

# Biological Survey of Canada Terrestrial Arthropods

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## Briefs

### **STATUS AND RESEARCH NEEDS OF CANADIAN SOIL ARTHROPODS**

A brief prepared by the Biological Survey of Canada  
(Terrestrial Arthropods) 1982

#### **Abstract**

This brief points out that knowledge of soil arthropods in Canada is strikingly deficient. Although the fauna of the soil is relatively rich, especially in the northern life-zones characteristic of the country, the expertise available in typical soil groups is very limited, especially in taxonomy.

The soil fauna is abundant and ecologically important, particularly in decomposition and nutrient-cycling, and hence of immediate concern in activities such as agriculture and forestry that depend on soil fertility. Some species of soil arthropods are directly important as pests, and others may serve as indicator species, agents of biological control, or aids for teaching.

Deficiencies of information are greatest for immature forms, especially in groups that contain many species, such as mites, springtails and flies; however, fewer than half of our estimated 18,000 or more soil species have been described even in the adult stage. These deficiencies reflect a general lack of support for study of soil arthropods at the present time. A basic problem is the lack of taxonomic expertise, which in turn greatly hinders ecological work. This brief is intended to provide a basis for initiatives and representations that can be made as circumstances permit to improve this situation.

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### **ÉTAT ET BESOINS DES RECHERCHES SUR LES ARTHROPODES TERRICOLES DU CANADA**

#### **Résumé**

Cette communication fait remarquer que la connaissance des arthropodes terricoles du Canada est étonnamment insuffisante. Bien que la faune terricole soit relativement riche, surtout dans les habitats septentrionaux caractéristiques de notre pays, on sait très peu de chose sur les groupes typiquement terricoles, et en particulier sur leur taxonomie.

La faune terricole est abondante et importante au point de vue écologique, surtout pour la décomposition et le recyclage des éléments nutritifs, donc d'un intérêt immédiat pour les activités qui, comme l'agriculture et la sylviculture, dépendent de la fertilité des sols. Certaines espèces d'arthropodes terricoles ont une importance directe comme animaux nuisibles et d'autres servent d'espèces indicatrices, d'agents de contrôle biologique ou d'aides pédagogiques.

Les lacunes qu'accusent les connaissances à ce sujet se manifestent principalement au sujet des formes immatures, en particulier chez les groupes qui rassemblent de nombreuses espèces, comme les acariens, les podures et les mouches; cependant, moins de la moitié de nos espèces terricoles - qu'on estime du nombre de 18 000 ou davantage - sont décrites, même pour la phase adulte. Ces lacunes résultent du peu d'appui que reçoit généralement l'étude des arthropodes terricoles à l'heure actuelle. Le manque de compétences taxonomiques est un problème fondamental qui entrave grandement le travail écologique. Cette communication tente d'ouvrir la voie aux initiatives et aux démarches visant à améliorer cette situation que permettront les circonstances.

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#### **Introduction**

The Biological Survey of Canada (Terrestrial Arthropods) develops and coordinates national initiatives in taxonomic and ecological entomology on behalf of the National Museum of Natural Sciences and the Entomological Society of Canada. Several active projects have been selected for special emphasis because of their particular scientific importance. The arthropods of the soil were readily recognized as an area of particular concern, but an active project could not be developed in this case because resources are inadequate; instead the importance of soil forms is indicated in this brief, which thus points out a significant deficiency in the national entomological effort. The brief is intended to provide general support for the development of appropriate studies in the future.

The enormous gap in our knowledge of soil animals has been recognized for over a decade, as the following statement for invertebrates other than insects (Lindsey *et al.* 1970) demonstrates: "Canada has no basic faunal studies of invertebrates compared to the extensive and well-illustrated series of books 'Fauna of the U.S.S.R.'. The abortive 'Canadian Fauna' series of the Fisheries Research Board, started some 40 years ago, has been discontinued. Except for molluscs, there is no check list of Canadian species in any major invertebrate group (and in the mollusc check list perhaps 50% of the identifications are erroneous)... Taxonomy of Canadian freshwater and land invertebrates is not in much better shape. Earlier remarks concerning the state of knowledge of spiders [Araneae], mites [Acari] and nematodes are particularly applicable to Canada. A list of groups for which there are no adequate keys to Canadian species would include most Orders and most Families of the invertebrates."

Canadian arthropod groups that have been well documented are mainly not permanent soil forms. They include: the fleas (Holland 1949, (and in press)), ticks (Gregson 1956), dragonflies (see Corbet 1979), specific groups of insects and spiders in the recent (since 1977) handbook series from the Biosystematics Research Institute (including crab spiders), centipedes (Kevan 1979), and orthopteroids (Vickery and Kevan, in press). The knowledge of collembolans has been greatly improved by a recent treatment for North America (Christiansen and Bellinger 1980), but is still deficient. However, for the majority of true soil forms the situation today has changed little since 1970, and perhaps for the worse, when compared to other advanced countries. This is difficult to understand, because the soil arthropod fauna is ubiquitous, abundant, diverse and ecologically important.

## Nature of the soil arthropod fauna

### Distribution

Soil arthropods occur wherever there is natural vegetation. Embryonic soils are populated by a few species, but the fauna of the soil grows in numbers and diversity to reach astronomical figures in mature forest soils. Virtually every arthropod Class, except the Pentastomida, is represented in one soil or another (Table 1). Some groups, such as the Acari and Collembola, are abundant even in cold arctic soils; others are significant only in localized areas. The majority of the taxa, listed in Table 1, are found throughout the country. The millipedes (Diplopoda) and terrestrial Malacostraca (some decapods, amphipods and isopods) are restricted to soils of the southern part of the country. The Dictyoptera, represented in the soil by termites, and Diplura are restricted to the southeastern and southwestern parts of Canada. The centipedes (Chilopoda) are absent only in the high arctic. In Canada, and indeed in North America as a whole, an increasing fraction of the northern fauna is found in the soil, because the advantages of this habitat increase as climates become more harsh, since soil habitats are relatively warm and stable compared with the air.

### Abundance and diversity

Densities of 200,000 arthropods/m should be common in Canadian soils, and 1,000,000 individuals/m were obtained from a black spruce stand in southern Quebec (Behan *et al.* 1978). Over 8,000 species have been recorded from our soils and more than this number still remain to be discovered. The estimate of uncollected species is very conservative. Dondale (1979) estimated that there were five species of Pseudoscorpionida (Arachnida), but emphasized that the group was inadequately collected in Canada. We now know that over 50 species of pseudoscorpions occur in Canada (D. K. McE. Kevan, pers. comm.). Similarly, the eight species of Protura estimated by Tomlin (1979) is small compared to the 40 known from Japan. Other comparable examples could be cited.

### Ecological Importance

#### Nutrient cycling

Although the microflora is responsible for mineralization, soil arthropods greatly accelerate decomposition because they comminute organic matter. The majority of soil arthropods are saprophagous or obtain their food from fauna and flora that themselves feed on dead organic matter. They serve as a reservoir of nutrients that become available to plants when the arthropods die. Soil arthropods stimulate fungal growth by cropping, and disperse bacterial and fungal spores, thereby enhancing mineralization. They may also condition dead organic materials in other ways that facilitate microfloral action. These animals improve soil aeration and water status by burrowing and other activities and by opening passages occupied by decaying roots. Their role as decomposers is critical under Canadian conditions, because of the paucity of macrofauna, such as earthworms, in most soils. A better knowledge of soil arthropods could also contribute greatly to our understanding of global issues such as carbon dioxide evolution and nitrogen cycling. Nitrogen is an important element for plant growth and is universally deficient in forest soils. With the advent of "no-tillage" or "direct-drilling", the role of arthropods in agricultural soils takes on new importance.

#### Indicator species

Soil arthropods have the potential of being excellent indicator species, because of their relatively short life history and limited tolerance to changes in environmental

conditions. However, such studies must be done at the species level: generic or suprageneric taxa are usually not sensitive enough to indicate the impact of human activities. Soil fauna might also be used as indicators of soil type. Such soil classification has been developed in the U.S.S.R. (Ghilarov 1965), but few attempts have been made in Canada to classify soil by its arthropod fauna. However, it has been suggested that the Diplopoda may be useful soil indicators for some of our forest lands.

### **Pests**

Apart from Tardigrada, Araneae, "other arachnids", Pauropods, Chilopoda and Protura, all taxa listed in Table 1 contain pest species that feed on germinants or underground parts of living plants. Some proturans feed exclusively on mycorrhizal fungi, an interesting association that might have implications for reforestation work. In addition to feeding on plants, some groups affect man in other ways. Soil mites contaminate stored products, and some species of one suborder, the Oribatei, transmit helminth pathogens to vertebrates and are therefore important to veterinary medicine. Collembolans also infest stored products and well water. Mites, collembolans and millipedes sometimes invade houses in such numbers as to constitute a nuisance. Termites (Dictyoptera) and some Hymenoptera, for example carpenter ants, cause structural damage to buildings. Some Diptera are important for reasons of public health and preventive medicine.

### **Biological Control**

Very little use has been made of soil arthropods to control pests. Ants are being investigated in Quebec as a potential agent for the control of insect pests in forests (Finnegan 1977; McNeil *et al.* 1978). Research with predaceous oribatid mites to control nematode pests is in progress in the U.S.A. (Rocket 1980), but no such work has been undertaken in Canada. Other potential control agents exist. Members of many other soil groups are predaceous (including spiders, some beetles, and larvae of various Diptera, for example). Several species of parasitoid Diptera and Hymenoptera are also associated with the soil.

### **Environmental impact studies**

Knowledge of the effects of agricultural and forestry practices on soil arthropods is essential if we are to manage our soils wisely. Limited information on the results of some practices, such as burning and the application of fertilizers and pesticides, is available, but nothing is known in Canada about other potential hazards, such as mine spills, sewage sludges, forest biomass removal, acid rain and radiation. Chemical and municipal waste dumps, for example, could benefit from using soil fauna as an index of the stability of waste storage. Before waste dumps are established, baseline studies of soil fauna in the proposed sites should be made for comparisons with the fauna after the dumps have been established.

### **Teaching aids**

Soil arthropods are excellent organisms to study genetic, physiological, ecological and evolutionary hypotheses. Some arthropod Classes, for example mites and collembolans, show great diversity of species and numbers in closely integrated ecosystems. They are readily accessible throughout the year to any university classroom, for even samples of frozen soil yield large numbers of specimens.

## **Research needs**

On the human time scale, soil is our most precious non-renewable resource. Canada is seriously lacking in the study of many phases of soil science, and particularly in sub-disciplines dealing with the fauna of the soil.

Table 1 points out several important deficiencies related to soil arthropods. There is a strong need for studying immature forms, especially in large taxa such as the Acari, Collembola and Diptera. Inadequate taxonomic knowledge also extends to adults, since more than half of our soil arthropods are still undescribed. This lack of taxonomic knowledge greatly hampers ecological work. The following quotation sums up this difficulty (Entomological Society of Canada 1974):

"The first part of any impact assessment program is one of conducting an inventory on the biota in the area of proposed impact. We have tried to use this approach but, because of the tremendous diversity of...invertebrates (especially Insecta), the inadequate taxonomic knowledge of immature forms, and the paucity of collections... in the areas of our studies we have encountered insurmountable difficulties. Despite the fact that we have expended vast amounts of time and money tackling these problems, the results are not encouraging. The general feeling within the group is that we were foolish to have even tried. More important, however, is that we are unlikely to embark on such surveys again in future studies. Thus, we have a paradox. Lower level taxonomic identifications are essential for the experimental part of our program, but we cannot spend the time and money doing taxonomic studies because of constraints intrinsic to impact assessment groups. (I dare say that other groups not doing impact assessment have similar problems, too)."

Coupled with these inadequacies of taxonomic knowledge is the lack of Canadian specialists for many groups of soil arthropods. Seven of the groups (Tardigrada, Pauropoda, Diplopoda, Symphyla, Protura, Diplura, and some "other arachnids") are not being studied by Canadian taxonomists. In the recent compendium, Canada and its Insect Fauna (Danks 1979), sections on the tardigrades, pauropods, diplopods and symphylids were written by non-Canadian authors. Even where taxonomists are available, they are too few to cope with the formidable array of soil arthropod species. For example, fewer than 4 person-years in Canada are devoted to the taxonomy of soil mites and dipterous larvae combined, although each group contains thousands of soil-dwelling species.

## Conclusions

The Canadian soil arthropod fauna is an important heritage that deserves more study than it has received in the past. The greatest need is increased taxonomic information; this is a prerequisite to ecological studies focussed on nutrient cycling and relationships with the soil microflora, indicator species of soil conditions, pests, biological control, and environmental impact studies. There is, of course, also a need for studies in other areas, including physiology, morphology, and behaviour.

Our fragmentary knowledge of soil arthropods has been obtained chiefly over the past two decades, primarily from a small group of universities, and Canada Departments of Agriculture and Environment. Attempts should be made to strengthen such incipient "centres of specialization", and to encourage other agencies to include soil arthropod research as part of their future programs. Agencies that fund research should also be made aware of this major deficiency in the study of the Canadian fauna, so that the problem may be addressed through soil zoology working groups, "strategic" research support, solicited or unsolicited proposals, or other specific vehicles.

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**Table 1. Major classes of arthropods in Canadian soils**

Taxon	Estimated No. Spp. <sup>1/</sup>			No./m <sup>2</sup> in a forest site <sup>2/</sup>	Canadian specialists (PY) <sup>3/</sup>
	Recorded	Uncollected	With immature instars described		
TARDIGRADA	48	162	0	9,132	0
ARACHNIDA					
Araneae	800	100	0	214	2
Acari	1,000	5,000	60	168,000	3
Other arachnids	54	?	?	233	<1
MALACOSTRACA	45	4	?	?	<1
PAUROPODA	0	20	0	516	0
DIPLOPODA	47	23	1	258	0
CHILOPODA	31	9	15	82	0.2
SYMPHYLA	1	10	0	107	0
PROTURA	3	50	?1	660	0
COLLEMBOLA	400	150	-	17,500	2
DIPLURA	2	3	0	201	0
INSECTA					
Coleoptera	2,800	500	300	75	2 <sup>4/</sup>
Dictyoptera (Termites only) <sup>5/</sup>	5	0	5	?	0.2
Diptera	3,000	3,000	600	1,400	0.5
Hymenoptera	200	50	?	25	2
Lepidoptera	500	50	350	31	1
Other insects	20	10	?	1,189	0
<b>TOTAL</b>	<b>8,956</b>	<b>9,141</b>	<b>1,331</b>	<b>199,623</b>	

1/ Based partly on Danks 1979, with non-soil forms excluded, and with more recent information added.

2/ Tardigrades from a Douglas-fir forest, B. C.; other figures from the Morgan Arboretum, southern Quebec (V. G. Marshall, unpubl.)

3/ PY = person years. These figures are intended only as general indicators of the effort applied to soil forms in the taxa listed.

4/ One working on larvae

5/ Excluding casual interceptions (non-soil forms)

[back](#)

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