Termites in eucalyptus forest plantations and forest remnants: an ecological approach

Térmitas em florestas implantadas de eucalipto e remanescentes florestais: uma abordagem ecológica

Luciane Kern Junqueira[1]
Elena Diehl[2]
Evoneo Berti Filho[3]

ABSTRACT

Changes in the composition and structure of plant communities may result from human actions, such as the intensive use of the soil for agriculture and deforestation for the plantation of eucalyptus forests. This article aims to reveal how such disturbances cause conspicuous, spatial changes in biodiversity and, consequently, in many features of the earth's ecosystems, affecting termite diversity, mainly those of the geophagous group. The reduction in the abundance of these insect species, the so-called "soil engineers", causes a decrease in carbon content and an imbalance in the functional groups, thus influencing the rate of soil degradation and causing further changes in biodiversity.

Key words: Termite diversity. Functional groups. Soil use. Forest disturbances.

RESUMO

Alterações na composição e na estrutura das comunidades vegetais podem ser resultantes de ações antrópicas como a intensificação do uso do solo para agricultura e desmatamentos para implantação de florestas comerciais de eucalipto. Este artigo visa discutir como tais alterações causam sensíveis mudanças espaciais na biodiversidade e, conseqüentemente, em muitas características dos ecossistemas terrestres, influenciando, sobremaneira, a diversidade de cupins, principalmente os do grupo dos geófagos. A redução da riqueza de espécies desses insetos, considerados "engenheiros do solo", causa um decréscimo

[1] Pontifícia Universidade Católica de Campinas, Centro de Ciências da Vida, Faculdade de Ciências Biológicas. Av. John Boyd Dunlop, s/n., Jardim Ipaussurama, 13060-904, Campinas, SP, Brasil. Correspondência para/Correspondence to: L.K. JUNQUEIRA. E-mail: <lkjunque@yahoo.com.br>.
[2] Universidade do Vale do Rio dos Sinos, Laboratório de Insetos Sociais. São Leopoldo, RS, Brasil.
[3] Universidade de São Paulo, Escola Superior de Agricultura Luís de Queiroz, Departamento de Entomologia, Fitopatologia e Zoologia Agrícola. Piracicaba, SP, Brasil.

nos teores de carbono e um desequilíbrio dos grupos funcionais, influindo no grau de degradação dos solos e provocando novas alterações da biodiversidade.

Palavras-chave: Diversidade de cupins. Grupos funcionais. Perturbações florestais. Uso do solo.

INTRODUCTION

Termite communities present great species diversity, with various types of feeding and nesting places. In terrestrial ecosystems, these insects carry the greatest responsibility - although not necessarily the dominant group - for decomposition and mineralization of carbon, thus affecting properties and soil structure (Bignell & Eggleton, 2002; Holt & Lepage, 2002). Together with earthworms and ants, they are the invertebrates most involved in the ingestion and/or manipulation of organic and mineral matter, forming subterranean tunnels and chambers which aid the redistribution of soil layers, aeration, porosity and increased drainage, hence they are also referred to as "soil engineers" (Jones et al., 1994; Lavelle et al., 1997; Folgarait, 1998). According to Jouquet et al. (2006), calling invertebrates "soil engineers," a name applied by Jones et al. (1994), quickly affected how people understood the organisms' role in the functioning of ecosystems. Thus, the increase in the number of studies on soil invertebrates, especially termites, observed over the previous decade, could be related to this new vision. Finally, one must still consider that termite soil activity in ecosystems, mainly the arid and semi-arid ones, by increasing water retention in the soil, will affect both the vegetation structure and local primary productivity. That is why they are regarded as indispensable organisms for the maintenance of the structural and functional integrity of terrestrial ecosystems.

At the same time as termite communities change the soil structure and composition they are also affected by local conditions. Plant structure influences the diversity of the insects through the quantity and quality of the available litter, the amount of shadow, the dampness, and the heating of soil and air. Changes in this structure from processes of fragmentation, deforestation, forestry or even regeneration and recomposition, can alter termite communities.

In forest systems, termite activity may be approached differently. In forests, they are important components of the soil fauna by playing a major role in organic matter decomposition, nutrient cycling, soil aeration and draining (Collins, 1981; Wood & Johnson, 1986; Berti Filho, 1995). They play the same role in forestry where they can also count among the major pests, in which case they cause significant economic losses (Berti Filho, 1995). These forests are more sensitive during the period of plantation when the attacked buds can die or result in smaller trees (Wilcken, 1992; Wilcken & Raetano, 1995).

Deforestation and the set-up of commercial forestry lead to changes in plant structure by modifying the availability of plant matter and/or changes in the ecological niche of the species. As a consequence, local diversity of termites can be modified by favoring some species and compromising others. With the former, the question is whether the favored species are those with potential to become pests (Wood & Johnson, 1986; Donovan et al., 2002). The question asked in the second case is whether, by compro-mising some species, their local diversity could become extinct (Constantino, 1992; De Souza & Brown, 1994), or whether the lost species would be replaced by others (Mill, 1982). But in either situation, the decomposition and nutrient cycling processes, the local soil structure and properties would be affected.

For Lavelle et al. (1997), modifications in the structure and composition of plant communities, intensification of soil usage, and physical changes in forests can decrease termite diversification by

affecting mainly the geophagous termites, and due to modifications in the availability of organic matter, some species can become pests. Mill (1982) believes that the most obvious effect of deforestation is the reduction in the number of tree-nidifying species or those which feed on living wood. Tree removal leaves the deforested area temporarily uninhabitable for some of these species, with their niches being occupied by other, less sensitive species which may become pests. Moreover, changing microclimatic conditions does not allow for the maintenance of colonies of very susceptible termite species.

The Neotropical region is the second largest in terms of the number of termite species, only surpassed by the Ethiopian region (Araújo, 1970; 1977). But the search for data in the Neotropical region is very limited when compared to the detailed collections and studies carried out on termites in some African sites. Bignell & Eggleton (2002) referred to the great number of publications on the ecology of tropical forest termites in the African continent, although information about these same insects in tropical forests, where geophagous species are prevalent, is still scarce, despite including some studies conducted in Malaysia, Sabah and Sumatra.

Most ecological studies on neotropical termites were conducted in the Amazon forest (firm ground forests and lowland sites) and the savanna-like ecosystem (Cerrado) (Fittkau & Klinge, 1973; Mathews, 1977; Mill, 1982; Domingos et al., 1986; Bandeira, 1989; Gontijo & Domingos, 1991; Constantino, 1992; 2005; Martius, 1994; De Souza & Brown, 1994). The revealing faunistic-ecological inventory by Mathews (1977) conducted in Mato Grosso is particularly notable. Some biomas, such as the rain forest and the Caatinga, have had their termite fauna investigated starting from the end of the 90's (Bandeira et al., 1998; Bandeira & Vasconcellos, 1999; Martius et al., 1999; Silva & Bandeira, 1999; Cancello, 2002; Mélo & Bandeira, 2004; Vasconcellos et al., 2005; Moura et al., 2006).

In South America studies on the taxonomy and the ecology of termites are still in the early stages. Many South American data are based on nest sampling, which could suggest that termite fauna is dominated by xylophagous species; but this is probably a pitfall of the soil subsampling (Bignell & Eggleton, 2002).

Surveys of the Brazilian termite fauna are still recent and scarce, mainly in primary forests and areas going through succession processes. There are also scant studies on the way changes in plant structure, resulting from forestry practices, interfere with these insect communities. Eucalyptus plays a major role among the various cultivated forestry trees; and, despite the still incipient suitable collection techniques and the information on this culture's termite species, they already display valuable data (Junqueira & Berti Filho, 2000). But it is still unclear whether the presence of termite-pests in the eucalyptus culture is connected or not with changes in these insect communities as a consequence of forestry practices (Figure 1), such as the plant removal and burning referred to by Berti Filho (1995). If it is, diagnosed sites which identify the richness and abundance of termite species can provide support for the adoption of local plant management during eucalyptus growing and cultivation.

Taking the example of countries where termite fauna is well known, Jones et al. (2003) recommend an agroforestry systems management with techniques that have less impact, that reduce losses in termite communities. They also recommend the maximization of fragment size and connexion, thus decreasing the expansion of borders and permitting wood decomposition in situ.

TERMITES IN EUCALYPTUS FORESTRY

In the burgeoning process of exotic forestry species in tropical regions, termites have caused such significant damage that they are regarded as one of the limiting factors in the implementation of commercial forests (Harris, 1971; Cowie et al., 1989). There are two groups of termite-pests in forests:

Termites which attack buds up to one year old, known as bud, root or soil termites, for example,
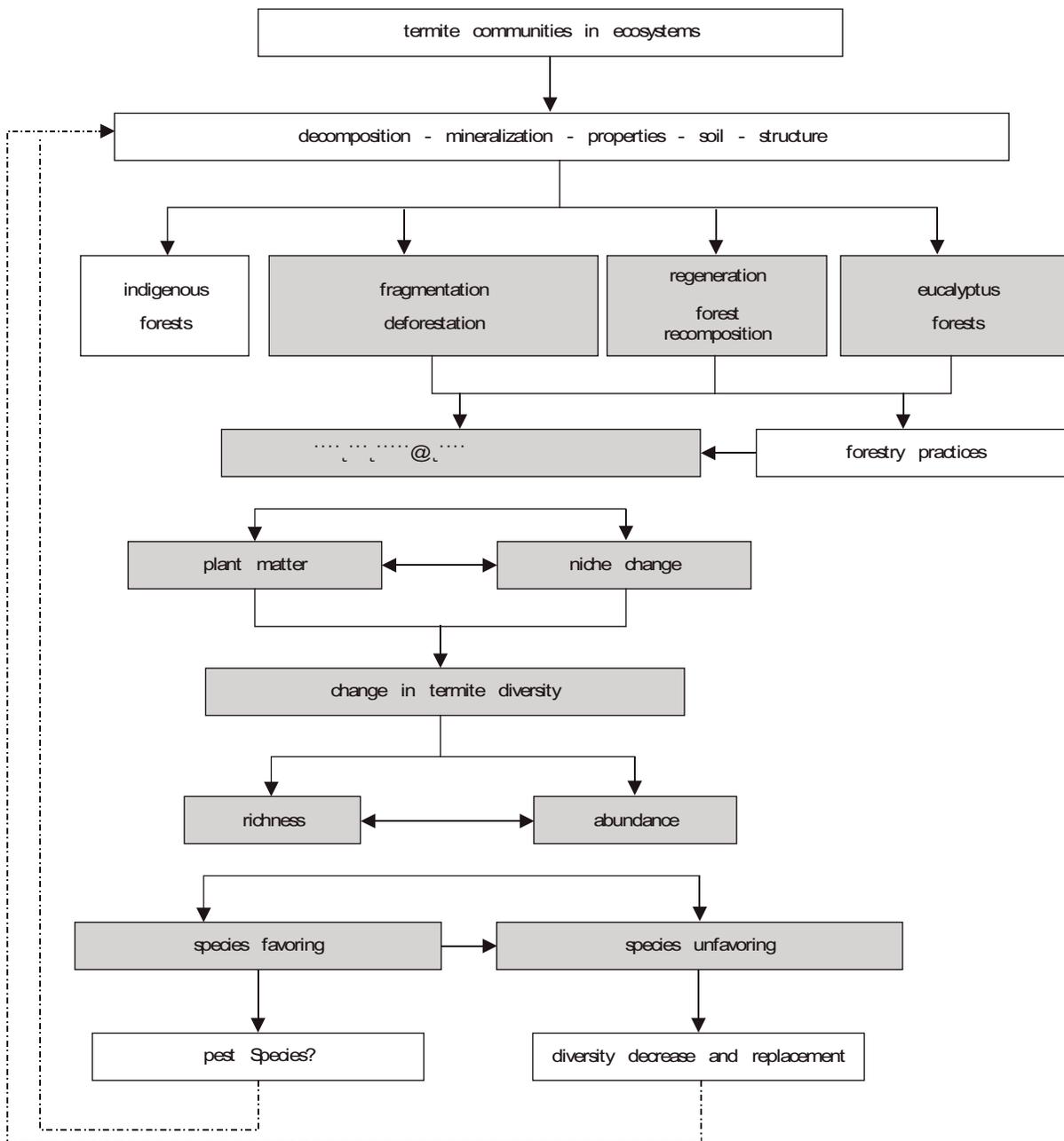
Figure 1. The problem of termites in eucalyptus forestry (Junqueira, 2004).

Syntermes molestus, Syntermes insidians, and Cornitermes cumulans (Termitidae, Nasutitermitinae), which destroy the root system and/or cause bud girdling in the colon area, damage that generally results in the death of the plant. Mortality in these instances is significant, affecting 18% of Eucalyptus grandis buds in Brazil, due to attacks from some species of Cornitermes. As for commercial cultivation, the accepted failure rate is between 2% and 5%, because above this level, replantation is burdensome. When buds resist attack, calluses are formed in the roots, which will originate a new root system on top of the destroyed one, or they will give off buds and form a new aerial portion in the area of the colon girdling. It follows that trees can have a deficient root system

and inappropriate sustenance, or become dominated trees due to the delay in their initial growth, with a decrease in the crop's economic value (Wilcken, 1992; Wilcken & Raetano, 1995).

Termites which attack two-year-old trees, or older, by destroying their inner portion, the so-called heartwood termites. The most prominent example is the Coptotermes testaceus (Rhinotermitidae). Termites get inside the roots and build galleries within the trunk, destroying the heartwood and leaving the trees hollow, with a drop in reforestation productivity. Inner damage becomes evident during tree cutting which makes prevention more difficult. Wilcken & Raetano (1998) showed a synthesis of the most attacked Eucalyptus species in Brazil and the respective damaged areas.

Nair & Varma (1985) suggest that factors such as termite species; population density; pace of seasonal activity; litter, and wood gathering; soil conditions; physiological state of the plant; age and condition of the growing set-up are also connected with termite-eucalyptus interaction in the forest. The lack of research programs on ecological relationships among termites, favorite host plant species, and probable correlations with different edaphic factors serve to only make things worse (Wardell, 1987).

The available data suggest that wood removal or certain cultural practices decrease termite richness and lead to the selective loss of some functional groups, mainly the geophagous ones (Wood et al., 1982). But the results of less drastic forestry practices are still unknown, such as the preservation of sub woods and wood remains (Eggleton et al., 1995). Deforestation and isolation also play a direct role in termite ecology in neotropical forests. As most primary forest termites are very sensitive to such effects, and do not survive habitat changes, the few species which manage to adjust can become serious forest pests (Mill, 1982).

FUNCTIONAL TERMITE GROUPS

Functional or trophic groups mean the gathering of termite species according to specific diet requirements (Mathews, 1977; Gontijo & Domingos, 1991; De Souza & Brown, 1994; Eggleton et al., 1995; Eggleton et al., 1997; Jones & Brendell, 1998; Jones, 2000). Since different authors consider a great number of functional groups, Bignell & Eggleton (2002) gathered the various categories reported in literature into five large groups:

• Geophagous: soil-feeding termites. They use very heterogeneous material, with a high proportion of organic matter and silica and, unlike other groups, low proportions of plant tissue. They are found only in Termitidae (Apicotermitinae, Nasutitermitinae, and Termitinae subfamilies).

• Xylophagous: they feed on wood, which can also be in the litter, including live and dead branches. Most inferior termites feed on wood, and the xylophagous species can be found in all Termitidae subfamilies, except for the Apicotermitinae. As for the use of the resource, there is a succession of species, according to wood decomposition due to the state of humidification and fungi.

• Intermediates between geophagous and xylophagous: they feed on extremely rotten wood which has already lost its structure and has become brittle, similar to the soil, or they feed on the soil near-the-surface. They can also feed on the inner portion of rotten logs or a mixture of litter and surface roots. When analyzing the communities, termites belonging to the geophagous/xylophagous interface group are generally classed with the geophagous. This category overlaps both anterior classes, being found only in the Termitidae (Apicotermitinae, Nasutitermitinae, and Termitinae subfamilies).

• Litter foragers: termites which feed predominantly on leaves in the litter or on small pieces of wood, and take them to the nests for temporary storage. They occur in all Termitidae (Apicotermitinae, Macrotermitinae, Nasutitermitinae, and Termitinae subfamilies).

• Grass eaters: termites which permanently

forage in grass and low vegetation, which is usually already dead and dry, by cutting and moving the cut material to the nest. They are found in the Hodotermitidae (Hodotermitinae subfamily), and in the Termitidae (Macrotermitinae, Nasutitermitinae, and Termitinae subfamilies).

There are also some smaller feeding groups which feed on fungi, algae or lichen on tree-trunk surfaces. Others are opportunistic and feed on manure and the corpses of vertebrates. Some species also use, as a contingent or compulsory food item, the nests which are built by other termite species.

Generally, the species assembled in each functional group show a similar consumer pattern (Eggleton et al., 1998). But classification into functional groups faces the need for a detailed knowledge of the feeding ecology of termites, mainly, the geophagous (Jones, 2000). It is worth stressing that, under unfavorable conditions, some species use more than one food source, which enables them to be placed into more than one functional group (Bignell & Eggleton, 2002).

Classification into functional feeding groups, according to the benchmark proposition, has some disadvantages, since there is no distinction between living or dead plant tissue. In forests, live trees are attacked by Coptotermes species, and small roots can be eaten, apparently, by geophagous termites. There are also examples which are harder to classify, such as the Macrotermitinae subfamily, where workers of various ages feed on a symbiotic fungus, as well as fresh litter or litter stored in nests, and use the soil as food (Tranielo & Leuthold, 2002).

Besides the functional groups, Eggleton et al. (1996) suggest the use of taxonomic groups to assess the effects of forest disturbances on the termite community, since those which feed on the soil show peculiar morphological and anatomical features. Thus, the community's taxonomic composition can be used as an indication of their ecological functioning.

MODIFYING THE NATURAL HABITAT: EFFECTS ON THE TERMITE COMMUNITY

Studies in Brazil

North: In the Central Amazon, Bandeira (1979) studied the effect of deforestation on termite populations by assessing the distribution and diversity of these insects in primary forest areas, secondary forest areas (capoeira) and grazing areas. The great majority of genera showed an equivalent distribution in the three areas. The Nasutitermes genus was the commonest, and the one with the greatest diversity, more frequent in grazing fields, where the largest number of nests was observed. Soil termites were found in greater numbers in secondary forests, followed by grazing areas and the primary forest. The author suggested that the removal of primary vegetation and the resulting microclimate changes would be responsible for the modification in the distribution of some groups.

By working in four sites near Manaus (AM), Mill (1982) found a greater density of termites in islands than in firm ground, probably due to food competition. He believes that termites which adjusted to life in secondary forests, islands, and igapos can become forest pests (e.g. Coptotermes and Nasutitermes). The termite fauna in non-flooded areas compared to the floodplain of the Brazilian Amazon was different, showing a lower degree of similarity. The species composition and diversity varied largely among sites, with no apparent correlation with climate or vegetation type. In part, these differences were caused by the collection effort and the different sampling methods employed.

By analyzing the termite fauna in primary forests of two Brazilian Amazon localities, Constantino (1992) confirmed that representatives of the Nasutitermitinae subfamily were the prevalent group, both in number and abundance of species, especially the genus Nasutitermes. Most of the species found were xylophagous, largely limited to rotten wood. Humivorous were the second largest group in number of species. The species composition and diversity varied among the different sites and, apparently, they did not show any correlation with climate or type of

vegetation.

De Souza & Brown (1994), in a pioneering study of forest fragments, studied termite communities in the Amazon forest and in fragments of neighboring isolated reserves. The geophagous were prevalent in the forest, richer in species and lesser in rare species, whereas in the fragments, the ones which used litter and those with a feeding habit between geophagy and xylophagy were the prevalent species. Moreover, the termites used forest habitats in a more equitable manner than in the fragments. Such results suggest a growing habitat non-adaptation to fragmentation, and that the composition of the termite communities in the fragments would result from the intrinsic forest pattern and the losses caused by fragmentation.

Northeast: When Bandeira et al. (2003) identified the termite fauna found in six environments, with various levels of disturbance in Brejo dos Cavalos (PE), they confirmed the decrease in diversity as disturbances became more profound, seeing that they were not able to find these insects in the area with chayote (Echuim edule) as a monoculture. Termites feeding on humus were more affected than those feeding on intermediate food. Concomitantly, those feeding on wood showed more resilience, whereas some favored species in areas of secondary forests showed a tendency to disappear in agricultural areas with less available wood.

Investigation of the termite fauna in a cerrado fragment in the Guaribas Biological Reserve, in Mamanguape, (PB), Sena et al. (2003) recorded most of the species as xylophagous while the largest frequency of transects was seen in the humivorous species. Richness was lower than that reported with cerrado vegetation, probably due to the isolation time and distance from the fragment in relation to the large cerrado areas in the Brazilian central region.

Southeast: Junqueira et al. (2004) conducted seasonal gatherings in a Eucalyptus pilulares cultivation in Anhembi (SP), through three complementary techniques: Termitrap® baits, soil samples with litter, and direct collections under/on tree bark. A low termite richness was found in

Winter and Spring (S=5), higher in Summer (S=7) and Autumn (S=9), the most frequent species over the course of the four seasons being Heterotermes tenuis.

Junqueira (2004) assessed the termite community in seven environments of Estação Florestal de Anhembi (SP), including areas of eucalyptus cultivation and forest fragments along three successive, distinct stages. The results obtained showed that changes in plant structure from both forestry activities and successive fragment stages affect both components (richness and abundance) of termite diversity. The fact that the relative abundance of some species changes from one environment to the other may point to the ability of some pest-potential species to become more abundant with increased disturbances. But this increase would not be so strongly marked (Figure 1), which conforms to the suggestion by Jones et al. (2003). According to them, some termite populations grow significantly with the intensification of forest fragmentation. Some increase in species may be due to their presence in the original assemblage of local species or its introduction through different human activities. But when a small gradient is shown, it is harder to find significant differences between the areas. Concomitantly, the occurrence of some termite species could still be related to the presence of wood remains on the ground. These species would not potentially cause damage to the seedlings and/or trees, since they nidify and feed on wood remains, suggesting that, by not removing this material, the diversity of the local community would be preserved. It is also noticeable that, in Anhembi, the distribution of Apicotermitinae species (Termitidae) showed that this group did not show a decrease in richness and abundance due to changes in plant structure resulting from the plantation of eucalyptus (Junqueira, 2004).

Calderon & Constantino (2007) evaluated a Eucalyptus urophylla culture in Buritis (MG). The authors recorded 28 species which represent a subset of the termites' indigenous fauna of the cerrado for that area, also showing a smaller proportion of humivorous species in relation to the original

community. Despite the amount of recorded species being regarded as pests, termites do not cause significant harm to the region.

South: In the Campos de Cima da Serra region, in the Northeast of Rio Grande do Sul, the Planalto das Araucárias is characterized by large expanses of indigenous fields, interspersed by areas of mixed ombrophilous forest, partly belonging to the Floresta Nacional de São Francisco de Paula (FLONA-SFP). For a long time this forest suffered from wood-extraction activity resulting in extensively deforested areas. About 50 years ago, a state government restoration program led to the reforestation of some areas with Araucaria angustifolia (araucária), while other areas underwent the growth of Pinus spp. and Eucalyptus spp.. Presently, the FLONA-SFP can be regarded as a mosaic of indigenous forest plots, with and without araucária; reforestation plots with araucária, and others with the growth of exotic species, surrounded by large expanses of indigenous fields.

Along the various forest plots of the FLONA-SFP and field area, Diehl et al. (2005) conducted systematic termite collections according to patterned protocols, with the recording of representatives of the Kalotermitidae and the Termitidae, only. From the first family one species was collected, whereas from the second family seven taxa were recorded. Besides the scarce richness, all taxa showed low occurrence, both in the indigenous plots and in the araucaria culture, the pinus culture and the field area. Richness never exceeded four species per environment, seeing that the greatest difference among the areas was in species' composition. For example, the Aparatermes genus (geophagous) was the only one seen in all forest plots, while Rugitermes (xylophagous) was found in reforestation areas with araucaria and pinus. In the field, only some nests of Cornitermes cumulans were found; in one nest representatives of Dihoplotermes were collected, which became the first recorded find of this genus in Rio Grande do Sul.

Before investigations in the FLONA-SFP, Junqueira et al. (2006) carried out a survey of the termite fauna in a commercial eucalyptus forest in Barra do Ribeiro, in the Litoral Médio of Rio Grande do Sul. In order to compare with the data from a survey conducted simultaneously at Anhembi (SP), the same methodology was used (Termitrap® baits and qualitative samplings in litter, fallen trunks and branches, on and under tree barks), with a similar sampling effort and over the same seasons of the year. But the data were polarized. Whereas the richness and abundance of termite species at Anhembi were high, only two samples of Kalotermitidae representatives were obtained in Barra do Ribeiro. The authors regarded these differences as a consequence of the different climate conditions of the two regions. But, when comparing the data obtained only in Southern Brazil, the temperature occurring in the FLONA-SFP (annual mean lower than 18ºC), possibly due to altitude (930m), is lower than in Barra do Ribeiro (annual mean of 28ºC) which is at sea level. That is, differences between the Anhembi and Barra do Ribeiro termite fauna are certainly due to other non-evaluated factors.

Data from FLONA-SFP show a termite richness similar to the one recorded by Laffont et al. (1998), in the Northwest of the Província de Corrientes (Argentina), a region with a temperate climate, however. These authors collected nine species representing two subfamilies in a Eucalyptus grandis forest. Cancello (2002), for his part, found between two and eight morphospecies in areas with a subtropical climate in the Floresta Atlântica (Santa Catarina), while in tropical areas of this same forest (next to Bahia) an average of 30 morphospecies were recorded.

Studies in other countries

Eggleton et al. (1995) conducted a qualitative evaluation of termites in five areas, with varied levels of forest disturbances, in the Mbalmayo Forest Reserve in Southern Cameroon. When compared to the primary forest, sites with severe disturbances

showed a marked decrease in species richness, while those going through a regeneration process showed a slight increase in this richness. Geophagous were prevalent in sites going through a regeneration process and in the primary forest, although their richness was smaller in sites that had undergone severe disturbances. As for the xylophagous, they seemed to be more resistant to disturbances than the geophagous, although the species' richness was low in the more disturbed areas. Later in the same forest reserve, the diversity, abundance and biomass of termite communities were assessed in five different sites, with varied disturbance levels, over two successive years (Eggleton et al., 1996). Abundance and biomass were high in sites similar to the primary forest and those going through an advanced succession process. Disturbances showed little effect on the abundance and biomass in forest areas, although there was a clear decrease in these components in the open areas. Differences were also found in the composition of the taxonomic groups, the abundance of nidification places and the composition of the functional groups between the sites which affected mainly the composition of the geophagous. The area similar to the primary forest showed a more heterogeneous community when compared to the more disturbed areas, probably due to the larger number of microhabitats available to termites.

The successional reaction of a termite community to experimental disturbances in forests of the Cameroon and its implications for forest restoration were investigated by Davies et al. (1999). Even in the treatments involving severe disorders of the soil and canopy cover, the termite richness and abundance recovered quickly when the dead wood was left on the ground. This availability of wood also resulted in occupation by a group of termites, including the xylophagous and geophagous species, different from the composition of other treated groups.

Dibog et al. (1999) studied the impact of plant cover on termite communities in agroforestry systems, with six- to eighteen-year-old Terminalia ivorensis (Combretaceae), in Southern Cameroon, where the forest was used to grow bananas and cocoa. In the planting of an 18-year-old T. ivorensis, the greatest abundance of termites occurred in areas with a denser canopy, regardless of the subforest type (banana or cocoa), the cultivation system (single or mixed) or the way the soil is prepared (by preserving or burning the straw, with the latter only to grow bananas). With the planting of six-year olds, there was no significant difference in termite abundance when compared to the lower and higher canopy density. From a total of 82 termite species found, 67 were geophagous.

To assess the impact of intensification of soil usage in termite communities in the rain forest of the Jombi Province (Sumatra, Indonesia), the community composition was identified in a gradient of seven disturbed environments, which included the primary forest, varied forestry systems, and areas with maniva planting (Jones et al., 2003). From a total of 54 species of termites collected, the primary forest showed the greatest richness, with 34 species, and the maniva planting showed the lowest richness, with just one species. Compared to the xylophagous, the relative abundance of the geophagous showed the highest decrease along the gradient. It was acknowledged that the basal area of the trees correlated highly with the richness and abundance of termites, thus reflecting the adaptive reaction of these insects to the progressive simplification of the physical structure of the habitat, resulting from the smaller canopy cover, the microclimate changes and the decrease in the number of feeding and nesting places. The authors also analyzed other researchers' studies by assessing termite communities along local disturbance gradients. In general, there was a tendency towards species richness and a decline in abundance with the increase in soil usage. This tendency becomes more apparent when more distinct gradients are assessed, from primary forests to places without trees.

FINAL CONSIDERATIONS

Ground invertebrates are regarded as

engineers of terrestrial ecosystems because they ingest and/or manipulate organic and mineral material by making microstructures. In this group, earthworms and termites are indicated as the most important since they are mediators of nutrient change, they affect the diversity and biota activity, and also the subordinate trophic levels. Vegetation in turn affects both the abundance and the richness of these organisms through the quality and quantity of the litter, by causing changes in the vegetation structure and composition to affect these organisms and, therefore, the functional ecologic processes. Clearly, such changes will lead to new and, very often, profound changes in the local biodiversity, and in some characteristics of the terrestrial ecosystems.

Results obtained by the various aforementioned authors and in the Estação Experimental de Anhembi (SP) (Junqueira, 2004) show that the type of soil usage and the forest disturbances are responsible for more immediate changes in the functional groups of termite communities. Disturbances affect these insects by decreasing their diversity, mainly the geophagous. Changes in the availability of organic matter can favor some other species by leading to an increase in abundance, which can even lead to them attaining pest status. Concomitantly, the decrease in the abundance of these soil engineers results in a decrease in carbon supplies and some inequality among the functional groups, which can also result in physical soil degradation, and, in a vicious circle, new changes in biodiversity.

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