SPATIAL DISTRIBUTION OF TABANIDAE (ADULTS AND LARVAE) IN TWO BOGS OF SOUTHERN QUEBEC

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ABSTRACT. The spatial distribution of horse flies and deer flies (adults and larvae) was studied within a bog and a fen of the Trois-Rivières area, Québec (46°21′N–72°31′W). Forty species were identified from 3 Malaise traps (21 *Chrysops*, 13 *Hybomitra*, 5 *Tabanus* and 1 *Atylotus*). Seven species were found only in the bog and 4 only in the fen. Of the total number of species, 11 were also found as larvae during a simultaneous sampling survey of the peat moss substrate of these bogs (2 *Chrysops*, 8 *Hybomitra* and 1 *Atylotus*). Mean larval density was evaluated at 1.49±1.62 larvae/0.1 m², randomly distributed (Poisson distribution). The potential productivity was estimated at approximately 146,000 larvae/ha. There is a statistically significant difference in larval distribution between open sites and forested areas. Adult trapping results and larval sampling data are compared and discussed.

INTRODUCTION

Larvae of Tabanidae develop mainly in wetlands and generally occur in low densities. Therefore, it is not easy to attempt quantitative studies of their population dynamics. Sampling methods are generally arduous, especially in peat moss substrate, and the number of collected larvae per sphagnum sample is often very modest.

Since 1974, members of our research group on biting flies have made a special effort to define and characterize the different types of mosquito larval habitats across Québec (Maire and Aubin 1980). From these results, we decided to study the spatial distribution of horse fly and deer fly larvae within a bog (acid) and a fen (less acid) located in the surroundings of Trois-Rivières (46°20°N) from which a vegetation analysis had already been made (Maire 1977). We attempted to verify if vegetation was as efficient a bioindicator for defining and locating larval habitats as it is for the Culicidae. That would be of great practical interest to eventually control populations of Tabanidae.

Several studies have been conducted on the distribution of Tabanidae species and their larval breeding sites, mainly in tidal marshes (Dukes et al. 1974a,b; Meany et al. 1976, Magnarelli and Anderson 1978). Such surveys have not been systematically conducted in bogs, even though entomologists sporadically collect larvae from these habitats. In the Boreal and Subarctic life zones, bogs and sphagnum covered grounds are predominant. As we are concerned with the ecology of the biting flies in northern areas, we were interested in checking the efficiency and the field feasibility of larval sampling methods in southern bogs, those being more accessible than northern ones.

MATERIAL AND METHODS

Two bogs were studied. The first, named "Tourbière des Grandes Prairies" (TGP), is located immediately east of Trois-Rivières (46°22′N–72°31′W), along the northern shore of the Saint-Lawrence River. This is a vast postglacial oxbow of the river. It is mainly ombrotrophic (or extremely oligotrophic) and pH in the 5 vegetal units distinguished in this bog is very acid (Table 1). The second, named "Tourbière du lac Saint-Paul" (LSP), is located along the southern shore of the river (46°18′N–72°29′W). This is a minerotrophic bog or fen (where the nutrients come from the soil). Four vegetal units were distinguished in LSP (Table 1).

A larval sampling survey was made from 26 April to 30 May 1978 in these 9 vegetal units. It was conducted only during the spring because larvae are easier to find during this season, when they are near the surface of the substrate (Miller 1951). During the summer, young immature stages appear in the samples. This increases the rearing difficulties and larvae between 8 and 10 mm in length are unidentifiable (Tashiro and Schwardt 1953).

Sampling techniques of Teskey (1962) were used for cutting pieces of peat moss (0.1 m² × 0.15 m) from hummocks, shallow depressions or water-covered sphagnum. Eighty-six samples were collected during the season: 68 in TGP and 18 in LSP respectively.

On site, peat moss was gently pressed in order to eliminate excess free water. Each sample was brought back to the laboratory in a plastic bag and larvae extracted in a multiple Burlese funnel (Teskey 1962). The larvae were reared in individual small vials (6 cm diam. × 5 cm high) filled with damp peat moss and covered with a perforated cap. Each larva was fed every 2 days with larvae of *Musca domestica* Linn. This diet was very efficient for the larvae of *Hybomitra* and *Tabanus;* nevertheless, larvae of *Chrysops* had a relatively high mortality rate. Three larvae of *H. minuscula* (Hine) died of

Table 1. Description of the vegetal units of the 2 studied bogs where larval samples were made.

A. *"Tourbière des Grandes Prairies" (TGP)*	
i) *Thuja occidentalis* unit: (14 samples)	A mixed forested habitat with 2/5 of the maximum incident insolation. *Abies balsamea* and *Acer rubrum* are the other abundant trees. Sphagnum covers all the ground. Numerous shallow temporary pools (pH in the peat-moss: 5.5).
ii) *Picea mariana* unit: (15 samples)	A dense coniferous forest (maximum incident insolation: 1/5). Numerous small snow melt pools also flooded after each spring and summer rain. Sphagnum covers all the ground surface (pH in the peat moss: 4.3).
iii) *Ledum groenlandicum* and *Kalmia polifolia* unit: (7 samples)	The driest part of the raised bog (open habitat: 4/5). Sphagnum covers all the ground surface.
iv) *Chamaedaphne calyculata* and *Carex oligosperma* unit: (16 samples)	The most expanded unit of the bog. Open habitat (5/5). Leather-leaf is predominant on the hummocks; sedge in the shallow depressions dispatched between the hummocks. All the ground surface is sphagnum covered (pH in the peat moss: 3.85)
v) *Carex strictior* unit: (16 samples)	The most minerotrophic unit of the bog. Open habitat (5/5). Ground is covered by sphagnum over most of its surface. Completely flooded by low running water during the snow melting; drying at the end of July approximately.
B. *"Tourbière du lac Saint-Paul" (LSP)*	
i) *Typha latifolia* unit: (2 samples)	A semi-permanent shallow pond with bottom covered by mud and organic matter. An open habitat (5/5).
ii) *Chamaedaphne calyculata* and *Carex obligosperma* unit: (10 samples)	Leather-leaf is confined to the hummocks, sedges and *Myrica gale* in the shallow depressions. Sphagnum covers all the ground surface. An open habitat (5/5).
iii) *Myrica gale* unit: (3 samples)	A mixed vegetal formation with *Alnus rugosa* and *Carex limosa*. Located immediately around the central pond and constituting a 5 m wide belt with a few *Chamaedaphne calyculata* covering hummocks. Completely sphagnum-covered. Open habitat: 5/5.
iv) *Nuphar* pond (3 samples):	At the center of the fen. *Sphagnum* rafts circumscribe the pond. Samples were collected in the most aquatic part of these rafts. Open habitat: 5/5.

parasitism (the genus involved was *Carinosillus* sp.: Tachinidae). From 25 April to 10 September 1978 adult trapping was made simultaneously in the 2 bogs using 3 Malaise traps (2 in TGP and the other in LSP). Traps were visited twice a week in TGP and once a week in LSP. Collected specimens were pinned in insect boxes. Larvae and pupae were identified using the key of Teskey (1969) and adults with those of Pechuman et al. (1961) and Pechuman (1972).

RESULTS AND DISCUSSION

A). ADULTS. All the data are presented in Table 2. A total of 2720 specimens was collected from the 3 Malaise traps. Forty species were identified: 21 *Chrysops,* 13 *Hybomitra,* 5 *Tabanus* and 1 *Atylotus.*

A Chi-square test was first applied to check if each Malaise trap was comparable to the others. This test was performed for each genus and for their total number of specimens. Results relative to *C. aestuans* Wulp are not considered (953 specimens in LSP; only 2 in the first Malaise trap of TGP; 0 in the second). There was no significant difference between the 3 traps for *Chrysops* ($\chi^2 = 4.563$; $0.10 < P < 0.05$). There is however a highly significant difference for both *Hybomitra* and *Tabanus* ($P < 0.001$). The same test applied to compare only the 2 Malaise traps located in TGP indicated no significant difference between the *Hybomitra* species ($\chi^2 = 0.716$; $0.50 < P < 0.25$), nor their total collected specimens ($\chi^2 = 0.058$; $0.90 < P < 0.75$). However, the difference is significant for the *Chrysops* species ($\chi^2 = 4.388$; $0.05 < P < 0.025$) and highly significant for the *Tabanus* species ($\chi^2 = 36$; $<< 0.001$).

A contingency table testing the homogeneity of the respective adult composition of the 2 bogs for the *Chrysops* species (*C. aestuans* excluded) ($\chi^2 = 163.233$), for the *Hybomitra* species ($\chi^2 = 315.48$) and for the *Tabanus* species ($\chi^2 = 71.924$), indicated a highly significant difference ($P << 0.001$) in the specific composition of each genus. TGP has more species than LSP: 18 *Chrysops* against 15; 13 *Hybomitra* against 8; 5 *Tabanus* against 4 or 37 species against 27 for LSP. Twelve *Chrysops,* 8 *Hybomitra* and 4 *Tabanus* were common to the 2 bogs.

Species collected in greater number in TGP were: *C. frigidus* Osten Sacken, *C. cuclux* Whitney, *C. sackeni* Hine; then *H. epistates* (Osten

Sacken), *H. affinis* (Kirby), *H. typhus* (Whitney, *H. minuscula* and *H. frosti* Pechuman; *T. similis* Macquart. The following were only found in TGP: *C. cuclux, C. nigripes* Zetterstedt, *C. carbonarius* Walker, *H. epistates, H. affinis, H. typhus, H. frosti* and *T. similis*. The most abundant species in LSP were: *C. aestuans, C. frigidus, C. vittatus* Wiedemann, *C. aberrans* Philip; then *C. montanus* Osten Sacken and *C. sackeni, H. lasiophthalma* (Macquart), *H. illota* (Osten Sacken) and *H. minuscula; T. quinquevittatus* Wiedemann. *Hybomitra illota, C. aestuans, C. montanus* and *T. quinquevittatus* were only found in this fen. *Chrysops frigidus, C. sackeni, C. vittatus, C. aberrans, H. lasiophthalma* and *H. minuscula* are common and abundant species in the 2 bogs.

B). LARVAE. From the 86 larval samples, 126 larvae were collected of which only 93 were identifiable (71 from TGP and 22 from LSP). Eleven species were identified (2 *Chrysops*, 8 *Hybomitra* and 1 *Atylotus*). All of these species were also found in the adult trapping. The mean larval density for all samples was: $\bar{x}$ =

Table 2. Respective number of adults and larvae collected in the 2 bogs.

	TGP					LSP		
	Malaise trap #1		Malaise trap #2			Malaise trap #3		
Species	F	M	F	M	Larvae	F	M	Larvae
C. carbonarius	15	—	4	—	—	—	—	—
C. lateralis	3	—	—	—	—	—	—	—
C. sordidus	2	—	—	—	—	—	—	—
C. nigripes	6	—	16	—	—	—	—	—
C. cincticornis	1	—	—	—	—	—	—	—
C. aberrans	8	—	3	—	—	24	—	—
C. ater	2	—	1	—	—	6	—	—
C. cuclux	74	—	26	—	—	2	—	—
C. indus	3	—	2	—	—	20	—	—
C. mitis	3	—	—	—	—	20	—	—
C. niger	1	—	1	—	—	2	—	3
C. frigidus	68	—	70	—	14	56	11	—
C. sackeni	28	—	24	—	—	33	—	—
C. vittatus	5	—	21	—	—	5	—	—
C. zinzalus	—	—	5	—	—	1	—	—
C. montanus	—	1	6	—	—	18	—	—
C. aestuans	2	—	—	—	—	953	—	—
C. excitans	—	—	—	—	—	4	—	—
C. univittatus	—	—	—	—	—	4	—	—
C. striatus	—	—	—	—	—	2	—	—
C. calvus	1	—	—	—	—	—	—	—
A. pemeticus	1	—	—	—	1	—	—	—
H. frosti	12	2	5	2	3	—	—	1
H. trepida	4	—	11	—	3	—	—	—
H. sodalis	3	—	3	—	7	—	—	—
H. typhus	12	3	21	—	—	—	—	—
H. frontalis	1	—	—	—	—	—	—	—
H. affinis	12	2	22	—	12	—	—	—
H. illota	1	—	7	—	—	37	—	—
H. lasiophthalma	89	1	112	6	—	69	24	—
H. nuda	1	—	2	1	—	2	—	—
H. zonalis	53	6	65	5	4	1	2	2
H. pechumani	193	7	128	2	3	2	—	—
H. minuscula	19	7	12	1	24	9	13	15
H. epistates	20	1	13	6	—	6	—	1
T. atratus	—	—	1	—	—	1	—	—
T. quinquevittatus	1	—	—	—	—	12	1	—
T. similis	18	—	70	1	—	4	—	—
T. marginalis	—	—	8	—	—	1	—	—
T. lineola	1	—	—	—	—	—	—	—
Total	663	30	658	24	71	1294	51	22
Total of adults			1375			1345		
Total of larvae					71			22

1.49 ± 1.66 larvae/0.1 m^2. A frequency distribution indicated a Poisson distribution (Fig. 1), ($\chi^2 = 5.7$; $0.25 < P < 0.10$), i.e., larvae are randomly distributed.

Similar larval densities were found in different types of habitats. Wilson (1969) estimated that the larval density of forested areas in Louisiana was more than 1 larva/ft^2 (about 0.1 m^2). Logothetis and Schwardt (1948) evaluated the productivity of a New York pasture at 1 larva/2 ft^2 with a sex ratio of approximately 1:1. Ellis and Hays (1973) noted in Alabama a density of 4.02 ± 0.15 larvae/ft^2, for a potential productivity of 134,600 to 202,989 adults/acre. Gingrich and Hoffman (1967) estimated a density of 3.6 ± 0.5 larvae/ft^2 in Texas. The unique results known from bogs are from Miller (1951) in Churchill, Manitoba. The estimated potential productivity of the bogs ranged from 67,200 to 200,900 larvae/acre. Our results give a potential productivity of about 146,000 larvae/ha (approximately 59,000 larvae/acre).

Table 3 indicates that *H. minuscula* is the commonest species collected in the 2 bogs, particularly in open areas. According to Teskey (1969): "Not only are the larvae apparently restricted to sphagnum bogs, but have been found only in loose saturated moss bordering the bog pond" (p. 108). *Hybomitra minuscula* larvae were collected in all units but the *Picea mariana* forest. *Hybomitra zonalis* (Kirby), never abundant, was found in different parts of the bogs, but with apparent preference for the open habitats.

In TGP, *C. frigidus* and *H. affinis*, relatively abundant, were found in open and forested habitats. *Hybomitra frosti* was collected both in the *Thuja occidentalis* unit of TGP and in the *Myrica gale* unit of LSP. Teskey (1969) stated: "One larva found in a sphagnum bog was taken in saturated moss bordering a shallow depression in an open part of the bog mat between the zone of leather leaf and the central pond" (p. 102). Our *Myrica gale* unit corresponds quite well with this described habitat. However, the *Thuja occidentalis* unit is a newly known habitat

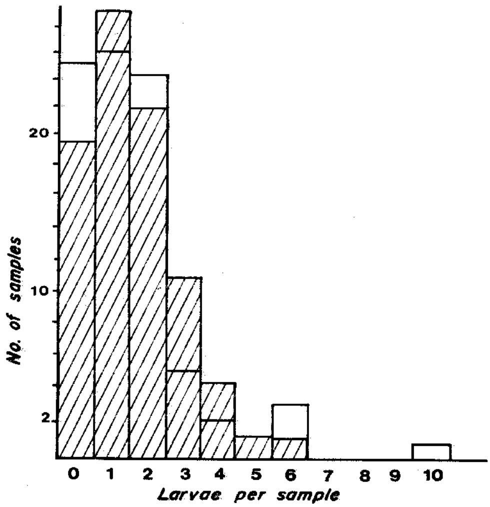

Fig. 1. Actual and theoretical (lined) distributions of the larval populations of Tabanidae in the peat moss samples.

Table 3. Distribution of Tabanidae larvae in the previously distinguished vegetal units of the 2 bogs.

	Ombrotrophic bog (TGP)					Minerotrophic fen (LSP)			
	Forested habitats		Open habitats			Open habitats			
Species	*Thuja occidentalis*	*Picea mariana*	*Ledum groenlandicum*	*Chamaedaphne calyculata*	*Carex strictior*	*Typha latifolia*	*Chamaedaphne calyculata*	*Myrica gale*	*Sphagnum* spp. (pond)
C. frigidus	5	4	—	2	3	—	—	—	—
A. pemeticus	—	1	—	—	—	—	—	—	—
H. affinis	8	—	—	3	1	—	—	—	—
H. pechumani	—	2	—	1	—	—	—	—	—
H. sodalis	5	1	—	1	—	—	—	—	—
H. trepida	—	1	2	—	—	—	—	—	—
H. minuscula	1	—	2	11	10	4	8	1	2
H. frosti	3	—	—	—	—	—	—	1	—
H. zonalis	1	—	1	1	1	—	—	2	—
H. epistates	—	—	—	—	—	—	—	—	1
C. niger	—	—	—	—	—	—	—	—	3
Total of larvae	23	9	5	19	15	4	8	7	3
Number of (0.1 m^2) samples	10	6	2	10	9	2	6	3	3

for this species. *Hybomitra sodalis* (Williston) apparently prefers forested areas.

Quantitative data on the spatial distribution of larval populations among the different described vegetal units are too meager for statistical analysis. However, we attempted to find if there was any difference between forested areas and open habitats of TGP, from which more larvae were collected. A contingency table indicated a highly significant difference between the 2 types of habitats ($\chi^2 = 30.376$; $\chi^2_{0.001,7} = 24.332$), *H. minuscula* being a distinctive species of the open areas while *H. sodalis* is characteristic of the forested sites. The same test applied to the open habitats of the 2 bogs also indicated a highly significant difference ($\chi^2 = 11.553$; $\chi^2_{0.05,5} = 11.070$; $0.05 < P < 0.025$) which may be attributed to *C. niger* Macquart larvae.

It would be of interest to test the distribution of the larvae in relation to the moisture level of their habitats (Tashiro and Schwardt 1949). Because of the general low number of collected larvae, we only tested the distribution of the *H. minuscula* larvae in the *Chamaedaphne calyculata* unit of TGP. Ten specimens were collected from 6 peat moss samples taken from hummocks and 3 from 5 samples taken from shallow depressions. As the expected theoretical distribution was 1.18 larvae per sample, a Chi-square test did not indicate a significant difference ($\chi^2 = 2.626$; $0.25 < P < 0.10$).

C). ADULTS VS LARVAE. Many differences may be noted between adult trapping results and larval sampling data. While 21 *Chrysops* species were present in the traps, 2 species only were found in larval samples. No larvae of *C. frigidus* were found in LSP while 77 adult specimens (including 11 males) were collected. Although 953 *C. aestuans* adults were found, no larvae were collected. Of the 18 *Chrysops* species captured in traps at TGP only 7 species were reported breeding in moss habitats: *C. nigripes*, *C. cincticornis* Walker, *C. aberrans*, *C. niger*, *C. frigidus*, *C. vittatus* Wiedemann and *C. excitans*. Adults of 15 species were trapped at LSP. *Chrysops excitans* has been found by several authors in moss substrates. According to Teskey (1969), 6 species (*C. ater* Macquart, *C. cuclux*, *C. mitis* Osten Sacken, *C. sackeni*, *C. aestuans* and *C. univittatus* Macquart) breed in slow-flowing streams. Considering that a small stream supplies the central pond of LSP, it might be possible that adults collected came from there. No larvae of *Tabanus* were found. *Tabanus* adults were never very abundant in traps; 88 females and 1 male of *T. similis* were trapped in TGP; 12 females and 1 male of *T. quinquevittatus* in LSP. Most of them may have come from surrounding habitats. In fact, only *T. marginalis* Fabricius, *T. lineola* Fabricius (Teskey 1969) and *T. novaescotiae* Macquart (Teskey and Burger 1976) are reported as breeding in sphagnum bogs. The last species was not collected at Trois-Rivières.

However, efficiency of larval sampling for the *Hybomitra* species was relatively high. Eight of the 13 species were found. All are reported to breed in moss substrata (Miller 1951, Teskey 1969). Nevertheless, as for the *Chrysops*, no larval *H. lasiophthalma* were collected. This is a relatively abundant trapped species in the 2 bogs (202 females and 7 males in TGP; 71 females and 24 males in LSP). Adult collections were proportionally more abundant for *H. zonalis*, *H. pechumani* Pechuman and Teskey, *H. epistates* (Osten Sacken), *H. typhus* and *C. frigidus*. However, larval collections were proportionally more abundant for *C. niger*, *H. sodalis*, *H. affinis* and, overall, for *H. minuscula*. A contingency table applied to the respective total number of adult and larval specimens collected for the 11 species indicated a highly significant difference between the 2 methods of collecting ($\chi^2 = 136.937$; $\chi^2_{0.001,7} = 24.322$). Four species particularly are responsible for these differences: *H. minuscula*, *H. pechumani*, *H. sodalis* and *H. affinis*.

From the larval distribution previously analysed, it is possible to indicate the presence of several species in TGP on the basis of adult collections. That is the case for *H. frosti* (21 adults; 4 males), *H. pechumani* (330 adults; 9 males) and *H. typhus* (36 adults; 3 males) and perhaps even for *C. cuclux* (100 specimens in TGP and 3 in LSP).

The difference between the 2 bogs may also be attributed to their respective types of habitats, very acid in TGP and rich in nutrients (minerotrophic) in LSP. As *Chrysops* larvae are presumed to be saprophytic, the open areas of LSP being more aquatic and minerotrophic, may be more attractive for species like *C. aestuans*, *C. aberrans*, *C. indus* Osten Sacken, *C. mitis* and also perhaps *H. illota*.

A few other species may be considered very typical of sphagnum bogs due to their wide distribution among the 2 bogs. This is evident for *H. minuscula* and *C. frigidus* and very probably for *H. lasiophthalma*. It might also be the case for *C. sackeni* and *C. vittatus*.

In conclusion, our initial objective was to make a quantitative survey of the larval populations of Tabanidae in 2 bogs where consecutive vegetal units along a moisture transect were previously distinguished. Because of the complexity of the larval studies these results were compared with a simultaneous adult trapping. The lack of sufficient quantitative data on larval collections makes it difficult to determine if vegetation could be used precisely to analyze larval habitats. However, it appears that there is a difference between closed and open areas such as between bogs and fens. One must note that the larval sampling method used is not very suitable for intensive surveys, at least in peat moss substrates. Considering that the number of collected samples per visit is limited and that the larval density per sample ranges between 0 to 5 larvae/0.1 m^2, the resulting quantity of collected specimens is never very high. It appears obvious that before more general surveys are conducted in isolated areas, such as in northern Quebec, more quantitative sampling methods need to be developed. Thomas (1971) describes a portable apparatus that can be used in the field to separate larvae from moss. However, this apparatus cannot be used for quantitative studies. The larval sampling method used by Teskey (1962) could be combined with emergence traps. Despite this modification, results would be meager and inadequate for subsequent statistical analysis.

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