

## Chapter 7

# The Robber Flies (Diptera: Asilidae) of Western Canadian Grasslands

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**Abstract:** Robber flies (Asilidae) are predatory Diptera that kill other insects with paralyzing saliva injected through the proboscis. Over 7,000 species of the family are described worldwide and, although there is no list of species, well over 200 are reported in Canada. The present analysis indicates that grasslands and grassland–forest interface areas in western Canada (Yukon and British Columbia east to Manitoba) support 134 species of robber flies, and more remain to be recorded. A checklist and a systematic overview of these species are presented. The geographical scope of the Canadian grassland fauna is described briefly with respect to the grasslands of the Cordillera and the Great Plains. The species' geographical ranges are defined and summarized. Of the 134 grassland species, seven are boreal (including two with Holarctic ranges), three are East Beringian, one is Palearctic–East Beringian, four are transition, 66 are Cordilleran, five are Pacific coastal, eight are western, 23 are Great Plains, four are southern, 10 are eastern, and three are widespread species, according to the definitions given here. A summary of studies on grassland Asilidae is provided, as well as recommendations for inventory and taxonomic research.

**Résumé.** Les asilides (Asilidae) sont des diptères prédateurs qui tuent d'autres insectes en leur injectant une salive paralysante à l'aide de leur trompe. Plus de 7 000 espèces de cette famille ont été décrites à travers le monde, et le nombre d'espèces présentes au Canada est de loin supérieur à 200, bien qu'on n'en ait pas encore établi la liste. La présente analyse indique que les habitats des prairies et de l'interface prairie–forêt de l'ouest du Canada (Yukon et Colombie-Britannique, jusqu'au Manitoba vers l'est) abritent 134 espèces d'asilides, et qu'il pourrait y en avoir plus. Ce chapitre présente une liste et un aperçu de la systématique de ces espèces. La portée géographique de la faune de la prairie canadienne est brièvement décrite en ce qui a trait aux habitats des prairies qui se trouvent dans la Cordillère et dans les Grandes Plaines. Les aires de répartition géographiques des espèces sont définies et brièvement décrites. Sept des 134 espèces répertoriées dans les prairies sont boréales (y compris deux à aire de répartition holarctique), trois sont de la Bérिंगie orientale, une vient de la zone paléarctique–Bérिंगie orientale, quatre sont des espèces de transition, 66 sont de la Cordillère, cinq sont de la côte du Pacifique, huit sont occidentales, 23 viennent des Grandes Plaines, quatre sont méridionales, 10 sont orientales et trois sont largement réparties, selon les définitions utilisées dans ce chapitre. Le chapitre présente un résumé des études réalisées sur les Asilidae, ainsi que des recommandations concernant les travaux d'inventaire et les études taxonomiques à réaliser.

### Introduction

The Asilidae contain over 7,000 described species worldwide (Geller-Grimm 2013). More than 200 species are reported in Canada (McAlpine 1979), although this number is out of date; no list exists, and the true number is certainly considerably higher. The Asilidae are predominantly a group of warm regions and are especially diverse in open arid and semi-arid environments. Grasslands are good places to find a wide range of genera and species, and probably more than half of the Canadian fauna is known from western grasslands.

Knowledge of the Canadian fauna as a whole is only fair, and any attempt to put the fauna of Canadian grasslands into perspective must be preliminary. Collections are full of unidentified and inaccurately identified specimens.

The world genera of Asilidae are examined by Hull (1962), and the North American genera are keyed by Wood (1981), although these treatments are out of date. Wood (1981) gives a summary of the morphology, biology, and classification of the North American fauna, and Fisher (2009) updates this with an excellent overview of the family, with special reference to Central America. A comprehensive website devoted to the Asilidae (Geller-Grimm 2013) covers topics from morphology and identification to behaviour and phylogenetics, and includes a worldwide catalogue.

The higher classification of the family is still in some turmoil and additional comprehensive phylogenetic studies are required to clarify understanding of the relationships of taxa at all levels. The scheme of Papavero (1973) and Artigas and Papavero (1988) for the New World fauna was adopted tentatively by Fisher and Wilcox in their Nearctic catalogue of the family (1997), and Fisher (2009) used a modified version of the Papavero classification in his major work on the Central American asilids. Dikow's (2009a, 2009b) phylogenetically based family classification was an ambitious and welcome attempt to inject scientific rigor and stability into the classification; the new work answered some old questions but also presented new ones. Fisher (2012) wrote a summary of his view of the problems and concluded by stating that some version of the Papavero classification is, for the time being, still preferable to any other. He recommended using the subfamilies found in Fisher and Wilcox (1997) without recognizing any tribes. I follow his suggestion in this chapter.

Although the oldest unambiguous asilid fossil is from the Lower Cretaceous of Brazil (97.5–144 million years before present (mbp)) (Grimaldi 1990), robber flies do not appear in the fossil record in western North America until the Late Early to the Late Middle Eocene, 52–47 mbp (Green River shales of the Utah Eocene) (Wilson 1978). The Florissant shales of Colorado (Oligocene, 23.7–36.6 mbp) contain a variety of genera living in Canadian grasslands today, including *Leptogaster* (Leptogastrinae); *Cophura*, *Lestomyia*, and *Nicocles* (Dasypogoninae); *Dioctria* and *Holopogon* (Stenopogoninae); and *Machimus* (Asilinae). The Florissant fossil site was subtropical savanna woodland (Cronquist 1978).

## Biology

Asilids are predatory flies that as adults pursue other insects (usually flying ones), seize them, and kill them with paralyzing saliva injected through the hypopharynx. The liquified contents of the prey are then sucked up through the proboscis (Wood 1981). The morphology of the adult fly (especially the prominent eyes separated by a cleft, the mouthparts, and the raptorial legs) reflects this mode of prey capture and feeding.

In temperate climates, robber flies usually hunt in open areas where there is plenty of light, and they are most active in the warmest parts of the day (Cannings 2002). Overcast skies greatly curtail their activity. Different genera, and often different species within a genus, have different hunting behaviours and preferences for perching sites (Fisher 2009).

There is usually little obvious difference between the sexes, except for the terminalia (the morphology of which is sometimes striking, as in *Efferia*), although females tend to be larger than males and often have broader abdomens. Colour patterns sometimes differ between males and females; this is particularly evident in some Canadian grassland species such as *Cyrtopogon bimaculus*, where the male's wings are prominently spotted and those

of the female are not. Other secondary sexual characteristics occur in males; some that are displayed in grassland species include the expanded silver abdominal apex in *Nicocles*, the striking white abdomens of *Efferia*, and the tarsal ornamentation of some *Cyrtopogon* species, especially *C. willistoni*. Males of these latter species signal with their decorated legs during mating displays.

Records of prey taken by Asilidae indicate that they are usually opportunistic predators, feeding upon any insect that they can subdue and kill. However, some species show a strong preference for prey from one or two insect orders (Wood 1981). In many instances, this may simply reflect the availability of prey in the habitat where the particular robber fly lives.

Detailed life history studies of robber flies are rare. In a study on Asilidae in Sweden, Melin (1923) showed that in northern species, at least, the larva is the overwintering stage and the pupal stage lasts two to six weeks. He estimated that the life cycle of *Laphria* species was at least three years and that of *Lasiopogon cinctus* (Fabricius) was at least two. Both genera are found in Canadian grasslands, although *Laphria* is predominantly a forest group. Larval growth is likely faster in warmer regions and many species probably live only one year (Theodor 1980).

Robber fly larvae are predators of the larvae and pupae of other insects in the soil or in rotting wood, although in a few species studied, the immature larvae are ectoparasitic on their hosts (Wood 1981). Knutson (1972) and Dennis *et al.* (2013) reviewed the literature on the biology of immatures, and Dennis *et al.* (2008) documented the diversity of Nearctic robber fly pupal cases. Dennis and Barnes (2013) described the pupal case of *Machimus occidentalis*, an important Cordilleran grassland species.

## Summary of Taxonomic and Biodiversity Studies in the Region

### *General Faunal Treatments and Annotated Lists*

The standard catalogue of North American Asilidae (Martin and Wilcox 1965) is significantly outdated but still useful. More modern treatments are Fisher and Wilcox (1997) and Geller-Grimm and Artigas (2004), although the latter contains some unfortunate innovations, such as the creation of new *Efferia* genera based on Wilcox's (1966) species groups. The basic work on Canadian Asilidae is Wood (1981), which outlines morphology and keys the genera of the North American fauna. The list of genera is out of date. Although the family's biology is summarized, there is no specific grassland context to the work. No list of species for Canada as a whole has yet been published. The most significant treatments of provincial or territorial faunas are for Yukon (Cannings 1997) and Alberta (Adisoemarto 1967), but the latter needs revision. There is an up-to-date annotated list for British Columbia (Cannings 2012), but not for any other province. Cannings (1994) added species names to the known fauna of Canada as a whole, as well as to that of British Columbia, Yukon, and the Northwest Territories.

Taxonomy at the genus level is often inadequate for species identification. The diverse and complex genera in the Asilini, for example, are major components of the grassland fauna, but species keys and descriptions are out of date. Few attempts have been made to revise this group (e.g., Martin 1975); therefore, the early treatments such as that by Hine (1909) remain useful.

However, some studies are essential to the inventory of Canadian grassland Asilidae. Revisions of large genera such as *Cyrtopogon* (Wilcox and Martin 1936), *Dioctria* and related genera (Adisoemarto and Wood 1975), *Efferia* (Wilcox 1966), *Lasiopogon*

(Cole and Wilcox 1938; Cannings 2002), *Machimus* (Martin 1975), and *Stenopogon* and *Scleropogon* (Wilcox 1971) included grassland species in Canada. The various taxonomic works of Curran, for example, on *Cyrtopogon* and *Eucyrtopogon* (Curran 1923), and other descriptions of new species (e.g., *Promachus dimidiatus* and *Laphystia canadensis*; Curran 1927) are also relevant. Treatments of other genera vary widely in their usefulness.

### ***Studies of Particular Areas or Sites***

Few published studies have examined the asilid fauna of particular areas or grassland sites. In British Columbia, Foxlee's intensive collecting around Robson in the Columbia Valley of the West Kootenay resulted in specimens (a few are reported in Foxlee 1942) that are still the main source of information for that region. Although the Robson area is mostly dry coniferous forest, the area is transitional with grasslands. Most of the species Foxlee recorded are forest species, but some, such as *Machimus callidus*, *Cyrtopogon montanus*, *C. banksi*, and *Laphria gilva*, are grassland–forest interface species. Others, including *Machimus occidentalis* and *Stenopogon inquinatus*, also are common grassland species. Cannings (1989) published an account of the species from a mesic *Festuca* grassland in the southern Okanagan Valley. Norman Criddle's collections of robber flies from Aweme, Manitoba, in the early 1900s (mostly in the Canadian National Collection of Insects) remain the basis of our understanding of the southern Manitoba fauna.

### ***Conservation Studies***

General inventories or conservation-motivated collecting in rare habitats (e.g., Cannings 1989, 2011a) have improved knowledge of the status of rare asilid species, but few species have been targeted for conservation study. It should be noted that in Ontario (outside the scope of this chapter), several robber fly surveys have been undertaken in threatened tallgrass prairie ecosystems (Skevington 1999; Skevington *et al.* 2000; Paiero *et al.* 2008, 2010). Nationally, species of various groups have been given a general conservation rank (Wild Species 2005, 2010), but the Asilidae have yet to be examined. Provincial and territorial jurisdictions have also not assessed or ranked robber flies. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has commissioned status reports on only one asilid, *Efferia okanaganana*, a grassland species from the southern interior of British Columbia. It is assessed as “Endangered” (Cannings 2011a; COSEWIC 2012).

### ***Other Studies***

Other specific studies dealing with taxonomy, morphological variation, distribution, life histories, and other aspects of asilid biology in Canadian grasslands are cited under the relevant genus or species in the systematic treatment below.

### ***Research Priorities***

Little significant directed inventory of robber flies has been undertaken in Canadian grasslands. Knowledge of the distribution and status of the species on the list in Table 1 has come mostly from sporadic collecting over many years and analysis of specimens in the following insect collections: Royal BC Museum, Victoria; Spencer Entomological Collection, Beaty Biodiversity Museum, University of British Columbia, Vancouver; Strickland Museum, University of Alberta, Edmonton; Royal Alberta Museum, Edmonton; Biological Sciences Collection, University of Calgary, Calgary; Royal Saskatchewan Museum, Regina; the Wallis-Roughley Museum, University of Manitoba, Winnipeg; University of Guelph Collection, Guelph; Royal Ontario Museum, Toronto, and especially

the Canadian National Collection of Insects, Agriculture and Agri-Food Canada, Ottawa. Increased inventory efforts would especially improve our knowledge of the species that probably range widely across grassland regions, but are known from few localities. A detailed examination of some of the genera in grassland–forest transition areas, such as *Cyrtopogon*, *Holopogon*, and *Laphria*, will result in a better understanding of species requirements and distributions in these habitats.

Unfortunately, despite considerable effort, many asilid specimens in Canadian collections remain unidentified or inaccurately identified because of a lack of expertise, time, modern generic revisions, and useful identification keys. Systematic work is required to clarify the identity and evolutionary relationships of species in a number of genera. *Leptogaster*, *Lestomyia*, *Eucyrtopogon*, *Machimus*, and other genera require revision. There are undescribed species in these genera and many specimens cannot be identified to species.

More studies are required to better define occurrence and abundance for almost all species of asilids in grasslands. This is especially true in parts of the Prairies Ecozone where some areas (southern Saskatchewan, in particular) have been poorly collected. Detailed, annotated site lists developed over several years would be extremely valuable in all regions. With potential climate warming, baseline data on distribution and habitat (including detailed soil and vegetational characteristics) are of the utmost value, and continuous monitoring of sites, especially in areas of transition between grassland and forest, would be useful in detecting any changes in species composition and abundance of asilid populations. Studies examining the effects of disturbance and habitat change on species are needed. No work has been undertaken that examines the effects of human activity on grassland robber flies, such as overgrazing and fire, increases in soil temperature, and infestations of alien plants. Our knowledge of the habitat requirements of most species is non-existent and more autecological studies would be helpful.

Climate change may significantly affect present asilid distributions if grasslands increase in extent and forest types shift in altitude and coverage. Hebda (1982, 1995) revealed that grassland-steppe vegetation was much more prevalent in the southern part of the Montane Cordilleran Ecozone (containing most grasslands in British Columbia) during warmer climatic regimes in the early to mid-Holocene than it is today. Arid grassland asilids such as *Lasiopogon albidus* Cole and Wilcox and *L. chaetosus* Cole and Wilcox, which now range as far north as the Columbia Basin in Washington State, might enter some of the valleys of southern British Columbia if dry habitats proliferate.

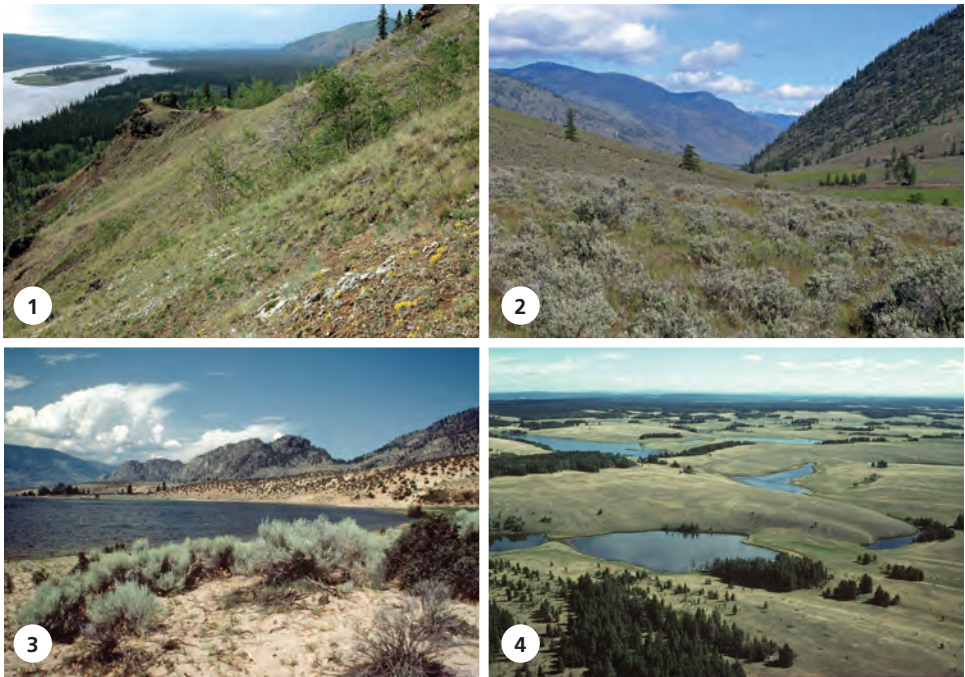
Monitoring of conservation status is also a priority as habitats and climate fluctuate in character. Even when species have already been assessed (such as *Efferia okanagana*, noted above), COSEWIC and provincial agencies require regular updates; therefore, more status reports will likely be required as drying habitats affect populations of rare species.

## Overview of the Asilidae of Western Canadian Grasslands

### *Grassland Habitats and Robber Fly Communities*

The correlation of robber fly distribution and habitat requirements with detailed schemes of grassland vegetation or soil classification is largely lacking in western Canada or elsewhere, except for the general association of species with particular sites or areas. Cannings (2011a) is a rare example of a study that links the presence of a robber fly species (*Efferia okanagana*) to particular vegetational and soil characteristics in the Thompson-Okanagan region of southern British Columbia.

Some complexities of robber fly communities in grasslands can be illustrated by a brief summary of a few grassland types in southern interior British Columbia and some asilid species associated with them. The dry intermountain grasslands or steppes are dominated by various bunchgrass species and occur in three biogeoclimatic zones (Bunchgrass, Ponderosa Pine, and Interior Douglas-fir zones) (Meidinger and Pojar 1991; Cannings and Cannings 1996; BC Ministry of Forests and Range 2013). Lower elevation grasslands, below about 500 m, are characterized by an arid community of plants dominated by bluebunch wheat grass, *Pseudoroegneria spicata* (Pursh) A. Löve, and big sagebrush, *Artemisia tridentata* Nutt. In sandy soils in the south Okanagan and southern Rocky Mountain Trench, antelope brush (*Purshia tridentata* (Pursh) DC.) may replace sagebrush as a shrub. Middle grasslands on north-facing slopes in the main valleys and in areas such as the Nicola Valley generally lack sagebrush. Sandberg bluegrass (*Poa secunda* J. Presl)



**Figure 1.** South-facing grassland slopes along the Yukon River, downstream of Minto Bluff, Yukon. The dominant grass is *Calamagrostis purpurascens*. Robber flies frequenting this habitat include *Lastopogon canus*, *L. hinei*, *L. prima*, *L. yukonensis*, *Cyrtopogon bimaculus*, and *Rhadiurgus variabilis*. Photograph courtesy of Syd Cannings. **Figure 2.** *Artemisia tridentata* (Big Sagebrush) steppe at Chopaka, British Columbia. View north up Similkameen Valley towards Keremeos. Typical robber flies in this habitat are *Stenopogon inquinatus*, *Scleropogon neglectus*, *Efferia benedicti*, *E. harveyi*, and *Machimus occidentalis*. Photograph by Rob Cannings. **Figure 3.** Sandy grassland on east shore of Osoyoos Lake, southern Okanagan Valley, British Columbia. Pale blue shrubs in foreground are Big Sagebrush (*Artemisia tridentata*); dark shrubs in middle distance are Antelope-brush (*Purshia tridentata*). *Efferia albibarbis*, *Proctacanthus occidentalis*, and *Stichopogon fragilis* are some asilid inhabitants of this area. Photograph by Rob Cannings. **Figure 4.** Aerial view of Becher's Prairie, Riske Creek, Chilcotin, British Columbia. Surrounded by coniferous forests on BC's extensive central plateau, these grasslands are home to asilids such as *Cyrtopogon willistoni*, *Dicropaltum mesae*, *Efferia coulei*, *Eucyrtopogon comantis*, and *Stenopogon rufibarbis*. *Laphria* species (e.g., *L. fernaldi*, *L. janus*, and *L. sadales*) and other forest asilids often appear in the grassland-forest interface. Photograph by Rob Cannings.



**Figure 5.** South Saskatchewan River Valley north of Burstall, Saskatchewan, just east of the Alberta border. *Efferia bicaudata*, *E. frewingi*, *Machimus aridalis*, *Ospricerus aeacus*, *Proctacanthella cacopiloga*, *Stenopogon coyote*, and *S. inquinatus*, among other species, live here. Photograph courtesy of John Acorn. **Figure 6.** Great Sand Hills, Saskatchewan. *Dicropaltum cumbipilosus*, *D. mesae*, *Laphystia flavipes*, *Lasiopogon terricola*, *Stenopogon inquinatus*, and *Stichopogon trifasciatus* are typical species. Photograph courtesy of John Acorn. **Figure 7.** Grasslands in the Aspen Parkland Ecoregion (Prairies Ecozone) along the north bank of the Assiniboine River at its confluence with the Souris River, northeast of Treesbank, Manitoba. Robber flies expected in this habitat include *Efferia helenae*, *Holopogon vockerothi*, *Machimus erythrocnemius*, *Proctacanthus milbertii*, and *Promachus dimidiatus*. Photograph courtesy of Colin Jones.

predominates with bluebunch wheat grass and other species. The Upper Grasslands lie above about 800 or 1,000 m on hillsides and on the southern plateaus. Various species of fescues (*Festuca* spp.) usually dominate the cover, although wheat grass and needlegrasses (*Stipa* spp.) are common and prevail in such regions as the Cariboo and Chilcotin plateaus (Nicholson *et al.* 1982). Some robber flies prefer specific grassland habitats that depend on elevation, soil type, and vegetation composition and structure; others are more widespread across different grassland types. Some species range into open ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson) or Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) woods because much of the understorey of such habitats is similar to that of adjacent grasslands. Widespread, common species include *Scleropogon neglectus*, *Stenopogon inquinatus*, *Efferia benedicti*, *E. harveyi*, *Proctacanthus milbertii*, *Machimus occidentalis*, and *Neomochtherus willistoni*. Examples of others that occur in grasslands and adjacent open forests in the southern valleys, but are rare, are *Dicolonus nigricentrus*, *Leptogaster formicata*, *Nicocles utahensis*, *Ospricerus aeacus*, and *Willistonina bilineata*. In low-elevation, sandy, xeric habitats, characteristic species are *Stichopogon fragilis*, *Efferia albibarbis*, and *Proctacanthus occidentalis*. In silty soil where big sagebrush flourishes, *Efferia benedicti* is common. If forbs are abundant, the rare *Megaphorus willistoni* may occur. *Efferia staminea* and *E. okanagan* prefer bluebunch wheat grass communities in well-drained sites. Middle and higher grasslands dominated by *Festuca* grasses support

species such as *Comantella pacifica* and *Lestomyia* sp., with *Myelaphus lobicornis* apparently occurring only where common rabbitbrush (*Chrysothamnus nauseosus* (Pall.) Britt.) grows. Species typical of the central plateaus tend to be widespread grassland species in British Columbia: *Dicropaltum mesae*, *Efferia coulei*, *E. harveyi*, *Stenopogon inquinatus*, *Scleropogon neglectus*, and *Machimus occidentalis*.

### **Robber Fly Faunas of Regional Grasslands Cordillera**

#### **Yukon**

The most familiar Yukon grasslands are those on steep south-facing slopes in dry parts of the south and central Yukon (Boreal Cordillera Ecozone), dominated by pasture sage (*Artemisia frigida* Willd.) and grasses such as *Calamagrostis purpurascens* R. Br., *Festuca brachyphylla* Schult. ex Schult. and Schult., and *Poa glauca* Vahl (Scudder 1997; Shorthouse 2010b) (Fig. 1). Extensive dune systems in southern Yukon, whose primary vegetation is sparse sedges and grasses (e.g., *Carex sabulosa* Tircz. ex Kunth and *Elymus calderi* Barkworth), support asilid species that are similar to those found on grassland ridges and the edges of dry, open pine and spruce woodlands. The main dune systems examined for asilids in Yukon are those at Carcross, Takhini River, Alsek River, Slims River, Sekulmun Lake, and several sand blowouts along the Yukon River, especially near Whitehorse (COSEWIC 2011). Characteristic robber flies of these grasslands are the East Beringian *Lasiopogon canus*, *L. prima*, and *L. yukonensis*, as well as the Palearctic–East Beringian *L. hinei*. The boreal *Rhadiurgus variabilis* is common, as is the boreal *Cyrtopogon bimaculus* and the Cordilleran *C. banksi*.

#### **British Columbia**

Shorthouse (2010b) discusses the wide distribution and complexity of grasslands in British Columbia. About three-quarters of the province's known asilid species are recorded in grasslands. Diversity is greatest in intermontane grasslands in the Montane Cordillera Ecozone east of the Coast Mountains (Cannings 2011b), especially in the warm valleys south of 51°N. Two biogeoclimatic zones, the Bunchgrass and Ponderosa Pine zones, in the Thompson–Okanagan, Cariboo–Chilcotin, and East Kootenay regions are the main focus. Big sagebrush and bluebunch wheat grass occur in the bottomlands of the Thompson and Okanagan valleys, usually below 500 m (Fig. 2), although antelope brush is often a more common shrub in sandy or gravelly soils (Fig. 3). At higher elevations and in more northern plateaus in the Cariboo–Chilcotin (Fraser Plateau Ecoregion) (Fig. 4), other grass ecosystems develop. East Kootenay grasslands lie in the Ponderosa Pine Zone at low elevations in the Southern Rocky Mountain Trench Ecoregion, immediately west of the Rockies. Although these grasslands are similar to those in the Bunchgrass Zone to the west, in some areas they support species typical of the Great Plains east of the Rockies, such as blue grama, *Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths. Asilid species found in the grasslands of the Montane Cordillera Ecozone that are absent or rare elsewhere in Canadian grasslands include *Dicolonus nigricentrus*, *Efferia benedicti*, *E. coulei*, *E. harveyi*, *E. okanagan*, *Stichopogon fragilis*, *Willistonina bilineata*, *Dioctria henshawii*, *Megaphorus willistoni*, *Myelaphus lobicornis*, and *Proctacanthus occidentalis*. Other characteristic species are *Efferia staminea*, *Machimus occidentalis*, *M. vesus*, *Neomochtherus willistoni*, *Proctacanthus milbertii*, *Scleropogon neglectus*, *Stenopogon inquinatus*, and *S. rufibarbis*.



In the Boreal White and Black Spruce Biogeoclimatic Zone east of the Rockies (Boreal Plains Ecozone), special grasslands occur on the south-facing slopes of the Peace River Valley (Peace Lowland Ecoregion). These river valley “breaks” are composed of grasses such as western porcupine grass (*Stipa curtisetata* Hitchc.) and Columbia needlegrass (*Achnatherum nelsonii* (Scribn.) Barkworth) and have characteristics that suggest they were connected to the mixed grasslands of what is now south-central Alberta during warmer and dryer periods, 4,000 to 8,000 years ago (Shorthouse 2010a). Most other grasslands in the ecoregion have been converted to agriculture. The robber fly fauna is similar to that of the adjacent Aspen Parklands of Alberta. Species such as *Stenopogon inquinatus* and *Lasiopogon hinei* are typical along trails in the grasslands, with the Great Plains species *Lasiopogon quadrivittatus* hunting along the banks of the Peace River itself.

The Garry oak meadows of southeastern Vancouver Island and the Gulf Islands are coastal grassland and savanna, the driest part of the Coastal Douglas-fir Biogeoclimatic Zone (Pacific Maritime Ecozone). Summer drought produces meadows and open parkland characterized by two broad-leaved trees, arbutus (*Arbutus menziesii* Pursh) and Garry oak (*Quercus garryana* Douglas ex Hook.). Characteristic asilid species include *Machimus occidentalis*, *Neomochtherus willistoni*, and *Scleropogon bradleyi*, all shared with the grasslands of the southern interior of the province. *Dicolonus simplex*, *Eudioctria nitida*, *Laphria ventralis*, *Nicocles canadensis*, and *N. rufus* are found in no other Canadian grasslands.

### Great Plains

Shorthouse (2010a) gives an overview of the grasslands of the Central Plains of western Canada. The Prairies Ecozone has a diverse asilid fauna with several notable, but not surprising, patterns. Cordilleran species such as *Cyrtopogon willistoni*, *Lasiopogon cinereus*, *Machimus callidus*, and *Nicocles utahensis* range east from the Rockies into the western Prairies Ecozone to varying degrees. Most of the asilids in the region have extensive ranges on the Great Plains of the United States; species such as *Efferia costalis*, *E. subcuprea*, *Megaphorus guildiana*, and *Scleropogon coyote* have extended from the south into the Mixed Grassland Ecoregion (Figs. 5 and 6). In southern Manitoba, a few eastern species (e.g., *Laphria flavicollis*, *Holopogon vockerothi*, *Machimus notatus*, and *Tipulogaster glabrata*) have penetrated prairie habitats in the Aspen Parklands (Fig. 7) and Lake Manitoba Plain ecoregions, and at least one, *Lasiopogon terricola*, at home in open, sandy areas, ranges all the way to Alberta. Other eastern species, such as *Cyrtopogon varans* and *Laphria cinerea*, have not moved westward from the grassland–forest interface in southeastern Manitoba. Boreal and transition species living in the forests of the Boreal Plains Ecozone to the north also appear in grasslands and transitional areas (especially in the Aspen Parklands and in isolated forested uplands such as Cypress Hills). These include *Laphria gilva*, *L. insignis*, *L. janus*, *L. scorpio*, *Cyrtopogon bimaculus*, *C. falto*, and others. Species more or less restricted to the Prairies Ecozone in Canada are *Cyrtopogon platycaudus*, *Dicropaltum cumbipilosus*, *Efferia bicaudata*, *E. costalis*, *E. helenae*, *E. subcuprea*, *Heteropogon wilcoxi*, *Holopogon seniculus*, *Laphystia canadensis*, *Lasiopogon quadrivittatus*, *L. terricola*, *L. trivittatus*, *Machimus adustus*, *M. aridalis*, *M. delusus*, *Megaphorus guildiana*, *Ospriocerus latipennis*, *Promachus dimidiatus*, and *Scleropogon coyote*. A few, such as *Proctacanthella cacopiloga* and *Laphystia flavipes*, are mostly Great Plains species, but range east into southwestern Ontario grassland and dune remnants.

### Defining Western Grassland Asilidae

There is a distinct robber fly fauna in western Canadian grasslands, although its composition

varies geographically. As in most insect groups, considerable mixing of forest and grassland species occurs at the interface between the two biomes. In British Columbia, for example, the complex interdigitation of forest and grassland areas, both altitudinally and latitudinally, promotes the presence, in some grasslands, of montane species (*Cyrtopogon montanus*, *Laphria fernaldi*, *Machimus callidus*) or northern species (*Laphria insignis*, *Rhadiurgus variabilis*). This also happens more broadly at the interface of grassland and forest in the Prairie Provinces where northern species, such as *Cyrtopogon bimaculus*, *Laphria gilva*, and *L. janus*, encroach on the grasslands, especially on south-facing hillsides in the Aspen Parklands, but also along the southern parts of the boreal forest and more discrete areas such as the forest “islands” of southern Manitoba and the Cypress Hills of Alberta and Saskatchewan. In extreme southeastern Manitoba a similar phenomenon occurs where the eastern forest fauna meets that of the Prairies. Some eastern species that are at home in open habitats have spread into grasslands (or urban or agricultural areas that once were grassland) (e.g., *Machimus notatus*, *Holopogon vockerothi*), but some eastern forest species remain tied to the forests or the forest–grassland interface near the Ontario–Manitoba border (e.g., *Laphria cinerea*, *Neoitamus orphne*). Savanna habitats such as the Garry oak meadows of southeastern Vancouver Island and the Gulf Islands support some primarily grassland species (e.g., *Dicolonus simplex* and *Scleropogon bradleyi*). Although the tallgrass prairie and oak savanna remnants of southwestern Ontario are not treated in this chapter, it should be noted that they contain some grassland species not found in western Canada (e.g., *Holcocephala abdominalis* (Say)), as well as some that are widespread in the West (e.g., *Proctacanthella cacopiloga* and *Stichopogon trifasciatus*) (Skevington 1999). Dune systems in the Prairies Ecozone (Fig. 6) and in Ontario (e.g. *Laphystia* species) and Yukon (especially Beringian *Lasiopogon* species) are also home to a fauna mainly characteristic of grasslands, even though some of these dune habitats may be isolated in forested environments. A core list of typical grassland species can be established, but the makeup of a more complete and accurate list is complicated by the difficulty of defining a grassland species. In this examination of the fauna, I have arbitrarily included all species recorded within the ecoregions and localities that I use to represent the grassland environments of western Canada.

The robber fly species shared by all the various types of western Canadian grasslands discussed here (from Yukon to Manitoba) are few and include only boreal species that enter grasslands mostly in the interface with forests: *Laphria insignis*, *L. posticata*, and *Cyrtopogon bimaculus*. The small Yukon list results in the omission of many common, more southerly species. With the deletion of typically woodland flies and the inclusion of only species widespread in the majority of Canadian grasslands (British Columbia and at least two of the Prairie Provinces), the list is longer: *Leptogaster coloradensis*, *Holopogon albipilosa*, *Ospriocerus aeacus*, *Stenopogon inquinatus*, *S. rufibarbis*, *Lasiopogon prima*, *L. quadrivittatus*, *Dicropaltum mesae*, *Efferia frewingi*, *Machimus erythrocnemius*, and *M. paropus*.

Some genera are typical of western grasslands. For example, the 11 species of western Canadian *Efferia* are found only in grasslands in the region. Most species of *Comantella*, *Dicolonus*, *Dicropaltum*, *Laphystia*, *Lasiopogon*, *Leptogaster*, *Lestomyia*, *Machimus*, *Megaphorus*, *Myelaphus*, *Negasilus*, *Ospriocerus*, *Proctacanthella*, *Proctacanthus*, *Promachus*, *Scleropogon*, *Stenopogon*, and *Stichopogon* are largely restricted to grasslands or dune fields in western Canada. Many of the species found in the habitats at the interface between grasslands and forests belong to the large genera *Cyrtopogon*, *Laphria*, and *Machimus*. Regional grassland species lists are usually strikingly different from each other; taxa more or less restricted to the various grassland regions of Canada are indicated in the section on regional faunas above.

## Systematic Review of the Grassland Asilidae

An annotated systematic checklist of the 134 western Canadian grassland species, including their faunal elements, is included in Table 1. The nomenclature follows that of Fisher and Wilcox (1997) and much of the information on total range is taken from this work. A brief review of these species, with biological and distributional information on selected taxa, is presented below. Terms such as “boreal,” “Cordilleran,” and “eastern” are faunal elements and are defined below in the section “Biogeography and Faunal Elements.” Localities listed, unless otherwise noted, are examples only; these places are often reduced to the name of the closest town or city.

**Table 1.** Annotated list of the Asilidae species of Canadian grasslands. Nomenclature in this list of 134 species is based on the catalogue of Nearctic species of Fisher and Wilcox (1997), still the best, most authoritative list of North American Asilidae. This list was developed to replace Martin and Wilcox (1965) as part of a new Nearctic Diptera catalogue that was never published. In general, there are no English names yet given to robber flies. The terms following the species name provide distributional information. The first term is the faunal element (range type as defined above), followed by the species total range (mostly from Fisher and Wilcox) and provincial and territorial abbreviations for western Canadian jurisdictions where the species occurs in grasslands (species may also occur widely in other habitats in the same or other provinces and territories). An additional “(int)” indicates that the species occurs at the forest interface of the grassland biome (the montane forests in the Cordillera, the boreal forest and Cypress Hills and other “forest islands” on the Great Plains, and the eastern forests of southeastern Manitoba) and is primarily a woodland species.

### Subfamily Leptogastrinae

*Leptogaster arida* Cole. Cordilleran. BC and Alberta to California and Arizona. BC, AB.

*Leptogaster coloradensis* James. Western. BC east to South Dakota, south to Kansas and Colorado. BC, AB, SK.

*Leptogaster fornicata* Martin. Cordilleran. BC to California. BC.

*Leptogaster* sp. One specimen of *Leptogaster* from Manitoba has been examined but, as yet, cannot be identified to species. MB.

*Tipulogaster glabrata* (Wiedemann). Eastern. Manitoba and Nebraska east to Quebec, south to Florida and Texas. MB.

### Subfamily Dasypogoninae

*Comantella fallei* (Back). Western. Alberta to Colorado and Utah. AB.

*Comantella pacifica* Curran. Cordilleran. BC to Utah and Nevada. BC.

*Comantella rotgeri* James. Western. Alberta to Arizona and New Mexico. AB.

*Cophura brevicornis* (Williston). Cordilleran. BC and Montana to Colorado and California; Nebraska. BC.

*Cophura vitripennis* (Curran). Cordilleran. BC to Wyoming. BC (int).

*Lestomyia* sp. (probably undescribed species; Fisher and Wilcox (1997)). Cordilleran. BC and Alberta to Utah and California. BC, AB.

*Nicocles canadensis* Curran. Pacific Coastal. BC to California. BC.

*Nicocles dives* (Loew). Cordilleran. BC to Nevada and California. BC (int).

*Nicocles pollinosus* Wilcox. Cordilleran. BC and Montana to California. BC (int).

*Nicocles rufus* Williston. Pacific Coastal. BC to California. BC.

*Nicocles utahensis* Banks. Cordilleran. BC and Alberta to Arizona and California. BC, AB.

### Subfamily Laphriinae

*Andrenosoma fulvicaudum* (Say). Southern. BC to New Brunswick, south to Florida and California; Mexico. BC (int).

*Laphria aeatus* Walker. Transition. Alberta east to Ontario and Vermont. AB (int)

*Laphria aimatis* McAtee. Cordilleran. BC and Alberta to New Mexico and California. BC (int).

*Laphria asackeni* Wilcox. Cordilleran. Alaska and BC to Montana, Colorado and California. BC (int).

- Laphria* sp. (*canis* group). Eastern. MB.
- Laphria cinerea* (Back). Eastern. Manitoba and Minnesota east to Michigan, New York and New Hampshire, south to Florida and Mississippi. MB (int).
- Laphria columbica* Walker. Cordilleran. Alaska, BC and Alberta to California. BC (int), AB (int).
- Laphria felis* (Osten Sacken). Cordilleran. BC and Alberta to New Mexico and California. BC (int).
- Laphria fernaldi* (Back). Cordilleran. BC and Alberta to New Mexico and California. BC.
- Laphria ferox* Williston. Cordilleran. BC and Montana to California. BC (int).
- Laphria flavicollis* Say. Eastern. Manitoba and Iowa to Nova Scotia and Maine, south to Florida and Texas. MB.
- Laphria franciscana* Bigot. Cordilleran. BC through Idaho and Washington to California. BC (int).
- Laphria gilva* (Linnaeus). Holarctic: Boreal. Northern Eurasia; Alaska and Yukon to New Brunswick, south to Pennsylvania, Colorado and California. YT (int), BC (int), AB, SK, MB.
- Laphria index* McAtee. Transition. BC to Oregon and Montana; Manitoba east to Quebec and Maine, south to South Carolina and Oklahoma. BC, MB.
- Laphria insignis* (Banks). Boreal. Yukon to Labrador and Nova Scotia, south to Maine, Michigan, Minnesota and BC. YT (int), BC (int), AB (int), SK (int), MB.
- Laphria janus* McAtee. Boreal. Alaska through Northwest Territories to New Brunswick, south to Pennsylvania, Colorado, Utah and Oregon. BC (int), AB, SK, MB.
- Laphria partitor* (Banks). Cordilleran. Yukon, BC and Alberta to California. YT (int), BC (int).
- Laphria posticata* Say. Boreal. Yukon to Quebec and Maine, south to Georgia, Tennessee, Wisconsin and British Columbia. YT (int), BC (int), AB (int), MB (int).
- Laphria sadales* Walker. Boreal. BC to New Brunswick, south to Connecticut, Pennsylvania, Colorado, Utah and California. BC (int).
- Laphria scorpio* McAtee. Transition. BC and Idaho to Quebec and Nova Scotia, south to Connecticut, Pennsylvania and Minnesota. BC (int), AB (int), SK (int).
- Laphria ventralis* Williston. Pacific Coastal. BC to California. BC.
- Laphria vivax* Williston. Cordilleran. Yukon and Alberta to New Mexico and California. YT (int), BC (int).
- Pogonosoma ridingsi* Cresson. Western. BC and Alberta to South Dakota, south to Texas and California; Michigan to Maine. BC (int), AB (int).

### Subfamily Laphystiinae

- Laphystia flavipes* Coquillett. Great Plains. Saskatchewan and Montana to Ontario and Minnesota, south to Kansas and Colorado. AB, SK, MB.
- Laphystia canadensis* Curran. Great Plains. Montana east to Manitoba, south to Iowa, Kansas and Wyoming. MB.

### Subfamily Stenopogoninae

- Callinicus pollenius* (Cole). Cordilleran. BC and Montana south to Wyoming, Utah and California. BC (int).
- Coleomyia hinei* Wilcox & Martin. Cordilleran. BC south to Montana, Idaho and Oregon. BC (int).
- Cyrtopogon ablautoides* Melander. Cordilleran. BC south to Utah and Oregon. BC.
- Cyrtopogon auratus* Cole. Cordilleran. BC and Alberta south to Colorado, Utah and Oregon. BC (int).
- Cyrtopogon aurifex* Osten Sacken. Cordilleran. BC and Alberta south to California. BC (int).
- Cyrtopogon banksi* Wilcox & Martin. Cordilleran. Yukon south to Colorado, Utah and California. YT, BC (int).
- Cyrtopogon bimaculus* (Walker). Boreal. Yukon to Quebec, south to New Mexico, Utah and Oregon. YT, BC (int), AB, SK, MB.
- Cyrtopogon dasyllis* Williston. Cordilleran. Alaska, Yukon and NWT south to Idaho and California. YT (int), BC (int).
- Cyrtopogon falto* (Walker). Transition. BC east to Nova Scotia, south to Florida and Illinois. AB, SK, MB.
- Cyrtopogon fumipennis* Wilcox & Martin. Cordilleran. Yukon south through BC to Wyoming and Utah. YT.
- Cyrtopogon glarealis* Melander. Cordilleran. Yukon and Alberta south to Colorado and California. YT, BC (int).
- Cyrtopogon inversus* Curran. Cordilleran. BC and Alberta south to Colorado, Nevada and Washington. BC.
- Cyrtopogon montanus* Loew. Cordilleran. BC and Alberta south to New Mexico and California. BC.
- Cyrtopogon platycaudus* Curran. Great Plains. Manitoba. MB.
- Cyrtopogon varans* Curran. Eastern. Manitoba to Quebec, south to Michigan. MB (int).
- Cyrtopogon willistoni* Curran. Cordilleran. BC and Alberta south to Colorado and California. BC, AB.
- Dioctria henschawi* Johnson. Cordilleran. BC to Utah and California. BC (int).
- Dioctria pusio* Osten Sacken. Cordilleran. BC south to Colorado, Utah and California; Baja California. BC (int).

- Dicolonus nigricentrus* Adisoemarto & Wood. Cordilleran. BC to Idaho and Oregon. BC.
- Dicolonus simplex* Loew. Pacific Coastal. BC to California. BC.
- Eucyrtopogon albibarbus* Curran. Western. Alberta and Saskatchewan south to Montana, Nevada and California. AB, SK.
- Eucyrtopogon calcaratus* Curran. Cordilleran. BC and Alberta south to Washington. BC, AB.
- Eucyrtopogon comantis* Curran. Cordilleran. BC and Alberta south to Colorado and Utah. BC, AB.
- Eucyrtopogon diversipilosis* Curran. Cordilleran. Yukon south to BC and Alberta. YT, BC, AB.
- Eucyrtopogon nebulo* (Osten Sacken). Cordilleran. BC and Alberta to Wyoming, Nevada and California. BC, AB (int).
- Eucyrtopogon* sp. near *nebulo*. Cordilleran. Northern Yukon. YT.
- Eucyrtopogon punctipennis* (Melander). Cordilleran. BC to Idaho and Washington. BC (int).
- Eucyrtopogon spiniger* Curran. Cordilleran. NWT to BC and Alberta. BC, AB.
- Eucyrtopogon varipennis* (Coquillett). Cordilleran. BC to California. BC.
- Eudiotria nitida* (Williston). Pacific Coastal. BC to California. BC.
- Eudiotria sackeni* (Williston). Cordilleran. BC south to Montana, Idaho and California. BC.
- Heteropogon senilis* (Bigot). Cordilleran. BC south to Utah and California. BC (int).
- Heteropogon wilcoxi* James. Great Plains. Alberta south to New Mexico and Arizona. AB.
- Holopogon albipilosus* Curran. Western. BC east to Manitoba, south to Minnesota, Utah, Nevada and California. BC, AB, SK, MB.
- Holopogon seniculus* Loew. Great Plains. Alberta and Saskatchewan east to North Dakota, south to New Mexico and California. AB, SK.
- Holopogon stellatus* Martin. Cordilleran. BC south to Utah, Nevada and California. BC.
- Holopogon vockerothi* Martin. Eastern. Manitoba east to Quebec, south to Connecticut, Georgia and Illinois. MB.
- Myelaphus lobicornis* (Osten Sacken). Cordilleran. BC to Colorado, Utah and California. BC.
- Ospricerus aeacus* (Wiedemann). Western. BC east to Saskatchewan and Minnesota, south to Texas and California; Mexico. BC, AB, SK.
- Ospricerus latipennis* (Loew). Great Plains. Alberta to Manitoba south to Texas, New Mexico and northern Mexico. AB, MB.
- Scleropogon bradleyi* (Bromley). Cordilleran. BC south to Utah, Nevada and California. BC.
- Scleropogon coyote* (Bromley). Great Plains. Alberta to North Dakota, south to Texas and Arizona. AB.
- Scleropogon neglectus* (Bromley). Cordilleran. BC and Alberta south to New Mexico and California. BC, AB.
- Stenopogon inquinatus* Loew. Western. BC east to Manitoba and Minnesota, south to Texas and California. BC, AB, SK, MB.
- Stenopogon rufibarbis* Bromley. Western. BC east to Saskatchewan, south to Colorado, Arizona and California. BC, AB, SK.
- Willistonina bilineata* (Williston). Cordilleran. BC south to Montana, Utah, Baja California. BC.

### Subfamily Stichopogoninae

- Lasiopogon canus* Cole & Wilcox. East Beringian. Alaska east through Yukon to NWT, YK.
- Lasiopogon cinereus* Cole. Cordilleran. BC and Alberta south to Wyoming, Utah and California. BC, AB (int).
- Lasiopogon hinei* Cole & Wilcox. Palearctic–East Beringian. Northwestern Russia to Bering Strait; Alaska, Yukon, BC and Alberta. YT, BC, AB.
- Lasiopogon prima* Adisoemarto. East Beringian. Alaska, Yukon, NT, and BC east through central Alberta and Saskatchewan. YT, BC, AB, SK (int).
- Lasiopogon quadrivittatus* Jones. Great Plains. British Columbia and Alberta east to Saskatchewan and North Dakota, south to Utah, New Mexico and Nebraska. BC, AB, SK.
- Lasiopogon terricola* (Johnson). Eastern. Alberta to Manitoba, Michigan, New York and New Hampshire, south to Virginia, Indiana and North Dakota. AB, SK, MB.
- Lasiopogon trivittatus* Melander. Great Plains. Alberta and Montana. Plains and eastern slopes of Rockies. AB.
- Lasiopogon yukonensis* Cole & Wilcox. East Beringian. Yukon. YT.
- Lasiopogon* n. sp. Misidentified as *L. canus* by Adisoemarto (1967). Great Plains. BC and Alberta. BC, AB.
- Stichopogon argenteus* (Say). Widespread. Manitoba and Ontario to Massachusetts, south to Maryland and Colorado. MB.
- Stichopogon fragilis* Back. Cordilleran. BC to New Mexico and Baja California. BC.
- Stichopogon trifasciatus* (Say). Southern. Alberta to Manitoba, Ontario and Quebec; most of US south to southern Mexico. AB, SK, MB.

**Subfamily Asilinae**

- Dicropaltum cumbipilosus* (Adisoemarto). Great Plains. Alberta. AB.
- Dicropaltum mesae* (Tucker). Western. BC east to Saskatchewan south to Kansas, New Mexico and California. BC, AB, SK.
- Efferia albibarbis* (Macquart). Southern. BC and Ontario; entire United States south to Costa Rica. BC.
- Efferia benedicti* (Bromley). Cordilleran. BC south to Arizona and California. BC.
- Efferia bicaudata* (Hine). Great Plains. Alberta and Saskatchewan south to Texas, New Mexico and Utah. AB, SK.
- Efferia costalis* (Williston). Great Plains. Alberta and Saskatchewan south to Texas, New Mexico and Arizona. AB, SK.
- Efferia coulei* Wilcox. Cordilleran. BC and Washington. BC.
- Efferia frewingei* Wilcox. Cordilleran. BC east to Saskatchewan south to Utah and California. BC, AB, SK.
- Efferia harveyi* (Hine). Cordilleran. BC south to Utah and California. BC.
- Efferia helenae* (Bromley). Great Plains. Alberta to Manitoba, south to Arizona and Texas. AB, SK, MB.
- Efferia okanagana* Cannings. Cordilleran. British Columbia. BC.
- Efferia staminea* (Williston) Cordilleran. BC south to Colorado and Utah. BC, AB.
- Efferia subcuprea* (Schaeffer). Great Plains. Alberta to Nevada, New Mexico and Arizona. AB.
- Megaphorus guildiana* (Williston). Great Plains. Saskatchewan south to Utah, New Mexico, Oklahoma and North Dakota. SK.
- Megaphorus willistoni* (Cole). Cordilleran. BC south to Arizona, Mexico and Nevada. BC.
- Proctacanthella cacopiloga* (Hine). Great Plains. Alberta east to southern Ontario, south to Indiana, Texas and Utah. AB, SK, MB.
- Proctacanthus milbertii* Macquart. Southern. BC east to Ontario (not in AB, SK?), south to Florida (but absent in NE US north of Virginia), Texas, and Arizona. BC, MB.
- Proctacanthus occidentalis* Hine. Cordilleran. BC south to Idaho, Nevada and California. BC.
- Promachus dimidiatus* Curran. Great Plains. Alberta to Manitoba, south to Wisconsin, Kansas, New Mexico and Utah. AB, MB.
- Machimus adustus* Martin. Great Plains. Alberta south to Arizona. AB.
- Machimus aridalis* (Adisoemarto). Great Plains. Alberta and Saskatchewan. AB, SK.
- Machimus callidus* (Williston). Cordilleran. Yukon, BC and Alberta south to Colorado and California. YT (int), BC (int), AB (int).
- Machimus delusus* (Tucker). Great Plains. Alberta and Saskatchewan south through Idaho and Montana to Wyoming, Utah and Arizona. AB, SK.
- Machimus erythrocnemius* (Hine). Widespread. BC east to Quebec south to Florida, New Mexico and Oregon. BC, AB, SK, MB.
- Machimus notatus* (Wiedemann). Eastern. Manitoba and Kansas east to New Brunswick and Maine, south to Texas and Florida. MB. A few specimens from Opal, Alberta are possibly this species but need more work for verification.
- Machimus occidentalis* (Hine). Cordilleran. BC south to Colorado and Baja California. BC.
- Machimus paropus* (Walker). Widespread. British Columbia east to Nova Scotia, south to Virginia, Texas and California. BC, AB, SK, MB.
- Machimus snowii* (Hine). Eastern. Manitoba east to Nova Scotia, south to Florida and Oklahoma. MB.
- Machimus vescus* (Hine). Cordilleran. BC south to Colorado, Arizona, Nevada and California. BC.
- Negasilus belli* Curran. Cordilleran. Washington, Alberta and Saskatchewan south to Colorado and California. AB, SK.
- Negasilus gramalis* (Adisoemarto). Great Plains. AB
- Neotamus brevicornis* (Hine). Cordilleran. BC south to Utah and California. BC (int).
- Neotamus orphne* (Walker). Eastern. Manitoba to Quebec and Maine, south to Georgia and Illinois; Montana, Colorado. MB (int).
- Neomochtherus willistoni* (Hine). Cordilleran. BC south to Arizona and California. BC.
- Rhadiurgus variabilis* (Zetterstedt). Holarctic: Boreal. Northern Eurasia; Alaska and Yukon east to Labrador, south to Michigan, Colorado and Oregon. YT, BC (int).
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**Subfamily Leptogastrinae (5 species)**

Members of the Leptogastrinae are extremely slender, long-legged, almost bare species that fly slowly and hover among grasses and other vegetation, searching for small perching prey or spiders in webs (Fisher 2009). The identification of many species is difficult; apparently four, and perhaps more, species of the delicate little flies in the large genus *Leptogaster* (almost 300 world species) live in western Canadian grasslands. All certainly need to be better collected and studied. For example, a specimen from Manitoba has been examined that cannot, at present, be identified to species. *Leptogaster coloradensis* is the most widespread species, ranging from the British Columbia interior east to Saskatchewan. Fig. 8 pictures *L. fornicata*, an uncommon Cordilleran species found in the valleys of southern British Columbia. *Tipulogaster glabrata*, an eastern species, ranges as far west as Manitoba in Canada; a single specimen from Winnipeg has been examined.



**Figure 8.** *Leptogaster fornicata*, male. Photograph courtesy of Werner Eigelsreiter. **Figure 9.** *Nicocles utahensis*, male. Photograph courtesy of John Acorn. **Figure 10.** *Laphria index*, male. Photograph courtesy of Werner Eigelsreiter. **Figure 11.** *Laphria janus*, female. Photograph courtesy of Deanna Dodgson. **Figure 12.** *Coleomyia hinei*, male. Photograph courtesy of Werner Eigelsreiter. **Figure 13.** *Dioctria pusio*, female. Photograph courtesy of Werner Eigelsreiter.

### ***Subfamily Dasypogoninae (11 species)***

The species of the Dasypogoninae reported in Canadian grasslands are small- to medium-sized flies in four genera: *Comantella*, *Cophura*, *Lestomyia*, and *Nicocles*. They are distinguished by a claw-like spur or curved spine at the apex of the fore tibia; Fisher (2009) discusses the phylogenetic problems associated with this structure. The three species of Canadian *Comantella* are Cordilleran flies, although *C. falli* and *C. rotgeri* are both recorded from Alberta's Mixed Grassland Ecoregion (Medicine Hat). *Comantella pacifica* was originally described from mesic grasslands at Penticton, in the Okanagan Valley of British Columbia. It has an unusual flight period, flying late into October, and is the first species to appear in the spring (late March). There is evidence that adults overwinter in protected places. Tiny *Cophura* species mostly live in open forests, but *C. brevicornis* is not uncommon at forest edges and in grasslands of southern British Columbia. A silvery little *Lestomyia* species (in literature as *L. sabulona* (Osten Sacken)) hunts from the bare ground in grasslands of the southern Okanagan and southern Alberta. The genus badly needs revision, and it appears that the Canadian species is not *L. sabulona*, but is an undescribed species (E.M. Fisher, pers. comm.). *Nicocles* is a genus of beautiful flies with brown-marked wings and in the male, with flattened, brilliant silver terminal abdominal segments. *Nicocles canadensis* is restricted in Canada to Garry oak savanna and adjacent dry woodland on southern Vancouver Island (Saanich is the type locality), as is *N. rufus*, the only red species in the genus. The most widespread grassland species is *N. utahensis* (Fig. 9), known from southern British Columbia and Alberta. Some *Nicocles* specimens, at least in Canada, are difficult to identify, and the northern populations of the genus would benefit from more systematic study.

### ***Subfamily Laphriinae (23 species)***

The Laphriinae is primarily a woodland group; larvae burrow in rotting logs and stumps and prey on insect larvae living there. Many of them are large and colourful and mimic bees and wasps. Adults perch on leaves or logs, stumps, and tree trunks and wait for prey to fly by. Beetles are a favourite prey of some species (e.g., Baker and Fischer 1975).

About half the Nearctic species of *Laphria* belong to *Laphria* in the strict sense; with their colourful, fuzzy, yellow and black or yellow, red, and black bodies, they resemble bumble bees. The remainder can be assigned to other groups, including the Old World genus *Choerades* (the males have distinctive lamellae formed from fused bristles in the genitalia) and several potential undescribed genera. These taxonomic changes have yet to be formalized.

*Laphria*, with 21 species recorded in western Canadian grasslands (12 of them reported strictly as grassland–forest interface species), is the largest of the three genera of Laphriinae on this list. There are eight boreal and transition species ranging across the continent in northern forests, nine Cordilleran species in the western mountains, one Pacific coastal species, and three eastern species restricted to Manitoba. Three of the more common species that fly in grasslands across the West are the boreal species *Laphria gilva*, *L. insignis*, and *L. janus*. *Laphria gilva*, placed in *Choerades* in the Old World, is one of only two Holarctic asilids, ranging from Britain to Japan, from Alaska to the Atlantic Provinces. In British Columbia, it is an interface species, but on the Great Plains it encroaches on the grasslands considerably more (e.g., Alberta: Lethbridge, Medicine Hat). The same is true for *L. janus* (Fig. 10). *Laphria insignis*, a beautiful little bumble bee mimic of northern forests, is an interface species from Yukon and British Columbia to Saskatchewan (e.g., Alberta: Bilby, Opal dunes), but lives deeper in the grassland zones of Manitoba (e.g.,



Aweme, Brandon). *Laphria index* (Fig. 11) is a transition species known only from British Columbia and Manitoba in western grasslands; it represents a distinctive group of species in which the males bear paired protuberances on the sixth abdominal segment. Along the margins of British Columbia grasslands, Cordilleran *Laphria* species are diverse; examples are *L. asackeni* (clothed with glowing orange-gold pile), *L. felis* (black with red abdomen and legs), and *L. fernaldi* (a black, orange, and yellow *Bombus* mimic). A few of these are recorded in Alberta grasslands, too; for example, *L. columbica* occurs at Grimshaw in the Peace River grasslands. *Laphria ventralis*, a Pacific coastal species, is restricted to the Garry oak meadows and adjacent dry woodlands of southern Vancouver Island and the Gulf Islands. In southeastern Manitoba, *L. cinerea*, an eastern species, lives at the grassland-forest interface (e.g., Sandilands) and *L. flavicollis*, also eastern, ranges well into the grasslands at Morden.

The other two genera of the Laphriinae in western Canada are *Andrenosoma* and *Pogonosoma*; each has a single species in grasslands. *Andrenosoma fulvicaudum* is a black and orange fly that ranges across the continent south of the northern forests. It is attracted to forest fires; the females lay eggs in burned trees, where the larvae prey on metallic woodboring beetle (Buprestidae) larvae (Fisher 1986). In British Columbia, it occurs on grassland edges adjacent to ponderosa pine and Douglas-fir woods. *Pogonosoma ridingsi*, another black species, is a widespread Cordilleran asilid mostly living in habitats that are similar to those of *Andrenosoma fulvicaudum* in southern British Columbia and in the foothills of southwestern Alberta.

#### ***Subfamily Laphystiinae (2 species)***

The Laphystiinae are closely related to the subfamily Laphriinae (and placed within it by many workers). The family is dominated by the large genus *Laphystia*, which is the only one in the subfamily in Canada. These asilids resemble small *Bembix* sand wasps and are frequently found on dunes. Western grasslands support only two species of *Laphystia*, both of the Great Plains faunal element and restricted to the Prairies Ecozone. *Laphystia flavipes* is recorded in Alberta (Empress dunes), Saskatchewan (e.g., Pike Lake, Sceptre) and Manitoba (Aweme, Glenboro, Onah), although it also occurs in southern Ontario dunes. *Laphystia canadensis* was described from Manitoba by Curran (1927); it is reported from Westbourne and Ste. Rose du Lac.

#### ***Subfamily Stenopogoninae (46 species)***

Fourteen genera of Stenopogoninae are recorded in western Canadian grasslands, but some, especially *Callinicus*, *Coleomyia* (Fig. 12), and *Dioctria* (Fig. 13), are interface taxa found only near forest edges. The subfamily's largest genus in Canada is the Holarctic *Cyrtopogon*, with 14 grassland-associated species in the West, although most of these species (and many more that are not listed) live in woodlands of various types. In western Canada, many (or all) of the species in some genera (*Dicolonus*, *Eucyrtopogon*, *Eudioctria*, *Heteropogon*, *Myelaphus*, *Ospricerus*, *Holopogon*, *Scleropogon*, *Stenopogon*, and *Willistonina*) are, to a large extent, grassland inhabitants.

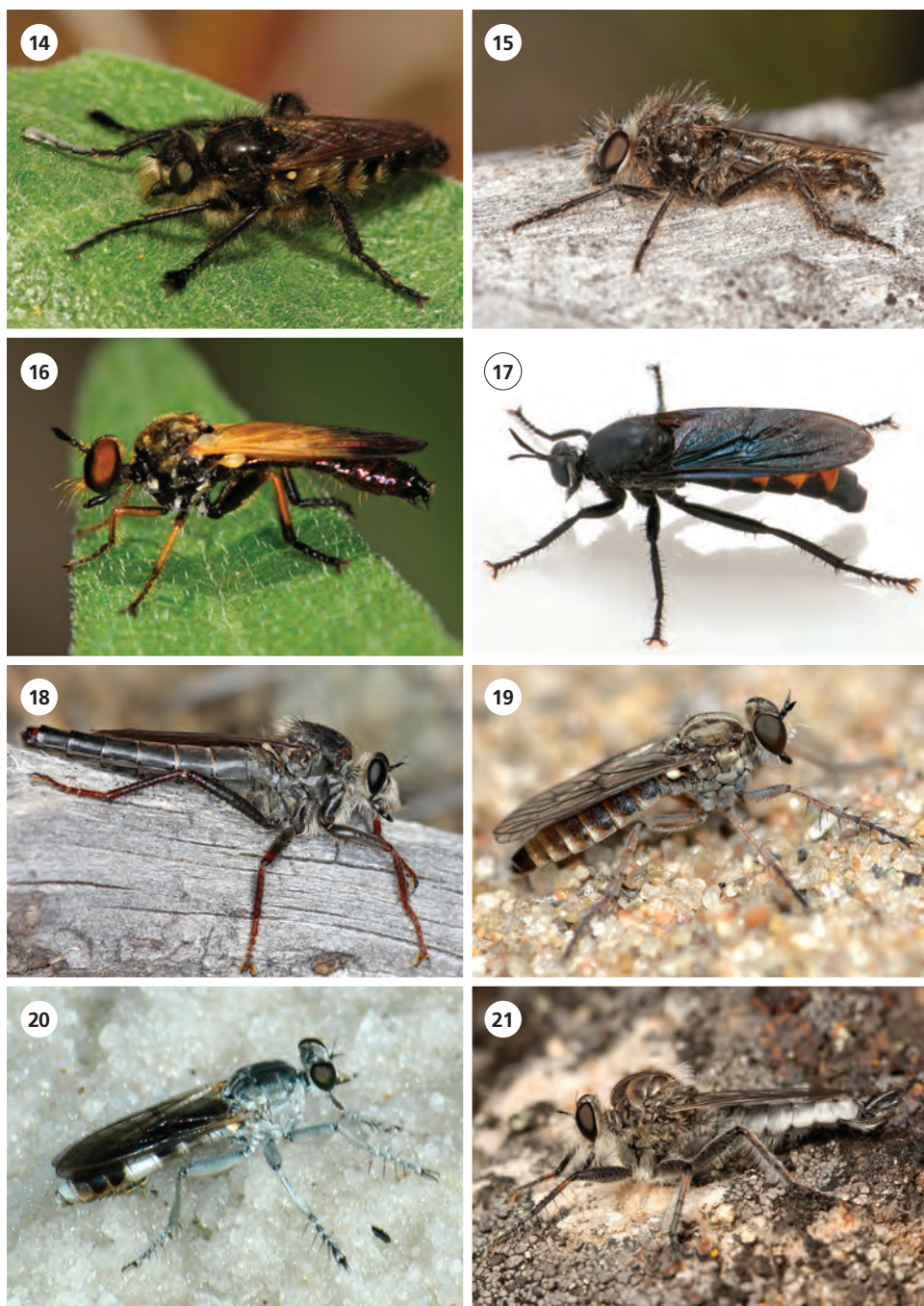
The Nearctic *Cyrtopogon* fauna is overwhelmingly western in distribution; this is reflected in the grassland species: 10 are Cordilleran, two are boreal, one is eastern, and one is a Great Plains species. With its fuzzy yellow and black abdomen, *C. dasyllis* looks a little like a *Laphria* species; it is an interface species in Yukon and British Columbia. *Cyrtopogon auratus* and *C. aurifex* are also interface species, but only in British Columbia, where most often they are found in montane and subalpine forests well away from grasslands.

However, the former lives east of the Coast Mountains and is recorded at the edge of interior grasslands, while the latter is a coastal mountain fly, found along the margins of Garry oak savanna on southern Vancouver Island. The males of both species have thick, tufted golden hair on the abdomen. *Cyrtopogon ablautooides* and *C. willistoni* (Fig. 14), both Cordilleran flies, are the most grassland-oriented of all Canadian *Cyrtopogon* species. The rare *Cyrtopogon ablautooides* is recorded only in dry grasslands in the Okanagan Valley, while *C. willistoni* is common in moist, often high-elevation grasslands across southern British Columbia and southwestern Alberta. The male has beautifully decorated legs with which it signals the female during mating displays. The fore tarsi are densely silver-haired and the mid tarsi are tipped with a fan-shaped tuft of black setae. The boreal *C. bimaculus*, with striking dark spots on the wings, is common across Canada and enters grasslands frequently, except in British Columbia, where it is largely a subalpine species. *Cyrtopogon falto* is one of the most often encountered asilids in eastern Canadian forests; in the West it has been recorded a few times in the Aspen Parkland in Alberta (e.g., Clyde, Opal, and Edmonton on south-facing, shrubby slopes; J. Acorn, pers. comm.) and Manitoba (e.g., Aweme, Erickson, Melita, Winnipeg). Manitoba is the only western province to record *C. varans*, an eastern species collected at Erickson, and *C. platycaudus*, a Great Plains species still known only from one place, the type locality at Glen Souris, from where it was described in 1924.

*Eucyrtopogon* (Fig. 15) contains 12 named species restricted to western North America, nine of which live in Canadian grasslands to some extent. The genus is badly in need of revision; specimens are frequently impossible to identify, and there certainly are undescribed species in collections. The wings are brown-spotted in both sexes and some species are abundantly hairy (Fig. 15), a feature that may help them regulate temperature. Some *Eucyrtopogon* species are notable for late or early seasonal activity and, like *Comantella* species, may overwinter as adults. For example, in British Columbia grasslands, *E. calcaratus* has been collected on 23 November in Vernon and 23 January in Penticton. Most of the *Eucyrtopogon* species listed here are recorded in both British Columbia and Alberta: *E. albibarbus* (also ranges east to Saskatchewan, e.g., Moose Jaw, Swift Current), *E. calcaratus*, *E. comantis*, *E. diversipilosis*, *E. nebulo*, and *E. spiniger*. *Eucyrtopogon diversipilosis* also lives on the Carcross dunes in the Yukon and a second, undescribed, Yukon species, similar to *E. nebulo*, is known from the sage slopes at Old Crow. Although I have designated this species as Cordilleran, it might have Beringian affinities with Asia, but *Eucyrtopogon* is not yet recognized there. Several *Eucyrtopogon*-like species are still placed in *Cyrtopogon* in the Eurasian fauna (Lehr 1998).

*Myelaphus lobicornis* lives in intermontane grasslands from southern British Columbia to California and Utah (Adisoemarto and Wood 1975). In Canada, it is known from only two grassland sites, one at Penticton and the other at Dutch Creek in the Rocky Mountain Trench. At Penticton, it flies only around rabbitbrush in June. With its almost hairless body, elongate antennae, red abdomen, yellow legs, and dark head, thorax, and wings, *M. lobicornis* resembles an ichneumon wasp.

*Dicolonus* and *Eudioctria* are related genera that contain both coastal and interior British Columbia grassland species. *Dicolonus simplex* is the most characteristic robber fly of the coastal Garry oak meadows, flying in April when camas and other wildflowers are in full bloom. Its Cordilleran relative in the grasslands east of the Coast Mountains, *D. nigriventris*, is seldom seen; it is recorded from Oliver and Keremeos. *Eudioctria sackeni* is a small dark asilid that hunts from leaves and twigs in forest openings and grassland copses at low and mid-elevations across southern British Columbia. It has two striking



**Figure 14.** *Cyrtopogon willistoni*, male. Photograph courtesy of Werner Eigelsreiter. **Figure 15.** *Eucyrtopogon* sp., male. Photograph courtesy of Werner Eigelsreiter. **Figure 16.** *Eudioctria sackeni*, male. Photograph courtesy of Werner Eigelsreiter. **Figure 17.** *Ospricerus aeacus*, female. Photograph courtesy of John Acorn. **Figure 18.** *Stenopogon inquinatus*, female. Photograph courtesy of Werner Eigelsreiter. **Figure 19.** *Lasiopogon terricola*, female. Photograph courtesy of Deanna Dodgson. **Figure 20.** *Stichopogon trifasciatus*, male. Photograph courtesy of Dennis Paulson. **Figure 21.** *Efferia benedicti*, male. Photograph courtesy of Werner Eigelsreiter.

colour morphs; in the male of the more common one, the wings are orange basally and dark gray apically (Fig. 16). The Pacific coastal *E. nitida* ranges from south coastal British Columbia to California; it lives in Garry oak savanna habitat but also occurs in open areas on the mainland.

*Heteropogon* and *Holopogon* contain species that are at home in both grasslands and woodland openings, where they usually hunt for prey from perches on the tips of bare branches of shrubs and small trees. *Heteropogon senilis*, a Cordilleran fly, is recorded from the margins of southern British Columbia grasslands; *H. wilcoxi* is a Great Plains species collected in southern Alberta. The four *Holopogon* species in western grasslands are symmetrically distributed: *H. albipilosa* from British Columbia (e.g., Vernon) across the Prairies to Manitoba (e.g., Glen Souris), *H. stellatus* in British Columbia (e.g., Penticton), *H. seniculus* in Alberta (e.g., Lethbridge) and Saskatchewan (e.g., Saskatoon), and *H. vockerothi* in Manitoba (e.g., Aweme).

The medium-sized to large elongate species of *Ospricerus*, *Scleropogon*, and *Stenopogon* are closely related; Canadian species are often typical of grasslands and hunt from the ground or low shrubs. The striking black and red, wasp-mimicking *Ospricerus aeacus* (Fig. 17) ranges widely in western grasslands, from British Columbia (e.g., Walhachin) to Saskatchewan (Matador). The gray and orange *O. latipennis* is strictly a Great Plains species in Canada and is reported from Alberta and Manitoba. *Scleropogon bradleyi* flies in late summer in Garry oak meadows on British Columbia's south coast, although there is a single record from east of the Coast Mountains (Lytton). The Cordilleran *S. neglectus* is one of the most common asilids of the southern interior British Columbia grasslands; it ranges east into the Alberta prairies around Medicine Hat. This dry Mixed Grassland Ecoregion in southern Alberta (e.g., Drumheller, Orion, Brooks) is also home to *S. coyote*. *Stenopogon inquinatus* (Fig. 18) is perhaps the most familiar robber fly in western Canada. Big, and varying from blackish to rust coloured, it hunts a variety of large prey in habitats ranging from arid sagebrush steppe to open pine forests. It ranges from British Columbia's Peace River district to the province's south coast and hot interior valleys, from southern Alberta and Saskatchewan to the Manitoba tallgrass prairies. The smaller, orange-haired *S. rufibarbis* also ranges widely, from British Columbia's interior grasslands east to Saskatchewan.

*Willistonina bilineata* is a Cordilleran asilid, the sole species in its genus. Seldom encountered in Canada, it inhabits open woods and grassland borders in the southern Okanagan Valley.

### ***Subfamily Stichopogoninae (12 species)***

Two genera represent the Stichopogoninae in western Canadian grasslands: *Lasiopogon* and *Stichopogon*. They are small gray, black, or brown flies that usually inhabit sandy areas where they hunt from rocks, logs, or the ground.

The large and widespread Holarctic genus *Lasiopogon* contains the only known Beringian fauna in the Asilidae (Cannings 1997). Three species (*L. hinei*, *L. canus*, and *L. prima*) are East Beringian species closely related to Eurasian forms; they or their ancestors entered North America through ice-free Beringia. *Lasiopogon yukonensis* is restricted to the southern and central Yukon and distributionally qualifies as an East Beringian species, but evidently is related to Pacific coastal species (Cannings 2011b). These four species live on the Yukon's south-facing grassland slopes and in dune habitats. *Lasiopogon hinei* is a Palearctic–East Beringian species, with most of its range across Eurasia; since the disappearance of continental glaciers, it has expanded its range down the east side of the

Rockies into central Alberta. *Lasiopogon prima* ranges through Alaska and Yukon, reaching the Arctic Ocean to the north, Saskatchewan's Athabasca dunes in the east, and Alberta's foothills in the south. An undescribed *Lasiopogon* species closely related to *L. canus* lives along rivers in central Alberta (e.g., Edmonton) and the Peace River region of British Columbia and Alberta. *Lasiopogon cinereus* is a widespread and common Cordilleran fly of cobbly stream banks; usually it lives in forested sites, but in British Columbia's Peace River area and along the Alberta foothills and adjacent prairie (e.g., Blackfalds), it spreads into grassland. *Lasiopogon trivittatus* and *L. quadrivittatus* are Great Plains species living along streams; the former is recorded only from Alberta (e.g., Edmonton, Redcliff) and Montana, but the latter is a common grassland asilid from northeastern British Columbia (e.g., Attachie) east to Saskatchewan (e.g., Elbow, Pike Lake) and south to Nebraska and New Mexico. *Lasiopogon terricola* (Fig. 19) is common in sandy sites in the northeastern United States; its distribution map shows a long narrow finger pointing northwestward into the grasslands of Manitoba (e.g., Aweme, Carberry) and Saskatchewan (e.g., Great Sand Hills) and all the way to Alberta (e.g., Orion).

Only three *Stichopogon* species are recorded in Canada and all of them live in grasslands and sandy spots such as dunes and beaches. *Stichopogon fragilis* is a tiny silver fly (about 4 mm long) from the Okanagan grasslands at Osoyoos, British Columbia, adjacent to the United States border. Only a single specimen has been collected in Canada. The common Canadian species, *S. trifasciatus* (Fig. 20), lives on the southern Prairies from Alberta (e.g., Medicine Hat, Pakowki Lake) through Saskatchewan (e.g., Condie) to Manitoba (e.g., Aweme, Mars Sand Hills, Onah). It is the most common dune species in the southern Prairies. It also lives in southern Ontario and Quebec and over most of the United States and Mexico (Barnes 2010). *Stichopogon argenteus* ranges mostly in the northeastern United States and the northern and central Great Plains; in western Canadian grasslands, it is confined to Manitoba (e.g., Onah) (Barnes 2013).

### ***Subfamily Asilinae (35 species)***

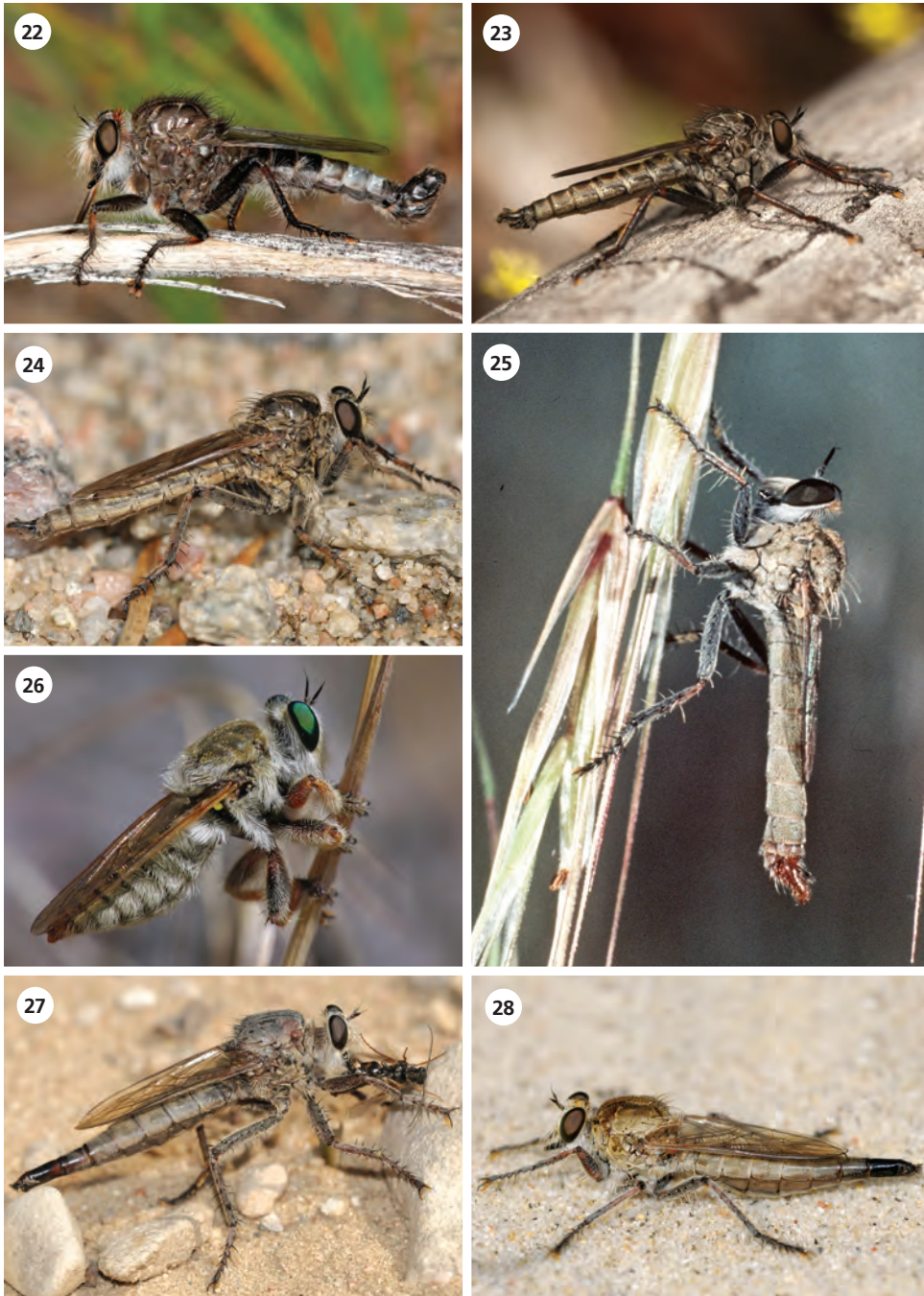
The 11 genera of western grassland asilines contain mostly gray or brown, elongate, medium-sized to large flies, although there are small species in several genera (e.g., *Dicropaltum*, *Machimus*, *Negasilus*).

Perhaps the most distinctive and abundant grassland robber flies in western Canada are the 11 species of *Efferia*. This is the largest genus of New World asilids, with about 230 named species and many undescribed species (Fisher 2009). The genus is most diverse in the western United States and Mexico. The males have large club-shaped genitalia; the ovipositors of the females are long and sword-like and are used to place the eggs in the soil and in dead plant inflorescences. Adults fly with a loud buzzing or whining noise and mainly perch on the ground, at least in northern North America. The larvae, as in all species in the subfamily, as far as is known, develop in the soil, and those studied feed on the larvae of scarab beetles (Knutson 1972). Adult males of all species have silver-white abdominal segments; in most, only the sixth and seventh segments are white, but in some, such as *E. benedicti* (Fig. 21) and *E. staminea*, most of the segments are white and clothed with long, white hairs parted along the midline. *Efferia albibarbis* is widespread across the United States, but in Canada it occurs only in sandy grasslands in the extreme southern Okanagan Valley in British Columbia and on the beaches and associated dunes of Lake Erie and Lake Huron in Ontario. In British Columbia grasslands, *Efferia coulei* and *E. okanagana* (Fig. 22) are spring species, flying mostly in May and early June; *E. benedicti* and *E. staminea* fly mainly from mid-June to the end of July.

*Efferia harveyi* is active mostly from August through September. *Efferia benedicti* and *E. harveyi*, especially, often occur in high densities. Where these species occur in the same locations, their staggered flight seasons allow them to fill similar ecological niches. *Efferia okanagana* is restricted to bluebunch wheat grass habitats, especially gravelly ones, in the Okanagan and Thompson valleys and is assessed as “Endangered” by COSEWIC (Cannings 2011a; COSEWIC 2012). In Canada, *E. frewingi* is mainly an asilid of the Prairies Ecozone (e.g., Alberta: Calgary, Manyberries; Saskatchewan: Eastend, Estevan), but in the United States, in most of its range, it is a Cordilleran species. It is Cordilleran in British Columbia, too; it lives in the grasslands along the Columbia and Kootenay rivers immediately west of the Rocky Mountains. *Efferia bicaudata* and *E. helenae* are Great Plains species closely related to *E. frewingi*; *E. bicaudata* is the common species of dry grasslands in Alberta and Saskatchewan, while *E. helenae*, although found in all three Prairie Provinces, is the only species in Manitoba (e.g., Aweme). *Efferia costalis* and *E. subcuprea* are seldom-collected species in the Mixed Grassland Ecoregion in Alberta, and *E. costalis* is also recorded from Saskatchewan (Rockglen, Saskatchewan Landing). Males of both, but especially *E. costalis*, have a thorax that is laterally compressed, with a dense mane of long setae along the midline.

*Machimus*, with 10 species in western grasslands, comes a close second to *Efferia* in species diversity in the region. Species can be abundant, however, and general collections of Canadian grassland Asilidae are usually dominated by *Machimus* specimens. Unfortunately, much work is needed on this large group and species are notoriously difficult to identify. Many *Machimus* species live in both grassland and open woodland habitats, and so they are frequently common along grassland edges. This is true of the common Cordilleran species *M. callidus* (e.g., Yukon: Whitehorse; British Columbia: Vaseux Lake, Victoria; Alberta: Cowley, Opal), *M. occidentalis* (e.g., British Columbia: Penticton, Victoria), and *M. vescus* (e.g., British Columbia: Kelowna, Oliver), although *M. occidentalis* (Fig. 23) is far more likely to be common in treeless grassland habitats than are the other two species. *Machimus aridalis* and *M. delusus* are species of the semi-arid Mixed Grassland Ecoregion of the Prairies Ecozone and prefer treeless ground. *Machimus aridalis* is recorded from many sites, including Dinosaur Provincial Park, Scandia, Medicine Hat, and Lethbridge in Alberta and Killdeer in Saskatchewan. *Machimus delusus* records include Orion, Empress, and Redcliff in Alberta and Tompkins in Saskatchewan. Two common species, *Machimus erythrocnemius* (Fig. 24) and *M. paropus*, belong to the widespread element and range across most of the continent; they live in western grasslands from southern British Columbia (Okanagan Valley) to southern Manitoba. *Machimus notatus* is an eastern species that ranges to Manitoba grasslands. Some *Machimus* specimens from Opal, Alberta, are possibly *M. notatus* (E.M. Fisher, pers. comm.), but more work is required to verify this identification and the resulting significant range extension.

*Neomochtherus*, *Neoitamus*, *Dicropaltum*, and *Negasilus* species look superficially like *Machimus* species. *Neomochtherus willistoni* lives across southern British Columbia in grasslands (including Garry oak meadows) and open coniferous woods, and flies in late summer, replacing *M. occidentalis* as the common slender gray robber fly in these habitats. *Neoitamus brevicornis* is a Cordilleran species active at the grassland–forest interface in southern British Columbia (e.g., Victoria); its congener, *N. orphne*, is an eastern equivalent living in southern Manitoba (e.g., Sandilands). *Dicropaltum* and *Negasilus* species are small asilines that are active in grasslands far from woodlands. *Dictropaltum mesae* (Fig. 25), a beautiful golden fly, is widespread in the West. It is common from British Columbia’s Chilcotin grasslands (e.g., Riske Creek) to the Okanagan Valley (e.g., Penticton), east into



**Figure 22.** *Efferia okanagana*, male. Photograph courtesy of Werner Eigelsreiter. **Figure 23.** *Machimus occidentalis*, male. Photograph courtesy of Werner Eigelsreiter. **Figure 24.** *Machimus erythrocnemius*, male. Photograph courtesy of Deanna Dodgson. **Figure 25.** *Dicropaltum mesae*, male. Photograph by Rob Cannings. **Figure 26.** *Megaphorus willistoni*, male. Photograph courtesy of Werner Eigelsreiter. **Figure 27.** *Proctacanthus milbertii*, female. Photograph courtesy of Deanna Dodgson. **Figure 28.** *Proctacanthella cacopiloga*, female. Photograph courtesy of Deanna Dodgson.

Alberta (e.g., Drumheller, Medicine Hat, Manyberries, Rolling Hills) and Saskatchewan (e.g., Empress Dunes, Ormiston). *Dicropaltum cumbipilosus* was described from Alberta (e.g., Etzicom Coulee, Welling, Orion, Lake Newell) (Adisoemarto 1967) and it is still not known from anywhere else. *Negasilus belli* and *N. gramalis* are similar small species that are at home in the dry Mixed Grasslands of the Prairies Ecozone, although *N. belli* is a Cordilleran element in its extensive range in the United States.

*Megaphorus*, *Promachus*, *Proctacanthus*, *Proctacanthella*, and *Rhadiurgus* round out the Asilinae fauna of western grasslands. *Megaphorus* species are little leaf-cutting bee mimics with fuzzy pale bodies, green eyes, and a bee-like flight around flowers. They are rare in Canada. In extreme southern British Columbia, the Cordilleran species *Megaphorus willistoni* is known from only one specimen (Chopaka, in the southern Similkameen Valley) and a single photograph (Fig. 26) from Oliver. A Great Plains species, *M. guildiana*, has been collected only in Grasslands National Park, Saskatchewan. *Promachus dimidiatus* is another Great Plains asilid from the dry southern Prairies, where it ranges from Alberta (e.g., Orion, Milk River) to Manitoba (e.g., Aweme). The two *Proctacanthus* species found in the Canadian West are the largest asilids in Canada, reaching a length of about 40 mm. Both are common in some grassland sites, especially sandy ones. *Proctacanthus milbertii* (Fig. 27), which ranges across much of the continent in the South, lives in southern British Columbia (e.g., Penticton) and Manitoba (e.g., Carberry, Elma), but has yet to be collected in Alberta or Saskatchewan. *Proctacanthus occidentalis* is a Cordilleran fly and in Canada is restricted to the southern interior of British Columbia (e.g., Osoyoos, Penticton, Big Bar). *Proctacanthella cacopiloga* (Fig. 28) is a Great Plains species common from Alberta (e.g., Medicine Hat, Writing-on-Stone Park, Wainwright), through Saskatchewan (e.g., Great Sand Hills) to Manitoba (e.g., Aweme). It is one of few Great Plains asilids that also occurs in tallgrass prairie remnants in southwestern Ontario, which at one time were connected to the more extensive western grasslands (Skevington 1999; Paiero *et al.* 2010). *Rhadiurgus variabilis* is an atypical grassland species. As a member of the boreal element, it is one of the most common asilids in the spruce forests of northern Canada, one of only two Holarctic robber flies, and one of the most northerly dwelling robber flies in the world. Cannings (1993) analyzed the geographical variation in *R. variabilis* over its huge range and documented its distribution. It is common on grassland slopes and dunes over much of Yukon, and in British Columbia, even in the south, it flies in grassland edges where high-altitude grasslands and sage steppes meet spruce and fir woods (e.g., Mt. Kobau, Osoyoos, 1,870 m).

### Biogeography and Faunal Elements

Species can be grouped with others that share similar distributions to form what can be termed faunal elements. The majority of the 134 species reported here from western Canadian grasslands are restricted to the Nearctic region, although two species (*Laphria gilva* and *Rhadiurgus variabilis*) are Holarctic (defined here as species with transcontinental ranges in both North America and Eurasia). This section describes the Nearctic faunal elements; the two species with Holarctic distributions are also assigned to a North American faunal element. Those relevant to Canadian grassland Asilidae are as follows:

1. Boreal (7 species). Species mainly occurring in the northern transcontinental forests dominated by spruce (*Picea*). In general, these species range from the Atlantic Provinces across the northern New England states, Quebec, northern Ontario, parts of the northern



tier of the midwestern states, the Prairie Provinces north of the Great Plains, and northern British Columbia, often ranging considerably southward in the mountains and plateaus of the Cordillera. *Laphria gilva*, *L. insignis*, *L. janus*, *L. posticata*, *L. sadales*, *Cyrtopogon bimaculus*, *Rhadiurgus variabilis*.

2. East Beringian (3 species). Species originating in the unglaciated areas of Yukon and Alaska and restricted to the eastern (North American) side of the Bering Strait. *Lasiopogon canus*, *L. prima*, *L. yukonensis*.

3. Palearctic East Beringian (1 species). East Beringian in North America (Alaska, Yukon, and adjacent areas), but with a widespread range across Eurasia. *Lasiopogon hinei*.

4. Transition (4 species). Species generally most common at the southern margin of the boreal forest (and Aspen Parkland on the Great Plains) and adjacent montane forests in the West and in the mixed and deciduous forests in the East. *Laphria aeatus*, *L. index*, *L. scorpio*, *Cyrtopogon fallo*.

5. Cordilleran (66 species). Species mostly confined to the western mountains and their intervening valleys and plateaus, but some species may extend on to the Great Plains to varying degrees. *Leptogaster arida*, *L. fornicata*, *Comantella fallei*, *C. pacifica*, *C. rotgeri*, *Cophura brevicornis*, *C. vitripennis*, *Lestomyia* sp., *Niocles dives*, *N. pollinosus*, *N. utahensis*, *Laphria aimatis*, *L. asackeni*, *L. columbica*, *L. felis*, *L. fernaldi*, *L. ferox*, *L. franciscana*, *L. partitor*, *L. vivax*, *Callinicus pollenius*, *Coleomyia hinei*, *Cyrtopogon ablautoides*, *C. auratus*, *C. aurifex*, *C. banksi*, *C. dasyllis*, *C. fumipennis*, *C. glarealis*, *C. inversus*, *C. montanus*, *C. willistoni*, *Dioctria henshawi*, *D. pusio*, *Dicolonus nigriventris*, *Eucyrtopogon calcaratus*, *E. comantis*, *E. diversipilosis*, *E. nebulo*, *E. sp. near nebulo*, *E. punctipennis*, *E. spiniger*, *E. varipennis*, *Eudioctria sackeni*, *Heteropogon senilis*, *Holopogon stellatus*, *Myelaphus lobicornis*, *Scleropogon bradleyi*, *S. neglectus*, *Willistonina bilineata*, *Lasiopogon cinereus*, *Stichopogon fragilis*, *Efferia benedicti*, *E. coulei*, *E. frewingi*, *E. harveyi*, *E. okanagana*, *E. staminea*, *Megaphorus willistoni*, *Proctacanthus occidentalis*, *Machimus callidus*, *M. occidentalis*, *M. vesusus*, *Negasilus belli*, *Neoitamus brevicornis*, *Neomochtherus willistoni*.

6. Pacific Coastal (5 species). Coastal species restricted to the lowlands and lower slopes of the mountains west of the Coast Mountains. *Niocles canadensis*, *Niocles rufus*, *Laphria ventralis*, *Dicolonus simplex*, *Eudioctria nitida*.

7. Western (8 species). Species of western mountains and associated lowlands, but extending considerable distances eastward, often to the 100th meridian (Mississippi River). *Leptogaster arida*, *Pogonosoma ridingsi*, *Eucyrtopogon albibarbus*, *Holopogon albibilosus*, *Ospricerus aeacus*, *Stenopogon inquinatus*, *S. rufibarbis*, *Dicropaltum mesae*.

8. Great Plains (23 species). Species more or less confined to the Great Plains. *Leptogaster* sp., *Laphystia canadensis*, *L. flavipes*, *Cyrtopogon platycaudus*, *Heteropogon wilcoxi*, *Holopogon seniculus*, *Ospricerus latipennis*, *Scleropogon coyote*, *Lasiopogon quadrivittatus*, *L. trivittatus*, *L. n. sp.*, *Dicropaltum cumbipilosus*, *Efferia bicaudata*, *E. costalis*, *E. helenae*, *E. subcuprea*, *Megaphorus guildiana*, *Proctacanthella cacopiloga*, *Promachus dimidiatus*, *Machimus adustus*, *M. aridalis*, *M. delusus*, *Negasilus gramalis*.

9. Southern (4 species). Species ranging from coast to coast south of the boreal and mixed forests. Transcontinental at least in the United States; in Canada only in extreme southern areas. *Andrenosoma fulvicaudum*, *Stichopogon trifasciatus*, *Efferia albibarbis*, *Proctacanthus milbertii*.

10. Eastern (10 species). Species ranging widely mostly east of the 100th meridian. *Tipulogaster glabrata*, *Laphria* sp. (*canis* group), *L. flavicollis*, *L. cinerea*, *Cyrtopogon varans*, *Holopogon vockerothi*, *Lasiopogon terricola*, *Machimus notatus*, *M. snowii*, *Neoitamus orphne*.

11. Widespread (3 species). Species with broad distributions in North America, from north to south and east to west, overlapping several of the other elements listed. *Stichopogon argenteus*, *Machimus erythrocnemius*, *M. paropus*.

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### References

- Adisoemarto, S. 1967. The Asilidae (Diptera) of Alberta. *Quaestiones Entomologicae*, **3**: 3–90.
- Adisoemarto, S., and Wood, D.M. 1975. The nearctic species of *Dioctria* and six related genera (Diptera, Asilidae). *Quaestiones Entomologicae*, **11**: 505–576.
- Artigas, J.N., and Papavero, N. 1988. The American genera of Asilidae (Diptera): keys for identification with an atlas of female spermathecae and other morphological details. Part I. Key to subfamilies, subfamily Leptogastrinae. *Gayana Zoologia*, **52**: 95–114.
- Baker, N.T., and Fischer, R.L. 1975. A taxonomic and ecologic study of the Asilidae of Michigan. *The Great Lakes Entomologist*, **8**: 3191.
- Barnes, J.K. 2010. Revision of Nearctic *Stichopogon* species (Diptera: Asilidae) with white-banded abdomens, including description of *Stichopogon venturiensis*, new species, from coastal California. *Proceedings of the Entomological Society of Washington*, **112**(3): 367–380.
- Barnes, J.K. 2013. The genus *Stichopogon* Loew (Diptera: Asilidae) in America north of Mexico. *Proceedings of the Entomological Society of Washington*, **115**(1): 936.
- BC Ministry of Forests and Range. 2013. Biogeoclimatic Ecosystem Classification Program. Research Branch, Victoria, British Columbia. Available from <http://www.for.gov.bc.ca/hre/becweb/> [accessed 13 February 2013].
- Cannings, R.A. 1989. The robber flies (Diptera: Asilidae) of a *Festuca* grassland in the Okanagan Valley, British Columbia. *Journal of the Entomological Society of British Columbia*, **86**: 14–26.
- Cannings, R.A. 1993. New synonymy of *Rhadiurgus variabilis* (Zetterstedt) (Diptera: Asilidae) with notes on morphology, natural history, and geographical variation. *The Canadian Entomologist*, **125**: 337–354.
- Cannings, R.A. 1994. Robber Flies (Diptera: Asilidae) new to Canada, British Columbia, Yukon, and the Northwest Territories with notes on distribution and habitat. *Journal of the Entomological Society of British Columbia*, **91**: 19–26.

- Cannings, R.A. 1997. Robber flies (Diptera: Asilidae) of the Yukon. *In* Insects of the Yukon. *Edited by* H.V. Danks and J.A. Downes. Biological Survey of Canada (Terrestrial Arthropods), Ottawa, Ontario. pp. 637–662.
- Cannings, R.A. 2002. The Systematics of *Lasiopogon* (Diptera: Asilidae). Royal British Columbia Museum, Victoria, British Columbia.
- Cannings, R.A. 2011a. *Efferia okanagan*, a new species of robber fly (Diptera: Asilidae) from the grasslands of southern British Columbia, Canada, with notes on taxonomy, biology, distribution and conservation status. *The Canadian Entomologist*, **143**: 578–593.
- Cannings, R.A. 2011b. Robber flies (Insecta: Diptera: Asilidae). *In* Assessment of Species Diversity in the Montane Cordillera Ecozone (version 2). *Edited by* G.G.E. Scudder and I.M. Smith. pp. 461–483. Available from <http://www.royalbcmuseum.bc.ca/assets/Montane-Cordillera-Ecozone.pdf> [accessed 9 October 2012].
- Cannings, R.A. 2012. A Checklist of the Robber Flies (Diptera: Asilidae) of British Columbia. Available from <http://www.geog.ubc.ca/biodiversity/efauna/documents/RobberFliesofBCApril2012.pdf> [accessed 2 August 2013].
- Cannings, R.J., and Cannings, S.G. 1996. British Columbia: A Natural History. Douglas and McIntyre, Vancouver, British Columbia.
- Cole, F.R., and Wilcox, J. 1938. The genera *Lasiopogon* Loew and *Alexiopogon* Curran in North America (Diptera - Asilidae). *Entomologica Americana*, **18**: 1–91.
- COSEWIC. 2011. COSEWIC Assessment and Status Report on the Dune Tachinid Fly, *Germaria angustata*, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario. Available from [http://www.sararegistry.gc.ca/virtual\\_sara/files/cosewic/sr%5Fdune%5Ftachinid%5Ffly%5F0911%5Feng%2Epdf](http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr%5Fdune%5Ftachinid%5Ffly%5F0911%5Feng%2Epdf) [accessed 10 August 2013].
- COSEWIC. 2012. COSEWIC Assessment and Status Report on the Okanagan *Efferia*, *Efferia okanagan*, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario. Available from [http://www.sararegistry.gc.ca/virtual\\_sara/files/cosewic/sr\\_asile\\_okanagan\\_efferia%20\\_0912\\_e.pdf](http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_asile_okanagan_efferia%20_0912_e.pdf) [accessed 15 September 2012].
- Cronquist, A. 1978. The biota of the intermountain region in geohistorical context. *Intermountain Biogeography: A symposium*. Great Basin Naturalist Memoirs, **2**: 3–15.
- Curran, C.H. 1923. Studies in Canadian Diptera. I. Revision of the asilid genus *Cyrtopogon* and allied genera. *The Canadian Entomologist*, **55**: 92–95, 116–125, 132–142, 169–174, 185–190.
- Curran, C.H. 1927. Descriptions of Nearctic Diptera. *The Canadian Entomologist*, **59**: 79–92.
- Dennis, D.S., and Barnes, J.K. 2013. Pupal cases of three Nearctic species of *Machimus* (Diptera: Asilidae). *Zootaxa*, **3683**(5): 561–570.
- Dennis, D.S., Barnes, J.K., and Knutson, L. 2008. Pupal cases of Nearctic robber flies (Diptera: Asilidae). *Zootaxa*, **1868**: 1–98.
- Dennis, D.S., Barnes, J.K., and Knutson, L. 2013. Review and analysis of information on the biology and morphology of immature stages of robber flies (Diptera: Asilidae). *Zootaxa*, **3673**(1): 164.
- Dikow, T. 2009a. Phylogeny of Asilidae inferred from morphological characters of imagines (Insecta: Diptera: Brachycera: Asiloidea). *Bulletin of the American Museum of Natural History*, **319**: 1–175.
- Dikow, T. 2009b. A phylogenetic hypothesis for Asilidae based on a total evidence analysis of morphological and DNA sequence data (Insecta: Diptera: Brachycera: Asiloidea). *Organisms, Diversity and Evolution*, **9**: 165–188.
- Fisher, E.M. 1986. A Reclassification of the Robber Fly Tribe Andrenosomini, with a Revision of the Genus *Dasyllis* Loew (Diptera: Asilidae). Ph.D. thesis. University of California, Riverside.
- Fisher, E.M. 2009. Asilidae (robber flies, assassin flies, moscas cazadoras, moscas ladronas). *In* Manual of Central American Diptera: Vol. 1. *Edited by* B.V. Brown, A. Borkent, J.M. Cumming, D.M. Wood, N.E. Woodley, and M.A. Zumbado. NRC Research Press, Ottawa, Ontario. pp. 585–632.
- Fisher, E.M. 2012. Asilidae Classification. Available from <http://bugguide.net/node/view/151> [accessed 15 February 2013].
- Fisher, E.M., and Wilcox, J. 1997. Catalogue of the Robber Flies (Diptera: Asilidae) of the Nearctic Region. Available from <http://royalbcmuseum.bc.ca/staffprofiles/files/2013/08/Catalog-Nearctic-Fisher-Wilcox-1997-manuscript-copy.pdf> [accessed 7 November 2013].
- Foxlee, H.R. 1942. A list of nineteen species of Asilidae collected at Robson, B.C. (Diptera). *Proceedings of the Entomological Society of British Columbia*, **38**: 14.
- Geller-Grimm, F. 2013. Robber Flies (Asilidae) [online]. Available from <http://www.geller-grimm.de/asilidae.htm> [accessed 12 June 2013].
- Geller-Grimm, F., and Artigas, J. 2004. Catalogue of the Nearctic Species of Asilidae. Available from <http://www.geller-grimm.de/genera/nearctic/catspecies.html> [accessed 12 September 2012].

- Grimaldi, D. 1990. Diptera. *In* Insects from the Santana Formation, Lower Cretaceous, of Brazil. *Edited by* D. Grimaldi. *Bulletin of the American Museum of Natural History*, **195**: 1–191.
- Hebda, R.J. 1982. Postglacial history of grasslands of southern British Columbia and adjacent regions. *In* Grassland Ecology and Classification Symposium Proceedings. *Edited by* A.C. Nicholson, A. McLean, and T.E. Baker. British Columbia Ministry of Forests, Victoria, British Columbia. pp. 157–191.
- Hebda, R.J. 1995. British Columbia vegetation and climate history with focus on 6ka BP. *Géographie Physique et Quaternaire*, **49**: 55–79.
- Hine, J.F. 1909. Robberflies of the genus *Asilus*. *Annals of the Entomological Society of America*, **2**: 136–172.
- Hull, F.M. 1962. Robber flies of the world: the genera of the family Asilidae. *Bulletin of the United States National Museum*, **224**: 1–907.
- Knutson, L.V. 1972. Pupa of *Neomochtherus angustipennis* (Hine), with notes on feeding habits of robber flies and a review of publications on morphology of immature stages (Diptera: Asilidae). *Proceedings of the Biological Society of Washington*, **85**: 163–178.
- Lehr, P.A. 1998. Robber flies of the genus *Cyrtopogon* Loew, 1847 (Diptera: Asilidae) of the Palaearctic [English translation from the Russian]. *Entomological Review*, **78**: 1042–1065.
- McAlpine, J.F. 1979. Diptera. *In* Canada and Its Insect Fauna. *Edited by* H.V. Danks. *Memoirs of the Entomological Society of Canada*, **108**: 389–424.
- Martin, C.H. 1975. The generic and specific characters of four old and six new Asilini genera in the western United States, Mexico, and Central America (Diptera: Asilidae). *Occasional Papers of the California Academy of Sciences*, **119**: 1–107.
- Martin, C.H., and Wilcox, J. 1965. Family Asilidae. *In* A Catalogue of the Diptera of America North of Mexico. *Edited by* A. Stone, C.W. Sabrosky, W.W. Wirth, R.H. Foote, and J.R. Coulson. United States Department of Agriculture, Agriculture Research Service, Washington, D.C. *Agriculture Handbook*, **276**: 360–401.
- Meidinger, D.V., and Pojar, J. (Editors) 1991. Ecosystems of British Columbia. Special Report Series 6, Research Branch, BC Ministry of Forests, Victoria, British Columbia. Available from <http://www.for.gov.bc.ca/hfd/pubs/Docs/Srs/Srs06.htm> [accessed 20 October 2012].
- Melin, D. 1923. Contributions to the knowledge of the biology, metamorphosis and distribution of the Swedish asilids in relation to the whole family of asilids. *Zoologiska Bidrag från Uppsala*, **8**: 1–317.
- Nicholson, A.C., Pojar, J., and Hamilton, E.H. 1982. Introduction. *In* Grassland Ecology and Classification Symposium Proceedings. *Edited by* A.C. Nicholson, A. McLean, and T.E. Baker. British Columbia Ministry of Forests, Victoria, British Columbia. pp. 157–191.
- Paiero, S.M., Marshall, S.A., Pratt, P.D., and Buck, M. 2008. Diptera. *In* Insects of Ojibway Prairie, a Southern Ontario Tallgrass Prairie. Available from [http://www.uoguelph.ca/debu/Insects\\_of\\_Ojibway\\_Species\\_List\\_2008.pdf](http://www.uoguelph.ca/debu/Insects_of_Ojibway_Species_List_2008.pdf) [accessed 31 March 2013].
- Paiero, S.M., Marshall, S.A., Pratt, P.D., and Buck, M. 2010. Insects of Ojibway Prairie, a southern Ontario tallgrass prairie. *In* Arthropods of Canadian Grasslands, Vol. 1: Ecology and Interactions in Grassland Habitats. *Edited by* J.D. Shorthouse and K.D. Floate. Biological Survey of Canada, Ottawa, Ontario. pp. 199–225.
- Papavero, N. 1973. Studies of Asilidae (Diptera) systematic and evolution. I. A preliminary classification in subfamilies. *Arquivos de Zoologica da Universidade de São Paulo*, **23**: 217–274.
- Scudder, G.G.E. 1997. Environment of the Yukon. *In* Insects of the Yukon. *Edited by* H.V. Danks and J.A. Downes. Biological Survey of Canada (Terrestrial Arthropods), Ottawa, Ontario. pp. 13–57.
- Shorthouse, J.D. 2010a. Ecoregions of Canada's prairie grasslands. *In* Arthropods of Canadian Grasslands, Vol. 1: Ecology and Interactions in Grassland Habitats. *Edited by* J.D. Shorthouse and K.D. Floate. Biological Survey of Canada, Ottawa, Ontario. pp. 53–81.
- Shorthouse, J.D. 2010b. Ecoregions with grasslands in British Columbia, the Yukon, and Southern Ontario. *In* Arthropods of Canadian Grasslands, Vol. 1: Ecology and Interactions in Grassland Habitats. *Edited by* J.D. Shorthouse and K.D. Floate. Biological Survey of Canada, Ottawa, Ontario. pp. 83–103.
- Skevington, J.H. 1999. New Canadian records of Asilidae (Diptera) from an endangered Ontario ecosystem. *Great Lakes Entomologist*, **32**: 257–265.
- Skevington, J., Stead, K., Caloren, D., and Connop, J. 2000. The Insects of North Lambton County, Ontario, Canada [online]. Lambton Wildlife Incorporated. Available from <http://www.uoguelph.ca/debu/Lambton-intro.htm> [accessed 24 July 2013].
- Theodor, O. 1980. Diptera: Asilidae. Fauna Palestina: Insecta II. The Israel Academy of Sciences and Humanities, Jerusalem.
- Wilcox, J. 1966. *Efferia* Coquillett in America north of Mexico (Diptera: Asilidae). *Proceedings of the California Academy of Sciences*, **34**: 85–234.

- Wilcox, J. 1971. The genera *Stenopogon* Loew and *Scleropogon* Loew in America north of Mexico (Diptera: Asilidae). Occasional Papers of the California Academy of Sciences, **89**: 1–134.
- Wilcox, J., and Martin, C.H. 1936. A review of the genus *Cyrtopogon* Loew in North America (Diptera - Asilidae). Entomologica Americana, **16**: 1–95.
- Wild Species. 2005. Wild Species: The General Status of Species in Canada [online]. Available from <http://www.wildspecies.ca/searchtool.cfm?lang=e> [accessed 28 June 2013].
- Wild Species. 2010. Wild Species: The General Status of Species in Canada. Available at <http://www.wildspecies.ca/wildspecies2010/results-insects-odonates.cfm?lang=e> [accessed 28 June 2013].
- Wilson, M.V.H. 1978. Paleogene insect faunas of western North America. Quaestiones Entomologicae, **14**: 13–34.
- Wood, G.C. 1981. Asilidae. In Manual of Nearctic Diptera. Vol. 1. *Coordinated by* J.F. McAlpine, B.V. Peterson, G.E. Shewell, H.J. Teskey, J.R. Vockeroth, and D.M. Wood. Agriculture Canada Monograph **27**: 549–573.