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Origins and Zoogeography of Flies (Insecta: Diptera) in Southern Yukon Grasslands

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IN 1995, I took a zoogeography course at McGill University with my current thesis supervisor, Terry Wheeler. The purpose of zoogeographic analysis is to answer the question: "What lives where, and why?" The question may be simple, but the answer often requires input from systematics, ecology, geology, climatology, paleoecology and other disciplines. Of all the nonbiological factors, glaciation is the single most important in determining the present distribution of the Canadian biota. During the Wisconsinan glaciation, almost all of Canada was covered with ice sheets; but some areas remained ice-free, acting as refugia for many plants and animals. The best-known and best-supported refugium in the north is Beringia, which extended from eastern Siberia across the Bering and Chukchi Seas to Alaska and the Yukon. After the Wisconsinan, the Beringian flora and fauna were again connected with the rest of North America, and the newly deglaciated area was colonized from both directions. Although they are not common, some animals still show a Beringian distribution; they have not expanded their range since the last glaciation. Beringia performed three roles that are significant in zoogeography: it acted as a refugium for many existing Nearctic species; it was a route for the immigration of Palaearctic species to North America; and it was an area of isolation where new species could evolve.

Because of its glacial history, the Yukon Territory is of great interest for biologists, and it is no secret that the region has a unique insect fauna (Danks and Downes, 1997). Most people who collect insects in the Yukon are attracted by the "typical" habitats of Beringia—the tundra, the mountain slopes, the extensive wetlands, rivers, and lakes. But there are many smaller, unusual, and often overlooked habitats in the Yukon with their own particular insect fauna.

One of these unusual habitats is a prairie-like ecosystem characterized by xeric-adapted plants dominated by sage (*Artemisia* spp.; Asteraceae) and several genera of grasses on warm, south-facing slopes and river valleys. These south-facing slopes are found mostly in the southern and central Yukon, particularly along the Yukon River. Further north, near Old Crow and on the Firth River, these grassland patches are more scattered and are present only on the steeper south-facing slopes. Such habitats are also present in northeastern Russia, Alaska, the interior valleys of British Columbia, and the Peace River valley of northern Alberta.

In the summer of 1995, I participated in a summer exchange program to the Peace River valley in Alberta. I spent my free time that summer collecting insects on the south-facing slopes along the river valley for my undergraduate research project. Back in Montreal that fall, I identified my Alberta flies and discovered that many of them were prairie species at the northern limit of their range. The isolated grasslands in that area reminded me of the grasslands that I knew were in the Yukon, and I decided then that I wanted to find out for myself if these prairie insect species could also be found in the southern Yukon grasslands. Although the grasslands from the Peace River region resemble the grasslands of the Yukon, their origins might be very different.

There are two possible origins for the *Artemisia*-grass community (and other species associated with this community, such as insects) on the south-facing slopes of the southern Yukon. They may be remnants of a xeric steppe community that was widespread in Beringia during the Pleistocene. They may also be the result of northward expansion of prairie species that occurred postglacially during the Hypsithermal warming interval, a period of warm, dry climate during the early Holocene. As the climate cooled again following the Hypsithermal, the grasslands were replaced by the boreal forest, but disjunct pockets of grassland may have survived on warm, south-facing slopes.

It was already known that these habitats contain a number of rare or disjunct plant species, as well as some grassland insects that show disjunct distributions from populations in the southern prairie grasslands (e.g., Scudder, 1993) and a small number of insects that are endemic to the region (Anderson, 1984), but there is almost no published information on the Diptera fauna of these habitats, despite their status as the most diverse order of insects in Canada. Therefore, the objectives of my study were to conduct a faunal inventory of the Diptera diversity in the southern Yukon grasslands and to determine the zoogeographic

South-facing slope near Carmacks, dominated by grasses and Artemisia.

Sweeping insects on a grassy slope near Carmacks.

affinities of the fly fauna of these habitats. I am testing the hypothesis that the Diptera fauna of this region is a composite, made up of widespread boreal and cordilleran species, Beringian species that survived the Wisconsinan glaciation in this refugium, and southern grassland species that have colonized the region postglacially, during the Hypsithermal.

I spent a total of 11 weeks in the southern Yukon during June and July 1997 and July 1998 in search of the flies on some of these south-facing slopes. The choice of sites was based on the presence of relatively undisturbed communities dominated by *Artemisia* and grasses and the ease of accessibility to the slope. Six sites were chosen: three were located along the Klondike highway south of Carmacks, one on the Alaska Highway west of Whitehorse near the Takhini River, one at the north end of Little Atlin Lake, and one just outside of Carcross at Nares Lake. The sites were all fairly steep slopes (between 20˚ and 45˚) with almost no trees. In addition to *Artemisia* and several genera of grasses (*Festuca*, *Calamagrostis*, *Elymus*, *Stipa*), other plants on the slopes included creeping juniper, kinnikinnick, wild rose, *Potentilla* and other less abundant herbaceous plants.

The fieldwork part of insect collecting is low-tech science. My collecting techniques included yellow pan traps (known to most people as plastic soup bowls) sunk into the soil surface and partially filled with preserving fluid. Pan traps capture both crawling insects that fall in over the edge and flying insects that are attracted to the colour of the trap and the presence of the fluid. At each site, I set 5 to 10 pan traps filled with propylene glycol (an effective preserving fluid that does not evaporate quickly in dry windy conditions and has a low toxicity to vertebrates) and a drop of dish detergent to decrease the surface tension. I visited the sites every 4–6 days to remove specimens and service the traps. On each visit to each sample site I swept the vegetation with an aerial net for 1–2 hours to capture flying insects and those resting or feeding on the plant surface. Finally, I collected by hand, using an aspirator or forceps to pick up specimens on the surface of the soil or around the bases of vegetation. Back at the university all the preserved flies were dried, mounted, and sorted in preparation for species identification. All specimens from both seasons have been roughly sorted, and identification to the species level is about 80% completed.

When I first saw my sites in 1997, they looked so barren, dry, and windswept that I didn't expect much diversity or abundance of flies. I was wrong. In the first season, I collected 15 000 specimens of Brachycera (the higher flies) from the study sites, which represented 30 families and over 180 species. The second field season was very different. 1998 was a very dry year in the Yukon, and the vegetation on my sites was stunted and even drier than usual; this affected the abundance of flies. This year I collected only 5200 flies, which included only 27 families and just over 115 species. Apart from the differences in overall abundance, the results in both years were similar. In the combined data from both years, the most abundant family by far was the predacious Chamaemyiidae or aphid flies (46% of all specimens collected), followed by the phytophagous and saprophagous Chloropidae or grass flies (26% of total specimens).

I have identified over 210 species to date. The most diverse families were the Agromyzidae or leaf-miner flies, with 32 species, and the Chloropidae, with 31 species. The parasitoid Pipunculidae or big-headed flies were third, with 20 species. Considering that only 100 described species of Pipunculidae have been recorded in the Nearctic, the diversity of this family on my sites was quite high. Saprophagous families were not as abundant or diverse as in many other habitats, and this may be due to the nature of my sites. These slopes are so dry and windy that dead organic material does not seem to accumulate. Most of the material just dries up and blows away. Many of the saprophagous species that are abundant on my sites may be flies that feed on dead insects rather than on decaying plant material.

Removing specimens from pan traps at a study site.

Sweeping insects on a site with relatively diverse vegetation, near Carcross.

My second objective was the zoogeographic analysis of the flies. As expected, most of the species (56%) are widespread in North America or widespread in North America plus Europe (Holarctic species). They have a transcontinental distribution, and they occur in many different habitats from the boreal forest to grasslands to tundra at the treeline. These species are mostly the saprophagous and predacious flies, which exploit a range of food sources; since they are often not restricted to a particular host or food type, they tend not to be restricted to a particular habitat or geographic area.

Other distribution patterns are of more interest to me. One of these is the disjunct distribution shown by many of my species: they have a mostly southern distribution and a northernmost limit in the Yukon with a gap between the populations. These species are most often found in the southern prairie grasslands, but some are associated with other habitats in eastern Canada, such as the deciduous forest. Most of the species in this category are phytophagous, and their distribution is often associated with the distribution of their host plant. It is difficult to reach a definite conclusion about the origin of these disjunct populations in the Yukon. One possibility is that the species survived in both refugia (Beringia and south of the ice sheet) but, for various reasons, never expanded their distribution beyond this range. This is especially likely in species that have a very large disjunction, such as between southern Alberta and the Yukon. But in some cases the disjunction is not as pronounced, with populations found in the grasslands of the Peace River region in Alberta and in central British Columbia. Here it is possible that these species colonized the Yukon from the south during the Hypsithermal warming interval, when the grasslands were more extensive and the climate more suitable. In these questionable cases, other evidence may be required to arrive at a definite answer on the history of these species. Molecular analysis of Yukon and southern populations may provide an estimate of the time of divergence of the populations, and might therefore determine whether or not the species came from the south postglacially or survived in Beringia.

Finally, there are the Beringian species. Different authors have different definitions of what could be classified as a Beringian species. My sites are found in the southern Yukon, an area that was glaciated, so none of my species will have a true Beringian distribution. The flies would have had to move southward postglacially to colonize my sites. Nevertheless, I consider any species that are known only from my sites or from my sites plus other places in the Yukon or Alaska as East Beringian species. One of the most outstanding examples that I have identified to date is an undescribed species in the genus *Olcella* (family Chloropidae). I collected almost 1500 specimens of this new species, in all my sites. My supervisor and I collected at several other sites in southern Yukon, northern British Columbia, and northern Alberta in 1997 and 1998, but found no specimens of this species at any other site. Furthermore, there are no specimens of this species in any of the museum collections that we have examined. Thus, this species seems to be restricted not just to East Beringia, but to south-facing grass slopes in the region. All known species of *Olcella* are restricted to the New World, so this species probably evolved in Beringia after being isolated from southern relatives. In the future, it would be worthwhile to collect in other grassland sites in central Yukon, Alaska, and eastern Siberia to determine the true range of this species.

The species discussed above are only a few examples, and my results are still preliminary, pending identification of the rest of my species. Unfortunately, some of my species will be impossible to include in the analysis, because many of them are undescribed, especially in the more diverse families. For example, 35% of my Chloropidae, 36% of my Pipunculidae, and 17% of my Agromyzidae are undescribed species. Furthermore, complete distributions are not known for many other species, especially in families that are not well-studied. Because of this, it is hard to know whether the disjunctions are real, or whether some of the apparently Beringian species are really Beringian. But despite these weaknesses that make Diptera a difficult group to study, I am pleased with what I have found so far. The Yukon grasslands have turned out to be an excellent place to collect. The Diptera diversity is higher than many people realize, and there are many undescribed and unrecorded surprises. So many new questions were raised during my Master of Science project, and so little is known about the Diptera of the Yukon, that I could spend several more seasons there getting to know the fly fauna.

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