

**ABUNDANCE AND SPECIES OF BUMBLE BEES
(HYMENOPTERA: APOIDEA: BOMBINAE) IN FIELDS OF
CANOLA, *BRASSICA RAPA* L., IN MANITOBA: AN 8-YEAR
RECORD**

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Abstract

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Bumble bees, *Bombus* spp., were inadvertently captured in Unitraps[®] baited with a bertha armyworm (*Mamestra configurata* Wlk.) sex attractant placed in fields of canola (oilseed rape, *Brassica rapa* L.) in four regions within the agricultural zone of Manitoba, 1986-1993. *Bombus rufocinctus* Cresson and *B. borealis* Kirby were the most abundant species, occurring in all four regions. Another 13 species were much less abundant. Species diversity and number of captures were greatest in the northwestern region (Swan River Valley), and least in the southeast (Red River Valley), coinciding with the amount of native vegetation in the region. Captures of *Bombus* spp. were largest in 1989, with smaller peaks in 1992, 1986, and 1993. The patterns of abundance among regions were very similar among years, suggesting that the abundance of bumble bees is controlled by weather-related factors, even though analyses of the temperature and precipitation during summer, winter, and the spring periods when queens are establishing new colonies did not reveal any relationships.

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Introduction

During the period 1986-1993, sex-attractant traps were being used to predict the abundance of the bertha armyworm, *Mamestra configurata* Wlk. (Noctuidae: Lepidoptera),

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a pest of canola (oilseed rape, *Brassica rapa* L.) (Turnock 1987). The traps were placed in canola fields throughout the flowering period and captured bumble bees, *Bombus* spp. as well as the target species. The bumble bees found in the traps were identified and counted. Our objectives were to describe the abundance and species composition of the bumble bee fauna in canola fields in Manitoba from 1986-1993, and to examine the annual changes in relation to physiographic area and weather. The data also provide a baseline for evaluating long term changes in the abundance of these pollinators in the agricultural area of Manitoba.

Methods

The traps used in this study were Unitraps[®] baited with a sex attractant for the bertha armyworm. In the first year (1986), we used yellow-green-white traps, which collected a large number of bumble bees. Experiments in Lethbridge, Alberta, on the effect of different colours of sex attractant traps for bertha armyworm, indicated that all-green traps were much less attractive to bumble bees than were traps of other colours (J. R. Byers, pers. comm., 20 November 1986). To conserve bumble bees, we used all-green traps in subsequent years. The lure was a mixture of 1.0 mg (Z)-11-hexadecen-1-ol acetate and 0.05 mg of (Z)-9-tetradecen-1-ol acetate (Underhill et al. 1977) impregnated in a red rubber septum (Steck et al. 1979).

Two traps, each 1 m above ground, were placed in each field of canola sampled. They were 100 m apart, 10 m in from the field margin, and where wind movement was not obstructed by nearby trees or tall shrubs. Inside the collecting bucket of each trap was a 15 mm square of insecticidal strip (Vapona[®]). The traps were deployed in mid June and examined at least every 2 weeks until early August. This included the full flowering period of canola. The total trapping period was about 7 weeks per year. At each collection time, the insects were removed from the trap, and the bumble bees were subsequently pinned, labelled, identified to species, and counted. Badly damaged specimens that could not be identified to species, were discarded. The remaining bees were identified by L. Dumouchel and T. Laverty. Voucher specimens are deposited in the R. B. Wallace Museum, Department of Entomology, University of Manitoba.

The canola fields in which traps were placed changed each year, because of crop rotation, but the selected fields in each area were within 10 km of each other, and often much closer. In most fields, the seed had been mixed with granular carbofuran before planting, for flea beetle control (Lamb and Turnock 1982), but none of the fields had additional insecticidal applications. The regions sampled were selected in response to the presence of populations of the bertha armyworm, which were most abundant in the Swan River Valley (Turnock 1987). Therefore, this region was sampled for eight years (1986-1993) and had 4-10 traps per year, but the other regions were sampled for fewer years (4-5) and had 2-6 traps per year.

The sampling locations, named after the nearest town, were situated in four distinct regions of the agricultural area of Manitoba (Fig. 1). The topography and original vegetation of these regions is described in detail by Smith et al. (1998) and Weir (1983).

The Swan River Valley Region (Durban, Kenville, Minitonas, Swan River, and Bowsman) is located in an area where the Manitoba Escarpment was breached in post-

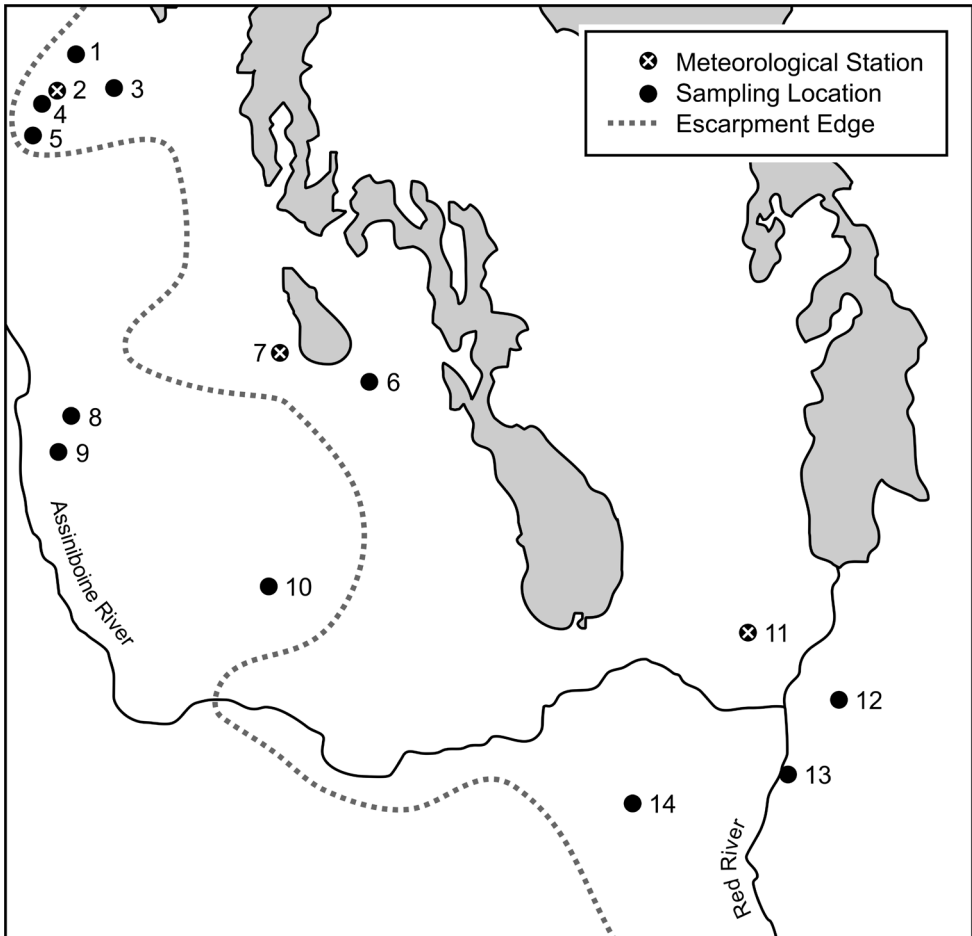


FIGURE 1. Map of southern Manitoba, showing the sampling locations: Location 1=Bowsman, 2=Swan River, 3=Minitonas, 4=Kenville (Swan River Valley Region), 5=Durban; Location 6=Ste. Rose, 7=Dauphin (Manitoba Lowlands Region); Location 8=Bield, 9=Russell, 10=Basswood (Western Uplands Region); Location 11=Stonewall, 12=Dugald, 13=Glenlea, 14=Carman (Red River Valley Region).

glacial times. The topography varies from flat to gently rolling and was originally forested by deciduous and coniferous trees.

The Western Upland Region (Basswood, Russell, and Bield) lies above the Manitoba Escarpment. The topography varies from rolling, near the edge of the Escarpment, to quite flat in areas further west. The original vegetation was a mixture of grassland with forest dominated by Trembling Aspen (*Populus tremuloides* Michx).

The Manitoba Lowlands Region (Dauphin and Ste. Rose du Lac) lies in the Manitoba Lowlands in the northwestern part of the Lake Manitoba Plain Ecoregion (Smith

et al. 1998). This region is generally flat, with thin and poorly-drained soils. The original vegetation was grassland and wetlands, with groves of deciduous trees.

The Red River Valley Region (Glenlea, Dugald, Stonewall, and Carman) is also part of the Lake Manitoba Plain Ecoregion, but in this southerly region, the soils are deeper and more fertile than in the Manitoba Lowlands area. The topography is level to gently sloping, and the soil is poorly drained. The original vegetation included tall grass prairie and extensive stands of deciduous forest.

The natural vegetation in all of the regions has been heavily modified by agriculture, but some trees and shrubs occurred on the headlands around most of the sampled fields. Trees and shrubs were least abundant in the Red River Valley and Manitoba Lowlands, and more abundant in the Western Uplands and the Swan River Valley. No major changes in land use occurred in any region during the years of sampling. The sampling sites were in the main canola growing areas of Manitoba, and although the area of canola varied from 352 100 to 627 600 ha in the years 1986-1993 (Anon. 1986-1993), there was always canola growing in the sampling areas.

All of the sampling locations were located along the northern boundary of the Cold Temperate Continental Zone (Trewartha and Horn 1980). This zone has warm to hot summers and cold winters. The impact of low winter air temperatures in this zone on insects overwintering on or below the soil surface is ameliorated by a generally deep and persistent snow cover, particularly in treed areas (Turnock and Fields 2005).

We calculated the following weather parameters for each of the years 1985-1993 for a representative meteorological station for the Swan River Valley (Swan River), the Manitoba Lowlands (Dauphin), and the Red River Valley (Stony Mountain). These included the summer of 1985 and the winter of 1985-86 which preceded the beginning of sampling. Suitable data for a weather station in the part of the Manitoba Uplands in which the traps were located were not available. Weather data were obtained by Agriculture and Agri-Food Canada from the Environment Canada database as part of the cooperative agreement for scientific research with the Environmental Service of Environment Canada. The summer weather (1 April–31 October) is described by the sum of degree-days above 5°C (DD05) and the total precipitation (mm). The winter weather (1 November–31 March) is described by the sum of degree-days below -10°C ($DD \leq -10$) and the total snowfall (cm). Mated queens of *Bombus* spp. emerge from hibernation and attempt to establish colonies from early spring to early summer (Curry 1984) and wet spring weather is detrimental to the establishment of colonies (Harder 1986). We calculated the mean temperature, total rainfall, and number of days with rain for the period 15 May to 15 June, for each year, for comparison with catch records.

The nonparametric Mann-Whitney U statistic (Siegel 1956) was used to test the hypothesis that the abundance and diversity of bumble bees captured in 1986 differed from the captures in other years. The 'α diversity' index, or species richness (Magurran 1988) was calculated for each region and year. Nonparametric rank correlation (Siegel 1956) and the Pearson product moment correlation (Zar 1998) were used to determine the correlation between diversity and abundance.

Results and Discussion

No bees were collected until the canola began to flower, about 1 week after the traps were set out. Most captures occurred during the peak period of flowering, usually from the last week of June to mid July, but a few bees were captured into early August.

The 'α diversity index' (Table 1) was correlated with abundance, significantly with the nonparametric rank correlation ($R=0.49$), and not significantly by the Pearson Product moment correlation ($R_s=0.19$). The number of bumble bees captured in 1986 (yellow–green–white traps) differed significantly from the abundance in other years (green traps) (Mann–Whitney test, $U=54$, $P<0.002$) but the difference in diversity was not significant (Mann–Whitney test, $U=37$, $P>0.2$). The occurrence of *B. rufocinctus* Cresson and *B. borealis* Kirby did not change between 1986 and the other years, but it did change for *B. perplexus* (Cresson), *B. sandersoni* Franklin, *B. nevadensis* (Cresson), *B. terricola* Kirby, *B. ashtoni* (Cresson), *B. vagans* Smith, and *B. ternarius* Say. In the Swan River Valley, nine species captured in 1986 were subsequently either not captured (three species) or captured in lower numbers (six species) (Table 1). The results for the Western Uplands and Manitoba Lowlands were similar to those in the Swan River Valley. The numbers of *B. rufocinctus* and *B. borealis* were higher in at least one of the years when the green traps were used than in 1986. Among the less abundant species, *B. fervidus* (Fabricius) was slightly more abundant, and *B. insularis* (Smith) as abundant, as in the year when the green traps were used. There were seven species in the Western Uplands and six species in the Manitoba Lowlands that were recorded in 1986 but not in subsequent years (Table 1). Trap colour seemed to have affected the less abundant species, but the location of the fields and of traps within fields in relation to topography and surrounding vegetation could have had a greater effect, obscuring the colour effect.

Species distribution and diversity

There were a total of 15 *Bombus* species (Table 1). The number of species varied from 12 (Swan River Valley) to 4 (Red River Valley) (Table 1). Only one species, *B. rufocinctus*, was found in all regions and in all years. *Bombus borealis* was found in all regions and in all years except 1990, when it was not collected in the Western Uplands and Manitoba Lowlands regions (Table 1). Four species, *B. terricola*, *B. ashtoni*, *B. vagans*, and *B. ternarius*, were recorded from all regions except the Red River Valley. Species with a more northwesterly distribution included *B. insularis*, *B. sandersoni*, and *B. nevadensis* in the Swan River Valley and Western Uplands regions, *B. perplexus* in the Swan River Valley and Manitoba Lowlands regions, and *B. suckleyi* Greene and *B. centralis* Cresson in the Swan River Valley. *Bombus huntii* Greene occurred in the Western Uplands and Manitoba Lowlands regions, *B. fervidus* in the Western Uplands and Red River Valley regions, and *B. griseocollis* (DeGeer) only in the Red River Valley.

Three species (*Psithyrus* spp.) that are social parasites in the nests of other bumble bee species, *B. (Ps.) ashtoni*, *B. (Ps.) insularis*, and *B. (Ps.) suckleyi*, occurred in the Swan River Valley, *B. ashtoni* and *B. insularis* in the Western Uplands, and only *B. ashtoni* in the Manitoba Lowlands. None of these species were collected in the Red River Valley.

TABLE 1. Number of bumble bees (*Bombus* spp) per trap, by species and year, captured in sex attractant traps located in canola fields in four areas of Manitoba. The traps were yellow–green–white in 1986, and solid green in all other years. Three species that are social parasites in the nests of other bumble bee species are included: *B. (Psithyrus) ashtoni*, *insularis*, *suckleyi*.

Species	1986	1987	1988	1989	1990	1991	1992	1993
Swan River Valley (Durban, Kenville, Minitonas, Swan River, Bowsman)								
<i>rufocinctus</i>	8.2	3.2	2.8	103.2	0.2	3.8	16.2	17.8
<i>borealis</i>	1.5	0.2	1.0	9.6	0.2	1.6	12.9	3.2
<i>insularis</i>	0.6	0.3	0.1	0.5	0.0	0.1	0.1	0.0
<i>perplexus</i>	0.2	0.0	0.0	0.0	0.1	0.1	1.2	0.5
<i>terricola</i>	8.9	0.0	0.0	0.4	0.0	0.1	0.0	0.0
<i>vagans</i>	1.5	0.1	0.0	0.0	0.0	0.0	0.1	0.0
<i>ternarius</i>	2.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0
<i>sandersoni</i>	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0
<i>ashtoni</i>	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>nevadensis</i>	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>centralis</i>	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>suckleyi</i>	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0
Other spp.	3.6 ¹	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Bombus (unident.)</i>	0.1	0.0	0.0	0.0	0.8	0.0	1.1	0.0
Sum	27.1	4.9	3.9	113.8	1.4	5.8	32.1	21.5
N traps	10	10	10	8	8	8	8	4
α diversity	11	5	3	4	3	5	8	3
Western Uplands (Bield, Russell, Basswood)								
<i>rufocinctus</i>	4.0	4.8	7.5	81.0	1.5			
<i>borealis</i>	0.7	0.3	0.2	2.0	0.0			
<i>insularis</i>	0.3	0.0	0.3	0.0	0.0			
<i>fervidus</i>	0.2	0.0	0.0	0.5	0.0			
Other species	6.0 ²	0.0	0.0	0.0	0.0			
<i>Bombus (unident.)</i>	0.2	0.0	0.0	0.0	0.0			
Sum	15.2	10.7	11.5	75.5	1.5			
N traps	6.0	6.0	6.0	2.0	2.0			
α diversity	11.0	2.0	3.0	3.0	1.0			
Manitoba Lowlands (Ste–Rose, Dauphin)								
<i>rufocinctus</i>	1.5	1.2	2.5	88.0	0.0			
<i>borealis</i>	0.5	0.0	0.2	7.0	0.0			
Other species	6.0 ³	0.0	0.0	0.0	0.0			
<i>Bombus (unident.)</i>	0.2	0.0	0.0	0.0	0.0			
Sum	6.2	1.2	2.8	95.0	0.0			
N traps	4.0	4.0	4.0	2.0	2.0			
α diversity	8.0	1.0	2.0	2.0	0.0			

TABLE 1. continued.

Species	1986	1987	1988	1989	1990	1991	1992	1993
Red River Valley (Stonewall, Dugald, Glenlea, Carman)								
<i>rufocinctus</i>	1.1	1.6	8.8	3.2				
<i>borealis</i>	0.1	0.0	0.6	0.2				
Other species	0.0	0.0	0.1 ⁴	0.2 ⁵				
<i>Bombus</i> (unident.)	0.2	2.5	0.0	0.2				
Sum	1.5	4.1	9.5	3.7				
N traps	8.0	8.0	8.0	6.0				
α diversity	2.0	1.0	3.0	3.0				

¹ Bees/trap: *ashtoni*–3.4; *nevadensis*–0.1; *centralis*–0.1.

² Bees/trap: *terricola*–4.8; *vagans*–0.3; *ternarius*–2.0; *sandersoni*–0.2; *ashtoni*–1.7; *nevadensis*–0.2; *huntii*–0.7.

³ Bees/trap: *perplexus*–0.5; *terricola*–1.8; *vagans*–0.5; *ternarius*–0.2; *ashtoni*–0.8; *huntii*–0.2.

⁴ *fervidus*.

⁵ *griseocollis*.

Abundance

The number of bumble bees/trap varied from none to 113.5 among regions and years (Table 1). In the Swan River Valley, the highest numbers occurred in 1989 (114/trap), 1992 (32/trap), 1986 (27/trap), and 1993 (22/trap). There were fewer than 10/trap in the other years (Table 1). The two most abundant species, *B. rufocinctus* and *B. borealis*, showed the same pattern of abundance. The rarer species did not have any clear trends in abundance. The pattern of abundance was similar in the other regions. In the Western Uplands and Manitoba Lowlands regions, numbers were also highest in 1989, lower in 1986, and very low in the other years. The peak year in the Red River Valley was also 1989.

The consistency in the trend of captures among years in all regions strongly suggests the impact of a physical factor, probably weather. Summer and winter temperatures and precipitation were similar among regions and showed similar trends among years. We examined the relationships among the weather factors and population trends for all four regions, but present data only for the Swan River region, which had the longest run of bumble bee captures.

In Swan River, these weather parameters and the mean temperature, total rainfall, and days with rain during the spring (18 May–14 June) did not show any clear relationships with the number of bees/trap (Table 2). High populations in one year did not predispose high populations in the next year, although populations did increase through 1990–1992 and 1987–1989. The high numbers in 1989, followed by the low in 1990, were associated with warm summers in 1988 and 1989, followed by moderately cold winters. The low numbers in 1990 cannot be related to any of the weather factors examined.

Although one or more weather factors may determine the annual variations in bumble bee numbers across the four regions of Manitoba, the differences among regions

TABLE 2. Weather data: degree days above 5°C (DD05), precipitation (Precip.) in mm of rain or cm of snow, and number of rainy days at Swan River in relation to number of bees/trap, Swan River Valley Region.

Year	Bees/trap (log X +1)	Previous summer		Previous winter		Spring		Summer		
		1 April - 3 October DD 05	1 October Precip. (mm)	1 November - 31 March DD	Snow (cm)	18 May - 14 June Tmean (°C)	Precip. (mm)	Rainy days	1 April - 31 October DD 05	Precip. (mm)
1989	113.8 (2.06)	1903	382	≤10	76	12.3	108	10	1864	448
1992	32.1 (1.52)	1826	415	492	83	13.7	28	7	1431	418
1986	27.1 (1.45)	1504	394	764	114	16.2	37	5	1656	499
1993	21.5 (1.35)	1431	418	492	83	10.6	80	15	1341	467
1991	5.8 (0.83)	1694	352	842	78	17.1	44	9	1826	415
1987	4.9 (0.77)	1656	499	359	76	14.8	56	11	1826	464
1988	3.9 (0.69)	1826	464	666	127	19.8	36	8	1903	382
1990	1.4 (0.38)	1864	448	798	144	14.8	52	12	1694	352

within years in both abundance and diversity seem to be controlled by other factors. Native vegetation near the fields influence bumble bee numbers (Morandin and Winston 2005), and captures were consistently higher in the Swan River Valley than in the regions where native vegetation was less abundant (Smith et al. 1998).

There is no evidence to indicate that pesticide usage differed among regions. Poor (cool, rainy) weather when the queens are establishing their nests in the spring may affect population numbers (Sladen 1912; Free and Butler 1959; Alford 1975; Harder 1986) but our data do not indicate such a relationship. Spillover of pathogens from commercial to wild populations may negatively affect wild populations (Colla et al. 2006), but bumble bees have not been used commercially in Manitoba glasshouses.

Research on bumble bees has neglected the factors controlling their abundance, and the general approach to the subject needs to be supplemented with experiments on overwintering survival, and colony establishment and growth.

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