Insect abundance in cow dung pats of different farming systems

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Cow dung pats in pastures provide suitable (micro)habitats for invertebrates to reproduce and to feed on. Therefore, their availability is important for invertebrate diversity in farmland landscapes. We investigated the differences in insect abundance in cowpats between three different farming systems: conventional dairy farms, organic dairy farms and nature conservation areas under grazing management. Furthermore, we compared the different grazing and mowing regimes of the farming systems to examine the availability and longevity of cowpats on the pastures. Cowpats in nature areas and at organic farms supported 50% more insects than those at conventional farms. So, the intensity of agricultural practice is related to the presence of insects in cowpats. Furthermore, different mowing and grazing regimes influence the dropping density in the field and are expected to influence invertebrate abundance too.

Introduction

During the last decades, agricultural landscapes have changed rapidly. A wide range of species of different taxa, including arthropods, birds and plants, suffered from intensified agricultural practices (Vickery *et al.* 2001, Burel *et al.* 2004). On pastures, intensified mowing regimes and the use of artificial fertilizer and insecticides negatively influenced insect abundances and diversity (Schekkerman 1997, Brickle *et al.* 2000). Grasslands with higher fertiliser inputs and intensified mowing regimes yield smaller insects and lower insect biomass and densities (Siepel 1990, Benton *et al.* 2002). Vickery *et al.* (2001) found lower abundances and diversities of invertebrates on pastures with reduced sward complexity due to intensive management. Besides insects living in and on the vegetation, also invertebrates living in and from cowpats suffer from changing management practices. For example, the use of artificial fertilizers and veterinary drugs negatively influences the abundance and diversity of dung beetles (Hutton & Giller 2003, Hempel *et al.* 2006). Anthelminthics such as ivermectin, used to control gastrointestinal parasites, have negative influences on the development of insect larvae living in cow dung (Madsen *et al.* 1990, McCracken & Foster 1993, Strong *et al.* 1996, Suarez *et al.* 2003).

Insects of various groups depend directly on cowpats, because they spend a greater part of their life cycle in them. Flies (Diptera) and beetles (Coleoptera) put their eggs in and on cow pats. The larvae emerge some hours or days later, feed on the dung and develop until they pupate in the pat or in the ground nearby (Putman 1983). Besides coprophagous insects and insects that depend on dung for reproduction, predatory insects like rove beetles (Staphylinidae) are attracted by cow dung and feed on the insects and larvae of the dung community (Skidmore 1991).

The aim of our field study is to gain more insight in the insect abundance in cowpats of different farming types. We tried to answer the following questions:

(i) Are there any differences between farming systems in insect abundance in cowpats?
(ii) Are there any differences between farming systems in availability and longevity of cowpats, influencing populations of insects?

We will discuss the implications of the answers for wader bird chicks that use insects as a potential food resource.

Material and methods

Farming systems of three different types were visited, all situated in the western peat-district of The Netherlands. We distinguished between conventionally managed dairy farms, organically managed dairy farms and nature conservation areas. Cowpats (figure 1) were collected from pastures of eight conventional farms (figure 2), six organic farms and six nature conservation areas grazed by cattle. The main difference between organic and conventional farms is that the former use neither chemical and synthetic pesticides nor artificial fertilizers. The nature conservation areas are grasslands owned by nature conservation organisations that have management agreements with conventional or organic farmers on extensive farming practices. The grasslands are grazed by young or dried-off cattle (cows temporarily not giving milk) of conventional or organic farms. The farms and nature conservation areas were situated within a region of about 200 km^2. They were visited randomly between the 24th of May and the 25th of June 2004.

Usually twelve cowpats of approximately ten days old were collected on each pasture. At a single conventional farm,

1. One of the sampled cow dung pats. Photo: Geert de Snoo
1. Een bemonsterde koeienvlaai.

2. Grazing cows on a conventional meadow. Photo: Peter Koomen
2. Grazende koeien op een gangbaar veehoudersbedrijf.

fourteen cow dung pats were collected in two pastures with different groundwater levels. We chose pats of ten days to allow the dung fauna to colonize the dung and to develop up to at least the larval stage. Dung pat age was estimated based on information from the farmers concerning the grazing periods (the cattle on the farms is moved between fields every few days) and on the comparison with dung pats of exactly known age.

The insects were collected by washing the pats through two sieves with mesh sizes of 5 and 2 mm, respectively. A mixture of insects and fibres remained in the second sieve. Insects were sorted out by hand and stored in ethanol 70%. Adult insects were identified up to genus level, except members of the family Histeridae, which were identified to family level. Larvae were identified to family level using Skidmore (1991).

A questionnaire about regimes of grazing (cattle number and density, first and last grazing day, number of grazing days per pasture, number of grazing hours per day), mowing, manuring (date, manure type) and anthelminthics use was sent to the farmers to investigate the availability of droppings on the parcels.

Two local weather stations provided information on mean temperature and precipitation. Cumulative mean temperature and precipitation of the ten days preceding the cowpat collection were used in statistical analyses. Mean temperature was not related to the number of insects in cowpats. Precipitation was correlated only with the number of insects in cowpats at organic farms (Pearson correlation = -0.256, $P = 0.03$) and not at the other farming types. As precipitation did not influence differences in insect abundance between farming systems, there was no reason to adjust the data for this factor.

order	family	conventional farms (n= 8)	organic farms (n=6)	nature areas (n=6)
Diptera	Sepsidae - larvae	33.66	45.61	58.28
Diptera	Muscidae - larvae	17.02	42.82	30.24
Coleoptera	Hydrophilidae - adults	9.05	12.47	10.74
Coleoptera	Hydrophilidae - larvae	10.80	12.71	18.01
Diptera	Anisopodidae - larvae	8.21	9.94	21.75
Coleoptera	Scarabaeidae - adults	6.32	13.51	12.89
Coleoptera	Scarabaeidae - larvae	3.91	1.04	1.25
Coleoptera	Staphylinidae - adults	5.32	9.65	10.40
Coleoptera	Staphylinidae - larvae	1.45	0.83	0.96
Diptera	Scathophagidae - larvae	4.31	7.31	1.19
Diptera	Stratiomyidae - larvae	1.01	0.29	0.26
Diptera	Psychodidae - larvae	0.00	0.03	1.14
Diptera	Syrphidae - larvae	0.35	0.17	0.65
Coleoptera	Histeridae - adults	0.42	0.04	0.14
Total insects	**101.82**	**156.43**	**167.90**	

Table 1. Mean insect numbers per cow dung pat for the three farming system. The family Staphylinidae was represented by the genera *Philonthus*, *Platystethus*, *Oxytelus*, *Anotylus*, *Xantholinus*, *Megarthrus* and the sub-family Aleocharinae, the family Scarabaeidae by the genera *Onthophagus* and *Aphodius*, and the family Hydrophilidae by the genera *Cercyon* and *Sphaeridium*.
Tabel 1. Gemiddeld aantal insecten per koeienvlaai voor de drie veehouderijvormen. De familie Staphylinidae werd vertegenwoordigd door de genera *Philonthus*, *Platystethus*, *Oxytelus*, *Anotylus*, *Xantholinus*, *Megarthrus* en de sub-familie Aleocharinae, de familie Scarabaeidae door de genera *Onthophagus* en *Aphodius* en de familie Hydrophilidae door de genera *Cercyon* en *Sphaeridium*.

3. Several observed species on cowpats (from upper left and clockwise): adults of Sepsidae, Scathophagidae, Scarabaeidae and Staphylinidae. Photos: Peter Koomen (Sepsidae) and Theodoor Heijerman (other three)
3. Enkele waargenomen soorten: imago's van Sepsidae, Scathophagidae, Scarabaeidae en Staphylinidae.

Results

Insects in cow dung pats

The arrangement in families of the sampled insects is given in table 1 (and see figure 3). All adult insects belonged to the order Coleoptera with 35% belonging to the genus *Aphodius*. Most larvae (84%) belonged to the order Diptera, with the main families Sepsidae (41%) and Muscidae (26%). The remaining larvae belonged to the order Coleoptera. The largest number of insects was found in a cowpat from a nature area: 1641 in total.

Abundance results

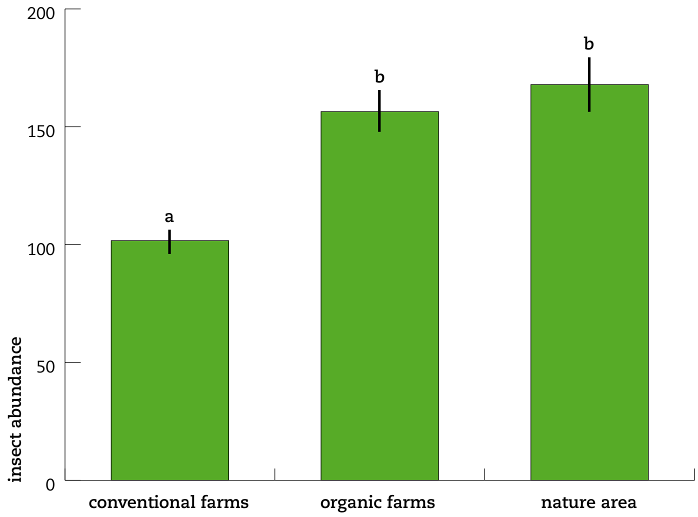
Insect abundance of cowpats varied significantly between the farming types (nested ANOVA: $F = 3.945$, $P = 0.039$, figure 4). Nature conservation areas and organic farms supported higher insect abundances than conventional farms. Cowpats of organic farms and nature conservation areas had over 50% more insects than pats of conventional farms. Differences between pats of organic farms and nature conservation areas were not significant.

Availability and longevity of cow dung pats

The availability of cowpats on pastures was investigated by a questionnaire on grazing and mowing regimes. The results are summarized in table 2. The mean date in spring that cows start grazing outside at conventional farms was on the 4th of May, though on two of them the first grazing day was not until mid-June. The cattle at nature conservation areas stayed outside day and night, at conventional and organic farms for about seven hours a day. The longevity of the droppings was influenced

Table 2. Farming practices at the farms where cow dung pats were sampled. Summary of the results of the questionnaire completed by the farmers. Mean numbers are given for each farming type, followed by the range of the estimates.
Tabel 2. Bedrijfsvoering van de boeren bij wie koeienvlaaien zijn bemonsterd. Samenvatting van de resultaten van de vragenlijst die door de boeren werden ingevuld. De gemiddeldes worden voor elke veehouderijvorm gegeven, gevolgd door het bereik van de schattingen.

	conventional Farms (n=8) mean (range)	**organic Farms (n=6)** mean (range)	**nature Areas (n=6)** mean (range)
First grazing day	4 May (10 April - 15 June)	9 April (15 March - 1 May)	18 April (10 April - 1 May)
Grazing duration per day [hours]	8 (7 - 9)	8 (6 - 8)	24 (24 - 24)
Timing of mowing or chain harrowing, after first grazing day on meadow [days]	22 (14 - 31)	25 (7 - 32)	after breeding season of wader birds
Use of anthelminthics during study period	0	0	0



4. Mean insect abundances per cow dung pat for the three farming systems. One standard error is given around the mean. A significant difference was found between a and b (P = 0.039).
4. Gemiddelde insectenabundantie per koeienvlaai voor de drie veehouderijvormen. Rond het gemiddelde wordt één standaardfout gegeven. Er kon een significant verschil aangetoond worden tussen a en b (P = 0,039).

negatively by agricultural activities on the pastures, such as mowing, manuring or chain harrowing. These activities were more intensive on conventional and organic farms (where the meadows were cultivated after a grazing period of about three weeks), than at nature conservation areas (where these activities take place only after the 15th of June). No anthelminthics were administered to the cattle at the time of this study. Two thirds (68%) of the farmers of all three types did use anthelminthics in their management, but applied them to calves only and did so later in the year (autumn).

Discussion

We found lower insect abundances in cowpats of conventional dairy farms compared to those of organic dairy farms and grazed nature conservation areas. Cow pats of conventional farms supported 40% less insects than those of nature areas and 35% less than those of organic farms. Insect abundances in cowpats of organic farms and nature areas did not differ significantly. Our findings are supported by the study of Hutton & Giller (2003), who investigated differences in biomass, species richness and densities of the dung beetle communities at organic and intensive farms. They found a higher abundance and biomass of dung beetles at organic farms than at intensive farms. They suggest that the lower insect densities are caused either by the application of anthelminthics, or by a lower density of shaded habitats, or by other soil characteristics. Negative effects of anthelminthics on dung insects have been shown in several studies (McCracken & Foster 1993, Strong *et al.* 1996, Hempel *et al.* 2006, Webb *et al.* 2007). However, no anthelminthics were administered to the cattle at the time of this study. Moreover, as most farmers in our study used them irrespective of their management type, they do not explain the differences found in insect densities. Furthermore, none of the sampled pastures had shaded areas and their soil types did not differ.

Compared to organic and conventional pastures, grazed nature areas seem to be the most suitable places to fulfil the life cycle of a cow dung insect. Early grazing regimes, twenty-four hours grazing per day and the absence of tillage activities before the 15th of June result in a relatively high availability of cowpats for insects. On both conventional and organic farms cattle start grazing outside much later in the year, for about eight hours per day and tillage practices are more intensive. The trend of a late grazing regime or even towards a no-grazing regime at conventional farming types generally applies for The Netherlands. Furthermore, the pastures of most organic and conventional farms are mowed three weeks after grazing. For many insects three weeks is not enough to complete larval development (Putman 1983). In that case a cowpat will rather become an ecological trap than a place for reproduction. Also the insect fauna feeding on cow dung during a part of their life cycle, would suffer from the disappearance of cow dung pats.

The availability of cow dung in pastures is not only essential for many invertebrate species, but is also relevant from a wider, ecological perspective: invertebrates as the basis of the agro-ecological food web. Fore example many chicks of wader birds forage on pastures and depend on invertebrates. The availability of invertebrate food during the breeding season plays an important role in the breeding success of farmland birds (Beintema *et al.* 1991, Johansson & Blomqvist 1996, Schekkerman, 1997). While lapwing chicks (*Vanellus vanellus*) feed on insects living inside dung, godwit chicks (*Limosa limosa*) catch their prey mainly from the surface of the pats. The study of Beintema *et al.* (1991) shows the importance of insects living in cow dung as chick food: In 20%, 30% and 49% of the faecal samples of lapwing chicks, they found remains of *Scathophaga*, *Aphodius* (Scarabaeidae) and Stratiomyidae larvae, respectively. Even in 73% of the faecal samples of godwit chicks remains of *Scathophaga* were found. Since the populations of several wader bird species are in decline, the availability of cow dung pats and their insect abundance is important.

Our findings show that there are differences in insect abundances between cow dung pats in different farming systems. We conclude that intensive farming management has negative consequences for the insect abundance in cow dung pats and that extensive management practices result in more pats with higher insect abundances.

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Samenvatting

Insecten in koeienvlaaien van drie verschillende typen landbouwbedrijven

Ongewervelde dieren (bijvoorbeeld insecten) vormen een belangrijke voedselbron voor weidevogels zoals de kievit en de grutto. Voor tal van ongewervelden bieden koeienvlaaien in weidegebieden geschikte (micro)habitats om zicht voort te planten en voedsel te zoeken. Daardoor is de beschikbaarheid van koeienvlaaien belangrijk voor de diversiteit van ongewervelde dieren in een agrarische omgeving. We onderzochten de verschillen in aanwezigheid van insecten tussen koeienvlaaien afkomstig van drie typen agrarisch beheer: conventionele en biologische melkveebedrijven, en natuurterreinen met begrazing door runderen. Ook vergeleken we de verschillen in graas- en maaibeheer tussen de drie beheerstypen, om de beschikbaarheid en de levensduur van koeienvlaaien in de wei te bepalen. Koeienvlaaien van natuurgebieden en biologische bedrijven huisvesten 50% meer insecten dan die van conventionele bedrijven. De intensiteit van het agrarisch beheer staat dus in relatie tot de aanwezigheid van insecten in koeienvlaaien. Verder beïnvloeden verschillen in maai- en graasbeheer de vlaaiendichtheid in het veld. Deze verschillen beïnvloeden dus waarschijnlijk óók de aanwezigheid van insecten, en daarmee hun beschikbaarheid voor weidevogels.

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