Dynamics of the Soil Macrofauna Influenced by Improved Fallows With *Andropogon gayanus* in Hydromorphic Soil at Bondoukuy (Western Burkina Faso)

Moïse YONI¹, Aristide Wendyam SEMPORE¹ & Kangbeni DIMOBE¹

¹ Université de Déougou, ISEDR, B.P. 176 Déougou, Burkina Faso

Correspondence: Moïse YONI, université de Déougou, ISEDR, B.P. 176 Déougou, Burkina Faso. E-mail: yoni_moïse@yahoo.fr

Received: August 15, 2022  Accepted: September 19, 2022  Online Published: October 13, 2022
doi:10.5539/ijb.v14n2p46 URL: https://doi.org/10.5539/ijb.v14n2p46

Abstract

In western Burkina Faso, in the Bondoukuy cotton zone, on silty-clay soils, the rarefaction of the perennial grass *Andropogon gayanus*, characteristic of old fallows, is noticed. This grass is known to restore the structural stability of the soil rather quickly, due to a stimulation of biological activity, while the storage of organic matter in the soil remains slow. The biological aspect has been prospected through the study of invertebrate populations in 3 sites, all of which present 4 situations: 30-year-old falls, 5-year-old natural falls, and 5-year-old *A. gayanus* improved falls and 10-year-old permanent crop fields.

The results show that invertebrate populations are very diverse. A total of 172 morphotypes were recorded, including 115 species of insects (24 species of social insects), 31 species of Chelicerata, 8 Myriapoda and 5 earthworms. In the fields, earthworms and Diplopo populations are less important than in old falls. On the other hand, the fields have the highest species diversity, 50 species on average. The most abundant population is found in natural falls, with a density of 835 individuals/m² and 43 species represented. Improved falls with *A. gayanus* have a lower stand density and species richness than natural falls (less than 50% and 43 species). In old falls, stands are stable with a richness limited to 30 species, while earthworms and myriapods have significantly reduced densities.

Soil invertebrate communities thus recover rapidly after crop abandonment and are fully active during the most intense phase of recovery in the first 5 years. Trees do not appear to have a significant effect on the conservation and stimulation of macrofauna except for Coleoptera.

Our results show that the cropping system adopted in the region allows for minimal conservation of soil macrofauna and that the macrofauna recovers rapidly during the fallow. Improved falls with *A. gayanus* differ from natural falls in limiting Termite density, while old falls and fields are of comparable density.

**Keywords:** *Andropogon gayanus*, improved falls, hydromorphic soil, macrofauna, invertebrates

1. Introduction

The western cotton zone of Burkina Faso is subject to an increased fertilized cropping system. The economic stakes are such that the movement of migrants to the region causes strong demographic pressure (Tersiguel, 1994). Shrub and tree fallows frequently used to restore the fertility of cultivated soils and fight against weeds are scarce (Serpantié, 2003). This poses a problem with the function of restoring the fertility of the fallow soil both ecologically (erosion, decline in biological activity) and in terms of production (cultivation skills, fodder and forest production).

One of the favourable effects of the fallowing is the stimulation of the biological activity, particularly that of invertebrates "ecosystem engineers" (Mathieu, 2004; Lavelle et al., 1998) with increased availability of organic residues in the fallow. However, it takes at least 10 years for these effects to be noticeable. The cultivation causes a reduction in the specific diversity and abundance of soil macrofauna which accompanies the physicochemical degradation of the soil (Rouland et al., 1993; Lavelle and Rouland, 1999).

In the western region of Burkina Faso, the reintroduction of perennial grass, *A. gayanus*, has been proposed for the improvement of fallow (Serpantié et al., 1997). This grass is known to restore the structural stability of the soil fairly quickly, due to a stimulation of biological activity, while the storage of organic matter in the soil remains slow.

The objective of this work is to identify the effect of the improved fallow land with *A. gayanus* on the dynamics of...
Two hypotheses were formulated to answer our objectives.

Hypothesis 1: the presence of the perennial grass *A. gayanus*, helps the rapid proliferation of soil macrofauna.

Hypothesis 2: tree stumps are refuges conducive to the development of soil macrofauna.

This study will allow us to evaluate the effect of the improved fallow land with *A. gayanus* on the faunal composition of soils and propose possible ways to conserve the diversity and abundance of macrofauna.

The findings of this comprehensive study are likely to shed light on the role of improved *A. gayanus* fallow in the dynamics of soil macrofauna in a hydromorphic soil under a semi-arid tropical climate and provide decision-makers with a robust management plan for efficient land use and soil conservation.

2. Environmental and Geological Context

Soil macrofauna samples were collected in Bondoukuy, situated on the northern border of the South Sudanian climatic zone, known as the cotton farming zone (Figure 1). Bondoukuy lies between 11°51'N and 3°45'W with an elevation above sea level of 360 m. The average annual rainfall of the study area is 850 mm with the maximum rainfall occurring in August. The daily maximum temperature ranges between 31 and 39°C with an average annual potential evapotranspiration of about 1900 mm. The natural vegetation cover in the area is predominantly composed of open woody savannah, whereas the dominant grass biome is *A. gayanus*, *Pennisetum pedicellatum* and *Loudetia togoensis* (Fournier *et al.*, 2001).

The geology of the study area is composed of sedimentary rocks made of sandstones and schist of the Palaeozoic and Infra Cambrian ages (Ouédraogo, 1998). The sandstone bedrock in the plateau is composed of quartz, whereas in the glacis (iron duricrust) it is of schist-dolomite (Ladmirant and Legrand, 1969). Different soil types are encountered along the local pedotoposequence unit. At the plateau, the pedological cover is predominantly composed of sandy loam (i.e., ferric lixisols), whilst at the glacis, soils are loamy (i.e., luvisols; Kissou, 1994; Ouattara *et al.*, 2006).

For centuries, human presence in Bondoukuy has markedly affected the local ecosystem. Subsistence (cereals) and cash crop (cotton) farming are the main activities practiced in the area. Although the most fertile soils are regularly ploughed, less fertile ones are increasingly subjected to a short period of fallowing (~5 years). The annual ploughing, based on cotton–maize rotations, usually leads to the collapse of soil structure, erosion and reduction of soil organic matter content. The second most common activity in the study area is extensive animal husbandry. As a result, the area is overgrazed and exposed to high demands for aerial biomass (tree bark, firewood and perennials stems) by the local rural communities.

Figure 1. Phytogeographical map of Burkina Faso, showing the study area (Modified from Guinko, 1984)
3. Materials and Methods

3.1 Choice of Plots

Four situations in 3 different sites were identified in the real environment from a prospection and a survey of farmers: a 30-year old fallow (OF), a short 5 years old fallow (YF), an improved 5 years old fallow with Andropogon gayanus (IFA) and a permanent cultivated field of 10 years old (PC). Which makes a total of 12 selected plots.

3.2 Soil Macrofauna Sampling

The soil macrofauna sampling method used is a modified version of that recommended by the TSBF (Tropical Soil Biology and Fertility) program (Anderson & Ingram, 1993). Sampling was carried out during the rainy season from late July to mid-August. Ten soil samples were taken from each plot: 5 samples under trees and 5 samples outside vegetation. The way of taking under trees is explained by the fact that in the fields of permanent culture, there are no grasses spared, except trees. Samples are taken every 5 m along a straight line (figure 2) in each plot.

The soil macrofauna samples were realized under trees and in open areas in the 12 plots. Samples are taken with a metal square of 25 cm side at a 30 cm depth. A flat iron spade is used to separate the block of soil obtained into 3 layers of 10 cm which are then isolated to be sorted. Manual sorting is done by crumbling the soil to collect, using metal tongs, all invertebrates visible to the naked eye. They are then stored and listed in vials containing 4% formalin to fix them before storing them in 70% alcohol. In the laboratory, using a binocular magnifying glass, invertebrates are determined down to order or family and classified into taxonomic units or morphotypes.

3.3 Vegetation Description and Soil Physico-Chemical Study

The vegetation of the selected sites was characterized by phytosociological surveys according to the Braun-Blanquet method (1932) improved by Delassus (2015).

The soil physicochemical study was carried out using composite soil samples were taken at 2 depths: 0-10 cm and 10-20 cm. To take into account intra-plot variability, 3 samples were taken per plot. The following Physico-chemical analyzes were carried out: particle size analysis by sedimentation, after the destruction of the organic matter, by the pipette method on an automatic particle sizer with 5 fractions according to the Atterberg scale (Clays: 0-2 µm, fine silts: 2-20 µm, coarse silts: 20-50 µm, Fine sands: 50-200 µm and Coarse sands: 200 µm-2 mm) (Cirad, 2017); Carbon (C) analysis using the modified Walkley-Black method (CEAE, 2003), Nitrogen (N) assay using the Kjeldahl method; assays of total P by an attack with nitric acid (Bouyer, 1958) and of assimilable P by the modified Olsen method (Dabin, 1963); Ca, Mg and K are measured by ICP spectrometry (Cirad, 2017); the CEC is obtained by measuring ammonium by continuous flow colorimetry (Cirad, 2017); the measurement of exchangeable bases is carried out by percolation (Cirad, 2017) and the measurements of pH-H2O and pH-KCl are carried out using an automated titration chain with a sampler (Cirad, 2017). All these analyses were carried out in the soil science laboratory at INERA-Kamboinsé (Burkina Faso).

3.4 Data Analysis

The data collected were subjected to an analysis of variance (PROC ANOVA) with 3 factors (sites, treatments and absence or presence of trees) and to a simultaneous test of comparison of means by Scheffé (1959) considered to be the most reliable test sensitive to small differences between means (Scherrer, 1989). All tests were performed with an alpha level of 5%. These analyses were performed using the Stat View software (SAS, 2020).

4. Results

4.1 Soil Physicochemical Characteristics

ANOVA performed on the averages of the soil data of the three sites, does not show any significant differences concerning the texture and the other chemical characteristics of the soil in the 4 situations (tables 1 a, b and c). Except for available P in sites I and II and total phosphorus in site III. In general, site I is richer than sites II and III, concerning all the parameters analyzed.
Figure 2. Soil macrofauna sampling device
Table 1a. Soil physicochemical characteristics of the different situations of the site I. Numbers with the same letter per line are not significantly different (n=3, p<0.005)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>PC 0-10</th>
<th>YF 0-10</th>
<th>IFA 0-10</th>
<th>OF 0-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse sands (%)</td>
<td>10.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>21&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fine sands (%)</td>
<td>(0.23)</td>
<td>(0.55)</td>
<td>(0.21)</td>
<td>(0.51)</td>
</tr>
<tr>
<td>Fine silts (%)</td>
<td>9.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Coarse silts (%)</td>
<td>(0.77)</td>
<td>(0.78)</td>
<td>(0.78)</td>
<td>(0.41)</td>
</tr>
<tr>
<td>Coarse sands (%)</td>
<td>16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fine sands (%)</td>
<td>(0.42)</td>
<td>(0.77)</td>
<td>(0.47)</td>
<td>(0.76)</td>
</tr>
<tr>
<td>Fine silts (%)</td>
<td>(0.52)</td>
<td>(0.97)</td>
<td>(0.51)</td>
<td>(0.96)</td>
</tr>
<tr>
<td>C (%)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>N (%)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>O/N</td>
<td>(0.2)</td>
<td>(0.18)</td>
<td>(0.2)</td>
<td>(0.19)</td>
</tr>
<tr>
<td>Total-P (ppm)</td>
<td>(1.7)</td>
<td>(1.39)</td>
<td>(1.7)</td>
<td>(1.4)</td>
</tr>
<tr>
<td>Olsen-P (ppm)</td>
<td>(0.26)</td>
<td>(0.45)</td>
<td>(0.26)</td>
<td>(0.5)</td>
</tr>
<tr>
<td>Ca (meq/100g)</td>
<td>(0.18)</td>
<td>(0.18)</td>
<td>(0.18)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>Mg (meq/100g)</td>
<td>(0.08)</td>
<td>(0.17)</td>
<td>(0.17)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>Exchangeable K</td>
<td>(0.0)1</td>
<td>(0.01)</td>
<td>(0.012)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Total-K (meq/100g)</td>
<td>(0.34)</td>
<td>(0.62)</td>
<td>(0.34)</td>
<td>(0.62)</td>
</tr>
<tr>
<td>CEC</td>
<td>3.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>pH H&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>(0.32)</td>
<td>(0.42)</td>
<td>(0.32)</td>
<td>(0.42)</td>
</tr>
<tr>
<td>pH KCl</td>
<td>(0.17)</td>
<td>(0.12)</td>
<td>(0.17)</td>
<td>(0.12)</td>
</tr>
</tbody>
</table>
Table 1 b. Soil physicochemical characteristics of the different situations of the site II. Numbers with the same letter per line are not significantly different (n=3, p<0.005)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>PC</th>
<th>YF</th>
<th>IFA</th>
<th>OF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-10</td>
<td>20 cm</td>
<td>0-10</td>
<td>20 cm</td>
</tr>
<tr>
<td>Clays (%)</td>
<td>10.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fine silts (%)</td>
<td>0.1</td>
<td>0.12</td>
<td>0.13</td>
<td>0.1</td>
</tr>
<tr>
<td>Fine sands (%)</td>
<td>9.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Coarse sands (%)</td>
<td>1.09</td>
<td>0.32</td>
<td>1.07</td>
<td>0.31</td>
</tr>
<tr>
<td>Coarse silts (%)</td>
<td>15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.9&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Coarse sands (%)</td>
<td>1.6</td>
<td>0.47</td>
<td>1.5</td>
<td>0.48</td>
</tr>
<tr>
<td>Fine sands (%)</td>
<td>0.32</td>
<td>0.65</td>
<td>0.33</td>
<td>0.66</td>
</tr>
<tr>
<td>Coarse sands (%)</td>
<td>0.51</td>
<td>0.66</td>
<td>0.52</td>
<td>0.65</td>
</tr>
<tr>
<td>C (%)</td>
<td>0.008</td>
<td>0.005</td>
<td>0.008</td>
<td>0.005</td>
</tr>
<tr>
<td>N (%)</td>
<td>0.005</td>
<td>0.008</td>
<td>0.005</td>
<td>0.008</td>
</tr>
<tr>
<td>Total-P (ppm)</td>
<td>10.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Olsen-P (ppm)</td>
<td>0.17</td>
<td>0.46</td>
<td>0.17</td>
<td>0.17</td>
</tr>
<tr>
<td>Ca (meq/100g)</td>
<td>0.17</td>
<td>0.21</td>
<td>0.17</td>
<td>0.22</td>
</tr>
<tr>
<td>Mg (meq/100g)</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Exchangeable K</td>
<td>0.01</td>
<td>0.005</td>
<td>0.017</td>
<td>0.01</td>
</tr>
<tr>
<td>Total K (meq/100g)</td>
<td>0.12</td>
<td>0.33</td>
<td>0.13</td>
<td>0.34</td>
</tr>
<tr>
<td>CEC</td>
<td>3.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.6&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>pH H₂O</td>
<td>0.22</td>
<td>0.12</td>
<td>0.21</td>
<td>0.13</td>
</tr>
<tr>
<td>pH KCl</td>
<td>0.22</td>
<td>0.08</td>
<td>0.22</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Table 1c. Soil physicochemical characteristics of the different situations of the site III. Numbers with the same letter per line are not significantly different (n=3, p<0.005)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>0-10</th>
<th>20 cm</th>
<th>0-10</th>
<th>20 cm</th>
<th>0-10</th>
<th>20 cm</th>
<th>0-10</th>
<th>20 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clays (%)</td>
<td>(0.33)</td>
<td>(0.9)</td>
<td>(0.33)</td>
<td>(0.9)</td>
<td>(0.33)</td>
<td>(0.9)</td>
<td>(0.33)</td>
<td>(0.9)</td>
</tr>
<tr>
<td>Fine silts (%)</td>
<td>(0.29)</td>
<td>(0.53)</td>
<td>(0.3)</td>
<td>(0.53)</td>
<td>(0.28)</td>
<td>(0.53)</td>
<td>(0.3)</td>
<td>(0.53)</td>
</tr>
<tr>
<td>Coarse silts (%)</td>
<td>(0.6)</td>
<td>(0.9)</td>
<td>(0.61)</td>
<td>(0.9)</td>
<td>(0.61)</td>
<td>(0.9)</td>
<td>(0.6)</td>
<td>(0.9)</td>
</tr>
<tr>
<td>Fine sands (%)</td>
<td>(1.06)</td>
<td>(1.1)</td>
<td>(1.06)</td>
<td>(1.1)</td>
<td>(1.06)</td>
<td>(1.1)</td>
<td>(1.06)</td>
<td>(1.1)</td>
</tr>
<tr>
<td>Coarse sands (%)</td>
<td>(1.88)</td>
<td>(2)</td>
<td>(1.88)</td>
<td>(2)</td>
<td>(1.88)</td>
<td>(2)</td>
<td>(1.88)</td>
<td>(2)</td>
</tr>
<tr>
<td>C (%)</td>
<td>(0.01)</td>
<td>(0.008)</td>
<td>(0.01)</td>
<td>(0.008)</td>
<td>(0.01)</td>
<td>(0.008)</td>
<td>(0.01)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>N (%)</td>
<td>(0.9)</td>
<td>(9.2)</td>
<td>9.5</td>
<td>9</td>
<td>9.6</td>
<td>9</td>
<td>9.2</td>
<td>9.1</td>
</tr>
<tr>
<td>C/N</td>
<td>(0.17)</td>
<td>(0.1)</td>
<td>(0.17)</td>
<td>(0.09)</td>
<td>(0.17)</td>
<td>(0.09)</td>
<td>(0.17)</td>
<td>(0.1)</td>
</tr>
<tr>
<td>Total P (ppm)</td>
<td>(1.07)</td>
<td>(0.34)</td>
<td>(1.07)</td>
<td>(0.34)</td>
<td>(1.08)</td>
<td>(0.34)</td>
<td>(1.08)</td>
<td>(0.34)</td>
</tr>
<tr>
<td>Olsen P (ppm)</td>
<td>(0.08)</td>
<td>(0.13)</td>
<td>(0.08)</td>
<td>(0.12)</td>
<td>(0.08)</td>
<td>(0.13)</td>
<td>(0.08)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>Ca (meq/100g)</td>
<td>(0.13)</td>
<td>(0.13)</td>
<td>(0.13)</td>
<td>(0.13)</td>
<td>(0.13)</td>
<td>(0.13)</td>
<td>(0.13)</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Mg (meq/100g)</td>
<td>(0.17)</td>
<td>0.85</td>
<td>0.16</td>
<td>0.8</td>
<td>0.15</td>
<td>0.9</td>
<td>0.17</td>
<td>0.9</td>
</tr>
<tr>
<td>Exchangeable K</td>
<td>(0.01)</td>
<td>(0.05)</td>
<td>(0.01)</td>
<td>(0.05)</td>
<td>(0.01)</td>
<td>(0.05)</td>
<td>(0.01)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Total K (meq/100g)</td>
<td>(0.1)</td>
<td>(0.1)</td>
<td>(0.1)</td>
<td>(0.1)</td>
<td>(0.1)</td>
<td>(0.1)</td>
<td>(0.1)</td>
<td>(0.1)</td>
</tr>
<tr>
<td>CEC</td>
<td>(0.13)</td>
<td>(0.22)</td>
<td>(0.13)</td>
<td>(0.22)</td>
<td>(0.13)</td>
<td>(0.22)</td>
<td>(0.13)</td>
<td>(0.22)</td>
</tr>
<tr>
<td>pH H₂O</td>
<td>(0.25)</td>
<td>(0.25)</td>
<td>(0.25)</td>
<td>(0.25)</td>
<td>(0.25)</td>
<td>(0.25)</td>
<td>(0.25)</td>
<td>(0.25)</td>
</tr>
<tr>
<td>pH KCl</td>
<td>(0.33)</td>
<td>(0.29)</td>
<td>(0.33)</td>
<td>(0.29)</td>
<td>(0.33)</td>
<td>(0.29)</td>
<td>(0.33)</td>
<td>(0.29)</td>
</tr>
</tbody>
</table>

PC: permanent cultivated field; YF: young fallow; IFA: improved fallow with Andropogon gayanus; OF: old fallow.
4.2 Floristic Characteristics

With exception of permanent fields, the floristic records obtained characterize the vegetation of fallow lands (table 2). However, there are species characteristic of old fallows such as *A. gayanus* in herbaceous plants and *Pterocarpus erinaceus* in woody plants. This flora remains fairly uniform and less diversified compared to other vegetal formations in the region. In the 3 sites, old fallows, despite their advanced resting stage compared to young fallows, do not present a significant floristic richness.

Table 2. floristic characteristics of the sites studied (most represented species)

<table>
<thead>
<tr>
<th>Site I</th>
<th>PC</th>
<th>YF</th>
<th>IFA</th>
<th>OF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation</td>
<td><em>Sorghum bicolor</em></td>
<td><em>Rottboelia exaltata,</em></td>
<td><em>Acacia polyacantha,</em></td>
<td><em>Andropogon gayanus,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Vitellaria paradoxa</em></td>
<td><em>Acacia sieberiana,</em></td>
<td><em>Pilostigma thonningii,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Pennisetum polystachyon,</em></td>
<td><em>Vitellaria paradoxa,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Desmodium velutinum</em></td>
<td><em>Anogeissus leiocarpus</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site II</th>
<th>PC</th>
<th>YF</th>
<th>IFA</th>
<th>OF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation</td>
<td><em>Gossypium spp</em></td>
<td><em>Andropogon pseudapricus,</em></td>
<td><em>Vitellaria paradoxa,</em></td>
<td><em>Andropogon gayanus,</em></td>
</tr>
<tr>
<td></td>
<td><em>Pennisetum typhoides</em></td>
<td><em>Tephrosia pedicellata</em></td>
<td><em>Pterocarpus erinaceus,</em></td>
<td><em>Pennisetum polystachyon,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Prosopis africana</em></td>
<td><em>Andropogon pseudapricus,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Tephrosia pedicellata,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Terminalia avicennoides,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Vitellaria paradoxa</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site III</th>
<th>PC</th>
<th>YF</th>
<th>IFA</th>
<th>OF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation</td>
<td><em>Zea mays</em></td>
<td><em>Andropogon pseudapricus,</em></td>
<td><em>Vitellaria paradoxa,</em></td>
<td><em>Andropogon gayanus,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Borreria stachydea,</em></td>
<td><em>Pterocarpus erinaceus,</em></td>
<td><em>Borreria stachydea,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Anogeissus leiocarpus,</em></td>
<td><em>Terminalia avicennoides,</em></td>
<td><em>Paspalum orbicurae,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Terminalia avicennoides,</em></td>
<td><em>Prosopis africana</em></td>
<td><em>Bulbostylis filamentosa,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Vitellaria paradoxa</em></td>
<td></td>
<td><em>Vitellaria paradoxa</em></td>
</tr>
</tbody>
</table>

PC: permanent cultivated field; YF: young fallow; IFA: improved fallow with *Andropogon gayanus*; OF: old fallow.

4.3 Soil Macrofauna Specific Diversity

One hundred seventy-two (172) different morphotypes were founded (table 3). We notice a dominance of arthropods, with 56 species of Coleoptera and 24 species of social insects on 115 species of insects and 31 species of Chelicerae. The specific richness was determined for each microsite (under trees and in open areas), each site and each situation (treatment).
Table 3. Description of different morphotypes identified

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beetles:</td>
<td>56</td>
</tr>
<tr>
<td>-15 larvae</td>
<td></td>
</tr>
<tr>
<td>-38 adults</td>
<td></td>
</tr>
<tr>
<td>-3 pupae</td>
<td></td>
</tr>
<tr>
<td>Arachnids:</td>
<td>29</td>
</tr>
<tr>
<td>-25 spiders</td>
<td></td>
</tr>
<tr>
<td>-3 mites</td>
<td></td>
</tr>
<tr>
<td>-1 white round larva</td>
<td></td>
</tr>
<tr>
<td>Ants</td>
<td>17</td>
</tr>
<tr>
<td>Diptera</td>
<td>10</td>
</tr>
<tr>
<td>Heteroptera</td>
<td>9</td>
</tr>
<tr>
<td>Termites</td>
<td>7</td>
</tr>
<tr>
<td>Thysanurans</td>
<td>5</td>
</tr>
<tr>
<td>Hymenoptera</td>
<td>2</td>
</tr>
<tr>
<td>Earthworms</td>
<td>5</td>
</tr>
<tr>
<td>Iules</td>
<td>4</td>
</tr>
<tr>
<td>Lepidoptera</td>
<td>3</td>
</tr>
<tr>
<td>Centipedes</td>
<td>2</td>
</tr>
<tr>
<td>Chilopoda</td>
<td>2</td>
</tr>
<tr>
<td>Homoptera</td>
<td>2</td>
</tr>
<tr>
<td>Orthoptera</td>
<td>2</td>
</tr>
<tr>
<td>indeterminate larvae</td>
<td>2</td>
</tr>
<tr>
<td>Pseudoscorpion</td>
<td>1</td>
</tr>
<tr>
<td>geophile</td>
<td>1</td>
</tr>
<tr>
<td>Scorpio</td>
<td>1</td>
</tr>
<tr>
<td>antlion</td>
<td>1</td>
</tr>
<tr>
<td>Dermaptera</td>
<td>1</td>
</tr>
<tr>
<td>Embiopter</td>
<td>1</td>
</tr>
<tr>
<td>Isopod</td>
<td>1</td>
</tr>
</tbody>
</table>

4.4 Population Density

There are on average more individuals in sites I and II, with respectively 595 and 492 individuals/m² than in site III with only 232 individuals/m² (figure 3)

![Figure 3. Density of invertebrates in the studied sites. Histograms with the same letter are not significantly different at the 5 % level](image)
4.4.1 Population Density According to the Different Groups

The different taxonomic groups are distributed in the same way. Termites dominate with a density three times higher than that of earthworms in sites I and II (300 termites for 200 earthworms) and twice as much in site III (100 termites for 50 earthworms) (figure 4). The densities of each group of invertebrates follow the gradient of fertility.

![Figure 4](image.png)

Figure 4. Distribution of population densities according to the different taxonomic groups in the sites

Senapati et al. 1996 and Decaens et al. 1996 defined the index which gives an idea of the quality of the soil which corresponds to the ratio of earthworms/termites. Table 4 gives the indices of the soil quality for the different sites. The index is generally lower in the fields and higher in the old fallows.

Table 4. Average soil quality index of the different sites

<table>
<thead>
<tr>
<th></th>
<th>Site I</th>
<th>Site II</th>
<th>Site III</th>
</tr>
</thead>
<tbody>
<tr>
<td>OF</td>
<td>0.04</td>
<td>0.13</td>
<td>3</td>
</tr>
<tr>
<td>YF</td>
<td>0.096</td>
<td>0.66</td>
<td>0.10</td>
</tr>
<tr>
<td>IFA</td>
<td>0.90</td>
<td>0.48</td>
<td>0.39</td>
</tr>
<tr>
<td>PC</td>
<td>0.028</td>
<td>0.013</td>
<td>0.15</td>
</tr>
</tbody>
</table>

PC: permanent cultivated field; YF: young fallow; IFA: improved fallow with *Andropogon gayanus*; OF: old fallow.

4.4.2 Effects of Site, Treatment and Proximity to Trees

The analysis of variance carried out on the densities of the various groups of invertebrates shows that the site and the treatment factors have significant to very highly significant effects (table 5).

Table 5. Results of the 3 factors variance analysis of macroinvertebrate densities (p = 0.05) (1 = site factor; 2 = treatment factor; 3 = tree factor)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1*2</th>
<th>1*3</th>
<th>2*3</th>
<th>1<em>2</em>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termites</td>
<td>0.0016**</td>
<td>0.0002**</td>
<td>0.52 ns</td>
<td>0.028*</td>
<td>0.99 ns</td>
<td>0.002**</td>
<td>0.07 ns</td>
</tr>
<tr>
<td>Earthworms</td>
<td>0.045*</td>
<td>0***</td>
<td>0.12 ns</td>
<td>0.0026**</td>
<td>0.033**</td>
<td>0.003</td>
<td>0.17 ns</td>
</tr>
<tr>
<td>Diploponds</td>
<td>0***</td>
<td>0***</td>
<td>0.15 ns</td>
<td>0***</td>
<td>0.0001***</td>
<td>0.85 ns</td>
<td>0.006**</td>
</tr>
<tr>
<td>Chilopoda</td>
<td>0.021*</td>
<td>0.00001***</td>
<td>0.28 ns</td>
<td>0.01*</td>
<td>0.88 ns</td>
<td>0.11 ns</td>
<td>0.009**</td>
</tr>
<tr>
<td>Coleoptera</td>
<td>0.0018**</td>
<td>0.00005***</td>
<td>0***</td>
<td>0.11 ns</td>
<td>0.55 ns</td>
<td>0.31 ns</td>
<td>0.103 ns</td>
</tr>
</tbody>
</table>

ns: not significant; *: significant; **: very significant; ***: very highly significant.
The results of the analysis of variance on the average of macroinvertebrate densities per site are presented in tables 6 a, b and c.

Table 6 a. Analysis of variance on the means of density of macroinvertebrates according to the site. Values with the same letter per line are not significantly different at the 5% level

<table>
<thead>
<tr>
<th>Site</th>
<th>Termites</th>
<th>Earthworms</th>
<th>Diplopods</th>
<th>Chilopods</th>
<th>Coleoptera</th>
<th>Ants</th>
<th>Arachnids</th>
<th>Diptera</th>
<th>Others</th>
<th>Total density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site I</td>
<td>281.93a</td>
<td>89.71a</td>
<td>21.51b</td>
<td>9.95ab</td>
<td>50.70a</td>
<td>18.21a</td>
<td>4.14a</td>
<td>4.61a</td>
<td>11.17a</td>
<td>491.93a</td>
</tr>
<tr>
<td></td>
<td>(43.4)</td>
<td>(13.11)</td>
<td>(9.36)</td>
<td>(11.17)</td>
<td>(12.45)</td>
<td>(29.09)</td>
<td>(6.09)</td>
<td>(7.13)</td>
<td>(10.55)</td>
<td>(19.82)</td>
</tr>
<tr>
<td>Site II</td>
<td>326.07a</td>
<td>66.06ab</td>
<td>58.84a</td>
<td>15.92a</td>
<td>50.70a</td>
<td>23.27a</td>
<td>7.66a</td>
<td>9.36a</td>
<td>7.66a</td>
<td>595.54a</td>
</tr>
<tr>
<td>Site III</td>
<td>94.69b</td>
<td>53.84b</td>
<td>20.65b</td>
<td>7.13b</td>
<td>28.07b</td>
<td>15.92a</td>
<td>3.24a</td>
<td>2.80a</td>
<td>6.08a</td>
<td>232.42a</td>
</tr>
<tr>
<td></td>
<td>(50.7)</td>
<td>(19.32)</td>
<td>(9.36)</td>
<td>(9.36)</td>
<td>(11.17)</td>
<td>(11.17)</td>
<td>(6.09)</td>
<td>(6.60)</td>
<td>(6.08)</td>
<td>(27.06)</td>
</tr>
</tbody>
</table>

Between the various treatments, young fallows with an average total density of 835 individuals/m² contain twice as much fauna as permanently cultivated fields (446 ind./m²) and improved fallows of A. gayanus (449 ind./m²) and up to four times more than old fallows (196 ind./m²) (figure 5 and table 6 b).

The density of Termites, Earthworms, Diplopods and Chilopods are identical for the young fallow and improved fallows with A. gayanus because they contain the highest densities of each of these taxonomic groups. Similarly, we notice that these are the permanently cultivated fields that contain the most Coleoptera, with 72 individuals/m² against 48 in the young fallows, 31 in the improved fallows with A. gayanus and 28 in the old fallows (figure 5).

Figure 5. Distribution of population densities according to treatments. PC: permanent cultivated field; YF: young fallow; IFA: improved fallow with Andropogon gayanus; OF: old fallow. Histograms with the same letter are not significantly different at the 5 % level.
Table 6b. Results of variance analyses on population densities according to the treatment. Values with the same letter per row are not significantly different at the 5% level

<table>
<thead>
<tr>
<th></th>
<th>OF</th>
<th>PC</th>
<th>YF</th>
<th>IFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termites</td>
<td>82.65  (34.60)</td>
<td>288.8  (35.77)</td>
<td>501.75  (58.84)</td>
<td>140.36  (53.84)</td>
</tr>
<tr>
<td>Earthworms</td>
<td>31.22  (14.49)</td>
<td>15.2  (16.67)</td>
<td>171.98  (17.43)</td>
<td>176.36  (13.11)</td>
</tr>
<tr>
<td>Diplopods</td>
<td>21.51  (9.36)</td>
<td>11.8  (11.80)</td>
<td>52.25  (9.36)</td>
<td>52.25  (8.78)</td>
</tr>
<tr>
<td>Chilopods</td>
<td>4.14  (5.58)</td>
<td>4.61  (7.13)</td>
<td>20.65  (12.45)</td>
<td>16.67  (13.79)</td>
</tr>
<tr>
<td>Coleoptera</td>
<td>28.06  (7.13)</td>
<td>71.93  (14.49)</td>
<td>47.7  (9.95)</td>
<td>31.22  (13.11)</td>
</tr>
<tr>
<td>Ants</td>
<td>12.45  (19)</td>
<td>25.13  (21.06)</td>
<td>24.19  (17.43)</td>
<td>16.67  (22.38)</td>
</tr>
<tr>
<td>Arachnids</td>
<td>4.14  (6.6)</td>
<td>4.14  (4.61)</td>
<td>7.13  (8.22)</td>
<td>4.14  (6.60)</td>
</tr>
<tr>
<td>Diptera</td>
<td>5.09  (7.13)</td>
<td>8.78  (11.80)</td>
<td>4.14  (5.09)</td>
<td>5.09  (6.09)</td>
</tr>
<tr>
<td>Others</td>
<td>7.66  (7.66)</td>
<td>8.20  (7.11)</td>
<td>5.58  (7.13)</td>
<td>6.60  (9.36)</td>
</tr>
<tr>
<td>Total density</td>
<td>196.92  (14.49)</td>
<td>438.66  (23.27)</td>
<td>835.37  (21.51)</td>
<td>449.36  (25.13)</td>
</tr>
</tbody>
</table>

PC: permanent cultivated field; YF: young fallow; IFA: improved fallow with Andropogon gayanus; OF: old fallow.

The presence of trees significantly affects the distribution of Coleoptera regardless of the treatment or the site, with on average three times more individuals per m² at the foot of trees (Table 6c). For the other groups, no significant difference appears although the total density is higher in all groups except Arachnids.

Table 6c. Results of variance analyses on population densities according to the presence of trees. Values with the same letter per row are not significantly different at the 5% level

<table>
<thead>
<tr>
<th></th>
<th>Trees Foot</th>
<th>Open area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termites</td>
<td>226.17  (44.83)</td>
<td>185.43  (43.44)</td>
</tr>
<tr>
<td>Earthworms</td>
<td>78.21  (14.49)</td>
<td>60.58  (16.67)</td>
</tr>
<tr>
<td>Diplopods</td>
<td>34.60  (9.36)</td>
<td>28.07  (9.95)</td>
</tr>
<tr>
<td>Chilopods</td>
<td>11.80  (7.66)</td>
<td>9.36  (11.80)</td>
</tr>
<tr>
<td>Coleoptera</td>
<td>64.19  (9.95)</td>
<td>26.08  (12.45)</td>
</tr>
<tr>
<td>Ants</td>
<td>26.08  (23.27)</td>
<td>13.11  (19)</td>
</tr>
<tr>
<td>Arachnids</td>
<td>4.14  (5.58)</td>
<td>5.09  (7.66)</td>
</tr>
<tr>
<td>Diptera</td>
<td>7.66  (9.95)</td>
<td>3.68  (4.61)</td>
</tr>
<tr>
<td>Others</td>
<td>9.36  (10.55)</td>
<td>7.13  (8.22)</td>
</tr>
<tr>
<td>Total density</td>
<td>462.21  (19.82)</td>
<td>338.53  (21.51)</td>
</tr>
</tbody>
</table>

The interaction between site and treatment factors is significant for the measurement of the density of Termites, Earthworms, Diplopods and Chilopods. The young fallow in the site I contained significantly more individuals (Termites, Chilopods and Diplopods) than all other treatments, which is easily understandable given the high density of termites (1998 individuals/m²) (table 7).

Table 7. Results of the test comparing the means of densities according to the site/treatment interaction. Values with the same letter per row are not significantly different at the 5% level

<table>
<thead>
<tr>
<th></th>
<th>Site I</th>
<th>Site II</th>
<th>Site III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OF</td>
<td>YF</td>
<td>IFA</td>
</tr>
<tr>
<td>Termites</td>
<td>147</td>
<td>1998</td>
<td>97.27</td>
</tr>
<tr>
<td>Earthworm</td>
<td>15.2</td>
<td>159.4</td>
<td>255.7</td>
</tr>
<tr>
<td>Diplopods</td>
<td>16.67</td>
<td>176.3</td>
<td>94.69</td>
</tr>
<tr>
<td>Chilopods</td>
<td>5.09</td>
<td>149.18</td>
<td>16.7</td>
</tr>
</tbody>
</table>

PC: permanent cultivated field; YF: young fallow; IFA: improved fallow with Andropogon gayanus; OF: old fallow.
The interaction between these factors does not affect the Beetle populations. In this group, the aggregate distribution (at trees foot) is not influenced by the different sites. The effect of the interaction between sites and the presence of trees is very significant within the Earthworm and Diplopods populations (table 7). For earthworms, all distributions are homogeneous, with an average of 64 individuals per m², except for those at trees foot on the site II (110 individuals/m²) and in the open area on the site III (37 individuals/m²) where the averages are significantly different. The "tree presence" effect plays a role according to the land management method in the case of earthworm and termite populations. Finally, the three factors combined significantly influence the distribution of Diplopoda and Chilopoda.

4.5 Macrofauna Vertical Distribution

Regardless of the site studied, the vertical distribution of the macrofauna is the same: the first 10 cm contains more animals with an average of 60% of the total density. The litter and the 20-30 cm layer contain fewer individuals (8 and 12% respectively). The intermediate level is the 10-20 cm layer with 20%. However, there are some exceptions in the permanent cultivated field of the site II and the improved fallow with A. gayanus in the open area of the site III where the 10-20 cm layer contains more individuals (respectively around 40 and 60%) (table 8).

<table>
<thead>
<tr>
<th>Site</th>
<th>Under trees</th>
<th>Open area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Litter</td>
<td>10 cm</td>
</tr>
<tr>
<td>Site I</td>
<td>OF</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>PC</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>YF</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>IFA</td>
<td>10%</td>
</tr>
<tr>
<td>Site II</td>
<td>OF</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>PC</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>YF</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>IFA</td>
<td>30%</td>
</tr>
<tr>
<td>Site III</td>
<td>OF</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>PC</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>YF</td>
<td>18%</td>
</tr>
<tr>
<td></td>
<td>IFA</td>
<td>16%</td>
</tr>
</tbody>
</table>

PC: permanent cultivated field; YF: young fallow; IFA: improved fallow with Andropogon gayanus; OF: old fallow.

5. Discussion

The sites studied have a high faunal diversity with 172 morphotypes sampled. Our sample is comparable to that of Mathieu (2004) in the forests and pastures of Central Amazonia where he obtained 156 morphotypes. On the scale of the 3 sites we have less than 100 different species, this number decreases further at the plot scale. On average, there are 30 different species in the old fallow, 42 in the young fallow, 31 in the improved fallow with A. gayanus, and 50 in the field. These results are surprising given that cultivation generally decreases species diversity, but understandable because the fields are the richest in Coleoptera. Trees are refuge areas for beetles, especially in fields and young fallow land, but the population density is not higher there. The study area is thus characterized by a fairly high diversity of soil macroinvertebrate populations. The soil fertility can explain the differences observed. Thus, there is a decreasing distribution along the fertility gradient (site I: 595 individuals/m²; site II: 492 individuals/m² and site III: 232 individuals/m²). This is very noticeable for termites, earthworms and beetles. In general, permanently cultivated fields and
old fallow lands are the least populated, whereas regenerating environments, symbolized by young fallow lands and improved fallow with A. gayanus have more abundant populations. Ayuke et al. (2009) also noted the same in their study. The hydromorphic nature of the soil may also explain these differences observed. A humid soil is favorable for the burial of macrofauna populations. This humidity, associated with plant debris, contributes to improving the structure of the soil. Because loose and well-aerated soil favor the exploration of deep layers. But beyond a certain depth, the absence of debris makes the soil structure very compact and difficult to explore by the macrofauna. As Szyszko-Podgórska et al. (2018) showed in their study, which corroborates our observations.

On the other hand, the fact that high densities of macrofauna are found in the 0-10 cm soil layer can be explained by the important presence of roots at this level of the soil, defined as the biologically active zone for plants. This is because plant debris consisting of leaves and roots are buried at this depth. It is therefore a rich zone for plants and soil macrofauna.

Beyond 10 cm the distribution of macrofauna is less important because the root activity which maintains the biological life of the soil is low. The distribution then decreases from the surface to the depth. Our work is similar to that of Sembiring et al. (2021) who showed that the thickness of an Andisol strongly influences the vertical distribution and diversity of the macrofauna.

This positive effect of permanent cultivated field populations can be partly explained by the maintenance of trees, which play a role in species conservation (Lavelle et al., 1998). The low degree of intensification and the regular supply of manure may explain why the crop has little impact on the macroinvertebrate populations. It is also assumed that the environment as a whole is already degraded, which would explain the low effect of annual crops. A sampling of natural environments that have never been cultivated before would allow this to be verified.

The succession of the fallow vegetation follows a chronological order that helps the repopulation of the soil macrofauna. From the field abandonment to the 5 years old fallow, we have vegetation dominated by grasses. These grasses are nests that serve as refuges and starting points for the populations of soil macrofauna. In our case, the dynamics of the soil macrofauna begins at the foot of the trees in the recently abandoned fields. Gradually, during the succession of fallow vegetation, the different species and types of macrofauna will proliferate until they colonize the spaces that are favorable for their reproduction. Thickets of perennial grasses and the feet of trees are the best areas that we have identified. Zulu et al. (2022) have observed the same pattern.

The invertebrate population of the improved fallow with A. gayanus does not differ significantly from that of the young fallow, except for Termites which are less numerous. It is, therefore, possible that the fodder of this grass, which is less appreciated by Termites, is more appreciated by other decomposers who can thus incorporate it into the soil. The nature of the vegetation in young fallows compared to those improved with A. gayanus may explain this similarity. The easy decomposition of plant debris by certain species of macrofauna justifies their abundance in the 5 years old fallow. Because the latter is covered by vegetation composed of annual and perennial herbaceous plants and some woody plants. In contrast, the improved A. gayanus fallow is exclusively dominated by perennial grasses. It is, therefore, assumed that the food resources available to the macrofauna in the two fallows are identical according to the vegetation stage. This finding is consistent with those of Mathieu (2004) in Brazil.

6. Conclusion
This study provided answers about the behavior of soil macrofauna under different land management practices. In general, soil invertebrates respond well to anthropogenic environments. The young fallow and the improved A. gayanus fallow maintain a certain diversity of populations. The natural systems that are being reconstituted have the most individuals. Hence, there are significantly more Termites, while all other groups are evenly distributed. Plots under permanent cultivation have a very negative effect on the distribution of earthworms and Diploponds, compared to other species. The old fallow land, on the other hand, had few individuals compared to the other situations, but its diversity was equivalent to that of the young short natural fallow land.

Our two hypotheses are thus verified, despite the lack of a clear difference in the macrofauna population between the young fallow and the fallow improved with A. gayanus at the same age.

To maintain the invertebrate population and to encourage their expansion from cultivated plots to fallow areas, we suggest leaving strips of A. gayanus along the cultivated areas. This would provide a starting point for large-scale colonization once the crops are abandoned. A more detailed study of the dynamics of the different groups in these different lands management modes could provide us with more information on the processes involved by these invertebrates in the regulation of soil fertility in Bondoukuy.
References


**Copyrights**

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (http://creativecommons.org/licenses/by/4.0/).