Universidade de Aveiro
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Departamento de Ambiente e
Ordenamento

Tiago van der Worp da Silva

The short-term effects of mulching on the soil-dwelling arthropod community after a wildfire

Os efeitos no curto prazo da aplicação de *mulch* sobre a comunidade de artrópodes que vivem no solo após um incêndio florestal

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia do Ambiente, realizada sob a orientação científica da Doutora Filomena Maria Cardoso Pedrosa Ferreira, Professora Associada do Departamento de Ambiente e Ordenamento da Universidade de Aveiro e coorientação do Doutor Nelson Abrantes, investigador auxiliar do Centro de Estudos do Ambiente e do Mar (CESAM), Departamento de Ambiente e Ordenamento da Universidade de Aveiro, e Doutor Jan Jacob Keizer, Investigador Auxiliar do CESAM e Departamento de Ambiente e Ordenamento da Universidade de Aveiro.

Esta dissertação foi desenvolvida no âmbito do projeto europeu do FP7:

"RECARE – Preventing and Remediating degradation of soils in Europe through Land Care" (no. 603498)

o júri

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agradecimentos

À orientação muito próxima e muito enriquecedora facultada pela Prof. Doutora Filomena Martins, pelo Doutor Nelson Abrantes e Doutor Jan Jacob Keizer.

Ao Doutor Jan Jacob Keizer pela oportunidade dada em trabalhar e colaborar no seio de um grupo de investigação.

Em especial ao João Puga por toda a disponibilidade, crítica, conselhos, constante apoio e partilha de conhecimento.

À minha família por me proporcionar sempre o melhor e pelo apoio incondicional neste percurso.

À Mariana pela presença sempre muito especial.

A todas as amizades e aprendizagens que nutri durante este percurso e que levo para a vida.

keywords

mulching effects, wildfires, ground-dwelling arthropods

abstract

Forest fires are common events in the Mediterranean basin, but due to human action and climate change, these have been increasing, especially in Portugal. It is in this context that a larger number of studies have emerged in regard to the impacts of forest fires on ecosystems, with special focus on the effects on soil and mitigation strategies in the post-fire period. In this regard, the application of mulch is one of the mitigation strategies studied since it is considered inexpensive and effective in reducing erosion and loss of soil nutrients in the post-fire. Moreover, the impacts of organic coverages application on soil fauna are still poorly understood. This study aims to assess the effect of the application of various mulch densities in the soil on the invertebrate community in a eucalyptus plantation, immediately after the fire. The ground fauna covered in this study were soil arthropods, a large existing community regarded as reliable bio-indicators. The type of mulch used was chopped eucalyptus bark. The study area, located in North-Central region of Portugal, is characterized by eucalyptus plantations in a schist soil. This study was conducted in order to understand the extent of the effects that mulch could produce in a short period after a fire. In order to achieve adequate results, different areas with and without the application of mulch, at different densities were selected and monitored for 5 months after the fire. Sampling was carried out with pitfall traps and identification of the collected specimens was made at Order level. The results suggest differences between the monitoring months and absence of differences among the densities of mulch application, suggesting seasonality as influence factor on the total community abundance. Small differences in the community richness suggested that a low density of mulch provided a faster ecological succession. The application of mulch also raised the hypothesis that it may have introduced unwanted specimens into the ecosystem.

palavras-chave

efeitos da aplicação de uma camada orgânica, incêndios florestais, artrópodes que vivem no solo

resumo

Os incêndios florestais são eventos comuns na bacia mediterrânica, mas devido à ação do homem e às alterações climáticas, estes têm vindo a aumentar em Portugal. É neste contexto que um maior número de estudos tem surgido, focando-se nos impactes dos incêndios florestais sobre os ecossistemas, e em especial sobre os seus efeitos no solo e em estratégias de mitigação no período pós-incêndio. Neste sentido, a aplicação de coberturas orgânicas sobre o solo é uma das estratégias de mitigação estudada, sendo considerada barata e eficaz na redução da erosão e perda de nutrientes no pós-incêndio. Por outro lado, o conhecimento dos impactes da aplicação de uma cobertura orgânica sobre a fauna presente no solo é ainda escasso. Este estudo pretende avaliar o efeito da aplicação de várias densidades de cobertura orgânica no solo sobre a comunidade de invertebrados do solo em eucaliptais, imediatamente após o incêndio, utilizando como cobertura orgânica raspas de casca de eucalipto. Os invertebrados do solo, formam uma comunidade muito diversa considerada como um bioindicador fiável. A área de estudo, situada na região Centro-Norte de Portugal, é caracterizada por plantações de eucalipto sobre um solo xistoso. A amostragem foi realizada com armadilhas de solo e a identificação dos espécimenes recolhidos foi feita até ao nível da Ordem. Os resultados obtidos sugerem diferenças entre os meses de monitorização e ausência de diferenças entre as densidades de aplicação e sem cobertura orgânica, sugerindo a sazonalidade como um fator de influência sobre a abundância total da comunidade. Pequenas diferenças na riqueza específica da comunidade sugeriram que uma baixa densidade de cobertura orgânica promoveu uma sucessão ecológica mais célere. A aplicação da cobertura orgânica levanta ainda a hipótese de esta ser uma fonte de introdução de espécies indesejadas no ecossistema.

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1. Introduction

1.1 Wildfires and the Portuguese context

A wildfire is an event that takes place in forest setting influenced by existing fuels, climate-weather relations, ignition agents and anthropologic activities (Flannigan, Stocks, Turetsky & Martínez-Mena, 2009), that ultimately produces effects on soil, hydrological regimes, vegetation and fauna (Moreira, Catry, Silva & Rego, 2010). Wildfires are seen as major ecological disturbances, although these have also been one important environmental change factor shaping the landscape in fire-prone ecosystems for millenniums, such has the Mediterranean basin, California, South Africa and Southwest Australia regions (Pausas, Llovet, Rodrigo & Vallego, 2008).

Considering this premise, it is believed that the global climate change scenario will be playing a significant role in increasing changes for fire periods and intensity regimes in the near future (Lavorel, Canadell, Rambal & Terradas, 1998; Bento-Gonçalves, Vieira, Úbeda & Martin, 2012). Larger temperature gaps between seasons as well as longer dry periods and less precipitation will influence directly fire severity and occurrence (Flannigan *et al.*, 2013).

Portugal has not been an exception in the Mediterranean Basin area since it is the European country with the largest record of wildfires and burnt area in the last decade (IPCC, 2013) (Figure 1). Moreover, this scenario is likely to continue in the near future (Bento-Gonçalves *et al.*, 2011).

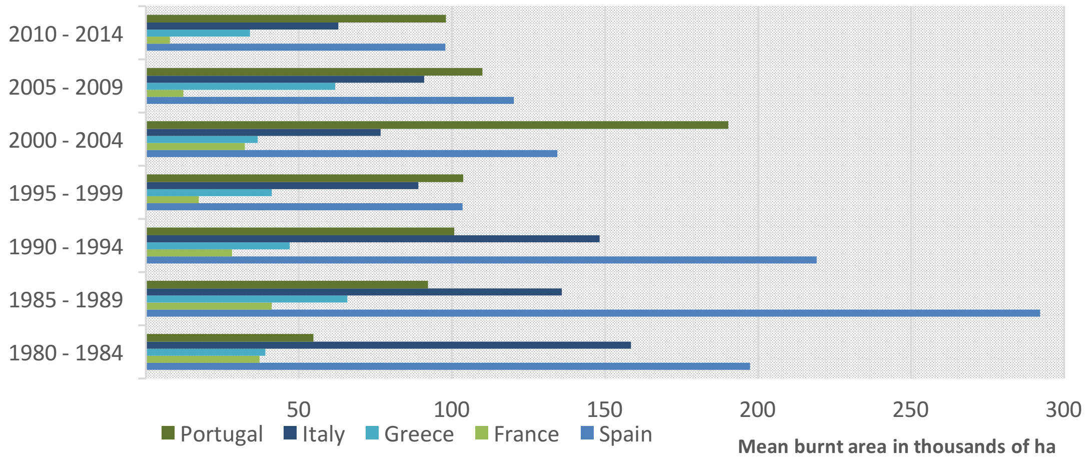

Figure 1. Mean burnt area per year on the Mediterranean climate countries (PORDATA, 2016)

These records are associated not only with the climate regime characterised by wet winter seasons in contrast with dry and hot summer seasons, but also due to socio-economic factors

(ICNF, 2013). These factors include: the extensive and intensive plantations of Eucalypt registered in Portugal that started in the 80's; the rural exodus that has led to the abandonment of forest areas leaving them more exposed to this hazard; and the lack of efficient land management policies that would prevent it (Shakesby, 2011; Shakesby & Doerr, 2006; Keeley *et al.*, 2012).

1.2 Wildfire impacts and studies

A wildfire leads to many effects on the ecosystem either directly or indirectly, by changing soil structure properties that later lead to changes in hydrological and geomorphological processes and consequently changes in the fauna and flora of an ecosystem (Certini, 2005).

Most of the recent studies undertaken in the Mediterranean region have been focused on physical and chemical effects on soil during the post-fire season (Neary, Ryan & DeBano, 2005; Keizer *et al.*, 2008, Shakesby, 2011) in order to comprehend how better coping strategies can be implemented in the pre and post fire periods.

Most of the mitigation strategies are focused on reducing soil erosion by water runoff in the burnt areas, such as: seeding, construction of physical barriers along the slope, scarifying and ploughing, application of hydro-mulch and mulching. These techniques are applied according to the physical characteristics of the burnt field, such as the slope and/or available resources such as rock and logs. In the overall, the most effective, easy to apply and low cost technique is mulching (Ferreira *et al.*, 2015).

Mulching consists on covering the bare soil surface with a biomass layer in order that in small areas, micro-traps are generated, as these will retain ashes and store some of the runoff water in the period after the fire. This technique conducts a very significant reduction of water runoff by 50% that consequently produces a reduction of soil erosion by 90% (Ferreira *et al.*, 2015). This same technique has also been studied and applied in the agricultural context, providing an increase in soil microbial activity, improving nutrient balance, moderating soil temperature and improving water infiltration and reducing soil erosion (Gill, McSorley & Branham, 2011; Chalker-Scott, 2007; Westerman & Bicudo, 2005; Altieri & Nichols, 2003). These advantages have also been observed in the post-fire application context (Ferreira *et al.*, 2015).

Mulching also occurs naturally in the ecosystem, especially in settings that had mid-low severity wildfire events, on which leaves remain on trees and later fall in the soil surface, working in the same way has the mulch application effects (Ferreira *et al.*, 2015; Prats, McDonald, Monteiro, Ferreira & Keizer, 2012). Nonetheless, mulch application depends on the local availability and price of the material (biomass) in order to be a feasible solution. Many materials have been proven to work effectively like straws, woodchips and hydro-mulch, although forest residuals have not been subjected to the same scrutiny (Ferreira *et al.*, 2015).

In that regard, studies in Portugal have looked into forest residues has a mulching material considering its availability, cost and also the density of its application (Prats *et al.*, 2012).

Following up the studies that focus on the effectiveness of mulching in the reduction of soil loss in burnt areas, awareness has risen to other effects that this technique might produce, specially to the soil-dwelling arthropod communities (Puga, 2016), which are widely affected by wildfires (Elia, Lafortezza, Tarasco, Colangelo & Sanesi, 2012).

1.3 Ground-dwelling arthropods

The soil is one of the most complex systems in Earth, although its biological systems are yet to be fully explored. It's the living surface for at least one or more stages of a life cycle for many animals, meaning that most, if not all, terrestrial organisms depend directly and indirectly on biological processes in the soil (Stork *et al.*, 1992).

The *Arthropoda* phylum roughly accounts for three quarters of the Earth's organisms having the most diverse *taxa* of invertebrates and being present in both water and land ecosystems. Arthropods are characterized by segmented bodies, with bilateral symmetry and chitin exoskeletons (McGavin, 2010).

The ground-dwelling arthropods are the ones who inhabit the leaf litter in the soil and range in many different forms and functions while acting has decomposers, playing a very important role on nutrient cycling and soil structure maintenance and fertility; as prey and predator, regulating populations of other organisms and enhancing the food-web; and also in enabling flowering plant reproduction (García-Domíngez, Arevalo & Calvo, 2010; Buddle *et al.,* 2005; Danks, 1992; Kremen *et al*., 1993 and Wiggins, Marshall & Downes, 1991).

In an ecological community, the ground-dwelling arthropods can be extremely susceptible to shocks that may alter their living environments and therefore being regarded as bio-indicators for accessing ecological changes due to their habitat requirements and potential sensitivity to changes and/or threats. Hence, arthropods have been widely studied as bio-indicators for pollution, habitat disturbance and climate change (McGeoch, 1998).

The threats that affect the integrity and resilience of this group in the Mediterranean ecosystems varied from habitat fragmentation, human exploitation, pest outbreaks, invasion of exotic species, overgrazing and forest fires (Elia *et al.*, 2012; Penman, Beukers, Kavanagh & Doherty, 2011). Forest fires conduct severe impacts on ecological communities directly, through mortality induced by heat and smoke (Gerson & Kelsey, 1997), and indirect by altering vegetation structure in the post-fire period (Whelan, 1995; Pickering, 1997). However, the extent of severity from these impacts is also dependent on the fire severity (Certini, 2005).

If fact, few studies have been conducted to assess the response of this group in the post-fire period. Nunes *et al.* (2006) found a decreasing tendency in ground beetle abundance in a Mediterranean Pine forest, proving that the fire does alter the ecological community composition. Although the short-term response of insect communities to fire remains to be fully explored in Mediterranean forest ecosystems, especially when post-fire effect mitigation techniques come to action.

Another study conducted by Puga (2016) focused on the effects of mulching on ground-dwelling arthropods, but on a later stage of the ecosystem recovery, approximately 5 years after the fire event. In this study it was observed a homogenous community in either mulched and untreated plots, suggesting that at an earlier stage after a wildfire, the presence of mulch can be of bigger influence on the re-establishment of the ground-dwelling arthropods, by possibly promoting a faster recovery on an early stage.

Hence, this study follows up the study undertook by Puga (2016), by focusing on the short-term impact of mulching on the re-establishment of ground-dwelling arthropods in a burnt eucalypt plantation area.

1.4 Research objectives

The main questions addressed by this study were:

1. How does the ground-dwelling arthropod community responds to fire-induced ecosystem alterations in the first month after the wild-fire event:
    1.1. Which are the main *taxa* present during this period?
2. How do the abundance and diversity of the ground-dwelling arthropod community change with time since the wildfire in the presence of mulch as opposed to without it?
    2.1. Is mulch promoting a faster recovery?
    2.2. Is mulch promoting specific *taxa* or ecological function levels?
    2.3. How does a high and low mulch application density impact the re-establishment of the ground-dwelling arthropod community?

2. Materials and methods

2.1 Study area and Sites

This study was conducted in two sites in the location of Semide, Municipality of Miranda do Corvo: one burnt (40°09'57.8"N 8°19'29.7"W) and one unburnt (40°09'49.9"N 8°19'44.7"W). The areas are located in north-central Portugal.

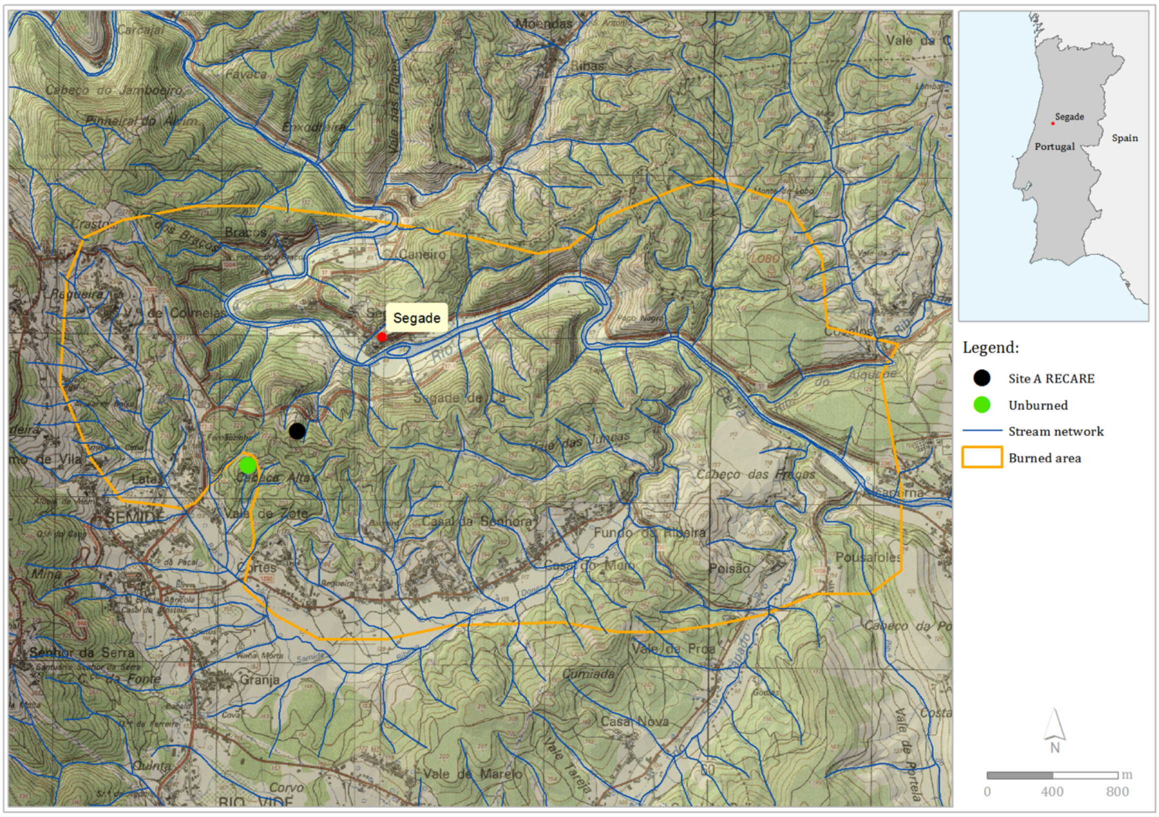

Figure 2: Location of the study fields, Burnt (black) and Unburnt (green).

Between August 9th and 10th, this area was fustigated by a wildfire that burnt approximately 715 ha (Figure 2). The fire severity was recorded between moderate and high, according to the soil severity index of Vega *et al.* (2013).

Regarding wildfire records, the study sites had two wildfires before, in 2000 and 2012.

The area is characterized by steep hills that connect with the Ceira river. The soils derive from pre-Ordovician schists of the Hesperic Massif (Pereira & FitzPatrick, 1995) and are classified according to the IUSS (2014) as acidic loamy Epileptic umbrisol. Soils are texture equilibrated, pH ranges between 4.6 and 4.8 and are rich in soil organic matter, approximately 15-18% into A layer. The climate of the study area can be characterized as humid meso-thermal (Köppen, Csb), with prolonged dry and warm summers. Mean annual temperature at the nearest climate station (CARAPINHAL (13H/09UG), SNIRH, 2012) is 12°C. Mean annual precipitation at the nearest rainfall station (12 km) is, on average, 851 mm (CARAPINHAL (13H/09UG), SNIRH, 2016). The areas are dominated by *Eucalyptus globulus* Labill plantations.

Both sites are eucalypt plantations (burnt and unburnt) that present very similar characteristics, distancing 500 meters away from each other. The burnt and unburnt sites face E-NE and E and have a hill slope degree of 27° and 26°, respectively. The sites were subjected to the same type of sampling of ground-dwelling arthropods: the pitfall trap method.

2.1.1 Sampling methodology and design

Immediately after the fire, a field setting was carried-out in the selected burnt slope to assess the effects of forest residue mulch on runoff and soil erosion. In this field setting, areas to assess the effects of forest residue mulch on the ground-dwelling arthropod community were also installed.

2.1.1.1 Pitfall traps

Figure 3. Picture of an uncovered pitfall trap in the burnt site

Pitfall trapping is the most commonly used collection method for sampling soil invertebrates. It is an efficient and low-cost technique to assess ground-dwelling fauna, despite its disadvantages. It consists, basically, on a cylindrical shaped container (in this case half of a plastic bottle) which is dug in the ground with a rim at surface level that ultimately will trap mobile animals that fall into it. Most of the times, it is slightly covered by rock or something similar in order to camouflage the hole, to protect the trap from sunlight and from other predators (Figure 3).

This method provides reasonable activity-density estimates for groups such beetles (Baars, 1979), spiders and ants (Wang, Strazanac & Butler, 2001).

There are also inevitably biases in pitfall sampling while comparing different groups of animals and different habitats. An invertebrate's probability of being captured depends on the structure of its habitat, such as the density of vegetation; activity of a certain *taxa* (higher physiological activity and/or larger area of influence); animal size, by being too large to be trapped or too small that it is not collected; and also from factors such has temperature and rain, which alter animal's behaviour. Comparisons between different groups must, therefore, take into account variation in habitat structure and complexity, changes in ecological conditions over time and the innate differences in species (Woodcock & Leather, 2007, chap. 3; Spence & Niemela, 1994).

Pitfall traps, while taking into consideration its limitations, are able to provide answers regarding ground-dwelling arthropod richness, which is the number of different taxonomic individuals identified; and abundance, which is the total number of collected individuals disregarding its taxonomical aspects. *Taxa* richness and abundance combined can provide information about the changes on the communities during the sampling period and evaluate how they evolve through time (Abbott & Le Maitre, 2010).

The traps used in this study had 8.5 cm in diameter and 12 cm height plastic bottom bottles. The bottom of the bottle was filled by water, a little bit of ethanol 70% that slows down the degradation of the captured animals and one drop of detergent that breaks the surface tension of the liquid in order to promote quick drowning.

2.1.1.2 Sampling design

A total of 12 pitfall traps were installed at the two study sites, 3 of which at the unburnt site (UNB) and 9 at the burnt site to compare three different treatments: heavy-treatment (HT), low treatment (LT) and no treatment (NT), where treatment stands for the mulch application at different densities. The field installation was performed from September until late October (Figure 4). The applied mulch material was chopped eucalypt bark, which is believed to be the best fit as mulch materials are regarded considering the site's characteristics, availability on site and application cost. The unburnt site acted as a control location being a reference of an ecosystem with very similar characteristics that has not been changed for at least 4 years.

Pitfall sampling was performed for a period of seven days, repeated in the months of September, October, November and January. The selection of sampling months had the intention of following the end of summer, including Autumn, which is a season that comprises many biological events (Gallinat, Primack & Wagner, 2015), and early Winter. The collection days were the 25th of September, the 14th of October, the 25th of November and the 27th of January. The unburnt site installation took place only at the end of October, thus, it only begun to be sampled from November on.

After the first sampling period of September, when no treatment had yet been applied, the plots at the burnt site were mulched: one with a density of mulch material of 0.26 kg.m^{-2} and another with 0.80 kg.m^{-2}; a third plot remained untreated. Each plot measures 2 meters in width and 8 meters on length, spacing 10 meters from each other, with three pitfalls linearly placed and equally spaced along the slope of the hill. The unburnt site followed the same setting, but had only one plot (Figure 4). This design ensured that a first assessment to the ground-dwelling arthropod community could be executed right after the wildfire event and also on later stages, conducting to data that could clarify the questions raised on this study regarding the use of mulch.

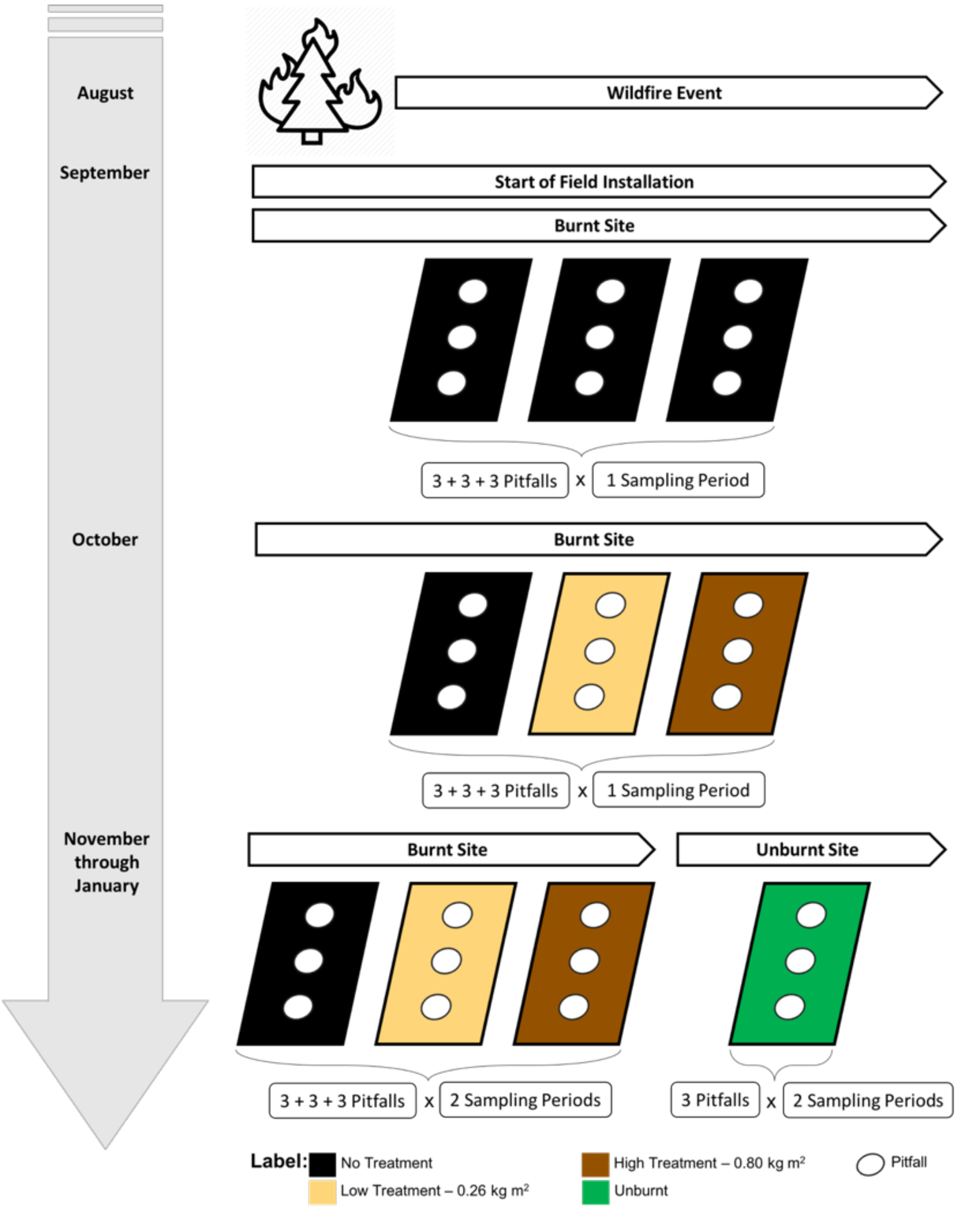

Figure 4. Sampling design display per sampling months.

2.2 Ground-dwelling arthropods collection and identification

Before the sampling period took place, every pitfall trap had to be re-set, in order to guarantee that the collection of arthropods was only from that 7-day period. Re-setting consisted on cleaning the interior of the pitfall and introducing water, ethanol and detergent, as listed before (Chapter 2.2.1). After the 7-day period, the interior of each trap was filtered by a small mesh (± 1mm) and the samples were transferred into a recipient, respectively labelled. The filtering process allowed elimination of accumulated water in the pitfall trap during the sampling period, being a very useful step during winter. However, micro-arthropods (smaller than the mesh size) could have been wasted in this process. Due to this limitation, the *Acari* order collected is considered not to be fully representative.

The samples collected in the field were later analysed in the laboratory. Firstly, a screening from dirt and animals took place (Figure 5). Secondly, a screening at order level from each pitfall was made (Figure 6). The screening process was done with the assistance of a stereoscopic magnifier (Figure 7), in order to easily identify the selected *taxa*. The identification process followed taxonomic keys from Chinery (1993) and was also supported by Barrientos (1988).

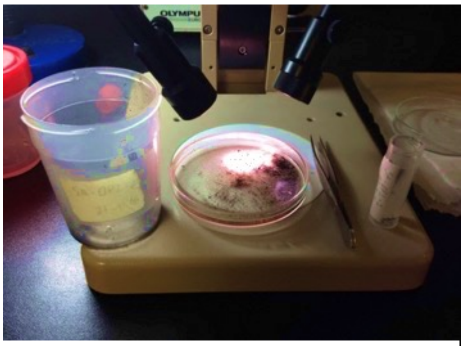

Figure 7. First screening process, separating trapped arthropods from litter.

Figure 6. Second screening, identifying and counting arthropods at order level per pitfall trap.

Figure 5. Stereoscopic magnifier

Identification was only done at the Order level, considering the time effort and the level of expertise needed to identify lower taxonomic levels. Nonetheless, the use of higher taxonomic levels can provide good outcomes when it comes to the study of arthropod communities in several ecosystems (Simão, Carretero, Amaral, Soares & Mateos, 2015). Arthropod larvae were not considered in the community analysis.

2.3 Ecological function

Four ecological functions were recognised for the *taxa* that had been identified in the various samples: microbial feeders, plant feeders, predators and omnivores. The selection of *taxa*, at the order level, for each functional group was performed considering the morphologic features found in the individuals from each sample and also based on Barrientos (1988).

For the group of predators, orders such as *Aranaea, Chilopoda, Opiliones* and *Pseudoscorpiones,* were automatically assumed considering the main morphology found in these orders. *Collembola* were considered as microbial feeders (feeding from fungi and dead organic matter). *Thysanura, Isopoda* and *Hymenoptera* were considered as omnivores. *Hymenoptera* individuals were only ants and therefore, these were also fitted into the omnivore group.

Coleoptera individuals had a sub-sampling procedure to characterise their community, since this order is one of the most diverse when it comes to ecological functions (Rainio & Niemela, 2003). Considering the large number of individuals in some samples, a sub-sampling was adopted to classify the collected specimens per ecological function based on morphological characteristics. On samples with a very larger number of individuals, only 10 specimens were classified.

Acari individuals were not considered in the ecological function since it is not possible to determine their function without identification at family level. *Diptera* was also excluded from these analyses since the sampling method (pitfall trap) is not adequate for this order.

2.4 Environmental variables

The environmental variables considered in this study were rainfall levels and temperature.

The selected environmental variables were collected by a meteorological station also installed by the ESP Team, near to the study sites, on the 24th of September. In order to interpret data provided by this station, which collected data on a 15-minute period, an average of temperature was calculated and the total precipitation was summed in a 10-day period, having at least 3 values for each month. The 10-day period was selected in order to obtain values that would match the number of samples in the four sampling months (3 plots x 4 months) and also considering the level of detail regarding environmental variables intended, which is seasonality.

2.5 Data analysis

The results obtained by the collected samples, after being screened and sorted, were later analysed statistically with SPSS 13.0 and Microsoft Excel 2015.

All *taxa* were analysed at order level, as mentioned before, and the data retrieved was used to calculate ground-dwelling arthropod community's structural parameters: total abundance, total richness, Shannon-Weiner diversity index (H') and Pielou's evenness index (J'). These parameters were organized by sampling months and per plots. The indexes were calculated from total abundance results at a plot level, in which the total abundance was the sum of the 3 pitfall-traps installed on each plot.

The Shannon-Weiner diversity index (H') and the Pielou's evenness index (J') were calculated accordingly to the following formulas.

$$H' = -\sum_{i=1}^{T} p_i ln(p_i)$$

- p_i = fraction of the entire population from order *i*;
- T = number of orders found;
- $\sum$ = sum from order 1 to order *T;*

$$J' = \frac{H'}{H'_{max}}$$

where, $H'_{max} = -\sum_{i=1}^{T} \frac{1}{T}\, ln \frac{1}{T} = \ln T$

- T = number of orders found;

These indexes were calculated accordingly with the total abundance at plot level for each sampling month.

Pearson's correlations were performed in order to comprehend relations between orders and between ecological function groups through the sampling period and also between total abundance and the environmental variables. Correlations were considered significant on a 2-tailed test.

A two-way ANOVA was used to test for significant differences among the months (October, November and January) as well as between treatments (NT, LT and HT) regarding the distinct community parameters analysed (total abundance, diversity and evenness). Specific differences between factors were analysed using the Tukey multiple comparison test. In the case of the ecological function analysis, a One-way ANOVA test was used per factor (months and treatments). Normality and homogeneity of variances of the data were assessed using the Shapiro–Wilk test and the Levene median test, respectively. If data is not statistically normal, a Naperian logarithm (ln) was applied to ensure a normal distribution. All statistical tests were carried out using a α of 0.05.

In the statistical analysis procedure, only total abundance was used. Total richness at order level in this study context displayed very small differences that lead to inconclusive statistical results. The UNB plot and the sampling performed in September were not considered on the statistical analysis regarding different sampling periods, because in September no mulch was present on any plot and the UNB site was only sampled in the last two months of this study (November and January). Due to these reasons, statistical comparison regarding richness was not applicable. *Acari* and *Diptera* were also excluded from the statistical analyses, considering the pitfall sampling limitations concerning these two orders.

3. Results

3.1 Environmental variables analysis

In Figure 8, it is seen that regarding precipitation, the first big events took place only at late December and early January. Before that period, small precipitation events were registered, always below 50mm in a 10-day period. Between mid-November and mid-December, there were few precipitation events. Meanwhile, average temperature in a 10-day period had a steady decline from late September to early November. The temperature had a major decline during November, from 15°C to a 7°C average. Afterwards, temperature rose until mid-December, reaching a peak at 13°C. In the same period that temperature reached its lowest, precipitation was also very scarce. January displays a mean temperature around 9°C.

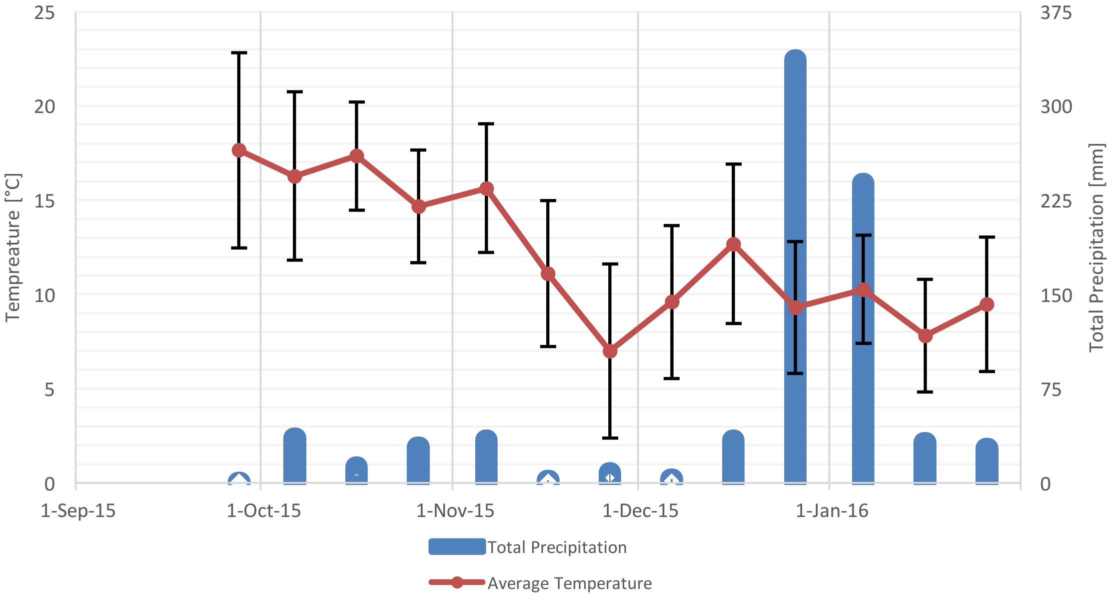

Figure 8. Mean and standard deviation for temperature and precipitation between late September 2015 and January 2016

3.2 Community analysis

3.2.1 Richness and Abundance

During the 4 sampling months, that comprise two seasons (Autumn and early Winter), 2303 ground-dwelling arthropods were retrieved by the pitfall traps, representing in total 14 orders (Richness): *Collembola, Coleoptera, Diptera, Hemiptera, Hymenoptera, Isopoda, Thysanura,* *Chilopoda, Araneae, Acari, Diplopoda, Pseudoscorpiones, Psocoptera* and *Opiliones* (Appendix 1 and 2).

Although 14 orders were found, only a maximum of 12 were identified on one single plot during the sampling period. Taking into account the conditions of the habitat in September, a considerable number of *taxa* was yet identified, namely 8 to 10 orders.

Total richness differences between September and January were no larger than 5. This higher difference occurred in the NT plot from October to November. The LT plot remained quite equal during the sampling period, with total richness of around 10, whereas the HT plot registered a peak from 8 to 11 between September and November. After the mulch application that occurred in October, it is seen that only the HT plot had an increase in total richness, whereas the LT remained stable and the NT had a decrease. On the other hand, in November, the NT and LT had a richness growth, more accentuated on the NT plot, whilst the HT decreased. In January, the LT and UNB had a decrease in total richness, HT remained identical to the previous month and the NT increased from 11 to 12 orders (Figure 9).

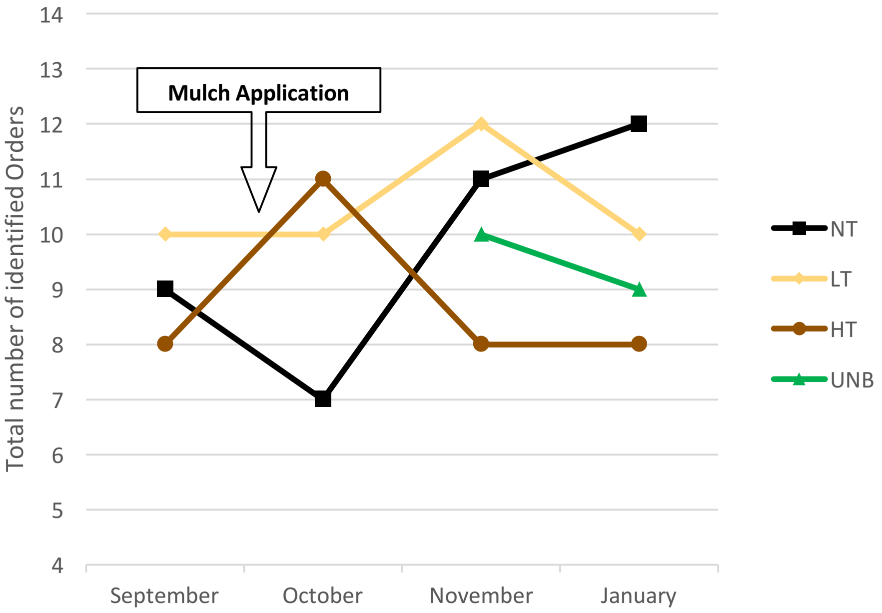

Figure 9. Total richness regarding sampling months and plots

No statistically significant differences were found between sampling months and treatments via a Two-way ANOVA test regarding total richness (Table 1). The test points out a significant interaction between months and plots (treatments) (Table 1). Significant differences were found for treatment in November, namely with the NT and the HT, and on months in the NT plot, namely within November and October and also within January and October for the same plot (Table 2).

Table 1. Two-way ANOVA summary regarding month and plot with total richness per trap. Significant statistical relations in bold type.

Source of Variation	DF	Sum of Squares	MS	F	P
Month	2	7.185	3.593	1.830	0.189
Treatment	2	6.741	3.370	1.717	0.208
Month x Treatment	4	23.259	5.815	2.962	**0.048**
Residual	18	35.333	1.963		
Total	26	72.519	2.789		

Normality Test (Shapiro-Wilk): passed (p=0.083)

Table 2. All Pairwise Tukey multiple comparison test within months and treatments.

Factor 1	Factor 2	Comparison	Diff of Means	p	P<0.05
Treatment	**October**	HT vs. NT	2.000	0.215	No
		HT vs. LT	0.333	0.954	Do Not Test
		LT vs. NT	1.667	0.334	Do Not Test
	November	NT vs. HT	3.333	**0.024**	Yes
		NT vs. LT	1.333	0.488	No
		LT vs. HT	2.000	0.215	No
	January	NT vs. HT	2.000	0.215	No
		NT vs. LT	0.667	0.831	Do Not Test
		LT vs. HT	1.333	0.488	Do Not Test
Month	**NT**	November vs. October	4.000	**0.007**	Yes
		November vs. January	1.000	0.663	No
		January vs. October	3.000	**0.044**	Yes
	LT	November vs. October	1.000	0.663	No
		November vs. January	0.333	0.954	Do Not Test
		January vs. October	0.667	0.831	Do Not Test
	HT	October vs. November	1.333	0.488	No
		October vs. January	1.000	0.663	Do Not Test
		January vs. November	0.333	0.954	Do Not Test

Looking to the abundance found during the sampling periods per plot, all of the sampled plots follow a similar trend. Earlier, it seems that before the mulch application process, the abundance in the sampled plots decreased. After this first period, in November, abundance increased, especially on the NT and HT plots. Between November and January, abundance decreased, but to higher levels while comparing with October (Figure 10).

Regarding total abundance variations on the sampling period, a trend is identified within the different plots. From September to October, all plots experienced a drop in total abundance which was later followed by an increase in all plots in November. On the last month, January, all plots had a decrease in total abundance, to levels a little higher than the registered in September.

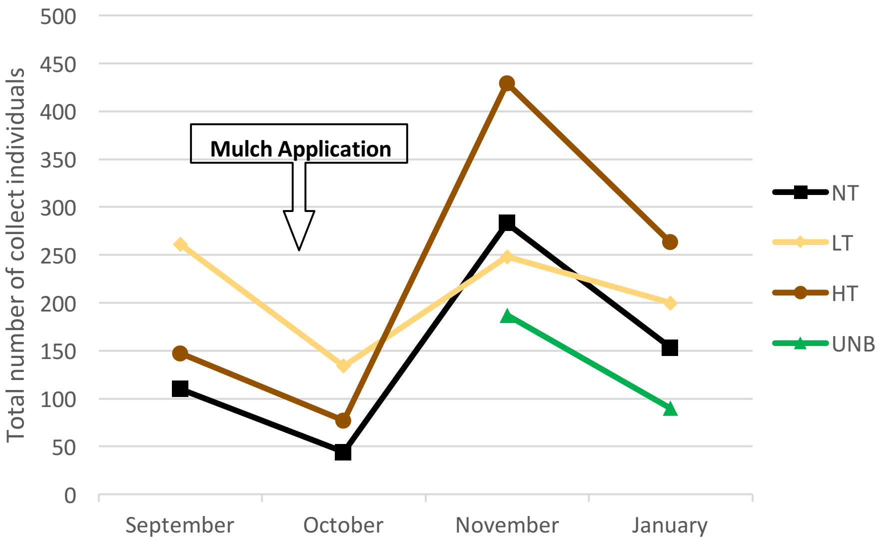

Figure 10. Total abundance regarding sampling months and plots.

In order to better interpret the data analysed on the previous figure, relative abundance was calculated by obtaining mean abundance per plot, considering abundance levels out of sets of three pitfall traps (Figure 11).

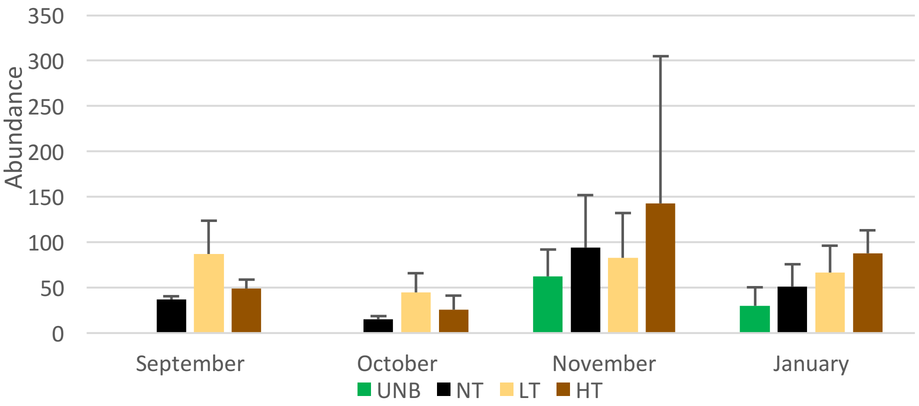

Figure 11. Mean abundance and respective standard deviation per sampling months and plots.

Regarding the mean abundance per plot, the treated plots (LT and HT) display higher values of relative abundance while comparing with the NT plots and the UNB. A decrease of proximately

50% less relative abundance is identified between September and October on each plot. The peak in total abundance identified in Figure 10 is also seen on relative abundance, where the NT and LT plot display similar values. On the other hand, relative abundance on the HT plot in November had a large disparity of total abundance between pitfall traps, since the standard deviation is larger than the mean abundance on that plot. In January, there is an increasing relative abundance from the UNB plot, to the NT, LT and the HT plot, between 25 and 75.

A Two-way ANOVA test was performed, considering the sampling months and the treatments as factors (Table 3) (Appendix 2).

Table 3. Two-way ANOVA summary regarding month and plot with total abundance per trap. Significant statistical relations in bold type.

Source of Variation	*df*	Sum of Squares	MS	*F*	*P*
Month	2	4.817	2.408	2.537	0.107
Treatment	2	0.282	0.141	0.149	0.863
Month x Treatment	4	2.484	0.621	0.654	0.632
Residual	18	17.089	0.949		
Total	26	24.671	0.949		

Normality Test (Shapiro-Wilk): passed (p=0.545)

Although there is not a statistically significant difference (p=0.107) between months, there are considerable differences in abundances. Regarding the abundances between treatments (plots) there are no differences. The interaction between months and treatments was also not significant.

Regarding *taxa* distribution along the study area (Figure 12), *Collembola* is the most abundant order, found on every plot and increasing along each sampling in most of the plots, followed by *Hymenoptera* and *Acari*. Contrary to *Collembola*, *Hymenoptera* individuals decrease steadily from September to January. *Diptera* are present in all plots, but in larger numbers during the months of November and January. *Acari* are also present in every plot, although they are more abundant in September and January in some plots. *Araneae* and *Coleoptera* are also represented in all plots, although a pattern is not yet identifiable. It is also seen that *Coleoptera* abundance in the HT plot in November is the main cause for the marked increase in abundance found earlier in Figure 9 and 10. Regarding the less represented orders, *Thysanura* was only found in the UNB plot and *Diplura* only present in the treated plots.

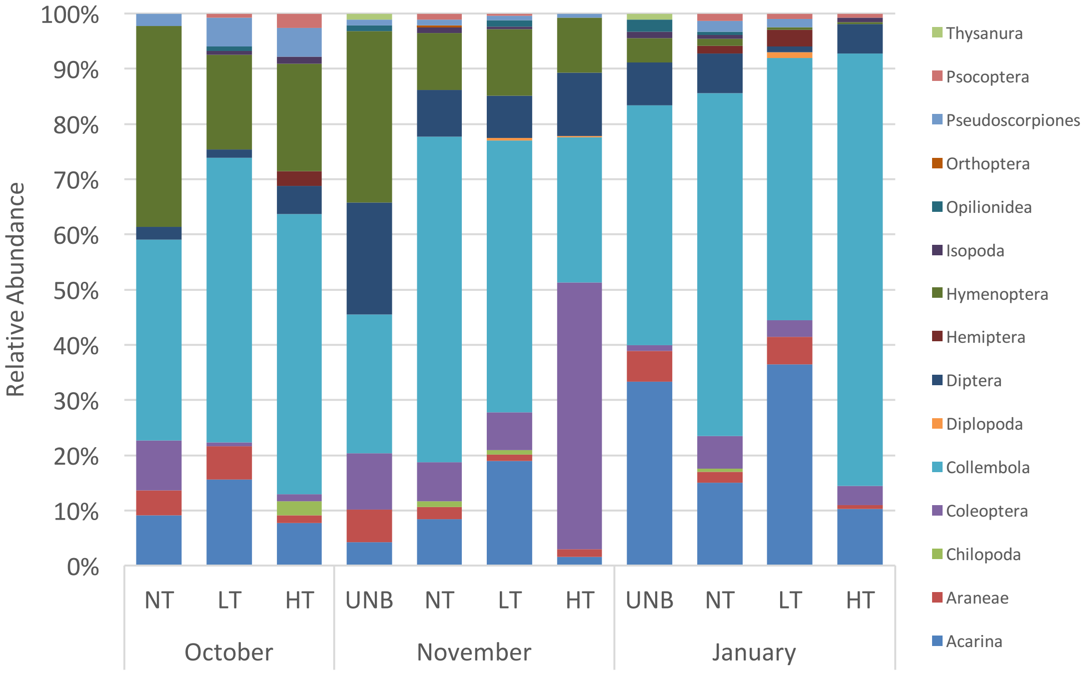

Figure 12. Relative abundance in percentage per plot during the sampling months.

Statistical significant correlations between orders are displayed on Table 4. A table displaying all results regarding the Pearson correlation test is found on Appendix 3.

Table 4. Pearson correlation between orders on each sampling month.

Month	Order Pair	N	Pearson Correlation	Sig. (2-tailed)
October	*Araneae & Hymenoptera*	3	1	0.011*
	Collembola & Pseudoscorpionidea	3	0.997	0.048*
November	*Coleoptera & Hymenoptera*	3	0.997	0.05*
January	*Acari & Coleoptera*	3	-0.997	0.046*

* Correlation is significant at the 0.05 level (2-tailed).

In October, statistically significant results are found regarding a correlation between *Araneae* and *Hymenoptera* and between *Collembola* and *Pseudoscorpionidea* (Table 2). Both correlation coefficients point towards a rise in total abundance between the pairs of orders. The *Collembola* and *Pseudoscorpionidea* correlation may be due to a trophic relation. On November there is also a significant correlation between *Coleoptera* and *Hymenoptera,* although ecologically it is a doubtable result considering the *Coleoptera* total abundance on the HT plot in November (Figure 12).

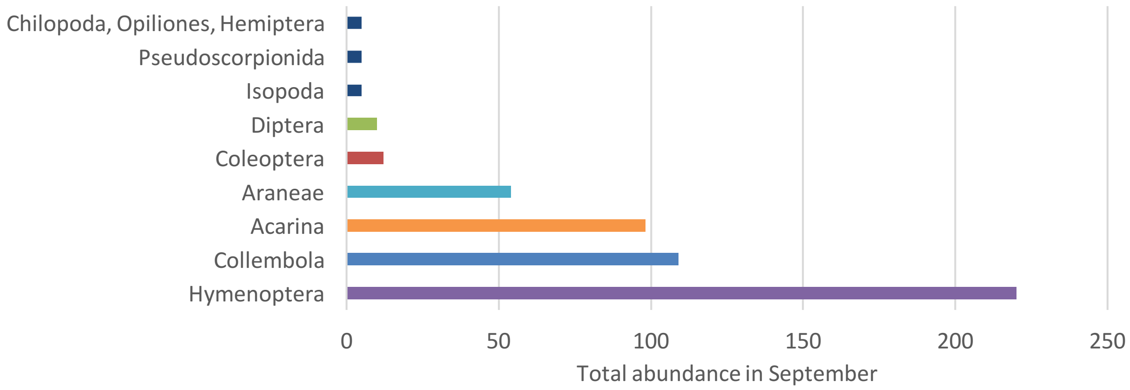

Figure 13. Total abundance per order in September

The total abundance of orders in September corresponds to the individuals trapped in a total of nine pitfalls (distributed over 3 plots, see Figure 4) (Figure 13). A total of 518 individuals were collected in September. It is seen that *Hymenoptera* is the largest represented order, followed by *Collembola*, *Acari* and *Araneae*. Richness, considering all plots together in this month, is 11 out of 14.

Figure 14 shows the distribution of the main orders per plot on each sampling month. The "Others" represent the *taxa* that is less abundant (<50 identified individuals during the whole sampling period), namely *Diplopoda, Pseudoscorpiones, Psocoptera, Opiliones, Orthoptera, Hemiptera, Isopoda, Thysanura* and *Chilopoda*. Although these are in a lower number, they are still relevant regarding ecological function in the post-fire period.

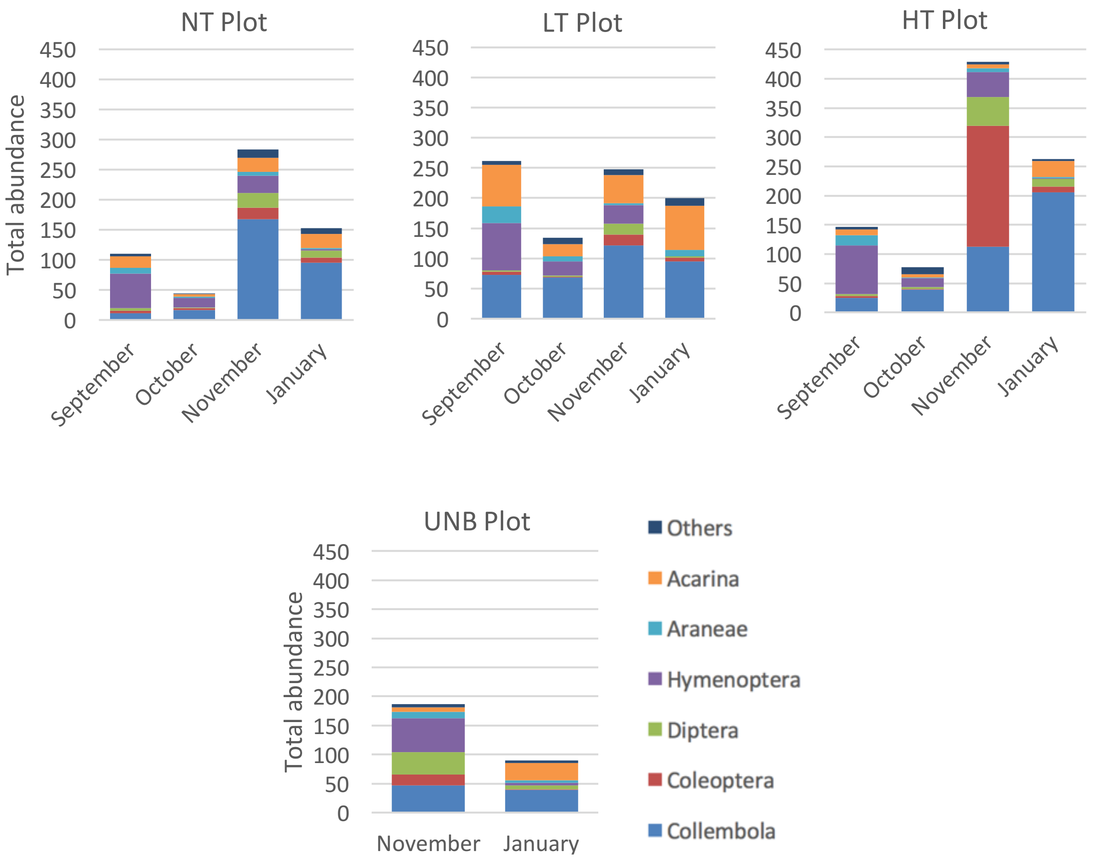

Figure 14. Total Abundance per plot during sampling months.

Total abundance follows as described on Figure 9, showing how much each *taxa* contributes and how each *taxa* evolves during the sampling period. October was the month with the lowest abundance whereas November displays the maximum total abundance.

Collembola shows a steady rise in abundance on the HT plot of almost four times as more from September to January. On the other plots, there was also a marked increase in *Collembola*, noted from October to November in the NT plot, and also on the LT plot, although not as much while comparing with other plots. On the HT plot, there is a very high total abundance of *Coleoptera* during November, one month after the application of mulch. This was also displayed in the previous figures. The UNB plot, despite displaying a lower total abundance as other plots, 200 individuals in November and 100 in January, it shows a more evenly distributed total abundance per Order.

3.2.1 Abundance and Environmental variables

Table 5 shows that temperature and total abundance are not significantly correlated by the Pearson correlation test, yet the *p*-value is close to be significant. However, even not significant, the total abundance decreases with decreasing temperature.

Table 5. Pearson correlation between total abundance and abiotic variables.

Variable Pair	N	Pearson Correlation	Sig. (2-tailed)
Temperature & Total abundance	3	-.638	0.065
Rainfall & Total abundance	3	-.232	0.548

3.2.2 Diversity (H') and Evenness (J')

Regarding diversity (H') and evenness (J') indexes there is a decreasing trend in both throughout the sampling periods (Figure 15). Nonetheless, the HT and NT plots show steeper decreases in both diversity and evenness in different periods: November on the NT plot and January on the HT plot.

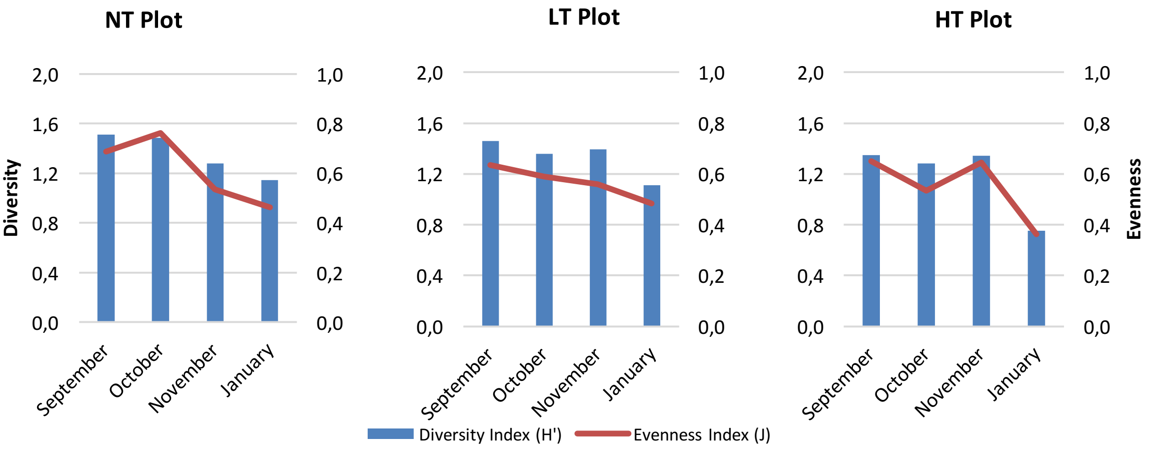

Figure 15. Total diversity and total evenness in the LT, HT and NT plots during sampling months

The Two-way ANOVA test pointed-out significant differences in diversity between months (Table 6), namely from October through January (Table 7). No differences were observed between different treatments (Table 6). The Two-way ANOVA test did not provide significant differences regarding evenness in different months and plots (Table 6).

Table 6. Two-way ANOVA summary regarding month and treatment as factors and diversity and evenness indexes has variables. Significant statistical relations in bold type.

Variable	Source of Variation	DF	SS	MS	F	P
Diversity*	Month	2	0.249	0.125	7.779	**0.042**
	Treatment	2	0.0574	0.0287	1.793	0.278
	Residual	4	0.0641	0.0160		
	Total	8	0.371	0.0463		
Evenness**	Month	2	0.0604	0.0302	3.389	0.138
	Treatment	2	0.00777	0.00389	0.437	0.674
	Residual	4	0.0356	0.00891		
	Total	8	0.104	0.0130		

*Normality Test (Shapiro-Wilk): Passed (p = 0.427) ** Normality Test (Shapiro-Wilk): Passed (p = 0.242)

Table 7. Tukey's multiple comparison of months regarding diversity.

Comparison	Diff of Means	p	p<0.050
October vs. January	0.369	0.050	-
October vs. November	0.0357	0.938	No
November vs. January	0.334	0.067	No

3.3 Ecological function analysis

Assignment of orders per ecological function group are found on Appendix 4.

In September, most of the *taxa* found were omnivore, followed by microbial feeders, predators and, at last, by very few plant feeders (Figure 16). After the treatment was applied, omnivores decreased and microbial feeders and plant feeders increased, from October to November. In November, the total abundance of omnivores stands out on the UNB plot, representing about 50% of the sampled individuals. In January, about 80% of the community is a microbial feeder on all plots (Figure 17).

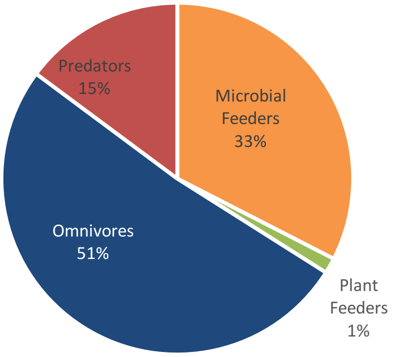

Figure 16. Ecological function distribution in September

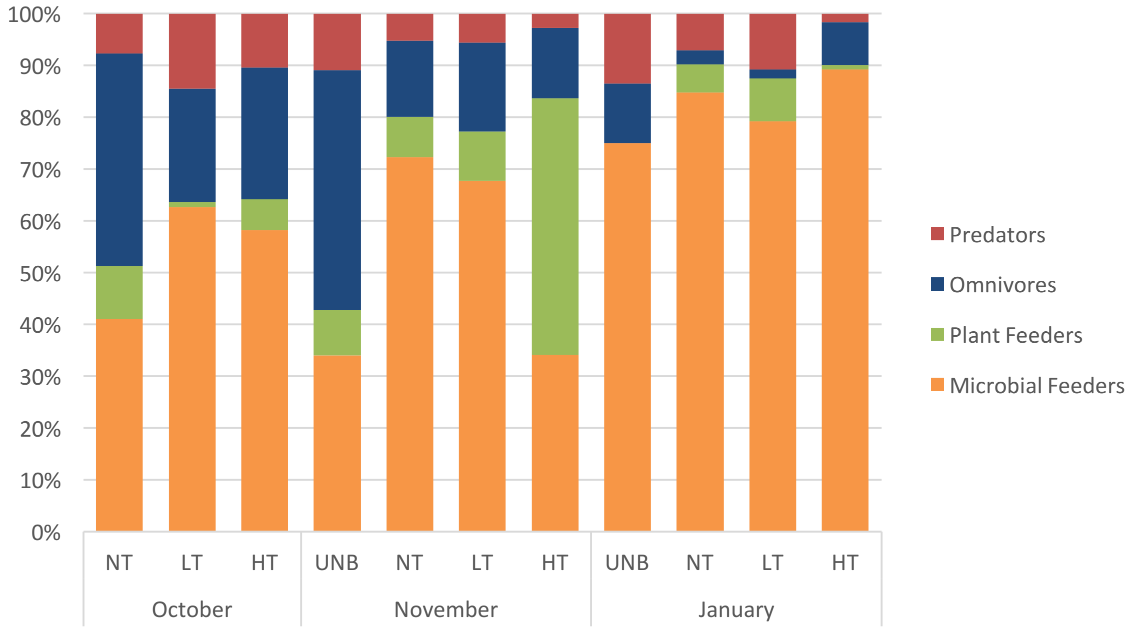

Figure 17. Ecological function relative abundance per plot during sampling months

Table 8 & 9 display the results of the Pearson correlations between ecological function groups. All correlation test results are found in Appendixes 5 & 6. When the months are considered, there is a significant correlation between plant feeders and predators. When plots are concerned, more significant correlations were found. The correlations have the predator group in common. On the NT plot a strong increasing trend between microbial feeders and predators was found. On the LT plot, there was a decrease of microbial and plant feeders related with an increase in the number of predators.

Table 8. Pearson correlation between ecological function groups on each sampling month.

Month	Group Pair	N	Pearson Correlation	Sig. (2-tailed)
January	Plant Feeders & Predators	3	1.000*	0.007

*Correlation is significant at the 0.01 level (2-tailed)

Table 9. Pearson correlation between ecological function groups on each Plot.

Plot	Group Pair	N	Pearson Correlation	Sig. (2-tailed)
NT	Microbial Feeders & Predators	3	0.999	0.024
LT	Microbial Feeders & Predators	3	-1.000*	0.007
	Plant Feeders & Predators	3	-0.997	0.046

*Correlation is significant at the 0.01 level (2-tailed)

Figure 18 complements the statistical correlations shown earlier. On the treated plots, LT and HT, the ecological function groups followed an identical trend. Omnivores and predators decreased, microbial feeders and plant feeders increased, reaching a peak in November, although at a different scale. Abundance per ecological function groups present also very similar number of individuals. Plant feeders on the HT rose steeply in November due to the high number of *Coleoptera*.

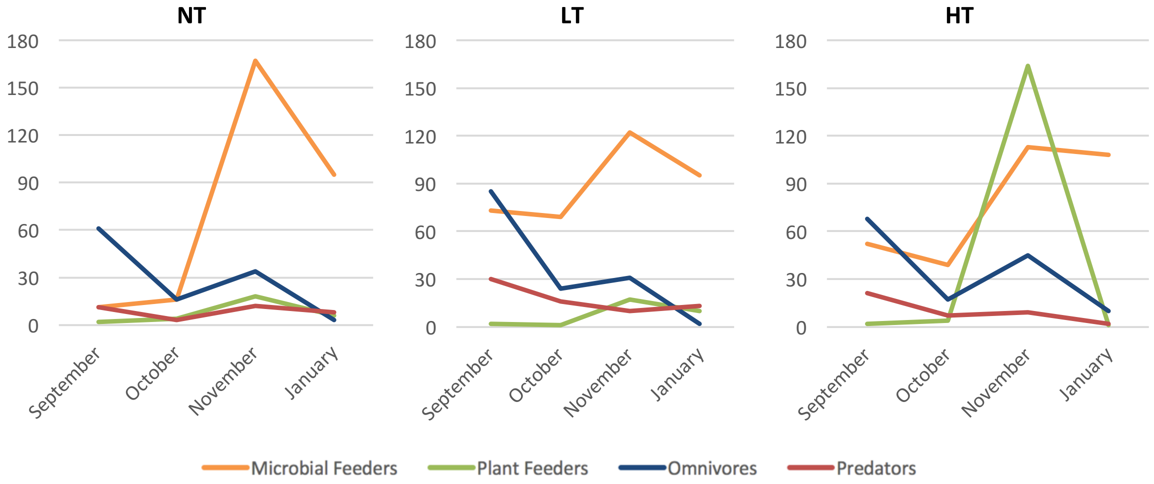

Figure 18. Ecological function groups total abundance per plot during sampling months.

The great majority of individuals found in September in the NT plot are omnivores. In October, most of the groups decreased, but the microbial feeders had a slight increase. The slight increase was followed by a steep increase in November, from 15 to 160 individuals, whilst other groups had a very small increase, of about 10 individuals. Ultimately, in January, omnivores and microbial feeders decreased in total abundance, while predators and plant feeders maintained their total abundance relatively to November (Figure 19).

A One-Way ANOVA was performed to assess significant differences in ecological function groups regarding different factors: months and treatments (Table 10 and 12).

Table 10. One-Way ANOVA on functional groups regarding sampling months.

Ecological Function		Sum of Squares	df	Mean Square	F	P
Microbial Feeders	Between Groups	13152.889	2	6576.444	12.333	**0.007**
	Within Groups	3199.333	6	533.222		
	Total	16352.222	8			
Plant Feeders	Between Groups	7698.667	2	3849.333	1.609	0.276
	Within Groups	14355.333	6	2392.556		
	Total	22054	8			
Omnivores	Between Groups	1510.889	2	755.444	24.545	**0.001**
	Within Groups	184.667	6	30.778		
	Total	1695.556	8			
Predators	Between Groups	10.889	2	5.444	0.212	0.815
	Within Groups	154	6	25.667		
	Total	164.889	8			

Table 11. Tukey multi-comparison test on microbial feeders and omnivores regarding different months

Dependent Variable	Month Pairs	Diff of Means	p	p<0.005
Microbial Feeders	October vs November	-92.66667	0.006	Yes
	October vs January	-58.00000	0.050	-
	November vs January	34.66667	0.236	No
Omnivores	October vs November	-17.66667	0.019	Yes
	October vs January	14.00000	0.049	Yes
	November vs January	31.66667	0.001	Yes

Table 12. One-Way ANOVA on functional groups regarding treatments.

Ecological Function		Sum of Squares	df	Mean Square	F	P
Microbial Feeders	Between Groups	118.222	2	59.111	0.022	0.978
	Within Groups	16234	6	2705.667		
	Total	16352.222	8			
Plant Feeders	Between Groups	4418	2	2209	0.752	0.511
	Within Groups	17636	6	2939.333		
	Total	22054	8			
Omnivores	Between Groups	66.889	2	33.444	0.123	0.886
	Within Groups	1628.667	6	271.444		
	Total	1695.556	8			
Predators	Between Groups	80.222	2	40.111	2.843	0.135
	Within Groups	84.667	6	14.111		
	Total	164.889	8			

Statistical differences were found only when considering the months as a factor (Table 10). Within the different months, microbial feeders and omnivores had statistically significant differences. These differences were statistically significant between all months in both ecological groups, except between November and January on the microbial feeders group (Table 11). As far as plots are concerned, no significant differences were found between the ecological function groups (Table 12).

4. Discussion

Wildfires conduct many direct and indirect impacts on ecosystems (Bowman *et al.*, 2013). One of the indirect impacts produced by wildfires is the alteration of the grown-dwelling arthropod community (Elia *et al.*, 2012), a key element on soil quality (Stork & Eggleton, 1992). Although some studies report a cause-effect relation between fire and insects (Bowman & Murphy, 2010), few studies are clear on this matter, regarding the ground-dwelling arthropod community's response to wildfire. These studies also do not provide homogeneous outcomes regarding the community response and resilience (Elia *et al.*, 2012). In fact, wildfire events are shaped by many different variables that consequently will impact on the extent of severity of post-fire events (Certini, 2005).

The wildfire acts directly as a mortality agent on a first stage, by cremation and lethal heat exposure to the less mobile arboreal and other foliage-feeding arthropods (New, 2014). Soil micro and macro-fauna are more susceptible depending on the fire severity impact, mostly related with heat intensity and exposure (Certini, 2005). On a second stage, right after the wildfire event, a window of opportunity opens to the more fire resistant and mobile groups, namely saproxylic insects and the soil-dwelling zoophagos and saprophagous (Moretti, Duelli & Obrist 2006). These groups, with higher tolerance to fire and more mobile, will also be part of the re-colonization process of the area after a fire, since a burnt site provides well suited habitat for their activities and ecological roles. Generally, predators are the most negatively affected by fire and detrivores are more abundant in fire prone sites (Engstrom, 2010). Indirectly, the wildfire transforming effects on the habitat setting, by removing vegetation and litter, will also promote different outcomes. The arthropod community composition will be dependent on ecological processes like starvation, predation or immigration (Engstrom, 2010). Starvation will be related with the availability of food to survive in association with the loss of vegetation, which is a vital source for herbivore arthropods (Haddad *et al.,* 2009). This can ultimately limit other food-web relations, such has predation. Outcomes from these processes will determine the population viability in the post-fire context (Engstrom, 2010). Ultimately, arthropod abundance and richness variations are usually related with the very distinct climate factors from the Mediterranean-type ecosystems, such has temperature, rainfall and day length (Simão *et al.,* 2015).

In the sense that most of the biomass (vegetation and litter layer) is lost during a wildfire, the application of mulch, in the form of chopped eucalyptus bark, is an amendment to the transformed habitat. This will very likely have some ecological value, since a great amount of biomass (2.6ton to 8ton/ha considering each treatment type regarding the mulching application) is added to an ecosystem that lost a great amount. It also has been witnessed that application of forest residuals has a mulching agent also increases the organic matter content in the soil (Prats *et al.*, 2014), which ecologically can have a positive effect. On the other hand, erosion can also dictate how fast an ecosystem can recover after a wildfire, considering that erosion rates and runoff in mono-specific plantations of eucalypt are high (Prats *et al.*, 2015). These effects promote the loss of nutrients contained in plant biomass and soil organic layers, especially after rainfall events (Machado *et al.*, 2015), which in this context can be vital to the life cycles of many ground-dwelling arthropods. Hence, the application of mulch contributes in the reduction of erosion, which can also, potentially, benefit the ground-dwelling arthropod community.

On this study context, it is necessary to take into account one of the main characteristics from the burnt area, which is the soil use in this area. The area has been widely used has a eucalypt plantation. Bremer and Farley (2010) stated that biodiversity in eucalyptus plantations is low and, if management practices and fire history are added (Oliver, MacNally & York, 2000), the conjugation of both often results on a lower biodiversity.

Focusing on the results of September, regarding total abundance, one of the most relevant fact is that *Hymenoptera*, exclusively ants, was the most abundant order collected, weighing about 50% of the total abundance (518 individuals, in 9 pitfall traps). Matsuda *et al.* (2011) considers ant's resistant to fire, since only about 2% of the population of a mature ant colony is active at surface level and, therefore, exposed to fire hazards. Ants are also known to be in the line of the first organisms to colonise disturbed areas, for instance by fire, due to their generalist and opportunist behaviour, exploiting space and resources efficiently (Antunes, Curado, Castro & Gonçalves, 2009). It should also be taken into account that in Portugal ants seem to thrive in eucalyptus plantation ecosystems (Zina, Garcia, Valente, Branco & Franco, 2015).

Other orders, namely *Collembola* and *Acari,* each representing about 20% of the total abundance and *Araneae* that represents about 10%, mostly characterize the community immediately after the wildfire event. *Collembola* is a very common order present on the soil that feeds mostly on fungi and decaying plants (Neher, Weicht & Barbercheck, 2012; Anslan, Bahram & Tederoso, 2016) and acting also as prey to spiders and beetles. It is also expected to some extent, depending on the severity of the wildfire, that collembolans profit from the effects produced by a wildfire. In fact, there is an increase of plant matter decay, considering that coarse woody debris leftovers from the fire that contribute in regenerating microbial activity and input of nitrogen and phosphorus to the soil (Marañón-Jiménez & Castro, 2013; Brais, Sadi, Bergeron & Grenier, 2005). *Acari* follow up *Collembola* has one of the most common orders in forest soils. *Acari* are highly diverse and regulate litter decomposition and nutrient mineralization rates (Camann, Gillette, Lamoncha & Mori, 2008). In this study, it is believed that the population of *Acari* sampled is mainly predators, due to their overall size and morphologic features seen during the screening process (Koehler, 1999). The size condition in *Acari* was imposed by the mesh measure used in the sampling process (Chapter 2.3), on which *Acari* individuals smaller than 1mm could have been washed away. Adding up, pittfall trapping is also not the most adequate sampling method for sampling the full extent of *Acari* biodiversity. The *Araneae* are predators widely represented in forest ecosystems and also adapted to forest fires (Buddle, Spence & Langor, 2000). *Araneae* is expected on a post-fire context at some level since most spiders can rapidly re-colonize via long-distance dispersal, like ballooning, and short-distance dispersal, mainly from unburned forest patches (Buddle *et al.*, 2000).

Regarding ecological function groups in September, the community sampled was 51% of omnivores, 33% of microbial feeders and 15% predators. These results translate the obtained values regarding abundance, where *Hymenoptera* was the most represented order. Only 1% of the sampled individuals were classified as plant feeders, which indicates to some extent the absence of vegetation to feed in the recently burnt area.

The second sampling took place in October, after the mulch application. Total abundance decreased in all plots. However, the plot with the largest density of mulch richness rose from 8 to 11 orders. Although there was a general decrease of total abundance in the area, the plot with a high density of mulch material attracted a larger diversity (order richness) of ground-dwelling arthropods. In fact, the LT plot registered a similar level of richness (10) and the NT plot had a decrease from 9 to 7. This observation may be due to the fact that the mulched areas may provide more opportunities to survival to more groups, such as shelter and food resources. Nonetheless, assumptions raised by analysing total richness in this study case need to be carefully considered. In one hand, pitfall trapping presents a flaw at this level, in the sense that there is a chance that orders with a very low total abundance were not sampled by causality. On the other hand, the level of detail from a community provided at a taxonomic level such as Order may not be enough to point out differences between treatments.

The fact that there was a decrease in abundance while comparing with the results from September, may be related with the rainfall and temperature registered during October. In late

September and early October, very little precipitation occurred, less than 50mm and temperature remained stable at a mean of approximately 17°C. In fact, the lack of rainfall on a post-fire context can represent a dual effect: low erosion from runoff, since there is not enough rainfall and low vegetation growth, in the sense that rainfall mostly improves soil moisture and nutrient availability that later promote vegetation growth, which a large number of arthropods rely on (Certini, 2005). Ultimately, these epigeic factors shape seasonality, which is a key factor influencing arthropod diversity and abundance (Shakir & Ahmed, 2014).

Summing up, October's unusual meteorological conditions seemed to delay the overall recovery process of the ecosystem despite the mulch application is suggesting a slight higher total abundance and richness of ground-dwelling arthropods in the mulched plots.

In November, the most relevant observation was the abundance growth noted in all plots. The plots that registered the largest growth were the HT and NT, from 77 to 429 and from 44 to 283 individuals, presenting about 6 times more specimens while comparing to October. In fact, considering that the total abundance growth took place in every sampled plot, this suggests that seasonality is playing an important role on shaping the ground-dwelling arthropod community. This observation has also some support by the statistical analyses, despite the differences not being entirely significant. Differences were only closer to be significant regarding different months and only noted between October and November. If we consider temperature and rainfall before the sampling campaign, it is seen a steep decrease of the mean temperature, a potential trigger that marks the end of Summer and the beginning of Autumn (Gallinat *et al.,* 2015). When we include functional groups to this assumption, the most represented group in November are the microbial feeders. This suggests that possibly the ecosystem conditions during late October through late November have promoted the development of fungi and consequently an increase in organic matter decomposition, a common ecosystem feature in Autumn season (Almagro, López, Querejeta & Martínez-Mena, 2009). Most of the total abundance registered is due to the microbial feeders, which in this study only comprise *Collembola*. Other functional groups total abundance rose in November, although very little. Differences were only statistically significant for microbial feeders and omnivores between different months. Considering the increase of microbial feeders, and the total abundance values regarding the population of predators, omnivores and other plant feeders, it seems that these populations may have responded to these changes, considering the trophic interactions within these groups. The Pearson correlation test unveils a significant and a strong correlation between plant feeders and predators in January and between microbial feeders and plant feeders with predators in the UNB and NT plots. Exceptionally, on the HT plot, the plant feeders increased much more its abundance in comparison with other groups. This observation is related with the high number of Coleoptera collected from a pitfall at the HT plot and the further sub-sampling performed in the laboratory. During this sub-sampling, it was possible to visualise that the largest number of these Coleoptera individuals, classified as plant feeders, had morphological features that suggested that these fed on woody remains. In fact, the forest residual applied to the plot surface could have lodged this kind of arthropods in its larvae stage. Abiotic and/or climacteric conditions such as temperature, rainfall or even seasonality could have triggered a rapid development of these Coleoptera morphospecies (Wermelinger & Seifert, 1999). The development of fungi in the area during November could also possibly been promoted by the growth of vegetation, by resprouting and by the development of shrubs (Rincón & Pueyo, 2010) as well as by the already stated seasonality.

At this stage of sampling, mulch impacts on the ground-dwelling community are not yet very clear, if we only take into account total abundance at order level and ecological groups. No statistical significant results were found between different treatments for total abundance and ecological function groups. When comparing richness between plots, it is seen an increase in total richness on the NT and LT plots, whereas the HT total richness decreased. This observation, taking into account the considerations above mentioned, suggests that mulch can be contributing to a certain degree of inhibition in the recovery of the habitat, in the sense that the mulch layer can dismiss the growth of some fungi and plants, by either creating a physical barrier, blocking light and even chemical control through the leaching of allelopathic chemicals present in wood (Chalker-Scott, 2007). This assumption can be related with the density of application, meaning that a larger density normally implies very little exposure of the other lower layers, which may inhibit plant development, whereas a less dense application allows much more heterogeneity of ground cover. This heterogeneity can provide room for the development of fungi and plants, increasing the variety of ecological niches in the area (Menta, 2012). Considering the scale of the area where ground-dwelling arthropods remain active, it is implicit that a more diverse community can be found due to the larger diversity of ecological niches available, shaped by plant richness (Haddad et al., 2009). These assumptions seem to be associated to observed richness variation, considering a growth on total richness from 7 to 11 *taxa* on the NT plot, a less accentuated increase on the LT from 10 to 12 *taxa*, that contrast with a decrease from 11 to 8 *taxa* on the HT plot. Unfortunately, the UNB was sampled from November on, and therefore, it is not possible to build comparisons taking into account previous months.

The last sampled month, January, presents a decrease of abundance when comparing to November. Winter season conditions only arrived in late December, bringing large rainfall events followed by low mean temperatures. Total abundance and season changes between months, specifically temperature changes were statistical significant, as mentioned before. Likewise, the UNB plot also suggests the same, a decrease of abundance also between the two sampling periods from November and January. When comparing total abundance with the other plots, abundance in the UNB plot is relatively lower. This suggests that the UNB plot, since it did not have a fire recently, it did not undergo the same physical and chemical conditions imposed by the wildfire in the burnt site. Additionally, UNB had a record of a wildfire in 2012 and, besides the mulch absence, it seems to present a more advanced and stable stage of ecological recovery, similar to results obtained by Puga (2016).

Regarding richness, the NT had its richness raised from 11 to 12, the LT and UNB dropped from 12 to 10 and 10 to 9 respectively, and the HT remained at 8. Taking into account the results found in the previous sampling months, all the plots present lower richness, in January, when comparing to the previous months. Nevertheless, the NT plot presents the highest total richness record in January, considering all sampling months. It seems that the NT plot, since it did not had mulch applied, took more time to perform initial ecological successions or did not had the necessary availability of resources to promote a faster recovery, unlike the HT and LT, whereas the richness peak in the treated plots was reached in October (HT) and November (LT). The HT plot displays less richness comparing to the UNB plot, pointing out that a larger density of mulch does not promote ground-dwelling arthropods diversity. On the other hand, supporting the above stated observation, the LT plot presents higher richness. Once more, the total richness related assumptions must take into account the fact that order level richness might not provide a reliable answer, as above-mentioned. In addition, the field design, the distances between traps, as well as the number of traps used and the overall area of each plot might not have been enough to trace significant differences in the community within different treatments.

Diversity (H') and Evenness (J') indexes support most of the observations discussed above. A decreasing trend in diversity and evenness is visible from month to month, which supports the idea that seasonality is shaping the community. This decreasing tendency is also supported by a statistically significant difference in variances between months, namely October and January. There are also some visible yet small differences within different treatments, where the most important one is found on January at the HT plot, which has a lower diversity and evenness when comparing with LT and NT. This observation is in line with the theory that a higher density of mulch could possibly reduce the number and diversity of ecological niches. When comparing the treated (LT and HT) and untreated plots (NT) with the UNB plot, a slightly larger diversity is found on the UNB plot regarding diversity and evenness. This observation is related by the wildfire history and seems to show a further stage of re-establishment of the community in the UNB plot. Once more, these indexes are calculated with total richness values and, therefore, should be interpreted considering the already stated limitations.

Taking into account the main orders found during the 4 sampling months, *Collembola, Coleoptera, Diptera, Hymenoptera, Araneae and Acari,* there are some observations that arise. *Collembola* is the order contributing the most on total abundance in all plots, especially from November on. This follows up with what was also observed regarding the ecological function groups. *Diptera* were only found, in a considerable number in November. This order is not suited to the pitfall sampling since this order can be attracted by the solution or animal remains present on the traps to lay eggs. *Hymenoptera* show an inverse evolution while comparing with *Collembola.* The population of *Hymenoptera* decreased from September until January. This steady decrease seems to be related with seasonality, regarding the temperature drop and how the activity of ants is related with temperature (Cerda, Retana & Cros, 1998). *Araneae* and *Acari* display a larger abundance in the LT plot, which might be related with the larger number of niches that the LT plot offers.

5. Conclusion

Hymenoptera was the most represented order in September, right after the wildfire. This finding was expected, considering that ants can usually survive to a wildfire event due to their burrowing capabilities. *Hymenoptera* total abundance gradually decreased during sampling months, most likely due to seasonality.

Although differences within treatment and sampling months were expected, only seasonality seemed to be the driver of abundance variations in this study context. Statistical results suggest seasonality as being a factor shaping the total abundance of the ground-dwelling arthropod community, as well as the decreasing tendency in diversity (H') and evenness (J') from October through January. Slight differences were found on community total richness during the sampling months, although not significant.

These non-significant differences may be related with the level of taxonomic identification used in this study. Family level could have unveiled better interpretations regarding ecological groups and potential relations between mulch material and certain families, yet, the time available to proceed with this study was limited and therefore, it was not possible to reach Family level.

A lower density of mulch application seemed to provide faster response regarding the invertebrate community, and therefore a faster recovery. A larger density of mulch, on the other hand, did not seem to produce an identical output, since total richness was lower and total abundance higher when comparing with a low density of mulch and no mulched areas.

In a general perspective, mulching seemed not to promote a specific order, since no evidence was found regarding significant differences between orders within different treatments. Nonetheless, an uncommon observation of hundreds of individuals of a Coleoptera species lead to the assumption that the application of mulch may have introduced organisms in the ecosystem.

6. Final considerations

Literature suggests that an accurate measure of fire severity can provide more evidence regarding ground-dwelling arthropod re-establishment after a wildfire (Malmström, 2010). This interpretation could allow a better understanding on how ground-dwelling arthropod community response is driven after a wildfire and how far does mulch impacts positively depending on the wildfire severity. Environmental factors such as pH, nutrient availability, quality of organic matter are related with the fire severity in a post-fire context (Certini, 2005) and are also important indicators to support ground-dwelling community parameters. Hence, fire severity accurate assessment can be very useful in this study context.

Forest residuals as a mulching agent should be also reviewed in the sense that it can carry alien species into the ecosystem, presenting a potential threat.

Some of the results obtained in this study raised the hypothesis that mulch could have contributed positively immediately on the re-establishment of ground-dwelling arthropods, although statistically, no significant results were achieved. In order to reach a better understanding about the extent of the impacts of mulch on ground-dwelling fauna, future studies should consider identification at family level, larger sampling plots and traps with larger distance intervals within sampling plots.

Adding an unburnt plot with similar characteristics in this type of studies can be very useful to comprehend how the ecological succession proceeds after the wildfire, in the sense that it will provide contrasting community parameters while comparing with an ecosystem that had a wildfire.

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Appendixes

Appendix 1. Total abundance per order on each pitfall trap and sampling date.

	Sampling Date	Order																Total
		Acari	Araneae	Chilop.	Coleop.	Collem.	Diplop.	Diptera	Hemip.	Hyme.	Isop	Opilio.	Orthop.	Pseudoscor.	Psocop.	Thysan.	Unindentifyed	
NTPF1	25/09/15	4	2		3	1		1		16	2		1	1			2	31
	14/10/15	1			2	4				5							2	12
	25/11/15	9		1	13	117		12		17	2		1	2	1			175
	27/01/16	10			7	52		8		1		1		1	1		7	81
NTPF2	25/09/15	9	4			7		4		16							3	40
	14/10/15	2	2			10				5				1			8	20
	25/11/15	10	4	1	5	23		12		7	1						7	63
	27/01/16	10	2			35		1						2	1		4	51
NTPF3	25/09/15	6	4		1	3				25							1	39
	14/10/15	1			2	2		1		6							1	12
	25/11/15	5	2	1	2	27				5				1	2		1	45
	27/01/16	3	1	1	2	8		2	2	1	1						14	21
LTPF1	25/09/15	52	4		5	3		2	1	27	1			1			3	96
	14/10/15	8	6			7		1		8	1			4			10	35
	25/11/15	27		2	8	44	1	14		26	1			2			44	125
	27/01/16	12	2			8		1	3					1			21	27
LTPF2	25/09/15	2	16	1		3				16							1	38
	14/10/15	11	2		1	47				9		1		3			1	74
	25/11/15	16	3		8	73		4		2		3			1			110
	27/01/16	44	1		4	40	2	1	2						2		14	96
LTPF3	25/09/15	15	7			67			1	36		1					3	127
	14/10/15	2				15		1		6					1		1	25
	25/11/15	4			1	5		1		2							2	13
	27/01/16	17	7		2	47			1	1				2			22	77
HTPF1	25/09/15	5	6			10		1		24				2			1	48
	14/10/15	1				35		1	1	4				4	1		2	47
	25/11/15	1				7				1							6	9
	27/01/16	3	1		3	35		10		1							6	53
HTPF2	25/09/15	3	2			8		1		25				1				40
	14/10/15	3	1	2		3			1	6	1				1			18
	25/11/15		2		4	22	1	3		17								49
	27/01/16	10				98		3			2				1		4	114
HTPF3	25/09/15	2	9		3	7		1		35	2						4	59
	14/10/15	2			1	1		3		5								12
	25/11/15	6	4		203	84		46		25				3			25	371

	27/01/16	14	1	6	73	1					1		2	**96**
UNBPF1	**14/10/15**													**0**
	25/11/15	3		6	3	4	14					1	4	**31**
	27/01/16	24	1	1	22	3	2	1	2			1	2	**57**
UNBPF2	**14/10/15**													**0**
	25/11/15	2	3	13	29	29	22		2	2			16	**102**
	27/01/16	4	4		14	2	1						5	**25**
UNBPF3	**14/10/15**													**0**
	25/11/15	3	8		15	5	22					1	3	**54**
	27/01/16	2			3	2	1						5	**8**

Appendix 2. Sample results transformation with the Naperian Logarithm.

Month	Plot	Trap Number	Total Abundance	ln(Total Abundance)
October	NT	Trap 1	12	2.4849
		Trap 2	20	2.9957
		Trap 3	12	2.4849
	LT	Trap 1	35	3.5553
		Trap 2	74	4.3041
		Trap 3	25	3.2189
	HT	Trap 1	47	3.8501
		Trap 2	18	2.8904
		Trap 3	12	2.4849
November	NT	Trap 1	175	5.1648
		Trap 2	63	4.1431
		Trap 3	45	3.8067
	LT	Trap 1	125	4.8283
		Trap 2	110	4.7005
		Trap 3	13	2.5649
	HT	Trap 1	9	2.1972
		Trap 2	49	3.8918
		Trap 3	371	5.9162
January	NT	Trap 1	81	4.3944
		Trap 2	51	3.9318
		Trap 3	21	3.0445
	LT	Trap 1	27	3.2958
		Trap 2	96	4.5643
		Trap 3	77	4.3438
	HT	Trap 1	53	3.9703
		Trap 2	114	4.7362
		Trap 3	96	4.5643

Appendix 3. Pearson correlation test results regarding orders.

			Araneae	Chilopoda	Coleoptera	Collembola	Diplopoda	Diptera	Hemiptera	Hymenoptera	Isopoda	Opilionidea	Orthoptera	Pseudoscorpiones	Psocoptera
October	Acarina	Pearson Correlation	0,971	.a	-0,59	0,943	.a	-0,082	.a	0,975	.a	.a	.a	0,915	-1,000**
		Sig. (2-tailed)	0,153	.	0,598	0,216	.	0,948	.	0,142	.	.	.	0,265	.
		N	3	1	3	3	0	3	1	3	2	1	0	3	2
	Araneae	Pearson Correlation		.a	-0,381	0,836	.a	-0,317	.a	1,000*	.a	.a	.a	0,792	-1,000**
		Sig. (2-tailed)		.	0,751	0,369	.	0,795	.	0,011	.	.	.	0,418	.
		N		1	3	3	0	3	1	3	2	1	0	3	2
	Chilopo.	Pearson Correlation			.a	.a	.a	.a	.a	.a	.a	.a	.a	.a	.a
		Sig. (2-tailed)			.	.	.	.	.	.	.	.	.	.	.
		N			1	1	0	1	1	1	1	0	0	1	1
	Coleoptera	Pearson Correlation				-0,826	.a	-0,756	.a	-0,397	.a	.a	.a	-0,866	.a
		Sig. (2-tailed)				0,382	.	0,454	.	0,74	.	.	.	0,333	.
		N				3	0	3	1	3	2	1	0	3	2
	Collembola	Pearson Correlation					.a	0,255	.a	0,846	.a	.a	.a	,997*	-1,000**
		Sig. (2-tailed)					.	0,836	.	0,358	.	.	.	0,048	.
		N					0	3	1	3	2	1	0	3	2
	Diplopo.	Pearson Correlation						.a	.a	.a	.a	.a	.a	.a	.a
		Sig. (2-tailed)						.	.	.	.	.	.	.	.
		N						0	0	0	0	0	0	0	0
	Diptera	Pearson Correlation							.a	-0,3	.a	.a	.a	0,327	1,000**
		Sig. (2-tailed)							.	0,806	.	.	.	0,788	.
		N							1	3	2	1	0	3	2
	Hemipte	Pearson Correlation								.a	.a	.a	.a	.a	.a
		Sig. (2-tailed)								.	.	.	.	.	.
		N								1	1	0	0	1	1
	Hymenopte	Pearson Correlation									.a	.a	.a	0,803	-1,000**
		Sig. (2-tailed)									.	.	.	0,407	.
		N									2	1	0	3	2
	Isopoda	Pearson Correlation										.a	.a	.a	.a
		Sig. (2-tailed)										.	.	.	.
		N										1	0	2	2
	Opilioni.	Pearson Correlation											.a	.a	.a
		Sig. (2-tailed)											.	.	.
		N											0	1	1

	Orthopt	Pearson Correlation												.a	.a
		Sig. (2-tailed)												.	.
		N												0	0
	Pseudoscor	Pearson Correlation													-1,000**
		Sig. (2-tailed)													.
		N													2
November	Acarina	Pearson Correlation	-0,906	-1,000**	-0,827	0,07	.a	-0,899	.a	-0,781	-1,000**	.a	.a	-0,906	-1,000**
		Sig. (2-tailed)	0,278	.	0,38	0,956	.	0,289	.	0,429	.	.	.	0,278	.
		N	3	2	3	3	2	3	0	3	2	1	1	3	2
	Araneae	Pearson Correlation		1,000**	0,512	0,359	.a	0,629	.a	0,444	1,000**	.a	.a	1,000**	1,000**
		Sig. (2-tailed)		.	0,658	0,766	.	0,567	.	0,707	.	.	.	0	.
		N		2	3	3	2	3	0	3	2	1	1	3	2
	Chilopoda	Pearson Correlation			1,000**	1,000**	.a	1,000**	.a	-1,000**	1,000**	.a	.a	1,000**	1,000**
		Sig. (2-tailed)			.	.	.	.	.	.	.	.	.	.	.
		N			2	2	1	2	0	2	2	1	1	2	2
	Coleoptera	Pearson Correlation				-0,618	.a	0,99	.a	,997*	1,000**	.a	.a	0,512	1,000**
		Sig. (2-tailed)				0,576	.	0,091	.	0,05	.	.	.	0,658	.
		N				3	2	3	0	3	2	1	1	3	2
	Collembol	Pearson Correlation					.a	-0,5	.a	-0,677	1,000**	.a	.a	0,359	1,000**
		Sig. (2-tailed)					.	0,667	.	0,526	.	.	.	0,766	.
		N					2	3	0	3	2	1	1	3	2
	Diplopo	Pearson Correlation						.a	.a	.a	.a	.a	.a	.a	.a
		Sig. (2-tailed)						.	.	.	.	.	.	.	.
		N						2	0	2	1	1	0	2	1
	Diptera	Pearson Correlation							.a	0,976	1,000**	.a	.a	0,629	1,000**
		Sig. (2-tailed)							.	0,14	.	.	.	0,567	.
		N							0	3	2	1	1	3	2
	Hemipte	Pearson Correlation								.a	.a	.a	.a	.a	.a
		Sig. (2-tailed)								.	.	.	.	.	.
		N								0	0	0	0	0	0
	Hymenopte	Pearson Correlation									-1,000**	.a	.a	0,444	-1,000**
		Sig. (2-tailed)									.	.	.	0,707	.
		N									2	1	1	3	2
	Isopoda	Pearson Correlation										.a	.a	1,000**	1,000**
		Sig. (2-tailed)										.	.	.	.
		N										1	1	2	2
	O	Pearson Correlation											.a	.a	.a

		Sig. (2-tailed)											.	.	.
		N											0	1	1
	Orthopt	Pearson Correlation												.a	.a
		Sig. (2-tailed)												.	.
		N												1	1
	Pseudosc	Pearson Correlation													1,000**
		Sig. (2-tailed)													.
		N													2
January	Acarina	Pearson Correlation	0,983	.a	-,997*	-0,436	.a	-0,951	1,000**	-0,561	1,000**	.a	.a	.a	.a
		Sig. (2-tailed)	0,119	.	0,046	0,713	.	0,2	.	0,621	.	.	.	.	.
		N	3	1	3	3	1	3	2	3	2	1	0	2	3
	Araneae	Pearson Correlation		.a	-0,993	-0,596	.a	-0,992	1,000**	-0,397	-1,000**	.a	.a	.a	.a
		Sig. (2-tailed)		.	0,073	0,593	.	0,081	.	0,74	.	.	.	.	.
		N		1	3	3	1	3	2	3	2	1	0	2	3
	Chilopo	Pearson Correlation			.a	.a	.a	.a	.a	.a	.a	.a	.a	.a	.a
		Sig. (2-tailed)			.	.	.	.	.	.	.	.	.	.	.
		N			1	1	0	1	1	1	1	1	0	1	1
	Coleoptera	Pearson Correlation				0,5	.a	0,971	-1,000**	0,5	.a	.a	.a	.a	.a
		Sig. (2-tailed)				0,667	.	0,154	.	0,667	.	.	.	.	.
		N				3	1	3	2	3	2	1	0	2	3
	Collembol	Pearson Correlation					.a	0,693	.a	-0,5	1,000**	.a	.a	.a	.a
		Sig. (2-tailed)					.	0,512	.	0,667	.	.	.	.	.
		N					1	3	2	3	2	1	0	2	3
	Diplopo	Pearson Correlation						.a	.a	.a	.a	.a	.a	.a	.a
		Sig. (2-tailed)						.	.	.	.	.	.	.	.
		N						1	1	1	0	0	0	1	1
	Diptera	Pearson Correlation							-1,000**	0,277	1,000**	.a	.a	.a	.a
		Sig. (2-tailed)							.	0,821	.	.	.	.	.
		N							2	3	2	1	0	2	3
	Hemiptera	Pearson Correlation								-1,000**	.a	.a	.a	.a	.a
		Sig. (2-tailed)								.	.	.	.	.	.
		N								2	1	1	0	2	2
	Hymenopte	Pearson Correlation									-1,000**	.a	.a	.a	.a
		Sig. (2-tailed)									.	.	.	.	.
		N									2	1	0	2	3
	Isop	Pearson Correlation										.a	.a	.a	.a
		Sig. (2-tailed)										.	.	.	.

	N	1	0		1		2
Opilionidea	Pearson Correlation		.a	.a		.a	
	Sig. (2-tailed)		.	.		.	
	N		0		1		1
Orthopt	Pearson Correlation			.a		.a	
	Sig. (2-tailed)			.		.	
	N				0		0
Pseudoscor	Pearson Correlation					.a	
	Sig. (2-tailed)					.	
	N						2

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed). “a” Cannot be computed because at least one of the variables is constant.

Appendix 4. Total abundance and ecological function for each pitfall and sampling date.

	Order	Collembola	Hemiptera	Psocoptera	Coleoptera	Thysanura	Isopoda	Coleoptera	Hymenoptera	Chilopoda	Pseudoscorpioni.	Coleoptera	Aranea	Opiliones
	Ecological Function	Microbial Feeders	Plant Feeders	Plant Feeders	Plant Feeders	Omnivores	Omnivores	Omnivores	Omnivores	Predators	Predators	Predators	Predators	Predators
LTPF1	**25/09/15**	10							24		2		6	
	14/10/15	35	1	1					4		4			
	25/11/15	7							1					
	27/01/16	35						3	1				1	
LTPF2	**25/09/15**	8							25		1		2	
	14/10/15	3	1	1			1		6	2			1	
	25/11/15	22			2			2	17				2	
	27/01/16	98		1			2							
LTPF3	**25/09/15**	7					2	3	35				9	
	14/10/15	1						1	5					
	25/11/15	84			162				25		3	41	4	
	27/01/16	73		1				6					1	
NTPF1	**25/09/15**	1			1		2	2	16		1		2	
	14/10/15	4			2				5					
	25/11/15	117		1	9		2	1	17	1	2			
	27/01/16	52		1					1		1			1
NTPF2	**25/09/15**	7							16				4	
	14/10/15	10							5		1		2	
	25/11/15	23			4		1	1	7	1			4	
	27/01/16	35		1							2		2	
NTPF3	**25/09/15**	3			1				25				4	
	14/10/15	2			2				6					
	25/11/15	27		2	2				5	1	1		2	
	27/01/16	8	2		2		1		1	1			1	
HTPF1	**25/09/15**	3	1				1	5	27		1		4	
	14/10/15	7					1		8		4		6	
	25/11/15	44			8		1		26	2	2			
	27/01/16	8	3								1		2	
HTPF2	**25/09/15**	3							16	1			16	
	14/10/15	47							9		3	1	2	1
	25/11/15	73		1	7				2			1	3	3
	27/01/16	40	2	2				1				3	1	

HTPF3	**25/09/15**	67	1						36				7	1
	14/10/15	15		1					6					
	25/11/15	5			1				2					
	27/01/16	47	1		2				1		2		7	
UNBPF1	**14/10/15**													
	25/11/15	3			5	1		1	14					
	27/01/16	22				1	1		2			1	1	2
UNBPF2	**14/10/15**													
	25/11/15	29			7			3	22		2		3	2
	27/01/16	14							1				4	
UNBPF3	**14/10/15**													
	25/11/15	15				1			22				8	
	27/01/16	3							1					

Appendix 5. Pearson correlation results regarding functional groups within months.

Date			Plant Feeders	Omnivores	Predators
October	**Microbial Feeders**	Pearson Correlation	-0,902	0,945	0,99
		Sig. (2-tailed)	0,285	0,212	**0,091**
		N	3	3	3
	Plant Feeders	Pearson Correlation		-0,993	-0,954
		Sig. (2-tailed)		0,073	0,194
		N		3	3
	Omnivores	Pearson Correlation			0,982
		Sig. (2-tailed)			0,121
		N			3
November	**Microbial Feeders**	Pearson Correlation	-0,624	-0,457	0,984
		Sig. (2-tailed)	0,571	0,698	0,113
		N	3	3	3
	Plant Feeders	Pearson Correlation		0,98	-0,752
		Sig. (2-tailed)		0,127	0,458
		N		3	3
	Omnivores	Pearson Correlation			-0,607
		Sig. (2-tailed)			0,585
		N			3
January	**Microbial Feeders**	Pearson Correlation	-0,896	0,993	-0,891
		Sig. (2-tailed)	0,293	0,073	0,3
		N		3	3
	Plant Feeders	Pearson Correlation		-0,941	1,000**
		Sig. (2-tailed)		0,219	0,007
		N		3	3
	Omnivores	Pearson Correlation			-0,937
		Sig. (2-tailed)			0,227
		N			3

** Correlation is significant at the 0.01 level (2-tailed).

Appendix 6. Pearson correlation test results regarding functional groups within treatments.

Treatments			Plant Feeders	Omnivores	Predators
NT	**Microbial Feeders**	Pearson Correlation	0,914	0,556	,999*
		Sig. (2-tailed)	0,266	0,625	0,024
		N	3	3	3
	Plant Feeders	Pearson Correlation		0,846	0,898
		Sig. (2-tailed)		0,359	0,29
		N		3	3
	Omnivores	Pearson Correlation			0,525
		Sig. (2-tailed)			0,648
		N			3
LT	**Microbial Feeders**	Pearson Correlation	0,997	0,242	-1,000**
		Sig. (2-tailed)	0,053	0,844	0,007
		N	3	3	3
	Plant Feeders	Pearson Correlation		0,161	-,997*
		Sig. (2-tailed)		0,897	0,046
		N		3	3
	Omnivores	Pearson Correlation			-0,231
		Sig. (2-tailed)			0,851
		N			3
HT	**Microbial Feeders**	Pearson Correlation	0,538	0,384	-0,181
		Sig. (2-tailed)	0,638	0,749	0,884
		N	3	3	3
	Plant Feeders	Pearson Correlation		0,985	0,732
		Sig. (2-tailed)		0,111	0,478
		N		3	3
	Omnivores	Pearson Correlation			0,839
		Sig. (2-tailed)			0,367
		N			3

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).