J. Acad. Entomol. Soc. 4: 7-13 (2008)

The diversity and abundance of Tabanidae in black spruce forests and sphagnum bogs in Gros Morne National Park, Newfoundland, Canada

Cheryl Butt, Barry Hicks, and Christine Campbell

ABSTRACT

Flies of the family Tabanidae are common, widespread pests, known to take blood meals from many mammals including humans, and are known vectors of a number of diseases. This study looks at diversity of tabanids within Gros Morne National Park (GMNP), Newfoundland & Labrador, Canada. Collections were made using six Malaise traps at three different locations within GMNP from June to August 2006. These locations represent various habitat types frequented by ungulates such as moose and caribou that are found throughout the park. Four hundred and eighty tabanids encompassing fourteen different species were collected in a 9-week period. Comparisons between this study and a similar study conducted in central Newfoundland found that the GMNP study showed higher species diversity (Shannon-Weiner H = 1.6298 vs. H = 1.5277), and had a higher than expected yield of species collected (14 vs. 12) based on rarefaction analyses.

RÉSUMÉ

Les mouches de la famille Tabanidae sont des insectes ravageurs bien connus et reconnus pour la prise de repas de sang de mamifères, entre autre d'humains, et leur habilité à transmettre des maladies. L'étude visait à étudier la diversité des tabanidae au parc national de Gros Morne (PNGM), Terre Neuve et Labrador, Canada. Les échantillons ont été fait à l'aide de six pièges de Malaisie installés à trois endroits dans le PNGM entre juin et août 2006. Les sites d'échantillonnages ont été choisis pour représenter les habitats fréquentés par les ondulés comme l'orignal et le caribou. Quatre cents quatre vingt tabanidés représentant quatorze espèces ont été capturés durant une période de neuf semaines. La comparaison de nos résultats avec des données semblables provenant de la région centrale de Terre Neuve montre une plus grande diversité en espèces (Shannon-Weiner H = 1.6298 vs. H = 1.5277) et un nombre total d'espèces plus élevé (14 comparé à 12) selon une analyse de raréfaction, dans les échantillons du PNGM.

INTRODUCTION

The Tabanidae is one of the most widely distributed families of flies in North America (Teskey 1990) and members of this family are well known for their blood-sucking behaviour. Ungulates including reindeer, moose, caribou, wild and domestic horses are attacked most often and tabanid harassment is known to negatively affect the health

Received 31 March 2008. Accepted 2 June 2008. Published on the Acadian Entomological Society website at http://www.acadianes.org/journal.html on 15 July 2008.

Cheryl Butt: Faculty of Forestry and Environmental Management, University of New Brunswick, P.O. Box 44555, 28 Dineen Dr., Fredericton, NB, E3B 6C2, Canada.

Barry Hicks[1]: College of the North Atlantic, 4 Pike's Lane, Carbonear, NL, A1Y 1A7, Canada.

Christine Campbell: Environmental Science, Sir Wilfred Grenfell College, Memorial University of Newfoundland, Corner Brook, NL, A2H 6P9, Canada.

[1]Corresponding author (email barry.hicks@cna.nl.ca).

of these animals (Hagemoen and Reimers 2002). Teskey (1990) recorded 145 species of Tabanidae in Canada and mentioned 5 additional species likely to occur here due to their northerly distribution extending close to Canada. He recorded 28 of these species in Newfoundland and Labrador. The collection housed at the Canadian Forest Service in Corner Brook, NL, has 33 species recorded from the province (Bowers and Pardy 1995).

The adult flies are active from late May to mid September but in more northern latitudes, the influence of temperature often results in their activity beginning later in the spring and finishing earlier in the summer (Lewis and Bennett 1977; Baribeau and Marie 1983; McCreadie and Colbo 1985; Teskey 1990). Flight activity occurs when the atmospheric temperature is above 13 ºC and because they are strong fliers, winds lower than 10 km/hr have little effect on their flight activity (Teskey 1990).

Little is known about tabanid diversity and distribution throughout the province of Newfoundland & Labrador. We are aware of only three studies (Graham 1992; McCreadie et al. 1985; McElligott and Lewis 1996), with none previously conducted within Gros Morne National Park (GMNP). Therefore, this current study was undertaken to examine temporal and spatial differences in tabanid assemblages between various ecologically different sites within Gros Morne National Park, Newfoundland & Labrador, Canada.

METHODS AND MATERIALS

Study location

GMNP encompasses 180,500 ha on the western shores of the Great Northern Peninsula of insular Newfoundland (Burzynski 1999). Past glacial activity has resulted in spectacular landforms being created including coastal lowlands, alpine plateaus, fjords, glacial valleys, waterfalls, and many pristine lakes. Faunal diversity is markedly reduced within the Park compared to mainland Canada, however, there are a number of species scarce in Canada that are found in GMNP, including lynx *Lynx lynx* (L., 1758) (Carnivora: Felidae), caribou *Rangifer tarandus* (L., 1758) (Artiodactyla: Cervidae), and arctic hare *Lepus arcticus* Ross 1819 (Lagomorpha: Leporidae) (Parks Canada 1986). Moose (*Alces alces* L. 1758 (Artiodactyla: Cervidae)), an introduced species, are also abundant.

To assess tabanid species diversity, two Malaise traps (Marris House Nets, Bournemouth, UK) were set up at each of three locations within GMNP from June to August 2006. Locations were: 1) Baker's Brook Falls Trail (trap 1 – 49°37.605'N, 57°55.728'W; trap 2 – 49°37.821'N, 57°55.649'W), 2) Western Brook Pond Trail (trap 1 – 49°47.220'N, 57°52.005'W; trap 2 – 49°47.058'N, 57°51.706'W), and 3) Green Point campgrounds (trap 1 – 49°41.513'N, 57°56.954'W; trap 2 – 49°41.491'N, 57°56.886'W) (see Fig. 1). All sites were along maintained park trails or service roads. The Baker's Brook area is a balsam fir /black spruce (*Abies balsamea* (L.) Mill. (Pinaceae))/(*Picea mariana* (Mill.) BSP (Pinaceae)) forest, the Western Brook area is a sphagnum bog with some stands of balsam fir/black spruce, and the Green Point area, which was located along a power line service road, is a sphagnum bog with some scattered black spruce and larch (*Larix laricina* (Du Roi) Koch (Pinaceae)) trees.

Fig. 1. The location of the tabanid sampling sites within Gros Morne National Park. BBF - Bakers Brook Falls trail; GP - Green Point; WBP - Western Brook Pond trail.

Malaise traps

Several studies have shown Malaise trapping to be very effective for collecting adult tabanids (Roberts 1972; 1974; 1976; Tallamy et al. 1976; Baribeau and Maire 1983). Malaise traps are commonly considered a preferred trap type since they intercept flight activity, and tend to capture both

sexes equally. Southwood and Henderson (2000) suggest that the colour as well as the form of the Malaise trap can influence collection numbers, with black traps collecting more specimens. The Malaise traps of this study had the side panels constructed of fine black mesh and the roof constructed of fine white mesh. The design of a Malaise trap collects flies when they hit the inner black wall of the trap and move upward towards the lighter, bright colour of the tent peak. Eventually they move into a collection bottle that can contain a killing or attractant fluid (Steyskal 1981). The fluid used as a killing agent in this study was 70% ethanol.

The traps were deployed on 8 June and retrieved on 9 August 2006. The bottles on each trap were changed weekly. Each trap was changed at approximately the same time every collection day. Bakers Brook traps were changed between 1000 and 1100 NDT, Western Brook Pond between 1100 and 1300 NDT, and Green Point between 1300 and 1500 NDT. Average daily temperature and total daily rainfall amounts were obtained from Environment Canada climate data online database (Environment Canada, online).

Statistical analysis

The counts from the two traps in each habitat were pooled for analysis. Jaccard's coefficient of similarity was determined between our collection and that of Graham (1992) and the collection records of Teskey (1990) for the island of Newfoundland.

Diversity in the collections was determined using the Shannon-Weiner (or Shannon) diversity index. Rarefaction analysis was used as a method to standardize this study in comparison to Graham's (1992) study. The two studies could not be compared without some form of standardization since there was great variation in sample size, with Graham's study collecting 4912 tabanids while the present study collected 480. Rarefaction analysis was conducted using an online program available from the University of Alberta (www2.biology.ualberta.ca/jbrzusto/rarefact.php).

RESULTS

Abundance and diversity of tabanids

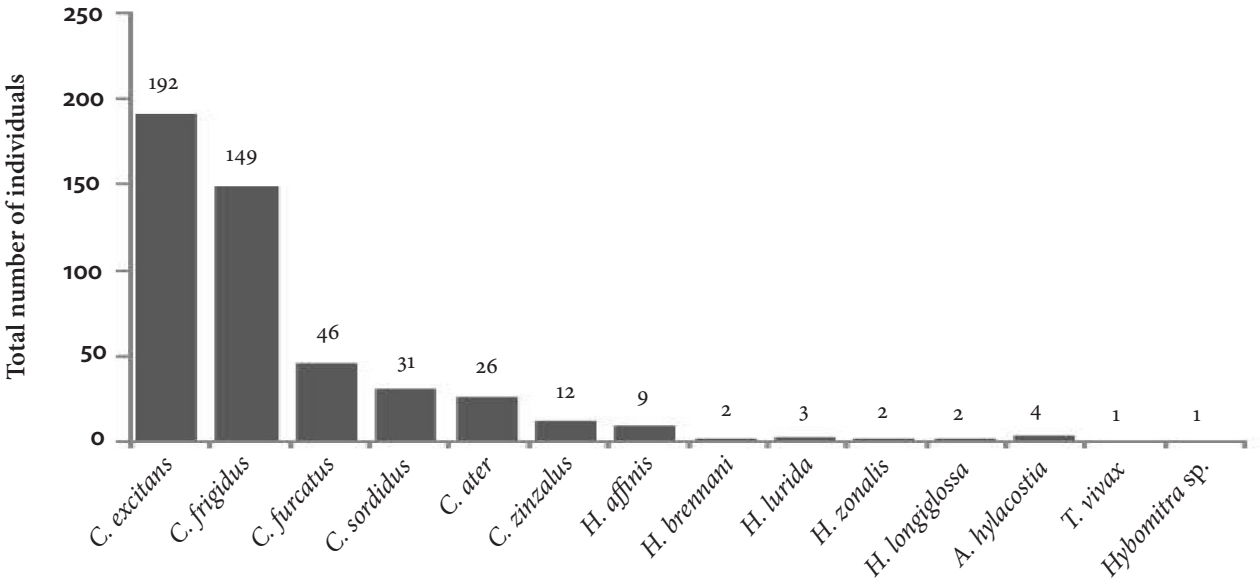
A total of 480 adult tabanids were sampled in the nine week period using Malaise traps (Table 1). On average every net was up for about four weeks during which no tabanids were collected. The last sampling period of 2–9 August yielded only one tabanid among all six nets. Also, some nets in general had poorer yields than others. The first net placed in Green Point had five weeks during which no tabanids were collected, while the first net in Bakers Brook had only two weeks with no tabanids collected. Total abundance was greatest overall for Western Brook Pond, with 278 individuals or 58% of the collection (Table 1). The sampling week with the highest abundance of collected tabanids for Western Brook Pond and Green Point was 5–12 July while the highest abundance for Baker's Brook occurred 28 June – 5 July (Table 1).

All collected tabanids were from 4 genera; *Chrysops, Hybomitra, Atylotus* and *Tabanus* (Fig. 2). Table 2 compares the GMNP data to data of Graham (1992) for central Newfoundland and that of Teskey (1990) for the island of Newfoundland. Only a single specimen of *Tabanus*

Table 1. The abundance of Tabanidae collected from three sites in Gros Morne National Park from June to August 2006. The numbers represent the pooled abundance from two Malaise traps at each site.

Sample Date	Baker's Brook	Western Brook	Green Point
June 14	4	1	1
June 21	3	6	0
June 28	5	14	15
July 5	33	10	0
July 12	27	165	58
July 19	15	73	28
July 26	4	8	4
August 2	1	1	3
August 9	1	0	0
Totals	**93**	**278**	**109**

Fig. 2. Total number of individuals for 14 species of Tabanidae collected from three sites from June to August 2006 at Gros Morne National Park, Newfoundland. *C = Chrysops*, *H = Hybromitra*, *A = Atylotus*, *T= Tabanus*.



vivax was collected in GMNP and this represents the only member of this genus known from the Province (Teskey 1990). Numbers were unevenly distributed between the four genera (Fig. 2). Six species of *Chrysops* comprised 95% of the collection. Of the 461 *Chrysops* collected, 193 were *C. excitans*; 149 *C. frigidus*; 46 *C. furcatus*; 32 *C. sordidus*; 29 *C. ater* and 12 *C. zinzalus*. Only 18 specimens of *Hybomitra* were collected (Fig 2). One unknown *Hybomitra* species was collected. It was thought to be either *H. pechumani* or *H. astute* (Monty Wood, Agriculture Canada, personal communication), neither of which has been recorded in Newfoundland (Teskey 1990). Four *Atylotus* specimens were caught, representing a single species, *A. hylacostia*. A slight variation in the collection time of the four genera was noticed, with the *Hybomitra* appearing first in June when very few *Chrysops* were collected. No *Hybomitra* were collected after the first week of July which was considered the peak collection for overall totals, but these totals are composed almost entirely of *Chrysops* species. The calculated Shannon-Weiner index for Tabanidae in this study was H = 1.6298.

Comparison with other collections from Newfoundland

The species composition of Tabanidae collected at GMNP showed 42.1% similarity with the collection by Graham (1992) and 54.5% similarity with the records for the entire island (Teskey 1990) (Table 3). Graham's (1992) collection in central Newfoundland was 66.7% similar with that of Teskey (1990).

Rarefaction analysis indicated that if Graham (1992) had only sampled 480 individuals, she would be expected to have collected only 12 species, whereas the present study collected 14 species (Fig. 3).

The average daily temperature during June in 2006 was 16 °C which is higher than the 30-year average (12 °C) for the same area. The total rainfall for June 2006 was 98.6 mm which is higher than the 30-year monthly total for June (79.9 mm).

DISCUSSION

There was a difference in the total abundance of collected Tabanidae between sites in Gros Morne National Park. A study by McCreadie and Colbo (1985) in western Labrador showed tabanids have strong habitat preferences. They collected *Chrysops excitans* more often on fens (92.4% of their collection) than in spruce forest (1.3% of their collection). Results from our study support their findings; the Baker's Brook (black spruce forest) site collected only 93 specimens while the Western Brook Pond site (sphagnum bog) had 278 specimens collected. McElligott and Galloway (1991), in Manitoba, suggested that peatland is essential for tabanid breeding as eggs are laid near water. McCreadie and Colbo (1985) suggested that the difference between forested sites and peatland sites may have to do with visual cues. Abundance of *C. excitians* and other species may be lower in forested areas as trees obscure

Table 2. List of species collected using Malaise traps at 3 sites in Gros Morne National Park during the summer 2006. The list of species recorded by Graham (1992) in central Newfoundland and those known to occur in insular Newfoundland by Teskey (1990) are also shown.

Species	GMNP (this study)	Central NFLD (Graham)	Insular NFLD (Teskey)
Hybomitra affinis Kirby 1837	X	X	X
H. arpadi (Szilady) 1923		X	X
H. astute (Osten Sacken) 1876 / *H. pechumani* Teskey & Thomas 1979	X?		
H. brennani (Stone) 1938	X		X
H. epistates (Osten Sacken) 1878		X	X
H. frontalis (Walker) 1884		X	X
H. longiglossa Philip 1931	X		X
H. lurida (Fallén) 1817	X	X	X
H. minuscula (Hine) 1907		X	X
H. zonalis (Kirby) 1837	X	X	X
Atylotus hyalicosta Teskey 1983	X		X
A. sphagnicola Teskey 1983			X
A. sublunaticornis (Zetterstedt) 1842			X
A. thoracicus (Hine) 1900			X
Tabanus vivax Osten Sacken 1876	X		X
Chrysops ater Macquart 1850	X	X	X
C. excitans Walker 1850	X	X	X
C. frigidus Osten Sacken 1875	X	X	X
C. furcatus Walker 1848	X	X	X
C. mitis Osten Sacken 1875		X	X
C. nigripes Zetterstedt 1838		X	X
C. sordidus Osten Sacken 1875	X	X	X
C. zinzalus Philip 1942	X	X	X
Total species	**14**	**15**	**22**

nets and therefore decreases the potential for the nets to act as visual cues. While abundance was higher at Western Brook Pond, Baker's Brook had greater species diversity with 11 of the 14 collected species (Western Brook Pond had only 8 species recorded). Moreover, Baker's Brook also had the highest collection of 5 representative insect orders in the Malaise traps including: Hymenoptera, Diptera, Lepidoptera, Coleoptera and Heteroptera (data not shown).

Various studies (Baribeau and Marie 1983; McElligott and Galloway 1991; McElligott and Lewis 1996) document preferred habitat type in different areas of Canada, with respect to month of the year, time of day and preferred temperature range. McElligott and Lewis (1996) pointed out that both boreal and subarctic peatlands were preferred habitat for tabanid larvae. They looked at water levels and found more tabanids in areas where water levels were at or below the substrate than where the substrate was submerged. Baribeau and Marie (1983) examined tabanids in Quebec habitats that were very similar to the GMNP study sites. Sites used by Baribeau and Marie (1983) were temperate peatland habitats at 46°N and 55°N latitude, while our study sites were all at 49°N latitude. They also found species that they classified as late emerging first appeared and peaked in the third week of July. The peak collection time for adult tabanids in eastern Canada occurs from early to late July (Lewis and Bennett 1977; McCreadie and Colbo 1985). In GMNP during 2006, peak numbers of tabanids were collected in the second and third weeks of July (5–19 July; Table 1). This is 76% of the collection (366 individuals) being caught in this two week period. There were few individuals caught before this period in June, and few were caught after this period in August.

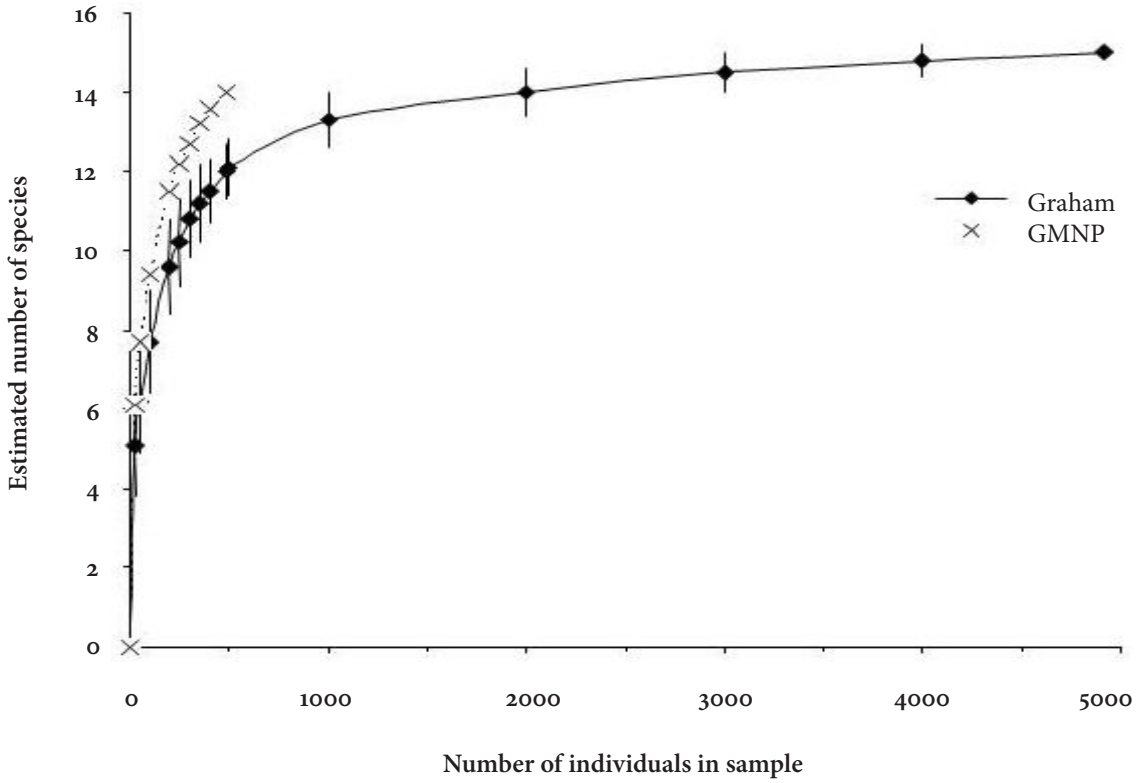
Table 3. Jaccard's coefficients of similarity between Tabanidae collected at Gros Morne National Park in the summer of 2006 and collections made by Graham (1992) in central Newfoundland and with the Teskey (1990) collection for all of insular Newfoundland.

	GMNP	Central NL (Graham 1992)
GMNP	-	-
Central NL*	0.421	-
Insular NL**	0.545	0.667

Note: * = (Graham 1992); ** = Teskey (1990)

Other seasonal variations may be attributed to the fact that host seeking in Tabanidae does not occur when temperatures fall below a certain threshold temperature (McElligott and Galloway 1991). Therefore, numbers of tabanids will be low if optimal summer conditions are not met. According to Environment Canada (online), the average daily temperature for June for Deer Lake, NL, was 16 °C which is higher than the 30-year average of 12 °C. However, 98.6 cm of rain fell in the area for the month of June, which is higher than the 30-year average of 79.9 cm. McElligott and Galloway (1991) suggest that it is hard to correctly determine the exact temperatures below which

Fig. 3. Rarefaction analysis for Tabanidae collected at Gros Morne National Park compared to a collection of Tabanidae in Central Newfoundland by Graham (1992).



tabanids are inactive, as there are multiple factors leading to their inactivity. However, they argued that no tabanid flight activity occurred below 12 °C, and that temperatures must reach 15–16 °C for optimal flight activity. In Quebec, Baribeau and Marie (1983) had their peak collection times corresponding to maximum temperature peaks of 25–30 °C. For our peak collection week of 5–12 July, the daily maximum temperature each day was over 20 °C.

Graham (1992) collected 15 species compared to the 14 species collected in GMNP but there was only a 42.1% similarity in the species between the two studies. The Shannon-Weiner index for Tabanidae collected at GMNP was H = 1.6298; while the same index for Graham's (1992) study was H = 1.5277. This indicates that while Graham collected 15 species, overall there were fewer rare species. The differences that we observe between the two studies may be more reflective of the differences in sampling methods employed than to actual differences in biodiversity. Graham (1992) used Manitoba traps, which are tent like structures similar to Malaise traps, as well as box traps baited with carbon dioxide. Traps baited with attracting agents are believed to be the preferred method of trapping biting flies and is the main reason why Graham (1992) had a much larger sample size of 4912 individuals over a sampling period of two summers. However, by baiting the traps only females were attracted to the traps while unbaited traps may also be better able to collect males as they intercept their flight paths when they seek their nectar food source. The rarefaction analysis showed that the number of species collected by the GMNP study was higher than what was expected from Graham (1992) if she had collected 480 specimens.

It is interesting to speculate why there was a higher than expected number of species collected in this study. Firstly, as GMNP is further north than the area sampled in Gander, NL by Graham (1992) it could be that northern species found in Labrador may have become established on this northern part of the island of Newfoundland, but have not yet managed to become established throughout the Island. The unknown *Hybomitra* species in this study is thought to be either *H. astuta* or *H. pechumani* both of which occur only in Labrador (Teskey 1990). Secondly, high ungulate concentrations may influence the abundance and diversity of tabanids within GMNP. While caribou populations are

on the decline in this area (Roberts et al. 2004), moose density is among the highest in the world (P. Deering, Gros Morne National Park, personal communication). This high density may mean higher than average available food sources for biting flies like the Tabanidae.

ACKNOWLEDGMENTS

This study was supported by a Gros Morne Co-operative Society-University Internship and a Sir Wilfred Grenfell Environmental Science study grant to C. Butt. We kindly acknowledge the help provided by Dr T. Knight and other GMNP staff. Thank you to D. Pelley, L. Morris and the Sir Wilfred Grenfell biology lab staff for transportation and field assistance. J. Fowler, Department of Geography, Memorial University of Newfoundland, prepared the map of Gros Morne National Park.

REFERENCES

Baribeau, L., and Marie, A. 1983. Abundance and seasonal distribution of Tabanidae in a temperate and in a subarctic locality of Quebec. Mosquito News **43**: 135-143.

Bowers W.W., and Pardy, K.E. 1996. Checklist of insect specimens in the museum of the Newfoundland Forestry Centre. Natural Resources Canada, Canadian Forest Servive, St. John's, NL. Information Report N-X-300.

Burzynski, M. 1999. Gros Morne National Park. Breakwater Books Ltd, St. John's, 143pp [online].

Available from http://www.weatheroffice.ec.gc.ca [accessed 12 October 2007].

Graham, J.L. 1992. Spatial distribution of female Tabanidae and Simuliidae (Diptera) among different terrestrial habitats in central Newfoundland. M.Sc. thesis, Memorial University of Newfoundland, St. John's, NL.

Hagemoen, R.I.M., and Reimers, E. 2002. Reindeer summer activity pattern in relation to weather and insect harassment. Journal of Animal Ecology **71**: 883-392.

Lewis, D.J., and Bennett, G.F. 1977. Biting flies of the eastern Maritime Provinces of Canada. I. Tabanidae. Canadian Journal of Zoology **55**: 1493-1503.

Magurran, A.E. 2004. Measuring Biological Diversity. Blackwell Science Ltd., Oxford, UK.

McCreadie, J.W., and Colbo, M.H. 1985. Notes on the Tabanidae (Diptera) of western Labrador. Journal of the American Mosquito Control Association **1**: 324-327.

McCreadie, J.W., Colbo, M.H., and Bennett, G.F. 1985. The seasonal activity of hematophagous Diptera attacking cattle in insular Newfoundland. The Canadian Entomologist **117**: 995-1006.

McElligott, P.E.K., and Galloway, T.D. 1991. Daily activity patterns of horse flies (Diptera: Tabanidae: *Hybomitra* spp.) in northern and southern Manitoba. The Canadian Entomologist **123**: 371-378.

McElligott, P.E.K., and Lewis, D.J. 1996. Distribution and abundance of immature Tabanidae (Diptera) in a subarctic Labrador peatland. Canadian Journal of Zoology **74**: 1364-1369.

Parks Canada. 1986. Gros Morne National Park. World Heritage Site Nomination Number 419.

Roberts, C., Gerrow, S., Knight, T., Knott, B., Anderson, M., and Burdet, B. 2004. Caribou population survey in Gros Morne National Park of Canada [online].

Available from http://www.pc.gc.ca/pn-np/nl/grosmorne/plan/plan4f_E.asp [accessed on 30 November 2007].

Roberts, R.H. 1972. The effectiveness of several types of Malaise traps for the collection of Tabanidae and Culicidae. Mosquito News **32**: 542-547.

Roberts, R.H. 1974. Diurnal activity of Tabanidae based on collections in Malaise traps. Mosquito News **34**: 220-223.

Roberts, R.H. 1976. The comparative efficiency of six trap types for the collection of Tabanidae (Diptera). Mosquito News **36**: 530-535.

Southwood, T.R.E., and Henderson, P.A. 2000. Ecological Methods 3rd ed. Blackwell Science Ltd., Oxford, UK.

Steyskal, G.C. 1981. A bibliography of the Malaise trap. Proceedings of the Entomological Society of Washington **83**: 225-229.

Tallamy, D.W., Hansens, E.J., and Denno, R.F. 1976. A comparison of Malaise trapping and aerial netting for sampling a Horsefly and Deerfly community. Environmental Entomology **5**: 788-792.

Teskey, H.J. 1990. The horse flies and deer flies of Canada and Alaska (Diptera: Tabanidae). The Insects and Arachnids of Canada Part 16. Agriculture Canada, Ottawa, Ontario. Publication Number 1838.