



# Slant-faced grasshoppers of the Canadian Prairies and Northern Great Plains

Dan L. Johnson

Environmental Health, Agriculture and Agri-Food Canada Research Centre, PO Box 3000, Lethbridge, AB, T1J 4B1; and University of Lethbridge, 4401 University Drive West, Lethbridge, AB, T1K 3M4 Canada, dan.johnson@uleth.ca



Striped slant-faced grasshopper (female) at Drumheller, AB (see also p. 9)



A very green four-spotted grasshopper (male) from Medicine Hat, AB (see also p. 14)

When many people hear the word grasshopper, the image that comes to mind is often an insect in the group called the slant-faced grasshoppers. In Canada, slant-faced grasshoppers are all in the “stridulating slant-faced grasshopper” subfamily, also called the tooth-legged grasshoppers because the males possess a row of pegs on the inner side of the leg. The taxonomic name for this group is the subfamily Gomphocerinae, in the family Acrididae, of the Order Orthoptera. The tooth-legged grasshoppers can be distinguished easily from the other subfamilies of grasshoppers because they have no spur or spine-like process of the prosternum (‘throat’ area) like that of the subfamily Melanoplinae, and they do not have large, lobed and often coloured wings like the subfamily Oedipodinae (described in previous articles: Johnson 2001, 2002). The tooth-legged grasshoppers differ morphologically and behaviourally from the subfamily Acridinae, a small group of “silent slant-faced grasshoppers” that do not have stridulatory pegs on the legs, and do not occur on western Canadian grassland.

The tooth-legged grasshoppers are mostly slender and often streamlined, with the head point-

ed and often tipped forward. They sing by stroking their back legs across the edges of their wings. Most of them eat grass, and they can be quite specific in their preferred diets, sometimes eating mainly one species of native grass. Although the gomphocerine grasshoppers are often dominant in European ecosystems (compared to other kinds of grasshoppers), and in the US they may be abundant to the point of being economic pests, on Canadian grassland they usually account for less than 5% of the grasshoppers that could be found at random at a typical site. There are cases on the Prairies in which the tooth-legged grasshoppers comprise more than 20% of the grasshopper species present, and 100% of the adult grasshoppers present (even in summer, such as Johnson 1989), but normally they are found on Canadian grassland at densities of around one per square metre, to as low as one per 100 or more square metres. Some gomphocerine grasshoppers can increase to high densities when extended warm, dry weather increases their survival and reproduction rates. In 2002, tooth-legged grasshoppers reached densities of over 50 adults per square metre at some grassland sites near the Milk River



in Alberta, and comprised more than 95% of the grasshoppers present, so we should not assume that they are destined to remain minor components of northern grassland ecosystems, compared to the more numerous and visible spur-throated and band-winged grasshoppers.

The wings of tooth-legged grasshoppers are usually clear, short and slender, and may not even support flight. When these grasshoppers do fly, they do not normally make sound (called crepitation, common among the band-winged grasshoppers). Tooth-legged grasshoppers call by sawing a row of spines or pegs on the inner surface of the hind femur along the tegmen (the leathery forewing), making the rasping grasshopper sounds that are commonly heard on summer days. The club-horned grasshopper is often heard in early summer at short grass prairie, making a scratching sound that can be heard some distance away. Later in the summer, especially at sites with taller grass, the marsh meadow grasshopper male sings with a regular scratching sound with separated syllables, like *skit-skit-skit-skit*. Although some species of tooth-legged grasshoppers can make a little sound in flight, their calls are usually restricted to this stridulating from positions secreted in the grass. They sound distinctly softer and more repetitive than the buzz or rattle of the band-winged grasshoppers (subfamily Oedipodinae) in flight (crepitation), although they might be mistaken at first for certain meadow katydids, in the family Tettigoniidae. Spur-throated grasshoppers (subfamily Melanoplinae) also flick their legs and softly trill and buzz to indicate readiness to either mate or repel competitors, but using legs that are too smooth to produce sounds that the human ear can detect from more than a few metres distance.

All of the tooth-legged grasshopper species discussed below are, so far, relatively harmless to

agriculture in Canada in most years, and in fact many serve as important sources of food for birds and other wildlife. Recognition of species is mainly of interest to naturalists and ecologists who are interested in biodiversity, but knowledge of species is also of value to farmers and ranchers who do not want to make the mistake of taking control actions against non-damaging grasshoppers. It may also become important in the future to distinguish species, because some have the potential to become pests under certain warmer climate. They will not damage crops, but they have the potential to reduce forage and grazing productivity.

A few specialized terms will help in identifying the grasshoppers in this subfamily. Grasshoppers have four wings, and the pair of leathery, protective forewings are called the tegmina (one is a tegmen). The saddle-shaped back that lies just behind the head of a grasshopper is called the pronotum, so-called because it is the top part (notum) of the prothorax, the front of the thorax. The central longitudinal ridge of the pronotum is the median carina. Cuts or lines that run across the median carina from side to side are called sulci (singular: sulcus). The central dent or depression that may be found on the tip of the grasshopper head is the fastigium. To either side of the fastigium are the lateral foveolae, shallow depressions surrounded by small ridges, which can be seen in the field with a 10 H or 20 H hand lens (to find them, look closely at the tip of the head, between and just ahead of the eyes). These structures provide ways to separate some similar tooth-legged species, as described below.

For each species below, I have added some brief personal observations on ecology and changes in distribution.



***Acrolophitus hirtipes* (Say)**



Male resting, but not feeding, on a wheat plant

**Green fool grasshopper**

This large, hairy, light-green grasshopper has a strongly pointed head and a unique round crest rising like a half-moon on the pronotum. The median carina of the pronotum is cut by three sulci, and lateral foveolae are absent. A light-coloured diagonal stripe marks the side of the head, and the antennae are usually orange. The hind wings are relatively long and there is a dark band on the hindwing – unusual for Gomphocerinae. In flight it flutters as though it has wings and legs that are a bit too long, and it is easy to catch. If you take up grasshopper watching on the Canadian Prairies, you might see only a few of this flagship of the Gomphocerinae per summer (usually one at a time, often stridulating), but it is worth the wait. Good places to look are on rolling hills covered with short grass, or coulees where blue grama grass (*Bouteloua gracilis*) is dominant, in August.

***Aeropedellus clavatus* (Thomas)**

This common spring species has a strongly constricted hourglass marking on the pronotum, as do many tooth-legged grasshoppers (this is called constricted lateral carinae, because the outer ridges on the back seem to be squeezed in toward the midline). The club-like shape of the apical segments of the antennae, especially noticeable on the male, provides a good basis for identification of this species, even for the nymphal instars (the velvet-striped grasshopper discussed below has more broadly flattened apical segments, not as confined to the tip). This grasshopper is usually grey with black accents, but it can be green and silver-grey. The median carina is cut by one sulcus. The lateral foveolae are narrow rectangles.

The club-horned grasshopper is found throughout the grassland biome of the Prairie provinces, as well in forested ecosystems of the foothills and as far north as continental treeline. It is very common in May and June of some years, and frequently confuses pest managers watching for an early hatch of grasshopper pest species. The club-horned grasshopper overwinters in the egg stage, but hatches

**Club-horned grasshopper**



Male from near Edmonton, AB

more than a month earlier than the pest species. It can be heard in June and July making a *scratch-scratch-scratch* sound in the grass, and a captured or even dead specimen will make a rasping noise if you hold the back legs by the tarsi (feet) and move the legs up and down against the wings.



The club-horned grasshopper was found to be an important item in the diet of songbirds on Alberta semi-native grass pastures (Martin et al. 2000). The tegmina (wings) are very short in the flightless female, but usually run almost to the end of the abdomen in the male. Males fly, but not great distances, and changes in sex ratio of this species at a given site have been investigated as evidence of migration (Johnson et al. 1986).

Although some references note that high numbers have followed years of wet weather (Pfadt 1989), the highest populations of this species that I have seen in Alberta and southwestern Saskatchewan were during runs of several exceptionally warm, dry years such as 1985–88, and 2000–2003.



Female club-horned grasshopper resting in a wooded meadow near Lacombe, AB

#### *Ageneotettix deorum* (Scudder)



Male captured by a robber fly (Diptera: Asilidae), near the Lost River, AB

#### White whiskers grasshopper

This small, delicate grasshopper is named for its grey and thread-like antennae (visible in the photo of a white whiskers grasshopper captured by a robber fly, south of Onefour, AB). The hind legs seem a little oversized compared to the rest of the body. The hind tibiae are orange, with prominent black ‘knees’ where they join the femora (like some other tooth-legged species). This species is usually found on short grass, typically where blue grama grass is common.

The lateral foveolae are large and rounded but rectangular, unlike the otherwise somewhat similar big-headed grasshopper described below, which has triangular foveolae. If you have trouble recalling which is which, remember that ‘deor’ is like door, a rectangle. Brooks (1958) and Otte (1981) have comparative drawings (recommended for the artwork as well as for the taxonomy, ethology and biogeography).





***Amphitornus coloradus* (Thomas)**



Female sitting on epilithic lichens near the Lost River, AB

This species is easily recognized by its strongly slanted head, and brown, grey and dull gold longitudinal stripes on the body. The antennae are thread-like. The hind tibiae are usually blue, even in dried specimens. The lateral foveolae are shallow or not visible.

**Striped slant-faced grasshopper**

The striped slant-faced grasshopper is considered to be a significant rangeland pest in the US, and might cause economic damage to grazing potential in southern Canada if climate warms. Populations on the Prairies have increased slightly each year since 1998, but still remain below the economic threshold throughout the Canadian range.



Male at Estevan, SK

***Aulocara ellioti* (Thomas)**

This robust, blue-grey grasshopper has a noticeably large head. It can be quickly separated from the similar but slightly smaller white whiskers grasshopper by the blue tibiae and the triangular lateral foveolae (they are rectangular on *Ageneotettix deorum*). The median carina is cut by one sulcus. This species was very common in 2002. It is sometimes noticed because of its active stridulating, courtship behaviour and aggressive stances to other *A. ellioti* males and also to other species of grasshopper. The big-headed grasshopper is considered to be a serious range pest in the US, and it might significantly compete with livestock grazing in Canada if climate warms.

In dry years, watch for a rare related species, *A. femoratum* (the white cross grasshopper) in the dry mixed grass ecoregion. The white cross grass-

**Big-headed grasshopper**



Pair on sand near Spring Coulee, AB (the male is the smaller)

hopper can be recognized by the slightly shorter wing, lighter colour, dark bands on the hind femur and smaller body size.



### ***Bruneria brunnea* (Thomas)**

This grasshopper looks a little like a slightly bigger, slightly darker version of the white whiskers grasshopper. The hind femur has three dark angled bands (occasionally joined to make two). The pale hind tibia may be orange or tan, and the head often has a light horizontal stripe on each side of the face. Some have a longitudinal mid-dorsal yellowish stripe. The hindwings are long and appear shiny, with spots (but not large and joined spots like the four-spotted grasshopper below). The median carina is cut by one sulcus. The abdomen, especially of the male, may appear striped with dark rings. The lateral foveolae are rectangular, but are not more than three times as long as wide. This species lives on grassland as far north as the Peace River region, and is often found in meadows or partially wooded sites. In 1987-90, this species reached densities of several per square metre on sites near Brooks, AB, and in some unusual cases made up more than 25%

### **Bruner's grasshopper**



Grey form of the normally brown Bruner's grasshopper (female) near Loverna, SK

of the grasshopper community (e.g., Johnson 1989). It occurred at low densities on dry mixed grass in southern Alberta and Saskatchewan during 1991-97 (usually less than one per 100 square metres, and less than one per thousand grasshoppers).

### ***Chloealtis conspersa* (Harris)**

### ***Chloealtis abdominalis* (Thomas)**



Female sprinkled grasshopper in Highwood Meadows, near Kananaskis, AB. Most are brown and speckled, not coloured like this one.

These stocky grasshoppers are mainly found in grass-sedge meadows, wooded areas, foothills fescue, or where grassland meets parkland, including at the northern edge of the grassland biome. The wings of the male extend almost to the end of the abdomen, and are held roof-like over the body, reminiscent of caddisflies (Order Trichoptera) but

### **Sprinkled grasshopper**

### **Cow grasshopper**

with a flat, squared off dorsal surface. Lateral foveolae are absent. The pronotum is robust and angular, with a strong media carina cut by one sulcus. *C. conspersa* has tightly packed venation in the upper portion of the male forewing, and *C. abdominalis* has wider, more rounded patterns in the venation. The female wing of *C. abdominalis* is shorter and more bract-like than that of *C. conspersa*. Usually there is a dark band on the hind femur. *C. consper-*



Female cow grasshopper resting on gravel near Cochrane, AB



sa females are sometimes a finely speckled walnut brown, and females of both species can be variations of a pink or chalky rose. I once observed *C.*

*abdominalis* females attempting to oviposit in decayed wood and densely packed moss, unusual sites for a grasshopper to lay eggs.

***Chorthippus curtipennis* (Harris)**



Green and shiny male from Drumheller, AB

Like the lesser migratory grasshopper, a widespread member of the spur-throated subfamily, the marsh meadow grasshopper has a distribution that covers nearly all of North America. On the Canadian Prairies, it is found where grass grows relatively tall and dense. It is often associated with moist habitat (hence the common name), but populations can build up in years of adequate moisture and persist through several dry years. In 2002, it was one of the more common species in the extremely drought-stricken regions of Alberta and west-central Saskatchewan. This species is easy to recognize, with its slim yellow and green body, and slanted head. The lateral foveolae of this species are very narrow rectangles, clearly visible with a hand

**Marsh meadow grasshopper**

lens. The eyes appear large in comparison to the body, and may be quite dark in colour. The male has a long wing, but the larger female has wings only half as long as the abdomen (depending on breeding status, because the abdomen elongates prior to egg-laying, as with most grasshopper females). The abdomen of either sex may appear yellow and striped with dark rings, but do not confuse this with the yellow-and-black striped abdomen of Dawson's grasshopper (*Melanoplus dawsoni*), a spur-throated grasshopper which is also found in fescue grass and similar moister environments.



Female walking across a wild strawberry leaf near Stavely, AB

***Cordillacris occipitalis***

This small grasshopper is usually found only on dry, sandy rangeland that is often home to band-winged grasshoppers and xeric spur-throated grasshoppers. This species looks a bit like *A. coloradus*, but without the prominent stripes. It has been very rare on the Canadian Prairies for years, usually oc-

**Occipital grasshopper**

curing at less than one individual per 10,000 grasshoppers, but about as high as 1% of grasshoppers collected at one site in the Canadian Forces Base Suffield National Wildlife Area, Alberta (observed by D. Johnson and C. Andrews, unpublished report to the Canadian Wildlife Service 1994).





### ***Eritettix simplex tricarinatus* (Thomas)**



Female sitting on red shale near the Oldman River, AB

Although published summaries of specimen data and maps indicate that it is confined to the extreme dry zone of southeastern Alberta and southern Saskatchewan, I have found this species on native pastures, and even in roadsides, throughout southern Alberta including north of the South Saskatchewan River and Oldman River, and also in central Saskatchewan, during collecting in May.

### **Velvet-striped grasshopper (or western velvet-striped grasshopper)**

The warmer summers in recent years might explain their northern increases.

This is one of a half-dozen species that overwinter on the Canadian Prairies as nymphs, and complete development in the spring. This early-season grasshopper is sleek in appearance, usually grass-green and silver grey (but sometimes tan). *Psoloessa delicatula* and *Aeropedellus clavatus* can also be grey and green, and are also among the small number of species found as adults on northern grasslands in April and May, so the colour and date of collection can cause confusion. To find this species, look on well-grazed pastures or rangeland where blue grama grass is common.

The fastigium (flattened part of top of head) of this species is obvious and pointed. The lateral foveolae are shallow, and not visible from above. Two dark longitudinal stripes on the pronotum are quite noticeable, and highlighted by thinner, light-coloured stripes. The antennae are slightly flattened.

### ***Mermiria bivittata maculipennis* Bruner**

This grasshopper is not to be confused with the much more robust two-striped grasshopper (*Melanoplus bivittatus*) in the spur-throated subfamily, which has lighter stripes on a darker green background, and sometimes causes crop losses in the tens of millions of dollars. The two-striped slant-faced grasshopper has the reverse pattern, usually with two dark green stripes on each side of a lighter tan, green or grey central band running the length of the stream-lined body. The antennae are strongly flattened and wider at the base, and triangular in cross-section. Wings extend to the tip of the abdomen, but I have seen shorter-winged variants. The hind tibiae are usually tan but can be orange.

### **Two-striped slant-faced grasshopper**

As with some other tooth-legged and slant-faced grasshoppers, I have found the two-striped slant-faced grasshopper to be rare but present on pastures and grazing land throughout southern Alberta, and even at 51 degrees N latitude, although authoritative summaries of collection records and maps (Otte 1981, Pfadt 1989, Vickery and Kevan 1985) indicate that it is confined to the extreme south, very close to the US border. Although sampling effort may explain some of the discrepancy with previous collectors, the marked increase that I have noticed in recent years may be a result of warm, dry weather.





***Opeia obscura* (Thomas)**

The small, often straw-coloured, narrow body of this species and a tendency to sit still may be the reasons for the obscure species name. In Canada, it occurs infrequently in dry short grass ecosystems, where blue grama is dominant. The antennae are flattened at the base and triangular in cross-section. It has a slight bug-eyed appearance from above, because of the narrow head and slight body size. A ridge on the top of the head will confirm the identification. Both sexes have wings that almost reach the tip of the abdomen. Wings of this species are



Female collected at Val Marie, SK

**Obscure grasshopper**



Male collected near Wild Horse, AB

often short in Canada. Pfadt, 1989, indicates that in western states the wings are as long as or surpassing the end of the abdomen. Note that species list, colour, stripes and wing length noted in western US guides such as Pfadt (1989) may vary from what we observe on Canadian grasslands. During 1990–2002, I saw this grasshopper occasionally as far north as Oyen, AB and Lloydminster, SK, although previous records indicated that it was restricted to the region near the U.S. border.

***Orphulella speciosa* (Scudder)**

***Orphulella pelidna* (Burmeister)**



The rare spotted-winged grasshopper (male), basking on a rock near Onefour, AB

**Pasture grasshopper**

(on the prairies, mainly from Manitoba)

**Spotted-winged grasshopper**

(found in Alberta and Saskatchewan)

These slim grasshoppers look a little like a less colourful version of *A. coloradus*, with generally uncoloured but finely chevroned hind femora. Although they are small to medium-sized and slender, they have long wings, often with a row of small dark spots. The lateral foveolae are not clearly visible. The pronotum appears to have a dark longitudinal line with a pale ivory line above it. The lateral carinae are cut by two faint sulci. This is a rare species that I have found in isolated patches of dense grass and sedge.



### ***Phlibostroma quadrimaculatum* (Thomas)**

This species has been rare in Alberta and Saskatchewan for much of the last two decades, but it has increased in numbers in recent years. The four-spotted grasshopper has a rugged and even stout appearance from the side or from above, with the head and pronotum broad and appearing slightly oversized, but without a slanted face. They are usually green or grey, and occasionally tan. The lateral foveolae are not clearly visible. Wings of Canadian species usually do not reach to the end of the abdomen. The tegmina have large dark brown spots on the otherwise tan, green or grey background. These spots are often four in number and often triangular; when joined they look like dark jack-o'-lantern teeth hanging down from the top. *Cordillacris crenulata*, the spotted-winged grasshopper, a relative of *C. occipitalis* mentioned above, and some other slant-faced grasshoppers also have similar blotches on the wings, but these are longer, slimmer species that have a distinctly slanted face.

### **Four-spotted grasshopper**



Four-spotted grasshopper found near Shaughnessy, AB

### ***Pseudopomala brachyptera* (Scudder)**



Female blending with stone colours at the Writing-On-Stone campground, AB

This grasshopper is so elongated in the body and with such a pointed head that some observers think they have found a walking stick. It is sometimes called a toothpick grasshopper. The antennae are long, strongly flattened at the base, and triangular in cross-section. This is also a characteristic of the obscure grasshopper and the two-striped slant-

### **Bunch grass grasshopper**

faced grasshopper, but the bunch grass grasshopper is both slimmer and longer, and has shorter wings relative to the abdomen. The wings of the female bunch grass grasshopper may be only one-fourth to one-third of the length of the twig-like abdomen. It is usually grey to cream-coloured. This species has probably increased in abundance and range during recent dry years, and it has apparently adapted well to the widespread distribution of brome grass on prairie roadsides, where it is often found. Vickery and Kevan (1985) show only one collection record in Alberta and none in Saskatchewan. Vickery and Kevan (1983) note that on the Prairies it had been collected only "in one small coulee, at Onefour, Alberta", citing Brooks (1958). From 1983 to 1993, I found that this species was rare on the Prairies, but more recently I have found it to be infrequent but present across the southern Prairies, and I have collected it as far north as Provost and Coronation, Alberta, well north of 52 degrees N latitude. It would be interesting to know how it disperses.



***Psoloessa delicatula* (Scudder)**



Female on exposed soil at a pasture margin near Barnwell, AB

This species is usually the first tooth-legged grasshopper found in the spring, appearing even earlier than the velvet-striped grasshopper and the club-horned grasshopper (Savage 2002). The adults are gone in mid-July, and first and second instars appear (Table 1), and fourth and fifth instars overwinter.

This species has been shown to be an important food item for the survival of the nestlings of grassland songbirds. More than 80% of the food that grassland songbirds feed to their nestlings are grasshoppers, and in May and June this species is often the main item on the menu, easy to catch and neither too large nor too small to feed to nestling songbirds (Martin et al. 1998). Size and colour distinguish these early tooth-legged grasshoppers immediately from the darker and more robust band-winged grasshoppers that overwinter as nymphs and appear early in spring, mainly the speckled-winged grasshopper (*Arphia conspersa*) and the red-shanked grasshopper (*Xanthippus corallipes*). The brown-spotted range grasshopper is mainly grey with strong black contrasts, although it can be green and grey, or even tan and grey. The lateral foveolae are rectangular, and the pronotum from above appears as a strongly restricted hourglass, with the side ridges (lateral carinae) squeezed in at the middle, even more so than the

**Brown-spotted range grasshopper**

other tooth-legged species. Note that the brown-spotted grasshopper, the four-spotted grasshopper, and the club-horned grasshopper all have grey and black hourglass markings on the pronotum (bird's eye view). *P. delicatula* is without clubbed antennae, and has a smaller head and smaller spots on the tegmina than the four-spotted grasshopper (which usually does not appear as an adult until July). The inside of the hind femora of the brown-spotted grasshopper are clearly marked with black triangles, when seen from above, whereas the four-spotted grasshopper and the club-horned grasshopper have broken, dark bars but no triangles on the legs.

Table 1. Age structure of *Psoloessa delicatula*, on short grass at Onefour, Alberta (column percentages sum to 100 for a given sampling date).

Instar	Date (2000)						
	Jn 22	Jl 5-6	Jl 17-18	Jl 31-Aug 1	Aug 14	Sep 13	Oct 23
1	0	0	98	94	6.6	0	0
2	0	0	0.8	5.6	84	16	0
3	0	0	0	0	9.5	49	17
4	0	0	0	0	0	35	69
5	0	0	0	0	0	0.6	14
Adult	100	100	0.8	0	0	0	0

N=1,248 *P. delicatula*, 45% of the total acridid community; from 19,200 sweeps with a 38-cm net



Female (green form) on Sandburg's bluegrass near Onefour, AB





## References

- Brooks, A.R. 1958. Acridoidea of southern Alberta, Saskatchewan and Manitoba (Orthoptera). *Canadian Entomologist Supplement* 9: 3–92.
- Johnson, D.L., B.D. Hill, C.F. Hinks and G.B. Schaalje. 1986. Aerial application of the pyrethroid deltamethrin for grasshopper (Orthoptera: Acrididae) control. *Journal of Economic Entomology* 79: 181–188.
- Johnson, D.L. 2001. Band-winged grasshoppers of the Canadian Prairies and the Northern Great Plains. *Arthropods of Canadian Grasslands* 7: 5–12; H.V. Danks, ed. *Biological Survey of Canada*, Ottawa.
- Johnson, D.L. 2002. Spur-throated grasshoppers of the Canadian Prairies and the Northern Great Plains. *Arthropods of Canadian Grasslands* 8: 16–25; H.V. Danks, ed. *Biological Survey of Canada*, Ottawa.
- Johnson, D.L. 1989. The effects of timing and frequency of application of *Nosema locustae* (Microspora: Microsporidia) on the infection rate and activity of grasshoppers (Orthoptera: Acrididae). *Journal of Invertebrate Pathology* 54: 353–362.
- Martin, P.A., D.L. Johnson, D.J. Forsyth and B.D. Hill. 1998. Indirect effects of the pyrethroid insecticide, deltamethrin on reproductive success of Chestnut-collared Longspurs. *Ecotoxicology* 7: 89–97.
- Martin, P.A., D.L. Johnson, D.J. Forsyth and B.D. Hill. 2000. Effects of two grasshopper control insecticides on the food resources and reproductive success of two species of grassland songbird. *Environmental Toxicology and Chemistry* 19: 2987–2996.
- Otte, D. 1981. *The North American grasshoppers. Vol 1. Acrididae: Gomphocerinae and Acridinae.* Harvard University Press, Cambridge, MA. 275 pp.
- Pfadt, R.E. 1989 (updated recently in electronic form). *Field Guide to Common Western Grasshoppers.* Wyoming Agricultural Experiment Station Bulletin 912.
- Savage, C. 2002. Peril of the prairie? *Canadian Geographic* May/June 2002: 42–50.
- Vickery, V.R. and D.K. McE. Kevan. 1983. A monograph of the orthopteroid insects of Canada and adjacent regions. *Lyman Entomological Museum and Research Laboratory Memoir* 13, Vol 2: 681–1467.
- Vickery, V.R. and D.K. McE. Kevan. 1985. The insects and arachnids of Canada. Part 14. The grasshoppers, crickets and related insects of Canada and adjacent regions. *Ultonota: Dermaptera, Cheleutoptera, Notoptera, Dictyoptera, Grylloptera and Orthoptera.* Agriculture Canada Publ. 1777. 918 pp.

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