Specific composition of flea beetles (*Phyllotreta spp*), the dynamics of their number on the summer rape (*Brassica napus* L. var. *oleifera* subvar. *annua)* Mascot

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Abstract. The specific composition of the flea beetle *Phyllotreta spp* (Coleoptera: Chrysomelidae), time of its appearance and dynamics of its number on the summer rape cultivar Mascot were determined. During the observation period, 6 species of flea beetles were found: *Phyllotreta undulata* Kutsch., *Ph. nemorum* L., *Ph. vittata* (*Ph. striolata*), *Ph. nigripes* F. *Ph. atra* and *Ph. vittula*. First flea beetles appeared at the time of the sprouting of rape plants. In the course of the entire observation period, the most numerous of these was the small striped flea beetle *Ph. undulata.* Proportion of the other species not often exceeded 10%. Very warm and dry weather following the sprouting of plants caused a rapid increase in the number of the pests and the maximum number was reached in a short time. A somewhat larger number of beetles was found on the edge plots. The field was sprayed three times, using Fastac (alphacypermethrin). Although after the first spraying the number of pests had decreased to almost zero, one week later the number of beetles began to rise again. Ten days after the spraying, the number of pests in the control and the sprayed variant had become equal, 2.0 and 2.2 individuals per plant. The second spraying lowered the number of pests again down to zero. At that time the plants were reaching the stage of 3–4 true leaves, the time when the growth rate is the fastest. The third spraying was primarily directed against pests damaging generative organs: pollen beetles and weevils, and at that time plants began to form secondary racemes, and primary racemes lengthened. For controlling of flea beetles spraying was no more necessary.

Key words: summer rape, flea beetles, damage, chemical control

INTRODUCTION

In Estonia the growing area of summer rape (*Brassica napus* L. var. *oleifera* subvar. *annua)* has increased year by year. If in 1990 the culture was grown on 1.015 thousand hectares, in 2002 already on 33.6 thousand (increase by 33 times), and 40.0 thousand hectares has been predicted for 2003. Mean yields have also increased, in 1990 - 1.200 kg/ha, in 2002 - 1.900 kg/ha. However, the yields are not equal in all areas because of different agrotechnologies, fertilising, and plant protection activities (data of the Statistical Office of Estonia from 2002). There are several pests on summer rape: at the beginning of summer the most dangerous ones are flea beetles, living on a small number plant species from the family *Brassicaceae* containing glucosinolates.

Flea beetles gnaw small round holes into leaves, decreasing assimilation surface and slowing down the growth of the plant (Gavlovski & Lamb, 2000). Heavy damage at the early stage of cotyledons may destroy a plant completely. For plants the critical period is the time until the appearance of 4–6 true leaves, later the damage is less harmful. Although rape plants are known for their extra strong compensation ability, pest control is often inevitable. The level of compensation primarily depends on how large part of a plant has been destroyed, the growing stage of the plant, weather and conditions of the growing site (Gavlovski & Lamb, 2000; Inouye, 1982). Dry and warm springs usually make pest control necessary. Sometimes repeated spraying is needed because of reinfestation of a crop by beetles from nearby areas. Since cultural and biological control has low efficiency, at present insecticides are the only viable option for controlling levels of damage caused by crucifer flea beetles.

The aim of this paper was to establish the specific composition of the flea beetle *Phyllotreta sp.* (Coleoptera: Chrysomelidae), time of its appearance and dynamics of its number on summer rape, and to estimate the effects of chemical control on the number of the pest. The experiment was carried out in Eerika experimental field on the outskirts of Tartu in 2002.

MATERIALS AND METHODS

In the experiment there was used the summer rape variety Mascot, bred and produced by Swedish company Weibull, that has been entered into the Estonian Variety List for the period 2001–2012. Technical data of the variety: raw fat content 40–43%, mass of 1,000 grains 3.5–4.5 g, glucosinolates 20 μmol/g, lodging resistance 6–8 points, height of plants 98–108 cm, growth period 90–108 days (Velička, 2003).

Seeds were sown on 7 May 2002, by calculating 200 germinating seeds per m^2, sowing depth 3–4 cm, pre-crop being potatoes, size of the field 600 m^2. A wheat field surrounded the experimental field from all sides, and on the East there was a strip of deciduous and coniferous trees at a distance of about twenty metres. Prior to the sowing, the field was sprayed with an intrasoil herbicide Trifluralin, and mineral fertiliser Opti Crop 21-8-12+S+Mg+B, calculating 120 N kg/ha, was applied. The field had been founded as plots of 10 x 1 m. The control included 4 and the trial 7 beds. To control pest insects, Fastac (alphacypermethrin) was used, calculating 0.15 l/ha (active substance agent). In the control variant there was no pest control.

The field was sprayed three times: first time on 27.05.02, when the plants were still at the cotyledon stage, according to the BBCH scale (Lancashire *et al.*, 1991) at growth stage 8−10, and the number of beetles per plant exceeded 2 individuals; second time on 06.06.02, when the number of individuals per plant was again more that 2, plants had reached growth stage 13−14, and 3−4 true leaves had appeared. The third spraying was performed on 14.06.02, when plants had reached growth stage 30–39, primary racemes had began to lengthen, first flower buds appeared. This spraying was primarily directed against the pollen beetle (*Meligethes* spp.) and weevils (*Ceutorhynchus* spp.).

Observation of plants was begun immediately after sprouting. Twice a week all flea beetles were counted on 10 randomly selected plants on 7 beds in the sprayed variant and on 4 beds in the control. The observations were carried out during a month, 8 counts in total. To avoid disturbing of pests, the shadow of the person counting could not fall over plants. The specific composition of flea beetles was determined at a laboratory, by collecting 100 individuals during each observation by means of an exhauster. To determine weather, observation data by the Environment Physics Institute of Tartu University and our own data were used. The field under observation formed a part of a complex experiment of the Department Field Crop Husbandry.

The significance of differences between the means was calculated by Student *t*-test ($P = 0.05$).

RESULTS AND DISCUSSION

Species of flea beetles, appearance times and proportions of different species.

During the observation period, 6 species of flea beetles were found. Different species appeared in the field at different times and their proportions differed as well. First, at the time when rape began sprouting, three species emerged: *Phyllotreta undulata* Kutsch., *Ph. nemorum* L. and *Ph. vittata* (*Ph. striolata*). The most numerous of these, in the course of the entire observation period, was the small striped flea beetle *Ph. undulata,* (Fig. 1). Single beetles of the species were detected still at the time when rape had ended flowering and pods were forming.

The large striped flea beetle *Ph. nemorum* first inhabits wild brassicae, and, when rape is sprouting, moves onto cultured plants. This is the only one of the flea beetles discovered, whose females lay eggs into leaf epidermises and whose larvae dig themselves into overground parts of plants. Last instar larvae enter the soil for pupation. The proportion of *Ph. nemorum* did not exceed 10% in any sample (Fig. 1); the pest was always low in number and appeared for a short time: in catches of 10–13 June there were no beetles found.

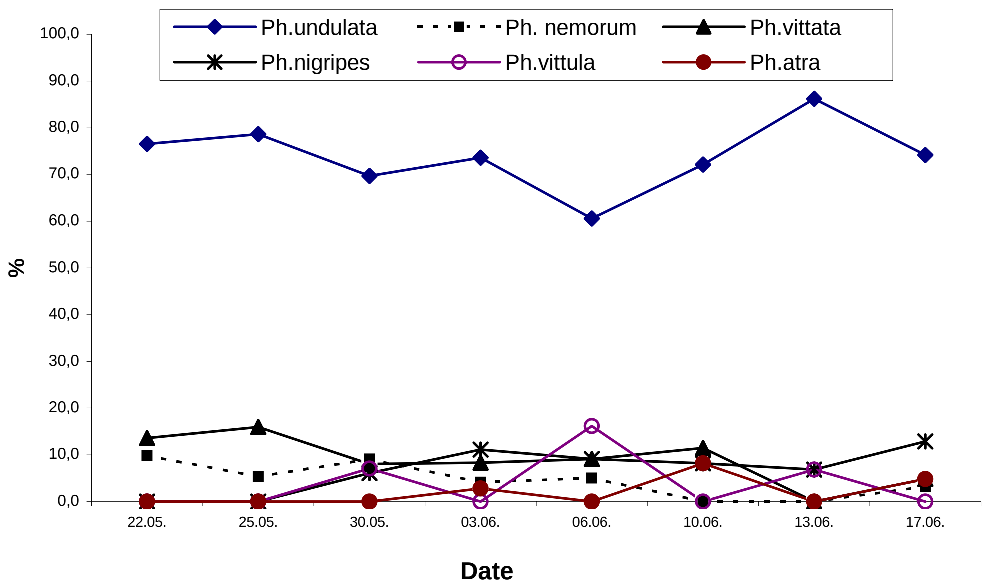

Fig. 1. Percentage of different flea beetles in catches from 22.05.03 to 17.06.03.

The proportion of the striped flea beetle *Ph. vittata* (*Ph. striolata*) reached nearly 20% at the beginning of the observation period, staying later within 10%. Striped flea beetle lays eggs into the soil, and, in the vicinity of *Sisymbrium officinale*, larvae prefer to feed on the tissue of the roots of that plant.

The barley flea beetles *Ph. vittula* and *Ph. nigripes* emerged somewhat later in the field: on the last days of May, when plants were forming first true leaves. Proportions of both the species were under 10% during the observation period (Fig. 1). The barley flea beetle is a polyfagous, preferring grasses but feeding also on brassicaes. It prefers to lay eggs near roots of grasses, larvae feed both on humus and roots (Haberman, 1962). *Ph. nigripes*, being not selective, feeds on several cultured and wild brassica plants, and, in their absence, even on trees and bushes.

The last species appearing in the field, at the beginning of June, was the black flea beetle *Ph. atra*. Only a few individuals of this species were detected during the observation period (Fig. 1).

Dynamics of the number of flea beetles. Effects of spraying.

Between 17.05...20.05, at the time of the sprouting of plants, the weather was not favourable for the movement of flea beetles, because of high air humidity, cloudiness and day-round low temperatures; at nights temperature fell to about 2 degrees over zero, at daytime it was below +10 °C. During the first counting, performed on 22 May, the number of beetles on plants was still small (Fig. 2), nevertheless, the pest could be seen also on the ground and weeds. Cotyledons were weakly damaged.

Warm and sunny days that followed attracted numerous flea beetles to the field; counting performed on 25 May showed that the number of beetles had increased rapidly, and there were counted 2 beetles per plant in both the variants (Fig. 2). During a couple of days, numerous small round pits had emerged on cotyledons. Only single leaves were still undamaged.

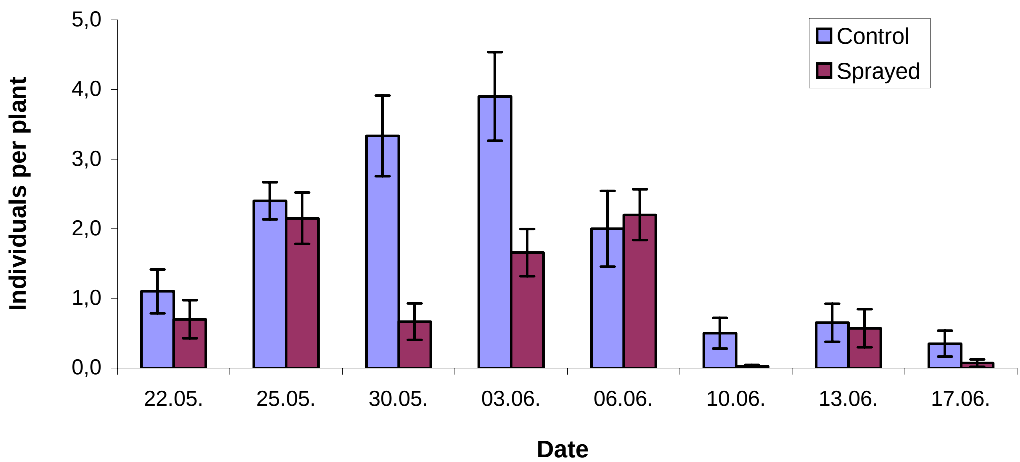

Fig. 2. Influence of Fastac on individual numbers of flea beetles on summer rape. Dates of spraying: 27.05.02, 06.06.02 and 14.06.02.

On 27 May, at the cotyledon stage, damaged plants reached 100% in both variants, and the first spraying was performed. Counting, carried out on the third day after the spraying (30 May) revealed that in the sprayed variant the number of pests had decreased rapidly, being 0.7 individuals per plant. At the same time, in the control the number of pests was still increasing, being 3.2 flea beetles per plant on average ($P = 0.015$).

In control the number of flea beetles reached the maximum height of the season by 3 June (mean 3.8 beetles per plant), and thereafter started to diminish (Fig. 2). In the sprayed variant, the number of beetles began to rise again at the same time, the mean being 1.6 individuals per plant (Student`s *t*-test, $P < 0.001$).

On 6 June, 10 days after the spraying, the number of pests in the control and the sprayed variant had become equal: 2.0 and 2.2 individuals per plant, respectively (Fig. 2), there were no reliable differences between the variants ($P = 0.71$). On the same day the second spraying was carried out at the time plants had reached growth stage 11–14, i.e. had formed 2–4 true leaves.

In the course of the next observation on 10 June, there were only single adults of flea beetles found: only 0.2 individuals per plant on average (Fig. 2). In the control the number of pests had also fallen rapidly, being only 0.5 individuals per plant on average, however, there was still a reliable difference between the variants ($P = 0.006$). Nevertheless, already a few days later the number pests in control and test variant had become equal again, 0.6 and 0.57 individuals per plant, respectively, and there was no statistically reliable difference between the variants ($P = 0.47$) (Fig. 2).

The third spraying (on 14 June) was primarily directed against pests damaging generative organs: pollen beetles and weevils. After spraying the number of flea beetles fell near zero, also in the control the number of flea beetles was only 0.35 individuals per plant (Fig. 2).

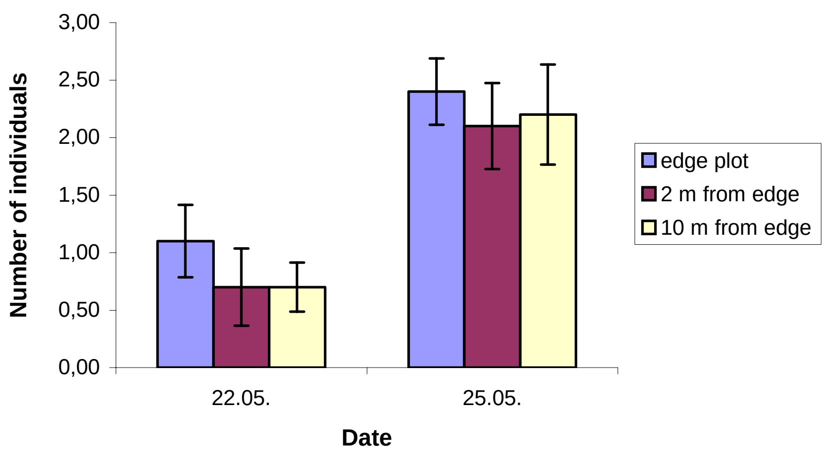

Fig. 3. The number of flea beetles at different distances from the field edges on 22.05.02 and 25.05.02.

To elucidate how the field had became infested by flea beetles, the numbers of the pests on plots situated at different distances from the field edge were compared. Counting procedures were performed before spraying. Comparing of a plot situated on the edge of the field with plots at distances of 2 and 10 m did not reveal any statistically reliable differences: $P = 0.5089$ and $P = 0.4961$ on 22 May, and $P = 0.2228$ and $P = 0.6783$ on 25 May, although the Fig. shows a somewhat larger number of beetles on plots near the edge of the field (Fig. 3).

In temperate areas flea beetles hibernate not only in brassicaceous fields but also on natural landscapes, on the edges of fields and ditches, fallow fields, forest decay (Kinoshita *et al*., 1979). Therefore, autumn cultivation of the soil does not destroy the pests. Due to the good mobility of flea beetles, crop does not prevent attacks. Also, establishing new fields in the following year at greater distances from earlier fields does not decrease attacks by the beetle. After hibernation, beetles first feed on wild brassicaceous growing everywhere. At the time of the sprouting of rape plants, 17.05–21.05, there was prevailing cool and windy weather, nevertheless, first flea beetles appeared in the field simultaneously, initially in small numbers (Fig. 2). The beetles first settled onto the soil surface and weeds between plots. Flea beetles become active already at 4.7°C but spread slowly in humid and cool weather (Lamb, 1984).

The rape field was infested gradually. The reason is the fact that beetle do not leave their hibernation sites all at one time: from more humid and cool sites they emerge up to two weeks later than from those warming more quickly (Burgess, 1981). Very warm and dry days following the sprouting of plants caused a rapid increase in the number of the pests. At a temperature over 14°C beetles start to fly, at a temperature below that they stay on the ground and move in jumps (Lamb, 1984). Thus it is the temperature that determines the way a field is infested: at lower temperatures mainly field edges are infested by pests, and at higher temperatures the whole field is evenly infested (Burgess, 1977). Due to the too small area of the described experimental field there were no statistically reliable differences between different plots, however, the figure shows a somewhat larger number of beetles on the beds on field edge (Fig. 3). That is an indication of their initial movement at the time when the temperature was still low.

With temperature rising, the number of beetles started to grow: prior to the first spraying there were over two beetles per plant (Fig. 2), and plenty of small holes in cotyledons, making it look lacy. Signals for the beetles were the odours of mustard oil, characteristic of plants in the *Brassicae* family containing them in high concentrations, especially in young plants (Smith, 2000). During active growth, mustard oil levels in young plants may be especially high, and the release of odorous is the most active at the time the plants are eaten by pests or injured mechanically (Bernays and Chapman, 1994.) There are data indicating that male flea beetles (*Phyllotreta* spp.) produce aggregation pheromone, favouring accumulation of the pests on cultures (Chengwang Peng *et al*., 1999).

The spraying of 27 May was necessary because of the prevailing dry and sunny weather and a continuous rise in the number of pests in the field. In the unsprayed control variant the maximum number of the pests was reached on 3 June, nearly 4.0 individuals per plant were counted then. The first spraying reduced the number of the pests, however, it began growing gradually again, and after 10 days the number of pests in all variants had become equal ($P = 0.7124$). Probably the effect of the insecticide had disappeared by that time, and rapid reinfestation of the crop from the nearby untreated areas occurred as in the control the number of the pest had fallen at the same time (Fig. 2).

The second spraying on 6 June lowered the number of the pests down to zero (Fig. 2). The number of the pests diminished also in the control, which is a natural process because of the short life-span of the beetles: they do not feed after oviposition and perish soon. At that time the plants were reaching the stage of 3–4 true leaves, when the growth rate is the fastest, and plants can tolerate damage themselves due to their high compensation ability.

The third spraying for controlling flea beetles was no more necessary; in the sprayed variant plants began to reach growth stage 50, i.e. had formed secondary racemes, primary racemes lengthened and first flower buds were appearing. Already after the stage of 6 true leaves plants can tolerate flea beetles (Gavlovski & Lamb, 2000).

It is often impossible to fight flea beetles without chemical control. In the control plants developed more slowly. Numerous small holes in seed leaves cause mortification of shoots, weak photosynthesis, slowing of growth (Canlovski & Lamb, 2000). Damages to vegetative cones may cause perishing of plants. When would be the optimum time for control? There have been presented several control criteria for flea beetles. In Finland there has been recommended to start control when there is one beetle per plant at the seedling stage (Augustin *et al*., 1986), in Canada when 25% of the leaf area of seedlings has been damaged, in the USA when 10% of plants show injury (Lamb, 1984). However, there can be no certain criterion for starting control since the weather and soil conditions of a field must be considered. In the case of a fertile and well-cultivated field and during a longer period of windy and humid weather, there may be no need for chemical pest control. Then the beetles feed less intensively and their development has been slowed down. In very good growing conditions plants may, at the stage of seedlings, tolerate the removal of 50% of the surface with no considerable yield loss (Burgess, 1977). In the case of great density of plants, the life activity of flea beetles decelerates, they accumulate at the tips of leaves, feeding only there, whereas hidden leaves remain undamaged (Burgess, 1977).

With no chemical pest control in the case of medium or small damage the plant may regenerate, however, there are other dangers: pods are not forming simultaneously, and many secondary racemes emerge. In our experiment secondary racemes were still flowering in the control, at the time when pods on sprayed beds were already turning yellow. The uneven ripening of seeds reduces seed quality, and, as a result of the overripening seeds on the primary raceme, a part of seeds falls to the ground.

There have been proposed several means for controlling flea beetles, relieving damage. Early-season trap crop – growing of attractant brassicas, sowing them a couple of weeks earlier than the main culture, in narrow strips that attract flea beetles and where chemical control can be performed. Adults may feed there for several weeks. The extent of the damage depends on the weight of seeds: damage of plants grown from bigger seeds is smaller (Elliot & Rakow, 1999).

Since the effect of Fastac on flea beetles proved short in the field, prophylactic sprayings for preventing damage were not purposeful. Therefore constant field inspection, from the period of sprouting to the stage of four to six leaves, is important. A need for repeated sprayings primarily depends on the state of plants and weather conditins.

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