NATURE RESTORATION AND THE ROLE OF THE MESOFAUNA IN DECOMPOSITION OF ORGANIC MATTER

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Summary

As to nature restoration in abandoned agricultural areas on sandy soils a malfunctioning appears in the process of decomposition of organic matter. In this paper a possible explanation is presented for the resulting litter accumulation and felting of the grassland vegetation. The soil mesofauna of the areas to restore has been influenced dramatically by agricultural management, as appears from the change in fractions of microarthropod life-history tactics. As a result of this change many species which stimulate decomposition are absent in agricultural areas. These species are not phoretic, have hardly any dispersal capacity, and will thus not reach the abandoned agricultural area soon. A possible solution is presented, to be carried out after a small-scale experiment.

INTRODUCTION

Before long an increasing surface of agricultural areas will be abandoned because of too high production quota for many agricultural products in the European Community. These areas should be made suitable for the restoration of natural communities and processes. Experience has been obtained in abandoned agricultural areas in The Netherlands for some years (Cranendonk, Soerendonk). A problem during the process of nutrient impoverishment is the felting of the grassland vegetation after some years. The removal of vegetation production is less than during the former agricultural situation, so much organic matter remains as litter. The accumulation of litter indicates a malfunctioning of the decomposition process. In this paper I give a possible explanation for the malfunctioning of decomposition in abandoned agricultural areas on sandy soils. Because of the naturally low pH, these soils have usually no high densities of earthworms, isopods and diplopods as primary decomposers among the macro-invertebrates. Primary decomposers such as bacteria and fungi are very good dispersers and their absence will
not be the cause of a lower decomposition rate. The key factor here is probably found in the mesofauna (nematods, mites and springtails); these animals influence the activity of the primary decomposers, not just by fragmentation of the litter but also by grazing on bacteria and fungi and recycling spare elements quickly in that way (Van der Dijk & Jansen 1977, Bååth et al. 1981, Ingham et al. 1981, Hanlon 1981, Hanlon & Anderson 1979).

THE MESOFONA OF AGRICULTURAL AND NATURAL GRASSLANDS

Siepel & Van de Bund (1988) showed an enormous difference in the species composition of unfertilized natural grasslands and highly fertilized agricultural grasslands. The reason for this shift in species composition lies in the interaction of the grassland management and the species life-history tactic. Species having a slow juvenile development and species having asexual reproduction (thelytoky) become less abundant under the unpredictable and highly dynamic conditions of an agricultural grassland (mowing, fertilizing several times each year). Good colonizers such as phoretics having a short development time become more abundant. In fig. 1 fractions of life-history tactics of mites and springtails from the microarthropod community in two grasslands are presented. The presented life-history tactics are an elaboration of those established by Siepel & Van de Bund (1986). Both grasslands are on the same soil type.

![Deelerwoud](image1)

![Arnhemse heide](image2)

Fig. 1. Fractions of life-history tactics of microarthropods in an agricultural grassland "Arnhemse heide" and a heathy natural grassland "Deelerwoud". Characterization of tactics: II (faculative phoretic), III (obligate juvenile phoretic), IV (obligate phoretic mainly as adult), V (obligate diapause), IX (thelytoky and seasonal iteroparity), X (thelytoky), XI (sexual reproduction) and XII (sexual reproduction and seasonal iteroparity).
a typical haplohumod, but "Arnhemse heide" has become an agricultural grassland during the last five decades whereas "Deelerwoud" remained a healthy natural grassland. The differences are very clear: tactics II (facultative phoresy), III (obligate juvenile phoresy), and IV (obligate phoresy mainly as adult) are more abundant in the agricultural grassland Arnhemse heide than in the natural grassland Deelerwoud. Tactics IX (thelytokous reproduction and seasonal iteroparity) and X (thelytokous reproduction) are more abundant in the natural grassland Deelerwoud than in the agricultural grassland Arnhemse heide. Species of tactic XI are sexually reproducing and are not phoretic. The presented differences are understandable; phoretic species are better adapted to sudden changes in their biotope, as a population they can easily turn aside for a while and colonize the grassland again later. Species from tactics IX and X (thelytokous species) on the contrary have no phoresy by definition and a way of reproduction adapted to very constant and predictable environments. The daughters inherit the same genotype as their mother had, which is successful only under the same, constant, conditions. Rapid colonization in those species will not occur.

THE FUNCTION OF THE MESOFAUNA IN DECOMPOSITION OF ORGANIC MATTER

Differences in species composition of mite and springtail communities among natural and agricultural grasslands can be explained by their life-history tactics. The question now is how do the different communities affect the process of decomposition of organic matter. When all mite and springtail species act roughly the same on the rate of decomposition, there will hardly be any change in effect. However, that these species all affect the process of decomposition in the same way is quite unlikely and has been found incorrect as appears in Table 1. Already among oribatid mites only several feeding guilds can be established. The five most common ones with their definition based on carbohydrase enzyme activities and a species example are presented in Table 1. The feeding guilds are defined by the activity of three important carbohydrase enzymes, that differentiate in the used food types. Trehalase activity means ability to digest trehalose, a sugar occurring predominantly in fungi (cell contents), chitinase activity means ability to digest chitin, occurring, next to the exoskeleton of many arthropods, predominantly in fungi (cell walls) and finally cellulase activity.

Table 1. Five different feeding guilds defined by their activity of carbohydrases are listed with their specifications (from Siepel & De Ruiter-Dijkman) and their influence on the rate of decomposition of organic matter, ch = chitinase activity, tr = trehalase activity, ce = cellulase activity, eff = effect on decomposition rate.

<table>
<thead>
<tr>
<th>Feeding Guild</th>
<th>ch</th>
<th>tr</th>
<th>ce</th>
<th>eff</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>fungivorous grazer</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>Punctoribates punctum</td>
</tr>
<tr>
<td>herbofungivorous grazer</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>Nothrus silvestris</td>
</tr>
<tr>
<td>herbivorous grazer</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>Parachipteria punctata</td>
</tr>
<tr>
<td>opportunistic herbofungivore</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>Carabodes labyrinthiscus</td>
</tr>
<tr>
<td>fungivorous browser</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>Chamobates borealis</td>
</tr>
</tbody>
</table>
means ability to digest cellulose, an important cell wall component of plants. According to table 1 fungivorous species, able to break down chitin (fungivorous grazers and herbofungivorous grazers), have a stimulating effect on the rate of decomposition. Species that do not feed on fungi (herbivorous grazers) have no effect at all and species feeding on fungi but digesting only the fungal cell contents (opportunistic herbofungivores and fungivorous browsers) have a inhibitory effect on the decomposition rate. Explanation of these differences lies in the impact of grazing of mites on the fungi and in the recycling of scarce elements. The impact of grazing is greater when a mite species retrieves its energy from cell contents of fungi only compared to one retrieving its energy from cell contents and cell walls as well. So opportunistic herbofungivores and fungivorous browsers will overgraze fungi sooner than fungivorous and herbofungi- vorous grazers do under the same mite to substrate mass ratio. (Differ-ences in size and energy requirements in mites have been corrected for by carrying out experiments with the same total mass of mites.) Overgrazing has been recorded by Hanlon & Anderson (1979) before as inhibiting. The stimulating effect of fungivorous and herbofungi- vorous grazers, can be explained by the recycling of scarce elements.
Most probable is nitrogen: it makes up 6.9% by mass of chitin, which can form up to 25% of cell wall mass of fungi. So an extra mass of up to 1.7% nitrogen from fungal cell walls is recycled by chitin digesting mites compared to mites without that chitin digesting ability. Under conditions of nutrient impoverishment which goes with restoration of natural processes and communities, this extra mass of recycling nitrogen may be of crucial importance in a well functioning of the decomposition process, especially when the change in the plant community from species having low C/N ratios to those with higher ones also takes place during the process of nutrient impoverishment. When the microarthropod species cannot reach the natural grassland in view, the process of nutrient impoverishment in grasslands on slightly acid sandy soils will result in the comparatively malfunctioning of the decomposition process and thus accumulation of litter and felting of the grassland vegetation. A situation in which germination of seeds from seed banks or from invading plant species is strongly inhibited.

DISCUSSION

Restoration of natural processes and communities in abandoned agricultural areas may not be achieved by just some nutrient impoverishment as one would wish. Decades of agricultural management have changed the soil and soil fauna tremendously and it might be a bit naive to suppose that restoration will take place just as is wished. I present in this paper not the solution of a detected problem of felting and the accumulation during nature restoration. I try to make acceptable that the mesofauna has an important and until now overlooked role in nature restoration, that this decomposer role is influenced by agricultural management, resulting in a change of the soil microarthropod species composition, and that it is unlikely without additional measures, to expect a functioning microarthropod community as existed before agricultural disturbance. However, theoretically acceptable, practice should prove whether or not the microarthropod community is the key factor in the problem of litter accumulation and felting of the grassland vegetation during the process of restoration of natural communities and processes. Man has caused the shift from a natural to an agricultural grassland microarthropod community and so it is not strange that man restores artificially the proper soil fauna. It can be done by grafting the abandoned agricultural area with soil and litter, including the mesofauna, from natural stands in the form of compost resulting from sod cutting in grassy heathlands. This possible solution should first be carried out on a small scale. As I have mentioned here, it has a good chance of success. When it has turned out to be a realistic and workable solution, a major problem in the restoration of natural processes and communities can be overcome.
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