On the target entomofauna of an organic winter oilseed rape field in Estonia

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Abstract: In May to July 2002, potential pests (phytophagous insects specialised on cruciferous plants) and their natural enemies (hymenopterous parasitoids and carabids as predators) were studied in an organic winter oilseed rape (*Brassica napus*) field in Estonia using yellow and black water traps and pitfall traps. Of the potential pests – *Meligethes aeneus* and *Ceutorhynchus assimilis* were the most numerous. However, they only fed on the rape plants and did not reproduce there. Their populations were low with peaks in early June. The peaks coincided with the population peaks of parasitic wasps including *Phradis morionellus*, a larval parasitoid of *Meligethes aeneus*, and *Mesopolobus morys, Stenomalina gracilis* and *Trichomalus perfectus*, larval parasitoids of *Ceutorhynchus assimilis*. 41 taxa of carabids were caught. Among them, the genus *Pterostichus* dominated, with *P. cupreus* and *P. melanarius* being the most numerous species. The presence of natural meadow as a field margin increased the abundance of potential pests, their parasitoids and the diversity of carabid species.

Key words: phytophagous cruciferous insects, parasitoids, Coleoptera, Carabidae.

Introduction

In Estonia, the area of oilseed rape (*Brassica napus* L.) is increasing rapidly and has exceeded 30, 000 ha; only 1,500 ha of this is winter-sown, however. This provides good preconditions for the population growth of potential pests, that is of the phytophagous insects specialised in cruciferous crops. The entomofauna of winter oilseed rape has not been systematically studied before in Estonia.

In Europe, the most common pests of oilseed rape are pollen beetles (*Meligethes aeneus* Fabr., *M. viridescens* Fabr.), cabbage seed weevil (*Ceutorhynchus assimilis* Payk.), cabbage stem weevil (*Ceutorhynchus pallidactylus* Panz.), rape stem weevil (*C. napi* Gyllenhal), brassica pod midge (*Dasineura brassicae* Winn.), cabbage stem flea beetle (*Psylliodes chrysocephala* L.) and flea beetles (*Phyllotreta nemorum* L., *P. undulata* Kutschera, *P. diademata*) (Free, Williams, 1978, 1979; Ekbom, Borg, 1993; Williams et al., 2002; Hansen, 2003).

The management of pests on the European oilseed rape crop still relies heavily on chemical pesticides, most often applied routinely and prophylactically, often without regard to pest incidence (Williams et al, 2002). This leads to over-use of chemical pesticides which reduces the economic competitiveness of the crop and threatens biological diversity. The pesticides also kill the natural agents of biological control, which would be a natural resource of great potential benefit to the farmer and consumer (Alford et al., 1995b; Williams, Murchie, 1995). By killing natural enemies, pesticide applications must be increased further to achieve pest control (Pickett et al., 1995; Murchie et al., 1997b).

The EU-funded project MASTER: MAnagement STrategies for European Rape pests (Williams et al., 2002) aims to develop economically viable and environmentally acceptable crop management strategies for winter oilseed rape which maximise biocontrol of key pests (Williams et al., 2002). This requires much greater knowledge of pest, parasitoid and predator taxonomy and biology throughout Europe. The present study contributes to the project MASTER. Its aim was to investigate the incidence and phenology of potential pests and their natural enemies in winter oilseed rape in Estonia.

Methods

Crop site

The study was carried out from crop flowering in May to crop harvest in July in an organically grown winter oilseed rape field (4.5 ha) at Puki farm, Vara commune, Tartu County, Estonia. The field was bordered to the north by a crop of winter wheat, to the east by a natural meadow and on the other two sides by a gravel road. The field margin between the oilseed rape field and the gravel road was covered mainly by sparse grassland. In the natural meadow, plants of various families (*Umbelliferae, Cruciferae, Papilionaceae, Compositae*) were growing. The winter oilseed rape (cv. Hansen) was sown on 8 August 2001 to follow clover which had been ploughed in. Very few cruciferous crops had previously been cultivated on the farm.

Meteorological data

Spring/summer of 2002 was warmer and much drier than usual. April was warmer by 1.7ºC, May by 2.9ºC, June by 2.5ºC and July by 3.6ºC than the long term average. Precipitation rate was lower in April by 11.9 mm, in May by 36.6 mm, in June by 25.1 mm and in July by 25.8 mm. than the long term average. The warmer spring promoted faster growth and the development of winter oilseed rape plants and earlier emergence of insects from hibernation sites.

Insect sampling and identification

Insects were collected at weekly intervals from yellow water traps (10), black water traps (10) and pitfall traps (21). The water traps were plastic bowls (210x310x90mm) containing about 2,5 l of fresh water. To sample insects that flew within the crop canopy, yellow traps were positioned at the height of the crop canopy. Black water trays on the ground were used to collect larvae leaving plants to enter the soil for pupation. To estimate the influence of different field margins on the target insects, yellow and black water traps were placed 15m into the crop from the different borders (Figure 1).

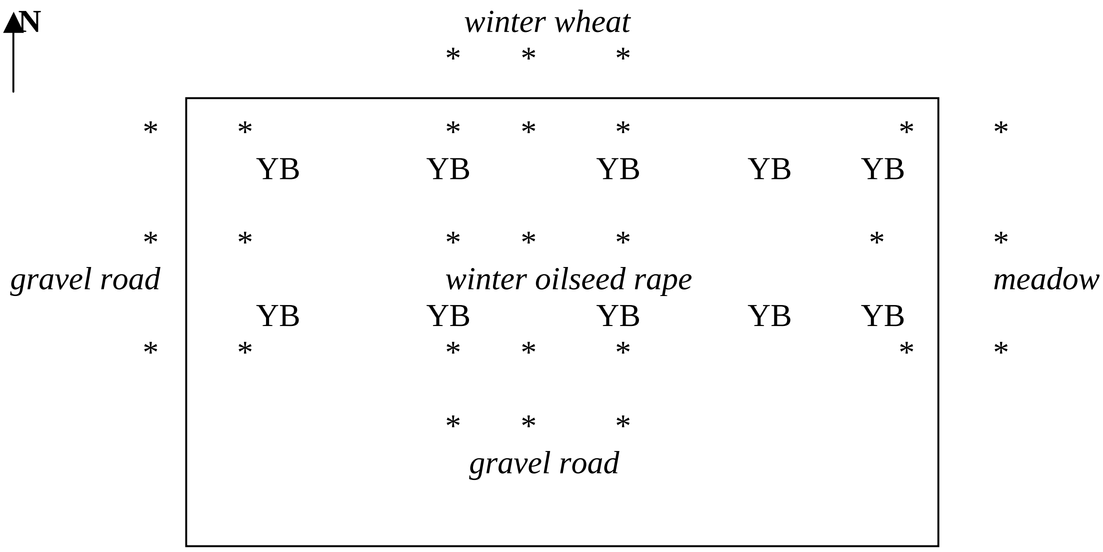

Figure 1. Locations of yellow (Y) and black (B) water trays and pitfall traps (*) in the organic winter oilseed rape field in Puki farm.

Pitfall traps for sampling predators (mainly carabids) were placed in the field margins, within the crop 5 m from the different margins and also in the field centre (three replicates in all places) (Fig. 1).Traps were put out on 8 May, when the plants were in growth stage (GS) 61–62 (10–20% of flowers on main raceme open, Lancashire et al., 1991). Traps were checked and insects collected at weekly intervals until harvest on 9 July.

Following collection, insect samples were pre-sorted into phytophagous insects, parasitoids and predators and stored in 70% ethanol at -18 °C. The target phytophagous insects and carabids were identified to species level. Hymenopterous parasitoids were identified to family level, except those specialised on the target phytophagous insects which were identified to species level. Insects of all identified taxa were counted.

The growth stage of the crop was recorded weekly using the Lancashire et al. (1991) growth stage key. Plant damage assessments were carried out four times (2 April, 8 May, 15 May, 29 May at GS 18–19, 61–62, 65–66, 71-72, respectively). Each time, 10 plants from 5 randomly chosen locations were collected for assessment of damage by *P. chrysocephala* and *C. pallidactylus* larvae. For assessment of damage by *C. assimilis* and *D. brassicae* larvae, samples of 10 mature plants from 5 randomly chosen points were taken on 29 May (GS 71-72, 10-20 % of rape pods have reached the final size). From each plant, ten pods were taken at regular spacing from the main raceme and ten were taken from the third lateral raceme. Each pod was examined for the presence of live or dead *C. assimilis* and *D. brassicae* larvae or an exit hole of emerged *C. assimilis* and *D. brassicae* larva or ectoparasitoid adult.

Mean numbers of target insects at different times and in different locations were calculated and the significance of differences statistically analysed using the Kruskal-Wallis ANOVA median test and the Wilcoxon pairs test.

Results and discussion

Crucifer-specialist insects and parasitoids

During the study period, 856 hymenopterous parasitoids and 2321 target cruciferous phytophagous insects were caught in the yellow water traps. Yellow water traps have been used in other studies to sample the coleopterous and dipterous pests of oilseed rape (Free, Williams, 1978; Free, Williams, 1979), as well as some of their parasitoids (Murchie et al., 1999a, 1999b). Yellow has long been recognised as one of the most effective colours for trapping insects on the rape crop. In this study, eleven species of crucifer-specialist insects were caught in the yellow water traps: *M. aeneus, M. viridescens, C. assimilis, C. floralis, C. rapae, C. pleurostigma, P. undulata, P. vittata, P. atra, P. armoraciae, P. nemorum. Psylliodes chrysocephala*, *C. pallidactylus* and *C. napi* were not found; neither was any evidence of plant damage by these stem borers. In the second week of May, *C. floralis* was abundant (Figure 2). The number of *M. viridescens* increased in the first week of June but numbers still remained small. This species prefers to reproduce in wild cruciferous plants (Billqvist, Ekbom, 2001a, 2001b). From the second week of June until harvest, *Meligethes* spp. and *C. assimilis* were present but in low numbers. Their populations peaks were at the beginning of June in GS 71-72 (10-20% of rape pods were reached final size) (Figure 3, 4). No *Meligethes* spp. larvae were found in the black water traps and no *C. assimilis* larvae or their damage in pods. The absence of larvae indicates that these beetles used the plants for maturation feeding and not for reproduction. Therefore despite the dominance of these two target species within the rape crop, their low number and the absence of plant damage by them means that they were not real pests in this crop.

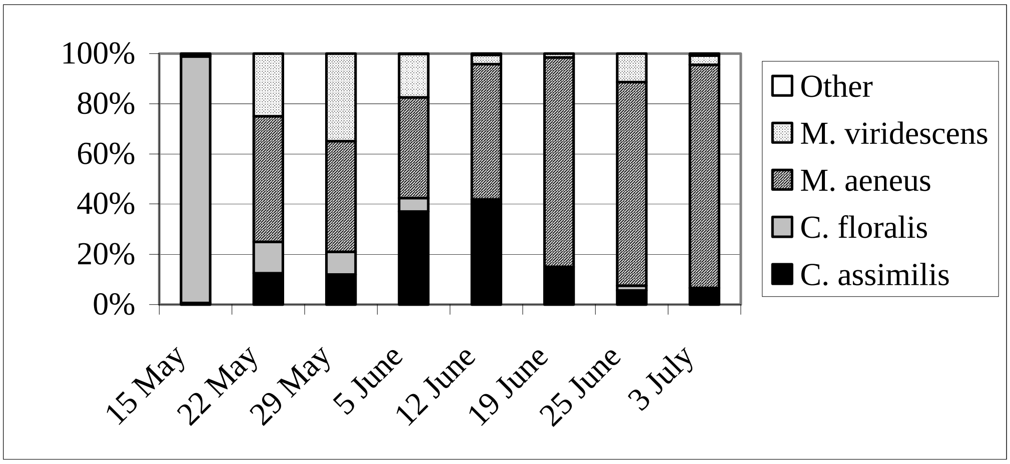

Figure 2. Percentage abundance of different target phytophagous species caught in yellow water traps at different times in the organic winter oilseed rape field in Puki Farm.

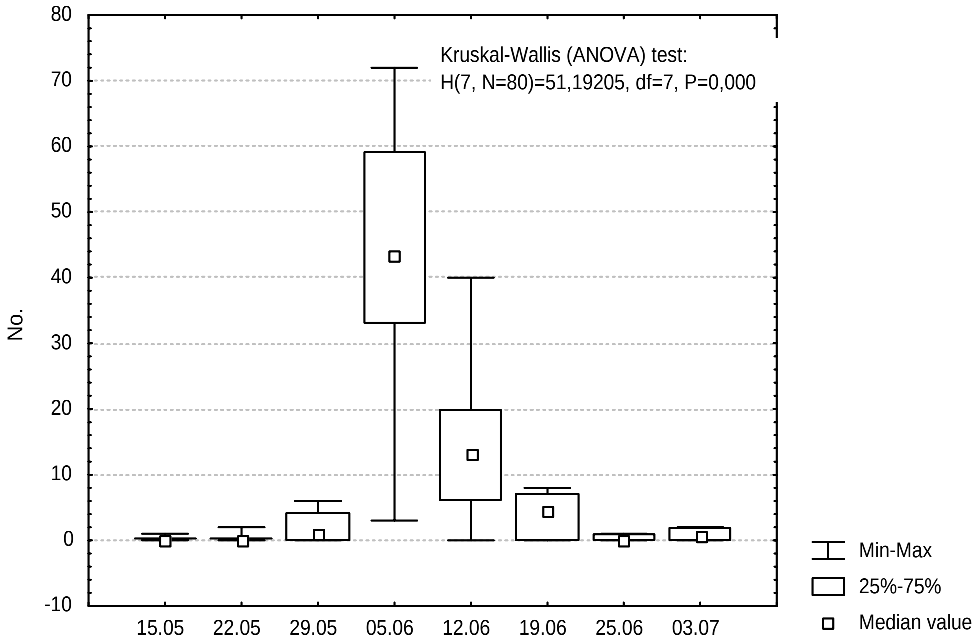

Figure 3. The mean numbers of *Ceutorhynchus assimilis* caught per yellow water tray at different times in the organic winter oilseed rape field in Puki Farm.

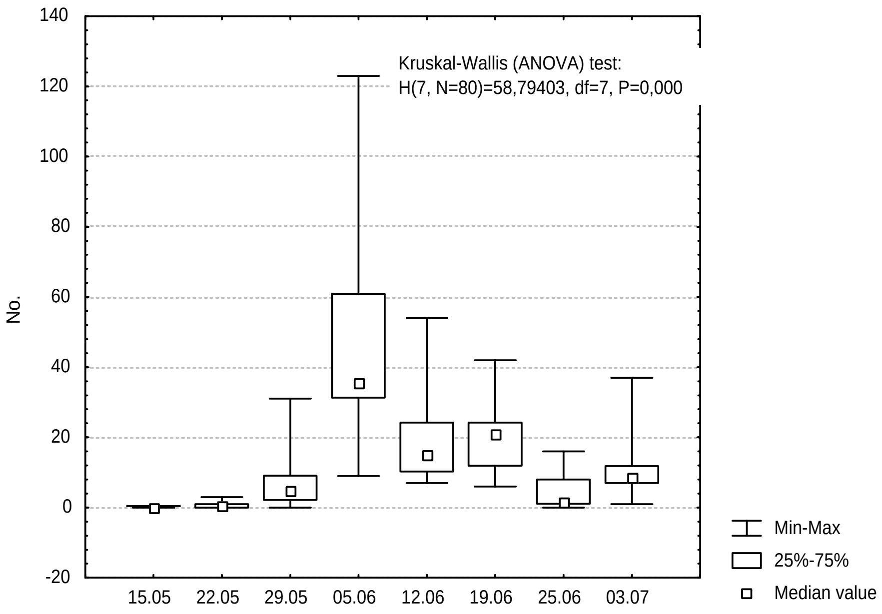

Figure 4. The mean numbers of *Meligethes aeneus* caught per yellow water tray at different times in organic winter oilseed rape field in Puki Farm.

The yellow water traps caught hymenopterous parasitoids from 16 families (Table 1), including the following six parasitoids of target phytophagous insects:

1. *Phradis morionellus* (Holmgren) (Ichnemonidae, Tersilochinae) - endoparasitoid of *Meligethes aeneus* larvae;
2. *Diospilus morosus* Reinardt (Braconidae) - ectoparasitoid of *Ceutorhyncus assimilis* larvae;
3. *Mesopolobus morys* (Walker) (Pteromalidae, Pteromalinae) - ectoparasitoid of *C. assimilis* larvae;
4. *Stenomalina gracilis* (Walker) (Pteromalidae, Pteromalinae) - ectoparasitoid of *C. assimilis* larvae;
5. *Trichomalus perfectus* (Walker) (Pteromalidae, Pteromalinae) - ectoparasitoid of *C. assimilis* larvae.
6. *Omphale clypealis* (Thomson) (Eulophidae, Entedontinae) - endoparasitoid of *Dasineura brassica* larvae.

Table 1. Hymenopterous parasitoids caught in the organic winter oilseed rape field in Puki farm in 2002.

Superfamily	Family	Subfamily/species	Host
Ichneumonoidea	Braconidae	Alysiinae *Diospilus morosus* Reinardt	Diptera larval endoparasitoids *C. assimilis* larval endoparasitoids
Ichneumonoidea	Braconidae	Euphorinae	Endoparasitoids of Coleoptera, Hemiptera, Neuroptera, Psocoptera, Orthoptera, Hymenoptera
Ichneumonoidea	Ichneumonidae	*Phradis morionellus* (Holmgren)	*Meligethes* spp. parasitoid
Cynipoidea	Eucoilidae	unknown species	Diptera larval endoparasitoids
Proctotrupoidea	Diapriidae	Diapriinae	Diptera larval endoparasitoids
Proctotrupoidea	Proctotrupidae	unknown species	Coleoptera larval endoparasitoids

Platygastroidea	Platygastridae	unknown species	Diptera, Coleoptera, Homoptera larval endoparasitoids
Platygastroidea	Scelionidae	unknown species	Insecta, Araneae egg endoparasitoids
Ceraphronoidea	Ceraphronidae	unknown species	Diptera, Lepidoptera larval endoparasitoids
Ceraphronoidea	Megaspilidae	unknown species	Homoptera, Diptera larval endoparasitoids
Chalcidoidea	Pteromalidae	*Mesopolobus morys* (Walker)	*C. assimilis* larval ectoparasitoids
Chalcidoidea	Pteromalidae	*Stenomalina gracilis* (Walker)	*C. assimilis* larval ectoparasitoids
Chalcidoidea	Pteromalidae	*Trichomalus perfectus* (Walker)	*C. assimilis* larval ectoparasitoids
Chalcidoidea	Eulophidae	unknown species	*C. assimilis* larval ectoparasitoids
Chalcidoidea	Entedontinae	*Omphale clypealis* (Thomson)	*Dasineura brassicae* larval endoparasitoids
Chalcidoidea	Encyrtidae	unknown species	Homoptera, Coleoptera (incl.*Meligethes* spp),Diptera, Lepidoptera, Hymenoptera egg and larval endoparasitoids
Chalcidoidea	Mymaridae	unknown species	egg parasitoids
Chalcidoidea	Eurytomidae	*Tetramesa* sp.	larval ectoparasitoids
Chalcidoidea	Trichogrammatidae	*Trichogramma* sp.	eggparasitoids

The abundance of target phytophagous insects and hymenopterous parasitoids differed adjacent to the different field margins. In the part of the field bordering the natural meadow, the total number of target phytophagous insects (P=0,088) as well as parasitoids (P=0,030) was significantly greater than in the parts bordering the gravel road (Fig. 5). In the centre of the field, the number of target phytophagous insects was significantly lower (P=0,018) than in two other parts. This greater edge abundance is typical of these phytophagous insects which immigrate to the field, in response to chemical and visual cues, from field margins where they overwinter (Bartlet, 1996;Murchie et a.l, 1997a). Previous studies in the UK have similarly reported a greater early abundance of both *C. assimilis* and of *M. aeneus* in crop edges at the beginning of migration with *C. assimilis* becoming more evenly distributed later in the season but *M. aeneus* retaining its greater edge distribution for longer (Ferguson et al., 2000; Free, Williams, 1978; Murchie et al., 1999a; Williams et al., 2000). The greater number of parasitoids in the part of the crop bordering the meadow may have been due to the diverse flowering plant community in the meadow providing a plentiful maturation feeding resource for them.

The seasonal dynamics of the abundance of the phytophagous insects and their natural enemies were synchronised with maximum numbers of both groups at GS 71–72 (10-20 % pods reached the final size).

Carabidae

The pitfall traps caught a total of 25,134 specimens from 41 taxonomic groups in the rape crop and its margins (Table 2). Dominant genera carabids were *Pterostichus, Amara, Agonum, Harpalus* and *Carabus*. Most carabids are polyphagous predators, especially those of the genera *Carabus, Calathus, Trechus, Bembidion* (Goldschmidt, Toft, 1997). *Agonum, Pterostichus* and *Harpalus* adults have a mixed plant and insect diet with the proportions of each dependent on the season. All carabid larvae are predators. Thiele (1977) has found that *Pterostichus melanarius* prefers a diet of animal food throughout the year whereas *Pterostichus cupreus* prefers it mainly in the summer. Winter oilseed rape offers a good overwintering habitat for many different insects, including carabids. This probably explains the rich carabid fauna found in this study. The seasonal dynamics of abundance of carabids was synchronised with the dynamics of phytophagous target insects (Figure 6) and suggests that the carabids may have utilised the latter as food. However, the number of carabids was much greater than the number of target phytophagous insects so these would have constituted only a small part of the food resource of the carabids as many other non-target insects were present in the field.

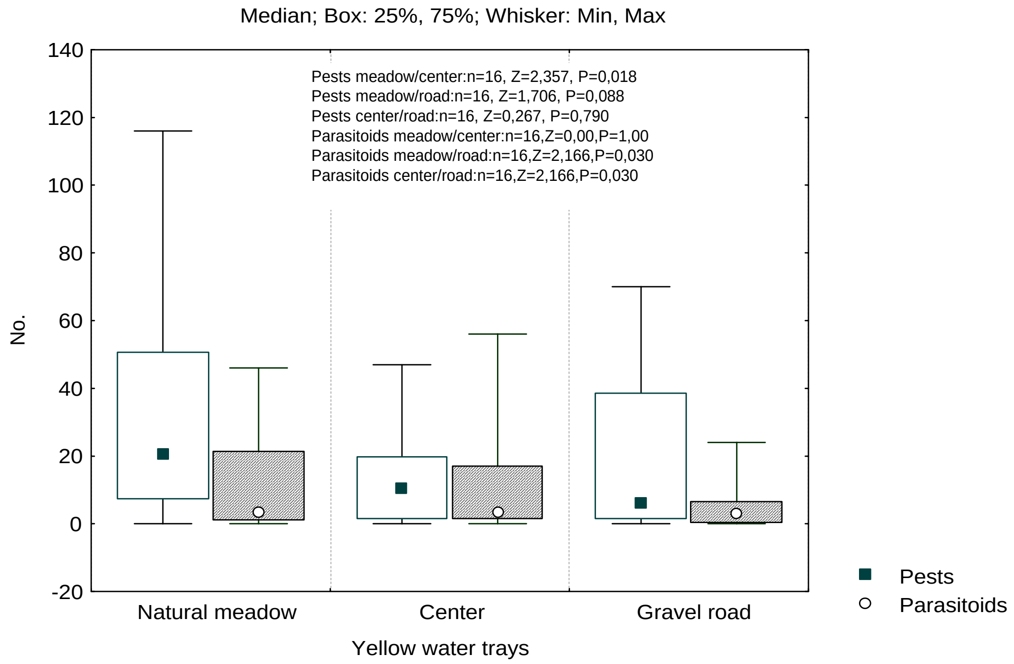

Figure 5. The mean numbers of target phytophagous insects and hymenopterous parasitoids caught per yellow water trap in different locations in organic winter oilseed rape field at Puki Farm.

Table 2. Mean number of predators per traps in different places in the organic winter oilseed rape field and field margins in Puki farm.

	Field centre	gravel road	5 m in gravel road	winter wheat field	5 m in winter wheat field	natural meadow	5 m in natural meadow
Cicindela campestris	0.0	0.3	0.0	1.0	0.0	0.3	0.3
Carabus granulatus	8.7	4.3	1.7	2.7	5.0	8.7	6.3
Carabus nemoralis	0.0	0.0	0.0	0.0	0.0	3.7	0.0
Carabus cancellatus	26.7	3.0	2.3	22.3	29.7	10.7	23.7
Clivina fossor	0.3	0.7	1.0	1.0	1.0	1.3	1.0
Dyschirius sp.	0.0	0.0	0.0	0.0	0.3	0.0	0.3
Asaphidion pallipes	0.7	0.0	0.3	0.0	0.7	0.0	0.3
Bembidion lampros	0.3	1.0	0.7	1.0	1.3	2.0	1.3
B. quadrimaculatum	0.0	0.0	0.3	0.0	0.0	0.0	0.0
B. properans	0.0	0.0	0.0	0.0	0.3	0.0	0.0

B. bruxellense	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Bembidion spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pterostichus cupreus	1129.3	44.7	57.0	537.3	1348.0	84.7	365.7
P. niger	10.0	4.3	1.3	9.3	10.0	3.0	8.7
P. oblongopunctatus	0.0	0.0	0.0	0.0	0.0	0.3	0.0
P. lepidus	0.0	0.0	0.0	0.3	1.0	0.0	0.0
P. crenatus	0.7	1.0	0.0	0.7	0.0	0.7	1.3
P. sternuus	0.3	0.0	0.0	0.3	0.0	0.0	0.7
P. melanarius	368.0	21.3	4.3	316.0	561.3	66.0	96.3
Pterostichus spp.	0.0	0.0	2.3	0.0	0.3	0.0	0.7
Calathus fusipes	0.3	0.0	0.0	0.0	0.0	0.0	0.0
C. melanocephalus	0.0	0.7	0.0	0.7	0.0	0.0	0.0
C. erratus	0.0	0.3	0.0	0.0	0.7	0.0	0.0
Synchus vivalis	2.0	0.7	0.3	0.0	0.0	0.3	0.0
Agonum muelleri	53.0	0.3	0.7	105.3	117.7	2.3	5.7
A. dorsale	50.0	0.0	1.3	60.7	98.7	0.7	9.7
A. sexpunctatum	0.7	0.3	0.3	0.3	2.7	0.0	0.3
Amara aulica	24.3	0.0	0.3	40.7	56.0	1.3	4.3
A. apricaria	33.0	1.3	7.0	3.7	3.3	1.3	2.7
A. ovata	0.0	0.0	0.3	0.3	4.3	0.0	0.3
A. communis	0.0	0.3	0.7	0.0	0.7	0.0	0.0
A. consularis	251.7	7.7	33.3	13.0	21.3	3.7	32.7
A. bifrons	2.7	3.0	5.0	3.0	10.3	1.7	3.3
A. similata	437.0	7.0	71.0	203.0	826.3	8.7	119.7
A. familaris	0.0	0.0	0.7	0.0	0.0	0.0	3.7
Amara ssp.	0.0	0.3	3.7	0.0	3.3	0.0	37.7
Harpalus pubescens	38.0	3.3	6.0	42.0	70.0	6.3	4.0
H. affinis	32.7	1.3	1.0	30.0	57.0	0.7	1.0
Harpalus sp.	2.7	0.3	0.0	0.3	0.3	0.7	0.0
Loricera pilicornis	3.7	0.7	4.7	0.7	3.3	1.0	4.3
Leistus sp.	0.0	0.3	0.0	0.3	0.0	0.0	0.3
Trechus secalis	0.0	0.7	0.3	1.0	0.3	0.0	0.7
T. quadristriatus	0.0	0.3	0.3	0.0	0.0	0.0	0.0
Patrobus atrorufus	0.0	0.3	0.7	0.0	0.0	0.0	0.0
Badister bipustulatus	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Carabids larvae	0.3	0.0	0.3	0.0	0.0	1.0	0.3
Other predators	185.7	71.3	97.3	111.0	226.7	138.3	205.0
Sum of carabids	2477.0	110.7	209.3	1397.0	3235.3	211.0	737.3
Total number	2662.7	182.0	306.7	1508.0	3462.0	349.3	942.3

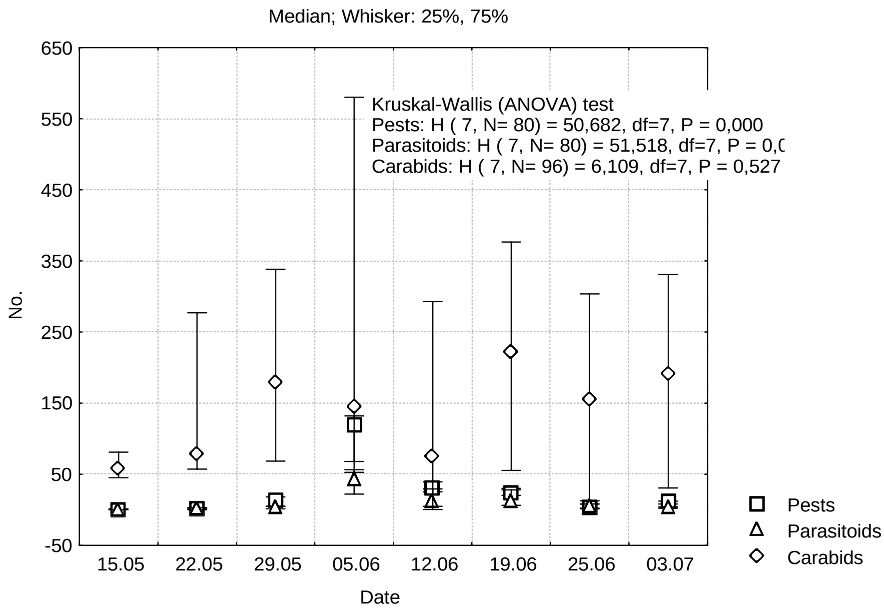

Figure 6. Seasonal dynamics of target phytophagous insects, hymenopterous parasitoids and carabids (mean number per trap) in the organic winter oilseed rape field in Puki Farm.

The different habitats provided by the varied field margins in this study influenced the abundance and species composition of the carabids caught in the field. This concurs with the findings of other studies (Luka et al., 1998; Szel et al., 1997; Andersen, 1995; Frank, 1997). The species diversity of carabids was greater while their total abundance was smaller in the parts of the field which bordered the gravel road and the meadow than in field centre (Table 2). However, the carabid fauna was most abundant in the rape field at 5 m from the winter wheat field (Table 2), indicating a positive influence from the adjacent winter wheat. In this part of the field and in the field centre, specimens of the genus *Pterostichus* were more numerous than elsewhere. The genus *Pterostichus* constituted 45 % of the total number of carabids caught with *P. cupreus* and *P. melanarius* being the most numerous species. *Pterostichus* spp are more hygrophilic than many other species (Thiele, 1977) and their abundance in both winter crops (wheat, rape) was probably associated with dense plant cover providing a suitably moist habitat and good overwintering site for them. In the meadow and the gravel road margins the abundance of *Pterostichus* was particularly low, probably due to the extremely dry conditions in 2002 which depressed the development and growth of the natural plant cover in the margins. and even killed that beside the gravel road.

Conclusions

This study of the entomofauna of an organic winter oilseed rape field in Puki Farm, Tartumaa, Estonia, has shown that:

- phytophagous crucifer-specialist insects caused little damage to the rape plants in this crop. Of the eleven target phytophagous insects (*M. aeneus*, *M. viridescens*, *C. assimilis*, *C. floralis*, *C. rapae*, *C. pleurostigma*, *P. undulata*, *P. vittata*, *P. atra*, *P armoraciae*, *P nemorum*) caught, only *M. aeneus* and *C. assimilis* were abundant but even their populations were low and they only fed on the rape plants and did not reproduce on them. They therefore did not reach pest status on this crop.
- the species diversity and abundance of both hymenopterous parasitoids (856 from 16 families) and carabids (25,134 from 41 taxa) caught suggests that they probably had a great influence on the population dynamics of the phytophagous insects in the crop.
- despite the absence of *M. aeneus* and *C. assimilis* larvae in the rape plants, their specialist parasitoids : *P. morionellus* (a larval endoparasitoid of *M. aeneus*), *D. morosus* (a

larval endoparasitoid of *C. assimilis*) and *M. morys, S. gracilis* and *T. perfectus,* (larval ectoparasitoids of *C. assimilis*) were caught in the traps, indicating that they were probably attracted by cues from the crop rather than from their host.

- the dominant genera of carabid were *Pterostichus, Amara, Agonum, Harpalus* and *Carabus* with the most numerous species were *P. cupreus* and *P. melanarius.*
- the margins of the field influenced the occurrence of both the phytophagous target insects and their natural enemies. They were particularly abundant and diverse adjacent to the natural meadow whereas the abundance of carabids (particularly *Pterostichus* spp.) was greater in the field centre and where the rape was adjacent to winter wheat.

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