RELATIONSHIPS BETWEEN SOIL FAUNA AND *APETHYMUS FILIFORMIS* OUTBREAKS IN ROMANIA

Thierry HANCE[1], **,V. CAMBIER**[1], **Constantin CIORNEI**[2], **Lăcrămioara CIUCĂ**[3]

[1]Unité d'écologie et de Biogéographie, Centre de recherche sur la biodiversité, Université catholique de Louvain, Belgique

[2]Forest Research and Management Institute, Station Hemeiuşi - Bacău, Romania;

[3] Natural Science Museum, Bacău, Romania

Abstract

Apethymus filiformis is a new defoliator in Moldavia oak forests which eonymph stages remain under diapause in the soil. To understand its development, soil fauna analyses were realised in nine locations presenting an infestation. It appeared that carabid fauna was very low in relationships with the proximity of a pesticide factory. Carabid densities were inversely correlated to DDT concentrations in soil samples. In the same time, densities of eonymphs were related to carabid assemblages indicating the potential role of ground beetles in the control of that new pest. Our hypothesis is thus that *A. filifomis* became resistant to the pesticide produced by the factory and transported by wind to the forest, whereas the predatory fauna was strongly reduced. This inverse relation had created the condition of that new pest outbreak.

Key words: *Apethymus filiformis*, oak forests defoliation, predatory soil fauna, carabid species, invertebrate soil fauna composition and abundance.

Introduction

Apethymus filiformis (*Hymenoptera,Tenthredinidae*) is a defoliator that was first recorded in 1994 in Romania in the oak forest of Heltiu (forest district Căiuți-Bacău) on *Quercus petraea* on a surface of 150 hectares. During the subsequent years, this species spread over a wider range of oak forests in the basin of Trotus river (East Romania) presenting weak to heavy infestations. Adults appear in September - October and females laid their eggs under the bark of young twigs where they overwinter.

Larvae hatch in spring and feed on leaves. In May, they fall from trees to the soil where they moult to eonymphs. Eonymphs may remain for several years (1-3) in the soil in diapause stage and constitute high populations that emerge under favourable climatic conditions. Densities up to 300 individuals/m^2 were currently observed in infested place.

Carabid and Staphilynid beetles are considered as major predators at the soil level both at larval or adult stage (Dajoz, 1998). *Apethymus filiformis* eonymphs are potential preys for the soil fauna that should act as regulatory factors. Preliminary observations in 2000 showed that soil fauna and particularly predatory beetles were poorly represented. A chemical factory producing insecticides is present in the same valley and pesticide drifts towards the forest may have influenced the insect fauna. Regarding the well know susceptibility of forest carabids to pesticides (Holopainen, 1987; Klenner, 1994), the following questions were asked:

1) Is the low Carabid abundance related to the presence of the chemical factory in the vicinity of first observations ?

2) Does *A. filiformis* become resistant to these pesticides?

3) Does pesticide drift to forest reduce the soil fauna?

In that context, this study aimed at:

1) Comparing the soil fauna assemblages on different locations where *A. filiformis* damages were recorded;

2) Analyzing the potential consequence of chemical wind drift from the chemical present at proximity on soil fauna.

Material and method

Nine stations presenting *A. filiformis* infestations were chosen in three *Quercus petraea* forests of the Caiuti district : five in Heltiu Forest, three in Paltinta Forest and one in Cornatel Forest. In 2001, twelve Barber traps were placed per station and collected monthly from 15 April till 19 October. All invertebrates were collected but the present study focused on Carabidae and Staphylinidae. Insect identifications were done at Bacau Natural Museum. Moreover, in each forest a soil sample was taken for DDT analyses, as DDT was produced by the chemical company till 1986 and is highly persistent in the soil.

Factorial analyses were used to determine the structure of the carabid assemblages in relation with stations. This kind of analyses summarised the information present in the data and represent it graphically in a two dimensional space while preserving the more important information (Legendre and Legendre, 1984).

Results

In total, 104 species were identified including 33 Carabidae (Annexe 1). Thirty-three families of invertebrates were caught in Heltiu forest representing 53 species and 20 species of carabids. For Paltinata forest, 31 families of invertebrates were collected and 45 species identified including 17 species of carabids. Finally, 28 families of invertebrates were recorded for Cornatel forest with a total of 37 species and 17 species of carabids. Difference in species number is related to sampling effort as more station were

Table 1: Comparison of the Carabid abundance in oak forests in Belgium (1993) and Trotus river region (Roumania).

Baguette (1993) Station number	Nb species	Nb individuals	Present study Station number	Nb Species	NB. individuals
7	13	773	18	17	138
14	11	359	51	13	95
15	12	899	58	15	242
23	19	267	68	15	97
52	16	627	87	17	404
53	15	553	45	12	65
58	10	252	62	14	127
59	10	159	73	21	298
			9	18	335
Mean	13.25	486.2	Mean	15.8	200,1

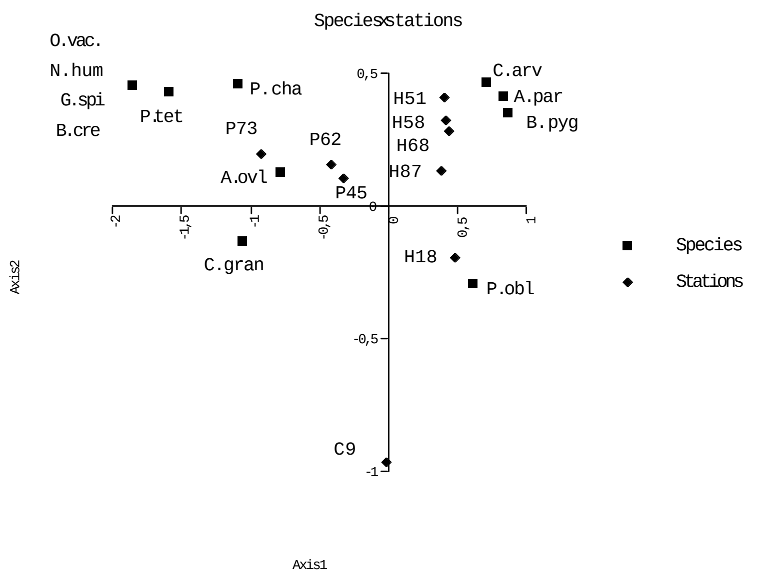

Figure 1: Ordination of the stations and species along the two first axis including all species. Aovl: Abax ovalis, A. par: Abax parallellus, B.pyg: Bembidion pygmaeus , B.cre: Brachinus crepitans, C. arv: Carabus arvensis, C. gra: Carabus granulatus:, G. spi.: Geotrupes spiniger , N.hum: Necrophorus humator, P.cha: Philonthus chalceus, P. obl: Pterostichus oblongopunctatus. P.tet.: Phyllotreta tetrastigma. H : Heltiu, P : Paltinata, C :Cornatel, numbers represent the plot identification in each forest.

taken in Heltiu. However, numbers caught were quite low particularly for carabids, and well under similar observations made elsewhere in Europe. Table 1 indicates that in a similar Quercus forest in Belgium, Baguette (1993) observed less species but at least two times more individuals. In his case, only 10 pitfall traps were placed per station.

Factorial analyses were made on all identified invertebrate species. The 2 axis explain respectively 22.5 and 16.8 % of the variation observed. Fourteen species contribute to 49 % of the structure observed, species contribution ranging between 6.68 % (*Carabus granulatus*) to 2.41 % (*Brachinus crepitans*).

Figure 1 presents the distribution of the stations and species along the two axes. It appeared that stations are regrouped by forest location, these one being clearly separated from each other.

Distinction between stations is probably linked to strand age, kinds of regeneration and to differences in sun exposition. However, necrophorous species play a major role in the position of Paltinata stations, mainly because 137 individuals of *N. humator* were caught in one location probably because of the proximity of carrion. In consequence,

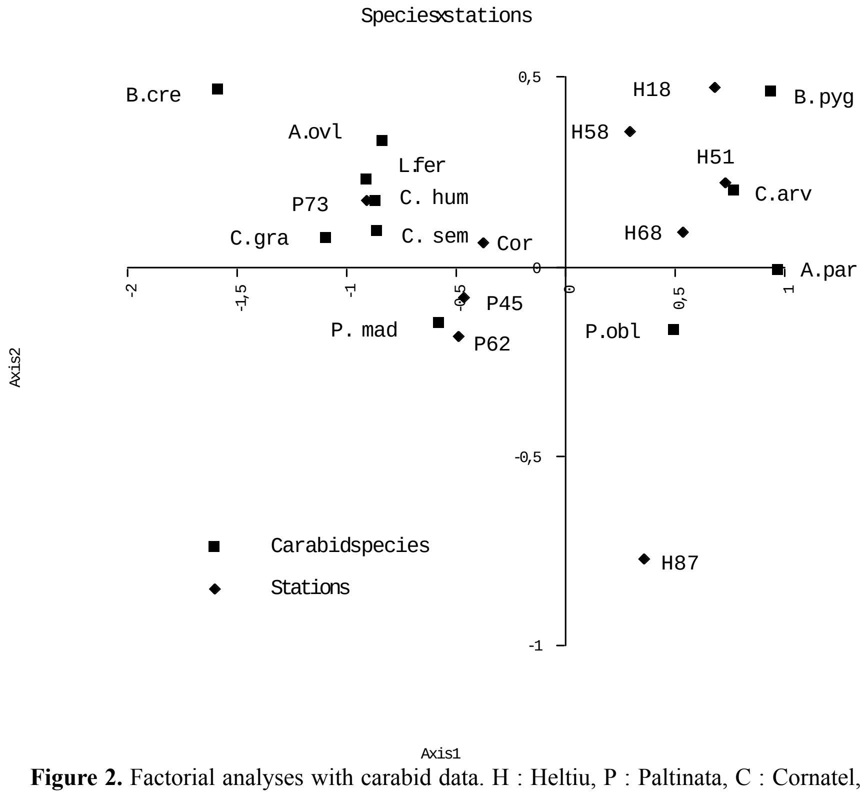

Figure 2. Factorial analyses with carabid data. H : Heltiu, P : Paltinata, C : Cornatel, numbers represent the plot identification in each forest. Aovl: Abax ovalis: open forests. A. par: Abax parallellus: hygrophylous species; B. pyg: Bembidion pygmaeus : proximity of water; B.cre: Brachinus crepitans: sun exposed, dry sol; C. arv: Carabus arvensis: open forest; C. gra: Carabus granulatus: open forest with herbaceous cove; C.hum: Cymindis humeralis: xerephylous species; C.sem: Cychrus semigranosus; L. fer: Leistus ferrugineus: xerophylous, open & dry forest; P. mad.: Pterostichus madens: dry soil; P. obl: Pterostichus oblongopunctatus: dense forest

this analysis was repeated using only carabid data. In that case, stations are ranked along axis 1 according to a humidity gradient. Indeed species like *Abax paralellus*, *Bembidion pygidium* are more hygrophylous whereas *Brachinus crepitans* and *Cymindis humeralis* are more xerophilous species. This axis discriminates between dryer (Paltinata) and

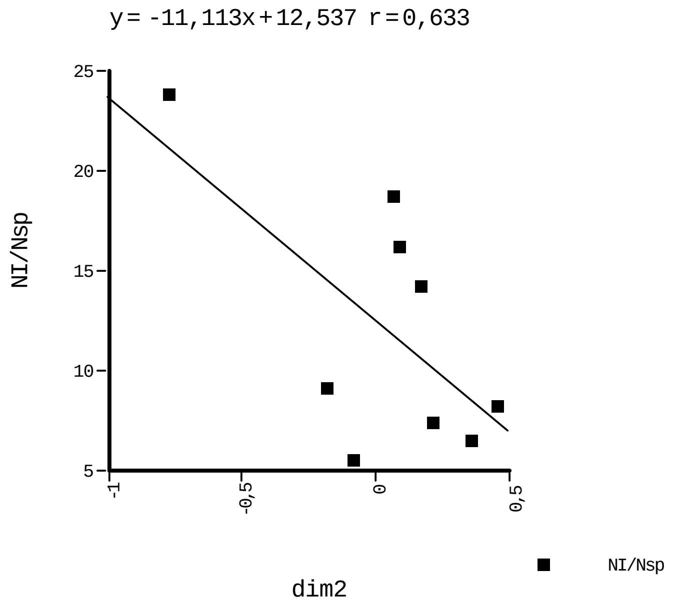

Figure 3: Relation between carabid (NI/Nsp) diversity and ordination on axis 2

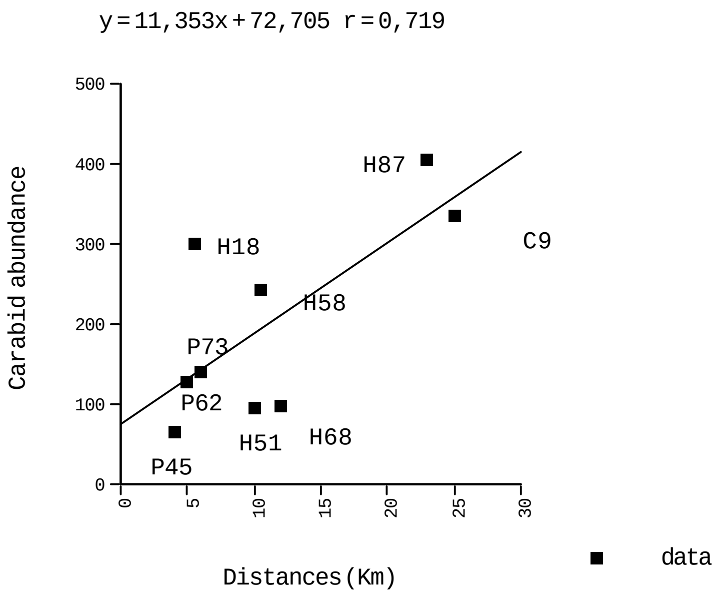

Figure 4: Relationships between carabid abundance and distance from the chemical factory.

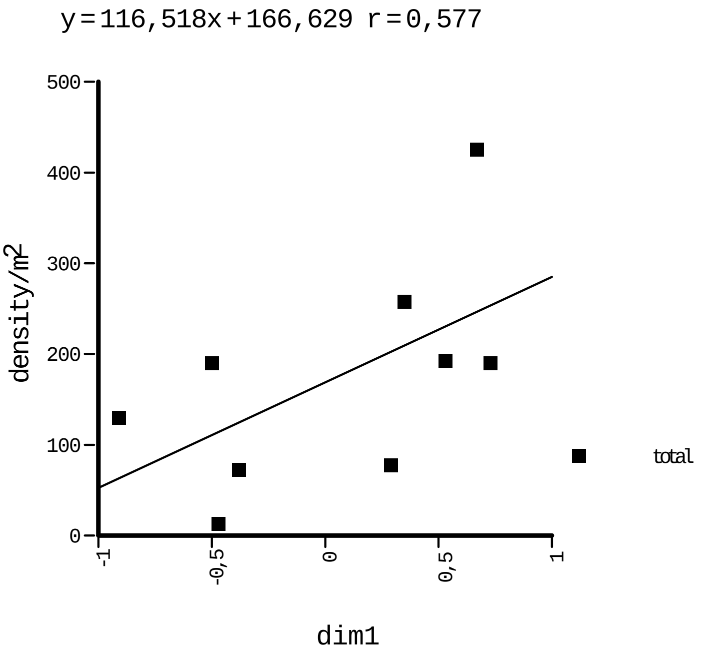

Figure 5: Relation between *A. filiformis* eonymph soil densities and coordinates of stations on Axis 1.

humid (Heltiu) forests. Axis 2 is probably associated to the density of the strands as *Abax ovalis* and *Carabus arvensis* are usually present in open forests whereas Pterostichus oblogopunctus is known to be abundant in dense forests. An inverse significant relationship is obtained when diversity calculated as the abundance divided by the number of species (NI/Nsp) is correlated with the coordinates of the stations on Axis 2, indicating that diversity seems to be related with threes densities and ages.

In the same time, the relationships between carabid abundance and distance from the chemical factory is significant and clearly underlines the strong influence of chemical drift to forest on carabid composition (Fig. 4). This relation is even more significant when NI/Nsp is taken into account (r = 0.76)

The soil densities of *A. filiformis* eonymphs ranged from $5/m^2$ to $313/m^2$. They are related to the coordinates of the stations on axis 1 (Fig. 5), but not to actual carabid densities (r = 0.111). This indicates that carabid assemblages seem to influence *A. filiformis* densities, probably because of the predation pressure of some species but not all. Species per species data are not presently sufficient to drawn such relation. In another way, eonymphs densities are not influenced at all by the proximity of the chemical factory (r = 0.07). This observation poses the question of resistance of *A. filiformis* to the chemical produced by this factory.

High concentrations of DDT, ranging from 0.26 to 1.2 ppm were recorded in soil sampled in the three forests. These concentrations may explain the low abundance of soil fauna as indicated in Fig. 6, and thus the possible high survival of resistant A. fili-

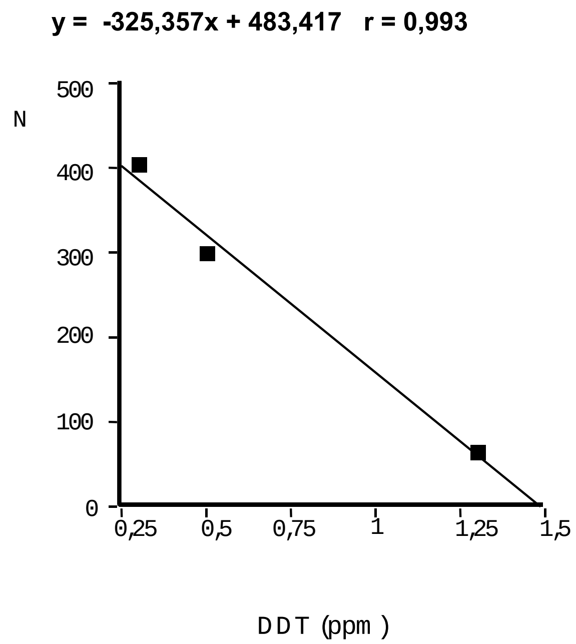

Figure 6: Relation between carabid abundance (N) and DDT soil concentration for tree sampled taken at increasing distances of the chemical factory.

formis strain to DDT, leading to important outbreaks. This hypothesis must be further confirmed by comparing the soil fauna assemblage with that of reserve forests without DDT residues.

Conclusions

This study underlined the complex relationships existing between station characteristics and invertebrate fauna composition and abundance. Moreover we have shown that *A. filiformis* eonymph soil densities were clearly related to carabid assemblages indicating that some species should have an important role as predator of that new pest. This must be confirmed by the diet analyses of carabid and behavioural experiments. These aspects are presently investigated. Concerning the role of pesticide pollution, it clearly influenced the carabid abundance and thus may be a factor explaining the outbreak of *A. filiformis*. To check this hypothesis several experiments remain to do. First, more soil analyses must be done and other pesticides should be search for. Relation between soil concentrations of pesticides and carabid abundance must then be verified on a larger scale. Secondly, we need to further characterise the invertebrate fauna by continuing the trapping during several years and by comparing it with reference unpolluted sites. These steps are also under investigation. The problem of soil contamination by DDT remains to be solved. These preliminary results clearly demonstrate the necessity to take into account the soil fauna in forest management in the context of sustainable forestry.

References

Baguette, M.,1993. Habitat selection of Carabid beetle in deciduous woodlands of southern Belgium. Pedobiologie, 37: 365-378.

Dajoz, R., 1998. Les insectes et la forȩt. Edt. Technique et Documentation, Paris, 594 pp.

Holopainen, J.K., 1987. Effect of insecticide applications on Carabid beetles in a forest nursery. Acta Phytopathologica et Entomologia Hungarica, 22 (1-4): 369-374.

Klenner, M.F, 1994. The carabid fauna of diflubenzuron-sprayed and unsprayed plots in Westphalian oak forests - a post treatment comparison. In: Desender, K. et al., (eds), Carabid beetles: Ecology and Evolution. Kluwer Academic Publisher, The Netherlands, 445-449.

Legendre, L. et Legendre P., 1984. Ecologie Numérique. Presse de L'Université du Québec. Québec, Canada, 335pp.

Annexes:

Annexe 1: list of the carabid species identified in 2001.

Abax ater
Abax ovalis
Abax parallelus
Amara aulica
Amara equestris
Amara ovata
Bembidium pygmaeus
Brachinus explodens
Aptinus bombardata
Leistus ferrugineus
Calathus melanocephalus
Brachinus crepitatus
Cymindis humeralis
Cychrus semigranosus
Carabus cancelatus
Carabus convexus

Dromius fenestratus
Carabus granulatus
Carabus coriaceus
Carabus arvensis
Carabus excelens
Carabus violaceus
Carabus planicollis
Calosoma sycophanta
Harpalus fulvipes
Harpalus pubencens
Harpalus rubripes
Harpalus griseus
Harpalus rufitarsis
Molops piceus
Nothiophilus bigutatus
Pterostichus oblongopunctatus
Pterostichus madens