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DIVERSITY OF AGROMYZIDAE (DIPTERA) IN CANADIAN TALLGRASS PRAIRIES

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ABSTRACT

An inventory of the Agromyzidae (Diptera) of Canadian tallgrass prairies was conducted in southern Manitoba. Specimens were collected at primary study sites between 1996-2000, by sweeping, malaise traps and pan traps. In order to establish species distributions in eastern grasslands, Agromyzidae were also obtained from other surveys in southern Ontario grasslands. Over 850 specimens were identified from 49 species (15 genera) from the Manitoba sites. The most diverse genera were *Liriomyza* (10 species) and *Cerodontha* (8 species), and the latter genus was the most abundant, primarily because of two dominant species: *C. superciliosa* and *C. inconspicua*. The zoogeographic distribution of tallgrass prairie agromyzids is dominated by Nearctic and Holarctic species, suggesting that many of the species are generalists. Species shared with eastern grasslands are primarily widespread Nearctic species. Twenty-eight percent of the species show grassland affinities; further investigation is required to confirm the distribution and habitat preference of these species.

RÉSUMÉ

Un inventaire de la famille Agromyzidae (Diptera) de la haute prairie canadienne a été entrepris dans le sud du Manitoba. Les spécimens ont été collectés sur les sites primaires d'échantillonage entre 1996 et 2000, par filet, pieges malaises, et pièges à cuvette. Afin d'établir les distributions des espèces presentes des les prairies de l'est, des spécimens d'Agromyzidae provenant d'inventaires des prairies sud ontariennes ont aussi été obtenus. Plus de 850 spécimens provenant des sites manitobains furent identifiés comme appartenant à 49 espèces (15 genres). Les genres les plus diversifiés étaient *Liriomyza* (10 espèces) et *Cerodontha* (8 espèces). Ce dernier était le plus abondant du à deux espèces, *C. superciliosa* et *C. inconspicua*. La distribution zoogéographique des Agromyzidae est dominée par des espèces néarctiques et holarctiques, suggérant que celles-ci sont généralistes. Les espèces communes aux prairies de l'est sont surtout des espèces répandues dans la zone néarctique. 28% des espèces montrent une affinité aux prairies; de plus amples recherches sont requises pour confimer leurs distributions.

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1. INTRODUCTION AND LITERATURE REVIEW

1.1. The Tallgrass Prairie Ecosystem

Grasslands are the most extensive North American vegetation formation (Sims 1988). The variety of grassland types in the prairie biome are characterized by similar climate, ecological communities and homogenous dominant vegetation, primarily grasses and grass-like plants (Carpenter 1940). Three or four plant species usually characterize a grassland site and account for the majority of its biomass (Sims et al. 1978).

Tallgrass prairies are the most mesic of the grassland types (Kucera 1992). They receive more rainfall and have greater north-south diversity and more dominant species than other North American grasslands (Walter 1985). Although the physical geology of tallgrass prairies is relatively homogenous, it varies across the landscape with changing climate and soils (Weaver 1954).

The plant species of tallgrass prairies originate from several geographic sources. These species have been subjected to a wide range of climates over time and, consequently, have developed broad ecological tolerances and are distributed over large geographical ranges (Risser et al. 1982).

The tallgrass prairie is characterized by an assemblage of dominant grasses (Poaceae) and broad-leaved herbaceous species or forbs. The most ubiquitous grass species, constituting 70-75% of the total plant biomass, are Big bluestem (*Andropogon gerardii* Vitman) and Little bluestem (*Schizachyrium scoparium* (Michx.) Nash.). Other characteristic grasses include Switchgrass (*Panicum virgatum* L.), Indian grass (*Sorghastrum nutans* (L.) Nash.), Prairie cord-grass (*Spartina pectinata* Link.) and

Prairie-dropseed (*Sporobolus heterolepis* A. Gray) (Kucera 1992). Many species of Asteraceae and Fabaceae are also dominant in this ecosystem. Mesic, poorly drained areas of tallgrass prairies are dominated by grasses in the genera *Calamagrostis* and *Spartina*, as well as rushes (Juncaceae) and sedges (Cyperaceae) (Carpenter 1940).

1.2. Postglacial History of Canadian Tallgrass Prairies

The repeated advances and retreats of Pleistocene glaciers had a profound influence on the formation of the prairies. During the Wisconsinan glaciation, 18 000 years B.P, grasslands were situated on the Texas-Mexican border (Howe 1994). As the glaciers retreated, the biota moved north, reinvading Canada (Downes and Kavanaugh 1988). The major period of prairie development in Canada started during the early part of the Hypsithermal warming interval (8500 to 7900 B.P.) (King 1981). Warming climate and increasing aridity resulted in the eastward advance of prairie species, reaching maximum expansion approximately 7000 B.P. (Wright 1968). The cooler, wetter conditions that have prevailed since the Hypsithermal have defined the current boundaries of the prairies (Anderson et al 1989); the present distribution of Canadian tallgrass prairie is relatively recent, having been established within the last 5000 years (Carpenter 1940).

Tallgrass prairie originally extended from southern Manitoba, south to central and eastern Texas, and east to eastern North Dakota and western Minnesota (Kucera 1992). (Fig. 1). Tallgrass prairies were maintained as open habitats by the grazing of ungulates and by fires ignited naturally by lighting, or accidentally or intentionally by aboriginal peoples (Sims 1988). These factors promoted the stability of the tallgrass prairie by

minimizing the effect of litter on the growth of grasses and arresting the spread of woody species. They also reduced competition from non-prairie invasive plants such as Kentucky bluegrass (*Poa pratensis* L.) and Smooth brome-grass (*Bromus inermis* Leysser.) (Sims 1988).

Within 50 years of the beginning of European settlement (1870), Canadian prairies were transformed from native grasslands to the most altered ecosystem in the country (Finnamore 1992). Fertile soils and favorable weather conditions encouraged the conversion of prairie vegetation to cropland (Jones 1987). By the mid-1930s over 90% of the original prairie landscape had been converted to tilled monocultures (Auclair 1976).

Human activity also led to the decline of principal herbivores such as wild bison which were extirpated in grasslands (Martin and Klein 1984). The natural fire regime of the prairies was interrupted and fires were contained and suppressed. In the absence of fire and herbivore grazing, woody species and exotic vegetation became established and the remaining prairie not used as cropland became forested (Joss et al. 1986).

1.3. Present Distribution of Tallgrass Prairie

Tallgrass prairie is now represented only by remnants of its original distribution. Tallgrass prairies originally occupied more than 570,000 km^2 of central North America. Within the last 200 years, this has been reduced to only 1% of the original prairie (Howe 1994). Because economic incentives favor agricultural development of the prairies over conservation, the remaining patches are often found on reserves of indigenous people or lands that were not considered profitable for farming (Aandahl 1982). Tallgrass prairies

must now be managed by government legislation in order to be preserved. The present distribution of tallgrass prairie is restricted to remnants that have been designated by government agencies as critical habitats or are under government jurisdiction. The main tallgrass prairie sites that remain in Canada include the St. Charles Rifle Range, the Tallgrass Prairie Preserve and the Living Prairie Museum in Manitoba, and Walpole Island and Ojibway Prairie in Ontario.

1.4. Similar Grassland Communities

There are other habitats, such as oak savannas and grassland alvars whose plant communities resemble those of tallgrass prairies. Like tallgrass prairies, these habitats have remained open mainly due to fires, grazing by herbivores and seasonal floods (Abrams 1992; Catling and Brownell 1995).

Savannas form an ecotone between prairie and deciduous forest. They occur on the eastern edge of the tallgrass prairie, and extend in a broad arc from Alberta, Saskatchewan, and Manitoba in the north, south to Texas (Anderson 1998). Savannas are defined as communities having less than 50% canopy (tree) cover, but more than 2.5 mature trees per hectare (Belcher et al. 1992). The understory contains many plant species that are shared with tallgrass prairies. Oaks, usually the dominant tree species, may occur in restricted groves or be scattered throughout the habitat (Anderson 1998). Like the tallgrass prairies, most of the savannas were cleared for agriculture with the influx of European settlement. The suppression of fires due to agricultural practices, converted the remaining savannas into closed oak forests (McCune and Cottam 1985). Most of the

remaining savannas are on privately owned lands (DePaul 1998).

Some alvar plant communities are similar to tallgrass prairies. The main differences between alvars and prairies are in the parent material and soil profile. Prairie soils are relatively deep in comparison to alvar soils. Alvars have a thin soil layer (20-30cm) overlying limestone or dolostone bedrock (Catling and Brownell 1995). The thin layer of soil allows the colonization of prairie associated plant species: grasses, sedges and forbs, while discouraging the establishment of larger plants and tree species. Most Canadian alvars are found in the Great Lakes region of southern Ontario from Manitoulin Island south to Pelee Island and east to Kingston and Ottawa (Belcher et al. 1992). There are also isolated sites in Quebec (Huggett 1993). Although there are six types of alvars, characterized by soil depth and dominant vegetation, only two (grassland alvars and grassland savanna alvars) share a number of plant species and other physical features with tallgrass prairies (Morton and Venn 1984). Both of these alvar types have relatively deep soil, sometimes up to 30 cm, with a relatively dense cover of grasses, sedges and forbs. Grassland alvars have about 10% tree cover whereas grassland savanna alvars have 10-50% cover (Catling and Brownell 1995).

1.5. Insects of Tallgrass Prairies

Arthropods make up about 64% of known global biodiversity and are associated with plants and vertebrates in every ecosystem (Danks 1979; Asquith et al. 1990). Arthropods are a significant component of faunal diversity in that they cycle nutrients, pollinate plants, maintain soil structure and are a major food source for other taxa

(Marshall et al. 1994). For these reason, they cannot be ignored in the assessment of biodiversity (Finnamore 1996). Arthropods have many qualities that make them suitable indicator groups in biodiversity studies: great abundance, rapid response to disturbance, ease of sampling, and trophic versatility (Holloway and Stork 1991).

In the prairie biome, the arthropod taxon that has received the most attention in recent years is the leafhoppers (Homoptera: Cicadellidae). They have been studied throughout the grassland ecosystem, but especially in shortgrass and mixed grass prairies (Ross 1970; Whitcomb 1987; Whitcomb et al. 1994). Recently, a number of tallgrass prairie studies have incorporated both plants and insects. There have been few baseline studies on the distribution and composition of plant species in the tallgrass praires (e.g, Smeins and Olsen 1970; Brotherson 1983; Hipp 1998) but the main focus has shifted to the role of fire and the reestablishment of plant species and populations of arthropods such as Hemiptera and Homoptera (Bock and Bock 1989; Evans 1989; Arenz 1995). All of these studies have been conducted in tallgrass prairie sites in Minnesota, Wisconsin, Iowa, Missouri and Kansas; studies on Canadian tallgrass prairies have been minimal. To address this lack of research, basic plant and arthropod studies are being undertaken at tallgrass prairie sites in Manitoba. At the Tallgrass Prairie Preserve in Gardenton the Nature Conservancy of Canada has begun an inventory of plants and arthropods (primarily butterflies) (Nature Conservancy of Canada 1999). At the St. Charles Rifle Range in Winnipeg, the Department of National Defense (DND) has funded a four year project on the role of prescribed burns as a management tool for conserving insect and plant diversity (Morgan 1994). The main insect group studied to date has been the

Coleoptera (R.E. Roughley, pers. comm.).

1.6. Agromyzidae of Tallgrass Prairies

There has been no comprehensive research to date on the Diptera of tallgrass prairies. In a biodiversity survey of the higher Diptera in grasslands of the southern Yukon Territory, Boucher and Wheeler (2001) found that the Agromyzidae, commonly known as leaf miner flies, were the most diverse family of flies, accounting for 15% of identified species from their study sites; unpublished data on specimens in the Lyman Entomological Museum collection indicate that this family is one of the most diverse groups of Diptera in other grasslands as well. Agromyzids are abundant in open habitats and are relatively simple to collect; they are also all phytophagous and have close interactions with their host plants. For these reasons, I chose to focus my study on the family Agromyzidae.

Adult agromyzids are minute to medium-sized acalyptrate flies, 1-4 mm in length. Their colour ranges from black, gray, green to entirely yellow (Sehgal 1971). The larvae, as the common name implies, are primarily leaf miners, although they will also mine in stems or roots, bore in cambium of tree branches, or induce galls in stems, roots or seeds (Spencer 1987). They are usually monophagous, feeding on a single species of plant and showing a high degree of host specificity, or oligophagous, feeding on more than one species from the same genus (Spencer 1969). Few species are polyphagous, feeding on a wide range of hosts from different genera or families (Spencer 1987). Two truly polyphagous species (*Liriomyza huidobrensis* (Blanchard) and *L. sativae* Blanchard) are

serious pest species in North America (Spencer 1987).

Females oviposit beneath the epidermis of the plant. The larvae emerge within a few days and begin to feed, generally forming mines on the upper surface of the leaf, within the palisade parenchyma. This layer is the main site of food production for the plant and is high in nutritional value for the flies (Needham et al. 1928). The shape of the mines can vary from basic linear mines to serpentine and blotch-like mines (Frost 1924). The position and pattern of the mine, and the arrangement of frass, are often species-specific (Frost 1924). Pupation normally takes place on the ground, although some species, such as those in the genus *Chromatomyia* Hardy, pupate within the mine. The mature larva molts into a puparium either within the mine, immediately after exiting from the mine, or a few hours after falling to the ground. After pupation, the adults emerge and females remain close to their host plant in order to oviposit. Adult agromyzids are often found on flowers, feeding on pollen and nectar (Malloch 1913; Spencer 1987).

Agromyzids are found worldwide and range from Arctic tundra to tropical rainforests. There are approximately 2500 described species and it is estimated that there may be as many as 3500 species still undescribed (Spencer 1987). About 70% of the described species are found in the Northern Hemisphere and of those, 25% of the species, in 19 genera, occur in the Nearctic region (Spencer 1987). In Canada, 305 species have been reported and it is estimated that a further 350 species are undescribed or unreported (McAlpine et al. 1979). The larvae are known for only 15 of the described Canadian species (McAlpine et al. 1979).

The first important systematic publications on North America Agromyzidae were

by Melander (1913) and Malloch (1913), who provided descriptions and keys for several species. Frick (1952, 1959) published a generic revision of the North American Agromyzidae and catalogued the New World species.

Spencer (1969) published the first comprehensive study of the Agromyzidae of Canada and Alaska, including the description of 147 new species and 23 new North American records. Spencer also provided keys to all described Canadian agromyzid genera and species.

Sehgal (1971) published a taxonomic survey of the Agromyzidae of Alberta, based on extensive collections from the province. Griffiths published a series of papers on the boreal (primarily western Canadian) fauna of the genera *Phytomyza* Fallén (Griffiths 1972a, b, 1973a, b, 1974b, d, 1975, 1976a, c) and *Chromatomyia* (Griffiths 1974a, c, 1976b, c, 1980), including several host records based on rearing adults from mined leaves.

Spencer (1981) revised the Agromyzidae of California and Spencer and Steyskal (1986) published a comprehensive revision of the Agromyzidae of the United States. These two publications provided descriptions of 132 and 85 new species, respectively.

Other than scattered papers on individual species or species groups, the only comprehensive work on Nearctic Agromyzidae since 1986 was by Boucher and Wheeler (2001), who recorded 34 species from 11 genera in relict grasslands of the southern Yukon.

1.7. Objectives

Because of the lack of knowledge of phytophagous Diptera in grasslands, and the lack of knowledge of Canadian Agromyzidae in general, the primary objective of my study was to conduct a faunal inventory of the Agromyzidae associated with two native tallgrass prairie sites in southern Manitoba. This inventory will contribute to a growing database on insect diversity in tallgrass prairies and allow eventual research on the ecological relationships of grassland arthropods. Such inventories also allow us to determine which species are restricted to grassland sites and, therefore, are candidates for conservation efforts.

My second objective was to establish the geographic distributions of the Agromyzidae collected in tallgrass prairies. The distributions of most Nearctic species of Agromyzidae are incompletely known and many species show disjunctions in their range. Once the distribution of agromyzids in the tallgrass prairies of southern Manitoba is known, it is necessary to establish, where possible, the distribution of the species elsewhere, in other grasslands and in non-grassland habitats. This additional information will help to determine the zoogeographic history of the agromyzid species and provide information on whether tallgrass prairie agromyzid species are habitat-specific to tallgrass prairies, restricted to prairie habitats in general, or are more widespread in a range of habitats.

2. MATERIALS AND METHODS

2.1. Sources of Material

Specimens were collected at two primary study sites in Manitoba tallgrass prairies (Fig. 2) selected on the availability of native grasslands. The primary sites contain the largest continuous areas of tallgrass prairie habitat in Canada (Morgan 1994; Nature Conservancy of Canada 1999).

Additional data were obtained from fieldwork at other grassland and non-grassland sites in 1999 and 2000, from sample residues collected by other researchers at grassland sites between 1996 and 2000, and from museum specimens deposited in the following collections (abbreviations used in text are in parentheses): Lyman Entomological Museum, McGill University, Ste-Anne-de-Bellevue, QC (LEM); Canadian National Collection of Insects, Ottawa, ON (CNC); University of Guelph Insect Collection, Guelph, ON (GUE).

The primary study sites and major additional sample sites are described in the following sections. Plant classification in site descriptions generally follows Gleason and Cronquist (1991); species not included in that publication follow Terrell (1977).

2.1.1. St. Charles Rifle Range (Primary Site)

The first primary site was located on the Department of National Defence's Canadian Forces Base Winnipeg. The largest and most undisturbed tallgrass prairie area on the Base occurs on the St. Charles Rifle Range (Fig. 3). It consists of over 190 ha of native prairie, of which 47.9 ha is high quality prairie (Morgan 1994). A total of 94 plant

species were recorded in 1993, of which 82 are native to the prairie (Morgan 1994). The northern limit of the St. Charles Rifle Range has a forest in early successional stage composed of Quaking aspen (*Populus tremuloides* Michx.), and Bur oak (*Quercus macrocarpa* Michx.). The tallgrass prairie has not become closed forest because of intense grazing by white tailed deer and prescribed burns (Morgan 1994). The soil is fairly dry, composed of glacial till with a few rock outcrops.

There was one main collecting site at the St. Charles Rifle Range (49°54.2'N, 97°20.3'W). The dominant grasses were *Andropogon gerardii*, *Schizachyrium scoparium* and *Sporobolus heterolepis*. Shrub species consisted mainly of *Rosa acicularis* Lindl.(Bristly rose), *Rosa arkansana* Porter (Dwarf prairie-rose), *Amelanchier alnifolia* Nutt.(Western serviceberry), *Symphoricarpos occidentalis* Hook. (Wolfberry), and *Prunus virginiana* L (Choke-cherry). I collected at the site from 11-21 June 1999, 11-18 August 1999, and 05-15 July 2000. Residues were obtained from previous collecting at the site from 11 June to 24 September 1997 and from 22 May to 22 July 1998.

2.1.2. Tallgrass Prairie Preserve (Primary Site)

The second site was located in Gardenton at the Tallgrass Prairie Preserve in southeastern Manitoba. The preserve is part of the Critical Wildlife Habitat Program monitored by the Nature Conservatory of Canada. There are over 2000 hectares of tallgrass prairie, with 200 recorded plant species protected within the preserve (Nature Conservancy of Canada 1999). Like the St. Charles Rifle Range, there are small stands of savanna with *Populus tremuloides* and *Quercus macrocarpa*, and to a lesser extent,

Boxelder (*Acer negundo* L.) and willows (*Salix* spp.), throughout the preserve. The alluvial soils are fairly moist and rockier than the other site.

There were two main collecting sites located in the north block of the Tallgrass Prairie Preserve (Fig. 4). The first site, referred to as Gardenton North, was located 5 km north of Gardenton (49°10.71'N, 96°40.76'W), and the second site, referred to as Gardenton South, was 4 km north of Gardenton (49°10.29'N, 96°40.40'W). The dominant grasses were *Andropogon gerardii* and *Schizachyrium scoparium*. The main shrubs included *Rosa woodsii* Lindley (Western rose), *Rosa acicularis* (Bristly rose), and *Symphoricarpos occidentalis* (Wolfberry). Horsetails (*Equisetum* spp.) and sedges (*Carex* spp.) were more abundant at the Gardenton sites than at the St. Charles Rifle Range. I collected at this site from 11-21 June 1999, 11-18 August 1999 and 05-15 July 2000. Residues were obtained from previous collecting at the site from 24 June to 09 July 1996.

2.1.3. Ojibway Prairie (Additional Site)

Agromyzidae from Ojibway Prairie in Windsor, Ontario, were borrowed from the University of Guelph Insect Collection. Ojibway Prairie contains 127 ha of native tallgrass prairie located in an area of poorly drained, sandy soil over a thick bed of clay (Ojibway Nature Center 2000). The dominant grass species included *Andropogon gerardii*, *Sorghastrum nutans* (L.) Nash., and *Spartina pectinata* Link. *Veronicastrum virginicum* (L.) Farw. (Culver's root), *Asclepias tuberosa* L. (Butterfly milkweed), and *Euphorbia corollata* L. (Flowering spurge) were the most abundant forb species at Ojibway Prairie. The specimens were collected from 17 June to 18 August, 1980.

2.1.4. Manitoulin Island Alvars (Additional Sites)

Sample residues from previous collecting in alvars on Manitoulin Island, Ontario, housed at the Lyman Entomological Museum, were sorted and agromyzids removed and prepared for identification. Of the four alvar sites sampled on Manitoulin Island, agromyzids were removed from two alvar types that possess a similar floral diversity to that of tallgrass prairies. The first site was a grassland savanna alvar located 10 km southwest of Gore Bay (45°52 'N, 82°31'W) and the second site was a grassland alvar located 10 km west of Gore Bay (45°53'N, 82°34'W). The dominant grasses in these alvars were *Andropogon scoparius*, *Poa compressa* L. and *Sporobulus heterolepis*. The shrubs consisted mainly of *Juniperus communis* L. (Common juniper), *Shepherdia canadensis* (L.) Nutt. (Rabbit-berry), and *Potentilla fruticosa* L. (Shrubby five-fingers) (Morton and Venn 1984). Specimens from residues were collected from 20 May to 02 September, 1996. I also collected specimens from the grassland savanna alvar southwest of Gore Bay and at a second grassland savanna alvar located 5km west of Dyer Bay, ON (45°10.9'N, 81°23.8'W), from 17-19 July, 2000.

2.1.5. Other Sample Sites

Because many agromyzid species show apparent disjunct distributions in western and central Canada, additional specimens were collected from several other grassland and non-grassland habitats in 1999 and 2000 to establish distribution records in Canada (Alberta, Saskatchewan, Manitoba, Ontario) and the United States (Wisconsin). Complete locality data on these sites are given in the annotated list of species.

2.2. Collecting Techniques

Several sampling methods were used to collect agromyzids. Most specimens were collected by sweeping, a method productively used in grasslands (Marshall et al. 1994). Additional techniques used at the primary study sites were pan traps and malaise traps. Specimens were swept at the St. Charles Rifle Range in 1997 to 2000 and at the Tallgrass Prairie Preserve in 1999 to 2000. Vegetation was swept with an aerial net approximately 2-3 times a week at the sites for a period of two hours. Flies were killed and preserved in 70% ethanol.

Pan traps were placed at one of the Tallgrass Prairie Preserve sites (49°10.71'N, 96°40.76'W) in 1999. Five pan traps were placed along a transect, 5 meters from one another. Traps were yellow plastic bowls (355 ml), 15cm in diameter and 4cm deep. They were set flush with the substrate and filled approximately half full with salt water as a preserving fluid. Two to three drops of Kodak Photoflo were added as a wetting agent. Traps were serviced every 3-4 days. Specimens were removed from traps and transferred to whirlpak bags containing 70% ethanol. After the specimens were removed, traps were refilled with fluid as needed.

Malaise trap residues were obtained from the St. Charles Rifle Range (collected in 1998) and the Tallgrass Prairie Preserve (collected in 1996).

Leaves with agromyzid mines were collected from the primary sites and kept in pill bottles until the larvae pupated and adults emerged. All flies that emerged were kept alive until they were fully sclerotized and then preserved in 70% ethanol.

Specimens from Manitoulin Island in 1996 were collected using sweep nets and

malaise traps. Additional specimens were collected in 2000 using sweep nets.

2.3. Specimen Preparation and Identification

Specimens preserved in ethanol were dried using Hexamethyldisilazane (HMDS) and mounted. All specimens have been deposited in the LEM. Genitalic dissections were made by removing the postabdomen of the specimens and clearing them in 85% lactic acid for 1-2 intervals of 30 seconds in a microwave oven. Specimens were cooled for one minute after every 30 second interval in the microwave. Cleared postabdomens were transferred to glycerin for further dissection and examination. After identification and/or drawing, the abdomens and genitalia were transferred to plastic microvials containing glycerin and pinned directly under the specimen.

All specimens were identified to species using keys and descriptions in Spencer (1969), Sehgal (1971), Griffiths (1972a-1980) or Spencer and Steyskal (1986). Species identifications were confirmed using identified specimens in the LEM and CNC collections.

Morphological terminology follows McAlpine (1981) for external characters and Boucher and Wheeler (2001) for male genitalic characters. Measurements also follow Boucher and Wheeler (2001) and are expressed as follows: *frons width* is measured at the anterior apex of the ocellar triangle; *eye width* is the maximum width of the eye in dorsal view; *gena height* is measured vertically at the centre of the gena from the ventral margin of the gena to the ventral margin of the eye; *eye height* is measured in a vertical line above the point of the gena height measurement; *wing length* is measured from the base

of the wing to the apex; *second costal sector* is the part of the costa between the apex of veins R_1 and R_{2+3}; *fourth costal sector* is the part of the costa between the apex of veins R_{4+5} and M_{1+2}.

Because deposition of a thesis in a library does not constitute publication according to the International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature 1999), all names proposed for newly described species in this thesis are to be considered *nomina nuda* until they are published in a refereed journal, or otherwise published according to the meaning of the Code.

2.4. Analysis of Species Diversity

Differentiation diversity (β diversity) between sites was determined using the Jaccard index (Magurran 1988), which considers only the presence or absence of species shared between the two sites. The index was calculated using the formula:

$$C_J = j / (a + b - j)$$

where j is the number of species found at the two sites and a and b are the number of species collected at site A and site B respectively. The value of the Jaccard Index ranges from 0, sites with no species in common, to 1, complete similarity between the sites.

Due to the qualitative nature of the sampling, and the use of different collecting techniques and sampling periods at different sites, other diversity indices that incorporate species abundance or are sample based were not calculated.

An estimate of the true total number of species at a site was calculated using the Chao 1 estimator (Chao 1984):

$$S_{CHAO\ 1} = S_{obs} + (a^2 / 2b)$$

where S_{obs} is the number of observed species collected at the site, a is the number of species represented by only one individual and b is the number of species represented by two individuals at the site. This estimator, which extrapolates total diversity based on the number of rare species collected at the site, performs well on a variety of data sets, especially on short range data sets that have large numbers of rare species (Colwell and Coddington 1995). This is commonly seen in diversity inventory studies, such as mine.

2.5. Zoogeographic Analysis

Geographic distributions of the species were established using published records (e.g., Spencer 1969; Sehgal 1971; Griffith 1972a-1980; Spencer and Steyskal 1986; Boucher and Wheeler 2001), and additional unpublished specimen records in the LEM, CNC and GUE collections.

Species distributions were divided into three broad categories generally following Danks (1994): *Holarctic:* species present in the Palaearctic and widespread in the Nearctic; *Widespread Nearctic:* species widespread in North America; *Western Nearctic:* species restricted to western North America from Manitoba and Texas to the Pacific. A fourth category, *Endemic,* was used for species restricted (so far) to tallgrass prairies in

southern Manitoba.

In addition to the broad categories described above, it was also noted whether species from the primary sites were near the western, eastern, or northern edge of their known distribution, and whether they are known primarily from grassland regions.

3. RESULTS

3.1. Annotated List of Species

The following list includes of all species identified in this study. Genera and species are listed in alphabetical order. Questionable species are denoted by "?". Collection data on specimens from the primary study sites are listed separately from data on specimens collected in additional grassland and non-grassland sites. The geographic distribution of each species is summarized and new provincial and state records from this study are included at the end of the known distribution. Known host plants are listed and comments on the ecology, distribution and taxonomy of the species are given where appropriate. New species described and illustrated (Figs. 5-18) are included in the list.

Subfamily Agromyzinae

Agromyza frontella (Rondani)

Specimens collected (primary sites): Canada: Manitoba: 2km W Gardenton, Tallgrass Prairie Field Station (49°04.37'N, 96°42.50'W), malaise in poplar grove edge, 24.vi-09.vii.1996, H.D. White (1♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 11.vi.1997, D. Pollock (2♀, LEM); same except 13.vi.1997 (1♂, 1♀, LEM); same except 18.vi.1997 (1♂, 4♀, LEM); same except 27.viii.1997 (1♂, 1♀, LEM); same except 29.viii.1997 (1♀, LEM); same except 03.ix.1997 (1♂, 1♀, LEM); same except 05.ix.1997 (1♀, LEM); same except 10.ix.1997 (1♂, 1♀, LEM); same except 24.ix.1997 (1♂, LEM); same except 22.v.1998, P. Bouchard (1♀, LEM); same except 27.v.1998 (2♂, 5♀, LEM); same except 29.v.1998 (1♂, 3♀,

LEM); same except 05.vi.1998 (1♂, LEM); same except 10.vi.1998 (4♂, 5♀, LEM); same except 10.vi.1998 (1♀, LEM); same except 12.vi.1998 (1♀, LEM); same except 15.vii.1998 (1♂, 4♀, LEM); same except 17.vii.1998 (2♂, 4♀, LEM); same except 22.vii.1998 (4♂, 4♀, LEM); same except 21.vii.1999, S. McMillan (1♀, LEM).

Distribution: Canada: MB; NB, NS, ON, PEI, QC; USA: MA, ME, NH, NJ, NY, PA, VT; Europe (Harcourt 1973; Thompson 1974; Guppy 1981; Spencer and Steyskal 1986; Lundgren et al 1999) (Fig. 19). [Holarctic]

Host-Plants: The larvae feed mainly on *Medicago*, particularly *M. sativa* L. (alfalfa) and less frequently on *Melilotus* and *Trifolium* (Spencer and Steyskal 1986).

Comments: This species was recently introduced from Europe and is a pest of alfalfa (Harcourt 1973). *Agromyza frontella* has been rapidly expanding its range westward; Manitoba is the westernmost limit of its North American range. Most specimens were collected in 1997 and 1998; it was much less abundant in 1999 and 2000.

Agromyza gonioverpa sp. nov.

(Figs. 5-7)

Holotype (♂): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie,18.vi.1999, T.A. Wheeler (LEM).

Paratype: Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie,16.vi.1999, V. Crecco (1♀, LEM).

Etymology: The species name is from the Greek *gonia* (angle) and the Latin *verpa* (phallus), referring to the sharp angle in the mesophallus.

Diagnosis: The specimens key to *Agromyza hockingi* Spencer in Spencer (1969) but can be distinguished from *A. hockingi* by the shorter wing, the narrower and longer distiphallus and the sharp angle in the mesophallus.

Description: Frons, orbits, and ocellar triangle dark brown to black; frons 1.25-1.3 times width of eye, slightly projecting above eye in profile; two inclinate frontal bristles and two reclinate orbital bristles; face dark brown to black; parafacial dark yellow; pedicel dark yellow to brown, first flagellomere dark brown to black; gena dark brown to black, 0.14-0.17 times eye height; vertex and occipital margin dark brown to black; palpus dark brown to black. Scutum and scutellum dark brown; no presutural dorsocentral bristles; 3 postsutural dorsocentral bristles; thoracic pleurites dark brown. Wing length 2.2-2.5 mm; costa extending to M_{1+2}; wing tip midway between R_{4+5} and M_{1+2}; second costal sector 3.4-3.6 times length of fourth; distance between r-m and dm-cu 1.4 times length of dm-cu. Calyptral fringe mostly pale with 8-10 dark bristles anteriorly in male; entirely pale in female. Femora and tibiae brown, junction of fore femur and fore tibia yellow. Tarsi paler, light brown to dark yellow. Abdomen black.

Male genitalia. Epandrium with 12-14 dorsal spines, surstylus with 3 stout spines and 2 weaker spines posteriorly (Fig. 7); mesophallus with anterolateral corners forming a sharp angle (Fig. 5).

Agromyza hockingi Spencer

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.6'N, 97°20.5'W), malaise in poplar forest/tallgrass prairie 03-10.vii.1998,

R.E. Roughley (1♂, LEM).

Distribution: Canada: AB, NB, ON, QC; USA: CO, TX, UT (Spencer 1969; Spencer and Steyskal 1986); MB (Fig. 20). [Widespread Nearctic]

Host-Plant: Unknown, but apparently Poaceae (Spencer and Steyskal 1986).

Comments: This is the first record in Manitoba.

Agromyza ?isolata Malloch

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 12.viii.1999, T.A. Wheeler (1♀, LEM).

Distribution: Canada: AB, ON, QC, SK; USA: CA, CO, MN, PA, TX, UT, WA (Spencer 1969; Spencer and Steyskal 1986); ?MB. [Widespread Nearctic]

Host-Plants: The larvae are leaf miners on *Populus* and *Salix* species (Spencer 1969; Spencer and Steyskal 1986).

Comments: Spencer (1969) described Canadian specimens as a new species, *Agromyza populoides*, and specimens from the west coast of the United States were misidentified by Frick (1959) as the European species *Agromyza albitarsis* Meigen. *Agromyza populoides* was synonymized with *A. isolata* by Spencer and Steyskal (1986). The specimen is a female and confirmation of its identity would require associated males. This is tentatively the first record in Manitoba.

Agromyza ?oliverensis Spencer

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 12.vi.1998, P. Bouchard (2♀, LEM).

Distribution: Canada: BC (Spencer 1969); ?MB. [Western Nearctic]

Host-Plant: The larvae feed on species of Poaceae (Spencer 1969).

Comments: The specimens were keyed to *A. oliverensis* the based on the distinctive black squamal fringe. However, the specimens are female and confirmation of their identity would require associated males. This is tentatively the first record in Manitoba and the easternmost record of the species.

Hexomyza schineri (Giraud)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 11.vi.1999, J. Perusse (1♀, LEM); same except T.A. Wheeler (1♀, LEM); same except 12.vi.1999 (1♀, LEM); same except 21.vi.1999 (1♂, LEM); same except J. Perusse (1♀, LEM).

Distribution: Canada: AB, BC, MB, NB, ON; USA: CA, CO, MA, NM, WA; Europe (Spencer 1969; Spencer and Steyskal 1986). [Holarctic]

Host-Plant: The larvae feed in stems of *Populus*, mainly *P. fremontii* S. Wats., *P. tremuloides* Michx., and *P. trichocarpa* T. & G. (Spencer 1969; Spencer and Steyskal 1986).

Comments: The species is Holarctic (Spencer 1969).

Melanagromyza martini Spencer

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 29.v.1998, P. Bouchard (1♂, LEM); same except 11.vi.1999, S. Boucher (1♂, LEM); same except 21.vi.1999 (1♂, LEM).

Distribution: Canada: AB, BC, ON, SK (Spencer 1969); MB. (Fig. 21). [Widespread Nearctic]

Host-Plant: The larvae are stem-borers in *Urtica* species (Spencer 1969).

Comments: This is the first record in Manitoba.

Melanagromyza modesta Spencer

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 03.vii.1998, P. Bouchard (1♀, LEM); same except 10.vii.1998 (1♀, LEM); same except 16.vi.1999, T.A. Wheeler (1♂, LEM).

Distribution: Canada: ON, QC (Spencer 1969); MB. (Fig. 22). [Widespread Nearctic]

Host-Plant: The host plant of this species is unknown, but most species of *Melanagromyza* are stem-borers.

Comments: This is the westernmost record of the species and the first record in Manitoba.

Melanagromyza shewelli Spencer

Specimens collected (primary sites): Canada: Manitoba: 2km W Gardenton, Tallgrass Prairie Field Station (49°04.37'N, 96°42.50'W), malaise in poplar grove edge, 24.vi-09.vii.1996, H.D. White (1♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 11.vi.1997, D. Pollock (2♀, LEM); same except 29.v.1998, P. Bouchard (1♀, LEM); same except 10.vi.1998 (1♂, 2♀, LEM); same except 16.vi.1999, T.A. Wheeler (1♀, LEM); same except 18.vi.1999 (1♂, LEM); same except 21.vi.1999, J. Perusse (3♂, LEM); same except S. McMillan (1♂, LEM); same except T.A. Wheeler (1♂, LEM); same except S. Boucher (1♀, LEM).

Specimens collected (additional sites): Canada: Ontario: Manitoulin Island, 10km SW Gore Bay (45°52'N, 82°31'W), sweep in grassland savanna alvar, 01.vi.1996, P. Bouchard (2♂, 5♀, LEM); same except 19.vi.1996 (1♂, LEM); same except malaise trap in grassland alvar, 20.v.1996, P. Bouchard (1♂, LEM); 10km W Gore Bay (45°53'N, 82°34'W), malaise trap in grassland alvar, 20.vi.1996, P. Bouchard (1♂, LEM).

Distribution: Canada: AB, BC (Spencer 1969); MB, ON. (Fig. 23). [Widespread Nearctic]

Host-Plant: The host plant of this species is unknown.

Comments: This is the first record in Manitoba and in Ontario and it is also the easternmost record of the species.

Melanagromyza verbesinae Spencer

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle

Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 27.vi.1997, D. Pollock (1♂, LEM); same except 07.vii.2000, V. Crecco and T.A. Wheeler (1♂, LEM).

Distribution: USA: OH, TN, TX (Spencer and Skeyskal 1986); Canada: MB. (Fig. 24). [Widespread Nearctic]

Host-Plant: The larvae are stem borers in *Verbesina alternifolia* (L.) Britton and probably other species of *Verbesina* and related genera (Spencer and Skeyskal 1986).

Comments: This is the first Canadian and Manitoba record for the species and is a major range extension.

Ophiomyia coniceps (Malloch)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°04.37'N, 96°42.50'W), sweep in tallgrass prairie, 14.vi.1999, T.A. Wheeler (3♂, 1♀, LEM); same except S. Boucher (1♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 11.vi.1997, D. Pollock (1♀, LEM); same except 03.vii.1998, P. Bouchard (1♀, LEM); same except 21.vi.1999, J. Perusse (1♂, 2♀, LEM); same except S. Boucher (5♀, LEM); same except T.A. Wheeler (1♂, 2♀, LEM); same except 14.vii.1999, S. McMillan (1♂, LEM).

Specimens collected (additional sites): Canada: Ontario: Manitoulin Island, 10km SW Gore Bay (45°52'N, 82°31'W), malaise trap in grassland savanna alvar, 30.v.1996, P. Bouchard (1♂, LEM); same except 19.vi.1999 (2♂, 5♀, LEM); same except 04.viii.1996 (1♂, 6♀, LEM); same except 18.vii.1996 (2♂, 2♀, LEM); same except 20.viii.1996 (1♂, 3♀, LEM); 10km W Gore Bay (45°53'N, 82°34'W), malaise trap in grassland alvar,

20.vi.1996, P. Bouchard (1♀, LEM); same except 03.vii.1996 (1♀, LEM); same except 05.viii.1996 (2♀, LEM); same except 21.viii.1996 (1♂, LEM).

Distribution: Canada: BC, MB, ON, QC, SK; USA: CA, IN, LA, UT (Spencer 1969; Spencer and Steyskal 1986) (Fig. 25). [Widespread Nearctic]

Host-Plant: The larvae are stem miners in *Sonchus asper* (L.) Hill and probably other related Asteraceae (Spencer and Steyskal 1986).

Comments: There were no species of *Sonchus* recorded at either of my sites, but related genera were present. Because *O. coniceps* was relatively abundant at my sites, it apparently has host plants other than *Sonchus* species.

Ophiomyia lauta (Spencer)

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 10.vi.1998, P. Bouchard (1♂, LEM).

Distribution: Canada: ON; USA: GA, MI (Spencer 1969; Spencer and Steyskal 1986); MB. (Fig. 26). [Widespread Nearctic]

Host-Plant: The host of this species is unknown.

Comments: The species was originally placed in *Melanagromyza* by Spencer (1969) based on external characters. Spencer and Steyskal (1986) transferred this species to *Ophiomyia*, based on the male genitalia. This is the first record in Manitoba and the westernmost record of the species.

Ophiomyia nasuta (Melander)

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 05.vi.1998, P. Bouchard (1♀, LEM).

Specimens collected (additional sites): Canada: Ontario: Point Pelee, 17.vii.1978, J.M. Cumming (1♂, GUE); same except 19.vii.1978, W.A. Attwater (1♂, GUE); Manitoulin Island, 10km SW Gore Bay (45°52'N, 82°31'W), malaise trap in grassland savanna alvar, 02.vi.1996, P. Bouchard (1♂, LEM); same except 19.vi.1996 (1♀, LEM).

Distribution: Canada: YT to QC; USA: CA to NY, NC; Europe; Japan (Spencer 1969; Spencer and Steyskal 1986). [Holarctic]

Host-Plant: The larvae feed on *Taraxacum officinale* Weber ex Wiggers (Frost 1924; Spencer 1969).

Comments: This species is Holarctic (Spencer 1969).

Ophiomyia secunda Spencer

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 11.vi.1997, D. Pollock (2♀, LEM); same except 27.v.1998, P. Bouchard (1♂, LEM); same except 16.vi.1999, T.A. Wheeler, (1♀, LEM); same except V. Crecco (1♀, LEM); same except S. Boucher (1♀, LEM); same except 18.vi.1999, T.A. Wheeler (1♀, LEM); same except J. Perusse (1♀, LEM); same except 21.vi.1999, S. Boucher (1♀, LEM); same except T.A. Wheeler (2♀, LEM).

Distribution: Canada: AB, ON (Spencer 1969); MB (Fig. 27). [Widespread Nearctic]

Host-Plant: The host of this species is unknown.

Comments: This is the first record in Manitoba.

Ophiomyia sexta Spencer

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 29.v.1998, P. Bouchard (2♂, 1♀, LEM); same except 05.vi.1998 (2♀, LEM); same except 12.vi.1998 (3♀, LEM); same except 11.vi 1999, T.A. Wheeler (1♂, LEM); same except V. Crecco (1♀, LEM); same except 16.vi.1999, (2♂, 3♀, LEM); same except V. Crecco (2♂, 2♀, LEM); same except S. Boucher (1♂, LEM); same except J. Perusse (1♂, 2♀, LEM); same except 17.vi.1999, T.A. Wheeler (1♀, LEM); same except 18.vi.1999 (10♂, 7♀, LEM); same except S. Boucher (2♂, 1♀, LEM); same except J. Perusse (3♂, LEM); same except 21.vi.1999, S. Boucher (6♂, LEM); same except 07.vii.2000, V. Crecco and T.A. Wheeler (1♀, LEM).

Distribution: Canada: AB, MB, NT, QC; USA: CO (Spencer 1969; Spencer and Skeyskal 1986) (Fig. 28). [Widespread Nearctic]

Host-Plant: The host of this species is unknown.

Subfamily Phytomyzinae

Calycomyza frickiana Spencer

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 03.vii.1998, P. Bouchard (1♂,

LEM).

Distribution: USA: IL, IN, MD, MN, SD, NY, PA, VA, ?WI (Spencer and Steyskal 1986); MB (Fig. 29). [Widespread Nearctic]

Host-Plant: The larvae form blotch mines on *Bidens, Helianthus,* and *Rudbeckia* (Spencer and Steyskal 1986).

Comments: This is the northernmost record of the species and the first Canadian and Manitoba record.

Calycomyza humeralis (Roser)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 17.vi.1999, S. Boucher (1♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 18.vi.1997, T.A. Wheeler (1♂, LEM).

Distribution: Canada: ON, QC, YT; widely distributed in USA; Argentina; Chile, Europe (Spencer 1969; Spencer and Steyskal 1986; Boucher and Wheeler 2001); MB. [Holarctic]

Host-Plant: In North America, the larvae are leaf miners on *Aster, Conyza, Heterotheca, Madia, and Solidago* (Spencer and Steyskal 1986).

Comments: This species is widespread in the Holarctic region and is also found in South America (Spencer and Steyskal 1986). This is the first record in Manitoba.

Calycomyza menthae Spencer

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 17.viii.1999, T.A. Wheeler (1♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 13.viii.1999, T.A. Wheeler (2♂, LEM).

Specimens collected (additional sites): Canada: Ontario: Manitoulin Island, 10km SW Gore Bay (45°52'N, 82°31'W), malaise trap in grassland savanna alvar, 19.vi.1996, P. Bouchard (1♂, 1♀, LEM); same except 20.viii.1996 (1♀, LEM); 10km W Gore Bay (45°53'N, 82°34'W), malaise trap in grassland alvar, 05.viii.1996, P. Bouchard (1♂, LEM); Windsor, Ojibway Prairie Reserve, 17.vi.1980, K.N. Barber (1♂, GUE); same except S. Beierl (1♂, GUE); same except 10.vii.80, K.N. Barber (1♀, GUE); Point Pelee, 27.vi.1979, K.L. Bailey (1♀, GUE).

Distribution: Canada: ON; USA: CA, FL (Spencer 1969; Spencer and Steyskal 1986); MB (Fig. 30). [Widespread Nearctic]

Host-Plant: The larvae are leaf miners on species of Lamiaceae, particularly *Monarda fistulosa* L., *Monardella odoratissima* Benth., *Mentha arvensis* L., and *Ocimum* sp. (Spencer 1969; Spencer and Steyskal 1986).

Comments: The status of *C. menthae* is questionable. It is indistinguishable from *C. jucunda* (Wulp) externally and the differences in the aedeagus of the two species are minor. The host plant of *C. jucunda* is unknown. More ecological study is necessary to determine whether or not the two species should be synonymized (Spencer and Steyskal 1986). This is the first record in Manitoba.

Calycomyza promissa **Frick**

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 17.vi.1999, J. Perusse (1♂, LEM); same except 14.viii.1999, T.A. Wheeler (1♂, LEM); same except 17.viii.1999 (4♂, LEM); same except 06.vii.2000, V. Crecco and T.A. Wheeler (4♂, 1♀, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 08.vii.1998, P. Bouchard (1♂, LEM); same except 11.vi.1999, S. Boucher (1♂, LEM); same except 16.vi.1999, T.A. Wheeler (2♂, LEM); same except S. Boucher (1♂, LEM); same except 13.viii.1999, T.A. Wheeler (1♂, LEM); same except 18.viii.1999 (1♂, LEM).

Specimens collected (additional sites): Canada: Alberta: 25km NE Onefour, Sage Creek (49°09.0'N, 110°17.1'W), sweep sedges near creek, 10.vii.2000, V. Crecco and T.A. Wheeler (2♂, 2♀, LEM); **Ontario:** 10km W Gore Bay (45°53'N, 82°34'W), malaise trap in grassland alvar, 03.vii.1996, P. Bouchard (2♂, LEM); same except 15.vii.1996 (1♂, LEM); same except 19.vii.1996 (1♂, LEM); same except 05.viii.1996 (1♂, LEM); **Saskatchewan:** Cypress Hills Provincial Park, east boundary (49°40.2'N, 109°27.5'W), sweep meadow near mixed forest, 10.vii.2000, V. Crecco and T.A. Wheeler (1♂, 2♀, LEM).

Distribution: Canada: ON, MB; USA: CA, FL, LA, NY (Spencer 1969; Spencer and Steyskal 1986); AB, SK (Fig. 31). [Widespread Nearctic]

Host-Plant: The larvae are leaf miners on species of *Aster*, mainly *A. chilensis* Nees, and

A. lateriflorus (L.) Britton. (Spencer and Steyskal 1986).

Comments: This is the first record in Alberta and Saskatchewan.

Calycomyza solidaginis (Kaltenbach)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 17.vi.1999, J. Perusse (1♀, LEM); same except S. Boucher (1♂, 1♀, LEM); same except 14.viii.1999 (2♂, LEM); 4km N Gardenton, Tallgrass Prairie Preserve (49°10.29'N, 96°40.40'W), sweep in tallgrass prairie, 17.vi.1999, T.A. Wheeler (1♀, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 18.vi.1997, D. Pollock (1♀, LEM); same except 16.vi.1999, V. Crecco (3♀, LEM); same except 18.vi.1999, T.A. Wheeler (1♂, 1♀, LEM); same except 21.vi.1999, V. Crecco (1♀, LEM); same except S. Boucher (1♀, LEM); same except 07.vii.1999, S. McMillan (1♀, LEM); same except 11.viii.1999, V. Crecco (1♀, LEM); same except 13.viii.1999, T.A. Wheeler (2♀, LEM).

Specimens collected (additional sites): Canada: Ontario: Manitoulin Island, 10km SW Gore Bay (45°52'N, 82°31'W), malaise trap in grassland savanna alvar, 04.vii.1996, P. Bouchard (1♂, 3♀, LEM).

Distribution: Canada: NS, ON, QC, YT; USA: widespread; Europe (Spencer 1969; Spencer and Steyskal 1986; Boucher and Wheeler 2001); MB. [Holarctic]

Host-Plant: The larvae are leaf miners on *Solidago* spp. (Spencer 1969).

Comments: This species is Holarctic (Spencer and Steyskal 1986). This is the first record in Manitoba.

Cerodontha capitata (Zetterstedt)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 12.vi.1999, J. Perusse (2♂, LEM); same except 17.vi.1999 (1♂, 1♀, LEM); same except S. Boucher (3♀, LEM); same except V. Crecco (1♂, LEM); same except T.A. Wheeler (1♂, LEM); same except 20.vi.1999, J. Perusse (2♂, 2♀, LEM); same except V. Crecco (2♂, 3♀, LEM); same except T.A. Wheeler (2♂, LEM); same except 06.vii.2000, V. Crecco (5♂, LEM); same except 13.vii.2000, T.A. Wheeler (1♂, LEM); 4km N Gardenton, Tallgrass Prairie Preserve (49°10.29'N, 96°40.40'W), sweep in tallgrass prairie, 17.vi.1999, S. Boucher (1♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 26.vi.1998, P Bouchard (1♂, 1♀, LEM); same except 15.vii.1998 (1♀, LEM).

Distribution: Canada: AB, MB, ON; USA; AK, CA, CO, MS, NC, WY, widespread in northern states; Europe (Spencer 1969; Spencer and Steyskal 1986). [Holarctic]

Host-Plant: The larvae are stem miners on *Juncus* spp (Spencer, 1969).

Comments: Unlike many species, *C. capitata* was only collected at the Gardenton site in 1999, not at the St. Charles Rifle Range. This is probably due to the fact that the host plant is more abundant at the Gardenton site. This species is Holarctic (Spencer 1969).

Cerodontha dorsalis (Loew)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 12.vi.1999, S.

Boucher (1♀, LEM); same except 17.vi.1999 (1♀, LEM); same except 14.viii.1999, T.A. Wheeler (1♂, 1♀, LEM); same except 17.viii.1999 (1♂, 3♀, LEM); same except V. Crecco (2♀, LEM); same except 06.vii.2000 (3♂, 2♀, LEM); same except 13.vii.2000 (1♂, 2♀, LEM); same except T.A. Wheeler (2♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 22.v.1998, P Bouchard (1♀, LEM); same except 08.vii.1998 (1♀, LEM); same except 10.vii.1998 (1♀, LEM); same except 14.vii.1999, S. McMillan (1♀, LEM); same except 11.viii.1999, T.A. Wheeler (1♀, LEM); same except 18.viii.1999 (2♂, LEM); same except 14.vii.2000, V. Crecco (1♂, LEM).

Specimens collected (additional sites): Canada: Ontario: Manitoulin Island, 10km SW Gore Bay (45°52'N, 82°31'W), malaise trap in grassland savanna alvar, 04.vii.1996, P. Bouchard (1♂, 2♀, LEM); same except 04.viii.1996 (1♀, LEM); same except 20.viii.1996 (1♂, LEM); 10km W Gore Bay (45°53'N, 82°34'W), malaise trap in grassland savanna alvar, 03.vii.1996, P. Bouchard (1♂, LEM); same except 15.vii.1996 (1♀, LEM); same except 05.viii.1996 (11♂, 5♀, LEM); same except 21.viii.1996 (1♂, 2♀, LEM); Indian Point Bridge, Campbell Bridge, (45°49.6'N, 82°23.2'W), sweep on beach, 17.vii.2000, V. Crecco and T.A. Wheeler (1♂, LEM); Windsor, Ojibway Prairie Reserve, 17.vi.1980, K.N. Barber (1♀, GUE); same except 18.vi.1980, S. Beierl (1♀, GUE); same except 10.vii.1980, K.N. Barber (2♂, 1♀, GUE); same except 11.vii.1980 (5♂, 8♀, GUE); Point Pelee, 20.vii.1978, K.N. Barber (1♀, GUE); same except 27.vi.1979, W.A. Attwater (1♀, GUE); same except 10.vii.1979, K.L. Runciman (2♀, GUE); same except W.A. Attwater (1♀, GUE); same except D. Morris (1♀, GUE); same except 11.vii.1979, W.A. Attwater

(1♂, 1♀, GUE); same except 22.vii.1979, K.N. Barber (2♂, 5♀, GUE); same except 7.vi.1980 (1♂, GUE); same except 8.vii.1980 (1♀, GUE); same except 9.vii.1980 (2♂, 1♀, GUE); same except S. Beierl (1♀, GUE).

Distribution: Canada: AB, BC, ON, QC; USA: widespread; Mongolia; Brazil; Guatemala; Puerto Rico (Spencer 1969; Spencer and Steyskal 1986); MB. [Holarctic]

Host-Plant: The larvae are leaf miners in a number of genera of Poaceae, including the following cultivated and wild genera: *Avena, Bromus, Dactylis, Eleusine, Elymus, Hordeum, Panicum, Phalaris, Phleum, Poa, Secale, Triticum*, and *Zea* (Spencer and Steyskal 1986).

Comments: *Cerodontha dorsalis* may attack cereal crops, but does not usually cause major economic damage (Spencer and Steyskal 1986). The species is Holarctic and Neotropical. This is the first record in Manitoba.

Cerodontha gibbardi Spencer

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 17.vi.1999, V. Crecco (1♂, LEM); same except S. Boucher (1♀, LEM); same except 20.vi.1999, T.A. Wheeler (1♂, 1♀, LEM).

Distribution: Canada: AB, BC, MB, SK, YT; USA: CO, ID (Spencer 1969; Spencer and Steyskal 1986; Boucher and Wheeler 2001). (Fig. 32). [Western Nearctic]

Host-Plant: The host plant of this species is unknown.

Comments: All specimens were collected at the Gardenton site, which suggests that it

may be more closely associated with wetland adapted monocots such as sedges or rushes.

Cerodontha incisa (Meigen)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 13.vii.2000, T.A. Wheeler (1♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 18.vi.1997, D. Pollock (1♀, LEM); same except 22.vii.1998, P Boucher (1♀, LEM).

Distribution: Canada: AB, NT, ON, QC, SK, YT; USA: AL, NC, WY, widespread in northern states; Europe; Pakistan (Spencer, 1969; Spencer and Steyskal, 1986); MB. [Holarctic]

Host-Plant: The larvae are leaf miners on Poaceae and have been recorded on *Agropyron, Phleum,* and *Zizania* (Spencer 1969; Spencer and Steyskal 1986).

Comments: This species is Holarctic (Spencer 1969). This is the first record in Manitoba.

Cerodontha inconspicua (Malloch) s. str.

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 14.vi.1999, T.A. Wheeler (2♂, LEM); same except 17.vi.1999, S. Boucher (1♀, LEM); same except J. Perusse (1♂, LEM); same except 20.vi.1999, T.A. Wheeler (1♀, LEM); same except 14.viii.1999, (1♀, LEM); 4km N Gardenton, Tallgrass Prairie Preserve (49°10'N, 96°40'W), sweep grasses near house, 05.vii.2000, T.A. Wheeler (1♂, 1♀, LEM); 2km W

Gardenton, Tallgrass Prairie Field Station, (49°04.37'N, 96°42.50'W), malaise in poplar grove edge, 24.vi-09vii.1996, H.D. White (1♂, 1♀, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 11.vi.1997, D. Pollock (1♂, LEM); same except 18.vi.1997 (1♀, LEM); same except 22.v.1998, P. Bouchard (2♀, LEM); same except 10.vi.1998 (1♀, LEM); same except 26.vi.1998 (1♀, LEM); same except 11.vi.1999, V. Crecco (1♀, LEM); same except T.A. Wheeler (1♂, LEM); same except 16.vi.1999 (1♀, LEM); same except J. Perusse (2♂, LEM); same except 18.vi.1999 (2♂, LEM); same except V. Crecco (2♂, LEM); same except S. Boucher (1♂, 2♀, LEM) same except T.A. Wheeler (10♂, 1♀, LEM); same except 21.vi. 1999 (3♂, 2♀, LEM); same except S. McMillan (1♀, LEM); same except J. Perusse (1♀, LEM); same except S. Boucher (13♂, 2♀, LEM); same except 21.vii, S. McMillan (1♂, 1♀, LEM); same except 11.viii.1999, T.A. Wheeler (1♂, LEM); same except 14.vii.2000, V. Crecco (1♂, 1♀, LEM); same except malaise in poplar forest/tallgrass prairie, 03-10.vii.1998, R.E. Roughley (2♂, 2♀, LEM).

Specimens collected (additional sites): Canada: Manitoba: near LaSalle, La Barriere Park, (49°43.2'N, 97°10.7'W), sweep oak savanna, 13.viii.1999, V. Crecco (2♂, LEM); same except 13.vii. 2000, V. Crecco and T.A. Wheeler (7♂, 3♀, LEM); Aweme, Criddle farm (49°42.5'N, 99°36.1'W), sweep grasses near house, 08.vii.2000, T.A. Wheeler (2♀, LEM); **Ontario:** Manitoulin Island, 10km SW Gore Bay (45°51.6'N, 82°31.5'W), sweep dry meadow at roadside, 17.vii.2000, V. Crecco and T.A. Wheeler (1♂, LEM); Windsor, Ojibway Prairie Reserve, 17.vi.1980, S. Beierl (1♂, 2♀, GUE); same except K.N. Barber (2♀, GUE); same except 18.vi.1980, S. Beierl (1♂, GUE); same except 10.vii.1980, K.N.

Barber (1♀, GUE); same except 11.vii.1980 (3♀, GUE); same except18.viii.1980 (1♀, GUE); Point Pelee, 18.vii.1978, K.N. Barber (1♀, GUE); Manitoulin Island, Indian Point Bridge, Campbell Bay (45°49.6'N, 82°33.2'W), sweep on beach, 17.vii.2000, V. Crecco and T.A. Wheeler (1♀, LEM); 4km E Thedford at Ausable River (43°09.0'N, 81°48.5'W), sweep vegetation at river, 19.vii.2000, V. Crecco and T.A. Wheeler (1♀, LEM); **Saskatchewan:** 8km W Ogema, (43°33.2'N, 105°01.4'W), sweep dry prairie along roadside, 09.vii.2000, V. Crecco and T.A. Wheeler (1♀, LEM).

Distribution: Canada: YT; USA: CO, CA, NC, UT (Spencer and Steyskal 1986; Boucher and Wheeler 2001); MB, ON, SK. (Fig. 33). [Widespread Nearctic]

Host-Plant: The larvae has been reared from *Agropyron repens* (L.) Beauv., and there are probably additional hosts in the Poaceae (Spencer and Steyskal 1986).

Comments: Spencer and Steyskal (1986) noted that the Canadian species illustrated by Spencer (1969) and the European species described by Nowakowski (1973) did not match the holotype from Colorado. Spencer and Steyskal (1986) considered the Canadian and European specimens an undescribed species. However, the specimens recorded from my sites agree with the holotype from Colorado and Spencer and Steyskal's (1986) illustrations. This is the first record in Manitoba, Saskatchewan and Ontario.

Cerodontha magnicornis (Loew)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 12.vi.1999, T.A. Wheeler (1♀, LEM); same except 14.vi.1999, S. Boucher (1♂, 1♀, LEM); same except

17.vi.1999, T.A. Wheeler (1♂, 3♀, LEM); same except V. Crecco (3♀, LEM); same except 20.vi.1999, J. Perusse (1♂, LEM); same except 06.vii.2000, V. Crecco (1♂, 1♀, LEM); 4km N Gardenton, Tallgrass Prairie Preserve (49°10.29'N, 96°40.40'W), sweep in tallgrass prairie, 17.vi.1999, T.A. Wheeler (1♀, LEM); same except S. Boucher (2♀, LEM); same except J. Perusse (1♀, LEM); same except 20.vi.1999, T.A. Wheeler (1♀, LEM); 2km W Gardenton, Tallgrass Prairie Field Station, (49°04.37'N, 96°42.50'W), malaise in poplar grove edge, 24.vi-09vii.1996, H.D. White (1♀, LEM); Winnipeg, St. Charles Rifle Range (49°54.6'N, 97°20.5'W), malaise in poplar forest/tallgrass prairie, 03-10.vii.1998, R.E. Roughley (2♂, LEM).

Specimens collected (additional sites): Canada: Manitoba: near LaSalle, La Barriere Park, (49°43.2'N, 97°10.7'W), sweep in oak savanna near river, 13.vii.2000, V. Crecco and T.A. Wheeler (1♂, LEM); Aweme, Criddle farm (49°42.5'N, 99°36.1'W), sweep understory in open forest, 08.vii.2000, T.A. Wheeler (2♂, 1♀, LEM); **Ontario:** Manitoulin Island, 10km SW Gore Bay (45°52'N, 82°31'W), malaise trap in grassland savanna alvar, 19.vi.1996, P. Bouchard (1♂, LEM); 10km W Gore Bay (45°53'N, 82°34'W), malaise trap in grassland savanna alvar, 05.vii.1996, P. Bouchard (1♂, LEM); **USA: Wisconsin:** Bayfield County, 10km W Ino, Chequamegon National Forest, (46°32.6'N, 91°17.1'W), sweep at campsite, 15.vii.2000, V. Crecco and T.A. Wheeler (1♂, LEM).

Distribution: USA: CO, IL, IN, MI, NH, PA, TN (Spencer 1969; Spencer and Steyskal 1986); Canada: MB, ON; USA: WI (Fig. 34). [Widespread Nearctic]

Host-Plant: The host plant of this species is unknown.

Comments: This species was synonymized with *C. morosa* Meigen by Spencer (1969), but Nowakowski (1973) recognized *C. morosa* and *C. magnicornis* as distinct species. This is the first record in Canada, Manitoba, Ontario and Wisconsin.

Cerodontha subangulata (Malloch)

Specimens collected (primary sites): Canada: Manitoba: 2km W Gardenton, Tallgrass Prairie Field Station, (49°04.37'N, 96°42.50'W), malaise in poplar grove edge, 24.vi-09vii.1996, H.D. White (1♂, LEM)

Distribution: USA: IL, MD (Spencer and Steyskal 1986); Canada: MB. (Fig. 35). [Widespread Nearctic]

Host-Plant: The host is unknown, but is probably *Carex* spp. (Spencer and Steyskal 1986).

Comments: This is the first Canadian and Manitoba record, and a major range extension for the species.

Cerodontha superciliosa (Zetterstedt)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 17.vi.1999, J. Perusse (1♂, LEM); same except 12.viii.1999, V. Crecco (2♂, 1♀, LEM); same except T.A. Wheeler (1♂, LEM); same except 14.viii.1999 (2♂, 1♀, LEM); same except 17.viii.1999 (25♂, 13♀, LEM); same except V. Crecco (7♂, 3♀, LEM); same except 06.vii.2000 (1♂, 2♀, LEM); same except 13.vii.2000, T.A. Wheeler (5♂, 5♀, LEM);

Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 08.viii.1997, D. Pollock (1♂, 2♀, LEM); same except 10.vii.1998, P. Bouchard (1♂, LEM); same except 15.vii.1998 (1♀, LEM); same except 17.vii.1998 (1♂, 1♀, LEM); same except 22.vii.1998 (3♂, 5♀, LEM); same except 16.vi.1999, J. Perusse (1♂, LEM); same except 18.vi.1999, T.A. Wheeler (1♂, LEM); same except 21.vi.1999, S. McMillan (1♀, LEM); same except 07.vii.1999 (1♀, LEM); same except 11.viii.1999 (41♂, 11♀, LEM); same except V. Crecco (41♂, 5♀, LEM); same except 13.viii.1999, T.A. Wheeler (28♂, 1♀, LEM); same except 18.viii.1999 (20♂, 9♀, LEM); same except V. Crecco (17♂, 7♀, LEM); same except 07.vii.2000, V. Crecco and T.A. Wheeler (1♂, 1♀, LEM).

Specimens collected (additional sites): Canada: Alberta: 25km NE Onefour, Sage Creek, (49°09.0'N, 110°15.1'W), sweep dry prairie at roadside, 10.vii.2000, V. Crecco and T.A. Wheeler (11♂, LEM); **Ontario:** 5km W Dyer Bay, Crane Lake Road, (45°10.9'N, 81°23.8'W), sweep alvar savanna, 18.vii.2000, T.A. Wheeler (2♀, LEM); Windsor, Ojibway Prairie, 11.vii.1980, K.N. Barber (1♀, GUE); **Saskatchewan:** Cypress Hills Provincial Park, east boundary (49°40.2'N, 109°27.5'W), sweep meadow near mixed forest, 10.vii.2000, V. Crecco and T.A. Wheeler (1♂, LEM).

Distribution: Canada: AB, MB, NB, NT, ON, QC, SK, YT; USA: AK, CA, CO, widespread in northern states; Europe; Japan (Spencer 1969; Spencer and Steyskal 1986; Boucher and Wheeler 2001). [Holarctic]

Host-Plant: The larvae are leaf miners on many genera of Poaceae, particularly *Avena, Elymus, Hordeum, Triticum,* and *Zea* in North America (Spencer 1969; Spencer and Steyskal 1986).

Comments: This species is Holarctic (Spencer 1969). Spencer (1969) referred to this species as *C. lateralis* (Macquart), but Nowakowski (1973) treated it as *C. superciliosa.*

***Chromatomyia caprifoliae* (Spencer)**

Specimens collected (primary sites): Canada: Manitoba: 2km W Gardenton, Tallgrass Prairie Field Station, (49°04.37'N, 96°42.50'W), malaise in poplar grove edge, 24.vi-09.vii.1996, H.D. White (1♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 02.vi.1997, D. Pollock (10♂, 3♀, LEM); same except 05.vi.1997 (1♀, LEM); same except 22.v.1998, P. Bouchard (1♀, LEM); same except 10.vi.1998 (1♀, LEM); same except 08.vii.1998 (1♂, LEM); same except 18.vi.1999, T.A. Wheeler (1♀, LEM); same except 21.vi.1999, V. Crecco (1♂, LEM); same except S. McMillan (1♀, LEM); same except J. Perusse (1♂, LEM); same except S. Boucher (1♂, LEM); same except T.A. Wheeler (2♂, 7♀, LEM); same except 14.vii.1999, S. McMillan (1♂, LEM); same except 07.vii.2000, V. Crecco and T.A. Wheeler (3♂, 2♀, LEM).

Specimens collected (additional sites): Canada: Ontario: Manitoulin Island, 10km SW Gore Bay (45°52'N, 82°31'W), malaise trap in grassland savanna alvar, 19.vi.1996, P. Bouchard (1♂, 1♀, LEM); same except 04.vii.1996 (2♀, LEM); **Saskatchewan:** Cypress Hills Provincial Park, east boundary (49°40.2'N, 109°27.5'W), sweep meadow near mixed forest, 10.vii.2000, V. Crecco and T.A. Wheeler (1♂, LEM).

Distribution: Canada: AB (Spencer 1969; Griffiths 1974a); MB, ON, SK. (Fig. 36). [Widespread Nearctic]

Host-Plant: The larvae are leaf miners on *Symphoricarpos* species (Spencer 1969; Griffiths 1974a).

Comments: Spencer (1969) described this species as *Phytomyza caprifoliae*. Leaf mines were abundant at the St. Charles Rifle Range and the Tallgrass Prairie Preserve throughout my field season. Two adults of *C. caprifoliae* emerged from a blotch mine on *Symphoricarpos occidentalis* Hook. on 27.vi.1999 and 29.vi.1999. The species is multivoltine, with at least three generations per year (Griffiths 1974a). This is the first record in Manitoba, Ontario and Saskatchewan, and the easternmost record of the species.

Liriomyza brassicae (Riley)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 12.vi.1999, V. Crecco (1♀, LEM); same except T.A. Wheeler (1♀, LEM); same except 14.vi.1999 (1♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 13.viii.1999, T.A. Wheeler (2♀, LEM); same except V. Crecco (1♀, LEM).

Distribution: Cosmopolitan; Canada: MB, ON, QC, SK; USA: probably in most states (Spencer 1969; Spencer and Steyskal 1986). [Widespread Nearctic]

Host-Plant: In Canada, the larvae are leaf miners on many genera of Brassicaceae and Capparidaceae (Spencer 1969). In the United States, they attack cultivated genera including *Brassica, Raphanus, Capparius, Rorippa*, and *Tropaeolum* (Spencer and Steyskal 1986).

Comments: *Liriomyza brassicae* is a pest species in California and Florida, but is not

known to cause serious economic damage in Canada (Spencer 1969).

Liriomyza fricki Spencer

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 12.vi.1999, J. Perusse (1♂, LEM); same except 20.vi.1999, T.A. Wheeler (1♂, LEM); same except 17.viii.1999(1♀, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 02.vi.1997, D. Pollock (1♀, LEM); same except 18.vi.1997 (1♂, 1♀, LEM); same except 11.vi.1999, T.A. Wheeler (1♀, LEM); same except 14.vi.1999 (1♂, LEM); same except 18.vi.1999, J. Perusse (2♀, LEM); same except 21.vi.1999, T.A. Wheeler (3♂, 1♀, LEM); same except 14.vii.1999, S. McMillan (1♀, LEM).

Distribution: Canada: AB, ON, QC, YT; USA: CA, WA, WI (Spencer 1969; Spencer and Steyskal 1986; Boucher and Wheeler 2001); MB (Fig. 37). [Widespread Nearctic]

Host-Plant: The larvae are leaf miners on many genera of Fabaceae, mainly *Lathyrus, Medicago, Trifolium*, and *Vicia* (Spencer 1969; Spencer and Steyskal 1986).

Comments: This is the first record in Manitoba.

Liriomyza lathyri Sehgal

Specimens collected (primary sites): Canada: Manitoba:5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 14.vi.1999, V. Crecco (1♂, LEM); same except J. Perusse (1♀, LEM); same except 17.vi.1999, V.

Crecco (1♀, LEM); 2km W Gardenton, Tallgrass Prairie Field Station, (49°04.37'N, 96°42.50'W), malaise in poplar grove edge, 24.vi-09.vii.1996, H.D. White (2♀, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 16.vi.1999, J. Perusse (1♂, 1♀, LEM); same except T.A. Wheeler (1♀, LEM); same except 21.vi.1999, J. Perusse (1♂, LEM).

Distribution: Canada: AB; USA: AR (Spencer and Steyskal, 1986); MB (Fig. 38). [Widespread Nearctic]

Host-Plant: The larvae are leaf miners on *Lathyrus* spp. Adults have been reared from L. *ochroleucus* Hook. (Sehgal 1971; Spencer and Steyskal 1986).

Comments: This is the first record in Manitoba.

Liriomyza lima (Melander)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 12.vi.1999, T.A. Wheeler (1♀, LEM); same except 17.vi.1999 (1♂, LEM); same except 20.vi.1999, S. Boucher (2♂, LEM); same except 12.viii.1999, T.A. Wheeler (1♂, 1♀, LEM); same except 17.viii,1999 (1♂, LEM); same except V. Crecco (1♂, LEM); 4km N Gardenton Tallgrass Prairie Preserve (49°10.29'N, 96°40.40'W), sweep in tallgrass prairie, 17.vi.1999, J. Perusse (1♀, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 11.vi.1999, T.A. Wheeler (1♀, LEM); same except S. Boucher (1♂, LEM); same except 21.vi.1999 (2♂, LEM); same except S. McMillan (1♂, 1♀, LEM); same except T.A. Wheeler (2♂, LEM); same except

14.vii.1999, S. McMillan (1♂, LEM); same except 13.viii.1999, T.A. Wheeler (1♂, 3♀, LEM).

Distribution: Canada: AB, YT; USA: ID, MT, SD (Spencer 1969; Spencer and Steyskal 1986; Boucher and Wheeler 2001); MB (Fig. 39). [Western Nearctic]

Host-Plant: The host plant of this species is unknown.

Comments: This is the first record in Manitoba.

Liriomyza ptarmicae de Meijere

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 12.vi.1999, J. Perusse (1♂, LEM); same except 17.vi.1999, T.A. Wheeler (1♀, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 11.vi.1999, T.A. Wheeler (1♂, LEM); same except J. Perusse (1♀, LEM); same expect 18.vi.1999, J. Perusse (1♀, LEM); same except 21.vi.1999, T.A. Wheeler (1♂, LEM); same except J. Perusse (1♂, LEM).

Distribution: Canada: AB; USA: CA, CO, WA; Europe (Spencer 1969; Spencer 1981; Spencer and Steyskal 1986); MB. [Holarctic]

Host-Plant: The larvae form linear leaf mines on *Achillea* spp. and *Chrysanthemum* spp (Spencer and Steyskal 1986).

Comments: Spencer (1969) treated this species as *L. millefolii*. The two species were synoymized by Spencer (1976). This is the first record in Manitoba.

Liriomyza sabaziae Spencer

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.6'N, 97°20.5'W), malaise in poplar forest/tallgrass prairie 03-10.vii.1998, R.E. Roughley (1♂, LEM).

Distribution: USA: CA, WA (Spencer and Steyskal 1986); Canada: MB (Fig. 40). [Western Nearctic]

Host-Plant: Asteraceae, mainly *Baccharis, Carduus, Cirsium, Dahlia, Gnaphalium*, and *Silybum* (Spencer and Steyskal 1986).

Comments: This is the first Canadian and Manitoba record and a major range extension for the species.

Liriomyza sinuata Sehgal

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep roadside vegetation, 13.vii.2000, T.A. Wheeler (1♂, LEM).

Distribution: Canada: AB (Sehgal 1971); MB (Fig. 41). [Western Nearctic]

Host-Plant: The host of this species is unknown.

Comments: This is the first record in Manitoba.

Liriomyza smilacinae Spencer

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep roadside vegetation, 13.vii.2000, V.

Crecco (1♂, LEM).

Distribution: Canada: AB, MB, ON; USA: CA (Spencer 1969; Spencer and Steyskal 1986) (Fig. 42). [Widespread Nearctic]

Host-Plant: The larvae form linear leaf mines on *Smilacina* spp. and have been reared from *Smilacina stellata* (L.) Desf. (Spencer and Steyskal 1986).

Liriomyza taraxaci Hering

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 13.vii.2000, T.A. Wheeler (1♀, LEM); 4km N Gardenton, Tallgrass Prairie Preserve (49°10.29'N, 96°40.40'W), sweep grasses near house, 05.vii.2000, T.A. Wheeler (1♂, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 16.vi.1999, J. Perusse (1♂, 1♀, LEM); same except S. Boucher (1♂, 3♀, LEM); same except 18.vi.1999, V. Crecco (1♀, LEM); 21.vi.1999, S. Boucher (1♂, 1♀, LEM).

Specimens collected (additional sites): Canada: Manitoba: near LaSalle, La Barriere Park, sweep in oak savanna near river, 13.vii.2000, V. Crecco and T.A. Wheeler (1♂, LEM).

Distribution: Canada: AB, ON, QC, YT; USA: ?WA, WI; Europe (Spencer 1969; Spencer and Steyskal 1986; Boucher and Wheeler 2001); MB [Holarctic]

Host-Plant: The larvae are leaf miners on *Taraxacum* spp. and have been reared from *Taraxacum officinale* (Spencer 1969; Spencer and Steyskal 1986).

Comments: This species is Holarctic (Spencer 1969). This is the first record in Manitoba.

Liriomyza togata **(Melander)**

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 06.vii.2000, V. Crecco (1♀, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 14.vii.2000, V. Crecco (1♂, LEM).

Distribution: USA: CA, WA (Spencer and Steyskal 1986); Canada: MB (Fig. 43). [Western Nearctic]

Host-Plant: It has been reared from *Baccharis douglasii* DC. and *Artemisia douglasiana* Besser (Spencer and Steyskal 1986).

Comments: This is the first Canadian and Manitoba record and a major range extension for the species. Although this species was described as having crossvein dm-cu absent, an unusual character in *Liriomyza*, dm-cu is present in the specimen collected at Gardenton. All other external and genitalic characters correspond to those of *L. togata*.

Metopomyza griffithsi **Sehgal**

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 12.vi.1999, J. Perusse (1♂, LEM); same except 14.vi.1999 (1♀, LEM); same except 17.vi.1999 (3♀, LEM); same except S. Boucher (3♀, LEM); same except V. Crecco (1♂, LEM); same except 20.vi.1999 (1♂, LEM); same except J. Perusse (1♀, LEM); same except S. Boucher (2♂, 1♀, LEM); same except T.A. Wheeler (2♂, 1♀, LEM); same except 14.viii.1999 (1♂, LEM); same except 06.vii.2000, V. Crecco (1♂, LEM); 4km N

Gardenton, Tallgrass Prairie Preserve, (49°10.29'N, 96°40.40'W), sweep in tallgrass prairie, 06.vii.2000, V. Crecco (1♂, LEM); 2km W Gardenton, Tallgrass Prairie Field Station, (49°04.37'N, 96°42.50'W), sweep in tallgrass prairie, 14.viii.1999, T.A. Wheeler (1♀, LEM); Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 05.vi.1997, D. Pollock (1♀, LEM); same except 11.vi.1997 (1♀, LEM); same except 19.ix.1997 (1♀, LEM); same except 21.vii.1999, S. McMillan (1♀, LEM).

Specimens collected (additional sites): Canada: Alberta: 25km NE Onefour, Sage Creek, (49°09.0'N, 110°15.1'W), sweep dry prairie at roadside, 10.vii.2000, V. Crecco and T.A. Wheeler (1♀, LEM).

Distribution: Canada: AB; USA: CA, OR (Sehgal 1971; Spencer and Steyskal 1986); MB (Fig. 44). [Western Nearctic]

Host-Plant: The hosts are unknown, although the larvae probably feed on *Carex* spp. (Spencer and Steyskal 1986).

Comments: Spencer (1976) identified this species as *M. scutellata* (Fallén).The two species were synonymized by Spencer (1981). This is the first record in Manitoba and the easternmost record for the species.

Nemorimyza posticata (Meigen)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 12.vi.1999, J. Perusse (1♀, LEM); 2km W Gardenton, Tallgrass Prairie Field Station, (49°04.37'N,

96°42.50'W), malaise in poplar grove edge, 24.vi-09.vii.1996, H.D. White (2♂, 2♀, LEM).

Distribution: Widespread in Canada and the USA; Japan; Europe; Costa Rica (Spencer 1969; Spencer and Steyskal 1986). [Holarctic]

Host-Plant: The larvae are leaf miners on many genera of Asteraceae, including *Aster*, *Baccharis*, *Erechtites*, and *Solidago* (Spencer 1969; Spencer and Steyskal 1986).

Comments: This species is Holarctic (Spencer and Steyskal 1986).

***Paraphytomyza crula* sp. nov.**

(Figs. 8-11)

Holotype (♂): Canada: Manitoba: Winnipeg, St. Charles Rifle Range, (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 11.viii.1999, V. Crecco (LEM).

Paratypes: Canada: Manitoba: 2km W Gardenton, Tallgrass Prairie Field Station, (49°04.37'N, 96°42.50'W), malaise in poplar grove edge, 24.vi-9.vii.1996, H.D. White (1♀, LEM); Winnipeg, St. Charles Rifle Range, (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 02.vi.1997, D. Pollock (1♂, LEM); same except 11.vi.1997 (1♂, LEM); same except 13.vi.1997 (1♀, LEM); same except 27.vi.1997 (1♀, LEM); same except 29.v.1998, P. Bouchard (1♀, LEM); same except 24.vi.1998 (1♀, LEM); same except 08.vii.1998 (1♀, LEM); same except 16.vi.1999, V. Crecco (1♂, 1♀, LEM); same except T.A. Wheeler (1♀, LEM); same except 18.vi.1999 (4♀, LEM); same except J. Perusse (1♀, LEM); same except 21.vi.1999 (1♀, LEM); same except V. Crecco (1♀, LEM); same except T.A. Wheeler (1♂, LEM); same except 07.vii.1999, S. McMillan (3♀,

LEM); same except 11.viii.1999, T.A. Wheeler (1♀, LEM); same except 13.viii.1999 (1♀, LEM); same except T.A. Wheeler (1♂, 4♀, LEM).

Etymology: This species name is from the Middle English *crul* (curl), referring to the bend in the distiphallus.

Diagnosis: The species keys to *P. luteoscutellata* (de Meijere) in Spencer (1969) and Spencer and Steyskal (1986). *Paraphytomyza crula* is smaller and darker than *P. luteoscutellata*, and has a longer phallus.

Description: Lunule and frons yellow, slightly infuscated; orbits yellow; ocellar triangle black; frons 1.6-2 times width of eye, slightly projecting above eye in profile; fronto-orbital setulae sparse, reclinate anteriorly and erect posteriorly; 2 inclinate frontal bristles and 2 reclinate orbital bristle; inner and outer verticals on dark ground; face dark brown; parafacial light brown; pedicel yellow; first flagellomere dark yellow to light brown, moderately pubescent; gena dark brown; 0.2 times eye height; vertex black; occipital margin yellow in males and slightly darker in females; margin of epistoma black; palpus dark yellow. Scutum matt, dark brown to black; scutellum dark brown, paler medially; notopleuron yellow; postpronotum yellow with brown spot centrally; acrostichals in 4 rows; 1+3 dorsocentral bristles; thoracic pleurites mainly dark; dorsal and posterior margin of anepisternum yellow. Wing length 1.8-2mm; wing tip midway between R_{4+5} and M_{1+2}; second costal sector 3.25-3.5 times length of fourth. Calyptral fringe dark. Femora 4/5 dark yellow to brown basally; tibia and tarsi yellow, at most with light brown striations. Abdomen brown.

Male genitalia. Epandrium with asymmetrical hairs at apex, surstylus with

posteroventral patch of spines (Fig. 11); distiphallus long and membranous with distinctive curvature (Fig. 9); ejaculatory apodeme very large (Fig. 10).

Paraphytomyza ?nitida (Malloch)

Specimens collected (primary sites): Canada: Manitoba: 5km N Gardenton, Tallgrass Prairie Preserve (49°10.71'N, 96°40.76'W), sweep in tallgrass prairie, 20.vi.1999, T.A. Wheeler (1♀, LEM).

Distribution: Canada: AB; USA: IA, IL, KS, MD, NC, VA (Spencer 1969; Spencer and Steyskal 1986); ?MB. [Widespread Nearctic]

Host-Plant: The host of this species is unknown (Spencer 1969).

Comments: Although the specimen keyed to *P. nitida* because of its conspicuously elongate mouthparts, the specimen is a female, whose identity cannot be confirmed without associated males. This is tentatively the first record in Manitoba.

Paraphytomyza orbitalis (Melander)

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 02.vi.1997, D. Pollock (5♂, 2♀, LEM); same except 05.vi.1997 (2♂, 2♀, LEM); same except 22.v.1998, P. Bouchard (2♂,1♀, LEM); same except 27.v.1998 (1♂, LEM); same except 29.v.1998 (1♀, LEM); same except 05.vi.1998 (1♀, LEM); same except 12.vi.1998 (3♀, LEM); same except 08.vii.1998 (1♀, LEM); same except 11.vi.1999, T.A. Wheeler (3♂, 3♀, LEM); same except 16.vi.1999 (1♀, LEM); same except J. Perusse (1♀, LEM); same except S.

Boucher (1♂, LEM); same except 21.vi.1999, T.A. Wheeler (1♂, LEM); same except J. Perusse (1♀, LEM); same except 14.vii.2000, V. Crecco (2♀, LEM); same except malaise in poplar forest/tallgrass prairie, 03-10.vii.1998, R.E. Roughley (4♂, LEM).

Specimens collected (additional sites): Canada: Manitoba: Aweme, Criddle farm (49°42.5'N, 99°36.1'W), sweep grasses near house, 08.vii.2000, T.A. Wheeler (1♂, LEM); same except sweep understory in open forest (3♂, 2♀, LEM); **Ontario:** Manitoulin Island, 10km SW Gore Bay (45°52'N, 82°31'W), malaise trap in grassland savanna alvar, 20.viii.1996, P. Bouchard (1♂, LEM).

Distribution: Canada: AB, MB; USA: CA, ID, WA (Spencer 1969; Spencer and Steyskal 1986); ON (Fig. 45). [Widespread Nearctic]

Host-Plant: The larvae are leaf miners on *Lonicera* spp. and *Symphoricarpos* spp. (Spencer 1969; Spencer and Steyskal 1986).

Comments: *Paraphytomyza orbitalis* was only collected at St. Charles Rifle Range, not at Gardenton, probably because of the greater abundance of *Symphoricarpos occidentalis* at the former site. This is the first record in Ontario.

***Phytobia vanduzeei* (Malloch)**

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), malaise in poplar forest/tallgrass prairie, 03-10.vii.1998, R.E. Roughley (3♂, LEM).

Distribution: USA: CA, CO (Spencer and Steyskal 1986); Canada: MB (Fig. 46). [Western Nearctic]

Host-Plant: The host is unknown for this species.

Comments: This is the first Canadian and Manitoba record and a major range extension for the species.

***Phytoliriomyza caroli* sp. nov.**

(Figs. 12-14)

Holotype (♂): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 16.vi.1999, J. Perusse (LEM).

Etymology: The species is a patronym for Carolus, the latinized form of Charles, referring to the type locality.

Diagnosis: The species keys to *P. conjunctimontis* (Frick) in Spencer and Steyskal (1986), because of the absence of crossvein dm-cu. *Phytoliriomyza caroli* can be distinguished by the projecting frons and four fronto-orbital bristles (three in *P. conjunctimontis*).

Description: Lunule, frons and orbits yellow; ocellar triangle dark brown to yellow; frons 1.8 times width of eye, moderately projecting above eye in profile; fronto-orbital setulae erect; 3 inclinate frontal bristles and 1 reclinate orbital bristle; both outer and inner verticals on yellow ground; face, parafacial, and antennae yellow; gena yellow; 0.33 times eye height; vertex and occipital margin yellow; palpus yellow. Scutum yellow with three matt, dark brown stripes, wider anteriorly; notopleuron and postpronotum yellow; scutellum yellow, brown laterally; acrostichals in 3-4 rows; two postsutural dorsocentral bristles; thoracic pleurites mainly yellow; katepisternum dark on ventral 2/3. Wing length

1.2 mm; dm-cu absent; second costal sector 4 times length of fourth. Calyptral fringe dark. Femora yellow; tibiae and tarsi dark yellow to light brown. Abdomen brown.

Male genitalia. Epandrium with two dorsal spines; surstylus with pronounced spine at apex (Fig. 14); distiphallus with club-like projections (Fig. 12).

Phytoliriomyza melampygae (Loew)

Specimens collected (primary sites): Canada: Manitoba: 2km W Gardenton, Tallgrass Prairie Field Station, (49°04.37'N, 96°42.50'W), malaise in poplar grove edge, 24.vi-09vii.1996, H.D. White (1♂, LEM).

Specimens collected (additional sites): Canada: Alberta: 25km NE Onefour, Sage Creek, (49°09.0'N, 110°15.1'W), sweep dry prairie at roadside, 10.vii.2000, V. Crecco and T.A. Wheeler (1♀, LEM).

Distribution: Canada: ON; USA: DC, MA, MD, MI, MN, NJ, NY; Europe (Spencer 1969; Spencer and Steyskal 1986); AB, MB [Holarctic]

Host-Plant: The larvae are leaf miners on *Impatiens* spp., particularly *Impatiens capensis* Meerb. and *I. noli-tangere* L. (Spencer 1969; Spencer and Steyskal 1986).

Comments: This species is Holarctic (Spencer 1969). This is the first record in Manitoba and Alberta. The specimen from Alberta is a female whose identity cannot be confirmed without associated males.

Phytomyza roughleyi sp. nov.

(Figs. 15-18)

Holotype (♂): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 30.vi.1999, S. McMillan (LEM).

Paratypes: Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 24.vi.1998, P. Bouchard (1♀, LEM); same except 26.vi.1998 (1♀, LEM).

Etymology: The species is named after Dr. R.E. Roughley, who has made a significant contribution to the arthropod inventory of Canadian tallgrass prairies.

Diagnosis: The species keys to *P. agromyzina* Meigen in Spencer (1969). It can be differentiated by the projecting frons, four fronto-orbital bristles (three in *P. agromyzina*) and two rows of acrostichals (four rows in *P. agromyzina*).

Description: Lunule yellow to light brown; margin of lunule yellow; frons and orbits dark yellow to light brown anteriorly and dark brown to black posteriorly; ocellar triangle black; frons 1.3 times width of eye, slightly projecting above eye in profile; 3 inclinate frontal bristles and 1 reclinate orbital bristle, anteriormost bristle weaker than others; outer and inner verticals on black ground; face dark brown; parafacial yellow; pedicel dark brown; first flagellomere black; gena dark yellow to brown with black margin, 0.33 eye height; vertex and occipital margin black; palpus dark brown. Scutum and scutellum dark brown; notopleuron and postpronotum dark yellow; acrostichals in two rows with sporadically arranged setulae anteriorly; 1+3 dorsocentral bristles; thoracic pleurites dark brown. Wing length 2.4-2.6 mm; dm-cu absent; wing tip midway between R_{4+5} and M_{1+2}; second costal sector 3.75-4 times length of fourth. Calyptral fringe dark. Legs predominately yellow, femora dark on basal 4/5. Abdomen dark brown.

Male genitalia. Epandrium with posterolateral patch of spines; surstylus with patch of bristles (Fig. 18); distiphallus well sclerotized, V-shaped (Fig. 15); ejaculatory apodeme with rounded blade (Fig. 17).

***Pseudonapomyza atra* (Meigen)**

Specimens collected (primary sites): Canada: Manitoba: Winnipeg, St. Charles Rifle Range (49°54.2'N, 97°20.3'W), sweep in tallgrass prairie, 22.v.1998, P. Bouchard (1♀, LEM).

Distribution: Canada: AB, MB, QC, SK; USA: CA, ND, NM, WA; Europe; Mongolia (Spencer 1969; Spencer and Steyskal 1986). [Holarctic]

Host-Plant: The larvae are leaf miners on many genera of Poaceae. *Pseudonapomyza atra* has been recorded in the United States on cultivated cereals such as *Avena sativa* L., *Hordeum vulgare* L., *Secale cereale* L., and *Agropyron repens* (L.) Beauv. (Spencer 1969; Spencer and Steyskal 1986).

Comments: This species is Holarctic (Spencer 1969).

3.2. Diversity and Abundance at Primary Study Sites

A total of 1141 agromyzids were examined in this study, 876 of which were collected from the primary study sites. Most of the specimens from the primary sites were collected in 1999 (607 specimens, 69%); 61 specimens (7%) were collected in 2000, and the remaining 208 specimens were collected between 1996-1998. Forty-nine species, in 15 genera, were identified (Table 1). Fifteen species (31%) were from the subfamily

Agromyzinae and 34 species (69%) were from the subfamily Phytomyzinae.

3.2.1. Diversity and Abundance of Genera

At all primary sampling sites combined, the most diverse genus was *Liriomyza* with 10 species (20% of all species), followed by *Cerodontha* (8 species, 16%). *Agromyza*, *Ophiomyia*, and *Calycomyza* were represented by five species each (10%). All remaining genera had four species or fewer (Fig. 47). The most abundant genus was *Cerodontha* with 426 specimens (45%), followed by *Ophiomyia* (86 specimens, 10%), and *Liriomyza* (75 specimens, 9%) (Fig. 48).

The most diverse genera at the St. Charles Rifle Range were *Liriomyza* (8 species, 20%) and *Cerodontha* (6 species, 15%) (Fig. 49). The most abundant genera at the St. Charles Rifle Range were *Cerodontha* with 275 specimens (43%), and *Ophiomyia* with 81 specimens (13%) (Fig. 50).

The most diverse genera at Gardenton North were *Liriomyza* (9 species, 35%) and *Cerodontha* (7 species, 27%) (Fig. 51). The most abundant genera at Gardenton North were *Cerodontha* (139 specimens, 66%) and *Liriomyza* (23 specimens, 11%) (Fig. 52).

At Gardenton South, the most diverse and abundant genera were *Cerodontha* (3 species, 43%; 8 specimens, 62%) and *Liriomyza* (2 species, 29%; 2 specimens 15%) (Figs. 53, 54), although the overall numbers of specimens collected at this site were too low to give meaningful values.

3.2.2. Diversity and Abundance of Species

A total of 49 species were identified, including four new species. The most abundant species at all primary study sites combined were *Cerodontha superciliosa* (270 specimens, 31%), *Cerodontha inconspicua* (69 specimens, 8%), and *Agromyza frontella* (63 specimens, 7%) (Fig. 55a). 27% of the species were represented by only a single specimen and 11% of species were represented by two specimens.

The most abundant species at the St. Charles Rifle Range were *Cerodontha superciliosa* (201 specimens, 32%) and *Agromyza frontella* (62 specimens, 10%) (Fig. 55b). At Gardenton North, the most abundant species were *Cerodontha superciliosa* (69 specimens, 33%) and *Cerodontha capitata* (26 specimens, 12%) (Fig. 55c). No more than two specimens of any species were collected at Gardenton South.

3.2.3. Diversity within Sites

The St. Charles Rifle Range had the highest number of species and individuals (40 species, 687 specimens). This is considerably higher than both Gardenton (26 species, 211 specimens) and Gardenton South (7 species, 13 specimens). Also, 41% of the species were collected only at the St. Charles Rifle Range, 14% were collected only at Gardenton North and no species were collected only at Gardenton South. In addition, 80% of all species of Agromyzinae were only found at the St. Charles Rifle Range.

3.2.4. Expected Diversity

According to Chao's estimator of true species diversity, 75% of the total number

of species were collected from St. Charles, Gardenton North and Gardenton South. Based on four years of sampling at the St. Charles Rifle Range, 80% of all species (Chao value = 50 species) (Fig. 56) were collected. Expected total species richness was not calculated for Gardenton North and Gardenton South because of low species diversity and abundance.

3.3. Diversity Between Sites

3.3.1 Diversity Between Primary Sites

The agromyzid fauna of the St. Charles Rifle Range and Gardenton North were more similar to each other than either was to Gardenton South. St. Charles and Gardenton North shared less than half their species (19 species, Jaccard Index = 0.40). St. Charles and Gardenton South shared 7 species (Jaccard Index = 0.18) and Gardenton North and Gardenton South also shared 7 species (Jaccard Index = 0.27). These values may be skewed by the low species diversity collected at Gardenton South.

3.3.2. Diversity and Abundance of Eastern Grasslands

A total of 265 specimens were identified from two additional data sources: 80 specimens from Ojibway Prairie (Appendix 1) and 185 specimens from grassland alvars and grassland savanna alvars on Manitoulin Island (Appendix 2).

Twenty six species from 10 genera were identified from the alvar sites. The most diverse genera were *Cerodontha* (6 species, 22%), *Calycomyza* and *Melanagromyza* (4 species, 15% each). The most abundant genera were *Cerodontha* (72 specimens, 39%),

Ophiomyia (30 specimens, 16%) and *Melanagromyza* (28 specimens, 15%). At the species level, *Cerodontha impercepta* was the most abundant (40 specimens, 22%), followed by *Ophiomyia coniceps* (28 specimens, 15%) and *Cerodontha dorsalis* (26 specimens, 14%).

At Ojibway Prairie, 19 species were identified from 11 genera. The most diverse genera were *Cerodontha* (5 species, 26%) and *Melanagromyza* (3 species, 16%). The most abundant genera were *Cerodontha* (34 specimens, 43%) and *Phytomyza* (11 specimens, 14%). The most abundant species were both from the genus *Cerodontha*: *C. dorsalis* (18 specimens, 23%) and *C. inconspicua* (12 specimens, 15%).

3.3.3. Diversity Between Primary Sites and Eastern Grasslands

Comparing the agromyzid fauna of the eastern grasslands to that of the tallgrass prairie sites, the alvars were the most similar to the tallgrass prairies, although all values were quite low. Gardenton North shared 7 species with the alvars (Jaccard Index = 0.16) and the St. Charles Rifle Range shared 6 species with the alvars (Jaccard Index = 0.10). Ojibway Prairie shared 4 species with both Gardenton North and the St. Charles Rifle Range (Jaccard Index = 0.10, 0.07; respectively). Site similarity was not calculated for Gardenton South because of low species numbers.

3.4. Zoogeographic Patterns

Of the 45 previously described agromyzid species collected at the primary sites, 31 species (69%) are new records to Manitoba and seven (16%) are new to Canada.

In terms of broad zoogeographic patterns, 23 agromyzid species were widespread in the Nearctic (47%), followed by 14 Holarctic species (29%), eight western Nearctic species (16%), and four endemic species (8%). The endemic species comprise only the four newly described species.

At the finer scale of Nearctic distributions of individual species, however, several species were at the limit of their known range.

Nine species were at the northern edge of their range: *Melanagromyza verbesinae, Ophiomyia lauta, Calycomyza frickiana, Calycomyza menthae, Calycomyza promissa, Cerodontha magnicornis, Cerodontha subangulata, Liriomyza togata* and *Phytobia vanduzeei.*

Seven species were at the eastern edge of their range: *Cerodontha gibbardi, Liriomyza lima, Liriomyza sabaziae, Liriomya sinuata, Metopomyza griffithsi, Liriomyza togata* and *Phytobia vanduzeei.*

Three species were at the western edge of their range: *Melanagromyza modesta, Ophiomyia lauta* and *Cerodontha subangulata.*

Five of the 23 species with widespread Nearctic distributions were apparently restricted to grassland habitats: *Melanagromyza martini, Melanagromyza shewelli, Ophiomyia secunda, Chromatomyia caprifoliae* and *Liriomyza smilacinae.*

4. DISCUSSION

4.1. Diversity and Abundance at Primary Study Sites

Over 850 Agromyzidae were collected from the tallgrass prairies of southern Manitoba. This abundance is higher than in the few similar small scale inventories of Agromyzidae in other habitats; Boucher and Wheeler (2001) collected 485 agromyzid specimens from xeric grasslands in the southern Yukon.

Most of the specimens were collected in 1999. In the summer of 2000, the rainy season extended into July, leaving most of the tallgrass prairie flooded. The vegetation was still at the early stages of growth. Since agromyzids are phytophagous and are therefore dependent on the growth of their host plants, it is not surprising to have collected less than 1/10 of the overall specimens in 2000. There may have been higher mortality in pupal stages because of extended periods of immersion under water and those individuals that did survive the flooding probably emerged later than usual in the season.

Forty nine species of Agromyzidae were collected from the tallgrass prairies. In terms of diversity, this is relatively high considering that there are 305 species of agromyzids recorded in Canada; 16% of which are represented in the tallgrass prairies (Danks 1979). Similar diversity was found by Boucher and Wheeler (2001), who identified 34 species of agromyzids from xeric grasslands. Beaulieu (2000) identified 11 species of agromyzids from wetlands in southern Quebec. The diversity was probably lower because that study was conducted in a sedge monoculture.

In other family level studies conducted at the St. Charles Rifle Range, Roughley (2001) identified 68 species of ground beetles (Coleoptera: Carabidae) after three years of

collecting at the site. There are 861 described species of ground beetles in Canada (Danks 1979), meaning that less than 10% of the Canadian ground beetles are represented at the St. Charles Rifle Range.

In studies of southern grasslands, Arenz (1995) identified 47 species of butterflies (Lepidoptera) after a three year monitoring program of the tallgrass prairie preserve in Osage County, Oklahoma. Panzer et al.(1995) identified 42 species of grasshoppers (Orthoptera: Acrididae) in remnant tallgrass prairies in the Chicago region.

Comparing the insect diversity of these previous studies to the diversity of agromyzids in southern Manitoba, the tallgrass prairies have a high diversity of agromyzids. However, because few inventories of this nature have been conducted, agromyzid species richness is difficult to assess.

4.1.1. Diversity and Abundance of Genera and Species

The most diverse genera both overall and per site were *Liriomyza* and *Cerodontha*. These numbers reflect the diversity of the genera in Canada. *Liriomyza* and *Cerodontha* are two of the largest genera in Canada, with 36 and 33 species, respectively (Spencer 1969). *Cerodontha* feeds exclusively on monocots; *Liriomyza* is mainly restricted to dicots, primarily Asteraceae and Fabaceae (Sehgal 1971; Spencer and Steyskal 1986). Their host plants were abundant at all the sites. *Phytomyza*, the largest Canadian genus with over 100 species, was collected in very low numbers in the tallgrass prairies. This is not surprising since the group is most diverse in more boreal regions (Spencer 1969; Griffiths 1972a; Griffiths 1973b) and the known host plants of many

species were absent or rare at the study sites.

Cerodontha was the most abundant genus, representing more than 40% of all specimens overall and per site. Most of the remaining genera represented no more than 13% of the total number of specimens. The high abundance of *Cerodontha* is mainly due to a few dominant species. *Cerodontha superciliosa* was by far the most abundant species overall and per site, and feeds on a number of species of Poaceae, which are the most abundant vegetation type in the tallgrass prairies (Kucera 1992). The second most abundant species overall was also a grass feeder, *C. inconspicua*.

At Gardenton North, the second most abundant species was also a species of *Cerodontha*, *C. capitata*. This species was not collected at the St. Charles Rifle Range, probably because its host plants, *Juncus* spp., were rare at the St. Charles Rifle Range and abundant at Gardenton North.

At the St. Charles Rifle Range, the second most abundant species was *Agromyza frontella*, a pest species on alfalfa. It has been introduced from Europe and is at its western limit in Manitoba (Fig. 19) (Lundgren et al 1999). *Agromyza frontella* was not collected at Gardenton North, either because of the low abundance of alfalfa or because the distribution of *A. frontella* is still patchy in southeastern Manitoba.

No conclusions can be drawn about the diversity and abundance of the taxa at Gardenton South because of low numbers. Since the study was based on qualitative sampling methods and sampling was of different durations at the primary sites, the low numbers may be due to collecting bias. The low diversity at Gardenton South will be discussed further in subsequent sections.

4.1.2. Diversity within Sites

The high agromyzid diversity at the St. Charles Rifle Range seems to be correlated with plant diversity. St. Charles Rifle Range had the highest plant diversity in comparison to the other two sites. The tallgrass prairie at St. Charles Rifle Range is surrounded by an encroaching aspen and oak forest (Morgan 1994). This adds to the overall plant diversity of the site and in turn, the overall agromyzid diversity. 80% of Agromyzinae species were only found at the St.Charles Rifle Range. Two of the dominant genera from this subfamily, *Ophiomyia* and *Agromyza*, feed on species of Ulmaceae, Salicaceae, and Rosaceae (Spencer 1969). These plant families were more abundant and diverse at St. Charles Rifle Range, which may explain the higher numbers collected at the site. Gardenton South had the lowest diversity and abundance of agromyzids, mainly because of low plant diversity; that was primarily a sedge and horsetail stand and had a low abundance and diversity of forbs.

4.1.3. Expected Diversity

The overall expected species diversity suggests that about 25% of the species were not collected. This is average for inventories of this type (Colwell and Coddington 1995; Beaulieu 2000). The observed diversity at the St. Charles Rifle Range should have been closer to the expected diversity (Fig. 56). This can be explained by low agromyzid abundance in the 2000 field season because of unfavourable weather conditions. Had the conditions been better, the observed species collectors curve might have approached the expected curve more closely.

It is difficult to see distinct trends at Gardenton North, since there were only two years worth of data. Over 65% of the predicted species were not collected. This percentage is an average of the two years of collecting and is not a true representation of the species richness at the site. Because of the poor collecting in 2000, the observed species richness was much lower than expected. In addition, many of the singletons that were collected in the first year were not the same species as singletons collected in the second year. This high proportion of species represented by singletons influences the overall expected diversity. These species may be truly rare or simply species that were, for various reasons, not collected in higher numbers.

4.2. Diversity Between Sites

4.2.1. Diversity Between Primary Sites

The similarity in agromyzid fauna between sites is at least partly dependant on the overall diversity and abundance of plants; the greater the diversity and abundance of suitable host plants, the greater the chance of similarity in Agromyzidae. St. Charles and Gardenton North were the most similar sites and also the sites with the greatest plant and agromyzid diversity. These results support the idea that Gardenton South has a low plant diversity and, therefore, low agromyzid diversity.

4.2.2. Diversity Between Primary Sites and Eastern Grasslands

Most specimens from eastern prairie outliers were either obtained from other museum collections or removed from a previous study whose focus was not fly diversity.

Therefore, the collecting techniques used may not have been the best suited for this purpose. It is consequently difficult to draw any conclusions on the diversity of these sites. The data are still tentative and only assumptions can be made until further research is conducted.

In terms of taxonomic diversity and abundance at the generic level, Ojibway Prairie and the alvars were similar to the tallgrass prairie sites in southern Manitoba. *Cerodontha* was the most diverse and abundant genus at both eastern sites. At the species level, the most abundant species was also from the genus *Cerodontha*, *C. impercepta* at the alvars and *C. dorsalis* at Ojibway Prairie. These species feed on sedges and on members of the grass family, respectively (Spencer 1969; Spencer and Stayskal 1986). These two species differ from the abundant species of Manitoba. Since the host plants are also found in abundance in Manitoba, other factors must influence the establishment of one species over the other.

The agromyzid fauna of the alvars was most similar to that of the tallgrass prairies, with less than 10 shared species with the Manitoba sites. Most of the shared species have Holarctic or widespread Nearctic distributions. The low number of shared species may be due to the small sample size from Ojibway Prairie and the alvars. The geographic location of the sites and the difference in plant diversity may also affect the similarity between eastern and Manitoba grasslands.

4.3. Zoogeographic Patterns

The analysis of zoogeographic patterns of the North American Agromyzidae is

made difficult by the largely unknown or incomplete distribution of many of the species. This is the case for the Manitoba agromyzids, where over 60% of the 49 species identified had not previously been recorded in Manitoba. This is mainly because agromyzids have been poorly collected in tallgrass prairies in southern Manitoba, and probably poorly collected in many other grassland and non-grassland habitats. Most Canadian agromyzids have been collected in Alberta, Ontario, Quebec and the Yukon (Spencer 1969; Sehgal 1971; Boucher and Wheeler 2001). These sporadic distribution records make it difficult to distinguish between true disjunct distribution patterns and collecting bias.

Since agromyzids are phytophagous and have close interactions with their host plant, the distribution of the species is usually dependant on the distribution of its host plant. The host plants of many agromyzids are still unknown, causing further difficulty in understanding why a species may or may not be found in a certain habitat.

The majority of the agromyzid fauna is dominated by widespread Nearctic or Holarctic species. Many of these species either feed on a variety of host plants or feed on a specific host that is widely distributed. *Cerodontha superciliosa* and *Liriomyza fricki* (Fig. 37) are examples of species that feed on a number of hosts. *Cerodontha superciliosa* and *L. fricki* feed on many genera of Poaceae and Fabaceae, respectively (Spencer 1969; Spencer and Steyskal 1986). *Cerodontha inconspicua* (Fig. 33) and *Ophiomyia nasuta* are host specific species and feed primarily on *Agropyron repens* (quack-grass) and *Taraxacum officinale* (common dandelion) (Spencer 1969; Spencer and Steyskal 1986). Both of these host plants are common and have widespread distributions.

The known zoogeographic distribution of some widespread Nearctic species is

based on few locality points. Many of the new Manitoba records represent major range extensions for these species. Many of these species feed on widespread hosts and are probably more common than previously recorded. *Calycomyza menthae* was previously known only from Ontario, Florida and California (Fig. 30). It feeds on many genera of Lamiaceae, which have wide distribution ranges (Spencer and Steyskal 1986). Similarly, *Cerodontha subangulata*, known only from Illinois and Maryland, feeds on widespread *Aster* spp.(Fig. 35) (Spencer and Steyskal 1986). The true distribution of most of these species is probably incomplete and a consequence of collecting bias. Their present known distribution is probably due to sporadic collecting.

A small proportion of species (16%) have western Nearctic distributions. Many of their host plants are unknown, making correlations between agromyzid and host plant distributions unfeasible.

Four species are endemic to the tallgrass prairies of Manitoba. These endemic species are newly described, and additional distribution records are required in order to accept or refute the status of these species.

4.4. Range Limits of Species

There are some finer scale patterns that should also be noted. The tallgrass prairie flora has plants originating from different geographical sources: north, south, west and east (Risser et al. 1982; Axelrod 1985). Some of the agromyzid species show similar patterns.

4.4.1. Northern Limit

Nine species (20% of species with known distributions) are at the northern limit of their range. Some of these species are primarily found in grassland habitats. *Liriomyza togata* is known from California, Washington and Manitoba (Fig. 43). All three areas have grassland habitats (Whitcomb et al. 1994). It feed on *Baccharis douglasii* and *Artemisia douglasiana* which are primarily found in the northwestern United States (Spencer and Steyskal 1986). These plant species are not found in the tallgrass prairies in southern Manitoba. There are other members of the same genera present, which suggests that *L. togata* probably has another host plant. *Liriomyza togata* may be a grassland specialist, but exact locality and habitat data for the Washington specimen was unavailable.

Many species have been collected in grassland habitats. Since not all the locality data is known for all the specimens collected, it is difficult to conclude whether the species is a grassland specialist or not. *Melanagomyza verbesinae* (Fig. 24) is known from Ohio, Tennessee, Texas and Manitoba and it feeds on *Verbesina alternifolia* and related genera. Although there are grassland habitats in all three states (alvars in Ohio, cedar glades in Tennessee, savannas in Texas) (Whitcomb et al. 1994), the host plant, *Verbesina alternifolia* is not restricted to grassland habitats. Without confirmation of exact locality data or further host plant information, grassland associations are difficult to establish. *Calycomyza frickiana* is known from grasslands in South Dakota, Minnesota, Illinois, Indiana and Manitoba. It is also known from New York, Pennsylvania, Virginia, and Maryland (Fig. 29). All these eastern states have patchy distributions of relict

grasslands. The known host plant genera (*Bidens*, *Helianthus* and *Rudbeckia*) are all too widely distributed to be able to say anything definite.

4.4.2. Eastern Limit

Seven species (16% of species with known distributions) are at the eastern extent of their range. Five of these species are known from grassland regions, but their hosts are unknown. For example, *Phytobia vanduzeei* is known from California, Colorado and Manitoba (Fig. 46); *Cerodontha gibbardi* is known from British Columbia, Alberta, Saskatchewan, Yukon, Manitoba, Colorado and Idaho (Fig. 32). The host plants of both these species are unknown, although larvae of *Phytobia* species are cambium borers in trees and shrubs, and *C. gibbardi* is probably associated with one or more species of monocots (Spencer 1969). No clear patterns can be seen in the remaining species due to incomplete locality data.

4.4.3 Western Limit

No conclusion can be made about the three species that are at the western limit of their range. The host plants for these species are unknown and the locality data are not specific enough to say whether the species are grassland specialists.

4.4.4. Grassland Affinities

There are five widespread Nearctic species that do not fit into any of the previous categories, but seem to be restricted to grassland habitats. Two of these species have

unknown hosts but were collected in grassland habitats. *Ophiomyia secunda* is known from Alberta, Ontario and Manitoba (Fig. 27); *Melanagromyza shewelli* is known from British Columbia, Alberta, Ontario and Manitoba (Fig. 23).

Melanagromyza martini has been recorded in British Columbia, Alberta, Saskatchewan, Manitoba and Ontario, often but not exclusively in grasslands (Fig. 21). It has been reared from species of *Urtica* (Spencer 1969), which are more abundant in open areas, but not restricted to grasslands.

Liriomyza smilacinae is known from grasslands in Alberta, Manitoba, and Ontario. It is also known from California, but the exact location is unknown (Fig. 42). It feeds on *Smilacina* spp. and has been reared from *S. stellata*. *Smilacina stellata* is found in moist sandy soils such as those in some prairies and near shorelines (Gleason and Cronquist 1991). This species is probably a grassland specialist.

Chromatomyia caprifoliae was previously known only from Alberta. This species was collected in the tallgrass prairies in Manitoba, and also in other grassland habitats in Saskatchewan and Ontario (Fig. 36). It feeds on *Symphoricarpos* spp., particularly *Symphoricarpos occidentalis* (wolfberry), from which it was reared (Griffiths 1974a). This plant species is restricted to and common in grassland habitats.

It is difficult to establish distribution patterns of agromyzids, since few host plant-species relationships are known and many distributions are incomplete. There have been similar studies correlating the distribution of leafhoppers in the shortgrass prairies with their host plants (Whitcomb et al. 1994). The leafhoppers showed clear patterns of prairie generalists and specialists. There are also 17 species of prairie-associated leafhoppers (i.e.

those restricted to prairie habitats) in the Great Lakes alvars (Bouchard et al. 2001). The alvars of southern Ontario have plant species with geographic affinities similar to those of the prairies (Catling et al. 1975; Catling and Brownell 1999). Unlike agromyzids, the distribution and host plants of many of the leafhopper species are well established. Since agromyzids are ecologically similar to leafhoppers, being phytophagous and diverse in grassland habitats (Panzer et al. 1995), their distributions may also be similar. If additional information was available on the distribution of agromyzids and their host plants, geographic and ecological affinities might be more evident.

Most Agromyzidae of the tallgrass prairies of southern Manitoba do not show any restricted distribution patterns. Over 70% of the species have either Holarctic or widespread Nearctic distributions implying that these species are generalists. There are still 28% of the species that show grassland affinities, or are endemic to the tallgrass prairies. At a finer scale, over 20% of the species may have grassland affinities. These results are still questionable and will require further distribution and host association data.

4.5. Recommendations for Future Research

My results indicate that the agromyzid fauna of tallgrass prairies is diverse. Ecological heterogeneity of prairie remnants is clearly an important factor in determining species diversity and abundance; there is a positive correlation between habitat diversity and insect populations (Panzer 1988). Diversity of tallgrass prairie plant species decreases towards the north (Walter 1985) and it would be interesting to see if agromyzids follow the same pattern. Further inventories are needed in remnant tallgrass prairies in the United

States to determine whether the agromyzid fauna of tallgrass prairies in southern Manitoba really is diverse compared to similar sites.

Because the second sampling year at the tallgrass prairies was unproductive, additional collecting should be done to determine if the species collectors curve would approach the expected diversity. This might also establish whether the species found in low numbers were actually rare or simply not collected during this study. More intensive sampling at Ojibway Prairie, in Great Lakes alvars and in eastern oak and pine savannas should be conducted in order to get a better representation of the Agromyzidae of these habitats. Information gathered from remaining tallgrass prairies in the United States and Ontario will clarify the similarities and/or differences between these sites. In addition to tallgrass prairie studies, other habitat types should be sampled to increase the known distribution of the species in order to establish true patterns of zoogeography and habitat preference.

My inventory of the Agromyzidae of the tallgrass prairies in Manitoba is a starting point for future diversity studies. Further studies are needed to continue to explore the diversity of agromyzids in grasslands and non-grassland habitats. As well, additional multitaxon studies should continue in tallgrass prairies to establish the overall faunal diversity of these sites.

5. REFERENCES

Aandahl, A.R. 1982. Soils of the Great Plains- land use, crops and grasses. University of Nebraska Press, Lincoln. 182 pp.

Abrams, M.D. 1992. Fire and the development of oak forests. *Bioscience* **42:** 346-353.

Anderson, R.C. 1998. Overview of midwestern oak savanna. *Transactions of the Wisconsin Academy of Science, Arts and Letters* **86:** 1-18.

Anderson, T.W., R.W. Mathewes, and C.E. Schweger. 1989. Holocene climate trends in Canada with special reference to the Hypsithermal Interval, Pp. 520-528. *In* R.J. Fulton (Eds.). Quaternary Geology of Canada and Greenland. Geology of Canada No.1. Geological Survey of Canada, Ottawa.1024 pp.

Arenz, C.L. 1995. Initiation of a butterfly monitoring program at the tallgrass prairie preserve, Osage County, Oklahoma. *Proceedings of the Oklahoma Academy of Science* **75:** 25-29.

Asquith, A., J.D. Lattin, and A.R. Modenke. 1990. Arthropods: the invisible diversity. *Northwest Environmental Journal* **6:** 404-405.

Auclair, A.N. 1976. Ecological factors in the development of intensive management ecosystems in the midwestern United States. *Ecology* **57:** 431-444.

Axelrod, D.I. 1985. Rise of the grassland biome, central North America. *The Botanical Review* **51:** 163-201.

Beaulieu, F. 2000. The community of higher Diptera associated with sedge meadows (*Carex*, Cyperaceae) in southern Quebec. Unpublished M.Sc. Thesis. McGill University. Montreal, Canada.

Belcher, J.M., P.A. Keddy, and P.M. Catling. 1992. Alvar vegetation in Canada: a multivariate description at two scales. *Canadian Journal of Botany* **70:** 1279-1291.

Bock, J. H. and C.E. Bock. 1989. Ecology and evolution in the Great Plains. Pp. 551-577. *In* J.H. Bock and Y.B. Linhart, (Eds.). The evolutionary ecology of plants. 600 pp.

Bouchard, P., K.G.A. Hamilton, and T.A. Wheeler. 2001. Diversity and conservation status of prairie endemic Auchenorrhyncha (Homoptera) in alvars of the Great Lakes region. *Journal of Insect Conservation* (submitted March 2001)

Boucher, S. and T.A. Wheeler. 2001. Diversity of Agromyzidae (Diptera) in disjunct grasslands of the southern Yukon Territory. *The Canadian Entomologist* (submitted December 2000).

Brotherson, J.D. 1983. Species composition, distribution, and phytosociology of Kalsow Prairie, a mesic tall-grass prairie in Iowa. *Great Basin Naturalist* **43:** 137-167.

Carpenter, J.R. 1940. The grassland biome. *Ecological Monographs* **10:** 617-673.

Catling, P.M. and V.R. Brownell. 1995. A review of the alvars of the Great Lakes region: distribution, floristic composition, biogeography and protection. *Canadian Field-Naturalist* **109:** 143-171.

Catling, P.M. and V.R. Brownell. 1999. An objective classification of Ontario Plateau alvars in the northern portion of the Mixedwood Plains Ecozone and a consideration of protection framework. *Canadian Field-Naturalist.* **113**: 569-575.

Catling, P.M., J. E. Cruise, K. L. McIntosh, and S. M. McKay. 1975. Alvar vegetation in southern Ontario. *Ontario Field Biologist.* **29**: 1-25.

Chao, A. 1984. Non-parametric estimation of the number of classes in a population. *Scandinavian Journal of Statistics*. **11:** 265-270.

Colwell, R.K. and J.A. Coddington. 1995. Estimating terrestrial biodiversity through extrapolation. Pp. 101-118. *In* D.L. Hawksworth (Ed.). Biodiversity: Measurement and estimation. Chapman and Hall, England 140 pp.

Danks, H.V. (Ed.). 1979. Canada and its insect fauna. *Memoirs of the Entomological Society of Canada* **108:** 1-573.

Danks, H.V. 1994. Regional diversity of insects in North America. *American Entomologist* **40**: 50-55.

DePaul, L. 1998. Incentives for savanna protection on private lands: past, present and future. *Transactions of the Wisconsin Academy of Science, Arts and Letters* **86:** 47-56.

Downes, J.A. and D.H. Kavanaugh (Eds.). 1988. Origins of the North American insect fauna. *Memoirs of the Entomological Society of Canada* **144:** 1-168.

Evans, W.E. 1989. Interspecific interactions among phytophagous insects of tallgrass prairie: an experimental test. *Ecology* **70:** 435-444.

Finnamore, A.T. 1992. Arid grasslands-biodiversity, human society, and climate change.Quantifying biotic responses associated with anthropogenic change, a prerequisite for interpreting biotic shifts in long-term climate change research. *Canadian Biodiversity* **2:** 15-23.

Finnamore, A.T. 1996. The advantages of using arthropods in ecosystem management. A brief from the Biological Survey of Canada (Terrestrial Arthropods). Biological

Survey of Canada. 11 pp.

Frick, K.E. 1952. A generic revision of the family Agromyzidae (Diptera) with a catalogue of New World species. *University of California Publications in Entomology* **8:** 339-452.

Frick, K.E. 1959. Synopsis of the species of agromyzid leaf miners described from North America (Diptera). *Proceedings of the United States National Museum* **108:** 347-465.

Frost, S.W. 1924. A study of the leaf-mining Diptera of North America. *Memoirs of the Cornell University Agricultural Experiment Station* **48:** 1-228.

Gleason, H.A. and A. Cronquist. 1991. Manual of vascular plants of northeastern United states and adjacent Canada. 2nd ed. The New York Botanical Garden. New York. 910 pp.

Griffiths, G.C.D. 1972a. Studies on boreal Agromyzidae (Diptera). I. *Phytomyza* miners on Saxifragaceae. *Quaestiones Entomologicae* **8:** 67-80.

Griffiths, G.C.D. 1972b. Studies on boreal Agromyzidae (Diptera). II. *Phytomyza* miners on *Senecio*, *Petasites* and *Tussilago* (Compositae, Senecioneae). *Quaestiones Entomologicae* **8:** 377-405.

Griffiths, G.C.D. 1973a. Studies on boreal Agromyzidae (Diptera). III. *Phytomyza* miners on *Cnidium* and *Conioselinum* (Umbelliferae). *Quaestiones Entomologicae* **9:** 3-11.

Griffiths, G.C.D. 1973b. Studies on boreal Agromyzidae (Diptera). IV. *Phytomyza* miners on *Angelica*, *Heracleum*, *Laserpitium* and *Pastinaca* (Umbelliferae). *Quaestiones*

Entomologicae **9:** 219-253.

Griffiths, G.C.D. 1974a. Studies on boreal Agromyzidae (Diptera). V. On the genus *Chromatomyia* Hardy, with revision of Caprifoliaceae-mining species. *Quaestiones Entomologicae* **10:** 35-69.

Griffiths, G.C.D. 1974b. Studies on boreal Agromyzidae (Diptera). VI. Further *Phytomyza* miners on Senecioneae (Compositae). *Quaestiones Entomologicae* **10:** 103-129.

Griffiths, G.C.D. 1974c. Studies on boreal Agromyzidae (Diptera). VII. A new *Chromatomyia* miner on *Valeriana. Quaestiones Entomologicae* **10:** 217-222.

Griffiths, G.C.D. 1974d. Studies on boreal Agromyzidae (Diptera). VIII. *Phytomyza* miners on *Artemisia* (Compositae). *Quaestiones Entomologicae* **10:** 295-314.

Griffiths, G.C.D. 1975. Studies on boreal Agromyzidae (Diptera). IX. *Phytomyza* miners of Boraginaceae in North America. *Quaestiones Entomologicae* **11:** 129-142.

Griffiths, G.C.D. 1976a. Studies on boreal Agromyzidae (Diptera). X. *Phytomyza* miners on Crassulaceae. *Quaestiones Entomologicae* **12:** 203-210.

Griffiths, G.C.D. 1976b. Studies on boreal Agromyzidae (Diptera).XI. *Chromatomyia* miners on Elaeagnaceae. *Quaestiones Entomologicae* **12:** 211-216.

Griffiths, G.C.D. 1976c. Studies on boreal Agromyzidae (Diptera).XII. *Phytomyza* and *Chromatomyia* miners on Astereae (Compositae). *Quaestiones Entomologicae* **12:** 239-278.

Griffiths, G.C.D.1980. Studies on boreal Agromyzidae (Diptera). XIV. *Chromatomyia* miners on Monocotyledones. *Entomologica Scandinavica Supplement* **13:** 1-61.

Guppy, J.C. 1981. Bionomics of the Alfalfa Blotch Leafminer, *Agromyza frontella* (Diptera: Agromyzidae), in eastern Ontario. *The Canadian Entomologist* **113:** 593-600.

Harcourt, D.G. 1973. *Agromyza frontella* (Rond.) (Diptera: Agromyzidae): A pest of alfalfa new to Canada. *Annals of the Entomological Society of Québec* **18:** 49-51.

Hipp, A. 1998. A checklist of carices for prairies, savannas, and oak woodlands of southern Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* **86:** 77-99.

Holloway, J.D. and N.E. Stork. 1991. The Dimensions of Biodiversity: The Use of Invertebrates as Indicators of Human Impact Pp. 37-62. *In* D.L. Hawksworth (Ed.). The Biodiversity of Microorganisms and Invertebrates: Its Role in Sustainable Agriculture. CAB International, Wallingford UK. 302 pp.

Howe, H.F. 1994. Managing species diversity in tallgrass prairie: assumptions and implications. *Conservation Biology* **8:** 691-704.

Huggett, I. 1993. The discovery of alvars at Aylmer. *Trail and Landscape*. **27**: 55-57.

International Commission on Zoological Nomenclature. 1999. International Code of Zoological Nomenclature. Fifth Edition. The Natural History Museum, London. 306 pp.

Jones, D.C. 1987. Empire of dust, settling and abandoning the Prairie Dry Belt. The University of Alberta Press, Edmonton. 316 pp.

Joss, P.J., P.W. Lynch, and O.B. Williams. 1986. Rangelands: a resource under siege. Cambridge University Press, Cambridge. 157 pp.

King, J.E. 1981. Late Quaternary vegetational history of Illinois. *Ecological Monographs* **51:** 43-62.

Kucera, C.L. 1992. Tall-grass prairie. Pp 222-268. *In* Coupland R.T. (Ed.). Ecosystems of the world 8A: Natural grasslands- introduction and western hemisphere. Elsevier, New York. 648 pp.

Lundgren, J.G., R.C. Venette, J. Gavloski, W.D. Hutchison, and G.E. Heimpel. 1999. Distribution of an exotic pest, *Agromyza frontella* (Diptera: Agromyzidae), in Manitoba, Canada. *The Great Lakes Entomologist* **32:** 177-184.

Magurran, A.E. 1988. Ecological diversity and its measurements. Princeton University Press. Princeton, New Jersey. 179 pp.

Malloch, J.R. 1913. A synopsis of the genera of Agromyzidae , with descriptions of new genera and species. *Proceedings of the United States National Museum* **46:** 127-154.

Marshall, S.A., R.S. Anderson, R.E. Roughley, V. Behan-Pelletier, and H.V. Danks. 1994. Terrestrial arthropod biodiversity: planning a study and recommended sampling techniques. *Bulletin of the Entomological Society of Canada* **26:** 1-33.

Martin, P.S. and R.G. Klein. 1984. Quaternary extinctions: a prehistoric revolution. University of Arizona Press, Tucson. 892 pp.

Melander, A.L. 1913. A synopsis of the dipterous groups Agromyzinae, Ochthiphilinae, and Geomyzinae. *Journal of the New York Entomological Society* **21:** 219-300.

McAlpine, J.F. 1981. Morphology and Terminology - Adults. Pp. 9-63. *In* B.V. Peterson, G.E. Shewell, H. J. Teskey, J. R. Vockeroth and D. M. Wood (Eds.). Manual of

Nearctic Diptera. Vol. 1. Research Branch of Agicultural Canada. Monograph No. 27. 674 pp.

McAlpine, J.F., J.A. Downes, D.R. Oliver, B.V. Peterson, G.E. Shewell, H.J. Teskey, J.R. Vockeroth and D.M. Wood. 1979. Diptera. Pp. 389-424. *In* H.V. Danks (Ed.). Canada and its insect fauna. *Memoirs of the Entomological Society of Canada* **108:** 1-573.

McCune, B. and G. Cottam. 1985. The successional status of a southern Wisconsin oak woods. *Ecology* **66:** 1270-1278.

Morgan, J. 1994. Prototype vegetation management plan, Canadian Forces Base-Winnipeg. Prairie Habitats, Inc. Winnipeg. 38 pp.

Morton, J.K. and J.M. Venn. 1984. The flora of Manitoulin Island and adjacent islands of Lake Huron, Georgian Bay and the North Channel. Second Revised Edition. University of Waterloo. 106 pp.

Nature Conservancy of Canada, 1999. Manitoba's Tallgrass Prairie. http://www.naturenorth.com/summer/wildlife/wildF.html

Needham, J.G., S.W. Frost, and B.H. Tothill. 1928. Leaf-Mining Insects. Williams and Wilkins, Baltimore. 351 pp.

Nowakowski, J.T. 1973. Monographie der europäischen Arten der Gattung *Cerodontha* Rond. (Diptera, Agromyzidae). *Annales Zoologici* **31:** 1-327.

Ojibway Nature Center. 2000. Ojibway Prairie. http://www.city.windsor.on.ca/ojibway/complex.htm

Panzer, R. 1988. Managing prairie remnants for insect conservation. *Natural Areas*

Journal **8:** 83-90.

Panzer, R., D. Stillwaugh, R. Gnaedinger, and G. Derkovitz. 1995. Prevalence of remnant dependence among the prairie and savanna inhabiting insects of the Chicago region. *Natural Areas Journal* **15:** 101-116.

Risser, P.G., E.C. Birney, H.D. Blocker, S.W. May, W.J. Parton, and J.A. Wiens. 1982. The true prairie ecosystem. Hutchinson Ross Publishing Company, Stroudsburg, Pennsylvania. 557 pp.

Ross, H.H. 1970. The ecological history of the Great Plains: evidence from grassland insects. Pp. 225-240. *In* Pleistocene and recent environments of the central Great Plains. The University Press of Kansas., Lawrence, Manhattan, Wichita, Kansas. 433 pp.

Roughley, R.E. 2001. Fire season impact on ground beetle (Coleoptera: Carabidae) biodiversity in tallgrass prairie in Manitoba. Abstract. Proceedings of the 6th Prairie Conservation and Endangered Species Conference, Winnipeg, Manitoba.

Sehgal, V.K. 1971. A taxonomic survey of the Agromyzidae (Diptera) of Alberta, Canada, with observations on host-plant relationships. *Quaestiones Entomologicae* **7:** 291-405.

Sims, P.L. 1988. Grasslands. Pp. 265-286. *In* M.G. Barbour and W.D. Billings (Eds.). North American terrestrial vegetation. Cambridge University Press, New York. 434 pp.

Sims, P.L., J.S. Singh, and W.K. Lauenroth. 1978. The structure and function of ten western North American grasslands, abiotic and vegetational characteristics.

Journal of Ecology **66:** 251-285.

Smeins, F.E. and D.E. Olsen. 1970. Species composition and production of a native northwestern Minnesota tall-grass prairie. *American Midland Naturalist* **84:** 398-410.

Spencer, K.A. 1969. The Agromyzidae of Canada and Alaska. *Memoirs of the Entomological Society of Canada* **64:** 1-311.

Spencer, K.A. 1976. The Agromyzidae (Diptera) of Fennoscandia and Denmark. *Fauna Entomologica Scandinavica* **2:** 305-606.

Spencer, K.A 1981. A revisionary study of the leaf-mining flies (Agromyzidae) of California. *University of California, Division of Agricultural Sciences Special Publication* **3273:** 1-489.

Spencer, K.A. 1987. Agromyzidae Pp. 869-879. *In* J.F. McAlpine, B.V. Peterson, G.E. Shewell, H.J. Teskey, J.R. Vockeroth, D.M. Wood (Eds.). Manual of Nearctic Diptera. Volume 2. Agriculture Canada Monograph **28:** 675-1332.

Spencer, K.A. and G.C. Steyskal. 1986. Manual of the Agromyzidae (Diptera) of the United States. United States Department of Agriculture. Agriculture Handbook No.638. 478 pp.

Terrell, E.E. 1977. A check list of names for 3,000 vascular plants of economic importance. U.S. Department of Agriculture. Agricultural Handbook 505.

Thompson, L.S. 1974. Alfalfa blotch leafminer, *Agromyza frontella* (Rond.). *Canadian Agricultural Insect Pest Review* **52:** 5.

Walter, H. 1985. Vegetation of the earth and ecological systems of the geo-biosphere.

Springer-Verlag, New York. 318 pp.

Weaver, J.E. 1954. North American prairie. Johnson Publishing, Lincoln, Nebraska. 348 pp.

Whitcomb, R.F. 1987. North America forests and grasslands: biotic conservation. Pp.163-176. *In* D.A. Saunders, G.W. Arnold, A.A. Burbidge, and A.J.M. Hopkins (Eds.). Nature conservation: the role of remnants of native vegetation. Surrey Beatty and Sons Limited, Maryland. 410 pp.

Whitcomb, R.F., A.L. Hicks, H.D. Blocker, and D.E. Lynn. 1994. Biogeography of leafhopper specialists of the shortgrass prairie: evidence for the roles of phenology and phylogeny in determination of biological diversity. *American Entomologist* **40:** 19-35.

Wright, H.E. 1968. History of the Prairie Peninsula. Pp.78-89. *In* R.E. Bergstrom (Ed.). The Quaternary of Illinois. Special Publication 14, University of Illinois, Urbana. 179 pp.

Table 1. Agromyzidae collected in tallgrass prairies in southern Manitoba. SCRR - St. Charles Rifle Range (1997-2000); GarN - Gardenton North (1999-2000); GarS - Gardenton South (1999-2000); TPFS - Tallgrass Prairie Field Station, Gardenton (1996). Site TPFS is included in overall calculations, but not in individual site calculations.

	Specimens / Site				
Species	**SCRR**	**GarN**	**GarS**	**TPFS**	**Total**
Agromyza frontella	62			1	63
Agromyza gonioverpa	2				2
Agromyza hockingi	1				1
Agromyza ?isolata		1			1
Agromyza ?oliverensis	2				2
Hexomyza schineri		5			5
Melanagromyza martini	3				3
Melanagromyza modesta	3				3
Melanagromyza shewelli	14			1	15
Melanagromyza verbesinae	2				2
Ophiomyia coniceps	14	5			19
Ophiomyia lauta	1				1
Ophiomyia nasuta	1				1
Ophiomyia secunda	11				11
Ophiomyia sexta	54				54
Calycomyza frickiana	1				1
Calycomyza humeralis	1	1			2
Calycomyza menthae	2	1			3
Calycomyza promissa	7	11			18
Calycomyza solidaginis	12	5	1		18
Cerodontha capitata	3	26	1		30
Cerodontha dorsalis	8	20			28
Cerodontha gibbardi		4			4
Cerodontha incisa	2	1			3
Cerodontha inconspicua	59	6	2	2	69

Table 1. (continued)

Species	Specimens / Site				Total
	SCRR	GarN	GarS	TPFS	
Cerodontha magnicornis	2	13	5	1	21
Cerodontha subangulata				1	1
Cerodontha superciliosa	201	69			270
Chromatomyia caprifoliae	37			1	38
Liriomyza brassicae	3	3			6
Liriomyza fricki	12	3			15
Liriomyza lathyri	4	3		2	9
Liriomyza lima	13	8	1		22
Liriomyza ptarmicae	5	2			7
Liriomyza sabaziae	1				1
Liriomyza sinuata		1			1
Liriomyza smilacinae		1			1
Liriomyza taraxaci	9	1	1		11
Liriomyza togata	1	1			2
Metopomyza griffithsi	5	18	2		25
Nemorimyza posticata		1		4	5
Paraphytomyza crula	29			1	30
Paraphytomyza ?nitida		1			1
Paraphytomyza orbitalis	42				42
Phytobia vanduzeei	3				3
Phytomyza roughleyi	3				3
Phytoliriomyza caroli	1				1
Phytoliriomyza melampygae				1	1
Pseudonapomyza atra	1				1
Total specimens	637	211	13	15	876
Total species	40	26	7	10	49

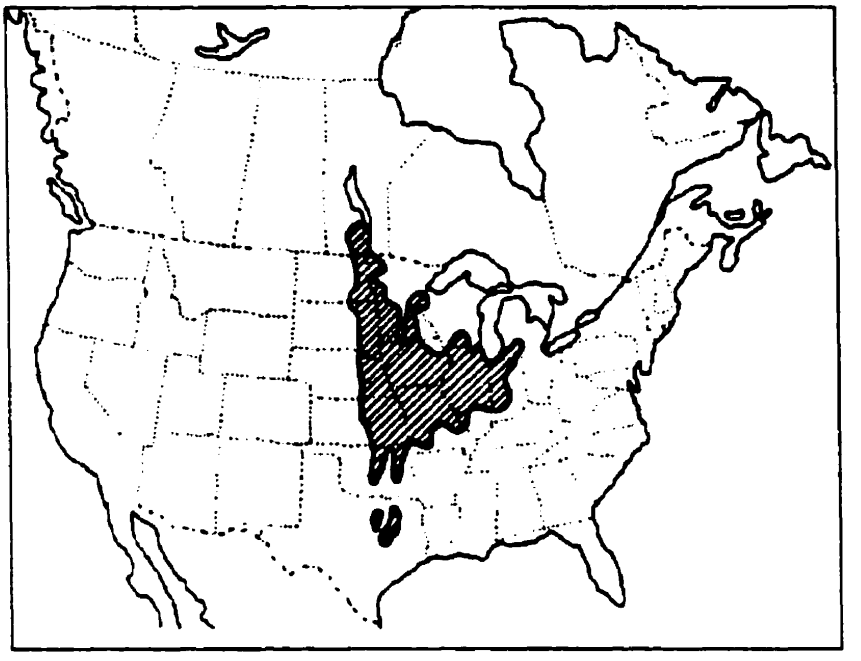


Fig. 1. Distribution of Tallgrass Prairies in North America.

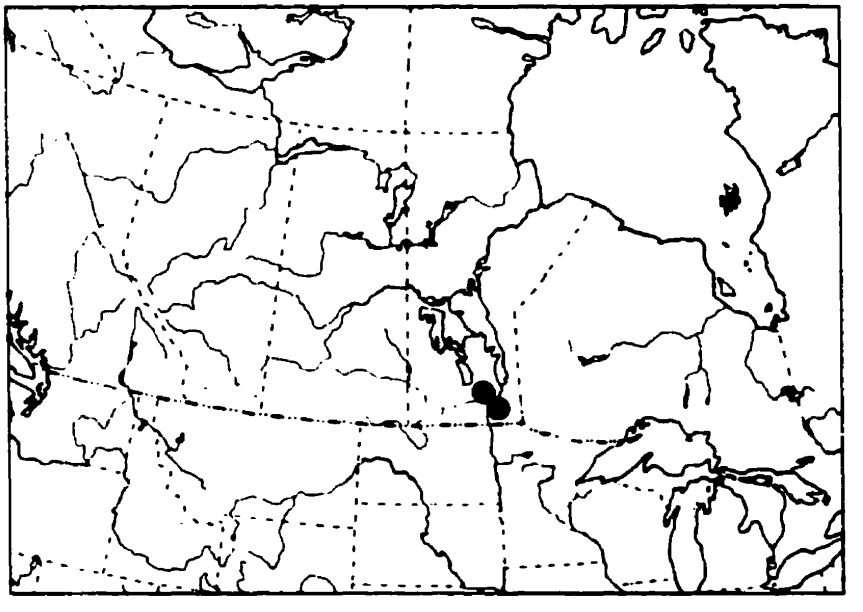


Fig. 2. Map of primary sites in southern Manitoba.

Fig. 3. Map of the St. Charles Rifle Range, CFB Winnipeg. Dark area represents base properties (adapted from Morgan 1994).

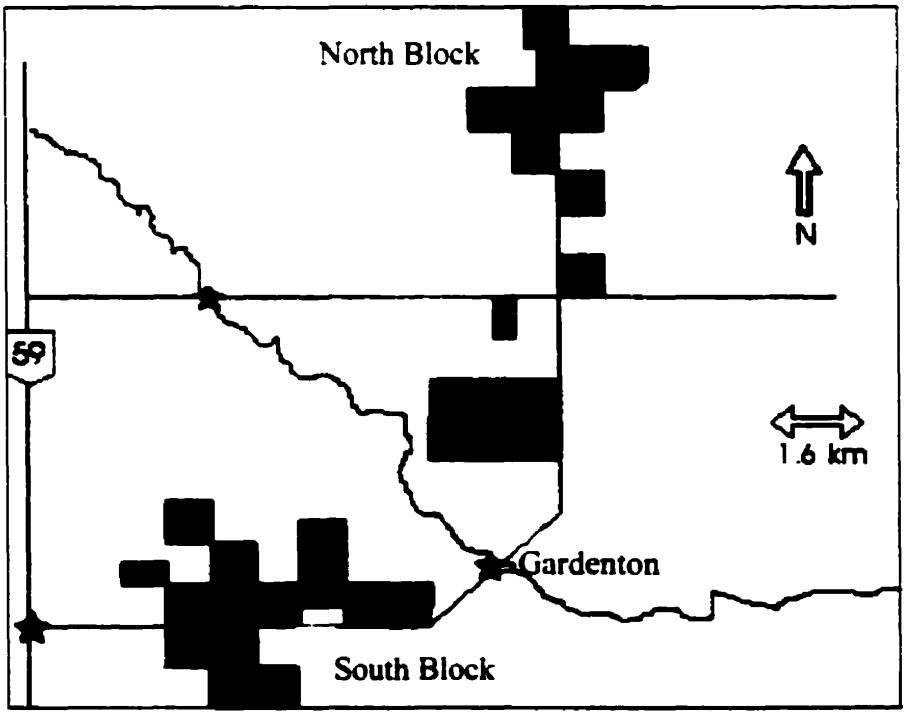
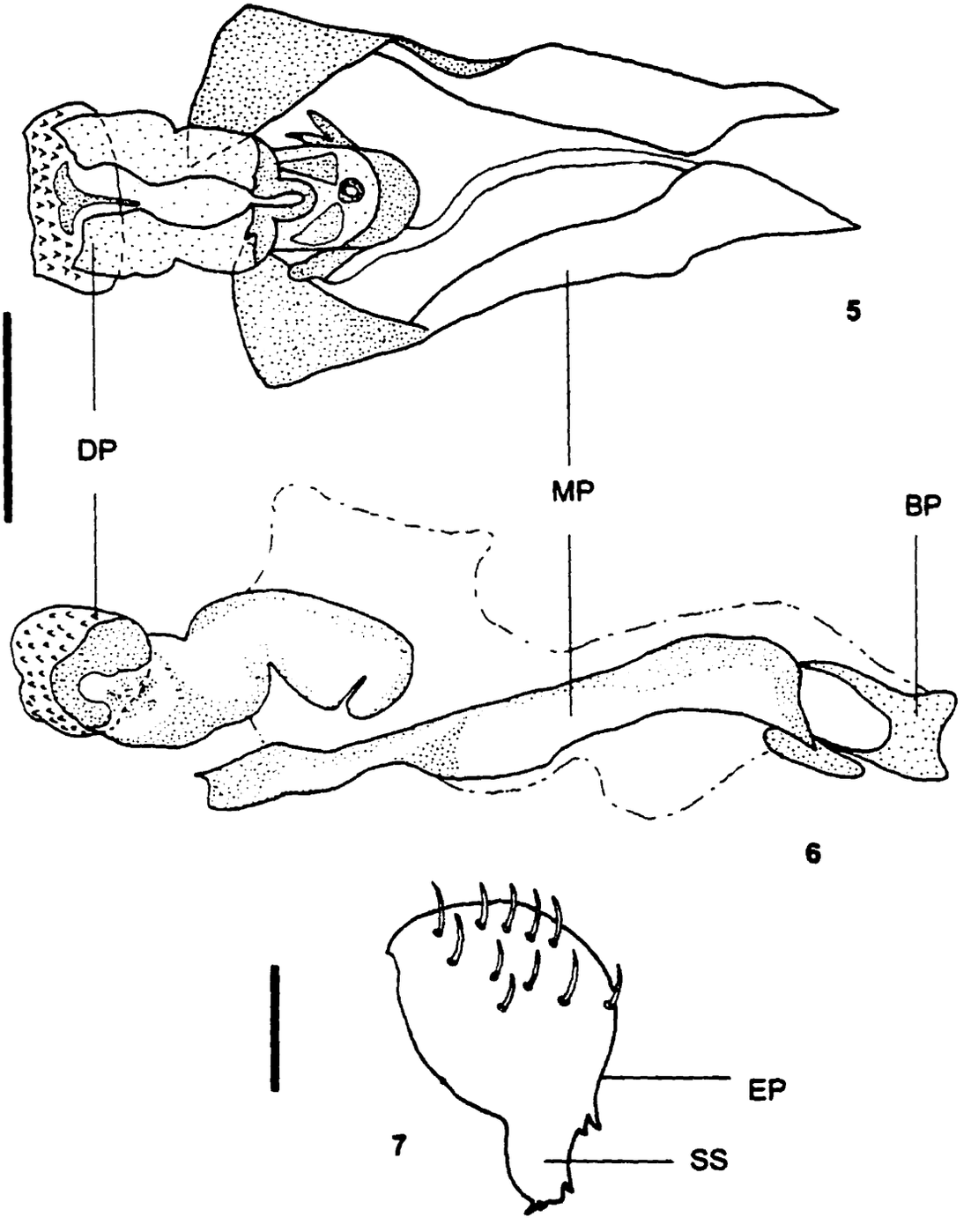
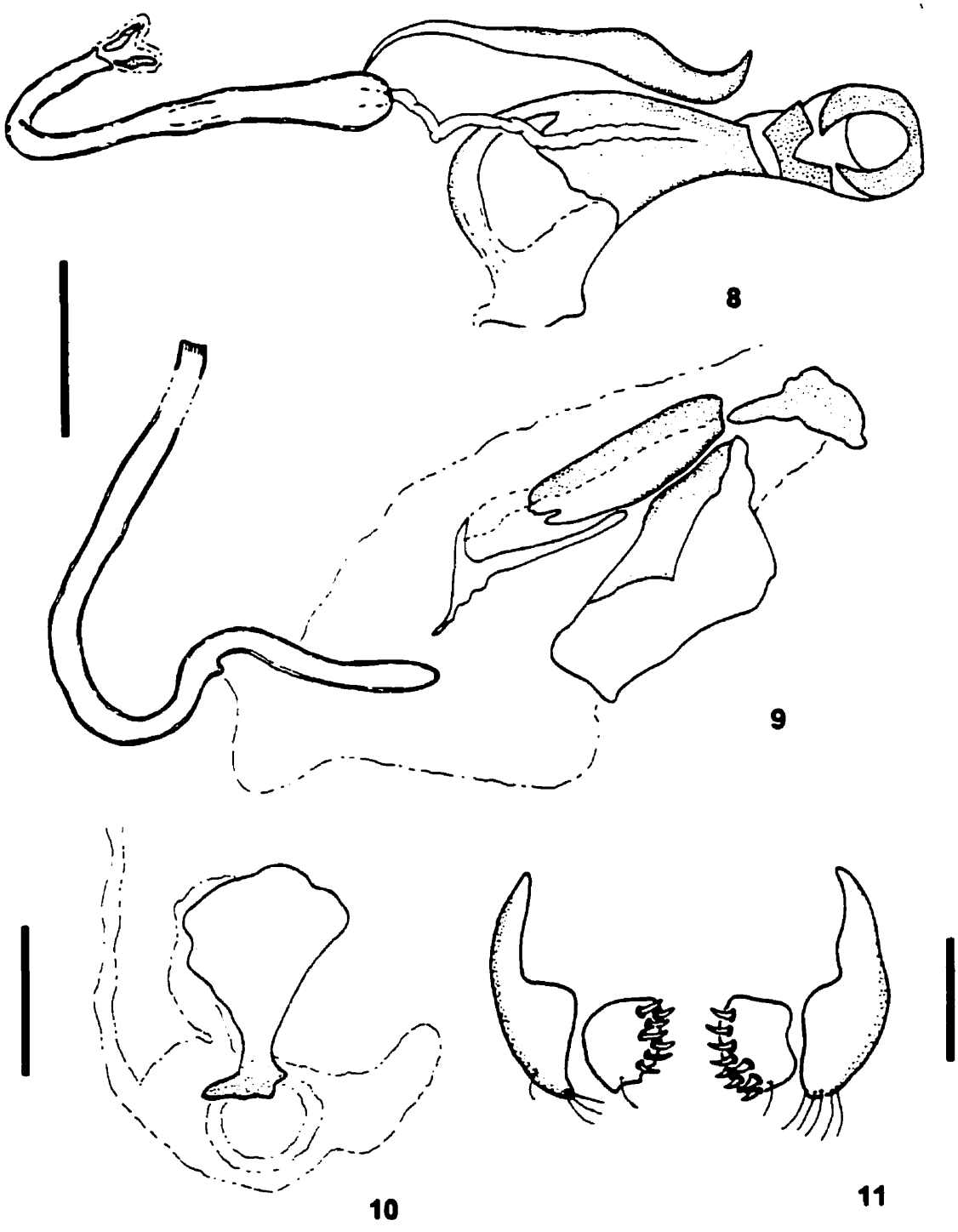


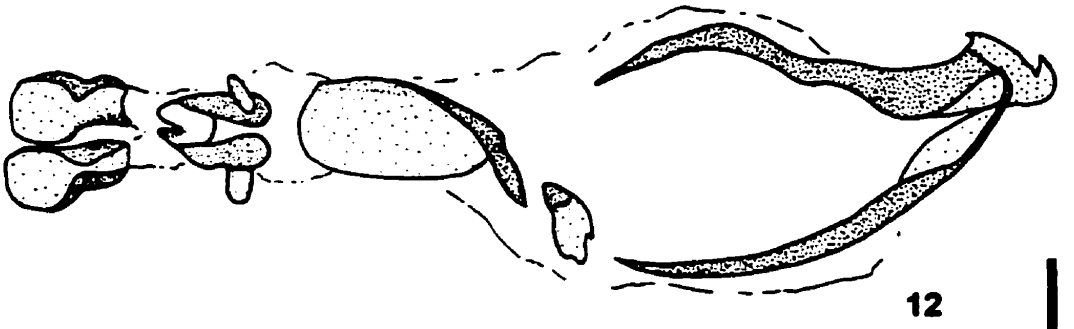
Fig. 4. Map of the Tallgrass Prairie Preserve, Gardenton. (adapted from Nature Conservancy of Canada 1999).



FIGS 5-7. *Agromyza gonioverpa* male genitalia: 5. Phallus (ventral); 6. Phallus (lateral); 7. Epandrium and surstylus (lateral). BP, basiphallus; DP, distiphallus; EP, epandrium; MP , mesophallus; SS, surstylus. Scale bars = 0.1mm.



FIGS 8-11. *Paraphytomyza crula* male genitalia: 8. Phallus (ventral); 9. Phallus (lateral); 10. Ejaculatory apodeme (ventral); 11. Epandrium and surstylus ventral. Scale bars = 0.1mm.



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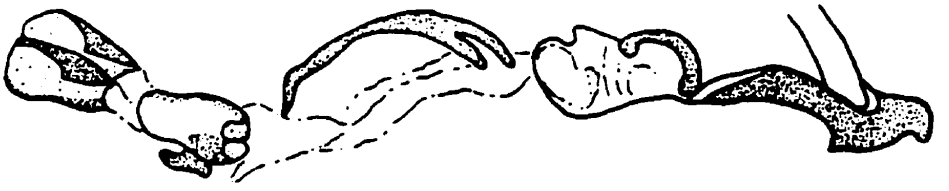

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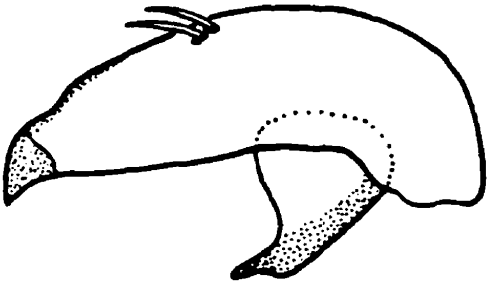

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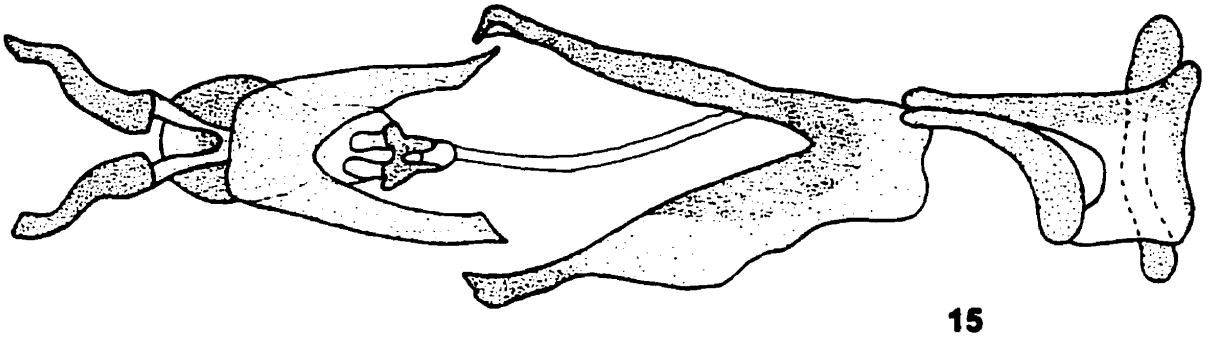
FIGS 12-14. *Phytoliriomyza caroli* male genitalia: 12. Phallus (ventral); 13. Phallus (lateral): 14. Epandrium and surstylus (lateral). Scale bars = 0.1mm



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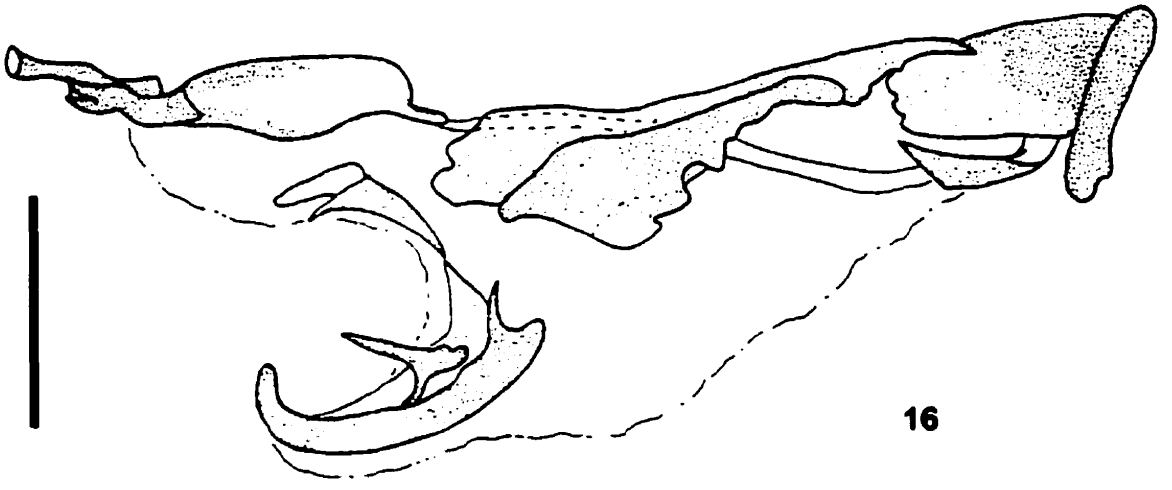

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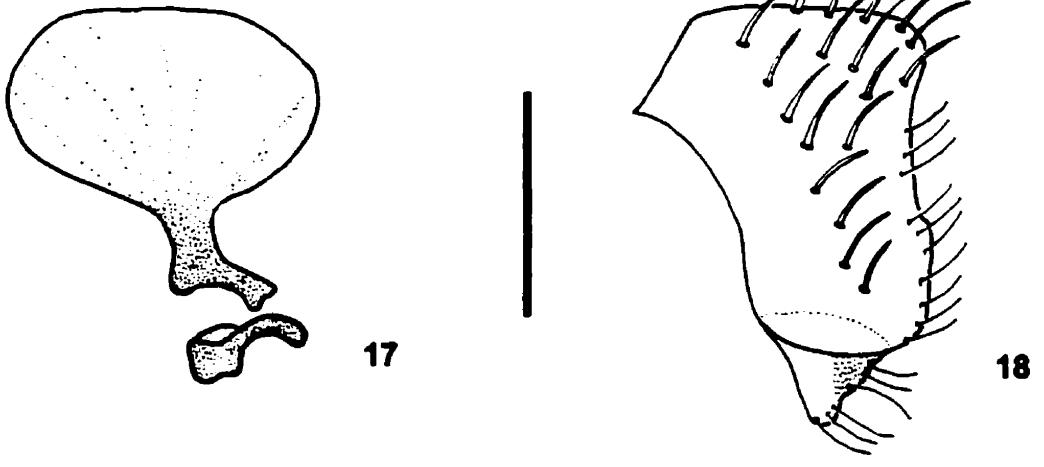

17 18

FIGS 15-18. *Phytomyza roughleyi* male genitalia: 15. Phallus (ventral); 16. Phallus (lateral); 17. Ejaculatory apodeme (ventral); 18. Epandrium and surstylus (lateral). Scale bars = 0.1mm.

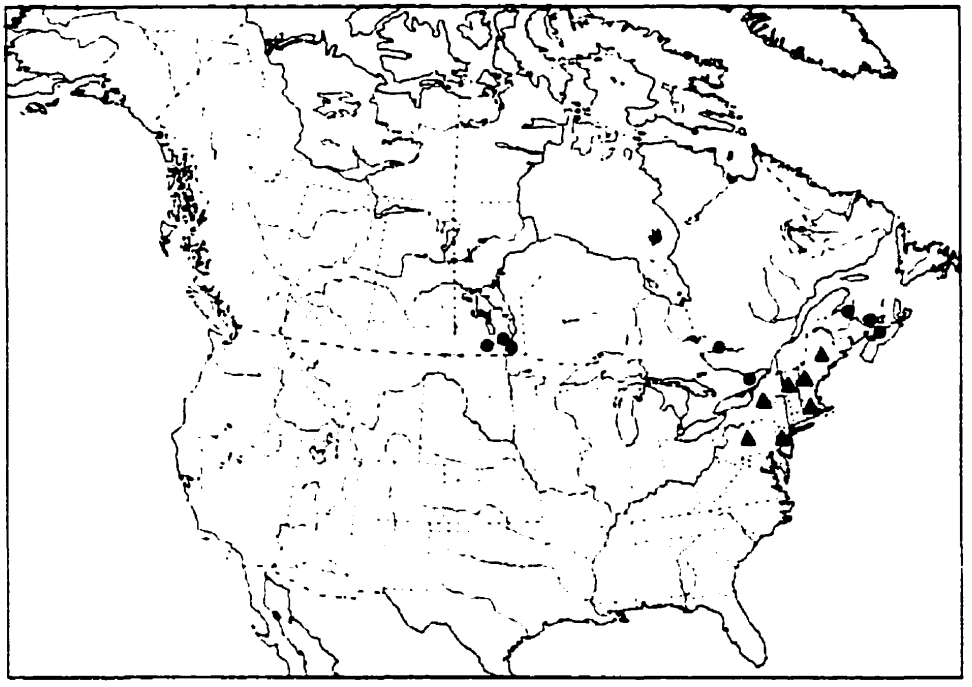

Fig. 19. North American distribution of *Agromyza frontella*. Triangles - state records only

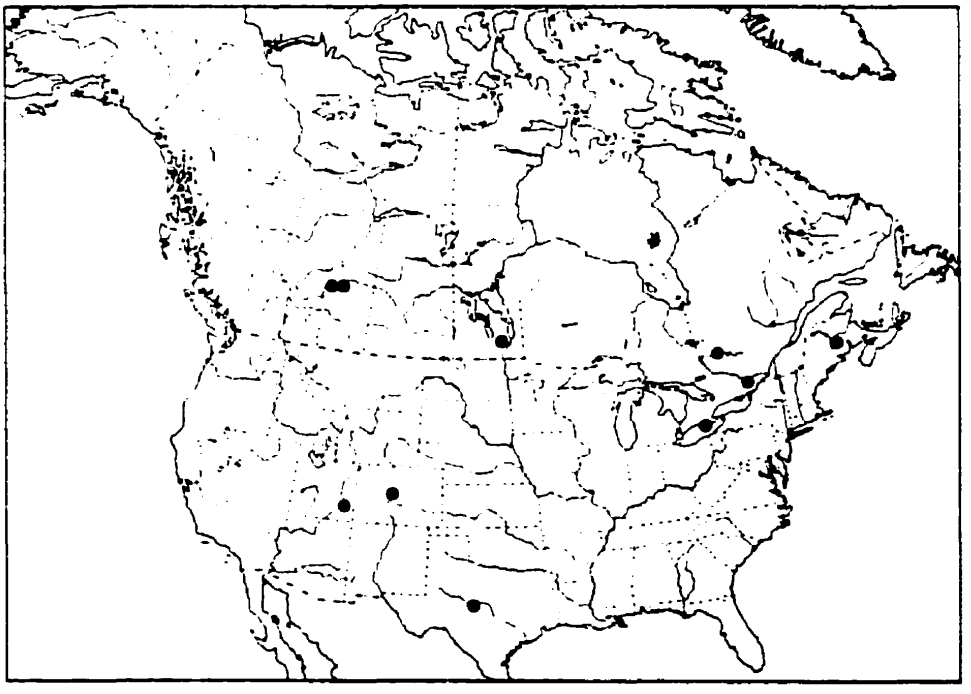

Fig. 20. Distribution of *Agromyza hockingi*

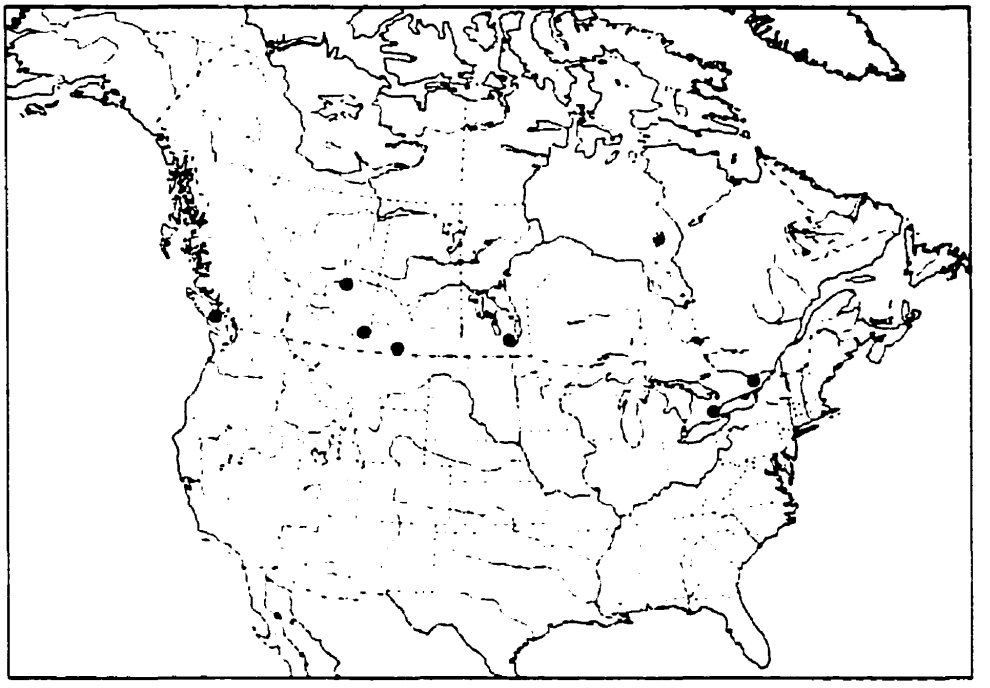

Fig. 21. Distribution of *Melanagromyza martini*

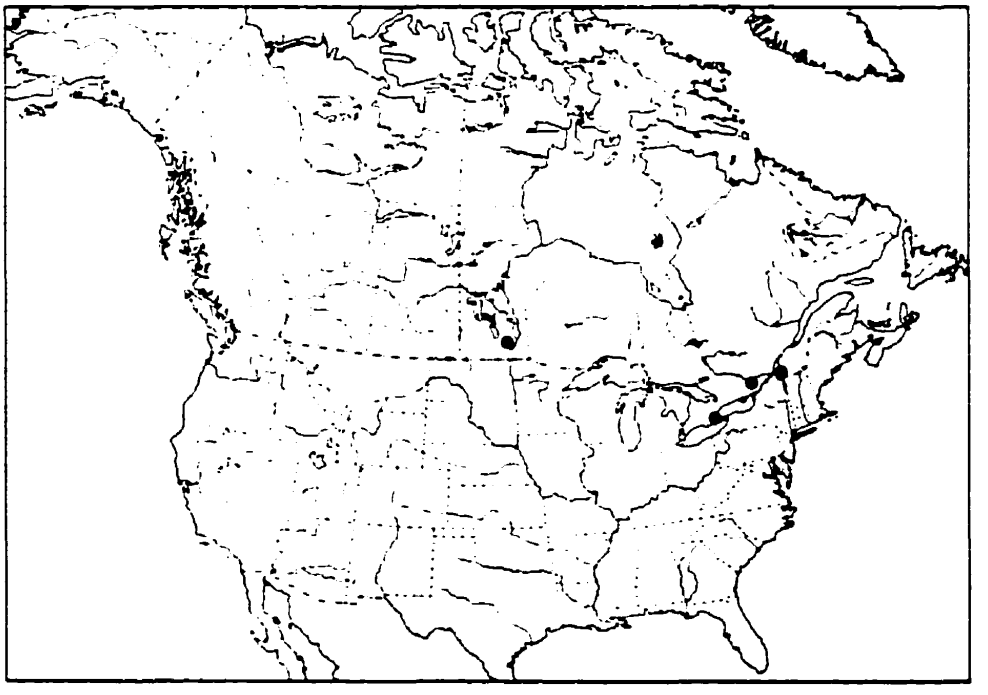

Fig. 22. Distribution of *Melanagromyza modesta*

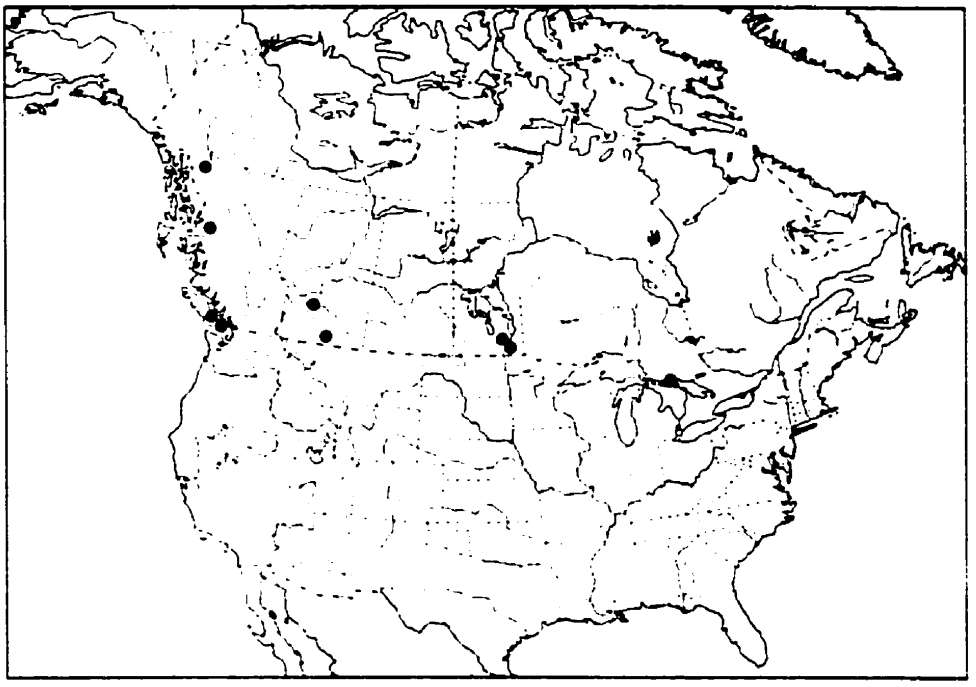

Fig. 23. Distribution of *Melanagromyza shewelli*

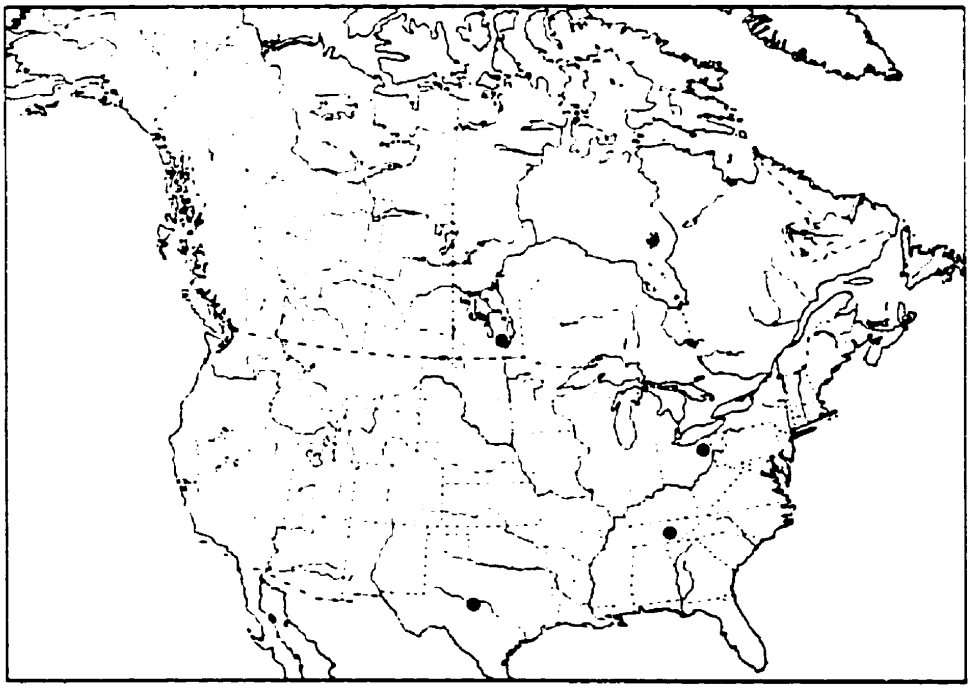

Fig. 24. Distribution of *Melanagromyza verbesinae*

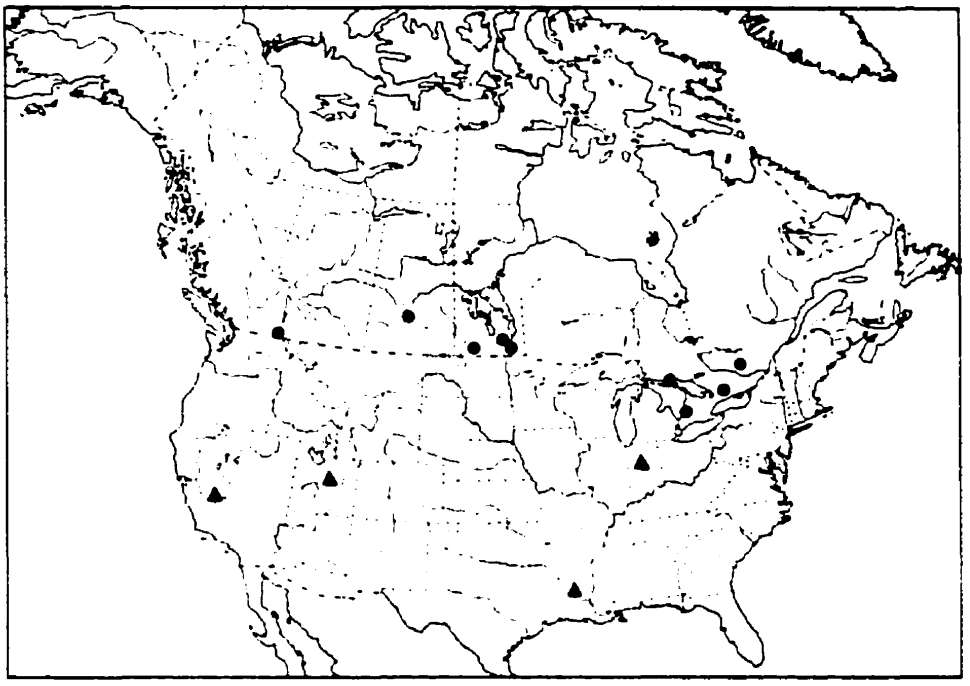

Fig. 25. Distribution of *Ophiomyia coniceps*. Triangles - state records only

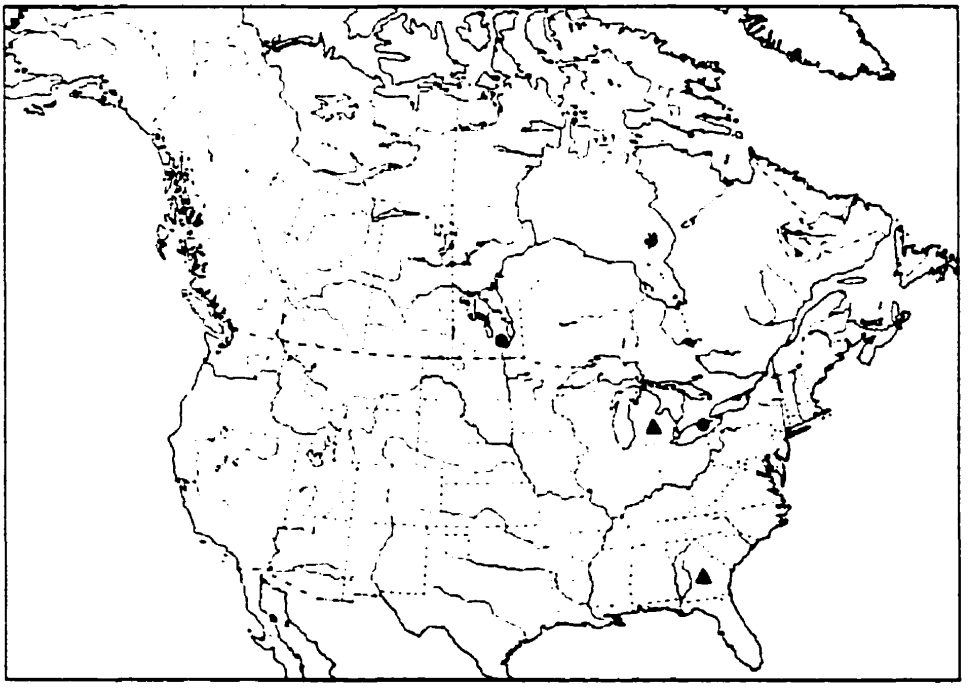

Fig. 26. Distribution of *Ophiomyia lauta*. Triangles - state records only

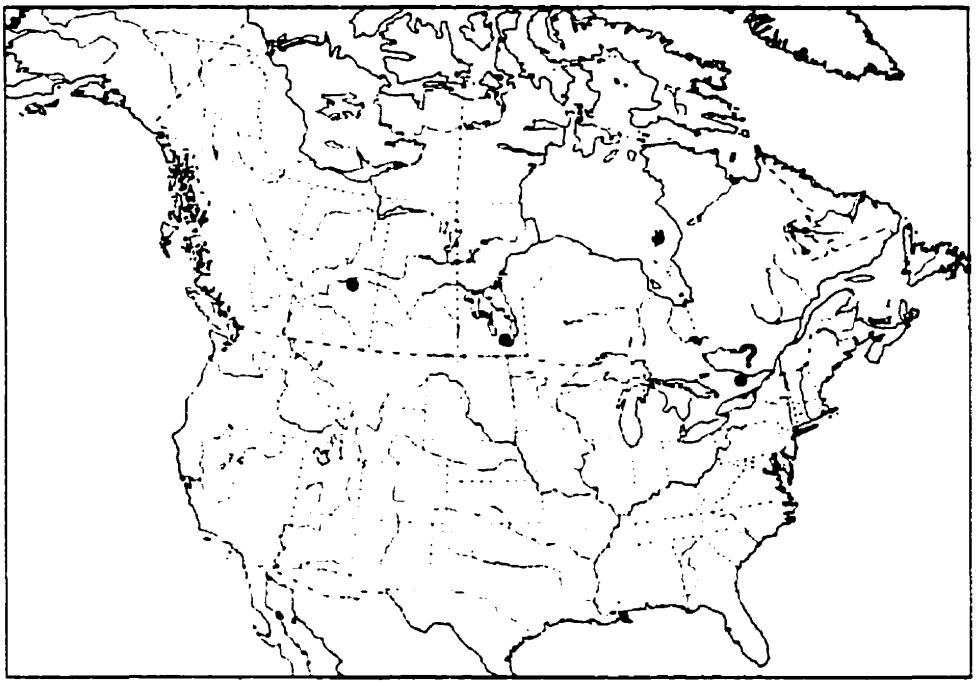

Fig. 27. Distribution of *Ophiomyia secunda*. ? - questionable record

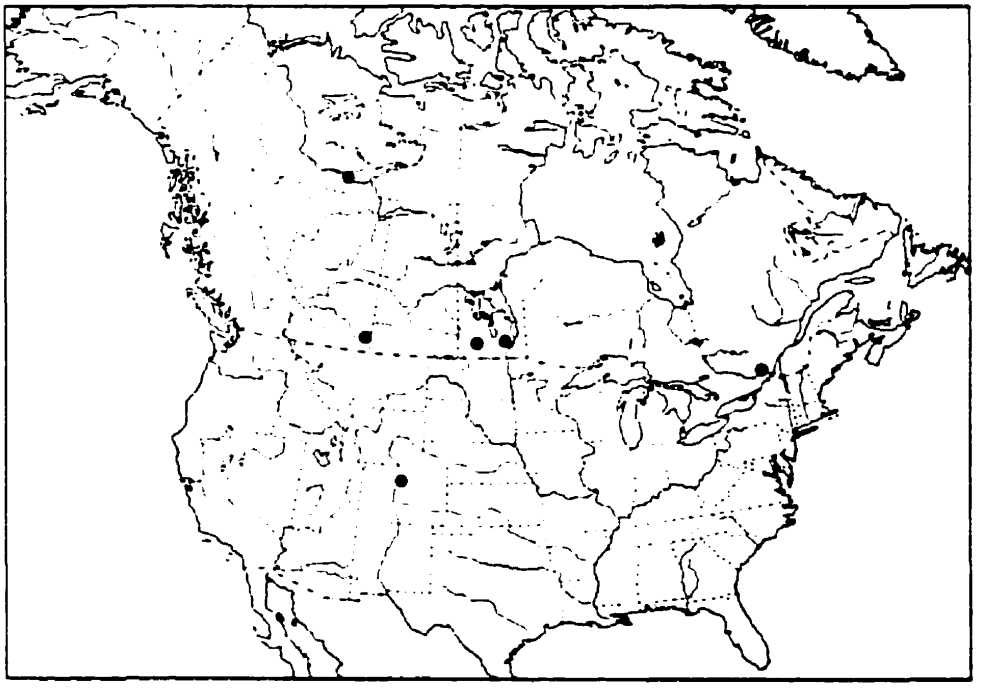

Fig. 28. Distribution of *Ophiomyia sexta*

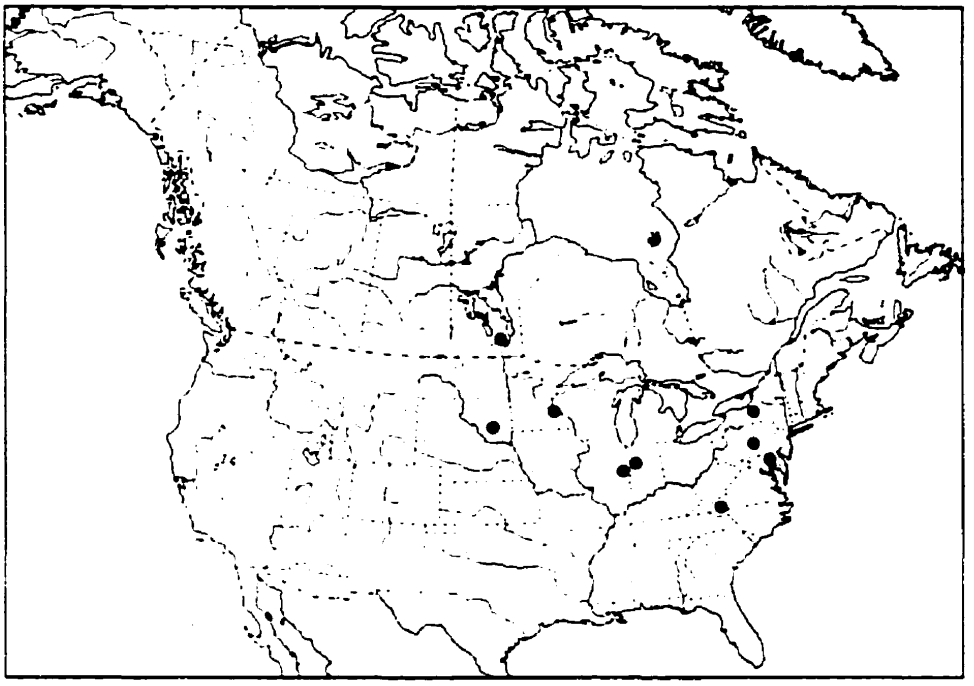

Fig. 29. Distribution of *Calycomyza frickiana*

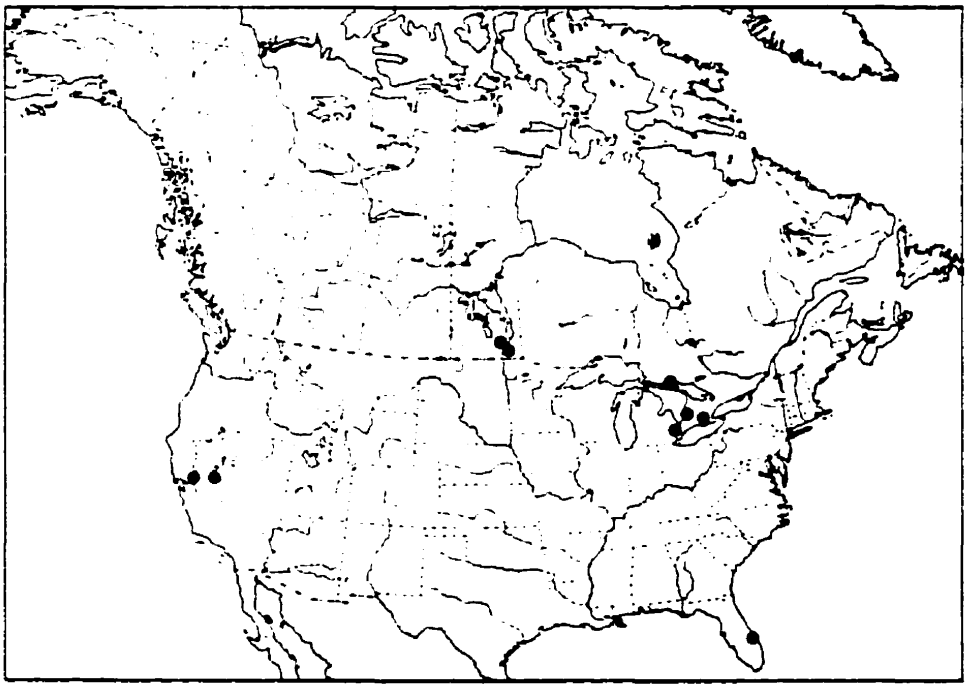

Fig. 30. Distribution of *Calycomyza menthae*

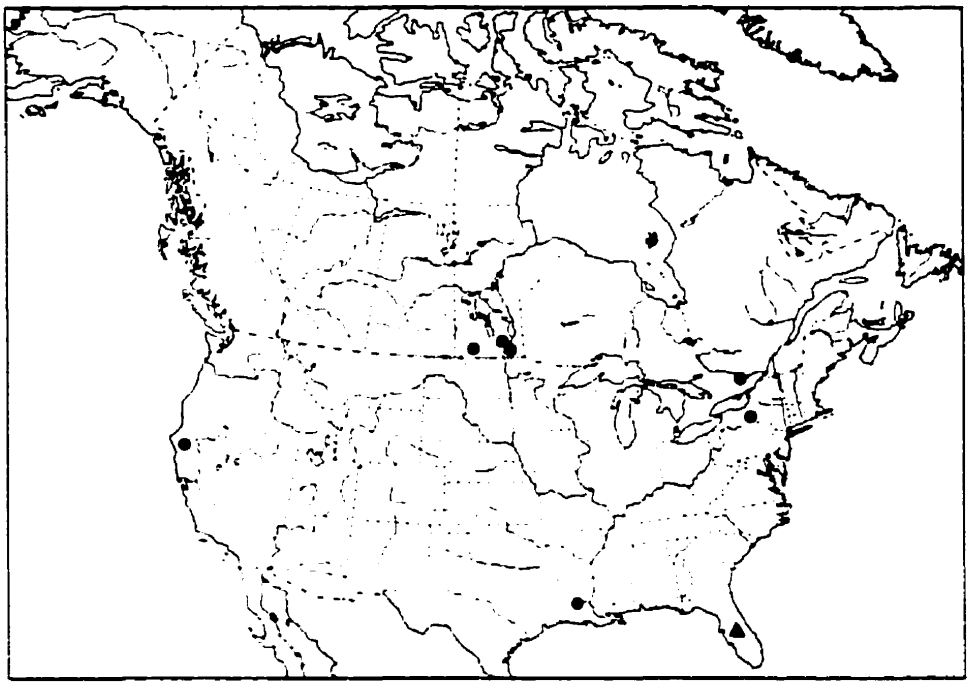

Fig. 31. Distribution of *Calycomyza promissa*. Triangle - state record only

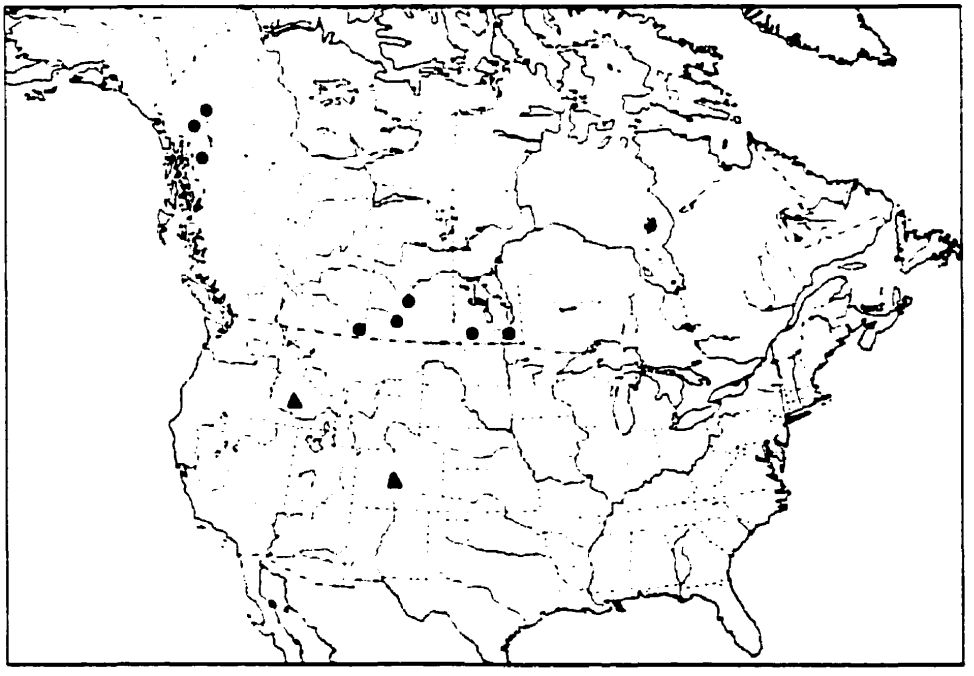

Fig. 32. Distribution of *Cerodontha gibbardi*. Triangle - state record only

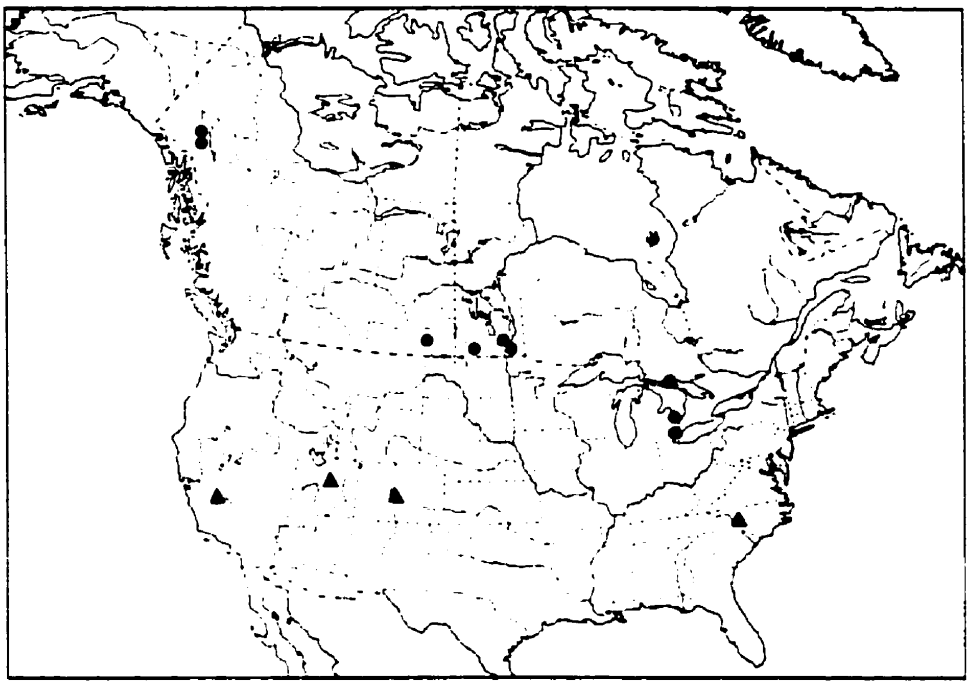

Fig. 33. Distribution of *Cerodontha inconspicua*. Triangles - state record only

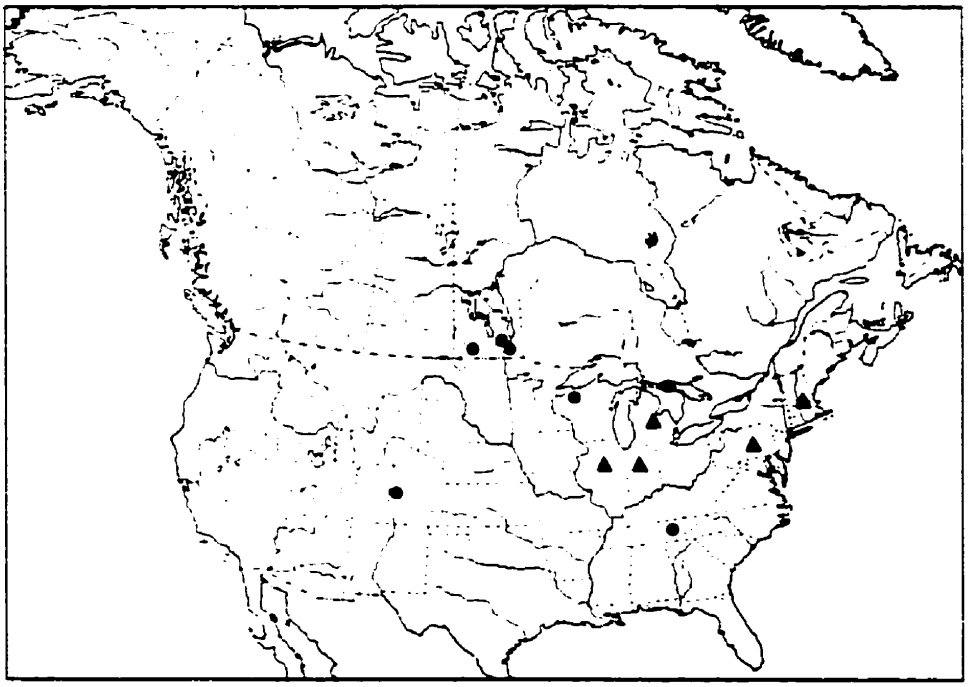

Fig. 34. Distribution of *Cerodontha magnicornis*. Triangles - state record only

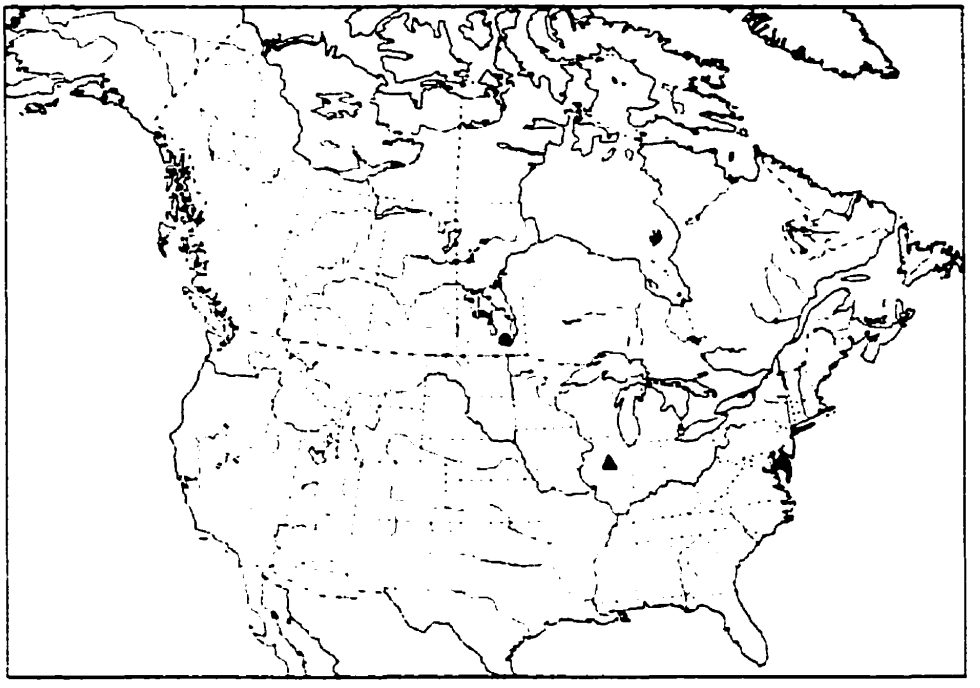

Fig. 35. Distribution of *Cerodontha subangulata*. Triangles - state record only

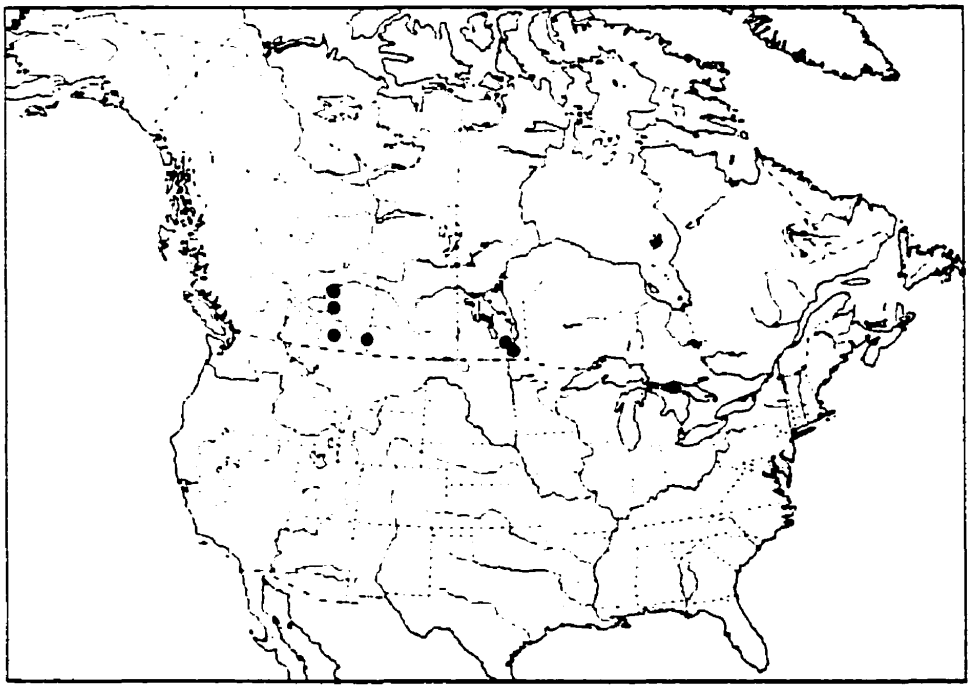

Fig. 36. Distribution of *Chromatomyia caprifoliae*

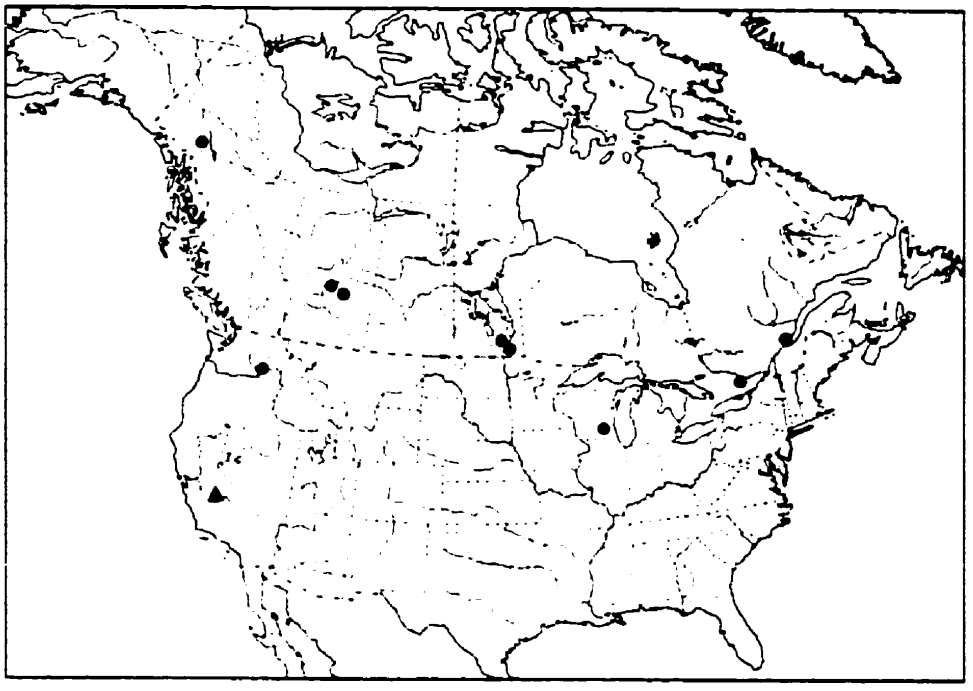

Fig. 37. Distribution of *Liriomyza fricki*. Triangle - state record only

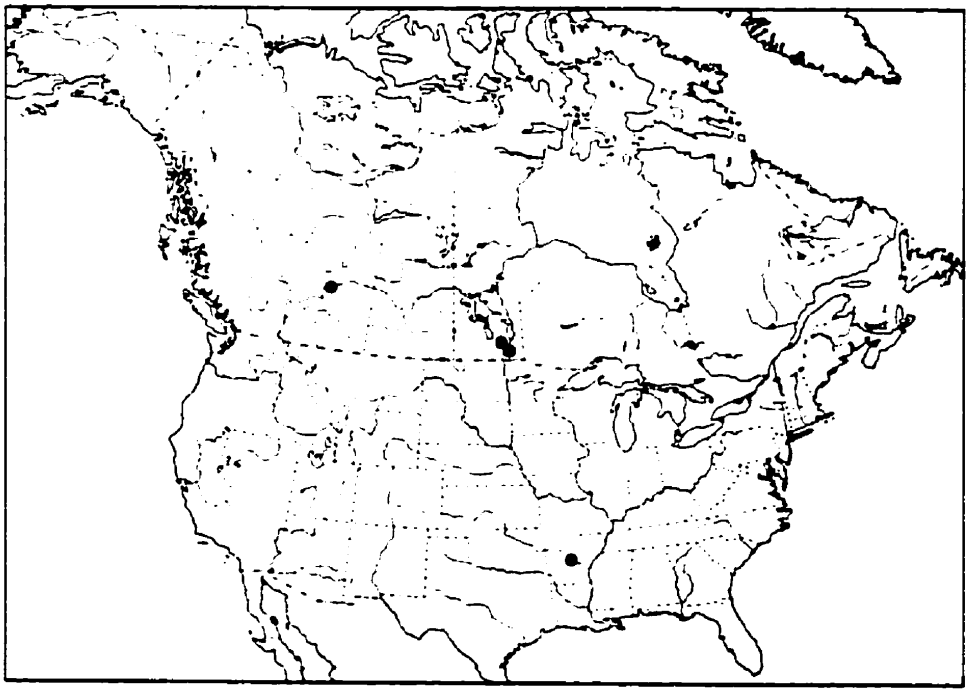

Fig. 38. Distribution of *Liriomyza lathyri*

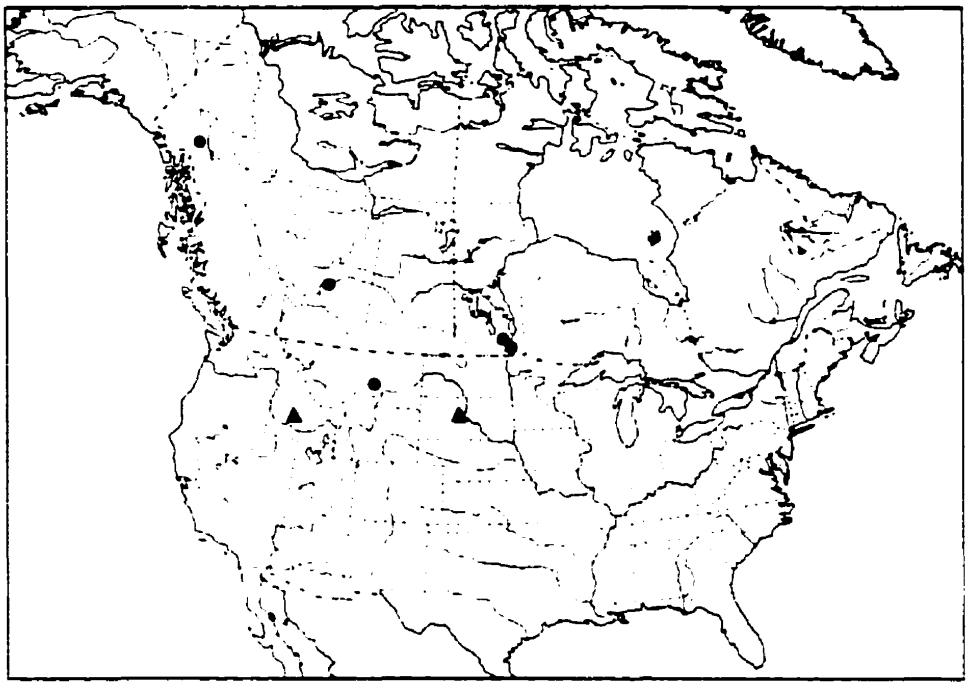

Fig. 39. Distribution of *Liriomyza lima*. Triangles - state record only

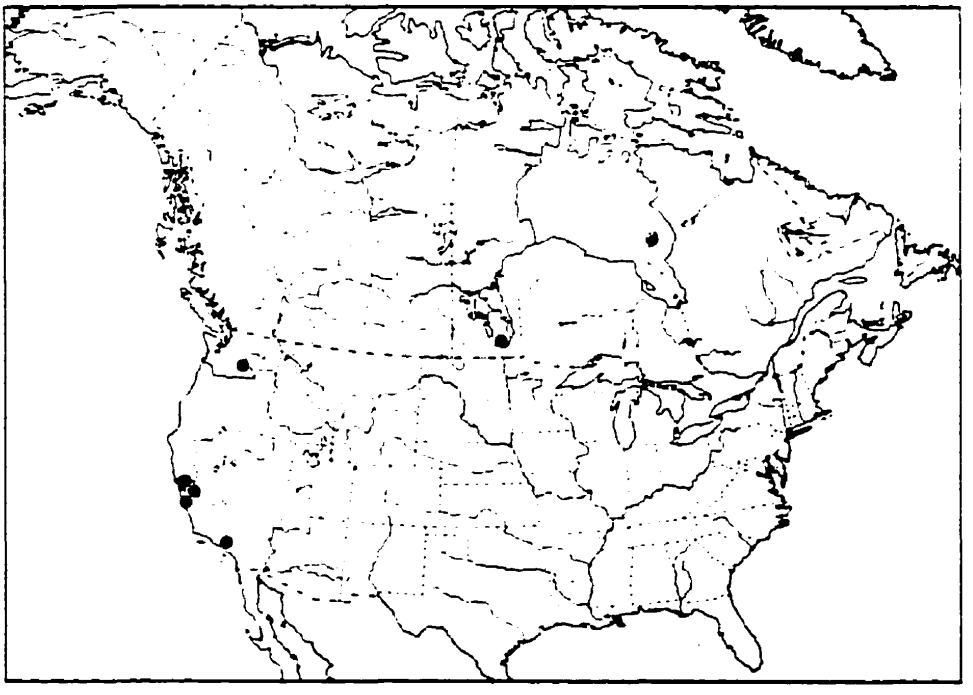

Fig. 40. Distribution of *Liriomyza sabaziae*

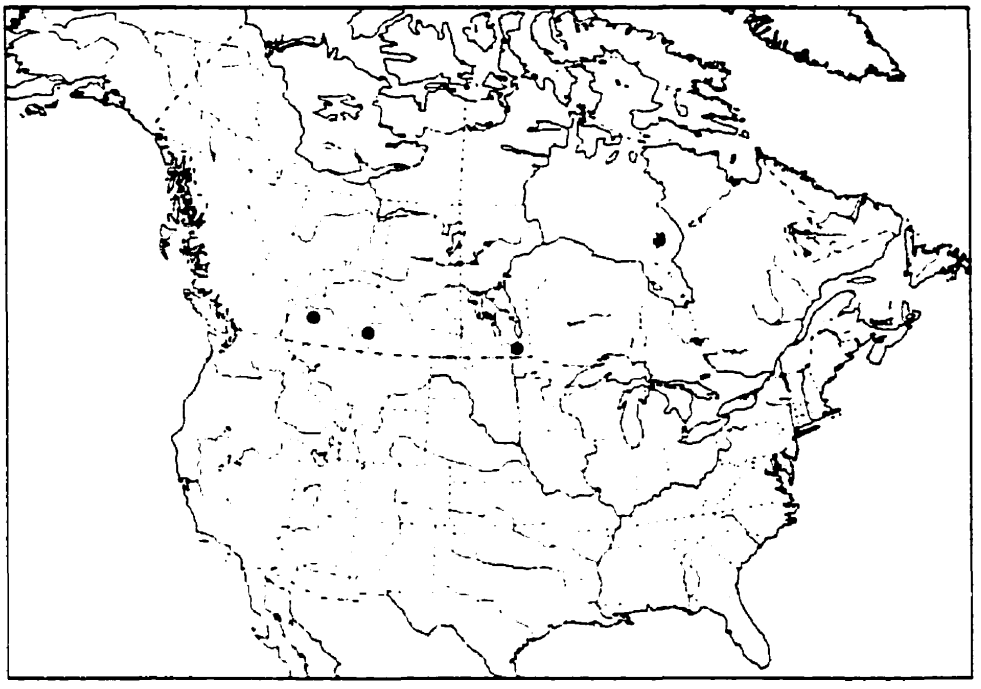

Fig. 41. Distribution of *Liriomyza sinuata*

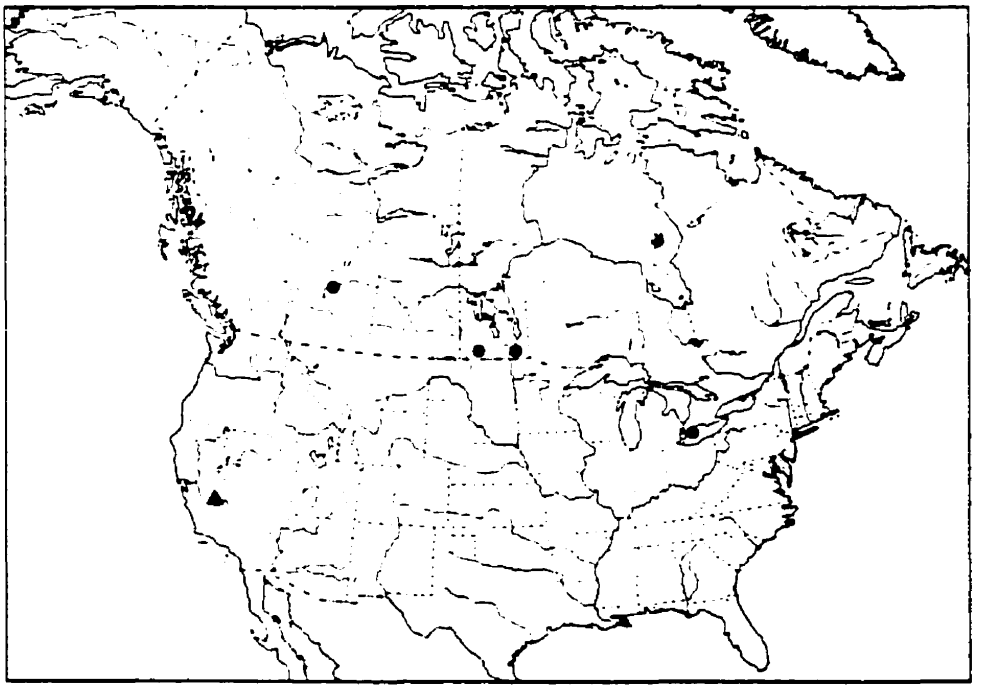

Fig. 42. Distribution of *Liriomyza smilacinae*. Triangle - state record only

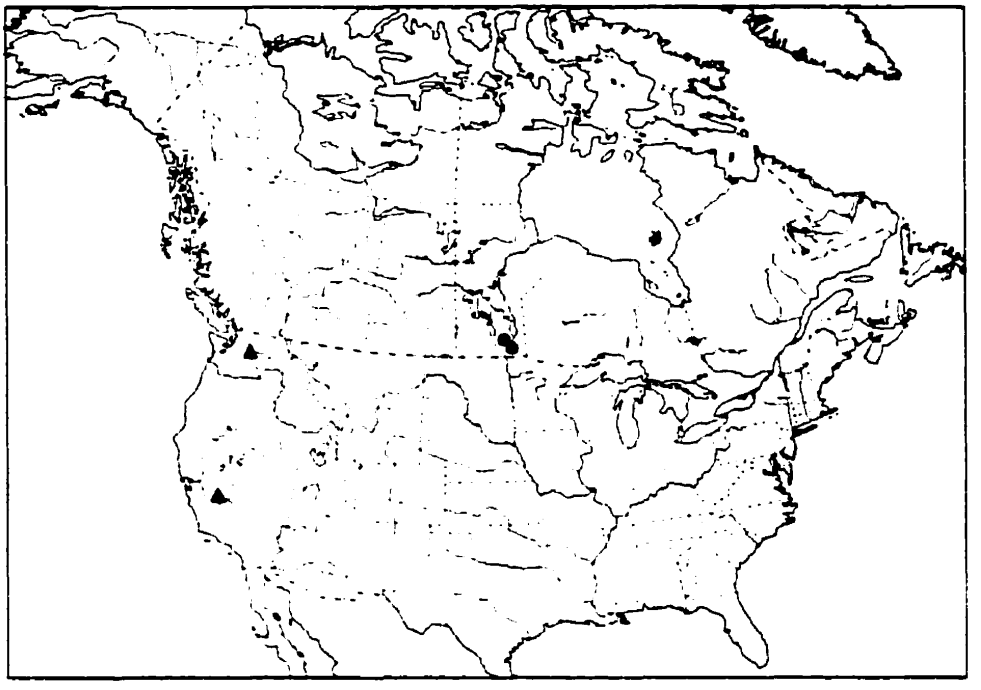

Fig. 43. Distribution of *Liriomyza togata*. Triangles - state record only

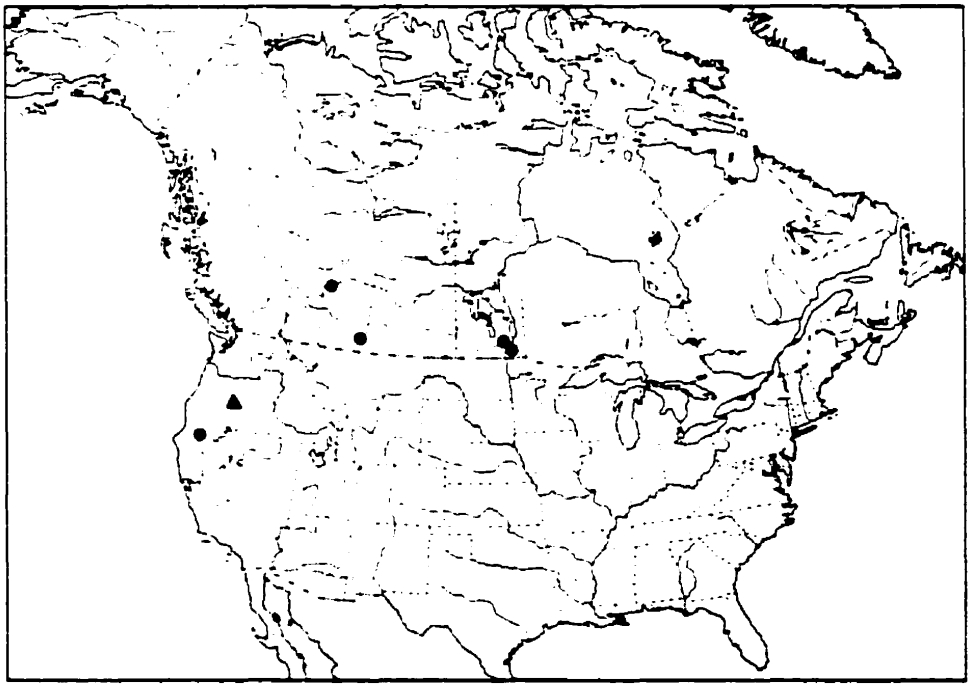

Fig. 44. Distribution of *Metopomyza griffithsi*. Triangle - state record only

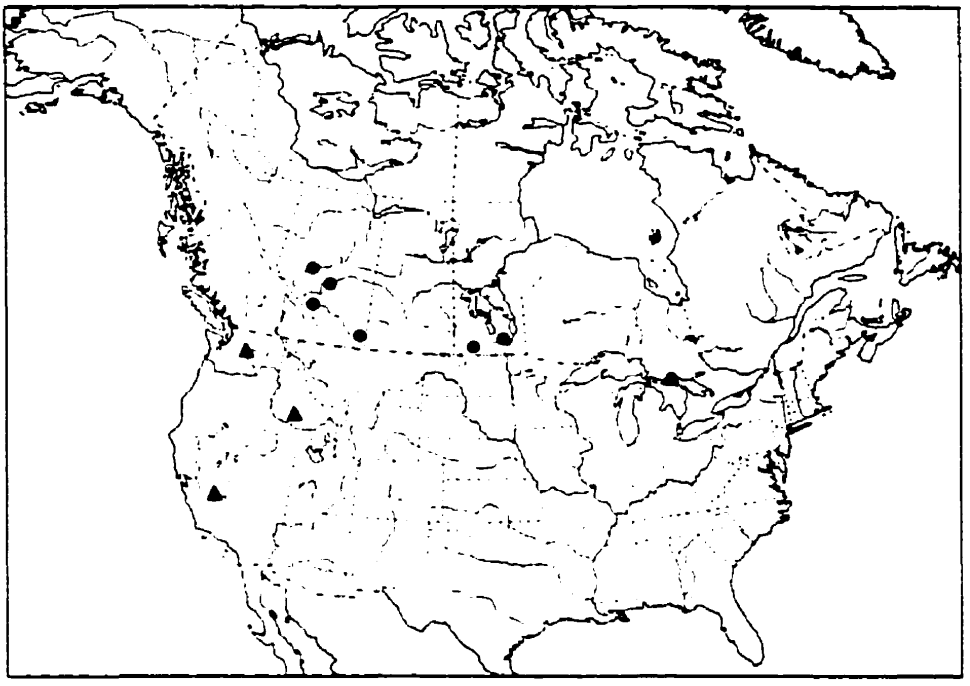

Fig. 45. Distribution of *Paraphytomyza orbitalis*. Triangles - state record only

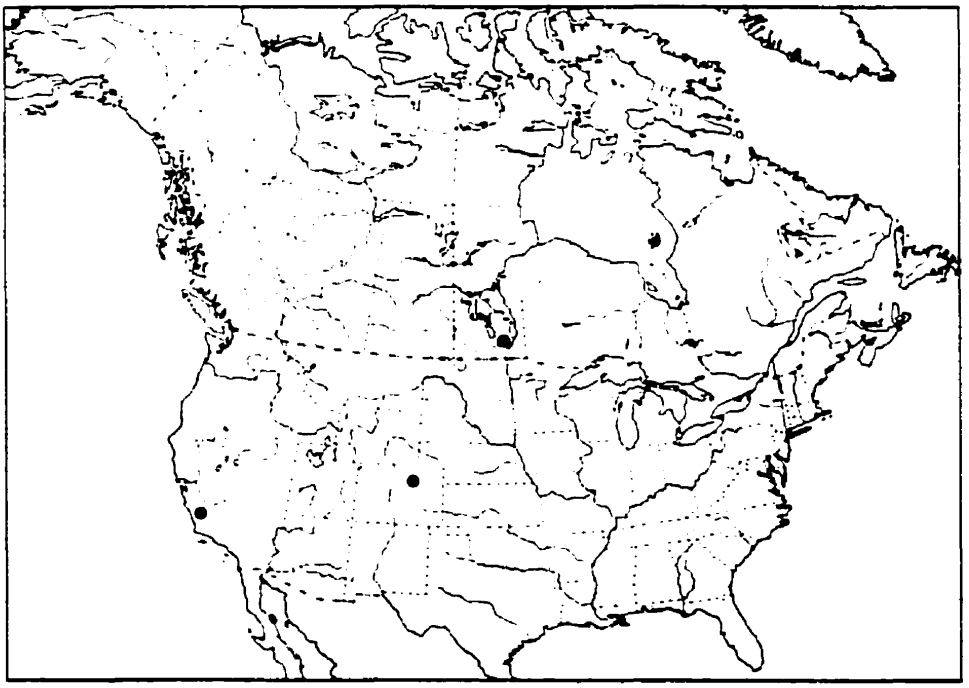

Fig. 46. Distribution of *Phytobia vanduzeei*

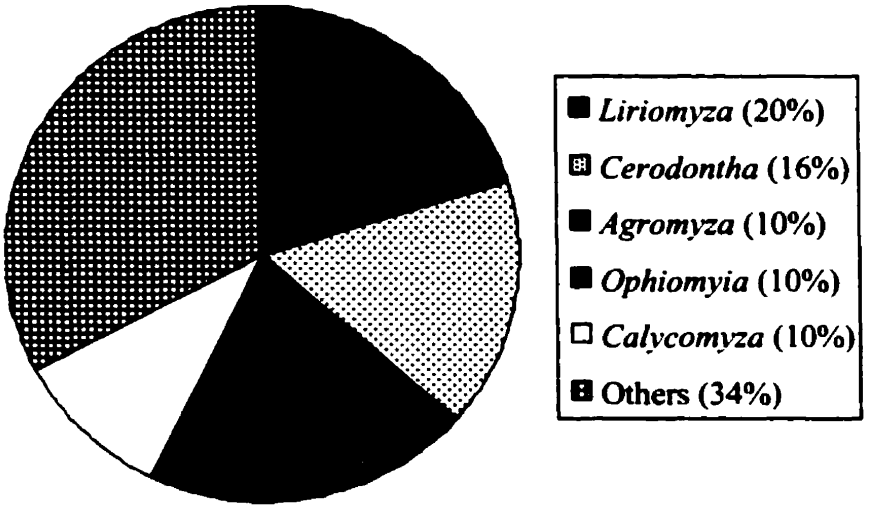

Fig. 47. Overall diversity of Agromyzidae genera at all sites in southern Manitoba. (1996-2000).

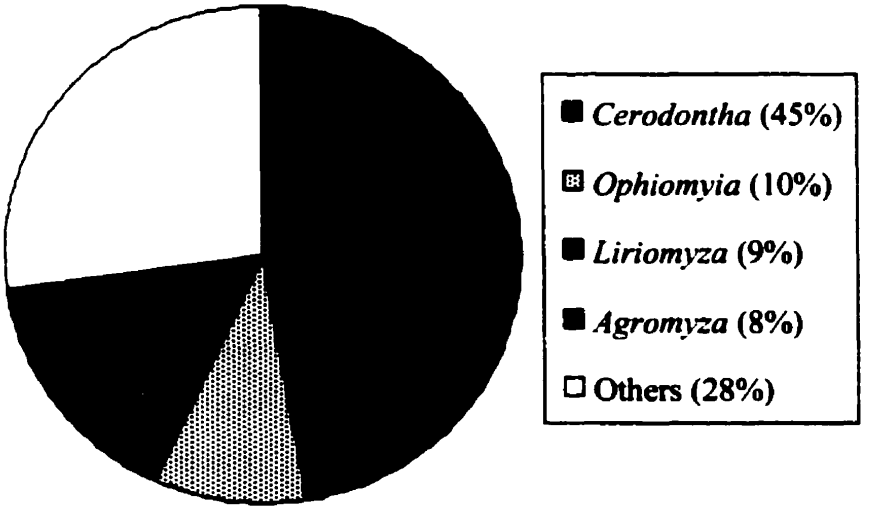

Fig. 48. Overall abundance of Agromyzidae genera at all sites in southern Manitoba. (1996-2000).

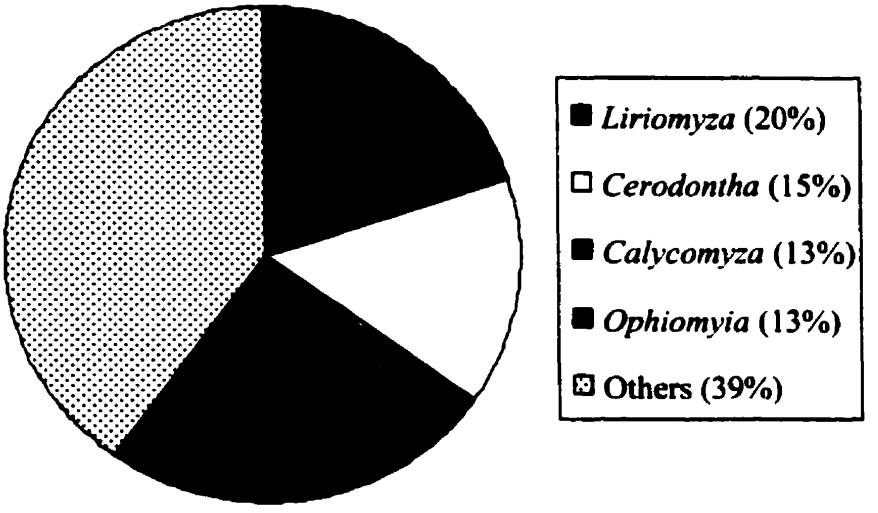

Fig. 49. Diversity of Agromyzidae genera at the St. Charles Rifle Range. (1997-2000)

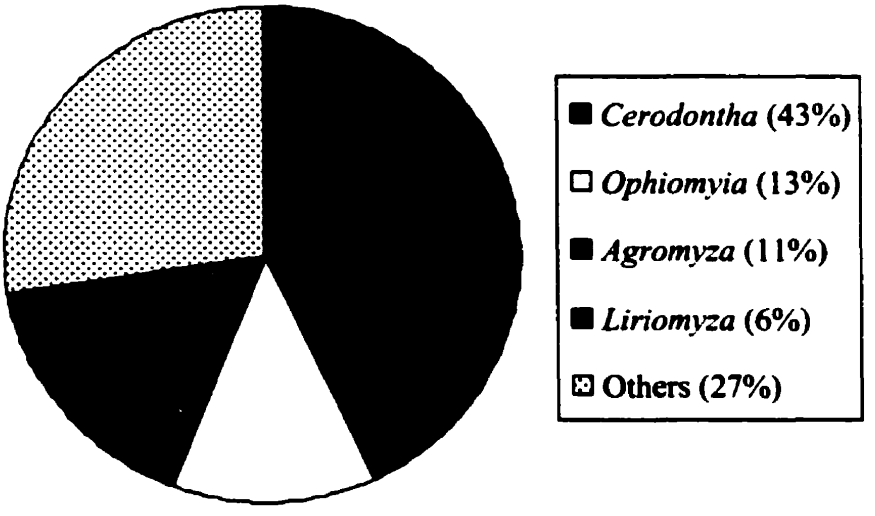

Fig. 50. Abundance of Agromyzidae genera at the St. Charles Rifle Range. (1997-2000)

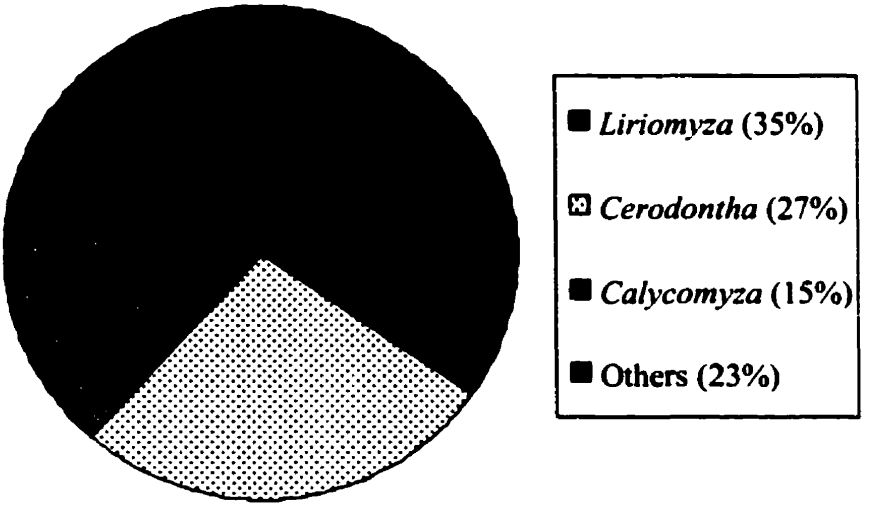

Fig. 51. Diversity of Agromyzidae genera at Gardenton North. (1999-2000).

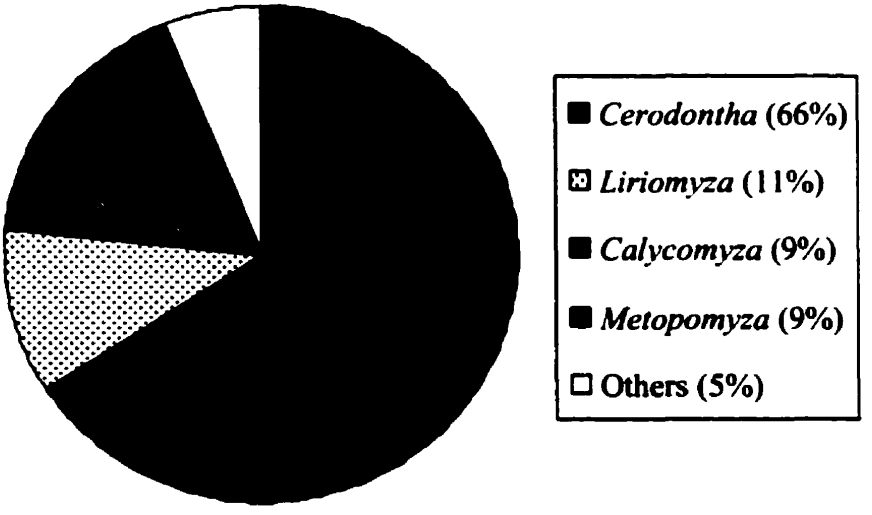

Fig. 52. Abundance of Agromyzidae genera at Gardenton North. (1999-2000).

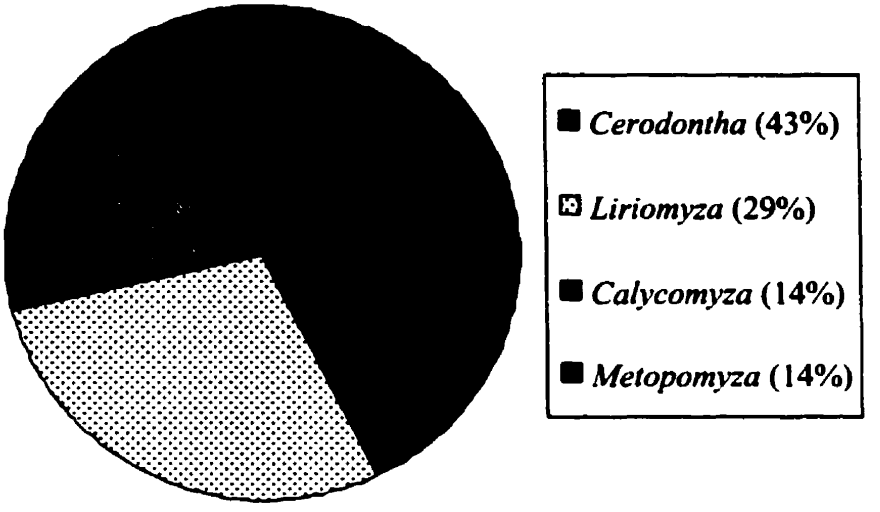

Fig. 53. Diversity of Agromyzidae genera at Gardenton South. (1999-2000).

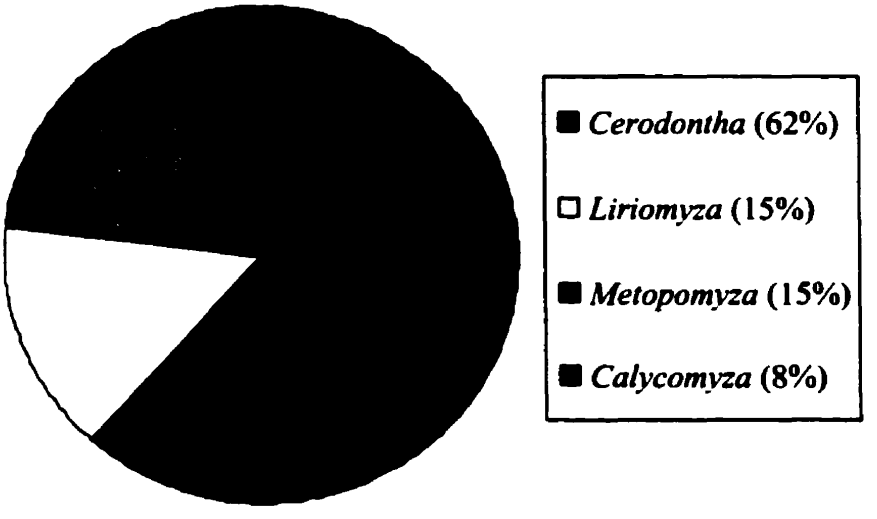

Fig. 54. Abundance of Agromyzidae genera at Gardenton South. (1999-2000).

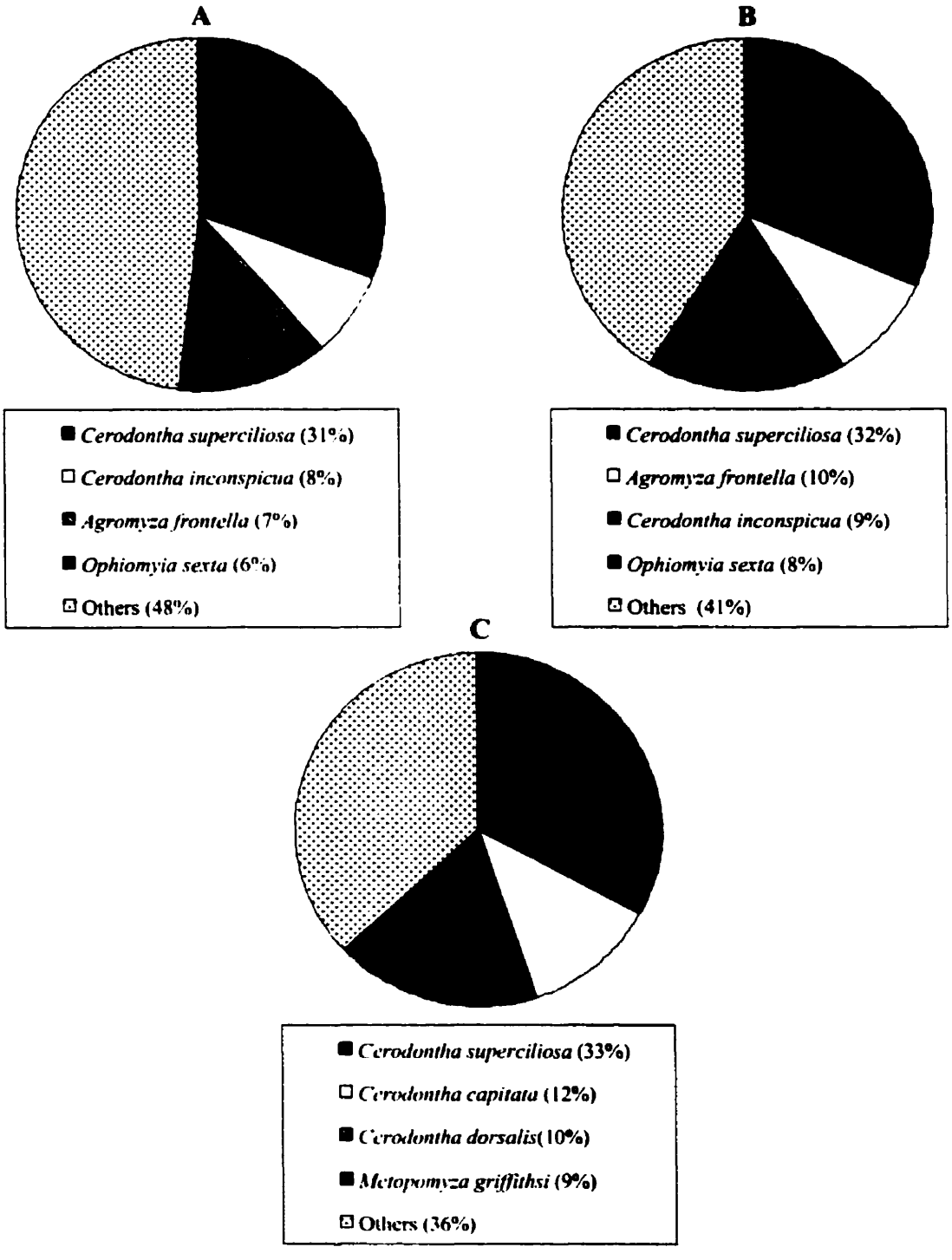

Fig. 55. Abundance of Agromyzidae species. A. Overall; B. St. Charles Rifle Range; C Gardenton North.

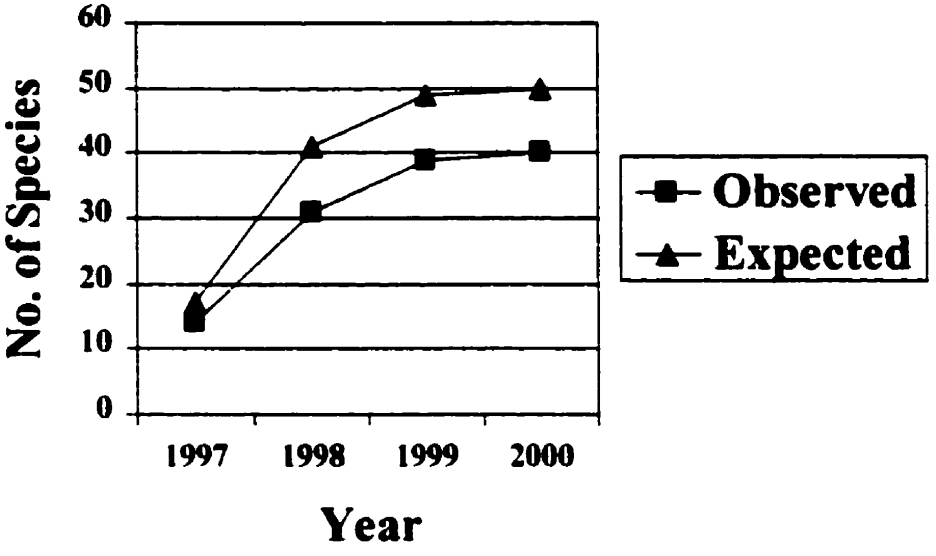

Fig. 56. Species Collectors Curve for St.Charles Rifle Range (1997-2000).

Appendix 1. Diversity and abundance of Agromyzidae identified from Ojibway Prairie, Ontario. Species shared with primary study sites are indicated.

Species	Specimens	Shared
Agromyza bispinata Spencer	4	
Hexomyza n. sp.	2	
Japanagromyza viridula (Coquillett)	4	
Melanagromyza buccalis Spencer	3	
Melanagromyza fastosa Spencer	4	
Melanagromyza virens (Loew)	3	
Ophiomyia texana Spencer	2	
Calycomyza menthae Spencer	3	✚
Cerodontha chaixiana (Groschke)	3	
Cerodontha dorsalis (Loew)	18	✚
Cerodontha inconspicua (Malloch)	12	✚
Cerodontha muscina (Meigen)	2	
Cerodontha pollinosa (Melander)	1	
Cerodontha superciliosa (Zetterstedt)	1	✚
Chromatomyia compta Spencer	1	
Liriomyza endiviae Hering	2	
Liriomyza trifolii (Burgess)	2	
Phytoliriomyza hilarella (Zetterstedt)	2	
Phytomyza n. sp.	11	
Total specimens	80	
Total species	19	

Appendix 2. Diversity and abundance of Agromyzidae identified from alvars on Manitoulin Island, Ontario. Species shared with primary study sites are indicated.

Species	Specimens	Shared
Agromyza albipennis Meigen	5	
Agromyza artistata Malloch	3	
Melanagromyza alaskae Spencer	2	
Melanagromyza shewelli Spencer	10	✚
Melanagromyza vernoniana Steyskal	3	
Melanagromyza virens (Loew)	13	
Ophiomyia coniceps (Malloch)	28	✚
Ophiomyia nasuta (Melander)	2	✚
Calycomyza menthae Spencer	4	✚
Calycomyza michiganensis Steyskal	4	
Calycomyza promissa Frick	5	✚
Calycomyza solidaginis (Kaltenbach)	4	✚
Cerodontha dorsalis (Loew)	26	✚
Cerodontha impercepta Spencer	40	
Cerodontha inconspicua (Malloch)	1	✚
Cerodontha magnicornis (Loew)	2	✚
Cerodontha pygmaea (Meigen)	1	
Cerodontha superciliosa (Zetterstedt)	2	✚
Chromatomyia caprifoliae (Spencer)	4	✚
Chromatomyia fuscula Zetterstedt	9	
Liriomyza eupatorii (Kaltenbach)	7	
Liriomyza virginica Spencer	3	
Paraphytomyza orbitalis (Melander)	1	✚
Phytobia betulivora Spencer	3	
Phytoliriomyza conspicua (Sehgal)	1	
Phytoliriomyza dorsata (Siebke)	1	
Phytoliriomyza pallida (Sehgal)	1	
Total specimens	185	
Total species	27	