Wider aspects of a career in entomology. 18. My introduction to Canada's fauna and environments, continued

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 recounts further encounters with the Canadian fauna, featuring moths and dragonflies.

Many insects in addition to the butterflies noted in the previous article (ESC *Bulletin* **54**: 11–20) crossed my path as I camped and hiked in Canadian habitats. They included moths, several groups of which were familiar to me from activities as an amateur in England, where nearly all of about 2 500 species are already known. Canada has well over 5 500 known species, but many additional species remain to be distinguished.

Therefore, even though most species are nocturnal and concealed or camouflaged during the day, moths are varied and abundant. Moreover, some of the large species are relatively easy to identify. Identifications are always important, because they allow access to the full range of information indexed under each scientific name.

The large maple spanworm (Figure 1) was found more than once, although it is nocturnal. The larvae feed on various kinds of trees and other plants, highlighting a recurring theme (also evident in butterflies): that insects exploiting widespread food sources, and tolerating a range of habitats, tend to be common and widely distributed, and thus are encountered more frequently.

H. Danks

Figure 1. Large maple spanworm moth, the geometrid *Prochoerodes lineola*. Wingspan 4.5 cm.

Other geometrid moths were met with too—more than 500 species of the family occur in Canada[1]. Typical species adopt a characteristic posture with spread and flattened wings, and most have banded or disruptive camouflage patterns. Markings on the forewings and hindwings match, appearing continuous across all four wings when the moth is resting. In the large

[1]The diversity of geometrids is confirmed by the fact that the large maple spanworm, the maple spanworm, and the lesser maple spanworm all occur in Canada. Although the common names are similar, the species belong to three different genera, and only the lesser maple spanworm feeds mainly on maple.

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.

maple spanworm, the markings mimic a dead leaf and its midrib, but the background colour is extremely variable. Such intraspecific variation potentially mimics different leaves, but also would prevent predators from developing a search image. Caterpillars of some geometrid species prompt similar theories because they have several different colour morphs (green, brown, and grey).

Camouflage disguises many moths when they rest on the bark of trees, or on substrates such as litter, lichens, and moss. Nevertheless, even small individuals were often detected during my hikes if they settled on contrasting backgrounds after being disturbed (e.g., Figure 2)—although few of the species seemed easy to recognize[2]. However, I failed to notice most of the hundreds of moths (in multiple families) that are even smaller!

Typical caterpillars too are concealed or camouflaged during the day, but some can be discovered because they attack specific plants (many species are monophagous) and create characteristic patterns of damage. Different species feed in particular ways, and favour seedlings, leaf edges, shoot tips, buds, or flowers, for example.

However, no special knowledge was needed to identify the extreme damage to trees caused by the introduced spongy moth (formerly called the gypsy moth[3]) (Figure 3). This species is known for sporadic outbreaks, and populations in southern Ontario built up recently over several successive years, resulting in the death of some trees[4].

Late-instar larvae tend to move down from the canopy on to the bark during the day, but after defoliating a tree they spread out to adjacent plants, even those that are not normal hosts (Figure 4)[5]. Oak is preferred, but the caterpillars will eat many kinds of trees, including conifers[6]. In the worst-affected places, large numbers of the diurnal males could be seen flying rapidly about during July, in their characteristic zig-zag way, searching for the flightless females.

Figure 2. Small moths with camouflage patterns: the geometrid *Xanthorhoe ferrugata* (top) (larvae eat several kinds of herbaceous plants); and the herminiine erebids *Phalaenophana pyramusalis* (middle) and *Chytolita morbidalis* (bottom) (larvae feed chiefly on leaf litter). Wingspans about 2–3 cm.

[2]Greg Pohl kindly identified or verified the species shown in Figure 2.

[3]The Entomological Societies of Canada and America have withdrawn the common name gypsy moth (as have many other organizations), because it is deemed hurtful to the Romani people. The replacement name is spongy moth, which aligns with the French spongieuse, reflecting the way egg masses are felted with hair.

[4]Even deciduous trees can withstand only one or a few complete defoliations before being seriously weakened.

[5]Each caterpillar consumes about one square metre of leaves during its lifetime, chiefly in the final instar. The total leaf area of temperate trees is usually 3–5 times the area of the ground underneath them. Therefore, the group of about 90 caterpillars visible in Figure 4 (if unconstrained by natural enemies) could fully defoliate a tree canopy 5 or 6 m in diameter.

[6]Ash is not attacked—but many of those trees have been killed instead by the emerald ash borer.

Figure 3. Flowering tree during May (L); and the same tree in June after complete defoliation by caterpillars of the spongy moth. This tree did not recover.

Figure 4. Caterpillars of the spongy moth, the lymantriine erebid *Lymantria dispar*: resting on bark during the day (L); and an individual, length about 4.5 cm, that had moved to an adjacent plant after a nearby tree was defoliated.

Mated females typically oviposit on bark, and the cold-hardy egg-masses, densely covered with hair, overwinter there. Eggs complete development before winter, but larvae remain inside the egg shell until spring. The success of overwintering and other life stages depends partly on weather, and warming climates may have played a role in the severity of the recent outbreak. In dense populations, young caterpillars disperse in spring by ballooning on silken threads, potentially for up to a kilometre or more, before starting to feed. Multiple traits therefore contribute to the species' potential for rapid increase and spread. An important modern addition is transport of egg masses laid on firewood, outdoor equipment, and vehicles.

The caterpillars were so abundant during the outbreak that the forest was filled with pattering sounds, caused by frass falling to the ground. Similar sounds were heard in stands of overmature balsam fir during outbreaks of the spruce budworm, especially in the 1970s, as frass rained down from the thousands of larvae feeding overhead.

Other moth larvae that leave diagnostic indicators on hostplants include native eastern tent caterpillars, which build unsightly webs on trees and shrubs (Figure 5). Populations fluctuate widely and sometimes reach outbreak numbers, but seldom damage hostplants to the same extent as the spongy moth.

CC0 (James Demers, Pixabay)

Figure 5. Tent of the eastern tent caterpillar.

Ryan Hodnett (CC BY-SA 2.0)

Figure 6. Eastern tent caterpillar, the lasiocampid *Malacosoma americanum*. Length about 5 cm.

This species has several remarkable adaptations. The female oviposits around branches, where the eggs will overwinter, and coats the egg mass with a secretion that is mixed with air to make a foamy covering, known as spumaline, that subsequently hardens. Spumaline can absorb water directly from the air, preventing desiccation of the unhatched first-instar larvae, which (as in the spongy moth) overwinter fully developed inside the eggs.

The multilayered tent becomes warmer than the surrounding air, and plays an essential role in modifying the temperature of the growing larvae. In particular, it allows caterpillars to warm up sufficiently on cool spring days to support feeding and digestion, and caterpillars also adjust their temperatures by aggregating. They leave the tent to forage, and can lay down pheromone trails to recruit tentmates to good food sources. Individuals (Figure 6) were often encountered fully grown, after descending to the ground and travelling widely to find protected pupation sites.

Frequently travelling about, too, were final-instar larvae of the banded woollybear (Figure 7), seeking sheltered places to overwinter. The species extends northward into Arctic regions. As in other common and widely distributed moths, the host range is particularly wide, and caterpillars will feed on grasses and trees as well as herbaceous plants.

H. Danks

Figure 7. Banded woollybear, the arctiine erebid *Pyrrharctia isabella*, moving in search of an overwintering site. (Disturbed larvae stop and shorten, and may curl up.) Length about 5 cm.

The roaming caterpillars are distinctive. Folklore claims that the width of the coloured band, or the direction of travel, predicts the severity of the coming winter. The claims are not supported by scientific evidence, but are so appealing that popular mentions of the species usually highlight them!

Large caterpillars of the pandora sphinx moth are also strikingly coloured. Especially when approached, a caterpillar withdraws its head and first two segments into the third thoracic segment (Figure 8). The habit is generally supposed to protect its head from predators[7], but I wondered if the trait is related to parasitism by tachinid flies with macrotype eggs. Those eggs remain on the surface of the host until they hatch. Some noctuid caterpillars are most susceptible to eggs deposited just behind the head (cf. my note in ESC *Bulletin* **51**: 92) because—unlike eggs

[7]If touched, a larva may also lash about and even regurgitate.

Figure 8. Larvae of the pandora sphinx moth, the sphingid *Eumorpha pandorus*, on Virginia creeper: feeding posture (top); and head withdrawn. Length about 9 cm.

elsewhere—the caterpillar cannot reach them to destroy hatching larvae. This is the area protected in the pandora sphinx. Unusual features of the insects discovered during my hikes raised a variety of such unanswered questions.

Dragonflies and damselflies were often observed, but for years their complex colours and behaviours confused me. Moreover, many were difficult to identify during casual observation; Ontario alone has more than 170 species. Even photographs might be inadequate, and in any event all dragonflies have excellent vision and some species will not allow a close approach. Obtaining focussed images of the large hawker dragonflies, such as the species shown in Figure 9, is unusually challenging on hot sunny days.

Figure 9. Lake darner dragonfly, the aeshnid *Aeshna eremita* (male). Length about 7 cm. This species, like many common dragonflies, inhabits a range of mostly still waters.

However, eventually many of the species I had seen were identified[8], leading to information that helped me to interpret my observations. A great deal of knowledge about ranges, habitats, behaviour, mating systems, sexual selection, and other features of a wide range of species has come from the efforts of both professional and amateur entomologists on several continents.

Colouration depends on one or a combination of pigments, structural colours, and pruinescence, and differences also stem from ultraviolet reflectance, providing cues visible to the insects but not to human observers. In many species, the colours of males and females are markedly different. Such sexual dimorphism is exemplified by eye-catching blue males but less brightly coloured females (e.g., Figure 10), and reflects the fact that males are more attractive to females if they are ostentatious, whereas females attract fewer predators if they are less visible[9].

The chalk-fronted corporal (Figure 11) is sexually dimorphic too, but the key markings are white, and (as the common name implies) come from pruinescence. The species often perches on the ground, and unlike others tolerates the close presence of humans.

[8]Rob Cannings kindly identified or verified many of my photographs of dragonflies.
[9]Similar differences, attributed to the same selective pressures, are also well known in butterflies.

Gail Hampshire (CC BY 2.0)

H. Danks

Figure 10. Blue dasher dragonfly, the libellulid *Pachydiplax longipennis*: male (top); and female. Length about 4 cm.

H. Danks

H. Danks

Figure 11. Chalk-fronted corporal dragonfly, the libellulid *Ladona julia*: male (top); and female. Length 4.3 cm.

In contrast to butterflies and moths, most dragonflies (especially males) change colour as they mature, increasing the difficulty of identification. For example, as the chalk-fronted corporal matures and darkens, from predominantly light reddish brown to the forms shown in Figure 11, the male develops the characteristic white pruinescence on the top of the thorax and first few abdominal segments, whereas the female acquires only a dusting of grey pruinescence on the abdomen.

The male autumn meadowhawk is yellowish brown soon after emergence, but matures to a bright red (Figure 12). Males of most

H. Danks

H. Danks

H. Danks

H. Danks

Figure 12. Autumn meadowhawk dragonfly, the libellulid *Sympetrum vicinum*: immature and mature males (top L and R); and females (bottom). Length about 3.0–3.5 cm.

H. Danks

Figure 13. Cherry-faced meadowhawk dragonfly, the libellulid *Sympetrum internum* (male). Length about 3 cm. (This individual was north of the known Ontario range of *S. rubicundulum*, which looks identical.)

H. Danks

Figure 14. Four-spotted skimmer dragonfly, the libellulid *Libellula quadrimaculata* (male). Length about 4.5 cm.

species of that genus undergo similar changes, and in a few of them (e.g., Figure 13) prominent black triangles contrast dramatically with the red colouration.

Wing colour can also change with age. For example, the original amber colour of the wings decreases (and the body becomes duller) in the four-spotted skimmer (Figure 14). In this species, the sexes are similar.

Conspicuous behaviour is associated primarily with feeding and with mating. Extraordinarily proficient flight is used to catch flying insects, although damselflies often pluck prey off vegetation. Most adults can live for several weeks or more, and older adults continue to fly strongly even when worn (e.g., Figure 15).

Mating takes place in the distinctive "wheel position" (Figure 16): the male grasps the back of the female's head (dragonflies) or her prothorax (damselflies) with his terminal claspers, and the female applies her terminalia to his secondary genitalia on the second abdominal segment. This location includes an aedeagus, and houses sperm transferred there from primary genitalia at the end of the abdomen.

H. Danks

Figure 15. Halloween pennant dragonfly, the libellulid *Celithemis eponina* (female), with worn wings. Length about 4 cm. Even in this condition they are strong fliers.

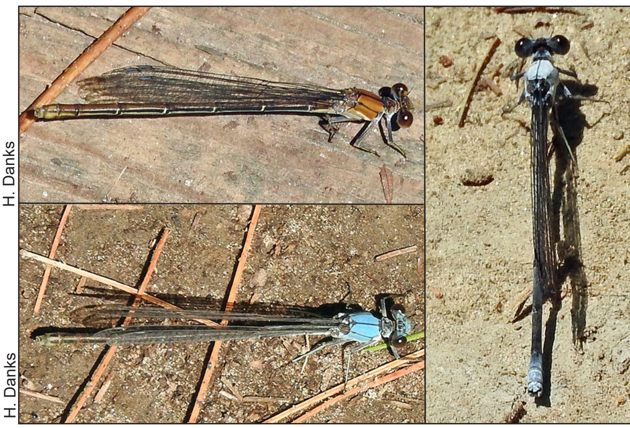
Paul Ritchie (CC BY-ND 4.0)

Figure 16. "Wheel position" of mating odonates (exemplified here by coenagrionid damselflies).

Males of many species are territorial, allowing them to mate with females entering the areas they control. Some species defend an area, conspicuously dashing about or darting from perches to chase off intruding males; others jostle each other for favoured perches. Spectacular colours, like bright blue or red, might signal to other males as well as to females how competent an individual is. Size is also an advantage (and possibly a signal too) in species like the blue dasher (Figure 10), because larger males can more easily drive away competitors for mates or food.

Nevertheless, although males of most species are aggressive towards other males, there are wide differences in the degree of territoriality. In some species, males simply patrol without any site attachment, as in the lake darner (Figure 9). In others, individuals can switch between territorial and non-territorial modes.

Female adaptations are equally complex. Some species have two forms, one of which resembles the male (e.g., Figure 17). This feature is supposed to reduce the extent to which females are harassed by males trying to mate, which interrupts their foraging. Consistent with this interpretation is that male-form females of some species prevail in high density populations where the level of harassment is high, but are less common when males are in short supply and females might not find a partner.



H. Danks

H. Danks

H. Danks

Figure 17. Powdered dancer damselfly, the coenagrionid *Argia moesta* (found mostly along rocky rivers and streams): brown form female (top L); and blue form female (bottom L), which resembles the male (R). Length about 4 cm.

Males have higher visibility, so the advantage to females of mimicking them is likely to be offset by higher predation. Potential predators are not only vertebrates: active species of dragonflies, such as the lake darner (Figure 9) and the four-spotted skimmer (Figure 14), prey on smaller species as well as on insects of other orders.

Female dragonflies normally fly far away from the aquatic habitats in which they developed, thereby avoiding the harassing males; they return later only for oviposition. Some limit detection when ovipositing by staying amongst emergent vegetation. Females of a few species, when approached by unwanted males, even drop and immediately become immobile. “Feigning death” to avoid copulation is a popular description of this behaviour!

Competition for mating success continues during mating. Females of most species mate more than once, and copulating males remove or disadvantage previously deposited sperm. Commonly, the male does this by scraping out sperm from the female’s bursa copulatrix before depositing his own. The aedeagal structures used for this purpose vary among species, but the behaviour occurs even in ancient lineages, confirming the strong role of mating competition in odonates. The fact that sperm will be replaced through subsequent pairing allows females of some species to mate with less desirable “satellite” males, but they do not lay eggs until mated with stronger territorial males.

Competition often continues after copulation too, when the male may guard the female to prevent other males from mating with or disturbing her as she oviposits. Some species remain

H. Danks

Figure 18. Widow skimmer dragonfly, the libellulid *Libellula luctuosa* (male). Length 4.7 cm.

H. Danks

H. Danks

Figure 19. Ebony jewelwing damselfly, the calopterygid *Calopteryx maculata* (which inhabits slow-moving wooded streams): male adopting a "cross position" during the mating display (top); and female displaying its different colour and markings. (Resting individuals hold the wings together over the back.) Length about 5 cm.

joined in tandem; in others the male perches or hovers nearby; but in some the male simply departs. Even members of the same genus differ: most species of *Libellula* skimmers guard, but the widow skimmer (Figure 18)—although it is territorial—seldom does so, and only when other males are abundant. The dark wing bands and territorial flight pattern of that species are distinctive (some people have even mistaken it for a butterfly), and it became familiar to me beside ponds, lakes, and marshes, where the larvae develop chiefly in muddy substrates.

A female's choice of partner can depend not only on the quality of the male, but also on the quality of the male's territory as potential larval habitat. This influence is most evident in species with males that do not just aggressively seize any female they see.

The distinctive males of the ebony jewelwing, with blue-green iridescence and black wings, try to attract females by a characteristic display in which they hold the hindwings out and raise the forewings and abdomen (Figure 19). Subsequent courtship follows a complex sequence. As might be expected, females are less showy than males.

Males of the variable dancer (Figure 20) are distinctively coloured too. However, only specimens from northern areas (including Canada) have the violet colour and clear wings shown in the figure. Southern populations are less colourful and the wings are dark or smoky, as echoed in the specific epithet. Other species differ among populations in

H. Danks

Figure 20. Variable dancer damselfly, the coenagrionid *Argia fumipennis* (male). Length about 3 cm.

body colour or, like the blue dasher (Figure 10), in wing colour.

Such variations have generally been formalized by naming subspecies. However, some North American odonatologists are reluctant to use the subspecific names because, although they capture geographical variation in species like the variable dancer, the subspecies may interbreed and intergrade where they overlap, without geographical separation or mating restriction. In any event, the reasons for such variation (including the possible effects of climate) remain largely unknown.

In summary, despite universal themes, some elements are not understood even in well-known odonates. Particularly striking to me were the wide differences among species. Clearly, as revealed by scientific work of all kinds (including my own studies of adaptations for cold hardiness and life-cycle control), ecological and other challenges are diverse, and any particular challenge can be met in a number of different ways.

The majority of my sightings were common species, of course, because I was merely wandering about in nature rather than seeking insects. However, adults of one dragonfly (larvae of which inhabit large rivers) tend to stay in treetops, and are so seldom seen that the common name is the "elusive" clubtail (Figure 21).

Dragonflies and butterflies can be more easily recognized and observed than most other groups of insects, and so some people have called them "honorary birds". That designation is supported by the fact that a substantial number of the species I noticed during my general explorations belonged to those groups!

Nevertheless, there are conspicuous insects in other taxa. Some of them will be introduced in the next article in this series.

H. Danks

Figure 21. Elusive clubtail dragonfly, the gomphid *Stylurus notatus* (male). Length about 6 cm.