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# Earthworms of Two Minnesota Forest Areas

R.O. MORGENWECK\*, W.H. MARSHALL\*\*

**ABSTRACT** - This paper reviews Lumbricidae records for Minnesota and reports on two collections in northern areas of the state. The first site, Itasca State Park, lies to the northwest with "Maple-basswood representative of climax forest to the south and southeast" and "Spruce-fir stands representative of climax forest to the north and northeast" (Buell and Gordon 1945). The Cloquet Forestry Center (CFC); site of the other collection, is near Duluth, 150 miles to the east, where the forests are largely coniferous. Here seven forest types, as described by Wenstrom (1973), and known to be used by American woodcock (*Philohela minor*), were sampled.

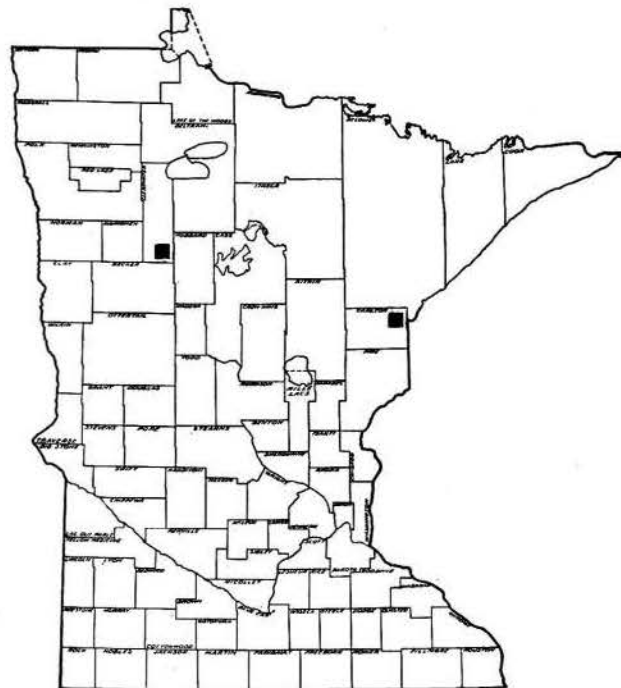
Minnesota records include Gates (1967) who list *Allolobophora caliginosa* (a classical category, now *Aporrectodea*, that included at least four species), *Eisenia foetida* and *Lumbricus terrestris* as being previously collected at St. Paul. Also, Gates reported in an unpublished manuscript that E.V. Komarek collected *Aporrectodea tuberculata*, *E. foetida*, *L. terrestris* and *Octolasion tyrtaeum* in St. Paul and *Ap. tuberculata* at Bethel.

Thirty-two plots near the University of Minnesota Forestry and Biological Station, Itasca State Park, were sampled between July 23 and August 16, 1968, a relatively dry summer. The soil in each 30.5 cm. x 30.5 cm. square plot was dug 8-12 cm. deep and sorted by hand. Specimens were preserved in medium textured forest soils with hardwood, brush, conifer, or grassland vegetation. One low-land brush site on a wet, mucky soil was sampled.

A CFC, a formalin solution containing 25 ml of formalin in four liters of water, was sprinkled on the soil after the leaf litter had been cleared from 61 cm. x 61 cm. square (Reynolds 1972a). Surfacing worms were collected over a 10-minute period at intervals between July 15 and October 22, 1973 - a summer of unusually high precipitation. A preliminary collection was made in 11 plots, preserved in formalin, and sent to J.W. Reynolds for identification. These were returned and provided guidance to Morgenweck in all subsequent identifications. During the rest of the summer, 246 plots were set out in the seven forest types. Lowland and upland brush contained 73 plots each. Aspen, mixed deciduous and conifer plantation forest type contained 10 each. The deciduous-conifer and upland conifer types contained 40 and 30 sample plots respectively. Dry weight biomass was calculated using an equation which required only measurement of the earthworm's length (Reynolds 1972b).

## New records from Itasca Park

Four hundred and forty-four specimens of 8 species were obtained. All were of European origin and 7 have been reported as new records for the state. One previously reported species (*L. terrestris*) was taken in the wet lowland brush site adjacent to the Squaw Lake boat landing which has been heavily used by fisherman for many years. *Ap. tuberculata* was the most abundant--74% of the total number and was collected in 94% of the



plots. *L. rubellus* occurred in 34 percent of the plots but made up only 10% of the total numbers. Each of the other species (*Dendrobaena octaedra*, *Ap. turgida*, *Ap. trapezoides*, *L. terrestris*, *Dendrodriilus rubidus*, and *Octolasion tyrtaeum*) made up 5% or less of the total number and were found only in 3-15 percent of the plots.

In the total collection *L. rubellus* was the most common, 57.9 percent of the specimens and found in 98.8 percent of the plots. The second most common species, *Ap. tuberculata*, was found in 86 percent of the plots and made up 34 percent of the numbers. *D. octaedra* was also widespread, occurring in 56 percent of the plots but was relatively uncommon--6.1 percent of the total. Two other species (*Dd. rubidus* and *O. tyrtaeum*) were insignificant in numbers and occurrence while a single specimen of *Allolobophora chlorotica*, identified by Reynolds, was a new record for the state.

In each of seven forest types, *L. rubellus* was found in 96.8 percent or more of the plots, *Ap. tuberculata* in 74 percent and *D. octaedra* in 36.4 percent. The plot frequency for the last two species was lowest in the two brush types. *Dd. rubidus* was found in 10 percent of the plots in five types and was absent in the other two. *O. tyrtaeum* was found in 60 percent of mixed deciduous plots, 35.5 percent of upland conifer plots but only 10 percent of deciduous-conifer plots and was absent in the other forest types.

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TABLE 1. Percent of the total number of specimens and percent total biomass collected (in parentheses) in each of seven forest types for each of the three most abundant species of earthworms.

SPECIES	FOREST TYPE <sup>1</sup>						
	LB	UB	A	MD	DC	UC	CP
<i>Apporectodea tuberculata</i>	17.0 (28.7)	25.7 (34.3)	56.2 (68.5)	51.5 (62.0)	44.2 (67.0)	38.2 (66.3)	60.3 (88.2)
<i>Lumbricus rubellus</i>	79.7 (70.5)	72.0 (65.2)	39.4 (31.0)	39.1 (35.4)	46.4 (30.8)	37.8 (27.2)	17.8 (7.8)
<i>Dendrobaena octaedra</i>	3.2 (0.7)	2.1 (0.4)	4.4 (0.5)	2.3 (0.5)	7.1 (1.3)	18.2 (3.6)	21.6 (3.7)

<sup>1</sup>LB = lowland brush UB = upland brush A = aspen MD = mixed deciduous  
DC = deciduous-conifer UC = upland conifer CP = conifer plantation

Of special interest is the relative abundance of the three most common earthworms in the seven forest types sampled (Table 1). *Ap. tuberculata* was lowest in the two brush types and varied between 38.2 and 60.3 percent in the other types. *D. octaedra* was low in relative abundance in the two brush types as well as in aspen and mixed deciduous (2.1-4.4 percent). However, it increased greatly in the coniferous forest types (7.1-21.6 percent). *L. rubellus*, conversely, was highest in the two brush types, lowest in the conifer plantation, and moderate in the rest. Field observations show that the occurrence of conifers increases from none in the lowland brush type to high in the conifer plantations. Both Table 1 and Figure 1 are, therefore, organized on a gradient from early stages of succession on the left to more advanced stages on the right.

Three of the species were not widespread and were taken in relatively low numbers. *Dd. rubidus* was found in all types except aspen and conifer plantation. However, its plot frequency was 10 percent or less and was 0.3 percent of the total number of specimens taken. *O. tyraeum* was most abundant in mixed-deciduous stands followed by upland conifer and deciduous-conifer. It composed 6.9, 5.5 and 2.0 percent of the total number of earthworms in each type.

The single *A. chlorotica* specimen was found in a conifer plantation, perhaps brought in from a forest nursery as suggested by Gates (1966).

#### Earthworm Associations at CFC

As discussed by Reynolds (1972a), earthworms are usually found in species associations which vary with habitat and geography. At CFC, association sizes ranged from three to five species per forest type. Aspen contained three species, the two brush types and conifer plantation held four, while the mixed deciduous, deciduous-conifer, and upland conifer types held five each.

These data are similar to those from other northern forested areas. Thus, Bornebusch (1930) examined forest locations in Denmark and found four to seven species with seven the most frequent. Ljungstrom (1967) found four species in coniferous and five species in deciduous habitats in Sweden.

In Finland, Huhta et. al. (1967) found three species in coniferous habitats. In Indiana, Reynolds (unpub. mss.) found one to three earthworm species in forested habitats with two being the most common.

#### Biomass in Different Cloquet Habitats

Since this study was related to questions of woodcock nutrition, earthworm dry weight biomass values were preferred for comparison to other reports which used wet weights, thus a division factor of 10 (derived from Table 4 in Reynolds, 1972b) was used to convert to dry weight. Also, the comparisons were limited to those studies utilizing formalin extraction techniques since different extraction methods have varying collection effectiveness.

Earthworm biomass was greatest in the aspen type while upland brush, deciduous-conifer, and mixed deciduous types were moderate in earthworm biomass (Table 2). Lowland brush, upland conifer, and conifer plantation were lowest.

The biomass percentages of the three abundant species (Fig. 1) show trends similar to relative abundance distributed by forest type. However, biomass values are somewhat lower for the smaller *L. rubellus* and much less for *D. octaedra* than comparable relative abundance percentages which indicate these organisms were smaller than *Ap. tuberculata*. *Dd. rubidus* was 0.1 percent or less of the biomass in each type while *O. tyraeum* was 2.8 percent or less in the three types where it was found.

Reynolds (1972a) showed that earthworms were not active during April and June 1970 in his Tennessee sampling locations. He attributed this to lack of precipitation. Other factors such as temperature will also affect earthworm activity (Satchell 1967). Therefore, to compare the earthworm biomass between forest types, collections were made in five forest types on August 22, 1973.

Aspen contained the greatest biomass of earthworms followed by the mixed deciduous type (Table 3). Upland conifer, conifer plantation, and lowland brush types all contained similar biomass values of earthworms. The upland brush and deciduous-conifer types were not sampled due to a sudden rainfall which probably altered earthworm vulnerability to

**Table 2. Biomass of earthworms (dry wt.) collected in 7 forest types - (g/m ±).**

LB	UB	A	MD	DC	UC	CP
2.8-12.7	2.2-23.0	27.4	18.8	4.4-19.0	7.1-10.2	9.8
1LB = lowland brush			UB = upland brush			
A = aspen			MD = mixed deciduous			
DC = deciduous conifer			UP = upland conifer			
CP = conifer plantation						

sampling. Ranking forest types in terms of earthworm biomass is similar whether data were collected over a four-month period or in one period of a few hours.

**Comparison of Biomass Data With Other Studies**

One often-cited earthworm biomass value is that of 6.1 g/m<sup>2</sup> in a Danish *Quercus* mull (Bornebusch 1930). This value lies in the lower part of the range found in the two brush types and deciduous-conifer and is lower than the other four types (Table 2). However, Satchell (1967) feels that Bornebusch's estimate is too low for woodland mulls and results from inadequate sampling technique. Satchell (1967) found 14.8-16.2 g/m<sup>2</sup> in a mixed wood mull which is higher than lowland brush, upland conifer, and conifer plantation values at CFC but falls within the range of upland brush and deciduous-conifer while being slightly less than values for Aspen and mixed deciduous. Raw (1959) recorded 15.3 g/m<sup>2</sup> in English apple orchards under arable cultivation, slightly higher than lowland brush, upland conifer, and conifer plantation; within the range of upland brush and deciduous-conifer; and lower than mixed deciduous and aspen. In English apple orchards under grass cultivation Raw (1959) recorded 28.7 g/m<sup>2</sup> which is higher than any value at CFC but is near the value for aspen. Raw (in Satchell 1967), sampling in arable land enriched with manure, recorded 5.0-10.6 g/m<sup>2</sup> which is within the range of lowland brush, upland brush,

**Table 3. Number of sample plots in, and mean dry weight (g/m ±) of earthworms in each sample set in five forest types at Cloquet, collected on August 22, 1973.**

	Forest Type				
	LB	A	MD	UC	CP
N	10	10	10	10	10
Mean	8.1	27.4	18.8	10.2	9.8

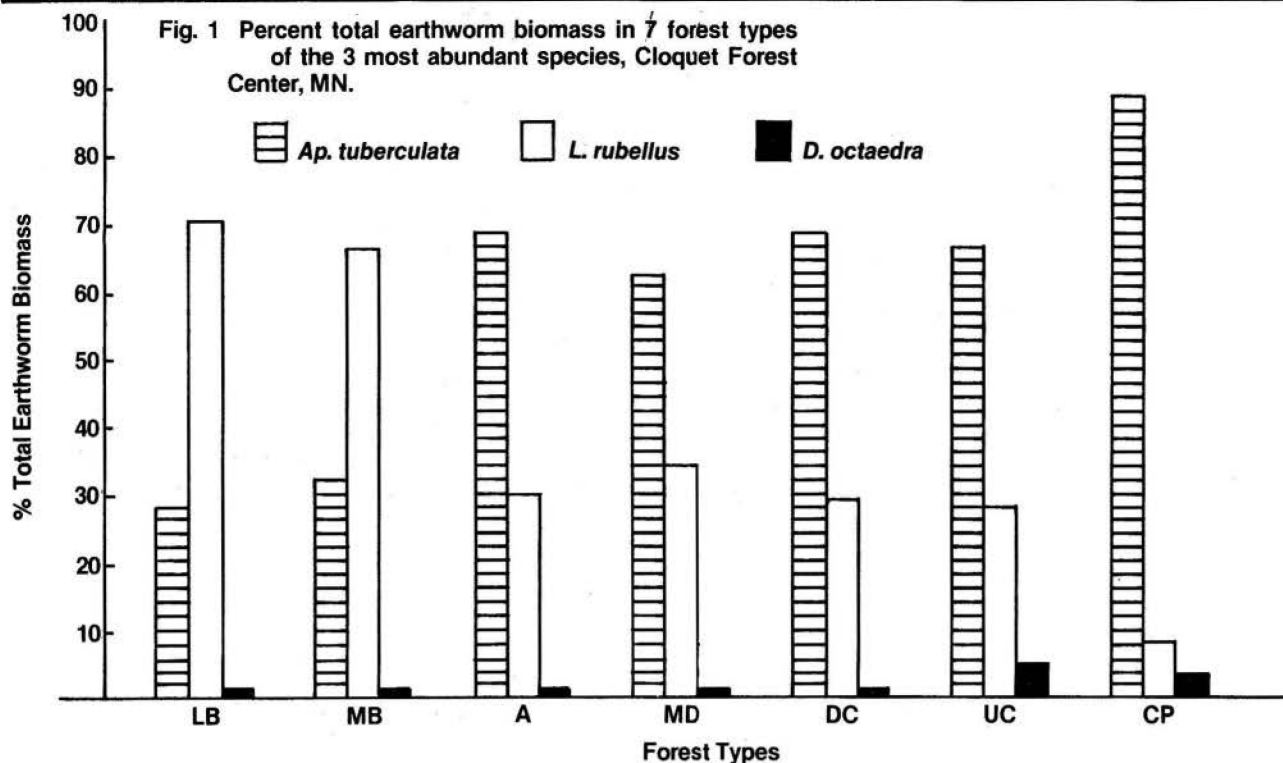
ANOVA F = 8.00 d.f. = 4,44

L.S.D. (0.05 level) A MD UC = LB = CP

deciduous-conifer, upland conifer, and conifer plantation. These values are lower than that of mixed deciduous and aspen. Reynolds (1972a) reported values of 0.25-16.64 g/m<sup>2</sup> in tulip poplar (*Liriodendron tulipifera*) forests in Tennessee. His values are similar to those at CFC, except for being slightly lower than estimates for aspen and mixed deciduous. Thus, these data indicate that earthworm biomass at CFC is similar in range to that of many other localities.

**Earthworm Abundance and Woodcock Habitat Use**

Of special interest in this study is the possible relationship to woodcock habitat preferences and nutrition. The rankings for abundance, distribution, and biomass by forest types compares closely with data on use of these types by woodcock during summer and fall as reported by Wenstrom (1973) and Godfrey (1974). Further, Morgenweck (1977) demonstrated, using sub-samples of the data reported here, that earthworm biomass was generally higher in defined woodcock "high use areas" when compared to the entire forest stand. Finally, the three species which made up nearly all the biomass and *Dd. rubidus* are the four species listed by Reynolds (1977) as recorded from 50 woodcock stomachs taken from the northeastern part of the birds' range. This verifies for the western part of the breeding range the statement "... earthworm abundance did influence woodcock distribution" (Reynolds et. al. 1977).



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