EARTHWORM ABUNDACE AMONG DIFFERENT SOIL AND VEGETATION TYPES AT COLONIAL POINT

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Abstract- The purpose of this study was to determine if there are different earthworm abundances in different soil or forest cover types at Colonial Point in Cheboygan County, MI. Vegetation, soil, and worm data were collected from several locations that were randomly selected among an area of Colonial Point with diverse soil and vegetation types. It was found that the dominant forest type and gross leaf litter weight had no significant effect on worm abundance. Soil type however, did show a significant difference in earthworm abundance between sand and clay soils. A moderate trend was also found positively correlating earthworm abundance and pH. This suggests that earthworms prefer mesic soils with favorable moisture and nutrient conditions. This information can be important in attempting to efficiently prevent the spread of invasive earthworms in the future.

Key Words- Earthworms, soil, vegetation, mesic, Colonial Point.

INTRODUCTION

The pre-settlement Northern forests of the Great lakes area represented a worm-free ecosystem (Proulx, 2003). This area was worm~free because of its glacial history which left the area initially devoid of life after the glacial retreat, an-d earthworms naturally spread at a very slow rate, roughly Y2a mile per 100 years (Natural Resources Research Institute, 2006). Thus the forests of the Great lakes area have accumulation rates of organic litter faster than the rates decomposition by bacteria and fungi, and have accumulated a thick, spongy organic forest floor (Natural Resources Research Institute, 2006). This thick organic layer is important because it provides habitat for a diverse community of decomposers, fungi, arthropods, and small vertebrates, and also acts as the seedbed for all forest plant species (Hale et. aI., 2006).

Earthworms are keystone detritivores that influence their environment by depleting the organic layer of the forest floor, change the processes of cycling and movement of water and nutrients, and also effect soil structure (Frelich et aI., 2006). European earthworms of the family Lumbricidae have been invading northern hardwood forests since European settlement; and the invasion has been accelerating over the past few decades via the widespread use of earthworms as bait for recreational fishing (Gates, 1982). These changes can have profound effects on the forest ecosystem, most notably on herbaceous species diversity. Herbaceous plant diversity has been shown to have a negative relationship with increased earthworm species diversity and increased earthworm biomass (Hale et. aI., 2006).

Previous studies have indicated that earthworm abundances and species composition are influenced by soil type, moisture and nutrient conditions, and pH (Staaf, 1987). The purpose of this study was to determine what factors are determining local earthworm abundances, specifically vegetation and soil properties.

MATERIALS AND METHODS

Data were collected from Colonial Point, using a grid system laid out in a previous study at Colonial Point (Albert and Mine, 1987). A main transect was laid out along a road with a North/South bearing, and a random plot was laid out on either side of the road every 200 meters. A random number table was used to generate a bearing between 45 and 135 degrees on the East side and between 225 and 315 degrees on the West side of the road and a distance between 10 and 100 meters for each plot. This was repeated twice to create a total of 6 plots and 5 additional plots were also created by traveling directly east and laying out a plot every 50 meters, as well as one 50 meters to the west, in order to gather more data from conifer dominated stands.

Vegetation, soil, litter, and worm data were collected from each plot. For vegetation data, the surrounding area split into 4 quadrants along the North/South and East/West lines, at the point designated by the random number table. The distance, diameter at breast height (DBH), and species was collected for the two closest dominant trees (>20 cm DBH) in each quadrant to determine the major, immediate influences of leaf litter for each plot. The overall dominant forest type for the area was also noted and classified as hardwood or conifer, in order to take into account the general vegetation of the area and include leaf litter which may have migrated from the surrounding area. Soil samples were taken within 2 meters of the point, the depth of each soil horizon was recorded, and the texture of the soil was also noted as sand or clay. A sample from each horizon was also brought back to the lab for pH analysis using a pH meter. Worms were shocked from a .25 m2 square sub-plot on the plot point, using four positive and four negative 1 meter electrodes receiving 250V for 25 minutes. A second sub-plot was also taken within 15 meters of the first sub-plot for 8 of the plots generating 18 data points total. leaf litter was gathered from each .25 m2 plot just before shocking for worms to determine the immediate

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leaf cover composition. The leaves were weighed, sorted, and a rough estimation of the leaf species composition was made. After the data were collected, a Kruskal-Wallis test, Mann-Whitney U test, and least squares regression analysis were used where appropriate.

RESULTS

First the four different soil and forest cover combinations were compared: Hardwood clay, Conifer clay, Hardwood sand, and Conifer sand. It was found there were significant differences between plot types (Figure 1, Kruskal-Wallis, $P = .003$). To investigate where the differences resided, the difference between the average number of worms under hardwood and conifer forest cover was analyzed; no significant difference was found (Figure 2, Mann-Whitney U, $P = .166$). Worm abundance and gross leaf litter mass were then compared and the relationship was found to be insignificant (Figure 3, least squares regression, $R^2 = .069$, $P = .465$). The average worm abundance with sand and clay soil types was compared and clay soils were found to have significantly higher worm abundance than sand (Figure 4, Mann-Whitney U, $P < .001$). It was also found that there was a moderate trend between worm abundance and soil pH ofthe top soil horizon (Figure 5, least squares regression, $R^2 = .365$, $P = .008$). To reinforce these results, a significant difference was also found between the pH of sand and clay at the top soil horizon (Figure 6, Mann-Whitney U, $P = .007$). Finally, all the data were summarized by comparing each of the original categories of forest cover and soil type (Hardwood clay, Conifer clay, Hardwood sand, and Conifer sand); significant differences were found only when comparing different soil types (Table 1, Mann-Whitney U).

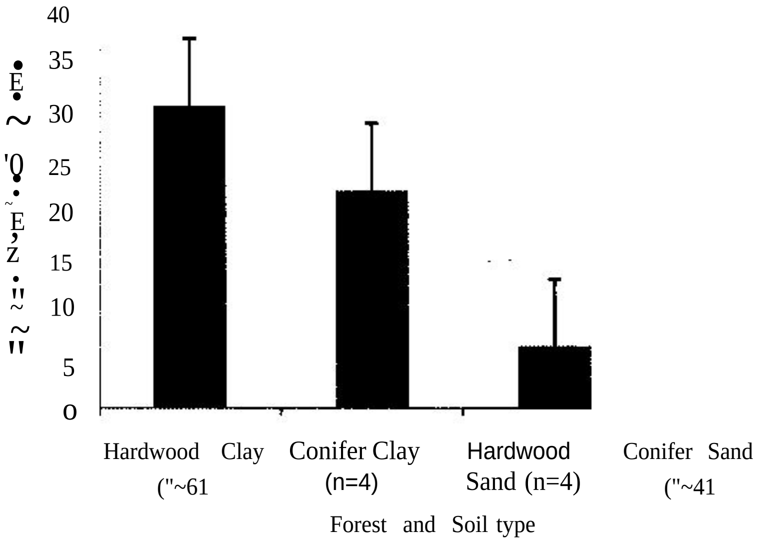

Figure 1. AVERAGE WORM ABUNDANCE IN 252 M PLOTS FOR DIFFERENT FOREST AND SOil TYPES. Error bars represent Standard Error of Means; Kruskal-Wallis, p::: .003

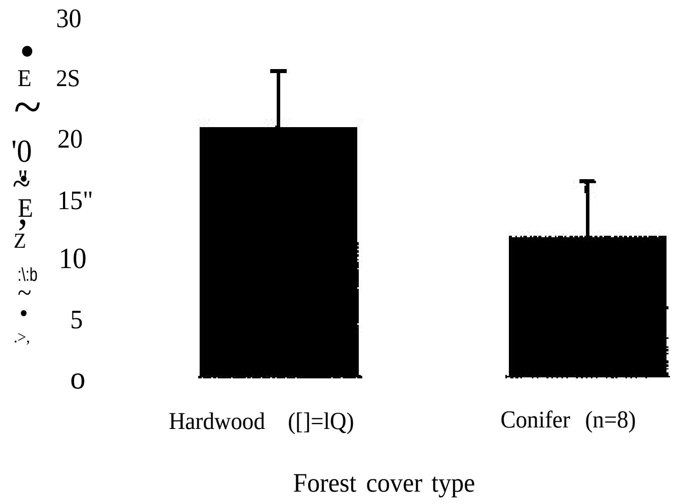

Figure 2. AVERAGE WORM ABUNDANCE IN 252 M PLOTS IN HARDWOOD AND CONIFER FOREST TYPES. Error bars represent Standard Error of Means; Mann-Whitney U, p::: .166

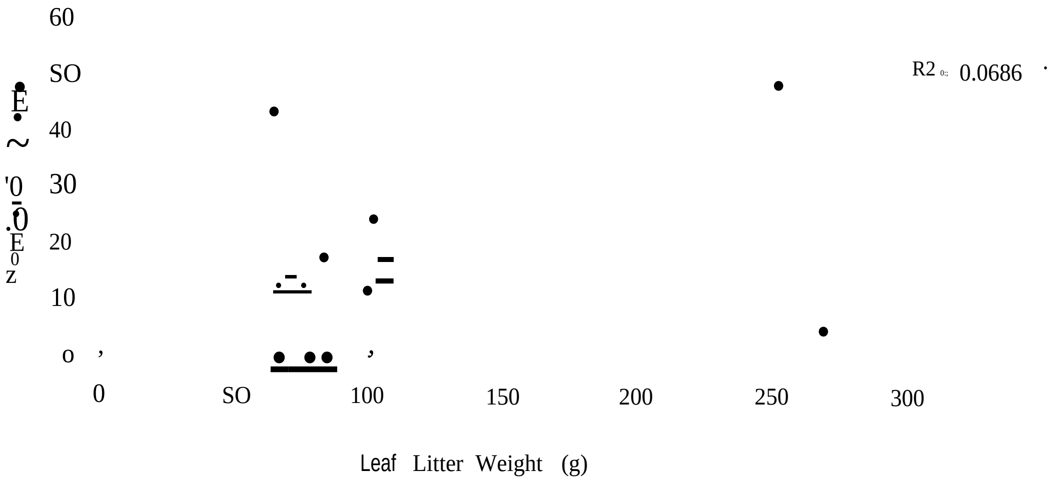

Figure 3. LEAST SQUARES LINEAR REGRESSION FOR GROSS LEAF LITTER WEIGHT COMPARED WITH WORM ABUNDANCE IN 252 M PLOTS. P = 0.465

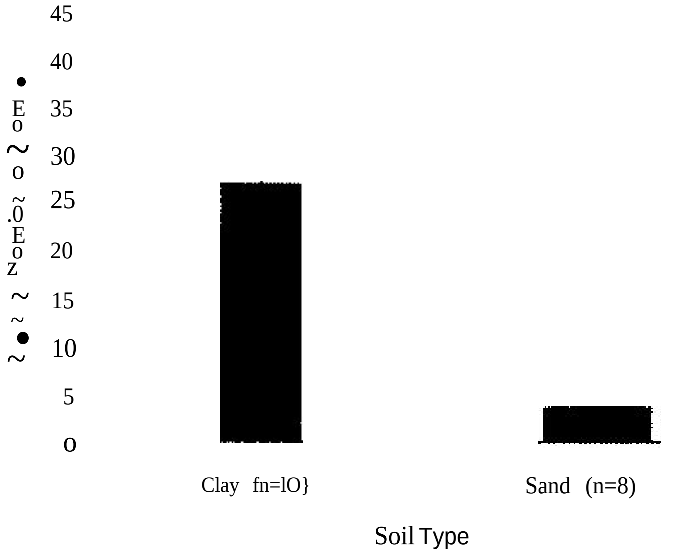

Figure 4. AVERAGE WORM ABUNDANCE IN 252 M PLOTS. Error bars represent Standard Error of Means; Mann-Whitney U, P < 0.001

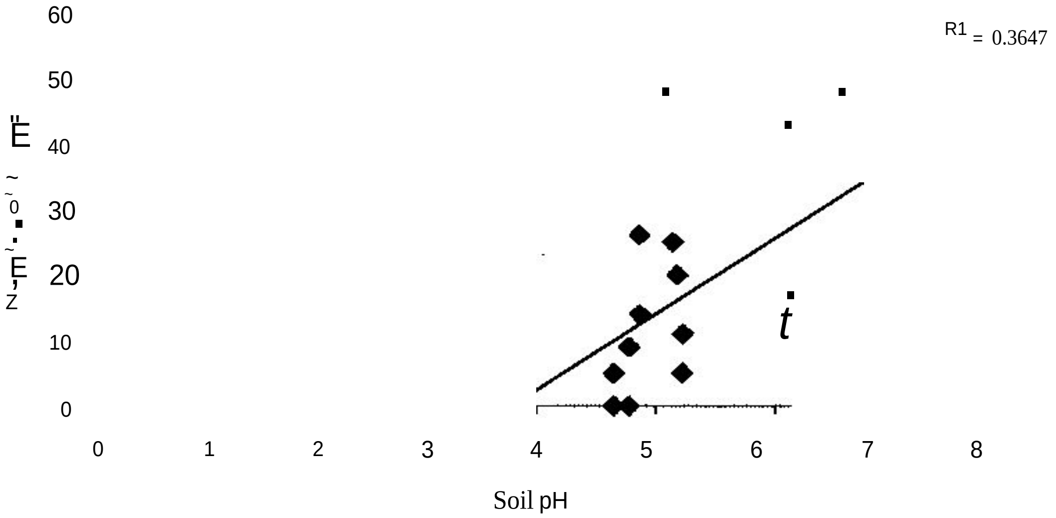

Figure 5. LEAST SQUARES LINEAR REGRESSION BETWEEN PH OF THE TOP SOIL HORIZON AND WORM ABUNDANCE IN ZS' M PLOTS. P = .008

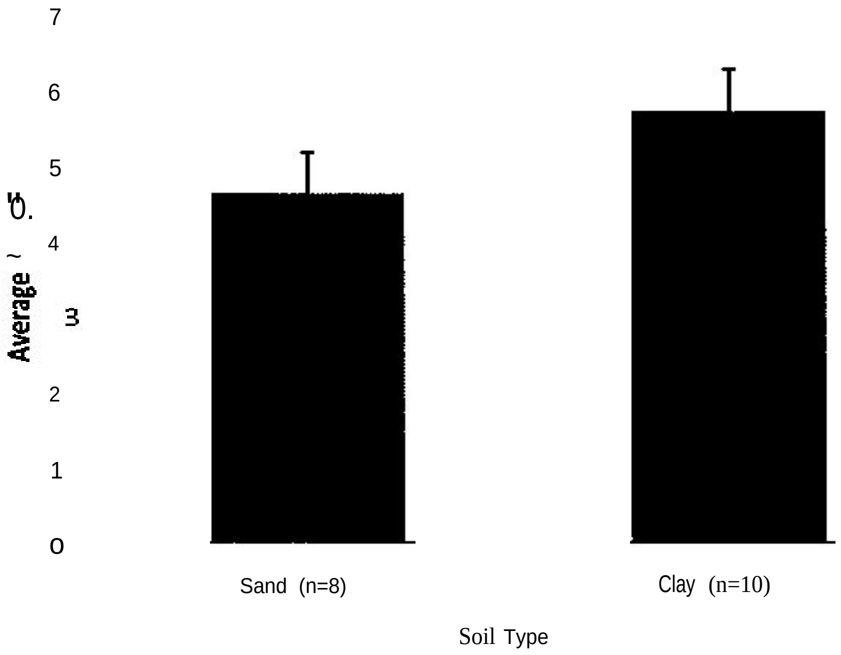

Figure6. AVERAGE SOIL PH OF THE TOP SOIL HORIZON FOR EACH SOIL TYPE.Error bars represent Standard Error of Means; Mann-Whitney U P <.001

Table 1. MANN-WHITNEY UP-VALUES COMPARING EACH COMBINATION OF CATEGORIES. Significant values are shown in bold; significance was only found when comparing different soil types.

	Hardwood Clay	Hardwood Sand	Conifer Clay
Hardwood Sand	0.01		
Conifer Clay	0.163	0.021	
Conifer Sand	0.009	0.122	0.018

DISCUSSION

The only significant influences on earthworm abundance appear to be soil texture. Forest cover type and gross leaf litter mass were found to be insignificant. A moderate trend was found between pH and earthworm abundance; however, since higher pHs are inherent for clay soils of Northern Michigan, we can conclude that the majority of the variation in earthworm abundance is from the soil texture, moisture, or nutrients. Moisture and nutrient levels were not analyzed in this study, but also tend to be inherent in clay soils and have been_correlated with worm abundance (Tinunov et. al., 2006). One interesting note is that that two of the data points that were initially Hardwood Sand (HWS) were subsequently moved to Hardwood Clay (HWC). These two plots were composed of a two.storied soil, composed of sand with an underlying layer of clay, and showed a much higher abundance of earthworms than the other HWS plots. These plots were assumed to have more clay like properties because of the underlying clay layer and were thus moved to HWC. Because the underlying clay presumably increases the favorability of the soil moisture, nutrients, and pH, these data suggest that they are critical controlling factors of earthworm abundance, as opposed to the actual texture of the soil. Plots such as this would make excellent controls for studying such factors separately from clay itself, however, since information on soil moisture and nutrients was not collected, and relatively few data points representing such plots were available, statistical tests were not implemented to determine the exact effects of these variables.

Although invasive earthworms are typically generalist that can withstand a wide range of environmental conditions (Natural Resources Research Institute, 2006), it has been shown that earthworm species increase in abundance and diversity in mesic conditions with favorable soil moisture, nutrients, and pH properties (Tinunov et. aI., 2006). This is especially important because the highest rates of native flora biomass and species diversity occur in these areas (partel et. aI., 2004). Mesic sites such as these are most at risk for earthworm invasion, and increased earthworm biomass and diversity has been negatively correlated with native species biomass and diversity (Hale et. aI., 2006). Most of these effects are probably due to the depletion of the forest floor, which is fundamental to the health of the forest ecosystem (Muratake, 2003).

This information is important because it can be critical in determining where efforts to stop the spread of earthworm invasions in the future should be focused; however there are currently no methods of eliminating worms once they have invaded (Natural Resources Research Institute, 2006). The results ofthis paper suggest that prevention efforts in the future should be focused on mesic areas because there is the most to lose in terms of the native ecosystem and they are at the highest risk, while invasions in harsher conditions are likely to be slower and less severe.

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