Key predator species in oilseed rape crops – results of a joint field trial in integrated and standard oilseed rape crop management in United Kingdom, Germany, Sweden, Poland and Estonia

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Introduction

In Europe there is a large number of pest insects infecting stems, buds or pods of winter oilseed rape plants as for example *Ceutorhynchus pallidactylus*, *C. napi*, *C. obstrictus*, (Coleoptera: Curculionidae), *Psylliodes chrysocephala* (Coleoptera: Chrysomelidae) and *Dasineura brassicae* (Diptera: Cecidomyiidae). The joint feature of all these pest insects is that their larvae drop to the ground to pupate in the soil. By this they are available as prey for predators active on the soil surface as there are mainly ground beetles (Coleoptera: Carabidae), rove beetles (Coleoptera: Staphylinidae) and spiders (Arachnida: Araneae). Thus, these predators can contribute to a high extent in the natural regulation of these pests Büchs (2003). However, it is not known how much the species assemblages and their dominance structures vary in different European countries and whether the same species can be identified as key predators of oilseed rape pest across whole Europe. For this purpose data sources from literature are hardly comparable as the setting of the data is different: Different dates of sampling, different years, different methods, different management intensities a.s.o. Therefore, a joint field experiment conducted parallel in several European countries which is basis of this paper plays an important role within the europewide identification of key predator species because

- oilseed rape growing and sampling occurred under defined and thus, very similar conditions
- the two management systems (see below) allow a comparison of the effects of different crop management techniques and their effects on the set of key predators.

The two systems differed mainly in tillage and insecticide input (ICM: no tillage, mulching, no insecticides; STN: ploughing; insecticide input according current agricultural practise; Felsmann & Büchs, 2006; Nilsson et al. 2006).Within the ICM/STN system comparison exemplarily ground beetles (Coleoptera: Carabidae) from pitfall trap samples were analysed as predator taxon. Research was done with standardised methods (pitfall traps in similar management systems, installed at the same time etc.)

Methods

The different oilseed rape management systems and their effects on pests and epigaeic predators (carabids, staphylinids and spiders) have been investigated from 2003 to 2005 in a winter oilseed rape field with an ICM-system (Integrated Crop Management) with reduced tillage and without any insecticide treatments and a ploughed STN-system (standardised oilseed rape management) with insecticide treatments (pyrethroids) at BBCH stages 12, 30, 53 and 60 (example dates for Braunschweig-Wendhausen, Germany). Traps for both pests and predators have been arranged at 21 sampling points in each system in 2003 and 2004 (in Germany) and 5 sampling points in each system in 2005, in all other countries 4 (Sweden) or 5 (all other countries) pitfall traps were installed in certain periods during the growing season (BBCH 65-97). As sampling period a minimum of 4 weeks of sampling was agreed starting when the dropping of Meligethes-larvae began about BBCH stage 65. Another 4 weeks sampling period was scheduled for the autumn period after emergence of the winter oilseed rape. Most partner countries exceeded the agreed minimum of sampling periods significantly. In the tables the countries involved in the joint ICM/STN field experiment are ordered in a geographical East-West gradient, starting with UK in the West and ending with Estonia in the East. ICM/STN results of summer 2003 from Estonia are from spring rape, because low temperatures in winter 2002/2003 destroyed the winter oilseed crop sown in August 2002. Therefore, the results of Estonia occur separated in the tables or are neglected (for the summer period) within the general phenological scheme (Fig. 1). All other results and statements rely on winter oilseed rape.

Results with discussion

Tab. 1 shows the list of Carabid species in ICM and STN between 2003 and 2005 which achieve more than 1% dominance. The crosses indicate the 3-years average of dominance. It is obvious that in the system with Standard crop management (STN) and the Integrated crop management system (ICM) the same 8 species.are predominating in 3 or more countries except *Bembidion lampros* which achieves higher levels of dominance only in Sweden. From Tab. 1 can be also derived that there are considerably more dominant/subdominant species in ICM (32) than in STN (23).

Tab. 1: Carabid species from pitfall traps in winter oilseed rape of ICM and STN between 2003 and 2005 ordered in three classes of dominance. Bold names for species which achieve a dominance level of more than 1% in more than 3 countries. Data of 2003 from Estonia are from spring rape. Variations of results caused by this fact are displayed in brackets. Results for Sweden are restricted to 2003 and 2004.

Summer 2003-2005	XXX = > 10%	XX = > 5%	X = > 1 %		
ICM	bold names = in 3 or more countries				
Sum					
	(UK)	**Germany**	(Sweden)	**Poland**	**Estonia**
Agonum muelleri					XXX
Amara aenea				X	
Amara familiaris		X			
Amara eurynota				X	XX
Amara plebeja	X				
Amara similata	XXX	XXX	XX		
Amara spp.					X
Anchomenus dorsalis	X	X	XX		X
Asaphidion flavipes	X	X			
Bembidion lampros	X		XX	X	
Bembidion properans					X
Brachinus crepitans				X	
Calathus fuscipes				X	
Carabus cancellatus					X
Carabus granulatus					X
Demetrias atricapillas	X				
Harpalus affinis	X	XX	XX	XX	X
Harpalus brevicollis				XX	
Harpalus cupreus				XX	
Loricera pilicornis	X	XXX	X		
Nebria brevicollis	XX	X			
Notiophilus biguttatus	X	X			
Notiophilus pusillus			X		
Poecilus cupreus	XX	XXX	X	XXX	XXX
Poecilus versicolor				X	X
Pseudoophonus rufipes	X	X	X	X	XX
Pterostichus macer		XX			
Pterostichus madidus	X				
Pterostichus melanarius	XX	XX	X	X	XX
Pterostichus niger					X
Stomis pumicatus		X			
Trechus quadristriatus	X	X			
32	15	14	9	12	13

2003-2005	XXX = >10%	XX = > 5%	X = > 1%		
STN	bold names = in 3 or more countries				
SUM					
	UK	**Germany**	(Sweden)	**Poland**	**Estonia**
Agonum muelleri					XX
Amara aenea				XX	
Amara bifrons					XX
Amara familiaris		X			
Amara eurynota				X	XX
Amara ovata	X				
Amara plebeja	X				
Amara similata	XXX	XXX	XX	X	
Amara spp.					
Anchomenus dorsalis	X	X	XX	X	XX
Anisodactylus binotatus				XX	
Asaphidion flavipes	X				X
Badister sodalis		X			
Bembidion lampros	X		XX		
Bembidion properans					
Calathus erratus					[X]
Calathus melanocephalus					[X]
Clivina fossor				X	X
Demetrias atricapillas	X				
Harpalus affinis	X	XX	XX	X	X
Harpalus brevicollis				X	
Harpalus cupreus				XX	
Leistus spinibarbis	X				
Loricera pilicornis	X	XX	X		X
Nebria brevicollis	XX	X			
Notiophilus biguttatus	XX	X			
Poecilus cupreus	XX	XX	X	XX	XXX
Poecilus versicolor					X
Pseudoophonus rufipes	XX	XX	X	X	X[XX]
Pterostichus macer		XX			
Pterostichus madidus	XX				
Pterostichus melanarius	XX	XX	X	X	XX
Pterostichus niger					
Stomis pumicatus		X			
Trechus quadristriatus		X			
23	12	10	5	9	7

Phenology. In Fig. 1 a monthly phenological pattern of the most dominant ground beetles (> 1%) according to the results of the joint ICM/STN field trial is shown. Due to the fact that there are reasonable differences regarding the phenology of ground beetle species and cases are observed with peak abundance in one of the countries, but a considerable lower activity in another country within the same month, the country acronym which is responsible for the peak abundance is underlined and – in contrast – countries with low activities or only single records in this period have been put in brackets.

Interpreting the phenologies of the joint field trial it has to be considered that sampling periods of the different countries were different (e.g. Start: Poland (PL) in April, United Kingdom (UK) and Germany (DE) in mid of May, Sweden (SE) at beginning of June; End: United Kingdom (UK) end of June, all other countries about mid of July). In order to be able to compare phenologies within the countries standardized dates were defined which not in all cases meet the exact date of pitfall trap controls in each country. In these cases pitfall trap results were ordered to that standardised sampling date which was next to the exact sampling date. It has to be noted that the phenological patterns of the pest species were derived from German results. In fig. **1** all phenological patterns (pests and predators) have been derived from the ICM system, due to the assumption that in a system without tillage and insecticide application phenologies are more undisturbed.

Within the joint field trial most ground beetle species (14 species) show reasonable or peak activities in June (Fig. 1). This is the time when larvae of the most pest species drop to the soil to pupate. Thus, it can be assumed that the majority of ground beetle species is phenologically adapted to the occurrence of pest larvae (see Felsmann & Büchs, 2006, Williams et al., 2006). If activity is related to predation rates, obviously June is the time period when most predation by ground beetles takes place.

Poecilus cupreus, but also *Bembidion lampros, Nebria brevicollis, Pterostichus melanarius* and other species showed a second reasonable activity peak in the autumn (September to November). Generally, in particular in the Eastern countries (Poland, Estonia) significant more species showed reasonable autumn activities than in Western countries (United Kingdom, Germany). If this reflects the average conditions it could affect the regulatory capacity of ground beetles against pests occurring in autumn.

= month with reasonable activity
= peak month

Species	April	May	June	July	August	September	October	November
Bembidion lampros	PL	UK, PL	SE	SE		PL, (EST)	PL, (EST)	
Poecilus cupreus	PL	UK, DE, PL	UK, DE, SE, PL	(SE), PL		(PL), EST	(PL), EST	
Amara plebeja	PL	UK, PL	UK, SE, PL	PL				
Nebria brevicollis		UK, DE	UK, DE			(PL)	UK	UK
Notiophilus biguttatus		UK, DE	UK, DE	DE				
Harpalus brevicollis	PL	PL	PL	PL				
Loricera pilicornis		UK, DE, PL	UK, DE, SE	(DE), SE, (PL)				
Harpalus affinis		UK, DE, PL	UK, DE, SE, PL	(DE), SE, PL		(PL), (EST)	(PL), (EST)	
Amara similata	(PL)	DE, (PL)	UK, DE, SE	DE, SE, (PL)				
Anchomenus dorsalis		(UK), DE, (PL)	(UK), (DE), SE, (PL)	SE		(PL), EST	(PL), (EST)	
Asaphidion flavipes	(PL)	UK	UK, (SE)					
Amara eurynota		PL	PL	PL				
Stomis pumicatus		DE	DE, (SE)	DE				
Bembidion properans	(PL)	(PL)	(PL)			PL	PL	
Pseudoophonus rufipes		UK, (DE), (PL)	UK, DE, SE, PL	(DE), SE		EST		
Pterostichus melanarius		(UK), DE	UK, (DE), SE, PL	(DE), SE, PL		(UK), (PL), EST	UK, (PL), EST	
Agonum mülleri						(EST)		
Pterostichus niger			SE	SE				
Calathus fuscipes						(PL), EST	PL, (EST)	(PL)
Calathus melanocephalus						PL, EST	PL, EST	PL
Trechus quadristriatus						(UK), PL	PL	PL
Pterostichus madidus		UK	UK			UK	UK	UK
Nebria salina						UK	UK	UK
Anisodactylus binotatus						(PL)	(PL)	
Harpalus cupreus						PL	PL	(PL)
Calathus erratus						(PL)	PL	(PL)
Leistus spinibarbis							UK	
Pests (phenology of larval drop / occurrence)								
Meligethes aeneus								
Ceutorhynchus palidactylus / napi								
Ceutorhynchus obstrictus								
Dasineura brassicae								
Athalia rosae								
Psylliodes chrysocephala								
Delia radicum								

Fig. 1: Monthly phenological patterns of the most dominant ground beetles (> 1%) according to the results of the joint ICM/STN field trial conducted in United Kingdom (UK), Germany (DE), Sweden (SE), Poland (PL) and Estonia (EST) (dark grey shading = peak abundance; light grey shading = considerable abundance; no shading, but with country acronym = low abundance; no shading, but with country acronym in brackets = single records; no shading, no country acronym = no records)

The phenological patterns of the joint field trial demonstrate significant differences in the seasonal occurrence of the most dominant ground beetle species. A different species composition or dominance structure of a species community affects also food preferences and consumption rates (e.g. if larger or smaller species predominate). As the occurrence of the pest larvae shows not such detrimental differences, it can be assumed that the regulatory power of ground beetles as natural enemies of oilseed rape pests varies very much from country to country. Thus, general statements on the predatory capacity seem to be difficult, but they have to be tailor-made to the individual conditions of each partner country. To summarize, these detailed individual phenological patterns state not only the country specific occurrence of peak activities, but moreover they demonstrate very clearly that within the same species the abundance levels vary extremely from country to country. For example shows *Poecilus cupreus* in Poland an average 40- to 80-fold abundance compared to the other countries during peak activity periods. Similar relations we find for *Harpalus affinis* and *Anchomenus dorsalis* (higher abundance level in Sweden) or *Nebria brevicollis* (higher abundance level in the United Kingdom).

Tab. 2: Species similarity of the ground beetle species composition of a) United Kingdom (UK), Sweden (SE), Germany (DE), Poland (PL) and Estonia (EST) in 2005 and b) in the ICM/STN systems within countries in 2004 and 2005 (shading from yellow to orange according to increasing similarity)

a)

Soerensen Similarity Index						
Total no. of species						
	UK	SE	DE	PL	EST	
UK						west
SE	55,8					⇑
DE	50,0	45,6				⇑
PL	47,1	46,2	37,1			⇑
EST	40,0	44,1	43,8	47,2		⇑
west	<=	<=	<=	<=	<=	east

b)

Soerensen Similarity Index					
Total no. of species					
	UK	DE	PL	EST	
UK					west
DE	59,3				⇑
PL	46,9	48,5			⇑
EST	37,7	47,3	52,3		⇑
west	<=	<=	<=	<=	east

ICM/STN	UK	DE	PL	EST	SE
2004	92,9	80,8	73,8	82,1	63
2005	94,3	92,0	92,1	89,4	*

The accidental introduction of spring rape into the joint field experiment by Estonia contributes some additional aspects:

although the sampling period started in spring rape nearly at the same time (mid of May) as in the other countries in winter oilseed rape, the phenology of those species that occur in both crops is completely different in spring rape and in winter oilseed rape. In spring rape the same species which show peak activities in winter oilseed rape in May or June occur at least one or two month later. It is well known that tillage in spring affects ground beetles and other epigaeic predators detrimentally (e.g. Büchs et al. 1999). Obviously the spring rape fields have to be nearly completely recolonised by epigaeic predators which happens mainly after the winter crops had been harvested.

From the differences in dominance levels of certain species in different countries arises the question for similarity of the complete species assemblages SOERENSEN-similarity index was used on the basis of all carabid species recorded in STN and ICM. Tab. 2 shows that for all years an East-West decrease of species similarity can be stated: the larger the geographical distance between countries is, the less is the similarity of carabid species composition. That means that in European oilseed rape fields exists no standard ground beetle community, each country shows a rather unique but - in respect to each country – very typical performance of the predator composition.

Within the countries the similarity of the Carabid species composition of ICM and STN system(s) shows large differences in 2004 (Tab. 2). Whereas the species set of both systems is highly identical in the United Kingdom (UK) it differs to the highest extent in Sweden (SE). In 2005 there is a slight but remarkable tendency that differences in the Carabid species composition between the two systems increase from West to the East what might be due to the fact that eastern climates show higher amplitudes in its performance (e.g. temperature) and so more extremes which obviously influence the predator assemblages in combination with crop management techniques.

Tab. 3: Abundances of ground beetles out of pitfall trap samples (ind/trap×season; see fig. 2) in different management intensities (ICM_{i0}, ICM_{ie}, STN_{ie},STN_{ii}) in United Kingdom (UK) , Germany (DE), Sweden (SE), Poland (PL) and Estonia (EST) (Highest abundances for each country are written in bold and grey shaded)

Carabidae Abundance (Ind/trap)	year	UK	DE	SE	PL	EST
ICM i0	**2003**	**121,4**	**153,5**	**316,3**	**719,4**	**444,6**
STN ie	**2003**	34,0	107,0	303,5	583,6	179,2
ICM i0	**2004**	54,0	**114,0**	**141,0**	**841,5**	**913,8**
STN ie	**2004**	**55,8**	106,2	97,8	649,3	850,8
ICM i0	**2005**	**188,3**	**126,0**	*	**457,0**	25,7
STN ie	**2005**	130,5	85,0	*	188,0	**32,4**

For abundances clear effects of the management system can be demonstrated: already in 2003 in all countries higher abundances were achieved in the ICM system and even for 2004 and 2005 we got a similar pattern (Tab. 3).

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