INDUSTRY BIOSECURITY PLAN FOR THE GRAINS INDUSTRY

THREAT-SPECIFIC CONTINGENCY PLAN

2005

COMMON NAME: Pea leaf weevil

SCIENTIFIC NAME: *Sitona lineatus Linnaeus*

SYNONYMS: *Curculio lineatus* Linnaeus, *Sitona lineata* Linnaeus, *Sitona cupreosquamosus* Goeze, *Sitona intersectus* Fourcroy, *Sitona neophytis* Herbst, *Sitona pisivora* Stephens, *Sitona squamosus* Gmelin, *Sitona griseus* Marsham, and *Sitones lineatus* Linnaeus.

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BACKGROUND

General

General background on the pea leaf weevil, *Sitona lineatus* Linnaeus (from hereon referred to as **PLW**) is given in Botha *et al*., 2004. The PLW is but one of many *Sitona* species posing a threat to the lupin and other pulse industries (family Fabaceae) in Australia. In Australia there is only one other member of the genus, namely *Sitona discoideus*.

Host range

The Larvae of the PLW attack the roots of many cultivated and wild legumes (Family Fabaceae), including *Lotus, Medicago, Pisum* and *Trifolium*. The adults prefer cultivated legumes.

Primary hosts: *Medicago sativa* (lucerne/alfalfa), *Medicago lupulina* (black medic), *Melilotus albus* (white sweet-clover), *Melilotus officinalis* (yellow sweet-clover), *Phaseolus vulgaris* (kidney bean), *Pisum sativum* (pea) and *Vicia faba* (broad bean).

Secondary hosts: *Amaranthus retroflexus* (redroot), *Arachis hypogaea* (groundnut), *Cicer arietinum* (chickpea), *Lathyrus* (peavines), *Lotus* (trefoils) such as *L. corniculatus* (bird's-foot trefoil) and *L. uliginosus* (greater lotus), *Lupinus* (lupins) such as *L. albus* (white lupin) and *L. luteus* (yellow lupin), *Onobrychis viciifolia* (sainfoin), *Trifolium* (clovers) such as *T. dubium* (yellow suckling clover), *T. fragiferum* (strawberry clover), *T. hybridum* (alsike clover), *T. incarnatum* (crimson clover), *T. pratense* (purple clover) and *T. repens* (white clover), *Vicia* (Vetch) such as *V. sativa* (common vetch) and *V. villosa* (hairy vetch).

Wild hosts: *Cytisus* (broom), *Robinia pseudoacacia* (black locust) and many others.

Part of plant/commodity affected

Leaves, shoots and roots

BIOLOGY

Identification

The egg is globular, 0.3 mm in diameter, ivory-white when first laid, and then blackens rapidly. Eggs are deposited singly, in small groups on the leaves or at the foot of the host plants. Larvae are milky-white, legless, curved (C-shaped), 5.5-6.5 mm in length, and with the head yellowish-brown and round. The pupa is white, and 3.5-5.5 mm in length. The adult is a slender, greyish-brown weevil about 5 mm long, with three light, inconspicuous lengthwise stripes on its thorax and wing covers. Wing covers are marked lengthwise by parallel striations. *Vide* Botha *et al*. (2004) and Emery *et al*., (2005) for images of damage and life stages.

The above dorsal and lateral view of the adult are copies from the Australian Pest & Disease Image Library http://www.planthealthaustralia.com.au/padil/

Symptoms

Adult feeding damage is characteristic, consisting of notches in the leaf margins, cut in close sequence and producing a scalloped effect. In most instances only minor damage occurs, but severe ragging of the leaves or complete defoliation can occur during heavy infestations. Although injury done by the adults is most obvious, larval damage is more serious and destroys nitrogen root nodules and roots of legume crops. The young larvae feed on nodules by chewing a hole through one end and consuming the contents.

Life history

The incubation period for PLW occurring in the Northern Hemisphere lasts about 3 weeks. Larval development takes 30-60 days, according to the ambient temperature. Eggs are laid in the soil near the plants, and the larvae move to the roots and feed principally on the nodules. There may be one or two generations per year. Mature larvae pupate in the soil. New adults begin to emerge from the soil, fly intensively for several weeks, and disperse widely in search of host plants.

A species such as *S. discoideus* (previously known as *S. humeralis*) provides a good indication of how other *Sitona* species may behave in Southern Hemisphere conditions. Its life history has been studied by Goldson *et al.* (1984) in New Zealand, Anon. (1967) in NSW, and Allen, (1971) in South Australia, which mentions that adults aestivate during summer months and then resume feeding during autumn as well as warmer periods in the winter. Based on experience with *Sitona discoideus*, the expectation is for PLW to only have one generation per year. Females become sexually mature with formation of the first eggs during April and oviposition continues throughout the winter months to mid-November for the last survivors. Adults live for about one year and most die by the end of October, with some surviving into November-December.

ESTIMATE OF ECONOMIC IMPACT ON PRODUCTION, ALLIED INDUSTRIES AND NATIVE ECOSYSTEMS

General

Field trials carried out in Germany in the early 1980's confirmed its status as a serious pest of pulse crops. Yield decline is due to the shedding of pods. The leaf-eating adults cause only a minor part of the damage, while 70-90% of losses are due to the larvae feeding on the nitrogen root nodules. If left untreated yield reduction (Fabaceae in general) could be up to 30%. These losses occur on a variety of legumes all over the distribution range of PLW. Only a few examples are given here.

The effect of PLW on nodulation and yield components of peas was studied in the laboratory and in the field in France. Larvae caused about 90% destruction of root nodules when 8-10 larvae per root were present (Cantot, 1987).

In the Ukraine, the shoots of pea, vetch and other annual leguminous plants are severely damaged by weevils of the genus *Sitona*, especially PLW (Dyadechko *et al*., 1975). Considerable damage is done by PLW to seed crops of spring vetch (*Vicia* sp.) in the Kursk region of the USSR (Stepanov, 1978). In Russia, with an economic threshold of 10 PLW per square metre on first-year clover, 5-9% of plants were lost (Karavynanskii *et al*., 1986).

The impact of PLW on *Vicia faba* was investigated in field cage experiments in Denmark using controlled attack levels. A decrease in yield of up to 28% was recorded due to a reduction in the number of pods per plant, whereas the number of seeds per pod and the individual seed weight were unaffected (Nielsen, 1990).

In addition to direct losses PLW has also been shown to transmit viruses and bacteria. For example in Austria, broad bean stain comovirus, affecting the production of *Vicia faba*, is transmitted by PLW (Wodicka, 1984). Two more of many examples are given below.

Since 1967, in the Algarve and Alentejo regions of Portugal, fields of *Vicia faba* have shown broad bean mottle bromovirus (BBMV) symptoms. Symptoms on faba bean are mild, but infection in peas can be lethal. BBMV was transmitted at a low rate (6-7%) by PLW which was also present in the broad bean fields and is probably the vector (Sequeira and Borges, 1989). BBMV was transmitted from infected to healthy *Vicia faba* plants by PLW and other weevils. PLW appeared to be an efficient vector; acquisition and inoculation occurred at the first bite, the rate of transmission was ca 41%, and virus retention lasted for at least 7 days. PLW transmitted the virus from faba bean to lentil and pea, but not to the three genotypes of chickpea tested.

In the former Czechoslovakian Republic, adults of PLW fed on inoculated lucerne and transmitted the bacterium *Corynebacterium michiganense* pv. *insidiosum* [*Clavibacter michiganensis* subsp. *insidiosus*] to healthy plants, inducing wilt symptoms. The bacterium was re-isolated (Kudela *et al*., 1984).

Estimate impact on trade

PLW is not a grain pests and not directly associated with seed. PLW is widespread and it is unlikely that International grain markets would be noticeably affected. PLW could occur as a grain contaminant.

Environmental Impact

PLW adults prefer cultivated legumes, and are unlikely to have any significant impact on the native flora. However, larvae do attack a range of cultivated and wild legumes, and may have a slight but probably low negative impact on native species. As mentioned earlier for *S. discoideus*, PLW could also become a nuisance insect during flight peaks.

Human Health Impact

If additional treatments against PLW are needed, operators and the public in general may be exposed to pesticide sprays or residues. Provided that pesticides such as aldicarb and some organophosphates are avoided, it is unlikely that there would be any serious implications.

GUIDELINES FOR THE SELECTION OF CONTROL TREATMENTS

Cultural Control

Infestation of legume crops by PLW in Germany can be largely avoided by good growing conditions, since vigorous young plants show least infestation (Raiser, 1983).

Mixtures of oats and broad beans in southern England were found to reduce the amount of notching of the bean leaflets by PLW (Baliddawa, 1984).

Examination of the yields of field experiments at Rothamsted Experimental Station, UK demonstrated an unexpected trend for higher yields in later-sown spring *Vicia faba* crops. It is suggested that this is because late sowing avoids infestation by PLW adult spring migrants (Hamon *et al.,* 1987).

Field studies were conducted in Poland during 1991-93 to study the effect of different methods of pea (*Pisum sativum* var. *arvense*) cultivation on the occurrence of insect pests. Two spacings (15 and 30 cm), two sowing dates and intercropping with white mustard (*Sinapis alba*) were used. Intercropping pea with white mustard reduced populations of *Sitona* adults and larvae, including PLW (Wnuk and Wiech, 1996a).

In Poland, covering a field of peas with polyethylene insect netting immediately after sowing gave good control (Vulsteke *et al.,* 1994).

Biological control

A range of fungi shows efficacy against PLW. For instance *Beauveria bassiana* strain 195 was tested in a semi-field experiment against adults of PLW overwintering in buckets with lucerne, white clover (*Trifolium repens*) or barley straw in Denmark. Near 100% mortalities were recorded. In laboratory and greenhouse tests in Germany, the fungus *Metarhizium anisopliae* was effective for the control of small insects (5 mm or less) such as PLW that live in soil for only a short time (about 7 weeks) (Muller and Stein, 1976). Conidial suspensions of *B. bassiana*, *Metarhizium anisopliae*var. *anisopliae, Metarhizium flavoviride, Paecilomyces farinosus* and *Paecilomyces fumosoroseus* were tested in the laboratory for pathogenicity to eggs and neonate larvae of PLW. *M. flavoviride* outperformed all other fungi, and was the only species effective against eggs of PLW.

In laboratory experiments in Germany, the nematodes *Steinernema carpocapsae*, *S. bibionis* and *Heterorhabditis bacteriophora* reproduced in PLW. Exposed to 30 infective larvae per weevil, 50% mortality occurred in 6 days and 100% in 14 days (Wiech and Jaworska, 1990). Mortality of PLW larvae caused by *S. carpocapsae* was significantly greater for larvae originally from peas than for those collected from *Vicia faba*. Young adults of this pest from pea-fed larvae were also more susceptible to the nematodes. However, larvae of PLW from beans appeared more favourable hosts for nematode multiplication than larvae from peas, because greater numbers of juveniles of *S. carpocapsae* emerged from bean-fed PLW (Jaworska and Ropek, 1994). The effects of different stages of insects and plant hosts on the susceptibility of PLW to infection by entomophilic nematodes were studied in the laboratory in Kracow, Poland. Early- and late-instar larvae, pupae and young adults were collected from soil and faba beans, peas and field peas in Poland. Survival of adults was 95% during the first week and 10% after a month at 23°C. Larvae and adults reared on early pea (Szesciotgodniowy) were highly susceptible to infection, while pupae were less susceptible. Adults were susceptible to infection, with differences in infection rates depending on nematode species (*S. carpocapsae, Steinernema feltiae* and *H. bacteriophora*) and on food plant. All three nematode species multiplied within PLW, with adults from early beans being the best hosts for *S. carpocapsae* and *H. bacteriophora* (Jaworska and Ropek, 1996).

Predatory arthropods on PLW are mainly ground beetles (Carabidae). In the UK, the five dominant carabid taxa of potential predators of PLW on spring- and winter-sown *Vicia faba* crops were *Pterostichus melanarius, Pterostichus madidus, Harpalus rufipes, Bembidion* spp. and *Agonum dorsale*, with *P. melanarius* being the most common and accounting for 31% of the catch on the winter crop in 1980 and 80% on the spring crop during the same year. Larval mortality due to predation ranged from 0.6 to 10.5%, while adult mortality due to predation ranged from 2.6 to 23.8%. It is suggested that carabids play a significant role in the population dynamics of PLW, and in years when abundant could reduce the numbers of larvae and overwintering adults by more than 30% (Hamon *et al.,* 1990). In the Ukraine in 1969-73, the ground beetles *Bembidion lampros* and *Bembidion quadrimaculatum* attacked the eggs and more rarely the larvae of PLW (Dyadechko *et al.,* 1975). In Russia, PLW and its carabid beetle predators *Bembidion properans, B. lampros* and *B. quadrimaculatum* were constant inhabitants of 1-year-old leguminous fodder plants (Shurovenkov, 1977). In Poland, Ropek and Jaworska (1994) reported the carabid beetles *B. properans* and *Pterostichus cupreus* as predators of PLW.

According to Berry and Parker (1950) in Europe, the braconid parasitoids *Perilitus rutilus*, *Pygostolus falcatus* and *Allurus muricatus* have been reared from PLW. The latter species was more common in France and in southern Italy (Aeschlimann, 1980). According to Aeschlimann (1986), the mymarid egg parasitoid *Anaphes diana* was reared from field-collected material of PLW. The tachinid fly *Microsoma exigua* was reared repeatedly from adults of PLW (Herting, 1960; Aeschlimann, 1990). In Romania, the most abundant parasitoid on lucerne was the braconid *P. falcatus*, and the degree of parasitism of PLW amounted to 7-24% (Lacatusu *et al.,* 1978).

Host-plant resistance

In the Soviet Union a collection of *Pisum sativum* introductions, lines and cultivars were screened in the field and laboratory. Some were resistant to adult feeding in the seedling stage. Resistant entries were either vigorous or had large leaflets. There was evidence of antibiosis in three entries:

P1356999, P1250442 and P1285727 produced the fewest root nodules in the field and greenhouse and supported the lowest population of larvae (Nouri Ghadbalani, 1978). Eight parental lines of *Pisum sativum* resistant to adult PLW, and of *P. sativum* var. *arvense*, were intercrossed in a non-reciprocal manner, and these and the F1 and F2 populations were evaluated for foliar damage and percentage defoliation as measures of resistance to PLW, under laboratory and field conditions. General combining ability (GCA) effects were present for resistance both in the field and laboratory analyses, whereas specific combining ability effects for resistance were significant in only half of the eight analyses. P1263010 and P1343983 had large negative GCA estimates for both measures of resistance, indicating their use as parents in the development of resistant cultivars. They were both generally more resistant than the commercial cultivars tested, in both field and laboratory evaluations, expressing resistance under the pressure of 16 adult PLW per plant (Auld *et al.,* 1980).

Most other studies are also on *P. sativum*. In studies of 10 pea cultivars registered in Poland, adults of PLW responded to visual and/or chemical stimuli (odour) when selecting plants. The preferred cultivars were Karat, Koral and Aster, while Legenda, Mihan and Hamil were avoided. The longest lifetime was observed for curculionids that had been fed pea cultivars Legenda and Perkun (Sledz and Kordan, 1994).

Reference to Fabaceae other than *P. sativum* is rare. In the UK, for PLW, only the *Trifolium repens* varieties AberHerald, Katrina, Gwenda and Olwen were less favoured than Grasslands Huia (Murray, 1996).

Chemical control

As shown in the table below there are more than enough pesticides which are effective against PLW. However, the possible negative effects on beneficials such as predators should be taken into account. For instance in the Ukraine, treatment of field edges of leguminous crops with phosphamidon, parathion-methyl or wettable BHC (gamma isomer) or trichlorfon killed 82-89% of the weevils, but also killed all the carabid predators. Seed treatments were then tested as being less dangerous to the carabid predators, and mixed treatments including phosphamidon, heptachlor and wettable BHC (gamma isomer), to be applied in a band 60 m wide round the fields, killed 81.5-96.8% of the weevils within 6 days, retained their toxicity for 12 days and were harmless to the predators. In further tests on one farm, excellent results were obtained by using seed treated with heptachlor and treating the soil round the edge with a mixture of phosphamidon and superphosphate. This gave high mortality of weevils for 26 days and was harmless to the predators. The edge treatment reduced not only the weevil population on the peas, but also the numbers overwintering on perennial crops (Dyadechko *et al.,* 1975).

Pesticides with proven efficacy against PLW

Common name	***Method***	***Reference***
Aldicarb	Soil systemic. Larvae & adults	Ward and Morse, 1995 McEwen *et al.,* 1979
Azinphos-methyl	Adults only	Sigvald, 1978
Bacillus thuringiensis ssp. *Tenebrionis* (cryIII endotoxin gene)	Cloned into strains of *Rhizobium* symbiotic bacteria occurring in root nodules of legumes. Larvae.	Kaiser, 1994
Bendiocarb	Seed coating	Baughan and Toms, 1984)
Benfuracarb, carbofuran, furathiocarb	Seed coating	Vulsteke *et al.,* 1994
Bromophos	Seed coating	Baughan and Toms, 1984)

Camphechlor & Polychlorpinene	Plant & soil	Stepanov, 1978
Chlorfenvinphos	Seedbed or furrow treatments	Bardner *et al.,* 1980
Deltamethrin	Foliar	Vulsteke and Seutin, 1985
Fenitrothion	Foliar	Olsson, 1980
Fenvalerate	Foliar	Olsson, 1980
Furathiocarb	Seed coating	Taupin and Janson, 1997 Ester and Jeuring, 1992 Salter and Smith, 1986
Permethrin	Foliar	Vulsteke and Seutin, 1985 Arnold *et al.,* 1984
Permethrin, triazophos and cyfluthrin	Foliar. Adults.	Griffiths *et al.,* 1986
Phorate	Seedbed or furrow treatments	Bardner *et al.,* 1983
Pirimicarb	Foliar	Olsson, 1980

Pheromonal control

In principle, populations of PLW can be manipulated with semio-chemicals when these are deployed in a 'push-pull' or 'stimulo-deterrent diversionary' strategy. Such a strategy, in which adults are diverted from the crop by a feeding deterrent made from neem oil and attracted to discard areas with an attractant pheromone, such as 4-methyl-3,5-heptanedione, could be developed for the management of this pest in arable agriculture (Smart *et al.,* 1994).

TECHNICAL INFORMATION FOR PLANNING SURVEYS

General

If the leaves of legumes are examined, they will show typical adult feeding damage consisting of semicircular or U-shaped notches in the leaf margins, cut in close sequence and producing a scalloped effect. Small, grey-brown weevils may be seen on the undersides of leaves. If legume plants are dug up, the root nodules will be found to contain small, white, legless larvae.

Targeted Surveillance including Trapping

The synthetic aggregation pheromone 4-methyl-3, 5-heptanedione can be used in cone traps to monitor the activity of PLW (Biddle *et al.,* 1996). Monitoring is mainly used to indicate the migration of PLW to crops and thus to time insecticide application efficiently. It could also show that pesticide application is unnecessary if the crop is not at a susceptible growth stage. In addition it may be worth investigating the possibility of using the pheromone in surveillance traps. A notation scale of leaf damage, an emergence trap (made under licence to INRA), a sampling cylinder and a soil washer were developed in Lusignan, France for the estimation of adult or larval densities of PLW in pea fields. The use of emergence traps is recommended by the Commission des Essais Biologiques (CEB). These can also be used to monitor the dynamics of field infestations by moving traps at each sampling date (Cantot, 1997).

Current distribution

The current range of PLW includes most of its native Europe as well as the United Kingdom. It was first discovered in the USA in 1936, and occurs in the Western United States and Western Canada. PLW also occurs in parts of North Africa. Australia and NZ remains free of PLW.

List of countries

Europe
Austria, Belarus, Belgium, Channel Islands, Czechoslovakia (former -), Denmark, Estonia, Finland, Former Yugoslavia, France, Germany, Gibraltar, Greece, Hungary, Ireland, Latvia, Lithuania, Netherlands, Poland, Portugal (Azores & Madeira), Romania, Russian Federation, Spain (Canary Islands), Sweden, Switzerland, Ukraine and the United Kingdom.

Asia
Cyprus, Iran, Israel, Syria and Turkey.

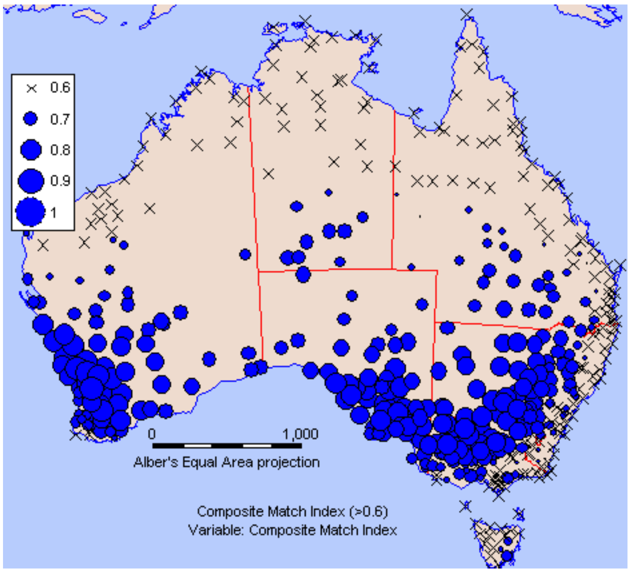
Africa
Algeria, Egypt, Morocco, Tunisia and Uganda.

Western Hemisphere
Bermuda, Canada (British Columbia) and USA (California, Idaho, Oregon, Virginia & Washington).

Oceania
Not established anywhere. Recorded as a quarantine intercept to New Zealand.

Potential distribution in Australia

Using for instance Aleppo in Syria as indication it points to the whole of the Australian wheatbelt being climatically suitable for PLW (see map below). However, the climatic range of PLW may be wider, and using for instance Aarhus in Denmark colder areas (eg. a larger part of Tasmania) becomes more suitable.



Dispersal

PLW feed on many different plants and because they are small and cryptic in habit, they can easily be transported in host plant material. The adults may also be present in other sheltered spots, including non-host plants, and sheds. Larvae can accidentally be transported in infested soil of potted plants.
PLW will generally only fly when temperatures are above 17º C. Less than 10% of newly emerged adults leave the crop by flight. The rest remain in the soil or walk to overwintering sites. Flight, however could be a very important avenue of spread.
Sitona weevils can disperse over long distances. *S. discoideus* adults have been recorded to fly over 20 km and higher than 300m. It has also been found landing on ships 10 km out to sea, and is a serious contaminant of export grain in Australia. During their flights to aestivational sites, and then again during the post aestivational period, there is a complete redistribution and no inclination to remain in a particular area. Geertzema & Volschenk (1993) are of the opinion that this phenomenon explains the rapid distribution of this species in South Africa.

RISK MITIGATION PROTOCOLS THROUGH DEVELOPMENT OF QUARANTINE ZONES AND MOVEMENT CONTROLS

There is no reference in the literature to specific phytosanitary risk mitigation procedures for PLW. For Australia it is likely that the first detection may be confined to an area or areas in a single specific State. The infested area should be demarcated with a buffer zone of about 20 km. Movement of host plant material or machinery used in host crops out of this area (the quarantine zone) should be restricted. Vehicles such as machinery and equipment used should be properly washed down. People working in areas within the quarantine zone(s) where they could come in contact with PLW should also follow set phytosanitary measures on leaving the possibly infested areas. Soil movement should also be restricted and subject to prior chemical treatment.

ERADICATION

Feasibility

Depending on the climatic region and intensity of infestation, PLW eradication may be feasible if detected before extensive spread has occurred. For Western Australia a Report was drawn up by Campbell White & Associates (2002).

Eradication Program

There are no set protocols for the eradication of PLW. If eradication is deemed feasible a combination of pesticides, targeting both the adults and the larval stages, would be needed. Information on effective pesticides is given earlier in this document. Azinphos-methyl is a commonly used and effective insecticide. Various other chemical control methods have been found to be effective, including the treatment of field edges of leguminous crops with phosphamidon (eg. Dimecron or Cildon, not registered in Australia), parathion-methyl (eg. Penncap-M or Folidol) or wettable BHC [gamma isomer] (eg. Amrocide or Lindacol, not allowed for use in Australia) or trichlorfon (eg. Lepidex or Neguvon), or by using seed treated with heptachlor (eg. Biarbinex or Cupincida, not allowed for use in Australia) and treating the soil round the edge with a mixture of phosphamidon and superphosphate. This gave high mortality of weevils for 26 days and was harmless to the predators (not a high priority during eradication campaigns, but an additional bonus). The edge treatment reduced not only the weevil population on the peas, but also the numbers overwintering on perennial crops (Dyadechko et al., 1975). Depending on the specific situation, a combination of chemical and cultural control methods (see previous sections) would be needed in order to achieve eradication. Possible hosts may have to be sprayed out with herbicides (scorched earth policy). This may need to be followed up by sowing a non-host such as oats, followed by a legume specific herbicide whenever required. If a particularly disruptive or dangerous pesticide is used a special permit may be required for use only during the eradication campaign. PLW numbers on foliage and in soil should be monitored, probably fortnightly, and claiming successful eradication would only be possible after at least 2 ½ years of not finding any live stages of the weevil.

TECHNICAL DEBRIEF AND ANALYSIS FOR STAND DOWN

General

When an incursion response and related cost sharing activities are terminated, certain generic procedures need to be followed. These are described in Merriman and McKirdy (2005). The debriefing report would vary depending on the reasons for stand down, and will need to reflect the changed status of action.
The technical issues that need to be evaluated in the event of an eradication attempt being unsuccessful include;

Containment of the infestation

If a delimiting survey properly identifies those areas infested with PLW then the aim should be to contain the pest. It also means that whenever an infestation is found, these newly infested properties should be recorded and special precautions introduced to contain the further spread. Producers should be made aware of important phytosanitary measures such as movement of host plant material and wash down of machinery as referred to earlier. At some stage the situation may occur where PLW is so widespread that further non-official "quarantine" measures would not be practical.

Research on control options and "living with" PLW

Some answers may be found in studying related species such as *S. discoideus,* which have established in the Southern Hemisphere. The adaptations required to the way that *S. discoideus* is managed and the ways in which PLW as a typically Northern Hemisphere weevil adapt to the Southern Hemisphere and climatic types in Australia would need investigation. For *S. discoideus* in WA it is believed that economical control of larvae can not be achieved because they are protected in the soil and extremely difficult to kill. Adults can be controlled using the insecticides as mentioned earlier, but, again, the economic returns on spraying are questionable unless large numbers are causing extensive yield loss. Killing adults to stop egglaying, and thus hopefully avoiding larvae feeding on roots, is not very effective. In WA *S. discoideus* has a history of severe outbreaks that die down after two to three years. The reasons for this are not clearly understood (Woods *et al*., 1990). Similar to *S. discoideus* PLW may also turn out to be a sporadic pest. In areas where these two pests occur simultaneously an integrated management approach will be followed.

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