Brazil-A Land of Mystery, Beauty and Culture

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&

Embrapa Soja

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My last drive in a land I'd only dreamt of, a land of beauty, a land you commonly see in "National Geographic", was surreal. I looked out the window as we lumbered toward the airport, wondering how I was this lucky and secondly, if I would ever have the chance to return.

Brazil was incredible, to put it simply. I tried to not have any ideas of what it would be like before I arrived there, and did nothing except research the area I would be spending two months of my life. As the plane soared over the hills before the airport, I looked out the small window and took in as much as I could. I stepped off the plane, walked to the airport, and stood in line as bags were brought in by hand. I glanced casually, so as not to look like a foreigner of course, at advertisements posted about coffee, sodas and safety. I picked up my bags and was faced with my first experience of naiveté. I had apparently breached some security measure by leaving without letting the armed guards know, and I was quickly advised to do something in Portuguese. Let me tell you, I will never make that mistake again. Headed toward the exit, I recognized two faces from pictures that were e-mailed to me earlier—the faces of my "mother" and "sister", one half of the family that I'd be residing with during my stay there. I met, was embraced, and yet again experienced more of the culture when I was kissed on both cheeks. Interesting.

I went home, and quickly got the hang of things. If I were up by 7:00, I could eat breakfast, prepared by the maid, and be out of the apartment and on my way to work. I worked from 8:00 a.m. to noon, had a one-hour lunch break, and went home at 5:00 p.m. I had about two hours to relax, and then supper was ready at 7:30, once again prepared by the maid. After supper, conversation followed, and then bed. It appears a relatively simple schedule.

But Brazil for me was so much more than a schedule. It was meeting new people, seeing the country, learning the language and customs of Brazil. The first encounter I had with something that remotely concerned me was the fourth day I was there, when some type of explosion happened right outside my window. I bolted out of bed and found the family sitting calmly around the television. They looked at me and laughed, explaining that "futbol" or soccer was taken very seriously in Brazil, as was the celebration of a game won. What I'd heard was simply a firework set off in jubilation of a goal made by Brazil's world famous team. I was already starting to like it, despite the lack of sleep the next morning.

The town I lived in was called Londrina, named after Londoners settling it in the early 1930's. Londrina is a large city of about 750,000 people—much larger than I am used to. It's mostly a business town, founded largely on the great profit made from soybean production in its early years. Land in the area of Londrina was relatively inexpensive at the time, and large lots were purchased by entrepreneur farmers who made just as much money, it seemed, as I toured the city, seeing the mansions they'd built. I lived in an apartment with the family on the 7^{th} floor. Surprisingly, there was hardly any accommodation that the house didn't have. Running water, though not running water, a gas stove, a microwave, a computer, televisions, satellite and even a surround-sound entertainment system. The house was great, but the first thing I noticed about the house was that there was no carpet, anywhere. In the U.S. almost every house has carpeting somewhere, but in Brazil, I didn't see carpet ever, only beautiful granite and marble floors or Brazilian hard wood. I came down with a cold while I was there, and I'm sure it was due to walking around barefoot on the cold floor.

Not many more differences were seen in housing and living arrangements, though I want to make it clear that I was living with a very financially positive family. Both parents worked at Embrapa, making a good living, due mostly to their positions; the mother was head of the entomology department and the father was the head of microbiology.

Another thing that took me time to get used to was the fact that we had a maid. I made a point of making my bed each morning, cleaning up the bathroom a little, and trying to put away my dishes. I say try, because the maid would almost get mad to think that I would do my own work. I offered to help do dishes of move furniture when cleaning but I was waved away.

Being at work for 45 hours per week was something that took a little time to get used to, but once I began to study and work with the things I found very interesting, the time flew. A few times, I even worked late and on the weekends.

My advisor, Mr. George Brown, was not at all what I expected. With his status I was envisioning a mid 40's graying man, who was obviously Brazilian, but someone had at sometime intermarried with a Londoner to have that sort of name. Instead, when I was introduced, I encountered a man in his mid 30's, and one who had no nationality distinction other than American. Over times spent talking at work and him graciously taking me sightseeing, I learned a lot about him. He, in fact, was born in the U.S. to native parents who moved to Brazil to pursue their entomological interests. George's father spoke fluent Portuguese as well as English, and George had the rare advantage of growing up learning two different languages. He attended a few levels of elementary education in Brazil, before his parents moved back to the U.S. He received the rest of his schooling in Wisconsin. After graduating from the University of Wisconsin, he moved to Mexico earned his Ph. D. and met his future wife. He worked in Mexico for a few years and then secured a position at Embrapa Soybean. In fact, George had only been working with Embrapa for about a year when I met him. Due to his multilingual capabilities, American culture, and my interests, he was assigned to be my advisor.

After the first week at Embrapa, George informed me that he would not be in the office for a few days, and when I inquired as to why, he explained the future international workshop that he was hosting at Embrapa. Interested, I found myself helping with planning and eventually meeting over 30 people from just as many countries. Presentations at this workshop were given in English, and through the three-day symposium, I learned of problems facing the rest of the world--Holland, Kenya, Cuba—and also solutions proposed. These problems focused mainly on soil quality, enrichment and erosion controls, all things that I'd spend my next month and a half studying.

After the workshop, things quieted down a little bit. George proposed many different topics and ways to study these topics so I could narrow down my interests in Brazilian Soil Management. I spent many nights poring over books and pamphlets from George's library about problems in Brazil's soil management system, reasons these problems existed, and how to fix these problems. The latter had little to no literature, and when researching specific information about soil fertility, just as little about actual testing and results was found. Then I stumbled onto a paper presented at a workshop in 2000 that George attended and found my area of research. I fell asleep that night on a book describing macrofauna, large insect and organisms in the soil that we can see, and mesofauna, the smaller organisms like mites that we can't see. I'd read in "Farmer's Almanacs" about how to control insects or fungi with other insects, but had never paid too much attention to it. Now, these processes, or proposed processes, were explained in detail and definite, specific relation to soil fertility, and the effect upon crops.

I went to work the next day and began to formulate a "plan of attack" with George. Embrapa has almost 300 acres of land dedicated specifically to test plots, whether it be a new crop variety, a different type of fertilizer, or an alternative row spacing experiment: almost anything could be found at this center. However, there was one thing that couldn't be found, and that was the one thing I wanted--soybeans. Soybeans are a summer crop in Brazil, usually planted alternately with wheat for two reasons. Wheat is a good nitrogen disperser for the next crop of soybeans. For the few farmers who practice no-tilling, wheat is an optimum ground cover and litter residue for future crops. However, it didn't change the fact that I would have preferred studying in a soybean field.

I had a general plan for studying levels of macrofauna and mesofauna in two different types of plots, no till and conventional till. After reading about agricultural problems that Brazil was facing, I thought I had integrated most of the key aspects into the experiment. Brazilian soil is a very red soil, with a high clay content. Because of this erosion is a large threat to farmers when heavy rains are predicted. Conventional till offers no protection against this threat. Soil being tilled every year loses any structure and is easily eroded by rain. On the other hand, no-till soil has a deep root structure in the soil, and a solid cover formed by crop litter. Rarely is erosion a problem in no-till soils.

Another problem facing Brazilian agriculturists is that of fertility. Brazilian soil, as compared with U.S. soils, is not very fertile to begin with, and with every crop and following tillage of soil, the nutrient and fauna levels become exhausted and not very productive. However, fauna, the life in the soil, live off not only each other, but off of crop litter as well. The by-product of the decomposition of this litter is a very rich mix of nutrients, in a usable form for crops. This saves farmers not only money on fertilizers but on fuel for their machinery as well.

Concerns with fuel usage is something I did not address, though I understood this was a problem. Right now in Brazil, approximately 60% of vehicles run off of fossil fuels. And almost all of the grain transported by road. Rivers in Brazil are either uncharted, or unable to be used for barge type transport. Likewise, railroads offer little help, because either railroads do not go where grain is needed, or they are in need of repair where they should go. Other road vehicles however run off alcohol, simply due to a price almost half that of gasoline. While in Brazil, I'd glimpse signs near gas stations touting R$1.85 with not much more thought. However, taking a close look I saw that this was R$1.85 per liter of fuel bringing that price to R$7.00 per gallon. Even considering the exchange rate of the Brazilian Real, in the U.S. we'd still pay almost $3.00 per gallon of gasoline! This translates to incredibly high fuel costs on the farm to apply not only fertilizer but pesticides, herbicides, fungicides, and also continuous tillage. In no-till land, money for fuel is only spent on small amounts of fertilizing and occasionally pest control. However, almost 25% of fuel usage for a year is spent in preparing a conventional till field for planting. This is 25% of unnecessary fuel. To put it simply, in many ways, farmers opting for minimum to no-till methods will find themselves spending less and producing more.

All of the previous four paragraphs are addressed in the following paper I prepared while in Brazil, entitled "Soil Macrofauna and Mesofauna Populations in No-Till and Conventional Tillage System". This technical paper was written for results, further hypothesis, and answers to the solutions needed in Brazilian Agriculture.

Background

One of the most important factors controlling crop yields, is the fertility of the soil that it is grown in. Soil fertility depends on many different things, but especially its physical, biological and chemical properties. For example, a pore space system must be present for water, air, and gas circulation in the soil, but there also must be sufficient mineral and organic material as well. These are not only important to the crops, but to everything living in the soil.

The living component of the soil is also important for soil fertility. One of these components is the soil fauna. There are two ways by which soil fauna affect properties of soil. First, many of them, such as earthworms, ants, and other burrowing animals construct tunnels that penetrate deep into the soil. These animals bring mineral-rich matter to the surface (and vice versa, burying materials) where it is needed and can be used by plants. Also, these animals are important steps in the degradation of the plant residues, organic matter and animal refuse. In this process, soil animals are able to convert inorganic substances fixed by the plants back into organic and inorganic substances in the soil. These actions of soil fauna are especially important in no-tillage systems, where these animals essentially replace the effects of mechanical tillage. These animals turnover the soil, incorporating organic matter into it, and altering it into useable forms for crops. Simply, soil animals are extremely beneficial to the soil, and the healthier soil ecosystem you have, the better crop output you will have as well.

The following work was performed at Embrapa Soybean, one of many institutions in Brazil dedicated especially to agricultural research for improved and sustained crop production. Embrapa Soybean has 300 ha of land dedicated to experimental research and a large number of laboratories studying various aspects of the soybean crop production system, from entomology to plant breeding. The work undertaken for this report was performed in the soil invertebrates laboratory, under the supervision of Dr. George Brown. All the work was performed on station, and samples were taken from long-term experiments in the Embrapa Soybean research farm.

Introduction

Soil macrofauna and mesofauna are relatively new research topics in tropical regions. This interest is spawned mostly from the advantage knowing the beneficial and adverse effects that these organisms may have on crop production. Soil fauna, regardless of size, are important to the soil, primarily in their effects on physical and chemical properties [Kuhnelt, 1976]. With a few *exceptions (root-feeding insect pests), soil fauna has been reported to have a positive effect on the soil, be it directly or indirectly, and a better understanding of their populations is needed to properly manage soil and protect their populations and activities.*

Proper management practices can preserve soil fauna and increase crop production and sustainability. Different tillage methods can affect soil fauna populations in different ways. In addition, soil fauna can affect soil conditions, and in turn affect crop productivity, soil aggregation, and overall soil quality and sustainability. Therefore, an important agricultural management aspect to consider is the soil fauna and their populations and activity.

Objectives

In the following work, we set out to test (prove or disprove) the hypotheses that:

(H1) Higher macrofauna numbers are present in no-till systems than in conventional tillage;

(H2) Higher mesofauna numbers are present in no-till systems than in conventional tillage;

(H3) Soil fauna populations are more diverse in no-till systems than in conventional tillage.

The alternative hypothesis (H0) was that there were no differences in diversity or populations of soil fauna between no-till and conventional tillage systems.

Definitions

Before beginning to present the actual work performed and the results obtained, it is important to become acquainted with whom we are dealing with. Plainly speaking, what is the soil fauna?

Many definitions exist for soil macrofauna. Some of them state that the soil macrofauna include all invertebrates which:

1. *Have a body length greater than 1cm,*
2. *Have a body width greater than 2 mm,*
3. *Are visible to the naked eye,*
4. *Have 90% or more of their specimens visible to the naked eye.*

Examples of the soil macrofauna include: termites, earthworms, beetles and their larvae, ants, millipedes, centipedes, spiders, snails & slugs, pseudoscorpions and some large pathogenic (to insects) nematodes. These are the most commonly present in tropical climates, though there are many more.

Macrofauna communities hold many different types of organisms. The beneficial macrofauna make up those organisms that are mineralizers and *decomposers, bioturbators or animals which ingest soil, and biocontrol agents or those animals which are predators upon harmful fauna, such as parasites and pests. Pest and parasitic macrofauna include some beetle grubs and other root-sucking or root-grazing animals. Together, all these animals help regulate soil structure and influence many soil properties and crop production [Hendrix, 1990].*

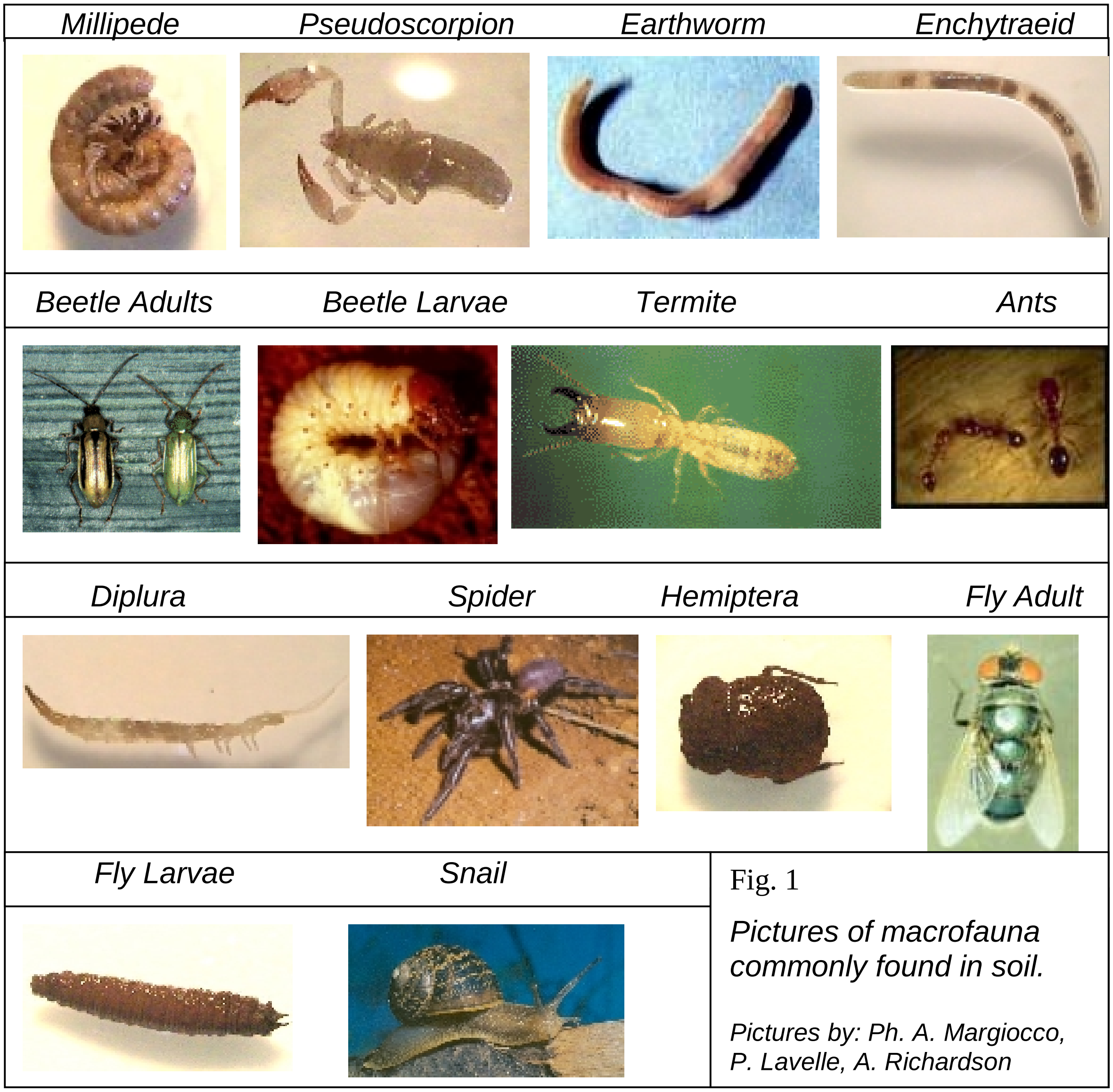


Fig. 1

Pictures of macrofauna commonly found in soil.

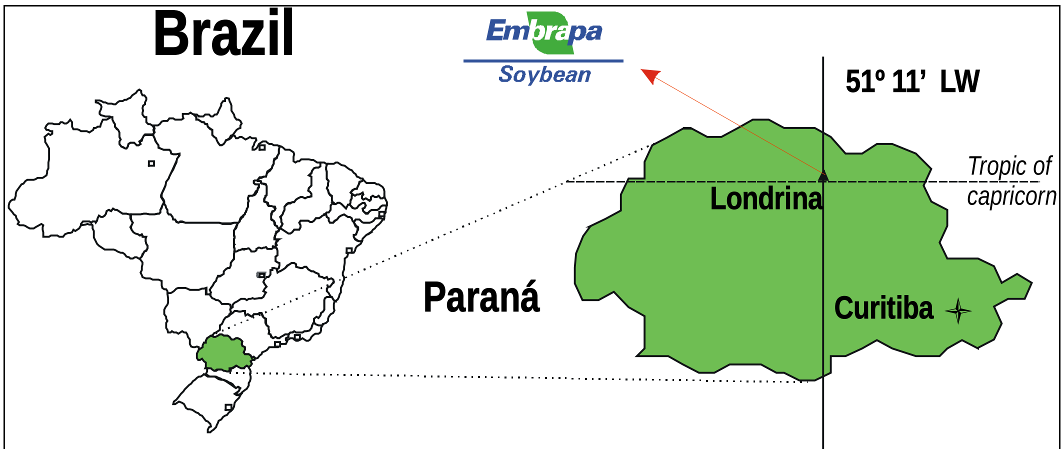
Pictures by: Ph. A. Margiocco, P. Lavelle, A. Richardson

Mesofauna are smaller than macrofauna, with body width within the range of 0.2 to 1 mm. These organisms include mites, springtails or collembolans, nematodes, diplura, and pot-worms or enchytraeids. They serve a variety of purposes, from ingesting and enriching the soil, to serving as food for macrofauna predators. Just like the macrofauna, mesofauna populations and presence are also affected by management practices and can also greatly alter soil attributes at a localized scale.

Materials and Methods

Research Plots

All samples were taken at Embrapa Soybean (Fig. 1), in a field with no-till plots that were 21 years old and conventional tillage that was at least as old and probably older (>23 years). All eighteen 8 x 50-meter plots were planted with wheat when the samples were taken in July of 2002. The plots had been managed in a soybean-wheat rotation since 1981. Samples were taken from no-till and conventional tillage plots.



Londrina
Alt: 590 m
Ann. Ppt: approx 1750 mm
MAT: 21º C (max. 27.5º, min. 15.4º)

Fig. 1

Macrofauna sampling

Six samples were taken from the no-till plots, and four from the conventional till, for a total of ten samples. The sampling date, July 17th, was in mid-winter, after an exceptionally dry but mild autumn (20´sºC). Rain had occurred four days before sampling. Samples were taken approximately 4.5 meters away from the southwest corner of each plot. A 25 x 25 cm square was made on the surface. Bags and 70% alcohol- or 4% formalin-filled containers were marked with the plot numbers, and any surface litter present was placed in the paper bags, and any surface fauna were placed in the containers. After all surface litter and fauna had been collected, the square was marked and large holes were then dug on two sides of the soil block, approximately 50cm deep and wide enough to allow for work to be accomplished in the hole. Using a metal plate driven into the soil, placed at 10cm depth, the first layer of soil was extracted, put into a tray and subsequently placed in a large plastic bag labeled with the plot number and the depth (X--A, B, C, or D, for 10, 20, 30 or 40cm deep layers respectively). This process was repeated, each time moving 10cm *downward, allowing for separate layers to be evaluated. Samples were then placed in the shade to avoid soil desiccation and heating.*

After field sampling was completed, samples were taken back to the laboratory, to be sorted. Due to the amount of samples, and considering the time available, field assistants were requested from UEL, the State University of Londrina. Sorting was performed by hand, in a simple matter, by looking through all the soil, and placing the fauna found into marked containers with 70% alcohol or 4% formalin (for earthworms). After a sample had been sorted, a small amount of soil was placed in another bag for chemical analysis.

The next step in assessing macrofauna levels was to identify and count the fauna collected. The samples were placed on a small, clear glass to aid identification, and the use of a microscope was required many times to make positive identifications. Each plot number and depth was marked on a pre-printed spreadsheet, and a tally was made for the number and type of animals that each sample contained. When all samples had been counted and recorded, numbers were transferred to a computer-generated spreadsheet, where graphs, averages and sums could be easily computed.

Mesofauna

Samples for mesofauna were taken from the same field and plots as the macrofauna samples. Due to the dryness of the soil on the first occasion, jugs of water were taken to the fields the afternoon before sampling, to wet the soil and allowing it to soften. The following week, after a moderate rainfall, six more samples were taken.

Sampling was performed using a 24.5cm^3 metal cylinder, being either pushed into the soil by hand, or driven in using a hammer. Using this cylinder, samples were more likely to be uniform, achieving better results. The cylinder was first driven 4cm deep, and then using a hand-hoe, soil was cleared from around it at about 5cm depth. The hoe was then pushed underneath the cylinder, and the sample was removed from the soil. Excess soil on the bottom of the sample was removed, as was any soil adhering to the exterior of the cylinder.

The top of the cylinder was then removed, and the soil was placed in a marked plastic container. This procedure was repeated again, but from 4-8cm depth. Only on the second sampling date (after the rainfall) were samples taken at 4-8 cm. Thus a total of 12 samples were taken from each system at 0-4 cm, and six and 4-8cm. After all sampling was completed, samples were taken to the laboratory to begin extraction.

Mesofauna were extracted from the samples using a Tullgren Funnel-type extractor. This extractor uses a heat gradient to facilitate extraction of mesofauna from the soil samples. In the extractor used, 12 samples could be extracted simultaneously. Soil samples were placed in a cylinder with a wire gauze bottom. This cylinder sat on top of a funnel. The funnel ended in an alcohol-filled container, where organisms fell into as they were driven out by the heat produced. Heat was applied using a 40-watt light bulb placed above the sample. It has been reported, though was not observed, that mesofauna leave the soil at two different times. Those organisms that are most sensitive to heat will move lower into the soil sample, eventually falling from it. Later, as the soil dries from the top down, insects sensitive to moisture content will likewise be driven out. Samples were left in the extractor for 4 days. After this time, the vials were removed from the funnels, and contents were placed into larger containers. Due to possible condensation on the walls of the funnel where mesofauna could become trapped, alcohol was used to rinse the sides, where the larger containers were useful for holding this additional alcohol. After the soil samples were removed, their dry weight was recorded.

After all extraction was completed, mesofauna populations were counted in much the same way as macrofauna. Due to their small size, a microscope was essential for the census. In addition, the microscope being used was equipped with a digital camera, which allowed for pictures to be taken of what was actually found in these samples. After all organisms had been quantified, the numbers were entered into computer spreadsheets and the averages for each management system were calculated.

Results and Discussion

Macrofauna populations

After the comparisons had been made between macrofauna populations in conventional tillage and no-till plots, it was obvious (from Fig. 2 and Table 1) that our first hypothesis had been proven correct through this experiment (H1

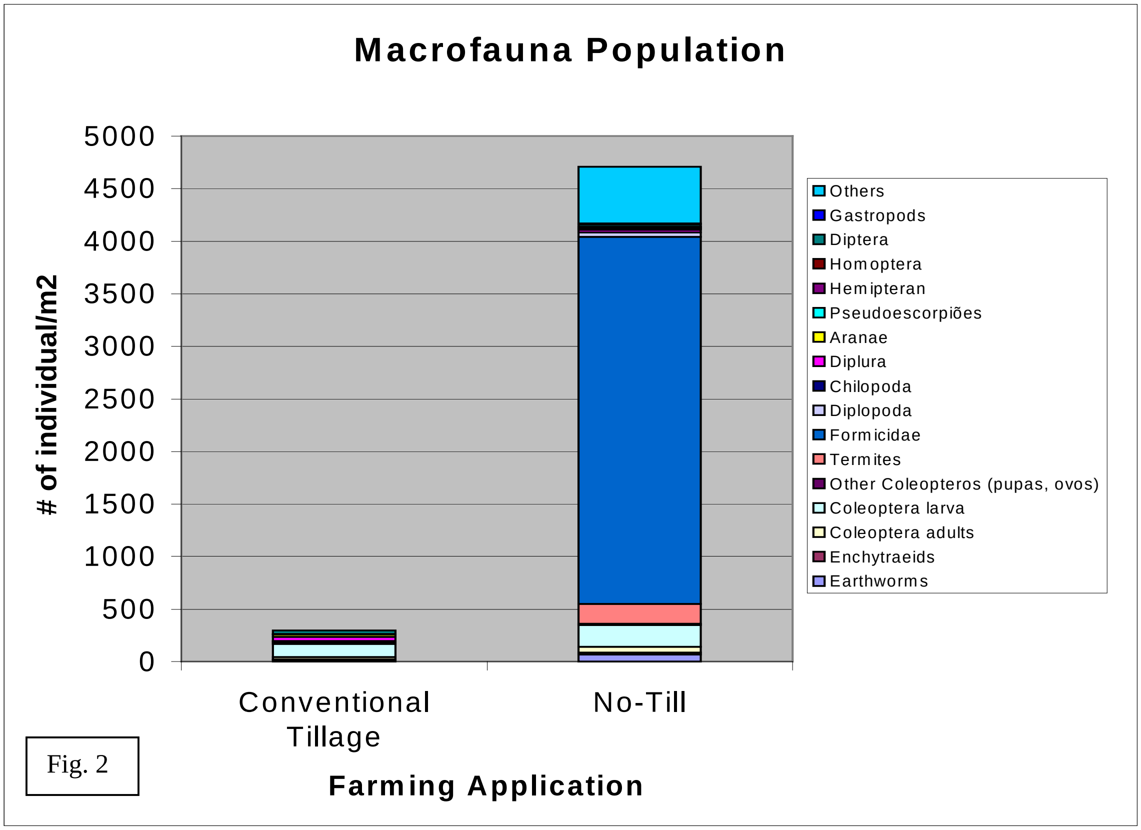


Fig. 2

was accepted). Macrofauna numbers were much higher in no-till plots, compared with conventional till plots. As can be seen, with the exception of diplura, aranae, and diptera –(all predators), no-till systems held higher populations in all of the remaining fauna. Ant populations were especially large in the no-till plots, with a mean of almost 3500 per m^2, compared with only 12 per m^2 in conventional till. Coleopteran levels per m^2 in no-till, both adults and larvae, were roughly twice those present in conventional till, with adults at 53 and 24, and larvae at 205 and 124 per m^2, for no-till and conventional till respectively. Termite abundance was 192 organisms per m^2 in NT, and only 16 organisms per m^2 in CT. One notable figure, is that no samples had any chilopods (centipedes). The total number of individuals present in the no-till systems per m^2 was almost sixteen times that found in the conventional tillage plots.

Table1. Total abundance of soil macrofauna per m^2 in no-till and conventional-till treatments.

Factor	Conventional Tillage	No-Till
Earthworms	16	69
Enchytraeids	4	19

Coleoptera adults	24	53
Coleoptera larva	124	20
Other Coleopterans (pupas, eggs)	0	13
Termites	16	192
Formicidae	12	3491
Diplopoda	0	43
Diplura	40	27
Aranae	24	5
Pseudoscorpions	0	5
Hemiptera	4	13
Homoptera	0	3
Diptera	32	21
Gastropods	0	11
Others	0	539
Total Taxonomic Groups	14	9

Finally Table 1 also shows that diversity of macrofauna was in fact higher in the no-till systems, with 14 taxonomic groups found, versus 9 in CT, proving that hypothesis H3 was partly correct. In CT no diplopods, pseudoscorpions, homopterans or gastropods were found.

Vertical distribution patterns of the soil macrofauna (Fig. 3 & 4) were also

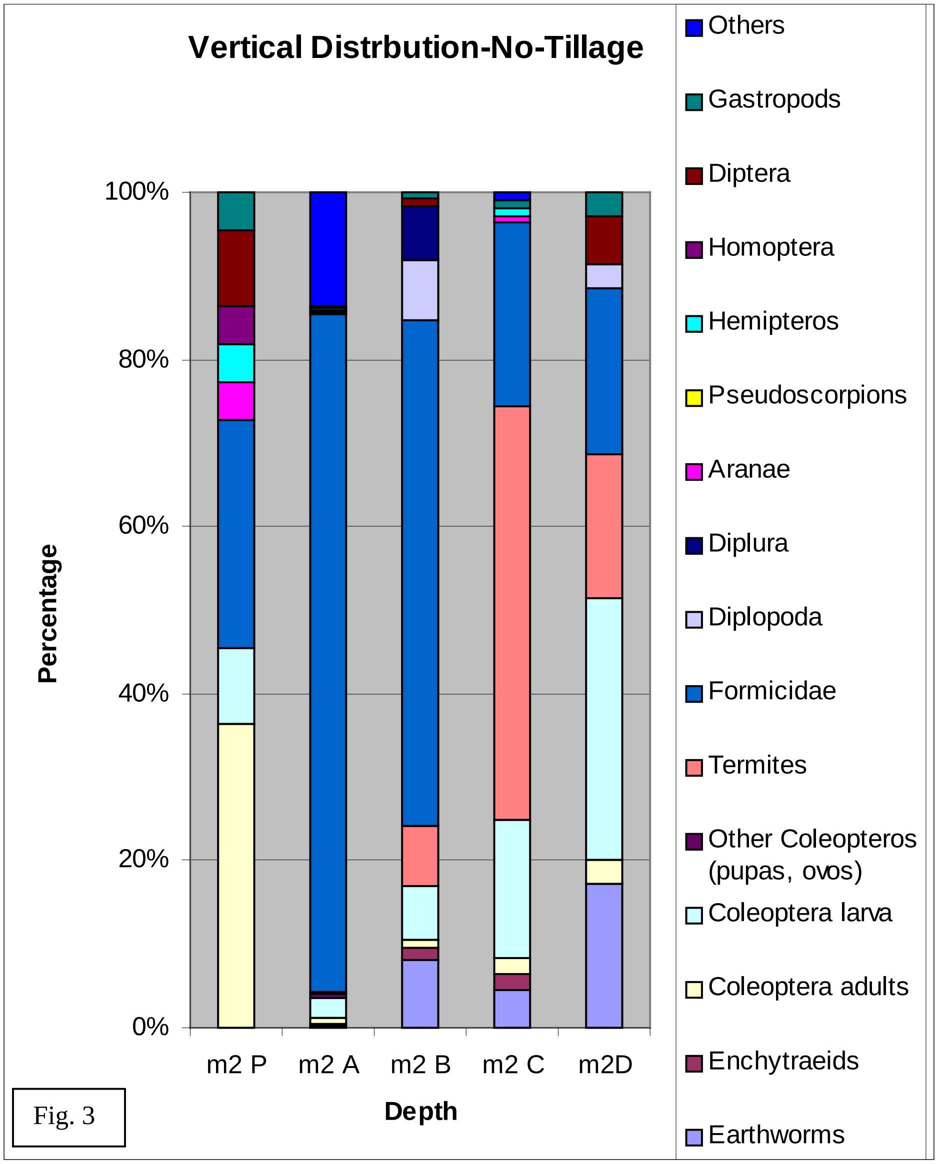


Fig. 3

interesting. Coleoptera larva distribution followed a similar pattern in both systems, however, more were found on the soil surface (P) compared to the A and B horizons in NT. Slightly over 15% of the macrofauna found in the D horizon in NT were earthworms, while the deepest earthworms found in CT were in the B horizon. In NT, 80% of the B horizon fauna were formicids, while only about 5% were present at that same layer in CT. The largest diversity of soil macrofauna in NT was observed in the B horizon, while the A horizon was the most diverse in CT.

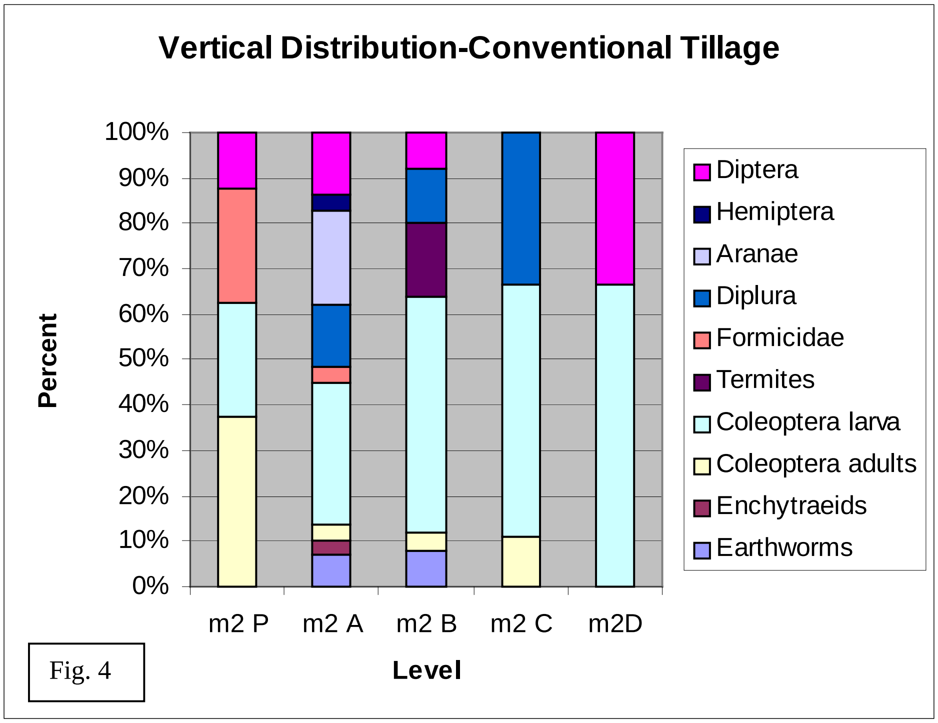


Fig. 4

When the present data were compared with samples taken in September of 2001, it could be seen that the results of the previous year were fairly similar. In 2001, almost all organisms (except centipedes, gastropods and homoptera) were significantly more abundant in no-till.

Mesofauna populations (1st sample, July 10)

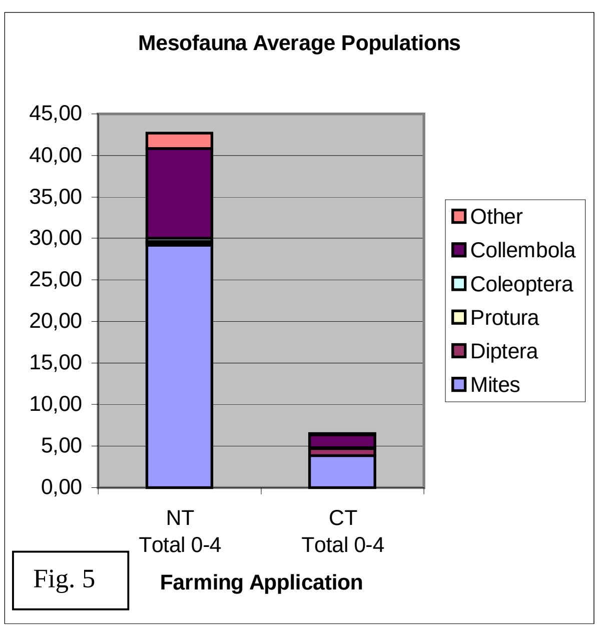


Fig. 5

The results for the first soil mesofauna sampling (Fig. 5) show that not only was the conventional tillage plot rivaled in diversity, but also in total organisms, by almost 7 times as much, compared with the NT plots. Mite abundance in NT reached close to 30 per m^2, while only close to 4 per m^2 were found in CT. This 7:1 ratio was similar also in collembola populations, where NT had close to 11 per m^2 and CT only 1.5 per m^2. The percentage distribution of the mesofauna population (Fig. 6 & 7) show how mites dominate the community, followed by springtails in both systems, but that diptera larvae represent a larger proportion of the population in CT.

Mesofauna populations (2nd sample, July15)

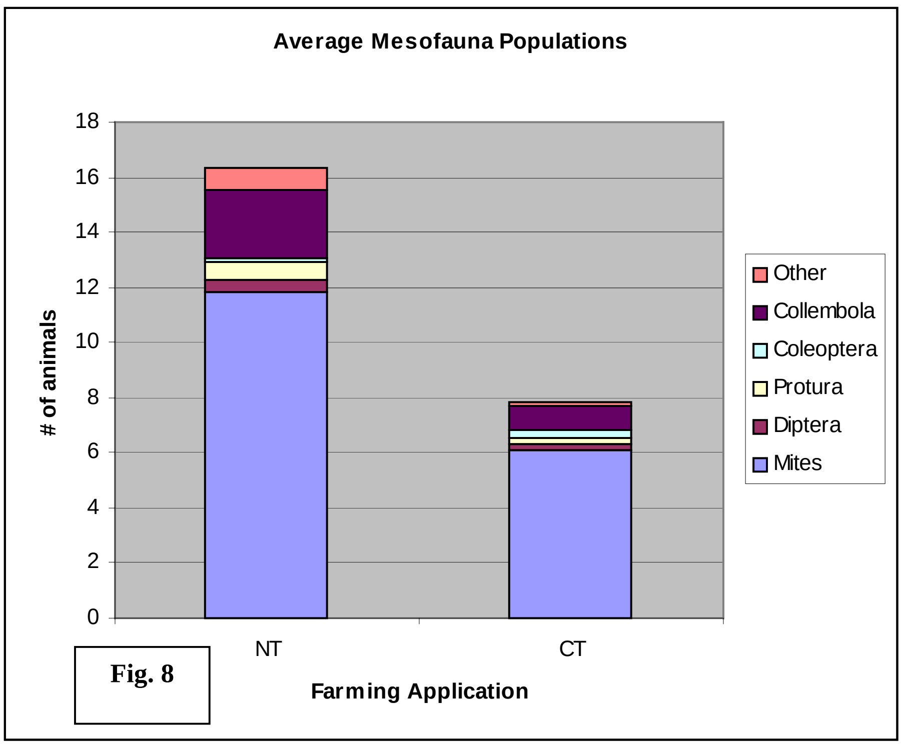


Fig. 8

Results of the average mesofauna populations on the second sample date (Fig. 8) were roughly similar to those on the first, but the difference between CT and NT was smaller. On average, 24 mites per m² were found in NT and 12 per m² in CT. About 5 collembola per m² were found in NT and 2 per m² in CT.

The individual numbers for each organism at different depths and in both systems is shown in Table 2. It also illustrates percentages of organisms present in each depth and percentages or organisms compared between the two systems.

Table 2. Mesofauna populations in CT and NT by sample depth.

		Mites	Diptera	Protura	Coleoptera	Collembola	Other
Avg. 0-4	NT	21	1	1	0	5	2
Avg. 4-8	NT	3	0	0	0	0	0
% in 0-4	NT	87%	60%	100%	50%	93%	100%
% in 4-8	NT	13%	40%	0%	50%	7%	0%
Avg. 0-4	CT	6,3	0,2	0,2	0,3	1,3	0,3
Avg. 4-8	CT	5,8	0,3	0,2	0,3	0,3	0,0
% in 0-4	CT	52%	33%	50%	50%	80%	100%
% in 4-8	CT	48%	67%	50%	50%	20%	0%

Vertical distribution patterns of the mesofauna (Fig. 9 & 10), showed that almost all of the animals (except mites) in no-till were found only in the upper sample layer, while in the conventional till areas, there was not much difference between the different sample depths.

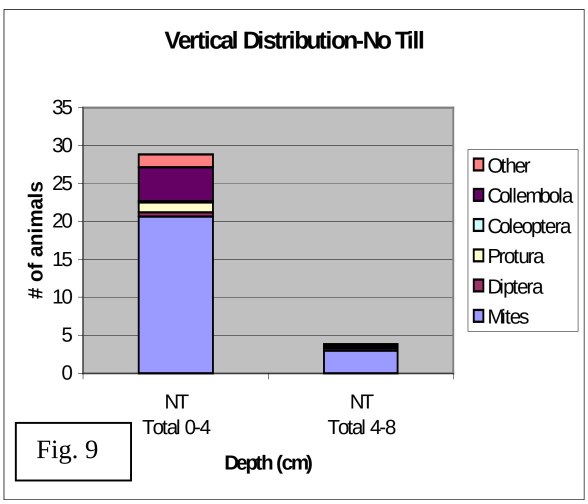


Fig. 9

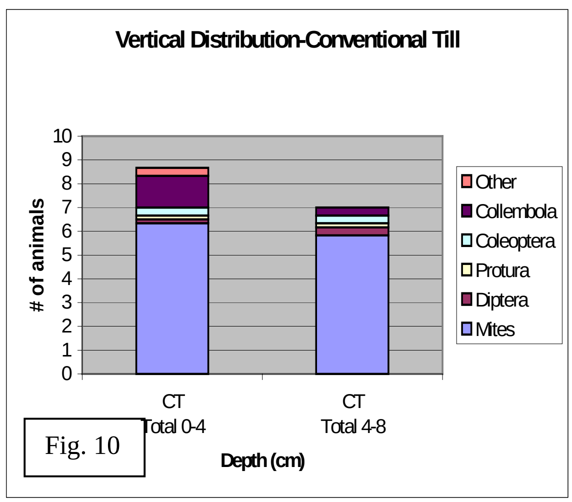


Fig. 10

Statistical comparison of the two sample dates revealed no significant differences, permitting a closer look at depths and the two management systems. No–till systems, on both dates, showed significantly higher numbers of mites, collembolans, other organisms, and total organisms than conventional till *systems, proving that the hypothesis H2 was correct. When depths were compared, there were no significant differences in conventional till samples, but in no-till samples, significant differences were observed between the two sampling depths.*

All the same organisms were found in both conventional and no tillage, indicating that mesofauna diversity was not different between the two systems, disproving the third hypothesis (H3). For mesofauna diversity the null (H0) hypothesis had to be accepted.

Litter Weights

Because organic matter is essential to maintaining a successful no-tillage operation and is a major food source for the soil organisms, the plant residue (litter) weights were also measured in each system.

An average of 236.8 grams of litter per m^2 were found on the soil surface of no-till plots, while an average of only 33g per m^2 were found on the surface of conventional till plots. Surface litter weights in CT plots ranged from as little as 14 g per m^2 up to almost 56 g per m^2. In no-tillage, the range of weights varied from 76 g per m^2 up to as much as 450 g per m^2, or slightly over 4.5 metric tons per ha. These values were up to almost 8 times greater than those in conventional-till plots.

Table 3-Surface Litter Weights in CT and NT plots.

Plot Number	Application	Weight (g)	g/m2
1	No-Tillage	18.98	303.68
7	No-Tillage	11.26	180.16
14	No-Tillage	28.17	450.72
16	No-Tillage	4.76	76.16
17	No-Tillage	10.84	173.44
3	Conventional Tillage	3.48	55.68
5	Conventional Tillage	0.88	14.08
11	Conventional Tillage	1.83	29.28
	Average No-Till Weight	14.80	236.83
	Average Conventional Till Weight	2.06	33.01

Conclusions

The results obtained in the present study show clearly that no-till systems are far superior to conventional till systems in terms of their ability to preserve and promote soil fauna. Soil macrofauna populations were almost 16 times higher in the no-till plots compared with the conventional till plots, and the soil mesofauna populations were from two to as much as more than five-times greater in no-till. Although diversity of mesofauna was not different, soil *macrofauna diversity was higher in no-till compared with conventional till systems.*

Various factors may be responsible for these results, although the most likely reason is probably related to soil disturbance; when the soil is turned over by plows or other tilling machinery, it brings animals to the surface. These animals are usually not adapted to surface life, and cannot burrow quickly enough to avoid the heat and desiccation on the surface, which ultimately leads to their death. Therefore, as tillage operations are repeated from year to year as in the conventional till system, substantial fauna is brought to the surface and dies, causing reoccurring low populations. Tillage also contributes to drying the soil and lower organic matter contents, as well as leaving the soil unprotected to wind and water erosion. As tillage is repeated yearly, the soil loses organic matter, becoming a poorer and less-favorable environment for the soil fauna.

A layer of litter on the soil surface provides adequate protection from rainfall, reducing erosion, and keeps the soil more moist by reducing water evaporation. Finally, this litter also serves as a food source for the soil fauna. As no-till treatments become older, more organic matter accumulates in the soil, allowing soil fauna populations to recover and multiply.

Considering that soil fauna have a role in biological tillage (bioturbation), organic matter decomposition and biological control, improving soil fertility and crop production, we expect that, because of their greater numbers in the no-till system, soil fauna will be more important for soil fertility and crop production in no-till than conventional tillage systems. These are probably major reasons for the success of no-tillage and why it is often considered a sustainable agricultural management practice.

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Though research was my primary reason for residing in Brazil, it would be ridiculous to not experience the rest of the culture. I took Spanish for two years in high school, and this was helpful when I took Portuguese lessons. I learned enough for small conversations, and somehow this connection allowed me to better appreciate Brazil. Whether I be hard at work in an office, rafting down the river flowing through beautiful Guartela Canyon or watching monkeys watch me, my memories of Brazil will be fond, important, and above all, useful. I learned skills in Brazil I'm not sure you could learn anywhere else. I've met contacts that only chance could introduce to you. I've heard languages you'd be so naive to think you'd never need let alone learn, and tasted food so good and intriguing, you'd swear you'd never have something like it again. Through all my limited experience in life, I can honestly say that I'm at a different point along my "trail" than most others. My eyes have only begun to open, because of a place called Brazil.