Beretning Nr. 96.

C. H. BORNEBUSCH:

THE FAUNA OF FOREST SOIL.

(SKOVBUNDENS DYREVERDEN).

(Særtryk af Det forstlige Forsøgsvæsen i Danmark, XI).
MCMXXX.

DET FORSTLIGE FORSØGSVÆSEN I DANMARK

udgives ved den forstlige Forsøgskommission under Redaktion af Professor A. OPPERMANN, i Hæfter sædvanlig paa 5—10 Ark, der udsendes fra Statens forstlige Forsøgsvæsen, Møllevangen pr. Springforbi. Cirka 25 Ark (400 Sider) udgør et Bind, for hvilket Subskriptionen er gældende; Prisen pr. Bind er 5 Kr., der tages ved Postgiro samtidig med Udsendelsen af 1ste Hæfte.

Bd. I (1905—1908): Nr. 1. H. BOJESEN: H. C. Ulrichs Bøgekulturer. — Nr. 2. O. G. PETERSEN: Nattefrostens Virkning paa Bøgens Ved. — Nr. 3. A. OPPERMANN: Nogle Træmaalings-Forsøg, I. — Nr. 4. P. E. MÜLLER: Om nogle Bælgplanters Udvikling i bearbejdet jydsk Hedejord. — Nr. 5. FR. WEIS: Nogle Vand- og Kvælstofbestemmelser i Stammer af Fyr og Gran. — Nr. 6. A. OPPERMANN: Egens Vækst i Jægersborg Hegn. — Nr. 7. A. OPPERMANN: Tilvirkning og Anvendelse af dansk Gavntræ, I. — Nr. 8. F. I. ANDERSEN: Gennemhugning og Grenekapning i Rødgran. — Nr. 9. P. E. MÜLLER og FR. WEIS: Studier over Skov- og Hedejord, I. — Nr. 10. A. OPPERMANN: Rødgranens Vækst paa god, midtjydsk Hedebund. — Nr. 11. L. A. HAUCH: Udhugning i unge Egebevoksninger. — Nr. 12. K. MØRK-HANSEN: C. H. Schrøders Udhugning i Bøg. — Nr. 13. A. OPPERMANN: En Prøveflade i Avnbøg. — Nr. 14: Forsøgsvæsenets Ordning og Ledelse.

Bd. II (1908—1911): Nr. 15. L. A. HAUCH: Nattefrostens Virkning i ung Bøgeskov. — Nr. 16. A. OPPERMANN: Vrange Bøge i det nordøstlige Sjælland. — Nr. 17. P. E. MÜLLER og FR. WEIS: Studier over Skov- og Hedejord, II. — Nr. 18. JOHS. HELMS: Forsøg med Lystræer paa Feldborg Skovdistrikt. — Nr. 19. A. OPPERMANN: En Prøveflade i Rødeg. — Nr. 20. A. OPPERMANN: Tilvirkning og Anvendelse af dansk Gavntræ, II. — Nr. 21. A. HOLTEN: Brud i staaende Granstammer. — Nr. 22—24. Forsøgsvæsenets Ordning og Ledelse.

Bd. III (1910—1913): Nr. 25. P. E. MÜLLER, K. RØRDAM, JOHS. HELMS, E. H. WØLDIKE: Bidrag til Kundskab om Rødgranens Vækstforhold i midtjydsk Hedebund. — Nr. 26. P. E. MÜLLER og JOHS. HELMS: Forsøg med Anvendelse af Kunstgødning til Grankultur i midtjydsk Hedebund. Med Bidrag til Hedebundens Naturhistorie. — Nr. 27. P. E. MÜLLER og FR. WEIS: Studier over Skov- og Hedejord, III.

Bd. IV (1912—1915): Nr. 28. A. OPPERMANN: Højdelag i Bøgebevoksninger (Höhenschichten in Buchenbeständen). — Nr. 29. A. OPPERMANN: Ædelgranens Vækst paa Bornholm (Le sapin pectiné à l'île de Bornholm). — Nr. 30. A. OPPERMANN: Den grønne Douglasies Vækst i Danmark (The Douglas Fir in Denmark). — Nr. 31. L. A. HAUCH og F. KØLPIN RAVN: Egens Meldug (L'oïdium du chêne). — Nr. 32. A. OPPERMANN: En Granbevoksning paa god, midtjydsk Hedebund (Ein Fichtenbestand auf gutem Heideboden im mittleren Jütland). — Nr. 33. A. OPPERMANN: Overvintring af Agern (Überwinterung von Eicheln). — Nr. 34. JOHS. HELMS: Iagttagelser over Rødgranens og Ædelgranens ydre Form (Beobachtungen über die äussere Form der Fichte und Weisstanne). — Nr. 35. A. OPPERMANN: Elleve Prøveflader i Bøgeskov (Elf Probeflächen in Rotbuchenbeständen). — Nr. 36. JOHS. HELMS: Forsøg med Lystræer paa Feldborg Skovdistrikt, II (Versuche mit Lichthölzern auf Heideboden). — Nr. 37. L. A. HAUCH: Proveniensforsøg med Eg (Provenienzversuche mit Eiche). — Nr. 38. FR. WEIS og C. H. BORNEBUSCH: Om Azotobacters Forekomst i danske Skove,

Forsvaret finder Sted Torsdag den 22. Maj 1930 Kl. 2 i Auditorium A, Universitetets Anneks, Studiestræde 6 o. G.

THE FAUNA OF FOREST SOIL

THE FAUNA OF FOREST SOIL

SKOVBUNDENS DYREVERDEN

BY

C. H. BORNEBUSCH

WITH 7 FIGURES IN THE TEXT
AND 28 PLATES

COPENHAGEN
PRINTED BY NIELSEN & LYDICHE (AXEL SIMMELKIÆR)
MCMXXX

Denne Afhandling er af det matematisk-naturvidenskabelige Fakultet antaget til offentlig at forsvares for den filosofiske Doktorgrad.

København, den 2. April 1930.

J. F. STEFFENSEN,
h. a. dec.

CONTENTS

Indholdsfortegnelse

Reprinted from Det forstlige Forsøgsvæsen i Danmark vol. XI.

PLATES

Billedtavler

I. Locality 10. Oak, Mull, Mercurialis. Eg, Muld, Bingelurt.
II. Locality 15. Beech, Mull, Anemone-Asperula. Bøg, Muld, Anemone-Bukkar.
III. Locality 5. Beech, Mull, Melica-Asperula. Bøg, Muld, Flitteraks-Bukkar.
IV. Locality 9. Beech, Mull, Oxalis. Bøg, Muld, Skovsyre.
V. Locality 2. Beech, Impoverished Soil, Polytrichum. Bøg, forarmet Bund, Skovjomfruhaar.
VI. Locality 4. Beech, Raw Humus, no Flora. Bøg, Maar, ingen Flora.
VII. Locality 20. Beech, Raw Humus, no Flora. Bøg, Maar, ingen Flora. Locality 7. Vaccinium myrtillus. Blaabær.
VIII. Locality 1. Spruce, Mull, Oxalis. Gran, Muld, Skovsyre.
IX. Locality 6. Spruce, Raw Humus, Moss Cover. Gran, Maar, Mos.
X. Locality 8. Spruce, Raw Humus, Moss Cover. Gran, Maar, Mos.
XI. Soil Sections from Localities 15 and 9. Jordbundsprofiler fra Lokaliteterne 15 og 9.
XII. Soil Sections from Localities 2 and 4. Jordbundsprofiler fra Lokaliteterne 2 og 4.
XIII. Soil Sections from Localities 1 and 6. Jordbundsprofiler fra Lokaliteterne 1 og 6.
XIV. Leaf and Raw Humus Layer from Locality 4. Løv- og Maarlag fra Lokalitet 4.
XV. Moss-Needle and Raw Humus Layer from Locality 6. Worm Casts from Beech Mull. Mos-Naalelag og Maarlag fra Lokalitet 6. Regnorme-Ekskrementer fra Bøgemuld.
XVI. Needle Layer and Surface Mull from Locality 1. Naalelag og Overflademuld fra Lokalitet 1.
XVII. Snails, Spider, False Scorpions and Insects. Snegle, Edderkop, Mosskorpioner og Insekter.
XVIII. Centipeds, Milliped and Trichoniscus. Skolopendere, Tusindben og Bænkebider.
XIX. Millipeds and Scutigerella. Tusindben og Scutigerella.
XX. Mites. Mider.
XXI. Mites. Mider.
XXII. Collembola. Springhaler.
XXIII. Crane-flies. Stankelben.
XXIV. Diptera Larvae. Larver af tovingede Insekter.
XXV. Diptera Imago and Larvae. Imago og Larver af tovingede Insekter.
XXVI. Beetles and Earwigs. Biller og Ørentviste.
XXVII. Beetles and Saw-fly. Biller og Bladhveps.
XXVIII. Beetles and Beetle Larvae. Biller og Billelarver.

PREFACE.

The idea of studying the fauna of forest soil in order to gain a thorough knowledge of its organization under varying conditions, has of late years been borne in upon me during my studies of the different types of forest soil in relation to their flora and soil-condition, and the decomposition of organic materials under the influence of microorganisms. It was quite natural to suppose that the fauna also would vary in organization from place to place according to types of forest soil. The following investigation will show to what extent this theory proves correct.

When the idea had become quite clear to myself, I laid it before Professor Dr. A. OPPERMANN, Director of The Experimental Forestry Service, who kindly approved of my pursuing the subject, carrying out a part of the work in the laboratory of the Service, whereupon, recommended by Professor OPPERMANN and Professor WESENBERG-LUND, I applied to THE CARLSBERG FUND, which accorded me a subsidy to defray the expenses for instruments, journeys, and assistants. While engaged upon the work I received the kind assistance of several zoologists, who settled for me questions of species, etc. In ascertaining the diptera and other insects respectively, I am especially indebted to Mr. W. LUNDBECK, Inspector, and Mr. K. L. HENRIKSEN, M. Sc., of the Zoological Museum, Copenhagen; but also to Mr. BRÆNDEGAARD, M. A.; Mr. HJ. DITLEVSEN, M. Sc.; Mr. H. FASMER, Student of Nat. Sc.; Mr. P. HAMMER, M. Sc.; Mr. VICTOR HANSEN, J. P.; Mr. KRYGER, Municipal School Teacher; Mr. MALTBÆK, M. A.; The Librarian, Mr. P. NIELSEN; Mr. K. STEFFENSEN, M. Sc.; and Mr. S. L. TUXEN, Student of Nat. Sc., all of Denmark; The Reverend HILDERIC FRIEND, Solihul, England; The Reverend KNEISSL, Oberalting, Bavaria (Bayern), and Mr. SCHENKEL, L. L. D., Basel, Switzerland.

I take this opportunity of tendering The Experimental Forestry Commission, the Directors of The Carlsberg Fund, as well as all the

gentlemen mentioned above, my sincerest thanks. I also desire to thank F. Hendriksen's Studios for the careful production of the plates, and to express my appreciation of the work performed by the two young ladies who have been my assistants: first, for six months, Student Miss VITA BAARCK, and next, for eighteen months, (now) Mrs. ASTA BRINKEL, who both worked assiduously and carefully for three hours every day in sorting and counting the great number of animals collected.

Introduction.

How many people, in passing through the forest, have any idea of the life teeming under their very feet, every plot of ground that they tread upon being alive with an immense number of small animals. It constitutes a world of its own, unobserved by our eyes. We see the roedeer and the hare; sometimes, especially towards dusk, we encounter the fox and the badger; we enjoy the singing of birds and watch with pleasure their activities; admire the birds of prey soaring majestically above our heads; observe the little squirrel as it nimbly skips from tree to tree. On closer observation we shall also catch sight of a timid little mouse, a frog hopping off and vanishing like a brown shadow, a little snail or a beetle crossing the forest path or crawling up a stem; and the butterflies, fluttering among the trees, are well known to us. But the abundance of life beneath our feet, we shall discover only by lying down and looking closely among the leaves, herbs, and grass. Then, descending to animals of a class far smaller in size, we shall be fairly taken aback by the profusion of animals disclosing themselves to our view. If we pick up a little bunch of leaves or a tuft of moss, we shall see a great number of animals, crawling and leaping out, so small that it is impossible for us to follow them with our eyes.

If we wish to study this particular fauna a little more closely, take along home a bunch of leaves, and in our room try to collect all the animals to see how many there are, we shall soon find that it is a most difficult task. A couple of sprightly beetles trying to escape across the table, are soon captured; some small red earthworms and white potworms, as also some white or gray grubs of two-winged insects do

not give much trouble either; with a wet hair-pencil we intercept a few of the largest mites, about one millimeter in length; with greater difficulty we catch some of the small bustling springtails, while others once more make their escape from the wet hair-pencil and disappear. After a great deal of trouble we finally succeed in collecting some of the larger specimens, but find that the leaves still contain no end of vivacious animals so small that we can hardly distinguish them, and in spite of all our pains we have to give it up. A thorough knowledge of the subject we shall not gain in this way, therfore we must resort to other methods, to which we shall return in due course.

Let us, however, first try to understand what interest, apart from satisfying our curiosity, we may have in getting to know these tiny animals of the forest soil, not their names only, but their numbers and habits as well.

In woodlands it is of only rare occurrence that we plough or harrow, weed or hoe; often we do not even sow or plant, but leave the soil undisturbed. We subject our stands to no other care than that of thinning, which, at any rate, is the main thing. If the soil undergoes a tilling process it is only at intervals of many, many years, and this only in case the soil is supposed to be too deteriorated for natural regeneration, or in case we wish to produce a stand of another species, not content, thus, with the natural regeneration of the old stand.

During these long periods the forest regulates itself, just like the primeval forest from time immemorial, and requires no artificial attention with the sole exception of thinning, which, moreover, causes traffic on the ground. At any rate, this should be the rule, but it must be admitted that man's encroachments upon nature have often made havoc of the naturally prevailing good condition of the soil. How is it possible, it may now be asked, thus to leave the forest soil to take care of itself?

The forest is of a very composite structure. It consists not only of trees. Under the tall trees we find undergrowth and shrubs; the soil is covered with herbs and grasses. All these penetrate the earth with their roots, smaller plants near the surface, trees often to great depths. The leaves of

trees and dead branches, the stalks and leaves of the soil flora, fagots left by the woodcutters — all this residue moulders on the forest ground; the carbon and hydrogen, by a slow process of combustion, are transformed into carbonic acid and water; the nitrogen is released as ammonia, which is often retransformed into nitric acid. The salts are released and, by means of rainwater, transferred to the roots in the ground, and in this way nitrogen and nutritive salts are once more absorbed by the plants. True, some of the salt is washed away, much nitrogen is lost in the air, but the roots of the trees carry other salts from the deeper layers of earth, and divers micro-organisms absorb fresh nitrogen from the air; otherwise, all forest plants, from the tallest tree to the smallest herb, would suffer from want of nourishment. This process goes on »of its own accord« without either work or care on the part of the forester, but not always equally well. If the various processes of decomposition are to take the most favourable course, and the trees are to grow as much as possible, all the factors working together to these ends must be brought to contribute to the utmost of their capacity, and one of these factors is the fauna of the forest soil.

Just as the farmer has to cultivate his field with plough and harrow, partly to render the soil friable, partly that the decaying manure may be covered with earth, so the soil in the forest must be subjected to mechanical cultivation that it may keep friable and porous, suitable to the plants, and also that organic residue may be decomposed, and to this end a mechanical work is required; this is to be effected by creatures capable of moving about, i. e. by animals. But these do not confine their work to this; they decompose leaves and branches, bite them into small bits, let the organic material pass through their intestinal canal, thus making it more easily accessible to the bacteria and fungi by the aid of which the final process of mull formation and the chemical combustion of the materials take place.

Foresters have for centuries been aware of the part played by big mammals, especially domestic animals. They knew how to benefit by pigs rooting up the forest ground, thus improving and preparing it for the lodging of the falling mast and furthering the natural regeneration of the

forest. But cattle, too, would often be useful in preparing the soil by the tread of their hoofs and by tearing loose the grass; especially, when forest areas, which had been used as pasture, were hedged in, an excellent young forest would often grow up. Also horses, sheep, goats, and deer may indeed prove equally useful in these respects, but the benefit is greatly counterbalanced by the damage caused by these animals, because they devour the bark and the young trees most voraciously, while cattle so much prefers grass to tree plants that a moderate grazing may be beneficial to the young growth of trees. In Lüneburger Heide great areas were in times past successfully sown with pine seed, which was then trodden down by large flocks of sheep.

All herbivorous animals, in transforming vegetable matter into manure, would of course so far seem to be useful to the soil, but too much grazing, taken together with the damage done to the undergrowth and the shrubs, which are to provide shelter in the forest, has proved to be detrimental to the good condition of the soil.

Badgers and foxes, within the limited areas of their burrows, very thoroughly prepare and fertilize the soil, activities resulting not only in a particular soil flora, but sometimes even in another species of trees (ash) than the surrounding woodland (Bornebusch 1923, p. 105). To the mole, a regular inhabitant of the soil, we shall return later on. To a smaller extent, mice, shrews, toads, and other small vertebrates, are good tillers of the topsoil. In other parts of the world various rodents play an important part in the preparation of the soil.

The direct influence on the forest soil as caused by birds is far smaller than that of mammals. The scratching of hens on the borders of the forest is often detrimental to the soil, because the leaves are stirred up and carried away by the wind, and the earth is left compact and deficient in mull; in sheltered parts, on the other hand, we may sometimes witness that the scratching of hens is conducive to regeneration. Crows, blackbirds, and other birds turning the leaves and the moss in hunting for caterpillars and worms, are no doubt frequently of importance in lodging the seed where it is best capable of germinating. But otherwise, the chief importance

of birds to the forest is mainly to be found in their checking the noxious insects, and in their eating and spreading of seed. They can indeed do much damage by eating the seed, but especially the jay, and also ducks, pigeons, and other birds have, on the other hand, greatly influenced the migration of species bearing heavy fruits, chiefly the oak and the beech, and have in this way proved a cultural factor of incalculable importance.

The idea that also the little animals living in the soil are useful, is traceable to WHITE (1789), who advanced the view, remarkably correct for his time, that the condition of the soil and the thriving of the plants are largely due to the influence of worms. His statements, however, seem to have been passed by rather unnoticed, while DARWIN's studies, which appeared half a century afterwards, gave rise to further investigations, resulting in an extensive literature, of which we shall mention the following: DARWIN (1840, 1881), HENSEN (1877, 1882), MÜLLER (1878b, 1884, 1887, 1889, 1894), BOAS (1882), TUXEN (1882), WOLLNY (1890, 1897), RIBAUCOURT & COMBAULT (1907). We have learned how worms carry the plant residues into the soil, where they subsequently devour it, and how they constantly deposit, on the surface, layers of good earth in form of excrements (worm casts); in this way, moreover, the stones sink below the layer of earth thus prepared by the worms and kept light and friable through their work. KEILHACK describes (1899) how tiger-beetles, scarabees, ants, burrowing wasps, etc., by their excavations in sandy soil, effect a similar kind of sorting process, thus bringing the fine earth up to the surface.

The realization of the part played by animal life has been gradually growing for the last fifty years. The theory formerly prevailing may be expressed by the following quotation from BREHM & ROSSMÄSSLER (1867): »Now as to the salutary influence of the inferior animals on the forest, this can of course only be an indirect one, through the extermination of animals detrimental to the forest.« It is not till SCHIÖDTE's dissertation (1875) and MÜLLER's »Studier over Skovjord« i. e. studies of forest soil (1878b, 1884; in German 1887; in French 1889) that the fauna of forest soil is referred to as a matter of interest. The latter work shows how it varies

according to condition of soil, and how good mull seems to be contingent upon earthworms. The views touched upon by the author made but little headway; in forest-zoological textbooks it is almost exclusively noxious animals and their foes that are dealt with. An exception to this is Dansk Forstzoologi by BOAS, for already in the first edition, 1896—98, the author mentions the earthworms (1896—98, p. 418, and 1923, p. 723); and their activities as salutary to the soil are also dealt with in textbooks on Danish forestry (HAUCH & OPPERMANN, 1898—1902, p. 18 ff.).

Foreign investigators of forest soil, however, have gradually come to realize the importance of terricolous fauna, e. g. RAMANN, whose interest was aroused by the works of MÜLLER, with which he was well acquainted, and who, in his »Bodenkunde« (1895, 1905; 1911 a) refers to the fauna of the soil. He writes (1911 b, p. 164) as follows: »Though as yet we have no definite opinion about the importance of the various animals to the transformation of the soil, we have every reason to further all that conduces to the development of the lower fauna and to ward off everything that may be detrimental to it. The derangement of the equilibrium of the natural factors through encroachments on the part of man has probably always proved detrimental.«

Of late years, indeed, a great deal has been written about the fauna of the forest soil, but thorough investigations are scarce. Thus RAMANN (1911 b) published some figures, in which however he distinguished between »Regenwürmer« (earthworms) and »Kleintiere« (smaller fauna) only. For ascertaining the number of the former, the samples are too small, and as the animals have only been picked off the earth, and no definite limit downwards is given, the numbers stated furnish but little information. For earthworms so big that, at any rate in mully soil, they can be picked off with approximate accuracy by merely searching the soil, earlier as well as later investigations as to their number and activities are not wanting. The small species of earthworms living in raw humus are difficult to find; hence the wrong view advanced that it is entirely devoid of earthworms (MÜLLER, 1878 b, p. 44). My investigations go to prove that, all in all, raw humus is far more abounding in animal life than was formerly supposed.

Objective studies of the fauna, including very small animals, have been made by the Indian, PILLAI (1922) and by v. PFETTEN (1925), both of ESCHERICH's laboratory, Munich (München), in pine and spruce forests respectively, though in the litter only, and the smallest animals, springtails and mites, have not been counted. An investigation by SOUDEK (1928), too, confines itself to the litter. In this way, for instance, only a small part of the important earthworms will be included. DOGIEL and EFREMOFF (1925), on the other hand, have made a fair attempt to collect the entire fauna of the soil; true, they have only picked out the animals, but that this work has been done with painstaking care, appears from the great number of mites and springtails. It has been interesting to compare the four investigations from coniferous woods last mentioned with results from similar types of forest soil in Denmark. In Sweden, both SCHOTTE and HESSELMAN have emphasized the desirability of getting the Swedish Experimental Forestry Service to undertake an examination of the fauna of the forest soil (Meddelanden från Statens Skogsförsöksanstalt, vol. 12, pp. 48 and 56), and some researches by TRÄGÅRDH have appeared (1928).

From the facts mentioned above we learn that there is practically no material from which it is possible to form an idea of how the fauna of the forest soil is organized under various conditions.

From his childhood the author has been acquainted with MÜLLER's investigations, and ever since his years of silvicultural training has keenly felt the deficiency in knowledge as regards the fauna of the forest soil, a chief factor in the natural economy of the forest. While for a decennium engaged upon the study of the various types of flora according to their respective soils, he became desirous of subjecting the fauna to a thorough examination as well. A study of the macroscopic fauna of the forest soil then presented itself as one of the domains where an effectual study was possible, this task being ever so much easier of accomplishment than for instance the study of the microorganisms of the soil, that it is rather surprising that our knowledge in this province has so long remained quite fortuitous and fragmentary.

Choice of Method and Materials.

While the forest plants, when we confine ourselves to the fanerogames, ferns, and mosses, are comparatively easy to survey; the animals, because of their locomotion, are more difficult to study. The trees we can count as well as measure; as for shrubs and young trees, it is, at any rate, practicable to make out the approximate areas covered, as also their ages and heights. Herbs, grass, and moss, plainly indicate which types of flora dominate the ground in different areas; and, if we should be desirous of entering into further particulars, we can roughly estimate in what proportions the various species of plants cover the ground, or we can ascertain their quantity statistically by the aid of small sample plots, and thus gain an objective representation of the organization of the flora.

Not so with the mobile animals. Domestic animals, which in former times used to play an important part in the forest, but now in this respect are of rather small significance, we can easily control, at least in the small forests of Denmark. In the case of deer, in an enclosed park without thick undergrowth, we can form a long cordon of men across the entire wood, and, while proceeding from one end to the other, count the animals as they retreat through the cordon. To count the deer in unenclosed areas is, of course, more difficult, but the huntsman daily scouring the forest is generally familiar with each herd of game; hence we possess reports from old times about the quantity of game in the royal forests. The huntsman, well acquainted with the localities, will also be able to state the approximate number of foxes and badgers, because he knows how many burrows are occupied; and, where there are not too many hares, it is also possible, though with greater difficulty, to calculate their number approximately. The number of breeding birds of prey, as also of rooks and crows, he will be able to ascertain; but at that the possibility of any direct estimate as to number of animals, must stop. The smaller animals are too apt to evade detection. Two methods of ascertainment are patent in dealing with them. One is a merely relative method (DAHL 1921): If thus, at the same time of the year and the same hours of the day, as

also during the same kind of weather, we pay a visit to the various parts of the forest, noting down all the birds we see or hear while crossing the area for a fixed number of hours, we shall get some idea as to what parts are relatively most abounding in birds, and also about their composite character in the various forest types. Corresponding relative estimates may be drawn by watching the results of mouse-catching in traps, or, in case we pursue entomological studies, by using a catcher among the plants at definite periods at the same hour of the day, by knocking down insects from branches, e. g. the noxious larvae infesting the oak, or by setting beetle-traps, i. e. jars sunk in the earth and provided with bait. If the holes we dig in the forest in order to examine the soil, are left over night, these will also serve as traps for beetles, frogs, salamanders, shrews, etc., and furnish us with an idea of how these animals differ from one place to another. There are other methods, however, by which it is possible to attain a better estimate as to quantities of animals. PALMGREN (1929) has calculated the birds in Finland by researching limited areas and in this way attained approximation to the total number. In a similar way I have counted up the birds in an area at times when they sing most vigorously. The absolute numbers we can only ascertain, when the animals are so small, so numerous, and so slow in their movements, as to make it possible to take a sample of the soil and examine everything it contains. In this way did deep sea explorers, as early as 1896, examine the fauna of the sea beds by taking up samples of $^1/_{10}$ m^2 (BOYSEN JENSEN & JOHS. PETERSEN, 1911), a study so important to the appreciation of the food resources of fishes, e. g. the plaice; thus also we may take samples of the forest soil and examine them. As may be imagined, regular statistical investigations of this kind are confined to worms, insects, and other smaller animals. Even of the larger species of beetles for instance, the individuals are so sporadic that no information is obtainable in this way. Such an important occupier of the soil as the mole is, of course, outside the range of direct counting. The main body of fauna living in the earth, however, may be examined by means of samples of the soil. These small animals may be divided into three groups, each of which must be treated differently.

The method of collecting annelids, insects, myriopods, spiders, mites, etc., is based upon the fact that these animals, when the sample is subjected to a heating and desiccating process, leave it of their own accord. To this end various devices have been constructed, of which (p. 21) we shall mention only TULLGREN's apparatus (TULLGREN, 1918), which has been taken as a model in the present investigations. Larger worms and insects, etc., may simply, as formerly done by RAMANN and others, be picked off when the sample is searched, but this method is slow and inaccurate, and is only to be recommended in the case of earthworms, and even of these to the exclusion of the small species in raw humus.

The next group comprises the microscopically small worms, the nematodes. These do not leave the soil when it is heated and desiccated, but encyst themselves; hence they must be separated from the soil by means of water, either by placing a compact clod of earth (sod, raw humus) in a shallow bowl of water, in which case the nematodes will swim out at the bottom of the bowl, there to be fished out under the microscope, or the earth (mull and mineral soil) may be washed out in water, the heavy parts are left to settle, and then the water is filtered through a fine strainer (miller's gauze), in which the nematodes, floating in the water, will be caught (COBB, 1918).

Finally, the protozoa, the minute unicellular animalcula: to ascertain their quantity is connected with great difficulties, the result being obtained only by a diffusion just as we do with bacteria, if we are not to be content with a merely superficial examination through the microscope. According to MÜLLER (1884, p. 71 ff.), testaceous rhizopods are very numerous in raw humus, while scarce in mull.

The first of these groups is undoubtedly of chief importance to the soil in making the topsoil friable and in devouring the residual products of plants or biting these into small pieces. (»The microscopic fauna .... can hardly, to any great extent, reduce the density and compactness of the mass«, MÜLLER, 1884, p. 74), and, being moreover the one most easy of access, it will, naturally, engage our attention first. Hence, the following pages are mostly confined to

a statistical investigation of what the forest soil contains of the fauna comprising the first group, a description of the number of animals, their quantities according to weight, etc., while the possible examination of the nematodes and protozoa must be deferred till some other time.

Neither time nor subsidies have been sufficient for a closer study of the life of the different kinds of animals and their importance to the soil; in these respects I must at present confine myself to references to the works of others; but, in my opinion, the statistical survey here furnished, giving information as to what animals so abound in the earth as to be considered of essential value to the same, constitutes the basis needed for the study of the part played by the fauna of the soil.

Denmark is a low country, in which level or slightly undulating plains alternate with hilly moraines, which hardly ever rise to 100 m above sea level; parts of the interior of Jutland, however, are somewhat higher, rising to as much as 172 m. Loose clayey, gravelly, or sandy layers, deposited during the glacial period, most often at considerable depths, cover the substrata from the tertiary and cretaceous periods. The clayey lands often contain a great quantity of carbonic lime, which the ice, in scouring across the layers of calcareous formations, packed into the masses of earth conveyed by the ice from the Scandinavian mountains; in some places along the shores the calcareous formations will appear as cliffs. Unique is the island of Bornholm, consisting of primitive rock and old formations, mostly covered, however, by deposits from the glacial period.

N. E. Sealand, north of Copenhagen, from which part most of the samples are taken, is a very hilly moraine country, where sandy and clayey lands alternate; its position is about 56^0 northern latitude and $12—12^1/_2{}^0$ longitude, east of Greenwich.

The climate is characterized by Denmark's proximity to the ocean and the Gulf Stream, a fact most often resulting in mild winters and rather cool summers, as also in precipitation quite copious in proportion to temperature, all of which conduces to a pronounced humid climate, as it also appears from the extensive raw humus and podsol formations, and

from the fact that carbonic lime, even on clayey lands, has mostly been washed out of the upper soil layers as deep as the lowest tree roots, and even deeper. Predominating westerly winds affect the shapes of the trees, and frequently prove detrimental to the condition of the soil, whenever they sweep through the forest.

Table I gives further particulars about temperature and precipitation, for the two years during which the investigations

Table I. Temperature and Precipitation, Lille Dyrehavegaard, near Hillerød.

Middeltemperatur og Nedbør.

	Mean Temperature, Centigrade			Precipitation, in all, Millimeter		
	1926	1927	Normal	1926	1927	Normal
January	0.5	2.0	÷0.9	53	70	43
February	0.7	0.4	÷0.6	72	15	39
March	2.7	4.8	1.2	17	48	46
April	7.5	5.7	5.6	30	70	43
May	11.0	8.2	11.0	56	40	43
June	14.6	12.3	15.1	83	84	51
July	18.2	17.6	16.6	78	107	76
August	16.4	16.9	15.6	44	156	84
September	12.8	12.5	12.5	77	74	56
October	6.1	8.4	7.7	106	131	71
November	5.4	2.0	3.4	48	50	56
December	1.4	÷2.9	0.7	40	34	55
Annum	8.1	7.3	7.3	604	879	663

were carried on, as also the averages for a longer period, at the meteorological station, Lille Dyrehavegaard, near Hillerød, this being the centre of the area where most of the samples are taken.

Thousands of years ago Denmark was almost entirely covered with vast forests, but as early as one thousand years ago, at the time Christianity was introduced, a great part of the country had been brought under cultivation and was fairly well populated. The forests had more and more to give way to the growing population, and about three hundred years ago, wood was already becoming so scarce that the authorities had to initiate restrictions in order to protect the

forests. The stock of trees was insufficient, and the forests were largely used for pasture; to this came the right of the yeomen of cutting down the undergrowth, which checked the growth of the young wood. Nowadays the Danish forests are covered with a good stock of trees representing a very considerable increase, as will appear from the descriptions of localities found in the next section. The forests comprise only about 8 per cent of the total area of the country; twice as much, however, in N. E. Sealand, the part of chief interest in this connection, and the forests in question are mostly State property.

For the present purpose I have endeavoured to present some of the chief types of Danish forest soils, and, to this end, have chosen a great many localities more particularly described in the following section.

The primeval forests of Denmark consist chiefly of beech *(Fagus silvatica* L.*)*, to the entire or partial exclusion of other trees. But there are considerable tracts of oak besides and smaller areas of ash, alder, or a mingling of various foliferous trees: oak, ash, elm, lime, maple, alder, etc. Through operations on the part of the foresters, especially during the last hundred years, extensive tracts of beech forests, mainly in loose and sandy soil, have been transformed into spruce stands *(Picea abies* L.*)*, sporadically also into Scotch pine *(Pinus silvestris* L.*)* and larch *(Larix decidua* Mill.*)*. To this may be added, also from the last century, large tracts of coniferous woods on heathland (calluna heaths) and downs, particularly the vast heath areas of the sandy moraines and plains of West- and Mid-Jutland. The trees here grown are mostly mountain pine *(Pinus montana* Mill.*)* and spruce *(Picea abies)*; in smaller quantities, the Scotch pine *(Pinus silvestris)*, and a few other conifers *(Pinus austriaca* Höss, *Pinus contorta* Loudon, *Picea sitkaensis* Trautv. & Mey., etc.).

Our beech woods present numerous types of forest soil according to climatic and other conditions, as described in previous articles (Bornebusch 1920, 1921, 1923, 1925), and here the subject will be touched upon only in broad outlines. Where the middle-aged beech stands are properly thinned, as is the case in Denmark, and where the soil is in a really good condition, a friable topsoil with good mull and with a

favourable nitrification, it will be covered with a flora of typical mull herbs with but slight interspersion of grasses, or none at all. Its chief representatives are the wood anemone (*Anemone nemorosa* L.) and the woodruff (*Asperula odorata* L.), frequently also the wood-sorrel (*Oxalis acetosella* L.). On good marlaceous soil with pronounced nitrification, the flora is supplemented by a number of other plants: larkspur (*Corydalis cava* L.), dog's mercury (*Mercurialis perennis* L.), weasel-snout (*Galeobdolon luteum*, Huds.), enchanter's nightshade (*Circaea lutetiana* L.) etc., etc. On the other hand, on more elevated and looser grounds, in less clayey, sandy, and gravelly soil, the flora is confined to anemone, woodruff, and wood-sorrel, in older stands intermingled with the wood violet (*Viola silvatica*, Fr.) and the greater stitchwort (*Stellaria holostea* L.). Decomposition is here a little tardier than in the more fertile soil, the upper mull being greyish or nearly black, but the ammonia released through the decomposition of the organic matter, is mostly wholly converted into nitric acid. This Anemone-Asperula type is represented by Localities 12, 14, and 15.

A constant breeze among the trees will often result in a thick, tough covering of melic-grass (*Melica uniflora* Retz.), and decomposition is somewhat tardier, the acidity of the soil being generally greater, and only a part of the ammonia released is converted into nitric acid. Locality 5 belongs to this Melica type. Considerably better is the condition of the soil where millet-grass (*Milium effusum* L.) is flourishing, Locality 3.

If the wind sweeps the borders of the forest, the leaves will be blown away, leaving the soil deficient in mull. The result will be a type with wood meadow-grass (*Poa nemoralis* L.), a mully soil, but heavy and poor, or a type with waved hair-grass (*Aira flexuosa* L.) and hair-moss (*Polytrichum attenuatum* Menz.), where the ground is covered with a very thin layer of raw humus, on the top of a slight streak of leached sand. The soil is very acid, the production of ammonia is but small, and only the minutest amount of nitric acid is traceable. To this Polytrichum type belongs Locality 2.

On very loose and sandy soil, as also wherever the climate is cold and damp, even though the beech stand be

carefully tended, nitrification is tardy, and a type prevails the flora of which consists of only wood-sorrel *(Oxalis acetosella* L.*)*. The mull is acid and approximates a little to raw humus, the topsoil is quite heavy and deficient in mull, frequently somewhat leached as well; the ammonia released is only partly reconverted into nitric acid. To this Oxalis type belong Localities 9 and 21. Locality 30 is from a somewhat better type with the wood-sorrel and the anemone, the Oxalis-Anemone type.

If the forest has been carelessly tended, thinning neglected, and the ground exposed to winds, it will often be covered with raw humus resulting from the leaf layer of the beech, frequently as a 8—10 cm deep layer on a leached sand. Locality 4 is a beech raw humus of the Majanthemum type, developed on the Asperula type. Locality 20 is a tardier raw humus of the Trientalis type developed on the Oxalis type.

Under oak stands *(Quercus pedunculata* Ehrh.*)* we often meet with a luxuriant flora of herbs and grasses. Especially on marlaceous soil the ground may be covered with dog's mercury, anemone, raspberry, tall grasses, etc., and nitrification is very brisk, as in the case of Locality 10.

It is quite a different matter if the oak stand has a thick undergrowth of young beech, as in Locality 22. In that case there is no flora, but a thick layer of leaves, decomposition is slow, and the soil is mainly influenced by the dense young beech undergrowth.

The unmixed oak forest, even on poor ground, apart from a single type with *Quercus sessiliflora* Salisb. and bilberry, will preserve the mull soil, as in the case of Locality 23, a young oak plantation on poor sandy heathland. The forest is still young and dense; accordingly, there is as yet no soil flora, which otherwise on poor sandy soil usually consists of plants characteristic partly of mull, partly of raw humus: *Anemone nemorosa* L., *Stellaria holostea* L., *Convallaria majalis* L., *Luzula pilosa* L., *Aira flexuosa* L., etc. etc.

Under other light broadleaved trees, e. g. the ash *(Fraxinus excelsior* L.*)*, as under the oak, we may find a very exuberant flora. Locality 16 is from an ash stand on very rich calcareous mull, with nettle *(Urtica diocea* L.*)*, dog's mercury *(Mercurialis perennis* L.*)*, and goutweed *(Aegopodium podagraria* L.*)*.

On fertile soil our spruce woods are distinguished by mull covered with a layer of needles, and in forests of middle age the ground will mostly become covered with a dense flora of the Oxalis type, as in Locality 1.

On loose and sandy soil, corresponding to the beech-Oxalis type, a thick layer of raw humus is often developed under spruce, and the ground is thickly covered with mosses: *Hylocomium triquetrum* L., *H. proliferum* L., *H. parietinum* L., *Hypnum purum* L., *Stereodon cupressiformis* L., *Dicranum scoparium* L., *Polytrichum attenuatum*, Menz., etc. To this type belong Localities 6 and 8, and the stand of mingled spruce and larch, Locality 11. Under pines, on similar soil, the ground will be thickly covered with bilberry: Localities 26 and 27; but not where there is spruce undergrowth: Locality 28, or beech undergrowth: Locality 29. All these 7 Localities belong to the Myrtillus type (CAJANDER, 1909, p. 60).

Locality 7 is from a small hill covered with bilberry and surrounded on all sides by spruce.

On heathland of inferior quality — the Vaccinium type (CAJANDER, 1909, p. 104) — we find raw humus and moss in spruce, but of a less vigorous growth: Locality 25 and 32; this ground is often planted with mountain pine: Locality 17.

Finally a few samples — Localities 18, 24, and 31 — were taken from heathland where the sand is covered with a thin layer of raw humus with a growth of heather *(Calluna vulgaris* L.*)*, crowberry *(Empetrum nigrum* L.*)*, lichens *(Cladina* species*)*, mosses, etc., and the soil is more or less podsolized. Locality 19 is taken under a juniper in the heath.

Seven of the most important of these localities have been constantly registered for two years. To these have later been added Nos. 10, 15, and 20, thus furnishing us with ten main localities, as follows:

No. of Locality	Species	Type of Flora	Kind of Soil
15	Beech	Anemone-Asperula	Mull
5	»	Melica-Asperula	»
9	»	Oxalis	»
2	»	Polytrichum	Impoverished
4	»	No Flora *(Majanthemum type)*	Raw Humus

No. of Locality	Species	Type of Flora	Kind of Soil
20	Beech	No Flora *(Myrtillus type)*	Raw Humus
10	Oak	Mercurialis	Mull
1	Spruce	Oxalis	»
6	»	Hylocomium *(Myrtillus type)*	Raw Humus
8	»	»	»

The following localities, moreover, have been examined some few times:

No. of Locality	Species	Type of Flora	Kind of Soil
14	Beech	Anemone-Asperula	Mull
22	Oak with Beech Undergrowth	No Flora *(Anemone-Asperula type)*	»

Only once have samples been taken from the following localities:

No. of Locality	Species	Type of Flora	Kind of Soil
12	Beech	Anemone-Asperula	Mull
3	»	Milium	»
30	»	Oxalis-Anemone	»
21	»	Oxalis	»
23	Oak	No Flora	»
16	Ash	Urtica-Mercurialis	»
11	Spruce and Larch	Hylocomium *(Myrtillus type)*	Raw Humus
25	Spruce	Hylocomium *(Vaccinium type)*	»
32	»	»	»
26	Scotch Pine	Myrtillus	»
27	»	»	»
28	Scotch Pine with Beech	»	»
29	» » » Spruce	»	»
17	Mountain Pine	No Flora *(Vaccinium type)*	»
19	Juniper	»	»
7	No Trees	Myrtillus	»
18	»	Calluna	»
24	»	»	»
31	»	»	»

The localities requiring constant registrations had to be confined to N. E. Sealand, partly with the object of facilitating

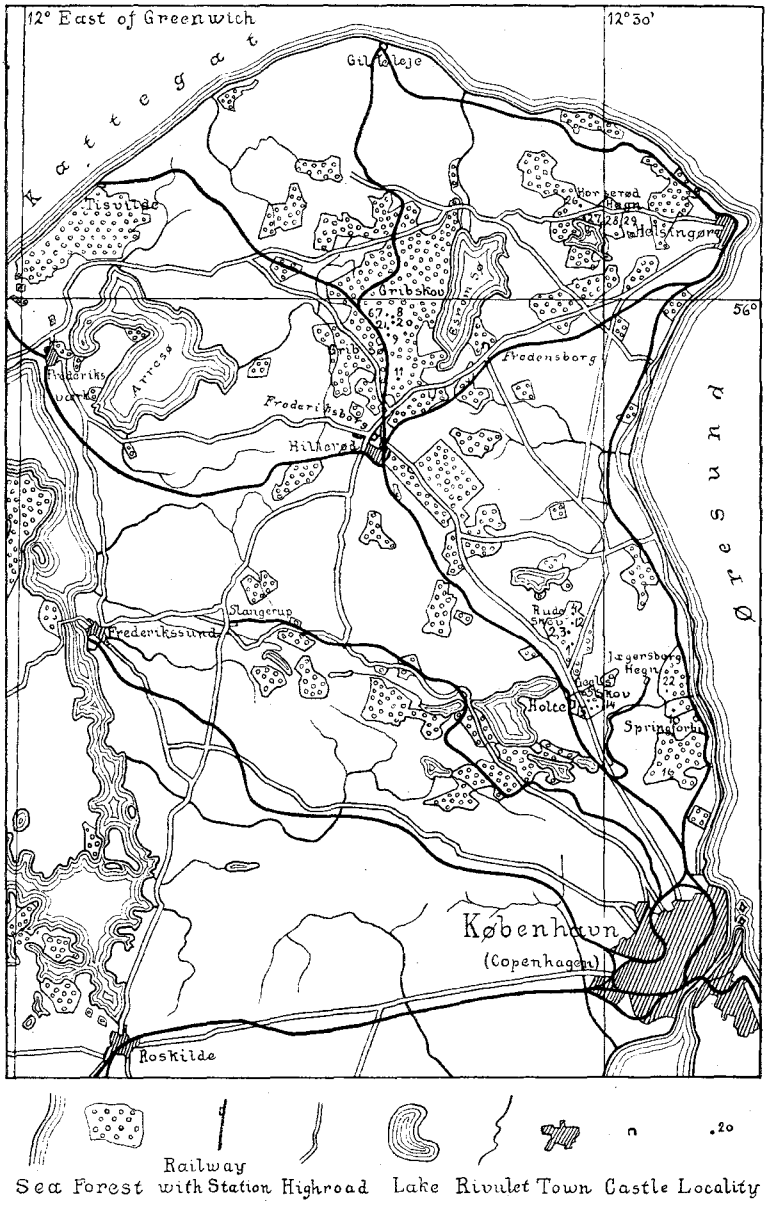


Fig. 1. Map of N. E. Sealand showing numbers of localities.
Scale 1 : 200 000.

the work, partly in order to have the samples examined as soon as possible. Most of the other samples, too, were taken from these parts (see map, Fig. 1). Samples Nos. 17, 18, 19, 23, 24, 25 and 32 are from the heathlands of Jutland, Nos. 30 and 31 from Bornholm.

The samples were taken out in the following way: Within a circular area of $^1/_{10}$ m^2 the whole layer of leaves or needles, including the vegetation of herbs or moss, as also dust and excrements of worms that happen more loosely to cover the ground, etc., was first removed and put into a close linen bag. The next part taken out was a 5—10 cm deep layer from the upper, porous, mull soil, of such a quality as to enable small animals to move about, and this was put into a separate bag. Finally, the lower and more compact topsoil, to a depth of 25 cm, was searched for earthworms, a number of which was often found, and for large grubs (a few *Bibio, Elateridae,* and *Scarabaeidae* larvae). On raw humus soil, too, the layer of leaves and moss, etc., was first taken, and then the entire layer of raw humus as far as the leached sand, while neither this nor any of the layers below was examined. Even if some animals were to be found in the lower strata, they would at any rate be so few in number as to be of only minimal importance, and are therefore left out of account in these investigations. Earthworms constitute an exception. Under favourable conditions they will keep near the surface, only during dry periods in summer and hard frosts in winter will they go to considerable depths, thus evading both our investigation and their participation in the decomposition of the soil. In a few places, where it has been difficult to separate the two layers, the entire sample has been taken in one batch, e. g. on heathlands.

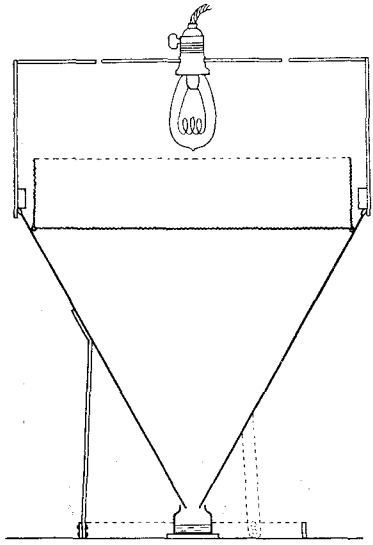


Fig. 2. Apparatus for driving out the animals. (1 : 10).

After their removal to the laboratory, either on the same day or the following morning, the samples were transferred to the apparatus designed for driving out the animals. This instrument, modelled on that of TULLGREN (1918), consists of the following parts (see Fig. 2): A large zinc funnel, supported by three legs at the bottom fastened to a ring, which constitutes the basis of the instrument; the funnel is 40 cm

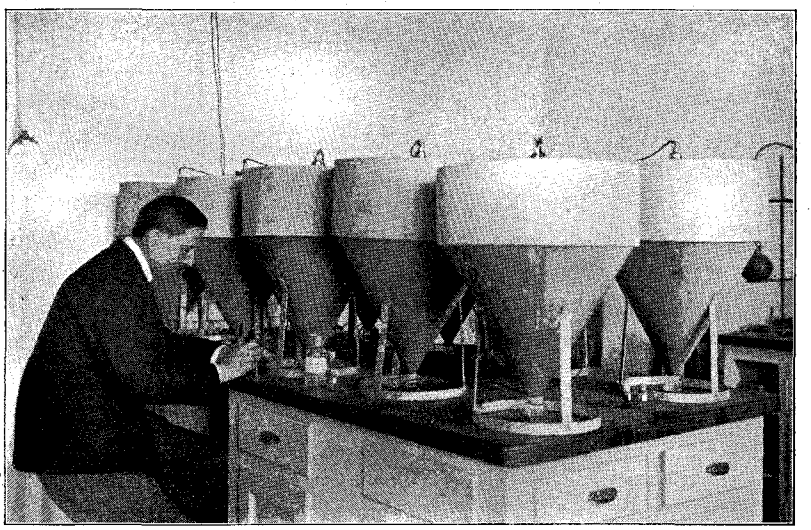


Fig. 3. The laboratory of The Experimental Forestry Service, with 10 apparatuses.

high and 46 cm in diameter at the top, and has at the bottom an opening of 20 mm. In the upper part of the funnel is placed a sieve of wire netting, 42 cm in diameter; the bottom of it with 3 mm meshes; 10 cm high sides, with 6 mm meshes. Covering the whole thing, resting on the rim of the funnel, there is a 21 cm high cap of plywood, at the upper, middle part of which as source of heat is installed a carbon filament electric bulb of 35 candle-power. It is of great importance that the bulb does not give too much heat, as this might kill the animals before they get time to make their escape from the sample. With the candle-power used the temperature did not exceed 40° C. as long as there were any animals left. Only when the samples were thoroughly exsiccated did the temperature in the upper part of the sample, close to the bulb, rise to 50—60° C. If the sample, while

still humid, had risen to this temperature, the animals might have been killed in the sieve. In order to accelerate the process of desiccation, some holes had been bored at the top of the wooden hood, an exit for the moist air.

The joint action of light, heat, and desiccation, affects the animals so as to make them move downwards, and when they have reached the bottom of the sieve, they drop into the funnel, from which they fall through the narrow opening at the bottom, and are collected in a glass containing alcohol. Only spiders and worms may cause some difficulties, the former because they let themselves down by means of their own web, and sometimes make their escape, the latter because of their slimy bodies often sticking to the sides of the funnel, where they dry fast and have to be loosened with the blade of a knife.

Most of the animals leave the sample in the course of 4—6 hours. In case of large quantities of mull or raw humus, however, a great number of animals may linger till the second, and even the third day, a fact proved by the replacement of fresh glasses with alcohol. The electric light was turned on only 8 hours a day. When no more animals leave the sample, this is searched for chrysalides and for animals that have proved too big to pass through the meshes of the strainer; this is chiefly the case with snails in shells and some large specimens of *Glomeris* and beetles.

The material collected is kept in alcohol until it can be sorted. The collembola, floating on the surface of the alcohol, are transferred to a separate glass, which facilitates the sorting. This process takes place in the following way: In small quantities the material is put on a flat-bottomed porcelain dish, where, under a binocular microscope of an 8-fold magnifying power, the animals are sorted by means of a crooked dissecting needle. The sorted and counted animals are, with a fine hair-pencil, transferred to small glass-tubes, 10×40 mm, where they are preserved in alcohol. Each glass is numbered and lettered so as to correspond to the inventory made contemporaneously with the counting of the animals.

The results are summarized in tables published with the following reports on the detail investigations. Before describing these, we must mention the different mistakes we are prone to make in the process.

By far the greatest risk of inexactitude is due to the fact that the small area of $^1/_{10}$ m^2, even though it be selected to the best of our ability so as to represent the average for the locality, does not exactly correspond to the actual stock of animals. The fact is that the animals, of course, are not equally distributed throughout the area, many of them tending to gregariousness; this holds true, not only of the larvae of the same hatch, as for instance many diptera larvae, but also of such nimble animals as the collembola, which are often found in flocks, attracted either by some particularly enticing nourishment or by a kind of social inclination. Whenever two samples were taken at the same time and in the same locality, the difference in the number of specimens of the same species often proved to be considerable. The difference, however, was mostly quantitative only, a great similarity always subsisting between parallel samples. It would have been preferable to have taken a number of samples each time from the same locality as ØKLAND has done by ascertaining the number of snails (1929), but this was impracticable if the object of our investigations was to be attained, viz: to ascertain the qualitative and quantitative differences between some of the chief types of forest soil fauna. It was requisite that samples from different localities which were to be compared, as far as possible should be taken out at the same time; hence, we had to confine ourselves to one or, at most, two samples from each, and then repeat the process in the various seasons of the year.

In the tables the annual mean for a square meter of each of the main localities has been arrived at by striking an average for each registration; where two parallel samples have been taken out, however, the mean of these has been adopted. The formation of annual means might perhaps, theoretically speaking, appear as a somewhat incorrect procedure; and so it really would be if the fauna was altogether different, also qualitatively, in the various seasons; but this is not the case. And yet considerable differences may obtain. Some collembola are most numerous at certain times of the year; others — even some of the chief species —, on the other hand, are numerically well represented all the year round, so that the soil teems with this group. The same holds good of

diptera larvae; most diptera pass through a short chrysalis and imago period in summer, but for the rest of the year are found as larvae in the forest soil; for a few species, as e. g. *Sciara* (army worm), however, the larval state is but of short duration, a fact resulting in one of the main variations due to the changing seasons of the year. Enchytraeids, too, are periodically met with in great quantities, particularly profuse was their number in the wet autumn of 1926 and the following mild winter. Spiders, mites, false scorpions, millipeds, centipeds, and woodlice, are species found all the year round; so are *Staphylinidae* and ground-beetles *(Carabidae),* as well as the larvae of these. The chief beetle larvae found in the forest ground, the *Elateridae* larvae, retain their larval state for several years, and so we find them, big and small specimens intermingled, throughout the varying seasons. Earthworms, too, are found all the year round, active in the friable mull soil and in the layer of leaves as soon as the weather makes it possible, and the forest soil is well protected against both exsiccation and frost.

The animals do not die when the forest ground becomes frozen. They only become torpid, and revive to renewed activity when the earth thaws, and as soon as the ground is warm enough in the month of March it once more teems with animal life. I have thus found small ground-beetles *(Notiophilus biguttatus)* hard-frozen in the moss carpet on the frozen raw humus soil in spruce woodlands, but after they had been warmed in the hand for a minute or so they ran about briskly enough.

The fauna of the forest soil thus presents both qualitative and quantitative differences during the course of the year, but is nevertheless so homogeneous that it is quite correct to use the annual mean when comparing the various types, just as we compare annual temperatures and precipitations which, from a biological point of view, must always be employed critically and with good sense.

In the main localities samples were taken out in March after the animals had revived to fresh activities, and in November after defoliation, but before the frosty season proper had set in; besides, in May and August, 1926, and in May, July, and September, 1927. This furnishes us with in-

formation about the quantities of animals at the times of the year in which they are active. Even though winter in Denmark is often mild and the forest ground remains frost-proof, the activity of the animals will probably be but small owing to the low temperature prevailing during such periods.

Miscalculations may of course also happen in case the animals, in one way or another, be lost either when samples are taken out or during transit. It is of the utmost importance to see that the animals be not squeezed or maimed, which in the apparatus would hinder them in leaving the sample; hence, the bags are to be as loosely packed as possible and the samples to be examined without any unnecessary delay. By careful management, these mistakes can be reduced to a minimum so as not to distort the actual facts presented by the fauna of the particular locality.

Detail Investigations.

In this section we pass on to examinations of the various localities and the results attained by our investigations. For each of the main localities we propose to describe in detail the stand of trees, the soil flora, and the soil, and in plates I—X at the end of the book we subjoin photographs of stands and soil flora. As for the rest of the localities, the descriptions are somewhat curtailed.

The number of animals collected are given in tables II—XIII; a column is set apart for each examination, and wherever the sample is divided into 2 or sometimes 3 layers, a separate column for each has been reserved. The scientific names of the animals, mostly the names of genera or families only, are found on the left, and the same list of names, with a few minor variations, recur in all the tables, that is to say, in different combinations the fauna is largely composed of the same elements, but in varying numbers. Further information about the individual kinds of animals and their mode of living is given in the following section, and in the plates XVII—XXVIII at the end of the book, pictures from photographs taken by the author of some of the chief animals, are subjoined. The object of these pictures is to give to practical foresters and other readers with no particular zoolog-

ical training an idea of how these small animals look, enabling them to recognize them whenever encountered in nature. We hope that especially foresters interested in Nature, will appreciate these portraits of some of their millions of small nurslings, and that their world, in this way, will grow more intelligible and vivid to them.

On the right in the tables will appear the annual mean of the number, an average of all the examinations being struck; where several examinations have been carried on at the same time, however, the average of these has been used in calculating the annual mean.

The next column gives in milligram (mgr.) the weight of animals per 1 square meter (m^2). For several reasons — especially because the weight of the alcohol preparations is not at all commensurate with that of the living animals, and because it would have entailed an immense work to weigh the numerous specimens — it was found practically impossible to weigh all the sorted animals in order to ascertain their exact weight. The approximate weight has been calculated, therefore, of each of the species, partly by having a number of samples of recently collected living animals weighed, partly, in the case of very small animals (collembola and mites), by measurement of the mean length of a large number of individuals of each species, and a subsequent calculation of their weight, judging from the weight of larger species of the same genus and of approximately the same form. This method of ascertaining weight must of course be designated mere calculative, but the accuracy is quite sufficient for our present object, which is to gain an approximately correct knowledge of the aggregate gravity of animals in the forest soil, and to ascertain the quantitative difference obtaining in the fauna of the various localities. Moreover, a great many casualties would in this way be equalized; for *Staphylinidae* and *Carabidae,* too, an average size has been taken for calculation, there being no special reason, in figuring out their weight, to take into account the few more straggling specimens of the larger species.

The last column, »Respiration«, the object of which is to show the »Intensity« of the animal life, we shall leave for a subsequent section.

First of all we shall deal with beech localities, starting with the best mull; then we pass on to some oak localities, and finally to spruce and other conifers, and heaths.

Beech, Mull, Anemone-Asperula.
Locality 15, Table II.

The stock of trees consisting of a vigorous beech stand, 80 years old, with an interspersion of fine, tall larches *(Larix decidua)*, 125 years old, comprises section 163 in Geels Skov (OPPERMANN 1923, p. 146). Where the sample was taken, the ground slopes but little southwards; towards the southern edge of the wood, somewhat more. The stock of trees, which had been thinned in 1924/25 and 1926/27, was, after thinning in 1927 (according to report kindly submitted by The Working Plans Bureau), estimated as follows, the numbers representing hectare; among beech a little oak and maple, among larch a very few specimens of silver fir, spruce, and Scotch pine, are included:

Species	Age	Height	Average diam.	Stems	Basal area	Volume
	Years	m	cm	Number	m^2	m^3
Beech.....	80	26.3	30	260	20.1	314
Larch.....	125	29.4	56	38	9.8	153

The thinnings of 1924/27 removed 61 m^3 beech per hectare, but no larch. The annual increment for the years 1912/27 was 14.6 m^3 per hectare, out of which 2.6 m^3 were larch. The growth of trees is thus very productive, the height of the beeches lying between the SCHWAPPACH (1912) quality class I and II. The tallest larches measured 33 m, and the thickest one had a diameter of 80 cm, breast-high.

At the place where the sample was taken out, the flora constitutes a rather close texture of *Anemone nemorosa* and *Asperula odorata* with an abundance of *Stellaria holostea* and some *Viola silvatica* intermixed. Small natural groups, 2—3 m high, of young *Acer pseudoplatanus*, are found in the neighbourhood. Under a loose layer of beech leaves, chiefly from last year's leaf fall, intermixed with some few larch needles, we meet with a friable and crumby mull, covered with a loose layer of earthworm excrements; the topsoil, too, is friable and

Table II. Locality 15. Beech, Mull, Anemone-Asperula. *Bøg, Muld, Anemone-Bukkar.*		August 1926				Novbr 1926	
		III a		III b		IV a	
		L	M	L	M	L	M
Gastropoda:	*Arion subfuscus*	2	.	.	.	3	
	shellbearing species, skalbærende	16	.	8	4	12	
Oligochaeta:	*Lumbricidae spp.*	9	11	18	11	23	
	Enchytraeidae spp.	44	5	7	30	110	
Crustacea:	*Isopoda terrestria spp.*	25	.	6	.	11	
Myriopoda:	*Lithobiidae spp.*	4	.	1	.	.	
	Geophilidae spp.	.	10	1	1	.	
	Julus spp.	4	8	8	11	9	
	Polydesmus spp.	2	.	8	2	1	
	Glomeris spp.	.	.	.	.	.	
Arachnida:	*Pseudoscorpiones spp.*	1	.	.	.	1	
	Araneina et Opiliones spp.	5	1	5	2	7	
»	*Acarina spp.*	175	35	650	62	468	
Collembola:	*Achorutes muscorum*	9	.	11	.	.	
	Onychiurus armatus	14	5	20	12	8	
	Folsomia quadrioculata	22	43	.	.	20	
	Isotoma viridis	1	.	.	.	.	
	Isotoma spp. (small, smaa*)*	23	.	80	50	38	
	Pogonognathus plumbeus	14	.	13	.	.	
	Lepidocyrtus lanuginosus	96	.	50	5	8	
Diptera:	*Imagines et Pupae div.*	.	.	.	1	.	
	Bibionidae spp., Larvae	.	.	.	.	.	
	Phaenocladius spp., »	.	.	.	.	.	
	Tipulidae spp., »	.	.	.	.	1	
	Leptidae spp., »	1	5	.	5	.	
	Dolichopodidae spp., »	.	.	.	.	.	
	Forcipomyia spp., »	.	.	.	.	.	
	Fannia spp., »	.	.	.	.	5	
	Anthomyiinae etc. spp., Larvae	.	.	.	.	16	
Coleoptera:	*Athous subfuscus, Imagines*	.	.	.	.	.	
	Larvae	.	2	.	.	.	
»	*Staphylinidae spp., Imagines*	2	2	4	4	4	
	Larvae	1	.	1	1	2	
	Carabidae spp., Imagines	.	.	.	.	.	
	Larvae	.	.	.	.	.	
	Cantharidae spp., »	.	.	.	12	.	
	Curculionidae spp., Imagines	.	.	.	.	5	
	Ptiliidae spp., »	6	.	25	1	.	
	Nitidulidae spp., »	.	.	.	3	.	
	Other species (andre)	.	.	.	.	1	
Lepidoptera:	*Larvae et Pupae div.*	.	.	.	.	.	
Hemiptera:	*Newsteadia floccosa*	5	1	9	15	17	
	Heteroptera spp.	.	.	.	.	.	
Orthoptera:	*Forficulidae spp.*	1	.	1	.	.	
Thysanoptera:	*Thripidae spp.*	.	.	.	.	.	

L = Leaf layer and soil flora *(Løv og Urter*

Novbr. 1926		March 1927				July 1927		Septbr. 1927		Novbr. 1927		Average Number *Middel Antal* per 1 m²	Weight *Vægt* mgr. per 1 m²	Respiration
IV b		V a		V b		VII		VIII		IX				
-	M	L	M	L	M	L	M	L	M	L	M			
2	.	.	.	7	.	5	.	.	1	6	.	32	4800	1265
0	2	1	.	18	1	.	.	2	.	.	.	73	146	162
												105	*4946*	*1427*
6	4	8	3	6	1	1	8	28	8	4	6	177	53100	11104
5	5	32	12	35	.	4	50	.	25	45	12	533	1066	1184
												710	*54166*	*12288*
0	1	11	.	8	1	2	.	25	.	1	.	149	149	209
3	.	.	.	.	.	.	.	1	.	.	.	8	240	108
2	1	1	5	1	8	.	15	1	2	.	3	70	1050	596
.	10	5	2	7	2	3	2	17	8	7	12	139	6950	2641
2	1	.	.	1	.	4	.	4	5	.	.	36	540	306
.	2	.	.	.	.	.	.	.	.	.	.	2	10	8
												404	*8939*	*3868*
6	.	.	.	2	.	.	.	1	.	.	.	10	1	3
.	1	2	2	1	.	.	.	.	.	2	.	27	27	38
												37	*28*	*41*
50	150	320	13	325	21	150	50	280	40	75	90	*3206*	*229*	*705*
.	.	.	.	.	.	.	.	.	.	.	.	17	1	2
.	6	.	13	8	8	.	10	17	18	.	.	168	7	28
9	68	75	55	56	6	4	4	22	3	.	3	363	11	49
.	.	.	.	3	.	.	.	.	.	.	6	13	6	11
12	4	29	5	52	6	8	20	46	8	.	19	418	4	26
.	.	.	.	3	.	.	.	.	.	.	.	25	16	26
.	.	.	.	.	.	15	.	22	.	.	.	194	10	37
												1198	*55*	*179*
.	1	.	.	.	.	1	.	.	.	.	.	3	3	4
.	.	.	.	.	.	.	.	.	.	.	.	2	40	21
.	.	9	6	43	5	.	.	.	.	.	.	53	27	47
3	1	1	.	1	1	.	.	.	.	.	.	8	1200	316
.	.	1	5	3	2	1	.	2	7	.	1	37	185	151
.	.	1	.	.	1	.	.	.	.	.	.	2	10	8
.	.	2	.	5	.	.	.	.	.	.	.	6	1	3
4	.	1	.	5	.	.	.	.	.	.	.	13	26	29
27	15	19	.	10	1	.	11	.	.	1	7	108	22	52
												232	*1514*	*631*
.	.	.	.	.	.	.	.	.	.	.	.	1	10	6
.	.	1	1	1	.	.	2	.	2	.	.	11	165	94
												12	*175*	*100*
1	2	4	.	3	1	.	.	2	.	.	2	35	70	77
.	3	.	.	5	1	1	.	.	2	1	1	22	44	48
1	.	.	.	.	.	.	.	.	.	.	.	3	15	12
.	.	.	.	1	.	.	.	1	.	.	.	3	15	12
.	.	.	.	1	1	.	.	.	.	.	.	12	24	27
1	.	2	1	2	.	2	.	1	.	1	.	16	160	104
11	3	4	.	14	2	.	3	12	.	.	1	84	1	5
.	1	.	1	3	.	.	.	2	.	.	.	13	1	4
.	.	.	1	1	.	.	.	1	.	1	.	4	10	10
												192	*340*	*299*
.	1	.	.	.	.	.	.	.	.	1	.	3	150	57
4	5	3	.	6	.	.	3	2	.	2	5	76	8	23
.	.	.	.	.	.	.	.	.	.	.	.	1	5	4
2	.	2	.	6	.	.	.	.	.	.	.	10	200	103
1	.	1	.	.	.	.	.	1	.	.	.	3	.	1
												93	*363*	*188*
1 = Mull soil *(Muldjord).*											**Total**	**6189**	**70755**	**19726**

rich in mull, made porous by earthworms and intersected by numerous mole tracks.

A soil section shows the following profile:

0— 2 cm: Black, gritty layer of mull, mixed with mineral soil.
2— 8 » : Dark, very friable topsoil, rich in mull.
8— 60 » : Brown, mully, friable topsoil.
60—100 » : Brownish, with spots of greyish sandy clay; rather friable and with very few stones.
100—200 » : Brownish sandy clay, with a little flint and many clods and grains of chalk.

At a depth of 110 cm and downwards the soil is effervescent with hydrocloric acid, hence abounding in carbonic lime. There is no ground water. Roots are plentiful as far down as 60 cm; a few roots may be found at a depth 150 cm and even more, thus extending into the chalky subsoil.

Mechanical soil analyses at depths of 90 cm, 140 cm, and 200 cm, give the following results:

Depth of sample cm	Gravel 20—2 mm per cent.	Percentage of fine soil under 2 mm				
		Coarse sand 2—0.2 mm	Fine sand 0.2—0.02 mm	Silt 0.02—0.002 mm	Loam <0.002 mm	Carbonic lime $CaCO_3$
90	1.6	25.6	42.5	14.6	17.3	0
140	9.3	26.9	40.7	19.8	12.6	0
200	5.5	23.9	37.4	14.8	7.3	16.6

The locality is characterized by the great number of earthworms, 177 per m^2, chiefly of large species. It teems with turgid worms *(Allolobophora turgida)*, living in the topsoil, while the reddish worm *(Lumbricus rubellus)*, plying both the topsoil and the layer of leaves above same, as also the minor species, of these especially the purple worm *(Lumbricus castaneus)*, mostly living in leaf layers, are quite numerous. The large species constituting about $^3/_4$ of all the worms, we are on the safe side if we fix their average weight at 300 mgr., or an aggregate weight for the earthworms of 53 gram (gr.) per m^2. Compared with this, the weight of all the other animals is but small, hardly 18 gr., the weight of the earthworms thus constituting 75 per cent. of the aggregate weight of all the animals.

Next in the order of weight comes the millipeds, about 140 specimens or 7 gr. per m^2. As No. 3 we should mention the snails, about 30 larger specimens without shells *(Arion subfuscus)* and about 70 quite small specimens with shells, all in all about 5 gr.; and, as No. 4, the diptera larvae, of which especially some smaller species of the crane-fly larva *(Tipulidae)* contribute considerably in weight, 232 specimens in all with a weight of 1.5 gr. Then follows the small, white potworms *(Enchytraeidae)* in a quantity of about 500, 1 gr. per m^2, and the threadlike, yellow *Geophilus* belonging to the centipeds, 70 specimens, about 1 gr. per m^2. Of beetles, the *Staphylinidae* species and their larvae, as also the click-beetle larvae *(Athous subfuscus)* are prevalent, the latter species, however, not by far in such great numbers as in raw humus soil.

In largest quantities do we find the mites, 3200 per m^2, but weighing only 0.2 gr. in all; and the collembola (springtails), about 1200 per m^2 with an aggregate weight of only 0.05 gr. per m^2. The quantities of mites and collembola, however, are much smaller than in raw humus soil. The collembola are mostly coloured species of the *Isotomidae* family. The small, white, blind *Onychiurus armatus* is relatively much less prominent here than in raw humus.

The rest of the fauna plays a comparatively small part. We note some *Carabidae,* weevils (most *Strophosoma*), larvae from *Cantharidae,* in abundance the almost microscopic small beetles *Ptiliidae* — whose hind-wings resemble small feathers — and earwigs, the common *Forficula auricularia* as well as *Chelidura acanthopygia,* which latter species has a pair of very long forceps.

Moreover, we find a number of *Newsteadia floccosa,* a species akin to the scale-insects; they are covered with a white, woolly, wax-like layer, and are of quite frequent occurrence in forest soil.

We can briefly characterize the fauna of the locality by saying that earthworms, especially the larger species perforating the topsoil, play the most important part, constituting, as they do, $^3/_4$ of the total weight of fauna. The arthropoda living on leaves and humus, of which the common milleped *(Julus)* is particularly conspicuous, occur in middling numbers.

Beech, Mull, Melica-Asperula.
Locality 5, Table III.

The stand is a fine beech wood, constituting compartment 146 in Geels Skov, in which the Experimental Forestry Service has a sample plot, S, (OPPERMANN 1914 a, p. 240; BORNEBUSCH 1923, p. 35) which, when measured in 1920 gave the following figures:

Age, 106 years; average height, 29.1 m; average diameter, 43.2 cm; number of stems, 186; basal area, at a height of 1.3 m, 27.3 m^2; volume of wood, 486 m^3 — all per hectare, after thinning. 46 trees with a total of 84 m^3 wood had been removed. The consecutive annual increment for the period 1906—1920 was 11.6 m^3 per hectare. Compared with SCHWAPPACH (1911), the height is a little over quality class II, but the trees are thicker than quality class I.

The stems are free from branches to a considerable height, and there is no undergrowth whatever; hence the ground has been exposed to winds, partly from the broad highway on the west, partly from clearings on the east side. The soil flora consists, in almost equal parts, of melic-grass, *(Melica uniflora),* on the one hand, and *Anemone nemorosa* and *Asperula odorata,* on the other.

On March 30, 1928, the forest soil was described. Between the stalks of the withered melic-grass there were about 3 cm beech-leaves from the previous autumn, but with small residues of older leaves. The soil profile is as follows:

0— 3 cm: Friable and crumbling black mull, with plentiful intermixture of mineral soil, and many white grains of quartz visible.

3— 10 » : Black, very friable, mully topsoil rich in humus.

10— 45 » : Brownish, humus-coloured (upper part more, lower part less), friable topsoil, somewhat sandy.

45—100 » : Yellowish-brown, slightly clayey soil rather pale in colour, resembling clay pan but not very hard, with a few straggling stones.

100—200 » : Brownish, very sandy clay, containing some granite for the first 20 cm, and a number of small white pebbles, at first glance resembling lime. Of carbonic lime there is none, nor any ground water.

In the upper 15 cm there were roots in great profusion, and below this, as far as 45 cm, a great number. Below this depth, as far as 85 cm, only a few tiny roots. Withered roots were found as far down as 100 cm.

Mechanical analyses of soil samples from the depths of 90 cm and 200 cm gave the following results:

Depth of sample cm	Gravel 20—2 mm per cent.	Percentage of fine soil under 2 mm: Coarse sand 2—0.2 mm	Fine sand 0.2—0.02 mm	Silt 0.02—0.002 mm	Loam < 0.002 mm
90	10.2	40.1	46.3	9.4	4.2
200	4.5	25.1	39.6	16.9	18.4

This locality has much in common with the one described above, Loc. 15. The mull soil is friable, but the lower topsoil is a little more compact, and the subsoil is without chalk. The ground is more exposed to winds; hence, the Anemone-Asperula type of flora is intermixed with large quantities of melic-grass, though not so much as to predominate.

Consequently, the fauna presents a composition almost corresponding to that of Loc. 15, though decidedly inferior in quantities. The aggregate weight of animals amounts to 38 gr. per m^2, compared with 71 gr. in No. 15. Earthworms amount to only 28 gr., or 74 per cent. of the entire weight, and the turgid worm is predominating.

For the other species, the numbers are correspondingly small, with a few exceptions, however. Snails figure as No. 2 in the order of weight, amounting to about 4 gr., while myriopods constitute only 2 gr., there being but 32 millipeds = 1.6 gr.. The diptera larvae are in larger quantities — 349 —, but their weight is only 1 gr., because there are hardly any of the big tipula larvae. In all probability this is due to the greater amount of mull in Loc. 15, which results in larger quantities of millipeds and tipula larvae. We find a comparatively large quantity of the click-beetle larvae in Loc. 5, and, besides the *Athous subfuscus*, a number of *Dolopius marginatus*. *Staphylinidae* and *Carabidae*, too, are more numerous than in Loc. 15, but otherwise the difference in the number of beetles is insignificant. Of *Newsteadia floccosa* there are fewer specimens. Of crustacean animals — isopods — there are, as in Loc. 15, about 150, nearly all of them very small *Trichoniscus*, while the

Table III. Locality 5.

Beech, Mull, Melica-Asperula.

Bøg, Muld, Flitteraks-Bukkar.

		March 1926 I		May 1926 II		August 1926 III a		III
		L	M	L	M	L	M	L
Gastropoda:	*Arion subfuscus*	.	.	4	.	.	.	2
	shellbearing species, skalbærende	1	2	1	.	6	.	13
Oligochaeta:	*Lumbricidae spp.*	.	.	5	8	3	6	4
	Enchytraeidae spp.	18	30	60	22	11	33	14
Crustacea:	*Isopoda terrestria spp.*	5	1	16	.	26	.	34
Myriopoda:	*Scutigerella immaculata*	.	.	.	.	.	.	.
	Lithobiidae spp.	1	.	.	.	.	.	4
	Geophilidae spp.	.	.	1	.	.	.	.
	Julus spp.	.	4	.	.	1	1	8
	Polydesmus spp.	.	.	.	.	.	1	6
	Glomeris spp.	1	3	1	.	3	.	1
Arachnida:	*Pseudoscorpiones spp.*	3	1	1	.	1	.	1
	Araneina et Opiliones spp.	.	11	.	.	6	2	7
»	*Acarina spp.*	120	280	70	10	150	63	220
Collembola:	*Onychiurus armatus*	40	18	2	4	17	27	.
	Folsomia quadrioculata	20	.	3	5	.	2	.
	Isotoma viridis	.	.	.	.	.	.	.
	Isotoma spp. (small, smaa)	15	.	7	.	.	20	.
	Pogonognathus plumbeus	4	.	3	.	4	.	30
	Lepidocyrtus lanuginosus	.	.	6	.	35	.	10
	Entomobryidae spp.	.	.	1	.	1	1	.
	Sminthuridae spp.	.	.	.	.	.	.	.
Diptera:	*Imagines et Pupae div.*	.	3	.	.	1	5	1
	Bibionidae spp., Larvae	.	3	.	.	.	.	.
	Phaenocladius spp., »	15	3	.	.	.	.	1
	Mycetophilidae spp., »	.	.	.	.	1	8	.
	Psychodidae spp., »	7	.	.	.	.	.	.
	Tipulidae spp., »	.	1	.	.	3	.	.
	Leptidae spp., »	.	.	1	.	1	5	.
	Dolichopodidae spp., »	.	.	.	7	.	1	.
	Forcipomyia spp. »	.	.	.	.	.	.	.
	Fannia spp., »	3	.	.	1	.	.	1
	Lonchoptera spp., »	.	.	.	.	.	.	.
	Anthomyiinae etc. spp., Larvae	11	20	5	100	.	10	3
Coleoptera:	*Athous subfuscus, Imagines*	.	.	.	.	.	1	.
	Larvae	1	.	.	6	.	.	.
	Dolopius marginatus, »	.	1	1	1	.	2	.
»	*Staphylinidae spp., Imagines*	6	2	3	1	1	4	5
	Larvae	.	3	.	.	.	3	.
	Carabidae spp., Imagines	1	1	.	1	1	3	.
	Larvae	.	.	.	1	1	.	2
	Cantharidae spp., »	5	3	2	1	.	7	1
	Curculionidae spp., Imagines	1	.	.	.	.	.	1
	Ptiliidae, spp., »	3	1	.	.	1	.	3
	Nitidulidae spp., »	.	1	.	.	.	8	.
	Other species (andre)	.	.	.	.	.	.	.
Lepidoptera:	*Larvae div.*	.	.	.	.	.	.	.
Hymenoptera:	*Larvae, Pupae et Imagines div.*	.	1	.	.	.	1	.
Hemiptera:	*Newsteadia floccosa*	2	2	1	.	2	3	.
	Heteroptera spp.	.	.	.	.	.	.	.
Orthoptera:	*Forficulidae spp.*	.	.	.	.	.	.	2
Thysanoptera:	*Thripidae spp.*	.	.	.	.	.	.	1

L = Leaf layer and soil flora (*Løv og Urt*

November 1926			March 1927		May 1927		July 1927		Septbr. 1927		Novbr. 1927		Average Number *Middel-Antal* per 1 m²	Weight *Vægt* mgr. per 1 m²	Respiration
V a	IV b		V		VI		VII		VIII		IX				
M	L	M	L	M	L	M	L	M	L	M	L	M			
.	1	1	5	.	2	.	3	1	2	.	1	.	26	3900	1028
1	9	.	1	.	3	.	.	.	4	.	.	1	40	80	89
													66	*3980*	*1117*
.	5	2	3	7	6	8	3	11	3	13	.	1	93	27900	5835
1	77	3	5	1	15	70	55	14	5	70	13	7	547	1094	1215
													640	*28994*	*7050*
1	3	.	16	1	4	.	23	.	22	.	3	5	151	151	211
.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1
.	1	.	.	.	.	.	.	.	1	.	.	.	6	180	81
.	.	.	.	.	.	.	.	.	.	.	.	.	1	15	9
2	.	.	1	.	1	.	9	3	.	1	.	3	32	1600	608
.	.	.	.	.	.	.	.	.	1	.	.	2	9	135	77
.	1	1	.	9	.	1	.	.	1	1	.	2	26	130	106
													226	*2212*	*1093*
.	6	.	1	.	.	.	.	.	.	.	.	.	14	1	4
3	5	2	2	2	1	.	3	.	1	1	1	2	42	42	59
													56	*43*	*63*
150	135	36	216	90	70	10	170	98	80	37	8	42	*1919*	*167*	*471*
20	18	9	10	18	17	20	27	20	16	12	.	5	311	12	51
15	40	.	13	25	.	.	19	16	13	10	2	17	236	7	32
.	.	.	2	.	.	.	1	.	.	.	.	.	3	2	3
.	7	.	14	15	60	15	25	12	30	10	.	1	287	3	19
.	10	.	2	.	.	.	.	.	3	.	1	.	44	29	46
.	.	.	.	.	.	.	.	.	.	.	.	.	32	2	6
.	2	.	.	.	.	.	.	.	1	.	.	.	6	6	8
.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	1
													920	*61*	*166*
.	.	.	.	.	.	2	1	3	.	.	.	.	14	14	20
.	.	.	3	7	.	.	.	.	.	.	.	.	14	280	144
.	.	2	.	.	.	.	.	.	.	.	.	.	22	11	19
.	.	2	.	.	.	.	1	.	.	1	.	.	9	5	8
.	.	.	6	.	.	.	.	.	.	.	.	.	14	14	20
.	.	.	1	.	.	.	.	.	.	.	.	.	2	300	79
3	.	2	1	2	1	6	1	10	4	13	.	2	58	290	237
.	.	2	.	.	.	.	.	.	.	.	.	.	11	55	45
.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	1
.	2	.	1	1	.	.	.	.	.	.	.	.	10	20	22
.	.	.	.	.	.	.	.	.	.	.	2	.	2	1	2
.	14	.	6	7	2	.	1	.	.	.	.	1	191	38	91
													349	*1029*	*688*
.	.	.	.	.	.	.	.	.	.	.	.	.	1	10	6
.	2	1	.	4	.	1	.	1	.	.	.	3	21	315	179
6	2	.	.	.	.	1	.	3	.	.	.	1	17	255	145
													39	*580*	*330*
4	4	1	6	4	1	1	1	3	2	3	1	4	54	108	120
2	1	4	.	1	2	2	2	2	3	1	.	3	28	56	62
.	1	1	.	.	1	.	1	.	.	.	.	1	12	60	49
.	.	.	.	.	1	1	1	.	.	.	.	.	9	45	37
.	.	2	.	.	.	.	.	.	.	.	.	.	20	40	44
.	2	.	2	2	.	.	.	.	1	.	1	1	12	120	78
.	.	.	6	1	.	.	.	12	.	.	.	.	28	.	2
7	.	.	.	1	2	.	.	.	.	.	.	1	14	1	4
1	3	.	.	.	.	.	1	.	.	1	.	.	6	15	17
													183	*445*	*413*
.	1	.	1	.	.	.	.	.	.	.	.	.	3	150	57
.	.	.	.	.	.	1	.	.	.	.	.	.	3	30	19
.	2	.	.	3	.	.	.	.	.	.	.	.	13	1	4
.	1	.	.	.	.	.	.	.	1	.	.	.	2	2	3
.	2	.	.	.	.	.	.	.	.	.	.	.	3	60	31
.	.	.	1	.	.	.	.	.	.	.	.	.	2	.	.
													26	*243*	*114*
= Mull soil (*Muldjord*).												**Total**	**4424**	**37754**	**11505**

larger common woodlouse *(Oniscus asellus)* only exceptionally is to be met with on the ground itself; it sticks to stumps of trees or big, dead branches, where it finds shelter under the bark.

Of mites there were only about 1900, weighing 0.17 gr.; of collembola only 920, but their weight, 0.06 gr., exceeding that of Loc. 15, because of the greater number of the big, leaden *Pogonognathus plumbeus*.

Beech, Mull, Oxalis.
Locality 9, Table IV.

The large beech stands in Grib Skov are largely situated on sand or gravel, which, however, mostly is somewhat clayey (BRÜEL 1916); the growth is slow, the ground is often lacking the fine covering of *Anemone* and *Asperula* so characteristic of Danish beech woods, wherever the soil is of the superior quality, and is only sparsely covered with wood-sorrel; hence I have called it the Oxalis type. The soil is mull, but nitrification is not complete as in the good beech mull in the localities just mentioned, and we find a considerable content of ammonia. The topsoil is often compact, sometimes showing strong traces of an incipient podsol formation owing to the fact that the ground for some time has been covered with raw humus. The northern part of sample plot BL belonging to the Experimental Forestry Service, just east of Grib Sø, Nøddebo State Forest district compartment 92, is a good representative of this type (BORNEBUSCH 1923, p. 13 & 42). Measurement of the sample plot in the Spring of 1927, in which year the stand was 77 years old, gave, after thinning, the following results: stems, 509; height, 20.8 m; average diameter, 24.8 cm; basal area 24.7 m^2; volume of wood, 285 m^3 per hectare. 112 trees = 44 m^3 had been removed. The increment for the period 1910—1927 was 11.4 m^3 annually — all per hectare. The height of the beeches lies between SCHWAPPACH's quality class II and III. The lower part of the stems are branchless; there is no undergrowth, and the ground is somewhat exposed to winds. A thick leaf layer with a sparse flora of wood-sorrel covers the thin, black, somewhat matted, layer of mull. A soil section showed the following profile:

0— 10 cm: Dark-grey, mully, friable and loose topsoil.
10— 38 » : Yellow-brown, upper part more coffee-coloured, lower part more ocherous, close and compact, sandy topsoil.
38— 65 » : Yellowish-grey sand, very stony and compact, approaching clay pan.
65— 90 » : Yellowish-grey, somewhat variegated in colour, very hard clayey sand, very stony.
90—130 » : Clayey sand, very stony.
130—145 » : Sandy clay, very stony.
145—165 » : Clayey sand, very stony.
165—200 » : Sandy clay, very stony.

Gravel, stones, and blocks of granite, abound. Of carbonic lime there is none. Roots are plentiful in the topsoil to a depth of 45 cm; below this, in smaller quantities to a depth of 100 cm. At a depth of 170 cm a little water was oozing out, but this must be due to the rainy period preceding, and cannot be taken for ground water in the proper sense.

Mechanical analyses of samples from depths of 50 cm, 100 cm, and 200 cm, gave the following results:

Depth of sample cm	Gravel 20—2 mm per cent.	Percentage of fine soil under 2 mm: Coarse sand 2—0.2 mm	Fine sand 0.2—0.02 mm	Silt 0.02— 0.002 mm	Loam < 0.002 mm
50	6.3	54.0	39.8	4.7	1.5
100	14.9	40.3	40.2	13.2	6.3
200	4.4	32.5	37.3	18.1	12.1

Compared with the two previous localitites, the fauna is remarkably sparse with an aggregate amount of only 12.9 gr., which tallies well with the poor quality of the soil. Earthworms constitute 5.9 gr., or only 46 per cent. of the entire weight. Of the worms, three were turgid worms *(Allolobophora turgida)* and two reddish worms *(Lumbricus rubellus)*. The rest were small species, for the most part or almost exclusively, the little octagonal worm *(Dendrobaena octoedra)*. Next figure the diptera larvae with 2 gr., of which chiefly the crane-fly larvae and, next in order, the *Leptidae* larvae, make up the weight. For the rest we note the great number of *Mycetophilidae* larvae in the samples of Nov. 1926 and July 1927. The larvae of the *Mycetophilidae* and the *Sciara* (army worm) resemble each

Table IV. Locality 9.

Beech, Mull, Oxalis.

Bøg, Muld, Skovsyre.

		March 1926 I a L	March 1926 I a M	March 1926 I b L	March 1926 I b M	May 1926 II L	May 1926 II M	August 1926 III a L
Gastropoda:	*Arion subfuscus*	.	.	.	.	.	.	1
	shellbearing species, skalbærende	.	.	1	1	.	.	1
Oligochaeta:	*Lumbricidae spp.*	4	2	1	1	5	3	9
	Enchytraeidae spp.	.	7	5	9	66	25	8
Crustacea:	*Isopoda terrestria spp.*	.	.	1	.	.	.	.
Myriopoda:	*Lithobiidae spp.*	.	.	.	.	.	.	.
	Geophilidae spp.	.	.	.	1	.	.	.
	Julus spp.	.	1	1	5	1	.	.
	Polydesmus spp.	.	.	.	.	.	.	.
	Glomeris spp.	.	.	.	.	1	.	.
Arachnida:	*Pseudoscorpiones spp.*	1	.	2	.	1	.	3
	Araneina et Opiliones spp.	4	1	5	.	10	3	2
»	*Acarina spp.*	160	215	460	200	170	30	300
Collembola:	*Achorutes muscorum*	.	.	2	.	.	.	.
	Onychiurus armatus	75	18	25	11	7	3	36
	Folsomia quadrioculata	50	.	42	3	55	5	25
	Isotoma viridis	.	.	3	.	.	.	.
	Isotoma spp. (small, smaa)	.	.	.	.	4	3	20
	Pogonognathus plumbeus	.	.	.	.	1	.	2
	Lepidocyrtus lanuginosus	13	.	6	.	.	.	.
	Entomobryidae spp.	1	.	6	.	.	.	.
Diptera:	*Imagines et Pupae div.*	.	7	.	2	.	.	.
	Mycetophilidae spp., Larvae	.	1	.	.	.	.	.
	Tipulidae spp., »	.	.	.	.	.	1	2
	Leptidae spp., »	1	5	.	.	1	6	3
	Dolichopodidae spp., »	2	1	2	.	.	.	.
	Fannia spp., »	4	.	3	.	1	.	.
	Anthomyiinae etc. spp., »	10	11	4	.	7	4	.
Coleoptera:	*Athous subfuscus, Imagines*	.	.	.	1	.	.	.
	Larvae	.	.	1	3	2	5	.
	Dolopius marginatus, »	.	.	.	.	.	3	.
»	*Staphylinidae spp., Imagines*	1	5	1	1	2	.	.
	Larvae	.	2	1	.	3	2	.
	Carabidae spp., Imagines	.	1	.	.	.	.	.
	Larvae	1	.	.	.	1	.	.
	Cantharidae spp., »	2	1	2	2	.	.	.
	Curculionidae spp., Imagines	.	.	.	.	.	.	.
	Larvae	.	1	.	.	.	.	.
	Ptiliidae, spp., Imagines	.	.	.	.	.	.	.
	Other species (andre) *Imagines*	.	.	1	1	.	.	.
	» *Larvae*	.	.	2	.	.	.	.
Lepidoptera:	*Larvae div.*	.	.	1	.	.	.	.
Hymenoptera:	*Imagines et Pupae div.*	.	1	.	1	1	.	.
Hemiptera:	*Newsteadia floccosa*	4	15	18	1	9	1	3
Orthoptera:	*Forficulidae spp.*	.	.	.	.	.	.	.
Thysanoptera:	*Thripidae spp.*	.	.	.	.	.	.	.

L = Leaf layer and soil flora *(Løv og Urte*

ıgust 926	November 1926				March 1927		May 1927		July 1927		Septbr. 1927		Novbr. 1927		Average Number *Middel-Antal* per 1 m²	Weight *Vægt* mgr. per 1 m²	Respiration
II b	IV a		IV b		V		VI		VII		VIII		IX				
M	L	M	L	M	L	M	L	M	L	M	L	M	L	M			
.	.	.	1	.	.	.	.	.	2	.	1	.	.	.	6	900	237
.	.	.	.	.	.	.	3	.	2	.	.	.	2	.	10	20	22
															16	*920*	*259*
3	7	2	4	1	5	1	5	2	4	3	8	6	.	2	73	5900	1733
1	73	1	120	.	11	1	11	13	.	31	5	13	19	15	359	718	798
															432	*6618*	*2531*
.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	3	3	4
.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	2	60	27
.	.	.	.	.	.	3	.	.	.	.	1	.	.	.	6	90	51
1	.	.	1	1	1	.	2	2	1	1	.	.	.	1	17	850	323
3	.	.	.	.	.	.	.	.	.	2	.	.	.	.	4	60	34
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5	4
															33	*1068*	*443*
.	2	1	.	.	1	.	.	.	2	.	1	.	.	.	12	1	4
.	1	1	9	1	11	8	2	.	3	1	4	.	4	.	66	66	92
															78	*67*	*96*
12	290	130	300	190	150	125	240	50	220	15	300	30	160	12	*3049*	*205*	*647*
.	.	.	10	.	.	.	.	.	.	.	4	.	2	.	13	.	2
.	41	110	37	33	25	39	10	8	18	20	90	20	9	15	508	20	83
.	37	30	27	7	45	4	30	26	.	8	75	7	58	5	482	14	65
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	3
.	24	3	25	3	30	6	25	.	25	5	2	4	8	3	198	2	13
.	3	.	12	.	8	.	5	.	.	.	.	.	2	.	30	20	32
.	.	.	24	.	.	.	.	.	60	1	20	.	.	.	133	7	25
.	5	.	8	.	.	.	.	.	.	.	4	.	.	.	16	16	22
															1383	*81*	*245*
.	.	1	.	.	1	4	.	.	.	.	2	.	.	.	13	13	18
1	12	26	180	46	.	2	.	.	.	125	.	.	.	.	289	145	255
.	1	.	.	.	.	.	.	.	.	.	1	3	1	1	10	1500	395
2	.	6	.	.	.	10	4	7	2	1	4	4	1	2	58	290	237
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	15	12
.	5	.	3	.	3	.	1	.	.	.	.	.	.	.	14	28	31
.	27	.	13	.	3	.	.	.	.	.	.	.	6	.	60	12	29
															447	*2003*	*977*
.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	2	20	13
.	.	6	.	10	1	29	.	4	.	1	.	1	.	14	78	1170	664
.	.	.	.	1	.	1	1	2	.	.	.	.	.	.	9	135	77
															89	*1325*	*754*
.	6	2	2	.	.	.	1	1	1	.	8	.	10	2	39	78	87
.	2	5	.	8	.	2	3	.	.	3	1	1	.	.	29	58	64
.	.	.	.	.	1	.	.	.	.	.	2	.	.	.	4	8	9
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	4	4
.	2	2	6	2	.	.	.	.	.	.	.	.	.	.	11	22	24
.	.	.	3	.	1	.	.	.	.	.	.	.	.	1	4	8	9
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	10	6
.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	2	2	3
.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	3	2	3
															97	*192*	*209*
.	.	.	.	.	.	.	.	1	.	.	.	.	4	.	7	350	133
.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	4	4	6
1	13	3	20	8	15	27	8	.	.	.	.	.	3	6	131	13	39
.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	2	40	21
.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.
															145	*407*	*199*
= Mull soil *(Muldjord)*.														**Total**	**5769**	**12886**	**6360**

other so much that it has been impossible to keep them apart. In all probability the batch taken in July, and possibly others, belongs to the notorious *Sciara* species which are so common in the forest soil, just at this time of the year making their appearance as larvae; sometimes men passing the deep woods may come across a troop of marching larvae, which by the name of army worm have aroused so much sensation and superstition, and of which further particulars will be given in a subsequent section. Millipeds and other *Myriopoda* are more sparsely represented than in the good beech mull; so are snails; and the specimens of *Trichoniscus,* too, are very few.

The *Tipulidae* larvae are quite numerous. The *Athous subfuscus* larvae are predominating, but otherwise beetles are very few. It is particularly noticeable that there are hardly any of the small *Ptiliidae.* It is strange to find the presence of moth larvae in so barren a soil, but they prove to be of the *Hepialus* genus, living on roots. *Newsteadia floccosa* is very numerous.

Of mites we find a number of 3000, weight 0.2 gr., which corresponds to the two previous localities. Of collembola the number happens to be greater, about 1400, weighing 0.08 gr. The white blind *Onychiurus armatus* is the most numerous, and next to that comes the grey *Folsomia quadrioculata;* but the weight of these 1000 little fellows is no greater than that of the 30 *Pogonognathus* and 16 *Entomobryidae.* Small *Isotoma* species and *Lepidocyrtus lanuginosus,* too, are quite numerous.

Beech, Impoverished Soil, Polytrichum.
Locality 2, Table V.

The samples have been taken from the margin of the beech stand, Rude Skov compartment 81, exposed to wind and sunshine owing to the clearing of an area on the western side about 30 years ago. A young wood is now growing up in the adjoining compartment, and the ground will find shelter against the wind. But when these samples were taken out, the defective condition of the soil was typical. The surface soil has become deficient in mull, compact, and covered with a quite thin layer of raw humus and a flora consisting of waved hair-grass *(Aira flexuosa), Polytrichum attenuatum, Dicranum scoparium,* and other mosses. The raw humus is densely

interwoven with grass roots and moss rhizoids, under which the soil is leached, for a few centimeters. Most of the leaves have been blown away, and only a few beech leaves are left between the tufts of grass, together with some twigs and cupules. A soil section made in March 1928 shows the following profile:

0— 3 cm: Thin layer of raw humus.
3— 18 » : Greyish, humus-coloured, friable but compact, sandy topsoil.
18— 38 » : Yellow, friable but compact, sandy topsoil.
38— 85 » : Light greyish-yellow, pale, compact and solid, fine sand, without stones.
85—125 » : Gravelly, a little clayey, coarse sand, with a lot of flint and granite, including a big granite block.
125—200 » : Brownish-yellow, variegated clayey sand and sandy clay, changing in patches; only a few straggling stones.

Roots are quite plentiful as far down as 38 cm; below this only a few tiny ones to the very bottom of the hole. No carbonic lime was found, and there was no ground water.

Mechanical analyses of samples from depths of 60 cm, 105 cm, and 200 cm, gave the following results:

Depth of sample cm	Gravel 20—2 mm per cent.	Percentage of fine soil under 2 mm Coarse sand 2—0.2 mm	Fine sand 0.2—0.02 mm	Silt 0.02— 0.002 mm	Loam < 0.002 mm
60	3.9	41.4	54.1	2.2	2.3
105	13.5	86.8	8.8	1.8	2.6
200	8.9	33.3	40.8	13.5	12.4

When the sun is shining, it is warm, dry, and pleasant for grown-up insects, but the place is very unpropitious to the soil fauna requiring humidity, and, consequently, same is sparsely represented. The aggregate weight of animals is only 5.2 gr. per m^2, i. e. no more than one fourteenth of what we found in the best beech locality. Earthworms constitute only $1^1/_2$ gr. or 28 per cent. of the aggregate weight, and, as far as it has been possible to ascertain the species of the individual animals, it is exclusively the tiny octagonal worm *(Dendrobaena octoedra)*, living in the raw humus without being affected by the desiccation of same; while the larger kinds generally riddling the mineral topsoil are entirely wanting.

Table V. Locality 2. Beech, Impoverished Soil, Polytrichum. *Bøg, forblæst og forarmet Bund, Skovjomfruhaar.*		March 1926 I	May 1926 II	Augı 192 III
Oligochaeta:	*Lumbricidae spp.*	.	4	
	Enchytraeidae spp.	3	16	
Myriopoda:	*Geophilidae spp.*	.	4	
Arachnida:	*Pseudoscorpiones spp.*	.	.	
	Araneina et Opiliones spp.	2	3	
»	*Acarina spp.*	150	215	38
Collembola:	*Achorutes muscorum*	.	.	
	Hypogastrura armata	.	.	
	Folsomia quadrioculata	1075	550	110
	Isotoma viridis	25	1	
	Isotoma spp. (small, smaa)	.	60	1
	Pogonognathus plumbeus	.	1	
	Lepidocyrtus lanuginosus	.	.	1
	Entomobryidae spp.	.	.	
Diptera:	*Imagines et Pupae div.*	1	2	
	Mycetophilidae spp., Larvae	1	.	
	Tipulidae spp., »	1	.	
	Leptidae spp., »	1	1	
	Other species (andre) »	11	20	
Coleoptera:	*Athous subfuscus, Imagines*	.	.	
	Larvae	2	9	
	Dolopius marginatus »	.	.	
»	*Staphylinidae spp., Imagines*	5	4	
	» *Larvae*	1	2	
	Carabidae spp., Imagines	1	.	
	» *Larvae*	.	.	
	Cantharidae spp., »	.	.	
	Curculionidae spp., Imagines	.	.	
	Other species (andre) »	.	.	
	» *Larvae*	.	.	
Lepidoptera:	*Larvae div.*	.	.	
Hymenoptera:	*Myrmica rufa*	.	.	
Hemiptera:	*Homoptera spp.*	.	.	
Orthoptera:	*Forficulidae spp.*	.	1	
Thysanoptera:	*Thripidae spp.*	.	.	

gust 926 I b	November 1926 IV a	 IV b	March 1927 V	July 1927 VII	Sept. 1927 VIII	Novbr. 1927 IX	Average Number *Middel-Antal* per 1 m²	Weight *Vægt* mgr. per 1 m²	Respiration
1	3	3	1	6	5	3	29	1450	551
4	1	7	10	47	2	.	108	216	240
							137	*1666*	*791*
2	2	10	1	4	5	1	*28*	*840*	*378*
.	1	.	.	.	.	.	1	.	.
7	3	1	.	3	5	3	29	29	39
							30	*29*	*39*
40	440	150	125	285	285	147	*2390*	*89*	*350*
.	.	.	.	.	.	2	3	.	.
.	.	240	90	.	.	8	273	5	28
00	100	40	150	36	7	129	3521	106	476
20	17	21	15	18	33	33	320	160	282
00	110	10	.	160	.	18	691	7	45
.	.	1	.	.	3	2	9	6	9
30	.	.	3	57	25	11	211	11	40
.	.	.	.	.	.	2	4	4	6
							5032	*299*	*886*
.	.	1	.	1	.	.	8	8	11
.	29	4	.	1	4	.	28	14	25
.	.	.	.	2	.	1	5	750	198
3	42	7	8	4	3	5	64	320	262
.	24	20	40	2	9	21	156	8	30
							261	*1100*	*526*
.	.	1	.	.	.	1	3	30	19
.	4	2	2	.	2	2	29	435	247
.	.	2	1	1	3	.	9	135	77
							41	*600*	*343*
4	12	48	4	8	8	4	84	168	187
1	8	11	3	4	6	9	45	90	100
.	4	1	1	1	3	.	11	22	24
.	.	.	.	2	.	1	4	8	9
.	.	.	.	.	8	.	13	26	29
.	2	3	5	.	1	.	13	130	84
5	4	6	.	.	.	.	10	1	3
1	1	.	.	.	2	.	5	1	2
							185	*446*	*438*
.	.	.	.	.	.	.	1	50	19
.	.	.	.	.	2	.	5	10	11
.	.	.	.	.	.	2	3	15	12
.	.	.	1	1	.	1	5	100	52
1	.	.	.	.	.	.	3	.	1
							17	*175*	*95*
						Total	**8121**	**5244**	**3846**

Next to the worms, the diptera larvae play the most important part. We here find some crane-fly larvae and some *Mycetophilidae,* together with some *Leptidae.* Further, there is a lot of very tiny larvae, chiefly of the *Cecidomyiidae* type, but their aggregate weight is quite insignificant. The preceding year, I found, in the same locality, a great number of *Bibionidae* larvae, a species that has not at all turned up in the present samples. This goes to prove that investigations of this kind can have no absolute validity as far as the details are concerned, inasmuch as changes may occur from year to year, without affecting the main character of the locality. Snails are entirely wanting; so are *Trichoniscus* and of *Myriopoda* there are only some of the long, slender *Geophilidae,* which are rapacious animals, while the millipeds, living on mull, are wanting. There are a lot of click-beetle larvae, mostly *Athous subfuscus,* and many *Staphylinidae;* of ground-beetles, especially the small copper-coloured *Notiophilus biguttatus;* moreover, there are some *Cantharidae* larvae and some weevils *(Strophosomus).* Both *Ptiliidae* species and *Newsteadia floccosa* are wanting

Of mites there are 2400, but they are very small, their weight amounting to only 0.09 gr. They are greatly outstripped by the collembola, of which there are no less than 5000. The little grey *Folsomia quadrioculata* is represented by the great number of 3500 per m^2. The white *Onychiurus armatus* is either entirely wanting or, at any rate, so sparsely represented as not to be noticed, but we meet with the tiny greyish-blue *Hypogastrura armata* instead. Moreover, a number of *Isotoma* and *Lepidocyrtus* are found. These are all of them sprightly and coloured animals, evidently able to endure the sunshine and its desiccating influence. The aggregate weight of collembola, 0.3 gr., is far in excess of any of the previous localities. We here find ourselves under unfavourable conditions, where the smaller animals, to all appearances, play a greater and more important part than in the good mull.

Beech, Raw Humus, no Flora.
Locality 4, Table VI.

The stand, compartment 29, at the north end of Rude Skov, is the last larger remnant of the old beech stands with raw humus, the late forest officer, H. C. Ulrich, having re-

generated most of them (BOJESEN 1905). Age 140 years; shape middling. There is indeed a number of trees of straight growth, but for the most part they are rather knotty, and some of them are bifurcated from the ground. They were subjected to a heavy thinning 10 years ago. The samples were taken from a more elevated part of the compartment in which a considerable layer of raw humus was found. At this place a sample plot showed an average height of 26.0 m, an inferior growth for their age lying between SCHWAPPACHS quality class III and IV. The number of stems per hectare was 207. The basal area at a height of 1.3 m was 30.5 m^2, hence the volume of wood, according to a form factor of 0.60 (OPPERMANN 1914 b, pp. 345 & 361), makes 476 m^3 per hectare; the average diameter is 42.8 cm; the largest trees attain more than 60 cm in diameter. In the sample plots the trees had not yet fully closed up after the last cuttings, and there were no trees for cutting. Under a heavy layer of leaves — about 2 cm from last autumn and about 2 cm old leaves — we met with a layer of raw humus about 10 cm thick, brown at the top, loose and swampy, full of beech roots and with a lot of gritty and crumbling raw humus, on the surface with small, sporadic heaps of excrements, especially from earthworms and crane-fly larvae. Lower down, the raw humus is more compact, and the nethermost couple of cm constitute a dense, amorphous, black mass of peat. A soil section showed the following profile:

0— 10	cm:	Raw humus.
10— 20	» :	Light, reddish-grey leached sand.
20— 25	» :	Dark, coffee-coloured soft pan, rich in humus.
25— 35	» :	Reddish-brown soft pan.
35— 50	» :	Light, ocherous, sandy topsoil.
50—100	» :	Pale, light greyish clayey sand; the layer, containing a number of small stones, resembles clay pan in colour, but is not so hard as that.
100—200	» :	Partly ocherous, sandy clay, with a number of small stones, especially flint, and a few larger granite stones, and some small white pebbles.

Roots abound in the raw humus and are rather numerous to a depth of 40—50 cm; some stray roots can be found as

Table VI. Locality 4.

Beech, Raw Humus, no Flora.

Bøg, Maar, ingen Flora.

		March 1926 I			May 1926 II		August 1926 III a		III b		Novembe 1926 IV a		
		L	H_1	H_2	L	H	L	H	L	H	L	H_1	
Gastropoda:	*Arion subfuscus*	1	.	.	1	.	.	.	.	.	4	.	
	shellbearing species, skalbærende	2	3	.	3	.	.	.	.	.	2	.	
Oligochaeta:	*Lumbricidae spp.*	3	4	1	9	.	.	3	.	3	15	.	
	Enchytraeidae spp.	13	12	1	20	2	.	20	.	3	270	.	
Crustacea:	*Isopoda terrestria spp.*	1	1	.	4	.	.	.	.	.	12	1	
Myriopoda:	*Lithobiidae spp.*	.	.	.	.	.	.	.	.	1	1	.	
	Geophilidae spp.	.	2	.	.	4	.	.	.	.	.	.	
	Julus spp.	.	4	1	3	.	.	.	1	.	1	4	
	Polydesmus spp.	.	.	.	.	.	.	.	.	.	.	.	
	Glomeris spp.	.	2	.	1	.	.	.	.	.	.	5	
Arachnida:	*Pseudoscorpiones spp.*	1	.	.	.	.	1	.	.	.	1	.	
	Araneina et Opiliones spp.	14	1	.	3	.	33	1	6	1	4	4	
»	*Acarina spp.*	365	475	50	550	280	560	300	200	350	350	250	
Collembola:	*Achorutes muscorum*	.	.	.	.	.	.	2	.	.	25	19	
	Onychiurus armatus	113	740	110	250	125	38	140	.	40	9	110	
	Folsomia quadrioculata	105	50	.	70	.	215	290	40	350	200	53	
	Isotoma viridis	3	1	.	.	.	.	.	.	.	.	.	
	Isotoma spp. (small, smaa)	.	.	.	10	.	.	35	.	.	60	7	
	Pogonognathus plumbeus	.	.	.	1	.	2	.	.	.	5	.	
	Lepidocyrtus lanuginosus	.	.	.	.	.	105	.	42	.	15	.	
	Entomobryidae spp.	.	.	.	.	.	5	.	6	.	4	.	
Diptera:	*Imagines et Pupae div.*	.	5	6	1	2	1	.	.	1	.	.	
	Mycetophilidae spp., Larvae	.	.	.	.	.	.	1	.	.	2	48	
	Phaenocladius spp., »	1	.	.	.	.	.	.	.	.	.	.	
	Psychodidae spp., »	5	4	.	.	2	.	.	.	.	.	.	
	Tipulidae spp., »	1	.	.	.	.	.	1	1	2	.	.	
	Leptidae spp., »	5	10	.	4	.	.	7	.	.	1	8	
	Dolichopodidae spp., »	1	12	.	1	.	.	1	.	.	2	.	
	Forcipomyia spp., »	.	1	.	.	.	.	.	.	.	8	.	
	Fannia spp., »	2	.	.	2	.	.	.	.	.	3	.	
	Anthomyiinae etc. spp., »	23	30	10	92	150	.	2	.	.	19	64	
Coleoptera:	*Athous subfuscus, Imagines*	.	.	.	.	.	.	.	.	.	.	.	
	» *Larvae*	1	11	6	3	32	.	13	.	16	.	18	
»	*Staphylinidae spp., Imagines*	5	6	.	6	1	4	8	2	4	5	1	
	Larvae	1	11	3	4	.	1	2	.	.	1	14	
	Carabidae spp., Imagines	.	.	.	.	.	.	.	.	.	1	.	
	Cantharidae spp., Larvae	4	8	2	1	.	.	6	.	2	4	3	
	Curculionidae spp., Imagines	.	.	.	.	.	1	.	.	.	.	.	
	Ptiliidae spp., »	3	1	.	.	1	.	.	.	.	2	.	
	Other species (andre) »	1	2	.	.	.	.	.	.	1	.	.	
	» *Larvae*	1	.	.	1	3	1	.	.	1	.	.	
Lepidoptera:	*Larvae div.*	1	1	.	1	.	.	.	.	.	.	.	
Hymenoptera:	*Tenthredinidae sp. Pupae*	.	.	1	.	.	.	.	.	.	.	.	
Hemiptera:	*Newsteadia floccosa*	5	16	1	12	1	8	1	1	1	10	.	
Orthoptera:	*Forficulidae spp.*	1	.	.	.	.	2	.	.	.	.	.	
Thysanoptera:	*Thripidae spp.*	.	.	.	.	.	2	.	5	.	6	.	

L = Leaf layer *(Løvlag);* H = Raw humus *(Maar);* H_1 = upper loose layer *(Formuldningslag*

ovember 1926 IV b			March 1927 V			May 1927 VI			July 1927 VII			September 1927 VIII			Novbr. 1927 IX		Average Number *Middel-Antal* pr. 1 m²	Weight *Vægt* mgr. pr. 1 m²	Respiration
	H_1	H_2	L	H_1	H_2	L	H_1	H_2	L	H_1	H_2	L	H_1	H_2	L	H			
.	.	.	3	.	.	7	.	.	.	.	.	.	.	.	5	.	21	3150	830
.	1	.	3	.	.	8	.	.	.	.	.	5	.	.	2	.	31	62	69
																	52	*3212*	*899*
3	3	.	2	.	.	8	1	.	5	3	.	4	3	.	5	9	81	5400	1482
)	6	1	140	11	.	102	1	3	19	.	3	18	31	3	95	9	782	1564	1738
																	863	*6964*	*3220*
(	.	.	9	1	.	16	.	.	1	1	.	1	.	.	5	1	53	53	74
(	.	.	1	2	.	5	.	.	1	.	.	1	.	.	.	.	13	390	176
.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	8	120	68
.	1	.	.	2	1	1	.	.	.	1	.	.	1	.	.	.	20	1000	380
(	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	3	45	26
.	.	.	1	.	.	4	.	.	2	.	.	.	.	.	1	.	16	80	66
																	113	*1688*	*790*
.	.	.	5	1	.	3	.	.	1	.	.	1	.	.	2	1	18	2	5
2	9	.	8	8	.	6	7	.	10	5	1	6	.	.	5	4	126	126	176
																	144	*128*	*181*
)	200	20	365	170	35	500	300	10	300	135	10	90	235	10	185	250	*6161*	*336*	*1152*
2	.	.	5	.	.	10	.	.	.	.	.	.	.	.	6	4	54	2	7
4	70	4	.	60	3	15	100	4	32	40	5	9	158	.	10	80	2303	92	377
)	200	4	170	34	1	33	4	1	84	110	2	25	235	.	176	39	2163	65	292
.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	10	5	9
2	4	.	.	.	.	54	85	2	5	35	13	.	.	.	25	3	347	3	23
.	.	.	1	.	.	2	.	.	.	.	.	2	.	.	1	.	12	8	13
2	.	.	6	.	.	3	.	.	20	.	.	21	35	.	5	.	192	10	36
.	.	.	2	.	.	.	.	.	.	.	.	16	.	.	4	.	33	33	46
																	5114	*218*	*803*
.	.	.	.	36	.	.	1	.	.	.	.	6	12	.	.	.	77	77	108
2	72	.	.	.	.	.	.	.	22	34	.	.	.	.	.	36	172	83	146
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1
.	.	17	6	2	.	2	.	.	.	.	.	.	.	.	.	.	33	17	29
3	1	.	.	.	.	1	.	.	.	.	.	5	5	.	.	3	21	6300	1318
.	2	1	.	7	.	1	7	.	.	.	.	.	10	.	.	.	63	315	258
.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	19	95	78
.	.	.	16	.	.	.	.	.	.	.	.	.	.	.	.	.	23	5	11
.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	8	16	18
2	5	.	4	6	.	3	14	.	.	.	.	.	.	.	42	166	659	132	316
																	1076	*7041*	*2283*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	10	6
.	10	5	.	23	4	2	9	3	.	32	4	.	12	2	.	17	231	3465	1967
																	232	*3475*	*1973*
2	2	1	1	3	1	5	6	1	.	1	.	10	3	.	9	20	103	206	229
3	6	2	1	9	1	1	5	.	6	7	.	.	8	.	.	25	110	220	244
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2
2	.	.	.	1	.	1	.	.	.	.	.	.	1	1	.	.	32	64	71
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	20	13
.	.	.	3	.	.	3	.	.	.	.	.	.	.	.	.	.	13	.	1
.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	8	8	11
.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	9	9	13
																	278	*529*	*584*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	150	57
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
1	9	.	3	5	.	10	5	.	2	5	.	.	4	.	2	6	103	10	31
1	.	.	1	.	.	.	.	.	.	1	.	5	.	.	1	1	13	260	134
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	10	1	2
																	130	*421*	*224*
$_2$ = lower compact humus *(nedre tætte Humusstoflag).*																**Total**	**14163**	**24012**	**12109**

far down as 130 cm; there is no carbonic lime and no ground water.

Mechanical soil analyses from depths of 90 cm and 200 cm gave the following results:

Depth of sample cm	Gravel 20—2 mm per cent.	Percentage of fine soil under 2 mm			
		Coarse sand 2—0.2 mm	Fine sand 0.2—0.02 mm	Silt 0.02— 0.002 mm	Loam < 0.002 mm
90	9.5	37.3	47.6	10.8	4.3
200	6.3	22.3	54.8	13.5	9.4

This beech raw humus is conspicuous for its abundance of fauna. We here find a far greater number of animals than in beech mull, viz. about 14000 per m^2, or about 140 million macroscopic animals per hectare. They are mostly tiny animals, however, the aggregate weight being thus only 24 gr., i. e. about one third of what we found in the best beech mull locality, or nearly two thirds of that in the melic-grass locality, but almost twice as much as in the Oxalis mull, and four and a half times as much as in the impoverished soil exposed to the wind.

As might have been expected, the fauna in this place is of quite another composition than that of the mull. In Locality 15 we had 53.1 gr. of earthworms and 17.6 gr. of other animals; in Locality 5 there were 27.9 gr. of earthworms and 9.9 gr. of other animals; in this raw humus we have only 5.4 gr. of earthworms, but 18.6 gr. of other animals. The difference thus consists in the small number of earthworms, constituting only 22 per cent. of the aggregate weight, while on the other hand the weight of other animals is considerable. The turgid worm *(Allolobophora turgida)* living in the mineral topsoil, is of course entirely wanting here in the podsolized soil; but we do find a few specimens of the reddish worm *(Lumbricus rubellus);* most of them, however, are quite small earthworms, which, as far as their species could be ascertained, were chiefly octagonal worms *(Dendrobaena octoedra),* characteristic of mossy and raw humus ground. *Lumbricus castaneus* and *Dendrobaena arborea,* too, are found. Both the reddish worm and the smaller species live in the raw humus and leaf layer.

The small white potworms, the *Enchytraeidae,* which, especially during the wet seasons — thus in the autumn and

mild winter of 1926/27 — abounded in the beech leaves, were still more numerous in this raw humus soil with its heavy layer of leaves than in the mull. Of slugs there were quantities similar to those in the mull; fewer of snails with shells. The number of myriopods is far smaller; especially is this the case with the millipeds living on organic residue in all 1.7 gr. as against 8.8 gr. and 2.1 gr. in the two localities from Geels Skov. On the other hand, the diptera larvae are present in very great quantities and weights. It is especially the large crane-fly larvae of various species, particularly *Tipula nubeculosa* that count in weight, outstripping even the earthworms in this respect. The table here gives 6.3 gr. of crane-fly larvae as against 5.4 gr. of earthworms. A special sample of 1 m^2 raw humus and leaf layer, which on March 23, 1927, was taken from this locality and examined, resulted in 4 *Lumbricus rubellus* and 22 worms of smaller sizes, some of which were purple worms *(Lumbricus castaneus)*, and the rest *Dendrobaena octoedra,* with an aggregate weight of 8.6 gr., and 39 crane-fly larvae, with an aggregate weight of 12.0 gr. The proportion between earthworms and crane-fly larvae thus corresponded, but the square meter was obviously taken from a particularly favourable spot. Of other diptera the *Mycetophilidae (*or *Sciaridae)* and *Leptidae* are numerous, besides large quantities of some tiny larvae of the *Anthomyiinae* and *Cecidomyiidae* types. The numerous perfect insects of diptera were *Sciara umbratica.*

The click-beetle larvae, entirely *Athous subfuscus*, too, which — like nearly all the diptera larvae — live on organic residue, were much more numerous than in the mull. We note that the number of *Staphylinidae* is large, and that of the *Carabidae* small, and that there are many *Cantharidae* larvae. *Newsteadia floccosa,* too, is numerous.

The quantities of mites, about 6000, are conspicuous, and so are the collembola, about 5100. Though these tiny animals are so numerous, their weight amounts to only 0.55 gr. or about 2 per cent. of the entire weight of the animals. When, later on, we deal with the »Intensity« of the animal life, however, we shall see that the part played by them is anything but insignificant, constituting, as they do, in this locality a considerable factor in the transformation of organic matter effected by animals.

The fauna of the locality may thus be broadly characterized as follows: Earthworms constitute only about 22 per cent. of the total weight of animals, and, like the other species, they are found in the raw humus and leaf layer only, not in the mineral soil. Outstripping the earthworms in aggregate weight, are the large crane-fly larvae which, together with other diptera species, presumably play a most important part in the process of decomposition. Conspicuous, too, are the click-beetle larvae, snails, myriopods, and potworms, as also the tiny mites and collembola.

Beech, Raw Humus, no Flora.
Locality 20, Table VII.

After having seen how abundant the fauna was on raw humus in Rude Skov, Locality 4, I chose out the above-mentioned locality. MÜLLER (1878 b, p. 44) having referred to the great scarcity of fauna in raw humus, I found it necessary to check my results by taking up a locality chosen under particularly unfavourable conditions, an apparently very lifeless raw humus under an old beech stand in Grib Skov, Nøddebo State district, compartment 88. The stand was not measured, but, judging from its appearance, I should characterize it as rather low, scanty in stems and volume of wood; the increment seems to be very slight. The ground is covered with a thick layer of leaves, from at least three years' fall, and the lower part of same forms a close and compact mass. The very heavy raw humus is more compact than in Rude Skov, and densely intersected with beech roots, and honey fungus rhizomorphs and fungal hyphae.

A soil section is described as follows:

0— 6 cm: Loose, brown raw humus.
6— 14 » : Black, compact, amorphous raw humus.
14— 25 » : From whitish to grey leached sand, darkest in the upper and lower parts.
25— 30 » : Coffee-coloured, soft pan abounding in humus.
30— 40 » : Ocherous, soft pan slightly indicated.
40— 70 » : From ocherous to light brownish, somewhat humus-coloured, friable topsoil.
70—100 » : Hard, grey clay pan, sandy, with many stones.

100—120 cm: Clay, irregularly mixed with sand.
120—170 » : Sharp sand, slightly clayey, with some stones.
170—180 » : A streak of sandy clay.
180—200 » : Clayey sand.

Many granite blocks, of varying sizes, are found in all the layers from 50 cm downward, especially from 50 to 130 cm; flint is rare. Roots abound in the raw humus, and are fairly plentiful as far down as 60 cm; a few straggling roots may be found reaching to the bottom of the hole. No carbonic lime, and no ground water.

Analyses of samples from depths of 75 cm, 105 cm, and 200 cm:

Depth of sample cm	Gravel 20—2 mm per cent.	Percentage of fine soil under 2 mm Coarse sand 2—0.2 mm	Fine sand 0.2—0.02 mm	Silt 0.02— 0.002 mm	Loam < 0.002 mm
75	14.4	48.8	35.0	11.6	4.6
105	7.1	36.0	36.4	15.4	12.2
200	6.8	60.2	30.3	5.9	3.6

As was to be expected, the aggregate weights of animals did not come up to those of Locality 4, but were by no means inconsiderable, viz. 16 1/2 gr., a figure exceeding that of the Oxalis mull, Locality 9, situated in the same forest and only a few hundred meters apart. After having studied Locality 4, we can now see that Locality 20 presents a still more pronounced raw humus fauna. Earthworms, of which only the little octagonal worm *(Dendrobaena octoedra)* is met with, constitute only 1.15 gr. or 7 per cent. of the aggregate weight. The number of *Enchytraeidae,* on the other hand, is not much below that of Locality 4. The number of myriopods is remarkably high, but this is due to a great quantity of the thin, yellow *Geophilus,* which, being a rapacious animal, must rather be considered an inhibiting factor. Of millipeds there are comparatively few.

Of animals living on humus, the diptera larvae figure highest, 3.35 gr., half as much as in Locality 4, and of these it is the crane-fly larvae that have the greatest weight. *Mycetophilidae* (or *Sciaridae*) are found in very large quantities. Moreover, there are many *Leptidae* and an abundance of quite small larvae of the *Anthomyiinae* and *Cecidomyiidae* types.

Table VII. Locality 20.

Beech, Raw Humus, no Flora.

Bøg, Maar, ingen Flora.

		March 1927 V		
		L	H_1	H
Gastropoda:	*Arion subfuscus*	1	1	
	shellbearing species, skalbærende	11	1	
Oligochaeta:	*Lumbricidae spp.*	1	1	
	Enchytraeidae spp.	70	1	
Crustacea:	*Isopoda terrestria spp.*	.	1	
Myriopoda:	*Geophilidae spp.*	.	47	
	Julus spp.	1	.	
	Glomeris spp.	1	.	
Arachnida:	*Pseudoscorpiones spp.*	4	.	
	Araneina spp.	16	7	
»	*Acarina spp.*	1200	470	
Collembola:	*Onychiurus armatus*	85	300	8
	Folsomia quadrioculata	166	30	
	Isotoma spp. (small, smaa*)*	16	.	
	Pogonognathus plumbeus	10	.	
	Entomobryidae spp.	.	.	
Diptera:	*Imagines et Pupae div.*	.	2	
	Mycetophilidae spp., Larvae	.	.	
	Tipulidae spp., »	1	2	
	Leptidae spp., »	1	1	
	Fannia spp., »	1	.	
	Anthomyiinae etc. spp., »	29	23	
Coleoptera:	*Athous subfuscus, Imagines*	.	.	
	Larvae	.	12	
	Dolopius marginatus »	.	1	
»	*Staphylinidae spp., Imagines*	4	2	
	» *Larvae*	4	6	
	Carabidae spp., Imagines	.	.	
	Cantharidae spp., Larvae	1	.	
	Ptiliidae spp., Imagines	6	.	
	Other species (andre) »	1	.	
Lepidoptera:	*Larvae div.*	.	.	
Hymenoptera:	*Pupae*	.	.	
Hemiptera:	*Newsteadia floccosa*	29	1	
Orthoptera:	*Forficulidae spp.*	.	.	
Thysanoptera:	*Thripidae spp.*	1	.	

L = Leaf layer *(Løvlag);* H = Raw humus *(Maar);* H_1 = upper lo
compact humus *(ne*

July 1927 VII		September 1927 VIII			November 1927 IX		Average Number *Middel-Antal* per 1 m²	Weight *Vægt* mgr. per 1 m²	Respiration
L	H	L	H_1	H_2	L	H			
.	.	2	.	.	.	.	10	1500	395
.	.	17	.	.	.	.	73	146	162
							83	*1646*	*557*
.	.	6	1	.	.	.	23	1150	437
69	6	50	.	2	40	.	595	1190	1322
							618	*2340*	*1759*
.	.	1	.	.	.	.	5	5	7
2	7	.	40	.	.	8	273	4095	2325
.	.	3	1	.	.	.	13	650	247
.	.	1	1	.	.	.	8	40	33
							299	*4790*	*2612*
.	.	2	.	.	.	.	15	2	5
1	1	2	2	.	5	.	85	85	119
							100	*87*	*124*
30	15	950	158	5	500	90	*9818*	*673*	*2136*
70	300	314	280	7	117	75	4070	163	666
40	24	250	17	.	225	10	2655	80	359
1	19	54	16	1	41	3	378	4	25
2	.	6	.	.	.	.	45	29	47
.	.	1	.	.	.	.	3	3	4
							7151	*279*	*1101*
.	.	.	.	.	1	.	8	8	11
63	112	.	.	.	3	6	468	234	413
1	.	3	.	.	.	.	18	2700	711
4	3	4	8	.	2	3	68	340	278
.	.	.	.	.	.	.	3	6	7
10	.	.	.	.	62	3	318	64	152
							883	*3352*	*1572*
.	.	.	.	.	.	1	3	30	19
.	14	5	13	1	2	23	185	2775	1575
.	.	.	.	.	.	.	3	45	26
							191	*2850*	*1620*
.	.	9	3	.	6	.	60	120	133
.	.	4	.	.	2	7	60	120	133
.	.	.	.	.	3	.	8	16	18
.	.	7	.	.	.	.	23	46	51
.	.	1	.	.	.	.	18	.	1
.	.	.	.	.	.	.	3	6	7
							172	*308*	*343*
.	.	.	.	.	1	.	3	150	57
.	.	.	.	.	.	.	3	6	7
.	.	5	2	.	2	.	98	10	30
.	.	.	.	.	1	.	3	60	31
.	.	.	.	.	.	.	3	.	1
							110	*226*	*126*
er *(Formuldningslag)*; H_2 = lower *te Humusstoflag)*.						**Total**	**19425**	**16551**	**11950**

Click-beetles *(Athous subfuscus),* too, abound, their number approaching that of Locality 4. There are many *Staphylinidae* and few *Carabidae,* just as in the case of Locality 4, and, likewise, there are some *Cantharidae* larvae and *Ptiliidae.* Of *Newsteadia floccosa* there are, as in Locality 4, about 100 per m^2.

There are almost 10000 mites with an aggregate weight of 0.67 gr., and there are more than 7000 collembola weighing 0.28 gr., far more than in Locality 4, accordingly. In Locality 4 the white *Onychiurus armatus* constitutes a little more than two fifths of the entire quantity; in Locality 20, it comes out as a fair majority. As shown by our special investigations, it mostly sticks to the uppermost loose layer of raw humus, while the species next in order as to frequency, the grey *Folsomia quadrioculata,* is mostly encountered in the leaf layer.

In Locality 20 we have nearly 20000 animals per m^2, a number corresponding to 200 million macroscopic animals per hectare. This »lifeless« raw humus soil thus contains more animals than any of the other localities examined, and the aggregate weight is by no means insignificant, in fact greater than that of the Oxalis mull. A striking peculiarity is the small number of earthworms, and these the little octagonal worm only, as also the great number of diptera larvae, click-beetle larvae, mites, and collembola.

Some other Beech Forest Localities.
Localities 3, 12, 14, 21 and 30, Table VIII.

Besides the beech forest localities mentioned above, samples have been taken from a few other places, the object being to check the results arrived at.

Locality 3 is from the same stand as No. 2, but some distance from the edge and where the ground is covered with millet-grass sprinkled with woodruff and anemone, where the leaves accumulate and the soil presents a fairly good mull formation. Here a number of earthworms were found, especially the turgid worm, and many millipeds. Diptera larvae are very numerous, e. g. *Tipulidae* and *Mycetophilidae.* Mites and collembola, too, abound. All in all, it is a very

typical mull fauna. That the aggregate number of animals is very large may be due to accidental circumstances, but also to the fact that the sample was taken in March 1926, when several of the other localities, too, were unusually rich in fauna.

Locality 12 is a good beech stand, some fifty years old, in compartment 52 of Rude Skov. The soil is covered with anemone and woodruff; the mull is friable, but apparently somewhat resembling the Oxalis mull. Only 2 small specimens of earthworms were found, presumably *Dendrobaena*, but there are many millipeds *(Julus)*, as always is the case in good beech mull, and very few diptera larvae. The quantities of mites and collembola are quite normal for beech mull.

Locality 14 presents a fine beech stand, 56 years old, in compartment 162 of Geels Skov, the Experimental Forestry Service's sample plot R (OPPERMANN 1914 a, p. 236; BORNEBUSCH 1923 p. 35), the increment of which is very considerable. The area was before this used as a nursery. The soil is covered with anemone and woodruff with an excellent mull. The fauna greatly resembles that of Locality 15, only some 200 m distant. There were both large and small earthworms and unusually many millipeds *(Julus)*. The number of mites and collembola was pretty normal; there were no click-beetle larvae.

Locality 21 in Grib Skov, Nøddebo State district, compartment 87, is not far from Locality 9; the conditions are parallel, or even a little more favourable, so that a comparison between the two will suit our purpose, especially of the two samples taken at the same time, July 1927. We found 11 earthworms, one of which a turgid worm, the rest *Dendrobaena* species, millipeds somewhat more plentiful, a corresponding number of mites and collembola, some diptera larvae, and of these — as in Locality 9 — many *Mycetophilidae;* moreover, *Staphylinidae* species and *Newsteadia floccosa* rather more abundant than in No. 9.

Locality 30, the Experimental Forestry Service's sample plot F in Almindingen, Bornholm (OPPERMANN 1914 a, p. 213; BORNEBUSCH 1923 p. 34), beech forest with a soil flora of anemone and wood-sorrel, is a type apart, rather poor in humus and with a rather compact topsoil. The fauna was but sparsely represented, except for the many click-beetle larvae and the great number of worms. But the sample

Table VIII.

Localities with Beech, Oak or Ash.
Bøge-, Ege- og Aske-Lokaliteter.

	Locality	3 Beech-Milium *Bøg-Miliegræs* March 1926		12 Beech-Asperula *Bøg-Bukkar* August 1926		14 Beech-Asperula *Bøg-Bukkar*		
		L	M	L	M	Aug. 1926 L	Aug. 1926 M	Novb. 19 L
Gastropoda:	*Arion subfuscus*	1	.	.	.	1	.	.
	shellbearing species, skalbærende	2	.	10	.	3	1	6
		3		*10*		*5*		*12*
Oligochaeta:	*Lumbricidae spp.*	1	21	.	2	16	6	6
	Enchytraeidae spp.	5	.	.	11	14	5	13
		27		*13*		*41*		*22*
Crustacea:	*Isopoda terrestria spp.*	1	1	3	1	19	.	3
Myriopoda:	*Lithobiidae spp.*	1	.	.	.	1	.	2
	Geophilidae spp.	.	.	.	2	1	8	.
	Julus spp.	1	37	1	18	3	23	2
	Polydesmus spp.	.	1	.	.	.	.	.
	Glomeris spp.	.	.	2	.	.	3	.
		42		*27*		*58*		*32*
Arachnida:	*Pseudoscorpiones spp.*	4	1	2	.	1	.	.
	Araneina et Opiliones spp.	4	2	5	2	1	2	2
		11		*9*		*4*		*2*
»	*Acarina spp.*	175	430	105	125	295	45	175
		605		*230*		*340*		*270*
Collembola:	*Achorutes muscorum*	.	.	.	.	.	.	.
	Hypogastrura armata	.	.	32	5	.	18	.
	Onychiurus armatus	13	210	10	65	15	40	.
	Folsomia quadrioculata	110	120	.	.	40	20	20
	Isotoma viridis	4	.	.	.	.	.	.
	Isotoma spp. (small, smaa*)*	.	.	12	17	18	.	13
	Pogonognathus plumbeus	2	.	4	.	.	.	.
	Lepidocyrtus lanuginosus	7	.	40	.	20	.	.
	Entomobryidae spp.	.	.	.	.	.	2	.
		466		*185*		*173*		*47*
Diptera:	*Imagines et Pupae div.*	.	18	.	1	1	.	.
	Mycetophilidae spp., Larvae	.	12	.	.	.	.	.
	Phaenocladius spp., »	.	.	.	.	.	.	4
	Psychodidae spp., »	5	4	.	.	.	.	.
	Bibionidae spp., »	.	1	.	1	.	.	.
	Tipulidae spp., »	.	6	.	.	.	.	1
	Leptidae spp., »	2	2	1	6	.	2	.
	Dolichopodidae spp., »	2	3	.	2	6	3	4
	Forcipomyia spp., »	2	.	.	.	.	.	8
	Fannia spp., »	1	.	.	.	.	.	2
	Lonchoptera spp., »	.	.	.	.	.	.	.
	Anthomyiinae etc. spp., »	16	38	.	.	.	.	20
		112		*11*		*12*		*50*
Coleoptera:	*Athous subfuscus, Larvae*	.	3	1	2	.	.	.
	Dolopius marginatus »	.	.	.	.	.	.	.
		3		*3*		*0*		*0*
»	*Staphylinidae spp., Imagines*	6	9	2	2	3	3	6
	» *Larvae*	1	14	.	.	4	1	5
	Carabidae spp., Im. et L.	1	.	.	.	.	.	3
	Cantharidae spp., »	1	5	.	.	.	.	.
	Curculionidae spp., Imagines	.	.	1	.	.	2	2
	Ptiliidae spp., Imagines	1	.	1	2	1	1	.
	Nitidulidae spp., »	.	.	.	1	.	1	2
	Other species (andre), *Im. et L.*	.	6	.	.	.	1	.
		44		*9*		*17*		*36*
Lepidoptera:	*Larvae div.*	.	1	2	.	.	.	.
Hymenoptera:	*Imagines et Pupae div.*	2	.	.	.	1	.	3
Hemiptera:	*Newsteadia floccosa*	7	.	4	3	9	6	40
Orthoptera:	*Forficulidae spp.*	2	.	.	.	2	.	2
Thysanoptera:	*Thripidae spp.*	.	.	1	.	.	.	2
		12		*10*		*18*		*67*
	Total	**1325**		**507**		**668**		**538**

L = Leaf layer and soil flora *(Løvlag og Bundflora*

21 ech-Oxalis *g-Skovsyre* uly 1927		30 Beech-Anem. *Bøg-Anemone* August 1926		22 Oak with beech undergrowth *Eg med Bøgeundervækst* July 1926		Septb. 1927		Novbr. 1927		23 Oak. *Eg* August 1927		16 Ash *Ask* July 1926
L	M	L	M	L	M	L	M	L	M	a L + M	b L + M	L + M
.	.	.	.	2	.	3	.	1	.	.	.	.
2	1	.	.	.	.	.	.	.	.	.	.	(340)
3		*0*		*2*		*3*		*1*		*0*	*0*	—
8	3	5	4	7	4	7	5	3	5	6	3	10
4	6	30	20	44	3	6	.	60	3	5	11	40
51		*59*		*58*		*18*		*71*		*11*	*14*	*50*
1	.	.	.	52	3	25	2	6	.	.	.	13
.	.	.	.	.	.	2	1	.	.	1	.	1
.	.	2	1	.	.	.	.	.	.	.	.	3
5	7	.	.	1	.	3	6	2	.	.	.	2
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	5
13		*3*		*56*		*39*		*8*		*1*	*0*	*24*
2	.	.	.	2	1	.	.	.	.	1	5	14
2	.	2	1	4	1	6	1	6	3	2	12	2
4		*3*		*8*		*7*		*9*		*3*	*17*	*16*
5	60	110	35	350	30	250	12	195	45	35	80	245
255		*145*		*380*		*262*		*240*		*35*	*80*	*245*
.	.	.	.	3	2	7	.	5	1	.	8	.
18	.	.	.	.	.	.	.	.	.	.	.	.
40	41	.	.	10	10	.	30	45	65	.	.	340
20	12	16	40	.	.	.	.	.	.	215	125	.
.	.	.	.	.	.	.	.	5	.	.	.	.
47	6	.	.	30	35	44	35	65	40	16	18	.
.	.	.	.	17	.	20	.	9	.	.	8	.
22	.	.	.	15	.	8	.	3	1	.	2	.
.	.	.	.	.	1	6	.	3	.	.	2	.
206		*56*		*123*		*150*		*242*		*231*	*163*	*340*
1	.	1	.	.	.	.	.	2	.	.	1	.
50	135	.	.	5	1	.	.	.	.	5	3	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	1	.	.	.	2	.	.	.	1	.	.
4	21	.	.	1	14	3	9	.	9	4	3	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	25	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	2	.	.	.	.
.	2	1	4	7	2	.	.	24	.	3	.	55
213		*7*		*30*		*14*		*62*		*13*	*7*	*55*
.	4	2	15	.	.	.	.	.	.	.	1	11
.	.	.	.	.	.	.	1	.	.	1	5	.
4		*17*		*0*		*1*		*0*		*1*	*6*	*11*
4	3	2	1	3	1	2	2	12	1	15	27	8
4	3	.	.	1	4	.	.	.	2	7	17	1
.	.	.	.	2	2	1	1	1	.	1	1	4
.		.	.	1	.	1	.	1	.	.	1	3
1	.	.	.	.	.	.	1	.	1	3	1	.
.	1	2	.	6	1	.	.	3	.	.	.	2
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	2	.	.	1	.	14
16		*5*		*21*		*10*		*21*		*27*	*47*	*32*
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	1	.	.
21	1	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	3	.	.	.	.
22		*0*		*0*		*0*		*3*		*1*	*0*	*0*
787		**295**		**678**		**504**		**657**		**323**	**334**	**773**

= Mull soil *(Muldjord).*

suffered from long transport and storing for several days after being taken out; hence, the small number of collembola. Consequently the small quantities of animals do not warrant any definite conclusions about the fauna of this type.

All in all, these five samples, taken out at random, prove to correspond to the main localities, thus supporting the view that these are anything but casual, giving, in fact, fair illustrations of the various types represented, and this in conformity with what we should naturally expect from the typical differences between the main localities.

Oak, Mull, Mercurialis.
Locality 10, Table IX.

The samples have been taken from Stampe Skoven 12 km north of Copenhagen, 1st Copenhagen district, section 299, inclosing the Experimental Forestry Service's sample plot AY (OPPERMANN 1905), which was measured in 1928 and gave the following result per hectare, after thinning: age 69 years, number of stems 215, height 20.3 m, average diameter 32.0 cm, basal area 17.2 m^2, volume of wood 222 m^3. Thinning removed 49 trees with an aggregate volume of wood of 32 m^3. The annual increment for the period 1908—1928 was 9.1 m^3 per hectare. It constitutes a stand of oak trees quite well shaped according to Danish conditions, in height between SCHWAPPACH'S quality class I and II and with a fairly good development of the crown. The soil is in an excellent mull condition with a very quick decomposition of the organic matter, so that it is brown on the very surface, and not dark humus-coloured, as in the beech woods. The fallen leaves have so quickly disintegrated that in summer but small quantities are left from the previous year. For the uppermost 12 cm the soil is very friable and porous, worm-riddled and full of mole tracks, and covered with a loose layer of worm casts. Under the oaks, there are a few large hawthorn bushes, but mostly the ground is covered with a very luxurious light-demanding flora, chiefly consisting of raspberry, tall grasses, and dog's mercury, as also, in spring, of an abundance of white anemones. The samples were taken at a spot where the ground was covered with dog's mercury.

A soil section showed the following profile:

0— 2 cm: Loose layer of mull, consisting of worm casts.
2— 12 » : Very friable, crumbling, brownish mull soil.
12— 50 » : Brownish, mully topsoil, somewhat lighter in colour and more compact.
50— 70 » : Greyish yellow, ocher-streaked, fairly compact, clayey sand. A great number of stones in the upper part of this layer.
70—140 » : Clay mixed with sand, variegated in colour, without lime; containing a lot of smaller and a few larger stones (granite). At a depth of 100—130 cm, large patches of sand; below this, more clay.
140—350 » : Was examined by means of boring. The soil remained the same as above; more sandy, however, for the last 100 cm.

There was no carbonic lime and no ground water. On the other hand, another hole bored at a distance of about 20 m in the same section and at the same elevation yielded carbonic lime at a depth of 250 cm. Oak roots abounded to a depth of 50 cm; below this, sporadically to the bottom of the hole proper (140 cm), and even deeper. Mechanical analyses of samples at various depths gave the following results:

Depth of sample, cm	Gravel 20—2 mm per cent.	Percentage of fine soil under 2 mm: Coarse sand 2—0.2 mm	Fine sand 0.2—0.02 mm	Silt 0.02—0.002 mm	Loam < 0.002 mm
60	9.4	28.0	46.2	17.8	8.0
80	12.0	31.3	41.8	11.7	15.2
115	2.0	39.0	52.7	5.6	2.7
130	5.2	27.2	39.9	14.6	18.4
300—350	3.2	29.9	50.2	10.4	9.5

The fact, that there is hardly any layer of leaves and humus, where small animals can resort to, is distinctly traceable in the fauna. The weight of fauna, indeed, was considerable, 77 gr. per m^2, but the number is only about 3000, i. e. less than in any of the beech localities. A little less than 500 collembola were found; of these, however, many large ones, weighing considerably; and there were less than 1000 mites. Earthworms predominate, constituting, as they do, 61 gr., or 79 per cent of the total weight, numbering

Table IX. Locality 10. Oak, Mull, Mercurialis. *Eg, Muld, Bingelurt.*		August 1926				Novemb 1926	
		III a		III b		IV a	
		L	M	L	M	L	
Gastropoda:	*Arion subfuscus*	.	.	1	.	4	
	shellbearing species, skalbærende	.	.	.	.	1	
Oligochaeta:	*Lumbricidae spp.*	.	3	.	3	3	1
	Enchytraeidae spp.	26	44	4	18	35	
Crustacea:	*Isopoda terrestria*	40	2	5	1	2	1
Myriopoda:	*Scutigerella immaculata*	.	1	.	.	.	
	Lithobiidae spp.	.	.	.	.	.	
	Geophilidae spp.	.	.	.	1	.	
	Julus spp.	.	3	2	8	3	
	Polydesmus spp.	3	1	1	4	.	
Arachnida:	*Pseudoscorpiones spp.*	.	.	.	.	.	
	Araneina et Opiliones spp.	10	1	8	.	3	
»	*Acarina spp.*	92	30	8	18	98	7
Collembola:	*Achorutes muscorum*	.	.	.	.	1	
	Onychiurus armatus	.	18	.	30	.	1
	Isotoma viridis	8	.	2	.	.	
	Isotoma spp. (*small*, smaa)	10	22	22	4	12	2
	Pogonognathus plumbeus	8	.	5	.	5	
	Lepidocyrtus lanuginosus	4	1	7	.	.	
	Entomobryidae spp.	5	.	7	.	.	
	Sminthuridae spp.	.	.	.	.	.	
Diptera:	*Imagines et Pupae div.*	1	.	.	.	.	
	Mycetophilidae spp., Larvae	.	2	.	.	.	
	Phaenocladius spp., »	.	.	.	.	.	
	Tipulidae spp., »	.	1	.	.	9	
	Leptidae spp., »	.	.	.	3	.	
	Lonchoptera spp., »	.	.	1	.	1	
	Forcipomyia spp., »	.	.	15	.	2	
	Fannia spp., »	3	.	.	.	3	
	Anthomyiinae etc. spp., Larvae	19	7	24	1	29	
Coleoptera:	*Athous subfuscus, Larvae*		1	.	1	.	
»	*Staphylinidae spp., Imagines*	.	1	.	6	1	
	Larvae	.	2	.	2	1	
	Carabidae spp., Imagines	.	.	.	1	1	
	Larvae	.	.	.	.	2	
	Cantharidae spp., »	1	2	.	.	.	
	Curculionidae spp., Imagines	.	.	.	.	.	
	Larvae	.	.	.	.	.	
	Ptiliidae spp., Imagines	2	14	.	6	2	
	Other species (andre), *Imagines.*	.	.	.	.	.	
Lepidoptera:	*Larvae div.*	1	.	.	.	1	
Hymenoptera:	*Imagines div.*	.	.	.	.	.	
Hemiptera:	*Heteroptera spp.*	1	.	.	.	1	
Orthoptera:	*Forficulidae spp.*	.	.	.	.	2	

L = Leaf and soil flora *(Løv og Urte*

vember 1926 IV b		July 1927 VII		September 1927 VIII		November 1927 IX		March 1928 X		Average Number *Middel-Antal* per 1 m²	Weight *Vægt* mgr. per 1 m²	Respiration
.	M	L	M	L	M	L	M	L	M			
5	.	4	2	3	.	6	.	1	.	35	5250	1383
2	.	5	.	5	.	2	.	6	.	33	66	73
										68	*5316*	*1456*
1	3	3	6	3	13	.	3	.	30	122	61000	10759
3	4	25	17	35	4	11	1	8	13	342	684	760
										464	*61684*	*11519*
2	5	19	5	22	.	4	74	6	2	283	283	396
.	.	.	1	.	4	.	.	.	.	10	10	14
.	3	.	1	1	.	.	1	.	.	10	300	135
.	2	.	2	1	1	.	.	.	5	20	300	170
1	2	4	12	4	13	1	3	.	4	87	4350	1653
3	1	1	.	1	2	.	.	.	3	23	345	196
										433	*5588*	*2564*
.	.	.	.	1	.	.	.	.	.	2	.	1
1	.	.	1	5	.	1	2	10	3	58	58	81
										60	*58*	*82*
1	16	72	15	150	16	12	31	25	78	*967*	*56*	*184*
.	.	.	.	10	.	.	.	2	.	23	1	3
.	35	.	11	.	15	.	.	.	2	130	5	21
5	.	.	2	.	.	2	22	.	.	57	29	50
.	.	.	18	18	12	.	.	.	.	157	2	10
4	2	3	.	4	.	2	15	1	.	70	46	74
.	.	.	.	.	.	.	13	.	.	33	2	6
.	.	.	.	2	.	2	.	1	.	18	18	25
.	.	.	.	3	.	.	.	.	.	5	1	2
										493	*104*	*191*
.	.	.	.	.	.	.	4	.	1	10	10	14
.	3	.	1	.	.	.	.	.	.	7	4	6
.	.	.	.	.	.	2	.	.	.	3	2	3
4	9	.	.	.	.	.	3	3	.	28	2800	845
2	5	.	5	.	8	.	3	1	4	45	225	184
.	.	2	2	.	.	.	.	.	.	10	2	5
.	.	.	.	9	.	.	.	.	.	30	6	14
.	.	3	.	.	.	.	.	1	.	13	26	29
10	.	.	4	.	.	5	.	7	10	125	25	60
										271	*3100*	*1160*
.	.	.	.	2	3	.	.	.	1	*12*	*180*	*102*
.	1	.	.	.	10	1	.	1	3	35	70	78
1	2	.	.	.	3	1	2	.	.	18	36	40
.	.	1	4	.	3	.	.	1	.	18	36	40
1	3	1	.	.	.	1	.	.	.	10	20	22
.	.	.	.	.	.	.	.	.	.	3	6	7
.	.	.	.	1	.	.	.	.	.	2	20	13
.	.	.	.	.	.	.	5	.	.	13	130	84
3	8	.	12	1	2	.	4	.	15	93	5	18
.	1	.	.	.	.	.	.	.	.	2	4	4
										194	*327*	*306*
.	.	1	.	.	.	.	.	.	.	5	250	95
1	.	1	.	.	.	.	.	.	.	3	15	12
.	.	.	.	.	.	.	.	.	.	3	15	12
1	.	1	.	.	.	.	.	.	.	5	100	52
										16	*380*	*171*
= Mull soil (*Muldjord*).									**Total**	**2978**	**76793**	**17735**

122 per m^2; and of these, especially the turgid worm *(Allolobophora turgida)*. The reddish worm *(Lumbricus rubellus)* and the smaller species are but sparsely represented. In searching a single m^2 in July 1928, a still greater number of earthworms were found, viz. 254, with an aggregate weight of 178 gr. For the rest, the fauna is conspicuous for its great number of slugs, many *Trichoniscus*, a lot of millipeds, both *Julus* and *Polydesmus* species, only few click-beetle larvae and comparatively few *Staphylinidae*, but many small *Carabidae* and a number of *Ptiliidae*. There were a lot of weevil larvae, probably *Phyllobius*. Diptera larvae are not very strongly represented.

Some Localities with Oak and Ash.
Localities 22, 23, and 16. Table VIII.

Locality 22 is an oak stand about 80 years old, in Jægersborg Hegn compartment 272, not far from Locality 10 and apparently on a similar subsoil, but the oaks have a thick undergrowth of young beech. There is a very heavy layer of beech leaves on the ground and no soil flora, but underneath the leaf layer there is a friable mull soil abounding in humus. The fauna of this locality differs from the unmixed oak stand of Locality 10; but it greatly resembles the Oxalis type of Locality 9, which also was to be expected, the ground being covered with the shedding of beeches the disintegration of which is but slow. The aggregate number and weight of animals, as well as the quantities of spiders, worms, mites, collembola and diptera larvae, are very much alike. Locality 22, on the other hand, contained a great many *Trichoniscus*, a fact which may possibly be due to the presence of the oaks, and there are many millipeds, but very few click-beetle larvae; features characteristic to the fauna of the good beech mull. The earthworms were octagonal worms *(Dendrobaena octoedra)*. All in all, the fauna of this mixed forest, too, is characteristic of the forest soil condition.

Locality 23 is a closed group of young oaks, 3 m in height, planted in a good heathland, Skærbæk Plantage near Silkeborg in Jutland (Map, DFF. vol. IX, p. 8 & 165). Before the oaks, which were sown in drills, had closed up, there was

heather between the rows, but now all soil vegetation is dead, and the surface is covered with a loose layer of oak leaves, under which the soil mostly appears as a mixture of humus and leached sand, which, under the oak trees, no doubt will become good mull soil. We here meet with some earthworms, but only *Dendrobaena octoedra,* which I found in the neighbouring heath as well. With the kind assistance of the forest officer WILLIAM MARK I later on added some larger earthworms *(Lumbricus rubellus* and *Allolobophora turgida),* in order to see if, under the changed conditions made favourable by the presence of oak trees, they would thrive in a place where formerly they were entirely wanting, and possibly improve the topsoil. Of millipeds there were none, and but few mites; collembola, on the other hand, were plentifully represented. Moreover, there were a number of diptera larvae and click-beetle larvae, and a great abundance of *Staphylinidae* species. As was to be expected, the fauna is rather peculiar, meeting with no parallel in any of the localities hitherto mentioned. As a closed oak wood the stand is as yet so new that the fauna cannot be expected to have become fully adjusted to the changed conditions.

Locality 16 is a fast growing ash stand on a steep declivity in Ermelunden, 8 km north of Copenhagen, with a heavy soil flora consisting of *Urtica dioeca, Stachys silvatica, Aegopodium podagraria* and *Mercurialis perennis.* There is no layer of leaves, but a layer of organic mull about 20 cm deep, abounding in lime, on a friable and clayey topsoil also abounding in lime. The organic soil abounds in snail-shells, 340 in all were found in only $^1/_{10}$ m^2. For the rest, the soil is conspicuous for its many earthworms; in the sample we found 1 *Lumbricus rubellus* and 9 *Allolobophora turgida,* but there are probably larger species as well, just as was the case in similar soil under dog's mercury, examined by me. Of collembola the sample contained a great number of the white *Onychiurus armatus,* living in the very mull, but, naturally enough, none of the coloured species, which usually abound in the leaf layer. I caught sight of some few of the large *Entomobryidae* and *Pogonognathus,* but they did not happen to be in the sample. *Trichoniscus* abounds, just as in the oak localities, Nos. 10 and 22; also some myriopods, and a number of the *Pseudo-*

scorpiones (of the species *Chernes scorpioides*), probably living on the *Onychiurus*. Quite common, too, are click-beetle larvae *(Athous subfuscus)*, as in all soils particularly rich in humus. The fauna, which is somewhat peculiar, like the locality itself, has the greatest affinity to that of the oak Mercurialis type, Locality 10.

Spruce, Mull, Oxalis.
Locality 1, Table X.

The sample has been taken from section 103 in Rude Skov in a low sheltered place in a spruce stand, 75 years of age. The trees are very fine, with large tops and an abundance of leaves (crown-proportion about 1/2), the stems are well-shaped, and frequent thinnings have kept the trees at suitable intervals. Some root rot appears, but the attack is not serious. In the Spring of 1928, one year after the last thinning, there were 625 stems per hectare, with an aggregate basal area, at a height of 1.3 m, of 43.0 m^2, and an average height of 26.8 m. At a form factor of 0.55 (DFF. vol. 1, p. 335), the stem volume of wood amounts to 634 m^3 per hectare. The average diameter is 28.6 cm, the largest trees attain about 1/2 m in diameter. It seems to be a very productive stand, the height of which lies between SCHWAPPACH's quality class I and II.

The soil is mull covered with a thin growth of wood-sorrel *(Oxalis acetosella)*. *Astrophyllum*, too, abounds, though not in the particular spot where the sample was taken, and this moss has spread considerably during the two years in which the investigations have taken place. Somewhat nearer the edge of the stand, raspberries are found under the spruce trees; the flora is changing into that of the nitrate type (BORNEBUSCH 1923, p. 18 & 1925, p. 220).

The soil is covered with a 1—2 cm loose layer of needles, under which there is about 2—3 cm loose, very fine and granulated mull, not to any great extent mixed with mineral soil. A soil section showed the following profile:

0— 3 cm: Loose, crumby, very fine-grained layer of mull containing but little mineral soil intermingled.

3—15 » : Dark brown topsoil, abounding in humus, friable but somewhat compact.

15— 28 cm: Sandy topsoil from coffee-coloured to light brown, friable but compact, rich in humus.
28— 40 » : Sandy topsoil. Light brown, friable but compact.
40— 60 » : Sandy topsoil. Ocherous, compact, and rather hard.
60— 75 » : Light, greyish, compact, fine sand, rather hard (as clay pan), but without any stones.
75—200 » : Variegated, rather tough, clayey soil, interspersed with but few stones and grains of gravel.

With the few exceptions mentioned, the soil is without stones. Of carbonic lime there was none. Spruce roots abounded to a depth of 40 cm; below this, only straggling roots to a depth of 75 cm. No ground water.

Mechanical analyses from depths of 65 cm, 100 cm, and 200 cm, gave the following results:

Depth of sample cm	Percent Gravel 20—2 mm	Percentage of fine soil under 2 mm			
		Coarse sand 2—0.2 mm	Fine sand 0.2—0.02 mm	Silt 0.02— 0.002 mm	Loam < 0.002 mm
65	0.4	21.7	68.5	6.9	2.9
100	3.8	13.3	32.4	28.3	26.0
200	2.7	15.9	46.4	20.1	17.6

Having now passed on to the coniferous forests, we meet with a fauna essentially different from that of the deciduous forests. Even here, on mull, we find that the animals are numerous and small, an aggregate weight of only 10.7 gr. corresponding to no less than 10800 animals. Earthworms which, just as in deciduous forest mull, play an important part, constitute however only 47 per cent. of the aggregate weight. The specimens belong chiefly to the *Dendrobaena* genus; a single specimen of the reddish worm was found, but no turgid worms. Snails, *Enchytraeidae,* and *Trichoniscus* species are very scarce. There are but few millipeds, but a number of *Geophilidae.* In August 1926 and July 1927 was found an abundance of *Mycetophilidae* probably of the *Sciara* genus, the presence of which, together with the *Tipulidae* larvae, *Leptidae* larvae, and *Bibionidae* larvae, result in a relatively prominent number of diptera larvae. Most numerous are the small larvae of the *Cecidomyiidae*-type, but their aggregate weight is only small. The

Table X. Locality 1. Spruce, Mull, Oxalis. *Rødgran, Muld, Skovsyre.*		March 1926		May 1926	August 1926		Novemb 1926	
		I a	I b	II	III a	III b	IV a	
		L+M	L+M	L+M	L+M	L+M	L	
Gastropoda:	*Arion subfuscus*	1	1	.	.	.	.	
	shellbearing species, skalbærende	.	.	.	.	.	.	
Oligochaeta:	*Lumbricidae*	6	1	17	9	12	21	
	Enchytraeidae	6	1	.	.	.	2	
Crustacea:	*Isopoda terrestria spp.*	.	.	.	.	.	.	
Myriopoda:	*Lithobiidae spp.*	.	.	.	1	.	.	
	Geophilidae spp.	1	1	11	.	1	1	
	Julus spp.	.	.	.	.	.	.	
	Polydesmus spp.	.	1	.	.	.	.	
Arachnida:	*Pseudoscorpiones spp.*	1	.	.	.	.	.	
	Araneina et Opiliones spp.	11	7	.	4	7	10	
»	*Acarina spp.*	940	750	600	555	300	1760	
Collembola:	*Achorutes muscorum*	1	.	.	3	wanting (*mangler*)	2	
	Hypogastrura armata	.	.	.	130		360	1
	Onychiurus armatus	205	30	40	.		.	
	Isotoma viridis	8	2	3	.		21	
	Isotoma spp. (small, smaa)	130	40	8	.		80	
	Pogonognathus plumbeus	.	17	.	.		.	
	Lepidocyrtus lanuginosus	16	.	5	280		.	
	Entomobryidae spp.	.	.	.	2		.	
Diptera:	*Imagines et Pupae div.*	1	1	2	3	.	.	
	Bibionidae spp., Larvae	9	.	.	.	.	.	
	Mycetophilidae spp., »	6	4	.	70	15	19	
	Tipulidae spp., »	1	2	.	.	1	1	
	Leptidae spp., »	1	4	3	.	2	.	
	Fannia spp., »	2	.	1	.	.	1	
	Cecidomyiidae etc. spp., Larvae	86	28	10	11	3	48	
Coleoptera:	*Athous subfuscus, Imagines*	1	.	.	.	.	.	
	Larvae	1	2	19	3	8	2	
	Dolopius marginatus, »	.	.	2	1	.	.	
»	*Staphylinidae spp., Imagines*	14	22	9	9	16	11	
	» *Larvae*	3	8	1	1	1	6	
	Carabidae, spp., Imagines	2	.	1	4	1	.	
	» *Larvae*	.	1	.	.	2	1	
	Cantharidae spp., »	1	.	.	.	.	1	
	Curculionidae spp., Imagines	3	.	4	.	.	1	
	Ptiliidae spp., »	1	.	.	.	.	.	
	Other species, andre »	4	1	.	.	.	1	
	» *Larvae*	.	.	.	.	.	.	
Macrolepidoptera:	*Larvae div.*	.	1	.	.	.	.	
Microlepidoptera:	*Tortrix sp.?, Larvae*	2	2	.	1	.	5	
Hymenoptera:	*Tenthredinidae spp., Pupae*	.	.	.	.	.	.	
	Other species (andre)	.	.	.	1	.	.	
Hemiptera:	*Heteroptera spp.*	.	.	.	.	.	.	
Orthoptera:	*Forficulidae spp.*	.	.	.	.	2	.	
Thysanoptera:	*Thripidae spp.*	2	.	.	.	1	1	

L = Litter: needles and soil flora *(Naale og Urter*

ovember 1926		March 1927		May 1927	July 1927		Sept. 1927	November 1927		Average Number *Middel-Antal* per 1 m²	Weight *Vægt* mgr. per 1 m²	Respiration
IV b		V a	V b	VI	VII a	VII b	VIII	IX a	IX b			
.	M	L+M	L+M	L+M	L+M	L+M	L+M	L+M	L+M			
.	.	.	.	.	.	.	.	.	.	1	150	40
.	.	1	1	.	.	.	1	.	.	3	6	7
										4	*156*	*47*
13	.	5	1	3	8	11	21	6	4	101	5050	1919
3	.	3	.	3	.	36	5	4	1	42	21	37
										143	*5071*	*1956*
.	.	.	.	.	.	.	.	2	.	1	1	1
.	.	.	.	.	1	.	.	.	.	2	60	27
.	1	6	1	4	.	4	3	1	.	33	495	281
.	.	1	.	.	1	.	3	.	.	6	300	114
.	.	.	.	.	.	.	2	1	.	4	60	34
										46	*916*	*457*
.	.	.	.	.	.	.	.	.	.	1	.	.
6	.	5	2	.	2	2	.	2	.	33	33	46
										34	*33*	*46*
25	10	1180	700	800	200	250	195	550	90	*7337*	*429*	*1379*
.	.	.	.	.	.	.	.	1	.	7	.	1
.	.	.	.	.	.	.	.	.	.	444	9	46
50	10	26	26	150	65	42	80	28	35	600	24	98
5	.	2	4	.	4	2	30	.	.	48	24	42
50	.	70	38	165	50	150	43	155	40	742	7	48
.	.	.	.	.	.	.	.	.	.	10	7	10
.	.	8	10	19	.	.	.	.	.	357	18	68
.	.	.	.	.	.	.	.	.	.	2	2	3
										2210	*91*	*316*
.	.	.	.	2	.	.	.	.	.	8	8	11
.	.	.	.	.	.	.	.	.	.	6	120	62
18	1	.	.	.	670	35	.	.	.	468	234	413
.	.	.	3	.	.	1	7	2	6	20	800	328
.	2	3	28	6	8	20	8	.	1	63	315	258
.	.	.	.	.	.	.	.	.	.	3	6	7
33	1	31	30	12	.	.	.	13	.	189	9	36
										757	*1492*	*1115*
.	.	.	.	.	.	.	.	.	.	2	20	13
.	2	2	12	.	1	6	1	.	.	49	735	417
.	.	.	.	2	2	1	.	.	.	8	120	68
										59	*875*	*498*
8	.	16	1	10	.	2	7	10	2	93	186	207
3	.	5	2	3	2	5	.	1	1	32	64	71
1	1	7	2	.	.	1	.	.	.	13	65	53
.	.	.	.	.	4	1	1	.	.	8	40	33
.	.	.	.	.	.	.	.	.	.	2	4	4
.	.	2	1	3	1	.	.	2	.	16	160	104
.	.	.	.	.	.	.	.	.	.	1	.	.
.	.	6	1	.	.	.	.	.	.	9	45	37
.	.	.	.	.	.	1	.	.	.	1	5	4
										175	*569*	*513*
.	.	.	.	.	.	.	.	.	1	2	300	79
4	.	.	.	.	.	.	.	2	2	11	550	209
.	.	3	.	2	.	.	.	.	.	4	200	76
.	.	.	.	.	.	.	.	.	.	1	1	1
1	.	.	1	1	.	.	.	.	.	3	3	4
.	.	.	.	.	.	.	.	.	.	1	20	10
.	.	.	.	.	.	.	.	.	.	3	.	1
										25	*1074*	*380*
1 = Mull layer *(Muldlag)*.									**Total**	**10790**	**10706**	**6707**

number of *Elateridae* larvae, too, is considerable, and it teems with *Staphylinidae* species. Of ground-beetles, the species are almost exclusively confined to the little *Notiophilus biguttatus*, of weevils, especially *Strophosomus spp.* Of other insects, it is especially some *Microlepidoptera* larvae that we here find, but, like the saw-flies *(Tenthredinidae)*, they are here only to find shelter in the ground, and take no part in the transformation of the soil.

The abundance of the animals, however, is due to the great number of mites, over 7000, constituting as they do, more than two thirds of the aggregate number of animals. Collembola, too, are very numerous, especially *Hypogastrura*, *Onychiurus*, and the tiny *Isotoma* species, while *Folsomia*, if found at all, is so sparsely represented as to be wholly overlooked.

The locality is conspicuous for the small amount in weight of its animals, less than half of which are made up of small earthworms, while the turgid worm, which will keep the topsoil friable and porous, was entirely wanting. Second in order we have the diptera larvae, and among these the *Sciara* larvae are particularly numerous. Mites are found in quantities corresponding to those of the raw humus soil.

Spruce, Raw Humus, Moss Cover.
Locality 6. Table XI.

The Experimental Forestry Service's sample plot BG in Grib Skov, Nøddebo state district, compartment 66, a very fine spruce stand, which in 1928 at an age of 75 years had an average height of 25.4 m, somewhat better than SCHWAPPACH'S quality class II. The stand has been carefully thinned. The stems of the trees are very beautiful and of an excellent shape, and the crowns are well developed and dense. There are 409 stems per hectare, with an average diameter of 30.1 cm. After thinning, the basal area was 29.2 m^2, the volume of stocks 388 m^3 per hectare. The thinning removed 119 trees comprising 93 m^3 in volume of stocks. The annual increment for the years 1893—1928 was 17.8 m^3 per hectare.

The ground slopes considerably eastwards ending in a dank gully. The soil is covered with a rather close and

deep moss carpet, consisting chiefly of *Dicranum scoparium* together with *Hylocomium proliferum* and *Hylocomium parietinum*. There are a few small spruce plants, and in the neighbourhood a few specimens of wood-sorrel, the number increasing towards the gully. An examination of the soil where the samples have been taken, under a 4—6 cm deep layer of moss, mixed with loose needles, showed the following profile:

0— 5 cm: Brown, very loose layer of raw humus, partly mouldering.
5— 8 » : Likewise brown raw humus, pretty friable, but somewhat more compact.
8— 10 » : Dark brown, compact raw humus.
10— 17 » : Black leached sand, abounding in humus.
17— 34 » : Light grey leached sand, with a reddish tint.
34— 40 » : Black soft pan, rich in humus.
40— 50 » : Reddish-brown soft pan.
50— 60 » : Light ocherous sand.
60—110 » : Yellowish-grey, rather fine sand.
110—200 » : Grey, very fine sand, conducting so much ground water as to make the sand flow into the hole.

A few 30—50 cm big granite blocks were found in the upper part of the quicksand. No carbonic lime could be made out. The ground water came fast, filling up the hole as far as 85 cm from the surface.

Spruce roots abounded in the raw humus and were quite plentiful in the topsoil as well, to a depth of 55 cm; a number of fine roots extended as far down as 140 cm, and possibly deeper.

Mechanical analyses of soil samples from depths of 80 cm and 140 cm gave the following results:

Depth of sample cm	Gravel 20—2 mm per cent.	Percentage of fine soil under 2 mm			
		Coarse sand 2—0.2 mm	Fine sand 0.2—0.02 mm	Silt 0.02— 0.002 mm	Loam < 0.002 mm
80	1.6	39.2	57.2	2.4	1.2
140	1.1	26.2	67.4	4.5	1.9

In taking out the sample, I made a distinction between a) The moss and needle layer, abounding in animal life, and b) The raw humus layer, the upper part of which is loose

Table XI. Locality 6.

Spruce, Raw Humus, Hylocomium.

Rødgran, Maar, Mos.

		March 1926		May 1926	August 1926		Novemb 1926	
		I a	I b	II	III a	III b	IV a	
		L+H	L+H	L+H	L+H	L+H	L	
Gastropoda:	*Arion subfuscus*	1	.	.	.	.	.	
	shellbearing species, skalbærende	.	.	.	.	.	.	
Oligochaeta:	*Lumbricidae spp.*	4	1	.	12	1	2	
	Enchytraeidae spp.	.	4	77	10	16	.	
Myriopoda:	*Geophilidae spp.*	.	.	1	3	2	.	
	Julus spp.	.	.	.	.	.	.	
Arachnida:	*Pseudoscorpiones spp.*	1	3	.	2	.	4	
	Araneina spp.	.	.	.	.	.	9	
»	*Acarina spp.*	965	385	190	2110	1020	1400	1
Collembola:	*Achorutes muscorum*	10	.	1	.	8	1	2
	Onychiurus armatus	315	110	108	100	130	2	
	Folsomia quadrioculata	105	.	50	150	145	5	
	Isotoma viridis	10	5	.	.	.	.	
	Isotoma spp. (small, smaa*)*	100	45	.	.	.	7	
	Pogonognathus plumbeus	14	10	1	4	.	4	
	Lepidocyrtus lanuginosus	.	.	.	.	.	.	
	Entomobryidae spp.	.	.	.	2	.	.	
	Sminthuridae spp.	.	.	.	1	.	.	
Diptera:	*Imagines et Pupae div.*	1	.	.	.	1	.	
	Bibionidae spp., Larvae	.	.	.	1	.	.	
	Mycetophilidae spp., »	.	.	.	15	10	3	
	Tipulidae spp., »	.	9	18	15	.	1	
	Leptidae spp., »	4	13	2	1	1	3	
	Fannia spp., »	.	.	.	1	.	.	
	Cecidomyiidae etc. spp., Larvae	68	30	.	7	1	16	
Coleoptera:	*Athous subfuscus, Imagines*	.	.	.	.	.	.	
	Larvae	7	1	25	38	13	1	1
	Dolopius marginatus, Larvae	.	.	.	2	1	.	
»	*Staphylinidae spp., Imagines*	3	8	3	8	3	13	
	» *Larvae*	2	3	4	6	2	6	
	Carabidae spp., Imagines	.	.	.	3	.	.	
	» *Larvae*	.	.	.	4	.	.	
	Cantharidae spp., »	.	1	.	.	.	5	
	Curculionidae spp., Imagines	.	.	1	.	.	1	
	Ptiliidae spp., »	6	.	.	1	2	.	
	Other species, andre »	1	6	.	.	1	.	
	Larvae	.	.	.	.	.	.	
Macrolepidoptera:	*Larvae div.*	.	.	.	.	.	1	
Microlepidoptera:	*Tortrix sp.?, Larvae*	.	1	.	.	1	21	
Hymenoptera:	*Tenthredinidae spp., Nymphae*	.	.	.	.	.	.	
	Lyda sp., Larvae	1	.	1	.	.	.	
Hemiptera:	*Heteroptera spp.*	.	.	3	1	.	.	
Thysanoptera:	*Thripidae spp.*	.	.	.	.	.	.	

L = Litter: needles and moss *(Naale og Mo*

vember 1926 IV b		March 1927 Va		Vb		May 1927 VI		July 1927 VII		Septbr. 1927 VIII		November 1927 IX		Average Number *Middel-Antal* per 1 m²	Weight *Vægt* mgr. per 1 m²	Respiration
	H	L	H	L	H	L	H	L	H	L	H	L	H			
.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	150	40
.	.	2	.	.		.	.	.	.	.	.	.	.	1	4	4
														2	*154*	*44*
2	.	3	.	.	.	.	.	.	.	1	.	.	1	18	900	342
5	.	4	1	3	.	11	40	.	15	36	20	.	11	258	129	228
														276	*1029*	*570*
.	4	.	5	.	4	3	11	.	2	.	1	.	14	49	735	417
.	.	.	.	.	.	.	.	1	.	.	.	.	1	2	100	38
														51	*835*	*455*
3	.	4	.	.	.	.	.	.	.	.	.	2	.	12	1	4
.	.	10	.	2	.	1	.	1	.	5	.	11	2	34	34	48
														46	*35*	*52*
5	140	700	46	500	66	600	30	500	25	500	20	700	75	*7828*	*620*	*1800*
.	.	18	.	14	1	2	.	.	.	.	.	.	.	43	1	6
0	32	80	6	120	29	33	25	8	19	44	.	12	70	879	35	144
5	.	.	.	2	.	1	.	17	12	7	.	1	.	394	12	53
.	.	.	.	5	.	.	.	.	.	.	.	.	.	12	6	11
0	.	60	.	26	.	48	5	35	10	58	.	16	.	330	4	23
.	.	15	.	8	.	.	.	.	.	1	.	4	.	38	25	40
.	.	.	.	.	.	4	.	.	.	.	.	.	.	4	.	1
.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1
.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
														1702	*84*	*279*
.	.	1	.	6	.	2	.	.	.	6	.	.	.	16	16	22
.	.	.	.	.		.	.	.	.	.	.	.	.	1	20	10
0	22	.	.	3	.	1	.	.	.	.	2	.	.	44	20	34
.	.	10	.	18	.	25	3	9	1	7	.	.	.	101	4040	1654
1	2	1	1	5	2	1	2	.	.	.	.	1	13	41	205	168
.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2
4	.	23	.	1	.	4	.	.	.	.	.	23	2	132	6	22
														336	*4309*	*1912*
.	2	.	1	.	.	.	2	.	.	.	.	.	.	6	60	39
.	22	29	23	24	15	14	23	2	30	1	10	.	14	239	3585	2035
.	.	.	.	1	.	.	.	1	.	.	.	.	.	4	60	34
														249	*3705*	*2108*
8	.	20	.	11	.	6	1	3	.	10	.	3	4	82	164	182
4	4	5	1	5	.	.	1	2	.	2	1	.	3	39	78	87
2	.	1	.	.	.	.	.	1	.	.	.	3	.	9	45	37
.	.	.	.	.	.	1	.	.	.	.	.	.	.	6	30	25
.	1	1	.	1	.	.	.	.	.	.	1	1	2	10	20	22
.	.	2	.	2	.	2	.	.	.	.	.	5	.	12	120	78
1	.	.	.	.	.	.	.	.	.	.	.	3	.	10	.	2
5	1	1	.	.	.	1	.	.	.	.	.	.	.	11	11	15
.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	1	1
														180	*469*	*449*
.	1	6	.	.	1	.	.	.	.	.	.	1	.	7	350	133
9	.	1	.	.	.	.	.	.	.	.	.	4	.	24	480	248
.	1	.	.	.	.	.	.	.	.	.	.	1	.	2	40	21
.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	90	41
.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	4	6
.	.	.	3	.	.	.	.	.	.	.	.	.	.	2	.	.
														42	*964*	*449*
= Raw humus *(Maar)*.													**Total**	**10712**	**12204**	**8118**

and abounding in animal life, while the middle part is closer, and the lowest quite compact, so that comparatively few, even of the stronger animals, as e. g. the click-beetle larvae, are found here.

The layer of leached sand, as also that underneath, is quite compact, consequently not traversed by macroscopic animals. A search for animals in the upper 20 cm of the mineral soil gave no results.

Earthworms in the spruce raw humus are but sparsely represented, 18 in a m^2 only, and confined to the very small species, the octagonal worm, *Dendrobaena octoedra*. In a sample of $^1/_2$ m^2 of the raw humus, which was taken on May 28, 1927, only two small earthworms were found; in the moss and needle layer there were none. From the weight of this species of worms found in other localities, we can figure 18 specimens, equal to 1 gr. per m^2, a mere trifle compared with what we found in the beech mull, and only between $^1/_6$ and $^1/_5$ of what we found in the spruce mull and beech raw humus of Rude Skov. On the other hand, it comes near to the quantities in the beech raw humus of Grib Skov. Of snails there are very few, and of *Trichoniscus* none at all; the latter seems to belong exclusively to deciduous forests. The myriopods, too, are sparsely represented; with the exception of two specimens of the common milliped *Julus*, we found only thin, yellow *Geophilidae*. *Pseudoscorpiones* and spiders are quite numerous in the moss. Mites are very prolific, but mostly of the smaller kinds, and this holds true of the collembola as well. Most numerous, however, is the white *Onychiurus armatus*, but *Isotomidae*, too, are abundantly represented in the *Folsomia quadrioculata* and the small *Isotoma* species. The large *Pogonognathus plumbeus* is fairly numerous, and the one that is most conspicuous if we look in the moss layer.

There is quite a number of diptera larvae; thus we found 100 crane-fly larvae per m^2, but only of the smaller kinds, and they do not by far come up to the weight obtained in the beech raw humus of Rude Skov, weighing as they do only about 4 gr. The 41 *Leptis* larvae would probably weigh about 0.2 gr., and the aggregate weight of the *Mycetophilidae*, *Bibionidae*, and the numerous tiny *Cecidomyiidae*, is small. *Staphylinidae* species and small ground-beetles *(Notiophilus)* were

found in similar numbers as in the above mentioned locality. Particularly numerous are only the click-beetle larvae, 240 *Athous subfuscus* and only 4 *Dolopius marginatus*, the aggregate weight of which amounts to nearly 4 gr. The total weight of fauna in this locality is a little over 12 gr. per m^2.

The locality is thus remarkable for its scarcity of earthworms, their only representative being the octagonal worm, and for the predominance of mites, collembola (especially *Onychiurus*), diptera larvae and click-beetle larvae *(Athous subfuscus)*.

Spruce, Raw Humus, Moss Cover.
Locality 8, Table XII.

The Experimental Forestry Service's sample plot BF in Grib forest, Nøddebo state district, compartment 89, is a fine 72 years old spruce stand, which however does not come fully up to Locality 6. Measurement in 1928 gave the following results per hectare, after thinning: Number of stems 528, average height 23.1 m, average diameter 26.7 cm, basal area 29.5 m^2, volume of stocks 385 m^3. 121 stems with a volume of 68 m^3 had been removed by thinning. The annual increment for the period 1893—1928 amounted to 17.3 m^3 per hectare.

The growth is thus somewhat inferior to Locality 6.

The sample plot is on the top of a small hill, the upper part of which is fairly level. The ground is covered with a layer of moss, which is thick, but not so deep as in Locality 6, a fact that would seem to indicate that this one is more dry, and *Dicranum scoparium* is more prevalent, to some extent replacing the *Hylocomium* species. The raw humus is more compact and peaty. A soil section showed the following profile:

0— 5 cm: Loose layer of needles and moss in the process of mouldering.
5—13 » : Black, compact, peaty raw humus.
13—20 » : Grey, leached sand.
20—26 » : Greyish-brown, humus-coloured, friable but compact layer of earth; incipient soft pan formation.
26—30 » : In patches, indications of soft pan.

Table XII. Locality 8.

Spruce, Raw Humus, Hylocomium.

Rødgran, Maar, Mos.

		March 1926		May 1926	August 1926		Novemb 1926	
		I a	I b	II	III a	III b	IV a	
		L+H	L+H	L+H	L+H	L+H	L	H
Oligochaeta:	*Lumbricidae spp.*	2	1	.	.	1	2	
	Enchytraeidae spp.	2	24	.	.	.	.	
Myriopoda:	*Geophilidae spp.*	5	6	.	1	4	.	
Arachnida:	*Araneina spp.*	5	14	8	1	6	7	
»	*Acarina spp.*	875	930	225	625	600	420	14
Collembola:	*Achorutes muscorum*	.	2	.	6	2	.	
	Onychiurus armatus	115	560	145	340	25	32	5
	Folsomia quadrioculata	10	30	.	50	12	53	
	Isotoma viridis	8	9	.	.	.	.	
	Isotoma spp. (small, smaa*)*	.	30	60	80	10	50	
	Pogonognathus plumbeus	.	4	3	28	.	5	
	Lepidocyrtus lanuginosus	.	.	.	.	10	.	
	Entomobryidae spp.	.	.	.	.	.	3	
Diptera:	*Imagines et Pupae div.*	.	.	.	.	.	.	
	Mycetophilidae spp., Larvae	.	.	.	.	.	14	3
	Tipulidae spp., »	.	6	2	.	1	.	
	Leptidae spp., »	.	.	.	.	.	.	
	Dolichopodidae spp., »	.	1	.	.	.	.	
	Cecidomyiidae etc. spp., »	185	65	.	14	.	70	
Coleoptera:	*Athous subfuscus, Imagines*	.	.	.	.	.	.	
	Larvae	9	17	5	8	24	3	1
	Dolopius marginatus, »	.	.	.	.	.	.	
»	*Staphylinidae spp., Imagines*	10	38	6	7	6	20	
	» *Larvae*	5	4	1	8	.	4	
	Carabidae spp., Imagines	.	6	.	1	6	.	
	» *Larvae*	.	.	.	.	.	.	
	Cantharidae spp., »	.	.	.	.	.	4	
	Curculionidae spp., Imagines	1	3	1	.	.	2	
	Ptiliidae spp., »	.	.	.	.	1	.	
	Other species (andre)	.	.	.	.	.	3	
Macrolepidoptera:	*Larvae div.*	.	5	.	.	.	.	
Microlepidoptera:	*Tortrix sp.?, Larvae*	1	.	1	.	.	13	
Hymenoptera:	*Tenthredinidae spp.*	.	.	.	.	.	.	
Hemiptera:	*Heteroptera spp.*	6	.	1	8	1	26	
Thysanoptera:	*Thripidae spp.*	.	.	.	.	.	1	

L = Litter: needles and moss *(Naale og Mos*

vember 1926 IV b		March 1927 V		May 1927 VI		July 1927 VII		September 1927 VIII		November 1927 IX		Average Number *Middel-Antal* per 1 m²	Weight *Vægt* mgr. per 1 m²	Respiration
	H	L	H	L	H	L	H	L	H	L	H			
8	.	1	.	2	.	1	.	15	.	1	.	31	1550	589
0	.	10	1	.	6	.	2	40	2	.	3	91	46	80
												122	*1596*	*669*
.	4	1	15	1	10	4	15	2	4	.	40	*117*	*1755*	*996*
4	1	6	.	4	3	2	1	1	.	3	2	*67*	*67*	*94*
0	145	700	70	400	100	2000	90	1000	105	510	250	*8270*	*449*	*1388*
5	1	.	.	5	.	3	.	2	.	4	1	27	1	4
1	65	6	.	30	70	20	23	105	78	11	114	1354	54	222
4	.	31	.	12	.	29	12	40	3	.	.	231	7	31
.	.	.	.	1	.	.	.	.	.	.	.	11	6	10
5	.	25	.	80	3	18	35	18	110	28	20	578	6	38
9	.	.	.	.	.	.	.	22	.	27	.	83	54	87
1	.	.	.	.	.	.	.	2	.	.	.	9	.	2
1	.	3	.	.	.	1	.	.	.	2	.	9	9	13
												2302	*137*	*407*
.	.	3	.	.	.	.	.	11	.	1	.	17	17	24
6	10	6	.	.	.	2	1	21	5	.	2	78	39	69
.	.	1	.	9	.	2	.	2	1	.	.	23	920	377
.	3	.	.	1	1	.	.	.	.	.	1	6	30	25
.	.	.	.	.	.	.	.	1	.	.	.	2	10	8
.	.	45	15	15	18	13	.	22	.	9	16	356	18	68
												482	*1034*	*571*
.	1	.	1	.	.	.	.	.	2	.	.	6	60	39
1	15	7	16	3	34	.	15	16	22	.	19	203	3045	1729
.	.	.	.	.	1	.	.	1	.	.	.	2	30	17
												211	*3135*	*1785*
4	1	8	1	10	3	8	2	25	7	16	9	154	312	342
1	.	6	5	1	.	3	2	15	15	.	3	71	142	158
.	.	.	.	.	.	.	.	1	.	5	.	14	70	57
.	.	.	.	.	.	.	.	.	1	.	.	1	5	4
5	.	1	.	.	1	.	.	1	1	.	.	10	20	22
.	.	1	.	4	.	.	.	.	.	1	.	11	110	71
.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
.	.	1	.	.	.	.	.	.	.	.	.	3	3	4
												265	*662*	*658*
.	.	2	.	.	.	.	.	.	.	.	2	8	400	152
3	.	3	.	1	1	.	.	.	.	2	.	24	480	248
.	.	.	.	.	.	1	.	.	.	.	1	2	40	21
3	1	.	.	8	.	1	.	1	1	25	.	67	67	94
.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
												102	*987*	*515*
= Raw humus *(Maar).*												**Total**	**11938**	**9822**	**7083**

30— 36 cm: Very hard, somewhat ocherous sand, with fine, black streaks of hard pan.
36— 55 » : Greyish-white very hard sand, ocherous in patches, a little clayey (clay pan).
55—150 » : Variegated brown and white, friable clay.
150—200 » : Sharp sand, mixed with gravel, clayey and with patches of clay, aquiferous at a depth of 130 and 150 cm.

A little water was oozing out at a depth of 150 cm; there was also a trace at a depth of 130 cm. Ground water at such small depths, however, may be ascribed to a very rainy period immediately preceding. Roots were plentiful for the upper 30 cm, sparse as far down as 50 cm, and wanting below this.

Mechanical analyses of samples from 100 cm and 180 cm gave the following results:

Depth of sample cm	Gravel 20—2 mm per cent.	Percentage of fine soil under 2 mm			
		Coarse sand 2—0.2 mm	Fine sand 0.2—0.02 mm	Silt 0.02— 0.002 mm	Loam < 0.002 mm
100	10.3	7.9	26.3	37.2	28.6
180	7.4	61.6	27.8	2.2	8.4

The fauna does not differ much from that of Locality 6; it is conspicuous, however, for its somewhat larger number of animals, about 12000 per m^2, and a somewhat smaller weight, 9.8 gr., a fact suggestive of less favourable conditions. The layer of humus is more compact, and the work of the animals less traceable. We did indeed find more earthworms than in Locality 6 (*Dendrobaena octoedra* only), 1.6 gr. or about 16 per cent. of the aggregate weight, but the number of *Tipula* larvae is far smaller, so that the weight of diptera larvae is only 1.0 gr. as against 4.3 gr. in Locality 6. There are more *Geophilidae,* however, but no millipeds. Of click-beetle larvae, on the other hand, the number is nearly as great as in Locality 6.

The number of *Staphylinidae* exceeds that of Locality 6; otherwise, the quantity of other insects is about the same, except for the many *Hemiptera (Orthostira cervina)* found here. Collembola and mites are somewhat more numerous than in Locality 6, and *Onychiurus armatus* is still more predominating.

Both of these spruce localities are noteworthy for their typical raw humus fauna. The difference between them — the great number of diptera larvae in the more favourable Locality 6, where the increment of the trees is the greater of the two, and the great number of quite small animals in the somewhat inferior Locality 8 — fairly well corresponds to the difference we found between the two beech localities, though it is not so pronounced because, on the whole, the difference between the two spruce localities is smaller.

Some other Conifer Localities, and Heaths.
Table XIII.

Locality 25 is a young and thriving stand of spruce on a heathland in Skærbæk Plantage, Mid-Jutland. In many places, after thinning, moss has appeared under the spruce trees, even as the process of decomposition has been accelerated: In places covered with moss, for instance, faggots will thus more quickly turn into mull than in places only covered with a layer of needles. Sample *a* was taken out in a spot where the stand was quite close and where the soil was entirely without moss, while sample *b* comes from a place where thinning has taken place, and where the soil was entirely covered with moss.

In several respects there is a striking similarity between the fauna of this heath plantation and the two spruce localities mentioned above. But the absence of myriopods and the small numbers of the important diptera larvae and click-beetle larvae characterize the fauna as being decidedly inferior and less active in the decomposition of the organic matter. It is evident that the moss-covering, due to thinning, has been greatly propitious to the fauna. Of particular interest is the appearance of many octagonal worms, *Dendrobaena octoedra,* under the moss; but, all in all, the number of animals (apart from mites and the casual appearance of *Cantharidae* larvae), is greatest in the locality containing moss, approaching to the good spruce localities mentioned above.

Locality 32 was selected in order to check our observations of Locality 25 as to the propitious influence of thinning, and the resulting moss covering on the fauna. The stand

Table XIII.

Coniferous Woods and Heaths.
Naaleskove og Heder.

		Locality:	25 October 1927 Spruce *Rødgran*		32 Septbr. 1929 Spruce *Rødgran*		11 August 1926 Spruce and Larch *Gran + Lærk*		26 April 19 Pine wi Myrtillu *Fyr-Blaat*	
			a	b	s	y				
			N	M	N	M	L	H	L	
Gastropoda:	*Arion subfuscus*		1	4	.	.	.	.	.	
	shellbearing species, skalbærende		.	1	.	.	.	.	.	
			1	*5*	*0*	*0*	*0*		*0*	
Oligochaeta:	*Dendrobaena octoedra*		.	24	4	23	.	.	.	
	Enchytraeidae spp.		.	68	1	.	.	7	15	
			0	*92*	*5*	*23*	*7*		*50*	
Crustacea:	*Isopoda terrestria spp.*		.	.	.	.	.	.	.	
Myriopoda:	*Lithobiidae spp.*		.	.	.	.	3	.	.	
	Geophilidae spp.		.	.	.	.	13	8	.	
	Julus spp.		.	.	.	.	.	.	8	
	Polydesmus spp.		.	.	.	.	.	.	4	
	Glomeris spp.		.	.	.	.	.	.	1	
			0	*0*	*0*	*0*	*24*		*24*	
Arachnida:	*Pseudoscorpiones spp.*		.	.	.	.	.	.	7	
	Araneina et Opiliones spp.		.	1	17	10	2	2	8	
			0	*1*	*17*	*10*	*4*		*21*	
»	*Acarina spp.*		175	90	2065	1334	1150	88	1970	22
			175	*90*	*2065*	*1334*	*1238*		*2190*	
Collembola:	*Achorutes muscorum*		7	2	2	14	4	.	.	
	Hypogastrura armata		.	.	.	.	.	.	12	
	Onychiurus armatus		120	175	90	30	200	16	21	1
	Folsomia quadrioculata		.	.	.	.	100	.	.	
	Isotoma viridis		11	7	6	9	.	.	.	
	Isotoma spp. (small, smaa*)*		135	312	380	420	300	30	.	
	Pogonognathus plumbeus		3	17	1	2	50	.	4	
	Lepidocyrtus lanuginosus		4	.	3	3	.	.	.	
	Entomobryidae spp.		.	.	1	5	.	.	.	
			280	*513*	*483*	*483*	*700*		*48*	
Diptera:	*Mycetophilidae spp., Larvae*		1	9	2	.	.	.	.	
	Phaenocladius spp., »		.	.	.	.	.	.	63	2
	Tipulidae spp., »		.	.	1	12	3	.	2	
	Leptidae spp., »		.	.	2	4	.	.	1	
	Dolichopodidae spp., »		.	9	.	.	.	.	4	1
	Cecidomyiidae etc. spp., »		75	85	52	65	.	3	16	
			76	*103*	*57*	*81*	*6*		*120*	
Coleoptera:	*Athous subfuscus, Imagines*		.	.	.	.	.	.	.	
	» *Larvae*		1	.	3	.	6	14	1	1
	Dolopius marginatus, »		.	.	.	.	.	.	.	
			1	*0*	*3*	*0*	*20*		*18*	
»	*Staphylinidae spp., Imag.*		3	20	36	32	2	.	2	
	» *Larvae*		12	19	2	7	.	.	.	1
	Carabidae spp., Imag.		1	.	.	3	.	.	2	
	» *Larvae*		.	.	1	.	.	.	.	
	Cantharidae spp., »		27	.	.	.	.	1	1	2
	Curculionidae spp., Imag.		.	4	.	5	4	.	.	
	Ptiliidae spp., »		.	.	.	.	.	.	.	
	Other species (andre) »		.	1	.	.	.	.	.	
			43	*44*	*39*	*47*	*7*		*12*	
Lepidoptera:	*Larvae div.*		.	.	.	.	.	.	.	1
Hymenoptera:	*Formicidae spp.*		.	.	.	.	4	3	.	
	Other species (andre)		.	.	.	2	.	2	.	
Hemiptera:	*Newsteadia floccosa*		.	.	.	.	8	1	6	2
	Other species (andre)		2	45	250	120	.	.	.	
Orthoptera:	*Forficulidae spp.*		.	.	.	.	.	.	.	
Thysanoptera:	*Thripidae spp.*		.	.	.	5	.	.	.	
			2	*45*	*250*	*127*	*18*		*9*	
	Total		**578**	**893**	**2919**	**2105**	**2024**		**2492**	

N = Needles and raw humus *(Naale og Maar)*; M = Moss, needles and raw humus *(Ma*

27 April 1928 Pine with Myrtillus *Fyr+Blaabær*		28 April 1928 Pine with Beech *Fyr+Bøg*		29 April 1928 Pine with Spruce *Fyr+Gran*		7 March 1926 Myrtillus *Blaabær*	17 Aug. 1926 Mountain pine *Bjergfyr*	19 Aug. 1926 Juniper *Enebær*	18 Aug. 1926 Calluna-heath *Lyng*	24 Okt. 1927 Calluna-heath *Lyng*	31 Aug. 1928 Calluna-heath *Lyng*
L	H	L	H	L	H	L+H	L+H	L+H	L+H	L+H	L+H
.	.	1	.	1	.	.	.	.	.	1	.
.	.	.	.	1	.	.	.	.	.	.	.
0		*1*		*2*		*0*	*0*	*0*	*0*	*1*	*0*
3	.	4	1	2	.	.	.	6	5	.	4
.	.	18	3	72	3	4	4	.	.	10	5
3		*26*		*77*		*4*	*4*	*6*	*5*	*10*	*9*
.	.	33	.	17	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	1	.
.	6	.	1	.	.	.	.	.	.	.	.
2	.	6	1	3	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	1
.	.	.	.	.	.	.	.	.	.	.	.
8		*41*		*20*		*0*	*0*	*0*	*0*	*1*	*1*
.	.	5	.	3	.	.	.	1	.	2	.
3	.	15	3	28	10	4	2	.	3	4	4
3		*23*		*41*		*4*	*2*	*1*	*3*	*6*	*4*
5	75	820	80	715	105	475	1150	270	40	208	135
700		*900*		*820*		*475*	*1150*	*270*	*40*	*208*	*135*
2	.	11	2	5	.	.	.	.	*wanting (mangler)*	11	.
7	.	.	.	.	.	.	.	.		.	.
8	22	50	20	60	.	30	.	.		.	.
5	.	6	.	184	.	.	.	75		35	65
.	.	.	.	.	.	.	.	.		1	3
0	.	10	.	18	.	.	20	86		3	3
1	.	1	.	15	.	17	90	.		2	.
.	.	.	.	.	.	.	2	.		15	.
.	.	.	.	1	.	.	.	.		1	.
205		*100*		*283*		*47*	*112*	*161*	—	*68*	*71*
.	.	.	.	.	.	.	.	.	.	7	.
1	1	.	6	22	.	.	3	.	.	.	.
.	.	5	1	2	.	4	.	.	.	.	
3	6	18	8	8	6	4	.	.	.	.	.
.	1	3	2	.	.	.	.	.	.	.	.
.	21	38	6	52	3	5	14	10	.	2	3
33		*87*		*93*		*13*	*17*	*10*	*0*	*9*	*3*
.	.	.	.	.	.	.	.	.	.	.	.
5	14	2	11	2	8	6	4	1	.	.	10
.	.	.	.	.	.	1	.	.	.	1	.
19		*13*		*10*		*7*	*4*	*1*	*0*	*1*	*10*
3	4	20	4	4	4	10	10	28	4	5	4
.	2	3	1	6	3	7	3	8	6	4	2
1	.	.	.	.	.	.	.	3	4	12	.
.	.	.	.	.	.	.	2	.	.	.	.
.	.	6	.	3	.	.	.	3	.	.	.
1	.	1	.	.	.	.	.	1	1	.	.
.	.	6	.	11	.	.	.	.	.	.	.
.	.	1	.	.	.	1	2	2	4	8	.
11		*42*		*31*		*18*	*17*	*45*	*19*	*29*	*6*
.	1	.	.	.	.	1	.	.	2	.	.
.	.	.	.	.	.	33	.	.	1	1	.
.	.	.	.	.	.	.	.	1	.	2	.
4	.	.	.	.	.	5	.	.	.	.	.
.	.	.	.	.	.	.	18	.	3	4	4
.	.	1	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
5		*1*		*0*		*39*	*18*	*1*	*6*	*7*	*4*
987		**1234**		**1377**		**607**	**1324**	**495**	**(73)**	**340**	**243**

uale og Maar); L = Litter, including soil flora *(Affaldslag og Bundflora);* H = Raw humus *(Maar).*

consists of spruce, 48 years old, in Hastrup Plantage, Mid-Jutland. The area, GG, is divided into a number of parts, where The Experimental Forestry Service is carrying out experiments on varying grades of thinning. In part litera *s* only dry trees are cut down. The ground is covered with a layer of needles, and is without any vegetation whatever. Directly underneath there is a thin, but very compact, layer of raw humus. In part litera *y* the usual heavy Danish thinning is practised, and, owing to the better access of light, the ground is covered with moss, and the layer of humus is thicker than in *s*, but far more friable and porous. The subsoil is of gravelly sand; previously the area was arable land, and the soil does not show any sign of podsol.

The results of our examinations of the fauna have been very instructive, fully corroborating our observations in Locality 25. It is to be particularly noted that the thinned, moss-covered part contained 23 earthworms *(Dendrobaena octoedra)* and 12 tipula larvae in $^1/_{10}$ m^2, while the unthinned one had only 4 earthworms and 1 tipula larva. The thinned part, moreover, contained more *Cecidomyiidae* larvae, while the unthinned one had more small *Hemipterae* specimens. Of particular interest, too, are the mites, of which the thinned part yielded 1334, the unthinned one 2065, but the latter were for the most part much smaller. The various genera were apportioned as follows: In part *s*, 148 *Gamasidae spp* (rapacious mites), 13 *Camisia spinifera*, and 19 other *Camisia spp* (rather large species), 1885 extremely small *Damaeosoma sp;* in part *y*, on the other hand, only 79 *Gamasidae spp* and 125 *Damaeosoma sp*, but 1130 of the big humus-eating *Camisia spp* (of these 30 *C. spinifera*). The mite fauna of the thinned parcel *y*, therefore, in spite of the smaller number, seems to be considerably more active in the transformation of humus than that of the dark and unthinned part.

Locality 11, The Experimental Forestry Service's sample plot BI in Grib Skov (DFF. vol. VII, p. 199), contains a stock of fine and tall larches, interspersed with shorter spruce trees. The stand is light, and the ground is partly covered with a lot of self-sown small spruces and some larches. There is a very thick layer of raw humus, and, where the sample was taken, a very heavy moss layer consisting of *Polytrichum attenuatum* and

Hylocomium species. There is a large ant-hill of *Formica rufa* just in the neighbourhood; hence, the ground is teeming with ants; the sample from $^1/_{10}$ m^2 contained 7 of them. This probably accounts for the peculiar fauna with quite exceptionally few diptera larvae, beetles, and other insects. Only the more robust click-beetle larvae, which are well concealed in the humus, are found in the usual quantities, and there is an abundance of mites and collembola, possibly because the fairly deep moss is propitious to them, possibly also because the ants have ousted their enemies, of which the *Staphylinidae* species may be supposed to play an important part. If it may be taken as a general rule that the large, red wood-ants in this way influence the fauna in the neighbourhood of the ant-hills, the question about their use or their harm in the forest is more complicated than hitherto supposed. But the *Formica rufa* ant-hills found in the coniferous woods of Denmark are in many places so sporadic that the importance of these ants must be rather insignificant.

The following four localities of Table XIII are stands of Scotch pine of a decidedly good Myrtillus type. In Locality 26, Horserød Hegn compartment 104, where there is no undergrowth, the soil flora is of the most pronounced type, consisting of a vigorous growth of bilberry *(Vaccinium myrtillus)* with an interspersion of cowberry *(Vaccinium vitis idaea)*, and with a lot of barren *Deschampsia flexuosa* and moss *(Hylocomium parietinum, H. proliferum, H. triquetrum, Dicranum undulatum)*, and, somewhat sporadically, *Trientalis europaea, Majanthemum bifolium, Luzula pilosa, Oxalis acetosella* etc. with a heavy layer of raw humus and leached sand underneath. In Localities 28 and 29 the flora of bilberry, etc. is entirely extinct, owing to a dense undergrowth of self-sown beech and spruce respectively; Locality 27 has been considerably impaired by the side-shade from this undergrowth. The last three localities are in the Experimental Forestry Service's sample plot CC, in the same forest, and, according to measurements in 1924 the 64 years old stand had a height of 19.7 m, corresponding to SCHWAPPACH'S quality class II. Average diameter 27.13 cm, number of stems 474, basal area 27.4 m^2, volume of wood 274 m^3 per hectare after thinning. 81 stems with a volume of 28 m^3 had been removed.

In the undisturbed Myrtillus type of Locality 26 we find an enormous number of animals. This is chiefly due to the abundance of mites; other animals do not appear in particularly large numbers. Some species are quite well represented however, e. g. millipeds genera *Julus*, *Polydesmus*, and *Glomeris*, as also many diptera larvae of the *Phaenocladius* genus, of which we have hitherto met with only a few specimens, but which seem particularly indigenous to this type. Click-beetle larvae are found in the usual quantities, but of *Staphylinidae* there are very few. This might be accidental, were it not that in Locality 27, too, *Staphylinidae* are scarce. To some extent spiders and *Pseudoscorpiones* may have replaced them. The absence of earthworms *(Dendrobaena octoedra)*, on the contrary, must be merely accidental, as they could just as well live here as in Locality 27.

The fauna is a typical raw humus one, which evidently is different from that of the spruce forest in several respects, but the material at our disposal is too scanty for us more closely to characterize the difference.

The three other localities are of even less interest; the shade is deeper, and their fauna approaches more closely to that of the spruce forests. It is no doubt due to the presence of beech in Locality 28, and beech leaves carried by the wind between the needles in Locality 29, that we found the great number of *Trichoniscus* and also a single earwig.

Locality 7, adjoining Locality 6, is a hillock with bilberries, surrounded on all sides by spruce. The sample was somewhat poorer than those just mentioned, possibly because of the presence of small red ants *(Myrmica sp.)*.

Locality 17 is a stand of mountain pine *(Pinus montana)* at Nørholm, near Varde in Jutland. No. 19 was taken from under a juniper *(Juniperus communis)* in the heath reservation belonging to Nørholm, and No. 18 is a sample from the common heathland with *Calluna vulgaris* in the same place. (The latter no doubt lost some of its value, because it was stored too long).

No. 24 is from a particularly good heathland in Skærbæk, Mid-Jutland, with moss among the *Calluna*, and with straggling junipers. No. 31 is from a good not podsolized heath with weeds and moss among the heather, at Højlyngen in Bornholm.

These samples from heath localities are of particular interest because they show that we find earthworms everywhere, even in the most unfertile heathlands, Locality 18. Sample 24, it is true, contains no earthworms; but when taking out the sample, I found them of frequent occurrence in the moss. On the other hand, when taking out the sample in Bornholm, I spent a considerable time without finding any earthworms, though they were present in considerable numbers, and from this experience I learned that these little worms, *Dendrobaena octoedra,* may very well be present without being directly noticeable; so well are they concealed in the raw humus. For the rest, the samples are of interest in as far as they prove that the fauna of the heathlands very largely consists of the same species or genera as in the forests; thus, for instance, we find the same collembola species; but the fauna of heathlands is, quantitatively, much poorer than that of forests. Of animals peculiar to heaths we would especially mention the chrysomela *Lochmaea suturalis,* which lives on the heather, and some years appears in such great multitudes as to damage the heather very considerably.

Description of the Animals, their Life and Habits.

In this section we shall proceed to describe the various species and genera of animals influencing the forest soil, and try to account for the part supposed to be played by them, taking them all in the order in which they have appeared in the foregoing tables, and including others not previously mentioned. First of all, however, we shall take a general survey of the place occupied by the various forms in the Animal Kingdom.

PROTOZOA.

Of these microscopic, unicellular animalcula there is an immense number of infusoria and rhizopods in the soil. FEHÉR (1929) thus found that their numbers in forest soils at Sopron in Hungary amounted to no less than between 5400 and 9000, per gr. humid soil, 2350 and 5200 active respectively, the rest encysted. They are said to live chiefly on bacteria, hence to

be of importance in the regulation of the number of these, but sometimes, perhaps, reducing their quantities too much. Our exact knowledge of the protozoa fauna of the forest soil is infinitesimal. The protozoa have not been included in this investigation.

METAZOA.

MOLLUSCA.

Of these we have in the forest soil, of the *Gastropoda* (snails), several species with and without shells, all of them belonging to the land pulmonate snails, the sub-order *Pulmonata Stylommatophora*.

NEMATHELMINTHES.

Microscopic *Nematoda* are present in the soil in very great numbers, but not included in this investigation owing to the special methods required for collecting them.

ANNELIDA.

Of these in the forest soil there is only the *Oligochaeta* order with the families *Lumbricidae*, earthworms, and *Enchytraeidae*, potworms.

ARTHROPODA.

CRUSTACEA, THE CRUSTACEA CLASS.

In the forest soil only the *Isopoda terrestria*, fourteen-legged crustacean animals (woodlice).

MYRIOPODA, THE MYRIOPODS CLASS.

All the three orders belonging to these are met with in the forest soil: the quite small *Symphyla* (represented by the *Scolopendrellidae* family, the *Scutigerella* genus); *Chilopoda*, centipeds (represented by the *Lithobiidae* and *Geophilidae* families); and the *Diplopoda*, millipeds, (the *Julus*, *Polydesmus* and *Glomeris* genera).

ARACHNIDA, THE ARACHNIDS CLASS.

In the Danish forest soil we find species of the following orders: *Pseudoscorpiones*, false scorpions; *Opiliones*, harvesters; *Araneina*, spiders (numerous); and *Acarina*, mites (very

numerous). Moreover: *Tardigrada*, tardigrades which we have not obtained in this investigation.

INSECTA OR HEXAPODA, THE CLASS OF INSECTS.

The sub-class of primitive insects, *Apterygota*, is represented by the various species of the *Collembola* order (springtails).

Of the *Pterygota* sub-class, winged insects (including however many species secondarily wingless), it is mostly the *Diptera* order, two-winged insects, and *Coleoptera*, beetles, we meet with. In smaller quantities we find the *Orthoptera* order, straight-winged (*Forficulidae*, earwigs); *Hemiptera* or *Rhynchota*, bugs (*Heteroptera*, genuine bugs; and *Homoptera*, cicadas, scale-insects and plant-lice), *Hymenoptera*, membrane-winged (*Formicidae*, ants; *Ichneumonidae*, ichneumon-flies; and *Tenthredinidae*, saw-flies as pupae, etc.); *Lepidoptera* (both macro- and micro-, as larvae and pupae); and *Thysanoptera*, physopoda (*Thripidae*, thrips).

VERTEBRATA.

AMPHIBIA, THE AMPHIBIAN CLASS.

In the forest soil we find our two salamander species: *Triton cristatus* Laur. and *Triton punctatus* Laur.; frogs, chiefly *Rana platyrrhinus* Steenstrup; and toads, especially *Bufo vulgaris* Laur.; they live on smaller animals, in all probability mostly earthworms. They hardly play any important part, except in some few places where the soil is propitious, and where they do a good deal of burrowing.

REPTILIA, THE REPTILIAN CLASS.

Both our species of lizards, *Lacerta agilis* L. and *L. vivipara* Jacq.; the blind-worm, *Anguis fragilis* L.; the snake *Tropidonotus natrix* L.; and the viper, *Vipera berus* L. — are found in the forest, but are of even less importance than the amphibians.

AVES, THE BIRD CLASS.

Regarding these we merely refer to what has been said in the introduction.

MAMMALIA, THE MAMMAL CLASS.

In the introduction we have called attention to the part played by the ruminants, *Ruminantia*, in their biting and trampling, and by carnivorous animals, *Carnivora* (foxes and badgers), rodents, *Rodentia*, and insectivores, *Insectivora*, through their burrowing activities. In this section we shall more particularly deal with the mole, *Talpa europaea* L, as a representative of the *Insectovora*.

Gastropoda, Snails.

The chief species in the forest soil is the naked, streaked, grey slug *Arion subfuscus* Drap., which is often seen crawling up stems whenever the air is humid. It is particularly numerous in deciduous forests, but is by no means scarce in coniferous forests. In deciduous forests 20 or 30 slugs were frequently found per m^2, and this comparatively large animal, therefore, becomes a factor of considerable importance. Its frequent occurrence in Locality 20 shows that it is not absolutely contingent on a soil flora. In all probability it often causes considerable damage. The many gnawings found on small beech plants, and which, especially in very shadowy places is detrimental to the plants, are often — judging from the form and appearance of the damage — due to slugs and snails, though probably to some extent also to moth larvae living in the forest soil, and to other insects. Besides *Arion subfuscus* we would mention the large black slug, *Arion ater* L., of which, on a 1.5 m wide path in Skaade Skov, south of Aarhus, I have counted 76 within a distance of 140 m, and about which STEEN (1890) states that it has caused considerable damage by devouring the cotyledons of young beech plants.

Of snails with shells we find several quite small species, most numerous (about 30—70 per m^2) in the soil of deciduous forests, both on mull and raw humus, very scarce or entirely wanting in coniferous forests. The samples collected contained especially *Vitrea crystallinus* Müll., *Hyalinia alliaria* Müll., *Patula rotundata* Müll. and *Trichia hispida* Müll. On beech

stems, it is chiefly *Clausilia* that is found; on soil abounding in lime, also numerous *Helix hortensis* Müll., and some other snails.

Lumbricidae, Earthworms.

As far as we know, the first to write about the importance of worms to soil and vegetation, was GILBERT WHITE (1789); we quote from a letter by him dated May 20, 1770, as follows:

»Earthworms, though in appearance a small and despicable link in the chain of Nature, yet, if lost, would make a lamentable chasm ... worms seem to be the great promoters of vegetation, which would proceed but lamely without them, by boring, perforating, and loosening the soil, and rendering it pervious to rains and the fibres of plants, by drawing straws and stalks of leaves and twigs into it; and, most of all by throwing up such infinite numbers of lumps of earth called wormcasts, which, being their excrements, is a fine manure for grains and grass. Worms probably provide new soil for hills and slopes where the rain washes the earth away ... Gardeners and farmers express their detestation of worms; ... But these men would find that the earth without worms would soon become cold, hard-bound and void of fermentation, and consequently sterile ...«

The chief points in our present knowledge of earthworms are here, at that early date, stated concisely and clearly. Not till nearly seventy years afterwards did DARWIN (1840) publish his lecture held in the Geological Society of London on November 1, 1837, from which we learn that earthworms, by constantly piling their excrements, chiefly consisting of earth, on the surface of the soil, buried stones, lime or coke, cause these to sink lower and lower. It was a farmer, Mr. WEDGEWOOD of Maer Hall in Staffordshire, DARWIN'S father-in-law, who had called DARWIN'S attention to this fact and furnished him with the correct explanation. Afterwards, DARWIN studied earthworms more closely (DARWIN 1881), partly assisted by his sons; he carried on investigations of how earthworms buried the old Roman ruins in England, and he studied most carefully their method of conveying leaves, peti-

oles, and paper into their burrows under the ground. It is of particular interest to read his observations of how they haul down pine needles, always with the bases foremost and plug up the mouth of the burrow with them, but do not eat any, evidently using them as a kind of convenient lining in the upper part of their burrows which they generally occupy. The leaves are softened by means of their pancreatic secretion and then devoured, while large stalks of leaves are once more pushed out of the burrows, after the softer parts of them have been consumed. DARWIN does not mention which species he examined, but it was probably the large *Lumbricus terrestris*.

DARWIN also ascertained the amount of earth brought to the surface by earthworms. On pasture land he figured it out to be a layer of as much as 5 mm per year. In many parts of England an annual weight of 25 tons earth per hectare passes through the intestinal canal of the worms and is deposited on the surface. By way of example he mentions how a stony, ploughed field, after having been left as pasture for a period of 30 years, became entirely smooth and apparently devoid of stones. Under trees, the activity of earthworms was often slight.

V. HENSEN (1877) investigated the vertical burrows of earthworms, to depths of 3, 4, and even 6 feet (about 2 m). At the bottom they ended in a small chamber, lined with small pebbles, occasionally with pear-pips (also other seeds etc. may appear). He attaches great importance to the activity of earthworms in preparing the way for the roots of plants, and in lining their tracks with humus. In every second burrow he found plant roots varying from $^1/_2$ to $^1/_4$ mm in diameter. The roots of fruit trees moved down vertically, branching out at the bottom of the burrow.

In his two dissertations, »Studier over Skovjord«, i. e. studies of forest soil, 1878 b and 1884, P. E. MÜLLER describes the importance of earthworms to forest soil. The former deals with beech forests, where on mull he found earthworms in great quantities. But his statement that it was the large earthworm, *Lumbricus terrestris*, is hardly correct; for in the same forests I have found only few of this species, but many reddish worms *(L. rubellus)*. He writes (1878 b, p. 18) that it looks as if the whole upper layer of earth, to a depth

of about 2 cm, exclusively consisted of worm casts, and that the brown mull layer (or rather mull soil) immediately underneath contains the same ingredients, but in a more dissolved and decayed condition. He has traced the vertical burrows of earthworms to a depth of about 1 m, and at a depth of about 60 cm, in Geels Skov, he has found 43 open burrows within 5 square feet (about $^1/_2$ m^2), which amount to nearly a million per hectare. In many of the burrows there were roots. Next, the author states that in the topsoil some smaller earthworms were found, especially *Allolobophora turgida.*

On large areas of woodland with mull, however, he found only the small purple worm *(L. castaneus)*, which lives mostly in the leaf layer without penetrating the ground to any considerable depth. This observation does not tally with my own, either, for even in poor beech mull (Oxalis mull) I have found both the turgid worm *(Allolobophora turgida)* and the reddish worm, although in smaller numbers than in the best soil.

Further, p. 24, we read as follows: »This great host of earthworms, which on typical beech mull probably amounts to several *(adskillige)* millions per *Td. Ld.* (0.55 ha) must perform a most important work for the condition of the soil; but to this must be added the effect caused by their enemy, the mole.« ... »The beech mull is thus to be conceived as a layer abounding in animal life, chiefly earthworms, deposited from the deciduous mass of the beech forest, decomposed into a loose and incoherent mass, in which the organic remnants are evenly *(inderlig)* mixed with the mineral soil. Below the mull, the topsoil is perfectly friable and homogeneously mixed.«

With this definition of the beech mull we can fully agree; not so with the author's description of the raw humus, of which he says (1878 b, p. 44) that earthworms are entirely excluded from the formation proper, that only once did he find a small enchytraeid, and that there was a scarcity of insects.

In contradistinction to this view, my investigations go to prove that the small octagonal worm *(Dendrobaena octoedra)* is present in all raw humus soil, and that in some beech raw humus, moreover, the reddish worm, the purple worm, and the tree worm *(Dendrobaena arborea)* are found; that enchytraeids are as numerous (sometimes amounting to several thousands per m^2) in raw humus soil as in mull; and that in-

sects as well as other arthropods are far more numerous in raw humus than in mull, even though, to some extent, the species are smaller in size. MÜLLER's definition of the raw humus as »a deposit of the deciduous mass of beech, extremely poor in animal life«, thus, cannot be maintained. In his second dissertation, the author (1884, p. 63) affirms that earthworms are the animals that are of greatest importance to the condition of the crust of the earth, and that they are found to be constantly coincident with the presence of mull in oak forests and heaths as well as in beech forests. In oak scrubs, the last remnants of the ancient oak forests on heathlands, he always found the three species: the purple worm, the reddish worm, and the turgid worm; he also found worms in the heath, wherever the soil was mull, but maintains that there were no earthworms in raw humus. In oak raw humus only did he find a couple of small specimens (probably the octagonal worm, *Dendrobaena octoedra*).

In 1894 MÜLLER gave an excellent description of how the underground rhizomes of herbs gradually sink deeper and deeper, because they are »hilled up« by earthworms. In a later dissertation on oak forests and heaths (1918) the author mentions only the microbiological differences between mull and raw humus, and does not touch on the fauna at all.

BOAS enlarges upon the subject of earthworms and their activity in the soil, in his Forstzoologi (1896—98, 1923), chiefly based on DARWIN and MÜLLER. His observation (1923, p. 738) — »When earthworms are ousted from a locality, the mull changes into raw humus« — is full of interest owing to his firm conviction as to the importance of earthworms. Another observation — »While thus entirely wanting in the heath proper, they soon make their appearance in the heath plantations« — is based on a statement made by JENSEN (1897) on the discovery of the reddish worm *(L. rubellus)* in a 20 years old plantation of spruce and mountain pine at Klelund, and is no doubt too optimistic. In my experience, conifers are so unfavourable to earthworms that, with the exception of the octagonal worm, it is most unlikely that they should have migrated there after the planting of the trees. More probably they have been there before. The soil in the locality

dealt with was rather favourable: the old layer of raw humus was covered with a 10 cm deep layer of driftsand; there was no hard pan; and in the neighbourhood there was arable land and scrub of oak. At any rate, the condition described is not of normal occurrence.

WOLLNY (1890) experimented on cultivation of various agricultural and horticultural plants in flower pots with and without earthworms, with the result that the seed crop in pots containing earthworms was 20—100 per cent. greater than in the others. These experiments and others by the same author (1897) showed that earthworms greatly increased the pore-volume in the soil, and made it much easier for water to penetrate the same.

The following experiments by RIBAUCOURT & COMBAULT (1907) deserve mentioning. Two small fields, surrounded by walls, yielded the same crop. One was thoroughly searched several times, and all the earthworms found were transferred to the other. Then rye was grown in both, and the field containing worms yielded a crop 25 per cent. in excess of the other. Corn grown in the casts of *Lumbricus terrestris* yielded crops twice as large as those grown on soil from which the casts had been removed. A large quantity of earthworms was taken to an entirely barren place in Switzerland, 2000 m above sea-level, and the following year the hitherto sterile ground was largely covered with a fine layer of humus. They even placed octagonal worms *(Dendrobaena octoedra)* on bare rocks. On crawling across the rocks, the worms left a slimy track, which was to be found again the following year, because lichens had grown on it. Lichens are the first kind of vegetation, which is gradually succeeded by a number of other plants. The octagonal worm thus gives rise to vegetation on the bare rock.

Sometimes in the morning a great number of earthworms are found dead on the ground; they comprise individuals, young and pubescent, of many different species. The phenomenon, occurring after a gentle rain during the night with cold and clear weather towards dawn (FRIEND 1924), has never been satisfactorily explained.

The importance of earthworms in the formation of soil, we can briefly characterize as follows: They convey vegetable matter into the ground, where they devour it after

it has turned soft; this accelerates the transmutation of all deciduous products. They riddle through and through the upper mully part of the topsoil, thus keeping it friable and porous. They devour a lot of earth, which in form of worm casts they deposit upon the surface of the ground; these worm casts consist of humus and mineral earth intermixed, constituting a most excellent soil for plants to grow in. Not merely the upper loose layer of mull, but the entire mully topsoil is presumably due to earthworm excrements, gradually deposited on the surface of the ground; hence the topsoil contains only little coarse mineral matter. Finally, earthworms form intersecting burrows in the subsoil, to which they resort whenever the weather is very dry or very cold, and these passages serve as drains for water and as tracks for roots to layers of soil underneath.

The different species of earthworms vary in importance. Some of them live in the leaf layer or in the raw humus (the *Dendrobaena* species, the purple worm), and the part played by them hardly differs much from that of the arthropoda, except that they swallow some mineral soil, which is thus mixed with the layer of leaves. Others stick to the mineral topsoil (mostly *Allolobophora* species). The deeper burrows are mostly formed by the large species, chiefly *Lumbricus terrestris*, but also by several smaller species which, however, do not go quite so deep *(Eisenia rosea)*.

Formerly, only 12 species of earthworms were known in Denmark (LEVINSEN 1883), a number which, by recent investigations (BORNEBUSCH 1928), has been raised to 19, more particularly dealt with below. By referring to the table p. 94, and the descriptions given, it is possible, with the aid of only an ordinary magnifying glass, to distinguish them by their outer characteristics alone, the chief ones being size, colour, shape of head, arrangement of bristles (setae), position of girdle and *tubercula pubertatis*.

The body of the earthworm is long and slender, and is composed of a great number of segments, often between 100 and 200. The form of the head is, in our species, either tanylobic (all *Lumbricus* species) or epilobic (or schizolobic) (nearly all the rest). On each segment there are 8 setae, either in pairs of 4 rows or separate in 8 rows. The girdle is a

swollen part, generally lighter in colour than the rest, glandular, and saddle-shaped; it is a development peculiar to individuals arrived at puberty, and covers several segments a little hehind the openings for the sexual organs. On the ventral side, under the girdle, there are some characteristic swellings, the so-called *tubercula pubertatis*, which, together with the position of the girdle, constitute some of the chief means of distinguishing the species; see Fig. 4.

Earthworms are hermaphrodites; the female pores are not distinguishable with the naked eye; but the male pores, situated ventrally on both sides, are plainly visible on the 15th segment (in most *Eiseniella* species, on the 13th), often on the point of a papilla. Because of their importance to the soil, we shall describe the Danish species which can be determined according to the key in Table XIV. Besides, I shall refer to Fig. 5, and to MICHAELSEN 1900, FRIEND 1923, BORNEBUSCH 1928.

Eiseniella tetraedra Savigny, square-tailed worm, is a small worm $2^1/_2$—5 cm, most often sepia-brown; quadrangular behind the girdle. It is very common in the leaves of forest ditches and in swampy soil, especially near springs. It is no doubt of importance in the formation of mull in wet places, especially in swamps with black alders.

Eiseniella hercynia Michaelsen, very much resembling the above, found in swampy soil under black alders near an elevated spring in Silkeborg Vesterskov in Jutland.

Bimastus eiseni Levinsen, Eisen's worm, and

Bimastus constrictus Rosa, constricted worm, are small reddish worms found in surroundings similar to those in which *Dendrobaena arborea* is found, but are so rare as to be of no importance at all.

Dendrobaena subrubicunda Eisen, gilt-tail, is 6—9 cm in length, reddish, much akin to the one mentioned below, chiefly distinguished from same by a more or less yellow hind end. It most frequently occurs in richly manured soil, also e. g. in wood yards, compost heaps, etc., but plays no important part in the forest.

Dendrobaena arborea Eisen, tree worm, smaller in size, only $2^1/_2$—6 cm in length, is found in large quantities especially in rotten stubs and under their moss cover. It often crawls up the bark of the trees, and may be found in rotten

Table XIV. Key for Ascertaining the Species of Earthworms.
Nøgle til Bestemmelse af Regnormearter.

Name	Shape of Head	Setae	Male Pore	Girdle	Tubercula pubertatis
Eiseniella tetraedra . . .	e	4	13	22, 23—26, 27	23—25, 26
» *hercynia* . . .	e	4	15	22, 23—27	23—25, 26
Bimastus eiseni	t	4	15p	24, 25—32	none
» *constrictus* . .	e	8	15p	26—31	none
Dendrob. subrubicunda	e	8	15p	25, 26—31, 32	28—30
» *arborea*	e	8	15p	26, 27—31, 32	29—30
» *octoedra*	e	8	15	27, 29—33, 34	31—33
Eisenia foetida	e	4	15p	24, 26—32	28—30, 31
» *rosea*	e	4	15p	24, 26—32, 33	29—31
Allolobophora turgida . . .	e	4	15p	27, 28—34, 35	31:33
» *trapezoides* .	e	4	15p	27, 28—34, 35	31—33
» *longa*	e	4	15p	27, 28—35	32—34
» *chlorotica* . .	e	4	15p	29—37	31:33:35
Octolasium cyaneum . .	e	8	15p	29—34	30—33
» *lacteum* . . .	e (t)	8—4	15p	30—35	31—34
Lumbricus rubellus . . .	t	4	15	27—32	28—31
» *castaneus* . .	t	4	15	28—33	29—32
» *terrestris* . .	t	4	15p	32—37	33—36
» *festivus* . . .	t	4	15p	34—39	35—38

Shape of head: e = epilobic, t = tanylobic.
Setae: 4 = setae in 4 pairs, 8 = setae in 8 rows.
Male pore: The figure refers to the number of the segment counting from the fore-end, p indicates that the male pore is on a papilla.
Girdle: Extend over the segments indicated; comma = or.
Tubercula pubertatis: — means that the tuberculae extend as a band over the said segments, colon means that they appear as papillas on same; comma = or.

knots at a great height. On being placed on a dry surface, for instance a sheet of paper, it will often jump several inches by flinging its serpentine body from side to side. This is probably the way in which it detaches itself from the bark of the trees and gains the ground, when the surface of the stem is getting too dry; otherwise it would stick to the bark and die. It is conducive to the decay of the stubs, and is also found active in the forest soil.

Dendrobaena octoedra Savigny, octagonal worm. This tiny $2^1/_2$—4 cm long worm is of a purple-brown colour with a dark

bronze sheen; the belt is of a pale reddish-yellow. I have found it everywhere in large quantities under moss on stones, rocks, and raw humus. It also occurs in the raw humus itself in both deciduous and coniferous forests, in heath plantations, and even in uncultivated heathlands. It is the most frugal of all European species, and occurs chiefly in the most unpropitious localities, otherwise evaded by earthworms. It is also met with in more northerly latitudes, e. g. in Nowaja-Semlja, and higher up the mountains than any other species. RIBAUCOURT & COMBAULT (1907) relate how it lives in the moss on the rocks of high mountains and here assiduously gathers the leaves

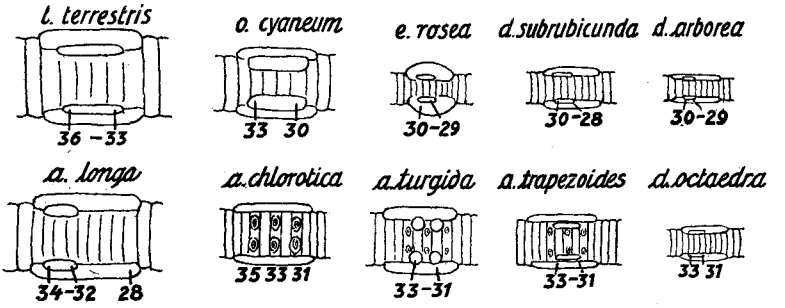


Fig. 4. Girdles and tuberculas of the most common earthworm species seen from beneath (scale 2 : 1).

carried by the wind, dragging them down and devouring them; how it swallows any earth it can find, and deposits it on the top of the moss in form of casts. In this way it conduces to the formation of mull in unpropitious localities. In Denmark it is of the utmost importance, being in most places the only species of earthworm living in raw humus soil. Our investigations show that it constitutes about 10 per cent of the weight of all the animals living in raw humus.

Eisenia foetida Savigny, the brandling, is noteworthy for its peculiar shade of colour, the segments forming nut-brown rings with intermittent yellow parts. This species, much in demand for angling, is found mostly in manure and compost, but I have also found it in mouldering wood and under moss on beech stubs.

Eisenia rosea Savigny, mucous worm, is 3—7 cm in length, of a pale rose or pink colour. It most frequently occurs in

clayey garden soil, where e. g. in winter and the dry periods of summer it may be found rolled up like a small, pink ball at the lower boundary of the mould. It is quite common, too, in rich, clayey forest soil, without however belonging to the more dominating species.

Allolobophora turgida Eisen, turgid worm, often attains a length of 10—15 cm, and is of a dull greyish colour, bordering on varying shades of reddish, greenish or bluish tints. It is no doubt the most numerous of all our earthworm species, occurring wherever we find a mull soil: in woodlands and in pastures, in field and in garden, in sandy as well as in clayey soil. It lives in the mully topsoil, especially in the uppermost, friable layer of same, directly under the leaf layer, but never in the latter itself. Consequently it never occurs in raw humus soil, but is the most typical mull soil species. Owing to its numerousness, it must be taken as the most important species of earthworms in mull soil.

Allolobophora trapezoides Dugès, trapeze worm, much akin to the above, which it resembles very much, and from which it is distinguishable only by examination of the tubercula pubertatis. We often find it under exactly similar conditions as the turgid worm, and together with same, but, being a more southerly species, it is not so numerous in Denmark.

Allolobophora longa Ude, the long worm, is of nearly the same size as the common large earthworm, with which it is easily confounded. It is, however, of a more brownish colour, not iridescent, and, on closer examination, is easily distinguishable. It most often occurs in rich garden soil; in the forest, I have come across it in mully hollows with dog's mercury, nettles, and *Circium oleraceum*. Its life and habits are said to correspond to those of the large earthworm.

Allolobophora chlorotica Savigny, green worm, a short, thick worm, 5—7 cm in length, characteristic for its proneness to roll up like a spiral when alarmed. The colour is generally yellowish- or greenish-grey, but may be of a pronounced green. It is a sluggish worm, most commonly found in very clayey soil, also in the forest, where however it is not so common.

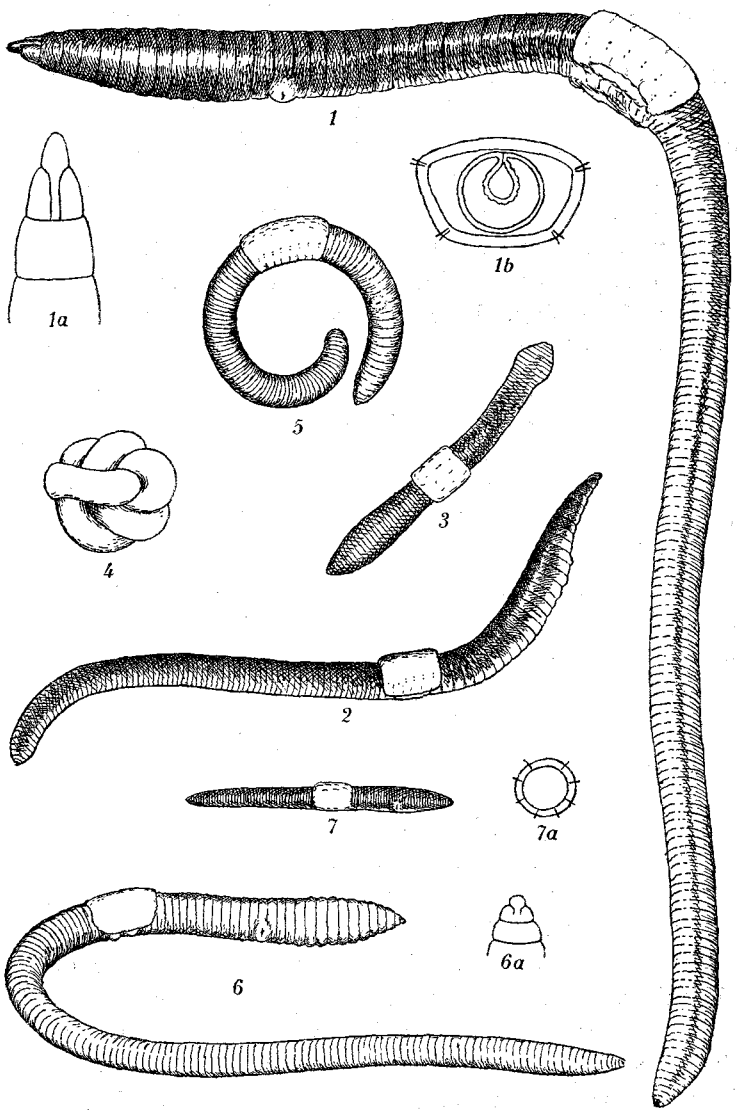


Fig. 5. Some of the most common Danish earthworms, in natural size. 1: *Lumbricus terrestris,* 1 a: Tanylobic head of same, dorsal view, 1 b: Transversal section behind girdle of same showing setae and gut. 2: *Lumbricus rubellus.* 3: *Lumbricus castaneus.* 4: *Eisenia rosea* in torpor. 5: *Allolobophora chlorotica.* 6: *Allolobophora turgida,* 6 a: epilobic head of same, dorsal view. 7: *Dendrobaena octoedra,* 7 a: Transversal section of same showing position of setae.

Octolasium cyaneum Savigny, blue worm, is a peculiar worm of considerable size and conspicious appearance. It is mostly 10—18 cm in length, the colour is quite light, of a delicate blue, mauve, or rose, and the skin has a very fine satin sheen. The foremost segments are of a light flesh-colour, the extreme hind part of the body a pronounced yellow. The skin is transparent, disclosing the blue or red dorsal vessel; the belt is yellowish or liver-brown, dull and wrinkled. This conspicuously pretty species I have found to be common in the environs of Jægersborg Deerpark, where it mostly prefers humid and mully hollows in foliferous woods, the flora of which was dog's mercury, nettles, and *Circium oleraceum*.

Octolasium lacteum Oerley, milky worm, is generally somewhat smaller than the turgid worm, which it often resembles in colour; but it may be of a brighter and more bluish tint, thus somewhat resembling the blue worm. I have found it in mully beech woods together with the turgid worm and the trapeze worm, but it is easily overlooked owing to the marked resemblance it bears to these. It is of less frequent occurrence than the two said species.

Lumbricus rubellus Hoffmeister, reddish worm, generally 10—12 cm long, has, in common with the other *Lumbricus* species, a dark pigment on the back, especially in front of the girdle, thus designating a species that is often found crawling on the surface of the ground. It is of a brownish-purple or reddish colour, ventrally light. As to the locality required, it is probably the most adaptive of all our earthworms, occurring, as it does, not only everywhere in mull soil in field, pasture and garden, but also everywhere in mully deciduous and coniferous forests. In Rude Skov, moreover, I have found it in great numbers in beech raw humus, where apparently it has been able to do without a mully topsoil; and it is said to occur in oak scrubs and in coniferous plantations on the heaths. It is a far more pronounced forest species than the large earthworm, and more frugal in its habits, but far less numerous than the turgid worm. It must be classed with the most important earthworm species of our forests.

Lumbricus castaneus Savigny, purple worm, only about 5 cm long, of the same colour as the above, but still more iridescent, is very numerous in the beech leaves, especially in

rich mull, but it also occurs under other deciduous trees, and outside the forest. This small bright-coloured species is characteristic for its agile movements, backing quickly when escaping. When suddenly alarmed it greatly contracts itself, having its hind part strongly spatulate, the position of the girdle thus being about the middle of the body. By means of these characteristics it is easily distinguishable from the small *Dendrobaena* species found in leaves.

Lumbricus terrestris Linné, the large common earthworm, the longest and biggest of our earthworms, sometimes attaining a length of nearly 30 cm, but most often 20—25 cm, is, in front of the girdle of a purple-brown colour, iridescent, not reddish, while the dorsal side of the hind part is rather pale with a darker streak down the middle. It is extremely common in pastures, fields and gardens, especially in rich soil. It has a particular preference for the immediate environments of houses and manure heaps, even though it be in the poor soil of the Jutish heathlands. In forests, it sticks to deciduous stands with a good soil condition. In beech forest, on elevated ground, it is often wanting or scarce, even in good mull soil, and it evades coniferous forests and sandy beech forest soil of the Oxalis type, and it never occurs in raw humus. It is chiefly this species that produces the deep vertical burrows, of such great importance to the condition of the soil and to vegetation. In those places of the forest where it occurs in large numbers, its work is no doubt of far greater importance than that of the reddish worm.

Lumbricus festivus Savigny, rubescent worm, is of the same size as the reddish worm, but of a darker colour, approximating dark brown mahogany. It is distinguishable, not only by its great number of segments in front of the girdle, but also by the plainly visible papillas with male pores, a feature not found in the reddish worm. This species, otherwise unknown except in the most westerly parts of Europe — France and Great Britain —, I have found to be common in Jægersborg Deerpark and immediate surroundings, under conditions similar to those of the reddish worm, and it does not seem to be very fastidious as to locality.

Besides the investigations described in our last section, I have made some calculations as to the number of earthworms

by digging and searching through a square meter of various forest localities. The earthworms collected were sorted according to species, counted, and weighed.

The largest quantity was found in a patch with dog's mercury in Møllevangen Skov at Springforbi; there was a layer of mull 80 cm deep, and the process of decomposition was very active. I also found a considerable number of earthworms by searching a square meter in Locality 10, oak with dog's mercury, in Stampeskoven, north of Jægersborg Deerpark.

	Møllevangen, June 3, 1927		Stampeskoven, July 7, 1928	
	Number	Weight, gr.	Number	Weight, gr.
Lumbricus terrestris	9	30	1	7.0
» *festivus*	2	2	1	1.2
» *rubellus*	40	28	23	13.7
» *castaneus*	25	6.5	9	1.5
Octolasium cyaneum	18	19	—	—
Allolobophora turgida	174	86	206	145.6
» *chlorotica*	90	28.5	—	—
» *longa*	—	—	4	7.0
Eisenia rosea	—	—	10	2.2
Total...	358	200	254	178.2

These figures correspond to $3^1/_2$ and $2^1/_2$ million earthworms per hectare, respectively. The weight, 2000 kgr. and about 1800 kgr. per hectare respectively, will be better understood, if we reflect that it comes up to the weight per hectare of the live stock of a first rate Danish farm. The systematic investigations in Locality 10, described in a previous section, however, gave a considerably lower estimate. The present sample was evidently taken out under particularly favourable conditions. We must remember that the actual number of earthworms and their presence in the upper layers of the soil, vary according to season of the year and condition of the weather.

The time chosen for investigating beech forest Localities 15 and 5 in Geels Skov, proved to be less favourable, the results being poorer than the average of the systematic investigations. Our collection on April 24, 1927 gave the following figures:

	Locality 15		Locality 5	
	Number	Weight, gr.	Number	Weight, gr.
Lumbricus rubellus	4	4.4	14	7.9
» *castaneus*	6	1.9	7	1.6
Allolobophora turgida	19	14.2	18	8.1
Eisenia rosea	3	1.2	—	—
Dendrobaena arborea (+ D. octoedra)	6	0.5	23	1.4
Total...	38	22.2	62	19.0

From forests belonging to the city of Aarhus I have received two samples, kindly submitted to me by the forest officer N. BANG, who had them dug out on Oct. 17, 1927. They represent earthworms taken from a square meter in the forests Riis Skov and Thorskov respectively. In the former, the forest soil in spring is covered with *Allium ursinum* (broad leaved garlic) later on without any flora, and the process of decomposition is so brisk that the ground is almost devoid of any leaf layer in the summer; in the latter forest, on the other hand, decomposition is rather slow; hence, there is a considerable layer of loose leaves.

	Riis Skov		Thorskov	
	Number	Weight, gr.	Number	Weight, gr.
Lumbricus terrestris	8	19.0	13	20.2
» *rubellus*	7	4.6	8	4.6
» *castaneus*	1	0.1	6	0.6
Allolobophora longa	2	3.6	—	—
— *turgida*	60	25.0	118	37.0
Octolasium lacteum	18	5.6	6	3.2
Eisenia rosea	34	8.8	29	4.7
Total...	130	66.7	180	70.3

These weights and numbers correspond very well with good beech mull, when examined at the most favourable time. They somewhat exceed the average figures given in our last section, but the types by Aarhus are different and more favourable, belonging to the *Circaea* group of types. In contradistinction to the localities in Geels Skov, moreover, we find the large earthworm *(Lumbricus terrestris)* in considerable quantities, and in Riis Skov, the long worm *(Allolobophora longa)* as well. We notice that Thorskov, the mull

formation of which is inferior to that of Riis Skov, has the greater number of earthworms, but they are smaller; even those of the same species proved to be lighter in weight.

An examination of 1 m^2 beech raw humus from Locality 4 in Rude Skov resulted in 8 *Lumbricus rubellus*, 6.2 gr., and 18 of small species, 2.3 gr., but 39 large *Tipulidae* larvae, 12.0 gr. A search for small species of earthworms in raw humus, however, is too circumstantial and results too unreliable; an apparatus for driving them out must here be resorted to.

Some samples of earthworms, collected in Pamhule Skov near Hadersley, gave very interesting facts about these animals in their relation to the coniferous forest, corroborating my observations in other places. There is a rather large eyot of spruce, some 80 years old, surrounded by beech. In the unmixed beech forest there proved to be *Lumbricus terrestris*, *Allolobophora turgida* and *Eisenia rosea;* from a patch of mixed beech and spruce, a sample contained *Lumbricus terrestris*, *L. rubellus*, *L. castaneus*, and *Allolobophora turgida;* while a sample from unmixed spruce stand, where the Experimental Forest Service has a sample plot, HR, comprised the following species only: *Lumbricus rubellus*, *Dendrobaena arborea*, and *D. octoedra*. Apparently, the coniferous forest is capable of scaring away the deep-burrowing *Lumbricus terrestris* and the two worms working in the mineral topsoil: *Allolobophora turgida* and *Eisenia rosea*, to the advantage of *Lumbricus rubellus*, which can live in the leaf and humus layer, and the small *Dendrobaena* species confined to these layers only; the result being that the deeper soil is left unriddled. Where beech and spruce were intermingled, the beech forest species of earthworms had remained.

In the forests on the cretacious cliffs of Møen, where the soil abounds in carbonic lime, under beech with dog's mercury, blue anemone, and other lime-demanding herbs, the earthworm fauna, just as in Pamhule Skov, comprised *Lumbricus terrestris*, *Allolobophora turgida* and *Eisenia rosea*. Under ash stands on marlaceous soil, at Visborggaard, N. E. Jutland, *Lumbricus terrestris*, *L. rubellus*, *Allolobophora longa*, *A. turgida*, and *Eisenia rosea*, were found; in mully humus soil with maple, in the same forest, also *Octolasium cyaneum* and *Allolobophora chlorotica*.

On the basis of these investigations, together with those described in our last section, corroborating other observations I have made about the occurrence of the earthworms, we can draw up a list of earthworm fauna for the different localities as follows:

Fresh mull soil, abounding in humus, most often in lime as well, with light-demanding trees: *Lumbricus terrestris, Allolobophora longa, Octolasium cyaneum, Allolobophora turgida, A. trapezoides, A. chlorotica,* and *Eisenia rosea.*

Fresh beech mull soil on clayey, particulary marlaceous ground, with *Anemone* and *Asperula* interspersed with lime-demanding herbs: *Lumbricus terrestris, L. rubellus, Allolobophora turgida* and moreover *Allolobophora longa, A. trapezoides, Octolasium lacteum, Eisenia rosea,* and *Lumbricus castaneus.*

Beech forest soil on more elevated ground, with *Anemone* and *Asperula: Lumbricus rubellus, L. castaneus, Allolobophora turgida,* and *Dendrobaena arborea;* less frequently: *Lumbricus terrestris* and *Eisenia rosea.*

Dry beech forest soil with *Oxalis;* in smaller quantities: *Lumbricus rubellus, Allolobophora turgida, Lumbricus castaneus, Dendrobaena arborea,* and *D. octoedra.*

Beech raw humus: *Dendrobaena octoedra,* and more rarely: *Lumbricus rubellus, L. castaneus,* and *Dendrobaena arborea.*

Coniferous forest mull: *Lumbricus rubellus, Dendrobaena arborea,* and *D. octoedra.*

Raw humus soil in coniferous forests and heaths: *Dendrobaena octoedra.*

Small brooks and swamps: *Eiseniella tetraedra.*

Compost, etc.: *Eisenia foetida* and *Dendrobaena subrubicunda,* often together with *Allolobophora chlorotica* and several others of the species mentioned above.

Enchytraeidae, Potworms.

Of these tiny white worms, several species of the genus *Henlea* occur in the forest soil. Most common is the 1—2 cm long *Mesenchytraeus setosus* Mich., in beech leaves, often very numerous, during rainy periods in autumn constituting as much as a couple of thousand per m^2. It is the species usually found in such environments. In coniferous forest soil some extremely slender forms are found.

Isopoda Terrestria, Woodlice.

The common woodlouse, *Oniscus asellus* L., properly belongs to mouldering wood and under dead bark, and when met with in the forest soil, it must be on its way from one place to another. Small isopods, on the other hand, of the genus *Trichoniscus* (*T. pusillus* Brandt), occur in very large numbers in good mull of deciduous forests. In the beech raw humus of Locality 4, too, it was found, but absent from the poor beech raw humus of Locality 20, the impoverished soil of Locality 2, and the spruce localities, except for two specimens in spruce mull. They live on decaying vegetable substances.

Myriopoda, Myriopods.

In judging the importance of this class to the forest soil, we shall have to distinguish between the order of *Chilopoda*, centipeds which are rapacious animals, and the order of *Diplopoda*, millipeds living on decaying vegetable matter.

Of the flat, brown centipeds, of the *Lithobiidae* family, we find several species in forest soil. They are mainly found in the samples from mull soil, possibly because earthworms constitute their favourite food.

The long, slender, yellow *Geophilidae*, on the contrary, occur in great numbers everywhere; but particularly so in the raw humus of Localities 20 (beech raw humus, 273 per m^2) and 8 (spruce raw humus, 117 per m^2).

Of *Diplopoda* we find the common millipeds of the genus *Julus*, the transverse section of which is circular, to be the most numerous. They occur in particularly large numbers in beech mull, more sparsely in the oak Locality 10 and in spruce mull, and are very rare in raw humus soil. Like most earthworms they thus show their preference for mull soil, in this respect contrasting with diptera and click-beetle larvae.

The *Polydesmus* species, flat-backed and of a peculiar, almost triangular, transverse section, are far less numerous in good beech mull, and seem to be somewhat more independent of the condition of the soil.

The *Glomeris* species, resembling woodlice, but easily distinguishable from these by the greater number of legs, two

pairs on each section, and capable of rolling up like a ball, have been found rather frequently in deciduous forest soil.

The small, pale *Scutigerella immaculata* Newp. was represented by only a few specimens per m^2 in Localities 5 and 10, though elsewhere no doubt of frequent occurrence.

Arachnida, Spiders.

Of false scorpions, *Pseudoscorpiones*, we have found *Obisium muscorum* Koch very common, both in deciduous and coniferous forests, often numbering 10—20 per m^2. It was not traced, however, in the spruce raw humus Locality 8; and in spruce mull, Locality 1, as also in beech soil, Locality 2, 1 specimen only was found in each. In the ash stand, Locality 16, *Chernes scorpioides* Herm. was found. *Pseudoscorpiones* are rapacious animals, chiefly preying on collembola.

Spiders, *Araneina*, are of most frequent occurrence everywhere in forest soil, the number varying from 30 to more than 100 per m^2. Most numerous are some quite small, pale species, especially *Colobocyba pallens*. Harvesters, *Opiliones*, are somewhat rarer. Both spiders and harvesters are rapacious animals, pursuing their prey on the forest soil, but hardly of any direct importance to same.

The entire bulk of material collected by me, with the exception of that of Locality 32, has been submitted to Mr. SCHENKEL of Basel, who has kindly specified same. A very great number, as might be expected, come under the category »undetermined« because the samples naturally contained a lot of quite young individuals, the species of which are doubtful or impossible to determine. I am greatly indebted to Mr. SCHENKEL for the great work he has undertaken, valuable, amongst other things, by discovering no less than 14 species not previously recorded amongst the Danish fauna, to wit: *Robertus scoticus*, *Minyriolus pusillus*, *Colobocyba pallens* (very numerous), *Micrargus herbigradus*, *Trachynotus obtusus*, *Wideria fugax*, *Dicymbium tibiale*, *Porrhomma microphthalmum*, *Centromerus silvaticus*, *Centromerus arcanus*, *Rhabdoria diluta*, *Lephthyphantes tenebricola*, *Lephthyphantes ericaeus*, and *Aulonia albimana*. *Trachynotus obtusus* and *Lephthyphantes ericaeus*, indeed, have been found in the Faroe Islands.

Table XV. Opiliones and Araneina in the 10 Main Localities.

Mejere og Edderkopper paa de 10 Hovedlokaliteter.

Locality No.	1	2	4	5	6	8	9	10	15	20
Researched Area (Undersøgt Areal) m²	1.5	1.0	1.1	1.1	1.3	1.2	1.2	0.8	0.9	0.4
OPILIONES: Nemastomatidae.										
Nemastoma lugubre Müller	.	.	.	4	.	.	.	3	.	.
Phalangiidae.										
Oligolophus tridens C. L. Koch	1	1	.	8	1	.	1	9	3	.
» *sp.*	.	.	.	.	.	.	11	.	.	.
Platybunus (pinetorum?) C. L. Koch	1	.	.	.	.	.	.	.	.	.
» *sp.*	.	.	.	.	.	.	.	.	1	.
ARANEINA.										
Cribellatae: Dictynidae.										
Amaurobius fenestralis Stroem	.	.	8	1	1	.	12	.	.	1
Ecribellatae: Theridiidae.										
Theridium sp.	.	.	.	.	.	.	.	.	.	2
Steatoda bipunctata Linné	.	.	1	2	2	.	.	.	.	1
Robertus lividus Blackwall	.	.	.	.	1	3	5	.	2	.
» *scoticus* Jackson	.	.	.	.	.	4	.	.	.	1
» *sp.*	.	.	.	1	.	.	.	1	2	.
Argiopidae.										
Tiso vagans Blackwall	.	2	.	.	.	.	.	.	.	.
Minyriolus pusillus Wider	.	.	.	.	.	1	.	.	.	.
Plesiocraerus latifrons Cambridge	19	2	.	.	6	1	.	6	.	.
» *picinus* Blackwall	.	.	.	1	.	.	.	.	.	.
Colobocyba insecta C. L. Koch	.	.	1	4	.	.	.	3	10	.
» *pallens* Cambridge	9	1	59	4	9	35	15	.	.	18
Dicymbium tibiale Blackwall	1	.	.	.	6	.	.	.	.	.
Savignyia frontata Blackwall	.	.	.	1	.	.	.	.	.	.
Wideria cucullata C. L. Koch	.	.	1	.	.	.	2	.	.	1
» *fugax* Cambridge	.	.	.	.	1	.	.	.	.	.
Trachynotus obtusus Blackwall	.	.	.	.	.	.	.	1	.	.
Cornicularia cuspidata Blackwall	.	.	.	.	.	2	.	.	.	.
Gonatium rubellum Blackwall	1	.	.	.	.	.	.	1	.	.
Tmeticus graminicola Sundevall	.	.	.	.	.	.	.	1	.	.
Porrhomma microphthalmum Cambr.	.	.	.	.	.	.	.	.	.	1
Micronela viaria Blackwall	.	.	1	5	.	.	.	1	3	.
Centromerus bicolor Blackwall	.	2	.	.	.	.	.	.	.	.
» *silvaticus* Blackwall	.	.	.	.	.	.	.	1	.	.
» *sp.*	.	.	1	.	.	.	.	.	.	.
Macrargus rufus Wider	1	1	.	2	.	.	.	.	1	.
Lephthyphantes tenebricola Wider	.	.	.	1	.	.	.	.	.	.
» *sp.*	.	.	.	1	.	.	.	.	.	.
Helophora (Linyphia) insignis Blckw.	.	.	.	.	.	.	.	2	.	.
Bathyphantes nigrinus Westring	.	.	.	.	.	.	.	1	.	.
Pachygnatha Listeri Sundevall	.	.	.	.	.	.	.	1	.	.
» *de Geeri* Sundevall	.	1	.	.	.	.	.	.	.	.
Clubionidae.										
Clubiona pallidula Clerck	.	.	.	.	.	.	1	.	.	.
Anyphaena accentuata Walckenar	.	.	.	.	.	.	.	1	.	.
Agalenidae.										
Cryphoeca sylvicola C. L. Koch	.	.	.	.	.	1	.	.	.	.
Lycosidae.										
Trochosa sp.	.	2	.	.	.	.	1	.	.	.
Aulonia albimana Walckenar	.	.	.	.	.	.	.	1	.	.
Salticidae.										
Euophrys aequipes Cambridge	.	.	.	.	1	1	.	.	.	.
Unknown (Ubestemte)	25	18	76	16	13	40	23	13	8	9
Total	58	30	148	51	41	88	71	46	30	34

The results from the 10 main localities can be seen in Table XV, and the numbers and species collected in the other localities are given in the following list. Besides several of the species mentioned in Table XV, we have collected the following species: *Oligolophus (Hanseni?* Kröpelin), *Theridium ovatum* Clerck, *Micrargus herbigradus* Blackwall, *Centromerus arcanus* Cambridge, *Rhabdoria diluta* Cambridge, *Lephthyphantes ericaeus* Blackwall, *Meta segmentata* Clerck, *Tegenaria Derhami* Scopoli, *Lycosa lugubris* Walckenar, *Lycosa nigriceps* Thorell.

Loc. 3 (0.1 m^2): 2 *Robertus lividus*, 3 *Colobocyba pallens*, 1 *Macrargus rufus*. 6 in all.
Loc. 7 (0.1 m^2): 1 *Cryphoeca sylvicola*, 3 unknown. 4 in all.
Loc. 11 (0.1 m^2): 1 *Colobocyba pallens*, 3 unknown. 4 in all.
Loc. 12 (0.1 m^2): 3 *Oligolophus tridens*, 1 *Robertus lividus*, 3 unknown. 7 in all.
Loc. 14 (0.2 m^2): 1 *Theridium ovatum*, 1 *Colobocyba pallens*, 1 *Helophora insignis*, 2 unknown. 5 in all.
Loc. 16 (0.1 m^2): 1 *Oligolophus tridens*, 1 unknown. 2 in all.
Loc. 17 (0.1 m^2): 1 *Centromerus silvaticus*, 1 unknown. 2 in all.
Loc. 18 (0.1 m^2): 1 *Trochosa sp.*, 2 unknown. 3 in all.
Loc. 19 (0.1 m^2): None.
Loc. 21 (0.1 m^2): 1 *Oligolophus (Hanseni?)*, 1 unknown. 2 in all.
Loc. 22 (0.3 m^2): 7 *Robertus lividus*, 2 *Robertus sp.*, 8 *Colobocyba insecta*, 1 *Microneta viaria*, 1 *Centromerus sp.*, 1 *Helophora insignis*, 1 unknown. 21 in all.
Loc. 23 (0.2 m^2): 9 *Robertus lividus*, 1 *Microneta viaria*, 1 *Centromerus silvaticus*, 1 *Rhabdoria diluta*, 2 unknown. 14 in all.
Loc. 24 (0.1 m^2): 1 *Centromerus sp.*, 1 *Lephthyphantes ericaeus*, 1 *Lycosa lugubris*, 1 *Lycosa nigriceps*. 4 in all.
Loc. 25 (0.2 m^2): 1 *Robertus sp.* 1 in all.
Loc. 26 (0.1 m^2): 1 *Oligolophus sp.*, 2 *Colobocyba pallens*, 1 *Trachynotus obtusus*, 1 *Micrargus herbigradus*, 1 *Porrhomma microphtalmum*, 1 *Centromerus arcanus*, 2 *Lephthyphantes sp.*, 1 *Meta segmentata*, 1 unknown. 11 in all.
Loc. 27 (0.1 m^2): 1 *Colobocyba pallens*, 1 *Centromerus silvaticus*, 1 *Tegenaria Derhami*. 3 in all.
Loc. 28 (0.1 m^2): 2 *Colobocyba pallens*, 1 *Cryphoeca sylvicola*, 15 unknown. 18 in all.
Loc. 29 (0.1 m^2): 4 *Plesiocraerus latifrons*, 7 *Colobocyba pallens*, 1 *Micrargus herbigradus*, 1 *Porrhomma microphtalmum*, 1 *Centromerus arcanus*, 24 unknown. 38 in all.
Loc. 30 (0.1 m^2): 2 *Steatoda bipunctata*, 1 unknown. 3 in all.
Loc. 31 (0.1 m^2): 2 *Steatoda bipunctata*, 2 unknown. 4 in all.

Acarina, mites, are the most numerous of all the arthropods in the forest soil, in the main localities found in numbers averaging from 1000 to 10000 per m^2. Only in Locality 2, ravaged by winds, do we find the small collembola predominating. Most of the species living in the forest soil live on decaying vegetable matter and small fungus, and so, owing to their

Table XVI.

Composition of the Acarina-fauna in the 10 Main Localities.

Sammensætning af Middefaunaen paa de 10 Hovedlokaliteter.

Locality Nr....	15	5	9	2	13	20	10	1	6	8
Gamasiformes										
Gamasoidea										
Amblygamasus spp,										
Pergamasus spp etc.	6	11	6	3	3	4	1	6	6	7
Nothrholaspis spp.	.	1	.	.	.	.	2	.	.	1
Veigaia spp.....	27	28	36	29	32	24	22	30	23	13
Asca spp	2	2	2	6	5	1	.	.	5	.
Epicrius spp	2	.	.	.	.	.	.	.	.	.
Uropodoidea										
Cilliba cassidea ..	10	10	.	.	.	5	4	.	.	.
Trombidiiformes										
Trombidioidea										
Leptus nemorum..	1	1	1	.	1	.	.	.	.	.
Sericothrombium sp.	.	.	.	.	.	.	1	.	.	.
Sarcoptiformes										
Oribatoidea										
Camisiidae										
Camisia spp	12	9	9	.	14	22	28	2	3	24
Damaeidae										
Oribata geniculata	6	7	4	.	2	8	1	6	16	3
Dameosoma spp etc.	.	2	.	18	5	.	.	16	7	34
Notaspididae spp	22	20	20	35	8	15	22	38	19	6
Phthiracaroidea spp	12	9	22	9	30	21	19	2	21	12
In all...	100	100	100	100	100	100	100	100	100	100
Per 100										
Weight, mg	7.15	8.70	6.73	3.72	5.49	6.85	5.76	5.85	7.92	5.44
Respiration	21.99	24.55	21.22	14.63	18.70	21.76	19.06	18.79	23.00	16.78
Pr. 1 m^2										
Total Number ..	3206	1919	3049	2390	6161	9818	967	7337	7828	8270
Total Weight, mg	229	167	205	89	336	673	56	429	620	449
Respiration	705	471	647	350	1152	2136	184	1379	1800	1388

large numbers, must play a considerable part in the process of transmutation, especially in raw humus. *Amblygamasus*, *Pergamasus*, *Veigaia*, and several other genera of the *Gamasoidae*, as also all *Trombidiiformes*, however, are rapacious animals, preying on small collembola, small mites, and other tiny animals, probably on nematodes as well.

It has proved impossible to sort the great bulk of material, but for each of the 10 main localities 100 mites have been counted off, provided there were so many, from each of the samples taken out in March, July, and October, 1927, including the various layers of same, thus for most of the localities amounting to about 600 mites. These were then sorted, and the number per cent. in which they occurred will be seen in Table XVI. The Reverend Mr. KNEISSL of Oberalting, Bavaria (Bayern), has been so kind as to determine 33 of the most common species for me, but a thorough examination of the entire material would have given a good many more. In v. PFETTEN's (1925) material from spruce forests in Bavaria, KNEISSL found 113 species; and from the present material, collected from both deciduous and coniferous forests as well as from heaths, the number would probably be found to be still larger. Of the 33 specified species from my material, only 17 are found in v. PFETTEN's list.

The species, determined from my samples, are as follows:

Gamasiformes.

Gamasoidea: *Amblygamasus septentrionalis* Oudms.
Pergamasus theseus Berl.
» *barbarus* Berl.
» *runcatellus* Berl.
Eugamasus cornutus Can.
Macrocheles hypochthonius Oudms.
» *longulus* Berl.
Nothrholaspis tridentinus Can.
Veigaia nemorensis C. L. Koch.
Asca pellata C. L. Koch.
Epicrius reticulatus Grube.
» *geometricus* C & F.

Uropodoidea: *Cilliba cassidea* Herm.

Trombidiiformes.

Trombidioidea: *Leptus memorum* C. L. Koch.
Microthrombidium oudemansi Gem.
Sericothrombium sp.

Sarcoptiformes.

Oribatoidea:
Camisiidae: *Camisia silvestris* Nic.
» *palustris* C. L. Koch.
» *spinifera* C. L. Koch.
» *segnis* Herm.
Damaeidae: *Oribata geniculata* L.
Tectocepheus velatus Mich.
Damaeosoma corrugatum Berl.
Notaspididae: *Banksia tegeocrana* Herm.
Ceratozetes gracilis Mich.
Notaspis colcoptrata L.
Galumna climata C. L. Koch.
Pelops torulosus C. L. Koch.
» *farinosus* Nic.
Phthiracaroidea: *Tritia berlesei* Mich.
Phthiracarus globosus C. L. Koch.
» *magnus* Nic.
» *nitens* Nic.

Collembola, Springtails.

Next to mites, collembola are the most numerous arthropods of the forest soil, in the main localities averaging per m^2 from 500 in oak mull and 900—1400 in beech mull to 5000—7000 in beech raw humus.

Of most frequent occurrence are the quite small species. The *Hypogastruridae* family is sometimes abundantly represented by the bluish-grey *Hypogastrura armata* Nic.; less numerous, but still very common, is the peculiar, clumsy, rugged, hairy, blue *Achorutes muscorum* Templ. Of the white, blind *Onychiuridae,* the *Onychiurus armatus* Tullb. abounds in raw humus soil and wherever it can conceal itself in layers of humus; but, lucifugous as the animal is, it will not thrive in dry soil poor in mull, as Locality 2. On the other hand, here we meet with coloured species of the *Isotomidae* family; the grey *Folsomia quadrioculata* Tullb. and some small purple

species of the *Isotoma* genus (*I. olivacea* Tullb., *I. albilla* Pack., *I. cinerea* Nic.), which, on the whole, are exceedingly numerous everywhere in the forest soil. In sorting these tiny creatures, which are very difficult to handle, it has not always been possible to keep them exactly apart. It is very troublesome to sort quite small specimens of *Folsomia*, *Hypogastrura* and small *Isotoma* species, and the figures for these will often contain a lot of one or both of the others; also *Onychiurus* may contain *Folsomia fimetaria*. In examining with the naked eye the deciduous layer or the moss cover of the forest ground, however, we do not particularly notice these tiny species, but the larger ones: the greenish or yellowish *Isotoma viridis* Bourl. Schött.; the leaden *Pogonognathus plumbeus* Templ. Ågr. of the *Tomoceridae* family, the long flagelliform antennae of which make it easily distinguishable; and several species of the *Entomobryidae* family, especially the large, black- and yellow-pied *Orchesella flavescens* Bourl., but more numerous is the little yellow *Lepidocyrtus lanuginosus* Tullb. Only exceptionally occur the globular species of the *Sminthuridae* family, of which the little yellowish-green ball, hopping on our lawns, *Sminthurus viridis* Lubb., is probably best known.

Collembola live on decaying organic matter, microscopic fungi, etc., and must therefore, owing to their great numbers, play an important part in the decomposition of the plant residue of the forest soil, especially so in that abounding in humus.

Diptera, Two-winged Insects.

Diptera larvae occur in the forest soil in great numbers and in many species, especially in raw humus. The vast majority of them live on decaying organic matter, and next to earthworms they are no doubt the most important of the smaller animals in the forest soil, especially in raw humus, where in number and weight they often exceed the earthworms.

Tipulidae. The crane-fly larvae, owing to their size, constitute the greatest amount in weight. I have taken larvae weighing more than 600 mgr., and the average weight of a large quantity from beech raw humus, Locality 4, was more than

300 mgr. each. These larvae were chiefly *Tipula nubeculosa* Meig. Further, *Tipula rubripes* Schwen. and *Tipula scripta* Meig. were hatched, but most likely there have been several other species. In beech mull both small and large larvae were found. In spruce forests, on the contrary, it was almost exclusively some far smaller *Tipula* larvae, weighing 30—50 mgr., that were found. A closer study of the occurrence of the various *Tipula* larvae in our forests, under conditions varying as to stand and soil, would no doubt have given interesting results, but a task of so special a character would have required more time than I had at my disposal.

The *Tipula* larvae, chiefly living on decaying plant residues, are probably of great importance as devourers of organic matter in raw humus, especially in beech forests, and contribute considerably to the decomposition of the raw humus, rendering it loose and coprogeneous in structure. Several species, however, are known for their attacks on living young plants, among others of forest trees, and to this fact may partly be due the well-known phenomenon that the number of plants in beech sowings gradually dwindles considerably.

The larvae of *Trichocera* species, too, live on decaying plant residues.

The *Triogma trisulcata* larva lives on fresh vegetable matter, especially anemones.

Mycetophilidae owe their name to the fact that the larvae of some species live in fungi (worm-eaten mushrooms). There are others, however, that move about freely, living in the forest soil, as for instance the *Sciara* species, by some investigators, however, assigned to another group. The larvae are small, white, and lucid animals, with black heads. The larvae of the different species are very much alike, and in our examination of them it has proved impossible to distinguish between them. In my samples they sometimes occur in very great numbers, both in deciduous and coniferous forests, though mostly in soil abounding in humus. The larvae found in the forest soil may be supposed chiefly to be of the *Sciara* species, living on decaying plant residues, and, owing to their great numbers, they must contribute largely to the decomposition.

The *Sciara* larvae are particularly well known because they give rise to the phenomen of the so-called »army worm«, which has played an important part in past superstitions. The army worm is a procession of *Sciara* larvae, consisting of many thousands, advancing in a column up to 6 m long, 2—3 cm wide, and more than 1 cm deep, with several layers of larvae on the top of one another. Their wanderings are supposed to take place immediately before their pupation. The phenomenon is quite common in the central parts of Europe. In Bavaria, from the 2nd to the 20th of July, FREUDING (1924) saw every day 5 to 12 of these army worms proceeding along the same path. In Denmark, HENRIKSEN (1925a, 1925b) records 6 observations made by different persons, 4 in Sealand, 1 near Stubbekøbing in Falster and 1 at Rye in Jutland; those registered date from July and August. In a beech stand in Tisvilde Hegn, on May 25, 1928, a very rainy day, I myself found an immense lot of larvae of the *Sciara* type, of a light and somewhat greyish colour, lumped together by the thousands in slimy masses. Each separate lump was a little more than the size of a hand; together they formed a row about 2 meter long, with short intervals between the various groups. I took them to be an army of worms about to break up. An attempt to hatch the larvae failed. None of the Danish army worm species have been specified, but it is reported that larvae of *Sciara gregaria* Bel., *S. militaris* Now., and perhaps (see BELING 1883) *S. Thomae* L., occur as army worms. On April 24, 1927, we found the imagoes of *Sciara umbratica* Zett., in samples from the following localities: 5 (beech mull with *Melica*), 4 (beech raw humus), and 1 (spruce mull). The greatest number was found in the beech raw humus, where I obtained 80 specimens by a thorough searching of a square meter of leaf layer and raw humus.

Bibionidae. The comparatively large, prickly larvae of *Bibio* species are frequently met with in the forest soil. The insects are big, black, long-legged gnats, generally found in beech forests at the beginning of summer. The larvae live on plant residue in the forest soil, but some of the species also attack living plants.

Chironomidae. The peculiar larvae of the genus *Phaeno-*

cladius abounded in some samples from pine forests with bilberry, but were elsewhere sparsely represented. Further, we have found larvae of the *Forcipomyia* and *Metriocnemus* species. They no doubt all live on decaying vegetable matter.

Psychodidae. Larvae of *Psychoda* have been found in Localities 4, 5, and 10 (deciduous forests). They live on decaying vegetable matter.

Leptidae. The smooth and white larvae of *Leptis (Rhagio)* proved to be very common ewerywhere in the forest soil. They are said to be rapacious.

Dolichopodidae. The larvae of this family, too, occurring somewhat more sparsely than the *Leptidae,* are also reported to be rapacious animals.

Lonchopteridae. The characteristic larva of *Lonchoptera,* somewhat resembling a woodlouse, lives on plant residue. It was represented by a few specimens in Localities 5, 10, and 22 (deciduous forest mull).

Anthomyiinae. The larvae of this order are mostly small, white, acephalous maggots. Especially in deciduous forest soil they occur in great numbers, living on plant residue, while other species mine leaves. To these belong also the odd-looking prickly larva of *Fannia.*

Cecidomyiidae. Small larvae of this or a similar type abounded especially in samples from coniferous forest soil. These larvae, too, presumably live on plant residue in the forest soil, while other species live as parasites in galls on living plants. PILLAI (1922) and v. PFETTEN (1925), too, in their examinations of Bavarian pine forests and spruce forests respectively, refer to the great number in which these larvae occur.

Coleoptera, Beetles.

Elateridae. The click-beetle larvae are very common in forest soil, but though many different species of click-beetles are found in the forests in summer, my samples contained larvae of only two species, one of them, *Athous subfuscus* Gyll., in very large numbers, the other, *Dolopius marginatus* L., rather sparsely. The noxious *Agriotes lineatus* L., so well known to agri- and horticulturists, I did not come across. Click-beetle larvae are rather hard, of a light brown and

sheeny colour. The 9th joint of the abdomen, because of its peculiar form, is the most important characteristic of the species. Noteworthy is the uniform occurrence of the click-beetle larvae in the soil; in all probability they constitute the particular family of forest soil fauna that is most regularly distributed, the numbers from samples taken from a certain locality in the various seasons of the year corresponding better than those of any other species. Moreover, the number was very regularly dependent upon the locality, so that in the two best mull localities we found only 12 larvae in a square meter, while the number increased when we approached mull formations with a slower process of decomposition. The four raw humus localities contained from 190 to 250 larvae per m^2.

In the raw humus localities, the weight of click-beetle larvae amounts to 14—32 per cent. of the aggregate weight of all animals. The larval state lasting for several years, they occur at all times, large and small, promiscuously. They generally live in the lower compact layer of raw humus, in contradistinction to earthworms, diptera larvae, and other animals, which prefer the leaf layer or the upper loose layer of raw humus. Click-beetle larvae decidedly belong to soil abounding in humus, and are independent of the soil flora. They are probably pronounced humus-eaters which do good work in the lower raw humus layers shunned by other animals.

However, they will also eat live vegetation when occasion offers. Several click-beetle larvae, amongst others the very species *Athous subfuscus* and *Dolopius marginatus* have proved to cause damage by perforating beech nuts lodged in the forest soil, thus destroying their power of germination. For this reason they must be considered as one of the causes why beech sowings frequently fail in soil abounding in humus. It is recorded by ALTUM that also other click-beetle larvae, *Corymbites aeneus* L., *Lacon murimus* L., *Agriotes lineatus* L.; according to BOAS, *Athous haemorrhoidalis* Fabr. and *Athous vittatus* Fabr. as well, have occurred in damaging numbers, attacking germinating seeds of beech, oak, and conifers, which seems to prove that *Athous subfuscus* is not always so exclusive as was the case during the years of my investigations. SEDLACZEK (1915) records for Austria *Athous subfuscus* as the predominating click-beetle

larva in the forest soil. PILLAI (1922) mentions, from pine forest soil in Bavaria, the genera *Dolopius*, *Athous*, *Elater*, and *Corymbites;* v. PFETTEN (1925), from spruce forest soil in Bavaria, *Athous subfuscus* and *Dolopius marginatus*.

Click-beetle larvae of the *Corymbites* and *Lacon* genera are said to pierce through saw-fly cocoons and devour the pupa, and in this way are of use (ESCHERICH 1925). I have not succeeded in getting the imprisoned *Athous subfuscus* to attack lophyrus pupas, but after the saw-flies had been hatched, they invaded the cocoon, probably to devour the remnants.

Staphylinidae, Rove-beetles, the predominating beetle family in the forest soil, occur in greatest numbers, about 100 per m^2 in raw humus: less numerous, 35—54 per m^2 in rich mull, where, on the other hand, several specimens of larger species are found. The number of *Staphylinidae* larvae was, on an average, about one half in proportion to full-grown beetles; in beech raw humus only, the numbers of both were nearly equal.

Two of the genera: *Atheta*, especially *A.* (sub-gen. *Sipalia*) *circellaris* Grav. and *Othius*, the somewhat bigger *O. punctulatus* Goeze., most numerous, however, the smaller species *O. melanocephalus* Grav. or *O. myrmecophilus* Kiew., abound in all localities; but in other respects there is a considerable difference in samples from deciduous and coniferous forest soils. In the former, we have hardly found any but the two named genera; only in spruce mull, a couple of *Tachinus*, and, in the raw humus Localities 6 and 8, also a few specimens of *Tachinus*, *Xantholinus*, *Lathrobium brunnipes* F. and the medium-sized *Philonthus* (chiefly *P. fuscipennis* Mannh.); in the deciduous forest localities, on the contrary, other species are abundantly represented. In the oak mull, Locality 10, we found *Atheta*, *Othius* (amongst others *O. punctulatus*), *Tachinus*, *Quedius mesomelinus* Mrsk., *Lathrobium brunnipes*, and *Stenus*. In the best beech mull, Locality 15, it was chiefly *Othius* (the small species as well as *O. punctulatus*); next in order, *Atheta*, *Lathrimaeum*, *Stenus*, *Tachinus*, and a few specimens of the larger *Philonthus* species. Locality 5, beech mull with melic-grass, is characteristic for its abundance of species, our collection comprising the following: *Atheta*, *Othius* (several species), *Lathrimaeum*, *Stenus*, *Tachinus*, *Tachyporus*, *Lathro-*

bium (*brunnipes* and another species), *Oxypoda*, *Baptolinus*, *Xantholinus*, and several specimens of *Philonthus*, more numerous here than in any other locality. Less abundant in species is the Oxalis mull, Locality 9 in Grib Skov, which resembles the spruce localities of the same forest, the *Othius* species being strongly predominating (both *punctulatus* and smaller species), besides which only *Atheta* and a single specimen of *Philonthus fuscipennis* were found in the samples. The impoverished soil, Locality 2, contains more individuals and species; *Othius* is indeed predominating, but also the following have been collected: *Atheta*, *Oxypoda*, *Tachyporus*, *Xantholinus*, (*X. punctulatus Payk.*), and *Philonthus*.

Beech raw humus is poor in species compared with good beech mull, but more abundant than the inferior mull formations. In our best raw humus, Locality 4, *Othius* was predominating, but also *Atheta*, *Tachyporus*, *Oxypoda*, *Tachinus*, and *Philonthus fuscipennis* were found, though only a few specimens of each. In inferior beech raw humus, Locality 20, *Othius* and *Atheta* predominated, while *Oxypoda* and *Stenus*, too, occurred.

In walking about the forest, however, we do not particularly notice these small species of rove-beetles, but the larger species, more sparsely represented, which, compared with the ones mentioned above, are veritable giants, e. g. the big, coal black *Staphylinus olens* Müller, the devil's coach-horse, a very ferocious rapacious animal that does not flinch from attacking and devouring ground-beetles of nearly the same size as itself.

Both beetles and larvae are closely attached to the forest soil, where they live on animals, alive or dead; some species, as imagoes, however, are said to live on vegetable matter.

Carabidae, ground-beetles, come next to the rove-beetles in number; they occur chiefly on the mull soil in deciduous forests, where both the greatest number and the largest species are found. In some holes in the ground, dug in the beech stands of Geels Skov and Rude Skov, a great number of ground-beetles were caught in a couple of days on beech mull, while holes dug in raw humus soil contained only very few specimens of these, but a number of scarabees. This is probably due to the fact that the larger species of ground-beetles live mostly on earthworms, which, on mull soil, crawl about

on the surface of the ground during the night. Both beetles and larvae are rapacious animals; some of them, however, live on vegetable matter as well, and may even be considered as noxious animals, though not causing any great damage to forest plants; while other species prove to be useful in catching noxious larvae, especially the *Calosoma* genus.

On the paths in the mully deciduous forests, we most easily catch sight of the large *Procrustes coriaceus* L., the largest Danish ground-beetle; the large species of the *Carabus* genus, especially *C. nemoralis* Müller and *C. violaceus* L.; and the largest of the *Pterostichus* species. The first three, however, occur so sporadically that we did not find them in any of the samples.

In beech mull we have found in Locality 15, Asperula mull, only *Loricera pilicornis* F.; but from Locality 5, melic-grass mull, *Leistus rufomarginatus* Duft., *Pterostichus oblongopunctatus* F., and several specimens of the little brown *Epaphius secalis* Payk. The Oxalis mull, Locality 9, contained *Amara familiaris* Duft. and *Calathus micropterus* Duft. The impoverished soil, Locality 2, is characteristic for the great number of the small, broad-headed, copper-coloured *Notiophilus biguttatus* F.; but *Pterostichus vulgaris* L., *Agonum Mülleri* Hbst., and *Anchonemus parumpunctatus* F., too, were found. On beech raw humus, a few specimens of *Agonum Mülleri* were caught. From oak mull, Locality 10, we have *Epaphius secalis*, *Clivina fossor* L., and several specimens of *Pterostichus* (amongst others *P. oblongopunctatus*). Spruce mull, Locality 1, contained some *Harpalus latus* L. and *Notiophilus biguttatus*. On the two spruce raw humus localities, *Notiophilus biguttatus* predominated, in Locality 6 we also caught a couple of specimens of *Pterostichus oblongopunctatus*.

Of other beetles the following deserve mention:

Cantharidae, the larvae of which are found in all the main localities investigated.

Curculionidae, weevils, of which *Strophosomus* (*rufipes* Steph. and *melanogrammus* Forst.) occurred in all localities, most numerously represented in spruce forests. From beech forests, moreover, may be mentioned *Ceutorrhynchus*, *Apion*, and *Orchestes fagi* L.; from spruce forests *Otiorrhynchus*, *Brachysomus echinatus* Bonsd., *Ceutorrhynchidius* (casual occur-

Table XVII. The most common Beetles are found as Imagoes in the following Number of Samples from the 10 Main Localities.

De almindeligste Biller er fundet i nedenstaaende Antal Prøver fra de 10 Hovedlokaliteter.

Locality	10	15	5	9	2	4	20	1	6	8
Staphylinidae.										
Atheta spp.	3	4	7	2	3	10	4	15	12	16
Othius spp.	2	12	6	14	8	13	5	14	15	15
Philonthus spp.	.	3	4	1	2	4	.	.	2	.
Tachinus spp.	1	3	2	.	.	1	.	3	.	1
Xantholinus spp.	.	.	1	.	2	.	.	.	.	1
Lathrobium spp.	2	.	2	.	.	.	.	.	3	.
Oxypoda spp.	.	.	1	.	1	1	1	.	.	.
Stenus spp.	1	3	5	.	.	.	1	.	.	.
Tachyporus spp.	.	.	2	.	2	1	.	.	.	.
Lathrimaeum spp.	.	3	4	.	.	.	.	.	.	.
Baptolinus spp.	.	.	1	.	.	.	.	.	.	.
Quedius mesomelinus	3	.	.	.	.	.	.	.	.	.
Carabidae.										
Notiophilus biguttatus	.	.	.	.	6	.	.	4	4	5
Pterostichus oblongopunctatus	2	.	1	.	.	.	.	.	3	.
» *vulgaris*	.	.	.	.	1	.	.	.	.	.
» *sp.*	2	.	.	.	.	.	.	.	.	.
Harpalus latus	.	.	.	.	.	.	.	5	.	.
Agonum Mülleri	.	.	.	.	2	1	.	.	.	.
Anchonemus parumpunctatus	.	.	.	.	1	.	.	.	.	.
Calathus micropterus	.	.	.	2	.	.	.	.	.	.
Amara familiaris	.	.	.	1	.	.	.	.	.	.
Epaphius secalis	2	.	3	.	.	.	.	.	.	.
Leistus rufomarginatus	.	.	1	.	.	.	.	.	.	.
Loricera pilicornis	.	1	.	.	.	.	.	.	.	.
Clivina fossor	1	.	.	.	.	.	.	.	.	.
Carabidae spp.	.	.	7	.	.	.	1	.	.	.
Nitidulidae.										
Meligethes spp.	1	6	6	1	2	.	.	3	1	.
Ptiliidae.										
Acrotrichis spp.	12	12	7	1	.	6	2	1	5	1
Curculionidae.										
Strophosomus spp.	1	8	8	3	4	1	.	5	6	7
Curculionidae spp.	.	1	2	.	4	1	.	5	3	1
Ipidae.										
Hylurgops sp. etc.	.	.	.	.	.	.	.	1	4	2
Coccinellidae.										
Coccinellidae spp.	.	1	3	1	.	.	.	.	.	.

rence), and *Cryptophagus*. In the oak locality, No. 10, some weevil larvae were found in the soil, where they live on roots; presumably *Phyllobius*.

Ptiliidae, minute beetles, the hind wings of which have been transformed into a small list surrounded by a hairy rim, making them look like small feathers, are represented by several species of the *Acrotrichis* genus. They were exceedingly numerous in good oak and beech mull, somewhat less so in beech raw humus, and only sparsely represented in the poor Oxalis mull and in the spruce forests; in the impoverished beech mull, entirely wanting.

Meligethes, abounded in the two beech mull localities, 15 and 5, where they live on the soil flora, but were found in most of the other localities as well.

Other beetles occurred in such small numbers as to render them accidental, and so we shall confine ourselves to merely mentioning what we found in each locality. Oak mull, Locality 10: *Ptinus* and *Phyllotreta;* beech-Asperula mull, Locality 15: *Hydrobius fuscipes* L. (also aquatic), *Nargus anisotomoides* Spence (found in mouse burrows), and a *Coccinella;* beech-Oxalis mull, Locality 9: *Calathus micropterus*, *Anatis ocellata* L., and a *Coccinella;* beech-Polytrichum soil, Locality 2: *Cryptopleurum minutum* F. and *Sphaeridium;* beech raw humus, Locality 13: *Rhagonycha lignosa* Müller, *Lathridius* and *Rhantus* (a water-beetle accidentally tumbled down); beech raw humus, Locality 20: *Stenichnus collaris* M. & K.; spruce mull, Locality 1: *Catops* (found in mole tracks), *Cryptophagus*, *Ernobius*, and *Brachysomus echinatus* (quite numerous); spruce raw humus, Locality 6: some species of *Hylurgops palliatus* Gyll. (living temporarily in the soil); and spruce raw humus, Locality 8: *Hylobius abietis* L. and *Hylastes*.

The above reference to beetles and their occurrence comprises the normal types only, as represented by the 10 main localities. Of other types may be mentioned:

Oak with beech undergrowth, Locality 22: *Othius*, *Atheta* (plentiful), *Lathrimaeum*, *Acrotrichis* (a good many), *Meligethes*, *Strophosomus*, *Trechus quadristriatus* Schrank.

Oak on heathland (Skærbæk), Locality 23: *Othius*, *Atheta*, *Tachyporus*, *Conosoma*, *Strophosomus*, *Lathrimaeum*, *Agathidium*.

Pine stand *(Pinus silvestris)* with bilberry *(Vaccinium myrtillus)*, Localities 26, 27, 28, and 29: *Othius punctulatus, Atheta, Lathrobium brunnipes, Oxytelus, Quedius, Notiophilus biguttatus, Pissodes, Meligethes, Acrotrichis.*

Heathlands, Localities 18, 19, 24, and 31: *Bradycellus* and *Lochmaea suturalis* Thoms. (these two particularly numerous); *Othius, Stenus, Olophrum,* and *Ceutorrhynchus. Lochmaea suturalis* sometimes occur on heather in large numbers, and are supposed, occasionally, to be the cause of the starvation of the plant (Entomologiske Meddelelser, vol. XVI, pp. 114—115).

From mountain pine, Locality 12, we note: *Othius, Lathrobium, Aleochara,* and *Meligethes.*

From ash, Locality 16: *Othius, Acrotrichis,* and *Hermacophaga mercurialis* F.

Apart from *Elateridae* and *Staphylinidae,* in the case of which the differences between deciduous and coniferous forests proved to be very pronounced, our material of beetles is too scanty to enable us to draw up further conclusions about the distribution of the species. I am greatly indebted to Mr. VICTOR HANSEN for having kindly determined the numerous beetles collected.

Table XVII gives a synopsis showing in how many samples the various chief species and genera were found.

Lepidoptera, Moths and Butterflies.

In the forest soil we find a few moth caterpillars, mostly of the *Agrotis* and *Hepialus* genera. As their number is confined to a few specimens per square meter, their presence in the forest soil is of no importance, but the *Agrotis* caterpillars may possibly be one of the concurrent causes of the destruction of young saplings. In spruce forest soil we found some larvae of *Microlepidoptera,* probably a *Tortricidae* species; but they occur as lodgers only, and do not affect the soil itself.

Hymenoptera, Membrane-winged Insects.

We meet with larvae and cocoons of saw-flies, roving ichneumons and other wasps; bumble-bees and wasps have their habitations in the forest soil. In spruce forest soil I have

found numerous cocoons of *Lophyrus hercyniae* Htg., in mountain pine plantations large quantities of *Lophyrus rufus* Kl. cocoons, several hundreds per square meter. In both places the hatching resulted in a great number of ichneumons, as well as saw-flies. None of these, however, play any part in the transformation of the forest soil.

Otherwise with the ants, *Formicidae*, which occur in such great numbers as to affect the soil, partly by preying on other animals living in the forest soil and thus perhaps changing the character of the fauna, partly by working the earth and demolishing the stubs. Their importance, however, is greater on grassy plains, where the soil surface undergoes a complete change owing to the numerous ant-hills, which grow higher and higher every year and are covered with a dry-flora of their own: *Thymus*, *Galium verum*, etc.

Hemiptera, Bugs.

In the spruce forest soil we found a number of bugs and their larvae, amongst others *Orthostira cervina* Germ. In deciduous forest soil the wax-covered *Newsteadia floccosa* Deg. was a regular inhabitant, probably sucking the roots of the trees. It was not found in my sample from unmixed spruce, but occurred in mixed larch and spruce forests, as also in pine stand with bilberry. v. PFETTEN found it common in Bavarian spruce forests. It is thus a quite regular inhabitant of the forest soil, but rarely occurring in numbers of more than 100 per square meter, this tiny animal is of very little importance.

Orthoptera, Straight-winged.

Forficulidae, earwigs, occur regularly in the soil of deciduous forests. We have found the species *Forficula auricularia* L. and *Chelidura acanthopygia* Géné. in the samples. In young coniferous forests, cockroaches of the genus *Ectobia* are numerous. In glades we come across several kinds of grasshoppers. None of these, however, are of much importance to the forest soil.

Thripidae, Thrips.

Of these minute insects we have only found a few specimens per m^2; so they cannot affect the forest soil at all.

The most common species was *Haplothrips aculeatus* Fab.; moreover, a number of larvae from *Liothrips hradecensis* Uz. were collected.

Talpa Europaea L., The Mole.

Moles live mostly on earthworms, but they also devour a number of insect-larvae and other small animals. By examining their stomachs, SACHTLEBEN (1925) found cockchafer larvae in 104 animals, click-beetle larvae in 99, millipeds in 96, and earthworms in only 65. These investigations would seem to prove that moles are really useful insectivores. Most authors state, however, that their chief food is earthworms, which they can devour in large quantities. TAUBER (1872) examined 50 moles, and found earthworms in all of them, of other animals only 11, mostly ground-beetles and geophilids, but also a few noxious larvae, amongst others the cockchafer. If the mole catches more earthworms than it can devour at once — according to HAUCHECORNE (1927) about 100 gr. a day — it bites off their heads so as to prevent them from escaping, and immures them in the tracks near its habitation. FR. DAHL (1883) found no less than 1280 earthworms thus immured in the surroundings of one habitation. Judging from its requirements as to food, we should think that the mole could very well live in raw humus soil. Yet I have never found it there, while in mull soil it occurs everywhere in Danish forests, with the exception of certain parts of Denmark, as for instance the islands of Bornholm (WINGE (1908) and Møen (POVLSEN 1921) and several of the smaller islands. Through Vester Hanherred and through Skodborg and Vandfuld Herreder in N. W. Jutland, it recently began to migrate (DEGERBØL 1923 & 1924 b).

When the mully forest ground often gives way under our foot, it is because we have stepped into a mole's hunting track running horizontally so near the surface that the upper part is on a level with the ground. In the soft earth directly under the leaf layer, the mole can form its tracks without having to dig. This is the reason that mole hills hardly ever occur in forests; practically the only exception is due to compactness of ground, thus e. g. in case the mole is to pass a rutted track, where the earth has been pressed together by the passage of carts,

or if it should stray into soil poor in mull. Mole tracks often run at a regular distance of about 40 cm, and are wonderfully parallel, as may be seen in Fig. 6, showing two gauged systems of hunting tracks in mully beech forests. I have found 4 m tracks per m^2, corresponding to about 40 km tracks per hectare. The mole tracks being 4 cm wide, they represent no less than 16 per cent. of the total area of the forest soil. Besides these hunting tracks, the mole has also a number of deeper ones, and the habitation itself is often at a considerable

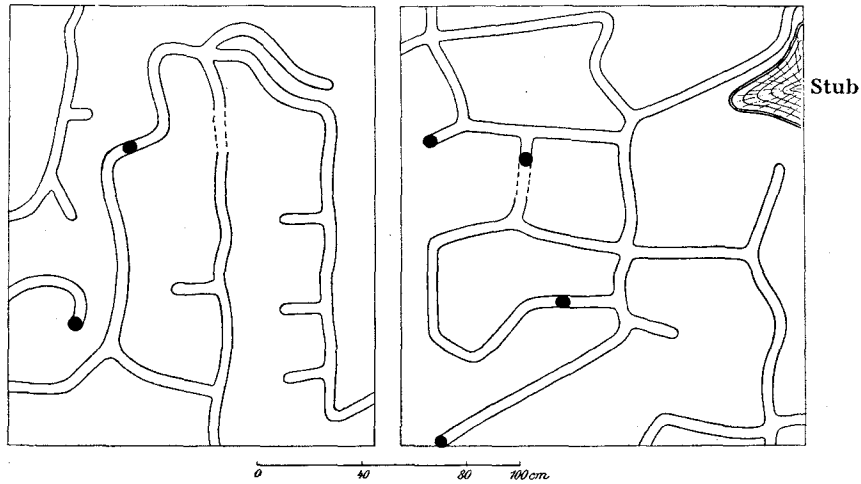


Fig. 6. Moles hunting track systems in the mull soil of a beech forest. The black points indicate entrances to deeper tracks.

depth, or hidden below the base of a tree. Only in wet bogs is its habitation sometimes raised above the ground in a suitably constructed mound of earth.

The work done by the mole is very considerable. The volume of the tracks in the drawings amounts to about 50 m^3 per hectare. Its extensive track systems must undoubtedly affect the distribution of water in the soil. The most conflicting views however have been put forward as to the value of same. ALTUM, who strongly emphasizes how useful the mole is as an insectivore, thus scorns the idea that it should be of any use as a drainer. There can hardly be any doubt, however, that its tracks, especially during heavy showers or sudden thaw when the earth is frozen, will absorb the water

and facilitate its distribution in the earth, where otherwise it would cause local inundations. On the sides of ditches we often see mole tracks acting as drains. Especially in flat and clayey areas, mole tracks contribute to the removal of water, which otherwise would remain on the surface, and in this way they may save both roots and earthworms from suffocation for want of oxygen. It happens that very hard and clayey soil is shunned by both moles and earthworms, but then the growth of trees is very poor. In grassy areas, numerous mole hills will make the surface uneven, giving rise to a diversified flora because of the fresh virgin soil, constantly appearing, in which the different seeds can germinate. Possibly the mole may cause some damage in keeping down the number of the indispensible earthworms; but it may also be that it is able to live sumptuously on a surplus of earthworms due to their enormous power of propagation. Even though the mole in working the earth far from copes with the earthworm, it must be supposed to belong to the most important of the animals useful in forest soil.

Localities compared.

A comparison between the various types of fauna in the forest soil is most feasible by putting together the figures for the chief groups of animals from the 10 main localities, from which we have made a whole series of observations and been able to strike averages. This has been done in Tables XVIII and XIX, showing the aggregate weight of animals and their numbers per square meter, respectively.

The fauna of the forest soil consists, partly of animals spending their whole life, or at any rate the greater part of it, in the forest soil, where they find their sustenance, partly of animals that only temporarily take up their abode in the soil, either as pupas or hibernating larvae or as full-grown insects, without consuming any food. It is evident that the latter category is of only the slightest significance in the economy of the forest soil; but our investigations also go to prove that these animals, in numbers and weight, normally represent so small a fraction of the entire fauna that we can leave them out of our present considerations altogether.

The fauna properly belonging to the forest soil we shall naturally divide into three groups. 1: Animals living on deciduous organic matter on the soil, at the same time, and to a considerable extent, mixing same with the mineral topsoil, which they riddle through, thus making it friable and porous; earthworms *(Lumbricidae)* only belong to this group. 2: Animals decomposing and devouring deciduous organic matter on the soil, thus contributing to the demolition of same, mostly without working in the mineral topsoil, which they do not at all, or at any rate very slightly, help to mix with organic matter: to this group belong *Gastropoda* (snails), *Enchytraeidae* (potworms), *Isopoda* (woodlice), *Diplopoda* (millipeds), *Acari* (mites), *Collembola* (springtails), *Diptera* (two-winged insects), *Elateridae* (click-beetles), and other insects except *Staphylinidae* and *Carabidae;* a few other exceptions obtain, a small number of mites, for instance, being rapacious animals. 3: Animals that live on prey; they devour other animals living in the forest soil, thus contributing to the regulation of their numbers, but perhaps often reducing their quantities more than desired so as to check the activities of useful animals, even as the protozoa have been considered a check on the activities of bacteria in the forest soil; to this group belong *Chilopoda* (centipeds), *Arachnida* (except *Acarina*), *Staphylinidae* and *Carabidae.* In the tables, these three groups of forest soil fauna have been summed up separately. (An exception is the mole, referred to above, which does a great excavating work, but lives on prey).

Let us first look at the weight of the fauna (Table XVIII), for in gauging the quantities we shall thus gain a better estimate than by the number of animals. The very first fact we ascertain is that the total weight of animals in deciduous forest soil gradually falls in proportion to the deterioration in soil quality, from 76.81 gr. per m^2 in the superior oak mull to 12.90 gr. in the Oxalis mull, and right down to 5.25 gr. in the impoverished soil where raw humus formation has set in. In beech raw humus, on the contrary, we find comparatively high weights: in the best raw humus, Locality 4 in Rude Skov, no less than 24.02 gr. and in the inferior raw humus of Grib Skov, 16.57 gr. both figures exceeding the weight of animals in Oxalis mull, Locality 9, Grib Skov.

In spruce forests there is no marked difference between the total weights from mull with *Oxalis* on one hand, and the two raw humus localities on the other, one of the latter being a little higher, the other a little lower than that of the mull locality. All three of them verge on the beech-Oxalis mull.

The same consecutive order obtains in deciduous forests for the weights of earthworms, varying from 61.00 gr. in oak mull to 5.90 gr. in Oxalis mull, and right down to 1.45 gr. in deteriorated soil. In the best beech raw humus we find, which is particularly worth noticing, the same weight of earthworms as in the Oxalis mull, corresponding to the weight of earthworms in spruce-Oxalis mull as well. In the inferior beech raw humus of Grib Skov, the weight of earthworms is about the same as in the two spruce localities with raw humus in the same forest.

For the second group of animals, living on humus, the proportions are quite different. In the deciduous forest mull localities, indeed, the aggregate weight of these animals corresponds to the quality of the soil, including that which has deteriorated; but when we come to the real raw humus soil, we find the best quality of same containing a weight exceeding all the mull localities, and the poorest beech raw humus is superior to the Melica mull. Of spruce localities, mull is lowest, while both this and the poorest spruce raw humus are inferior to the beech-Oxalis mull, and the best spruce raw humus is much higher, — equal to the inferior beech raw humus.

Regarding the rapacious animals, the figures at a first glance seem to be somewhat fortuitous and, moreover, quite low. Yet it is interesting to note that the poorest raw humus soils contain comparatively many. But we must also consider the relative number of rapacious animals, in which case their weights gradually rise from a little more than 1 per cent. in the best mull to as far as 3 per cent. in Oxalis mull, and then jump to about 20 per cent. in the Polytrichum type. In good beech raw humus, rapacious animals amount to only about 4 per cent.; in spruce mull and good spruce raw humus, hardly 10 per cent.; but in the poor beech raw humus and in the poorest spruce raw humus, nearly 25 per cent., of the total animal weight. The difference is chiefly due to the great number of *Chilopoda*, the inferior raw humus soils containing

Table XVIII. Weight of Fauna in the 10 Main Localities, Grammes per 1 m^2.

Faunaens Vægt i Gram pr. m^2 paa de 10 Hovedlokaliteter.

Stand	Oak	Beech						Spruce		
Soil	Mull	Mull			Poly-	Raw Humus		Mull	Raw Humus	
Soil Flora	Mercur-ialis	Asper-ula	Melica	Oxalis	trichum Type	no Flora	no Flora	Oxalis	Hylo-comium	Hylo-comium
Locality Nr.	10	15	5	9	2	4	20	1	6	8
1. Lumbricidae	*61.00*	*53.10*	*27.90*	*5.90*	*1.45*	*5.40*	*1.15*	*5.05*	*0.90*	*1.55*
Gastropoda	5.32	4.95	3.98	0.92	—	3.21	1.65	0.16	0.15	—
Enchytraeidae	0.68	1.07	1.09	0.72	0.22	1.56	1.19	0.02	0.13	0.05
Isopoda	0.28	0.15	0.15	0.00	—	0.05	0.01	0.00	—	—
Diplopoda	4.70	7.50	1.87	0.92	—	1.13	0.69	0.36	0.10	—
Acarina	0.06	0.23	0.17	0.21	0.09	0.34	0.67	0.43	0.62	0.45
Collembola	0.10	0.06	0.06	0.08	0.30	0.22	0.28	0.09	0.08	0.14
Diptera	3.10	1.51	1.03	2.00	1.10	7.04	3.35	1.49	4.31	1.03
Elateridae	0.18	0.18	0.58	1.33	0.60	3.48	2.85	0.88	3.71	3.14
Other Insects (÷ *Staphylinidae & Carabidae)*	0.55	0.56	0.42	0.45	0.33	0.52	0.28	1.29	1.12	1.12
2. Diff. Humivorous Animals	*14.97*	*16.21*	*9.35*	*6.63*	*2.64*	*17.55*	*10.97*	*4.72*	*10.22*	*5.93*
Chilopoda	0.61	1.29	0.20	0.15	0.84	0.51	4.10	0.56	0.74	1.76
Arachnida (÷ Acarina)	0.06	0.03	0.04	0.07	0.03	0.13	0.09	0.03	0.04	0.07
Staphylinidae	0.11	0.11	0.16	0.14	0.26	0.43	0.24	0.25	0.24	0.45
Carabidae	0.06	0.03	0.11	0.01	0.03	0.00	0.02	0.11	0.08	0.08
3. Rapacious Animals	*0.84*	*1.46*	*0.51*	*0.37*	*1.16*	*1.07*	*4.45*	*0.95*	*1.10*	*2.36*
Total	**76.81**	**70.77**	**37.76**	**12.90**	**5.25**	**24.02**	**16.57**	**10.72**	**12.22**	**9.84**

Table XIX. Number of Animals in the 10 Main Localities per 1 m^2.

Antal Dyr pr. m^2 paa de 10 Hovedlokaliteter.

Stand	Oak	Beech						Spruce		
Soil	Mull	Mull			Poly-trichum Type	Raw Humus		Mull	Raw Humus	
Soil Flora	Mercur-ialis	Asper-ula	Melica	Oxalis		no Flora	no Flora	Oxalis	Hylo-comium	Hylo-comium
Locality Nr.	10	15	5	9	2	4	20	1	6	8
1. Lumbricidae	*122*	*177*	*93*	*73*	*29*	*81*	*23*	*101*	*18*	*31*
Gastropoda	68	105	66	16	0	52	83	4	2	0
Enchytraeidae	342	533	547	359	108	782	595	42	258	91
Isopoda	283	149	151	3	0	53	5	1	0	0
Diplopoda	110	177	67	22	0	39	21	10	2	0
Acarina	967	3206	1919	3049	2390	6161	9818	7337	7828	8270
Collembola	493	1198	920	1383	5032	5114	7151	2210	1702	2302
Diptera	271	232	349	447	261	1076	883	757	336	482
Elateridae	12	12	39	89	41	232	191	59	249	211
Other Insects *(÷ Staphylinidae & Carabidae)*	129	222	106	168	58	194	154	54	86	127
2. Diff. Humivorous Animals	*2675*	*5834*	*4164*	*5536*	*7890*	*13703*	*18901*	*10474*	*10463*	*11483*
Chilopoda	40	78	8	8	28	21	273	35	49	117
Arachnida (÷ Acarina)	60	37	56	78	30	144	100	34	46	67
Staphylinidae	53	57	82	68	129	213	120	125	121	225
Carabidae	28	6	21	6	15	1	8	21	15	15
3. Rapacious Animals	*181*	*178*	*167*	*160*	*202*	*379*	*501*	*215*	*231*	*424*
Total	**2978**	**6189**	**4424**	**5769**	**8121**	**14163**	**19425**	**10790**	**10712**	**11938**

an abundance of the thin, yellow *Geophilidae* species, a fact that might seem to indicate that these animals represent an inhibiting factor.

If thus we take a look at Table XIX, we are at once struck with the peculiarity that the number of animals in all the deciduous forest localities rises in proportion to the deterioration of the soil, from nearly 3000 in the good oak mull to about 20 000 in the poorest beech raw humus; only Locality 15 is to some degree an exception.

This observation seems to express the conformity to a law, which may be formed as follows: The soil in which decomposition is most active contains the greatest weight of animals, but the lowest number; where decomposition is slow so that a heavy layer of raw humus is formed, we find the greatest number of animals, but, on an average, these are very small, and their total weight is lower than that of the best soil. In other words: The good forest soil contains few and large animals; the inferior one, many and small animals.

There is no such difference between spruce mull and spruce raw humus in our localities; but in the proportion between the two spruce raw humus localities, the rule again applies, as the inferior one, Locality 8, contains a greater number and a smaller weight than the better Locality 6.

In the next place, the two tables will tell us a good deal about the various groups of fauna in their relation to the different types of forest soil.

Gastropoda, snails, clearly belong to deciduous forests; there were most of them on the best mull, but quite a number on raw humus as well; while in the spruce localities there were but very few; one of the spruce raw humus localities and the impoverished beech soil were without snails.

Enchytraeidae, the tiny white potworms, abounded in deciduous forests, except in the Polytrichum soil. In spruce forests there were but few of them.

Isopoda, woodlice, are indigenous to deciduous forest mull, but some few occur in beech raw humus, too.

Diplopoda, millipeds, first and foremost, belong to the mull of deciduous forests, but occur largely in beech raw humus as well; more sparsely in good spruce forest soil.

Diptera. Larvae of two-winged insects, mostly prefer good

raw humus soil, both in beech forests and spruce forests, crane-fly larvae in particular playing an important part.

Still more closely attached to raw humus, however, are *Elateridae* (click-beetle) larvae, of which there are 20 times as many in raw humus as in good mull. As in the case of diptera larvae, however, the good quality of raw humus fosters the greater number. Click-beetle larvae and diptera larvae are the most prevalent animals in raw humus soil.

The two groups of minute arthropods, *Acarina* (mites) and *Collembola* (springtails) constitute, numerically, by far the greater part of the fauna, but their weight amounts to very little. Greatest is their number in beech and spruce raw humus, where, for the three Grib Skov localities, they constitute 6 per cent. of the aggregate weight; in the poor Polytrichum soil, their weight exceeds 7 per cent. In deciduous forest mull, mites were nearly twice as numerous as collembola, but in beech raw humus the difference was rather small, and in the Polytrichum type there were more than twice as many collembola as mites. In spruce forest soil, the number of mites is from 3 to 5 times as great as that of collembola. Mites are thus strongly predominating in spruce forest soil, and in the poor soil of heath plantations their number would be still greater than in any of the samples here referred to.

As for *Chilopoda*, we have already mentioned the enormous amount of *Geophilidae* in the two inferior raw humus localities.

The number of spiders seem to be greatest in the beech raw humus, and that of rove-beetles greatest in beech raw humus and in spruce forests. Ground-beetles are apparently most prolific in mull soil, and the large species are mostly found here, but the number of them is too small to allow of conclusions.

In order better to understand the connection between certain types of forest soil and the particular groups of fauna, we shall more closely examine the upper soil of different types. Plates XI, XII, and XIII represent photographs of pillars of soil, 30 cm in height, cut out by means of zinc boxes made for the purpose, in the following six localities. 15: Good beech mull with *Anemone* and *Asperula;* 9: Beech-Oxalis mull; 2: Impoverished beech soil of the *Polytrichum* type; 4: Heavy

beech raw humus abounding in fauna; 1: Spruce with Oxalis mull; and 6: Spruce raw humus with a thick moss covering of *Hylocomium* species. The samples were, in the zinc boxes, taken to the study, and there photographed.

The profile of Locality 15, where earthworms predominate in the fauna, exhibits, for the uppermost 20 cm, a homogeneous coarse structure of lumps, which in size correspond to worm casts, of which evidently the layer is composed. At the foot of Plate XV, worm casts and fragments of leaves are represented in their natural size. Below the forenamed layer the earth is more compact, but still retains to some extent the same structure a little lower down. The colour is uniformly greyish-brown throughout. The earth, less acid than any of the subsequent samples, has the greatest acidity, $p_H = 4.6$, in the topsoil, just below the layer most strongly affected by the worms, and grows less acid downwards, as follows: $p_H = 5.1$ at a depth of 70 cm, $p_H = 5.6$ at 90 cm. At a depth of 140 cm, the earth contains carbonic lime, and has $p_H = 7.2$. At 200 cm $p_H = 7.5$.

The profile of beech-Oxalis mull, Locality 9, too, has a very loose layer on top, but as the earth is more sandy, and consequently less cohesive, the lumpy structure is less pronounced. The mull soil is more largely mixed with demi-black, mouldered, organic substances, giving it a greyish colour. At a depth of 20 cm, the soil is very compact, which may be due to the relative absence of the larger, earth-riddling worms, and the dense topsoil, as shown by the photograph, is somewhat decolorized. Acidity culminates at 15 cm, higher than in Locality 15, but the soil is far more acid, $p_H = 3.9$; from this point acidity decreases gradually downwards, p_H attaining 5.3 at a depth of 1 m and 5.5 at 2 meter.

In the Polytrichum type, Locality 2, where no large-sized earthworms occur, the soil proves to be equally compact to the very top, and covered with a thin, dark layer of raw humus, interwoven by roots. The topsoil is greatly decolorized, especially the uppermost 20 cm, which not long ago must have been friable mull soil, and immediately below the thin layer of raw humus, appears a 2 cm wide streak of leached sand, and underneath, a narrow, dark streak of soft pan. Acidity culminates at this point, where there are no

earthworms, much higher than in the two previous localities, viz. in the podsolized streak immediately below the raw humus. That the earth here is a little less acid, $p_H = 4.0$, than in the Oxalis soil is no doubt due to the fact that the deterioration of the soil is of comparatively recent date, and that the earth is more clayey.

The Photo from Locality 4 shows the 10 cm deep raw humus, the upper part of which is brown and loose, the lower one black and compact, differing so markedly from the very light leached sand, under which we find a streak of soft pan, at a depth of 20—26 cm. Under this again we have the somewhat lighter, normal-coloured topsoil. Acidity culminates at $p_H = 3.6$ in the lower part of the raw humus, that is to say, as in the previous localities, in the upper part of the layer not affected by fauna; from this point acidity gradually sinks to $p_H = 4.8$ at a depth of 90 cm, and $p_H = 5.3$ at 200 Centimeter.

The profile of spruce mull, Locality 1, shows an upper layer of needles and the black layer of mull, rather markedly distinguished from the topsoil, the 3 upper centimeters of which are of a very dark humus-colour. The topsoil is very compact, which in the picture appears from the smooth-cut section, and at a depth of 9—15 cm it is distinctly decolorized. The profile shows that fauna, including earthworms, keep to the surface mull, and, in examining the fauna, we also ascertained that the turgid worm *(Allolobophora turgida)*, the chief worker of the upper topsoil, was wanting in this form of mull. The earth is most acid in the upper mineral topsoil, where same is mixed with humus; that is, immediately below the layer affected by the fauna. The mull layer is very acid, $p_H = 4.3$, and the upper, most acid, topsoil layer has $p_H = 4.1$, a degree of acidity that is not far removed from that of the raw humus. Acidity sinks rapidly to $p_H = 5.2$ at a depth of 1 meter, and $p_H = 5.6$ at 2 meter.

The profile of spruce raw humus from Locality 6 shows moss on top; directly underneath, about 10 cm loose, brown, upper raw humus (mouldering layer), abounding in animal life; and about 5 cm of compact, black raw humus (amorphous humus layer), where only few animals are found (Vermoderungsschicht and Humusstoffschicht, HESSELMAN 1926, p. 516). The transition to the compact layer of leached sand is abrupt, while

Table XX. Analysis of four Soil Sections.

Analyser fra fire Jordbundsprofiler.

Description of Localities and Soil	p_H	After 6 Weeks Storing mgr. in 1 kgr. Dry Soil		Percentage of Dry Matter			Total-N Percentage of Dry Soil
		Am-N	Nitr-N	Organic Matter	Hygroscop. Water	Ignition Rest	
Loc. 15: Beech, Mull, Anem.-Asper.							
Newly-fallen leaves, 1.5 cm	5.9	Trace	2.2	78	11	11	1.15
Old leaf layer, 0.5 cm	6.1	84	1200	54	8	38	0.92
Worm casts	5.8	8	264	22	3	75	0.42
Upper mull soil, 0—5 cm depth	5.4	4	48	14	2	84	0.29
Lower mull soil, 5—15 » »	5.2	2	7.5	7	1	92	0.15
Topsoil, at 35 » »	4.6	0	0.5	4	1	95	0.08
Subsoil, » 70 » »	5.1						
» » 90 » »	5.6						
» » 140 » »	7.2						
» » 200 » »	7.5						
Loc. 4: Beech, Raw Humus.							
Newly-fallen leaves, 2 cm	5.9	0	3.0	82	11	7	1.19
Old leaf layer, 2 cm	5.6	252	20	80	11	9	1.58
Upper raw humus, 0—4 cm depth	4.3	388	Trace	76	10	14	1.68
Middle » 4—7 » »	3.7	95	Trace	59	8	33	1.23
Lower » 7—9 » »	3.6	32	0	63	9	28	1.26
Leached sand at 15 » »	3.8	0	0	3	1	96	0.06
Soft-pan, » 30 » »	3.9	0	0	4	1	95	0.08
Topsoil, » 45 » »	4.6						
Subsoil, » 90 » »	4.8						
» » 200 » »	5.3						
Loc. 1: Spruce, Mull, Oxalis.							
Needle layer, 1 cm	4.7	336	75	61	8	31	1.15
Mull layer, 0—2 cm depth	4.3	80	26	37	6	57	0.82
Upper topsoil, at 8 » »	4.1	2	5.0	6	2	92	0.15
Topsoil, » 22 » »	4.2	0	1.0	4	1	95	0.08
» » 35 » »	4.3						
» » 50 » »	4.5						
» » 65 » »	4.8						
Subsoil, » 100 » »	5.2						
» » 200 » »	5.6						
Loc. 6: Spruce, Raw Humus, Moss.							
Moss & needle layer, 4 cm	4.3	462	7.5	77	12	11	1.47
Upper raw humus, 0—5 cm depth	3.6	115	0.8	76	12	12	1.42
Middle » 5—8 » »	3.5	32	Trace	70	10	20	1.18
Lower » 8—10 » »	3.5	21	0	49	7	44	1.06
Leached sand, at 20 » »	3.6	0	0	2	0	98	0.04
Soft pan, » 30 » »	3.7	2	0	6	2	92	0.11
Topsoil, » 40 » »	3.9						
» » 50 » »	4.3						
» » 60 » »	4.7						
» » 80 » »	4.7						
» » 100 » »	4.5						
» » 140 » »	4.8						

same is succeeded by soft pan at a depth of 28 cm. Just as in beech raw humus, acidity culminates in the lower compact raw humus, $p_H = 3.5$, and sinks rapidly to $p_H = 4.7$ at a depth of 60 cm. At a depth of 140 cm, $p_H = 4.8$.

Analyses of Localities, 15: Good beech mull with *Anemone -Asperula*, 4: Beech raw humus, 1: Spruce mull with *Oxalis*, and 6: Spruce raw humus, (taken Dec. 1926) see Table XX.

We see how on beech mull the newly-fallen leaves recently initiate the process of nitrification, which in leaves from past year proves to be so brisk as to keep pace with the formation of ammonia nitrogen. At the same time, acidity has fallen a little. In the loose layer of wormcasts, immediately underneath, the natural size of which we see at the foot of Plate XV, nitrification is very brisk, too, but sinks as we go down, at first slowly, later on, rapidly. The earth gets more acid a little way down in the topsoil, but decreases in acidity, once more, towards the subsoil, the upper part of which having a p_H corresponding to ordinary mineral soil poor in bases; the deeper subsoil, abounding in carbonic lime, is alkaline.

On beech raw humus, the upper layer of newly fallen leaves reacts in the same way as on mull, but already in one year old leaves (Plate XIV, at the top) the difference proves to be considerable, the amount of ammonia being many times greater than that of nitric acid, and the quantity of released, assimilable nitrogen is much smaller per cent., than in the mull; but, owing to thickness of the layers, the aggregate quantity is very considerable. As against what we found on the mull, the old leaf layer is more acid than the newly-fallen one. In the raw humus the degree of acidity rises very rapidly, and the lowest layers are the most acid. In the upper loose raw humus (the mouldering layer) the chief domain of fauna, and where still many fragments of leaves are traceable (Plate XIV, bottom left corner), the formation of ammonia is very brisk; less so in the intermediate, more compact, raw humus; and down in the compact, amorphous layer of humus (Plate XIV, bottom right corner), where only very few animals occur, the formation of ammonia is very slight; only a trace of nitric acid was found in the raw humus. In leached sand and soft pan, no release of assimilable nitrogen at all was traceable. We find the highest degree of acidity in the lowest part of the raw humus, gradually sinking as we reach the

topsoil underneath, until in the subsoil it is about equal to that part of the subsoil in Locality 15 situated above the lime boundary.

The original material for the formation of humus, viz: beech leaves, is apparently the same in 15 and 4, and the local climate now differs but very slightly. If we are to look for the causes why the processes diverge so strongly in the two localities we shall have to emphasize two factors. One of these is the soil flora on the mull, offering a contribution of organic matter very easily decomposable and acting as a stimulant on bacteria, as I have shown by laboratory experiments (BORNEBUSCH 1925, p. 236), as also on other organisms, e. g. the *Enchytraeidae*. The other factor is the presence of earthworms, depositing in the leaf layer their casts abounding in mineral soil and bases, the probability being that the process of decomposition comes to a standstill on raw humus owing to a deficiency in mineral matter, so indispensible to the life of bacteria. That the difference cannot be due to the rest of the fauna, chiefly arthropods, is obvious, for these are just as numerous in the raw humus as in the mull. Because of the slower process of decomposition, the leaf layer on raw humus is much thicker than on mull; in the course of a few years, however, it undergoes a transformation, because the fauna of the raw humus gnaws it to fragments and devours it, changing it into the loose, upper raw humus (the mouldering layer), consisting of fragments of leaves intermixed with the excrements of animals, in which the formation of ammonia is still quite briskly going on. In the process of decomposition, the mass more and more changes into amorphous humus and becomes more compact; the decomposition grows slower, without however stopping altogether in the lower layers.

On spruce mull, the process of decomposition is considerably slower than on beech mull. Nitrification is slight, and the quantities of ammonia nitrogen are 4 resp. 3 times as great as nitrate nitrogen, in the needle and the mull layers, down in the topsoil, the formation of nitric acid predominates, and the total amount of nitrogen released is not inconsiderable. Plate XVI shows the upper needle layer, and, directly below, the upper and lower layers of mull. We can see how the needles, little by little, are bitten into tiny

fragments by the animals living in the soil, and more and more mixed with their excrements.

On spruce raw humus nitrification is very slight, was in fact traceable only in the moss layer and needle layer (Plate XV, at the top) and the upper part of the raw humus, which we call the mouldering layer, consisting of needles reduced to tiny fragments intermixed with animal excrements, just as the spruce mull, though more cohesive (Plate XV, centre, left). But the formation of ammonia is considerable, and the quantity of assimilable nitrogen in the needle and mouldering layers is by no means inferior to that of the spruce mull. The difference inheres in the formation of nitric acid, and here we must think of earthworms, which, in spruce mull, even though their work of mixing the soil is not so intensive as in the deciduous forest mull, convey a considerable lot of mineral earth up into the humus layer. The fact is that, while in the moss-needle layer and upper raw humus we found only 11 and 12 per cent. of ashes, in the corresponding layers from spruce mull we find no less than 31 and 57 per cent., respectively, which must be due to a considerable intermixture of mineral earth. In the lower layers of the raw humus, consisting of a compact, concrete mass (Plate XV, centre, right), the decomposition, as in beech raw humus, is but slight, and we find ammonia only, no trace whatever of nitric acid. While the leached sand apparently is quite sterile, some decomposition goes on down in the soft pan, which also contains more organic matter and nitrogen than the leached sand.

The degree of acidity is subject to alterations, through the different layers, similar to those of the beech forest. We observe, however, that even the mull layer is perceptibly more acid than the needle layer, and that the upper, mully topsoil is more acid than is the case farther down. Hence, acidity culminates quite near the surface, even as in raw humus soil. The spruce raw humus was still more acid than the beech raw humus, but the difference between the layers of the former was not so great as in those of the latter, possibly because the original materials, needles and moss, are rather acid. As under beech, acidity culminates in the lowest parts of the raw humus.

These analyses show the following connection between

fauna and decomposition in forest soil. In good beech mull, where earthworms were predominating, giving rise to an intensive mixture of mineral soil and deciduous organic matter, we found decomposition brisk and the process of nitrification almost perfect. In spruce mull, where earthworms constituted only 5 gr. per m^2, or about one half of the total weight of the fauna, and where the comminution of the needles was largely due to the activities of the insect larvae, etc., the intermixture of mineral soil and humus was incomplete; above the topsoil, but distinctly marked off from same, there was a mull layer relatively poor in inorganic matter, and nitrification was rather slight. Where, finally, in raw humus under beech and spruce, earthworms represented only 23[1]) and 7 per cent., respectively, of the total animal weight, a fauna constituted mostly of arthropods, the organic matter was but slightly mixed with mineral soil. Decomposition was rather brisk, attended by formation of ammonia in the upper layers, where the fauna is active; in the deeper, compact raw humus, on the other hand, decomposition was very slow. Nitrification was but slight in the leaf and needle layers, and was hardly, or not at all, traceable in the raw humus layer.

Intensity of animal life.

In the previous section we have seen that the number of animals is no standard for the intensity with which fauna may be supposed to work in the forest soil; indeed, that we find the smaller number of animals where the activity of decomposition in the soil is brisker. Far greater importance must be ascribed to the total weight of animals. If we consider the matter more closely, however, we shall find that this does not afford any satisfactory standard either. When watching large and small animals side by side, we cannot fail to notice that the small ones are far more agile than the large ones; and so the probability is that 100 small insects, weighing 1 mgr. each, must, together, be capable of putting forth far more energy than a single insect weighing 100 milligram.

I have therefore been searching for another unit to express the intensity of animal life, and have stopped at the

[1]) In the inferior beech raw humus only 7 per cent.

metabolic process of the animals, a process that must be directly proportionate to the development of their energy, and most likely, at any rate for homogeneous animals closely akin and of similar mode of living, bears some relation to their activities in the soil. As a standard for the consumption of matter and the development of energy we chose, then, the respiration of the animals, their inhalation of oxygen and exhalation of carbonic acid.

According to the surface law, the proportion between the consumption of oxygen in animals of different size is not equal to the proportion between their weights, but to the proportion between their superficies. This law has proved to hold true for warm-blooded animals (e. g. large and small dogs) as also for cold-blooded animals. Whether it be applicable in comparisons between the various species of cold-blooded animals of the forest soil, e. g. earthworms, spiders, and insects, the affinity of which is not very close, — this was the problem for our further investigation. To this end I have, by the aid of KROGH'S micro-respiration-apparatus, ascertained the intensity of respiration of 25 of the most common species of animals in the forest soil.

The method, as described in various papers by KROGH (1914 a, b, c; 1916), is in principle as follows: Two glass reservoirs of equal size are submerged in a water-thermostat, and connected by means of a micro-manometer containing petrol as manometer-liquid. The animal to be examined is placed in one of the reservoirs, in which is also put a little filtering paper soaked in potash lye, which will absorb the carbonic acid developed in the glass. As the animal consumes the oxygen, a corresponding diminution of pressure in the reservoir will occur, resulting in a rise of the fluid in the manometer, on the basis of which the consumption of oxygen may be figured out. The calculatory formula, which is quite simple, will not be touched on here; but in referring the reader to KROGH'S paper (1914 a), I merely beg to remark that I have preferred to use mgr. instead of cm^3 as the unit of oxygen. With this respiration-apparatus it is possible to ascertain the metabolism of very minute creatures, and even, for instance, that of a single butterfly egg.

If the animals I have examined obey the surface law,

they must all consume the same amount of oxygen, when, according to the same law, they are converted into animals of 1 gr. each. In doing this, I have not taken into account the different forms and the actual superficies of the various animals, for this would be next to impossible, but have presumed their respiration to be proportionate to $\sqrt[3]{w^2}$, w representing the weight of the animal and by this method of comparison I have attained a conformity sufficient for our present purpose. If the weight be w mgr., and the consumption of oxygen per hour, R, the consumption of oxygen for a gramme-individual, converted according to the law, would be $100\ R : \sqrt[3]{w^2}$.

For the animals to conform closely to this law, it is requisite that they be all in the same condition during the experiment. In the case of larger animals (vertebrates), this has been achieved by ascertaining respiration in a state of insensibility. TAGE ELLINGER (1916) also examined the respiration of gnats *(Culex annulatus)* in the torpid state of hibernation. Such was not possible in the case of my forest soil animals, but they were examined in a state of relative inaction, alone and without food in the experiment glasses, where they could move about at pleasure, but without receiving any impulses from without. Owing to the varying conditions and temperaments of the different individuals and species, the specimens experimented on have been brought into no exact conformity; but in ranging the 25 individuals examined according to weight and striking an average for each 5, the conformity between the large and the small animals, converted into gramme-individuals, was very satisfactory, as will appear from Table XXI. The table also shows respiration per gr., which in the case of the smaller animals greatly exceeds that of the larger ones. All the experiments were made at a temperature of 13° C., and the respiration of a gramme-individual, when an average of all the 25 experiments was struck, proved to be 0.14 mgr. O per hour[1]).

[1]) I will by no means conclude that the various orders of animals of forest soil have precisely the same respiration according to the law, but the difference is less than between individuals of the same family and is, in any case, so small that we may permit ourselves to make the following comparisons.

In making use of this empirical figure as a starting point for our further investigations, we can now calculate the respiration each species of animals must have, according to the surface law, if only we know the weight of the individuals. In this way, the figures of the column »Respiration« in Tables II—XIII have been calculated, a certain average weight being struck for each species and a corresponding respiration per individual animal.

In Table XXII we find the respiration values, specified as mgr. *O* per hour for 1 m^2 at 13^0 C., extracted from the 10 main localities, the animals being grouped as in Tables XVIII and XIX. We shall first use the figures for a comparison of the various localities, which we can do without any scruples, because, for this purpose, the figures are only required to be relatively correct, while we can abstract from the absolute values.

With this in mind, we find that the most intensive animal life obtains in the two best mull localities; next to these, the two beech raw humus localities, the intensities of which being a little above the Melica mull and greatly exceeding the Oxalis mull and the deteriorated soil. In the spruce-Oxalis mull we find very much the same intensity as in the beech-Oxalis mull; while in the two spruce raw humus localities, the intensity proves to be greater.

From this we learn, that the fauna of the raw humus soil must play a still more important part in transmutation than their weights would lead us to conclude. Further, we note that, while earthworms in the best mull constitute about 80 per cent. of the total weight of animals, they represent only 60 per cent. of the respiration; in the best beech raw humus, they represent 22 per cent. of the weight and only 12 per cent. of the respiration. Moreover, not til now do we understand that the very small arthropoda, mites and collembola, in spite of their aggregate weights being so small, can be of comparatively great significance in the decomposition of matter, especially in raw humus soil. In beech raw humus, Locality 4, these tiny animals constitute 2.3 per cent. of the total weight of fauna, but no less than 16.1 per cent. of the respiration; in Locality 20, the respective figures are 5.7 and 27.1 per cent.; in Locality 1, spruce mull, 4.8 and 25.2 per cent.; in Locality 6, spruce raw humus, 5.7 and 25.6

Table XXI. Respiration of several Animals from Forest Soil. Determined as Oxygen Consumption at 13° C.

Respiration hos forskellige af Skovbundens Dyr, bestemt som Iltforbrug ved 13° C.

Species, *Art*	Weight, *Vægt* mgr. = w	$\sqrt[3]{w^2}$	mg *O* in 1 hour = R	$\frac{R \times 100}{\sqrt[3]{w^2}}$	$\frac{R \times 1000}{w}$	$\frac{R \times 100}{\sqrt[3]{w^2}}$	$\frac{R \times 1000}{w}$
Lumbricus terrestris (Lumbricidae)	1211	113.6	0.0958	0.084	0.079		
Lumbricus rubellus (Lumbricidae)	1030	102.0	0.1238	0.121	0.120		
Carabus nemoralis (Carabidae)	644	74.58	0.1725	0.231	0.267		
Tipula sp. Larva (Diptera)	607	71.69	0.1127	0.157	0.186		
Tipula sp. Larva (Diptera)	277	42.49	0.0643	0.153	0.232	0.149	0.177
Pterostichus striola (Carabidae)	271	41.88	0.0572	0.137	0.211		
Staphylinus olens (Staphylinidae)	247	39.37	0.0644	0.164	0.261		
Geotrupes vernalis (Lamellicornae)	168	30.45	0.0341	0.112	0.203		
Pterostichus striola (Carabidae)	149	28.11	0.0546	0.194	0.366		
Dendrobaena arborea (Lumbricidae)	93.8	20.64	0.0245	0.119	0.261	0.145	0.260
Nebria brevicollis (Carabidae)	84.0	19.18	0.0345	0.180	0.411		
Elateridae sp. Larva (Elateridae)	62.0	15.66	0.0242	0.155	0.390		
Loricera pilicornis (Carabidae)	22.8	8.04	0.00730	0.091	0.320		
Lycosa sp. (Araneina)	15.1	6.11	0.00747	0.122	0.495		
Patrobus excavatus (Carabidae)	15.0	6.08	0.0128	0.210	0.853	0.152	0.494
Leptidae. Larva (Diptera)	8.3	4.10	0.00358	0.087	0.431		
Notiophilus biguttatus (Carabidae)	7.5	3.831	0.00820	0.214	1.093		
Nemastoma sp. (Opiliones)	3.8	2.435	0.00207	0.085	0.545		
Orchesella flavescens (Collembola)	3.5	2.305	0.00263	0.114	0.751		
Pogonognathus plumbeus (Collembola)	2.5	1.842	0.00209	0.113	0.836	0.123	0.731
Epaphius secalis ♀ *(Carabidae)*	2.2	1.692	0.00219	0.129	0.995		
Staphylinidae sp. (Staphylinidae)	1.9	1.534	0.00150	0.098	0.789		
Orchesella flavescens (Collembola)	1.8	1.480	0 00118	0.080	0.656		
Pogonognathus plumbeus (Collembola)	1.3	1.191	0.00147	0.123	1.131		
Epaphius secalis ♂ *(Carabidae)*	1.2	1.129	0.00160	0.142	1.333	0.114	0.981
					Average: *Middeltal*	0.137	
Culex annulatus II *(Diptera)*	8.4	4.132	0.00345	0.083	0.410		
C. annulatus III *(Diptera)* (ELLINGER 1916)	7.9	3.967	0.00280	0.071	0.354		

Table XXII. Respiration of Fauna, Mgr. *O* per Hour per 1 m² at 13° C.

Faunaens Respiration i mg Ilt pr. Time pr. m² ved 13° C.

Stand	Oak	Beech						Spruce		
Soil	Mull	Mull			Poly-	Raw Humus		Mull	Raw Humus	
Soil Flora	Mercur-ialis	Asper-ula	Melica	Oxalis	trichum Type	no Flora	no Flora	Oxalis	Hylo-comium	Hylo-comium
Locality No.	10	15	5	9	2	4	20	1	6	8
1. Lumbricidae	*10.76*	*11.10*	*5.84*	*1.73*	*0.55*	*1.48*	*0.44*	*1.92*	*0.34*	*0.59*
Gastropoda	1.46	1.43	1.12	0.26	—	0.90	0.56	0.05	0.04	—
Enchytraeidae	0.76	1.18	1.22	0.80	0.24	1.74	1.32	0.04	0.23	0.08
Isopoda	0.40	0.21	0.21	0.00	—	0.07	0.01	0.00	—	—
Diplopoda	1.85	2.96	0.79	0.36	—	0.47	0.28	0.15	0.04	—
Acarina	0.18	0.71	0.47	0.65	0.35	1.15	2.14	1.38	1.80	1.39
Collembola	0.19	0.18	0.17	0.25	0.89	0.80	1.10	0.32	0.28	0.41
Diptera	1.16	0.63	0.69	0.98	0.53	2.28	1.57	1.12	1.91	0.57
Elateridae	0.10	0.10	0.33	0.75	0.34	1.97	1.62	0.50	2.11	1.79
Other Insects *(÷ Staphylinidae & Carabidae)*	0.30	0.34	0.25	0.24	0.21	0.33	0.19	0.53	0.57	0.61
2. Diff. Humivorous Animals	*6.40*	*7.74*	*5.25*	*4.29*	*2.56*	*9.71*	*8.79*	*4.09*	*6.98*	*4.85*
Chilopoda	0.32	0.70	0.09	0.08	0.38	0.24	2.33	0.31	0.42	1.00
Arachnida (÷ Acarina)	0.08	0.04	0.06	0.10	0.04	0.18	0.12	0.05	0.05	0.09
Staphylinidae	0.12	0.13	0.18	0.15	0.29	0.47	0.27	0.28	0.27	0.50
Carabidae	0.06	0.02	0.09	0.01	0.03	0.00	0.02	0.09	0.06	0.06
3. Rapacious Animals	*0.58*	*0.89*	*0.42*	*0.34*	*0.74*	*0.89*	*2.74*	*0.73*	*0.80*	*1.65*
Total	**17.74**	**19.73**	**11.51**	**6.36**	**3.85**	**12.08**	**11.97**	**6.74**	**8.12**	**7.09**

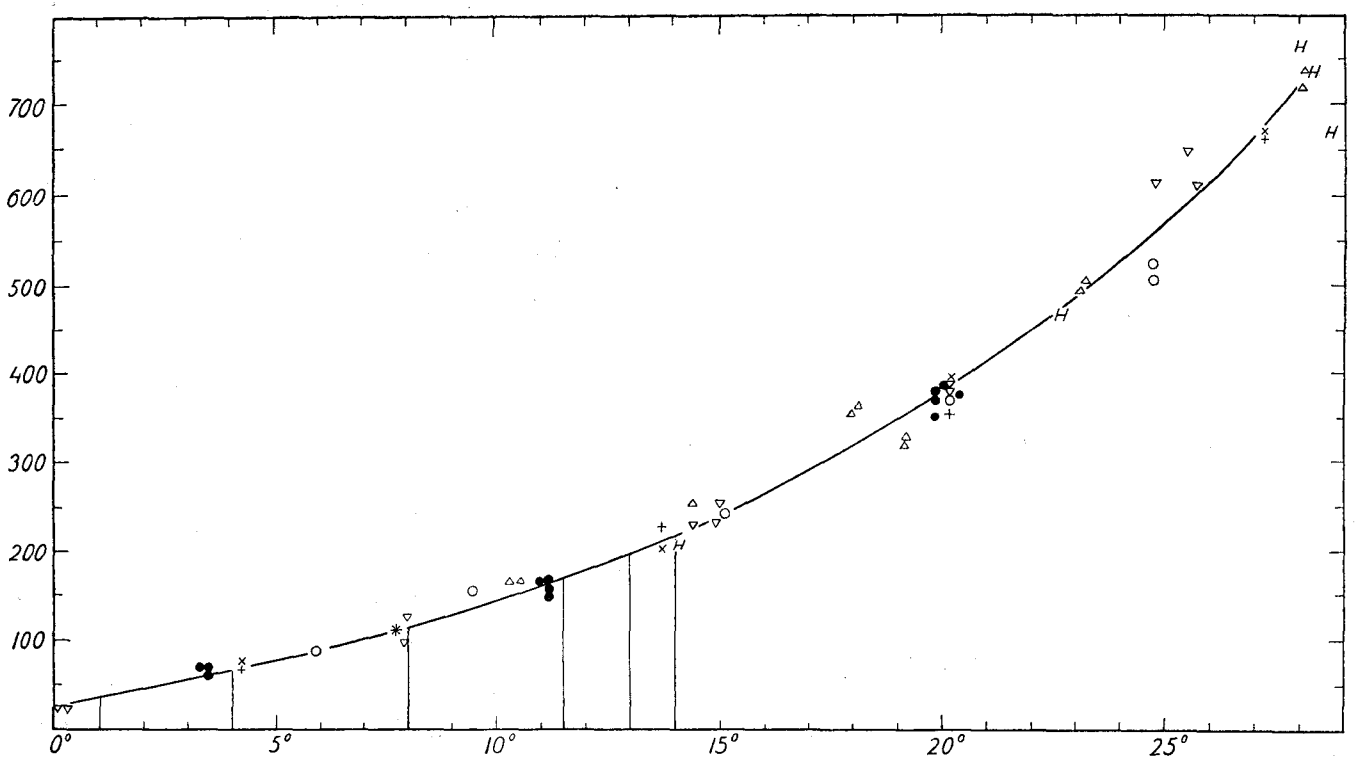


Fig. 7. Temperature-metabolism curve of cold-blooded animals, compiled by KROGH. (ELLINGER 1916).

per cent.; in Locality 8, spruce raw humus, 6.0 and 25.4 per cent. In the deteriorated soil of Locality 2, the figures are 7.4 and 32.2 per cent. respectively.

In dealing with the absolute values of respiration, we shall have to be more reserved. It would be of particular interest to know the total annual respiration per m^2, inasmuch as we should then have a means of concluding to what extent fauna takes part in combustion of the deciduous organic matter on the ground. In our calculations we shall have to take into account the changes due to the varying seasons, above all the influence of temperature on respiration. To this end KROGH (1914) compiled a curve bearing upon cold-blooded vertebrates, and ELLINGER (1916), in examining gnats, proved that the curve is equally applicable in the case of insects (Fig. 7). The validity of the curve is contingent upon the animals being in the same state under the varying temperatures; a condition which is fulfilled in the manner we have mentioned on page 141. Our forest soil animals, in their natural state, are generally not in such a uniform condition, but, for the time being, we shall have to see how great would be the annual values of respiration if they corresponded to KROGH's curve.

According to our observations at Møllevangen (BORNEBUSCH 1926), the temperature of the forest soil may be set down as follows:

February and January	March and December	April and November	May and October	June and September	July and August	Annual Average
0	1	4	8	11.5	14	6.4° C.

If in Fig. 7, showing the respiration curve, we erect perpendiculars at the points of the abscissa axis corresponding to the above temperatures, and also at 13° C., we shall be able, when taking respiration at 13° C. as a unit, by measurements on the figure, to find the following relative respiration values for the various months:

February and January	March and December	April and November	May and October	June and September	July and August	Annual Average
0.15	0.20	0.35	0.58	0.86	1.11	0.54

The annual average respiration is thus 0.54 times the respiration at 13° C., or, the year having 8760 hours, 4730 times as great as the respiration for 1 hour at 13° C. From this it is easy to compute the annual respiration of the fauna in the various localities.

First of all, however, we shall have to see whether we are justified in calculating these annual respiration values on the basis of the figure found in our experiments: 0.14 mgr. oxygen per gramme-individual at 13° C. In the first place, forest soil animals are comparatively placid creatures, and do not spend the enormous amount of energy as e. g. insects do in flying about; even while moving or feeding — at any rate in the case of herbivorous animals — they do so with a certain composure. Nevertheless, we must presume that during the warm season of the year their respiration is, to some extent, in excess of the values found in our experiment glasses. To counterbalance this, however, the animals are torpid for some part of the winter, and then their respiration is lower than we have figured in our calculation. For ELLINGER'S gnats, the respiration in a state of torpor was 0.08 and 0.07 mgr. *O* an hour at 13° C. per gramme-individual. Some of the animals experimented on by me, had a similarly low respiration, and have probably also been in a torporific state; thus the respiration of a scarabee, too, proved to be very low during the night, evidently because of its dormant state, while a ground-beetle, examined at the same time, displayed no difference in its day and night respirations (vide Table XXIII). These minimum values go to show that respiration in a torporific state probably amounts to about half the respiration which we make the basis of our calculation.

Inasmuch as the animals are torpid for only a short part of the cold season of the year — during which time respiration is low anyhow — while during the greater part of the year their respiration must exceed our calculation, I am of opinion that we can quite safely take it for granted that the respirations we arrive at through our calculations constitute minimum values; but, at the same time, I suppose we are not very far removed from the maximum values. However, we are chiefly interested in learning the minimum values of

Table XXIII. Day and Night Respiration of *Geotrupes vernalis* and *Pterosticus striola* at 13° C.
Started Nov. 1st. 1928.

Dag- og Nat-Respiration hos en Skarnbasse og en Løbebille ved 13° C. Begyndt 1. Nov. 1928.

Hour of Day	mg *O* in 1 hour = R	$\frac{R \times 100}{\sqrt[3]{w^2}}$	Day or Night
Geotrupes vernalis. $w = 168$ mg, $\sqrt[3]{w^2} = 30.45$			
11.40—20.40	0.0549	0.180	D
20.40— 8.15	0.0236	0.078	N
16.00—21.15	0.0433	0.142	D
21.15— 5.30	0.0237	0.078	N
11.15—19.30	0.0485	0.159	D
19.40— 7.00	0.0165	0.054	N
7.00—15.15	0.0544	0.179	D
16.30— 9.20	0.0225	0.074	N
9.20—12.10	0.0620	0.204	D
Average...	0.0341	0.112	
Pterosticus striola. $w = 271$ mg, $\sqrt[3]{w^2} = 41.88$			
11.40—20.35	0.0570	0.136	D
20.40— 8.15	0.0494	0.118	N
8.20—18.45	0.0535	0.128	D
18.55— 5.30	0.0724	0.173	N
11.15—19.30	0.0598	0.143	D
19.35— 7.00	0.0526	0.126	N
7.50—16.30	0.0563	0.134	D
Average...	0.0572	0.137	

the annual respiration of the animals. Multiplication of the respiration figures found for the ten main localities by the factor 4730 gives the following figures representing the annual consumption of oxygen in gr. per m^2:

	Oak Mull	Beech Mull Asperula	Beech Mull Melica	Beech Mull Oxalis	Beech Polytrich.	Beech Raw Humus	Beech Raw Humus	Spruce Mull	Spruce Raw Humus	Spruce Raw Humus
Locality:	10	15	5	9	2	4	20	1	6	8
Grammes *O* per 1 m^2:	84	93	54	30	18	57	57	32	38	34

By combustion of the ordinary humus material of forest soil, the quantity of oxygen consumed is about equal to the amount of organic matter decomposed by the process of com-

bustion; hence, the above figures very nearly correspond to the quantity of matter consumed by the animals. The annual layer of fallen leaves in beech forests and spruce forests amounting to about 400 gr. per m^2, in oak forests and pine forests somewhat less, we can, in spite of some uncertainty in our calculation, safely conclude that the quantity of organic matter reduced by combustion owing to the respiration of fauna constitutes a very considerable part of the total amount of material annually decomposed in forest soil.

The annual decomposition in forest soil, when no humus accumulates, will somewhat exceed that which corresponds to the annual fall of leaves, including other deciduous matter such as branches and twigs as well as roots and withering soil flora. This decomposition is chiefly carried on by bacteria and fungi, but from the above we learn that fauna, besides its indirect bearing on the decomposition process by mechanical work, directly participates in the combustion of matter to a considerable extent. Besides the animals included in the above calculations, we must not forget the nematodes and protozoa, with which the soil teems. In short, therefore, it is hardly an exaggeration to assert that the quantities of organic matter consumed by the metabolic process of fauna, in places amount to between one fifth and one fourth, or even possibly more, of the total combustion of matter.

A Retrospect of Results.

From the above investigations we learn that forest soil fauna comprises a series of different types closely attached to certain types of forest soil, chiefly as these present themselves to our view by means of the soil flora and through our examinations of the forest soil profiles.

The difference between flora types and fauna types is very striking, for while among flora types totally different species of plants occur, fauna types mostly display quantitative differences.

The plants of the forest soil are distinguished for their constancy of habitat. They are chiefly perrennial plants, frequently with root-stocks (rhizoma), and one or more species

of plants, in competing with other species, will seize upon the ground so as to make it difficult, if not impossible, for other species to intrude upon their domains, unless a change in the prevailing conditions take place. The species particularly adaptable to a certain locality will be the predominating ones, and will maintain their hold most vigorously.

In the case of fauna things are different. The life time of the animals is limited, and it is out of the question, as in the case of plants, for a few suitable species to keep a place all to themselves; moreover, the number of individuals often undergoes fluctuations from year to year without any adequately assignable cause. Further, animals are locomotive, so that they can seek out the most favourable places in the soil, and thus be more independent of the conditions offered them. Finally, it seems as if many kinds of animals are more adaptive concerning the exigencies of life than plants.

The consequence then is that, while we could characterize flora types by certain species, our characterization of the fauna types is essentially of a relative nature. Earthworms, to some extent, constitute an exception the species of which are more or less markedly circumscribed by the qualities of the soil. We can distinguish between the following main types of fauna:

The fauna of deciduous forest mull or Mull soil fauna: It consists chiefly of earthworms (50—80 per cent. of the weight), riddling the topsoil and mixing it with organic matter from the surface of the ground. The characteristic animal is the turgid worm *(Allolobophora turgida)*, in the best mull soil also the common earthworm *(Lumbricus terrestris)*, (see further p. 103). Of arthropods, the chief species are the common millipied, the *Trichoniscus*, and some ground-beetle species. The slower the decomposition the lower the total weight of animals per square meter, and the greater the number of arthropods; click-beetle larvae, diptera larvae, collembola, and mites will increase in number in proportion as earthworms grow fewer.

The fauna of spruce forest mull or Surface mull fauna: Earthworms constitute only about one half the weight of animals, and comprise such species as the reddish worm *(Lumbricus rubellus)*, purple worm *(L. castaneus)*, and the *Dendro-*

baena species, all inhabiting the upper humic mull, to which they convey but little mineral soil. Turgid worm, and other pronounced mull soil species, are wanting. The arthropods are mostly mites, millipeds, diptera larvae, and click-beetle larvae.

Deciduous forest raw humus fauna: Earthworms (hardly any but *Dendrobaena* species) constitute from a few per cent. to about twenty per cent. of the weight, and inhabit the layer of humus, which is but slightly mixed with mineral soil. The fauna mainly consists of arthropods, of which, chiefly, diptera larvae, click-beetle larvae, millipeds, collembola, and mites predominate. The two latter orders are equally represented.

Beech forest soil poor in mull, of the Polytrichum type, is particularly poor in fauna. Earthworms are very rare. We here find an arthropod fauna comprising some diptera larvae and click-beetle larvae; collembola abound, and are far in excess of mites.

Spruce forest raw humus fauna: Earthworms are sparse (rarely exceeding ten per cent. of the weight), and confined to the octagonal worm *(Dendrobaena octoedra).* It is an arthropod fauna, characterized by the absence of *Trichoniscus;* millipeds are rare, while mites abound and far exceed collembola in number. Diptera larvae, and especially click-beetle larvae, predominate in weight. A peculiarity, moreover, is the great number of *Geophilidae.* In inferior spruce localities, e. g. heath plantations, mites play a still more important part than in superior soil.

In the superior mull, where decomposition was particularly brisk, we found the weight of animals preponderating, but their number small; in soil where the process of decomposition is slow and accumulation of humus takes place, we found the greatest number of animals, but these were minute, and their total weight was lower, yet exceeding that of the inferior mull forms. As a standard for the activity of fauna in the forest soil, weight is more reliable than numbers, but neither of these standards is satisfactory. A far better standard is that of respiration. Calculations of animal respiration go to show that it evidently constitutes quite a considerable part of the total respiration of the forest soil.

Of the most striking significance in the forest soil are the

larger earthworm species (*Lumbricus terrestris*, *L. rubellus*, and *Allolobophora turgida;* moreover, *Eisenia rosea*, *Allolobophora trapezoides*, *A. chlorotica*, *Octolasium lacteum*, and others), riddling the topsoil through and through and mixing it with deciduous organic matter. The deep and friable mull soil, as we find it in deciduous forests, is contingent upon the activity of these animals.

Where the above-mentioned earthworms are wanting, we shall in most favourable cases have a surface mull, as we quite commonly find it in spruce forests. There is indeed a number of smaller earthworms (*Lumbricus rubellus*, *L. castaneus*, and the *Dendrobaena* species), conveying some mineral soil up into the humus layer, but they do not carry on the intensive mixing of mineral soil and humus performed by the larger species.

Arthropods are of the greatest importance to raw humus soil, where organic matter is deposited on the surface of the mineral soil without being intermixed with same. They here perform a great work by gradually decomposing and consuming all deciduous leaves, etc., and in this way transforming same into an upper layer of humus (the mouldering layer) in which a brisk process of decomposition takes place, releasing a great amount of ammonia. The raw humus is distinguished from the surface mull by an incompleted process of decomposition, resulting in the gradual accumulation on the top of the mineral soil of a humus layer not easily transmutable. The difference may, to some extent, be inherent in the geological qualities of the soil, but may also be due to the fact that earthworms of the surface mull carry mineral soil into the humus layer and mix it with same, a process conducive to the propagation of bacteria, which are requisite for carrying the processes of decomposition to their completion.

On the basis of our investigations we are justified in concluding that fauna is of very great importance to the process of decomposition in forest soil, indeed constitutes a prominent feature of this process, and is a constituent principle in the determining of the soil we get. It therefore behoves the forester, when fulfilling his duties, always to keep in view whatever may be conducive to the progress of fauna, and to avoid everything that may be detrimental to same.

Of particular importance is the promotion of the large earthworm species, which seem to be requisite for the development and preservation of the good mull soil and the type of soil called Brown Forest Soil (RAMANN's Braunerde); otherwise the topsoil will easily become compact and be exposed to leaching. Foliferous trees, especially those bearing easily decomposable leaves; a soil flora of herbs; and good shelter — all these factors are propitious to earthworms. An interspersion of light-demanding trees, such as oak, ash, maple, and larch, in beech stands will prove favourable to the soil flora and to bushes as well as to lower trees and underwoods, affording shelter against the wind. Conifers are apt to scare away the most important species of earthworms, and an interspersion of foliferous trees, therefore, will be profitable. The heavy and frequent thinnings — every second year —, introduced by forest officer Mr. E. MOLDENHAWER at Frijsenborg in Jutland, will, at any rate on superior soil, result in a herb flora under the spruce trees, which must prove for the benefit of earthworms. In poorer conifer soil, as in heath plantations, we may perhaps not be able altogether to check the raw humus formations, but our investigations in localities 23 and 32 show that heavy thinnings in spruce stands result in a moss covering and a subsequent abundance of fauna, especially octagonal worms and diptera larvae, giving the humus a far looser and more pleasing character. If in these forests we can pass from raw humus to surface mull, it will be of great advantage, but possibly we shall be able to learn how to cultivate the forest so as attain to a genuine mull soil. To this end, an exact knowledge of animal requirements will be necessary, and we shall therefore have to study it thoroughly.

The provisions mentioned above, the intermingling of various species of trees and the carrying out of heavy and frequent thinnings, fully accord with the ideas of modern Danish sylviculture. To these must be added endeavours to procure shelter in the outskirts of the woods, light-demanding trees with an undergrowth of brushwood being requisite for this purpose. With a more luxurious vegetation, better shelter and cover in the forest, a more abundant bird fauna, too, will flourish, aiding us in checking the spread of noxious insects.

In conclusion we shall merely glance at the problems presenting themselves for future study. We have seen that different fauna types occur, each affecting the forest soil in its own particular way, and we have gained a little insight into the life and habits of some of the chief species of animals. But we cannot stop here; we shall have to know the nutriments and habits of all the chief species of animals, and a study along these lines will often be possible by quite simple expedients. Further, we must subject the nematoda and protozoa faunas to a thorough investigation. We must also follow up our investigations about the influence on the fauna, of our sylvicultural measures, particularly those of thinning and regeneration. A number of problems thus present themselves for our consideration, problems that must be solved before the forester can reap full benefit of the activities carried on by fauna in forest soil.

BIBLIOGRAPHY.

ALTUM, BERNH. (1876—82): Forstzoologie. I Säugetiere, II Vögel, III Insekten.

BELING, TH. (1883): Der Heerwurm. Zeitschr. f. Naturwissenschaften, vol. 5.

BERGSØE, VILH. (1915—16): Fra Mark og Skov I—II. I ny Bearbejdelse ved C. WESENBERG-LUND.

BLAKE, IRVING HILL (1926): A comparison of the animal communities of coniferous and deciduous forests. Illinois Biological Monographs, vol. 10.

BOAS, J. E. V. (1882): Regnormene, deres Liv og Virksomhed. Collin: Skildringer af Naturvidenskaben for alle.

— (1896—98): Dansk Forstzoologi.

— (1923): Dansk Forstzoologi, 2. Udg.

BORNEBUSCH, C. H. (1920): Om Bedømmelse af Skovjordens Godhed ved Hjælp af Bundfloraen. Dansk Skovforenings Tidsskrift, vol. 5.

— (1921): Objektiv Bedømmelse af et Skovdistrikts Urteflora. Dansk Skovforenings Tidsskrift, vol. 6.

— (1923): Skovbundsstudier I—III (Disquisitions on flora and soil of Danish woodlands I—III). DFF., vol. 8.

— (1925): Skovbundsstudier IV—IX (Disquisitions on flora and soil of Danish woodlands IV—IX). DFF., vol. 8.

— (1926): Iagttagelser over Jordtemperatur i Skov. DFF., vol. 8, p. 336.

— (1928): De danske Regnorme. (Dansk) Flora og Fauna 1928.

— (1929): Danmarks Skovtyper. Commentationes in honorem professoris A. K. Cajander. Acta forestalia fennica, vol. 34.

BOJESEN, H. (1905): H. C. Ulrichs Bøgekulturer. DFF., vol. 1.

BOYSEN JENSEN, P. & C. G. JOHS. PETERSEN (1911): Havets Bonitering I. Beretning til Landbrugsministeriet fra den danske biologiske Station XX.

BOYSEN JENSEN, P. (1919): Limfjordens Bonitering I. Studier over Fiskeføden i Limfjorden 1909—1917. Beretning til Landbrugsministeriet fra den danske biologiske Station XXVI.

BREHM, A. E. & E. A. ROSSMÄSSLER (1864): Die Tiere des Waldes. I: Die Wirbeltiere.

— — (1867): Die Tiere des Waldes. II: Die wirbellosen Tiere.

BRÜEL, G. (1916): Jordbunden i Grib Skov (Der Boden in Grib Skov bei Hillerød). DFF., vol. 5.

CAJANDER, A. K. (1909): Ueber Waldtypen. Acta forestalia fennica, vol. 1.

CAMERON, A. E. (1913): General survey of the Insect Fauna of the soil within a limited area near Manchester. Journ. Econom. Biology, vol. 8.

COBB, N. A. (1918): Estimating the nema-population of soil. U. S. Dep. of Agric. Bur. of Plant Industry. March 14., 1918.

COMBAULT, A. & E. DE RIBAUCOURT (1907): Utilité des vers de terre en agriculture. Bulletin de la société centrale forestière de Belgique.

DAHL, FRIEDERICH (1883): Über Nahrungsvorräthe im Bau des Maulwurfs. Schr. d. naturh. Vereins f. Schlesw. Holstein, vol. 5. III.

— (1921): Grundlagen einer ökologischen Tiergeographie.

DARWIN, CHARLES (1840): On the formation of mould (Read Nov. 1. 1837). Transact. Geol. Soc. vol. 5, 1840.

— (1881): The formation of vegetable mould through the actions of worms.

DEGERBØL, MAGNUS (1923): Om Muldvarpens Fremtrængen i Vester-Hanherred. Vid. Medd. f. Dansk naturh. Foren., vol. 76.

— (1924 a): Nogle Iagttagelser over en Muldvarp i Fangenskab. Naturens Verden, Aarg. 8.

— (1924 b): Muldvarpens Vandring gennem Skodborg og Vandfuld Herreder. Vid. Medd. f. Dansk naturh. Foren., vol. 78.

DEICHMANN, ELISABETH (1917): Hvorledes fortærer Muldvarpen sine Regnorme. Vid. Medd. f. Dansk naturh. Foren., vol. 68.

DFF. = Det forstlige Forsøgsvæsen i Danmark (The Danish Experimental Forestry Service).

DOGIEL, V. & G. EFREMOFF (1925): Versuch einer quantitativen Untersuchung der Bodenbevölkerung im Fichtenwalde. Travaux de la société des naturalistes de Leningrad, vol. 55 part 2.

EBERMAYER, ERNST (1876): Die gesammte Lehre der Waldstreu.

EIDMANN, H. (1927): Die forstliche Bedeutung der roten Waldameise. Zeitschr. f. angew. Entomologie, vol. 12.

ELLINGER, TAGE (1916): Über den Ruhe-stoffwechsel der Insekten (Culiden) und seine Abhängigkeit von der Temperatur. Internat. Zeitschr. für physik-chem. Biologie, vol. 2.

ESCHERICH, K. (1925): Die Übertragung der Drathwürmer durch Waldstreu. Anz. f. Schädlingskunde 1925.

FEHÉR, D. (1929): Untersuchungen über den zeitlichen Verlauf der Bodenatmung und der Mikrobentätigkeit des Waldbodens. Biochemische Zeitschrift, vol. 206.

FEHÉR, D. & L. VARGA (1929): Untersuchungen über die Protozoen-Fauna des Waldbodens. Erdészeti Kisérletek (Forest Researches), Sopron, vol. 31.

FREUDING, OTTO (1923): Ein kleiner Beitrag zur Biologie der Heerwurmtrauermücke (Sciara militaris). Zeitschr. f. angew. Entomologie, vol. 9.

FRIEND, HILDERIC (1923): British Earthworms and how to identify them.
— (1924): The Story of British Annelids.
HAUCH, L. A. & A. OPPERMANN (1898—1902): Haandbog i Skovbrug.
HAUCHECORNE, F. (1927): Studien über die wirtschaftliche Bedeutung des Maulwurfs. Zeitschr. f. wissench. Biologie, Abt. A, vol. 9.
HENRIKSEN, KAI L. (1925 a): Hærormen i Danmark. Entomologiske Meddelelser, vol. 14.
— (1925 b): Hærormen i Danmark II. Entomologiske Meddelelser, vol. 16.
HENSEN, V. (1877): Die Thätigkeit des Regenwurms (Lumbricus terrestris L.) für die Fruchtbarkeit des Erdbodens. Zeitschr. f. wissensch. Zoologie, vol. 28.
— (1882): Ueber die Fruchtbarkeit des Erdbodens in ihre Abhängigkeit von den Leistungen der in der Erdrinde lebenden Würmer. H. Thiel: Landwirtschaftliche Jahrbücher, vol. 11.
HESSELMAN, H. (1926): Studier över barrskogens humustäcke (Studien über die Humusdecke des Nadelwaldes). Medd. f. Statens Skogsförsöksanstalt, vol. 22, nr. 5.
JENSEN, BOYSEN vide BOYSEN JENSEN.
JENSEN, C. (1897): Regnorme i en Hedeplantage. Tidsskr. f. Skovvæsen, vol. 9.
— (1902): Mulddannelsen i Hedeplantager. Tidsskr. f. Skovvæsen, vol. 14.
JENSEN, HANS L. (1925): Nyere Undersøgelser over Jordbundens Protozo-Fauna. Tidsskrift for Landbr. Planteavl, vol. 31.
KEILHACK (1899): Bodenbildende Thätigkeit der Insekten in Norddeutschland. Zeitschr. d. Deutsch. Geol. Ges. vol. 51.
KROGH, AUG. (1914 a): Ein Mikrorespirationsapparat und einige damit ausgeführten Versuche über die Temperatur-Stoffwechsel von Insektenpuppen. Biochem. Zeitschr. vol. 62 cfr. vol. 66.
— (1914 b): On the rate of development and CO_2-production of chrysalides of *Tenebrio molitor* at different temperature. Zeitschr. f. allgem. Physiologie, vol. 16.
— (1914 c): The quantitative Relation between Temperature and Standard Metabolism in Animals. Internat. Zeitschr. f. physikchem. Biologie, vol. 1.
— (1916): The respiratory exchange in animals and men.
LEVINSEN, G. M. R. (1883): Systematisk-geografisk Oversigt over de nordiske Annulata, Gephyrea, Chaetognathi og Balanoglossi.
MICHAELSEN, WILH. (1900): Oligochæeta. Das Tierreich, 10. Lief.
MÜLLER, P. E. (1878 a): Nogle Undersøgelser af Skovjord, Tidsskrift for Landøkonomi 1878.
— (1878 b): Studier over Skovjord. I: Om Bøgemuld og Bøgemor paa Sand og Ler. Tidsskrift for Skovbrug, vol. 3, 1879.
— (1879): Nogle Træk af Skovens Naturhistorie. Nordisk Tidskrift.
— (1882): Skovbruget. Danmarks Statistik, vol. 2, 1887.
— (1884): Studier over Skovjord. II: Om Muld og Mor i Egeskove og paa Heder. Tidsskrift for Skovbrug, vol. 7.

MÜLLER, P. E. (1887): Studien über die natürlichen Humusformen und deren Einvirkung auf Vegetation und Boden.
— (1889): Recherches sur les formes naturelles de l'humus et leur influence sur la végétation et le sol. Annal. sci. agronom. franc. et étrang., Nancy, I.
— (1894): Regnormenes Forhold til Rhizomplanterne, især i Bøgeskove. Oversigt over d. K. D. Vidensk. Selsk. Forh. 1894.
— (1918): Fortsatte Iagttagelser over Muld og Mor i Egeskove og paa Heder. Dansk Skovforenings Tidsskrift, vol. 3.
OPPERMANN, A.; L. A. HAUCH & (1898—1902): Haandbog i Skovbrug.
OPPERMANN, A. (1905): Egens Vækst i Jægersborg Hegn. DFF., vol. 1.
— (1914 a): Elleve Prøveflader i Bøgeskov (Elf Probeflächen in Rotbuchenbeständen). DFF., vol. 4.
— (1914 b): God dansk Bøgeskov belyst ved tre Tilvækstoversigter (Gute dänische Buchenwälder in drei Ertragstafeln dargestellt). DFF., vol. 4.
— (1923): Dyrkning af Lærk i Danmark (Cultivation of Larch in Denmark). DFF., vol. 7.
PALMGREN, PONTUS (1929): Kvantitativa undersökningar över fågelfaunan i Finlands skogar. Beretning om det 18. Skandinaviske Naturforskermøde i København.
PETERSEN, C. G. JOHS.; P. BOYSEN JENSEN & (1911): Havets Bonitering I. Beretning til Landbrugsministeriet fra den danske biologiske Station XX.
PFETTEN, JOSEF FREIHERR VON (1925): Beiträge zur Kenntniss der Fauna der Waldstreu. Fichtenstreu-Untersuchungen. Zeitschr. f. angew. Entomologie, vol. 11.
PILLAI, S. K. (1922): Beiträge zur Kenntniss der Fauna der Waldstreu. Kiefernstreu-Untersuchungen. Zeitschr. f. angew. Entomologie, vol. 8.
POULSEN, ERIK M. (1921): Findes Muldvarpen paa Møen. Vid. Medd. f. Dansk naturh. Foren., vol. 72.
RAMANN, E. (1895): Forstliche Bodenkunde und Standortlehre.
— (1905): Bodenkunde, 2. Aufl.
— (1911 a): Bodenkunde, 3. Aufl.
— (1911 b): Regenwürmer und Kleintiere im deutschen Waldboden. Internationale Mitteilungen für Bodenkunde, vol. 1.
RIBAUCOURT, E. DE (1897): Notice physiologique sur les lombricides d'Europe. Bulletin scientifique de la France et de la Belgique, vol. 30.
RIBAUCOURT, E. DE; A. COMBAULT & (1907): Utilité des vers de terre en agriculture. Bulletin de la société centrale forestière de Belgique.
ROSSMÄSSLER, E. A.; A. E. BREHM & (1864—67): Die Tiere des Waldes.
SACHTLEBEN (1925): Untersuchungen über die Nahrung des Maulwurfs. Arbeiten a. d. Biol. Reichsanstalt f. Land- und Forstw., vol. 14.
SAVIGNY (1821): Analyse des Travaux de l'Académie Royale des Sciences pendant l'anné 1821, Partie Physique par M. le Baron Cuvier (with the report of Savigny p. 176—184). Memoires de l'Académie Royale des Sciences de l'Institut de France 1826.

SCHIØDTE, J. C. (1875): Insekterne og Mulddannelsen. Tidsskrift for Skovbrug, vol. 1, 1876.
SCHREITEMÜLLER (1923): Meine Beobachtungen am Maulwurf. Wiegmanns Archiv für Naturgeschichte, Jahrg. 89 A, Heft 8.
SCHWAPPACH, ADAM (1911): Die Rotbuche.
— (1912): Ertragstafeln der wichtigeren Holzarten.
SEDLACZEK, W. (1915): Die Etholcgie der Tierwelt des Buchenwaldes. Centralblatt f. d. ges. Forstwesen, Jahrg. 41.
SOUDEK, ST. (1928): Fauna lesni hrabanki (Fauna of the Forest Soil). Bulletin de l'école superiéure d'agronomie, Brno, R. Č. S., Faculté de silviculture.
STEEN, A. (1890): Om Skovsneglenes Virksomhed. Forsttidende No. 3.
STEENBERG, JOHANNE (1925): En levende, kæmpende Lilliputverden i det nedfaldne Bøgeløv. Tidens Kvinder, Aarg. 3, No. 3.
TAUBER, P. (1872): Om Tandsæt og Levemaade hos de danske Flagermus og Insektædere. Naturh. Tidsskr., 3. series, vol. 8.
TRÄGÅRDH, IVAR (1928): Undersökningar över det lägre djurlivet i marken (Studies on the Fauna of the Soil in Swedish Forests). Festskrift utg. m. anl. av Skogshögskolans 100-års Jubileum.
TULLGREN, ALB. (1918). Ein sehr einfacher Ausleseapparat für terricole Tierformen. Zeitschr. f. angew. Entomologie, vol. 4.
TUXEN, C. F. A. (1882): Regnormenes Virksomhed ved Mulddannelsen. Tidsskr. f. Landøkonomi.
WAKSMAN, SELMAN A. (1925): The soil population. Proc. of. the nat. acad. of science, U. S. A., vol. 11, No. 8.
VARGA, L.; FEHÉR, D. & (1929): Untersuchungen über die Protozoen-Fauna des Waldbodens. Erdészeti Kisérletek (Forest Researches), Sopron, vol. 31.
WESENBERG-LUND, C., vide BERGSØE, VILH.
WHITE, GILBERT (1789): The natural history of Selborne. Edit. 1901.
WINGE, HERLUF (1908): Danmarks Fauna. Pattedyr.
WOLLNY, E. (1890): Untersuchungen über die Beeinflüssung d. Fruchtbarkeit d. Ackerkrüme durch die Thätigkeit der Regenwürmer. Forschungen a. d. Geb. d. Agrikultur-Physik, vol. 13.
— (1897): Die Zersetzung der organischen Stoffe und die Humusbildungen.
ØKLAND, FRIDTHJOF (1929): Quantitative Researches concerning the Land-Fauna, especially the Molluscs. Beretning om det 18. Skandinaviske Naturforskermøde i København.

SKOVBUNDENS DYREVERDEN.

Forkortet Gengivelse af foranstaaende Afhandling.

Indledning.

Vildtets Færden, Fuglenes Sang, Insekternes Summen hører uløseligt med til det Helhedsbillede af Skoven, som vi bevarer i vort Sind. Dyrelivet er en Del af Skoven selv, en Del af den naturhistoriske Enhed hvormed Forstmanden arbejder; et Stykke Natur som er underkastet Menneskets økonomiske Herredømme, og som dog har bevaret Naturens rige Mangfoldighed. Skovens Dyreverden griber dybt ind i Skovens Liv, langt dybere end man i Almindelighed tænker paa, fordi vort Kendskab til denne Fauna er meget overfladisk. Det er de store Dyr, navnlig de jagtbare, som gennem Tiderne har interesseret Skovens Folk; senere, med det mere intensive Skovbrug, kom Interessen for Skadedyrene, navnlig de der kunde hærge og ødelægge store Skovstrækninger med deres uhyre Masser. Med Studiet af disse fulgte Opdagelsen af at andre Dyr: Fugle, Rovinsekter, Snyltehvepse og Snyltefluer, hjalp os med at bekæmpe de skadelige Insekter. For den Del af Faunaen, som stille og ubemærket arbejder for os, Dag ud og Dag ind, i Skovbunden, har Interessen derimod hidindtil været yderst ringe. Og dog er det denne Del som har langt den største Betydning i Skovens Liv.

Den første Beretning om, at Dyrelivet gavnede Jordbunden og Plantelivet, skyldes vistnok GILBERT WHITE, som i et Brev dateret 20. Maj 1770 (trykt 1789) paa mange Omraader klart gør Rede for Regnormenes nyttige Virksomhed ved at gøre Jorden porøs og gennemtrængelig for Vand, og ved deres Dannelse af Muldjord, derved at de lægger deres Ekskrementer paa

Jordoverfladen. (Citeret S. 87). Hans Iagttagelser forblev ubemærkede, og først mange Aar senere, i 1837, holdt CH. DARWIN i Geological Society i London et Foredrag (trykt 1840) om hvorledes Regnormene ved at aflejre deres Udtømmelser oven paa Jorden fik Sten, Kalk og Kokes til at synke ned i denne. DARWINS Meddelelse vakte stor Opmærksomhed og efterfulgtes af en Række Undersøgelser over Regnormenes Liv, af hvilke vi maa nævne V. HENSEN 1877, P. E. MÜLLER 1878b, 1884 og 1894, CH. DARWIN 1881, WOLLNY 1890 og 1897, RIBAUCOURT & COMBAULT 1907. De vigtigste af disse Undersøgelser er for os absolut P. E. MÜLLERS, i hvilke det fremhæves, at Regnormene er knyttede til den gode Muldjord og ved deres Virksomhed danner denne. Studier over den øvrige Jordbundsfaunas Betydning mangler saa godt som ganske; og ligeledes maa vor Viden om hvorledes Faunaen staar i Relation til Jordbundsforholdene siges at være ganske minimal, bortset fra hvad MÜLLER har sagt om Regnormene.

Et nøjere Studium af Skovjordens Fauna maatte derfor synes i høj Grad paakrævet. Vi maa antage at Jordbundsfaunaen særlig i Skovjorden, som kun undtagelsesvis underkastes en Bearbejdning fra Forstmandens Side, maa have den allerstørste Betydning, idet en Løsnen og Omblanding af Jordens Bestanddele i Hovedsagen maa udføres af det makroskopiske Dyreliv, som er i Stand til at udføre et mekanisk Arbejde. Hos Forfatteren, som fra sin Barndom har været kendt med P. E. MÜLLERS Arbejder og allerede fra sin Studietid har følt Savnet af Kendskab til Skovbundsfaunaen og dens Betydning, opvoksede der efterhaanden en stærk Trang til at trænge dybere ind i Sagen.

Jeg har vist, at der er et nøje Sammenhæng mellem Skovbundens Plantevækst og Skovens hele Tilstand. Træarten og dennes Alder og Bonitet saavel som Jorden og dennes mer eller mindre gode Tilstand giver sig Udtryk i bestemte Floratyper, og naar vi først kender disse Typer og deres Betydning, kan vi i dem finde Oplysning baade om Boniteten og Skovens hele Tilstand. Det var nu sandsynligt, at ogsaa Skovbundens Fauna stod i Relation til disse Floratyper, og Hovedformaalet med nærværende Undersøgelse har netop været at undersøge dette Forhold. Ved Studiet af Skovbundens Dyreliv maatte man nemlig som første Maal sætte sig at faa konstateret, hvor-

ledes Faunaen i de forskellige Skovbundstyper er sammensat, kvalitativt saavel som kvantitativt, for derefter, naar man var klar over, hvilke Dyr der optræder saa talrigt, at de kan antages at være af Betydning i Bunden, at faa undersøgt disse Dyrs Levemaade og Virken nærmere. Det følgende er en Beretning om Undersøgelser af Skovbundsfaunaen paa en Række karakteristiske danske Lokaliteter, som er udført i Aarene 1926 og 1927, og paa Grundlag af disse vil vi søge at opstille Love for Sammenhøret mellem Skovbundstype og Faunatype, og for Faunaens Betydning i Skovbunden.

Valg af Metode og Materiale.

Undersøgelse af Skovens Fauna byder langt større Vanskeligheder end Undersøgelse af dens makroskopiske Flora, fordi Dyrene er bevægelige. Antallet af større Dyr som Hjortevildt saavel som Antallet af ynglende Rovfugle og andre større Fugle vil man vel ofte vide nogenlunde Besked med. Derimod vil mindre Pattedyr saavel som mindre Fugle unddrage sig en direkte Tælling. Man kan dog for Fuglenes Vedkommende faa omtrentlig Begreb om Antallet inden for mindre Skovarealer; jeg har saaledes selv søgt at opgøre Antallet af Fugle i Ermelunden, ved at tælle Hanner i den Tid, hvor de synger mest livligt, og denne Metode synes at have givet et godt Resultat. Vilde man derimod søge at bestemme Antallet af Mus, Muldvarpe, Spidsmus, Tudser, Snoge, store Løbebiller eller lignende, staar man over for saa store Vanskeligheder, at man egentlig kun kan faa et Skøn om mange eller faa eller højst en Talbestemmelse inden for yderst vide Grænser. Særlig vanskelig er Bestemmelsen naturligvis, naar det gælder Dyr, der lever skjult i Skovbunden.

De meget smaa og talrige Dyr er vi derimod i Stand til at bestemme med stor Sikkerhed, fordi vi kan udtage en Prøve af et vist Areal af Skovbunden og føre den hjem med os. Den danske Havforskning har allerede fra 1896 foretaget nøjagtige Optællinger af Havbundens Dyr, ved at optage Bundprøver à 0.1 m^2 og undersøge disse, og paa samme Maade kan vi tage Prøver af Skovbunden og bringe dem med os hjem og undersøge dem. Der møder os imidlertid nu den Vanske-

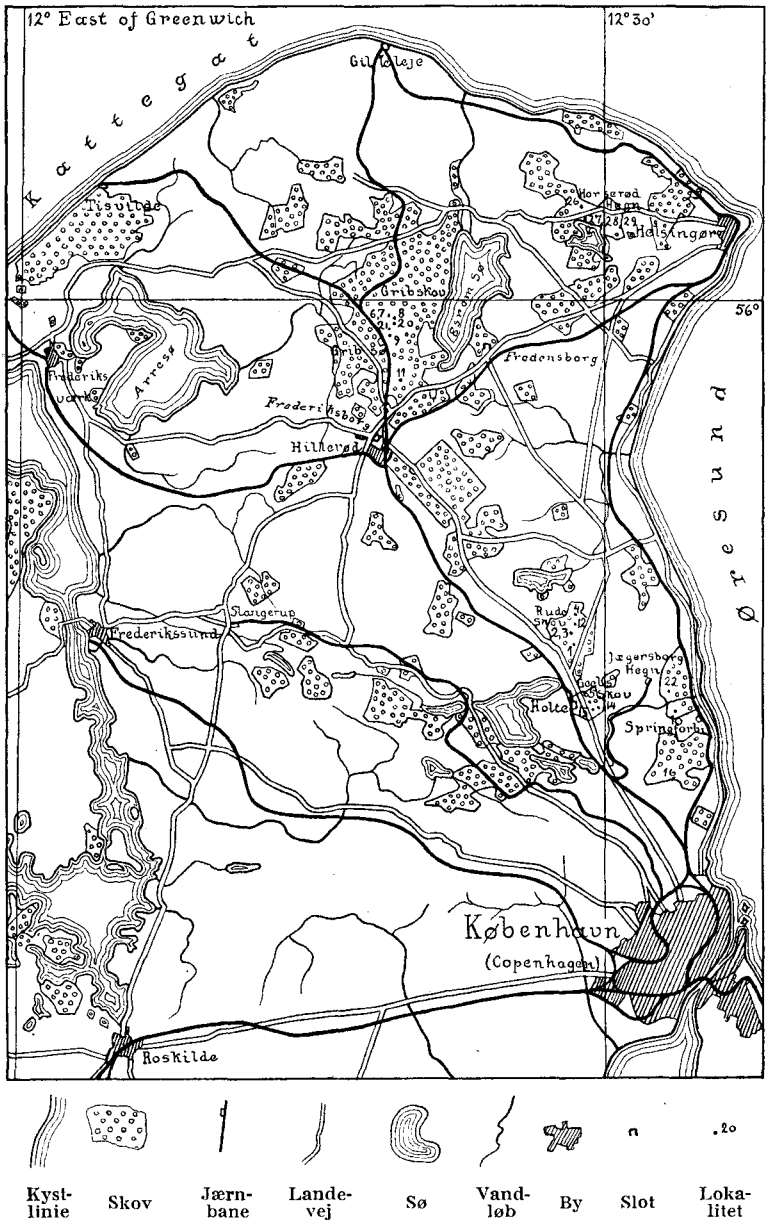


Fig. 1. Kort over Nordøstsjælland med Lokalitetsnumre.
Maalestok ca. 1 : 200 000.

lighed, at Skovbundens Dyr for største Delen er saa smaa, at vi kun vanskeligt eller slet ikke kan finde dem i Prøven med ubevæbnet Øje, saa et Forsøg paa at gennemsøge Prøven og pille Dyrene fra vil kun give et yderst mangelfuldt Resultat. Vi maa derfor ty til andre Metoder, som er forskellige for forskellige Dyregrupper.

1: Større Biller og Larver, og de større Regnormearter der lever i Muldjord, vil vi kunne bestemme ved at gennemgrave og omhyggeligt gennemsøge bestemte Arealer, f. Eks. à 1 m^2, og opsamle Dyrene.

2: Alle Orme, Snegle og Leddyr (Insekter, Tusindben m. v.) kan vi bestemme ved at vi udtager Bundprøver à 0.1 m^2 og tager disse med hjem, hvor vi bringer Dyrene til selv at forlade Prøven, hvorefter de opsamles. Hertil er konstrueret forskellige Apparater, men vi skal kun omtale det, som er benyttet ved disse Undersøgelser, og som er forfærdiget efter TULLGRENS Forbillede (TULLGREN 1918); se Fig. 2 og 3.

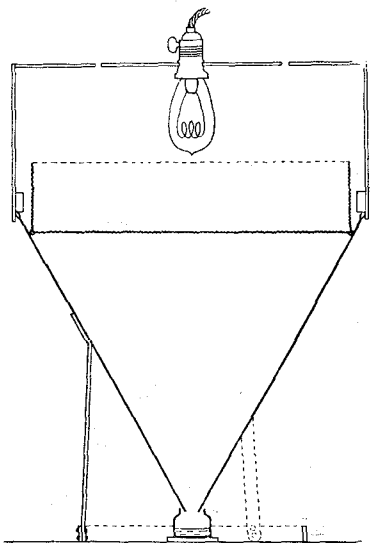


Fig. 2. Apparat til Uddrivning af Dyrene. Maalestok 1:10.

Prøven anbringes i en Sigte med 42 cm Tværmaal forfærdiget af 3 mm Traadnæt i Bunden, medens de 10 cm høje Sider har 6 mm Masker. Sigten stilles oven i en Zinktragt med 46 cm Diameter og 40 cm Højde med en 2 cm vid Aabning forneden. Tragten bæres af tre Ben, forneden fæstnede til en Ring. Over Tragten er anbragt en 21 cm høj Hætte af Krydsfiner, og i Midten af denne sidder en 35-Lys Kultraadspære som Varmekilde. Naar Lampen tændes, vil Prøven efterhaanden opvarmes og tørres, og Dyrene vil da søge nedad, falde ned i Tragten og ud af dennes Munding, hvor de opsamles i et Glas, som indeholder Alkohol.

3: Nematoderne, de smaa hvide Traadorme, kan man ikke samle paa denne Maade, da de indkapsler sig, naar Jorden varmes og tørres. De maa derfor fraskilles med Vand,

enten ved at man anbringer en lille Klump af Prøven (Græstørv, Maar) i en Glasskaal med Vand paa Bunden, og Nematoderne vil da svømme ud i Vandet, hvor de kan opsamles under Mikroskopet med en fin Naal; eller en Jordprøve (Muld eller mineralsk Jord) slæmmes op i Vand, og naar de grove Bestanddele har bundfældet sig, sir man Nematoderne, som paa Grund af deres Lethed endnu svæver i Vædsken, fra, ved at hælde Vandet gennem en fin Sigte af Møllergaze.

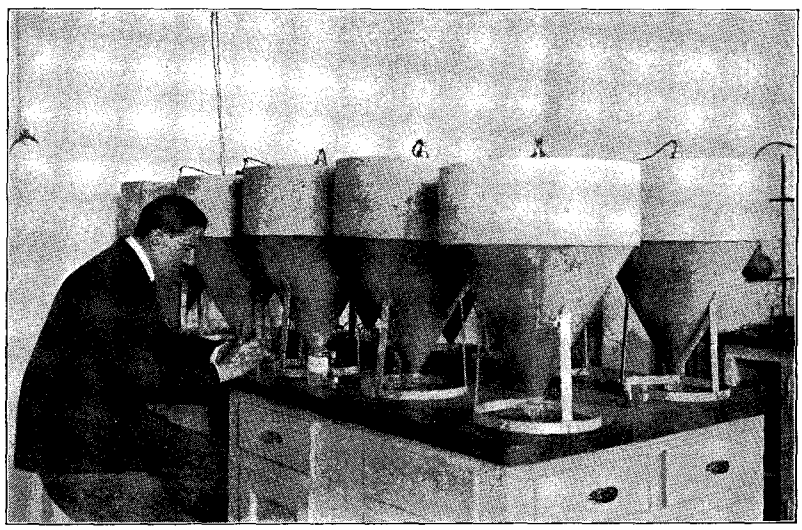


Fig. 3. Forsøgsvæsenets Laboratorium med 10 Apparater.

4: Endelig er der de smaa encellede Dyr, Protozoerne, der maa bestemmes ved Spredning paa lignende Maade, som naar man tæller Bakterier.

I de foreliggende Undersøgelser har vi ikke beskæftiget os med Nematoder og Protozoer, som fordrer særlige Indsamlingsmetoder, men nøjedes med at bestemme Orme, Snegle og Arthropoder, der ogsaa, i alt Fald for den mekaniske Bearbejdning af Skovens Affald og af Overgrunden, maa have den ganske overvejende Betydning: »Det mikroskopiske Dyreliv . . . kan næppe i væsentlig Grad forringe Massens Tæthed og Fasthed.« (P. E. MÜLLER 1884, S. 74).

Prøveudtagningen er sket paa den Maade, at man har taget alt Materiale fra 0.1 m^2, i Regelen saaledes at man først har taget Løvlaget eller Mos- og Naalelaget og fyldt det i en

tæt Lærredspose, dernæst Muldjords- eller Maarlaget og fyldt i en anden Pose, og bragt det hele hjem til Laboratoriet, hvor det blev behandlet i det skildrede Apparat; hver Prøve for sig. Undertiden er dog alt Materialet taget i een Prøve. Den mere tætte Overgrund eller Blegsandslaget under Maaren er ikke medtaget, da der er relativt set yderst faa eller ingen smaa Dyr her; men muldet Overgrund er undersøgt for Regnorme og større Larver.

For at lette Arbejdet og for at undgaa langvarig Transport, der kunde skade Dyrene, saa de mistede Evnen til at forlade Prøven i Apparatet, er langt de fleste Prøver taget i Nordøstsjælland. Kortet Fig. 1 (Side 162) viser disse Lokaliteter. Desuden er der taget nogle Prøver fra Jylland og fra Bornholm.

Fra de ti af Lokaliteterne er der taget Prøver flere Gange i Løbet af de to Aar, Undersøgelsen varede, og for disse ti Hovedlokaliteter er der dannet Middeltal for en Kvadratmeter, der skal svare til en omtrentlig Middelmængde af Fauna for hele Perioden.

De ti Hovedlokaliteter er følgende:

Nr.	Træart	Floratype	Jordbund
15	Bøg	Anemone-Bukkar	Muld
5	»	Flitteraks-Bukkar	»
9	»	Skovsyre	»
2	»	Skovjomfruhaar	Forarmet
4	»	Ingen Flora	Maar
20	»	»	»
10	Eg	Bingelurt	Muld
1	Rødgran	Skovsyre	»
6	»	Mos (Blaabærtype)	Maar
8	»	»	»

Desuden er der taget enkelte Prøver fra følgende Lokaliteter:

Nr.	Træart	Floratype	Jordbund
12	Bøg	Anemone-Bukkar	Muld
14	»	»	»
3	»	Miliegræs	»
30	»	Skovsyre-Anemone	»
21	»	Skovsyre	»
22	Eg med Bøg	ingen Flora	»
23	Eg	ingen Flora	»
16	Ask	Nælde-Bingelurt	»

Nr.	Træart	Floratype	Jordbund
11	Gran + Lærk	Mos (Blaabærtype)	Maar
25	Gran	Mos (Tyttebærtype)	»
32	»	»	»
26	Skovfyr	Blaabær	»
27	»	»	»
28	Skovfyr + Bøg	»	»
29	Skovfyr + Gran	»	»
17	Bjergfyr	Ingen Flora (Tyttebærtype)	»
19	Enebær	»	»
7	Ingen	Blaabær	»
18	»	Lyng	»
24	»	»	»
31	»	»	»

Den største Vanskelighed ved at opnaa tilfredsstillende Resultater af en Undersøgelse over Skovbundsdyrenes Antal ligger i, at dette varierer stærkt fra Plet til Plet, saaledes at man, selv om man har søgt at tage Prøven paa et Sted, der mest muligt synes at svare til det for Lokaliteten gennemsnitlige, dog maa være forberedt paa at faa en ikke ubetydelig Fejl. Hvor der er taget flere Prøver samtidig fra samme Lokalitet, viser der sig da ogsaa temmelig store Forskelligheder, dog saa godt som kun af kvantitativ Art. Der er altid stor Lighed mellem to Parallelprøver. Paa Grund af de mange Prøver, der er taget fra de ti Hovedlokaliteter, vil disse Fejl derfor i det væsentlige være udjævnede i Middeltallet. Endvidere varierer Antallet af Dyr stærkt fra Tid til anden, men ogsaa her nærmest kun kvantitativt, idet de fleste af Skovbundens Dyrearter er til Stede i Bunden hele Aaret eller i alt Fald den største Del af dette. Selv i Vintertiden findes de fleste Smaadyr oppe i de øverste Lag, i Dvale, stivfrosne, men ikke døde, i Stand til at leve op igen saa snart de varmes op. Større Regnorme vil derimod gaa dybt ned i Frostperioder om Vinteren og i tørre Perioder om Sommeren, men er jo saa heller ikke aktive i Bunden. Collemboler (Springhaler), Mider, Edderkopper, Mosskorpioner, Tusindben, Skolopendere, Bænkebidere, Løbebiller og Rovbiller og disses Larver træffes hele Aaret rundt. Smælderlarver er fleraarige, og man træffer derfor til alle Aarstider store og smaa imellem hinanden. Enchytræider og Dipterlarver er derimod for en Del Arters Vedkommende kun til Stede til

visse Tider og foraarsager de største Sæsonvariationer i Faunaen. Alt i alt er Faunaen dog saa ensartet Aaret igennem, at jeg anser det for ganske forsvarligt at danne Aarsmiddeltal, saaledes som jeg har gjort det for de ti Hovedlokaliteters Vedkommende.

Det havde været ønskeligt om man kunde have taget mange Prøver, f. Eks. 10 fra hver Lokalitet ved hver Prøveudtagning, men dette var ganske uoverkommeligt, naar det andet vigtigere Resultat, et Materiale der egnede sig til Sammenligning af forskellige typiske Lokaliteter, skulde naas.

De enkelte Undersøgelser.

For hver af Hovedlokaliteterne er Træbestand, Bundflora og Jordbund beskrevet, og der gives her en kort Karakteristik af hver, medens Tal for Træbevoksningen og dennes Tilvækst, Beskrivelse af Jordbundsprofil og Analyser af Jordbunden maa søges foran i den engelske Tekst. For de øvrige Lokaliteter er Beskrivelsen ganske kortfattet. Antallet af indsamlede Dyr er opført i de foranstaaende Tabeller II—XIII, medens der her gives en Beskrivelse i Ord af hver Lokalitets Fauna. Oplysning om de enkelte omtalte Dyrearters Navn og systematiske Stilling m. v. findes i det følgende Afsnit. Billedtavlerne I—X bag i Bogen gengiver Fotografier af Bevoksning og Skovbund paa de ti Hovedlokaliteter samt Lok. 7. Tavlerne XI—XVI viser nogle Jordbundsprofiler og Affaldslag, der omtales i et senere Afsnit, og paa Tavlerne XVII—XXVIII gengives Fotografier, som Forfatteren har taget af en Del af Skovbundens vigtigste Smaadyr. Hensigten med de sidstnævnte Tavler er at give den praktiske Forstmand og andre ikke særlig zoologisk kyndige Læsere et Begreb om en Del af disse smaa Dyrs Udseende, og særlig haaber jeg at Forstmænd vil have Glæde af Fotografierne, der viser nogle af deres Milliarder smaa Plejebørn, og at Skovbundsdyrenes Verden gennem Billederne maa blive gjort mere levende og tilgængelig for Læseren.

Af de tre Kolonner længst til højre i Tabellerne II—XIII angiver den første Middelantallet pr. m^2. Den anden Kolonne er Totalvægten af Dyr pr. m^2, men denne Vægt kunde dog

ikke bestemmes umiddelbart ved Vejning af alle Dyrene, men er udregnet efter en Bestemmelse af Middelvægten hos hver Art, for levende Individer. Den yderste Kolonne, en Kalkulation af Respirationen i 1 Time ved 13° C., vil vi først komme til at beskæftige os med i et senere Afsnit.

Bøg, Muld, Anemone-Bukkar.
Lokalitet 15. Tavle II, S. 28.

En 80aarig Bøgebestand i god Vækst, blandet med smukke 125aarige Lærk, Afd. 163 i Geels Skov. Terrainet hælder svagt mod Skovens Sydudkant. Der er en kraftig Flora af Anemone og Bukkar med noget Stor Fladstjerne og Skovviol indblandet. I Prøvestedets Nærhed findes Grupper af 2—3 m høj Opvækst af Æretræ. Under det løse Lag Bøgeblade findes 8 cm skør Muldjord paa en 60 cm dyb, muldet Overgrund. Undergrunden er sandet Ler, der fra 110 cm Dybde er kalkrig (Bruser med Saltsyre).

Lokalitetens Fauna udmærker sig ved det store Antal Regnorme, 177 pr. m^2, især store Arter. Det vrimler med Graa Orm, der lever i Overgrunden; Skovregnormen, der lever saavel i Overgrunden som oppe i Løvlaget, og de mindre Arter, navnlig Løvregnorm, der ene holder sig til Løvlaget, er ganske talrige. De større Arter udgør tre Fjerdedele af Antallet, og den samlede Vægt kan derfor ansættes til 53 g pr. m^2, eller 75 pCt. af Faunaens samlede Vægt, idet andre Dyr tilsammen kun vejer knap 18 Gram.

Næst efter Regnormene kommer ægte Tusindben, ca. 140 Stk. eller 7 g pr. m^2. Nr. 3 er Snegle, ca. 30 af den nøgne graa *Arion subfuscus* og ca. 70 ganske smaa Snegle med Skal, i alt ca. 5 g. Nr. 4 er Dipterlarver, især Stankelbenlarver, 232 i alt, med en samlet Vægt af 1.5 g. Derefter følger de smaa hvide Orme, Enchytræiderne, 500 eller ca. 1 g pr. m^2 og de næsten traadformige, lange gule Geophilider, der hører til Skolopendrene, 70 Stk. eller 1 g pr. m^2. Af Biller er navnlig Rovbiller og deres Larver fremtrædende, Smælderlarver findes almindeligt, men ikke tilnærmelsesvis i saadanne Mængder som paa Maarbund.

Størst Antal, 3200 pr. m^2, naar Miderne, men de vejer kun 0.2 g i alt; og Springhalerne 1200 pr. m^2 med en

samlet Vægt af kun 0.05 g pr. m². Antallet af Mider og Springhaler er dog langt mindre end paa Maarbund. Springhalerne er især farvede Arter af Familien *Isotomidae;* den lille hvide, blinde *Onychiurus armatus* er forholdsvis langt mindre fremtrædende her end paa Maarbund.

Resten af Faunaen spiller kun en ringe Rolle. Der findes nogle Løbebiller, Snudebiller (især *Strophosomus)*, Blødbillelarver *(Cantharidae)*, en Mængde af de næsten mikroskopisk smaa Biller, Ptilier, hvis Bagvinger ligner smaa Fjer, og Ørentviste, saavel den almindelige *Forficula auricularia* som *Chilidura acanthopygia* der har en meget lang Tang. Endvidere finder vi en Mængde af den lille *Newsteadia floccosa*, der hører til Skjoldlusene og er dækket af et hvidt, voksagtigt Lag, og optræder meget hyppigt, navnlig i Løvskov.

Faunaen kan kort karakteriseres ved, at Regnorme, især større Arter som lever i Overgrunden, udgør tre Fjerdedele af den samlede Vægt af Dyr. Mængden af Leddyr, som lever af organisk Stof, navnlig ægte Tusindben, *Julus*, er nærmest middelstor.

Bøg, Muld, Flitteraks-Bukkar.
Lokalitet 5. Tabel III, S. 34.

En godt 100aarig, god Bøgebevoksning i Afd. 146 i Geels Skov, hvori Forsøgsvæsenets Prøveflade S findes. Lokaliteten har megen Lighed med den foran omtalte. Der er en skør Muldjord, men Overgrunden er lidt fastere, og Undergrunden mangler Kalk. Bunden er mere udsat for Træk, og dette giver sig til Kende ved, at Anemone-Bukkar-Floraen er stærkt blandet med Flitteraks, uden at man dog kan tale om en ondartet Melica-Tilstand.

I Overensstemmelse hermed har Dyrelivet en ganske lignende Sammensætning som paa Lokalitet 15, men er kendelig fattigere, idet den samlede Vægt af Dyr kun udgør 38 g pr. m² mod 71 g paa Nr. 15. Regnormene udgør 28 g eller 74 pCt. af Vægten, og Graa Orm er den mest fremtrædende.

For de andre Dyreslægter finder vi tilsvarende mindre Tal med nogle faa Undtagelser. Snegle kommer her som Nr. 2 med ca. 4 g, medens Myriopoderne kun udgør 2 g, idet der kun var 32 ægte Tusindben. Dipterlarver er flere i Tal, men

vejer kun 1 g, fordi de store Stankelbenlarver næsten helt mangler. Det er antagelig Lokalitet 15's større Muldrigdom, der gør, at den er rigere paa ægte Tusindben og Stankelbenlarver. Vi finder forholdsvis mange Smælderlarver paa Lok. 5; foruden *Athous subfuscus* en Del *Dolopius marginatus.* Rovbiller og Løbebiller er ogsaa talrigere end paa Lok. 15; af *Newsteadia floccosa* er der derimod færre. Af Isopoder findes som paa Lok. 15 ca. 150 pr. m^2, næsten udelukkende de meget smaa Trichoniscer, medens den store almindelige Bænkebider *(Oniscus asellus)*, der hører hjemme i Træstubbe og under død Bark, kun undtagelsesvis træffes ude paa Skovbunden.

Af Mider findes kun 1900 med 0.17 g Vægt; af Springhaler kun 920, men Vægten er større end paa Lok. 15, fordi der er mange af den store blygraa *Pogonognathus plumbeus.*

Bøg, Muld, Skovsyre.
Lokalitet 9. Tabel IV, S. 38.

En omtrent 80aarig Bøgebevoksning i Grib Skov nær ved Gribsø, Nøddebo Distrikt Afd. 92, Forsøgsvæsenets Prøveflade BL. Undergrunden er foroven leret Sand, dybere nede lagvis afløst af sandet Ler, meget gruset og stenet. Det er en udpræget Skovsyretype med et temmelig tykt, noget sammenvævet Løvlag og et surt men skørt Muldlag. Floraen er ren, svag Skovsyre; Bøgens Vækst er temmelig langsom.

Sammenlignet med de to foregaaende Lokaliteter er Dyrelivet paafaldende fattigt med i alt kun 12.9 g Dyr, hvilket svarer godt til Stedets hele fattige Karakter. Heraf udgør Regnormene 5.9 g eller kun 46 pCt. af den totale Vægt. Mellem de fundne Orme var der 3 Graa Orm og 2 Skovregnorm, medens Resten var smaa Arter, ganske overvejende (eller maaske udelukkende) den lille Mosorm *(Dendrobaena octoedra).* Derefter følger Dipterlarver med 2 g, af hvilke særlig Stankelbenlarver, dernæst Leptidelarverne vejer til. I øvrigt bemærker man det store Antal Mycetophilidelarver i Novemberprøverne 1926 og i Juliprøverne 1927. Larverne af Mycetophilider (Svampemyg) og Sciarider (Hærmyg) ligner hinanden saa meget, at de ikke har kunnet adskilles. Det er sandsynligst at i alt Fald Julifundet er en Art af den berømte Hærmygslægt, der er almindelig i Skovbunden som Larve netop paa

denne Aarstid, og som undertiden optræder i de mærkelige vandrende Larvetog, der under Navnet Hærorm har foraarsaget megen Sensation og Overtro. Tusindben og andre Myriopoder er noget sparsommere her end paa den gode Bøgemuld, Snegle ligeledes. Trichoniscer er yderst faatallige.

Smælderlarver er temmelig talrige, ganske overvejende *Athous subfuscus*, men ellers er der temmelig faa Biller; især bemærker man, at de smaa Ptilier næsten helt mangler. Paafaldende er Forekomsten af Sommerfuglelarver paa en saa bar Bund, men de tilhører Slægten *Hepialus*, der lever i Jorden af Rødder. *Newsteadia floccosa* er meget talrig.

Af Mider har vi et lignende Antal, ca. 3000 og Vægt 0.2 g, som paa de to foran omtalte Lokaliteter; Springhaler er rigeligere, omtrent 1400, vejende 0.08 g. Den hvide *Onychiurus armatus* er talrigst, men omtrent lige saa talrig er den graa *Folsomia quadrioculata;* men disse 1000 smaa Væsener vejer tilsammen ikke mere end de 30 *Pogonognathus* og 16 *Entomobryidae.* Temmelig talrige er ogsaa smaa Isotomer og *Lepidocyrtus lanuginosus.*

Bøg, forarmet Udkant, Skovjomfruhaar.
Lokalitet 2. Tabel V, S. 42.

Prøverne er taget i Udkanten af en ældre Bøgebevoksning, Fiskerbakken, Rude Skov Afd. 81, som er blevet udsat for Sol og Træk, ved at Bevoksningen Vest for blev hugget bort i Tiden omkring Aarhundredskiftet. Der er nu ved at vokse ung Skov op paa Naboafdelingen, som vil give Læ for Jorden, men endnu da Prøverne blev taget, var den ondartede Jordbundstilstand meget typisk. Overgrunden er blevet muldfattig og fast og er dækket af et ganske tyndt Maarlag bevokset med Bølget Bunke samt Skovjomfruhaar, Kostmos og andre Mosser. Maaren er tæt gennemvævet af Græsrødder og Mosrhizoider, og de øverste Par Centimeter af Overgrunden er forandret til Blegsand. Jordbunden er Sand i de øverste 125 cm, derunder leret.

I Solskin er her varmt, tørt og behageligt for voksne Insekter, men Forholdene er meget ugunstige for Jordbundsfaunaen, som for største Delen ikke taaler stærk Udtørring. Denne er da ogsaa overordentlig fattig. Hele den samlede Vægt

af Dyr er kun 5.2 g pr. m^2 eller ikke mere end en Fjortendedel af, hvad vi fandt paa den bedste Bøgelokalitet. Heraf udgør Regnorme kun $1^1/_2$ g eller 28 pCt. af den samlede Vægt, og det er, saa vidt Individerne har kunnet bestemmes, udelukkende den lille Mosorm *(Dendrobaena octoedra)*, der færdes oppe i Maaren og i særlig Grad taaler Udtørring, medens de store Arter, som skal bearbejde Overgrunden, mangler. Næst efter Ormene spiller Dipterlarver den største Rolle; her er enkelte Stankelbenlarver og Mycetophilider samt en Del Leptider, og en Mængde ganske smaa Larver af Cecidomyide-type. Snegle mangler ganske, ligeledes Trichoniscer, og af Myriopoder findes kun en Del Geophilider, som er Rovdyr, medens de muldædende ægte Tusindben mangler. Der er en Del Smælderlarver, mest *Athous subfuscus*, og mange Rovbiller; af Løbebiller især den lille kobberglinsende *Notiophilus biguttatus*. Endvidere findes nogle Blødbillelarver *(Cantharidae)* og Snudebiller *(Strophosomus)*. Ptilier mangler og ligeledes *Newsteadia floccosa*.

Af Mider har vi 2400, men de er meget smaa, saa Vægten bliver kun 0.09 g. De overgaas her langt af Springhalerne, hvoraf der er fem Tusinde. Talrigst er den lille graa *Folsomia quadrioculata* med halvfjerde Tusinde Individer pr. m^2. Den hvide *Onychiurus armatus* mangler, eller har i alt Fald været saa faatallig i Prøverne, at den ikke er bemærket; men den erstattes af den lille blaagraa *Hypogastrura armata*. Endvidere er her mange *Isotoma* og *Lepidocyrtis*. Det er alt sammen livlige, farvede Former, der kan taale Lyset og Udtørringen. Den samlede Vægt af Springhaler, 0.3 g, er langt større end paa nogen af de foranstaaende Lokaliteter; vi er her under ugunstige Forhold, hvor ganske smaa Dyreformer synes at spille en relativt langt større Rolle end paa den gode Muldbund.

Bøg, Maar, ingen Flora.
Lokalitet 4. Tabel VI, S. 46.

Rude Skovs gamle, maarklædte Bøgearealer blev i Hovedsagen forynget af Forstraad H. C. Ulrich. Tilbage staar kun enkelte Partier, af hvilke den her undersøgte Bevoksning, Afd. 29 i Skovens nordre Ende, er meget karakteristisk. Alderen er 140 Aar; Væksten temmelig ringe. Under et tykt

Løvlag, 2 cm fra sidste Aars Løvfald og 2 cm gammelt Løv, findes ca. 10 cm Maar, foroven brun, løs, svampet og med en Del Smaabunker af Ekskrementer især af Regnorme og Stankelben (Formuldningslaget), i de nederste Par Centimeter en tæt, amorf, sort Tørv (Humusstoflaget). Der er ca. 10 cm Blegsand og ca. 15 cm skør Rustjord. Undergrunden er sandet Ler.

Denne Bøgemaar udmærker sig ved et overordentlig rigt Dyreliv. Vi finder et langt større Antal Dyr end paa Bøgemulden, nemlig ca. 14000 pr. m^2, eller pr. ha 140 Millioner Dyr, der er saa store, at de i alt Fald kan skimtes med det blotte Øje. Det er her ganske overvejende meget smaa Dyr, saa den samlede Vægt er kun ca. 24 g, hvilket er næsten kun en Tredjedel af, hvad vi fandt paa den bedste Bøge-Muldlokalitet, men dog omtrent to Tredjedele af Resultatet fra Flitteraksmulden, omtrent dobbelt saa meget som fra Bøg-Skovsyremulden og $4^1/_2$ Gange saa meget som paa den forarmede Bund, Lok. 2.

Som man kunde vente, har Dyrelivet en helt anden Sammensætning end paa Mulden. Paa Lokalitet 15 havde vi 53.1 g Regnorme og 17.6 g andre Dyr, paa Lokalitet 5 var der 27.9 g Regnorme og 9.9 g andre Dyr; her paa Maaren 5.4 g Regnorme og 18.6 g andre Dyr. Forskellen fra Muldbunden ligger saaledes først og fremmest i, at her er meget faa Regnorme, der kun udgør 22 pCt. af den samlede Vægt, medens der til Gengæld er en større Vægt af andre Dyr; Graa Orm *(Allolobophora turgida)*, som lever nede i Overgrunden, mangler ganske her paa den podsolerede Bund; derimod finder vi enkelte Skovregnorme *(Lumbricus rubellus)*, men Hovedmængden er dog ganske smaa Regnorme, nemlig Mosormen *(Dendrobaena octoedra)*, som er karakteristisk for Mos og Maarbund, og enkelte Løvregnorm *(Lumbricus castaneus)* og Stuborm *(Dendrobaena arborea)*. Baade Skovregnormen og de smaa Arter lever oppe i Maaren og Løvlaget.

De smaa hvide Orme, Enchytræiderne, der navnlig i fugtige Perioder, saaledes i Efteraaret og den milde Vinter 1926—27, færdes i store Mængder i Bøgeløvet, var paa denne Maarbund med det rigelige Løvlag endnu talrigere end paa Muldbunden. Snegle fandtes i lidt mindre Mængde end paa de bedste Muldlokaliteter. Myriopoderne staar langt tilbage i Antal, bl. a. er der færre af de humusædende ægte Tusindben, i alt

1.7 g mod 8.9 g og 2.2 g paa de to Lokaliteter fra Geels Skov. Til Gengæld findes Dipterlarver i meget stort Antal og Vægt. Det er især store Stankelbenlarver af forskellige Arter, vist især *Tipula nubeculosa*, der vejer til og endog overgaar Regnormene i Vægtmængde. Tabellen her giver 6.3 g Stankelbenlarver mod 5.4 g Regnorme. En særlig Undersøgelse af 1 m^2 Maar og Løv, som blev taget hjem fra denne Lokalitet d. 23. Marts 1927 og gennemsøgt i Stuen, gav 4 *Lumbricus rubellus* og 22 mindre Orme, mest Mosorm, der tilsammen vejede 8.6 g, og 39 Stankelbenlarver, der tilsammen vejede 12 g. Prøven var saaledes særlig gunstig, men ogsaa i denne var Stankelbenlarver i Overvægt. Af andre Dipterlarver er Mycetophilider (eller Sciarider) og Leptider talrige, og desuden findes en stor Mængde ganske smaa Larver af Typerne *Anthomyiinae* og *Cecidomyiidae*. De talrige fuldvoksne Dipterer var især *Sciara umbratica*.

Ogsaa Smælderlarver, udelukkende *Athous subfuscus*, der ligesom de fleste Dipterlarver lever af organisk Affald, var meget talrigere end paa Muldbunden. Vi bemærker, at Antallet af Rovbiller er meget stort, af Løbebiller lille, og at der er mange Blødbillelarver. Endvidere er *Newsteadia floccosa* talrig.

Særlig imponerende er Antallet af Mider, ca. 6000, og Springhaler, 5100. Trods deres Talrighed udgør disse smaa Dyr dog kun tilsammen 0.55 g eller et Par Procent af Faunaens samlede Vægt. Senere, naar vi kommer til at tale om Dyrelivets Intensitet, vil vi imidlertid se, at de ikke kan betragtes som uvæsentlige, men at de tværtimod paa Maarlokaliteter udgør en anselig Faktor i den af Dyrene foraarsagede Omsætning af det organiske Stof.

Lokalitetens Dyreverden kan i store Træk karakteriseres ved, at Regnorme kun udgør 22 pCt. af den samlede Vægtmængde af Dyr, og at de ligesom de andre Dyrearter kun færdes oppe i Maaren og Løvlaget, ikke i Mineralbunden. Store Stankelbenlarver overgaar Regnormene i Vægtmængde og spiller formodentlig sammen med andre Dipterlarver den største Rolle ved Omsætningen. Endvidere er Smælderlarver, Snegle, Tusindben og Enchytræider, saavel som de smaa Mider og Springhaler meget fremtrædende.

Bøg, Maar, ingen Flora.
Lokalitet 20. Tabel VII, S. 52.

Denne Lokalitet blev optaget, efter at jeg havde set, hvor overordentlig rig en Fauna der fandtes paa Maarbunden i Rude Skov, Lokalitet 4. Da P. E. MÜLLER taler om Maarens store Fattigdom paa Dyreliv, fandt jeg det nødvendigt at kontrollere Resultaterne fra Lokalitet 4 med en Lokalitet, der virkelig var udvalgt paa et særlig ugunstigt Sted, en tilsyneladende meget død Maar under gammel Bøgeskov i meget ringe Vækst i Grib Skov, Nøddebo Distrikt Afd. 88. Jorden er dækket af et tykt Lag Løv, som mindst udgør tre Aars Løvfald, og dette Lag danner nederst en sammenhængende Kage. Den meget svære Maar er tættere end i Rude Skov og opfyldt af Bøgerødder og Honningsvamprhizomer samt Svampehyfer. Under et ca. 6 cm tykt, brunt, løst Formuldningslag som paa Lokalitet 4 finder vi her ca. 8 cm sort, tæt, amorf Maar (Humusstoflag). Det er altsaa en Maar af særlig ondartet Karakter. Under Maaren er der ca. 10 cm Blegsand og ca. 15 cm Rustjord; fra 70 til 100 cm Dybde er der Leral; Undergrunden er sandet Ler vekslende med leret Sand og meget rig paa Granit. Kulsur Kalk fandtes ikke.

Som man kunde vente var den samlede Vægtmængde af Dyr mindre her end paa Lokalitet 4, men dog ingenlunde ubetydelig, nemlig $16^1/_2$ g, hvilket er mere end paa Skovsyremulden, Lokalitet 9, der ligger i samme Skov i faa Hundrede Meters Afstand. Vi kan nu, efter at vi kender Lokalitet 4, se, at Lokalitet 20 har en endnu mere udpræget Maarfauna, hvor Regnorme, hvoraf her kun er fundet den lille Mosorm, kun udgør 1.15 g eller 7 pCt. af Faunaens samlede Vægt. Derimod ligger Vægten af Enchytræider ikke meget under Lokalitet 4. Myriopoder staar mærkeligt højt, men dette skyldes en stor Mængde af de tynde, gule Geophilider, som er Rovdyr og derfor snarest maa være en hemmende Faktor. Ægte Tusindben findes, men er faatallige.

Af Humusædere staar Dipterlarver højest med 3.35 g, halvt saa meget som paa Lokalitet 4, og heraf overvejende Stankelben. Mycetophilider (eller Sciarider) findes i meget stort Antal. Desuden er der mange Leptider og en Mængde ganske smaa Larver af *Anthomyiinae*- og *Cecidomyiidae*-Type.

Ogsaa Smælderlarver, *Athous subfuscus*, er talrige, og nærmer sig Lokalitet 4 i Antal. Som paa denne er Rovbiller talrige, Løbebiller faa, og der findes nogle Blødbille-*(Cantharidae)*-larver og Ptilier. Af *Newsteadia floccosa* er der ligesom paa Lokalitet 4 ca. 100 pr. m^2.

Der er omtrent 10000 Mider med en samlet Vægt af 0.67 g, og over 7000 Springhaler, tilsammen 0.28 g, altsaa langt flere end paa Lokalitet 4. Medens den hvide, blinde *Onychiurus* paa Lokalitet 4 udgør godt to Femtedele af Springhalernes Antal, saa er den paa Lokalitet 20 langt i Overtal. Som Enkeltundersøgelserne viser, holder den sig mest nede i den øvre, løse Maar, medens den næsttalrigste Art, den graa *Folsomia quadrioculata*, overvejende træffes oppe i Løvlaget.

Paa Lokalitet 20 har vi nær ved 20000 Dyr paa 1 m^2, eller pr. ha ca. 200 Millioner Dyr, der er saa store, at de i alt Fald kan skimtes med det blotte Øje. Denne »døde« Maarbund indeholder saaledes flere Dyr end nogen anden af de undersøgte Lokaliteter, og Faunaens samlede Vægtmængde er ingenlunde ringe.

Karakteristisk for Typen er det ringe Antal Regnorme, udelukkende den lille Mosorm, den betydelige Mængde af Dipterlarver, Smælderlarver og Geophilider, og det enormt store Antal Mider og Springhaler.

Nogle andre Bøgeskovslokaliteter.
Lok. 3, 12, 14, 21 og 30. Tabel VIII, S. 56.

Foruden de forannævnte Bøgeskovslokaliteter er der taget Prøver fra nogle faa andre Steder, der skal tjene som Kontrol paa de fundne Resultater.

Lokalitet 3 er fra samme Bevoksning som Nr. 2, men et Stykke inden for Udkanten, hvor Bunden er dækket med Miliegræs blandet med Bukkar og Anemone, Løvet samler sig, og Jorden er i en temmelig god Muldtilstand. Der fandtes mange Regnorme, især Graa Orm, og mange ægte Tusindben. Dipterlarver er meget talrige, bl. a. Stankelben og Mycetophilider; Mider og Springhaler er talrige. Det er helt igennem en meget typisk Muldbundsfauna. At det samlede Dyreantal er meget stort kan skyldes Tilfældigheder, men ogsaa at Prøven er taget

i Marts 1926, hvor flere af de andre Lokaliteter indeholdt særlig mange Dyr.

Lokalitet 12 er en halvhundredaarig, god Bøgebevoksning i Afd. 52 i Rude Skov. Bunden er bevokset med Anemone og Bukkar, og der er en skør Muld, som dog tilsyneladende nærmer sig noget til Oxalismuld. Der blev kun fundet 2 smaa Regnorme, vistnok *Dendrobaena*, men her er en Del ægte Tusindben, som paa anden god Bøgemuld, og meget faa Dipterlarver. Antallet af Mider og Springhaler er ganske normalt for Bøgemuld.

Lokalitet 14 er 56aarig smuk Bøg i Geels Skov, Afd. 162, Forsøgsvæsenets Prøveflade R, som staar med en meget betydelig Tilvækst. Bunden er bevokset med Anemone og Bukkar og i fortrinlig Muldtilstand. Faunaen ligner meget Lokalitet 15, som kun er et Par Hundrede Meter derfra. Der var baade store og smaa Regnormearter og usædvanlig mange ægte Tusindben. Antallet af Mider og Springhaler var temmelig normalt; Smælderlarver blev ikke fundet.

Lokalitet 21 i Grib Skov, Nøddebo Distrikt Afd. 87, er tæt ved Lok. 9 under ganske tilsvarende, maaske en Kende bedre Forhold. Den svarer da ogsaa særdeles godt til denne, navnlig til den samtidig tagne Prøve, Juli 1927. Vi fandt 11 Regnorme, hvoraf 1 Graa Orm, Resten smaa *Dendrobaena*-Arter, noget rigeligere af ægte Tusindben, tilsvarende Tal for Mider og Springhaler, en Del Dipterlarver, hvoraf ligesom paa 9 mange Mycetophilider; endvidere Rovbiller og *Newsteadia floccosa* noget rigeligere end paa 9.

Lokalitet 30, Forsøgsvæsenets Prøveflade F i Almindingen paa Bornholm, Bøgeskov med Bundflora af Anemone og Skovsyre, tilhører en særlig Type med en temmelig humusfattig og noget tæt Overgrund. Faunaen var temmelig fattig, naar lige undtages mange Smælderlarver og et ganske rigeligt Antal Regnorme. Prøven havde muligvis lidt noget under langvarig Transport.

I det hele stemmer disse fem vilkaarligt valgte Stikprøver saa godt med Resultaterne fra Hovedlokaliteterne, at de i høj Grad støtter den Mening, at disse ingenlunde er tilfældige, men tværtimod giver særdeles gode Billeder af Faunaen paa de forskellige Typer, som de skal repræsentere; hvilket ogsaa den Lovbundenhed, der umiddelbart træder frem i Forskellen mellem Hovedlokaliteterne, fremkalder Indtrykket af.

Eg, Muld, Bingelurt.
Lokalitet 10. Tabel IX, S. 60.

En ganske smuk ca. 70aarig Egebevoksning i Stampeskoven Afd. 299 med Forsøgsvæsenets Prøveflade AY, lige Nord for Eremitagesletten. Der findes nogle faa spredte Tjørnebuske, men i øvrigt er Jordbunden dækket af Bingelurt, Hindbær og højt Græs; om Foraaret af et overordentlig frodigt Anemoneflor. Omsætningen i Jorden er meget livlig, der findes om Sommeren næsten ingen Rester af forrige Aars Løv, Muldjorden er skør og brun og foroven dækket af et Lag Regnormeekskrementer. Jorden er skørt Ler, og i Dybden træffer man kulsur Kalk.

Dyrelivet paa denne Lokalitet er tydeligt præget af, at der næsten ingen Løv- og Humuslag findes, som kan tjene til Skjul for smaa Dyr. Der blev fundet en anselig Vægtmængde, 77 g, Dyr, men Antallet, knap 3000 pr. m^2, er mindre end paa nogen af Bøgelokaliteterne. Der fandtes kun knap 500 Springhaler, men heraf forholdsvis mange store Former, saa Vægten naar 0.1 g, og der er knap 1000 Mider. Det er Regnormene der præger Dyrelivet, idet de udgør 61 g eller lige ved 80 pCt. af Faunaens totale Vægt; i alt 122 pr. m^2, ganske overvejende Graa Orm, kun temmelig faa Skovregnorme og smaa Former. Ved Gennemsøgning af en enkelt Kvadratmeter i Juli 1928 fandtes endnu større Mængder Regnorme, nemlig 254 Stkr. med en samlet Vægt af 178 Gram.

I øvrigt er Faunaen karakteriseret ved mange nøgne Snegle, mange Trichoniscer, mange ægte Tusindben, baade *Julus* og *Polydesmus*, kun faa Smælderlarver og forholdsvis faa Rovbiller, men temmelig mange smaa Løbebiller og en Mængde Ptilier. Der fandtes en Del Snudebillelarver, formodentlig *Phyllobius*. Dipterlarver spiller kun en ringe Rolle.

Nogle Lokaliteter med Eg og Ask.
Lokaliteterne 22, 23 og 16. Tabel VIII, S. 56.

Lokalitet 22 er en ca. 80aarig Egebevoksning i Jægersborg Hegn Afd. 272, ikke langt fra Lokalitet 10 og vist paa en meget lignende Jordbund, men Egene har en tæt Undervækst af ung Bøg. Der er et meget tykt Lag Bøgeløv paa Jorden og ingen

Bundflora, men under Løvlaget findes en skør, humusrig Muldjord. Denne Lokalitets Fauna ligner ikke den lige omtalte rene Egeskovs. Derimod er der stor Lighed med Skovsyretypen Lokalitet 9, og dette er ogsaa ret nærliggende, da Bunden er præget af Bøgeskovsaffald i langsom Omsætning; saavel totalt Antal og Vægt af Dyr som Mængden af Orme, Spindlere, Mider, Springhaler og Dipterlarver er meget ens. Derimod er her en Mængde Trichoniscer, hvilket maaske maa sættes i Forbindelse med Overskoven af Eg, og her er mange ægte Tusindben, men meget faa Smælderlarver; Træk hvori Faunaen nærmer sig til den gode Bøgemulds Fauna.

Lokalitet 23 er et sluttet, 3 m højt Parti af en ung Egebevoksning frembragt paa en god Lynghede i Skærbæk Plantage i Midtjylland. Før Egene, der er en Rillesaaning, sluttede sig, var der Lyng imellem Rækkerne, men nu er al Vegetation dræbt af Skyggen paa dette Sted, og Bunden er dækket af et løst Lag Egeblade, hvorunder Jorden er en Blanding af Humus og Blegsand, som nu under Egeskoven nok vil udvikle sig til virkelig Muldjord. Der findes en Del Regnorme, men det er udelukkende den lille Mosorm, som jeg ogsaa fandt i Lyngheden i Nærheden. Med velvillig Hjælp af Hr. Skovrider W. MARK har jeg senere sat en Del større Regnorme (Graa Orm og Skovregnorm) ud, for at se om de nu, efter at Forholdene er forandrede i gunstig Retning, skulde kunne trives og maaske forbedre Overgrunden. Ægte Tusindben fandtes der ingen af, der var kun faa Mider, men derimod godt med Springhaler. Endvidere fandtes mange Dipterlarver og Smælderlarver; Rovbiller fandtes i meget stor Mængde. Det er en temmelig egenartet Fauna, der ikke kan sidestilles med nogen af de tidligere omtalte.

Lokalitet 16 er stærktvoksende Ask paa en vældrig Skraaning i Ermelunden; i Bunden med kraftig Flora af Nælde, Skovgaltetand, Skvalderkaal og Bingelurt. Der er ingen Løvlag, men et ca. 20 cm tykt Lag kalkrig, sort Muld paa skør, leret, kalkrig Overgrund. Det kalkrige Muldlag er rigt paa Sneglehuse; der taltes 340 i alt i Prøven fra 0.1 m^2. I øvrigt er Jorden præget af mange Regnorme; i Prøven fandtes 1 Skovregnorm og 9 Graa Orm. Af Springhaler var her en Mængde af de hvide *Onychiurus*, som lever nede i Mulden, medens de smaa farvede Arter, som man plejer at træffe i Løv-

lag, manglede. Der saas enkelte af de store *Entomobryidae* og *Pogonognathus*, men de er ikke kommet med i Prøven. Her er mange Trichoniscer ligesom paa Egeskovslokaliteterne 10 og 22, og nogle Myriopoder, samt mange Mosskorpioner (*Chernes scorpioides*), som formodentlig lever af at jage *Onychiurus*. Ligeledes er Smælderlarver (*Athous subfuscus*) almindelige som paa al særlig humusrig Bund. Faunaen, der er særpræget som Lokaliteten i øvrigt, har størst Lighed med Eg-Bingelurt-Typen, Lokalitet 10.

Rødgran, Muld, Skovsyre.
Lokalitet 1. Tabel X, S. 66.

En meget smuk 75aarig Granbevoksning i fortrinlig Vækst og med god Kroneudvikling, Afd. 103 i Rude Skov. Bunden er dækket af et tyndt Tæppe af Skovsyre. Det løse Naalelag er 1—2 cm tykt, og derunder findes ca. 3 cm løs, finkornet Muld, som kun i forholdsvis ringe Grad er blandet med Mineraljord; en Overflademuld som er temmelig skarpt adskilt fra Overgrunden, der i de øverste Par Centimeter er mørk og humusrig, men i øvrigt er humusfattig og tæt. Undergrunden er fint Sand ned til 75 cm, derunder Ler.

Idet vi nu er gaaet over til Granskovene, møder vi en Fauna af et væsentlig andet Præg end Løvskovenes. Selv her paa Muldbunden bemærker vi, at Dyrene er talrige og smaa, idet vi paa en samlet Vægt af kun 10.7 g har 10800 Dyr. Regnormene, der ligesom paa Løvskovsmulden spiller en fremtrædende Rolle, udgør dog her kun 47 pCt. af den samlede Vægt. Det er væsentligst smaa *Dendrobaena*-Arter, en enkelt Skovregnorm blev fundet, men ingen Graa Orm. Snegle, Enchytræider og Trichoniscer er meget faatallige. Der findes kun ganske faa ægte Tusindben, men en hel Del Geophilider. Der er mange Mycetophilider eller for August 1926 og Juli 1927 antagelig *Sciara* (Hærmyg)-larver, der sammen med Stankelbenlarver, Leptidelarver og nogle Bibionidelarver foraarsager, at Dipterlarverne er relativt fremtrædende. De meget talrige smaa Larver af *Cecidomyiidae*-Type vejer kun lidt til. Ogsaa Antallet af Smælderlarver er ganske stort, og det vrimler med smaa Rovbiller. Løbebillerne er næsten udelukkende den lille, kobberglinsende *Notiophilus biguttatus*, Snudebillerne især *Stropho-*

somus. Af andre Insekter maa nævnes nogle Smaasommerfuglelarver, vistnok en Vikler der lever paa Granerne, men de har ligesom nogle Bladhvepsepupper kun et Skjul i Bunden, og deltager ikke i Stofomsætningen i denne.

Det er dog navnlig det store Antal af Mider, over 7000, som tæller til, idet de udgør to Tredjedele af det samlede Dyreantal. Springhaler er talrige.

Lokaliteten er karakteriseret ved en temmelig ringe Vægtmængde af Dyr, hvoraf noget under Halvdelen udgøres af smaa Regnormearter, medens Graa Orm, som arbejder i Overgrunden og holder denne skør og porøs, ikke blev fundet. Som Nr. 2 i Vægt kommer Dipterlarver, af hvilke Hærmygglarver(?) er særlig talrige. Mider findes i et lignende stort Antal som paa Maarbund.

Rødgran, Maar, Mos.
Lokalitet 6. Tabel XI, S. 70.

En meget smuk 75aarig Rødgranbevoksning, Forsøgsvæsenets Prøveflade BG i Gribskov, Nøddebo Distrikt Afd. 66. Terrainet hælder stærkt mod Øst ned mod et snevert, fugtigt Drag. Bunden er dækket af et temmelig tæt, 4—6 cm tykt Mostæppe af Kostmos, Etage-Kransemos og Trind Kransemos. Lidt Skovsyre findes i Nærheden, tiltagende i Mængde ned imod Lavningen. Maarlaget er meget svært, bestaaende af 8 cm brunt, meget løst, til Dels smuldrende, nedad noget tættere Formuldningslag, og derunder 2 cm sortebrunt, tæt Humusstoflag. Herunder findes omtrent 25 cm Blegsand og 15 cm øverst noget alagtig Rustjord. Undergrunden er lerfrit Sand, som fra 110 cm Dybde var meget fint og førte Vand (Flydesand).

Regnormene er her paa Granmaaren kun til Stede i meget ringe Antal, gennemsnitlig 18 pr. m^2, og det er udelukkende den lille Mosorm, *Dendrobaena octoedra*. Efter Vejninger af denne Ormeart vil de 18 Orme give en Vægt af knap 1 g pr. m^2, hvilket kun er ganske forsvindende imod, hvad vi finder i Bøgemulden, og kun mellem $^1/_6$ og $^1/_5$ af, hvad vi fandt i Granmulden og i Bøgemaaren fra Rude Skov, men ligger nær ved Regnormemængden i den nærliggende Bøgemaar Lok. 20 i Gribskov. Snegle er meget faatallige, og Bænkebidere mangler ganske; de synes at være særlig knyttede til Løvskovene.

Ogsaa Myriopoder er svagt repræsenterede, og kun ved de tynde, gule Geophilider og et ganske enkelt Tusindben *(Julus)*. Mosskorpioner og Edderkopper er temmelig talrige i Mosset. Mider forekommer i meget stort Antal, og det samme gælder Springhaler. Talrigst af disse er den hvide *Onychiurus armatus*, men ogsaa Isotomer er rigeligt repræsenterede ved *Folsomia quadrioculata* og smaa *Isotoma*-Arter. Den store *Pogonognathus plumbeus* er temmelig talrig, og det er nærmest den, som man vil faa Øje paa, hvis man undersøger Moslaget ude i Skoven.

Larver af tovingede Insekter er temmelig talrige, bl. a. fandtes 100 Stankelbenlarver pr. m^2, men det er udelukkende smaa Former, saa vi naar ikke tilnærmelsesvis op paa samme Vægt som i Bøgemaaren fra Rude Skov; Vægten kan ansættes til ca. 4 g. De 41 Leptidelarver vil veje ca. 0.2 g, og Mycetophilider, Bibionider og de talrige smaa Cecidomyider vejer kun ubetydeligt. Rovbiller og smaa Løbebiller *(Notiophilus)* er til Stede i lignende Antal som paa Granmuld-Lokaliteten. Særlig talrige er kun Smælderlarverne, 240 *Athous subfuscus* og kun 4 *Dolopius marginatus*, hvis samlede Vægt er 4 g. Den totale Vægt af Dyr er 12.2 g pr. m^2.

Som man ser udmærker Lokaliteten sig især ved at Regnorme er sparsomme og kun repræsenterede ved Mosormen, og at Mider, Springhaler (især *Onychiurus*), Dipterlarver og Smælderlarver *(Athous subfuscus)* er de vigtigste Bestanddele af Dyreverdenen.

Rødgran, Maar, Mos.
Lokalitet 8. Tabel XII, S. 74.

En smuk, godt 70aarig Rødgranbevoksning, Forsøgsvæsenets Prøveflade BF i Gribskov, Nøddebo Distrikt Afd. 89. Væksten er god, men staar dog noget tilbage for foregaaende. Mostæppet er lavere, og Kostmos er mere fremtrædende, hvilket tyder paa, at her er mere tørt. Maaren er tyndere, kun ca. 8 cm i alt, men mere tørveagtig. Der er ca. 7 cm Blegsand, men kun Antydning af Rustjordsdannelse. Undergrunden er leret Sand og sandet Ler; fra 36 til 55 cm Dybde er Jorden leralagtig.

Faunaen ligner meget Lokalitet 6, men er dog ejendommelig ved et noget større Antal, omtrent 12000, og en noget mindre Vægtmængde, 9.8 g, af Dyr, svarende til at Forholdene er knap saa gunstige. Humuslaget er ogsaa tættere og mindre præget af Dyrenes Arbejde. Her er ganske vist lidt flere Regnorme, 1.6 g eller ca. 16 pCt. af Vægten, ligesom paa Lok. 6 kun Mosorm; til Gengæld er der langt færre Stankelbenlarver, saa der kun bliver 1.0 g Dipterlarver i alt mod 4.3 g paa Lokalitet 6; der er flere Geophilider, men ingen ægte Tusindben; Smælderlarver er derimod næsten lige saa talrige som paa Lok. 6.

Her er flere Rovbiller end paa foregaaende, men ellers er Mængden af Insekter temmelig ens, bortset fra mange af de smaa Tæger *Orthostira cervina*. Springhaler og Mider er en Del talrigere, og den hvide *Onychiurus armatus* er endnu mere fremtrædende.

Begge disse Granmaar-Lokaliteter udmærker sig ved en typisk Maarfauna, overvejende dannet af Arthropoder. Forskellen imellem dem, der især ligger i det store Antal Dipterlarver paa Lokalitet 6, som er den gunstigste og hvor Granerne har størst Tilvækst, og det store Antal ganske smaa Dyr paa den knap saa gode Lokalitet 8, svarer ganske til den Forskel, vi fandt mellem de to Bøgemaarlokaliteter, men er blot ikke saa udpræget, fordi Forskellen mellem de to Granlokaliteter i det hele taget er mindre.

Andre Naaleskovslokaliteter samt Heder.
Tabel XIII, S. 78.

Lokalitet 25 er en ung, vellykket Bevoksning af Rødgran paa Hedebund i Skærbæk Plantage i Midtjylland. Efter at Bevoksningen er blevet tyndet, er der mange Steder kommet Mos under Granerne, ligesom der er kommet langt mere Liv i Omsætningen, bl. a. formulder Kvaset langt hurtigere paa Steder med Mos, end hvor man kun har det nøgne Naalelag. Prøven *a* blev taget, hvor Bevoksningen endnu var meget tæt og Mostæppe manglede, medens Prøven *b* blev taget, hvor Bevoksningen var lysnet, og hvor der var Mostæppe over hele Bunden. I flere Henseender ligner denne Hedeplantages Fauna meget de foran omtalte Granlokaliteters, men Mangelen

af Myriopoder og det meget ringe Antal af de vigtige Dipterlarver og Smælderlarver karakteriserer Faunaen som mere fattig og mindre aktiv ved Stofomsætningen. Det ses tydeligt, at det med Hugsten fulgte Mostæppe har begunstiget Faunaen i høj Grad. Særlig interessant er Forekomsten af de mange Mosorme under Mosset, men Antallet af Dyr er i det hele taget, bortset fra Mider og (tilfældige) Blødbillelarver, helt igennem størst paa Lokaliteten med Mos, der nærmer sig til de foranstaaende, gode Granlokaliteter.

Lokalitet 32 blev optaget for at kontrollere Iagttagelsen fra Lokalitet 25, af Tyndingens og det deraf følgende Mostæppes gunstige Indflydelse paa Faunaen. Bevoksningen er en 48aarig Rødgranbevoksning i Hastrup Plantage i Midtjylland; Arealet benævnes GG og er delt i en Mængde Parceller, hvor Forsøgsvæsenet udfører Forsøg med forskellige Tyndingsgrader. Paa Parcel Litra *s* hugges kun tørre Træer, Jorden er dækket af et Naalelag og uden Spor af Vegetation; derunder findes et tyndt, men meget tæt lejret Humuslag. Paa Parcel Litra *y* føres en almindelig stærk dansk Tynding, og Bunden er her, paa Grund af den rigeligere Lystilgang, dækket af et Mostæppe; Humuslaget er tykkere end paa *s*, men langt mere skørt og porøst. Undergrunden er grusblandet Sand, Arealet har tidligere været Ager, og Jorden er ikke podsoleret i kendelig Grad.

Resultatet af Dyreundersøgelsen er meget lærerigt, og bekræfter ganske Iagttagelserne fra Lokalitet 25. Særlig maa man lægge Mærke til, at den tyndede, mosdækkede Parcel havde 23 Regnorme (Mosorm) og 12 Stankelbenlarver i en Prøve fra 0.1 m^2, medens den ikke tyndede kun havde 4 Regnorme og 1 Stankelbenlarve. Ligeledes indeholdt den tyndede flere Cecidomyider, medens den ikke tyndede havde flere smaa Tæger. Særlig interessante er ogsaa Miderne, hvoraf den tyndede Parcel gav 1334, den ikke tyndede 2065, men disse var for største Delen meget mindre. Fordelingen til Slægter var nemlig saaledes: paa Parcel *s* fandtes 148 Gamasider (Rovmider), 32 Camisier (temmelig store Arter), 1885 yderst smaa Damæosomer; paa Parcel *y* fandtes derimod kun 79 Gamasider, og kun 125 Damæosomer, men til Gengæld 1130 af de store humusædende Camisier. Den tyndede Parcels Midefauna maa derfor, trods det ringere Antal, antages at være betydelig

mere virksom ved Humusomsætningen end den mørke ikke tyndede Parcels.

Lokalitet 11, Forsøgsvæsenets Prøveflade BI i Grib Skov, er bevokset med store, smukke Lærk blandet med en Del lavere Rødgraner. Bevoksningen er meget lys, og der er en Mængde naturlig Opvækst af Gran og Lærk. Der findes en meget svær Maar, og hvor Prøven blev taget var der et meget svært Mostæppe af Jomfruhaar og Grenmosser. Bunden er gennemjaget af store røde Skovmyrer fra en Tue lige i Nærheden, i Prøvens 0.1 m^2 var der 7 Myrer. Dette er muligvis Grunden til den ejendommelige Fauna med ganske usædvanlig faa Dipterlarver, Biller og andre Insekter. Kun de robuste, skjult levende Smælderlarver findes i sædvanligt Antal, og Mider og Springhaler optræder i enorme Masser, maaske fordi det høje Mos er gunstigt for dem, men dog maaske ogsaa fordi Myrerne har fordrevet deres Fjender, blandt hvilke smaa Rovbiller kunde tænkes at spille en stor Rolle. Hvis det er almindeligt, at de store Skovmyrer paa denne Maade præger Skovbundsfaunaen i Nærheden af deres Tuer, er Spørgsmaalet om deres Nytte eller Skade i Skoven mere kompliceret end man hidtil har antaget. For øvrigt er Forekomsten af de store Myrers Tuer i mange danske Naaleskove saa sparsom, at deres Betydning hos os maa være noget begrænset.

De følgende fire Lokaliteter, 26, 27, 28 og 29, i Horserød Hegn er Skovfyrbevoksninger af god, udpræget *Myrtillus* (Blaabær)-Type. Paa Lokalitet 26, der mangler Underskov, er Bundfloraen mest typisk og bestaar af kraftig Blaabær og Tyttebær isprængt en Mængde gold Bølget Bunke og Mos, samt enkelte Skovstjerner og Tormentil; derunder findes svær Maar og Blegsand. De andre tre Prøver er taget paa Forsøgsvæsenets Prøveflade CC; paa 28 og 29 er Bundfloraen helt dræbt af tæt, selvsaaet Underskov af henholdsvis Bøg og Gran, paa 27 er den stærkt svækket af Sideskyggen fra denne Underskov. Paa den uforstyrrede Blaabærtype, Lok. 26, finder vi en uhyre Mængde Dyr, hvilket dog udelukkende skyldes det store Antal Mider; de andre Dyreformer optræder ingenlunde i usædvanlig stor Mængde. Der er ganske rigeligt med ægte Tusindben, baade *Julus*, *Polydesmus* og *Glomeris*, og mange Dipterlarver af Slægten *Phaenocladius*, som vi ellers kun har truffet ganske enkelte af, og som synes at høre særlig hjemme

paa denne Type. Smælderlarverne optræder i sædvanlig Mængde, men Rovbiller er der, saavel her som paa Lok. 27, meget faa af; de synes delvis erstattet af Edderkopper og Mosskorpioner. At Mosormen ikke blev fundet i Prøven maa være en Tilfældighed; den fandtes paa Lok 27. Faunaen er en typisk Maarfauna, som aabenbart i flere Henseender adskiller sig fra Granskovens, men Materialet er for lille til nærmere at præcisere Forskellen.

De tre andre Skovfyrlokaliteter er af mindre Interesse, de er mere mørke, og deres Dyreliv nærmer sig Granskovens. Det er formodentlig Tilstedeværelsen af Bøg paa Lok. 28 og tilblæste Bøgeblade mellem Grannaalene paa Lok. 29, der giver Anledning til de mange Trichoniscer og en enkelt Ørentvist.

Lokalitet 7, i Grib Skov lige ved Lokalitet 6, er en lille Høj med Blaabær omgivet af Granskov paa alle Sider. Prøven var en Del fattigere end de foran omtalte, maaske fordi her var smaa røde Myrer.

Lokalitet 17 er en Bjergfyrbevoksning ved Nørholm i Nærheden af Varde, Lokalitet 19 er taget under en Enebærbusk i den til Nørholm hørende fredede Hede, og Lokalitet 18 er en Prøve af den almindelige Hede sammesteds (denne Prøve har vistnok taget Skade ved for lang Opbevaring). Nr. 24 er fra en særlig god Lynghede ved Skærbæk Plantage i Midtjylland med meget Mos mellem Lyngen og spredte Enebærbuske; Nr. 21 er en god, ikke podsoleret Hede fra Bornholms Højlyng, med Urter og Mos mellem Lyngen. Disse Prøver fra Hedelokaliteter har navnlig Interesse derved, at de viser, at vi kan finde Regnorme overalt ude i Lyngheden selv paa tarvelig Hede som Lokalitet 18; selve Prøven fra Lokalitet 24 indeholdt ganske vist ingen, men jeg fandt mange Regnorme i Mosset rundt om, da jeg udtog Prøven; det er dog altsammen udelukkende den lille Mosorm *(Dendrobaena octoedra)*.

I øvrigt har Prøverne Betydning ved at vise, at Faunaen i Heden for en meget stor Del bestaar af de samme Arter eller Familier som i Skoven, saaledes træffer vi de samme Springhalearter; men Hedebundens Fauna er kvantitativt fattigere end Skovbundens. Af særlige Dyr for Lyngheden maa fremhæves Bladbillen *Lochmaea suturalis*, der lever paa Lyngen,

og i enkelte Aar optræder saa talrigt, at Lyngen svækkes stærkt derved, ja endog er antaget at kunne gaa ud efter Angreb af denne Bille.

Beskrivelse af de fundne Dyr og deres Levevis.

I dette Afsnit vil vi omtale de forskellige Arter, Slægter eller Familier af Dyr, som spiller en Rolle i Skovbunden, og undersøge hvilken Betydning de kan have for Skovbunden. Vi tager Dyrene i den Rækkefølge, hvori de er opført i de foranstaaende Tabeller, og medtager tillige flere andre vigtige Dyr. Samtidig gøres der Rede for de forskellige Formers Stilling i Systemet.

PROTOZOA, URDYR.

Af disse mikroskopiske, encellede Dyr findes Infusionsdyr og Rhizopoder i uhyre Mængder i Jordbunden. FEHÉR fandt saaledes i Skovjorden ved Sopron i Ungarn et Antal af fra 5400 til 9000 pr. Gram fugtig Jord; heraf henholdsvis 2350 og 5200 aktive, Resten indkapslede og i Dvaletilstand. Det angives at de væsentligst ernærer sig af Bakterier, og de faar saaledes Betydning ved at regulere Antallet af disse, maaske ofte ved at sætte Bakterieantallet skadeligt ned. Vi har kun et meget ringe Kendskab til Skovjordens Protozofauna, og den er ikke medtaget i nærværende Undersøgelse.

METAZOA, FLERCELLEDE DYR.

MOLLUSCA, BLØDDYRENES RÆKKE.

I Skovbunden findes adskillige Arter af Snegle, *Gastropoda*, baade med og uden Skal, alle hørende til Land-Lungesneglene, *Pulmonata Stylommatophora*. Den vigtigste Snegl i Skovbunden er den nøgne, stribede, graa *Arion subfuscus*, af hvilken vi i Løvskovene fandt 20—30 pr. m^2. Mindre talrigt forekommer den almindelige, store, sorte Skovsnegl *Arion ater*. Af smaa Snegle med Skal fandt vi i Løvskoven ca. 30—70 pr. m^2, men meget faa i Naaleskovene. Alle Snegle gør utvivlsomt betydelig

Skade ved at begnave smaa Skovplanter som, navnlig hvor der er stærk Skygge, gaar til Grunde derved. STEEN (1890) angiver, at den sorte Skovsnegl gjorde følelig Skade ved at æde Cotyledonerne af Bøgekimplanter.

NEMATHELMINTHES, RUNDORMENES RÆKKE.

Mikroskopiske Nematoder forekommer i meget stort Antal i Jorden, men de er ikke taget med i denne Undersøgelse, da de fordrer særlige Indsamlingsmetoder.

ANNELIDA, LEDORMENES RÆKKE.

Heraf har vi i Skovjorden kun Ordenen *Oligochaeta* med Familierne *Enchytraeidae*, Enchytræider, og *Lumbricidae*, Regnorme.

Af de smaa, hvide Enchytræider forekommer en Del Arter af Slægten *Henlea* i Skovbunden. Særlig optræder den 1—2 cm lange *Mesenchytraeus setosus* ofte i stort Antal i Bøgeløv. I det fugtige Efteraar 1926 kunde man finde op til et Par Tusinde pr. Kvadratmeter. I Naaleskovenes Bund findes nogle mindre, meget tynde Arter.

Regnorme, *Lumbricidae*, har som først fremhævet af WHITE (1789) og DARWIN (1840, 1881) en overordentlig stor Indflydelse paa Jordbundsdannelsen. Deres Betydning i Skovjorden er beskrevet af P. E. MÜLLER i »Studier over Skovjord« 1878 b og 1884. Den første Del omhandler Bøgeskovene, i hvis Muldbund han fandt Regnorme i Mængde. Han skriver 1878 b, S. 18: »Det synes som om hele det øverste Jordlag indtil $^1/_2$ eller 1 Tommes Dybde udelukkende bestaar af . . . Regnormeekskrementer, og at det nedenunder liggende brune Muldlag (hvad vi nu vil kalde Muldjord) endnu bestandig er det samme Stof i mere opløst og henfalden Tilstand«. Naar det angives at være Stor Regnorm, er det dog næppe rigtigt, da jeg i de samme Skove fandt den mindre Skovregnorm i stor Mængde, men kun yderst faa Stor Regnorm. Desuden nævner MÜLLER Graa Orm der færdes i Mængde øverst i den mineralske Overgrund og Løvregnormen der lever i Løvlaget. Videre læser man S. 24: »Hele denne Hærskare af Regnorme, der paa den typiske Bøgemuld vistnok beløber sig til adskillige Millioner pr. Td. Ld. (efter mine Tællinger dog i Almindelighed kun henved 1, sjældent op imod 2 Millioner), maa udføre et for Jordens Beskaffenhed højst

betydningsfuldt Arbejde; men hertil kommer endnu den Virkning, som deres Fjende, Muldvarpen udøver«. . . . . »Bøgemulden er saaledes at opfatte som en paa dyrisk Liv, navnlig Regnorme, rig Aflejring af Bøgeskovens Affaldsmasse, omsat til et løst og usammenhængende Lag, i hvilket de organiske Rester ere inderlig blandede med den mineralske Jord. Under Mulden er Overgrunden fuldkomment skør og ensartet blandet«.

Disse Udtalelser om Bøge-Muldjorden kan vi ganske tiltræde, men anderledes stiller det sig med Bøgemaaren, om hvilken han skriver S. 44: »Maaren er saaledes at opfatte som en paa dyrisk Liv yderst fattig Aflejring af Bøgeskovens Affaldsmasse, sammenbundet til en fast Tørv af Bøgerødder og et meget varigt Svampemycelium«. Vore Undersøgelser foran har netop vist, at Maaren havde en uhyre rig Fauna, med et Antal af Dyr der langt overgik Muldens, og den samlede Vægt af Dyr var meget anselig, større end paa tarveligere Muldbund. Selv Regnorme fandtes, den lille Mosorm altid, undertiden tillige Skovregnorm, Løvregnorm og Stuborm. Ogsaa i Afhandlingen 1884, der omhandler Egeskove og Heder, fremhæves at Regnormene er konstant bundne til Mulden; selv i Egekrattene fandt han stedse Løvregnormen, Skovregnormen og Graa Orm.

I 1894 skildrer MÜLLER, hvorledes Rhizomplanternes Jordstængler efterhaanden synker dybere, fordi Planterne »hyppes« af Regnormene. I en senere Afhandling om Egeskove og Heder (1918) omtaler han kun de mikrobiologiske Forskelligheder mellem Muld og Maar, og kommer slet ikke ind paa Dyrelivet.

BOAS, der skildrer Regnormene indgaaende i sin Forstzoologi (1896—98 og 1923) skriver (1923, S. 738): »Naar Regnormene forjages fra en Lokalitet, forvandles Mulden til Maar«. En anden Udtalelse: »Medens de saaledes ganske mangler paa den egentlige Hede, indfinder de sig snart i Hedeplantagerne« hviler paa en Meddelelse af C. JENSEN (1897), om Fund af Skovregnormen i en 20aarig Plantning af Gran og Bjergfyr paa Klelund, og er sikkert for optimistisk. Efter mine Erfaringer er Naaletræer saa ugunstige for Regnorme, med Undtagelse af Mosormen, at en Indvandring efter Plantningen er meget usandsynlig; de har snarere været her i Forvejen. Bunden var meget godartet Hede, den ældre Maar var dækket af

ca. 10 cm Flyvesand, der var ingen Al, og der var Ager og Egekrat i Nærheden. Det skildrede Tilfælde er i alt Fald ikke normalt.

Vi vil i et senere Afsnit nærmere definere Muldens og Maarens Faunatyper, saaledes som vi har lært dem at kende gennem de i foregaaende Afsnit meddelte Undersøgelser.

Regnormenes Betydning for Jordbundsdannelsen kan vi kort karakterisere saaledes: De trækker nedfaldent Løv m. m. ned i Jorden, hvor det blødgøres, hvorefter Ormene fortærer det; herved fremskyndes Omsætningen af det organiske Affald. De gennemroder den øverste, muldrige Del af Overgrunden paa Kryds og Tværs og holder den derved skør og porøs. De sluger en Mængde Jord, som de i Form af Ekskrementer aflægger oven paa Jordoverfladen; disse Ekskrementer bestaar af en Blanding af Humus og Mineraljord, og er ganske udmærket Voksebund for Planter. Maaske ogsaa deres alkaliske Fordøjelsesvædske har Betydning. Ikke blot den øverste, løse Muldjord, men hele den muldede Overgrund maa, som MÜLLER fremhæver, antages at være fremgaaet af Regnormens Udtømmelser. Endelig danner Regnormene Gange ned i Undergrunden, hvor de søger Tilflugt i stærk Tørke og Kulde, og disse Gange tjener dels som Dræn, dels som Veje for Planterødderne ned til de dybere Jordlag.

De dybtgaaende Rør laves især af Stor Regnorm, men ogsaa af mindre Arter, f. Eks. Rosa Orm, som dog ikke gaar fuldt saa dybt. Graa Orm og andre Arter af Slægten *Allolobophora* m. fl. lever navnlig i den øvre Del af Overgrunden og holder denne skør. Andre igen holder sig især til Løv- eller Maarlaget: Mosormen og andre *Dendrobaena*-Arter samt Løvregnormen.

Der kendes i alt 19 Regnormearter fra Danmark, hvoraf de 12 var kendt fra tidligere, medens Forfatteren har fundet de 7. Om Bestemmelse af Arterne se S. 92 flg. og Forfatterens Afhandling om Danmarks Regnorme (BORNEBUSCH 1928). Om de forskellige Regnormearter skal meddeles følgende:

Stor Regnorm, *Lumbricus terrestris*, er oftest 20—25 cm lang, Forkroppen er violetbrun med Irisglans paa Ryggen, Undersiden er lys. Bagved Bæltet er den bleg med en smal, mørk Stribe ned ad Ryggen. Denne Art er meget udbredt i Græsgange, Marker og Haver. I Skoven holder den sig til den

bedste Muldbund, skyr tarveligere Muldbund og Naaleskove og træffes aldrig paa Maar.

Skovregnormen, *Lumbricus rubellus*, er mindre, oftest 10—12 cm lang, noget mere rødlig og stærkere farvet end Stor Regnorm. Den er endnu mere udbredt, da den er mindre fordringsfuld; saaledes findes den overalt selv paa tarveligere Muldbund i Skove og Krat, og kan endog træffes i Maar.

Mørk Regnorm, *Lumbricus festivus*, ligner den meget, men er nærmest mahognibrun. Kun truffet i Jægersborg Dyrehave og Omegn.

Løvregnormen, *Lumbricus castaneus*, er kun 5 cm lang, af livlig rødlig Farve paa Ryggen og stærkt iriserende. Forekommer talrig i Bøgeløvet paa Muldbund, men ogsaa under andre Løvtræer og uden for Skoven. Den kendes fra andre smaa Arter i Løvet ved, at den gerne flygter baglængs, og ved at Bagenden bliver meget bred og flad naar den forskrækkes.

Lang Orm, *Allolobophora longa*, ligner Stor Regnorm meget, men er mere brunlig og mangler Irisglans. Den forekommer kun paa særlig frugtbare, muldrige Steder i Skoven, men er almindelig i Haver.

Graa Orm, *Allolobophora turgida*, er den talrigste Orm paa Muldbund; graa med grønlig, blaalig eller rødlig Tone, 10—15 cm lang. Det er Muldjordens mest udprægede Karakterorm, da den aldrig mangler paa denne og ikke kan leve paa Maarbund.

Trapez-Orm, *Allolobophora trapezoides*, ligner foregaaende meget og forekommer ofte sammen med den, men er en mere sydlig Form, som er mindre talrig hos os.

Grøn Orm, *Allolobophora chlorotica*, er kort, tyk, 5—7 cm lang, graagul eller graagrøn, og ruller sig gerne spiralformig sammen. Findes mest paa stiv Lerjord.

Blaa Orm, *Octolasium cyaneum*, en meget smuk 10—18 cm lang Orm, rosa eller lyseblaa, med gennemsigtig, atlaskglinsende Hud, hvorigennem man ser det røde eller blaa Rygkar. Bæltet er brunligt eller gulligt, Forenden altid lyst kødfarvet, Bagkroppens Spids stærkt gul. Træffes især i muldrige, frugtbare Lavninger.

Mælket Orm, *Octolasium lacteum*, ligner for det meste Graa Orm i Farve og forveksles let med denne, men er gen-

nemgaaende noget mindre. Undertiden er den blaalig, nærmende sig Blaa Orm i Farve. Findes i god Skovmuld.

Rosa Orm, *Eisenia rosea*, er en lille, smukt rosenrød Orm, der er almindelig paa leret Jord. Om Vinteren og i tørre Perioder om Sommeren kan man træffe den talrigt i Dvale, sammenrullet som et lille Nøgle, øverst i Undergrunden.

Brandorm, *Eisenia foetida*, er ejendommelig ved at Segmenterne fremtræder som nøddebrune Ringe adskilte ved gullige Mellemrum. Indtil 10 cm lang. Almindelig i Gødning og Kompost; træffes undertiden i Træstubbe.

Stuborm, *Dendrobaena arborea*, er en ca. 4 cm lang tynd rødlig Orm, der mest lever i Stubbe og under Mos paa Træstammer, men ogsaa træffes ude i Skovbunden i Løvet. Den klatrer ofte højt op i Træerne, hvor den da træffes i aabne raadne Knaster (Tude).

Haveorm, *Dendrobaena subrubicunda*, som er lidt større og har gul Bagkropspids, træffes mest i stærkt gødet Jord og i Kompost. I Skoven kan man finde den paa Brændepladser.

Mosorm, *Dendrobaena octoedra*, er ca. 4 cm lang, brunlig med graalig Bronzeglans. Den forekommer overalt under Mos paa Sten, Klipper og paa Maarbund, saavel som i selve Maaren baade i Løvskove, Naaleskove og paa Heder. Det er den mest fordringsløse og haardføre af alle Regnorme, og den gaar højere til Fjælds og længere mod Nord end nogen anden Art. Hos os har den stor Betydning som Maarens, i Regelen eneste, Regnormeart.

Bækorm, *Eiseniella tetraedra*, er en ca. 4 cm lang, oftest brunlig Orm, hvis Bagkrop har kvadratisk Tværsnit. Findes ofte i stor Mængde i Løvet i Skovbække og i kilderig Bund, og har formodentlig stor Betydning for Mulddannelsen i Ællesumpe.

En nær Slægtning, *Eiseniella herzynia*, har jeg fundet ved en højtliggende Kilde i Silkeborg Vesterskov. Endvidere kendes fra Danmark *Bimastus constrictus* og *Bimastus Eiseni*, smaa rødlige Orme, som er sjældne og derfor uden Betydning.

Da Regnormearterne stiller meget forskellige Fordringer til Jordbunden, kan vi opstille en Række Typer af Regnormefaunaer baseret paa Undersøgelser i danske Skove:

Humusrig, oftest kalkrig, frisk Muldbund med Lystræer:

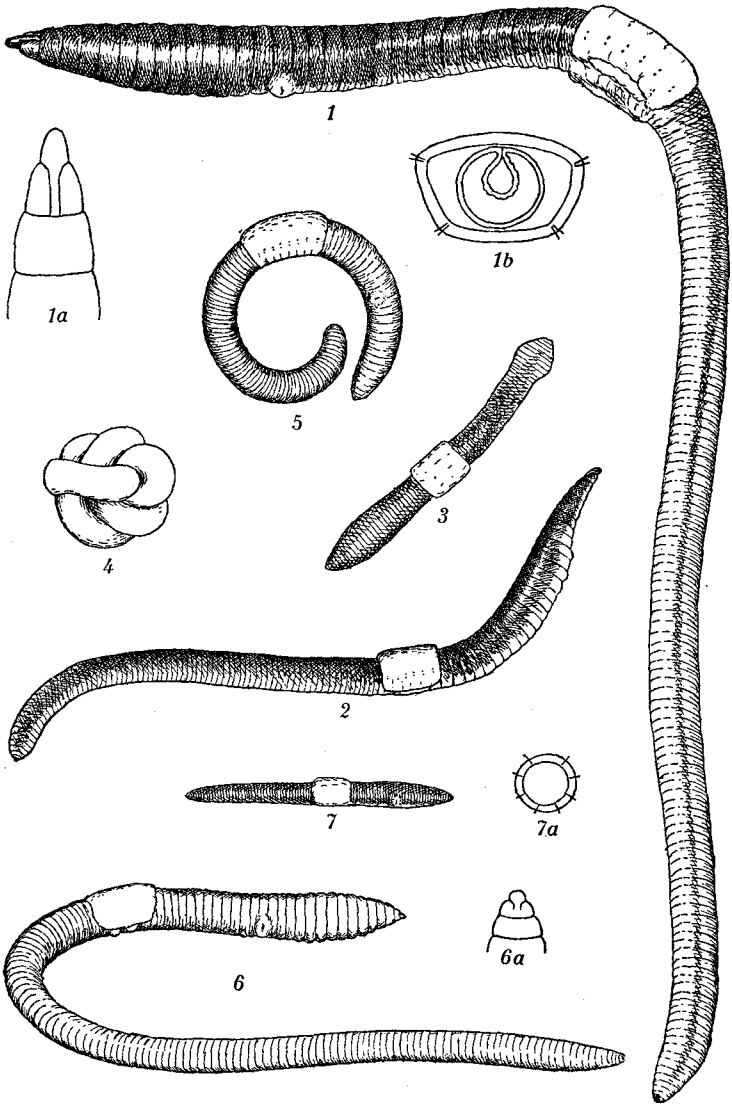


Fig. 5. Nogle af de almindeligste Regnorme, i naturlig Størrelse. 1: Stor Regnorm (1 a: Hoved fra oven, 1 b: Tværsnit bag Bæltet af samme, forstørrede). 2: Skovregnorm. 3: Løvregnorm. 4: Rosa Orm i Dvale. 5: Grøn Orm. 6: Graa Orm (6 a: Hoved af samme set ovenfra, forstørret). 7: Mosorm (7 a: Tværsnit af samme, forstørret).

Stor Regnorm, Lang Orm, Blaa Orm, Graa Orm, Trapez-Orm, Grøn Orm og Rosa Orm.

Frisk Bøgemuld paa leret Jord, især Mergelbund, med Anemone-Bukkar-Flora blandet med kalkyndende Skovbundsurter: Stor Regnorm, Skovregnorm, Graa Orm, Trapez-Orm, Mælket Orm, Rosa Orm, Lang Orm og Løvregnorm.

Mere høj Bøgebund med Anemone og Bukkar: Skovregnorm, Løvregnorm, Graa Orm, Stuborm; sjældnere Stor Regnorm og Rosa Orm.

Tør Bøgebund med Skovsyremuld: Forholdsvis sparsom Forekomst af Skovregnorm, Graa Orm, Løvregnorm, Stuborm og Mosorm.

Bøgemaar: Mosorm, sjældnere tillige Skovregnorm, Løvregnorm og Stuborm.

Granskovsmuld: Skovregnorm, Stuborm og Mosorm.

Maarbund i Naaleskove og paa Heder: Mosorm.

Vandløb og Sumpe: Bækorm.

Kompost og lignende: Brandorm og Haveorm ofte sammen med Grøn Orm og flere andre af de foran nævnte Arter.

ARTHROPODA, LEDDYRENES RÆKKE.

Crustacea, Krebsdyrenes Klasse er i Skovbunden kun repræsenteret ved Bænkebidere, *Isopoda terrestria*. Den almindelige Bænkebider *(Oniscus acellus)* hører hjemme i formuldende Træ og under død Bark og træffes kun undtagelsesvis i Skovbunden. Derimod forekommer smaa Isopoder, *Trichoniscus pusillus*, i Mængde paa den gode Løvskovsbund, hvor de lever af henraadnende Plantedele.

Myriopoda, Tusindben. Med Henblik paa disses Betydning i Skovbunden maa vi skelne mellem Ordenen *Chilopoda*, Skolopendere, som er Rovdyr, og Ordenen *Diplopoda*, de ægte Tusindben, som lever af henraadnende Plantedele. Af Chilopoder har vi de flade brune egentlige Skolopendre af Familien *Lithobiidae*, der mest træffes paa Muldbund, maaske fordi de med Forkærlighed tager Regnorme, og de tynde gule *Geophilidae*, som træffes under alle Forhold, men især er talrige i Maar, hvor der kan være flere Hundrede paa en Kvadratmeter. Af Diplopoderne er de almindelige, cylindriske, ægte Tusindben af Slægten *Julus* især talrige paa Bøgemuld. Den flad-

ryggede *Polydesmus* synes mere uafhængig af Boniteten. De bænkebiderlignende *Glomeris*, der kan rulle sig sammen til en Kugle, træffes især i Løvskovsmuld. Endvidere er fundet den lille, blege *Scutigerella immaculata*.

Arachnida, Spindlernes Klasse, er repræsenteret i Skovbunden ved Mosskorpioner, Edderkopper, Mejere og Mider. Af Mosskorpioner, *Pseudoscorpiones*, træffes *Obisium muscorum* saavel i Løvskovs- som Naaleskovsbund, ofte i et Antal af 10—20 pr. m^2. Antallet af Edderkopper, *Araneina*, varierer fra henved 30 til over 100 pr. m^2. Hyppigst er ganske smaa, blege Arter. Mejere, *Opiliones*, er mere faatallige. Mosskorpioner, Edderkopper og Mejere er alle Rovdyr, der jager i Skovbunden, men næppe har nogen videre stor Betydning for denne. Langt vigtigere er Miderne, *Acarina*, der er fundet i et Antal af fra 1000 til 10000 pr. m^2 og saaledes er Skovbundens talrigste Leddyr. Kun paa den forarmede Bund, Lok. 2, overgik Springhalerne dem i Antal. De fleste Mider lever af henraadnende Plantedele og smaa Svampe, og maa derfor, paa Grund af det enorme Antal, spille en betydelig Rolle i Stofomsætningen. En Del Arter er dog Rovdyr (alle Trombidier og en Del af Gamasiderne). I øvrigt henvises til Tabel XVI S. 108 i den engelske Tekst.

Insecta, Insekternes Klasse. Af det enormt store Antal Arter, der findes i Skovbunden, skal vi her kun nævne nogle af de almindeligste Former.

Af Urinsekter, *Apterygota*, finder vi Springhalerne, *Collembola*, som er de talrigste næst efter Mider, ja paa en enkelt Lokalitet endog overgaar dem i Tal. Deres Mængde varierer fra 500 paa Egemulden og 900—1400 paa Bøgemulden til 5000—7000 paa Bøgemaaren. Særlig talrige er smaa Arter, den hvide, blinde *Onychiurus armatus* og de farvede Arter af Familien *Isotomidae: Folsomia quadrioculata* og smaa *Isotoma*-Arter; af *Hypogastruridae:* den blaagraa *Hypogastrura armata* og den mørkeblaa, mærkeligt knudrede *Achorutes muscorum*; af *Entomobryidae:* den gule *Lepidocyrtus lanuginosus*. Man faar dog kun vanskeligt Øje paa disse smaa Arter, undtagen den hvide, men lægger mere Mærke til den store, blygraa *Pogonognathus plumbeus*, den sort- og gul-brogede *Orchesella flavescens* og den gulgrønne *Isotoma viridis*.

Af *Pterygota*, Vingede Insekter (hvoraf dog mange er sekundært vingeløse), har følgende Ordener Betydning:

Diptera, Tovingede Insekter, hvis Larver forekommer i stor Mængde i Skovbunden, navnlig paa Maarbund, hvor de spiller en stor Rolle som Humusædere. Særlig Betydning har de store Stankelbenlarver, *Tipulidae*, og de ofte talrige Larver af *Mycetophilidae*, hvorunder Larver af *Sciara*, den forunderlige Hærmyg, er regnet. Det er *Sciara*-Larverne der optræder i de ejendommelige flere Meter lange, 2—3 cm brede og 1 cm tykke Baand af Tusinder af vandrende Larver, der kaldes »Hærormen« og i tidligere Tider har givet megen Anledning til Overtro. I Mellemeuropa er Fænomenet almindeligt, saaledes saa FREUDING (1924), i Tiden fra 2.—20. Juli daglig 5—12 Hærormtog vandre op ad samme Sti. Her fra Landet kendes kun 6 Iagttagelser, fire fra Sjælland, et ved Stubbekøbing og et ved Ry (HENRIKSEN 1925a og b). Af andre humusædende Dipterlarver skal nævnes Familierne *Bibionidae*, *Chironomidae* (hvortil hører *Phaenocladius*, *Forcipomyia* og *Metriocnemus*), *Psychodidae*, *Anthomyiinae* (hvorunder hører Slægten *Fannia*), *Cecidomyiidae* og de ejendommelige Larver af Slægten *Lonchoptera*. De almindelige hvide Larver af Familierne *Leptidae* og *Dolichopodidae* lever derimod af Rov.

Coleoptera, Biller. Larver af Smældere, *Elateridae*, træffes overalt i Skovbunden, talrigst, 190—250, paa Maarbunden, færre paa Muldbunden; paa de bedste Muldlokaliteter fandtes kun 12 pr. m^2. Vægten løb paa Maarlokaliteterne op til fra 14 til 32 pCt. af den samlede Vægt af Dyr. Da man maa antage, at de overvejende er Humusædere, spiller de en stor Rolle for Stofomsætningen, ikke mindst fordi de arbejder meget nede i den tætte nedre Maar (Humusstoflaget) som skys af andre Dyr. Vi fandt mærkeligt nok kun to Arter, *Athous subfuscus* meget talrigt og *Dolopius marginatus* sparsomt, i Skovbunden. Den fra Mark og Have berygtede skadelige *Agriotes lineatus* blev ikke fundet. Smælderlarver gør ofte Skade i Besaaninger ved at begnave spirende Frø, og man forstaar at dette Angreb er særlig farligt paa Maarbund, hvor de findes i stort Antal, og de bidrager maaske sammen med Stankelbenlarver væsentligt til at Kulturer ofte mislykkes paa meget humusrig Bund.

Rovbiller, *Staphylinidae*, er Skovbundens mest fremtrædende Billefamilie, idet deres Antal beløber sig fra 35—54

pr. m^2 paa Muldbunden til omkring 100 pr. m^2 paa Maarbunden. Antallet af Rovbillelarver var gennemgaaende ca. halvt saa stort som af fuldvoksne Biller. Løvskovene har betydelig flere forskellige Arter end Naaleskovene. De talrigst repræsenterede Slægter er de smaa brune *Othius* og *Atheta* og de mellemstore sorte, grønt metalglinsende *Philonthus*. Bedst kendt er vel den store, sorte, glubske *Staphylinus olens*. Baade Billerne og Larverne lever af Rov, nogle af de voksne skal dog ogsaa tage Planteføde.

Løbebiller, *Carabidae*, findes i en Mængde Arter i Skovbunden lige fra den store sorte Læderløber *(Procrustes coriaceus)* til ganske smaa Arter af omkring 1 mg Vægt. De fleste af dem er ligesom Rovbillerne Rovdyr, og de har ingen videre Betydning for Stofomsætningen i Bunden.

Af Blødbiller, *Cantharidae*, finder vi Larver overalt i Skovbunden. Ligeledes er Snudebiller, *Curculionidae*, meget almindelige; en Del af Arternes Larver lever af Rødder i Bunden. I ofte stor Mængde finder vi de yderst smaa sorte Ptilier, *Ptiliidae*, hvis Flyvevinger ligner smaa Fjer. Glansbiller, *Meligethes*, er talrige paa Muldbunden, hvor de lever paa Bundfloraen. I øvrigt træffes en Mængde andre Biller, men de er saa faatallige, at de er ganske uden Betydning.

Af Sommerfugle, *Lepidoptera*, træffes enkelte Larver i Bunden hørende til Slægterne *Hepialus* og *Agrotis* m. fl. Agrotislarverne kan maaske gøre Skade ved at æde smaa Træplanter, Hepialuslarverne lever af Rødder. I Granskovenes Bund traf vi en Del Smaasommerfuglelarver.

Aarevingede Insekter, *Hymenoptera*. Vi finder Larver og Kokoner af Bladhvepse, omstrejfende Snyltehvepse og Rovhvepse; Humlebier og Gedehamse har deres Boer i Jorden, men ingen af dem har nogen direkte Betydning. Derimod er Myrerne ofte saa talrige, at de dels maaske kan omprege Faunaen, dels ved deres Gravearbejde og Minering i Træstubbe kan fremme Nedbrydningen. Størst Betydning har de dog nok paa aabent Terrain, hvor de smaa Arter ved deres Jordtuer præger Landskabets Overflade saavel som Vegetationen.

Næbmundede, *Hemiptera*. Vi finder nogle Tæger, *Heteroptera*, og disses Larver, navnlig i Naaleskovsbund, og tilfældige Bladlus. Den til Skjoldlusene hørende *Newsteadia floccosa*, der er dækket af et hvidt Vokslag, var regelmæssigt til Stede

i Løvskovsbunden i et Antal af ca. 100 pr. m^2, men kan næppe tillægges nogen Betydning.

Af Retvingede, *Orthoptera*, forekommer Ørentviste *(Forficula auricularia* og *Chelidura ancanthopygia)* overalt i Løvskovsbunden.

Thrips, *Thripidae*. Af disse yderst smaa Insekter fandtes ofte nogle faa Stykker pr. m^2.

VERTEBRATA, HVIRVELDYRENES RÆKKE.

Padder, *Amphibia*, og Krybdyr, *Reptilia*, findes almindeligt i Skoven, men har kun ringe Betydning; mest maaske Skruptudser, der paa Steder kan udføre noget Gravearbejde.

Fugle, *Aves*, har mest indirekte Betydning ved Bekæmpelse af Insekter og Spredning af Frø. Maaske kan de ogsaa ved at vende Løvet og Mostæppet for at lede efter Larver hjælpe Frøet til et bedre Leje for Spiring.

Pattedyr, *Mammalia*. De store Pattedyr, Husdyrene og Hjortevildtet har navnlig i tidligere Tider spillet en stor Rolle i Skoven, som de ofte ganske prægede. Drøvtyggernes Traad og Opruskning af Græstuer og Svinenes Roden i Bunden fremmede Frøets Spiring. Ræve og Grævlinger præger Bunden og dens Flora omkring deres Grave, ja kan endog bevirke at der kommer til at raade en anden Træart (Ask) end i den omgivende Skov (Bøg). De smaa Gnavere og Spidsmusene udfører en Del Jordarbejde, men det er dog her til Lands kun af temmelig ringe Betydning, Jordrotten kan vel undertiden bearbejde Jorden ret intensivt, men Virksomheden er begrænset til smaa Arealer. Derimod har Muldvarpen *(Talpa europaea)*, som er et ægte Jord-Dyr, meget stor Betydning. Om dette Dyrs Ernæring er der meget delte Meninger, idet enkelte Undersøgelser har vist at den tog skadelige Insektlarver, særlig Oldenborrelarver, i stor Mængde, medens de fleste Undersøgelser tyder paa at den ganske overvejende lever af Regnorme, og for saa vidt nærmest maa betegnes som skadelig, da Regnormene er vore nyttigste Jordbundsdyr. Imidlertid formerer de sig saa stærkt, at Muldvarpen maaske næppe nogen Sinde holder deres Antal skadeligt langt nede, men noget sikkert herom kan man ikke sige. Muldvarpen udfører selv et meget stort Jordarbejde, som vel ikke staar paa Højde med

Regnormenes, men som dog vist ofte er ganske betydningsfuldt. Dens talrige Jagtgange, som løber overfladisk i Skovbunden, ofte med en forbavsende ensartet Afstand af 40 cm, beløber sig paa de i Fig. 6 afbildede Gangsystemer til ca. 4 m paa 1 m^2 eller 40 km paa 1 ha, og da de er henved 4 cm brede, indtager de 16 pCt. af Skovbundens Areal. Alene disse Ganges Volumen udgør henved 50 m^3 pr. ha. Hertil kommer dybere Løbegange, hvori Muldvarpen kan søge Skjul, naar den forfølges, og selve Boet som ligger dybt eller skjult

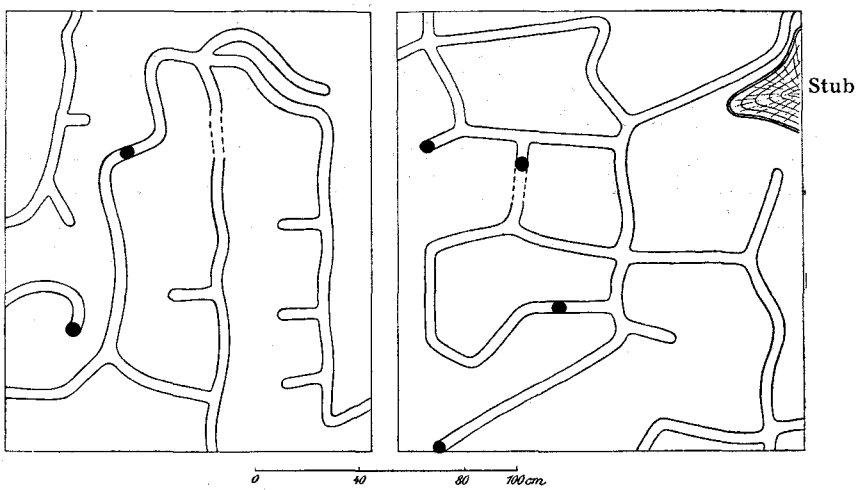


Fig. 6. To Kort over Muldvarpens overfladiske Gangsystemer i Nærheden af Bøgemuld-Lokalitet 15 i Geels Skov.

inde under et Træ. Kun paa fugtig Mosebund bygges Boet i en særlig lavet Jordhøj. Disse Gangsystemer maa have stor Betydning for Vandfordelingen i Jorden, særlig ved at de under stærke Regnskyl og ved Tøbrud kan hindre lokale Oversvømmelser, ved hvilke baade Trærødder og Regnorme kunde lide under Iltmangel. Man ser ofte, at en Muldvarpegang, der udmunder i en Grøfteside, fungerer som Drænledning. Paa Græssletter og Enge bidrager Muldvarpeskudene sammen med Myretuer til at præge Overfladen og dennes Vegetation. I Skoven er Muldvarpeskud sjældne, fordi Muldjorden er saa blød, at Muldvarpen kan bore sig frem i den uden at grave, og de dybe Gange bevares antagelig gennem lange Tider.

Sammenligning af Lokaliteterne.

En Sammenligning mellem de forskellige Skovbundstypers Faunaer foretager vi bedst ved at samle Tallene for de vigtigste Dyregrupper fra de 10 Hovedlokaliteter, fra hvilke vi har en hel Række Enkeltiagttagelser, hvoraf vi har dannet Middeltal. Dette er sket i Tabellerne XVIII og XIX, der viser henholdsvis den samlede Vægt af Dyr og disses Antal paa en Kvadratmeter.

Skovbundens Fauna bestaar dels af Dyr, der tilbringer hele deres Liv eller i alt Fald største Delen deraf i Skovbunden, og tager deres Næring her; dels af Dyr der kun opholder sig i Bunden midlertidigt, enten som Pupper eller som overvintrende Larver eller fuldvoksne Insekter, uden at de tager Næring til sig. Det er klart at de sidstnævnte kun har yderst ringe Betydning i Skovbundens Husholdning, men vore Undersøgelser viser tillige, at de i Tal og Vægt — under normale Forhold — udgør en saa ringe Brøkdel af den samlede Fauna, at vi kan se bort fra dem ved de Betragtninger, som vi nu skal komme ind paa.

Den i Skovbunden hjemmehørende Fauna deler vi naturligt i tre Grupper. 1: Dyr som lever af det organiske Affald paa Skovbunden, men tillige i betydelig Grad blander dette sammen med den mineralske Overgrund, som de gennemroder og derved gør skør og porøs; hertil kan vi kun henføre Regnormene *(Lumbricidae)*. 2: Dyr som sønderdeler og fortærer det organiske Affald paa Bunden, og saaledes medvirker ved Nedbrydningen af dette, men som ikke eller i alt Fald kun i ringe Grad arbejder nede i den mineralske Overgrund, og som derfor ikke bidrager væsentligt til at blande denne med det organiske Stof; hertil henregner vi *Gastropoda* (Snegle), *Enchytraeidae* (Enchytræider), *Isopoda* (Bænkebidere), *Diplopoda* (ægte Tusindben), *Acarina* (Mider), *Collembola* (Springhaler), *Diptera* (Tovingede Insekter), *Elateridae* (Smældere) og andre Insekter med Undtagelse af Rovbiller og Løbebiller, selv om der er enkelte Undtagelser, f. Eks. at et mindre Antal af Miderne er Rovdyr. 3: Dyr der lever af Rov; de fortærer andre af Skovbundens Dyr og bidrager derved til at regulere disses Mængde, men sætter maaske ofte Antallet længere ned end ønskeligt, saaledes at de kan komme til at virke som hemmende Faktor, paa samme Maade som man har ment at

Protozoerne kan virke hemmende paa Bakterievirksomheden i Jordbunden; herunder *Chilopoda* (Skolopendere), *Arachnida* (Mosskorpioner, Edderkopper og Mejere), *Staphylinidae* (Rovbiller) og *Carabidae* (Løbebiller). I Tabellerne er disse tre Grupper af Skovbundsfaunaen summeret op hver for sig. (En Særstilling indtager Muldvarpen, som vi har omtalt lige foran, der udfører et stort Gravearbejde, men lever af Rov).

Vi vil først se paa Faunaens Vægt, Tabel XVIII, fordi denne Størrelse giver et langt bedre Maal for Mængden end Antallet, og vi bemærker da allerførst, at den samlede Vægt af Dyr paa Løvtræskovenes Muldbund falder jævnt med Jordbundstilstandens Godhed, fra 76.81 g pr. m^2 paa den fortrinlige Egemuld til 12.90 g paa Oxalismulden, og helt ned til 5.25 g paa den forarmede Bund, hvor der er indledet en Maardannelse. Kommer vi derimod over paa den egentlige Bøgemaar, møder vi temmelig store Vægtmængder. Paa den bedste Maar, Lok. 4 i Rude Skov, ikke mindre end 24.02 g og paa den ringere Maar fra Grib Skov 16.57 g, begge Tal større end Vægten af Dyr paa Oxalismulden, Lok. 9, i Grib Skov.

I Granskoven er der ikke nogen udpræget Forskel mellem Totalvægtene fra Mulden med Oxalis og fra de to Maarlokaliteter, af hvilke den ene ligger noget over, den anden noget under Muldlokaliteten. De ligger alle tre nær op ad Bøg-Oxalis-Mulden.

Den samme Rækkefølge finder vi i Løvskoven for Vægten af Regnorme, som varierer fra 61.00 g paa Egemulden til 5.90 g paa Oxalismulden og gaar helt ned til 1.45 g paa den forarmede Bund. Paa den bedste Bøgemaar finder vi, hvad der er særlig værd at lægge Mærke til, samme Vægt af Regnorme som paa Oxalismulden, hvilket ogsaa er lig Vægten af Regnorme paa Gran-Oxalis-Mulden. Paa den tarveligere Bøgemaar fra Grib Skov er Regnormevægten omtrent den samme som paa de to Granskovslokaliteter med Maar fra samme Skov.

For de andre humusædende Dyr i Skovbunden stiller Forholdet sig anderledes. Paa Løvskovsmuld-Lokaliteterne aftager Summen af disse Dyrs Vægt ganske vist jævnt med Jordens Godhed, ogsaa naar vi tager den forarmede Bund med; men naar vi kommer over paa den egentlige Maarbund, finder vi paa den bedste Maar en Vægtmængde, der overgaar alle Muldlokaliteterne, og den ringeste Bøgemaar staar over Melica-

Tabel XVIII. Faunaens Vægt i Gram pr. m² paa de 10 Hovedlokaliteter.

Træart	Eg	Bøg						Rødgran		
Jordbund	Muld	Muld			Forarmet Bd.	Maar		Muld	Maar	
Bundflora	Bingelurt	Bukkar	Flitteraks	Skovsyre	Jomfruhaar	Ingen Flora	Ingen Flora	Skovsyre	Mostæppe	Mostæppe
Lokalitetens Nr.	10	15	5	9	2	4	20	1	6	8
1. Regnorme	61.00	53.10	27.90	5.90	1.45	5.40	1.15	5.05	0.90	1.55
Snegle	5.32	4.95	3.98	0.92	—	3.2I	1.65	0.16	0.15	—
Enchytræider	0.68	1.07	1.09	0.72	0.22	1.56	1.19	0.02	0.13	0.05
Bænkebidere	0.28	0.15	0.15	0.00	—	0.05	0.01	0.00	—	—
Ægte Tusindben	4.70	7.50	1.87	0.92	—	1.13	0.69	0.36	0.10	—
Mider	0.06	0.23	0.17	0.21	0.09	0.34	0.67	0.43	0.62	0.45
Springhaler	0.10	0.06	0.06	0.08	0.30	0.22	0.28	0.09	0.08	0.14
Tovingede Insekter	3.10	1.51	1.03	2.00	1.10	7.04	3.35	1.49	4.31	1.03
Smældere	0.18	0.18	0.58	1.33	0.60	3.48	2.85	0.88	3.71	3.14
Andre Insekter (undt. Rovbiller og Løbebiller)	0.55	0.56	0.42	0.45	0.33	0.52	0.28	1.29	1.12	1.12
2. Andre Humusædere	14.97	16.21	9.35	6.63	2.64	17.55	10.97	4.72	10.22	5.93
Skolopendere	0.61	1.29	0.20	0.15	0.84	0.51	4.10	0.56	0.74	1.76
Spindlere (undt. Mider)	0.06	0.03	0.04	0.07	0.03	0.13	0.09	0.03	0.04	0.07
Rovbiller	0.11	0.11	0.16	0.14	0.26	0.43	0.24	0.25	0.24	0.45
Løbebiller	0.06	0.03	0.11	0.01	0.03	0.00	0.02	0.11	0.08	0.08
3. Rovdyr	0.84	1.46	0.51	0.37	1.16	1.07	4.45	0.95	1.10	2.36
I alt	76.81	70.77	37.76	12.90	5.25	24.02	16.57	10.72	12.22	9.84

Tabel XIX. Antal Dyr pr. m^2 paa de 10 Hovedlokaliteter.

Træart	Eg	Bøg						Rødgran		
Jordbund	Muld	Muld			Forarmet Bd.	Maar		Muld	Maar	
Bundflora	Bingelurt	Bukkar	Flitteraks	Skovsyre	Jomfruhaar	Ingen Flora	Ingen Flora	Skovsyre	Mostæppe	Mostæppe
Lokalitetens Nr.	10	15	5	9	2	4	20	1	6	8
1. Regnorme	122	177	93	73	29	81	23	101	18	31
Snegle	68	105	66	16	0	52	83	4	2	0
Enchytræider	342	533	547	359	108	782	595	42	258	91
Bænkebidere	283	149	151	3	0	53	5	1	0	0
Ægte Tusindben	110	177	67	22	0	39	21	10	2	0
Mider	967	3206	1919	3049	2390	6161	9818	7337	7828	8270
Springhaler	493	1198	920	1383	5032	5114	7151	2210	1702	2302
Tovingede Insekter	271	232	349	447	261	1076	883	757	336	482
Smældere	12	12	39	89	41	232	191	59	249	211
Andre Insekter (undt. Rovbiller og Løbebiller)	129	222	106	168	58	194	154	54	86	127
2. Andre Humusædere	2675	5834	4164	5536	7890	13703	18901	10474	10463	11483
Skolopendere	40	78	8	8	28	21	273	35	49	117
Spindlere (undt. Mider)	60	37	56	78	30	144	100	34	46	67
Rovbiller	53	57	82	68	129	213	120	125	121	225
Løbebiller	28	6	21	6	15	1	8	21	15	15
3. Rovdyr	181	178	167	160	202	379	501	215	231	424
I alt	2978	6189	4424	5769	8121	14163	19425	10790	10712	11938

Mulden. Af Granlokaliteterne staar Mulden lavest, og baade den og den ringeste Granmaar staar under Bøg-Oxalis-Mulden, medens den bedste Granmaar staar meget højere, — paa Højde med den ringere Bøgemaar.

For Rovdyrenes Vedkommende synes Tallene ved første Øjekast at have et noget tilfældigt Præg, og det er tillige ret smaa Tal. Dog er det interessant, at de ringeste Maarformer har en forholdsvis stor Mængde. Vi maa imidlertid ogsaa tage Hensyn til Rovdyrenes relative Mængde, og finder da, at denne stiger fra godt 1 pCt. paa den bedste Muld til 3 pCt. paa Oxalismulden for paa Polytrichumbunden at springe op over 20 pCt. Paa den gode Bøgemaar udgør Rovdyrene kun ca. 4 pCt., paa Granmulden og den gode Granmaar knap 10 pCt., men paa den tarvelige Bøgemaar og den ringeste Granmaar omtrent 25 pCt. af den samlede Vægt af Dyr. Forskellen ligger især i Mængden af Chilopoder, idet de ringere Maarformer indeholdt særlig mange af de tynde gule Geophilid-Arter, og man kunde derfor være fristet til at betragte disse Dyr som en hemmende Faktor.

Gaar vi nu over til at betragte Tabel XIX, lægger vi straks Mærke til det ejendommelige Forhold, at Antallet af Dyr for alle Løvskovslokaliteterne stiger efterhaanden som Jordbundstilstandens Godhed aftager, fra knap 3000 paa den gode Egemuld til nær ved 20000 paa den ringeste Bøgemaar; kun Lok. 15 bryder Rækkefølgen noget.

Denne Iagttagelse synes at være Udtryk for en Lovmæssighed, der kan udtrykkes saaledes: Den Jordbund, hvor Omsætningen er livligst, har den største Vægtmængde af Dyr, men det ringeste Antal; hvor Omsætningen er langsom, saa der dannes svær Maar, finder vi det største Antal Dyr, men de er gennemgaaende meget smaa, og deres samlede Vægt er mindre end paa den bedste Bund. M. a. O.: Den gode Skovbund har faa og store Dyr, den tarvelige har mange og smaa Dyr.

Mellem Granmulden og Granmaaren træder en saadan Forskel ikke frem i vore Lokaliteter, men derimod finder vi Regelen meget tydeligt igen i Forholdet mellem de to Granmaarlokaliteter, idet den ringeste, Lok. 8, har et større Antal og en mindre Vægtmængde af Dyr end den bedre Lok. 6.

De to Tabeller lærer os dernæst en hel Del om de forskellige Dyregruppers Forhold til forskellige Skovbundstyper.

Gastropoder, Snegle, er tydeligt knyttede til Løvskovene, hvor der var flest paa den bedste Muldbund, men ogsaa temmelig mange paa Maaren, medens der var meget faa paa Granlokaliteterne; den ene Granmaar og den forarmede Bøgebund manglede Snegle.

De smaa hvide Orme, Enchytræiderne, var meget talrige i Løvskovene undtagen paa Polytrichumbunden. I Granskovene var der kun faa.

Isopoderne, Bænkebidere, er decideret knyttede til god Løvskovsmuld, forekom dog ogsaa i ringere Antal i Bøgemaaren.

Diplopoderne, de ægte Tusindben, er ligeledes først og fremmest knyttede til Løvskovsmulden, men forekommer dog tillige i ret stort Antal i Bøgemaaren; mere sparsomt i den bedre Granskovsbund.

Dipterlarver, Larver af tovingede Insekter, er derimod særlig knyttede til de bedre Maarformer baade i Bøgeskov og i Granskov, og navnlig spiller Stankelbenlarver en stor Rolle.

Endnu mere udpræget henvist til Maaren er dog Elater-(Smælder)-larverne, af hvilke der er henved 20 Gange saa mange i Maaren som i den gode Muld. Der er dog ligesom af Dipterlarver flest i den gode Maar. Dipterlarver og Smælderlarver maa regnes til Maarens allervigtigste Dyreformer.

De to Grupper af yderst smaa Arthropoder, Acarina (Mider) og Collembola (Springhaler), udgør talmæssigt den ganske overvejende Del af Faunaen, men de vejer kun meget lidt. Størst er deres Mængde i Bøgemaaren og i Granmaaren, hvor de for de tre Gribskovs-Lokaliteters Vedkommende udgør 6 pCt. af den samlede Vægt; paa den fattige Polytrichumbund udgør de over 7 pCt. af Vægten. Paa Løvskovsmulden var Mider omtrent dobbelt saa talrige som Collemboler, paa Bøgemaaren var Forskellen i Antal derimod ret ringe, og paa Polytrichumbunden var der over dobbelt saa mange Collemboler som Mider. Paa Granbunden er Antallet af Mider omtrent 3—5 Gange saa stort som Antallet af Collemboler. Miderne er saaledes navnlig fremtrædende i Granbunden, og kommer vi ud paa den fattige Bund i Hedeplantagerne, bliver deres Antal endnu langt større end i de her omtalte Prøver.

For Chilopodernes Vedkommende har vi omtalt det meget store Antal Geophilider paa de to ringere Maarlokaliteter. Edderkoppernes Antal synes at være størst i Bøgemaaren, og Antallet af Rovbiller størst i Bøgemaaren og i Granskoven. Løbebillerne er øjensynlig mest fremtrædende paa Muldbunden, og de store Arter træffes ganske overvejende her; men for deres Vedkommende er Tallene for smaa til, at man kan drage Slutninger af dem.

For bedre at forstaa det her omtalte Sammenhør mellem bestemte Skovbundstyper og Dyreverdenen i disse vil vi nærmere undersøge den øverste Del af Bunden paa nogle forskellige Typer. Billedtavlerne XI, XII og XIII viser Fotografier af 30 cm høje Jordpiller, som er udskaaret, med dertil lavede Zinkkasser, paa de seks Lokaliteter 15: God Bøgemuld med Anemone og Asperula, 9: Bøg-Oxalis-Muld, 2: Forarmet Bøgebund af Polytrichum-Typen, 4: Svær Bøgemaar med rigt Dyreliv, 1: Granskov med Oxalismuld og 6: Granmaar med tykt Mostæppe af Hylocomium-Arter. Prøverne blev bragt hjem til Atelieret i Zinkkasserne og fotograferet her.

Profilen fra Lok. 15, hvor Regnorme dominerer i Faunaen, viser i de øverste 20 cm en ensartet, grov Struktur af Klumper der svarer i Størrelse til Regnormenes Ekskrementer, som Jordlaget ogsaa maa antages at være dannet af. Nederst paa Billedtavle XV ses Regnormeekskrementer og Bladstumper i naturlig Størrelse. Under Muldjorden bliver Jorden tættere, men bevarer dog til Dels den nævnte Struktur endnu et Stykke længere ned. Farven er ensartet graabrun hele Vejen. Jorden, som er mindre sur end nogen af de efterfølgende, er surest, $p_H = 4.6$ i Overgrunden lige under det af Ormene stærkt bearbejdede Lag, og Surheden aftager nedad, saaledes at vi finder $p_H = 5.1$ ved 70 cm og $p_H = 5.6$ ved 90 cm Dybde. Fra 140 cm indeholder Jorden rigeligt kulsur Kalk og har $p_H = 7.2$.

Bøg-Oxalis-Muld-Profilen har ligeledes en meget løs Lejring foroven, men da Jorden er mere sandet og følgelig mindre sammenhængende, er Klumpstrukturen meget udvisket. Muldjorden er mere blandet med sort, halvt formuldet organisk Stof, som giver den en graa Farve. Fra 20 cm Dybde er Jorden meget tæt lejret, hvilket kan forklares ved, at der er langt færre af de større, jordbearbejdende Regnorme her, og

den tætte Overgrund er, som Fotografiet ogsaa viser, noget bleget. Surheden kulminerer noget højere oppe end paa Lok. 15 og er langt mere udpræget, $p_H = 3.9$. Den aftager derefter jævnt nedad og p_H naar 5.3 i 1 m og 5.5 i 2 m Dybde.

Paa Polytrichum-Bunden, der mangler større Regnorme, ser man at Jorden er ensartet tæt lejret helt op og overdækket med et mørkt, tyndt Maarlag, gennemvævet af Rødder. Overgrunden er stærkt bleget, særlig i de øverste 20 cm, som formodentlig for ikke ret lang Tid tilbage har været skør Muldjord, og oppe lige under det tynde Maarlag ses en 2 cm bred Blegsandsstribe og derunder en smal, mørk, rustjordsagtig Stribe. Surheden kulminerer her, hvor der mangler Regnorme, langt højere oppe end paa de to foregaaende Lokaliteter, nemlig i Blegsandsstriben lige under Maaren. At her er knap saa surt, $p_H = 4.0$, som paa Oxalisbunden, skyldes sikkert at Jordbundsforarmelsen er ret ny, og Jorden noget mere leret.

Billedet fra Lok. 4 viser den ca. 10 cm svære, foroven brune og løse, nederst sorte og tætte Maar, der er skarpt adskilt fra det meget lyse Blegsand, hvorunder vi finder en Rustjordsstribe fra 20 til 26 cm Dybde. Derunder kommer den noget lysere, normalt farvede, brungule Overgrund. Surheden kulminerer med $p_H = 3.6$ nederst i Maaren, altsaa som i de foregaaende Lokaliteter i det øverste af de Lag, der ikke er bearbejdede af Dyrelivet, og derefter aftager Surheden nedad til $p_H = 4.8$ ved 90 cm, og $p_H = 5.3$ ved 200 cm Dybde.

Profilen fra Granmulden viser øverst Laget af Grannaale og det sorte, overfladiske Muldlag, som er temmelig brat adskilt fra Overgrunden, der i de øverste 3 cm er meget mørkt humusfarvet. Overgrunden er meget tæt, hvilket paa Billedet viser sig ved det glatte Snit, og fra 9 til 15 cm Dybde er den synligt bleget. Profilen viser at Dyrelivet, ogsaa Regnormene, holder sig oppe i det overfladiske Muldlag, og vi konstaterede ved Undersøgelsen af Faunaen, at Graa Regnorm *(Allolobophora turgida)*, som er den vigtigste Bearbejder af den øvre Overgrund, manglede paa denne Form af Muldbund. Jorden er surest foroven i den mineralske Overgrund, hvor denne er blandet med Humus, altsaa ogsaa her lige neden under det af Dyrelivet bearbejdede Lag. Muldlaget er meget surt, $p_H = 4.3$, og det øverste, sureste Overgrundslag har $p_H = 4.1$, altsaa en Surhedsgrad der ikke ligger langt fra Maarens.

Tabel XX. Analyser fra fire Jordbundsprofiler.

Beskrivelse af Lokalitet og Jordlag	Surheds-tal	Efter 6 Uger fandtes mg i 1 kg Tørstof		Af stuetørt Stof var Procent			Total-*N* i Procent af tørt Stof
	p_H	*Am.-N*	*Salp.-N*	Organisk Stof	Hygroskop. Vand	Glødningsrest	
Lok. 15: Bøg, Muld, Bukkar.							
Nyfaldent Løv, 1½ cm	5.9	Spor	2.2	78	11	11	1.15
Gammelt Løv, ½ cm	6.1	84	1200	54	8	38	0.92
Regnormeekskrementer	5.8	8	264	22	3	75	0.42
Øvre Muldjord, 0—5 cm Dybde	5.4	4	48	14	2	84	0.29
Nedre » 5—15 » »	5.2	2	7.5	7	1	92	0.15
Overgrund i 35 » »	4.6	0	0.5	4	1	95	0.08
Undergrund i 70 » »	5.1						
» 90 » »	5.6						
» 140 » »	7.2						
» 200 » »	7.5						
Lok. 4: Bøg, Maar, ingen Flora.							
Nyfaldent Løv, 2 cm	5.9	0	3.0	82	11	7	1.19
Gammelt Løv, 2 cm	5.6	252	20	80	11	9	1.58
Øvre Maar, 0—4 cm Dybde	4.3	388	Spor	76	10	14	1.68
Mellemste Maar, 4—7 cm Dybde	3.7	95	Spor	59	8	33	1.23
Nedre » 7—9 » »	3.6	32	0	63	9	28	1.26
Blegsand i 15 » »	3.8	0	0	3	1	96	0.06
Rustjord i 30 » »	3.9	0	0	4	1	95	0.08
Overgrund i 45 » »	4.6						
Undergrund i 90 » »	4.8						
» 200 » »	5.3						
Lok. 1: Rødgran, Muld, Skovsyre.							
Naalelaget, 1 cm	4.7	336	75	61	8	31	1.15
Muldlaget i 0—2 cm Dybde	4.3	80	26	37	6	57	0.82
Øverste Overgrund i 8 cm Dybde	4.1	2	5.0	6	2	92	0.15
Overgrund i 22 » »	4.2	0	1.0	4	1	95	0.08
» 35 » »	4.3						
» 50 » »	4.5						
» 65 » »	4.8						
Undergrund i 100 » »	5.2						
» 200 » »	5.6						
Lok. 6: Rødgran, Maar, Mos.							
Mos og Naalelag, 4 cm	4.3	462	7.5	77	12	11	1.47
Øvre Maar i 0—5 cm Dybde	3.6	115	0.8	76	12	12	1.42
Mellemste Maar i 5—8 cm Dybde	3.5	32	Spor	70	10	20	1.18
Nedre » 8—10 » »	3.5	21	0	49	7	44	1.06
Blegsand i 20 » »	3.6	0	0	2	0	98	0.04
Rustjord i 30 » »	3.7	2	0	6	2	92	0.11
Overgrund i 40 » »	3.9						
» 50 » »	4.3						
Undergrund i 60 » »	4.7						
» 80 » »	4.7						
» 100 » »	4.5						
» 140 » »	4.8						

Surheden aftager hastigt nedad til $p_H = 5.2$ i 1 m, og $p_H = 5.6$ i 2 m Dybde.

Granmaar-Profilen fra Lokalitet 6 viser øverst Mosset, derunder 10 cm løs, brun, paa Dyreliv rig, øvre Maar (Formuldningslaget, HESSELMAN 1926), og 5 cm tæt, sort, amorf Maar (Humusstoflaget, HESSELMAN 1926), hvor der kun findes ganske faa Dyr. Overgangen er brat til det tæt lejrede Blegsand, som i 28 cm Dybde afløses af Rustjord. Ligesom paa Bøgemaaren kulminerer Surheden i den nedre, tætte Maar, her med $p_H = 3.5$, og den aftager hastigt nedad til $p_H = 4.7$ i 60 cm Dybde. I 140 cm Dybde er $p_H = 4.8$.

Nogle Analyser af Prøver tagne Dec. 1926 fra de fire Lokaliteter 15: God Bøgemuld, 4: Bøgemaar, 1: Granmuld og 6: Granmaar, er meddelt i Tabel XX.

Vi ser, hvorledes der paa Bøgemulden allerede i det nyfaldne Løv er begyndt en svag Salpetersyredannelse, som i det fjorgamle Løv stiger til en ganske overordentlig Livlighed, der holder godt Trit med Frigørelsen af Ammoniakkvælstof. Samtidig er Surheden aftaget lidt. I det derunder liggende løse Lag Regnormeekskrementer, som vi ser i naturlig Størrelse nederst paa Billedtavle XV, er Salpetersyredannelsen ligeledes meget livlig, og aftager saa først langsomt, senere hurtigt, nedad, ligesom Jorden bliver surere efterhaanden som vi kommer et Stykke ned i Overgrunden, hvorpaa Surheden atter aftager ned imod Undergrunden, hvis p_H foroven svarer til almindelig basefattig Mineraljord; den dybere Undergrund, som indeholder rigeligt kulsur Kalk, er alkalisk.

Paa Bøgemaaren forholder det øverste nyfaldne Løv sig paa samme Maade som paa Mulden, men allerede i det fjorgamle Løv (Billedtavle XIV foroven) viser der sig en betydelig Forskel, idet Ammoniakmængden her er mange Gange større end Salpetersyremængden. Mængden af frigjort, assimilabelt Kvælstof er procentisk langt mindre end paa Mulden, men den samlede Mængde er paa Grund af Lagenes Mægtighed meget betydelig. I Modsætning til hvad vi fandt paa Mulden, er det gamle Løvlag surere end det nyfaldne. I Maaren tiltager Surheden meget stærkt, og de nederste Lag er surest. Der er en meget kraftig Ammoniakdannelse i den øvre løse Maar, Formuldningslaget, hvor Dyrelivet hovedsagelig findes og hvor der endnu er mange tydelige Bladrester (Billedtavle XIV nederst

til venstre); mindre i den mellemste, mere tætte Maar; og nede i det tætte, sorte, amorfe Humusstoflag (Billedtavle XIV nederst til højre), hvor der næsten ingen Dyr forekommer, er Ammoniakdannelsen svag. Af Salpetersyre fandtes kun svage Spor i Maaren. I Blegsand og Rustjord foregik overhovedet ingen paaviselig Frigørelse af assimilabelt Kvælstof. Vi finder den største Surhedsgrad nederst i Maaren, og Surheden aftager efterhaanden som vi kommer ned i Overgrunden, for i Undergrunden at naa omtrent samme Værdi som i den Del af Undergrunden paa Lok. 15, der ligger oven over Kalkgrænsen.

Udgangsmaterialet for Humusdannelsen de to Steder, Bøgebladene, synes at være ens, og de lokale klimatiske Forhold er nu for Tiden næppe videre forskellige. Vil vi søge efter Aarsagen til at Processerne forløber helt forskelligt paa de to Lokaliteter, maa vi fremhæve to Faktorer. Den ene er Bundfloraen paa Mulden, som giver et Tilskud af meget let omsætteligt organisk Stof, der virker som et Stimulans paa Bakterielivet, hvad jeg har paavist ved Karforsøg (BORNEBUSCH 1925 p. 236), saavel som paa andre Organismer f. Eks. Enchytræiderne. Den anden Faktor er Regnormene, som aflægger deres paa Mineraljord og Baser rige Ekskrementer oppe i Løvlaget; det er nemlig sandsynligt, at Omsætningen paa Maaren gaar i Staa, fordi Bakterielivet mangler Tilskud af mineralske Stoffer. At Forskellen ikke kan skyldes den øvrige Del af Dyrelivet, væsentligst Arthropoder, fremgaar af at disse er lige saa fremtrædende paa Maaren som paa Mulden. Løvlaget er meget tykkere paa Maaren end paa Mulden, men det omdannes dog i Løbet af faa Aar, fordi Maarens Dyreliv søndergnaver det og fortærer det, hvorved det omdannes til den af smaa Løvdele og Dyrenes Ekskrementer bestaaende løse, øvre Maar, Formuldningslaget, hvori der endnu foregaar en ret livlig Ammoniakdannelse. Efterhaanden som Sønderdelingen fortsættes bliver Massen mere humificeret og tæt, og Omsætningen bliver langsommere, men er dog ikke helt standset i de nedre Lag.

Paa Granmulden staar Omsætningen betydeligt tilbage for Omsætningen paa Bøgemulden. Salpetersyredannelsen er meget mangelfuld, og Mængden af Ammoniakkvælstof er 4 og 3 Gange saa stor som Mængden af Salpetersyrekvælstof i hen-

holdsvis Naalelaget og Muldlaget; nede i Overgrunden er Salpetersyredannelsen den overvejende, og den samlede Mængde frigjort Kvælstof er ikke uvæsentlig. Billedtavle XVI viser øverst Naalelaget, derunder det øvre og nedre af Muldlaget. Man ser hvorledes Bundens Dyr efterhaanden har ædt eller bidt Naalene i smaa Stykker og blandet dem mere og mere med Ekskrementer.

Paa Granmaaren er Salpetersyredannelsen meget ringe og kunde overhovedet kun paavises i Mos og Naalelaget (Billedtavle XV foroven) og i den øvre Del af Maaren, som vi kalder Formuldningslaget, og som bestaar af søndergnavede Naale og Ekskrementer af Bundens Dyr ligesom Granmulden, men er mere sammenhængende (Billedtavle XV i Midten til venstre). Ammoniakdannelsen er derimod betydelig, og Mængden af frigjort assimilabelt Kvælstof staar i Naalelaget og Formuldningslaget ingenlunde tilbage for Granmuldens. Forskellen ligger i Salpetersyredannelsen, og atter her maa vi tænke paa Regnormene, der selv om de ikke udfører et saa intensivt Blandingsarbejde som paa Løvskovsmulden, dog paa Granmulden blander en betydelig Mængde Mineraljord op i Humuslaget. Medens vi nemlig i Mos og Naalelaget og i Formuldningslaget paa Maarbunden kun fandt 11 og 12 pCt. Glødningsrest, finder vi i de tilsvarende Lag fra Granmulden henholdsvis 31 og 57 pCt., hvilket maa skyldes Indblanding af Mineraljord. I Maarens dybere Lag, der bestaar af en tæt sammenkittet Masse (Billedtavle XV i Midten til højre) er Omsætningen ligesom paa Bøgemaaren kun ringe, og vi finder kun Ammoniak men ingen Spor af Salpetersyre. Medens Blegsandet synes ganske goldt, er der nogen Omsætning nede i Rustjorden, som ogsaa indeholder mere organisk Stof og Kvælstof end Blegsandet.

Surhedsgraden gennemløber lignende Ændringer gennem de forskellige Lag, som i Bøgeskoven. Dog bemærker vi, at Granskovens Muldlag er kendeligt surere end Affaldslaget, og at den øvre muldede Overgrund er mere sur end længere nede; vi træffer altsaa ligesom paa Maarbund Kulminationspunktet for Surheden ret højt oppe, nær Overfladen. Granmaaren er endnu surere end Bøgemaaren, men Forskellen mellem Lagene er ikke saa stor som der, maaske fordi Udgangsmaterialet

Naale og Mos er temmelig surt. Ligesom under Bøg kulminerer Surheden nederst i Maaren.

Disse Analyser viser følgende Sammenhæng mellem Faunaen og Omsætningen i Skovbunden. Paa den gode Bøgemuld, hvor vi havde en dominerende Regnormefauna, saaledes at Sammenblandingen af Mineraljord og organisk Affald kunde foregaa intensivt, fandt vi en livlig Omsætning med en næsten fuldstændig Salpetersyredannelse. Paa Granmulden, hvor Regnormene kun udgjorde 5 g pr. m^2, eller ca. Halvdelen af Faunaens totale Vægt, og hvor Sønderdelingen af Naalene for en væsentlig Del udføres af Insektlarver m. v., var Blandingen af Mineraljord og Humus ufuldstændig; vi fandt et paa uorganisk Stof relativt fattigt Muldlag oven paa Overgrunden, ret skarpt adskilt fra denne, og Salpetersyredannelsen var højst mangelfuld. Hvor endelig, som paa Bøgemaaren og Granmaaren, Regnormene kun udgjorde henholdsvis 23[1]) og 7 pCt. af den samlede Vægt af Faunaen, der saaledes nærmest maa betegnes en Arthropodfauna, var det organiske Stof kun i ringe Grad blandet med Mineraljord. Der var en temmelig livlig Omsætning ledsaget af Ammoniakdannelse i de øvre Lag, hvor Faunaen arbejder; i den dybere, tætte Maar var Omsætningen derimod meget langsom. Salpetersyredannelsen var ubetydelig oppe i Løv- eller Naalelaget og manglede ganske eller var i alt Fald kun antydet nede i Maarlaget.

Dyrelivets Intensitet.

Vi har i det foregaaende Afsnit set, at Antallet af Dyr ikke kan bruges som Maal for den Intensitet, hvormed vi maa antage at Faunaen virker i Skovbunden; ja, at Antallet af Dyr endog er mindst, hvor Omsætningen i Bunden foregaar med størst Livlighed. Langt større Betydning maa vi tillægge Dyrenes samlede Vægt, men naar vi ser nøjere paa Sagen, finder vi dog, at heller ikke denne er en tilfredsstillende Maalestok. Naar vi betragter større og mindre Dyr ved Siden af hinanden, kan vi ikke undgaa at lægge Mærke til, at de smaa Dyr udfører deres Bevægelser meget hurtigere end de store; vi maa derfor ogsaa antage at f. Eks. 100 smaa In-

[1]) Paa den ringere Bøgemaar, Lokalitet 20, udgjorde Regnorme kun 7 Procent af Faunaens Vægt.

sekter paa 1 mg hver tilsammen maa udfolde en langt større Energi end et enkelt Insekt, som vejer 100 Milligram.

Jeg har derfor søgt efter en anden Enhed for Dyrelivets Intensitet og er standset ved Dyrenes Stofskifte, der maa være proportionalt med deres Energiudfoldelse, og, i alt Fald saa længe vi har at gøre med ensartet formede, nær beslægtede Dyr med ensartet Levemaade, maa antages at staa i Forhold til deres Arbejde i Bunden. Et godt Maal for Stofskiftet og Energiudviklingen har vi i Dyrenes Respiration, deres Optagelse af Ilt og Udskillelse af Kulsyre.

Ifølge Overfladeloven er Forholdet mellem Iltforbrugene hos Dyr af forskellig Størrelse ikke lig Forholdet mellem deres Vægt, men lig Forholdet mellem deres Overflader. Denne Lov har vist sig at gælde saavel for varmblodede Dyrs (f. Eks. store og smaa Hunde) som for koldblodede Dyrs Vedkommende. Om den ogsaa kunde bruges ved Sammenligning mellem Skovbundens forskellige Arter af koldblodede Dyr, der som Regnorme, Spindlere, Tusindben og Insekter ikke var nær beslægtede, var det nu Opgaven at faa undersøgt. Jeg har derfor ved Hjælp af KROGHS Mikrorespirationsapparat bestemt Aandedrættet hos i alt 25 af Skovbundens almindeligt forekommende Dyrearter.

Metoden, som er beskrevet i forskellige Afhandlinger af KROGH (1914 a, 1914 b, 1914 c, 1916), er i Princippet følgende: Man har to lige store Glasbeholdere nedsænkede i en Vandtermostat og forbundne med hinanden ved et Haarrørsmanometer med Petroleum som Manometervædske. Dyret som skal undersøges anbringes i den ene af Beholderne, hvori der tillige er anbragt lidt Filtrerpapir vædet med Kalilud, som vil optage den i Glasset dannede Kultveilte. Efterhaanden som Dyret forbruger Ilt vil der fremkomme en hertil svarende Trykformindskelse i Beholderen, der vil medføre et Udslag paa Manometeret, hvorefter Iltforbruget kan beregnes. Formelen for Beregningen, som er ganske lige til, skal jeg ikke komme ind paa her, men henviser til KROGHS Afhandling (1914 a), kun maa jeg bemærke, at jeg har foretrukket at benytte mg Ilt som Enhed i Stedet for cm^3 Ilt. Med dette Respirationsapparat kan man følge Aandedrættet hos meget smaa Væsener, ja endog f. Eks. et enkelt Sommerfugleæg.

Hvis de Dyr, som jeg har undersøgt, følger Overflade-

loven, skal de alle have samme Iltforbrug, naar man efter Overfladeloven omregner dem til Dyr af 1 Gram Vægt. Ved disse Omregninger har jeg ikke taget Hensyn til de forskellige Dyrs forskellige Form og virkelige Overflade, hvilket vilde være uoverkommeligt, men er gaaet ud fra, at Respirationen skal være proportional med $\sqrt[3]{w^2}$, hvor w er Dyrets Vægt, og ved denne Sammenligningsmetode har jeg opnaaet en Overensstemmelse, som er ganske tilstrækkelig for vort Formaal. Hvis Vægten er w mg og Iltforbruget i Timen R, skal Iltforbruget omregnet til et »Gram-Individ« efter Loven være $100\ R : \sqrt[3]{w^2}$.

Betingelsen for at Dyrene skal følge Loven nøjagtigt er, at de alle er i samme Tilstand under Forsøgene. Ved større Dyr (Hvirveldyr) har man opnaaet dette ved at bestemme Respirationen hos bevidstløse Individer. TAGE ELLINGER har (1916) ligeledes undersøgt Respirationen hos Myg, der var i absolut Ro i Vinterdvale. Noget saadant var ikke muligt med mine Skovbundsdyr, men de er undersøgt i uvirksom Tilstand, gaaende alene og uden Føde i Forsøgsglasset, hvor de kunde bevæge sig, om de havde Lyst, men ikke fik Impulser udefra. Paa Grund af de forskellige Individers og Arters forskellige Tilstand og Temperament har der ikke kunnet opnaas nogen særlig nøje Overensstemmelse mellem de enkelte Forsøgsdyr, men naar vi ordner de 25 undersøgte Individer efter Vægt, og tager Middeltal af dem 5 og 5, bliver Overensstemmelsen mellem store og smaa Dyr, omregnede til Gram-Individer, særdeles god, saaledes som det fremgaar af Tabel XXI S. 142. I Tabellen er tillige opført Respirationen pr. Gram, der er meget større hos de smaa Dyr end hos de store. Alle Forsøgene udførtes ved en Temperatur af 13° C., og Respirationen for et Gram-Individ var, naar vi tager Middeltal af alle 25 Forsøg, 0.14 mg O pr. Time. For et Dyr paa 1 mg bliver Respirationen efter Loven en Hundrededel heraf eller 0.0014 mg O pr. Time. Jeg vil ingenlunde af disse Tal slutte, at Skovbundens forskellige Dyreordener har nøjagtigt samme Respirationsintensitet efter Loven, men Forskellene synes ikke at være større end mellem Individer af samme Familie, og er i alt Fald relativt smaa nok til, at vi kan tillade os de efterfølgende Sammenligninger.

Tabel XXII. Faunaens Respiration i Milligram Ilt i Timen pr. m² ved 13° C.

Træart	Eg	Bøg						Rødgran		
Jordbund	Muld	Muld			Forarmet Bd.	Maar		Muld	Maar	
Bundflora	Bingelurt	Bukkar	Flitteraks	Skovsyre	Jomfruhaar	Ingen Flora	Ingen Flora	Skovsyre	Mostæppe	Mostæppe
Lokalitetens Nr.	10	15	5	9	2	4	20	1	6	8
1. Regnorme	10.76	11.10	5.84	1.73	0.55	1.48	0.44	1.92	0.34	0.59
Snegle	1.46	1.43	1.12	0.26	—	0.90	0.56	0.05	0.04	—
Enchytræider	0.76	1.18	1.22	0.80	0.24	1.74	1.32	0.04	0.23	0.08
Bænkebidere	0.40	0.21	0.21	0.00	—	0.07	0.01	0.00	—	—
Ægte Tusindben	1.85	2.96	0.79	0.36	—	0.47	0.28	0.15	0.04	—
Mider	0.18	0.71	0.47	0.65	0.35	1.15	2.14	1.38	1.80	1.39
Springhaler	0.19	0.18	0.17	0.25	0.89	0.80	1.10	0.32	0.28	0.41
Tovingede Insekter	1.16	0.63	0.69	0.98	0.53	2.28	1.57	1.12	1.91	0.57
Smældere	0.10	0.10	0.33	0.75	0.34	1.97	1.62	0.50	2.11	1.79
Andre Insekter (undt. Rovbiller og Løbebiller)	0.30	0.34	0.25	0.24	0.21	0.33	0.19	0.53	0.57	0.61
2. Andre Humusædere	6.40	7.74	5.25	4.29	2.56	9.71	8.79	4.09	6.98	4.85
Skolopendere	0.32	0.70	0.09	0.08	0.38	0.24	2.33	0.31	0.42	1.00
Spindlere (undt. Mider)	0.08	0.04	0.06	0.10	0.04	0.18	0.12	0.05	0.05	0.09
Rovbiller	0.12	0.13	0.18	0.15	0.29	0.47	0.27	0.28	0.27	0.50
Løbebiller	0.06	0.02	0.09	0.01	0.03	0.00	0.02	0.09	0.06	0.06
3. Rovdyr	0.58	0.89	0.42	0.34	0.74	0.89	2.74	0.73	0.80	1.65
I alt	17.74	19.73	11.51	6.36	3.85	12.08	11.97	6.74	8.12	7.09

Vi kan nu, idet vi vil benytte forannævnte Erfaringstal som Udgangspunkt, beregne hvor stor Respiration hver enkelt Dyreart efter Overfladeloven skal have, naar vi kender de enkelte Individers Vægt. Paa denne Maade er Kolonnen »Respiration« i Tabellerne II til XIII beregnet, ved at der for hver Art er regnet med en vis Middelvægt og den hertil svarende Respiration pr. Individ.

I Tabel XXII finder vi Respirationsværdierne, angivne som mg *O* pr. Time for 1 m^2 ved 13° C., sammendraget fra de 10 Hovedlokaliteter, idet vi har grupperet Dyrene paa samme Maade som i Tabellerne XVIII og XIX. Vi vil først benytte Tallene til en Sammenligning af de forskellige Lokaliteter, hvad vi maa kunne gøre med god Samvittighed, fordi der hertil kun fordres, at Tallene er relativt rigtige, medens vi kan se bort fra den absolutte Rigtighed af Værdierne.

Vi ser da at vi har det mest intensive Dyreliv paa de to bedste Muldlokaliteter, men næst efter disse kommer de to Bøgemaarlokaliteter, hvor Intensiteten ligger lidt over Melicamulden og langt over Oxalismulden og den forarmede Bund. Paa Gran-Oxalis-Mulden har vi meget nær samme Intensitet som paa Bøg-Oxalis-Mulden, medens vi paa de to Granmaar-Lokaliteter finder en større Intensitet. Vi lærer saaledes straks heraf, at Dyrelivet paa Maarbunden maa spille en endnu større Rolle for Omsætningen, end vi kunde slutte af Vægtforholdene. Vi ser endvidere, at medens Regnormene paa den bedste Muld udgør omtrent 80 pCt. af den samlede Vægt af Dyr, præsterer de kun 61 pCt. af Respirationen; paa den bedste Bøgemaar udgør de 22 pCt. af Vægten og yder kun 12 pCt. af Respirationen. Endvidere forstaar vi først nu, at de ganske smaa Dyr, Miderne og Collembolerne, trods deres ringe samlede Vægt, kan have ret stor Betydning for Stofomsætningen, navnlig paa Maarbunden. Paa Bøgemaaren Lok. 4 udgør disse smaa Dyr 2.3 pCt. af Vægten men 16.1 pCt. af Respirationen, paa Lok. 20 er Tallene henholdsvis 5.7 pCt. og 27.1 pCt., paa Lok. 1, Granmulden, 4.8 og 25.2 pCt., paa Granmaaren Lok. 6 henhv. 5.7 pCt. og 25.6 pCt., paa Granmaaren Lok. 8 henhv. 6.0 og 25.4 pCt. Paa den forarmede Bund Lok. 2 er Tallene 7.4 pCt. og 32.2 Procent.

Mere forbeholdne maa vi være ved Betragtninger over de absolutte Værdier af Dyrelivets Respiration. Særlig Betydning

vilde det have for os at kende den totale aarlige Respiration pr. m^2, idet vi deri vilde have et Middel til at bedømme hvor stor en Rolle Dyrelivet spiller ved Omsætningen af det organiske Affald paa Bunden. Vi maa ved Beregningen tage Hensyn til at Forholdene varierer med Aarstiden, først og fremmest til Respirationens Afhængighed af Temperaturen. For denne har KROGH (1914) udarbejdet en Kurve, gældende for koldblodede Hvirveldyr, og ELLINGER har (1916) vist, ved Undersøgelser af Myg, at Kurven ogsaa gælder for Insekter. Betingelsen for at Kurven har Gyldighed er, at Dyrene ved de forskellige Temperaturer er i samme Tilstand, saaledes som vi har omtalt ovenfor paa Side 214. I en saadan ensartet Tilstand er vore Skovbundsdyr ikke i Naturen, men vi vil nu foreløbig se, hvor stor deres aarlige Respiration vilde være, hvis de fulgte KROGHS Kurve.

Temperaturen i Skovbunden kan vi efter Iagttagelser fra Møllevangen (BORNEBUSCH 1926) ansætte saaledes:

Februar og Januar	Marts og December	April og November	Maj og Oktober	Juni og September	Juli og August	Hele Aaret
0	1	4	8	11.5	14	6.4° C.

Naar vi paa Fig. 7, der viser Respirationskurven, oprejser Perpendikulærer i de til ovennævnte Temperaturer svarende Punkter paa Abscisseaksen, og tillige ved 13° C., kan vi, idet vi tager Respirationen ved 13° C. som Enhed, beregne følgende relative Værdier for Respirationen i de forskellige Maaneder:

Februar og Januar	Marts og December	April og November	Maj og Oktober	Juni og September	Juli og August	Hele Aaret
0.15	0.20	0.35	0.58	0.86	1.11	0.54

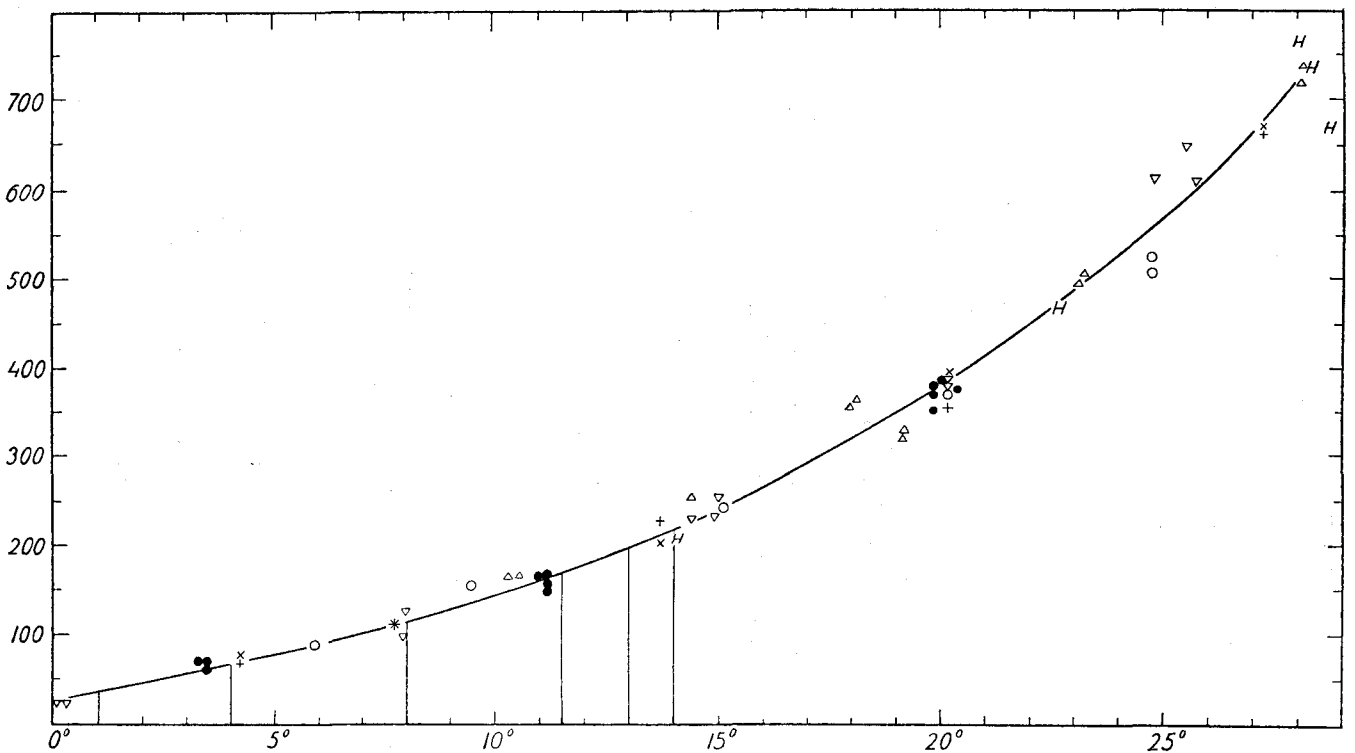
Den gennemsnitlige aarlige Respiration bliver saaledes 0.54 Gange Respirationen ved 13° C., eller, da Aaret har 8760 Timer, 4730 Gange saa stor som Respirationen i 1 Time ved 13° C. Herefter vil vi meget let kunne beregne Dyrelivets aarlige Respiration paa de forskellige Lokaliteter.

Vi maa imidlertid først se, om der kan være nogen Rimelighed i at beregne disse Aars-Respirationer ud fra den ved Forsøgene fundne Værdi: 0.14 mg *O* for et Gram-Individ ved

13° C. For det første er Skovbundens Dyr meget rolige Væsener, der ikke kommer op paa lignende voldsomme Energiforbrug som f. Eks. Insekter der flyver omkring; selv naar de færdes omkring eller æder, sker det, i alt Fald for de planteædende Formers Vedkommende, med en vis Sindighed. I den varme Aarstid maa Respirationen dog ligge noget over de i Forsøgsglassene fundne Værdier. Til Gengæld er Dyrene i en Del af den kolde Vintertid i Dvale, og derfor nede paa en lavere Respiration, end den vi her har regnet med. For ELLINGERS Myg var Respirationen i Dvale 0.08 og 0.07 mg *O* pr. Gram-Individ i Timen ved 13° C., nogle af mine Forsøgsdyr havde en lignende lav Respiration, og har antagelig ogsaa været i Dvaletilstand; en Skarnbasse havde om Natten ligeledes en meget lav Respiration og har øjensynlig sovet paa denne Tid, medens en Løbebille, der undersøgtes samtidig, ikke viste nogen Forskel paa Dag- og Nat-Respiration (se Tabel XXIII S. 147). Disse Minimumsværdier tyder paa, at Dvalerespirationen maa være omkring halv saa stor som den Respiration vi regner med. Da Dyrene kun er i Dvale en kortere Del af den kolde Aarstid, hvor Respirationen i Forvejen er ringe, medens de den største Del af Aaret maa have en større Respiration end den vi regner med, mener jeg, at vi med ret stor Sikkerhed tør gaa ud fra, at de Respirationer, vi regner os til, er Minimumsværdier; men for øvrigt er det sandsynligt, at vi heller ikke er særlig langt fra Maksimumsværdierne. Det interesserer os dog især at vide, hvor stor Dyrenes aarlige Respiration i det mindste maa være. Multiplikation af de fundne Respirationstal for de ti Hovedlokaliteter med Faktoren 4730 giver følgende Tal for aarligt Iltforbrug i Gram pr. m^2:

	Ege-Muld	Bøgemuld Asperula	Bøgemuld Melica	Bøgemuld Oxalis	Bøg forarmet	Bøge-Maar	Bøge-Maar	Gran-muld	Gran-maar	Gran-maar
Lok.	10	15	5	9	2	4	20	1	6	8
Gram *O* pr. m^2	84	93	54	30	18	57	57	32	38	34

Ved Forbrænding af Humusstoffer er den forbrugte Iltmængde omtrent lige stor med den forbrændte Mængde organisk Stof, og de ovenstaaende Tal svarer derfor omtrent til Dyrenes Stofforbrug. Da det aarlige Løvfald i Bøgeskov og Granskov beløber sig til omkring 400 g pr. m^2, i Egeskov og Fyrreskov til noget mindre, kan vi, trods Usikkerheden i vore



● Myg. × Decerebreret Tudse. + Urethaniseret Frø. ○ Curariseret Frø. ▽ Normal Fisk. △ Narkotiseret Fisk. *H* Ung Hund.

Fig. 7. KROGHS Temperatur-Respirations-Kurve for koldblodede Dyr. (ELLINGER 1916).

Beregninger, med Sikkerhed slutte, at den ved Dyrelivets Respiration forbrændte Mængde organisk Stof udgør en meget betydelig Part af den samlede aarlige i Skovbunden omsatte Stofmængde.

Skovbundens aarlige Stofomsætning vil, naar der ikke opsamles Humus, være en Del større, end hvad der svarer til Løvfaldet, idet tillige nedfaldne døde Grene og Kviste, Frugter, døde Rødder og eventuel Bundflora maa medregnes. Denne Omsætning besørges overvejende af Bakterier og Svampe; men vi ser af ovenstaaende, at ogsaa Dyrelivet, foruden den indirekte Betydning det har for Omsætningen ved sit mekaniske Arbejde, direkte deltager i Stofomsætningen i en betydelig Grad, og saa kommer endda hertil, foruden de i ovenstaaende Beregninger medtagne Dyr, baade Nematoder og Protozoer, der forekommer i Bunden i uhyre Mængder. Det er derfor næppe for meget sagt, at den ved Dyrelivets Stofskifte forbrændte Mængde organisk Stof paa gunstige Steder løber op til en Femtedel, en Fjerdedel, eller maaske mere af den samlede Stofomsætning.

Tilbageblik over Resultaterne.

Vi lærer af de foranstaaende Undersøgelser, at Skovbundens Fauna optræder i en Række forskellige Typer, der paa det nøjeste er knyttet til Skovbundstyperne, saaledes som disse navnlig træder frem for vort Øje gennem Bundfloraen og ved Undersøgelse af Skovbundens Profil.

Medens der paa de forskellige Floratyper optræder helt forskellige Plantearter, viser Faunatyperne imidlertid overvejende kvantitative Forskelligheder.

Skovbundens Planter udmærker sig ved stor Stedfasthed. Det er overvejende mangeaarige Planter, ofte med Rodstokke, og en eller nogle faa Plantearter vil under Konkurrencen mellem de forskellige Arter bemægtige sig Terrainet saa fuldstændigt, at det er vanskeligt for andre Arter at trænge sig ind, medmindre der sker en Ændring i de forhaandenværende Kaar. De til en vis Lokalitet særlig egnede Arter vil blive ganske dominerende og vil fastholde deres Terrain med stor Styrke.

For Faunaens Vedkommende er Forholdet et andet. Dyrenes

Levetid er stærkt begrænset, saaledes at der ikke paa samme Maade som ved Planterne er Tale om, at al Plads til Stadighed holdes besat af nogle faa særlig egnede Arter, og de enkelte Arters Individantal undergaar ofte store for største Delen uopklarede Svingninger fra Aar til Aar. Endvidere er Dyrene bevægelige, saaledes at de kan ty hen til de gunstige Steder i Bunden, og de er derved mere frit stillede over for Kaarene. Endelig synes det ogsaa, som om mange Dyrearter er langt mere elastiske i deres Livskrav end Planter.

Følgen er da, at medens vi kunde karakterisere Floratyperne ved bestemte Plantearter, maa Karakteriseringen af Faunatyperne i Hovedsagen være af kvantitativ Art. En Undtagelse danner til en vis Grad Regnormene, hvis Arter er mer eller mindre stærkt begrænsede af Jordbundens Egenskaber. Vi kan skelne mellem følgende Hovedtyper af Fauna:

Løvskov-Muld-Fauna eller egentlig Muldjordsfauna: Bestaar overvejende af Regnorme (50—80 pCt. af Vægten), som gennemroder den mineralske Overgrund og blander den med organisk Stof fra Jordoverfladen. Karakterdyr er Graa Orm *(Allolobophora turgida),* paa den bedste Muldbund tillige Stor Regnorm (*Lumbricus terrestris),* (Se i øvrigt nærmere S. 194). Af Arthropoder (Leddyr) maa fremhæves ægte Tusindben, Trichoniscer og store Løbebillearter. Jo langsommere Omsætningen er, desto mindre vil den samlede Vægt af Dyr pr. Kvadratmeter være, og desto flere Arthropoder finder vi; Smælderlarver, Dipterlarver, Collemboler og Mider vil tage til i Antal, samtidig med at Regnormene aftager.

Granskov-Muld-Fauna eller Overflademuld-Fauna: Regnorme udgør kun ca. Halvdelen af Vægten af Dyr, og det er udelukkende Arter som Skovregnormen *(Lumbricus rubellus),* Løvregnormen *(L. castaneus)* og *Dendrobaena*-Arterne (Mosorm og Stuborm), der lever oppe i den humøse Muld, og kun i mindre Grad blander Mineraljord op i denne. Graa Orm og andre udprægede Muldjordsarter mangler. Arthropoderne er væsentligst Mider, ægte Tusindben, Dipterlarver og Smælderlarver.

Løvskov-Maar-Fauna: Regnorme (næsten udelukkende *Dendrobaena*-Arter) udgør fra nogle faa Procent op til en Snes Procent af Vægten og holder sig til Humuslaget, som kun i yderst ringe Grad blandes med Mineraljord. Faunaen er en

Arthropodfauna, hvor først og fremmest Dipterlarver, Smælderlarver, Tusindben, Collemboler og Mider spiller en Rolle. De to sidste Ordener er omtrent lige talrigt repræsenterede.

Forarmet Bøgebund af Polytrichumtypen har en særlig fattig Fauna. Regnorme forekommer yderst sparsomt. Vi finder her en Arthropodfauna med en Del Dipterlarver og Smælderlarver. Collemboler er overordentlig fremtrædende og overgaar Mider langt i Antal.

Granskov-Maar-Fauna: Regnorme er sparsomme (sjældent over en halv Snes Procent af Vægten) og saa godt som udelukkende Mosorm *(Dendrobaena octoedra)*. Det er en Arthropodfauna karakteriseret ved at Trichoniscer mangler, ægte Tusindben er sjældne, Mider er uhyre talrige og overgaar langt Collembolerne i Antal, Dipterlarver og navnlig Smælderlarver er de mest fremtrædende i Vægten. Ejendommelig er desuden den store Mængde Geophilider. Paa ringere Granlokaliteter, f. Eks Hedeplantager, spiller Mider en endnu mere fremtrædende Rolle end i Maaren paa den bedre Bund.

Paa den bedste Muldbund med særlig livlig Omsætning fandt vi den største Vægtmængde af Dyr, men det mindste Antal; paa Bund med langsom Omsætning og med Ophobning af Humus fandt vi det største Antal Dyr, men disse er yderst smaa, og Totalvægten er mindre, men dog større end paa de ringeste Muldformer. Som Maal for Dyreverdenens Virksomhed i Skovbunden er Vægten bedre end Antallet, men ingen af disse Størrelser tilfredsstiller. Et langt bedre Maal har vi i Respirationen, der kan kalkuleres ved Benyttelse af Overfladeloven. Beregninger af Dyrenes Aandedræt viser, at dette maa udgøre en ganske betydelig Del af Skovbundens samlede Respiration.

Den mest fremtrædende Betydning i Skovbunden har de store Regnormearter *(Lumbricus terrestris, L. rubellus* og *Allolobophora turgida,* endvidere *Eisenia rosea, Allolobophora trapezoides, A. chlorotica, Octolasium lacteum* med flere), der gennemarbejder Overgrunden og blander den med det organiske Affald. Den dybe, skøre Muldjord, som vi finder i Løvskovene, er betinget af disse Dyrs Virksomhed.

Hvor de ovennævnte Regnorme mangler vil vi i gunstigste Tilfælde faa en Overflademuld, saaledes som vi finder den ganske almindeligt i Granskovene. Der er vel en Del mindre

Regnorme (*Lumbricus rubellus, L. castaneus* og *Dendrobaena*-Arterne) i denne, der blander nogen Mineraljord op i Humuslaget, men de udfører ikke den intensive Blanding af Mineraljord og Humus som de store Arter.

Arthropoderne har størst Betydning paa Maarbunden, hvor det organiske Stof aflejres oven paa Mineraljorden uden at blandes med denne. De udfører her et stort Arbejde, ved at de efterhaanden sønderdeler og fortærer alt det nedfaldne Løv m. v., og derved omdannes dette til det øvre Humuslag, Formuldningslaget, hvori der foregaar en livlig Omsætning med rigelig Ammoniakdannelse. Maaren adskiller sig fra Overflademulden ved at Omsætningen ikke løber til Ende, men at et Lag af Humus, der meget vanskelig omsættes, efterhaanden opsamles oven paa Mineraljorden. Forskellen skyldes vel for en Del Jordbundens geologiske Egenskaber, men dog især at Overflademuldens Regnorme blander nogen Mineraljord op i Humuslaget, hvilket fremmer det Bakterieliv, som skal føre Omsætningsprocesserne til Ende.

Vi maa af vore Undersøgelser slutte, at Dyrelivet har meget stor Betydning for Stofomsætningen i Skovbunden, ja i en betydelig Grad præger dennes Forløb, og er væsentligt bestemmende for, hvilken Jordbundstype vi faar. Forstmanden maa derfor ved sin Behandling af Skoven stedse have for Øje at fremme Dyrelivet og undgaa alt hvad der kan skade det.

Særlig Vægt maa vi lægge paa at begunstige de store Regnormearter, der synes at være afgørende for Frembringelsen og Bevarelsen af den gode Muldjord og den Jordbundstype, som vi kalder Brun Skovjord (RAMANNS Braunerde); i modsat Fald vil vi faa en Fortættelse og Udvaskning af Overgrunden. Regnormene begunstiges af Løvtræer, især saadanne med let omsætteligt Løv, af en Urteflora paa Bunden, og af gode Læforhold i Skoven. Indblanding af Lystræer som Eg, Ask, Æretræ og Lærk i Bøgebevoksninger vil være gunstig baade for Bundfloraen og for Buske, Opvækst og Træer af 2den Etage, der kan give Læ i Skoven. Naaleskovene bortskræmmer de vigtigste Regnormearter, og Indblanding af Løvtræer vil derfor være gavnlig. De stærke, hyppige Tyndinger — hvert 2det Aar — som er udført af Overførster MOLDENHAWER paa Frijsenborg i Jylland, vil i alt Fald paa bedre Bund medføre en Urteflora under Granerne, der maa være til Gunst for Regn-

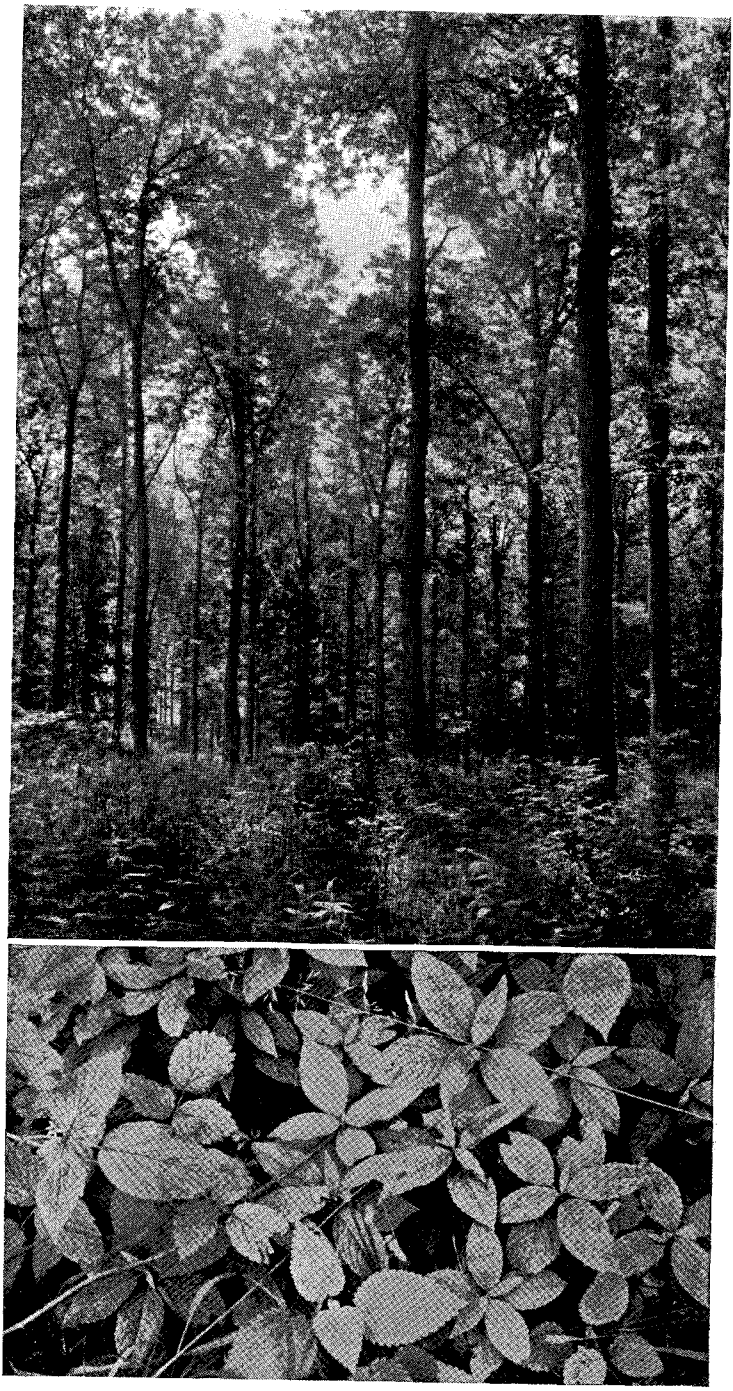
ormene. Paa den tarveligere Naaleskovsbund, som i Hedeplantagerne, vil man maaske ikke kunne slippe helt for Maardannelse, men vore Undersøgelser fra Lokaliteterne 23 og 32 viser, at der med stærk og hyppig Hugst i Granskoven følger et Mostæppe og et rigt Dyreliv, især af Mosorm og Dipterlarver, som giver Humusen en langt mere løs og tiltalende Karakter. Kan vi blot naa fra Maar til Overflademuld i disse Skove, vil det være en stor Fordel, men maaske vil vi kunne lære at dyrke Skoven saaledes, at vi kan naa til en virkelig Muldjord. Hertil fordres et nøje Kendskab til Dyrelivets Krav, som vi derfor maa søge at trænge til Bunds i.

De foran nævnte Foranstaltninger, Blanding af Træarter og Udførelse af stærke og hyppige Tyndinger, harmonerer med det moderne danske Skovbrugs Ideer. Hertil maa føjes Bestræbelser for at skaffe Læ i Skovenes Udkanter, ved at disse holdes bevoksede med Lystræer og Buske. Med en rigere Vegetation og mere Læ og Skjul i Skoven vil ogsaa følge et rigere Liv af Fugle, som yder os Hjælp ved Bekæmpelsen af skadelige Insekter.

Til Slut vil vi se paa de Opgaver, der melder sig for fremtidigt Studium. Vi har set, at der optræder forskellige Faunatyper, som har hver sin særlige Indflydelse paa Skovbunden, og til nogle af de vigtigste Dyrearters Levevis har vi lidt Kendskab. Men hermed kan vi ikke lade os nøje. Vi maa kende alle de vigtigste Dyrearters Ernæring og Levesæt, og et Studium heraf vil ofte kunne foretages med ganske simple Hjælpemidler. Endvidere maa vi have undersøgt baade Nematodfaunaen og Protozofaunaen indgaaende. Vi maa ogsaa gaa videre med Undersøgelser over vor Skovbehandlings, navnlig Tyndingens og Foryngelsesarbejdets, Indflydelse paa Dyrelivet. Der foreligger her en Mængde Opgaver, som maa løses, inden Forstmanden kan drage fuld Nytte af det Arbejde, Dyrelivet udfører i Skovbunden.

PLATES I—XXVIII

Billedtavler



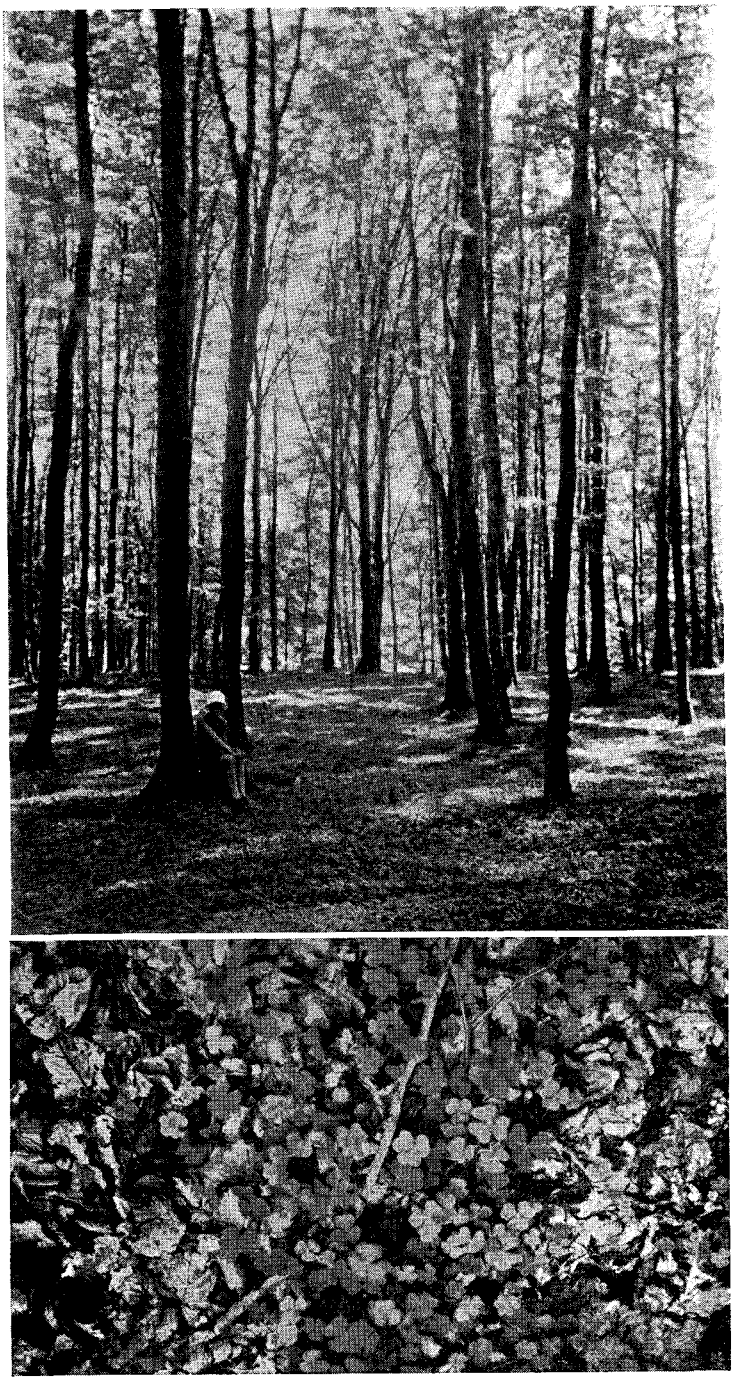
Locality 10. Oak, Mull, Mercurialis.
Eg, Muld, Bingelurt.
Mercurialis perennis, Stachys silvaticus, Rubus idaeus, Avena elatior, Dactylis glomerata.

PLATE II

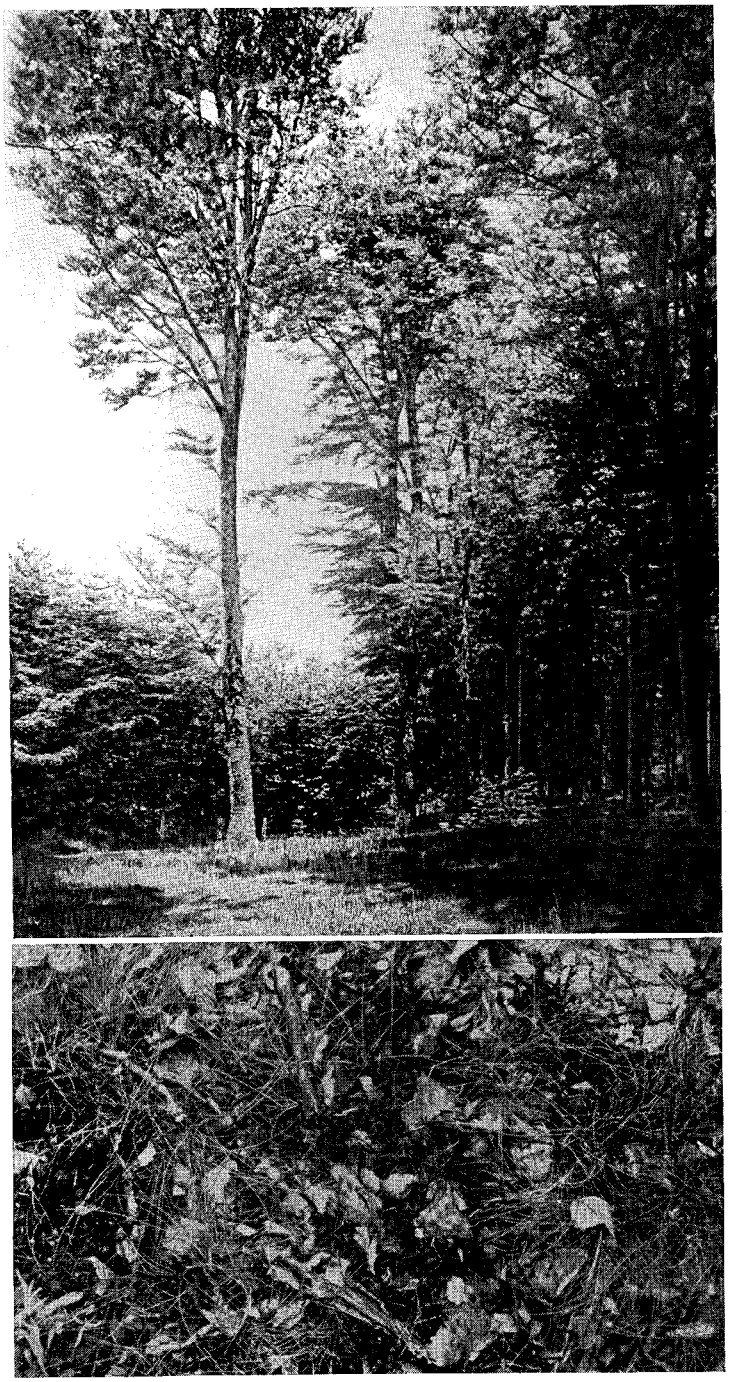
Locality 15. Beech, Mull, Anemone-Asperula.
Bøg, Muld, Anemone-Bukkar.
Asperula odorata, Anemone nemorosa, Oxalis acetosella, Stellaria holostea, Viola silvatica.

Locality 5. Beech, Mull, Melica-Asperula.
Bøg, Muld, Flitteraks-Bukkar.
Melica uniflora, Asperula odorata, Anemone nemorosa.

PLATE IV



Locality 9. Beech, Mull, Oxalis.
Bøg, Muld, Skovsyre.
Oxalis acetosella.



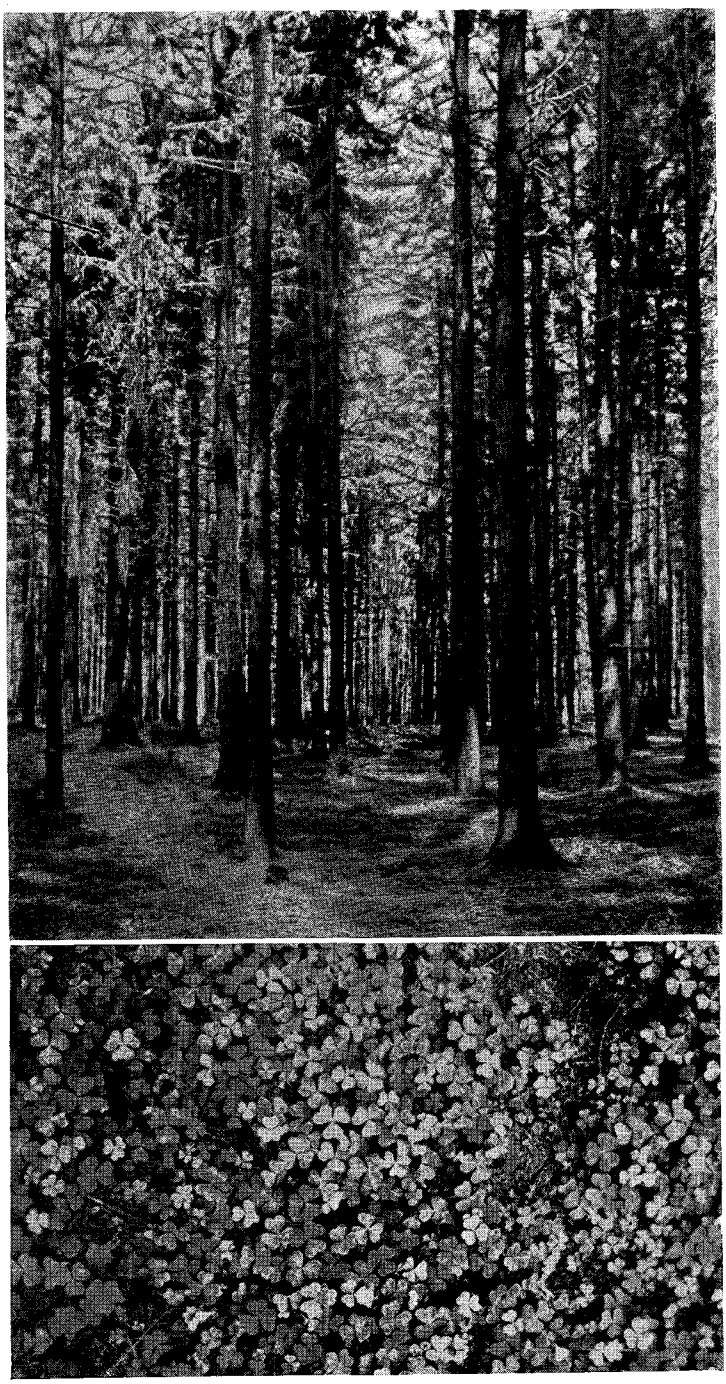
Locality 2. Beech, Impoverished Soil, Polytrichum.
Bøg, forarmet Bund, Skovjomfruhaar.
Aira flexuosa, Melampyrum pratense, Polytrichum attenuatum, Dicranum scoparium.

PLATE VI

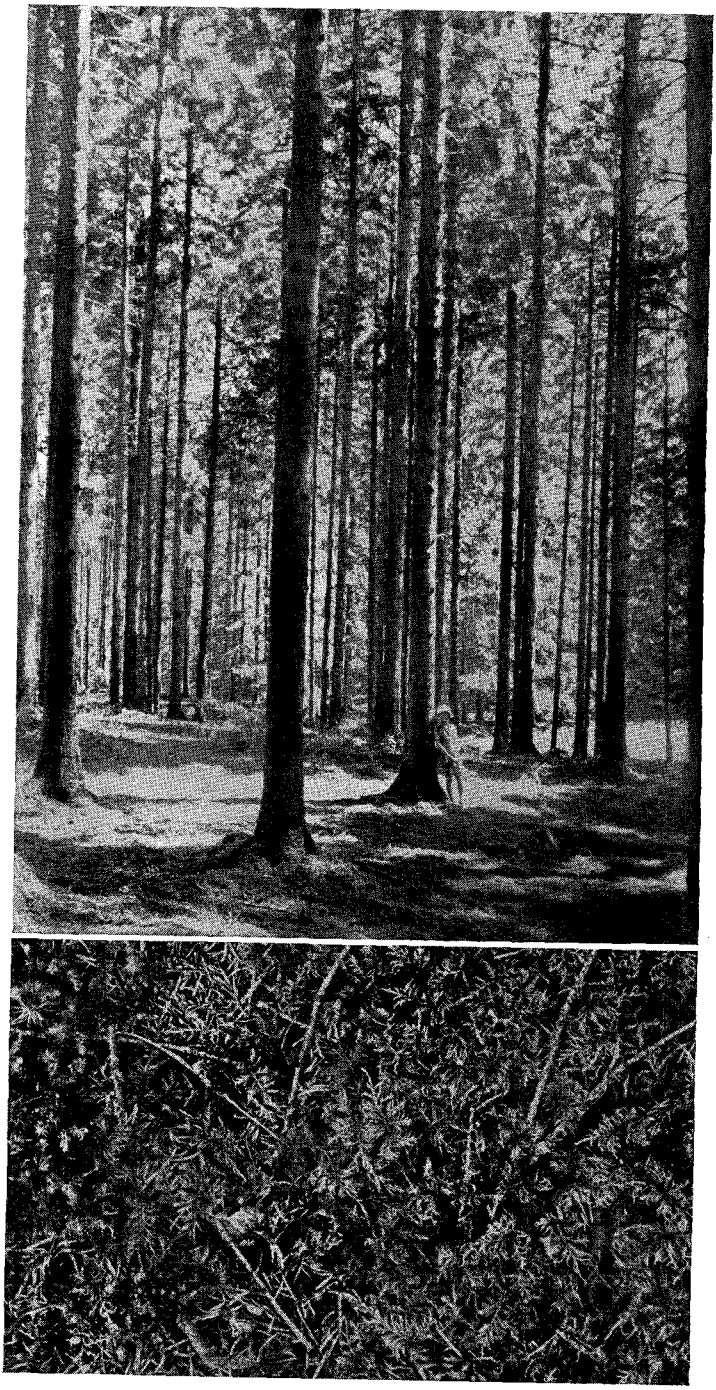
Locality 4. Beech, Raw Humus, no Flora.
Bøg, Maar, ingen Flora.
Leaf Layer, Løvlag.

Locality 20. Beech, Raw Humus, no Flora.
Bøg, Maar, ingen Flora.
Locality 7. Myrtillus. Blaabær.
Vaccinium myrtillus, Picea abies.

PLATE VIII

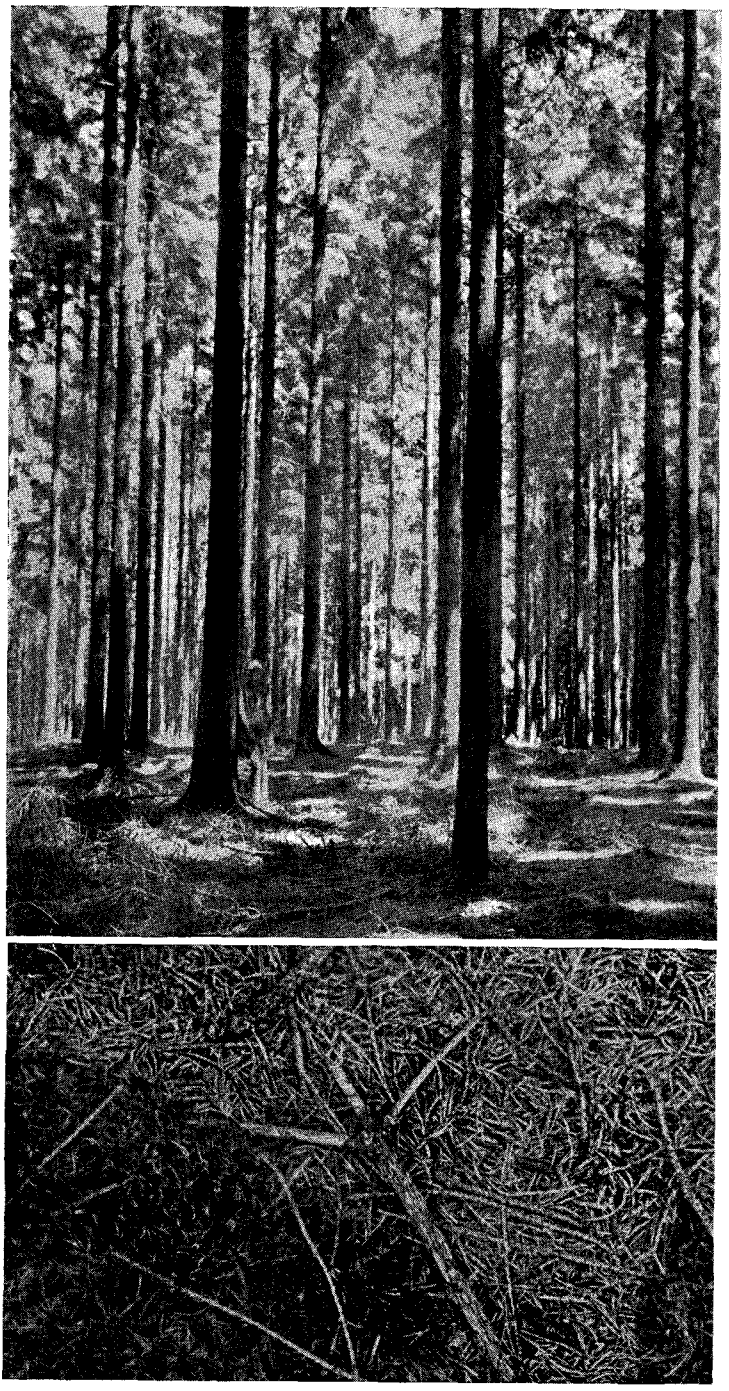


Locality 1. Spruce, Mull, Oxalis.
Rødgran, Muld, Skovsyre.
Oxalis acetosella.

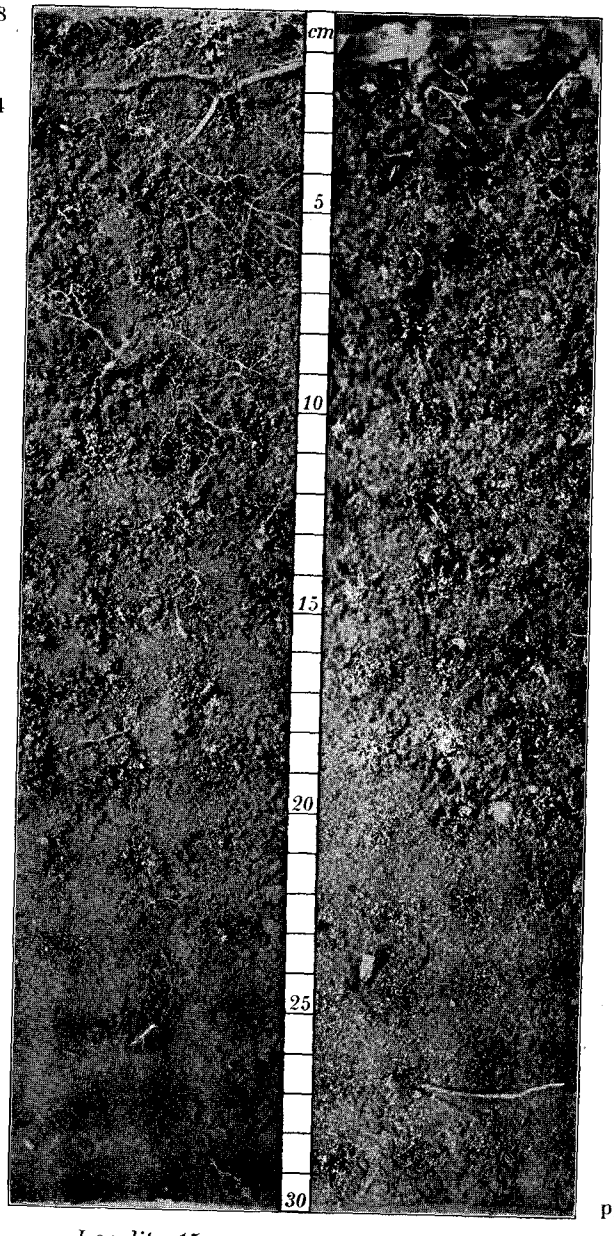


Locality 6. Spruce, Raw Humus, Moss Cover.
Rødgran, Maar, Mos.
Hylocomium proliferum, H. triquetrum, H. parietinum.

PLATE X



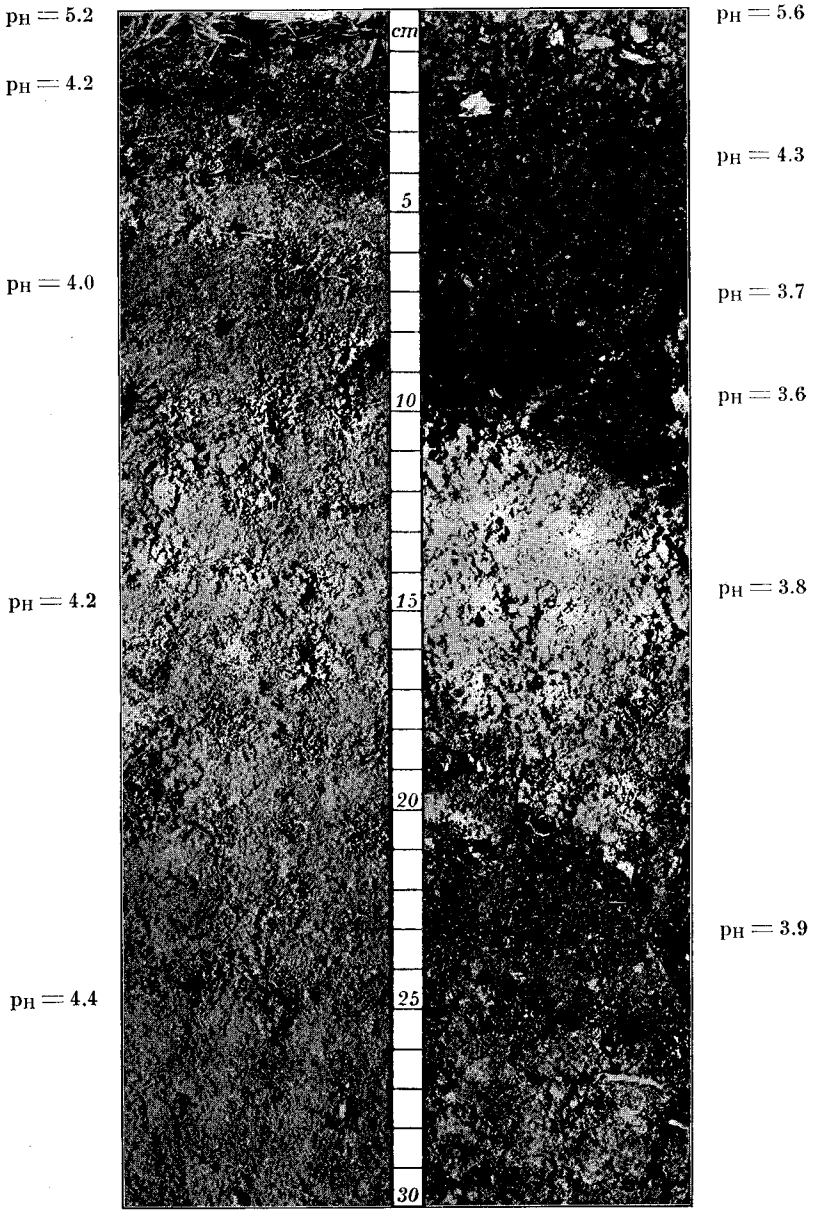
Locality 8. Spruce, Raw Humus, Moss Cover.
Rødgran, Maar, Mos.
Dicranum scoparium.



Locality 15.
Beech-Asperula Mull Soil.
Bøg-Bukkar-Muldjord.

Locality 9.
Beech-Oxalis Mull Soil.
Bøg-Skovsyre-Muldjord.

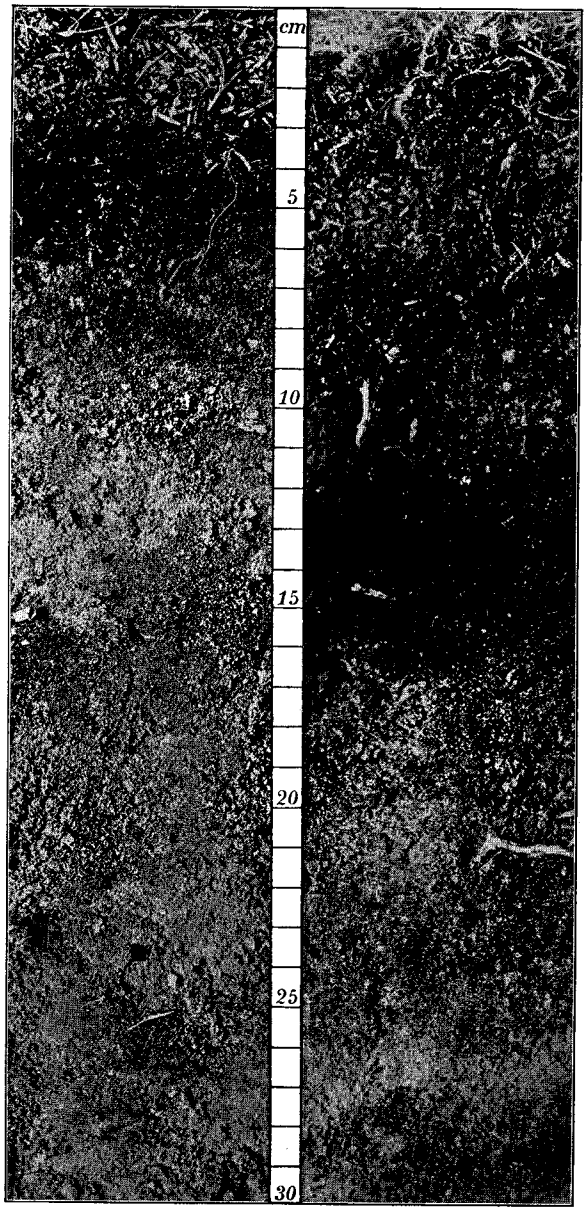
PLATE XII



Locality 2.
Impoverished Beech Soil.
Forarmet Bøgebund.

Locality 4.
Beech Raw Humus.
Bøgemaar.

PLATE XIII



$p_H = 4.7$

$p_H = 4.3$

$p_H = 4.1$

$p_H = 4.2$

$p_H = 4.3$

$p_H = 4.3$

$p_H = 3.6$

$p_H = 3.5$

$p_H = 3.5$

$p_H = 3.6$

$p_H = 3.7$

Locality 1.
Spruce Surface Mull.
Gran-Overflademuld.

Locality 6.
Spruce Raw Humus.
Granmaar.

PLATE XIV

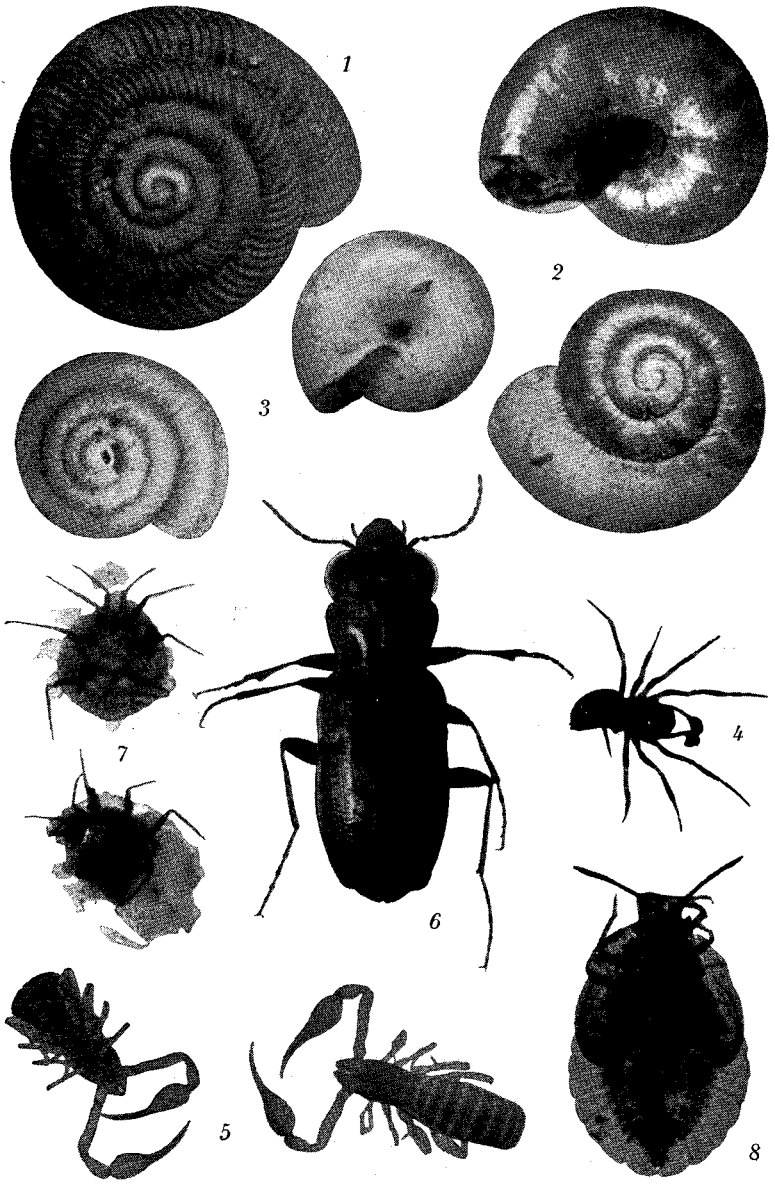
Locality 4. Newly fallen and old Leaf Layer, upper and lower Beech Raw Humus.
Nyt og gammelt Løvlag, Formuldningslag og Humusstoflag fra Bøgemaar.
Scale 1 : 1.

PLATE XV

Locality 6. Moss-Needle Layer, upper and lower Spruce Raw Humus. — Worm Casts from Beech Mull.
Mos-Naalelag, Formuldningslag og Humusstoflag fra Granmaar. — Regnorme-Ekskrementer fra Bøgemuld.
Scale 1 : 1.

PLATE XVI

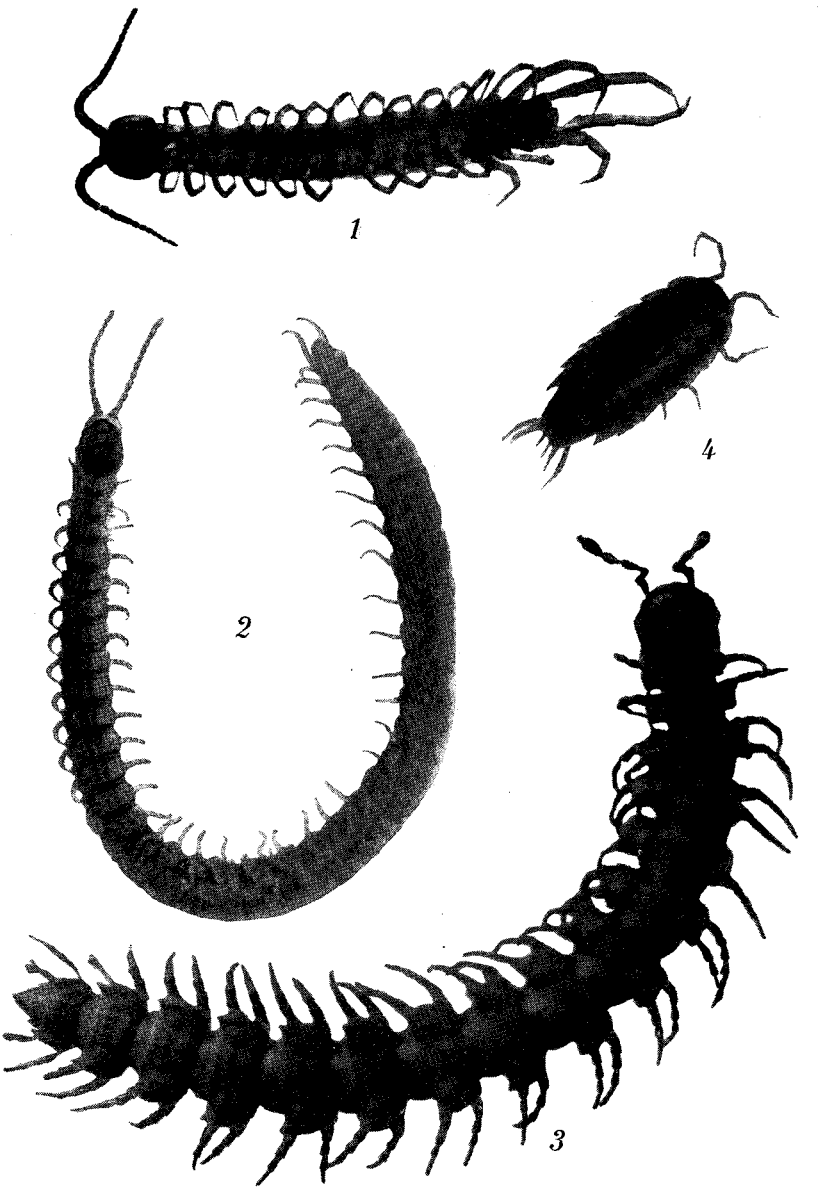
Locality 1. Needle Layer, upper and lower Spruce Surface Mull.
Naalelag, øvre og nedre Gran-Overflademuld.
Scale 1 : 1.



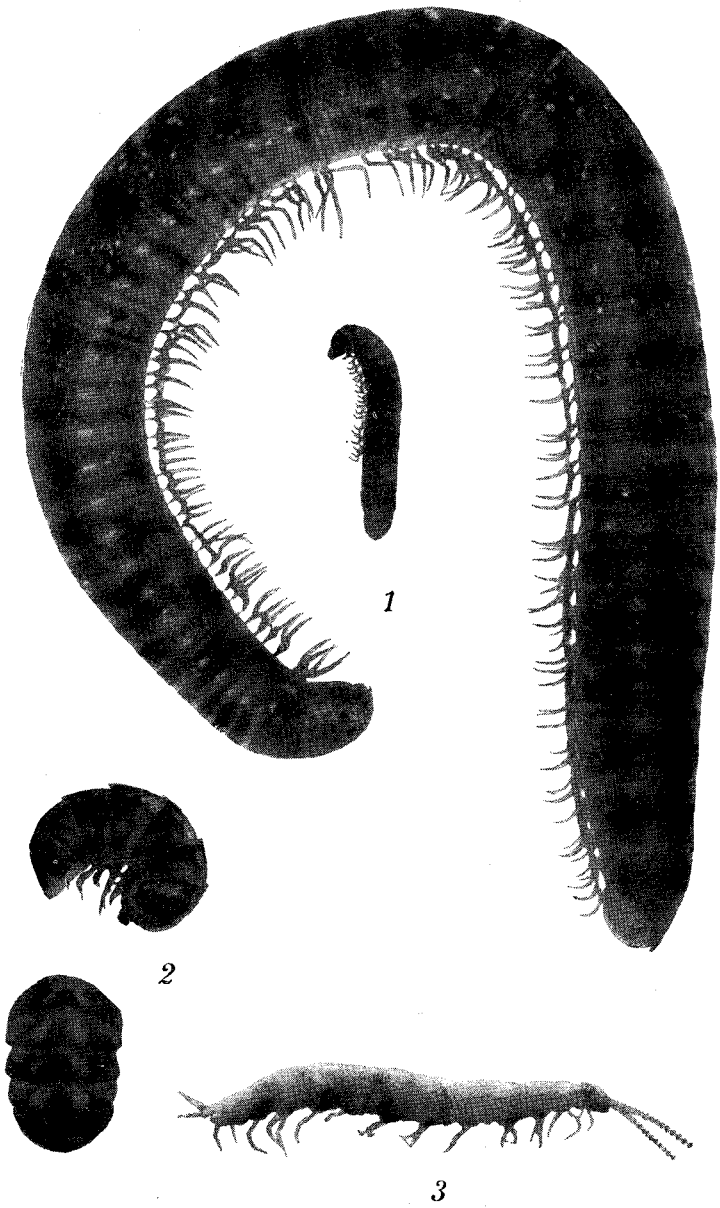
Snails, Spider, False Scorpions, and Insects.
Snegle, Edderkop, Mosskorpioner og Insekter.

1 Patula rotundata. 2 Hyalina alliaria. 3 Vitrea crystallinus. 4 Araneina sp. ♂. 5 Obisium muscorum. 6 Notiophilus biguttatus. 7 Newsteadia floccosa. 8 Orthostira cervina. Scale 10:1.

PLATE XVIII

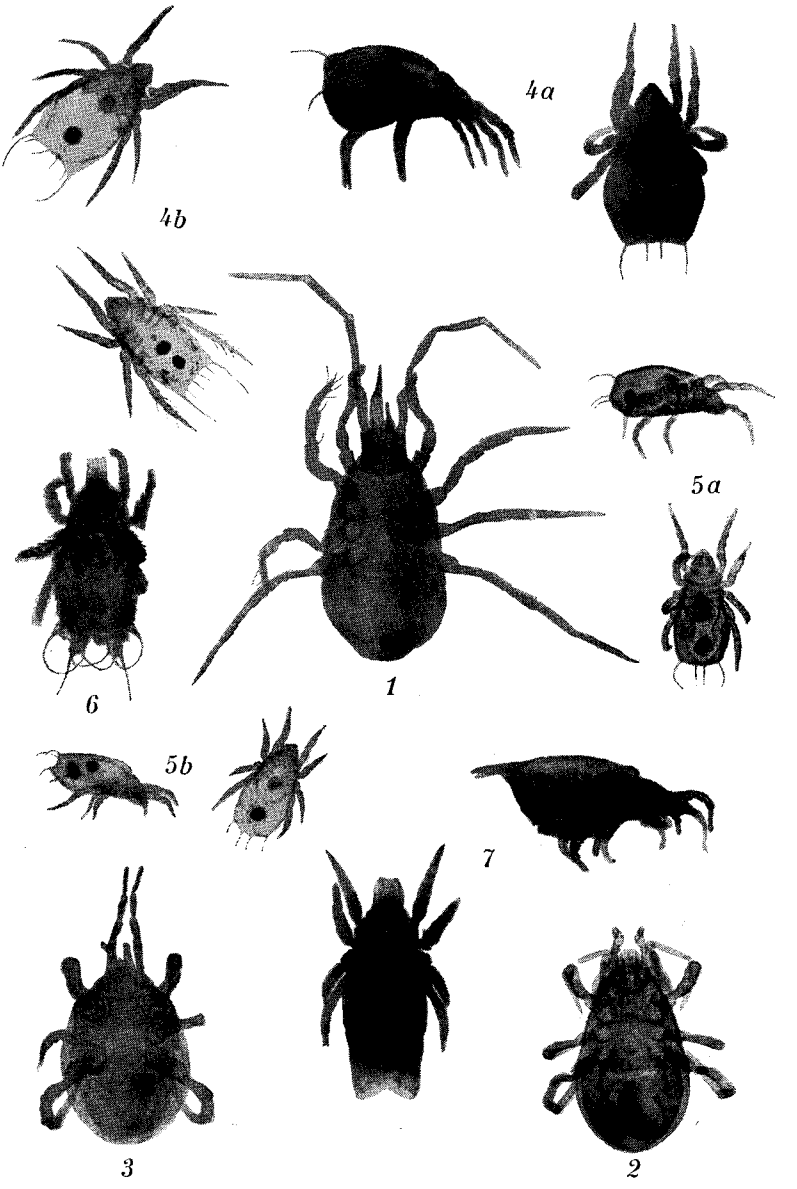


Centipeds, Milliped, and Trichoniscus.
Skolopendere, Tusindben og Bænkebider.
1 Lithobiidae sp. 2 Geophilidae sp. 3 Polydesmus sp. 4 Trichoniscus pusillus. Scale 10 : 1.



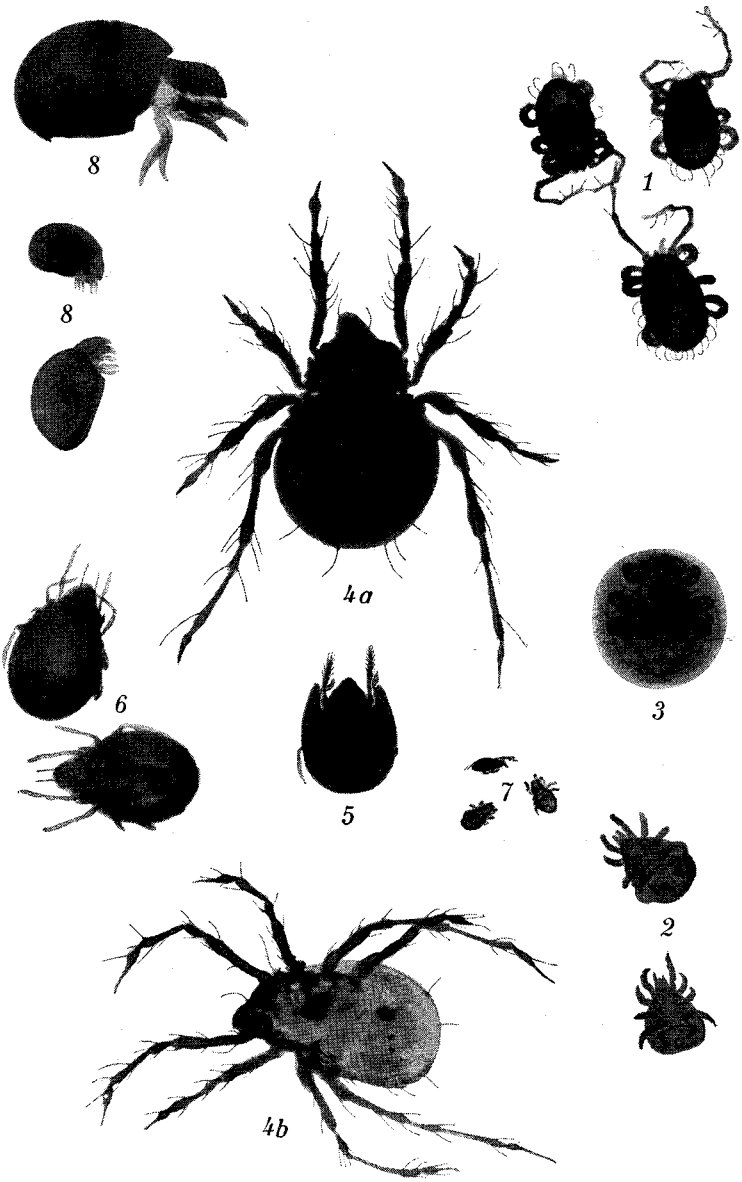
Millipeds and Scutigerella. Tusindben og Scutigerella.
1 Julus sp. 2 Glomeris sp. 3 Scutigerella immaculata. Scale 10 : 1.

PLATE XX



Mites. Mider.

1 Amblygamasus septentrionalis. 2 Pergamasus theseus. 3 Nothrholaspis tridentinus. 4 Camisia palustris, a adult, b nymphe. 5 Camisia silvestris, a adult, b nymphe. 6 Camisia spinifera. 7 Camisia segnis. Scale 20 : 1.



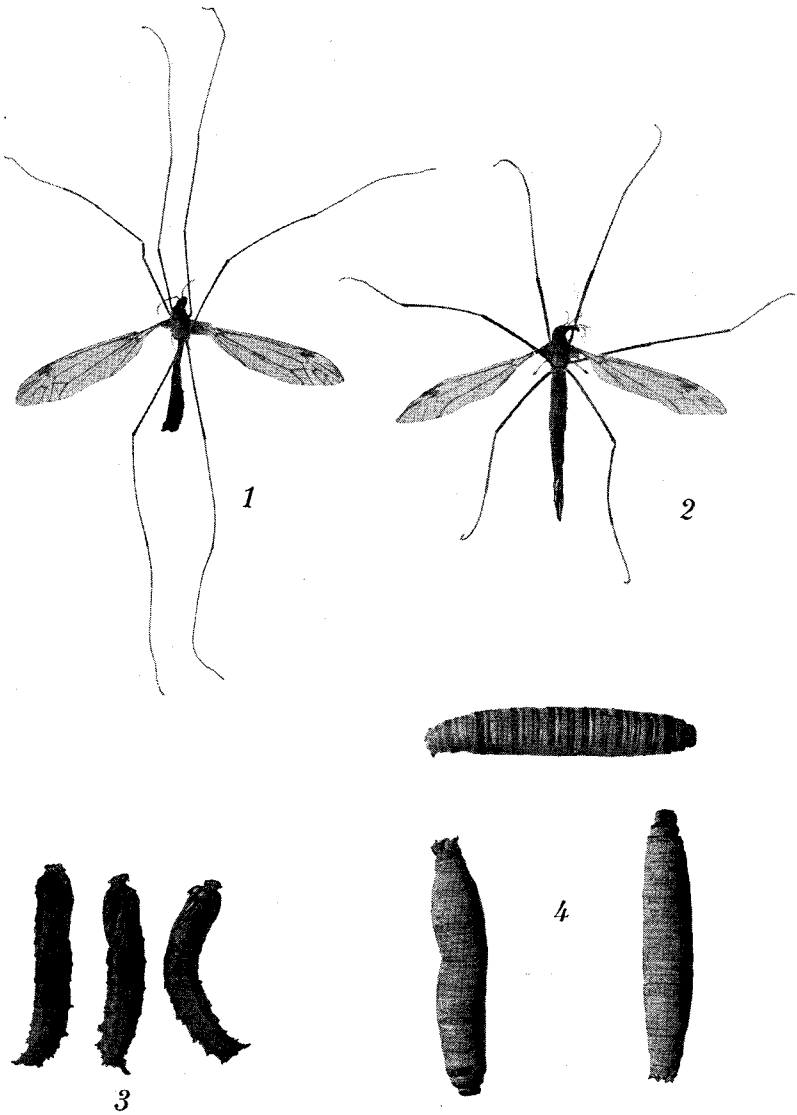
Mites. Mider.

1 Epicrius reticulatus. 2 Asca pellata. 3 Cilliba cassidea. 4 Oribata geniculata, a adult, b nymphe. 5 Galumna climata. 6 Banksia tegeocrana. 7 Damaeosoma sp. 8 Phthiracarus spp. Scale 20 : 1.

PLATE XXII

Collembola. Springhaler.

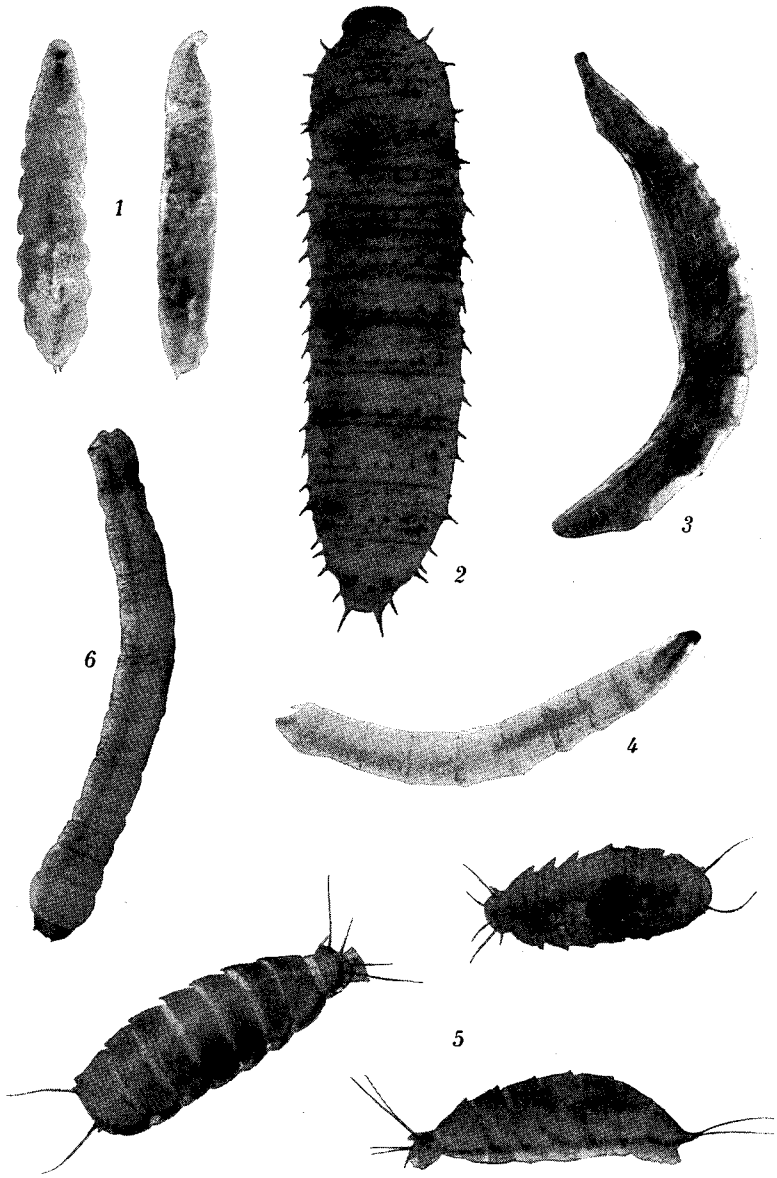
1 Hypogastrura armata. 2 Achorutes muscorum. 3 Onychiurus armatus. 4 Folsomia quadrioculata. 5 Isotoma cinerea. 6 Isotoma viridis. 7 Pogonognathus plumbeus. 8 Lepidocyrtus lanuginosus. 9 Orchesella flavescens. Scale 20 : 1.



Crane-flies. Stankelben.

Tipula nubeculosa. *1* ♂, *2* ♀, *3 Pupae, 4 Larvae. Scale 1:1.*

PLATE XXIV



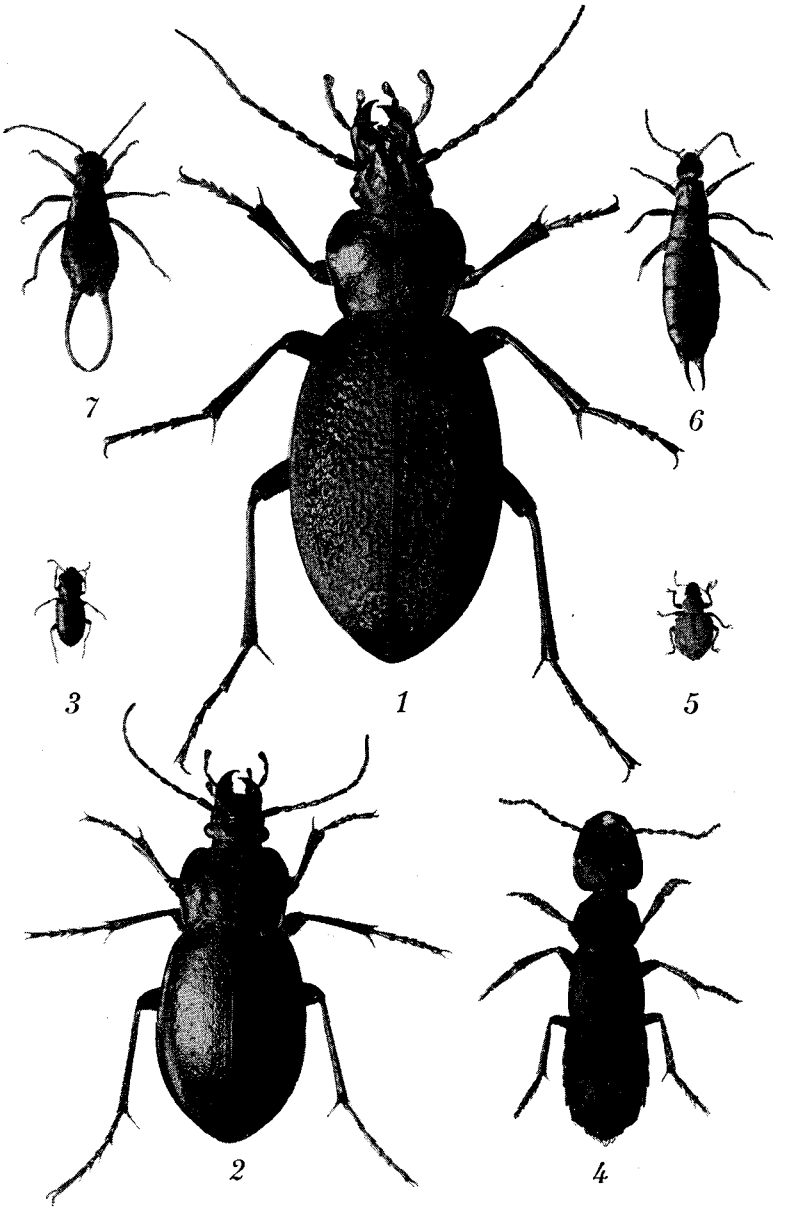
Diptera Larvae. Larver af Tovingede Insekter.

1 Anthomyiinae sp. 2 Bibio sp. 3 Leptis sp. 4 Dolichopodidae sp. 5 Lonchoptera sp. 6 Tipulidae sp. Scale 10 : 1.

Diptera Imago and Larvae.
Imago og Larver af Tovingede Insekter.

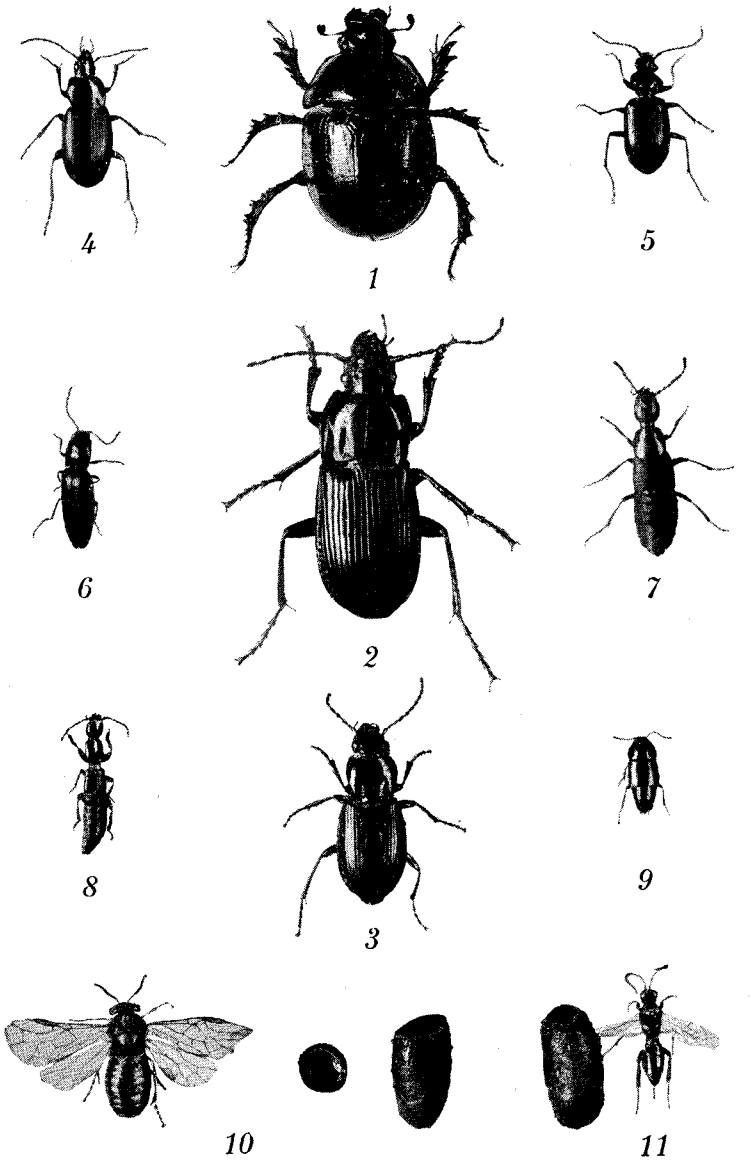
1 Sciara umbratica. 2 Mycetophilidae sp. 3 Forcipomyia sp. 4 Phaenocladius sp. 5 Fannia sp. 6 Cecidomyiidae sp. Scale 10 : 1.

PLATE XXVI



Beetles and Earwigs. Biller og Ørentviste.

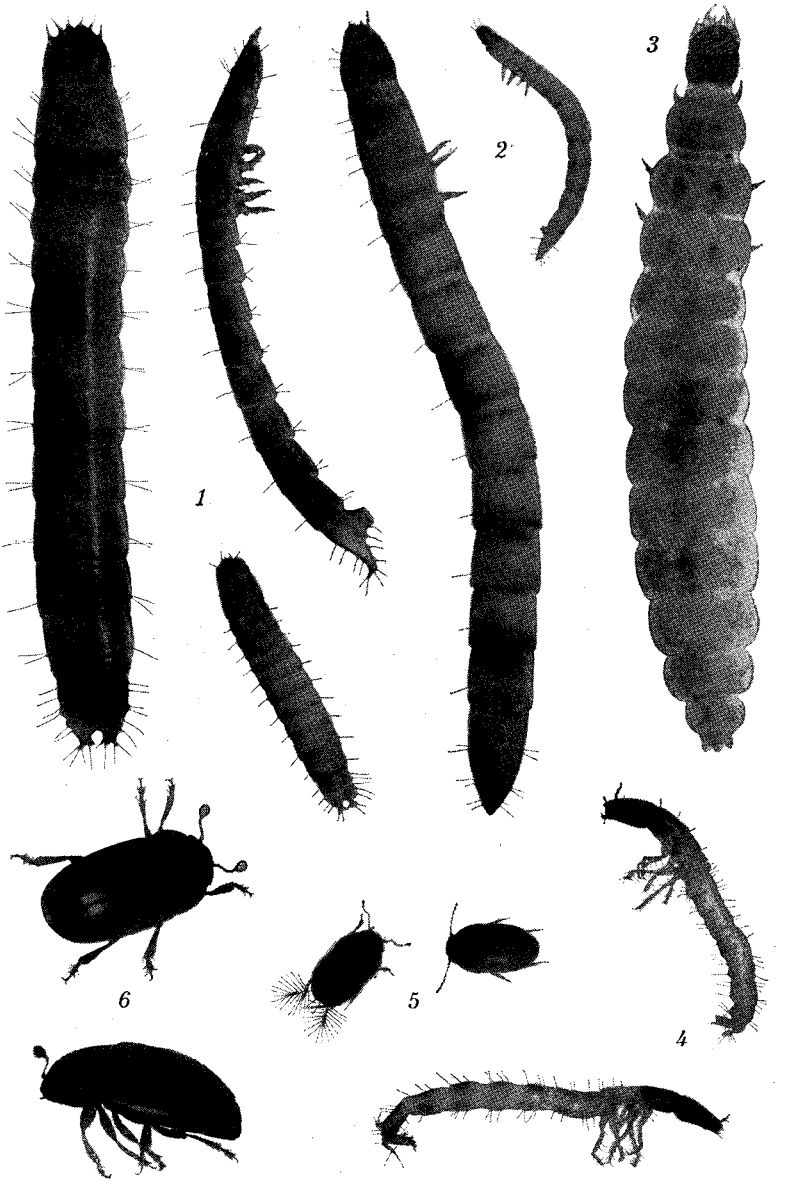
1 Procrustes coriaceus. 2 Carabus nemoralis. 3 Notiophilus biguttatus. 4 Staphylinus olens. 5 Strophosomus melanogrammus. 6 Forficula auricularia ♀. 7 Chelidura acanthopygia ♂. Scale 2:1.



Beetles and Saw-fly. Biller og Bladhveps.

1 Geotrupes vernalis. 2 Pterostichus striola. 3 Pterostichus oblongopunctatus. 4 Calathus micropterus. 5 Loricera pilicornis. 6 Athous subfuscus. 7 Philonthus decorus. 8 Lathrobium brunnipes. 9 Tachinus sp. 10 Lophyrus hercyniae with cocoon. 11 Ichneumonidae sp. hatched from Lophyrus cocoon. Scale 2:1.

PLATE XXVIII



Beetles and Beetle Larvae. Biller og Billelarver.

1 Athous subfuscus. 2 Dolopius marginatus. 3 Cantharidae sp. 4 Staphylinidae sp. 5 Acrotrichis sp. 6 Meligethes sp. Scale 10 : 1.

samt om Azotobacterprøvens Betydning for Bestemmelsen af Skovjorders Kalktrang (Über das Vorkommen des Azotobacter in dänischen Wäldern, sowie über die Bedeutung der Azotobacterprobe für die Bestimmung des Kalkbedürfnisses der Waldböden). — Nr. 39. A. OPPERMANN: God dansk Bøgeskov, belyst ved tre Tilvækstoversigter (Gute dänische Buchenwälder, in drei Ertragstafeln dargestellt). — Nr. 40. L. A. HAUCH: Udhugning i unge Egebevoksninger, II (Durchforstung junger Eichenbestände, II). — Nr. 41. S. M. STORM: Fremmede Naaletræer paa Søllestedgaard (Foreign coniferous trees of Søllestedgaard estate). — Nr. 42. A. OPPERMANN: Den grønne Douglasies Vækst i Danmark, II (The Douglas Fir in Denmark, II). — Nr. 43. A. OPPERMANN: Septemberskovet Brænde (Austrocknung von im Herbst gefälltem Brennholz). — Nr. 44. Forsøgsvæsenets Ordning og Ledelse (Das forstliche Versuchswesen in Dänemark. — The Danish Experimental Forestry Service. — Station des Recherches forestières du Danemark).

Bd. V (1916—1921): Nr. 45. A. OPPERMANN: Bjærgfyr i Danmark paa Flyvesand og hævet Havbund (Die Bergkiefer in Dänemark auf Flugsand und ehemaligem Meeresboden). — Nr. 46. K. H. MUNDT: Den enstammede franske Bjærgfyr i Danmark (Le pin de montagne Français en Danemark). — Nr. 47. L. A. HAUCH: Nattefrostens Virkning i ung Bøgeskov, II (Die Wirkung des Spätfrostes in jungen Buchenwaldungen, II). — Nr. 48. G. BRÜEL: Jordbunden i Grib Skov (Der Boden in Grib Skov bei Hillerød). — Nr. 49. AXEL S. SABROE: Skovtræer i det nordlige Japan (Forest trees in Northern Japan). — Nr. 50. K. MØRK-HANSEN: C. H. Schröders Udhugning i Bøg, II (Eine Untersuchung der Buchendurchforstung C. H. Schröders). — Nr. 51. A. OPPERMANN: Sommerfældning i Bøgeskov (Sommerfällung von Buchenbrennholz). — Nr. 52. L. A. HAUCH: Proveniensforsøg med Eg, II (Experiments regarding proveniences of oak). — Nr. 53. JOHS. HELMS og PAUL WEGGE: Prikleforsøg paa Silkeborg og Vemmetofte Skovdistrikter (Versuche über Verschulung von Fichte und Tanne). — Nr. 54. C. J. HOLM: Et Forsøg med fremmede Løvtræer paa Esrom Skovdistrikt (Des arbres feuillus étrangers dans la forêt »Grib Skov«, Séeland septentrionale). — Nr. 55. A. OPPERMANN: Tilvirkning og Anvendelse af dansk Gavntræ, III (Preparation and use of Danish timber). — Nr. 56. FR. WEIS og K. A. BONDORFF: Kemisk-biologisk Undersøgelse af Skovjord under overernærede Graner i Lyngby Skov (Recherche concernant la cause de l'hypertrophie de l'épicéa). — Nr. 57. JOHS. HELMS: Proveniensforsøg med Skovfyr (Provenienzversuche mit Weisskiefer). — Nr. 58. W. JOHANNSEN: Orienterende Forsøg med Opbevaring af Agern og Bøgeolden (Experiments on storing acorns and beech-nuts). — Nr. 59. Forsøgsvæsenets Ordning og Ledelse (Station des Recherches forestières du Danemark).

Bd. VI (1922): Nr. 60. A. OPPERMANN: Studier over Bøgebrænde (Studien über Buchenbrennholz). — Nr. 61. A. OPPERMANN: Granskovens Sundhedstilstand (La santé de l'épicéa en Danemark). — Nr. 62. JOHS. HELMS: Grankulturerne i Borbjerg og Sevel Plantager (Die Fichtenkulturen in den Borbjerg und Sevel Plantagen). — Nr. 63. A. OPPERMANN: Skovfyr i Midt- og Vestjylland (Die Weisskiefer in Jütland). — Nr. 64. P. E. MÜLLER: Revision af Forsøgskulturerne med Gran i Gludsted Plantage (Revision der Versuchskulturen mit Fichte in der Gludsted-Plantage). — Nr. 65. A. OPPERMANN: Den grønne Douglasies Vækst i Danmark, III (The Douglas Fir in Denmark, III). — Nr. 66. A. OPPERMANN: Sitka-

granens Vækst i Danmark (The Sitka Spruce in Denmark). — Nr. 67. Forsøgsvæsenets Ordning og Ledelse (Station de Recherches forestières du Danemark). — Nr. 68. C. H. BORNEBUSCH: En Studierejse i Sverige (Eine Studienreise nach Schweden).

Bd. VII (1923—1924): Nr. 69. A. OPPERMANN: Dyrkning af Lærk i Danmark (Cultivation of Larch in Denmark). — Nr. 70. A. OPPERMANN: Vort ældste Kulsvieri (Die Grubenköhlerei in Dänemark). — Nr. 71. A. OPPERMANN: Korsikansk Fyr i Danmark (Le pin de Corse en Danemark).

Bd. VIII (1923—1926): Nr. 72. C. H. BORNEBUSCH: Skovbundsstudier, I—III (Disquisitions on flora and soil of Danish woodlands, I—III). — Nr. 73. O. GALLØE og L. A. HAUCH: Likener paa Bøgens Bark (Lichens on beechbark). — Nr. 74. C. H. BORNEBUSCH: Skovbundsstudier, IV—IX (Disquisitions on flora and soil of Danish woodlands, IV—IX). — Nr. 75. J. A. NIELSEN: Fra norske Fyrreskove (From Norwegian pineforests). — Nr. 76. A. OPPERMANN og C. H. BORNEBUSCH: Fra Skov og Planteskole, 1—12 (Aus dem Walde und dem Forstgarten). — Nr. 77. Forsøgsvæsenets Ordning og Ledelse (Station de Recherches forestières du Danemark).

Bd. IX (1925—1928): Nr. 78. LORENZ SMITH: Gødningsforsøg ved Nyanlæg af Skov paa midtjydsk Hedejord (Essai de fumage dans le boisement d'une lande du Jutland central). — Nr. 79. LORENZ SMITH: Supplerende Beretning om Gødningsforsøg paa Hedejord (Compte rendu supplémentaire de quelques essais de fumage dans le boisement d'une lande du Jutland central). — Nr. 80. JOHS. HELMS: Forsøg med Lystræer paa Feldborg Skovdistrikt, III (Versuche mit Lichthölzern auf Heideboden, III). — Nr. 81. JOHS. HELMS: Proveniensforsøg med Skovfyr, II (Provenienzversuche mit Weisskiefer, II). — Nr. 82. P. BOYSEN JENSEN og D. MÜLLER: Undersøgelser over Stofproduktionen i yngre Bevoksninger af Ask og Bøg (Untersuchungen über die Stoffproduktion in jungen Beständen von Esche und Rotbuche). — Nr. 83. JUST HOLTEN: Prøveflader i Lærk (Probeflächen in Lärchenmischbeständen und natürliche Verjüngung von Lärche). — Nr. 84. A. OPPERMANN: En Studierejse i Schweiz 1924 (Eine Studienreise in der Schweiz 1924). — Nr. 85. A. OPPERMANN: En Studierejse i Frankrig 1924 (Un Voyage d'études en France, en 1924). — Nr. 86. C. H. BORNEBUSCH: En Studierejse til Holland, Belgien og Nordvesttyskland (A Study Tour to Holland, Belgium, and Northwest Germany). — Nr. 87. Forsøgsvæsenets Ordning og Ledelse, VIII (The Danish Experimental Forestry Service).

Bd. X, H. 1—5: Nr. 88. L. A. HAUCH: Proveniensforsøg med Eg, III (Provenienzversuche mit Eiche, III). — Nr. 89. A. OPPERMANN og C. H. BORNEBUSCH: Højskov af Ask (Futaie de frêne). — Nr. 90. A. OPPERMANN: Racer af Douglasie og Sitkagran (Races of Douglas Fir and Sitka Spruce). — Nr. 91. A. OPPERMANN: Kulsvidning af Bøgeknippel i Ovn og i Mile (Charbonnage de hêtre par meule et par four). — Nr. 92. A. OPPERMANN: Karpaterbøg i danske Skove (Karpathenbuchen in Dänemark). — Nr. 93. A. OPPERMANN: Efterskrift til Beretning Nr. 92 (Nachschrift zum Bericht Nr. 92). — Nr. 94. A. OPPERMANN: Bøgeskov paa Fiskerbakken (Ein Rotbuchenbestand auf Nordseeland). — Nr. 95. A. OPPERMANN: Japansk Lærk i Danmark (Larix leptolepis in Denmark).

KJØBVN. – NIELSEN & LYDICHE (AXEL SIMMELKIÆR)