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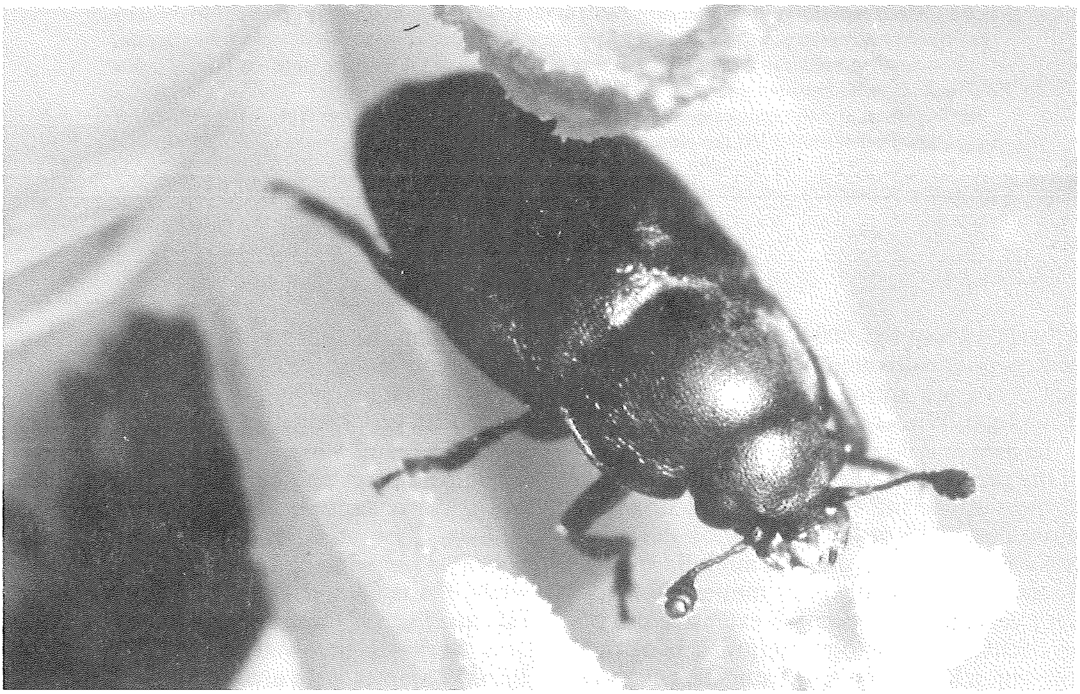

Rapsbagge — *Meligethes aeneus.* Foto: Karl-Fredrik Berggren.

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The pollen beetle *(Meligethes aeneus F.)* in winter and spring rape at Alnarp 1976—1978. I. Migration and Sex Ratio

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NILSSON, C. 1989. The pollen beetle *(Meligethes aeneus* F.) in winter and spring rape at Alnarp 1976—1978. I. Migration and sex ratio. Växtskyddsnotiser 52: 6, 134—138.

The occurrence of pollen beetles in three winter rape crops and two spring rape crops was determined by counting beetles on plants and by sweepnetting. *M. aeneus,* the only beetle species present, had a 50:50 sex ratio. No more than 3.5 beetles per m² overwintered in rape fields of the previous year. A large proportion of the beetles invaded the fields during the same 1—2 day period. Pollen beetles began arriving at the winter rape fields at maximum temperatures substantially lower than the generally accepted threshold of 15 °C. Migration only occured when winds were from the east, thereby carrying beetles to Alnarp. The developmental stage of the winter rape at the time of beetle invasion differed between years.

Immigration into the spring rape fields occurred when about half of the plants had formed their first buds. Pollen beetles left the plants (winter as well as spring rape) towards the end of the bud development period and the early part of the flowering period. By the peak in flowering nearly the entire population had left the crops.

In Sweden about 165.000 ha of cruciferous oilseed crops is cultivated annually. The dominant crops are spring varieties of rape and turnip rape. Winter rape accounts for ca 20% of the area and is cultivated mainly in Skåne. Of the pest insects, the pollen beetle is clearly the most important: economic losses are often substantial, even at low population densities (Nilsson 1987). As a rule, this nitidulid species occurs in large numbers in numerous fields every year, precipitating the extensive use of insecticides. Owing to the seriousness of this problem, a large number of studies, covering pollen beetle biology, economic significance, and population dynamics, were conducted during the late 1970s. These studies constituted the Swedish part of an inter-Nordic cooperative project and was financially supported by the Swedish Council for Forestry and Agricultural Research. Certain parts of the investigation are reported in this and the two following articles treating various aspects of population biology, oviposition, and the most comon mortality factors. In this article pollen beetle populations and the ways in which they are affected by climatic factors are described.

Methods

All research trials were conducted in the vicinity of Alnarp, about 5 km north of Malmö. Fields containing crops cultivated by local farmers (winter rape 1977—78) as well as fields with crops sown for the expressed purpose of research were utilized. The crops were sown, cared for, and harvested in customary ways. The distance between rows was 0.44—0.48 m. Plant density was 43 86, and 80 plants/m² in winter rape during 1976—1978 while it was 58 and 151 plants/m² in spring rape during 1977 and 1978 respectively. The only varieties involved were Gulliver and Brink. Samples were always taken randomly in each of four plots. In field tests involving insecticides untreated plots were often used. All samples were collected between 8 am and 12 pm. Weather data were obtained from a National Weather Service station in Lund and from a local station in Alnarp.

Sweepnetting was generally conducted twice weekly, taking 5 single sweeps per parcel with a 32-cm-diam net. The beetles captured in this way were used for determining *Meligethes* species composition and sex ratio. Where possible, 100 beetles (25 per parcel) from each sampling date were examined.

Sex determinations were made by dissection. The insect collection at the Dept. of Zoology, Univ. of Lund provided the reference material needed for species determination. In total, 3.800 pollen beetles from 40 sampling dates in five crops were examined.

Where pollen beetles were counted on plants, one plant from each side of the parcel was chosen at random. From this starting point every 10th plant in the given row was examined until counts had been made on five plants. The developmental stage of these plants was determined according to the scale presented by Harper & Berkenkamp (1975). The distance between the first and last plant examined was also measured. The mean row length and inter-row distance were used to calculate the average density of the crop. In this way five plants from every treatment in each of eight locations were examined twice a week during the study period. Significant changes in plant density during the test period were not recorded.

Results and discussion

Species composition and sex ratio

The species composition of the overwintered pollen beetle population can vary greatly between locations. Since the temperature threshold for activity is lower in *M. aeneus* F. than in most of the other pollen beetle species it is the dominant species of *Meligethes* in Northern European winter rape crops up until flowering, generally accounting for about 90% of the pollen beetles present. (Bollow 1950, Cmoluch 1960, Fritzsche 1957, Jurek 1972, Nielsen 1959, Nolte & Fritzsche 1952, Scherney 1953, Šedivý 1960). Thereafter other species begin to appear, primarly *M. viridescens* F. Populations in spring rape were investigated in southern Norway in 1962 and 1963 (Rygg, T. pers. comm., unpublished 1964 manuscript by Bjerely available at Oslo University). Almost all of the 14.000 pollen beetles collected were *M. aeneus* while *M. viridescens* comprised about 3% of the beetles present during most of the summer. A preliminary survey in Uppland during 1975 indicated that *M. viridescens* could occasionally form a substantial proportion of the population (Nilsson unpublished). This indication was confirmed by the results of a 1978 investigation in two areas within the Mälaren Region (Karltorp & Nilsson 1981), in wich the proportion of *M. viridescens* rose to 10 and 30% towards the end of July.

In the present study from Skåne *M. aeneus* was the only species found. Uncertainty as to species affiliation occurred in only three cases. No *viridescens* were found. The optimal temperatures for activity and egg development are higher in this species than in *M. aeneus* (Fritzsche 1957). In winter rape, which was the only commercially cultivated oilseed crop in the investigated area, the temperatures were so low during the first part of the bud development period that only *M. aeneus* was able to utilize these buds for oviposition.

The populations consisted of about equal proportions of males and females. No change in the sex ratio was detected at any time during the investigation (Table 1).

Table 1. Sex ratio of the pollen beetle population by year and crop.

		No. animals	% females	SE	n
1976	Winter rape	307	50.4	5.17	6
1977	Winter rape	928	56.0	1.39	9
1978	Winter rape	686	53.6	3.75	6
1977	Spring rape	694	51.4	4.81	7
1978	Spring rape	1 196	49.2	2.45	12
Total		3 811	52.0	1.47	40

Overvintering and occurrence in winter rape

Pollen beetles overwinter in the soil under herbaceous vegetation as well as in densely forested areas, where they can often be aggregated (Blatzejewska 1961, Fritzsche 1957, Müller 1941, Renken 1956, Weiss 1940). Fritzsche did not find any beetles among the stubble on rape and grain fields, or in gardens, meadows, pastures, fruit tree orchards, or conifer forests, and only a few were found in meadows surrounded by forest, in ditches, or under trees and bushes growing in the open. *M. aeneus* becomes active during the spring once temperatures have reached 5—10 °C. Although they can fly over short distances at 12 °C, long-distance dispersal is generally not considered to occur at temperatures below 15 °C (Müller 1941, Fritzsche 1957, Masurat 1966). Even relatively short periods of warm weather can lead to extensive dispersal activity. By marking beetles with radioactive isotopes beetles have been shown capable of dispersing up to 5 km per day. (Taimr et al. 1967). Wind speeds of up to 7 m/s do not inhibit flight (Nolte 1959). The beetles are transported by wind (Steckmann & Schütte 1976) at relatively high altitudes.

During the three year investigation in winter rape at Alnarp a few pollen beetles were generally found towards the end of April. In emergence boxes placed out in the previous year's unploughed rape fields or in winter wheat sown after rape (Nilsson 1985) spring emergence rates were generally around 3.5/m^2 (Table 2).

The main invasion usually occurred during the first 10 days of May (Fig. 1). During this period, populations grew rapidly in size, sometimes reaching final densities after only one day. During 1976 the main invasion occurred on the 8th or 9th of May. Between the 7th and 10th of May maximum temperatures were 17, 20, 24 and 23 °C respectively. On the 9th, SE winds were blowing from 1—4 m/s. During 1977 the invasion occurred between 29 April and 1 May, when maximum temperatures were 11.5, 13.2, and 12.5 degrees respectively. Winds were from the E-SE at 0—9 m/s and a few millimeters of rain fell. The few beetles reaching the study field during 1978 arrived during 10—21 April, when the highest temperatures were 14.5—14.6 degees and winds were from the east at 7 m/s, and 5—9 May, when maximum temperatures were 16—19 degrees and winds were from the east at velocities between 1 and 12 m/s.

During all three years invasions occurred during periods when winds were from the east. On several occasions the temperatures measured at Lund and Alnarp were clearly below the 15 degree threshold cited most often in the literature. Although, Müller (1941) observed flight at temperatures as low as 10.5 °C, this only occured where the soil surface temperature was above 15 °C.

The length of time that temperatures remained just under the activity threshold had no effect on the timing of the invasion. Consequently, the developmental stage of winter rape at the time of invasion can vary greatly from year to year. For example, in 1976 the average plant was in the middle-bud stage at the time of invasion; in contrast, only 70% of the plants had reached the late-bud stage in 1977 whereas in 1978, 40—70% of the plants had reached the late bud stage. Obviously, the time at which immigration occurs is an important factor determining the extent of economic losses caused by the pest.

Beetles leave the winter rape crop gradually over a 5—10 day period (Fig. 1). The fate of these migrants is unknown. Under constant environmental conditions the life span of this species was estimated at ca 50 days (Fritzsche 1957), suggesting that instead of dying these individuals seek out other flowers, late-blooming winter rape fields, wild crucifer species or after some weeks, spring rate crops. During 1976, population density began to decrease when the average plant had just begun to flower, while the decrease began somewhat earlier during 1977 and 1978. Thus beetle populations reached their highest densities during the bud stages. In 1976 and 1977, the occurrence of eggs in buds coincided closely with the peak in availability of buds suitable for oviposition. During 1978 the pollen beetle population was too low to allow such a comparison. Around the peak in bud occurrence, at which time the production of new buds is on the decline, it is probable that competition among females was one factor leading to emigration.

The mean density of beetles during the period betweeen the immigration and emigration phases was 111, 127, and 37/m^2 during 1976, 1977, and 1978 respectively.

Table 2. Degree of emergence of pollen beetles from fields used for cultivating oil seed crops the previous year.

	Crop	Previous crop	No. of emerging pollen beetles/m^2
1977	ploughed	winter rape	0.4
1977	ploughed/stubble	spring rape	0
1978	ploughed/stubble	spring rape	3.6
1978	winter wheat	winter rape	2.9
1981	winter wheat	winter rape	3.7
1982	winter wheat	winter rape	1.5
1983	winter wheat	winter rape	3.5

Occurrence in spring rape

Immigration into spring oilseed crops peaked on 10 June 1977 and 5 June 1978, by which time about half of the plants had formed buds within the leaf rosettes. Thus immigration occurred at about the same stage in plant development both years. Population densities increased rapidly within a short period. After a certain degree of spatial redistribution in the field, during which time densities decreased, the mean density lay around 95 and 346 beetles/m^2 during 1977 and 1978. During the first 9 days of June 1977 the maximum temperature was over 15 °C. on all but one day; on 10 June maximum temperatures rose above 20 degrees, and this warm weather persisted for the remainder of the month. On 9 June winds were from the southeast at 1 m/s, while during midday on 10 June they blew from the east at 7 m/s. In contrast, during the first 8 days of June midday winds consistently blew from the west or southwest. During 1978 maximum temperatures reached over 25 °C during the first 6 days of June. During this period there was no midday wind or only a mild southwest breeze on all dates except for 5 June, when winds blew from the southeast at 5 m/s. Thus pollen beetle immigration followed the same pattern as that described for winter oilseed crops. During early July the population increased dramatically in 1977 and markedly, but to a lesser extent, in 1978. The beetles flying into the crop at this time comprised the new generation emerging from the winter rape fields. Thus, the decrease in ovipositing adults that occurred during late June was masked. As was osberved in winter rape, the first-generation adults in spring rape had nearly disappeared completely by the peak in flowering.

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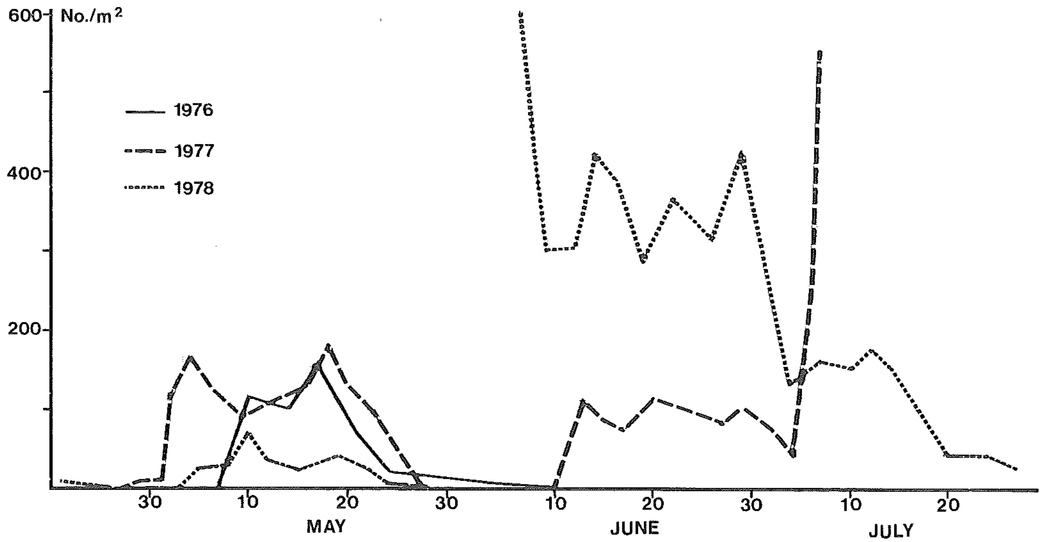

Figure 1. Abundance of pollen beetles in winter and spring rape, 1976—1978.

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NILSSON, C. 1988. Rapsbaggar (*Meligethes aeneus* F.) på höst- och vårraps i Alnarp 1976—1978. I. Migration och könskvot. *Växtskyddsnotiser 52:*6, 134—138.

Förekomsten av rapsbaggar på 3 höstrapsgrödor och 2 vårrapsgrödor bestämdes genom räkning på plantorna och slaghåvning. Populationerna bestod endast av *M. aeneus* och av lika antal hanar och honor. En liten del av populationen, högst 3,5 djur/m^2, övervintrade i fjolårsfältet. Större delen av populationen invaderade fälten under 1—2 dygn. Rapsbaggarna anlände ibland till höstoljeväxtfälten när maximumtemperaturen låg betydligt under den angivna gränsen på 15 °C. Vinden blåste däremot alltid från öster. Höstoljeväxterna befann sig olika år i olika knoppstadier vid rapsbaggarnas ankomst till fälten.

Invandringen till våroljeväxterna skedde när hälften av plantorna hade bildat första knopparna. Rapsbaggarna lämnade plantorna (höst- såväl som vårraps) under sista delen av knoppstadiet och första delen av blomningen. Vid full blom hade nästan hela populationen lämnat grödorna.

The pollen beetle (*Meligethes aeneus* F.) in winter and spring rape at Alnarp 1976—1978. II. Oviposition

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NILSSON, C. 1989. The pollen beetle (*Meligethes aeneus* F.) in winter and spring rape at Alnarp 1976—1978. II. Oviposition *Växtskyddsnotiser 52:*6, 139—144.

Oviposition and egg occurrence were investigated in three winter rape and two spring rape crops. Oviposition in winter rape during the first two years began immediately after flying in from the overwintering sites. During the third year, when temperatures were lower than normal prior to flying to winter rape, it took nearly a week before beetles arriving at the field began ovipositing. Oviposition in winter rape was limited by temperature and the number of medium-sized buds available. The point in time at which females finished maturation feeding was also an important variable affecting the timing of oviposition. The only limiting factor in spring rape was the availability of suitably sized buds. Females selected 2—3 mm long buds for oviposition. Eggs were rarely found in flowers. At very high population densities in spring rape, eggs were also found in buds that were 1.5—3 mm long. The same bud was often oviposited in several times. Between 0.5 and 2 buds larger than 2 mm were damaged per animal per day. Of these damaged buds, 55—88% contained eggs. On average, every female laid 4.5—6.5 eggs/day. In total, every female laid 85—105 eggs in winter rape and between 95 and 120—185 in spring rape.

Feeding and oviposition by the pollen beetle cause economically significant damage to rape plants. The first article in this series described the occurrence of pollen beetles in winter and spring rape crops at Alnarp. In this paper estimates of oviposition by these populations are presented, and the factors limiting egglaying are described.

Methods

The characteristics of the study sites and the methods used to estimate beetle numbers on plants were described in the previous article.

Plant samples used for determining the number of eggs and level of damage were collected twice weekly. They were taken from plots with a row distance of 0.44—0.48 m except for spring rape 1977 when the row distance was 0.11 m, giving a plant density of 248 plants/m^2. Plants to be sampled were chosen in the same way as were plants used for counting beetles. In fact, the same plants were often used for both purposes. At least one sample of five plants was taken per parcel. The plants were placed in plastic bags and frozen within 1—2 h. Every such sample of five plants was treated as a unit since plants often broke in the bags, and it was therefore impossible to relate loose flowers or buds to specific plants. The samples were examined under a dissecting microscope. All buds with signs of external damage were examined.

Buds were divided up into two size classes ($<$2 mm and $\leqq$2 mm long) by comparing them with a scale mounted on the examination surface. The accuracy of this classification procedure was evaluated by determining the exact size of 370 preclassified buds with a measurement ocular. Buds 1.9 mm and smaller as well as those 2.7 mm and larger were all classified correctly. Ninety percent of the buds between 2.3 and 2.6 mm were placed in the correct category, while the corresponding figure for buds between 2.0 and 2.2 mm was 60%.

The number of eggs per female, per bud, etc., was only determined for the rising part of the egg density curve. The increase in the number of eggs and larvae between any two sampling dates was assumed to correspond to the mean number of beetles counted on the plants at these two dates corrected for the time between sampling dates. In the presentation of egg and larval numbers (Table 2) buds containing both eggs and larvae were placed in the category ''bud with eggs'', since such larvae were always newly emerged.

Results and discussion

Choice of oviposition site

Of those buds longer than 2 mm, 0.5—2 were damaged per beetle per day (Table 1). The damage values for the various crops were similar although pollen beetle population densities differed greatly between them.

The size distribution of buds with eggs and larvae is shown in Table 2 (this material is partly the same as that presented in Table 3). On 23 June the 10 plants sampled contained a total of 59 buds with eggs and 2 buds with larvae. Buds containing eggs primarily fell within the 1.6—3.0 mm length interval. Four days later, on 27 June, there were 40 buds with larvae; thus, as expected, many of the eggs had hatched. Most of the larvae were in the 3.1—4.5 mm size group. Of the 87 buds with eggs registered at this later point in time, 21 should have been laid before 23 June while the remainder (66) should have been newly laid. Many (57) of the newly laid eggs were found again in the buds within the 1.6—3.0 mm length interval. Thus, it is obvious that the beetles prefer to lay eggs in buds shorter than 3 mm and longer than 1.5 mm. As shown in Tables 4 and 5 the beetles preferred buds somewhat longer than 1.5 mm i.e., at least around 2 mm, if they had a choice. Similar observations have been made by Jourdheuil (1962). The proportion damaged buds containing eggs and/or larvae (55 and 80% respectively) was not associated with crop type or beetle density. The proportion of buds with eggs increased with time. Table 3 shows the distribution of egg and larval numbers per bud for 50 rape plants examined on 5 dates in 1977. The distribution was skewed with much higher frequencies for high values than for low ones. This supports the hypotheses that oviposition does not occur at random and that several females oviposit in the same bud. In a greenhouse experiment, one, three, or five female pollen beetles were placed in a cage with a rape plant (Table 4). At the highest density almost all buds larger than 2 mm and about one third of the smaller buds were utilized. Even though up to 21 eggs per bud were found, the availability of buds was still limited, resulting in lower egg production per female per day, compared with the lower beetle densities. The fact that the number of eggs per damaged bud increased along with population density suggests that the degree to which females utilized buds already containing eggs was also greater at higher female densities.

Table 1. Relationship between oviposition rate and damage.

	Time period	Damaged buds ≧ 2 mm per beetle and day	Eggs per female and day	Eggs per bud with eggs	% damaged buds ≧ 2 mm with egg/ larvae
Winter rape					
1976	7.5—20.5	1,9	6.6	2.0	59
1977	2.5—22.5	1.7	4.6	1.7	68
1978	28.4—25.5	0.6	4.8	1.7	55
Spring rape					
1977	13.6—30.6	1.3	5.0	2.0	80
1978	5.6—25.6	0.6	3.4	2.7	79

Table 2. Number of eggs and larvae per bud related to bud length. Unsprayed spring rape 1977. Number of buds per 10 plants.

Bud length	23 juni total	23 juni with eggs	23 juni larvae	27 juni total	27 juni with eggs	27 juni larvae
1.6—3.0	150	49	0	267	57	2
3.1—4.5	11	10	1	89	30	92
4.6—6.0	1	0	1	11	0	9
Total	162	59	2	367	87	40

Table 3. Number of eggs/larvae per bud in buds longer than 1.5 mm. Unsprayed spring rape 1977. Total per 50 plants from 5 dates.

Eggs + larvae per bud	No. buds	Corresponding Poisson distribution
0	1 153	854
1	148	536
2	160	168
3	69	35
4	42	5
5	15	1
6	4	
7	6	
8		
9	1	
10	1	

Table 4. Oviposition related to population density. Greenhouse trial.

Females/ plant	Eggs per female and day	% damaged buds <2 mm	% damaged buds ≧2 mm	Eggs per damaged bud
1.2	5.8	6.3	56.5	2.2
2.6	6.4	5.5	73.6	4.8
5.3	4.3	29.8	95.4	5.9

Table 5. Recovery of eggs from small buds and flowers.

Crop	% buds <2 mm long with eggs	% of the eggs in flowers
1977 Winter rape	2.8	0.2
1978 Winter rape	5.0	0.5
1977 Spring rape	9.8	0.1
1978 Spring rape	17.3	0.4

Table 1 shows the number of eggs per egg-containing bud for the five investigated crops. The values are remarkably constant. Winter rape had about 1.7—2.0 eggs per bud while the values for spring rape were 2.2 and 2.7. Buds grow rapidly in size and are only attractive for a short period. Since females prefer buds of certain sizes the egg density within the buds is never very high, even though eggs are often laid in egg-containing buds. Apparently, eggs are never laid in flowers (Table 5). At very high population densities, even very young buds are utilized. For example, in the 1978 spring rape crop 17% of the egg-containing buds were less than 2 mm in length. The female's ovipositor is inserted into the bud base and pushed forward into the bud in a direction parallel to her body. The ovipositor is about half the length of the female's body. Since the female averages 2.5 mm in length (Ext 1920, Fritzsche 1955), oviposition in buds less than 2 mm should be fraught with difficulties. Moreover, the smaller the bud the larger is the risk that biting a hole in it will lead to abortion, and consequently to the loss of the depositied egg.

Oviposition in winter rape

After overwintering the males — but not the females — are sexually mature (Börner & Blunck 1920, Fritzsche 1957, Müller 1941 a). The females can mature by eating pollen in spring flowers prior to flying into the winter rape fields (Muller 1941 a, 1941 b). It takes about 10—14 days at 15 °C or 6—10 days at temperatures over 20 °C for the ovaries to mature (Fritzsche 1957). Free & Williams (1979) found that females with fully developed eggs were already present in the rape fields early in the spring. However, the first signs of oviposition were not found until about 3 weeks later. In the present study, eggs were first recovered in the 1976 and 1977 winter rape fields at about the same time as the adults arrived there.

The curves for egg and adult abundance (Fig. 1) in 1976 and 1978 had similar shapes both years with egg densities rising and declining a few days after corresponding changes had occurred in adult populations. In contrast, during 1977 there was a delay of about a week between arrival of adults at the field and the initiation of oviposition. During this period there were several days with temperatures between 15 and 25 °C. Oviposition only occur at temperatures above 15 °C (Fritzsche 1957), e.g. weather-related prerequisities for egg-laying existed. An examination of 24 females captured at the time that eggs first appeared in the buds revealed that only two (8%) contained mature eggs. April 1977 was substantially colder than April 1976 and 1978; consequently, it is likely that beetles flew directly from their overwintering sites to the rape fields in 1977. During the three years the abundance of eggs was closely correlated with the abundance of winter rape buds longer than 2 mm.

Thus, there were three major factors affecting the timing and extent of oviposition in winter rape: temperature, the timing of ovarial maturity, and the availability of medium-sized buds.

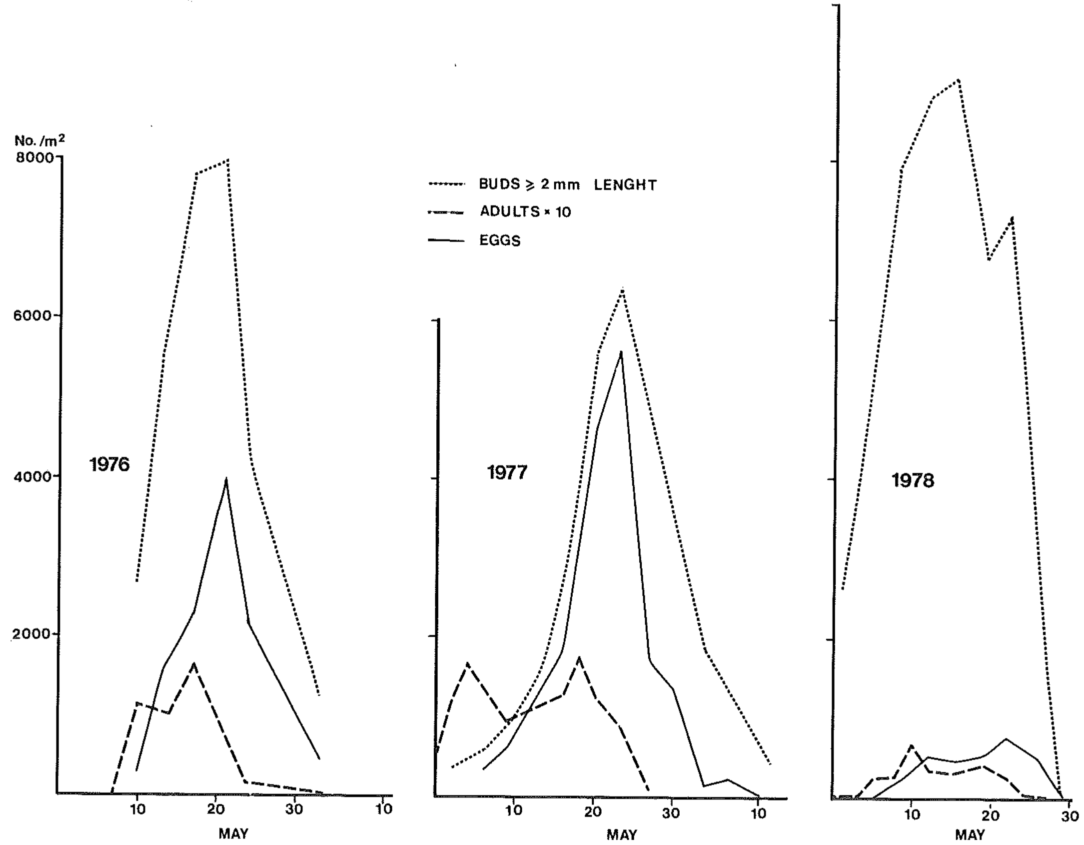

Figure 1. Temporal relationship between availability of buds suitable for oviposition and numbers of adults (× 10) and eggs in winter rape during 1976 to 1978.

Oviposition in spring rape

Pollen beetles captured in spring rape fields were always found to be sexually mature. Unlike the situation in winter rape, temperature did not have any limiting effect on oviposition. Beetles arrived at the fields at a very early stage in plant development, at which time there was a complete lack of buds suitable for oviposition. Consequently, egg-laying began as soon as the buds had reached ca 1.5 mm in length. For instance, prior to 15 June 1978, practically all eggs were recovered in such buds, and it was not until 22 June that the abundance of buds longer than 2 mm was so high that more eggs were found in this size class than in smaller buds (Fig. 2). Competition for buds of preferred size was great, thereby forcing females to also exploit smaller buds.

The relationship was similar in the 1977 spring rape crop. Eggs were recovered in buds at least 1.6 mm long. In this case, however, oviposition in buds shorter than 2 mm was not as extensive. During both 1977 and 1978 weather conditions were very favourable for oviposition. Compared with 1978, however, fewer beetles invaded during 1977, resulting in a ca 50% lower population density.

Thus, in the spring oilseed crops the availability of suitably sized buds was the major factor regulating oviposition.

Oviposition rate and total number of eggs laid

The number of eggs laid per female per day during the most active part of the oviposition period has been calculated and is shown in Table 1. Mean values are around 4.5—6.5

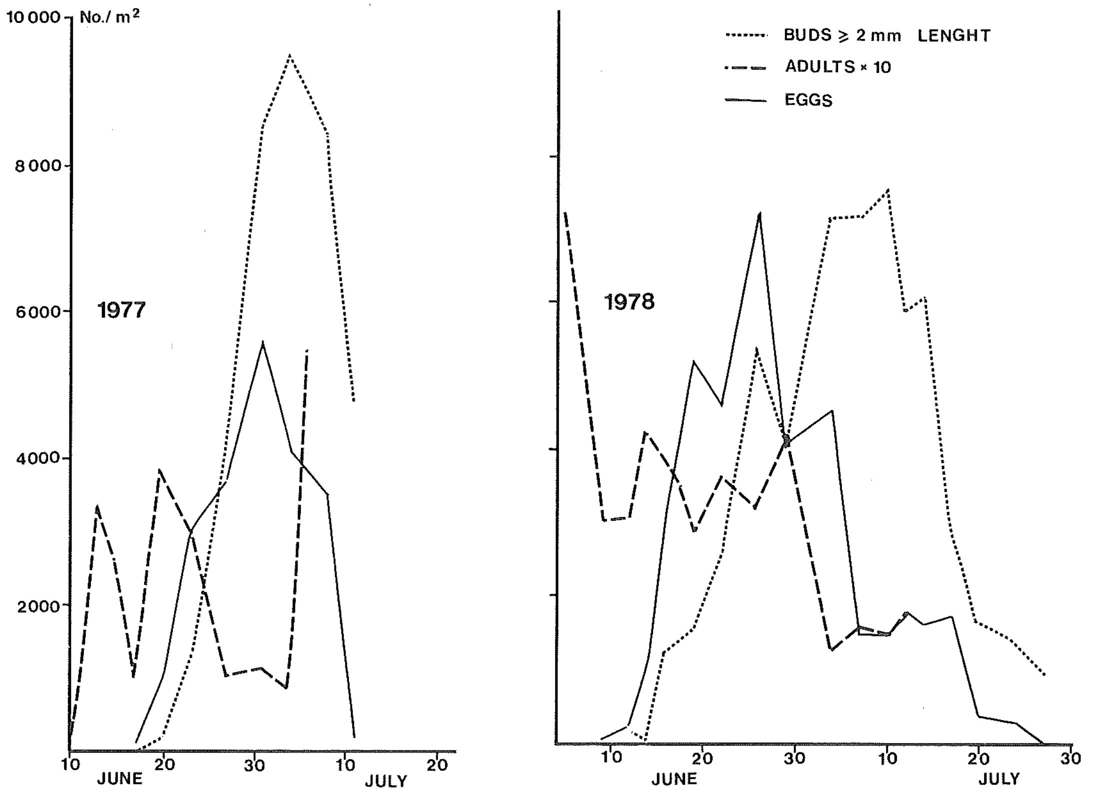

Figure 2. Temporal relationship between availability of buds suitable for oviposition and numbers of adults (× 10) and eggs in spring rape during 1977 and 1978.

eggs per female per day. Similar values were also obtained in the greenhouse trial (Table 4). As mentioned earlier, the values for spring rape in 1978 deviate from the values for all other years and crops.

According to Fritzsche (1957) total egg production is strongly dependent on temperature, increasing from ca 80 eggs/female at 15—16 °C to ca 210 at 20 or 27 °C. However, if the humidity sinks to ca 75% and temperatures are over 20 °C, the number of eggs laid is drastically reduced. Although several other investigations have reported the total number of eggs produced per female, the environmental conditions during the time at which the measurements were made were not given. Values vary from 40—50 up to 350 eggs/female (Blunck 1921, Börner & Blunck 1920, Friederichs 1920, Scherney 1953, Zambelli 1962).

Thus, based on the existing literature it can be concluded that during her lifetime a female pollen beetle can produce between 200—300 eggs given that the weather conditions are fairly normal. In the present study, means of 85, 90, and 105 eggs/female were recorded in winter rape while the corresponding values in spring rape were 95 and 120—185 (the differences depending on whether or not the number of eggs estimated as occurring in aborted buds was taken into account). These values indicate that not more than about half of the total eggs produced were laid in any particular crop. If, however it is assumed the beetles ovipositing in the spring rape had migrated there after first reproducing in winter rape, then the calculated values would increase to within the range of 200 and 300 eggs/female.

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NILSSON, C. 1988. Rapsbaggar (*Meligethes aeneus* F.) på höst- och vårraps i Alnarp 1976—1978. II Äggläggning. *Växtskyddsnotiser 52:*6, 139—144.

Äggläggning och äggförekomst undersöktes i 3 höstraps och 2 vårrapsgrödor. Äggläggningen i höstraps började omedelbart efter inflygningen från övervintringsplatserna under två av åren. Det tredje året, då temperaturen var lägre än vanligt före överflygningen till höstrapsen, dröjde det nästan en vecka efter det att djuren anlänt till fältet, innan äggläggningen började. Äggläggningen i höstraps begränsades av temperatur, tidpunkt för äggmognad, och förekomsten av medelstora knoppar. Endast knoppförekomsten hade betydelse i vårrapsen. Honorna valde att lägga ägg i knoppar som var 2—3 mm långa. Ägg hittades mycket sällan i blommor. Ägg i knoppar 1,5—2 mm långa förekom i vårrapsen vid mycket hög populationstäthet.

Ägg lades ofta i samma knopp upprepade gånger. Mellan 0,5 och 2 knoppar större än 2 mm skadades per djur och dygn. Av dessa innehöll 55—80% ägg.

I genomsnitt lade varje hona 4,5—6,5 ägg/dygn. Totalt lade varje hona 85—105 ägg i höstrapsen och mellan 95 och 120—185 i vårrapsen.

The pollen beetle (*Meligethes aeneus* F.) in winter and spring rape at Alnarp 1976—1978. III. Mortality factors

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NILSSON, C. 1989. The pollen beetle (*Meligethes aeneus* F.) in winter and spring rape at Alnarp 1976—1978. III. Mortality factors. *Växtskyddsnotiser 52:*6, 145—150.

Pollen beetle populations were studied in three winter rape and two spring rape crops. Between 1 and 8% of the eggs did not develop into larvae. Although egg plus larval mortality attributable to bud abortion was not measured it was estimated to be ca 25% in one of the spring rape crops and near zero in the others.

It took from 7 to 10 days for eggs to hatch. The first larval instar lasted 5—10 days, and larval development was complete after 45—50 days. The lower values typically occurs in spring rape and the higher values in winter rape. Development of the host from the bud to pod stage generally occurs so rapidly that larvae are forced to move between flowers to ensure a steady supply of food. As a consequence, many larvae fall to the ground and are unable to climb back up the plants. Between 5 and 30% of the larvae on the soil surface were in their first larval instar while 10—20% were immature second-instar larvae. The latter showed twice as high a mortality rate compared with full-grown larvae. High rates of parasitism were recorded, primarly attributable to *Tersilochus heterocerus.* Mortality in the soil prior to and during the pupal stage was very high. The new generation was up to 10 times as large as the parental generation.

The application of insecticide is the only method currently available for effectively reducing damage by pollen beetles in cruciferous oilseed crops. Although nematodes, catch crops, and crop rotation strategies have been evaluated in field trials (Jourdheuil et al 1974, Schütte 1976, Mörner 1980, Hokkanen et al 1986), these methods were found to be difficult to implement on a large scale.

The material presented here was collected towards the end of the 1970's. The major aims of this work were to determine the factors limiting pollen beetle populations with the hope of obtaining information useful in developing environmentally sound strategies for reducing beetle damage.

Methods

A description of the study sites as well as the methods used for counting beetles, taking plant samples and determining egg densities are presented in the two earlier papers in this series.

For the 1977 winter rape as well as the 1977 and 1978 spring rape crops the proportion of nonhatching eggs was determined by placing buds containing eggs on filter paper in petri dishes that were floating on water in a covered container. Only complete inflorescences were used since single buds rapidly shriveled. About 100 eggs were tested each year. About 2—3% disappeared between counts. It is probable that these also hatched but that the larvae succeeded in hiding or escaping. Only recovered larvae were used in the calculations.

In order to measure the number of larvae falling to the ground, collectors were placed out in and between rows. In those cases where they were set out early during flowering, prior to petal-fall, no larvae were recovered. Two types of collectors were used: shallow, rectangular trays (0.098 m^2) and round 850 ml plastic bowls (0.010 m^2). The latter were placed both within and between rows while the former were only placed between rows. Collectors were half-filled with water and emptied twice weekly.

In winter as well as spring rape the trays captured about 15% fewer larvae than the bowls (ANOVA; spring rape: $p = 0.03$). On the other hand, there was no significant difference between the numbers of larvae captured within rows and between rows. Values for the bowls were used for estimating larval populations. The egg population, as estimated on winter rape plants, reduced by the proportion of unhatched eggs was approximately equal to the estimate of larval numbers as measured with the bowl collectors.

For spring rape in 1978 there is no reliable method for measuring the egg population owing to the high level of bud abortion. Thus estimates based on bowl collections were accepted as the best measure of the larval population. In both crops during 1978 and in winter rape during 1977 the tray collections were used for determining the incidence of parasitism and the abundance of immature larvae.

In the laboratory a study was undertaken to determine the relationship between larval size, on the one hand, and ability to pupate and metamorphose into a normal adult, on the other. Each treatment consisted of two pots with sandy or clayey, somewhat moist moraine soil. Thirty larvae of a given developmental stage -1.e., first-instar larvae, not fully grown second-instar larvae, full-grown larvae, were placed in each of these pots. The pots were then covered with black plastic into which a glass tube, with its open end covered with netting, was inserted. One pot in each set was placed on the laboratory floor at 20—25 °C, while the other was placed in an incubator set at 17 °C.

The factors responsible for larval and pupal mortality were studied in thin, square-shaped plexiglass containers with 20-cm-long sides and with room for a 3-mm-thick layer of soil between the plates. After supplying 13 containers, filld with moist soil, with larvae, the containers were placed upright in the dark for about a month. The contents of the pupal cells were examined by lifting off one side of the container.

White, wooden emergence boxesd (0.11 m²) with a screened glass tube inserted in one side were used to estimate the number of pollen beetle adults and polyvoltine parasitic wasps in the new generation. The tube was not installed until several days had past so that insects on the soil surface could leave the box. With the exception of 1976, when boxes of another design were used, the boxes were moved only at the first collection, and then only if they had remained on th same spot for several weeks. In winter rape the surface area under the boxes was 1.2, 1.4, and 0.9 m² during 1976, 1977, and 1978 respectively. In spring rape the surface area covered was 1.8 and 0.9 m² in 1977 and 1978 respectively.

In 1978 adult emergence began while there were still larvae present on the plants. Concequently, an extra set of emergence boxes were set out once larvae had finished moving down to the soil surface. Wen calculating the number of emerged adults the figures for the first set of boxes were added together with those from the second set to form an emergence curve.

Emergence boxes have effects on both soil temperature and soil moisture (when placed over a section of soil). Therefore an attempt was made to measure the temperature changes induced in a winter rape field in 1977. Thermistors, connected to a battery-driven recorder taking hourly measurements, were stuck down ca 3 cm into the soil within as well as just outside of two emergence boxes. Measurements were then taken for 2 weeks. On sunny days the soil inside the boxes was up to 4.6 degrees warmer than that outside of them, whereas on cloudy days the temperature differential was less than 1 degree. In contrast, during the early morning hours the temperature inside the boxes was generally about 1 degree — and at most 2.5 degrees — lower than that outside them. Based on the higher daytime temperatures under the boxes, it can be assumed that the developmental times recorded for the pollen beetle were a few days shorter than they would have been under natural conditions.

Estimates of the duration of egg and larval instars were taken from the density curves at the point where numbers started to increase rapidly. Thus, the very first individuals of each instar observed were ignored, and interest was concentrated instead on the more or less parallel parts of the curves.

Results

Egg mortality

Between 1 and 8% (mean = 5.4%) of the eggs incubated in the laboratory during 1977 and 1978 never hatched. There were no signs of damage to the eggs and no observable changes in the appearance of these eggs during the 5-day-long course of the experiment, suggesting that they were unfertilized. Thus a constant egg mortality rate of 6% has been assumed.

Bud abortion induced by oviposition

Serious damage to a bud, especially if it involves the pistil or ovary, can be expected to lead to bud abortion (Williams & Free 1978). As a consequence, any eggs and larvae in the aborted bud die. This type of mortality is most prevalent when high population densities occur early in the rape plant's development, as happened in the 1978 spring rape crop. Although no exact measurements were made of the numbers of eggs lost through bud abortion, this source of mortality could have been important. It was estimated as follows:

On 15 June 1978, 15 plants were marked so that the development of 170 buds could be monitored during the following 2 weeks. One hundred buds and 10 newly formed pods aborted during this period. On 15 other plants in the same crop yellowish, withered buds that easily dropped off the stalk were collected. In total, 32 such buds were collected, which were between 1 and 3.5 mm long. Together, the buds longer than 2 mm contained a total of 23 eggs and 12 newly hatched larvae.

At the peak in bud occurrence, the number of buds longer than 2 mm was ca 60% lower on untreated top racemes compared to corresponding parts of insecticide-treated plants. This level of bud-fall corresponded well with that observed on the marked plants described above. Between 50 and 80% of the damaged buds found on the plants contained eggs. A large proportion of the aborted buds should also have contained eggs or newly emerged larvae.

Another way of estimating the proportion of eggs lost through bud abortion is to compare the number of eggs laid per female per day. This value was 30% lower in spring rape 1978 than in spring rape 1977 and 30% lower than the mean for winter rape crops 1976—1978. Based on these different estimates the rate of egg loss in spring rape 1978 was tentatively set at 25%. Based on the above calculations it can be presumed that the actual density of eggs laid in spring rape 1978 was greater than 30,000 per m². Thus a female could have laid about 185 eggs. This is not an unreasonable result since eggs were found in spring rape for 45 days during 1978 as compared with only 25 days in 1977, when females produced an average of 95 eggs.

Larval development

Eggs hatched within ca 10 days in winter rape and 7 days in spring rape. The first larval instar was completed within 5—10 days in winter rape and 5 days in spring rape. The values for the length of the later larval stages are less exact since the density curves were not completely parallel. The time elapsed between oviposition and the recovery of larvae on the soil surface, which was measured in three instances, was 20—25 days in winter rape and 17 days in spring rape. The total time elapsed for development from egg to adult was about 50 days in winter rape and 45 days in spring rape (Table 1).

The amount of time available for larval development was sometimes very short. In winter rape the time elapsed between the appearance of buds longer than 2 mm and flowering was 13—20 days, while the corresponding values for spring rape were 10—20 days. The life span of the rape flower was highly variable. In winter rape it was between 5 and 13 days long, whereas pods in spring rape could appear after only a few days flowering. In spring rape the time elapsed between budding and pod appearance was only ca 2 weeks. Buds and flowers were present for 3—4 weeks on side shoots.

Williams and Free (1978) have shown that larvae can move up the stalk in search of flowers. Thus, most larvae were ready to pupate before the end of the flowering period. While the larvae are in the flowers or wandering between them they are much more exposed to potential predators and parasitoids as compared to when they are within a bud.

Table 1. Developmental times for the pollen beetle and its host plant.

	Winter rape			Spring rape	
	1976	1977	1978	1977	1978
Egg — 1st instar	9	9—11	11—12	6	8
1st—2nd instar	4—7	7—10	4	6	4—6
Egg — larvae on soil surface	—	23—25	20—22	—	17
Egg-adult	53	54	52	47	50
Buds >2 mm — flowers	—	13	16—20	9—14	11—18
Flowers — pods	—	4—6	12—14	1—2	1

Table 2. Developmental stage of *Meligethes aeneus* on the soil surface and incidence of 2nd-instar parasitization by *Tersilochus heterocerus.*

		2nd instar			Examined
	1st instar	immature	mature	% paras.	number of larvae
Winter rape 1977	5	11	84	23	4 200
Winter rape 1978	10	16	73	51	1 200
Spring rape 1978	30	18	52	11	16 800
Spring rape 1979	15	26	59	0	990

Furthermore, larvae in flowers risk falling to the ground at petal-fall. Therefore, to maximize its probability of survival, a larva should remain within a bud for as long as possible. The choice of 2 to 3-mm-long buds for oviposition provides the longest possible time for larval development within the buds without risking an increased probability of bud abortion owing to oviposition damage.

Once the larvae are fully developed they fall to the ground. Collections of fallen larvae easily divided up into three size categories corresponding to first-instar larvae, early to mid-second-instar larvae, and late second-instar larvae, whose large body signified that they were ready to pupate. First-instar larvae constituted 5 and 10% of the larvae on the soil surface under winter rape, but 40% under spring rape in 1978 (Table 2). For the sake of comparision the values for spring rape 1979 are also presented. In this case, first-instars constituted 15% of the fallen larvae. This instar was recovered at about the same levels throughout the period when larvae were found on the soil surface. In 1977 the non-fully grown second-instar larvae constituted 11% of the fallen larvae in winter rape, while in 1978, corresponding figures were 16 and 18% for winter and spring rape respectively.

Tests were conducted to determine the extent to which the three larval groups could be reared to adulthood at two temperatures (20—25 °C and 17 °C). No adults emerged at the highest temperature. Neither did any adults emerge from first-instar larvae at any of the temperatures. At the lower temperature an average of 35% of the early and 72% of the late second-instar larvae emerged. A mortality rate of 50% was therefore assumed.

Parasitoids and predators

Ladybird beetles and other predators were too rare to have been of any importance. Nor was there any significant predation on larvae on the soil surface that were ready to pupate (Nilsson & Andreasson 1987).

Parasitoids, primarily *Tersilochus heterocerus* (Thomson), *Phradis morionellus* (Holmgren) and *P. interstitialis* (Thomson) and occasionally also *Diospilus capito* Nees, were important mortality factors. Detailed investigations of these parasitoids have been reported earlier (Nilsson & Andreasson 1987). The univoltine parasitoids tend to lay most of their eggs in older second-instar larvae. The frequency of parasitism, which can be high (50%), is determined mainly by the parasitoid/host larvae ratio. The frequency of parasitism for *T. heterocerus,* whose eggs can be seen easily through the larval integument, has been measured with great accuracy. However, similar measurements for other parasitoid species with transparent eggs are less reliable.

Pupal stage

From the 455 larvae initially added to the plexiglass containers, used to study mortality during the pupal stage, 97 pollen beetle and parasitoid adults emerged. In addition, 100 dead larvae and pupae were recovered. Thus a large proportion (57%) of the initially present larvae were not recovered, and all of the larvae and pupae found were brown or black and had begun to disintegrate. Many were also covered with white, grey or green fungal mycelium.

Discussion

The main part of the pollen beetle population arriving at the experimental fields had originated to the east, longer in from the coast. Mortality can be assumed to be very high during such mass migrations, and it can be further presumed that random events determined the population densities at Alnarp. Until measurements are made over an entire region, it will not be possible to measure changes in populations from year to year. Neither will it be possible to compare different areas

Table 3. Population changes and age specific, successive mortality for the pollen beetle in winter and spring rape. Figures in cursive are based on observations. The other figures are calculated.

	Winter rape 1976		Winter rape 1977		Winter rape 1978		Spring rape 1977		Spring rape 1978	
	% killed	No. alive per m²	% killed	No. alive per m²	% killed	No. alive per m²	% killed	No. alive per m²	% killed	No. alive per m²
Adults		*110*		*130*		*40*		*220*		*350*
females		*60*		*70*		*20*		*110*		*170*
Eggs		*4 760*		*6 960*		*1 820*		*10 810*		31 350
Eggs/female		85		105		90		95		185
bud abortion									25	23 510
unfertilized eggs	6	4 480	6	6 540	6	*1 750*	6	10 160	6	*22 100*
Larvae										
1st instar on soil surface			*5,3*	6 190	*7,7*	1 440			*29,3*	15 620
Pupae										
parasitized *T. heterocerus*			*23,1*		*50,8*		*5,6*		*10,5*	
parasitized, other parasitoids			*2,2*		0,0		*28,9*	6 660	*2,0*	
immature 2nd-instar larvae			*5,6*	4 280	*7,0*	610			*11,5*	11 870
other reasons	75,8	*1 080*	71,1	*1 240*	91,8	*50*	90,4	*640*	80,6	*2 300*
Gen 2: Gen 1		9,8		9,7		1,4		2,9		6,7

or to forecast the need for insecticide treatment. Such calculations would only be possible where overwintering areas are interspersed throughout an area used to cultivate oilseed crops. Thus under the present circumstances population dynamics calculations had to be limited to single fields and specific years. In Table 3 an attempt has been made to summarize the data presented in this and the preceding two papers. Many of the variables were measured, but in certain cases only rough estimates were obtainable. Thus, the estimate of egg mortality owing to bud abortion in 1978 spring rape is uncertain. This mortality factor only becomes important given an extreme situation in which the beetle attack is allowed to continue for such a long time and at such a high intensity that harvest losses exceed 50%. Adult population densities varied greatly between years, while egg populations varied even more, the latter depending on the availability of buds suitable for egg laying and, in some instances, on the weather. Mortality factors other than bud abortion can be divided up into three groups: non-mature larvae, parasitization, and mortality occurring under the soil surface. The latter comprises a very important but poorly investigated source of mortality. A more detailed investigation would help fill in the gaps in our knowledge here.

The frequency with which larvae fail to mature is primarily dependent on the relationship between the rates of larval and host development. It should be possible to manipulate this relationship through plant breeding. If the blooming period could be shortened, even at temperatures under 20 °C, as well as the period during which 2 to 3 mm-long buds are available, the importance of the above-mentioned mortality factors should increase.

Even though the most common parasitoids are an important source of mortality in pollen beetle populations, they show a weak functional response. Hence, possibilities for increasing the abundance of parasitoid species showing a better functional response should be more closely examined. Treatments designed to protect parasitoid wasp populations (Nilsson & Andreasson 1987, Nilsson 1985) should be able to increase their population density thereby increasing the incidence of parasitization.

The ratio between the abundance of the ovipositing generation and that of their progeny varied from 1:1 and 1:10. Small changes in the strength of certain mortality factors can cause drastic differences in progeny survival. For example, an incorrect choice of insecticide or incorrect timing of the application -e.g. during the blooming period, can be the decisive factor precipitating a dramatic increase in beetle populations. Likewise, the growth characteristics of future rape varieties will play a substantial part in determining abundance of the pollen beetle.

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NILSSON, C. 1988. Rapsbaggar (*Meligethes aeneus* F.) på höst- och vårraps i Alnarp 1976—1978. III Dödlighetsfaktorer. *Växtskyddsnotiser* 52: 6, 145—150.

Rapsbaggepopulationerna studerades i 3 höstraps och 2 vårrapsgrödor. Mellan 1 och 8% av äggen utvecklades inte. Ägg och larvdödligheten orsakad genom aborterande knoppar har inte mätts, men en försiktig uppskattning ger 25% i en av vårrapsgrödorna och nära ingenting i övriga grödor.

Det tog 7—10 dagar innan äggen kläcktes. Första larvstadiet varade 5—10 dagar och hela utvecklingstiden 45—50 dagar. Det lägre talet avser som regel vårrapsen och det högre höstrapsen. Rapsens utveckling från medelstora knoppar till skidor går ofta snabbare än ägg/larvers, vilket gör det nödvändigt för larverna att vandra mellan blommorna. Många larver hamnar ofrivilligt på markytan, utan att kunna ta sig tillbaka upp på plantorna. Mellan 5 och 30% av larverna på markytan befann sig i första larvstadiet och 10—20% var icke fullvuxna larver i andra larvstadiet. De senare hade dubbelt så hög dödlighet som fullvuxna larver. Höga parasiteringsfrekvenser uppmättes främst av *Tersilochus heterocerus*. Dödligheten i marken före och under puppstadiet var mycket hög. Den nya generationen var upp till 10 ggr större än föräldragenerationen.

The number of larval instars of *Meligethes aeneus* (F.) in southern Sweden

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NILSSON, C. 1988. The number of larval instars of *Meligethes aeneus* (F.) in southern Sweden. *Växtskyddsnotiser: 52:* 6, 151—152.

Head capsule widths were measured on larvae of *Meligethes aeneus* (F.) collected in spring rape or hatched from eggs collected in spring rape. Two instars were found with head capsules averaging 0.30 and 0.44 mm.

Introduction

Several investigations have reported that the pollen beetle, *Meligethes aeneus* (F.), has two larval instars. Results of these studies were based on measurements of head-capsule width. Scherney (1953) determined mean head-capsule widths to be 0.34 and 0.46 mm for the first and second instars. Osborne (1965) conducted a detailed investigation, rearing 10 larvae in isolation from each other and taking daily measurements of the head-capsule. He also concluded that there were two larval instars with mean head-capsule widths of 0.32 and 0.46 mm. Fritzsche (1955) on the other hand, reported three instars, also based on detailed measurements of larvae reared individually in the laboratory. Both Osborne and Fritzsche verified their findings with measurements on field collected animals. Only first-instar larvae have been reported as having spatulate setae, not found in later instars.

The purpose of this study was to determine the number of larval instars in pollen beetles inhabiting southern Sweden. This information is needed for studies on early larval mortality and oviposition preferences by parasitic Hymenoptera as well for constructing a computer model describing larval development on oilseed rape.

Methods

Larvae were collected from commercially grown spring rape on 5 occasions during bud and flowering stages in June and July 1977. Eggs collected during 1977 and 1979 were hatched in the laboratory. Width of head capsules were determined using a measuring ocular at 100× magnification. All material was preserved in 70 percent ethanol alcohol prior to measurement.

Results and discussion

Only two larval instars were found. The mean width of their head-capsule was 0.30—0.31 and 0.44 mm (Table 1). The first instar had spatulate setae. The head-capsule widths of both instars were about 0.02 mm smaller than those reported by Osborne and Scherney. Fritzsche's second instar did not have spatulate setae, while his first instar did. This first instar, which had a head-capsule width of only 0.26 mm lasts for about 2—3 days at 20 °C (Fritzsche, 1957). In contrast, the second and third instars each last for about 7—11 days. In my material one batch of larvae less than a day old had head capsules of similar width to field collected first-instar larvae. The first instar in southern Sweden lasts for about 4—10 days depending on the temperature. Evidently there are only two instars in southern Sweden, in agreement with the data of Osborne and Scherney and corresponding with Fritzsche's first + second and third instars, both in duration of development and in head-capsule width. It is possible, however, that under certain rarely met environmental conditions, pollen beetles have an extra first instar, as decribed by Fritzsche.

Table 1. Mean (±S.D) head-capsule widths (in mm) for larval instars of *Meligethes aeneus*. No. of measured animals within parentheses (*denotes an instar with spatulate setae).

Reference	Larval instar								
	I			II			III		
Fritzsche 1955	0.26	0.01	(30)*	0.33	0.01	(30)	0.43	0.02	(30)
Scherney 1953	0.34	0.02	(—)*	0.46	0.03	(—)			
Osborne 1965	0.32	0.02	(82)*	0.46	0.02	(47)			
This investigation									
Spring rape 1977	0.30	0.02	(329)*	0.44	0.02	(123)			
Laboratory 1977	0.31	0.01	(71)*						
Lab. 1979, <18h old	0.30	0.02	(35)*						

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Kemisk bekämpning av rapsjordloppa

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NILSSON, C. 1988. Kemisk bekämpning av rapsjordloppa. *Växtskyddsnotiser 52:* 6, 153—157.

I 22 fältförsök 1982—1984 har olika appliceringstekniker, doser och preparat provats mot rapsjordloppa i sydvästra Skåne.

Betning med Oftanol T har i genomsnitt givit 10% skördeökning vid pelletering och 7% vid puderbetning. Kemiska analyser av olika fröpartier visade att stora delar av puderbetmedlet förlorades i hanteringen. Betningarna halverade larvpopulationerna. Effekten var ungefär propertionell mot tillförd mängd betmedel. Pelletering och inkrustering med isofenfos, liksom jämförbara doser med Promet eller Marshal gav likvärdiga resultat. Halten isofenfos i plantorna sjönk snabbt när plantorna tillväxte.

Sprutning med pyretroid reducerade larvpopulationen med minst 75% och ökade skörden 15—25%. Sprutning på våren med triklorfon hade däremot ringa effekt.

Rapsjordloppan (*Psylliodes chrysocephala* (L.)) är ett av de mer betydelsefulla skadedjuren i höstraps i södra Sverige. Angreppen är som regel störst i Skånes kustnära områden. Populationsstorlekarna varierar kraftigt mellan åren. Den viktigaste mortalitetsfaktorn är sannolikt vinter- och vårtemperaturen. Perioder med ihållande kyla dödar ofta en stor del av larverna.

Under de senaste 20 åren har Konsulentavdelningen-Växtskydd/Prognos i Alnarp (Andersson 1986) mätt larvtätheten. Resultatet avgör om höstoljeväxtutsädet det aktuella året skall insekticidbetas eller inte. Prognosutfallet följs närmast fullständigt av fröfirmor och lantbrukare.

Som alternativ bekämpningsmetod har sprutning med fenitrotion eller metoxyklor använts. Effekten är mycket kortvarig och för ett bra resultat krävs dels att djur inte invandrar till fälten efter bekämpningen och dels att sprutningen sker under skymning eller kväll när djuren är aktiva och exponerade på plantorna. Det är emellertid vanligt med flera flygningsperioder, bl.a. därför att den spillraps som dragit till sig rapsjordloppor förstörs i samband med förberedelserna för sådden av höstsäd.

Under normala år sås höstrapsen mellan den 10 och 20 augusti medan den huvudsakliga invandringen av rapsjordloppor kommer en vecka in i september. Detta innebär att koncentrationen av betningsmedel i hjärtbladen och de örtblad som ev. hunnit utvecklas ibland kan vara alltför låg för att en fullgod effekt skall erhållas när djuren angriper plantorna. Både valet av preparat, mängden och appliceringstekniken kommer härvid att ha betydelse. Även om betningstekniken utnyttjas maximalt kan situationer uppstå där andra bekämpningstekniker, främst sprutning under hösten eller mot larverna på våren, kan krävas. Den här redovisade undersökningen har försökt belysa dessa frågeställningar.

Metoder

De olika bekämpningsmedlen och bekämpningsteknikerna har prövats i randomiserade fältförsök med fyra block. Försöken har anlagts och skötts av hushållningssällskapets försökspatruller och genomförts under 1982 till 1984. De låg främst i sydvästra Skåne inom ett område begränsat av Barsebäck, Alstad och Trelleborg, med undantag för 2 försök på Brinkagården vid Svalöv. Flertalet, eller 14 av 22 försök låg söder om Vellinge. Under de tre åren förekom 2, 5 resp 3 betningsförsök där de olika doseringarna och teknikerna provades, samt under 1982 också en enklare plan i 5 försök där endast torrbetning och mikropelletering jämfördes med obehandlat. Under 1983 hade dessa försök också 3 sprutningsled.

Besprutningsförsöken lades under 1982 och våren 1983 ut i av odlarna anlagda grödor där betat utsäd använts. Besprutningsförsöken hösten 1983 såddes däremot med obetat utsäde, för att effekten av besprutningen skulle kunna utvärderas. Utsädesbetningarna har gjorts av Hilleshögs specialfrödivision i Landskrona (mikropelletering och torrbetning) och Saat-und Erntetechnik Gmbh i Eschwege (SUET) i Västtyskland (inkrustering). Samma fröparti har använts till alla led i försöken under samma försöksår.

Sorterna Emil (1982) och Jupiter har använts, som regel med 6—7 kg utsäde per ha vid hackrensningsavstånd, men i några enstaka fall har andra mängder förekommit (5 resp 10 kg/ha). Utsädesmängderna i varje försök har korrigerats med hänsyn till den ökning av tusenkornvikten som utsädesbehandlingen i vissa fall medfört. Endast i två försök (1983) har korta radavstånd förekommit. Förfrukter har som regel varit korn eller konservärt, i några fall vall.

Såtidpunkterna har varierat något mellan åren som en följd av de aktuella väderleksförhållandena. Hösten 1981 såddes försöken mellan den 6 och 14 augusti samt i ett fall den 26 augusti. Hösten 1982 såddes 2 försök den 4 augusti och resten den 9—15 augusti. Det sista försöksåret, hösten 1983, såddes försöken den 10 och den 17—19 augusti.

Sprutningen på hösten utfördes vid 2—4 utvecklade örtblad. Då sprutningen var bunden till raspens utvecklingsstadium, skedde den hösten 1982 vid så varierande datum som den första och sista september. Hösten 1983 skedde sprutningarna 21—28 september, samt i ett led den 1 november. I två försök som lades ut under våren 1983 gjordes sprutningen under tidig vår, den 9 och 11 mars. Temperaturen var vid dessa bekämpningar +3 resp +7 °C Höstsprutningarna skedde vid 12—16 °C.

Undersökning av isofenfoshalterna i växande plantor har skett på material dels från ett fältförsök vid Lund och dels från växthus. I båda fallen togs 25 plantor från varje led. Provtagning i fältförsöket gjordes av Hilleshög AB. I växthuset odlades höstraps i mars under konstljus i krukor. Prov togs vid olika tidpunkter. Plantorna klipptes av med sax vid rothalsen och frystes direkt.

Plantprover uttogs under vårvintern i januari— mars, innan plantorna börjat växa. Från varje parcell togs slumpmässigt 10 plantor vid ett tillfälle. Stam och bladskaft skivades under stereomikroskop och antalet levande och döda larver räknades. Metoden ger en mycket exakt bild av larvtätheten. Döda larver kan dock förloras genom att blad som dött under vintern har fallit av från plantorna och alltså inte kommit med i proven. Alla bearbetningar har skett med variansanalys. Såväl levande som döda larver har räknats samman eftersom larverna med säkerhet dött av andra orsaker än genom bekämpningsåtgärderna. Alla beräkningar på larvtätheten har gjorts på 10-logaritmen för larvantalet +1.

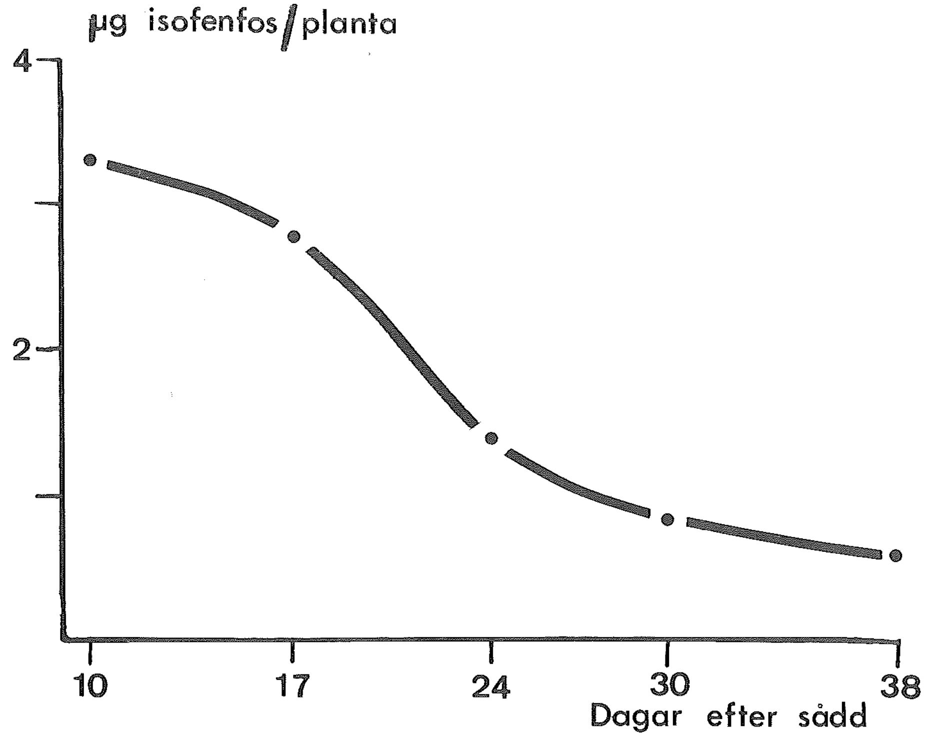
Resultat och diskussion

Angreppen varierade starkt under de tre åren. Både under 1982 och 1984 förekom som mest 3 larver per planta, men 1984 var angreppen i många parceller lägre än 1982. Ända upp till 20 larver per planta uppmättes däremot 1983.

Betningarna med Oftanol T har i genomsnitt för de 15 försöken givit en skördeökning med 10% för pelletering och 7% för puderbetning (tab. 1). I båda fallen har 16 g isofenfos tillförts per kg utsäde. Kemisk analys av använda fröpartier visade att den dos som kvarstannade på fröet efter torrbetning var ungefär 40% lägre. Inga förluster av preparat noterades däremot för mikropelleterat eller inkrusterat frö. Analys av 5 slumpvis utvalda utsädespartier som levererats till lantbrukarna

Tabell 1. Effekt av olika betningstekniker mot rapsjordloppa. Resultat av 15 försök 1982—84. Medelvärden följda av samma bokstav är inte signifikant skilda (P<0.001). — *Effects of different seed dressing techniques in 15 trials 1982—84. Values followed by the same letter are not significant different (P<0.001).*

	Dos *Dose* *g/kg*	Antal larver per planta *No. larvae per plant*	Råfettskörd *Crude fat* *dt/ha*	Rel.tal *Rel.*
Obehandlat (Untr.)		2,5 a	10,2 a	100
Pud Oftanol T	40	1,6 b	10,9 b	107
Pell Oftanol T	40	1,3 b	11,2 b	110



Figur 1. Isofenfoshalten i plantor odlade i växthus från utsäde inkrusterat med 16 g isofenfos/kg. — *Isofenphos concentrations in plants grown in a greenhouse (µg/ plant and days after sowing). Seed with 16 g isofenphos/kg (micropelleted, SUET).*

visade att endast 20% av den tillförda mängden isofenfos kunde återfinnas på fröna. Det är sannolikt att det frö som hamnade i jorden inte ens hade denna dos, då preparat alltid nöts av i sålådan och under utmatningen. Man kan sannolikt räkna med att i många fall, endast 1—2 g av tillförda 16 g isofenfos verkligen var aktiva mot rapsjordlopporna.

Betningen resulterade i en halvering av larvpopulationen. Skillnaderna i effekt mellan leden stod ungefär i proportion till skillnaden i dos. I två försök 1982 jämfördes doserna 4, 8, 12 och 16 g isofenfos mikropelleterat med 8, 12 och 16 g inkrusterat. Larvpopulationerna sjönk med ungefär 5% för varje gram ökning av isofenfosdosen. Anmärkningsvärt är också att i samtliga försök 1982 där olika doseringar i en eller annan form använts ligger regressionslinjerna för sambandet mellan skörd och larvantal för de lägre doserna under linjerna för de högre doserna. Ibland är skillnaden i intercept mellan linjerna mycket stor. Skörden vid låg dos är alltså lägre än vid hög också vid samma larvantal. Detta kan möjligen tolkas så att fler av de tidigt kläckta larverna dött under hösten vid de högre doserna än vid de lägre och att det därför fanns storleksskillnader mellan larverna i de båda grupperna. Mätningar av dessa faktorer har dock inte gjorts. Det är oklart om isofenfos har effekt på jordlopporna, de nykläckta larverna, eller bådadera. Om inverkan på jordlopporna skall vara av betydelse, måste invandringen till fälten ske på ett tidigt stadium i rapsplantans utveckling, eftersom halten isofenfos per g växtvävnad snabbt avtar när de första örtbladen börjar utvecklas. Prover tagna från ett fält i Lund, visade en sänkning av halterna med en tiopotens på en vecka, både i mikropelleterade och inkrusterade led. I ett växthusförsök erhölls också en snabb utspädning och nedbrytning av isofenfos (fig. 1). Man kan därför räkna med att när rapsjordlopporna invaderar fälten 3—5 veckor efter sådd så kan isofenfoshalterna i plantorna på de tidigast sådda fälten vara lägre än 10—20%

av initiala halter. Det är därför förvånansvärt att man överhuvudtaget funnit effekter av torrbetning i praktisk odling.

Oftanol T tillfört i form av mikropelletering eller inkrustering har givit samma resultat vid samma dosnivåer (tab. 2). Även andra bekämpningsmedel har provats, däribland Promet (40 g/kg utsäde) och Marshal 25 EC och 25 ST (60 g/kg utsäde), som pelletering. Resultaten från de försök under 1984 (för Promet även 1983) där dessa led ingick är likvärdiga med pelleterat Oftanol T (40 g/kg utsäde).

Det finns ofta ett behov av att nå bättre bekämpningseffekter än de som betningen kan erbjuda. Skördeförlusterna uppstår, åtminstone vissa år redan vid mycket låga larvtätheter (Nilsson 1988), vilket gör att även dyrare insatser, som t ex sprutning kan vara ekonomiskt motiverade. Pyretroider har provats under 1983 och 1984 i 8 olika försök, både sådana där utsädet betats och sådana som såtts med obetat utsäde. Resultaten har varit mycket goda. Larvantalet har minskat med minst 75%, ibland med mer än 85%, och skördeökningen har legat på 15—25% (tab. 3).

Tabell 2. Effekt av olika drageringstekniker. Resultat av 7 försök 1982—83. Medelvärden följda av samma bokstav är inte signifikant skilda (P<0.001). *Effects of different seed dressing techniques in 7 trials 1982—83. Values followed by the same letter are not significant different (P<0.001).*

	Dos *Dose g/kg*	Antal larver per planta *No. larvae per plant*	Råfettskörd dt/ha *Crude fat dt/ha*	Rel.tal *Rel.*
Obehandlat (Untr.)		8,5	9,9 a	100
Nak Oftanol T	40	7,1	10,7 c	108
Pell Oftanol T	40	5,9	11,3 b d	115
Pell Oftanol T	30	6,7	10,7 b c	109
Ink Oftanol T	40	6,2	11,5 b d	116
Ink Oftanol T	30	5,4	11,0 b	111

Pud = puderbetat (seed dust); Pell = pelleterat (micropelleted);
Ink = inkrusterat (pelleted by SUET in W-Germany).

Tabell 3. Sprutning mot rapsjordloppa på hösten vid 2—4 utvecklade blad, samt 1 månad senare (tidp. II). *—Result of an autumn spraying at 2—4 true leaves and 1 month later (tidp. II).*

	Dos l-kg/ha	Medeltal av 3 försök 1984 *Means for 3 trials in 1984* Antal larver per planta *No. larvae per plant*	Råfettskörd *Crude fat* dt/ha	Rel.tal	Medeltal av 2 försök 1983 *Means for 2 trials in 1983* Antal larver per planta *No. larvae per plant*	Råfettskörd *Crude fat* dt/ha	Rel.tal	Medeltal av 3 försök 1983 *Means for 3 trials in 1983* Antal larver per planta *No. larvae per plant*	Råfettskörd *Crude fat* dt/ha	Rel.tal
Obehandlat		2,1 a	7,9 a	100	8,1 a	9,3 a	100	10,2 a	8,9 a	100
Cymbush DG	0,5	0,3 b	9,3 b	118	0,2 b	10,6 b	114			
Decis	0,3/0,4	0,5 b	9,5 b	121				1,2 b	11,2 b	126
Sumicidin 10 FW	0,4	0,8 b	9,4 b	119						
Cymbush DG, tidp. II	0,5	0,4 b	8,8 b	112						

Utsädet 1983 dessutom puderarbetat med Oftanol T
Also seed dressing with Oftanol T dust 1983

Försök har också gjorts att bekämpa larverna i plantorna tidigt på våren, genom besprutning med triklorfon (Dipterex, 0,75 kg/ha) på två platser under våren 1983. Endast obetydliga effekter noterades.

Inventeringarna av rapsjordloppa i Skåne och Halland har under lång tid styrt betningen av utsädet. Vid två tidpunkter har populationerna ökat kraftigt med maximal förekomst 1975 och 1983 (Andersson 1986). Betning av utsädet har satts in när det förekommit mer än ca 0,5 larver/planta. När detta skett har alla odlingar berörts. Trots detta förefaller det inte som om betningen haft någon inverkan på populationsuppbyggnaden, i varje fall har en fortsatt ökning av populationsstorleken inte kunnat förhindras.

Om prognosen istället utnyttjades för att utlösa sprutning av alla odlingar inom en region, så skulle rapsjordloppspopulationerna kunna styras i det närmaste fullständigt och antalet år som bekämpningsmedel behövde användas begränsas avsevärt. Skördevinsterna under år med stora rapsjordloppspopulationer skulle också bli betydande, vilket sannolikt väl skulle kompensera för den ökning av bekämpningskostnaden som sprutningen innebär. Nackdelarna med denna strategi är att en sprutning alltid utgör ett större ingrepp i miljön än betning och att det kan vara svårt att få lantbrukarna att spruta när det behövs och att låta bli när det är onödigt.

Litteratur

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Nilsson, C. 1989. Yield losses in winter rape caused by cabbage stem flea beetle larvae (Psylliodes chrysocephala (L.)). *IOBC/WPRS Bulletin* in prep).

NILSSON, C. 1988. Insecticides against Cabbage Stem Flea Beetle. *Växtskyddsnotiser 52:*6, 153—157.

Different insecticides, application techniques and doses were tested in 22 field trials against cabbage stem flea beetle in the SW of Skåne.

Seed dressing with Oftanol T (isofenphos + thiram) gave in average a 10% yield increase applied as a micropelleting and 7% as a seed dust. Chemical analysis of seed lots sold to the farmers showed that most of the seed dust was lost before sowing.

Larval populations were halfed by the seed dressings and the effect was appr proportional to the dose. Micropelleting with isofenphos, Promet or Marshal gave equivalent results at comparable doses. Isophenfos concentration in green parts of the plants decreased rapidly as they growed.

A pyrethroid spray reduced the larval population with at least 75% and increased yield with 15—25%. Spraying with trichlorophon in early spring had almost no effect.

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