Changes in Arthropod Soil Fauna due to Afforestation with Eucalyptus Globulus

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The area planted with Eucalyptus globulus has been increased in the recent years in Portugal reaching about 400,000 ha. These plantations are exploited as coppiced stands and are usually blamed to have negative effects on biological soil conditions. It was thus thought necessary to evaluate the impact of E. Globulus plantations on soil fauna, since this is supposed to be essential in the forest dynamics /LEBRUN, 1971/. In a previous work CABRAL and MARTINS /1985/ concluded that population densities of soil arthropods did not vary much between different rotations of E.globulus but were lower than the densities found in Pinus pinaster soils. An experiment was carried out, to understand better the modifications on the arthropods population densities under E. globulus plantations. We compared the densities of arthropods population, along the year, in soils under E.globulus with those under Q.suber. This paper deals with some results obtained during the first year of the experiment.

Materials and methods

The E.globulus plantations and stands of native vegetation dominated by Quercus suber were studied in central Portugal. The mean annual temperature is about 15°C; the monthly mean maximum /≈20 °C/ occurs in July and August, while January is normally the coldest month /≈10 °C/. The mean annual rainfall is about 880 mm, 75% occurring between November and April, and only 8% in the summer.

The soils studied are Dystric Cambisols /MADEIRA, 1988/ derived from sandstones poor in bases, mainly in calcium. These soils have a sandy loam texture and pH values about 5. The soil depth is about 25-30 cm and the bulk density increases dramatically at this depth. The E.globulus plantation studied was planted at 2x2 m and did not have herbaceous and shrub layers. It was coppiced at the end of the 2nd rotation /11 years/. The Q. suber stand has a shrub layer composed by Arbutus unedo, Ulex minor, Erica sp., Cistus sp., Rubus sp., Hedera helix, Lonicera etrusca, Myrtus communis, Chamaespartium tridentatum and Pteridium aquilinum.

In the organic horizons /forest floor/ samples /14 replicates/ were taken by cylinders with a 10 cm internal diameter. The samples from mineral horizons were taken by cylinders of 6.5 cm internal diamater and 8.0 cm height, considering the layers of 0-5, 5-10, 10-17.5 and 17.5-25 cm depth. In each layer the sampling was replicated 14 times. Samples were taken during 1988 at four occasions: 29 March, 23 May, 14 September and 9 December. Soil animals were extracted by Berlese - Tüllgren funnel and counted under stereomicroscope. The temperature during extraction was 40 ± 2 °C, which took 16 hours to reach. The samples waiting for extraction were kept in the freezer at 5-6 °C. The arthropod fauna was separated in Collembola Oribatida, other Acari and other Arthropoda /other Insecta, Myriapoda and other Arachnida/. The population density of total arthropods and of the groups considered was quantified as individuals m^{-2} cm^{-1} in the mineral layers. In the forest floor we also considered the number of animals per unit of dry weight /individuals 100 g^{-1}/. The comparison between the population densities of arthropods in the soils studied was made by a non-parametric test /Mann-Whitney U-test/.

Results and discussion

The density of arthropods /ind. · m^{-2}/, along the year, was lower in the forest floor under E. globulus than in that under Q. suber /Table 1 and Fig. 1A/. It was significantly lower /$P \leq 0.10$ U-test/ under the former

Table 1

Population densities of soil arthropods /and U-test decision/ in forest floor and mineral layers under /E/ E. globulus and /Q/ Q. suber in different seasons of 1988

Soil layers	Stand	29 March	23 May	14 September	9 December
Forest floor /a/	E	3 849	6 943	2 303	19 793
	Q	8 509	12 840	7 235	37 201
		E<Q /P=0.01/	E<Q /P=0.03/	E=Q /P=0.12/	E<Q /P=0.01/
Mineral layers/b/ 0-25 cm	E	279	219	1 195	1 702
	Q	355	175	1 835	2 015
		E=Q /P=0.29/	E=Q /P=0.03/	E<Q /P=0.02/	E=Q /P=0.38/
0- 5 cm	E	344	486	4 453	3 881
	Q	878	585	5 822	5 430
		E<Q /P=0.03/	E=Q /P=0.22/	E<Q /P=0.05/	E=Q /P=0.24/
5-10 cm	E	585	370	654	2 543
	Q	172	56	1 794	2 638
		E=Q /P=0.98/	E>Q /P=0.03/	E<Q /P<0.01/	E=Q /P=0.32/
10-17.5 cm	E	83	46	152	703
	Q	298	103	729	861
		E=Q /P=0.29/	E=Q /P=0.24/	E<Q /P<0.01/	E=Q /P=0.51/
17.5-25 cm	E	227	115	427	688
	~	186	52	310	479
		E=Q /P=0.91/	E=Q /P=0.23/	E=Q /P=0.98/	E=Q /P=0.33/

/a/ - Density: ind · m^{-2}; /b/ Density: ind · m^{-2} cm^{-1} /ind · dm^{-3}/

P - Ho /E=Q/ probability

than in the latter in the samplings of March, May and December; in the sampling of September the difference was less pronounced /P = 0.12/ /Table 1/. The differences referred to above were more accentuated when we considered the number of arthropods per unit of dry weight /ind. 100 g^{-1}/. In fact, we found that the number of arthropods per 100 g was always significantly lower in the forest floor under E. globulus than in that under Q.suber. MADEIRA /1988/ indicates that the forest floor quantity tends to be lower under Q. suber than under E. globulus. Therefore, the differences found in arthropod population densities are essentially related to the greater concentration of animals in the forest floor of Q. suber. This conclusion agrees with the statements of SEASTEDT /1984/ related to the influence of the amounts and quality of organic detritus on arthropods densities.

Fig.1A shows a great density fluctuation in both total arthropod and respective group populations. The trend of this fluctuation was similar in both soils. An increase of density was observed between March and May, followed by a decrease in September when the lowest density was found. The highest density was registered in December. The fluctuation in the number of individuals was also evident, considering the number of arthropods per unit of dry weight /Fig. 1/. This fluctuation was, however, less pronounced in the case of the forest floor under E. globulus /Fig. 1A/. The decrease

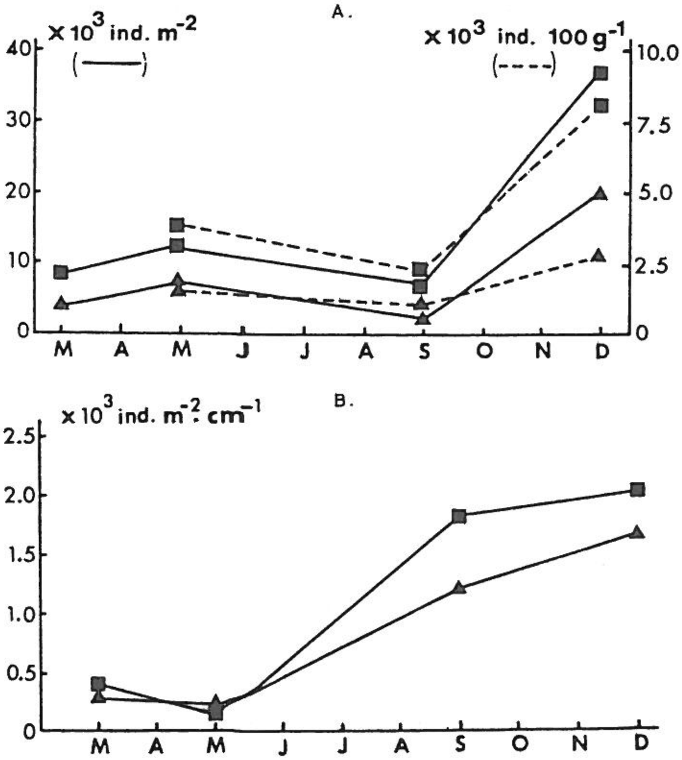

Fig. 1

Population densities of arthropods /ind.$\cdot m^{-2}$/ and number of arthropods per unit of dry weight /ind. $\cdot$100 g^{-1}/ during 1988 in the forest floor /A/, and in the 0-25 cm mineral layer of soils /B/ under Q. suber /■/ and under E. globulus /▲/

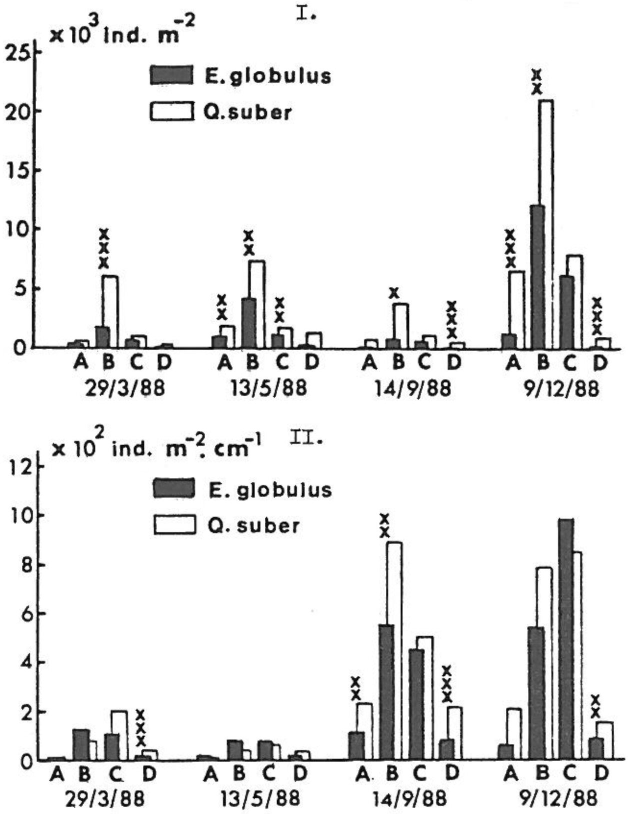

Fig. 2

A. Population densities of Collembola /A/, Oribatida /B/, other Acari /C/ and other Arthropods /D/ along the year in the forest floor and B. Population densities of arthropod groups in the 0-25 cm mineral layer of soils under E. globulus and Q. suber. Symbols x, xx, xxx indicate significant differences between soils studied at $P < 0.10$, $P < 0.05$ and $P < 0.01$, respectively

in arthropods density measured in September was coincident with the lowest values of moisture content /14%/ and the highest values of mean temperature /22 °C/.

In both soils the oribatids group was the dominant /Fig. 2 /. Its density was always significantly higher in the forest floor under Q. suber. The other acari ranked second in the arthropods population and their density was similar in both E. globulus and Q. suber. The collembolans population density was higher under Q. suber than under E. globulus but was significantly different only in May and December. The other Arhropoda /other Insecta, Myriapoda and other Arachnida/, which exist in low density, were normally significantly higher under Q. suber.

The density of arthropods in the mineral layer, to 25 cm depth, tends to be lower in soils under E. globulus /Table 1 and Fig. 1B/. However, the difference was only significant in summer /$P \leq 0.10$/. Such differences were more pronounced when we considered the 0-5 cm layer /Table 1/. The arthropod density tends to decrease regularly with depth, in soils under Q.suber. In the soils under E. globulus there was normally an increase of animals in the 17.5-25 cm layer relatively to the layer immediately above. This may be a result of a higher root concentration at that depth coinciding with the increase of bulk density.

In the mineral layers there was a strong fluctuation in the density of total arthropods /and in the groups considered/ along the year. This seasonal variation was different from that observed in the forest floor /Figs.1A and 1B/. The arthropod populations tend to decrease between March and May, while there was an increase in forest floor for the same period. There was also a strong increase in arthropod population between May and September simultaneously with a strong decrease in forest floor. Such particularity may be the result of the migration of animals, in summer, from the forest floor, when the moisture and temperature conditions are not favourable /POINSOT-BALAGUER and TABONE, 1985/, to the deeper horizons. These animals will find better conditions in the mineral layers /MACKAY et al., 1987/ in spite of a water content near the wilting point.

The order of dominance among the groups considered in the mineral layers was different from that observed in the forest floor /Fig. 2B/. The oribatids group was not dominant along the year, being surpassed some times by the other Acari. The proportion of the other Arthropoda was more important than in the forest floor. The proportion of collembolans in the mineral layers was similar to that of other Arthropoda. Moreover, the differences between population densities of groups were less pronounced in the mineral layer than in the forest floor. However, they were more evident in the summer, when conditions for the migration of animals from forest floor to the mineral layers occurred.

References

CABRAL, M.T. and MARTINS, S.C., 1985. Estudo comparativo da fauna do solo de povoamentos de Eucalytus globulus Labill. de varias idades e de Pinus pinaster Ait. Actas do I Congresso. Iberico de Entomologia 75-84.

LEBRUN, P., 1971. Ecologie et biocenotique de quelques peuplements d'arthropodes edaphiques. Institut Royal des Sciences Naturelles de Belgique. Memoire 165.

MACKAY, W.P., SILVA, S. and WHITFORD, W., 1987. Diurnal activity patterns and vertical migration in desert soil microarthropods. Pedobiologia 30. 65-71.

MADEIRA, M.A.V., 1988. Changes in soil properties under Eucalyptus plantations in Portugal. In: Biomass Production by Fast-Growing Trees. /Eds.: PEREIRA, J. S. and LANDSBERG, J. J./ 81-99. Kluwer Academic Publishers. Dordrecht.

POINSOT-BALAGUER, N. and TABONE, E., 1985. Etude d'un ecosissteme forestier Mediterraneen 1. Composition et structure des peuplements microarthropodiens du sol dans un foret mixte /Chenes vertes, Quercus ilex L. - chenes blancs, Quercus pubescens W.F. de la region provencale. Bull. Ecol. 16. /2/ 149-160.

SEASTEDT, T.R., 1984. The role of microarthropods in decomposition and mineralization processes. Ann. Rev. Entomol. 29. 25-46.