The cabbage seedpod weevil, *Ceutorhynchus obstrictus* (Coleoptera: Curculionidae) - a review

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ABSTRACT

The cabbage seedpod weevil, *Ceutorhynchus obstrictus* (Marsham), which has recently become established in southern Alberta, is a serious pest of oilseed rape (*Brassica napus* L.) in Europe and the USA and poses a major threat to the economic sustainability of canola production in western Canada. This paper reviews the biology and control of this pest and identifies future research needs. Control strategies in Europe and the USA have so far relied on insecticides because no cultural or biological control methods have been successful. Research on plant resistance is in progress at several research centres and could provide the long term solution. Several parasitoid species are known to suppress populations of the weevil in Europe and are candidates for biocontrol programs in North America. Current research priorities in western Canada are to quantify the effects of weevil densities on canola seed yield, to establish economic thresholds and to design control strategies that integrate chemical, cultural and biological controls. Research programs should be established to screen a wide range of *Brassica* germplasm to identify sources of resistance for use in developing resistant cultivars for western Canada. Research on the overwintering ecology and seasonal activity of this weevil is needed to model how its range is likely to expand to other canola growing regions of Canada and to enable forecasting of outbreaks.

Key words: *Brassica*, oilseed rape, Ceutorhynchinae, *Ceutorhynchus assimilis*, *Ceutorhynchus obstrictus*, canola insect pests

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INTRODUCTION

The cabbage seedpod weevil, *Ceutorhynchus obstrictus* (Marsham) (Coleoptera: Curculionidae) was first detected in southern Alberta in 1995 (Butts and Byers 1996). By 2000, the weevil had become a major pest of canola[2] throughout southern Alberta (Dosdall *et al.* 2001) and had spread eastward into adjacent areas of Saskatchewan (Fig.1). *Ceutorhynchus obstrictus* poses a serious threat to the canola industry in western Canada and has prompted provincial and federal entomologists to initiate research programs to develop effective management strategies. This paper reviews the history and biology of the cabbage seedpod weevil, its damage, and strategies for its control. We also propose research priorities that will enable more effective and sustainable management of this pest.

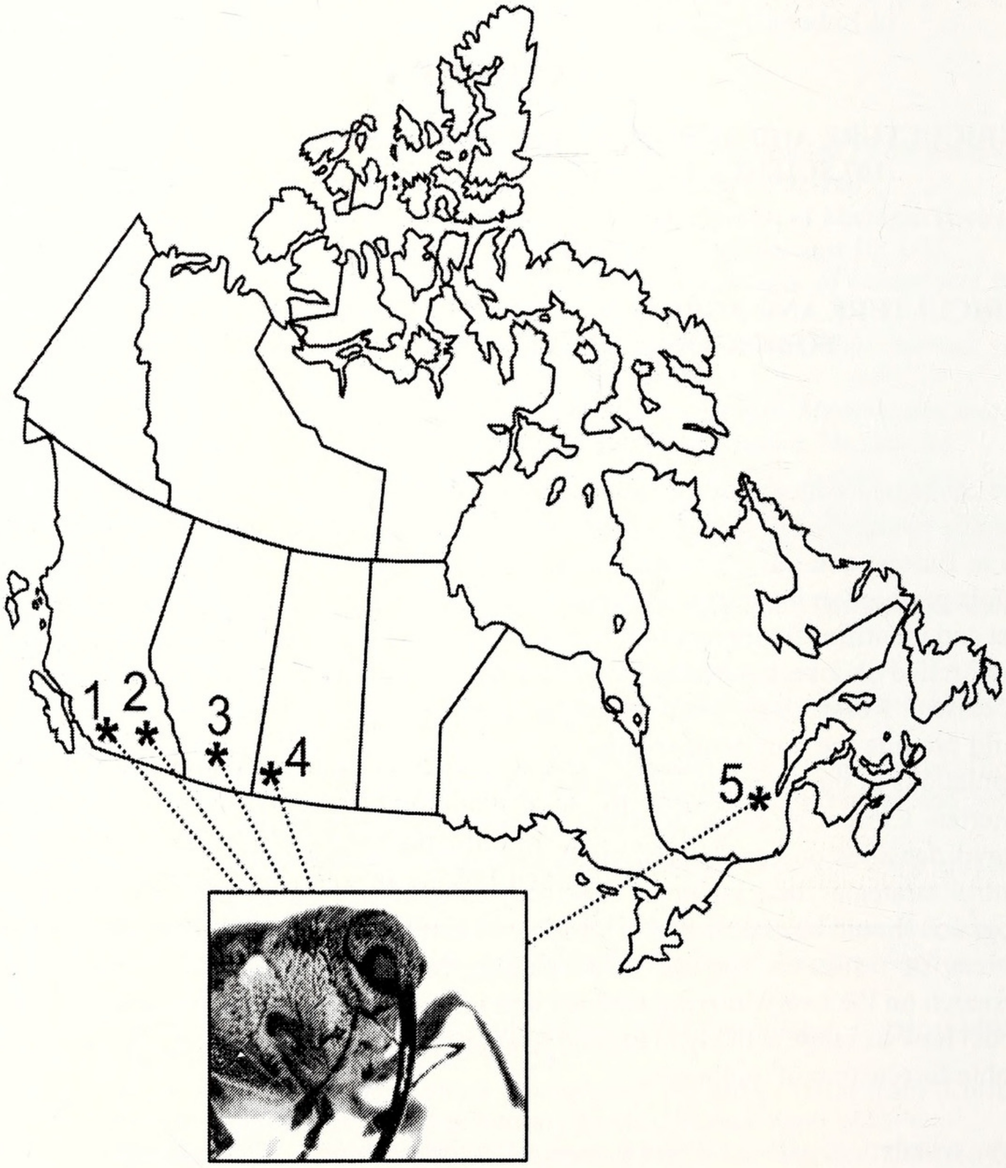

Figure 1. Distribution of the cabbage seedpod weevil in Canada as of 2000.
References: 1) McLeod 1953; 2) Philips 2000; 3) Dosdall *et al.* 2001; 4) Olfert unpublished data; 5) Brodeur *et al.* 2001. Photo by Eric Kokko, AAFC, Lethbridge, AB

[2] Canola is the term used for cultivars of oilseed rape (*Brassica napus* L. and *B. rapa* L.) that are low in erucic acid and glucosinolate; attributes desirable for the production of food grade vegetable oil and livestock meal.

HISTORY

As recommended by Colonnelli (1990, 1993) the name *C. obstrictus* Marsham will be used in this paper instead of the synonym, *C. assimilis* Paykull, used in most previous publications on this species. The cabbage seedpod weevil (CSW), also known as the turnip seed weevil or seed weevil in Europe, has been recognized as a pest of crucifers from the Mediterranean to Scandinavia since the beginning of the 19th century (Bonnemaison 1957). In North America, it was first recorded near Vancouver, British Columbia in 1931 (Baker 1936; McLeod 1953) and is now well established in the interior in both the Okanagan and Creston valleys (Philips 2000). By 1946 it had spread throughout the Pacific North-West and California (Hagen 1946, Crowell 1952). It is well established in Georgia (Buntin 1990) and Tennessee (Boyd and Lentz 1994) and probably now occurs throughout most of the USA. In 2000 it was found in Quebec (Brodeur *et al.* 2001).

BIOLOGY

Ceutorhynchus obstrictus is univoltine with the adults overwintering under leaf litter in treed areas, shelterbelts and field margins (Dmoch 1965a). A chill period of about 16 weeks at 4°C is required to break diapause (Ni *et al.* 1990). The adults, which are strong fliers, disperse from the overwintering habitats in spring when air temperatures reach 15°C (Ankersmit and Nieukerken 1954; Dmoch 1965a). They feed on the buds and flowers of various crucifers for several weeks before they start to oviposit (Doucette 1947; Dmoch 1965a; Ni *et al.* 1990). In southern Alberta they are abundant on early flowering cruciferous weeds, especially flixweed (*Descurania sophia* L. Webb) and hoary cress (*Cardaria draba* L. Desv.), until canola begins to bloom. Little ovarian development occurs below 10°C or above 25°C (Ni *et al.* 1990). Weevil numbers peak when the host crop begins flowering (Dmoch 1965b; McCaffrey *et al.* 1986). The most common host crops are cultivated crucifers, including canola, other oilseed rape, cole crops (e.g. *B. oleracea* L.) and brown mustard (*B. juncea* L). Yellow (or white) mustard, *Sinapis alba* L. is not attacked (Doucette 1947). Females lay eggs singly into young pods through feeding punctures and usually only one egg is laid per pod unless weevil densities are high. After oviposition the females brush the pod with the tip of their abdomen, apparently to apply an oviposition deterrent pheromone (Kozlowski *et al.* 1983). The larvae undergo three instars and consume three to six seeds each. When mature they chew an exit hole in the wall of the pod, drop to the ground and pupate in the soil. The new generation adults emerge from 9-30 days after exit from the pods depending on temperature (Hanson *et al.* 1948; Bonnemaison 1955, 1957; Dmoch 1965a). In southern Alberta we (L.D.) have found that this sometimes takes only 7-10 days. The entire development from egg to adult usually takes 4-6 weeks (Bonnemaison 1957). The new adults can disperse several km or more in search of food, especially late maturing crucifers, to accumulate fat reserves before finding overwintering habitats in early fall (Doucette 1947).

DAMAGE, ECONOMIC THRESHOLDS AND SAMPLING

Cabbage seedpod weevils can significantly reduce the seed yield of canola in several ways. Feeding by the overwintered adults on buds and flowers in the spring and early summer causes blossom blasting and pod abortion which may reduce the yield by up to 14% (Coutin *et al.* 1974). However, under good growing conditions canola plants can compensate for up to 60% loss of buds and flowers (Williams and Free, 1978, 1979; Free *et al.* 1983). Reduced yield can also occur as a result of interaction between the feeding or oviposition activity of the CSW adults and other insect pests. In Europe, CSW feeding punctures are used for oviposition by the pod midge, *Dasyneura brassicae* Winn. (Free *et al.* 1983). Seed losses are considerably higher when both pests occur together and as a consequence, the economic threshold for CSW adults in England is only one per plant (Free *et al.* 1983). The feeding punctures can also be used by other small insects, such as thrips, to gain access to the seeds; without the weevils, thrips feed only on the surface of the pods and cause little damage (K.M. Fry, 2000, Alberta Research Council, personal communication). This interaction might potentially be a problem in those regions where thrips are sometimes abundant in canola during flowering. Under moist conditions a reduction in seed yield and quality can also result from fungal pathogens that gain entry through the feeding punctures or larval exit holes.

The principal damage caused by CSW occurs during the larval stages (McCaffrey *et al.* 1986; Buntin 1999). Depending on seed size, three to six seeds are consumed by each larva (Dmoch 1965a) or about 20 to 30% of the seeds in each pod. With high weevil densities two to three larvae may infest a pod and consume most of the seeds. Additional losses occur at harvest because infested pods ripen prematurely and tend to shatter prior to or during harvest.

Late seeded or late maturing canola can be seriously damaged in late summer or early fall by new generation adults feeding through the pod wall on the immature seeds. Buntin *et al.* (1995) found that in Georgia and Idaho feeding by adults reduced the weight of punctured seeds by about 16% and the oil content by about 2%. The incidence of damaged seed ranged from 8 to 17% in untreated fields in Georgia and 5 to 10% in fields treated with insecticide in Idaho. Although the overall yield loss was less than 2%, a 40% decrease in germination of the damaged seed and a high incidence of abnormal seedlings, would be of concern for certified seed producers.

The relationship between weevil densities and yield loss has been little studied although this relationship is necessary for establishing economic thresholds. Studies in Scandinavia showed a clear negative relationship between weevil densities and yield (Tulisalo *et al.* 1976; Sylven and Svenson 1975). In Tulisalo's cage study, two weevils per plant reduced yield by 50% and they estimated that one weevil per four plants warranted the use of an insecticide. They found that at high weevil densities the plants attempted to compensate by producing more pods, but this was more than offset by a reduction in the average seed weight.

The presence of other pests can also affect the economic threshold for CSW. Free *et al.* (1983) determined that, in England, densities below one weevil per plant caused pod infestation rates of less than 26% and on their own did not warrant control. However, in the presence of the pod midge, *Dasyneura brassicae*, losses were much higher and control at lower weevil densities was warranted. Other studies in France (Lerin 1984) and the USA (Buntin 1999) have also found that, because of plant compensation, there is little yield loss at pod infestation levels below about 25%. Although the CSW has been a serious pest of winter canola in the US Pacific Northwest, no economic threshold has been established. However, preliminary studies from Idaho indicate that three to six weevils per 180° sweep with a standard 38 cm diameter sweep net warrants control because at these population levels yields in unsprayed plots were 15 to 35% lower than in sprayed plots (McCaffrey *et al.* 1986). A similar threshold of three to four weevils per sweep is being used in southern Alberta (Dosdall *et al.* 2001) until results from current cage and plot studies are available.

Sampling methods vary with the objective of the investigation. For population monitoring, a sweep net is normally used. Dmoch (1965a,b) determined that 4 samples of 25 sweeps each estimated weevil populations with adequate accuracy. In plot insecticide trials, the sweep net is also the usual sampling method and the number of sweeps per plot can be as low as six to eight in small plots (Buntin 1999). When the crop is fully podded and sweeping becomes difficult other methods such as dislodging the weevils into buckets or pans have been used (Brown *et al.* 1999). Yellow pan traps have been used to study the seasonal pattern of activity of seasonal activity and to monitor weevil arrival in fields (Bonnemaison 1957). Flight intercept traps have also been used to provide information about CSW spatial distribution and phenology

(Ferguson *et al.* 2000). As suggested by Dolinski (1979) we have found that pitfall traps are useful for studying the arrival of adults at, and departure from, overwintering habitats. No studies relating the results of the various trapping or sweeping methods to actual weevil densities per plant have been published. Because the weevils are concentrated on the buds and flowers in the uppermost part of the crop canopy, ongoing studies (H.A.C.) are finding the efficiency of sweep net sampling to be about twice the 10% reported for lygus bugs (Wise and Lamb 1998).

CONTROL STRATEGIES

Biological control. In Europe, and those parts of North America where it has been established for some time, the CSW is host to a number of parasitoids. Surveys in Washington (Hanson *et al.* 1948; Doucette 1948), Oregon (Doucette 1948), California (Carlson *et al.* 1951), and British Columbia (McLeod 1953) found 11 parasitoid species associated with this weevil. The pteromalid wasps, *Trichomalus perfectus* (Walker) [syn. *T. fasciatus* (Thomson)] and *Mesopolobus morys* L. (syn. *Xenocrepis pura* Mayr) were the most abundant parasitoids. *Trichomalus perfectus* and *M. morys* were also important parasitoids in northern Idaho, although the eulophid, *Necremnus duplicatus* Gahan was present in substantial numbers (Doucette 1948; Walz 1957). Recently Harmon and McCaffrey (1997) found that the introduced European braconid, *Microctonus melanopus* Ruthe, reduced survival of overwintering adult weevils in Idaho and Washington, with parasitism levels as high as 70%. In Europe, many parasitoids are known to attack the CSW (Dolinski 1979; Herting 1973; Kuhlmann and Mason 1999) with the most common being the braconids *M. melanopus* and *Diospilus oleraceus* Haliday, and the pteromalids *M. morys* and *T. perfectus* (Kuhlmann and Mason 1999, Kuhlmann *et al.* 2001).

Chemical control. Several insecticides control CSW effectively, although none are currently registered in Canada (Dosdall *et al.* 2001). Pyrethroids such as deltamethrin and alphacypermethrin are used in Europe for control of adults when the crop is at the early flowering stage (Alford *et al.* 1996). Parathion applied at the end of flowering was reported to control the larval stage of CSW in the Pacific NW of the USA and was recommended over endosulfan which was more expensive and less effective against adults (McCaffrey *et al.* 1986). In Georgia, Buntin (1999) found that the pyrethroids, bifenthrin, esfenvalerate, permethrin, and zetacypermethrin controlled CSW on winter oilseed rape more effectively than the other insecticides, including methyl parathion and endosulfan, currently registered in the USA. However, only treatment with esfenvalerate increased yield relative to untreated plots and two applications were required (Buntin 1999). However, preliminary results (H.A.C. & L.D) indicate that in most fields only one application of insecticide will be needed for control of CSW on spring canola in Canada.

Insecticide applications should, ideally, be timed to spare parasitoids and minimize disruption of biological control. Research in the UK has shown that *T. perfectus*, an ectoparasite of CSW larva, arrives in rape fields towards the end of flowering about two weeks after the weevil (Alford *et al.* 1996). Therefore, insecticide applications applied at early flowering should largely spare the parasitoid (Murchie *et al.* 1997). Buntin (1998) found that the use of esfenvalerate during bloom indirectly reduced *T. perfectus* numbers because of a reduction in the number of available hosts, but a greater proportion of the remaining host larvae were attacked. Another recent UK study (Ferguson *et al.* 2000) found that CSW tend to be spatially aggregated within fields and it might be possible to spot-spray such areas, thereby reducing mortality of beneficials. Earlier studies had shown that at low populations the weevils are aggregated along field edges (Free and Williams 1978). As part of an integrated pest management program developed in France in the 1970's, it was found that spraying only the field borders usually gave adequate control of CSW and enhanced parasitism in the rest of the field (Jourdheuil *et al.* 1974).

Cultural control. Cultural control methods for CSW have received little attention. There are no published studies on effects of rotation, intercropping, planting date or seeding rate. Because the adults disperse widely (Kjaer-Pedersen 1992), crop rotation is unlikely to reduce damage. Intercropping should be investigated because it has been shown that interplanting of canola with barley provides some protection against crucifer specialists such as flea beetles (Butts *et al.* 1999). Mixed planting with non-host crops might interfere with the chemical host finding cues used by CSW (Evans and Allen-Williams 1992). Late planted fields and experimental plots have been observed to largely escape weevil damage in southern Alberta, however, too late a seeding date exposes the crop to damage by new generation adults. Although an increase in seeding rate of canola can counteract damage by root maggots, *Delia* spp., (Dosdall *et al.* 1998) the effect of seeding rate on CSW is unknown.

Buntin (1998) investigated trap cropping as a method of managing CSW in winter oilseed rape. He used 0.35 ha plots with the peripheral 4.9 m planted with a spring cultivar (trap crop) and the rest planted with a conventional winter cultivar (main crop). Both were planted at the same time in the autumn and as a consequence the spring cultivar flowered several weeks earlier the following spring. Although weevils were more numerous in the trap crop, their control with esfenvalerate did not prevent damage and loss of yield in the unsprayed main crop. However, he speculated that trap cropping might work better at the field scale. Buechi (1990) also failed to reduce losses in oilseed rape (*B. napa)* by using turnip rape (*B. rapa*) as the trap crop. However, he did not spray the trap crop to kill the CSW adults which apparently preferred to oviposit in the oilseed rape. Ongoing studies in Alberta (Cárcamo *et al.* 2001) using an earlier flowering Polish cultivar (*B. rapa*) as the trap crop and a later flowering Argentine cultivar (*B. napa*) planted at the same time or staggered planting of the same cultivar, with the trap crop border being planted 1 to 2 weeks earlier, show that invading CSW adults are highly concentrated in the trap strips. Growers may be able to prevent damage to the main crop if the trap strip is sprayed before the CSW disperse into the later flowering main crop. Trap cropping has the potential to substantially reduce insecticide use, thereby lowering production costs and sparing nontarget species, especially pollinators and natural enemies.

Host plant resistance. The development of cultivars of canola with genetic resistance to the CSW would provide the ultimate solution. In a laboratory assay, Harmon and McCaffrey (1997) observed reduced feeding and oviposition on excised pods of a *B. rapa* line compared to two *B. napus* lines in choice tests. However, the differences were less pronounced in no-choice tests and might not be meaningful in the field.

Because yellow mustard (*S. alba)* is immune to CSW attack (Doucette 1947), hybrids of *S. alba* and *B. napus* have been produced with the expectation that these might be resistant to CSW (Brown *et al.* 1997). Although the hybrids were attacked by CSW, fewer larvae completed development in the hybrids than in the *B. napus* parent (McCaffrey *et al.* 1999). The authors attributed the effect to high concentrations of *p*-hydroxybenzyl glucosinolate inherited from the *S. alba* parent. An alternative to developing such hybrids for control of CSW is to develop cultivars of *S. alba* that produce canola quality oil. Research currently well underway at the Saskatoon Research Centre (Agriculture and Agri-Food Canada) has made good progress to developing canola quality *S. alba* lines that are better adapted than canola to the brown soil zone of Alberta and Saskatchewan and hopefully have retained the resistance to CSW.

RESEARCH PRIORITIES

Several basic and applied questions about the ability of the CSW to adapt to the Canadian prairies need answers to aid the development of sustainable management strategies. In an earlier review (Dolinski 1979) it was speculated that CSW had limited potential to become a pest of canola in western Canada because of the cold climate and apparent lack of suitable overwintering habitats. However, now that we know that it can survive here, at least in some areas, research is needed on its overwintering ecology to determine its likely range extension. Systematic surveys need to be conducted to track its spread and identify those areas where populations are increasing most rapidly. The phenology of CSW also needs to be studied in more detail to determine if it is, or can readily become, synchronized with that of canola in the more traditional production areas in the parkland ecoregions in the three prairie provinces and the Peace River region of Alberta and BC.

Of more immediate concern is the development of economic thresholds specific to the southern prairies that will enable canola growers to avoid unnecessary spraying. Detailed cage and plot experiments are required to objectively relate CSW density to seed yield and quality. Implementation of the established economic thresholds will depend on the adoption of a standardized sampling protocol. Sweep net sampling is the simplest and, although imperfect, by far the most practical method. However, conversion factors appropriate for each crop stage will be needed to relate the sweep net catches to actual CSW densities.

Interactions with other insect pests that may occur at the same time, such as lygus bugs, thrips, bertha armyworm and diamondback moth need to be investigated so that rational economic thresholds and IPM strategies for management of the insect pest complex of canola can be recommended. Insecticides known to be effective, such as pyrethroids, need to be registered, but registration should take into consideration the impact on pollinators and natural enemies. This is important because to control CSW the insecticide will probably have to be applied during flowering.

Studies should also be undertaken to further assess cultural control methods such as planting date (e.g. fall-planted spring canola), intercropping and trap cropping. Integration of appropriate cultural practices with longer-term strategies such as biological control and resistant cultivars should ensure the environmental and economic sustainability of the canola industry in Canada.

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