Biocontrol of Oilseed Rape Pests

Edited by

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Preface

Oilseed rape is an important arable crop in many parts of the world, including much of central and northern Europe. The crop is attacked by a wide range of insect pests, many of which are of considerable economic importance. Traditionally, such pests have been targets for the application of insecticides. However, nowadays, there is an increasing demand to reduce chemical inputs on arable crops, and an increasing awareness of the potential benefits to be gained from the adoption of non-chemical methods for pest control within sustainable crop management strategies. Although thresholds for chemical control treatments are available for certain oilseed rape pests, these rarely if ever take account of the presence of naturally occurring biocontrol agents (BCAs), and oilseed rape crops are often sprayed unnecessarily. This is wasteful and can have unwarranted detrimental effects on parasitoids and other natural enemies; it can also be harmful to non-target organisms, including pollinating insects such as bees. Although knowledge and expertise of natural enemies of oilseed rape pests exist within Europe, information is fragmented, incomplete and largely parochial. It is also dispersed and not readily available to practitioners and farmers. This is a major barrier to the full exploitation of research on the natural enemies of oilseed rape pests that, otherwise, could enable a better-targeted approach to integrated crop management (ICM) on oilseed rape to be advocated and implemented.

In 1997, a three-year programme of work began in which participants from various European countries reviewed the natural enemies of oilseed rape insect pests. The work was done mainly with financial support from the Commission of the European Communities, Agriculture and Fisheries (FAIR) specific RTD programme, as Project CT96-1314 – *Minimizing pesticide use and environmental impact by the development and promotion of bio-control strategies for oilseed rape pests.* The various outputs from this project form the basis for the current monograph, but this publication does not necessarily reflect the Commission's views and in no way anticipates the Commission's future policy in this area.

The EC-funded project, under the acronym BORIS, reviewed the whole range of antagonists associated with insect pests on oilseed rape crops in western Europe, with emphasis being placed in three specific areas: parasitoids, predators and pathogens. The present monograph relies heavily on the output of the BORIS project but presents a broader geographical view, taking due regard of data from eastern Europe and elsewhere. The monograph also benefits from the wider experience and expertise of BORIS participants and from the inputs of several other specialists who were not part of the BORIS consortium.

Throughout the course of BORIS, and also during the preparation of this monograph, authors were frequently aware of gaps in current knowledge. In particular, taxonomic expertise on the parasitoids, predators and pathogens of oilseed rape insect pests clearly requires further development, with particular reference to entomopathogenic fungi and the larval stages of hymenopterous parasitoids, predatory diptera and staphylinid (rove) beetles.

Biocontrol of Oilseed Rape Pests, which is a synthesis of current knowledge within Europe, commences with reviews of the oilseed rape crop (Chapter 1), the pests (Chapter 2) and pest management strategies (Chapter 3). These introductory chapters are followed by specialist chapters on parasitoids of specific pests or groups of pests (Chapters 4–9). Rearing and trapping methods for parasitoids are also reviewed (Chapter 10). The reliable identification of parasitoids (most of which are hymenopterans) can be a formidable barrier to their further study. Therefore, a specific chapter (Chapter 11) on the identification of adult hymenopterous parasitoids has been included. It had been planned, also, to include a key to the larval stages of such parasitoids. However, unfortunately, information in this area is very limited and insufficient material was available for study. Authors of the various parasitoid chapters have been at pains to interpret published (and often questionable) names of organisms in line with current thinking; however, they are aware that future work may require amendments to be made. The situation is often confused, at least in the older literature, owing to some 'records' of supposed parasitoids of pests being invalid since, in reality, they refer to hyperparasitoids (i.e. to parasitoids of parasitoids).

Although there have been a vast number of studies on predators in arable cropping systems, relatively few of these relate to oilseed rape. Predators are often abundant in oilseed rape fields and, cumulatively, they are capable (at least potentially) of causing significant mortality amongst pest populations. However, unlike certain parasitoids, they do not specifically target oilseed rape pests. Also, unlike parasitoids (which often show a significant degree of host specificity), predators tend to be opportunist feeders that attack a wide range of prey. As an aid to their future study, information is presented in Chapters 12 and 13 on the nomenclature and taxonomy of the main groups of predators inhabiting oilseed rape fields. Methods for their study (Chapter 14) and the importance of on-farm landscape structure on predator populations (Chapter 15) are also reviewed, as is the impact (or potential impact) of predators on oilseed rape pests (Chapter 16).

Information on pathogens in arable cropping systems is generally scarce, with relatively little available of direct relevance to oilseed rape. However, for completeness, a brief review of current knowledge is given in Chapter 17.

Appropriate exploitation of naturally occurring BCAs has the potential to improve environmental quality on European farmland and to bring about socio-economic benefits to the industry as a whole. It is hoped, therefore, that this monograph will form a useful basis for further work on the biocontrol of oilseed rape pests, and will help to bring about a greater understanding of the beneficial role and potential of natural enemies of crop pests on arable farms. Hopefully, this will lead to the enhancement of populations of BCAs on arable farms and encourage their greater utilization in future pest management strategies.

It is a pleasure to thank my partners on the BORIS project, namely Dr. Yannick Ballanger (France), Dr. Rudulf Büchi (Switzerland), Dr. Wolfgang Büchs (Germany), Dr. Barbara Ekbom (Sweden), Lars Monrad Hansen (UK), Professor Heikki M. T. Hokkanen (Finland), Dr. Bernhard Kromp (Austria), Alan Lane (UK), Dr. Christer Nilsson (Sweden), Dr. Bernd Ulber (Germany), Professor Ingrid H. Williams (UK) and John E. B. Young (UK), and also guest participants Dr. Jörgen Eilenberg (Denmark), Dr. Anne Piirainen (Finland) and Professor Stefan Vidal (Germany), all of whom have advanced our knowledge on the biocontrol of oilseed rape pests and have contributed to a greater or lesser extent to this monograph. Thanks are also due to other named contributors and to Dr. Bernd Ulber (University of Göttingen), Mr. James E. Ashby and Dr. Andrew W. Ferguson (IACR Rothamsted) for the loan of specimens to supplement available material upon which drawings were based.

David V. Alford
Editor
April 2002

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1

The Oilseed Rape Crop

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Introduction

Oilseed rape is an important crop in European agriculture, having risen particularly to prominence during the latter part of the 20th century (Bunting, 1986). The European crop is dominated by *Brassica napus* (Brassicaceae), often cited as *Brassica napus* ssp. *oleifera*; to a lesser extent, turnip rape (*Brassica campestris*) is also grown, especially in Finland and Sweden. Turnip rape is sometimes afforded subspecific status, as follows: *B. campestris* ssp. *oleifera*. *Brassica napus* is grown extensively outside Europe, notably in Australia and Canada, where it is most often known as canola. In Asia (e.g. in China, India and Japan), the rape crop is dominated by *B. campestris*. *Brassica campestris* is a native plant throughout Europe, central Asia and the Middle East. *Brassica napus*, however, arose in cultivation in southern Europe and is not represented in the wild, except nowadays as feral 'weed' populations on, for example, fields margins and roadside verges; such populations have often originated from seeds spilt from trailers and combines following the harvesting of nearby oilseed rape crops. For further details see de Rougemont (1989).

On a world scale, the oilseed rape crop area approaches 30 million ha, about 5 million ha of which is grown in Europe (FAO, 2001). The crop is particularly important in central and northern Europe, notably in the Czech Republic, Denmark, France, Germany, Hungary, Poland, the UK and the Ukraine (Table 1.1).

Usually, seed from oilseed rape is crushed to extract the oil. This oil is used for culinary purposes, for fuel and as a lubricant, especially on machinery in the food-processing industry; it is also used in the production of soaps and synthetic rubber. The seed residue (seed-cake) is used for cattle fodder; the uncrushed seed also has a market as bird feed. Less significantly, the crop is sometimes grown as a green salad, as cattle feed and as on-farm standing food and shelter for game birds.

The Oilseed Rape Plant

Oilseed rape is an annual herbaceous plant, with erect branching stems, typically 1–2 m in height and with a long, thin tap root. The foliage is smooth, bluish-green, with deeply incised margins; in common with many brassicaceous plants, the leaves are coated with a waxen bloom. The four-petalled flowers are yellow and borne in clusters (rosettes), on both terminal and lateral shoots, in the form of racemes. The developing fruits are green,

Table 1.1 Area of oilseed rape grown in various European countries in 1999 (FAO, 2001).*

Country	Area grown ('000 ha)
Austria	66
Belarus	85
Czech Republic	350
Denmark	142
Finland	58
France	1,369
Germany	1,201
Hungary	182
Poland	466
Russia	160
Slovakia	113
Sweden	55
UK	542
Ukraine	222

* Countries with <50,000 ha excluded.

elongate pods (siliquas) that eventually ripen to brown. A siliqua is formed from an ovary of two united carpels (these form the pod walls), separated by an inner central wall (the septum) into two compartments (locules) within each of which a row of seeds develops; the ripe seeds, for which the crop is usually grown, are black and hard at maturity, similar in appearance to lead shot. A siliqua dehisces by an upward splitting and parting of the carpels from the base, leaving the septum (to which the seeds may, temporarily, remain attached) entire.

Crop growth stages

Keys to the growth stages of oilseed rape have been presented by various authors. Sylvester-Bradley & Makepeace (1984) introduced a decimal code, ranging from 0.0 to 9.9 that included gross classifications as follows:

- Stage 0 – germination and emergence;
- Stage 1 – leaf production;
- Stage 2 – stem extension;
- Stage 3 – flower bud development;
- Stage 4 – flowering;
- Stage 5 – pod development;
- Stage 6 – seed development;
- Stage 7 – leaf senescence;
- Stage 8 – stem senescence;
- Stage 9 – pod senescence.

This code was later revised (Sylvester-Bradley, 1985), but the essential elements remained the same. The Sylvester-Bradley codes are often cited in relevant UK-based pest control strategies, e.g. by Lane & Gladders (2000). Particularly on an international level, however, the system introduced by Lancashire *et al.* (1991) – commonly known as the BBCH (BASF/Bayer/Ciba/Hoechst) code – is more frequently adopted. The BBCH code, in common with that of Sylvester-Bradley, counts the number of internodes to measure stem elongation, but this is soon overtaken by assessments of bud development. Although bud development and flower development in both systems are similar, in the case of the former pod and seed development are combined. Gross categories in the BBCH scheme are as follows:

- Stage 0 – germination;
- Stage 1 – leaf development;
- Stage 2 – formation of side shoots;
- Stage 3 – stem elongation;
- Stage 4 – development of harvestable vegetative plant parts (not applicable to oilseed rape);
- Stage 5 – inflorescence emergence;
- Stage 6 – flowering;
- Stage 7 – development of fruit;
- Stage 8 – ripening;
- Stage 9 – senescence.

Each BBCH gross category is further subdivided into up to 10 detailed categories. The flowering stage, for example, runs from 60 (= 'first flowers open') to 69 (= 'end of flowering').

Crop Agronomy and Husbandry

It is not the intention here to provide an account of the agronomy and husbandry of oilseed rape but rather to review, briefly, current cultivation methods as a background to the accounts that follow on oilseed rape pests, their naturally occurring biocontrol agents (BCAs) and integrated crop management (ICM). For detailed reviews, readers are referred to, for example, Scarisbrick & Daniels (1986) and Kimber & McGregor (1995).

Crop rotation

In Europe, winter oilseed rape is normally grown as an annual break crop in three- to four-year arable rotations with cereals (winter wheat or winter barley) and break crops such as peas or beans. One-year set-aside also features in many rotations and often precedes oilseed rape.

Conventionally, crop rotation has been adopted partly to reduce the carry-over of pest and disease problems from one crop to another. Soil-borne diseases such as sclerotinia (*Sclerotinia sclerotiorum*), verticillium wilt (*Verticillium dahliae*) and club root (*Plasmodiophora brassicae*) often restrict the use of oilseed rape in close rotation with itself or with other host crops such as peas, potatoes, sunflowers and winter beans.

Soil cultivation, drilling and crop establishment

Primary cultivations depend, strongly, on soil type and weather conditions. Ploughing is often used in conventional systems. However, non-inversion methods of minimal tillage, including various combinations of discing, rotary cultivation and harrowing, may also be used. Other options include direct drilling or the broadcasting of seed into stubble. There are advantages and disadvantages attached to all of these techniques. Seed rates for conventional cultivars are in the region of 5–8 kg/ha, with a target plant population of at least 80 plants/m^2 (cf. hybrid cultivars, below).

Oilseed rape is either sown in late summer (= winter rape), for cropping in the following summer, or in spring (= spring rape). Winter rape is more vigorous than spring rape and has greater potential to compensate for damage caused by pests and other factors. However, a larger proportion of spring rape and spring turnip rape is grown in Finland and Sweden because of the more extreme winter conditions regularly experienced in these areas.

Occasionally, oilseed rape can be difficult to grow, and extensive losses may occur at establishment. In particular, slugs and wood pigeons can cause complete crop failure at this critical time; on spring-sown crops, cabbage flea beetles (*Phyllotreta* spp.) may also be important. The optimum sowing time for winter oilseed rape in Europe is from early August to early September. Yield penalties are incurred if sowing is delayed later than the first week of September. Early sowing can lead to problems from cabbage root fly (*Delia radicum*) or can create an excessively vigorous crop with increased risk from foliar diseases. Plant population density, row spacing and choice of cultivar, including hybrid and genetically modified (GM) cultivars (see below), may all exert indirect effects on the impact and incidence of pests. The architecture of the crop canopy is influenced by a number of factors, including plant population, growth habit and nitrogen use.

Nitrogen and other nutrients

Winter rape is responsive to nitrogen and most crops receive up to approximately 200 kg/ha, principally as spring applications.

The use of sulphur is becoming increasingly common on oilseed rape, and is generally targeted at crops growing in light, sandy soils in districts of low atmospheric sulphur deposition (e.g. non-industrial areas). However, the demand for supplementary use of sulphur is becoming more widespread. Phosphate and potash are applied to the seedbed to maintain levels within acceptable limits on a rotational basis.

Growth regulators

Growth regulators are not widely used, and in some countries (e.g. Sweden) they are not even registered for use on the crop. However, there is potential to manipulate crop physiology and canopy structure through the use of growth regulators and nitrogen. Conventional growth regulators, such as chlormequat, may be applied to shorten and thicken the stems, and help the canopy remain more erect during seed growth. The fungicide tebuconazole, applied for disease control in early spring, has a similar growth-regulating effect.

Cultivars

Agronomic changes during the mid- to late 1980s included the rapid move away from the growing of high erucic acid cultivars in favour of low erucic acid (single-low) cultivars and, finally, the adoption of double-low cultivars, i.e. to those with seeds low in both erucic acid and glucosinolates; these are also, alternatively, designated 'single-zero' or 'double-zero' (0 or 00) cultivars. Domination by double-zero cultivars in European agriculture reached virtually 100% by the autumn 1990 drilling. However, at present, some high erucic acid cultivars continue to be grown for industrial uses.

The top-yielding cultivars of oilseed rape are now hybrids. The commercially available hybrids are of two types: restored hybrids and cultivar associations. In the case of restored hybrids all plants are fully fertile, capable of producing pollen and setting seed without cross-pollination. Cultivar associations are composed of field mixtures of male-sterile hybrid plants which produce no pollen, and male-fertile plants of one or more cultivars whose principal function is to supply pollen and which contribute little to the overall yield. In the case of cultivar associations, recent work has shown that male-fertile plants are more heavily infested by both adult and larval pollen beetles (*Meligethes aeneus*), highlighting the need for control of this pest to ensure adequate pollination of the crop (Cook *et al*., 1999).

Hybrid cultivars, offering higher yields, have a seed rate of 2–4 kg/ha, aiming at 40–50 plants/m^2 (cf. conventional cultivars, above). Nowadays, various disease-resistant cultivars are available (see under 'Disease control', below).

No insect pest preferences have been demonstrated for particular cultivars of oilseed rape, although characteristics of specific cultivars may make some more likely to be attacked than others. Büchi (1996), for example, showed that early-flowering (early-developing) oilseed rape cultivars, irrespective as to whether single-zeros or double-zeros, were more likely to be attacked by egg-laying females of rape stem weevil (*Ceutorhynchus napi*) than moderately-early-flowering to late-flowering ones. Büchi (1996) also related stem-splitting propensity of cultivars to the likelihood of their being attacked by rape stem weevil, especially in the face of high pest pressure, and in his experiments found that single-zero cultivars (cvs Bienvenu and Jet Neuf) had fewer split stems than double-zero ones (notably cvs Idol and Eurol).

None of the studies on the seed concentrations of glucosinolates in oilseed rape has demonstrated preferential pest preferences for ensuing crops: examples include Milford *et al*. (1989b) on pollen beetle; Rawlinson & Williams (1991) on cabbage stem flea beetle (*Psylliodes chrysocephala*), pollen beetle, cabbage seed weevil (*Ceutorhynchus assimilis*) and brassica pod midge (*Dasineura brassicae*), and Williams & Bartlet (1993) on cabbage stem flea beetle. However, this may be explained by differences in seed concentrations of glucosinolates not being reflected in concentrations of glucosinolates in the vegetative parts of the crops (Milford *et al*., 1989a).

Glucosinolates and their catabolites, such as the isothiocyanates and nitriles, are important cues to host selection by cruciferous pests, aiding both orientation to and recognition of the host plant (Bartlet, 1996). Two strategies have been proposed for improving the glucosinolate content of the vegetative parts of oilseed rape for pest resistance (Bartlet *et al*., 1999). The first involves rape lines with low constitutive, but high induced, glucosinolate levels; these would be unobtrusive to brassica-specialist pests in the absence of attack, but would be protected from generalist feeders and pathogens once damaged. The second involves rape lines with a high proportion of glucosinolate types that do not catabolize to isothiocyanates; the overall glucosinolate concentration of the plant would be maintained as protection from other herbivores and disease, but the plants would be less attractive to brassica-specialist pests. Recent advances in genetic engineering and plant breeding are now being used to alter the glucosinolate composition of oilseed rape tissues, to reduce susceptibility to both pests and diseases (Mithen & Murphy, 1994; Giamoustaris & Mithen, 1996).

Transgenic oilseed rape

The next decade is likely to see the widespread cultivation and use of genetically modified (GM) cultivars of oilseed rape in Europe. These are already widely cultivated in North America.

Herbicide-tolerant GM cultivars are likely to be among the first to be cultivated commercially in Europe. They have already been released extensively in field experiments throughout Europe and are currently being evaluated in farm-scale trials in, for example, the UK, for their effects on farmland biodiversity (Firbank *et al*., 1999). At present, broad-leaved weeds in oilseed rape cannot be controlled effectively by farmers because the crop itself is susceptible to the required herbicide. The introduction of herbicide tolerance genes, therefore, promises more effective control of weeds. The genes code for plant enzymes capable of detoxifying specific herbicides, such as the broad-spectrum but short-lived glufosinate-ammonium and glyphosate (e.g. Sweet *et al*., 1997). These crops offer more flexibility in weed management and improved control of the more difficult weeds and volunteers, which may at least benefit field populations of predators (see Chapter 15).

Insect-resistant GM cultivars of oilseed rape are also being developed. For example, plants are being modified to contain *Bt* toxins and proteinase inhibitors (PIs), and these have potential to reduce insecticide application.

Bt is a natural toxin produced by the soil-dwelling bacterium *Bacillus thuringiensis*. Different strains of *Bt* produce different toxins, usually specific to a particular order of insects. Although none of the major European pests of oilseed rape has yet been shown to be susceptible to *Bt* toxins, the minor pest cabbage root fly and certain Lepidoptera, e.g. diamond-back moth (*Plutella xylostella*), are known to be susceptible (Hokkanen & Wearing, 1995). Hokkanen & Wearing (1995) have also postulated that several major pests of European oilseed rape crops, such as brassica pod midge, cabbage seed weevil, cabbage stem flea beetle, cabbage flea beetles, pollen beetle and turnip sawfly (*Athalia rosae*), could be considered potentially susceptible to *Bt* toxins of a suitable strain.

PIs are proteins that inhibit the activity of proteinase enzymes that split proteins into peptides. Genes coding for PIs are being introduced into oilseed rape plants to target the digestive enzymes of insect pests, aiming to cause starvation and death following ingestion.

Harvesting

Harvesting may be accomplished through direct combining or by swathing prior to combining. Frequently, a desiccant herbicide (e.g. diquat) may be applied prior to direct combining.

Crop Protection

Pest control

In conventional rape crops, the main threat from pests arises from slugs, wood pigeons and various insects, notably cabbage seed weevil, cabbage stem flea beetle, cabbage stem weevil (*Ceutorhynchus pallidactylus*), pollen beetle and rape stem weevil. Slug control is obtained using molluscicide pellets applied before or after sowing during crop establishment. Chemical control of insect pests is now dominated by synthetic pyrethroid insecticides. In many countries there is a large element of prophylactic insecticide use against cabbage stem flea beetle in the autumn, ceutorhynchid stem weevils in the late winter or early spring, and pollen beetle and cabbage seed weevil in the spring. For further details see Chapter 2.

Disease control

The main diseases, often requiring treatment in the autumn, are canker (*Leptosphaeria maculans*, anamorph: *Phoma lingam*) and light leaf spot (*Pyrenopeziza brassicae*, anamorph: *Cylindrosporium concentricum*). Canker causes leaf spotting over the winter period and, later, cankers on the stem. During the autumn/winter period this disease is commonly referred to as 'phoma leaf spot'. Stem canker causes premature ripening and weakening of the stem, and this can cause lodging. In conventional crops, a conazole or a triazole fungicide is often applied as a spray in November, with a repeat application in spring (late February or early March) at early stem extension. During the spring/summer period, treatment is often required against alternaria (*Alternaria brassicae*) and sclerotinia stem rot (*Sclerotinia sclerotiorum*) (but not in Sweden or Finland). Sclerotinia control is of prime concern, and tends to dominate fungicide treatment decisions in the spring. Sclerotinia fungicides are often tank-mixed with insecticides applied for cabbage seed weevil control, although in some countries (e.g. Sweden) this is not allowed. Frequently used sclerotinia sprays include formulated mixtures containing an MBC compound. Alternatively, products such as a protectant dicarboximide fungicide may be applied. Crops are not often sprayed for alternaria alone, as the broad-spectrum fungicides applied against sclerotinia also provide control of this disease. For further details, see Lane & Gladders (2000).

Weed control

In conventional crops of winter oilseed rape, herbicides are applied during the autumn months to control broad-leaved weeds, grass weeds and volunteer cereals. The control of volunteer cereals is of primary concern. In some countries, including the UK, a residual anilide herbicide may be applied pre-emergence to control broad-leaved weeds. The additional use of a post-emergence graminicide may be required to control grass weeds and volunteer cereals. Alternatively, residual, pre-emergence herbicides (such as a residual amide herbicide) may be used in some countries for broad-spectrum weed control. For further details see, for example, Naylor (2002).

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2
Insect Pests of Oilseed Rape Crops

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Introduction

In northern Europe, oilseed rape is attacked by a wide range of insect pests. Some of these pests occur virtually wherever the crop is grown, whereas others have a more limited distribution. No pests are specific to oilseed rape, but several 'rape pests' are restricted to brassicaceous plants, including seed crops, forage crops, vegetable brassicas and wild hosts such as charlock (*Sinapis arvensis*).

In addition to insects, various nematodes are recorded as pests of oilseed rape. These include beet cyst nematode (*Heterodera schachtii*), brassica cyst nematode (*H. cruciferae*), needle nematodes (*Longidorus* spp.) and stubby-root nematodes (*Paratrichodorus* spp. and *Trichodorus* spp.). Slugs, especially field slug (*Deroceras reticulatum*), and wood pigeons (*Columba palumbus*) can also be of importance, especially in autumn and early winter. Apart from brief mention under integrated crop management (ICM) (Chapter 3) and passing mention in Chapter 16, non-insect pests are not discussed in this monograph.

Major pests

The following pests are considered of particular importance on oilseed rape crops in Europe, although not necessarily in all regions:

- brassica pod midge – *Dasineura brassicae*
- cabbage seed weevil – *Ceutorhynchus assimilis*
- cabbage stem flea beetle – *Psylliodes chrysocephala*
- cabbage stem weevil – *Ceutorhynchus pallidactylus*
- pollen beetles – *Meligethes* spp. (especially *M. aeneus*) [Note 1]
- rape stem weevil – *Ceutorhynchus napi*

Note 1. In this monograph, where the term 'pollen beetle' is used in the singular, reference to *M. aeneus* should be inferred.

The majority of observations on the biocontrol of oilseed rape pests relate to these species, and accounts of their natural enemies form the basis of the present monograph.

Minor pests

Several other insect pests occur in oilseed rape crops, but they are usually of only minor importance. These include:

- cabbage aphid – *Brevicoryne brassicae*
- cabbage flea beetles – *Phyllotreta* spp.
- cabbage root fly – *Delia radicum*
- peach/potato aphid – *Myzus persicae*
- rape winter stem weevil – *Ceutorhynchus picitarsis*
- turnip sawfly – *Athalia rosae*

In some situations, all of the above-listed species can be of some significance on oilseed rape. The two aphid species, for example, are potentially important vectors of virus diseases in autumn-sown (i.e. winter) rape crops. Further, larvae of cabbage root fly and adults of cabbage flea beetles can be a problem at establishment, especially on spring-sown oilseed rape. At least in France, weevils of the genus *Baris* are also associated with oilseed rape crops. Further details are given below.

Some insect pests, although very occasionally reported on oilseed rape crops, are of little or no importance and, in any case, are not primarily associated with them. Examples are given in Table 2.1. For further details of most of these species, which are not considered in any depth in the present monograph, see Alford (1999).

Incidental pests

A small number of non-specific, polyphagous pests may attack oilseed rape crops. These include: cutworms, e.g. the larvae of turnip moth, *Agrotis segetum* (Lepidoptera: Noctuidae); leatherjackets [the larvae of crane flies such as *Tipula oleracea* (Diptera:

Table 2.1 Examples of pests found on oilseed rape crops but associated mainly with other brassicaceous hosts.

Vernacular name	Scientific name	Order: Family
blue stem weevil	*Ceutorhynchus sulcicollis* (Paykull)	Coleoptera: Curculionidae
cabbage moth	*Mamestra brassicae* (Linnaeus)	Lepidoptera: Noctuidae
diamond-back moth	*Plutella xylostella* (Linnaeus)	Lepidoptera: Yponomeutidae
field thrips	*Thrips angusticeps* Uzel	Thysanoptera: Thripidae
green-veined white butterfly	*Pieris napi* (Linnaeus)	Lepidoptera: Pieridae
large white butterfly	*Pieris brassicae* (Linnaeus)	Lepidoptera: Pieridae
mustard beetle	*Phaedon armoraciae* (Linnaeus)	Coleoptera: Chrysomelidae
small white butterfly	*Pieris rapae* (Linnaeus)	Lepidoptera: Pieridae
swede midge	*Contarinia nasturtii* (Kieffer)	Diptera: Cecidomyiidae
turnip gall weevil	*Ceutorhynchus pleurostigma* (Marsham)	Coleoptera: Curculionidae
turnip root fly	*Delia floralis* (Fallén)	Diptera: Anthomyiidae
larva = a leaf miner	*Scaptomyza flava* (Fallén)	Diptera: Drosophilidae
larva = a leaf miner	*Scaptomyza pallida* (Zetterstedt)	Diptera: Drosophilidae
larva = cabbage leaf miner	*Phytomyza rufipes* Meigen	Diptera: Agromyzidae

Tipulidae)], mirid bugs (Heteroptera: Miridae, e.g. *Closterotomus norvegicus* and *Lygus rugulipennis*) (Hoßfeld, 1963) and wireworms [the larvae of click beetles such as *Agriotes lineatus* (Coleoptera: Elateridae)]. They are not considered further in this monograph.

The pest complex on winter and spring rape

Although some pests may occur on both winter rape and spring rape, owing to their phenology several pests occur only (or mainly) on one or the other. Also, as indicated in the previous chapter, the greater potential for a winter crop to compensate for pest damage can affect the relative importance of certain pests. The relative importance of the main pests of oilseed rape is summarized in Table 2.2.

Nomenclature of the Pests

Over the past many years, various scientific and vernacular names have been used in the literature for one and the same species of oilseed rape pest, and this has been at the very least a potential cause of confusion. To maintain an element of standardization, the names used in this monograph are those adopted and advocated by participants in the 1997–1999 EC-funded BORIS project (see Preface).

Scientific names

The following are the generally accepted scientific names for the main insect pests of oilseed rape mentioned in this monograph:

Table 2.2 Relative importance of the main pests of oilseed rape in Europe.

Pest	Winter rape	Spring rape
Baris weevils	– [Note 1]	×
brassica pod midge (*Dasineura brassicae*)	+	+
cabbage aphid (*Brevicoryne brassicae*)	(+)†	(+)
cabbage flea beetles (*Phyllotreta* spp.)	–	(+)
cabbage root fly (*Delia radicum*)	–	(+)
cabbage seed weevil (*Ceutorhynchus assimilis*)	+	+
cabbage stem flea beetle (*Psylliodes chrysocephala*)	+	×
cabbage stem weevil (*Ceutorhynchus pallidactylus*)	(+)	(+)
peach/potato aphid (*Myzus persicae*)	†	–
pollen beetles (*Meligethes* spp.)	+ [Note 2]	+
rape stem weevil (*Ceutorhynchus napi*)	+	×
rape winter stem weevil (*Ceutorhynchus picitarsis*)	(+)	×
turnip sawfly (*Athalia rosae*)	–	(+)

+ Often damaging in areas where it occurs.
(+) Occasionally or locally damaging.
– Present but of little or no importance.
† Potentially important as a virus vector.
× Not present.

Note 1. Recorded mainly in France.
Note 2. Rarely of significance on winter oilseed rape in the UK.

Order HEMIPTERA	
Family APHIDIDAE	*Brevicoryne brassicae* (Linnaeus)
	Myzus persicae (Sulzer)
Order COLEOPTERA	
Family NITIDULIDAE	*Meligethes* spp., e.g. *M. aeneus* (Fabricius) and to a lesser extent *M. viridescens* (Fabricius)
Family CHRYSOMELIDAE	*Phyllotreta* spp., e.g. *P. nemorum* (Linnaeus)
	Psylliodes chrysocephala (Linnaeus)
Family CURCULIONIDAE	*Baris* spp., e.g. *B. coerulescens* Scopoli
	Ceutorhynchus assimilis (Paykull) [Notes 1 and 2] syn. *Ceutorhynchus obstrictus* (Marsham)
	Ceutorhynchus napi Gyllenhal [Note 2]
	Ceutorhynchus pallidactylus (Marsham) [Notes 1 and 2] syn. *Ceutorhynchus quadridens* (Panzer)
	Ceutorhynchus picitarsis Gyllenhal [Note 2]
Order DIPTERA	
Family CECIDOMYIIDAE	*Dasineura brassicae* (Winnertz)
	syn. *Dasyneura brassicae* (Winnertz)
Family ANTHOMYIIDAE	*Delia radicum* (Linnaeus)
	syn. *Chortophila brassicae* (Bouché)
	syn. *Delia brassicae* (Bouché)
	syn. *Delia brassicae* (Weidemann)
	syn. *Erioischia brassicae* (Bouché)
	syn. *Erioischia brassicae* (Weidemann)
	syn. *Phorbia brassicae* (Bouché)
	syn. & misspelling: *Hylemyia brassicae* (Bouché)
Order HYMENOPTERA	
Family TENTHREDINIDAE	*Athalia rosae* (Linnaeus)
	syn. *Athalia colibri* (Christ)

Note 1. See comments on homonyms, below.

Note 2. *Ceuthorrhynchus* or *Ceuthorhynchus* appear frequently in the literature, including many well-known reference works (e.g. Ritter, 1916; Balachowsky, 1963; Schmidt, 1970), but are misspellings.

Vernacular names

The English vernacular names adopted in this monograph for insect pests of oilseed rape are listed below; examples of vernacular names in several other European languages are also given:

Athalia rosae	English:	Turnip sawfly
	French:	Tenthrède de la rave
	German:	Rübsenblattwespe
	Danish:	Kålbladhveps

	Swedish:	Kålbladstekel
	Finnish:	Rapsipistiäinen
Baris spp.	English:	–
	French:	Baris des crucifères
	German:	Spitzmaulrüßler
	Danish:	–
	Swedish:	–
	Finnish:	–
Brevicoryne brassicae	English:	Cabbage aphid
	French:	Puceron cendré du chou
	German:	Mehlige Kohlblattlaus
	Danish:	Kålbladlus
	Swedish:	Kålbladlus
	Finnish:	Kaalikirva
Ceutorhynchus assimilis	English:	Cabbage seed weevil [Note 1]
	French:	Charancon des siliques
	German:	Kohlschotenrüßler
	Danish:	Skulpesnudebille
	Swedish:	Blygrå rapsvivel
	Finnish:	Rapsikärsäkäs
Ceutorhynchus napi	English:	Rape stem weevil
	French:	[Gros] Charancon de la tige du colza
	German:	Großer Rapsstängelrüßler
	Danish:	–
	Swedish:	–
	Finnish:	–
Ceutorhynchus pallidactylus	English:	Cabbage stem weevil [Note 2]
	French:	Charancon de la tige du chou
	German:	Gefleckter Kohltriebrüßler
	Danish:	Bladribbesnudebille
	Swedish:	Fyrtandad rapsvivel
	Finnish:	–
Ceutorhynchus picitarsis	English:	Rape winter stem weevil
	French:	Charancon du bourgeon terminal
	German:	Schwarzer Kohltriebrüßler
	Danish:	–
	Swedish:	–
	Finnish:	–
Dasineura brassicae	English:	Brassica pod midge [Note 3]
	French:	Cécidomyie des siliques
	German:	Kohlschotenmücke
	Danish:	Skulpegalmyg

	Swedish:	Skidgallmygga
	Finnish:	Litusääski
Delia radicum	English:	Cabbage root fly
	French:	Mouche du chou
	German:	Kleine Kohlfliege
	Danish:	Lille kålflue
	Swedish:	Liten kålfluga
	Finnish:	Pikkukaalikärpänen
Meligethes spp.	English:	Pollen beetles [Note 4]
	French:	Méligèthes des crucifères
	German:	Rapsglanzkäfer
	Danish:	Glimmerbøsse
	Swedish:	Rapsbaggar
	Finnish:	Rapsikuoriainen
Myzus persicae	English:	Peach/potato aphid [Note 5]
	French:	Puceron vert du pêcher
	German:	Grüne Pfirsichblattlaus
	Danish:	Ferskenbladlus
	Swedish:	Persikbladlus
	Finnish:	Persikkakiva
Phyllotreta spp.	English:	Cabbage flea beetles [Note 6]
	French:	Altises des crucifères/Petites altises
	German:	Kohlerdflöhe
	Danish:	Jordlopper
	Swedish:	Vanliga jordloppor
	Finnish:	Kirppa
Psylliodes chrysocephala	English:	Cabbage stem flea beetle
	French:	Altise d´hiver du colza/Grosse altise
	German:	Rapserdfloh
	Danish:	Rapsjordloppe
	Swedish:	Rapsjordloppa
	Finnish:	Rapsikirppa

Note 1. Acceptably abbreviated to 'seed weevil' in English advisory literature.

Note 2. Acceptably abbreviated to 'stem weevil' in English advisory literature, but care must be taken to avoid confusion with related species, notably 'rape stem weevil', and with the use of the term 'stem weevils' in a wider (i.e. non-specific) sense.

Note 3. Acceptably abbreviated to 'pod midge' in English advisory literature.

Note 4. *Meligethes aeneus* is often, acceptably, cited as 'pollen beetle' and *M. viridescens* as 'bronzed pollen beetle'.

Note 5. Use of a solidus (forward slash), as opposed to a hyphen or an en-dash, is preferred (see Alford, 1999).

Note 6. Acceptably abbreviated to 'flea beetles' where this does not cause confusion.

Homonyms

Recent proposed name changes for various species within the family Curculionidae include two well-known insect pests of oilseed rape, namely:

Ceutorhynchus assimilis (Paykull, 1792) **HOMONYM** [= cabbage seed weevil] syn. *obstrictus* (Marsham, 1802)
Ceutorhynchus quadridens (Panzer, 1795) **HOMONYM** [= cabbage stem weevil] syn. *pallidactylus* (Marsham, 1802)

This issue is of considerable significance with regards insect pests of oilseed rape because the names *obstrictus* Marsham (for *assimilis* Paykull) and *pallidactylus* Marsham (for *quadridens* Panzer) have been given priority by Colonnelli (1983, 1990); this usage has been followed in *Die Käfer Mitteleuropas* (Lohse & Lucht, 1994), the latter publication subsequently having resulted in their wider uptake, particularly in continental Europe.

Two observations are worthy of mention:

a) Until the publication of *Die Käfer Mitteleuropas*, the name *Ceutorhynchus obstrictus* (for cabbage seed weevil) appears virtually unused in entomological literature, and the name is certainly unknown to the vast majority of applied entomologists. On the other hand, a very large number of scientific and popular articles have been published on, or have made reference to, cabbage seed weevil – all under the name of *Ceutorhynchus assimilis*, without any mention of *obstrictus* as a synonym or otherwise.
b) The name *Ceutorhynchus pallidactylus* has been used occasionally in applied entomological literature, although until now it has usually been relegated to a synonym of *Ceutorhynchus quadridens* (e.g. by Seymour, 1989) – publications on this pest (usually as *C. quadridens* but sometimes as *C. pallidactylus*) are relatively infrequent.

In line with the comments on homonyms by Pope (1977), there would appear no good reason to adopt *obstrictus* at the expense of *assimilis*. Indeed, the confusion generated by so doing would be enormous. Further, UK taxonomists have in any case expressed doubt about the validity of using the name *obstrictus* for *assimilis*. A case to resist the change from *quadridens* to *pallidactylus* for cabbage stem weevil is less strong as, here, many of the objections to the adoption of the name *obstrictus* for cabbage seed weevil do not apply.

Therefore, within this monograph the name *Ceutorhynchus assimilis* is maintained for cabbage seed weevil; *C. obstrictus* is treated as a synonym. For cabbage stem weevil, however, the name *Ceutorhynchus pallidactylus* is adopted and *C. quadridens* treated as a synonym. To avoid unnecessary confusion in the crop protection literature, it is advocated strongly that this approach be taken by other applied entomologists when citing these pests.

Pest Status and Phenology

The following is a brief account of the status and lifecycles of the main pests associated with oilseed rape crops in Europe. For extensive information on the coleopterous pests of oilseed rape, which form the bulk of harmful insects associated with the crop, reference should be made to Balachowsky (1962, 1963). See also Paul (1992), Paul & Rawlinson (1992), Ekbom (1995), Garbe *et al*. (1996), Alford (1999) and Lane & Gladders (2000).

Inflorescence and bud pests

Brassica pod midge

This is a potentially important pest throughout Europe. Adults (Fig. 2.1) appear from mid-May onwards, emerging from cocoons in fields that grew oilseed rape in the previous four years (C. Nilsson, *unpublished*). Mating takes place at the emergence site and mated females migrate to rape crops. Adults live for only a few days. Eggs are deposited in batches of 20–30 in pods previously damaged by other pests, particularly cabbage seed weevils, utilizing in the first place weevil feeding punctures and, later in the season, larval exit holes. The midge eggs hatch a few days later. The larvae then feed gregariously on the inner wall of the pod for up to a month. Infested pods are discoloured and distorted, and may appear bloated (hence the name 'bladder pod midge', which has often been applied to this pest), although this symptom seems to be less evident in modern-day oilseed rape cultivars. Midge-infested pods split open or shatter prematurely to release the fully grown larvae, and this results in considerable loss of seed and, hence, crop yield. On falling to the ground, the larvae burrow beneath the soil to a depth of 5 cm or less, where they spin small silken cocoons in which to pupate. Some larvae pupate immediately, giving rise to adults about two weeks later, but an increasing proportion of the larvae enters winter diapause with each successive generation (Buhl, 1960; Czajkowska, 1978). The winter is spent as larvae within cocoons, pupation taking place in the spring just before adult emergence. The number of generations on winter oilseed rape is restricted to two, but, under favourable conditions and situations, the pest is capable of producing at least a partial third, especially when winter and spring rape are grown in the same area (Williams *et al*., 1987a, 1987b). Infestations are often most severe on the headlands of crops, and also especially important on spring-sown crops, as in Sweden. The adult midges are weak fliers and the mated females usually disperse no more than a few hundred metres from their emergence sites.

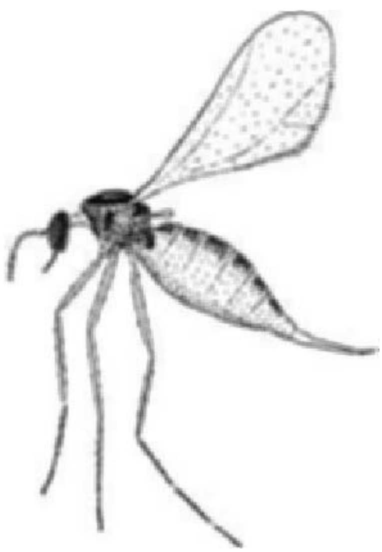

Fig. 2.1 Female brassica pod midge (*Dasineura brassicae*) (×20).

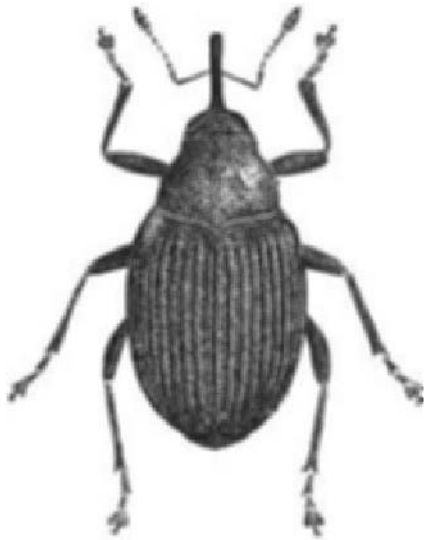

Fig. 2.2 Cabbage seed weevil (*Ceutorhynchus assimilis*) (×18).

Cabbage seed weevil

This widely distributed weevil (Fig. 2.2) is a major pest in both Europe and North America. It is of importance as a primary pest and also because its activities can predispose pods to subsequent invasion by brassica pod midge (see above). Adult weevils emerge from their overwintering sites during the flowering stage of winter rape. They feed on the developing pods, in which mated females eventually deposit eggs, typically one per pod. Following oviposition, the pod is 'marked' with a pheromone to deter egg-laying by rival females (Ferguson *et al*., 1999). Eggs hatch one to two weeks later. Each larva then attacks the developing seeds, usually destroying about five seeds before becoming fully grown. It then bores through the wall of the pod, leaving a distinct emergence hole about the size of a pinhead. Individuals drop to the ground and pupate in the soil, new adults emerging from late July onwards. These new adults feed briefly on various brassicaceous plants, sometimes damaging nearby vegetable brassica crops such as broccoli and cabbage, and then hibernate in the shelter of perennial vegetation and leaf litter of field margins and woodlands. There is one generation annually.

Pollen beetles

Pollen beetles (notably *Meligethes aeneus*) (Fig. 2.3) are generally abundant throughout Europe on both winter and spring rape, but are usually more important on the latter crop. The adult beetles, which hibernate in woods and other sheltered sites, emerge in the spring and migrate to winter rape fields when air temperatures exceed 12–15°C. They feed on pollen from most plants, but eggs are laid only in buds of brassicaeous plants and when the buds are at least 3 mm long. The eggs hatch after a few days. Larvae, which pass through two instars, then feed on pollen before eventually dropping to the ground to pupate in the soil. The development from egg to new adult takes about a month and new adults appear from the middle of the summer, when they congregate on the flowers of various plants before eventually overwintering. There is just one generation annually.

Fig. 2.3 Pollen beetle (*Meligethes aeneus*) (×25).

Adult and larval damage can result in the presence of blind stalks (in place of pods) on the developing racemes. Damage caused by the beetles triggers a compensation reaction from the plant, which leads to an increased production of new racemes and buds. There is then often a normal, final pod number even after extensive damage. In many cases this results in pod filling becoming unsynchronized with the photosynthetic area of the plant; this leads to a lower seed number per pod and, later, to compensate for this, a slightly higher 'thousand kernel' weight. Backward crops, and spring crops with a faster development than winter crops, suffer most. Crops are particularly susceptible at the early bud stages and become less and less sensitive as the plants develop (Nilsson, 1988, 1994). At flowering, control measures are rarely implemented (Nilsson, 1987). Winter rape is often past the susceptible bud stages before the main invasion of beetles to the crop occurs. Pollen beetles are of particular importance in countries, such as Finland and Sweden, where spring rape dominates. Although *M. aeneus* is the dominant species on oilseed rape, *Meligethes viridescens* also occurs, but, compared with *M. aeneus*, requires higher temperatures for both oviposition and development (Fritzsche, 1957). In Scandinavia and central Europe, other species of *Meligethes* on oilseed rape are usually present in only small numbers (Nolte & Fritzsche, 1952; Jurek, 1972; Karltorp & Nilsson, 1981).

Stem borers

Cabbage stem flea beetle

Cabbage stem flea beetle (Fig. 2.4) is an important pest of winter rape; spring-sown crops are not attacked. The pest is widely distributed in northern parts of Europe with a maritime climate. It also occurs in Asia, Canada and North Africa (Balachowsky, 1963; Bonnemaison, 1965). At least in central parts of northern Europe it has a cyclic appearance with peaks in populations at intervals of about seven years. Its importance as a pest in the British Isles, however, has declined following the extensive use of autumn-applied pyrethroid insecticides.

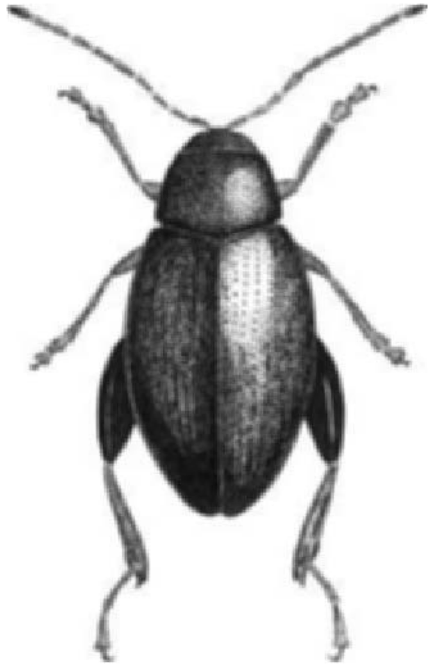

Fig. 2.4 Cabbage stem flea beetle (*Psylliodes chrysocephala*) (×12).

Young adults appear in the summer at about harvest time. Shortly afterwards they enter a period of aestivation, reappearing and then invading newly germinating autumn-sown rape crops from late August or early September onwards. Adults on the young winter crop are usually most abundant during September and October, but if conditions are favourable individuals may survive in decreasing numbers throughout the winter period. Adults graze the tissue of host plants and can cause considerable damage to the leaves and cotyledons of slowly growing plants. Eggs are laid in the soil, close to host plants, mainly during September and October. Under favourable weather conditions, oviposition continues throughout the winter up to the spring (Schulz, 1985). Eggs hatch from late September onwards, the duration of incubation varying considerably according to temperature (Bonnemaison & Jourdheuil, 1954; Alford, 1979). The young larvae bore into the petioles, where they form extensive galleries. Infestations may also spread to the stems and growing points. The larvae feed gregariously and heavy infestations can result in considerable crop damage (Graham & Alford, 1981; Ballanger, 1984; Lane & Cooper, 1989; Nilsson, 1990; Winfield, 1992). Feeding continues throughout the winter period and is completed in the spring, in some years as late as the end of May or in early June. Fully fed larvae (then in their third and final instar) pupate in the soil, a few centimetres from the surface. There is just one generation annually. For further details see, for example, Günthardt (1949), Dosse (1951) and Ballanger (1984).

Cabbage stem weevil

Adults of this generally common and widely distributed weevil (Fig. 2.5) appear from the bud stages of winter rape onwards. They then invade brassicaceous plants, including oilseed rape. Eggs are laid in small groups, preferably in the underside of petioles and,