WHO NEEDLESSLY SETS FOOT UPON A WORM

By D. C. F. FAYLE¹

D. C. F. Fayle was born in England in 1932 and received his early education there. After serving in the Royal Artillery, he studied forestry at the University of Toronto, obtaining his B.Sc.F. degree in 1957. He received a Diploma in Forestry from Oxford University in 1959. Mr. Fayle joined the Ontario District staff of the Federal Department of Forestry in 1957 and has been concerned with research in silviculture of tolerant hardwoods.

ABSTRACT

Interest in the role of soil animals in humus formation is currently at a low ebb in North America. In this paper, the results of animal activity are briefly described as an aid in identifying and understanding the evolution of certain types of forest humus layers formed under aerobic conditions. No specific references are made to the available literature, but a few general texts are listed.

INTRODUCTION

"I would not enter on my list of friends,
(Though graced with polish'd manners
and fine sense,
Yet wanting sensibility), the man
Who needlessly sets foot upon a worm."²

William Cowper was no forester but he appreciated those animals which work beneath our feet; there are few foresters with this appreciation. But why should we be concerned with the soil animals? Because it is their activity which effects the disintegration of the plant debris, its incorporation with the soil, and the creation of certain beneficial soil structures, thus implicating the nutrient cycle, regeneration problems, and so forth. This is not to discount the vital role of fungi and micro-organisms in decomposition. And yet, despite their importance, the existence of the soil animals is rarely acknowledged in articles. Current lack of interest is shown again by the fact that they are hardly mentioned in the reports of the First North American Forest Soils Conference—a conference on forest-soil relationships.

The purpose of this paper is to arouse an awareness in practising foresters and research men of the life in the humus layers. The factors affecting the soil animals and their activity in humus formation are briefly outlined. Use of this information is discussed in relation to the identification of types of humus. Space does not permit elaboration on this theme by reference to specific cover types and soil conditions; the reader is invited, for the present, to examine the humus layers in his own area.

¹ Research Officer Forestry, Forest Research Branch, Department of Forestry, Ottawa.

² From *The Task*. Book VI, *Winter Walk at Noon*, by William Cowper.

FACTORS AFFECTING SOIL POPULATION

The factors which affect humus formation and the occurrence of the soil animals are the physical and chemical properties of the soil and vegetation, the aeration, temperature and moisture conditions, and the soil flora. These factors are interrelated as shown in Fig. 1.

FIGURE 1. Interrelation of humus-forming factors.

Relatively few of the soil animals feed directly on fresh material; partial decomposition by members of the soil flora is required. Preference is often shown for certain vegetation or parts of a plant, for instance basswood leaves are preferred to beech, mesophyll tissue to vascular. Generally, litter rich in calcium and with a low carbon-nitrogen ratio is favoured. This may be due in part to the more rapid decomposition by other agencies. In addition, some animals feed on fungi, bacteria, living or dead animals, or on animal excrement; they may not necessarily be restricted to one type of food alone. Soil animals avoid strong acid substrates; thus the richest life evolves in neutral and slightly alkaline conditions. Many fungi, on the other hand, can tolerate acid conditions.

The amount of activity and distribution of the population will fluctuate during the year with changes in moisture and temperature. The occurrence and extent of excessive or deficient moisture are quite as important as the average moisture conditions. Extended dry periods may reduce the number and activity of animals, such as mites and millipedes, which live in the surface humus layers; water-logging of the soil will reduce the earthworm population. Good aeration and adequate moisture are necessary for a continuing soil population.

The soil affects the animal population not only through its chemical composition, aeration and moisture, but also through its structure and texture. For instance, millipedes, which push their way through material like a wedge rather than burrowing, prefer a sandy to a clay soil, unless the latter has a good crumb structure; some snails live in the soil cracks; sharp material is not suitable for soft-bodied animals such as earthworms.

SOIL ANIMALS

Worms

The most commonly sought-after animal in the soil, whether by the fisherman, the proverbial early bird, or the mull-seeking humus-classifier, is the earthworm (*Lumbricidae*). How many people, nevertheless, consider earthworms collectively, and do not realize that there are important differences in

size (adults may range from less than 6 centimetres to over 20 centimetres in length), distribution, and in activity of various species?

Three broad groups of earthworms may be recognized. First, there are the deep-working individuals, containing most of the large species, whose activity may extend from the surface humus layers to a depth of several feet in the soil. Acid conditions are not tolerated, and they are most active in a well-drained, basic, clayey soil with a hardwood cover. Over 100 individuals per square metre may be found. These earthworms pull litter material into their burrows where it is consumed and subsequently mixed with the mineral soil as surface or sub-surface castings. This action encourages rapid decomposition of the organic matter and, in conjunction with the formation of tunnels and a crumb structure, improves the aeration and moisture-holding capacity of the soil.

A second group comprises the shallow-working earthworms, which generally include a high proportion of the smaller species. These individuals work in the humus layers and adjoining soil surface, and are less active than the first group in mixing mineral and organic matter. They can tolerate acid conditions and, unlike the above group, may be found on sandy soils and under conifer material. Some herbaceous vegetation may be required to sustain the population. Individuals may be found also in well-decomposed wood. In many ways their activity is closer to that of the larger arthropods than to the deep-working earthworms. Their number is much less than 100 per square metre. A third group contains ubiquitous species.

Closely related to the earthworms are the enchytraeids (*Enchytraeidae*), commonly called potworms. These whitish-coloured worms are often overlooked as they are much smaller than earthworms; only the largest individuals may extend up to two centimetres in length. Since enchytraeids are acid-tolerant, however, they may be very important in conditions unsuitable for earthworms, for instance in coniferous humus layers. Their number may range up to 100,000 per square metre; there tends to be an inverse relationship between earthworms and enchytraeid populations.

Enchytraeids do not follow the extensive burrowing activity of many earthworms and are active primarily in the organic matter and adjoining mineral soil. They can produce extensive microcrumb structure in the soil similar to the large crumb structure of earthworms.

Arthropods

Unlike the majority of earthworms, arthropods are most abundant in the humus layers and are seldom influenced directly by the composition and structure of the subsoil. Their activity, however, is easily affected by temperature and moisture changes at the surface.

The arthropods chiefly responsible for humus formation may be divided into two groups, based on their size and activity. First, there are the woodlice (*Isopoda*), also known as *sow bugs* or *pill bugs*, millipedes (*Diplopoda*), and various insect larvae. These animals are visible to the naked eye.

The requirements of woodlice and millipedes are essentially the same. They are found primarily in the upper humus layers, sheltering under the surface

debris or in bark cracks of trees. They do not tolerate acid conditions and generally prefer hardwood to conifer material. The number of millipedes and woodlice may range up to 100 per square metre each. Both animals, especially millipedes, are active in the skeletonization of leaf tissue; their excrement is often visible as small cylindrical or flattened droppings. At the same time, some mixing of the mineral soil with organic matter may occur; up to 25 per cent mineral soil has been found in millipede excrement.

Larvae of flies (*Diptera*) are the most numerous and influential of the insect larvae in the decomposition of vegetable debris. They are found primarily in the lower humus layers and their activity is similar to that of the small, surface-dwelling, acid-tolerant earthworms. The larvae often occur in small groups, with their overall number possibly exceeding 1,000 per square metre.

The second group of arthropods includes the mites (*Acarina*) and springtails (*Collembola*). These animals average about one millimetre only in length, but are of great importance in the fragmentation of plant debris. A fair amount of springtail and mite activity occurs inside plant tissue and is apparent only when the outer layers have disintegrated, unless cross sections are examined. In addition to the mining activity, considerable skeletonizing of leaf tissue occurs. Springtails may penetrate into the mineral soil.

Acid conditions are tolerated and both hardwood and conifer material are inhabited. If placed nose-to-tail the number of individuals found in a square metre could extend over half a mile. Densities of 100,000 springtails and 200,000 mites per square metre have been found. Other small arthropods like bristle-tails (*Thysanura*) and *Paurapoda* feed on organic debris, but their numbers are far less.

As many arthropods feed on fungal mycelia and spores, the development of fungi is probably restricted by a large arthropod population.

Other Animals

Some plant debris is consumed by slugs and snails (*Gastropoda*). Their feeding habits are probably similar although slugs may not require calcium to the same extent. A few species are predaceous. The population is generally less in conifer material than in hardwood, where up to 100 individuals per square metre may be found. Soil factors often limit the size of population.

Predaceous animals which may be seen are spiders (*Araneae*), false scorpions (*Chelonethida*), most adult beetles (*Coleoptera*), some mites (*Acarina*) and insect larvae, and centipedes (*Chilopoda*). The latter have one pair of legs per segment, whereas millipedes have two pair.

Some of the microfauna (*Protozoa*, *Nematoda*, *Turbellaria*, etc.) perform an important function in the decomposition of organic matter.

DISCUSSION

For practical field purposes, the classification of forest humus in North America has been based on easily visible morphological features. There has been, however, a lack of recognition or understanding of how these features have been formed, with the result that confusion occurs in attempting to identify and distinguish formations. This confusion is compounded by such

terminology as duff mull, mull-like-mor, and moder—all of which can be synonyms—and it is not surprising that the forester is distracted like the poor centipede:

“The centipede was happy quite
Until a toad in fun
Said, “Pray, which leg goes after which?”
That worked her mind to such a pitch,
She lay distracted in a ditch,
Considering how to run.”^a

No solution to the problem is propounded here, but it will be shown how some of the characteristics and anomalies that occur in the evolution of humus layers may be clarified by a knowledge of the activity of the soil population.

The appearance of the humus layers will vary according to the number and type of soil animals present. In a humus layer developed mainly by arthropods there is little disturbance to the natural layering, some matting from mycelial development occurs, the litter material is gradually skeletonized or internally attacked, animal excrement accumulates between the plant material, the size and amount of plant fragments decrease with increasing depth in the profile and the amount of animal excrement increases. Scattered mineral grains are present, having been transported by the larger arthropods (such as millipedes, insect larvae) or by the occasional small earthworm which may be present. The boundary between mineral and organic matter may not be distinct.

A humus layer developed mainly by earthworms will show a loose, crumbly structure of generally well-preserved earthworm casts. The litter material is fragmented and mixed directly with the mineral soil, becoming indivisible from it as the material is reworked. Arthropods are restricted as they are deprived of their food by the earthworms. It is not necessary to see an earthworm to identify this type for during dry periods the earthworms may be inactive and difficult to find. Conversely, finding an earthworm does not indicate that the humus layer is developed entirely by earthworms as it may be a shallow-working species and have accomplished little or no mixing of the organic matter and mineral soil. Thus it is essential to be able to recognize the results of the animal activities.

Where for some reason (perhaps unfavourable litter or desiccation) the animal population is low, the humus layers may be developed by fungi. In this case there will be a strong matting of the organic debris by mycelia as well as the development of a luxuriant fungus mould. The active life span of the mycelia may be short but the cell walls remain for some time. The fungi decompose the cell substance without producing visible waste material as do most soil animals. With the exhaustion of their available food the fungi disappear, leaving the plant material little changed in physical form. The material accumulates above the mineral soil, with no intermixing.

The appearance of the humus layers will depend, too, on the combination of the above types. For instance, if the litter or soil material is not highly

^a From *Pinafore Poems*, by Mrs. Edward Craster, 1871.

favourable for earthworms, the humus layer can be developed by the joint action of earthworms and arthropods. The arthropod excrement and fine plant debris do not accumulate but are mixed into the soil by the earthworms. The arthropods may assist in breaking down the litter material for the earthworms. The variations are obviously innumerable.

Naturally, the chemical and physical aspects of humus evaluation cannot be ignored, but by direct examination of the biological and morphological peculiarities of humus formation, a foundation can be laid for further study.

SELECTED BIBLIOGRAPHY

- BIRCH, L. C., and D. P. CLARK. 1953. Forest soil as an ecological community with special reference to the fauna. *Quart. Rev. Biol.* 28(1): 13-36.
- BORNEBUSCH, C. H. 1930. The fauna of forest soil. *Forstl. Forsogsv. Danm.* 11. 224 pp.
- EATON, T. H., and R. F. Chandler. 1942. The fauna of forest-humus layers in New York. Cornell Univ., Agr. Expt. Sta. Memoir 247. 26 pp.
- HARTMANN, F. 1952. *Forstökologie. Zustandserfassung und Standortsgemäße Gestaltung der Lebensgrundlagen des Waldes* (The science of forest site types on the basis of ecological factors). Verlag Georg Fromme Co., Vienna. 461 pp.
- JACOT, A. P., 1940. The fauna of the soil. *Quart. Rev. Biol.* 15(1): 28-58.
- KEVAN, D. K. McE. (Editor). 1955. *Soil Zoology. Proceedings of the University of Nottingham Second Easter School in Agricultural Science.* Butterworths Scientific Publications, London.
- KUHNELT, W. 1950. *Bodenbiologie—mit besonderer Berücksichtigung der Tierwelt.* (Soil biology—with special reference to the world of animals). Verlag Herold, Vienna. 368 pp.
- MURPHY, P. W. 1953. The biology of forest soils with special reference to the mesofauna or meiofauna. *Jour. Soil. Sci.* 4: 155-193.
- NEF, L. 1957. *État actuel des connaissances sur le rôle des animaux dans la décomposition des litières de forêts* (The present state of our knowledge regarding the role of the soil fauna in the decomposition of forest litter). Repr. from *Agricultura, Louvain* (Sér. 2), 5(3): 245-316.

WOOD LOT OWNERS

Have you heard of the new National Association?

CANADIAN TREE FARMERS' ASSOCIATION

for information write to Sec. Treas.:

J. A. MacDonald, B.Sc.F.,
33 Chippewa Ave.,
Ottawa 5, Ont.

SLOGAN: "VALUABLE CROPS FROM WOOD LOTS"