Wider aspects of a career in entomology. 19. My introduction to Canada's fauna and environments, concluded

Hugh V. Danks

This series of articles outlines some ancillary aspects of my entomological career, for the potential amusement of readers. It reports the sometimes-unexpected challenges of working in new places and in the real world, an approach that serves also to expose some conclusions about entomological activities, and some information about insects and their environments. This article continues an account of my introduction to the Canadian insect fauna.

My explorations of Canada's fauna revealed many insects in addition to the butterflies, moths, and dragonflies featured in previous articles (ESC *Bulletin* **54**: 11–20; **54**: 66–75). However, most of the species were unfamiliar to me.

They were also more difficult to identify than the ones I had met in the United Kingdom. There, only a few species remain to be discovered, and more than 24 000 species of all orders have already been described. In Canada, nearly all groups are less well known and more diverse.

Nevertheless, the large and strikingly coloured species seen on my hikes could usually be identified. Their names allowed me to discover noteworthy details about the natural history and adaptations of each species, just as for the groups previously featured.

Tiger beetles are active and showy (and there are six times as many species in Canada as in the UK). There has been much faunistic and ecological research, including the potential of tiger beetles as bioindicators, as well as studies of activity (in relation to temperature and solar radiation), vision, locomotion, and predation. One common species (Figure 1) usually pounces on prey that come close, rather than pursuing prey over greater distances as in most other species.

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Figure 1. Six-spotted tiger beetle, the cicindelid *Cicindela sexguttata*. Length 1.3 cm.

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Figure 2. Elder borer, the cerambycid *Desmocerus palliatus*. Length about 2.5 cm.

The elder borer (Figure 2) has dramatic warning coloration that is believed to mimic that of toxic lycid beetles. However, because this longhorn beetle feeds on elderberry flowers and leaves, and its larva bores in the stems and roots, it may be toxic in its own right through substances obtained from the elderberry plant[1]. Moreover, confirming the general complexity of interspecific interactions in insects, a few other species of longhorn beetles not only mimic but also prey on lycids.

[1]Elderberry contains cyanogenic glycosides. Lycid beetles are protected by lycidic acid, apparently generated by the beetles (their larvae do not eat higher plants, but live under bark and are believed to eat myxomycetes or metabolic products of fungi, although they were once thought to be predaceous).

Hugh Danks (hughdanks@yahoo.ca) retired in 2007 after many years as head of the Biological Survey of Canada. In that role, he helped to coordinate work on the composition and characteristics of the arthropod fauna of the country, and to summarize the results. In addition, his research studied cold hardiness, diapause, and other adaptations to seasonality in northern regions.

The milkweed leaf beetle (Figure 3) has warning colouration too, despite its relatively small size. It is one of many orange and black species in the complex of mainly unpalatable mimics associated with milkweed, which in Canada also includes the milkweed longhorn beetle, the larva of the milkweed tussock moth, large and small milkweed bugs, the viceroy butterfly, and the monarch butterfly[2]. Adults and larvae of the milkweed leaf beetle cut several side-veins of the leaf prior to feeding, to tap off the sticky exudate that would otherwise be produced at the feeding site.


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Figure 3. Milkweed leaf beetle, the chrysomelid *Labidomera clivicollis*. Length about 1 cm.


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Figure 4. Two common pest beetles: rose chafer, the scarabeid *Macrodactylus subspinosus* (L), length about 1 cm; and Japanese beetles, the scarabeid *Popillia japonica*, length 1.5 cm, on a leaf damaged by their feeding.

Other beetles were noticed because they are especially abundant. Some were pests, both native species like the rose chafer, and introduced ones such as the Japanese beetle (Figure 4). Many such pests have extraordinarily wide host-plant ranges. Japanese beetles will eat more than 300 kinds of herbaceous plants, shrubs, and trees belonging to about 80 plant families, and they feed on flowers and fruits as well as foliage.

Cicadas attracted my notice because they are large and noisy. Even so, individuals are hard to see as they sing high in the trees, but the exuviae of nymphs that have emerged from the soil relatively recently (and the adults that came from them) are visible on tree trunks. Most cicadas are annual, although the periodical ones in which the whole population emerges together only every 13 or 17 years get most of the attention. The "annual" species evidently take more than 1 year to develop, given the nutritionally poor xylem fluid on which cicadas feed, but are not synchronized and so appear every year. Many of the relatively common "green *Tibicen* species" in eastern Canada (e.g., Figure 5) are difficult to distinguish.


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Figure 5. An annual cicada, the cicadid *Neotibicen* sp., probably *N. linnei*. Length about 4 cm.

Grasshoppers were often seen or heard in open areas, sometimes in large numbers. The Carolina grasshopper is particularly common, and easy to see when it flies suddenly—revealing spectacular hind wings, which are dark with a pale border. Extended flights, frequent in hot weather, are unpredictable and never linear, a pattern that would hinder pursuit by predators. Moreover, as soon as the insect settles it becomes perfectly camouflaged (Figure 6).

The courtship behaviour of this species is distinctive. Males hover above the ground, rising and falling, and crackling their wings. After the males land, they stridulate, alternating hind legs in a characteristic way, until a female approaches. I once saw a

[2]Milkweed toxins, sequestered by the monarch and some other species, are cardenolide glycosides (cardiac glycosides).

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Figure 6. Carolina grasshopper, the acridid *Dissosteira carolina*. Length about 4.5 cm.

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Figure 7. Twostriped grasshopper, the acridid *Melanoplus bivittatus*. Length about 3.5 cm.

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Figure 8. Migratory grasshopper, the acridid *Melanoplus sanguinipes*. Length about 2.5 cm.

male attempting this behaviour although it had lost one hind leg. Its courtship was not successful!

Many common species of grasshoppers belong to the genus *Melanoplus*, which includes the twostriped grasshopper (Figure 7). That species is easily recognized, but many of its congeners are not, a problem exacerbated by considerable variation in colour. The migratory locust (Figure 8) is one such species. Like the twostriped grasshopper, it is distributed across the continent, and eats many kinds of forbs and grasses. Therefore, especially given migratory behaviour, the species are major pests of grasslands and crops, consuming grains, vegetables, and forages. Shrubs and trees, and even other individuals, will also be attacked when populations are high and food is short.

The abundance, pest status, and relatively large size of *Melanoplus* grasshoppers make them frequent subjects for research, and interesting discoveries have been made about insect nutrition and development, swarming and migration in both nymphs and adults, resource transfer during mating, egg diapause, and other matters. For example, during bouts of copulation lasting many hours, nutrients are transferred by the male in the form of spermatophores, and are subsequently used by the female. Females therefore obtain proteins and other resources for egg development though multiple mating.

The fact that these grasshoppers (and some of the butterflies and moths noted in earlier articles) will eat such a broad array of plants reinforces the theme that many abundant insects of all groups are broadly adapted to a range of conditions. In the same way, common species of many orders exploit widely available food types, such as decaying materials and prey organisms. Other adaptations that frequently bring success in cold or variable Canadian environments are tolerance to a range of climates, substantial cold hardiness in relevant stages, and sophisticated control of life-cycle timing (such as multiple programmed delays in development, which include complex egg diapauses in some grasshopper species).

More specialized insects such as gall makers are widespread too. One conspicuous gall, up to 5 cm long, occurs on sumac (Figure 9). Each gall is founded by a single egg laid on the underside of a sumac leaf in spring by a female aphid. These females (and the males that mate with them) arise from asexual generations that develop and overwinter in moss, the alternate host. The egg


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Figure 9. Sumac pouch gall, caused by the eriosomatine aphid *Melaphis rhois*, on staghorn sumac. Length about 5 cm.


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Figure 10. Cast exoskeleton of a stonefly nymph. Length about 2 cm.

hatches into a stem mother, which stimulates the formation of a gall. Inside it, an aphid colony builds up through several parthenogenetic generations. When the gall splits open, typically in late summer, winged females are released and move to the alternate host, often by simply dropping on to mosses beneath the sumac bearing their gall.

Many galls on the leaves and twigs of oaks are relatively large too, with a range of forms, giving rise to names like apple, gouty, and horned galls; some smaller leaf galls are brightly coloured. Most of these oak galls are induced by cynipid wasps. Characteristic galls on goldenrod (illustrated in ESC *Bulletin* **53**: 190–191) belong to a fly and to a moth.

As can be seen from the descriptions above, looking at vegetation during my hikes revealed species of interest that extended well beyond caterpillars. Attention was also particularly worthwhile at the edges of aquatic habitats, in the vicinity of artificial lights at night, and on flowers.

Adult dragonflies are the most conspicuous insects near water (see ESC *Bulletin* **54**: 70–75). Exuviae left by nymphs that have crawled out on to emergent vegetation to transform into adults are encountered too. The exuviae of stonefly nymphs (e.g., Figure 10) are much less common, but were a rewarding discovery because stoneflies are key indicators of cool, unpolluted habitats, and so are most frequent far from civilization! Chironomid midges (see below) are everywhere, both close to water bodies and away from them.

Water striders are regular denizens of the water surface. A few of the ways in which they drew my attention are shown in Figure 11. For example, in sunshine, gerrids cast strange shadows on the substrate because the surface film is depressed by the long, flexible legs that distribute the weight evenly as they support the animals, while hydrofuge hairs on the legs and body prevent them from breaking through the surface. All of them feed on invertebrates that have fallen onto the water surface. There are species and stages of many different sizes, and the smallest are especially difficult to photograph. Veliids often assemble in masses of tiny individuals that seethe in perpetual motion.


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Figure 11. Water striders (gerrids) and broad-shouldered water striders (veliids). L and R from top to bottom: shadows cast where the surface film is depressed by the legs; gerrid feeding on a dead caddisfly; two tiny individuals on calm water; cluster of hundreds of individuals of *Rhagovelia* sp. Lengths 0.3–1.2 cm.

Thirty species of water striders have been reported from Canada, living on various still and running waters. In some species, the wings of different individuals have two or more different lengths: long, short, or absent (as in nymphs). Such variation reflects adaptations to seasonality, dispersal, resource use, and calmness of the water surface, depending on habitat features such as permanence and turbulence.

Many insects (including some typically diurnal species) were attracted to my camping lantern, and in later years to the lights of motels and hotels. Large moths are most conspicuous, but many other arthropods arrive too (e.g., Figure 12). Small moths and even smaller flies are abundant, as are crane flies. Beetles, mayflies, caddisflies, lacewings, bugs, mantids, and others also come. Harvestmen frequently visit lights on the ground. Most of the species in this diverse assemblage are not easy to identify. Nevertheless, the species attracted to light are obviously different in each place. In addition to wide-ranging generalists, there are specialists from woodlands, wetlands, agricultural fields, or other habitats in the local area.

Hotel-room windows provide good views of insects resting there (e.g., Figure 13), whether or not those individuals have come to the lights.

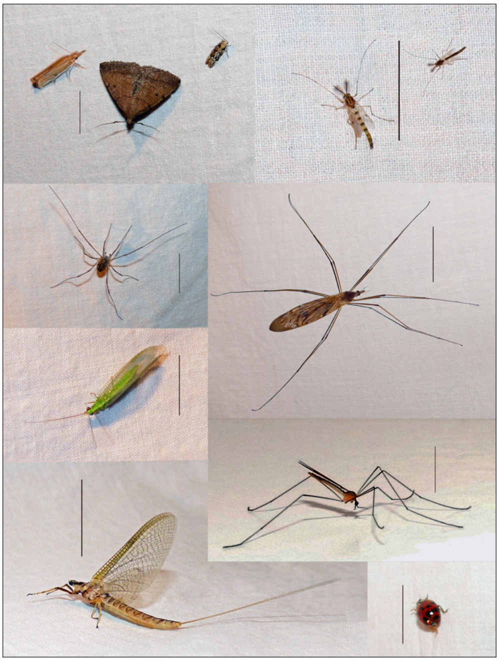

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Figure 12. A sample of the many kinds of arthropods that come to light. Clockwise from top L: small moths; chironomids; crane flies; lady beetle; mayfly; lacewing; harvestman. Scale lines, 1 cm.

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Figure 13. Insects on hotel windows: lake chironomids (L); and a mayfly alongside its subimaginal exoskeleton.

Flowers attract many kinds of insects, and are the best places to observe bees. Canada has more than 40 species of bumble bees, some of them Holarctic. A few widely distributed species dominate the observations (e.g., Figure 14), as for insects everywhere, but some that were once common are in decline, like the yellow-banded bumble bee (Figure 15). The reasons for such changes are seldom understood, although presumably they stem partly from loss of habitat, climate change, pesticide use, and other general factors. Pathogens and parasites from honey bee colonies are a more specific threat to bumble bees.

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Figure 14. Common eastern bumble bee, the bombid *Bombus impatiens*, an adaptable species and the one most frequently encountered in eastern Canada. Length 1.3 cm.

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Figure 15. Yellow-banded bumble bee, the bombid *Bombus terricola*, a species now greatly reduced in numbers in much of Canada. Length 1.3 cm.

Solitary bees vastly outnumber bumble bees, and are likely to be threatened by the same changes, but most species are too small (and active) to identify or photograph easily.

Like larger bees, several of the insects already mentioned are conspicuous because they have warning colouration. This category includes wasps[3], such as the familiar aerial yellowjacket (Figure 16). Like other yellowjackets, its notoriety depends on the fact that workers regularly come into contact with humans, are aggressive (especially near large nests, and if harassed[4]), and have an excruciating sting that produces severe allergic reactions in some people.

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Figure 16. Aerial yellowjacket, the vespid *Dolichovespula arenaria*. Length about 1.2 cm.

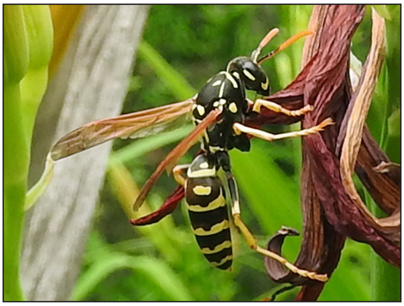

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Figure 17. European paper wasp, the polistine vespid *Polistes dominula*. Length about 1.2 cm.

Commonly encountered as well is the European paper wasp (Figure 17) a social species that was introduced relatively recently, but has spread rapidly across the country. Its success depends partly on the use of diverse nest sites, including man-made structures, and on the fact that it collects a wide range of food types. In some areas it seems to have interfered with populations of a native species, but this does not appear to be the case in Ontario.

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Figure 18. Red paper wasp, the polistine vespid *Polistes carolina*. Length about 2 cm.

[3]Many identifications in the species-rich family Vespidae were challenging until an excellent and profusely illustrated guide was published in 2008 in the *Canadian Journal of Arthropod Identification* [no. 5] (https://cjai.biologicalsurvey.ca/). Even so, photographs alone may be insufficient if they do not show all of the relevant characters.

[4]Foraging workers will sting well away from the nest if they feel threatened, and some individuals do so with little provocation (prompting the advice: "Don't flap at wasps"!).

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Figure 19. Black-and-yellow mud dauber, the sphecid *Sceliphron caementarium*. Length 2.5 cm.

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Figure 20. A potter wasp, the eumenine vespid *Eumenes fraternus*. Length about 1.7 cm.

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Figure 21. Pigeon tremex, the siricid *Tremex columba*, a horntail that develops in the wood of deciduous trees. Length about 3 cm.

Most wasps, even some dangerous-looking social species like the red paper wasp (Figure 18), are not aggressive except at the nest. The red paper wasp makes grey paper nests in protected locations, and is often seen on flowers.

The large black-and-yellow mud dauber (Figure 19), which stocks spiders in multiple cells in sheltered mud nests, looks equally formidable. However, it is solitary and builds a number of structures successively, rather than defending a continuously occupied nest as the social species do. Therefore, individuals seldom sting.

Potter wasps of the genus exemplified in Figure 20 (easily diagnosed by the distinctively shaped petiolate abdomen) are solitary too. Typical species stock caterpillars in pitcher-shaped nests made of mud.

Based mainly on lessons taught by yellowjackets and hornets, however, many people unduly fear all wasps, including docile and harmless species. Other harmless insects with similar warning colours—e.g., horntails (Figure 21), the large sawflies that attack chiefly dead or dying trees—produce the same response.

Such warningly coloured insects advertise their

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Figure 22. Flies at resources. Top to bottom: the tabanid *Stonemyia tranquilla* (length about 1.5 cm), on a flower; several polleniids, *Pollenia vagabunda* (length about 1 cm), on sap from a cut branch; sheep blow fly, the calliphorid *Lucilia sericata* (length about 1 cm), on dung.

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Figure 23. A swarm of chironomid midges around a tree top. The scale is indicated by a crow taking flight.

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Figure 24. Dead chironomids in the same area, about 4 weeks after the swarm shown in Figure 23: on a leaf; and on a tree stump. Length of individuals less than 1 cm.

presence. In contrast, small flies and parasitoid wasps do not, and as a result, they were seen far less during my explorations than would have been justified by their diversity and ecological importance. Both groups are particularly well represented in northern climates like Canada's.

A few families of parasitoid wasps, such as ichneumonids and gasteruptiids, contain large diurnal species that are easy to see as they hunt for prey. Even so, typical genera have many similar species, and individuals are constantly in motion. Observing any of the thousands of smaller, unidentifiable, parasitic wasps (belonging to nearly 40 different families) is not a profitable pursuit for the casual hiker!

Many flies can be seen when they assemble at resources such as flowers, sap, and dung (Figure 22). However, most of these and other species are difficult to identify. Although some of the 116 families of flies currently known from Canada are readily recognized, most identifications to species are challenging and require detailed examination of multiple characters. For instance, chironomid midges, especially swarms of males, are abundant near water (e.g., Figure 23), but even common species cannot normally be identified in the field.

Extraordinary numbers emerge in spring from large lakes, when swarms like that shown in Figure 23 are common across hectares of the land nearby. A few weeks later, their dead bodies coat surrounding surfaces (e.g., Figure 24). They are so plentiful that birds (including ducklings, which rely on rich insect food even in species with an adult diet of plants) consume only a negligible fraction of the population.

Decaying materials support many species. Their diversity is exemplified by sphaerocerids, common but diminutive microbial grazers that develop in a wide range of moist microhabitats. The family is much better known than in the past (the Canadian list of 35 species of sphaerocerids in 1979 has grown to more than 180 species), but in the field I could barely distinguish the family, let alone the species[5]!

[5]However, I did have an early experience with sphaerocerids: one of the graduate students who shared my laboratory in England studied them, including species reared on decaying grass clippings. An ample supply of this rearing medium was once left unattended indoors over a long summer weekend, after which the stench of rotting vegetation rendered the laboratory virtually uninhabitable for hours. (The response: "Oh, sorry, I forgot.")

Therefore, it was rewarding to find large and distinctive species of flies. The red-and-black crane fly *Ctenophora dorsalis* (Figure 25) mimics a wasp. Its presence indicates relatively undisturbed forest, because the larvae feed on rotting wood.

Of course, mosquitoes, black flies, and horse flies also forced themselves into notice during most hiking and camping journeys. Their unwelcome presence there—eliciting numerous biting comments from family members—will be considered in the next article in this series.

Many conspicuous species crossed my path over the years, therefore, but they proved to be a mere fraction of the fauna. Recent figures suggest that more than 44 100 species of insects, arachnids, and related groups are already known from Canada. Moreover, even conservative estimates suggest that between 27 000 and 42 600 additional species remain to be discovered.


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Figure 25. A wasp-mimic crane fly, the tipulid *Ctenophora dorsalis*. Length 2 cm.

Indeed, when I first saw cabinet drawers in the Canadian National Collection of insects, one feature stood out. A few genera of parasitic wasps, flies, and other taxa that had been studied in detail were labelled with the names of dozens of species; but many other similar genera bore only a handful of names, because they had not yet been revised, and many of the species were not even described. Such lack of knowledge adds to the difficulty of identification, hindering research of all kinds. It underscores the value of concerted efforts to characterize the fauna, such as the Biological Survey of Canada[6], which was established by the ESC.

Consequently, although my personal introduction to Canada's fauna and environments taught me many interesting things, those experiences served equally to emphasize how little I knew!

[6]Biologicalsurvey.ca