CANADIAN PERSPECTIVES: ARTHROPOD HABITATS IN NORTHERN REGIONS[1]

The potential variety of habitats in relation to the small size of arthropods often makes it difficult to determine what conditions the organisms actually experience. This article discusses some habitat features from a northern (Canadian) perspective, emphasizing conditions in summer, the period of growth and activity for most species.

– Terrestrial habitats –

Key features of northern terrestrial habitats depend on exposure and quality of the substrate. Especially farther north, a very important factor is solar radiation, which warms superficial habitats well above air temperature. Thus, maximum temperatures of 20°C may be reached at the soil surface even in the high arctic, while deeper layers remain much colder.

Different types of ground use solar heat differently: darker substrates absorb more incident radiation, for example. Sunshine also warms the south side of trees more than the north side. Northside temperatures stay close to ambient air temperatures, but the south side may be 20 or 30°C hotter than the air at midday.

Moisture conditions also vary critically for arthropods over short distances. For example, the humidity of adjacent microclimates within vegetation (even the upper and lower sides of a leaf) may be surprisingly different. In the soil, moisture supply depends on depth, drainage, and other factors. Exposure (in or on vegetation; in or on the soil) also determines how vulnerable the insects are to general predators. Therefore, different microhabitats can differ in a large number of ways important to arthropods.

Above the ground surface, vegetation greatly modifies physical conditions on various microclimatic scales (compare the general conditions in a forest with those on a prairie). Insolated clumps of vegetation, or even flowers, can be especially warm. Vegetation also acts as a source of food for some species. Hence there are especially great differences in arthropod populations between vegetated and unvegetated sites. In the high arctic, for example, Collembola may occur in densities of only 9,000 individuals/m^2 in bare sites, but under moss cushions populations resemble those of temperate regions, close to 200,000/m^2. Similar differences occur between moist and dry sites. However, even closely related species may have very different microhabitat preferences, some species preferring the drier or less vegetated sites that are least colonized by others.

The majority of northern, especially arctic, species live at the ground surface. This layer is the warmest zone, especially in treeless sites exposed to the sun, and litter accumulates there, supporting populations of saprophages and their predators. If the soil surface is exposed, the wind may cool it by removing the warm surface layer of air. Strong winds create little more cooling than moderate winds, since air is disturbed enough even by light winds for significant convective losses, but it is worth noting that only a modest vegetation cover is needed to conserve the warmer surface layer.

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[1] This article is condensed from a seminar on similar themes presented by H.V. Danks at a few entomological centres in Canada during visits on behalf of the Biological Survey.

Deeper in the soil, organisms are protected and conditions are relatively stable, but this zone is moist and cool, and may lack organic matter. Conditions there depend greatly on soil type: welldrained sand is warmer than heavy clay, and limestone soils are warmer still, creating significant local differences in the suitability of habitats for microarthropods.

A few other discrete types of habitat, such as rot holes, have a more or less defined fauna, and are of particular interest in northern regions because they provide special conditions.

– Aquatic habitats –

The key features of aquatic sites as habitats for insects are flow rate (which especially influences substrate type) and depth: smaller, shallower and slower bodies of water usually are warmer, richer, and less stable (and in extreme cases, temporary).

Ponds, for instance, are warmer than the air even in the far north. For example, when mean air temperatures for the first half of July in the high arctic are about 6°C., shallow saucer-shaped ponds average 10-12°C. Such shallow habitats behave somewhat like the soil surface but are more stable since they warm up (from sunshine) more quickly than they cool down. In fact, these warm ponds contribute a great deal to northern productivity. Pond conditions are much modified by shape, depth, exposure, vegetation, and other factors. Local relief, and hence effective insolation, also influences temperatures there. Seasonal changes in depth can alter the features of otherwise similar ponds. One key to understanding arthropod occurrence therefore is the small-scale variation that occurs among different habitats of the same type.

In northern lakes, central areas are stable, but bottom sediments tend to be cold (4°C. in the deepest temperate lakes; only about 0.5°C. in deep arctic lakes in winter, 4°C. in summer). Conditions near the edge of lakes may resemble those in ponds, but destructive wave action and ice scour introduce other components of variation. The greater depth of lakes compared with ponds, and thermally (and chemically) induced stratification leads to particular temperature profiles that change seasonally. Some species are characteristic of the deep, cool water, of the sublittoral (unvegetated, but not below the thermocline), or of the littoral (vegetated) zones. Most insects live in the sediments. Sediments beneath deeper water, and lower layers of the sediment, are more stable. Seasonal changes are large enough that some advantage can be gained by arthropods that move to warm, shallow water in summer, but into more stable deep water for winter. Such movements are feasible because conditions in aquatic habitats change relatively slowly, without the sudden freezing events experienced on land. They make it more difficult to understand microhabitat preferences.

Northern streams that flow rapidly tend to maintain fairly constant low temperatures. The more rapid streams generally are cooler and have coarser substrates. In these habitats, some stages of a surprising number of arthropods live deep in the substrate, where temperatures are especially low and stable. Several species (e.g. crustaceans) live there permanently. Food supply in streams depends partly on surrounding vegetation, because characteristic input comes from fallen leaves. Indeed, some insect growth in streams is timed in autumn and winter to take advantage of leaf fall, though other species rely on summer-growing algae and other foods. Stream microhabitats are very numerous and varied: substrate features, especially particle size, seem to be particularly important. Indeed, current affects the parts of a rock differently, in turn modifying the potential supply of food for insects, since that food is brought by water or grows on the rock. Moreover, species may move between microhabitats during the life cycle, for example from edge to centre of the stream, or from deep to superficial layers of the substrate. Northern streams therefore show especially well the multitude of seasonal and microscale variations that characterize insect microhabitats.

Finally, some discrete aquatic habitats such as springs and temporary ponds provide unusual conditions in northern regions and have interesting faunas.

– Variation –

Microhabitat conditions that influence arthropods also can be understood in terms of temporal and spatial variations, as already suggested for several habitats.

Temporal variation in northern habitats is most striking from winter to summer, but conditions change also through the season. Spring and fall conditions may be especially critical in both terrestrial and aquatic habitats. For example, flow rates in running water vary very greatly through the year, especially because of spring inputs of meltwater from snow.

The spring thaw is earliest in terrestrial habitats that are exposed and accumulate less snow. Thus, high arctic fjeldmark thaws well before low-lying river valleys or terrain with deep, sheltered snowbanks (which may persist through July). Some arctic species appear to overwinter on high ridges, despite the lower winter temperatures experienced there, so that they can resume development as early as possible in the season. The rate of development in spring, of course, everywhere depends on developmental thresholds in relation to habitat conditions. Day-degree accumulations differ from one microhabitat to another (e.g. plant cushions compared to the air above; shallow versus deep substrates). For example, chironomid midge larvae only 2 cm deep in the sediment of high arctic ponds may take twice as long to develop to emergence after the thaw as individuals at the sediment surface.

Spatial variation among habitats is evident from a regional scale down to a microscopic scale. Latitude and macroclimates broadly control regional conditions, but surprising differences among local climates may be produced by relief (e.g. insolational heating and shading on slopes of different aspect; funnelling of winds by topography; reduction of insolation by clouds produced by cloud-generating ridges or hills; Föhn winds), and by proximity to the sea (e.g. coastal locations are moister and cloudier – and hence cooler – in summer, though not as cold in winter, and they experience sea breezes produced by land-ocean temperature differences). Substrate effects (e.g. calcareous soils are warmer) are added to these effects of regional or local climate.

Such differences, together with disturbance caused by fire and other factors, produce fragmentation of habitats. A typical area of “coniferous forest” shows remarkable heterogeneity, for example. Toward the north, trees generally drop out in a patchwork, not a sudden, fashion; rich sedge meadows are found in favoured high arctic locations interspersed in larger areas of relatively barren terrain. Arthropod populations are likewise fragmented at the northern edge of their range, with implications for population processes, dispersal, and other features. Toward the south, cold bogs or other habitats may be intercalated in warmer areas.

Similar spatial variability occurs on smaller and smaller scales, including adjacent locations within vegetation, and even on one plant. The centres of some arctic flowers (which are heliotropic and have parabolic corollas) and certain other plant parts are especially warm compared with most other sites.

– Conclusions –

The life cycles of northern arthropods must be viewed in relation to habitat, including some very "small-scale" features, because habitats and microhabitats are integrated with important variations in food habits, developmental rates, resistance to adverse conditions, population processes, community structure, interhabitat movement during the life cycle, dispersal of adults, and so on.

These microhabitat influences on phenology, populations, and other characteristics have important implications for every field of entomology, since they impinge on all elements of species biology, as well as on sampling efficiency, modelling, pest management, and other fields. Therefore, Canadian entomologists need to be aware of the great potential complexity of arthropod relationships with habitat, and of the ways in which some of these relationships are emphasized in northern regions.

[Information for this article comes from general texts and from numerous scattered references. Selected sources, including those that cite other salient work, are: Chernov, Yu. I., B.R. Striganova, and S.I. Ananjeva. 1977. Soil fauna of the polar desert at Cape Cheluskin, Taimyr Peninsula, USSR. *Oikos* 29(1): 175-179; Danks, H.V. 1971. Overwintering of some north temperate and arctic Chironomidae. 1. The winter environment. *Can. Ent.* 103(4): 589-604; Danks, H.V. 1978. Modes of seasonal adaptation in the insects. I. Winter survival. *Can. Ent*. 110(11): 1167-1205; Danks, H.V. 1979. Terrestrial habitats and distributions of Canadian Insects. pp. 195-210 in H.V. Danks (Ed.), Canada and its insect fauna*. Mem. ent. Soc. Can*. 108. 573 pp; Danks, H.V. 1981. Arctic Arthropods. A review of systematics and ecology with particular reference to the North American fauna. Entomological Society of Canada, Ottawa. 608 pp; Geiger, R. 1965. The climate near the ground. Harvard Univ Press, Cambridge, Mass; Oliver, D.R. and P.S. Corbet. 1966. Aquatic habitats in a high arctic locality: the Hazen Camp study area, Ellesmere Island, N.W.T. Def. Res. Bd Can., D Phys R(G), Hazen 26. 115 pp. + 267 figs; Williams, D.D. 1979. Aquatic habitats of Canada and their insects. pp. 211-234 in H.V. Danks (Ed.), Canada and its insect fauna. *Mem. ent. Soc. Can.* 108. 573 pp.]