Recovering of Natural Processes in Abandoned Agricultural Areas: Decomposition of Organic Matter

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Introduction

Since agricultural production is higher than the present needs for food, one tries to restore former agricultural areas to more natural ones. Some incidental areas were changed already twenty years ago, but recently an increasing number of hectares are considered as potential nature reserves. Of course with the vanishing agricultural management on those sites natural processes should be recovered. Nutrient inputs are stopped and a process of nutrient impoverishment is started. One expects a natural herb-rich grassland after about 10-20 years of nutrient impoverishment by frequently mowing. Grassland production indeed decreases to a level usually associated with a high plant-diversity, but instead of this high diversity a felted grassland with few species and accumulated litter is the result. Obviously the process of decomposition of organic matter is not functioning as it should do. As we can hardly assume that bacteria or fungi are absent, the shortage may be of animal origin. On slightly acid sandy soils, where most of the abandoned areas are located, naturally few earthworms, isopods or diplopods occur. The fauna possibly playing a role in decomposition are predominantly microarthropods. Microarthropods, however, are abundantly present, but in another species composition due to the former agricultural management (Andren and Lagerlöf 1983, Bhattacharya *et al.* 1980, Edwards and Lofty 1974, Siepel and van de Bund 1988). It is interesting to know whether this change in species composition is reflected in the composition of life-history tactics; or even more in the one of feeding guilds, and finally, what the consequences of possible changes can be for the decomposition process.

Life-history tactics and feeding guilds of soil microarthropods

A further elaboration of life-history tactics of microarthropods as presented by Siepel and van de Bund (1986) resulted in the definition of twelve tactics (Siepel subm.). parasites (1), facultative phoretics (2), obligate phoretics as juveniles (3), obligate phoretics as adults (4), species with obligate diapause (5), facultative diapause or quiescense and semelparity (6), facultative diapause or quiescense and anemochory (7), or only facultative diapause or quiescense (8), and species with

Table 1. Distribution of microarthropods over the life-history tactics in some (semi-)natural (Deelerwoud, Bovenbuurt) and some agricultural grasslands (Arnhemse heide, Droevendaal, Dijkgraaf)

Life-history tactics	Deelerwoud	Bovenbuurt	Arnhemse heide	Droeven-daal	Dijkgraaf
1 parasites	0.00	0.04	0.00	0.00	0.00
2 facultative phoretics	5.12	7.89	59.89	62.42	55.22
3 obligate phoretics juv.	0.24	0.24	0.11	1.58	6.72
4 obligate phoretics ad.	0.00	0.17	7.38	3.67	5.97
5 obligate diapause	0.58	1.32	6.52	0.29	0.75
6 facultative diapause semelparity	0.00	0.00	0.00	0.00	0.00
7 facultative diapause anemochory	0.00	0.24	0.00	0.22	0.37
8 facultative diapause	0.00	0.00	0.00	0.00	0.00
9 thelytoky seasonal iteroparity	0.21	0.04	0.21	0.00	0.37
10 thelytoky	21.58	9.95	2.46	1.37	0.00
11 sexual reproduction	72.19	77.68	23.21	30.31	30.60
12 sexual reproduction seasonal iteroparity	0.08	2.45	0.21	0.12	0.00
Number of individuals	3790	5439	935	1389	268

thelytokous reproduction, long juvenile development and seasonal iteroparity (9), thelytokous reproduction (10), sexual reproduction (11), and, finally, sexual reproduction and seasonal iteroparity (12). Distribution of soil microarthropods over these life-history tactics is presented in Table 1 for some (semi-)natural and some agricultural grasslands. In agricultural grassland there is a larger fraction of phoretics, both facultative and obligate, while species with thelytokous reproduction are present in smaller fractions compared to (semi-)natural grasslands. These shifts may be caused by the dynamic character of the agricultural grasslands, which favours species having high colonizing capacities (phoretics) and injures species having limited possibilities to adapt (thelytokous species). In this context the change in species composition is explainable, but what are the consequences? Table 2 presents the distribution of microarthropods over the feeding guilds (as defined by Siepel and De Ruiter-Dijkman subm.). Next to a higher fraction of predators in the agricultural grasslands, there is also a high fraction of fungivorous browsers, species digesting fungal cell-contents only, while in (semi-)natural grasslands fungivorous and herbo-fungivorous grazers make up half the microarthropod fauna. Grazers can digest both fungal cell-walls and contents. The implications of

Table 2. Distribution of microarthropods over the feeding guilds in some (semi-)natural (Deelerwood, Bovenbuurt) and some agricultural grasslands (Arnhemse heide, Droevendaal, Dijkgraaf)

Feeding guilds	Deelerwoud	Bovenbuurt	Arnhemse heide	Droevendaal	Dijkgraaf
Herbivorous grazer	0.00	3.99	0.11	0.00	0.37
Herbivorous browser	15.20	6.69	13.26	12.46	12.31
Herbofungivorous grazer	1.48	6.12	0.53	0.22	0.37
Fungivorous grazer	48.18	60.30	2.78	4.46	4.85
Fungivorous browser	7.23	5.49	61.92	46.15	44.78
Opportunistic herbo-fungivore	14.68	7.57	0.21	0.50	0.75
Omnivore	1.71	1.40	6.52	0.29	0.75
General predator	6.07	8.00	7.28	32.69	26.12
Arthropod predator	0.03	0.83	0.00	1.01	1.45
Nematode predator	0.00	0.17	7.29	2.16	2.24
Bacteriovore	0.00	0.09	0.11	0.07	5.60
Number of individuals	3790	5439	935	1389	268

species having different feeding guilds on the process of decomposition have been investigated by Siepel and Maaskamp (subm.).

Table 3 reviews briefly five feeding guilds, their definition by carbohydrase enzyme-activity and their effect on the decomposition of organic matter. Grazers stimulate decomposition and browsers inhibit that process. Stimulation may be caused by the release of nitrogen from chitin, which is scarce in (semi-)natural

Table 3. Five different feeding guilds defined by their activity of carbohydrases are listed with their specifications (from Siepel and De Ruiter-Dijkman, subm.) 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 (after Siepel and Maaskamp, subm.)

	ch	tr	ce	eff	
Fungivorous grazer	+	+	-	+	*Punctoribates punctum*
Herbo-fungivorous grazer	+	+	+	+	*Nothrus silvestris*
Herbivorous grazer	-	-	+	0	*Parachipteria punctata*
Opportunistic herbo-fungivore	-	+	+	-	*Carabodes labyrinthicus*
Fungivorous browser	-	+	-	-	*Chamobates borealis*

Table 4. Distribution of microarthropods over the life-history tactics at the abandoned agricultural areas (19B and C) and along the roadside (25B) in Cranendonk, The Netherlands.

Life-history tactics	25B	19B	19C
1 parasites	0.00	0.00	0.00
2 facultative phoretics	1.43	6.78	7.35
3 obligate phoretics juv.	3.09	2.31	3.78
4 obligate phoretics ad.	0.00	0.00	0.00
5 obligate diapause	2.49	5.12	2.10
6 facultative diapause semelparity	0.00	0.00	0.00
7 facultative diapause anemochory	3.09	12.56	2.31
8 facultative diapause	0.00	0.00	0.00
9 thelytoky seasonal iteroparity	3.21	29.92	39.50
10 thelytoky	24.94	9.26	10.50
11 sexual reproduction	49.88	33.72	32.56
12 sexual reproduction seasonal iteroparity	11.88	0.33	1.89
Number of individuals	842	605	476

Table 5. Distribution of microarthropods over the feeding guilds at the abandoned agricultural areas (19B and C) and along the roadside (25B) in Cranendonk, The Netherlands

Feeding guilds	Cranendonk		
	25B	19B	19C
Herbivorous grazer	3.21	29.92	39.50
Herbivorous browser	12.00	17.52	10.51
Herbo-fungivorous grazer	10.74	6.12	1.47
Fungivorous grazer	37.41	9.59	4.83
Fungivorous browser	2.25	1.82	6.72
Opportunistic herbo-fungivore	11.51	6.45	14.07
Omnivore	2.49	5.12	2.10
General predator	20.19	20.32	19.12
Arthropod predator	1.19	2.32	1.05
Nematode predator	0.00	0.00	0.00
Bacteriovore	0.00	0.00	0.00
Number of individuals	842	605	476

grasslands and frequent in agricultural ones. Thus nutrient impoverishment in abandoned agricultural areas should go with a change in microarthropod species composition for a good recovering of the process of decomposition of organic matter.

Hypothesis

Abandoned agricultural areas on slightly acid sandy soils, where during the process of nutrient impoverishment accumulation of litter and felting of the grass takes place, will have a microarthropod fauna which is functionally more related to the one of an agricultural soil than of a natural soil.

Test of the hypothesis

In Cranendonk (near Soerendonk, province of Northern Brabant, The Netherlands) an agricultural area of several parcels was taken out of agricultural production in 1970. From that year on a process of nutrient impoverishment was started to create a plant species-rich semi-natural grassland. The whole site is grazed by horses. Today plant biomass-production is very low, thus nutrient impoverishment has been successful. But plant species-diversity is still low, litter is accumulated and grasses (*Agrostis* spp. and *Festuca* spp.) are felting. These conditions, with the fact that the soil is a slightly acid sandy soil, make the site appropriate to test the formulated hypothesis.

May 15, 1991 five soil samples of 100 cc were taken on each of two former agricultural parcels in the site (19B and 19C). For reference on the roadside along the area also five samples of 100 cc were taken (25B) (The roadside never had an agricultural management like the parcels.) Table 4 presents the distribution of microarthropods over the life-history tactics. Apart from the slightly higher fraction of obligate phoretics the grasslands did not differ from other (semi-) natural ones with respect to tactics having either phoresy (2, 3 and 4) or thelytoky (9 and 10). Total number of individuals, however, is still as low as agricultural sites. Apparently the dynamic component, characteristic of agricultural grasslands has vanished. All sample sites at Cranendonk have rather larger fractions of life-history tactics containing seasonal iteroparity, an adaptation to overcome adverse seasons. The whole site may be quite sensitive to summer-drought. Table 5 presents the microarthropod fauna distributed over the feeding guilds. The roadside does not differ in fractions of fungivorous and herbo-fungivorous grazers or fungivorous browsers from (semi-)natural grasslands. General predators are abundant like in agricultural grasslands. The parcels themselves, however, differ considerably from (semi-)natural grasslands: fungivorous and herbo-fungivorous grazers are present in small fractions, and herbivorous grazers and browsers are present in comparatively large fractions.

It is concluded that decomposition of organic matter does not play an important role in the abandoned agricultural areas in Cranendonk, because only small fractions of fungivorous microarthropods are present. The microarthropod fauna is functionally, with respect to fungivory, not related to the one of (semi-)natural grasslands. The hypothesis, therefore, can be confirmed.

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