable habitat. Again, the small amount of precipitation in 1975 (Fig. 4, pp. 33-34) in relation to that of 1973 and 1974 was probably detrimental to the tabanids. The high temperatures of 1975 (Fig. 3, pp. 30-31) probably increased the development rate of larval and pupal tabanids, since adults were collected a week earlier in that year than in the previous two (Fig. 20, pp. 115-116). Then the high temperatures and small amount of precipitation probably interacted to dry out the larval and pupal habitats, thus resulting in a smaller adult population than in the previous two years (Fig. 20, pp. 115-116). Also in 1975, due to the high temperatures and reduced precipitation, adults of all the biting fly groups may have been affected by desiccation and their regular behavior patterns may have been suppressed or altered.

Seasonal Abundance -- Culicidae

Studies of the seasonal abundance of culicids in eastern North

America are few, and include those of Main *et al.* (1968) in Massachusetts; Baldwin and Chant (1975), Belton and Galloway (1966), and Beckel and Atwood (1959) in Ontario; and Haufe (1952) in Labrador. All of these studies were based on light trap collections with the exception of that of Beckel and Atwood (1959), who presented a seasonal abundance of the most common biting species, and Haufe (1952) who presented seasonal and relative abundance of adult females captured in nature.

These studies indicated that *A. abserratus*, *A. communis*, *A. punctor*, and *A. stimulans* were usually the first species encountered in the spring. *Aedes abserratus* occurs from mid May to mid July in Ontario (Belton and Galloway, 1966) and from early June until late October in Massachusetts (Main *et al.*, 1968) where the peak occurs early in June. *Aedes communis* occurs from mid May until mid August in Ontario (Beckel and Atwood, 1959) where it is most abundant in late May (Baldwin and Chant, 1975) or early June (Beckel and Atwood, 1959). Belton and Galloway (1966) collected specimens during late July in Ontario, while Haufe (1952) found this species from mid June until mid July in Labrador. *Aedes punctor* was found from mid May (Belton and Galloway, 1966) until early September (Beckel and Atwood, 1959) in Ontario, where it reaches its peak of abundance in early June (Baldwin and Chant, 1975) or late June (Beckel and Atwood, 1959). Haufe (1952) reported that *A. punctor* was taken from mid June until mid July in Labrador, and that this species was most abundant during mid June. As indicated earlier, *A. punctor* in the Tantramar Marshes probably includes *A. abserratus* and *A. communis*. This group of species follows a similar pattern throughout their range in eastern North America. They are taken about two weeks earlier in Ontario than in the Tantramar Marshes, although the peaks of abundance are about the same time.

Aedes cinereus, *A. excrucians*, and *A. fitchii* usually emerge in late May. Adults of *A. cinereus* may be collected until late September in Ontario (Belton and Galloway, 1966) where they are most abundant early in June (Baldwin and Chant, 1975). Main *et al.* (1968) found that *A. cinereus* occurred in Massachusetts until October and indicated that its peak was early in June. Haufe (1952) collected this species during the first week of July in Labrador. Adults of *A. cinereus* are taken about two to three weeks later in the Tantramar Marshes than in Ontario and Massachusetts. The peak of abundance is also two to three weeks later in maritime Canada. *Aedes excrucians* occurs until late August in Ontario (Baldwin and Chant, 1975) where it is most abundant in early June. Main *et al.* (1968) also reported that the peak of abundance of this species and *A. fitchii* was early June in Massachusetts, but indicated that adults may be taken in small numbers as late as September or October. Haufe (1952) collected *A. excrucians* from early to mid July in Labrador. *Aedes fitchii* may be collected until early August in Ontario (Baldwin and Chant, 1975), and during early to late July in Labrador (Haufe, 1952). *Aedes excrucians* emerges in late May in Ontario (Belton and Galloway, 1966) and Massachusetts (Main *et al.*, 1968), but not until early June in the Tantramar Marshes. This species is taken in maritime Canada until late August, but may be encountered until September in Ontario (Beckel and Atwood, 1959), or Massachusetts (Main *et al.*, 1968). The abundance peak of this species is during early June in maritime Canada, Ontario (Baldwin and Chant, 1975), and Massachusetts (Main *et al.*, 1968).

Aedes canadensis, *A. cantator*, *A. vexans*, *Cs. impatiens* and *Cs. morsitans* all occur during the first half of June. *Aedes canadensis* may be taken throughout the summer in Massachusetts (Main *et al.*, 1968), but is most numerous in June. Beckel and Atwood (1959) indicated that *A. canadensis* is most abundant near the end of July in Ontario and found adults until the end of August. Baldwin and Chant (1975) also collected adults near the end of August in Ontario. Haufe (1952) collected this species from early to late July in Labrador. *Aedes canadensis* occurs about two weeks later in the Tantramar Marshes than in Ontario and Massachusetts, but persists until late August in all areas. This species is not numerous enough to show a definite peak of abundance in maritime Canada. Main *et al.* (1968) found that *A. cantator*, *A. vexans* and *Ca. morsitans* occurred throughout the summer in Massachusetts and that the peak for each of these species was in June. *Aedes cantator* in the Tantramar Marshes closely follows the pattern of this species in Ontario and Massachusetts. Peaks of abundance of this species in the Tantramar Marshes are related to earlier periods of precipitation. *Aedes vexans* may be taken until early October in Ontario (Belton and Galloway, 1966), but is most abundant in late July (Baldwin and Chant, 1975). *Aedes vexans* is not abundant in the Nova Scotia–New Brunswick border area. It occurs about a month later in this area than in Massachusetts and Ontario, and it is collected until October in Massachusetts and Ontario, which is about a month longer than in the Tantramar Marshes. Main *et al.* (1968) reported that the peak of *Ca. impatiens* occurs in late August and found specimens until October. Haufe (1952) collected this species from mid July until early August in Labrador. *Culiseta impatiens* was collected only during late July in the Tantramar Marshes. In Ontario, Baldwin and Chant (1975) collected specimens of *Ca. morsitans* until late August, but Belton and Galloway (1966) did not collect it until mid July and found it until late October. *Culiseta morsitans* was taken in net sweeps during late June and late August in the Tantramar Marshes. Emergence commences during late June and late July and, since adults are rarely attracted to man, its abundance and longevity are uncertain.

Mansonia perturbans occurs from about mid June until early September in Ontario (Beckel and Atwood, 1959) where it is most abundant near mid July. In Massachusetts it occurs from about mid June until October and is also most abundant in mid July (Main *et al.*, 1968). This species follows an identical pattern in the Tantramar Marshes, although it is unknown how long the females persist after the end of August.

Anopheles walkeri was collected in mid June in Ontario (Baldwin and Chant, 1975), but it may be collected from mid June until late August in the Tantramar Marshes. *Anopheles earlei* was taken during late July and early August in Labrador (Haufe, 1952) while it was found during the first half of August in the Tantramar Marshes.

Belton and Galloway (1966) collected *A. stimulans* from mid May until early August in Ontario. This species was encountered during mid June, 1973 in the Tantramar Marshes.

Haufe (1952) encountered *W. smithii* from mid July until early August in Labrador; however, adults were not taken in the Tantramar Marshes.

A comparison of seasonal succession and abundance studies from the Tantramar Marshes and Massachusetts and Ontario indicates that the seasonal variation of culicids in the Tantramar Marshes is very similar to that in other regions of eastern North America. Some of the species may occur a week or so earlier or later in the season, but this is probably related to climatological conditions. Also, since certain species of mosquitoes have different behavior patterns, the number of species and abundance of those species attracted to light traps may be quite different from those attracted to and collected in aerial net sweeps about man.

The species composition of the regular aerial net sweeps in the Tantramar Marshes during 1973 to 1975 is presented in Table 9 (p. 53). The figures for 1973 must be interpreted with caution since the numbers of mosquitoes and net sweeps were much lower than in the subsequent two years. More sweeps were made in 1975 than in 1974 but fewer mosquitoes were obtained. The percentage composition did not change very much over the two-year period with the exception of *An. walkeri* which rose from 1.0% to 3.5%. It is thought that *M. perturbans* did not increase in numbers from 1973 to 1974 as indicated by these figures: rather, the percentage was low in 1973 due to considerably higher numbers of *A. punctor* and *A. cantator* collected in 1973 (Fig. 5, pp. 45-46) than during 1974 (Fig. 6, pp. 47-48), and 1975 (Fig. 7, pp. 49-50).

Swarming. Observations of swarming, particularly *M. perturbans*, in the Tantramar Marshes agree with similar observations of *M. perturbans* by Nielsen (1964), and of mosquitoes generally by Downes (1969). They indicated that swarms usually fly in relation to a more or less conspicuous element of the landscape. In the Tantramar Marshes the element or 'swarm marker' was the northern corner of Impoundment V (opposite the northeastern corner of Impoundment III (Fig. 2, pp. 17-18)). Nine of the 17 irregular aerial net sweep collections were made in this same location during 1974 and 1975. Downes (1969) also indicated that the swarm, which may consist of a single individual or countless millions, is typically stationary and has a rather definite position and boundary in relation to the marker. Both swarms recorded in Table 10 (p. 57) were shown to consist of at least several thousand specimens and their positions were two meters above the surface of the dyke and about three meters in diameter. The swarm of 2-VIII-74 exhibited upwind orientation and both swarms were observed to be in a relatively constant up-and-down movement. These observations confirm those of Downes (1969). The swarm encountered in the Tantramar Marshes consisted almost entirely of *M. perturbans*; the few specimens of the other species obtained were probably accidental catches and not actually part of the swarm. Downes (1969) reported that a swarm typically consists of a single species even when other related species are available in the same area. Observations made by the author, Downes (1969), and Nielsen (1964) suggest that the existence and position of a swarm may be determined by visual responses to the characteristics of the marker.

Seasonal Abundance - Simuliidae

Studies on the seasonal succession and/or seasonal abundance of simuliids in eastern North America are few and include those of Davies (1950, 1952) in Ontario, Peterson and Wolfe (1958) in Quebec, and Lewis and Bennett (1974*b*) in Newfoundland.

The studies by Davies (1950, 1952) and Peterson and Wolfe (1958) are based on adult catches. The total catches of adult simuliids in the Tantramar Marshes are so small that no useful comparisons can be made (Fig. 15, pp. 93-94). The study by Davies (1950) is based on emergence cage collections, while the study by Davies (1952) is based on aerial sweep collections. He collected almost 4,000 simuliids in about two months whereas the present study in the Tantramar Marshes yielded fewer than 200 adults in three summers of aerial sweeps.

The study by Lewis and Bennett (1974*b*) in Newfoundland was based on collections of immatures, and is really the only one comparable to the present study in the Tantramar Marshes. Immatures of *P. mixtum* were taken until early June in Newfoundland, while *P. mixtum* was not collected after late May in the Tantramar Marshes (Fig. 11, pp. 79-80). Similarly, *C. mutata* was taken until early June in Newfoundland, but was not found after mid May in the Nova Scotia-New Brunswick border region. In Newfoundland, the *S. venustum-verecundum* complex was first collected in late May, while it was collected three weeks earlier in the Tantramar Marshes (Fig. 11, pp. 79-80). In both areas, immatures were taken until the end of August. *Simulium tuberosum* was collected throughout the summer in the Tantramar Marshes, but there were two distinct generations in Newfoundland; the first extends from early May through late June or early July, and the second extends from mid July through early to mid August. The first generation of *S. aureum* is apparently lacking in the Pickavance Creek area of Newfoundland, but the second occurs at the same time as the second generation in the Tantramar Marshes. This is during late August. The immatures of the first generation of *S. aureum* are taken throughout May until mid June in the Nova Scotia-New Brunswick border area.

Although differences in seasonal succession from one area to another may be related to climatic conditions, the larval simuliids of streams in the Tantramar Marshes appear to be developmentally about two to three weeks ahead of those in Newfoundland. This is probably related to stream temperatures. The streams 'warm up' much earlier in the Tantramar Marshes than in Newfoundland. Also, since Newfoundland usually experiences a shorter summer, the number of generations or broods of multivoltine simuliids may be reduced.

Seasonal Abundance - Tabanidae

Studies on the seasonal abundance of tabanids are recorded by Davies (1959) and Smith *et al.* (1970) in Ontario, Robert (1958) in Quebec, Pechuman and Burton (1969), Matthysse *et al.* (1974), and Jamnback (1969*b*) in New York, and Thompson (1969*b*) in New Jersey. The times of activity and abundance of tabanids from these areas have been compared with tabanids of the Tantramar Marshes in the individual species considerations.

Tabanid Traps. Specimens from tabanid traps accounted for only 5.3 % of the total tabanids collected. One hundred and twelve adults were collected; these included four species of *Chrysops* and seven species of *Hybomitra* (Table 22, p. 98). *Hybomitra illota* accounted for 41.1% of the tabanids collected in the traps, while *H. epistates* comprised 29.5%. The most abundant deer fly was *C. mitis* which was 12.5% of the trapped tabanids. Since so few specimens were collected, a quantitative analysis of abundance and a meaningful seasonal succession are not possible.

Thompson (1972) reported that *H. illota* was the most abundant tabanid taken in the Manitoba trap in Maryland. Studies of Tabanidae in New York (Matthysse *et al.*, 1974; Pechuman and Burton, 1969) and Maryland (Thompson, 1970) have indicated that trapping with the Manitoba trap is not the best method for obtaining *Chrysops* species, and is selective for adults of *Tabanus* and *Hybomitra*. Also in New Jersey, Rockel and Hansens (1970) reported that the Manitoba trap caught primarily females that had not taken a blood meal and, since the entrance of the trap was on the bottom, it was more effective for catching low-flying species such as *T. nigrovittatus*.

Studies in the Tantramar Marshes neither confirm nor contradict these observations, since relatively few tabanids were collected in the trap. The tabanid trap was not used solely for quantitative studies in the Tantramar Marshes, rather, to complement collections from aerial net sweeps and biting and flight activity catches about man and cattle.

Effects of Environmental Modification and Marsh Management

No studies have been made to determine the effect of environmental management on biting fly populations. Environmental modification and management must affect biting fly populations when the modifcation or management includes manipulation of water. The environment was modified prior to and during this study to create, increase, and maintain habitats for breeding and migrating waterfowl. Biting fly productivity was apparently not considered prior to, or during, environmental modification, nor is it considered by the management agencies now - even though personnel of these agencies complain about the annoyance of biting flies.

Prior to the impounding of the man-made marshes in the Tintamarre National Wildlife Area and the Missaquash Marsh, much of the land in those areas was used for agricultural purposes, either for hay or cattle grazing. This flat pasture land was interspersed with temporary pools, and in some areas, permanent pools, which contributed to the mosquito population. Obviously the size of the mosquito population would be related to precipitation. Simuliids would not occur in these areas, except where streams meander through this pasture land. These streams are not ideal simuliid habitats since many of them have sandy or muddy substrates and are unsuitable sites for larval and pupal attachment. Usually, where simuliids are found in these streams, they are confined to marginal trailing grassblades. Also, this type of habitat would be restricted to tabanids which utilize damp or dry sod for larval habitat.

On subsequent impounding of these marshlands by construction of dykes, flooding, introduction of plant species, and maintenance of permanent water levels such as to benefit waterfowl, the temporary pool mosquitoes were eliminated from this area. Simuliids were also eliminated since the streams in those areas were no longer flowing and the tabanids, which utilize damp or dry sod as larval habitat, were probably eliminated since their habitat became saturated.

At the same time, the now permanent man-made marshes provided large areas for the larvae of permanent water mosquitoes. Since these impoundments must have control structures for the manipulation of water levels, there is, at least on occasion, flowing water and this provides larval habitat for simuliids. The impoundments also provide large permanent areas for larvae of those species of tabanids which prefer or are restricted to marsh habitats.

It appears, at least superficially, that this type of environmental modification is more beneficial rather than detrimental to biting fly populations. The Culicidae would probably benefit the most from this change of environment. The number of species decrease but the numbers of individuals of the permanent water species would increase. The Simuliidae may not increase in abundance, but the species composition may well reflect a change in larval habitat from a natural stream to an artificial one. Changes in species or numbers of Tabanidae would be more difficult to evaluate, since specific larval habitats of the tabanids in the antramar Marshes have not been determined.

The simuliids have not been previously recorded in the literature as pests in the Nova Scotia-New Brunswick border area nor were they found to be pests during the present study.

McIntosh (190[illegible]) recorded *A. impiger* and *ulex* sp. from New

Brunswick and indicated that *A. impiger* was a very common mosquito. This species has not been collected in the Tantramar Marshes during the period 1973–1975 and there are no specimens contained in the Canadian National Collection, Ottawa. C. R. Twinn has made several observations on the mosquitoes of maritime Canada. Twinn (1931) indicated that the species of mosquitoes that "infest permanent waters in eastern Canada are comparatively unimportant pests when compared with the species associated with snowpool, floodwater, and rainpool mosquitoes". Twinn (1949) reported that the towns of Amherst, Nova Scotia and Moncton and Sackville, New Brunswick were greatly bothered by mosquitoes from the Tantramar Marshes. Twinn (1949) also indicated that immense numbers of *A. cantator* and *A. vexans* were breeding in the Tantramar Marshes. It appears from these observations that *M. perturbans* has become a pest in recent years, undoubtedly due to the impounding of water for waterfowl marshes. Aerial sweeps conducted during this study, the results of which are contained in Table 9, p. 53), illustrate how unimportant *A. vexans* is and, although *A. cantator* is widespread and sometimes pestiferous, it has not occurred in densities comparable to those of *M. perturbans*. Gibson (1941) indicated that drainage ditches in the Tantramar Marshes were not properly graded or kept clean, with the result that they contained stagnant water. Undoubtedly, these ditches provided the larval habitats for *A. cantator* and *A. vexans* later reported by Twinn (1949). Many of these ditches are still not properly maintained and provide ideal larval habitats for mosquitoes such as *A. vexans* and *A. cantator*.

McIntosh ([illegible]) recorded 11 species of tabanids from New Brunswick, and indicated that *C. excitans*, *C. carbonarius* and *H. lasiophthalma* were the most abundant. *Chrysops carbonarius*, and to a lesser extent, *C. excitans*, were relatively uncommon tabanids during 1973-1975 in the Nova Scotia-New Brunswick border region.

Studies with respect to biting flies have not been done in freshwater marshes, although have been considered incidentally in Delaware (Darsie and Springer, 1957). Mosquito problems associated with salt marshes are well known in Delaware (Darsie and Springer, 1957), Florida (Provost, 1968), New Jersey (Chapman and Ferrigno, 1956), and Utah (Rees, 1969). Therefore, comparisons with other areas in terms of seasonal succession and abundance of marsh mosquitoes and the numbers produced per square meter cannot be made.

As indicated earlier, the adult mosquitoes of all five species collected in emergence cages emerged a full week earlier in 1975 than in 1974 (Fig. 9, pp. 60-61). This is thought to be related to generally higher water temperatures experienced in most marshes during 1975 (Fig. 10, pp. 63-64).

The reasons for the apparent decrease in numbers of mosquitoes collected in emergence cages from 1974 to 1975 are unknown (Table 12, p. 65). Decreases of this magnitude are not apparent from aerial net sweeps (Table 9, p. 53). While the higher temperatures and lack of appreciable precipitation may have had some effect, permanent marshes and their fauna would not be affected in the same way as small temporary and/or semipermanent pools. The abundance and changes in abundance of mosquitoes are thought to be due primarily to water level management procedures. The drawdown is an effective method of maintaining the productivity of a waterfowl marsh, and can improve cover, food, and fertility of a marsh (Kadlec, 1960). In the Tantramar Marshes, drainage of a marsh is usually completed by mid summer and the marsh is usually reflooded in the fall of that year or early spring of the following year. The reduction in numbers of mosquitoes in emergence cages may also be related to the larval distribution and abundance of *M. perturbans* in a given marsh. It is unknown why specimens of *M. perturbans* have been collected in only one of two emergence cages positioned over cattail in one area, and within 10 m of each other.

The reasons for the apparent paucity of mosquitoes in Impoundment II (Tables 13, p. 66; 14, p. 70) are unknown, although it is thought that the abundance of Odonata may be of some importance. In 1974 and 1975, Impoundment II had an average of 104.8 Odonata per cage; this is more than five times the average number found in Impoundment IV which was the next highest producer of odonates. It is possible that odonate nymphs, as well as some carnivorous beetles and their larvae, may have been predators of mosquito larvae in the marsh. In addition to any predation here, it may have also occurred in the emergence cages, since it has been shown that odonates will feed on mosquitoes in small cages.

Impoundment III was drained in the summer of 1974 and reflooded in the spring of 1975. Obviously, the water drawdown is not detrimental to *A. excrucians* (Table 13, p. 66). In the course of drainage and subsequent flooding, this marsh may have appeared a little more favorable to ovipositing females of this species.

The Missaquash Marsh was drained by the Nova Scotia Department of Lands and Forests in the fall-winter of 1973 and reflooded in the spring of 1974. In November 1973, prior to water drawdown, there were 57.1 larvae of *M. perturbans* per square meter, while in April 1974, following the reflooding, there were 0.6 larvae per square meter (R. Hall, 1974-pers. comm.). The method used by Hall to sample larvae of

M. perturbans was that of Hagmann (1952). It would appear that a water drawdown during the winter effectively reduces the *M. perturbans* population and, while it probably does, the actual values obtained by Hall must be seriously challenged. In November, prior to marsh drainage, the water was undoubtedly very cold and consequently the larvae of *M. perturbans* were probably much colder than they would be in April. This would probably cause the larvae to detach from the plants much more slowly than they would in warmer water during April. While emergence cages were not used in 1973, data from aerial net sweeps would suggest that the drawdown is effective in controlling *M. perturbans*. Aerial net sweeps contained an average of 14.3 mosquitoes per sweep in 1973, but only 5.9 in 1974.

Examination of Table 16 (p. 72) indicates that the most productive marsh appears to be the 3.5 year old category. This disagrees with observations by Whitman (1974, 1976) who reported that Culicidae increased rapidly upon flooding and reached maximum abundance in impoundments less than one year of age. Whitman (1974) recorded the Culicidae obtained as *Chaoborus*, *Culex*, and *Megarhinus*, but did not indicate species or numbers of each genus obtained. It is interesting that the results of the author's study have shown that only *A. excrucians* and *Ca. morsitans* were obtained in impoundments of less than one year of age (Table 16, p. 72). Whitman (1974) did not collect either of these genera. The reason why Whitman (1974) did not obtain *M. perturbans* is probably related to his sampling procedures, which included aquatic net sweeps and activity traps, neither of which would have collected larvae and pupae of *M. perturbans*. These types of sampling procedures, particularly activity traps, would provide an indication of the nektonic community but a rather poor idea of the numbers and species of benthos. Following the peak of mosquito productivity in the 3.5 year old marsh, the numbers decline but an increase is noticeable in the natural marshes. The reasons for this are not understood although the data for marshes of 5.0 to 9.0 years of age may be inaccurate since Impoundment II, which was 5.0 years old in 1974 and 6.0 years old in 1975, also contained considerably higher numbers of Odonata. Also, the 8.0 and 9.0 year old marsh is the Missaquash, and these values may be low due to water level management.

In comparing the overall results of the emergence cage mosquitoes, the effect of wetland management is apparent. Initial impounding and water drawdown operations are beneficial to *A. excrucians*. The water drawdown apparently decreases or eliminates *M. perturbans* for a year or two. It is significant that *An. walkeri*, *A. excrucians*, and *C. territans* increased in numbers and percentage from 1974 to 1975 even though the total mosquitoes collected decreased by 64.6%.

Whitman (1974) concluded that marsh impoundments less than four years of age are the most desirable for waterfowl production. He also indicated that at the age of seven years a dense emergent vegetation producing little vegetable food for waterfowl has evolved, water and soil quality have declined, and invertebrates are composed of species that are less abundant and not as available to waterfowl as food. Whitman (1974, 1976) also reported that waterfowl production begins to stabilize or decline when the impoundment is seven or eight years of age and recommended waterlevel drawdown for impoundments between the ages of five and seven years to improve food and cover for waterfowl.

Examination of Table 16 (p. 72) will reveal that water drawdown of marshes between five and seven years of age will ensure continual mosquito production; in fact, water drawdown would most likely occur following the peak of mosquito production, which apparently occurs in marshes 3.5 years of age.

While little information is available on the immatures of *M. perturbans*, the attachment sites of immatures of this species in the Tantramar Marshes agree with those published. Hagmann (1952, 1953) found eggs of *M. perturbans* closely associated with *Carex* sp. in New Jersey and also under overhanging mats of cattail debris. He also indicated that larvae of *M. perturbans* apparently have little plant preference and collected larvae from five genera and seven species of plants. McNeel (1932) recorded larvae of *M. perturbans* from seven genera and nine species of plants in marshes of the United States. Bidlingmayer (1968) indicated that larvae of *M. perturbans* were collected from 18 species of plants in Florida. Dorer *et al.* (1950) reported that arrowhead was the principal plant used by larvae and pupae of *M. perturbans* in Virginia.

Sex Ratios. Observations of mosquitoes collected in emergence cages in the Tantramar Marshes indicated that the greatest emergence of males occurred at least several days before that of females. This has also been observed in the Yukon Territory (Curtis, 1953) and in Ellesmere Island, N. W. T. (Corbet and Danks, 1973). Observations of the present study in the Tantramar Marshes also agree with those of Curtis (1953) and Danks and Corbet (1973) who found a predominance of females in emergence cage collections. The usual sex ratio is apparently unity, at least in the laboratory (Gilchrist and Haldane, 1947; Lamborn, 1913; Qutubuddin, 1953), although some workers, including Christophers (1947)

Gordon (1922), and Mattingly (1956) indicated that during emergence there was usually a preponderance of males in laboratory rearing of mosquitoes. Young (1922) reported that a greater percentage of males appears to be a constant feature under laboratory conditions, but Qutubuddin (1953) concluded that sexes emerge 1:1 although a small number of aberrant cases with a significant majority of one sex or the other may occur.

RECOMMENDATIONS FOR MOSQUITO CONTROL

The impounding of fresh water in the Tintamarre National Wildlife Area and the Missaquash Marsh effectively eliminated most species of mosquitoes previously produced in these areas. As indicated earlier, much of the now managed marshes was formerly agricultural areas with numerous pools producing primarily *Aedes* mosquitoes. By dyking and flooding this land, the pools were eliminated and so were the fauna. Florschutz (1959) and Tindall (1961) reported that *Aedes* production could be reduced by impounding fresh water in Delaware. This is precisely what has happened in the Tantramar Marshes. Florschutz (1959) and Tindall (1961) also indicated that with proper management of water levels, the mosquito production would be held at a minimum or eliminated entirely.

However, the development of waterfowl marshes has at times resulted in the production of mosquitoes. This has been observed in California (Fraser, 1961; Kozlik, 1969; Magy, 1968) and Utah (Andersen and Rees, 1963; Rees *et al.*, 1966; Smith, 1961). Of course, this is true not only for waterfowl marshes, but also reservoirs in South Carolina (Atchley *et al.*, 1955) and South Dakota (Edman, 1964), and other impounded waters and developed water resources in Utah (Rees, 1961, 1964, 1968, 1969), Virginia (Gladney and Turner, 1968), and Tennessee

(Gartrell *et al.*, 1972). Bennett (1962) also indicated a correlation of mosquito production with the management of artificial bodies of water, without referring to specific localities.

Presently, marsh management in the Tantramar Marshes is for waterfowl production only. However, if biting flies, particularly mosquitoes, continue to be pests in this area, then marsh management will have to include mosquito control. In many areas, such as New Jersey (Ferrigno and Jobbins, 1968), the major objective of marsh management is to eliminate mosquito production from a given acreage of marsh for as long a period of time as possible without affecting or, better yet, improving these marshes for wildlife.

In the Tantramar Marshes, there are two problems which must be considered if mosquito control is to be attempted. The first includes *A. excrucians, An. walkeri, Ca. morsitans* and *C. territans*. Larvae of these mosquitoes are found primarily along the shoreline of the marshes, but may also be found in isolated pools formed by floating mats of vegetation throughout the marshes. The second problem is *M. perturbans*. Larvae and pupae of this mosquito attach to the roots and stems of aquatic plants. These problems can be reduced by (i) shoreline modification, and (ii) maintenance of constant water levels.

Aedes excrucians, An. walkeri, Ca. morsitans and *C. territans* could be reduced in numbers in these marshes if the shoreline areas were modified. The shallow shorelines, particularly in Impoundments III and IV, provide larval habitats for these mosquitoes. If these shorelines were modified, either by filling or deepening, conditions favoring larval development of these mosquitoes would be eliminated. At the same time predators such as odonates, beetles, and small fish, would be able to occupy this area. This type of shoreline modification has been effective in eliminating mosquito larval production in margins of marshes in many areas of the United States (Pest Control, 1961), including Utah (Andersen and Rees, 1963; Arnold and Rees, 1967; Rees, 1961, 1969; Rees and Winget, 1968, 1969), Virginia (Dorer, 1970), and Tennessee (Gartrell *et al.*, 1972).

Shoreline modification is not enough to discourage mosquito production by itself. It must be accompanied by maintenance of constant water levels. This would prevent flooding of margins of the marshes where mosquitoes can develop. Sufficiently high water levels also discourage mosquito oviposition. The maintenance of constant water levels has eliminated or significantly reduced mosquitoes in marshes in areas of the United States (Springer, 1964), including Massachusetts (Bodola, 1968), Utah (Andersen and Rees, 1968; Rees, 1961), Florida (Provost, 1968), and Delaware (Darsie and Springer, 1957). Franz (1963) indicated that mosquito abundance and distribution seemed to be correlated with changing water levels on salt marsh impoundments in New Jersey, and reported that this may also be related to the ability of predators of mosquito larvae to reach their prey. Angerilli and Beirne (1974) indicated that several species of aquatic plants, such as *Lemna minor* which occurs in the Tantramar Marshes (Table 3, p. 26), caused significantly high mortality of mosquito larvae in British Columbia. They reported that *L. minor* may affect mosquito larvae in two ways: a physical effect by way of a continuous surface mat that can prevent oviposition and/or larval breathing; and the chemical effect of a juvenile hormone-like compound. It would appear that further research on the interactions of mosquito larvae and aquatic plants is worthy of investigation and that positive results from this type of study could well be applied to fresh-water marshes such as exist in the Tantramar Marshes.

There still exists the *M. perturbans* problem. None of the studies discussed have had serious problems with this mosquito. Since this is the dominant mosquito of the Tantramar Marshes, any management of marshes for mosquito control must be designed for elimination or reduction of this pest. It appears that a water drawdown during the winter is effective in reducing the population. The larvae of *M. perturbans* overwinter, so a drawdown during this time would be ideal. A water drawdown for the control of *M. perturbans*, however, must not be detrimental to the various nutritional foods and/or vegetation for cover required by waterfowl. This would include invertebrates and certain species of plants, such as wild rice (*Zizania aquatica*). Since the drawdown of the Missaquash Marsh during the fall of 1973 did not appear to be detrimental to waterfowl populations, and since drawdown has been shown to be effective in maintaining productivity of waterfowl marshes (Kadlec, 1960), then it would seem practical to implement such a drawdown program in the managed wetlands of the Nova Scotia-New Brunswick border region. This suggests the need for cooperation between personnel of mosquito abatement agencies and waterfowl managers. The present study has also indicated that marshes newly created or drained do not produce *M. perturbans* in any numbers for at least a couple of years. This suggests that a drawdown would not be necessary more often than once every two or three years. Since Whitman (1974) indicated that marsh impoundments less than four years of age are the most desirable for waterfowl production, this proposed *M. perturbans* control program would ensure desirable marshes at all times. The drawdown should commence at the end of the mosquito season, and reflooding to constant water levels should be completed in the spring prior to the mosquito season.

Hagmann (1953) indicated that the best method of control of *M. perturbans* in New Jersey is through water manangement. He reported that this is not always possible and indicated that pelleted dusts gave promising reductions in the larval population. Dorer *et al.* (1950) recommended a system in Virginia whereby water control would allow the larval areas of *M. perturbans* to be dried for two months during the non-growing season, thereby reducing the mosquito population. A summer drawdown is effective in reducing numbers of *M. perturbans* in New Jersey (Chapman and Ferrigno, 1956) and Delaware (Darsie and Springer, 1957).

Kozlik (1969) indicated that many plants that are good producers of wildlife food in California also produce few mosquitoes. Most of these are of the emergent type with naked stems and include spikerushes, bulrushes, and some of the pond weeds. On the other hand, there are many plants which encourage mosquito production and produce little or no food for wildlife. These plants include cattails, water hyacinths, water primrose, and the milfoils. Both mosquito abatement personnel and wildlife managers consider these plants as pests.

In New Jersey, studies have developed water level management techniques designed to eliminate mosquito production and at the same time provide an abundance of waterfowl food plants (Chapman and Ferrigno, 1956).

In Utah, water management has improved the marshes as waterfowl habitats and greatly reduced the number of mosquitoes previously produced on these marshes (Collett and Rees, 1972; Nagel, 1967; Rees, 1965). Andersen and Rees (1963) reported that many of the problems associated with mosquito problems on marshlands in Utah could have been prevented if mosquito abatement measures had been included in the development plans. Cookingham (1971) indicated that mosquito control will always be an important part of marsh management in New Jersey. Studies have shown that as long as there is cooperation and coordination between the agencies involved, quality marsh management can provide excellent mosquito control and may in some instances increase marsh productivity. Nagel (1968) emphasized the importance of coordination between mosquito abatement and waterfowl management personnel, and Bennett *et al.* (1973) reported that management of habitat for waterfowl is also management for *biting flies. It is as inappropriate for an individual with no wildlife* background to enter into the complex problem of waterfowl management and mosquito control as it would be for a person with no knowledge of mosquito problems to attempt the same project. Low (1968) indicated that three things must be learned with respect to marsh management and mosquito control. While Low (1968) referred to the marshlands of Utah, his statements could apply to all marshes including those in the Nova Scotia-New Brunswick border area: (i) habitat manipulation must be equally conducive to reducing larval habitats of mosquitoes and enhancing wildlife habitat, (ii) increasing attention must be given to protection of the marshes and their fauna and flora in the face of increasing human pressures, such as any ill-planned mosquito suppression programs intended to relieve the discomfort and disease danger to people living near wetlands, and (iii) the economic values of marshlands, although partially recognized, have not been fully realized.

SUMMARY

One hundred and eight species of biting flies are now recorded from Maritime Canada. These include 32 species of Culicidae, 20 species of Simuliidae, and 56 species of Tabanidae. Fifty-nine species of these biting flies were collected in the Tantramar Marshes, situated in the Nova Scotia-New Brunswick border region.

Nineteen species of mosquitoes were collected in the Tantramar Marshes. Larvae and pupae of *A. abserratus, A. canadensis, A. cinereus, A. communis, A. excrucians, A. fitchii,* and *A. punctor* were found in temporary pools of snowmelt origin. These are thought to be univoltine, and probably overwinter in the egg stage. Species found in temporary floodwater pools included *A. cantator, A. vexans,* and *C. restuans*. These are thought to overwinter in the egg stage and, with the exception of univoltine *C. restuans*, the others are multivoltine. *Aedes cantator* was also found in semipermanent pools. Permanent pools and marshes provided suitable habitat for larvae and pupae of *A. excrucians, An. walkeri, Ca. morsitans, C. territans,* and *M. perturbans*. *Anopheles walkeri* and *Ca. morsitans* were apparently bivoltine, while *C. territans* and *M. perturbans* were univoltine. *Aedes cantator* and *A. sollicitans* were found in salt marshes. *Aedes sollicitans* was apparently restricted to this type of habitat in the Nova Scotia-New Brunswick border region, and it is probably multivoltine. The pitcher plant *Sarracenia purpurea* was found to be the only habitat used by *W. smithii*. Although only 10 species of mosquitoes were taken feeding on man, it is thought that most of the 19 species encountered will feed on man with the exceptions of *Ca. morsitans* which is apparently primarily ornithophilic, *C. territans* which probably prefers amphibians, and *W. smithii* which probably does not feed on blood.

Aedes cantator, *A. punctor*, and particularly *M. perturbans* were usually the only really serious mosquito pests of man. *Aedes punctor* became annoying in early June and decreased in numbers following mid to late June, although females were taken until the end of August. *Aedes cantator* was a pest throughout the summer because it is multivoltine and because larvae and pupae are found in a wide range of aquatic habitats. *Mansonia perturbans* was the most abundant mosquito encountered during the study. Adults became annoying early in July and catches of mosquitoes throughout July and August usually consisted mostly, or entirely, of this species. The abundance of this mosquito appears to be related to the recent acquisition and flooding of formerly agricultural land to provide habitat for breeding and migratory waterfowl. While *A. excrucians*, *C. territans*, *Ca. morsitans*, and *An. walkeri* were also found in these waterfowl marshes, together they comprised less than 24% of adults taken in emergence cages positioned in these marshes.

Larvae and pupae of *M. perturbans* attach to the roots and stems of aquatic plants which include *Acorus calamus*, *Carex lasiocarpa*, *C. limosa*, *C. rostrata*, *Sparganium eurycarpum*, *Typha glauca*, and *T. latifolia* in the Tantramar Marshes. Since these plants do not become immediately established in newly created marshes, *M. perturbans* has not been taken from marshes younger than 2.5 years of age. *Anopheles walkeri* and *C. territans* have not been taken from marshes less than 2.5 years of age, while *A. excrucians* and *Ca. morsitans* were collected from marshes which were 0.5 years of age. *Aedes excrucians* and *Ca morsitans* have not been taken from natural marshes. Based on observations during 1974 and 1975, the man-made marshes produced 2.5 times as many mosquitoes as the natural marsh.

Damsel flies and dragon flies were shown to prey on mosquitoes in small cages and, therefore, estimates of mosquito productivity based on emergence cage collections were minima.

Observations of sex ratios of mosquitoes obtained in emergence cages generally demonstrated a predominance of females.

Nine species of blackflies were found in streams of the Nova Scotia-New Brunswick border region. All species were found in permanent streams and, with the exceptions of *C. mutata* and *S. decorum*, all were also found in temporary streams. Estimation of population density was made using a standard artificial substrate. Adult simuliids were not usually bothersome in the Tantramar Marshes. With the exceptions *S. aureum*, *S. decorum*, and *S. latipes*, all species of simuliids were taken feeding on man. *Simulium decorum* was netted about man, but *S. aureum* and *S. latipes* were never observed in the vicinity of man, and are thought to be mainly ornithophilic.

Adults of 31 species of tabanids were collected in the Nova Scotia-New Brunswick border region. Larval and pupal habitats were not determined, but immatures of *H. epistates* are found at least in freshwater marshes. Feeding habits of 20 species of tabanids were determined; 15 of these were taken feeding on man, and nine on cattle. *Chrysops mitis* was the most abundant deer fly in the Tantramar Marshes and accounted for 14.6% of the tabanid population, 40.1% of the deer flies collected, and 52.6% of the deer flies feeding on man. *Hybomitra epistates* was the most abundant tabanid of the Nova Scotia-New Brunswick border region and accounted for 20.9% of the tabanid population and 32.9% of *Hybomitra* population. *Hybomitra frontalis* was the most abundant horse fly feeding on man, and comprised 74.2% of this group. *Chrysops frigidus* accounted for 42.9% of the deer flies feeding on cattle, while *H. typhus* Form A accounted for 50% of the horse flies feeding on cattle. *Hybomitra illota* was the most abundant tabanid (41.1%) taken in tabanid traps. Generally, species of *Chrysops* were more annoying to man while species of *Hybomitra* were more of a pest to cattle. Species of *Tabanus* were uncommon.

The seasonal succession of mosquitoes, blackflies, deer flies, and horse flies of the Tantramar Marshes very closely follows the seasonal succession of the same species in other regions of eastern North America. Variations in succession from region to region, or from year to year in the same region are probably due to climatic conditions. The abundance of species in different areas and from year to year in given areas is related not only to availability and amount of suitable larval habitat, but also to the amount of precipitation. Aspects of the biology of the 59 species encountered in the Tantramar Marshes agree with similar observations made by other workers for these species in other regions of eastern North America.

The abundance of *M. perturbans*, the most abundant mosquito of the Nova Scotia-New Brunswick border region, is apparently related to the amount of suitable habitat contained within the marshes which are currently managed for waterfowl. And, since it has been recommended by wildlife personnel that these marshes, particularly the man-made marshes, be drained every five to seven years to decrease the rate of community succession, a method of control of *M. perturbans* has been suggested. This would involve a waterlevel drawdown during the summer about every three to four years. Results of this study have shown that mosquitoes were most abundant in marshes of 3.5 years of age. And, since wildlife personnel have indicated that impoundments less than four years of age are the most desirable for waterfowl production, it would appear that water level drawdown of marshes three to four years of age would not be seriously detrimental to the waterfowl, other fauna, or the flora. It is suggested that such a drawdown would probably eliminate or at least effectively control *M. perturbans* for two or three years, and, if practiced regularly, *M. perturbans* would probably be controlled indefinitely. Shoreline modification of the marshes, either by deepening or filling with soil, in conjunction with maintenance of constant water levels, would also decrease production of *A. excrucians*, *Ca. morsitans*, *C. territans*, and *An. walkeri*, although these are of minor importance in relation to *M. perturbans*. Eastern equine encephalitis has been recorded from Quebec and since *M. perturbans* is capable of transmitting this disease, serious consideration of controlling this mosquito should be made now. The success of waterfowl management programs could be negated by increased prevalence of parasites vectored by biting flies associated with managed wetlands.

LITERATURE CITED

Abdelnur, O. M. 1968. The biology of some black flies (Diptera: Simuliidae) of Alberta. Quaest. Entomol. 4: 113-174.

Andersen, D. M. and D. M. Rees. 1963. A report of the first year study on development of techniques for multipurpose management of reusable water. Proc. Utah Mosq. Abat. Assoc. 16: 29-30.

Andersen, D. M. and D. M. Rees. 1968. Conclusions to date from cooperative multi-purpose water management studies conducted in Utah. Proc. Utah Mosq. Abat. Assoc. 18: 9-11.

Anderson, J. F. 1970. Induction and termination of embryonic diapause in the salt marsh mosquito, *Aedes sollicitans* (Diptera: Culicidae). Conn. Agric. Exp. Stn. Bull. 711: 22 pp.

Anderson, J. F. 1971. Autogeny and mating and their relationship to biting in the saltmarsh deer fly, *Chrysops atlanticus* (Diptera: Tabanidae). Ann. Entomol. Soc. Am. 64: 1421-1424.

Anderson, J. F. 1973. Biting behavior of saltmarsh deer flies (Diptera: Tabanidae). Ann. Entomol. Soc. Am. 66: 21-23.

Anderson, J. F. and F. R. Kneen. 1969. The temporary impoundment of salt marshes for the control of coastal deer flies. Mosq. News 29: 239-243.

Anderson, J. R. and G. R. DeFoliart. 1961. Feeding behaviour and host preferences of some black flies (Diptera: Simuliidae) in Wisconsin. Ann. Entomol. Soc. Am. 54: 716-729.

Anderson, R. C. 1956. The life cycle and seasonal transmission of *Ornithofilaria fallisensis* Anderson, a parasite of domestic and wild ducks. Can. J. Zool. 34: 485-525.

Angerilli, N. P. D. C. and B. P. Beirne. 1974. Influences of some fresh-water plants on the development and survival of mosquito larvae in British Columbia. Can. J. Zool. 52: 813-815.

Anthony, D. W. 1960. Tabanidae attracted to an ultraviolet light trap. Fla. Entomol. 43: 77-80.

Arnold, F. D. and D. M. Rees. 1967. Effects of a planned agricultural land improvement program on mosquito production. Proc. Utah Mosq. Abat. Assoc. 20: 10-11.

Atchley, F. O., W. R. Traylor and A. A. Weatherbee. 1955. Effects of variations in reservoir levels, rainfall, and temperature on anopheline densities in a coastal plains area in South Carolina. J. Parasitol. 41: 273-280.

Aubin, A., J. P. Bourassa and M. Pellisier. 1973. An effective emergence trap for the capture of mosquitoes. Mosq. News 33: 251-252.

Baldwin, W. F. and G. D. Chant. 1975. Seasonal succession of the mosquitoes (Diptera: Culicidae) of the Chalk River area. Can. Entomol. 107: 947-952.

Barnes, R. C. 1945. *Anopheles walkeri* in diurnal shelters in Massachusetts. J. Econ. Entomol. 38: 114.

Barnes, R. C. 1946. The occurrence of *Anopheles quadrimaculatus*, *Anopheles occidentalis* and *Anopheles walkeri* in Vermont. Mosq. News 6: 32-33.

Barnes, R. C., H. L. Fellton and C. A. Wilson. 1950. An annotated list of the mosquitoes of New York. Mosq. News 10: 69-84.

Bartosewitz, W. V. 1945. Notes on mosquitoes in Rhode Island. Mosq. News 5: 19-20.

Bast, T. F. and J. W. H. Rehn. 1963. Vertical distribution of mosquitoes as indicated by light trap collections in two environments. Proc. N. J. Mosq. Exterm. Assoc. 50: 219-229.

Bean, J. L. 1946. A preliminary list of the mosquitoes of Maine (Culicidae Diptera). Can. Entomol. 78: 25-28.

Beaudette, F. R. 1946. Common mosquito borne diseases of birds. Proc. N. J. Mosq. Exterm. Assoc. 33: 31-36.

Beckel, W. E. and H. L. Atwood. 1959. A contribution to the bionomics of the mosquitoes of Algonquin Park. Can. J. Zool. 37: 763-770.

Bellavance, R., E. Rossier, M. LeMaître and N. G. Willis. 1972. Eastern equine encephalomyelitis in eastern Canada. Can. J. Public Health 64: 189-190.

Belton, P. 1967. The effect of illumination and pool brightness on oviposition by *Culex restuans* (Theo.) in the field. Mosq. News 27: 66-68.

Belton, P. and M. M. Galloway. 1966. Light-trap collections of mosquitoes near Belleville, Ontario, in 1965. Proc. Entomol. Soc. Ont. 96: 90-96.

Benach, J. L. 1970. Observations of a colony of *Culex territans* Walker. Proc. N. J. Mosq. Exterm. Assoc. 57: 70-76.

Bennett, G. F. 1960. On some ornithophilic blood-sucking Diptera in Algonquin Park, Ontario, Canada. Can. J. Zool. 38: 377-389.

Bennett, G. F. and R. F. Coombs. 1975. Ornithophilic vectors of avian hematozoa in insular Newfoundland. Can. J. Zool. 53: 1241-1246.

Bennett, G. F. and A. M. Fallis. 1960. Blood parasites of birds in Algonquin Park, Canada, and a discussion of their transmission. Can. J. Zool. 38: 261-273.

Bennett, G. F., C. M. Herman and W. Threlfall. 1973. The implications of habitat management for parasites of waterfowl. The Waterfowl Habitat Management Symposium, Moncton, New Brunswick, July 30-August 1, 1973. pp. 266-281.

Bennett, G. F., A. D. Smith, W. Whitman and M. Cameron. 1975. Hematozoa of the Anatidae of the Atlantic flyway. II. The Maritime Provinces of Canada. J. Wildl. Dis. 11: 280-289.

Bennett, G. F. and S. M. Smith. 1968. Phosphorus^{32} for marking Tabanidae (Diptera). Mosq. News 28: 559-569.

Bennett, G. W. 1962. Management of artificial lakes and ponds. Reinhold Publishing Corporation. New York. 283 pp.

Bequaert, J. and W. T. Davis. 1923. Tabanidae of Staten Island and Long Island, N. Y. Bull. Brooklyn Entomol. Soc. 18: 113-122.

Berg, M. and S. Lang. 1948. Observations of hibernating mosquitoes in Massachusetts. Mosq. News 8: 70-71.

Bidlingmayer, W. L. 1954. Description of a trap for *Mansonia* larvae. Mosq. News 14: 55-58.

Bidlingmayer, W. L. 1966. Use of the truck trap for evaluating adult mosquito populations. Mosq. News 26: 139-143.

Bidlingmayer, W. L. 1967. A comparison of trapping methods for adult mosquitoes: species response and environmental influence. J. Med. Entomol. 4: 200-220.

Bidlingmayer, W. L. 1968. Larval development of *Mansonia* mosquitoes in central Florida. Mosq. News 28: 51-57.

Bidlingmayer, W. L. 1974. The influence of environmental factors and physiological stage on flight patterns of mosquitoes taken in the vehicle aspirator and truck, suction, bait and New Jersey light traps. J. Med. Entomol. 11: 119-146.

Blickle, R. L. 1952. Notes on the mosquitoes (Culicinae) of New Hampshire. Proc. N. J. Mosq. Exterm. Assoc. 39: 198-202.

Bodola, A. 1968. Which method of water control? Proc. N. J. Mosq. Exterm. Assoc. 55: 58-64.

Botsford, R. C. 1936. Progress of mosquito control in Connecticut, 1935. Proc. N. J. Mosq. Exterm. Assoc. 23: 151-153.

Bourassa, J.-P. et A. Aubin. 1974. Conditions physico-chimiques printanières de quelques gîtes culicidens de la Basse-Maurice, Québec. Ann. Limnol. 10: 85-97.

Brown, A. W. A., R. P. Thompson, C. R. Twinn and L. K. Cutkomp. 1951. Control of adult mosquitoes and black flies by DDT sprays applied from aircraft. Mosq. News 11: 75-84.

Buescher, E. L., R. J. Byrne, G. C. Clarke, D. J. Gould, P. K. Russell, F. G. Scheider and T. M. Yuill. 1970. Cache Valley virus in the Del Mar Va Peninsula. I. Virologic and serologic evidence of infection. Am. J. Trop. Med. Hyg. 19: 493-502.

Butts, W. L. 1974. An extended survey of mosquito populations in an ecological research tract in eastern New York. Mosq. News 34: 224-228.

Carpenter S. J. 1950. Notes on mosquitoes in North America: I- New distribution records for eastern United States during 1946 and 1947. Mosq. News 10: 64-65.

Carpenter, S. J. and W. J. LaCasse. 1955. Mosquitoes of North America (north of Mexico). University of California Press. Berkeley, California.

Catts, E. P. 1970. A canopy trap for collecting Tabanidae. Mosq. News 30: 472-474.

Chant, G. D. and W. F. Baldwin. 1972. Dispersal and longevity of mosquitoes tagged with ^{32}P. Can. Entomol. 104: 941-944.

Chapman, H. C. and F. Ferrigno. 1956. A three-year study of mosquito breeding in natural and impounded salt-marsh areas in New Jersey. Proc. N. J. Mosq. Exterm. Assoc. 43: 48-64.

Christophers, S. R. 1947. Mosquito repellents. J. Hyg. 45: 176-231.

Chutter, F. M. 1970. A preliminary study of factors influencing the number of oocytes present in newly emerged blackflies (Diptera: Simuliidae) in Ontario. Can. J. Zool. 48: 1389-1400.

Collett, G. C. and D. M. Rees. 1972. Approaches to mosquito control on the marshes of the Great Salt Lake, Utah. Proc. N. J. Mosq. Exterm. Assoc. 59: 26-29.

Conradi, A. F. 1905. Black-fly studies. U. S. Dept. Agric., Bur. Entomol. Bull. 52: 100-101.

Cookingham, R. A. 1971. Mosquito control - an important part of wetlands management. Proc. N. J. Mosq. Exterm. Assoc. 58: 34-39.

Corbet, P. S. and H. V. Danks. 1973. Seasonal emergence and activity of mosquitoes (Diptera: Culicidae) in a high-arctic locality. Can. Entomol. 105 837-872.

Coyne, G. E. and L. E. Hagmann. 1970. Distribution of *Wyeomyia* species in New Jersey. Proc. N. J. Mosq. Exterm. Assoc. 57: 190-195.

Crans, W. J. 1964. Continued host preference studies with Jew Jersey mosquitoes. Proc. N. J. Mosq. Exterm. Assoc. 51: 50-58.

Crans, W. J. 1970. The blood feeding habits of *Culex territans* Walker. Mosq. News 30: 445-447.

Crans, W. J. and E. G. Rockel. 1968. The mosquitoes attracted to turtles. Mosq. News 28: 332-337.

Curtis, L. C. 1953. Observations on mosquitoes at Whitehorse, Yukon Territory (Culicidae: Diptera). Can. Entomol. 85: 353-370.

Curtis, L. C. 1968. A method for accurate counting of blackfly larvae (Diptera: Simuliidae). Mosq. News 28: 238-239.

Danks, H. V. and P. S. Corbet. 1973. Sex ratios at emergence of two species of high-arctic *Aedes* (Diptera: Culicidae). Can. Entomol. 105: 647-651.

Darsie, R. F. 1951. Pupae of the culicine mosquitoes of the northeastern United States (Diptera, Culicidae, Culicini). Cornell Agric. Exp. Stn. Mem. 304: 3-67.

Darsie, R. F., Jr. and P. F. Springer. 1957. Three-year investigation of mosquito breeding in natural and impounded tidal marshes in Delaware. Univ. Del. Agric. Exp. Stn. Tech. Bull. 320: 65 pp.

Davies, D. M. 1950. A study of the black fly population of a stream in Algonquin Park, Ontario. Trans. R. Can. Inst. 28: 121-159.

Davies, D. M. 1952. The population and activity of adult female black flies in the vicinity of a stream in Algonquin Park, Ontario. Can. J. Zool. 30: 287-321.

Davies, D. M. 1953. Longevity of black flies in captivity. Can. J. Zool. 31: 304-312.

Davies, D. M. 1959. Seasonal variation of tabanids (Diptera) in Algonquin Park, Ontario. Can. Entomol. 91: 548-553.

Davies, D. M. and B. V. Peterson. 1956. Observations on the mating, feeding, ovarian development, and oviposition of adult black flies (Simuliidae, Diptera). Can. J. Zool. 34: 615-655.

Davies, D. M., B. V. Peterson and D. M. Wood. 1962. The black flies (Diptera: Simuliidae) of Ontario. Part I. Adult identification and distribution with descriptions of six new species. Proc. Entomol. Soc. Ont. 92: 70-154.

Davies, D. M. and P. D. Syme. 1958. Three new Ontario black flies of the genus *Prosimulium* (Diptera: Simuliidae). Part II. Ecological observations and experiments. Can. Entomol. 90: 744-759.

Davies, L. 1961. Ecology of two *Prosimulium* species (Diptera) with reference to their ovarian cycles. Can. Entomol. 93: 1113-1140.

Davies, L. 1963. Seasonal and diurnal changes in the age-composition of adult *Simulium venustum* Say (Diptera) population near Ottawa. Can. Entomol. 95: 654-667.

Davis, C. C. 1971. A study of the hatching process in aquatic invertebrates. XXV. Hatching in the blackfly, *Simulium* (probably *venustum*) (Diptera, Simuliidae). Can. J. Zool. 49: 333-336.

DeFoliart, G. R. and C. D. Morris. 1967. A dry ice-baited trap for the collection and field storage of hematophagous Diptera. J. Med. Entomol. 4: 360-362.

Dimond, J. B. and W. G. Hart. 1953. Notes on the blackflies (Simuliidae) of Rhode Island. Mosq. News 13: 238-242.

Dorer, R. E. 1970. How mosquito control works in Virginia. Rep. Water Resour. Res. Inst. 36: 115-120.

Dorer, R. E., R. G. Carter and W. E. Bickley. 1950. Observations on the pupae of *Mansonia perturbans* (Walk.) in Virginia. Proc. N. J. Mosq. Exterm. Assoc. 37: 110-112.

Downe, A. E. R. 1962. Some aspects of host selection by *Mansonia perturbans* (Walk.) (Diptera: Culicidae). Can. J. Zool. 40: 725-732.

Downe, A. E. R. and P. E. Morrison. 1957. Identification of blood meals of blackflies (Diptera: Simuliidae) attacking farm animals. Mosq. News 17: 37-40.

Downes, J. A. 1969. The swarming and mating flight of the Diptera. Annu. Rev. Entomol. 14: 271-298.

Downes, J. A., A. E. R. Downe and L. Davies. 1962. Some aspects of the behaviour and physiology of biting flies that influence their role as vectors. Proc. XIth Int. Congr. Entomol. 3: 119-121.

Dunbar, R. W. 1958. The salivary gland chromosomes of two sibling species of black flies included in *Eusimulium aureum* Fries. Can. J. Zool. 36: 23-44.

Dyar, H. G. 1902. Notes on mosquitoes of Long Island. Proc. Entomol. Soc. Wash. 5: 45-51.

Dyar, H. G. 1903. Notes on mosquitoes in New Hampshire. Proc. Entomol. Soc. Wash. 5: 140-149.

Dyar, H. G. 1909. A report on mosquitoes at Dublin, New Hampshire, particularly on the occurrence of *Mansonia perturbans* Walker. Proc. Entomol. Soc. Wash. 11: 145-149.

Dyar, H. G. 1921. The mosquitoes of Canada. Trans. R. Can. Inst. 13: 71-120.

Dyar, H. G. 1922. The mosquitoes of the United States. Proc. U. S. Natl. Mus. 62: 1-119.

Easton, E. R., A. Price and O. H. Graham. 1968. The collection of biting flies in West Texas with Malaise and animal-baited traps. Mosq. News 28: 465-469.

Edman, J. D. 1964. Control of *Culex tarsalis* (Coquillett) and *Aedes vexans* (Meigen) on Lewis and Clarke Lake (Gavins Point Reservoir) by water level management. Mosq. News 24: 173-185.

Ezenwa, A. O. 1974. Ecology of Simuliidae, Mermithidae, and Microsporida in Newfoundland freshwaters. Can. J. Zool. 52: 557-565.

Fallis, A. M. 1964. Feeding and related behavior of female Simuliidae (Diptera). Exp. Parasitol. 15: 439-470.

Fallis, A. M. and G. F. Bennett. 1958. Transmission of *Leucocytozoon bonasae* Clarke to ruffled grouse (*Bonasa umbellus* L.) by the blackflies *Simulium latipes* Mg. and *Simulium aureum* Fries. Can. J. Zool. 36: 533-539.

Fallis, A. M. and G. F. Bennett. 1962. Observations on the sporogony of *Leucocytozoon mirandae*, *L. bonase*, and *L. fringillinarum* (Sporozoa: Leucocytozoidae). Can. J. Zool. 40: 395-400.

Felt, E. P. 1904. Mosquitoes or Culicidae of New York State. N. Y. State Mus. Bull. 79: 241-400.

Fellton, H. L., R. C. Barnes and C. A. Wilson. 1950. New distribution records for the mosquitoes of New England. Mosq. News 10: 84-91.

Ferrigno, F. 1961. Variations in mosquito-wildlife associations on coastal marshes. Proc. N. J. Mosq. Exterm. Assoc. 48: 193-203.

Ferrigno, F. and D. M. Jobbins. 1968. Open marsh water management. Proc. N. J. Mosq. Exterm. Assoc. 55: 104-115.

Florschutz, O., Jr. 1959. Mosquito production and wildlife usage in impounded, ditched and unditched tidal marshes at Assawoman Wildlife Area, Delaware, 1957-1958. Proc. N. J. Mosq. Exterm. Assoc. 46: 103-111.

Franz, D. R. 1963. Production and distribution of mosquito larvae on some New Jersey salt marsh impoundments. Proc. N. J. Mosq. Exterm. Assoc. 50: 279-285.

Fraser, J. C. 1961. Wetlands, wildlife, and some conflicts. Calif. Vector Views 8: 35-37.

Fredeen, F. J. H. 1961. A trap for studying the attacking behaviour of black flies, *Simulium arcticum* Mall. Can. Entomol. 93: 73-78.

Freeman, J. V. and E. J. Hansens. 1972. Collecting larvae of the salt marsh greenhead *Tabanus nigrovittatus* and related species in New Jersey: comparison of methods. Environ. Entomol. 1: 653-658.

Ganong, W. F. 1903. The vegetation of the Bay of Fundy salt marshes, an ecological study. Bot. Gaz. 36: 161-186, 280-302, 349-367, 429-455.

Gartrell, F. E., W. W. Barnes and G. S. Christopher. 1972. Environmental impact and mosquito control water resource management projects. Mosq. News 32: 337-343.

Gibson, A. 1934. Mosquito suppression work in Canada in 1933. Proc. N. J. Mosq. Exterm. Assoc. 21: 102-112.

Gibson, A. 1938. Mosquito suppression work in Canada in 1937. Proc. N. J. Mosq. Exterm. Assoc. 25: 176-185.

Gibson, A. 1939. Mosquito suppression work in Canada in 1938. Proc. N. J. Mosq. Exterm. Assoc. 26: 109-116.

Gibson, A. 1940. Mosquito suppression work in Canada in 1939. Proc. N. J. Mosq. Exterm. Assoc. 27: 44-53.

Gibson, A. 1941. Mosquito suppression work in Canada in 1940. Proc. N. J. Mosq. Exterm. Assoc. 28: 167-176.

Gilchrist, B. M. and J. B. S. Haldane. 1947. Sex linkage and sex determination in a mosquito, *Culex molestus*. Hereditas 33: 175-190.

Gillies, M. T. 1974. Methods for assessing the density and survival of blood-sucking Diptera. Annu. Rev. Entomol. 19: 345-362.

Gjullin, C. M., R. I. Sailer, A. Stone and B. V. Travis. 1961. The mosquitoes of Alaska. U. S. Dep. Agric. Agric. Res. Serv., Agric. Handb. 182: 98 pp.

Gladney, W. J. and E. C. Turner, Jr. 1968. Mosquito control on Smith Mountain Reservoir by pumped storage water level management. Mosq. News 28: 606-618.

Gojmerac, W. L. and C. H. Porter. 1969. Nuisance mosquitoes in two Wisconsin parks; occurrence and correlation between biting and light trap catches. Mosq. News 29: 484-486.

Gordon, R. M. 1922. Notes on the bionomics of *Stegomyia calopus* Meig. in Brazil. Ann. Trop. Med. Parasitol. 16: 425-439.

Graham, P. 1969. A comparison of sampling methods for adult mosquito populations in central Alberta, Canada. Quaest. Entomol. 5: 217-261.

Gross, H. P., W. F. Baldwin and A. S. West. 1972. Introductory studies on the use of radiation in the control of black flies (Diptera: Simuliidae). Can. Entomol. 104: 1217-1222.

Hagmann, L. E. 1952. *Mansonia perturbans*. Recent studies in New Jersey. Proc. N. J. Mosq. Exterm. Assoc. 39: 60-65.

Hagmann, L. E. 1953. Biology of "*Mansonia perturbans*" (Walker). Proc. N. J. Mosq. Exterm. Assoc. 40: 141-147.

Hansens, E. J. 1952. Some observations on the abundance of salt marsh greenheads. Proc. N. J. Mosq. Exterm. Assoc. 39: 93-98.

Hansens, E. J. and J. W. Robinson. 1973. Emergence and movement of the saltmarsh deer flies *Chrysops fuliginosus* and *Chrysops atlanticus*. Ann. Entomol. Soc. Am. 66: 1215-1218.

Harrison, R. J. et G. Cousineau. 1973. Les moustiques au Québec, leur importance médical, vétérinaire, économique et la nécessité d'un programme de démoustication. Ann. Entomol. Soc. Qué. 18: 138-146.

Haufe, W. O. 1952. Observations on the biology of mosquitoes (Diptera: Culicidae) at Goose Bay, Labrador. Can. Entomol. 84: 254-263.

Hayes, R. O. 1961. Host preferences of *Culiseta melanura* and allied mosquitoes. Mosq. News 21: 179-187.

Hayes, R. O. 1962. The diel activity cycles of *Culiseta melanura* (Coquillett) and allied mosquitoes. Mosq. News 22: 352-356.

Hayes, R. O., R. E. Bellamy, W. C. Reeves and M. J. Willis. 1958. Comparison of four sampling methods for measurement of *Culex tarsalis* adult populations. Mosq. News 18: 218-227.

Hayes, R. O., L. C. LaMotte, L. A. White and L. D. Beadle. 1960. Isolation of eastern encephalitis virus from the mosquito *Culex restuans* collected in New Jersey during 1959. Mosq. News 20: 190.

Headlee, T. J. 1921. The mosquitoes of New Jersey and their control. N. J. Agric. Exp. Stn. Bull. 348: 1-229.

Headlee, T. J. 1931. The biology of the important economic species of mosquitoes occurring in New Jersey. Proc. N. J. Mosq. Exterm. Assoc. 18: 40-69.

Headlee, T. J. 1945. The mosquitoes of New Jersey and their control. Rutgers University Press. New Brunswick, N.J. 326 pp.

Headlee, T. J. and F. W. Miller. 1927. Mosquito control. N. J. Agric. Exp. Stn., Rep. Dep. Entomol. for 1926, pp. 237-254.

Herman, C. M. and G. F. Bennett. 1976. Use of sentinel ducks in epizootiological studies of anatid blood protozoa. Can. J. Zool. 54: in press.

Hocking, B. and W. R. Richards. 1952. Biology and control of Labrador black flies (Diptera: Simuliidae). Bull. Entomol. Res. 43: 237-257.

Holbrook, F. R. 1967. The black flies (Diptera: Simuliidae) of western Massachusetts. Ph.D. Thesis, University of Massachusetts.

Howitt, B. F., H. R. Dodge, L. K. Bishop and R. H. Gorrie. 1948. Recovery of the virus of eastern equine encephalomyelitis from mosquitoes (*Mansonia perturbans*) collected in Georgia. Science 110: 141-142.

Iversen, J. O., R. J. Wagner, C. deJong and J. McLintock. 1973. California encephalitis virus in Saskatchewan: isolation from boreal *Aedes* mosquitoes. Can. J. Public Health 64: 590-594.

Jackson, C. I. and J. W. Maxwell. 1971. Landowners and land use in the Tantramar area, New Brunswick. Can. Land Invent., Dep. Reg. Econ. Expan., CLI Rep. 9: 37 pp.

James, H. G. 1960. Note on effects of drought on larvae of *Aedes vexans* Meigen (Diptera: Culicidae). Mosq. News 20: 320-321.

James, H. G. 1962. Winter mortality in larvae of *Aedes trichurus* (Dyar). Mosq. News 22: 123-125.

James, H. G. 1963. Larval habitats, development, and parasites of some Tabanidae (Diptera) in southern Ontario. Can. Entomol. 95: 1223-1232.

James, H. G., G. Wishart, R. E. Bellamy, M. Maw and P. Belton. 1969. An annotated list of mosquitoes of southeastern Ontario. Proc. Entomol. Soc. Ont. 100: 200-230.

Jamnback, H. 1952. The importance of correct timing of larval treatments to control specific blackflies (Simuliidae). Mosq. News 12: 77-78.

Jamnback, H. 1956. An illustrated key to the blackfly larvae commonly collected in New York State. N. Y. State Sci. Serv., Univ. State N. Y. (Rep. of Investigations). 10 pp.

Jamnback, H. 1969*a*. Field tests with larvicides other than DDT for control of blackfly (Diptera: Simuliidae) in New York. Bull. W.H.O. 40: 635-638.

Jamnback, H. 1969*b*. Bloodsucking flies and other outdoor nuisance Arthropods of New York State. N. Y. State Mus. Sci. Serv. Mem. 19: 90 pp.

Jamnback, H. and D. L. Collins. 1955. The control of blackflies (Diptera: Simuliidae) in New York. N. Y. State Mus. Bull. 350: 113 pp.

Jamnback, H. and J. Frempong-Boadu. 1966. Testing blackfly larvicides in the laboratory and in streams. Bull. W.H.O. 34: 405-421.

Jamnback, H., J. D. M. Marr, B. B. Waddy and L. Kartman. 1971. Blackflies in the Americas. WHO/VBC/71.283, 24 pp.

Jamnback, H. and R. Means. 1966. Length of exposure period as a factor influencing the effectiveness of larvicides for blackflies (Diptera: Simuliidae). Mosq. News 26: 589-591.

Jamnback, H. and R. G. Means. 1968. Formulation as a factor influencing the effectiveness of Abate® in control of blackflies (Diptera: Simuliidae). Proc. N. J. Mosq. Exterm. Assoc. 55: 89-94.

Jamnback, H. and W. Wall. 1959. The common salt-marsh Tabanidae of Long Island, New York. N. Y. State Mus. Sci. Serv. Bull. 375: 77 pp.

Jamnback, H. and A. S. West. 1970. Decreased susceptibility of blackfly larvae to p, p'-DDT in New York State and eastern Canada. J. Econ. Entomol. 63: 218-221.

Jenkins, D. W. and K. L. Knight. 1950. Ecological survey of the mosquitoes of Great Whale River, Quebec. Proc. Entomol. Soc. Wash. 52: 209-223.

Johnson, A. F. and D. H. Pengelly. 1966. A cone trap for immature blackflies (Diptera: Simuliidae). Proc. Entomol. Soc. Ont. 96: 120.

Joyce, J. M., Jr. and E. J. Hansens. 1968. The influence of weather on the activity and behavior of greenhead flies, *Tabanus nigrovittatus* Macquart and *Tabanus lineola* Fabricius. J. N. Y. Entomol. Soc. 76: 72-80.

Judd, W. W. 1950. Mosquitoes collected in the vicinity of Hamilton, Ontario during the summer of 1948. Mosq. News 10: 57-59.

Judd, W. W. 1954*a*. Results of a survey of mosquitoes conducted at London, Ontario in 1952 with observations on the biology of the species collected. Can. Entomol. 86: 101-108.

Judd, W. W. 1954*b*. Observations on the duration of the pupal stage of ten species of mosquitoes reared at London, Ontario. Can. Entomol. 86: 464-465.

Kadlec, J. H. 1960. The effect of a draw down on the ecology of a waterfowl impoundment. Ph.D. Thesis, University of Michigan.

King, W. V., G. H. Bradley and T. E. McNeel. 1944. The mosquitoes of the southeastern states. Revised Edition. U. S. Dep. Agric. Misc. Publ. 336: 96 pp.

Knight, K. L. 1964. Quantitative methods for mosquito larval surveys. J. Med. Entomol. 1: 109-115.

Knight, K. L. 1967. Distribution of *Aedes sollicitans* (Walker) and *Aedes taeniorhynchus* (Wiedemann) within the United States (Diptera, Culicidae). J. Ga. Entomol. Soc. 2: 9-12.

Knutson, H. 1943. The status of the mosquitoes of the Great Swamp in Rhode Island during 1942. J. Econ. Entomol. 36: 311-319.

Kozlik, F. M. 1969. The State Department of Fish and Game - its role and interest in vector control. Proc. Calif. Mosq. Contr. Assoc. 37: 37-40.

Lake, R. W. 1953. New mosquito distribution records for New Jersey. Proc. N. J. Mosq. Exterm. Assoc. 40: 152-155.

Lamborn, W. A. 1922. The bionomics of some Malayan anophelines. Bull. Entomol. Res. 13: 129-149.

Larson, D. R., J. E. Rowe, R. O. Hayes, P. Holden and G. C. Parikh. 1971. Preliminary report on arbovirus isolations from South Dakota mosquitoes collected during the summer of 1969. Mosq. News 31: 157-159.

Lathrop, F. H. 1939. Mosquitoes collected in Maine. Maine Agric. Exp. Stn. Bull. 397: 828-829.

Le Maître, M. P. 1972. Première observation d'encephalité équine (Type est) dans la Province de Québec. Méd. Vét. 2: 33-35.

Leonard, M. D. 1928. A list of the insects of New York. Family Tabanidae. Cornell Univ. Agric. Exp. Stn. Mem. 101: 754-758.

Lewis, D. J. 1973. The Simuliidae of insular Newfoundland and their dynamics in small streams on the Avalon Peninsula. M.Sc. Thesis, Memorial University of Newfoundland.

Lewis, D. J. and G. F. Bennett. 1973. The blackflies (Diptera: Simuliidae) of insular Newfoundland. I. Distribution and bionomics. Can. J. Zool. 51: 1181-1187.

Lewis, D. J. and G. F. Bennett. 1974*a*. An artificial substrate for the quantitative comparison of the densities of larval simuliid (Diptera) populations. Can. J. Zool. 52: 773-775.

Lewis, D. J. and G. F. Bennett. 1974*b*. The blackflies (Diptera: Simuliidae) of insular Newfoundland. II. Seasonal succession and abundance in a complex of small streams on the Avalon Peninsula. Can. J. Zool. 52: 1107-1113.

Lewis, D. J. and G. F. Bennett. 1975. The blackflies (Diptera: Simuliidae) of insular Newfoundland. III. Factors affecting the distribution and migration of larval simuliids in small streams on the Avalon Peninsula. Can. J. Zool. 53: 114-123.

Lounibos, L. P. and W. E. Bradshaw. 1975. A second diapause in *Wyeomyia smithii*: seasonal incidence and maintenance by photoperiod. Can. J. Zool. 53: 215-221.

Low, J. B. 1968. Waterfowl interests in relation to vector control programs. Proc. Utah Mosq. Abat. Assoc. 19: 25-30.

Lowry, P. R. 1929. Mosquitoes of New Hampshire. A preliminary report. N. H. Agric. Exp. Stn. Bull. 243: 1-23.

Mackay, R. J. 1969. Aquatic insect communities of a small stream on Mont. St. Hilaire, Quebec. J. Fish. Res. Board Can. 26: 1157-1183.

Magy, H. I. 1968. Vector and nuisance problems emanating from man-made recreational lakes. Proc. Calif. Mosq. Contr. Assoc. 36: 36-37.

Main, A. J., R. O. Hayes and R. J. Tonn. 1968. Seasonal abundance of mosquitoes in southeastern Massachusetts. Mosq. News 28: 619-626.

Malaise, R. 1937. A new insect-trap. Entomol. Tidskr. 58: 148-160.

Malloch, J. R. 1914. American black flies or buffalo gnats. U. S. Dep. Agric. Bur. Entomol. Tech. Ser. 26: 82 pp.

Matheson, R. 1944. Handbook of the mosquitoes of North America. 2nd ed. Comstock Publishing Company, Inc. Ithaca, New York. 314 pp.

Matheson, R. and J. Belkin. 1943. *Anopheles occidentalis* in central New York. Proc. N. J. Mosq. Exterm. Assoc. 30: 7-11.

Matheson, R. and H. S. Hurlbut. 1937. Notes on *Anopheles walkeri* Theobald. Am. J. Trop. Med. 17: 237-242.

Matheson, R. and R. C. Shannon. 1923. The anophelines of northeastern America (Diptera, Culicidae). Ins. Ins. Mens. 11: 57-64.

Matthysse, J. G., D. E. Mock and H. R. Netherton. 1974. Seasonal flight period and relative abundance of Tabanidae (Diptera) near Ithaca, New York. Ann. Entomol. Soc. Am. 67: 158-166.

Mattingly, P. F. 1956. Species hybrids in mosquitoes. Trans. R. Entomol. Soc. Lond. 108: 21-36.

McAlpine, J. F. 1961. Variation, distribution and evolution of the *Tabanus (Hybomitra) frontalis* complex of horse flies (Diptera: Tabanidae). Can. Entomol. 93: 894-924.

McDaniel, I. N. 1975. A list of Maine mosquitoes including notes on their importance as pests of man. Mosq. News 35: 232-233.

McDaniel, I. N. and W. R. Horsfall. 1963. Bionomics of *Aedes stimulans* (Diptera: Culicidae). I. Effect of moisture on the distribution of eggs. Amer. Midl. Nat. 70: 479-489.

McDaniel, I. N. and D. R. Webb. 1974. Identification of females of the *Aedes stimulans* group in Maine including notes on larval characters and attempts at hybridization. Ann. Entomol. Soc. Am. 67: 915-918.

McIntosh, W. 1903. The Diptera of New Brunswick. Bull. Nat. Hist. Soc. N. B. 5: 123-128.

McIver, S. B. 1969. Notes on the biology of *Culex territans* Walker. Mosq. News 29: 135-136.

McLean, D. M., S. K. A. Bergman, E. A. Graham, G. P. Greenfield, J. A. Olden and R. D. Patterson. 1974. California encephalitis virus prevalence in Yukon mosquitoes during 1973. Can. J. Public Health 65: 23-28.

McLintock, J., A. N. Burton, J. A. McKiel, R. R. Hall and J. G. Rempel. 1970. Known mosquito hosts of western encephalitis virus in Saskatchewan. J. Med. Entomol. 7: 446-454.

McNeel, T. E. 1932. Observations on the biology of *Mansonia perturbans* (Walk.) Diptera, Culicidae. Proc. N. J. Mosq. Exterm. Assoc. 19: 91-96.

Means, R. G. 1965. *Culex territans* Walker biting man in nature. Mosq. News 25: 489.

Means, R. G. 1968. Host preferences of mosquitoes (Diptera: Culicidae) in Suffolk County, New York. Ann. Entomol. Soc. Am. 61: 116-120.

Metcalf, C. L. 1932. Black flies and other biting flies of the Adirondacks. N. Y. State Mus. Bull. 289: 5-58.

Metcalf, C. L. and W. E. Sanderson. 1932. Control of biting flies in the Adirondacks. N. Y. State Mus. Bull. 289: 59-75.

Meyer, C. L. 1974. Studies on the life history and natural transmission of *Plasmodium circumflexum* Kikuth, 1931. M.Sc. Thesis, Memorial University of Newfoundland.

Meyer, C. L. and G. F. Bennett. 1976. Observations on the sporogony of *Plasmodium circumflexum* Kikuth and *Plasmodium polare* Manwell in New Brunswick. Can. J. Zool. 54: 133-141.

Meyer, C. L., G. F. Bennett and C. M. Herman. 1974. Mosquito transmission of *Plasmodium (Giovannolaia) circumflexum* Kikuth, 1931, to waterfowl in the Tantramar Marshes, New Brunswick. J. Parasitol. 60: 905-906.

Miles, V. I. and R. W. Rings. 1946. Distribution records for mosquitoes of the southeastern States in 1945. J. Econ. Entomol. 39: 387-391.

Minson, K. L., J. E. Graham and G. C. Collett. 1970. A comparison of light traps and larval surveys to measure mosquito abundance. Mosq. News 30: 474-476.

Morgan, N. O. and E. C. Uebel. 1974. Efficacy of the Assateague insect trap in collecting mosquitoes and biting flies in a Maryland salt marsh. Mosq. News 34: 196-199.

Morris, K. R. S. and M. G. Morris. 1948. The use of traps against tsetse in West Africa. Bull. Entomol. Res. 39: 491-528.

Mulhern, T. D. 1942. New Jersey mechanical trap for mosquito surveys. N. J. Agric. Exp. Stn. Circ. 421: 1-8.

Mullen, G. R. 1971*a*. Sweeping as a mosquito sampling technique. Proc. N. J. Mosq. Exterm. Assoc. 58: 93-97.

Mullen, G. R. 1971*b*. Diurnal resting sites of mosquitoes based on sweeping collections in central New York. Proc. N. J. Mosq. Exterm. Assoc. 58: 185-188.

Nagel, J. E. 1967. Habitat manipulation for wildlife and mosquito control. Proc. Utah Mosq. Abat. Assoc. 20: 9.

Nagel, J. E. 1968. Coordination and responsibility in wildlife management and mosquito control. Proc. Utah Mosq. Abat. Assoc. 19: 34.

Neys, W. A., R. J. Lavigne and G. P. Roehrkasse. 1971. Attraction of Wyoming Tabanidae (Diptera) to decoys suspended from modified Manitoba fly traps. Univ. Wyo. Agric. Exp. Stn. Sci. Monogr. 22: 11 pp.

Nielsen, H. T. 1964. Swarming and some other habits of *Mansonia perturbans* and *Psorophora ferox* (Diptera: Culicidae). Behaviour 14: 67-89.

Norris, M. 1946. Recovery of a strain of western equine encephalitis virus from *Culex restuans* (Theo.) (Diptera: Culicidae). Can. J. Res. Sec. E 24: 63-70.

O'Kane, W. C. 1926. Blackflies in New Hampshire. N. H. Agric. Exp. Stn. Tech. Bull. 32: 1-23.

Ozburn, R. H. 1944. Preliminary report on anopheline mosquito survey in Canada. Part 1 - A report on light trap collections. Proc. Entomol. Soc. Ont. 75: 37-44.

Pechuman, L. L. 1938. Additions to the New York state list of Tabanidae. J. N. Y. Entomol. Soc. 46: 457-460.

Pechuman, L. L. 1949. Some notes on Tabanidae (Diptera) and the description of two new *Chrysops*. Can. Entomol. 81: 77-84.

Pechuman, L. L. 1957*a*. Some Tabanidae (Diptera) not previously recorded from Canada. Entomol. Soc. Ont. Annu. Rep. 87: 27-28.

Pechuman, L. L. 1957*b*. The Tabanidae of New York. A distributional study. Proc. Rochester Acad. Sci. 10: 121-179.

Pechuman, L. L. 1964. A list of the Tabanidae (Diptera) of Quebec. Can. Entomol. 96: 1495-1496.

Pechuman, L. L. 1972. The horse flies and deer flies of New York (Diptera, Tabanidae). Cornell Univ. Agric. Exp. Stn. Search Agric. 2(5): 72 pp.

Pechuman, L. L. and J. J. S. Burton. 1969. Seasonal distribution of Tabanidae (Diptera) at Texas Hollow, New York in 1968. Mosq. News 29: 216-220.

Pechuman, L. L. and H. J. Teskey. 1967. A new eastern Nearctic *Chrysops* (Diptera: Tabanidae). Can. Entomol. 99: 645-650.

Pechuman, L. L., H. J. Teskey and D. M. Davies. 1961. The Tabanidae (Diptera) of Ontario. Proc. Entomol. Soc. Ont. 91: 77-121.

Pest Control. 1961. Management of water for mosquito control. Pest Control 29: 38-39, 72.

Peterson, B. V. 1962. Observations on mating swarms of *Simulium venustum* Say and *Simulium vittatum* Zetterstedt (Diptera: Simuliidae). Proc. Entomol. Soc. Ont. 92: 188-190.

Peterson, B. V. 1970. The *Prosimulium* of Canada and Alaska (Diptera: Simuliidae). Mem. Entomol. Soc. Can. 69: 216 pp.

Peterson, D. G. and L. S. Wolfe. 1958. The biology and control of blackflies (Diptera: Simuliidae) in Canada. Proc. Xth Int. Congr. Entomol. 3: 551-564.

Philip, C. B. 1962. Records of Tabanidae from Labrador and Newfoundland. Opusc. Entomol. 27: 230-236.

Philip, C. B., H. V. Weems, Jr. and G. B. Fairchild. 1973. Notes on eastern Nearctic *Haematopota*, *Merycomyia*, and *Chrysops*, and description of male of *C. zinzalus* (Diptera: Tabanidae). Fla. Entomol. 56: 339-346.

Pickavance, J. R., G. F. Bennett and J. Phipps. 1970. Some mosquitoes and blackflies from Newfoundland. Can. J. Zool. 48: 621-624.

Provost, M. W. 1968. Managing impounded salt-marsh for mosquito control and estuarine resource conservation. *In* LSU Marsh and Estuary Symposium, 1967. pp. 163–171.

Qutubuddin, M. 1953. The emergence and sex ratio of *Culex fatigans* Wied. (Diptera, Culicidae) in laboratory experiment. Bull. Entomol. Res. 43: 549–565.

Ramsay, A. 1963. The composition of the submerged forest at Fort Lawrence, Nova Scotia. Hon. Thesis, Mt. Allison University.

Rees, D. M. 1961. Water management requirements for mosquito abatement. Proc. Utah Mosq. Abat. Assoc. 14: 9-10.

Rees, D. M. 1964. Comments on water resource development and use, and mosquito control in Utah. Proc. Utah Mosq. Abat. Assoc. 17: 13-14.

Rees, D. M. 1965. Cooperative research on water management for wildlife, mosquito abatement and other beneficial use. Mosq. News 25: 91–93.

Rees, D. M. 1968. Cooperative water management for mosquito control and wildlife production. Proc. Utah Mosq. Abat. Assoc. 19: 30–33.

Rees, D. M. 1969. Insect pests and vectors on waterfowl marshes in Utah and non-chemical abatement. Coop. Res. Proj., Univ. Utah, Cent. Environ. Biol., 104 pp.

Rees, D. M., F. D. Arnold, D. M. Andersen and G. C. Collett. 1966. Multipurpose management for reusable water in Utah. Coop. Res. Proj. Univ. Utah, Inst. Environ. Biol. Res., Rep. 4, Terminal, 174 pp.

Rees, D. M. and R. N. Winget. 1968. Water management units and shore line modifications used in mosquito control investigations. Mosq. News 28: 305-311.

Rees, D. M. and R. N. Winget. 1969. Mosquito control in Utah by shore line modification. Mosq. News 29: 368–370.

Robert, A. 1958. Les Tabanidés du Parc du Mont Tremblant. Ann. Entomol. Soc. Qué. 4: 25–32.

Roberts, D. R. and J. E. Scanlon. 1974. An area sampler for collecting mosquito larvae in temporary woodland and field pools. Mosq. News 34: 467–468.

Rockel, E. G. 1969. Autogeny in the deerfly, *Chrysops fuliginosus* (Diptera: Tabanidae). J. Med. Entomol. 6: 140–142.

Rockel, E. G. and E. J. Hansens. 1970. Distribution of larval horse flies and deer flies (Diptera: Tabanidae) of a New Jersey salt marsh. Ann. Entomol. Soc. Am. 63: 681–684.

Schmitt, J. B. 1942. Five species of mosquitoes, new to New Jersey, found in last five years. Mosq. News 2: 26-29.

Scott, J. W. 1948. Initial mosquito work in Vermont. Proc. N. J. Mosq. Exterm. Assoc. 35: 102-105.

Scott, J. W. 1949. Mosquito breeding situation in Vermont for 1948. Proc. N. J. Mosq. Exterm. Assoc. 36: 170-171.

Scott, J. W. 1950. Report on mosquitoes in Vermont for 1949. Proc. N. J. Mosq. Exterm. Assoc. 37: 187-189.

Service, M. W. 1969. The use of traps in sampling mosquito populations. Entomol. Exp. Appl. 12: 403-412.

Shaw, F. R. 1959. New records and distributions of the biting flies of Mt. Desert Island, Maine. Mosq. News 19: 189-191.

Shewell, G. E. 1957. Interim report on distributions of the black flies (Simuliidae) obtained in the Northern Insect Survey. Can. Dep. Nat. Def., Def. Res. Bd. Environ. Prot. Tech. Rep. 7.

Smith, D. A. 1961. Participation in mosquito control by the Department of Fish & Game. Proc. Utah Mosq. Abat. Assoc. 14: 4-5.

Smith, J. B. 1904. The common mosquitoes of New Jersey. N. J. Agric. Exp. Stn. Bull. 171: 40 pp.

Smith, M. E. 1958. The *Aedes* mosquitoes of New England. Part I: Key to adult females. Bull. Brooklyn Entomol. Soc. 53: 39-47.

Smith, M. E. 1969. The *Aedes* mosquitoes of New England (Diptera: Culicidae). II. Larvae: Keys to instars, and to species exclusive of first instar. Can. Entomol. 101: 41-51.

Smith, S. M. and R. A. Brust. 1971. Photoperiodic control of the maintenance and termination of larval diapause in *Wyeomyia smithii* (Coq.) (Diptera: Culicidae) with notes on oogenesis in the adult female. Can. J. Zool. 49: 1065-1073.

Smith, S. M., D. M. Davies and V. I. Golini. 1970. A contribution to the bionomics of the Tabanidae (Diptera) of Algonquin Park, Ontario: seasonal distribution, habitat preferences, and biting records. Can. Entomol. 102: 1461-1473.

Smith, S. M. and R. M. Trimble. 1973. The biology of tree-holes of Point Pelee National Park, Ontario I. New mosquito records for Canada (Diptera: Culicidae). Can. Entomol. 105: 1585-1586.

Springer, P. F. 1964. Wildlife management concepts compatible with mosquito suppression. Mosq. News 24: 50-55.

Stage, H. H. and J. C. Chamberlin. 1945. Abundance and flight habits of certain Alaskan mosquitoes, as determined by means of a rotary-type trap. Mosq. News 5: 8-16.

Steward, C. C. and J. W. McWade. 1961. The mosquitoes of Ontario (Diptera: Culicidae) with keys to the species and notes on distribution. Proc. Entomol. Soc. Ont. 91: 121-188.

Stone, A. 1964. Guide to the insects of Connecticut. Part VI. The Diptera or true flies of Connecticut. Ninth Fascicle. Simuliidae and Thaumaleidae. St. Geol. Nat. Hist. Survey Bull. 97: 126 pp.

Stone, A. and H. A. Jamnback. 1955. The black flies of New York State (Diptera: Simuliidae). N. Y. State Mus. Bull. 349: 144 pp.

Stone, A., C. W. Sabrosky, W. W. Wirth, R. H. Foote, and J. R. Coulson. 1965. A catalog of the Diptera of America north of Mexico. U. S. Dep. Agric., Agric. Res. Serv., Agric. Handb. 276: 1696 pp.

Sutherland, D. J., D. M. Jobbins and L. E. Hagmann. 1967. Source reduction through water management. Proc. Calif. Mosq. Contr. Assoc. 35: 31-33.

Tarshis, I. B. 1965. A simple method for the collection of black fly larvae. Bull. Wildl. Dis. Assoc. 1: 8.

Tarshis, I. B. 1968. Use of fabrics in streams to collect black fly larvae. Ann. Entomol. Soc. Am. 61: 960-961.

Tashiro, H. and H. H. Schwardt. 1949. Biology of the major species of horse flies of central New York. J. Econ. Entomol. 42: 269-272.

Tashiro, H. and H. H. Schwardt. 1953*a*. Some natural enemies of horse flies in New York. J. Econ. Entomol. 46: 680-681.

Tashiro, H. and H. H. Schwardt. 1953*b*. Notes on the biology of *Tabanus giganteus*. J. Econ. Entomol. 46: 681-682.

Tashiro, H. and H. H. Schwardt. 1953*c*. Biological studies of horse flies in New York. J. Econ. Entomol. 46: 813-822.

Teskey, H. J. 1960. Survey of insects affecting livestock in southwestern Ontario. Can. Entomol. 92: 531-544.

Teskey, H. J. 1969. Larvae and pupae of some eastern North American Tabanidae (Diptera). Mem. Entomol. Soc. Can. 63: 147 pp.

Thompson, P. H. 1969*a*. Collecting methods for Tabanidae (Diptera). Ann. Entomol. Soc. Am. 62: 50-57.

Thompson, P. H. 1969*b*. Abundance and seasonal distribution of the Tabanidae of the Great Swamp, New Jersey. Part II. The second year. Ann. Entomol. Soc. Am. 62: 1429-1433.

Thompson, P. H. 1970. Tabanidae (Diptera) of Patuxent Wildlife Research Center, Laurel, Maryland. Ann. Entomol. Soc. Am. 63: 572-576.

Thompson, P. H. 1972. Tabanidae of Patuxent Wildlife Research Center, Laurel, Maryland. The second year. Proc. Entomol. Soc. Wash. 74: 188-192.

Thompson, P. H. and L. L. Pechuman. 1970. Sampling populations of *Tabanus quinquevittatus* about horses in New Jersey, with notes on the identity and ecology. J. Econ. Entomol. 63: 151-155.

Thorsteinson, A. J. 1958. The orientation of horse flies and deer flies (Tabanidae, Diptera): I. The attractance of heat to tabanids. Entomol. Exp. Appl. 1: 191-196.

Tindall, E. E. 1961. A two-year study of mosquito breeding and wildlife usage in the Little Creek impounded salt marsh, Little Creek Wildlife Area, Delaware, 1959-60. Proc. N. J. Mosq. Exterm. Assoc. 48: 100-105.

Townes, H. 1962. Design for a Malaise trap. Proc. Entomol. Soc. Wash. 64: 253-262.

Travis, B. V. 1966. The biology and control of black flies. Proc. N. J. Mosq. Exterm. Assoc. 53: 194-197.

Travis, B. V. 1967. Biology and control of biting flies in New York State. N. Y. State Coll. Agric. Ext. Bull. 1186: 38 pp.

Travis, B. V. 1968. Some problems with simulated stream tests of black-fly larvicides. Proc. N. J. Mosq. Exterm. Assoc. 55: 129-134.

Travis, B. V., D. L. Collins, G. R. DeFoliart and H. Jamnback. 1951. Strip spraying by helicopter to control blackfly larvae. Mosq. News 11: 95-98.

Travis, B. V. and D. Guttman. 1966. Additional tests with blackfly larvicides. Mosq. News 26: 157-160.

Travis, B. V., D. Guttman and R. R. Crafts. 1967. Tests (1966) with black fly larvicides. Proc. N. J. Mosq. Exterm. Assoc. 54: 49-53.

Travis, B. V., D. C. Kurtak and L. C. Rimando. 1970. Tests (1969) with black fly larvicides. Proc. N. J. Mosq. Exterm. Assoc. 57: 106-110.

Travis, B. V. and S. M. Schuchman. 1968. Tests (1967) with black fly larvicides. J. Econ. Entomol. 61: 843-845.

Travis, B. V. and D. P. Wilton. 1965. A progress report on simulated stream tests of blackfly larvicides. Mosq. News 25: 112-118.

Troubridge, D. A. and D. M. Davies. 1975. Seasonal changes in physiological age composition of tabanid (Diptera) populations in southern Ontario. J. Med. Entomol. 12: 453-457.

Tulloch, G. S. 1930. A key to the biting mosquitoes of New England. Psyche J. Entomol. 37: 234-244.

Tulloch, G. S. 1939. A key to the mosquitoes of Massachusetts. Psyche J. Entomol. 46: 113-136.

Twinn, C. R. 1926. Notes on the mosquitoes of the Ottawa district. Can. Entomol. 58: 108-111.

Twinn, C. R. 1931. Notes on the biology of mosquitoes of eastern Canada. Proc. N. J. Mosq. Exterm. Assoc. 18: 10-22.

Twinn, C. R. 1936*a*. The blackflies of eastern Canada (Simuliidae, Diptera). Part I. Can. J. Res. Sec. D 14: 97-130.

Twinn, C. R. 1936*b*. The blackflies of eastern Canada (Simuliidae, Diptera). Part II. Can. J. Res. Sec. D 14: 131-150.

Twinn, C. R. 1949. Mosquitoes and mosquito control in Canada. Mosq. News 9: 35-41.

Twinn, C. R. 1953. Mosquitoes and their control in Prince Edward Island. Mosq. News 13: 185-190.

Vannote, R. L. 1970. A lifetime with *Aedes vexans*. Proc. Utah Mosq. Abat. Assoc. 23: 20-21.

Wall, W. J., Jr. and O. W. Doane, Jr. 1960. A preliminary study of the bloodsucking Diptera on Cape Cod, Massachusetts. Mosq. News 20: 39-44.

Wallis, R. C. 1959. Diapause and fat body formation by *Culex restuans* Theobald (Diptera, Culicidae). Proc. Entomol. Soc. Wash. 61: 219-222.

Wallis, R. C. 1960. Mosquitoes in Connecticut. Conn. Agric. Exp. Stn. Bull. 632: 30 pp.

Wallis, R. C. 1962. Common Connecticut flies. Conn. Agric. Exp. Stn. Bull. 650: 23 pp.

Wallis, R. C. and J. Frempong-Boadu. 1967. Colonization of *Wyeomyia smithii* (Coquillett) from Connecticut. Mosq. News 27: 9-11.

Wallis, R. C. and A. J. Main, Jr. 1974. Eastern equine encephalitis in Connecticut. Mem. Conn. Entomol. Soc. pp. 117-144.

Watts, D. M., P. R. Grimstad, G. R. DeFoliart, T. M. Yuill and R. P. Hanson. 1973. Laboratory transmission of LaCrosse encephalitis virus by several species of mosquitoes. J. Med. Entomol. 10: 583-586.

Weed, C. M. 1904*a*. An experiment with black flies. U. S. Dep. Agric. Bur. Entomol. Bull. 46: 108-109.

Weed, C. M. 1904*b*. Experiments in destroying black-flies. N. H. Coll. Exp. Stn. Bull. 112: 133-136.

Welch, H. E. and H. G. James. 1960. The Belleville trap for quantitative samples of mosquito larvae. *Mosq. News 20: 23-26.*

West, A. S., A. W. A. Brown and D. G. Peterson. 1960. Control of blackfly larvae (Diptera: Simuliidae) in the forests of eastern Canada by aircraft spraying. Can. Entomol. 92: 745-754.

West, A. S. and A. Hudson. 1960. Notes on the mosquitoes of eastern Ontario. Proc. N. J. Mosq. Exterm. Assoc. 47: 68-73.

Whitman, W. R. 1974. The response of macro-invertebrates to experimental marsh management. Ph.D. Thesis, University of Maine.

Whitman, W. R. 1976. Impoundments for waterfowl. Can. Wildl. Serv. Occas. Pap. 22.

Wilson, B. H. 1968. Reduction of tabanid population on cattle with sticky traps baited with dry ice. J. Econ. Entomol. 61: 827-882.

Wishart, G. and H. G. James. 1945. Notes on the anopheline mosquitoes of the Kingston, Trenton and Peterborough, Ontario, areas. Proc. Entomol. Soc. Ont. 76: 39-48.

Wolfe, L. S. and D. G. Peterson. 1958. A new method to estimate levels of infestations of black-fly larvae (Diptera: Simuliidae). Can. J. Zool. 36: 863-867.

Wolfe, L. S. and D. G. Peterson. 1959. Black flies (Diptera: Simuliidae) of the forests of Quebec. Can. J. Zool. 37: 137-159.

Wolfe, L. S. and D. G. Peterson. 1960. Diurnal behavior and biting habits of black flies (Diptera: Simuliidae) in the forests of Quebec. Can. J. Zool. 38: 489-497.

Wood, D. M., B. V. Peterson, D. M. Davies and H. Gyorkos. 1963. The black flies (Diptera: Simuliidae) of Ontario. Part II. Larval identification, with descriptions and illustrations. Proc. Entomol. Soc. Ont. 93: 99-129.

Young, C. J. 1922. Notes on the bionomics of *Stegomyia calopus* Meig. in Brazil. Ann. Trop. Med. Parasitol. 16: 389-406.

APPENDIX A

Keys to adult female Culicidae of maritime Canada

(Adapted, in part, from Carpenter and LaCasse (1955) and Steward and McWade (1961))

Key to the Genera

1. Abdomen without scales; palpi nearly as long as proboscis . . . . *Anopheles*

   Abdomen densely scaled; palpi short 2

2. Postnotum with a tuft of setae; wing squamae without fringe of hairs . . . . *Wyeomyia* *(W. smithii)*

   Postnotum without a tuft of setae; wing squamae with a fringe of hairs 3

3. Spiracular bristles present . . . . *Culiseta*

   Spiracular bristles absent 4

4. Postspiracular bristles present; tip of abdomen pointed . . . . *Aedes*

   Postspiracular bristles absent; tip of abdomen blunt 5

5. Wing scales broad, brown and white mixed; proboscis with median wide white ring; hind tarsi with broad white bands . . . . *Mansonia* *(M. perturbans)*

   Wing scales narrow, dark; proboscis without median wide white ring; hind tarsi without broad white bands . . . . *Culex*

Key to the Species of *Anopheles*

1. Wings with patches of white scales . . . . . . *punctipennis*

   Wings entirely dark scaled 2

2. Tip of wing with a silver or copper-colored fringe. . . *earlei*

   Tip of wing without a pale fringe . . . . *walkeri*

Key to the Species of *Culiseta*

1.	Hind tarsi with pale rings on some segments. . . .	2
	Hind tarsi entirely dark	*impatiens*
2.	Wing with dense patches of dark scales	*incidens*
	Wing uniformly scaled, without dense patches of dark scales	*morsitans*

Key to the Species of *Aedes*

1.	Tarsal segments, at least on hind legs, with white rings	2
	Tarsal segments without white rings	9
2.	Tarsal segments with white rings basally only . . .	3
	Tarsal segments with white rings basally and apically	8
3.	Proboscis with white ring near middle.	*sollicitans*
	Proboscis without white ring near middle.	4
4.	Basal rings of tarsal segments broad, at least one-third as long as segments on hind tarsi. . . .	5
	Basal rings of tarsal segments narrow, at most one-fifth as long as segments on hind tarsi	7
5.	Tarsal claws with main tooth abruptly bent near base of lateral tooth, main tooth and lateral tooth parallel with each other	*excrucians*
	Tarsal claws with the main tooth bent beyond the base of the lateral tooth, main tooth and lateral tooth not parallel	6
6.	Lower mesepimeral bristles usually two or less. . .	*fitchii*
	Lower mesepimeral bristles usually three or more . .	*stimulans*
7.	Lower mesepimeral bristles absent; seventh abdominal tergite mostly dark-scaled	*vexans*
	Lower mesepimeral bristles present; seventh abdominal tergite mostly pale-scaled	*cantator*
8.	Wing with dark and white scales intermixed	*dorsalis*
	Wing entirely dark-scaled.	*canadensis*

9. Scutum with contrasting lines or stripes 10

Scutum without contrasting lines or stripes 18

10. Scutum with a broad median longitudinal stripe, widening considerably posteriorly . . . . . . *aurifer*

Scutum with or without a median longitudinal stripe, but if present not very broad and not widening posteriorly. 11

11. Scutum with a pair of broad submedian white or yellow stripes, separated by a brown stripe of about the same width . . . . *trivittatus*

Scutum without two broad submedian whitish stripes. . 12

12. Lower mesepimeral bristles present 13

Lower mesepimeral bristles absent 17

13. Hypostigial scale patch of few to many white scales . 14

Hypostigial scale patch absent 15

14. Sternopleuron with scales extending about half way to anterior angle; 1 to 3 lower mesepimeral bristles . *implicatus*

Sternopleuron with scales extending to anterior angle; 3 to 6 lower mesepimeral bristles . . . . *trichurus*

15. Wing usually with a patch of white scales at base of costa . . . . *communis*

Wing usually lacking a patch of white scales at base of costa 16

16. Scutum with broad dark brown stripe, occasionally divided by a narrow yellow line . . . . *punctor*

Scutum uniformly brown, or almost so . . . . . . *abserratus*

17. Abdominal tergites with narrow basal white bands extending across the segments and widening laterally . . . . *sticticus*

Abdominal tergites without white bands extending across the segment, but with narrow lateral triangular white patches . . . . *diantaeus*

18. Lower mesepimeral bristles present 19

Lower mesepimeral bristles absent . . . . *cinereus*

19. Scutum with many long black or brownish setae, giving a hairy appearance to the thorax; lower mesepimeral bristles 3 to 8 . . . . *impiger*

Scutum with normal setae, uniformly golden brown, occasionally with faint median lines; lower mesepimeral bristles 1 to 5 . . . . *intrudens*

Key to the Species of *Culex*

1. Abdominal tergites with basal (anterior) bands or patches of white scales 2

Abdominal tergites with apical (posterior) bands or patches of white scales . . . . *territans*

2. Abdominal tergites each with a rather broad basal whitish dorsal band. 3

Abdominal tergites with a narrow basal yellowish dorsal band . . . . *salinarius*

3. Scutum covered with uniformly golden coarse scales . . *pipiens*

Scutum covered with fine scales, usually with two pale spots near the middle . . . . *restuans*

APPENDIX B

Keys to adult female Simuliidae of maritime Canada

(Adapted, in part, from Davies *et al.* (1962) and Peterson (1970))

Key to the Genera

1. Costa with fine hair only, not interspersed with spinules; radial sector forked apically; legs unicolorous; calcipala absent . . . . *Prosimulium*

   Costa with spinules interspersed among the fine hair; radial sector simple, legs unicolorous or of contrasting colors; calcipala usually present. 2

2. Length of vein R at least one-third the remaining distance to apex of wing, with hair dorsally; second basal cell of wing usually distinguishable; legs unicolorous; second hind tarsal segment without pedisulcus or this represented by a shallow depression only . . . . *Cnephia*

   Length of vein R usually much less than one-third the remaining distance to wing apex, with or without hair dorsally; second basal cell of wing incomplete or absent; legs usually of contrasting colors; second hind tarsal segment with a distinct, usually deep pedisulcus . . . . *Simulium*

Key to the Species of *Prosimulium*[1]

1. Arm of genital fork with a rounded to subquadrate terminal plate, bearing a short, broad, rounded or bluntly pointed, inner distal process 2

   Arm of genital form with a triangular or subtriangular, terminal plate, bearing a longer, slender, sharply pointed, inner distal process 3

2. Anteroventral margin of anal lobe with a distinct anterior projection; sclerotization pattern along inner margin of ovipositor lobe broadly expanding laterally into a shoulder at proximal end of lobe; arm of genital form short, conspicuously narrowing distally to point of attachment of terminal plate . . . *fuscum*

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[1]Females of *P. approximatum* are not definitely known (Peterson, 1970).

Anteroventral margin of anal lobe with an indistinct anterior projection; sclerotization pattern along inner margin of ovipositor lobe narrow, not expanding laterally into a shoulder at proximal end of lobe; arm of genital fork long, broad, and of uniform width along its length . . . . *multidentatum*

3. Sensory vesicle of third palpal segment opening directly to exterior by means of a wide mouth, neck absent or very short; scape and pedicel of antenna yellowish or orange brown, contrastingly lighter than flagellomeres; humeral angles of thorax yellowish brown, contrasting with darker scutum; femora and tibiae usually yellow; ovipositor lobe broadly rounded along entire outside margin. . . . . *fontanum*

Sensory vesicle of third palpal segment opening to exterior by a conspicuous neck which does not expand to form a mouth much wider than neck itself; scape and pedicel of antenna concolorous or only slightly lighter than flagellomeres; humeral angles of thorax usually not lighter than scutum; femora and tibiae usually light brown to beige, ovipositor lobe usually somewhat concave along outside margin near middle . . . . *mixtum*

Key to the Species of *Cnephia*

1. Claws simple . . . . *mutata*

Claws each with a small, sub-basal tooth. . . . . . *dacotensis*

Key to the Species of *Simulium*

1. Vein R with hair dorsally. 2

Vein R without hair dorsally. 5

2. Claws simple . . . . *furculatum*

Claws each with a large, thumb-like basal projection. . . 3

3. Basal two thirds of tibiae (integument and vestiture) yellow, contrasting with the distal black portion (integument and vestiture); postscutellum with two patches of gold hair . . . . *aureum*

Tibiae not as above, integument darker basally and distally, usually connected by a dark strip along the dorsal edge, or tibiae brown, gray or black; postscutellum usually bare 4

4. Katepisternum with a patch of hair along the dorsal margin . . . . *croxtoni*

Katepisternum bare . . . . *latipes*

5. Claws with a large thumb-like, basal projection; fore coxa yellow . . . . *rugglesi*

Claws simple or with a small, distinct, sub-basal tooth; fore coxa variable. 6

6. Claws with a small, distinct, sub-basal tooth 7

Claws simple 8

7. Anal lobe large, quadrate, rounded anteriorly; anterior tibia with a conspicuous, bright, white patch; claws small, curved, sub-basal tooth minute; hair of stem vein, pleural tuft, and fine scutal hair, pale. . . . *corbis*

Anal lobe subtriangular, narrow dorsally, expanding ventrally, anterior margin concave, posterior margin nearly straight; anterior tibia entirely black; claws long, slender, gently curved, with a conspicuous sub-basal tooth; hair of stem vein, pleural tuft and fine hair of scutum black . . . . . *parnassum*

8. Pale gray species with conspicuous vittae on dorsum of scutum; abdomen with a distinct black and light gray pattern; fore coxa dark. . . . . *vittatum*

Brownish or blackish species without conspicuous vittae on dorsum of scutum; if pale, or with thoracic stripes, abdomen never gray and without a distinct black and light gray pattern; fore coxa variable 9

9. Frons and terminal abdominal tergites pollinose; anal lobe large, subquadrate, narrow dorsally, greatly broadening ventrally, anteroventral margin rounded, with a short, posteroventral projection under cercus . . . . *decorum*

Frons and terminal abdominal tergites shining black or brown; anal lobe not as above 10

10. Fore tibia with, at most, a narrow, grayish-white streak on anterior surface covering, at most, one-third the width of the tibia; small, dark species. . . *tuberosum*

Fore tibia with a conspicuous, bright, yellowish-white patch on anterior surface covering at least one-half the width of the tibia; size and color variable 11

11. Subcosta with a row of fine hair on ventral surface; dorsum of thorax, viewed from front, grayish with two widely separated dark patches on anterolateral margins; thoracic hair pale yellow; median area of anal lobe not produced anteriorly, about same horizontal length as cercus 12

Subcosta without a row of fine hair, or, at most, with about four hairs on ventral surface; dorsum of thorax, viewed from front, shining black or only faintly grayish, without two dark patches on anterolateral margins; thoracic hair darker and more sparse; median area of anal lobe produced anteriorly to about twice horizontal length of cercus . . . . *jenningsi*

12. Inner margin of ovipositor lobes straight and slightly diverging distally; anterior margin of anal lobe not noticeably more sclerotized than rest of lobe . . . . *venustum*

Inner margin of ovipositor lobes concave, with an oval space between them; anterior margin of anal lobe noticeably more sclerotized than rest of lobe . . . *verecundum*

APPENDIX C

Keys to adult female Tabanidae of maritime Canada

(Adapted, in part, from Pechuman (1972) and Pechuman *et al.* (1961))

Key to the Genera

1.	Hind tibiae with 2 apical spurs	2
	Hind tibiae without apical spurs.	3
2.	Flagellum of antenna with 8 distinct annuli.	*Stonemyia*
	Flagellum of antenna with 5 distinct annuli	*Chrysops*
3.	Basal callus well developed, nearly as wide as frons .	4
	Basal callus absent or vestigial.	*Atylotus*
4.	Vertex with distinct denuded ocellar tubercle	*Hybomitra*
	Vertex without ocellar tubercle	*Tabanus*

Key to the Species of *Stonemyia*

1.	Legs reddish brown; posterior margins of abdominal segments with grayish hairs	*rasa*
	Legs black; posterior margins of segments with yellow hairs	*tranquilla*

Key to the Species of *Chrysops*[1]

1.	Apex of wing beyond crossband hyaline	2
	Apex of wing beyond crossband infuscated so that an apical spot is present	9
2.	Second basal cell hyaline; frontoclypeus without median pollinose stripe.	3
	Second basal cell at least half infuscated; frontoclypeus with median pollinose stripe	4

[1]McIntosh (1903) reported *C. proclivis* from New Brunswick but Stone *et al.* (1965) restrict the distribution of this species to the Yukon Territory, Alberta, south to California and Colorado. Since it is doubtful whether *C. proclivis* occurs in maritime Canada, it is not included in this key to the species of *Chrysops*.

3. Bare integument runs from ocellar area to occiput uninterrupted by pollinose areas; sublateral thoracic stripes distinct . . . . *calvus*

Bare integument of ocellar area interrupted by pollinose band; sublateral thoracic stripes indistinct . . . . *niger*

4. Abdomen entirely dark, sometimes with an indefinite pattern of grayish pollinose areas 5

Abdomen with pale areas on at least first 2 abdominal segments. 8

5. Fifth posterior cell with hyaline area at base . . . 6

Fifth posterior cell infuscated at base 7

6. Crossband reaches hind margin of wing rather broadly, outer margin straight or slightly bowed; hyaline spot at base of fifth posterior cell large, distinct, and clear-cut . . . . *carbonarius*

Crossband usually not broadly reaching hind margin of wing, outer margin irregular; hyaline spot at base of fifth posterior cell not clear-cut, sometimes almost indistinct. . . . . *ater*

7. Pleura with yellow to orange-red pile; crossband broadly reaches hind margin of wing. . . . . . . *cincticornis*

Pleura with grayish or pale yellowish pile; crossband narrowly or not at all reaching hind margin of wing. . . . . *mitis*

8. Wing picture pale; pleura with gray pile; no median abdominal triangles . . . . *cuclux*

Wing picture dark; pleura with yellow or orange pile; median abdominal triangles present . . . . . *excitans*

9. Frontoclypeus black with a median pollinose-stripe. . 10

Frontoclypeus shining yellow at least in center; without median pollinose stripe 12

10. Legs often with considerable yellow, hind tibiae never completely black; apical spot covers entire upper branch of third longitudinal vein . . . . . . *frigidus*

All femora and tibiae predominantly black, hind tibiae completely so; apical spot rarely covers entire upper branch of third longitudinal vein 11

11. Apical spot paler than crossband and indefinite in outline; outer margin of crossband rather straight. . . . *sordidus*

Apical spot dark as crossband, reaching and usually crossing upper branch of third longitudinal vein; outer margin of crossband bowed . . . . *zinzalus*

12. Crossband and apical spot broken by dilute areas along veins; abdomen striate . . . . *shermani*

Dark markings of wing not broken by dilute areas . . . 13

13. Wing markings rather pale; a conspicuous spot, which is often connected to strongly bowed crossband, covers bifurcation of third longitudinal vein; apical spot fills second submarginal cell; dull blackish species . *fuliginosus*

Not with above combination of characters; if spot is present at bifurcation, apical spot is narrow . . . 14

14. First basal cell completely infuscated, rarely with subhyaline spot at apex. 15

First basal cell always at least half hyaline, sometimes almost entirely so 17

15. Fifth posterior cell mostly infuscated; scutellum yellow . . . . *vittatus*

Fifth posterior cell almost entirely hyaline; scutellum dark, with or without paler apex and/or sides. 16

16. Apical spot nearly fills second submarginal cell; 2 central stripes of abdomen rarely joined on second segment; frontal callus usually yellow, sometimes brown or black. . . . . *aberrans*

Apical spot only half fills second submarginal cell; 2 central abdominal stripes usually join on second segment; frontal callus usually black, sometimes brownish, rarely yellowish. . . . . *striatus*

17. Apical spot narrow, including at most only extreme apex of second submarginal cell 18

Apical spot broad, entering second submarginal cell over at least one-third of upper branch of third longitudinal vein. 19

18. Crossband dilute and leaving about half of discal cell hyaline; cheeks black; frontoclypeus with large black spot on each side . . . . *delicatulus*

Crossband saturate and covering discal cell; frontoclypeus and cheeks yellow or orange . . . . . *aestuans*

19. Blackish species with a mid-dorsal yellow abdominal stripe, sometimes with shorter stripes on each side. . . *univittatus*

Abdomen with a different pattern and showing more yellow. 20

20. Hyaline triangle distinctly crosses second longitudinal vein nearly separating apical spot from crossband . . . 21

Hyaline triangle at most reaches second longitudinal vein . . . . *montanus*

21. First basal cell at least half infuscated . . . . . *furcatus*

First and second basal cells are almost completely hyaline . . . . *lateralis*

Key to the Species of *Atylotus*

1. Pleural hairs bright yellow; basal portion of third antennal segment about as broad as long. . . . . . . *bicolor*

Pleural hairs gray; basal portion of third antennal segment variable, slender to broad 2

2. Hair of abdomen whitish; if yellow hairs are present laterally, more than half of hind femora black; frons moderately wide; eye in life usually with a diagonal band. . . . . *ohioensis*

Hair of abdomen yellow; femora variable, completely yellow to half black; frons rather narrow; eye in life with or without diagonal band 3

3. Abundant black hair on palpi and prescutal lobe; abdomen dark brown, narrowly yellowish on sides of first two segments; hair of venter often white on first two segments; genae yellowish at least on upper portions; eye in life often with band . . . *pemeticus*

Only scattered black hairs on palpi and prescutal lobe; abdomen fuscous in center, broadly yellowish on sides; hair of venter mostly yellow; genae usually gray with gray hairs; eye in life without band . . . *thoracicus*

Key to the Species of *Hybomitra*

1. Abdomen without median stripe or triangles; but posterior margins of all segments with yellowish or whitish bands . . . . *zonalis*

   Abdomen with median markings 2

2. Subcallus denuded and shining. 3

   Subcallus pollinose 7

3. Abdomen broadly orange-brown laterally, the median black area constricted on third segment 4

   Abdomen not broadly orange-brown laterally, if paler laterally the median dark area on third segment is broad and not constricted 5

4. Basal callus shiny and protuberant; all cross veins strongly spotted with brown . . . . *lasiophthalma*

   Basal callus flat and wrinkled; spots on cross veins, if present, not clear-cut . . . . *nuda*

5. Palpi extremely slender; proboscis elongate; thorax subshining . . . . *longiglossa*

   Palpi not slender; proboscis normal; thorax not subshining 6

6. Abdomen usually with considerable orange-brown laterally; bifurcation of third longitudinal vein with a dark spot; costal cell infuscated; palpi stout; third antennal segment stout ; no stump vein at bifurcation of third longitudinal vein. . . . . . *lurida*

   Not with this combination of characters; a stump vein often present at bifurcation of third longitudinal vein. . . . . *liorhina*

7. Abdomen black with a median row of distinct white triangles and no sublateral spots . . . . . . *sodalis*

   Abdomen otherwise marked 8

8. Abdomen broadly orange-brown laterally, median black area constricted on third segment 9

   Abdomen not as above, if paler laterally median dark area of third segment broad and not constricted. . . 12

9. Second palpal segment rather stout, especially at base; antennae mostly orange . . . . *epistates*

Second palpal segment slender; at least annuli of antennae dark 10

10. Second palpal segment unusually slender, at least 5 times as long as greatest width; basal portion of third antennal segment about four-fifths as long as wide and annulate portion rather short, almost no dorsal excision . . . . *trepida*

Second palpal segment moderately slender, about three times as long as greatest width; basal portion of third antennal segment not more than three-fifths as long as wide and annulate portion relatively long, dorsal excision distinct 11

11. Basal callus quadrangular, rarely joined to median callus; basal portion of third antennal segment rather deeply excised; palpi yellowish white; about 3 times as long as greatest width . . . . *affinis*

Basal callus rounded above and often joined to median callus; basal portion of third antennal segment rather slender and not deeply excised; palpi yellow, 3½ to 4 times as long as greatest width . . . . *aurilimba*

12. Second palpal segment slender, scarcely thickened at base 13

Second palpal segment stout, especially at base. . . . 18

13. Femora, except base of hind femora, brown; sides of abdomen reddish-brown; second palpal segment extremely slender; third antennal segment practically without dorsal excision . . . . *minuscula*

Femora usually black; if brown, sides of abdomen not with considerable orange brown 14

14. Prescutal lobe black; hair of palpi long, uneven and semi-erect. . . . . *astuta*

Prescutal lobe pale; hair of palpi as above or short and lying smoothly against segment 15

15. Frons about twice as high as wide; frontal callus pale brown; femora brown; costal cell clear. . . . . . *itasca*

Frons more than twice as high as wide; frontal callus brown to black; femora usually at least partly black, rarely dark brown; costal cell infuscated. 16

16. Hair of palpi long and uneven, semi-erect; base of third antennal segment narrow; hind femora black on basal half, remainder brown . . . . *frosti*

Hair of palpi short and lying smoothly against segment; base of third antennal segment not very narrow; hind femora brownish to completely black 17

17. Femora brown or partly black; frontal callus brown; palpi slightly swollen at "knee" and tapering acutely to a point . . . . *typhus* Form A

Femora black; frontal callus black or dark brown; palpi slender but not acutely tapered from "knee". . *typhus* Form B

18. Bifurcation of third longitudinal vein with a distinct spot; third antennal segment stout. . . . . *illota*

Bifurcation of third longitudinal vein without a distinct spot; third antennal segment more slender . 19

19. Legs nearly uniformly brownish, rarely femora somewhat darker; third antennal segment very slender; prescutal lobe black. . . . . *microcephala*

Femora black or grayish; third antennal segment not especially slender; prescutal lobe rarely black . . *frontalis*

Key to the Species of *Tabanus*

1. Abdomen with a longitudinal median stripe which may or may not be somewhat widened at posterior margins of segments. 2

Abdomen with median markings not forming an uninterrupted stripe 4

2. Prescutal lobe usually paler than mesonotum; frons widened above; annulate portion of third antennal segment usually shorter than basal portion; costal cell usually hyaline; eye in life with 2 purple bands *similis*

Prescutal lobe concolorus with rest of mesonotum; frons nearly parallel-sided; annulate portion of third antennal segment usually longer than basal portion; costal cell infuscated; eye in life with single purple band 3

3. Costal cell deep yellow; thorax bright yellow pollinose; palpi yellow . . . . *quinquevittatus*

Costal cell weakly colored; thorax grayish; palpi whitish . . . . *nigrovittatus*

4.	Abdomen with median and sublateral spots	5
	Abdomen without sublateral spots, although may be paler laterally	7
5.	Bifurcation of third longitudinal vein with dark spot; grayish species	*reinwardtii*
	Bifurcation of third longitudinal vein without dark spot; color variable	6
6.	First antennal segment swollen above; sides of subcallus with few hairs laterally	*fairchildi*
	First antennal segment not swollen above; sides of subcallus without hairs.	*marginalis*
7.	Fore tibiae bicolored	*novaescotiae*
	Fore tibiae unicolorous.	*catenatus*