Industry Biosecurity Plan for the Grains Industry
Threat Specific Contingency Plan

Barley stem gall midge
Mayetiola hordei

Prepared by Dr Mallik Malipatil
and Plant Health Australia

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1 Purpose of this Contingency Plan

This Contingency Plan provides background information on the pest biology and available control measures to assist with preparedness for an incursion into Australia of Barley stem gall midge (*Mayetiola hordei*). It provides guidelines for steps to be undertaken and considered when developing a Response Plan to this pest. Any Response Plan developed using information in whole or in part from this Contingency Plan must follow procedures as set out in PLANTPLAN and be endorsed by the National Management Group prior to implementation.

2 Pest information/status

2.1 Pest details

Mayetiola hordei (Kieffer), 1909

Other Names: *M. mimeuri*

Common Names: Barley stem gall midge

2.1.1 General information

Taxonomic position – Phylum: Arthropoda; Class: Insecta; Order: Diptera; Family: Cecidomyiidae

Barley stem gall midge is a destructive pest of barley in the barley growing Mediterranean regions of southern Europe (Italy and Spain) and northern Africa (Morocco, Algeria and Tunisia)(Gagne et al 1991; Lhaloui et al 1988). In Morocco, barley fields may be infested by both barley stem gall midge and Hessian fly, although barley stem gall midge is the more important. This insect can cause up to 35% barley grain yield loss each year, levels similar to the losses caused by Hessian fly on wheat in Morocco (Lhaloui et al 1992).

M. hordei or barley stem gall midge, is a small fly (2-4 mm in length) found in northern Africa and some European countries (Makni *et al.,* 2000). There is limited information available on this insect due to taxonomic confusion that exists between this and *M. destructor* (Hessian fly). Both pests are morphologically similar, can have overlapping distributions and cause similar symptoms on host plants. Distinguishing the two species can be achieved through close examination of morphological characteristics of the adults and pupae, the presence or absence of gall formation on host plants, and the molecular diagnostic tests (Makni *et al.,* 2000; Mezghani *et al.,* 2002).

When the barley stem gall midge becomes established in a region or country, infestation rates and yield losses can become significant. For instance, estimations of between 30 and 50% of the barley crops in Libya and Tunisia are infested with this pest, and the grain yield in Morocco has been estimated to have decreased by about 35% due to the damage caused by *M. hordei* (ICARDA Annual Report, 2001). To combat these detrimental effects, resistant crop varieties are being developed for use in countries already infested with *M. hordei*. However, like Hessian fly (Naber *et al.,* 2003) genetic variations occurring within barley stem gall midge populations result in rapid breakdown of resistance.

Infestation of barley, or occasionally wheat, rye and oats, by the barley stem gall midge occurs throughout the growing season and can occur on both young and mature plants. Symptoms in young seedlings are mainly a yellowing of new growth, and can occasionally result in death of the plant. In mature plants, the barley stem gall midge feeds at the base of the plant between the leaf sheath and

the stem, producing the characteristic swellings (galls), leading to stem weakening and loss of grain yield and quality (Parker *et al.* 2001).

More detailed information on Barley stem gall midge can be found in the PhD thesis by Saadia Lhaloui on the "Biology, host preference, host suitability, and plant resistance studies of the Barley stem gall midge and Hessian fly (Diptera: Cecidomyiidae) in Morocco" (1995) Kansas State University.

2.1.2 Life cycle

There is no information available on the specifics of the barley stem gall midge's life cycle other than the information found in Lhaloui (1995). The following text relates to some more general comments on the life cycle of all gall midges.

Gall midges have a relatively long-lived larval stage, which is specialised for feeding. It is during this stage of development that the adverse effects on crop plants occur. The adult stage of the life cycle is short lived, generally between 1-2 days, and it is specialised for reproduction. During the adult stage, the insect will not feed, and will rely on internal energy stores and the uptake of water (Gagné, 1989). During this short time, the adult fly must mate, locate suitable host plants and lay the eggs (up to 400).

Mating systems of gall midges are based on the female-produced sex pheromones (Harris & Foster, 1999). These are produced shortly after the female has emerged from the pupal stage (eclosion). Commonly, female gall midges are monogamous (Gagné, 1989), as they remain near the sex pheromone release site for several hours after mating, before becoming active during the oviposition phase. On the other hand, males remain active after mating and will continue to mate with virgin females until death (Bergh *et al.,* 1992).

Eggs are generally deposited on a number of different plants within the crop. Females will fly to a suitable host plant and lay a small number of eggs, before flying off to another, usually close by suitable host plant. This process is repeated many times. In many gall midges, adult females do not discriminate between host plants that carry resistance genes. This results in many larvae dying due to the host plant resistance.

2.2 Affected hosts

2.2.1 Host range

Barley (*Hordeum vulgare*) is the preferred host of barley stem gall midge (Gagné *et al.* 1991). This pest has also been recorded on oat (*Avena sativa*), wheat (*Triticum aestivum*) and rye (*Secale cereale*). Defining the host range of barley stem gall midge has been difficult due to confusion with *M. destructor.*

2.2.2 Geographic distribution

Limited information is available on the distribution of *M. hordei* due to confusion with *M. destructor*. However, barley stem gall midge has been recorded in Northern Africa (Libya, Morocco, Tunisia; Makni *et al.,* 2000), Spain, United Kingdom and France (Global Biodiversity Information Facility, www.gbif.org).

2.2.3 Symptoms

Symptoms produced by infestation with *M. hordei*, which mainly occurs on barley, are not significantly different to those caused by *M. destructor*, occurring mainly on wheat. These symptoms, as described for *M. destructor*, are detailed below. The main difference is the presence of a gall during *M. hordei* infestation (Makni, 1993). In contrast, galls are not formed with *M. destructor* infestation.

The first sign of attack in plants is often a change in leaf colour to a darker green or bluish-green colour (Brown, 1997). Infested young plants are generally stunted, lack an emergent leaf and have leaves which are shorter, broader and more erect than the leaves on healthy plants. When heavily infested the plant may be killed, resulting in gaps in the crop. In older plants stems may be weakened by larval feeding, which occurs at the nodes leading to collapse of the plant. Tillers may show signs of withering (white heads) and lodging, which causes loss of yield since ear heads fail to develop. Any grain developing in affected heads will be of poor quality and shrivelled. Significant reduction in grain yields can occur and it is not uncommon for crops infested by Hessian fly to have 40-70% of stems affected. In the USA damage from Hessian fly is greatest in winter wheat seeded early, before the so-called fly-free date, and in spring wheat seeded late, in synchrony with a spring generation of the pest (Cook & Veseth, 1991).

2.3 Entry, establishment and spread

There is no specific information on the natural spread and dispersal of *M. hordei* however literature on Hessian fly (*Mayetiola destructor*) describes it as a light (weight) insect that normally flies low over crops. An early study showed that the insect could be dispersed from emergence sites by winds and thermal currents over distances up to 9km (McColloch 1923). The Hessian fly is not often dispersed further as it prefers to avoid higher wind speeds and under these conditions will not usually leave the host plant (Withers and Harris 1997).

The literature also suggests *M. destructor* is of European origin and was accidently introduced by humans into North America, England and New Zealand (Barnes 1956). The method of introduction was unclear but it is thought that the importation of straw as packing material also contained the fly, flaxseed and/or larvae.

The following information on the entry, establishment and spread of Hessian fly (*Mayetiola destructor*) has been taken from the Hessian fly (*Mayetiola destructor*) Grains Industry Biosecurity Pest Datasheet/Pest Risk Review by Smith et al (2007). As wheat and barley are grown in the same regions in Australia, similar ratings would be expected for the entry, establishment and spread of Barley stem gall midge (*M. hordei)* within barley crops.

Entry potential: Rating = Medium

The probability of entry of *M. hordei* is considered to be medium. There is a possibility of transportation of larvae and pupae in inadequately fumigated hay or as a contaminant in imported products. Introduction by natural introductions or with tourists is unlikely. The Hessian fly is very small (2mm) and eggs are barely visible (<1mm) and therefore either stage would easily escape detection at entry points.

Establishment potential: Rating = High

Establishment potential is high due to the large distribution of hosts in the grain growing regions of Australia and the suitability of climate in these areas. Barley stem gall midge is small and not easily detected in the field but damage to cereal crop is obvious in the death of plants and the subsequent gaps in crops. Such damage would ensure rapid detection. Barley stem gall midge has also established widespread in countries following its introduction.

Spread potential: Rating = Medium

Spread potential is considered to be medium, as in calm weather this pest flies above the crop and may be taken up in thermals. Adults have been recorded to disperse over distances of at least 8 km in the closely related species Hessian fly. The climate of Australia is suited for Hessian fly and would be expected to be equally suited for Barley stem gall midge.

Natural spread will probably not occur between the two separate cereal production areas (Eastern and Western Australia). However once established Hessian fly will spread rapidly through most of the favourable regions within these two areas and would be difficult to eradicate as the climate and abundance of host plants will facilitate establishment and spread.

Economic impact: Rating = Significant

Arrival and establishment of *M. hordei* is expected to cause large losses in barley production and increased expenditure on insecticides and other management practices. In Tunisia, Libya and Morocco, estimated yield losses of 30-50% occur and considerable input in breeding for tolerance/resistant has been undertaken (ICARDA Annual Report 2001).

Trade in hay to Japan may be affected if *M. hordei* became established.

Environmental impact: Rating = Negligible

There is no or negligible potential to degrade the environment or otherwise alter ecosystems by affecting species composition or reducing the longevity or competitiveness of wild hosts.

Overall risk: Rating = High

2.4 Diagnostic information

2.4.1 Diagnostic protocol

Check for symptoms in the crop (as outlined in Section 2.2.3) accompanied by the presence of galls in stems.

In contrast to *M. destructor*, pupae of *M. hordei* cause stem swellings (peanut sized galls) and are generally partially embedded within plant tissue. Pupae are almost entirely smooth and hold firmly to the plant tissue and are difficult to separate from the plant (Gagné *et al.* 1991). As a result, plant tissue generally adheres to the gall when removed from the stem.

The adults look like small mosquitoes and are similar in appearance to Hessian fly. The larvae, which cause all the damage, are maggot-like and pale red at first, turning to white as they mature, can grow to about 3 mm in length (Parker *et al.* 2001). All stages can be confused with those of Hessian fly, therefore field-collected specimens should be sent to a specialist for confirmation.

Distinguishing between *M. hordei* and *M. destructor* can be achieved through observing the following:

- The number of spicules on the pupae, the shape of the adult female abdomen and the structure of the male terminalia are different between the species.
- Gall formation occurs at infestation sites of *M. hordei* but not with *M. destructor*.
- *M. hordei* is found almost exclusively on barley, while *M. destructor* is found mainly on wheat plants.
- Molecular tests based on diagnostic alleles at two loci (Makni *et al.,* 2000) and by their mitochondrial DNA haplotypes (Mezghani *et al.,* 2002).
- Microsatellite loci that have revealed a strong effect on host plant on the population genetic structure of *M. hordei* have been developed (Mezghani-Khemakhem *et al.* 2006).

2.5 Response checklist

2.5.1 Checklist

Guidelines for Response Checklists are still to be endorsed. The following checklist provides a summary of generic requirements to be identified and implemented within a Response Plan:

- Destruction methods for plant material, soil and disposable items
- Disposal procedures
- Quarantine restrictions and movement controls
- Decontamination and farm cleanup procedures
- Diagnostic protocols and laboratories
- Trace back and trace forward procedures
- Protocols for delimiting, intensive and ongoing surveillance
- Zoning
- Reporting and communication strategy

Additional information is provided by Merriman and McKirdy (2005) in the Technical Guidelines for Development of Pest Specific Response Plans.

2.6 Delimiting survey and epidemiology study

Delimiting surveys should comprise local surveys around the area of initial detection and/or areas of concern identified from trace back/trace forward operations. Initial surveys should concentrate on areas of poor growth or symptoms of the pest and/or within the area of initial pest detection. The extent of the survey beyond the initial infected crop should be guided by the test results from the surrounding crops.

2.6.1 Sampling method

Sampling of barley stem gall midge can be achieved during all stages of the life cycle; however, collection of the larvae and pupae is the most reliable due to the presence of the stem gall highlighting location. Removal of galls from the plant is difficult without causing significant damage. Therefore, collection of larvae/pupae should be achieved through removal of the entire stem region surrounding the gall. Pupae collection is also helpful, as the number of spicules on the pupae can distinguish *M. hordei* from *M. destructor*.

The small size of the midges' eggs makes detection and collection difficult. Eggs are only laid in small clusters. Adult flies can also be collected using techniques such as suction, or sticky/water traps, however the mixed catches resulting from these approaches can make identification difficult. Pheromone traps for *M. hordei* are yet to be developed.

Any personnel collecting insect or leaf samples for assessment should notify the diagnostic laboratory prior to submitting samples to ensure expertise is available to undertake the diagnosis. General protocols for collecting and dispatching samples are available within PLANTPLAN (2008) Appendix 3.

Number of specimens to be collected

A large number of specimens would be preferable. Both the male and female allow for species level identification and distinguishing from *M. destructor*. Due to the small size of this insect, large numbers will be required to carry out any diagnostic testing. All life stages can be collected, however only the adults can be identified to a species level by morphological features. Molecular test (see Section 2.4.1) can be carried out on any stage of the life cycle.

How to preserve plant samples

Stems with suspect pupae and larvae can be stored between sheets of dry newspaper and suitability contained to prevent escape of material.

How to transport plant sample

Stems with suspect pupae and larvae should be mailed as a flat package between sheets of dry newspaper.

How to preserve barley stem gall midge sample

Adults and larvae can be placed in 70% ethanol and stored indefinitely, although their colour fades gradually with time. Specimens required for molecular diagnostic work should be killed and preserved in absolute ethanol or frozen (-80°C).

How to transport barley stem gall midge sample

Vials of ethanol should be sealed to avoid leakage and packed with cushioning material in a strong box.

2.6.2 Epidemiological study

The number of infected plants within a crop will depend on the initial numbers of pest present in the system and whether conditions have been favourable for the pest to spread from initial foci.

Sampling of crops within a district and beyond will be based upon the origins of the initial suspect sample(s). Factors to consider will be:

- The proximity of other susceptible crops to the initial infested crop, both in the current growing season and previous season. This will include the growers own crops and those on neighbouring properties.
- What machinery or vehicles have been into the infested crop.
- The extent of human movements into the infested crop.
- The movement of hay or plant material from sites of infestation.

2.6.3 Models of spread potential

No modelling data is available.

Some general information and comments about possible mechanisms of spread are:

- In calm weather *M. hordei* adults fly among and above the crop, and can then be taken up in thermals.
- Adults do not feed and are capable of significant flight (up to 8 km).
- In areas of intensive cultivation or areas with a continuous presence of suitable hosts, adult insects may successfully disperse to adjacent fields.
- Barley stem gall midge eggs, larvae and pupae are readily transported with agricultural products in infested plants.

2.6.4 Pest Free Area (PFA) guidelines

Points to consider are:

- Design of a statistical delimiting field survey for symptoms on host plants and for the presence or absence of barley stem gall midge eggs, larvae, pupae or adults.
- Plant sampling should be based on at least 100 plants taken at random from each crop.
- Survey around transport routes of any machinery that may have inadvertently transported the pest.

Additional information is provided by the IPPC (1995) in Requirements for the Establishment of Pest Free Areas. This standard describes the requirements for the establishment and use of pest free areas as a risk management option for phytosanitary certification of plants and plant products. Establishment and maintenance of a PFA can vary according to the biology of the pest, pest survival potential, means of dispersal, availability of host plants, restrictions on movement of produce, as well as PFA characteristics (size, degree of isolation and ecological conditions).

2.7 Availability of control methods

Should *M. hordei* be introduced, it is unlikely that eradication or containment would be feasible options as adults are capable of significant flight, and it is assumed that the insect would be distributed quite widely before detection occurred. Treatment of large areas of stubble and/or crops of barley and wheat, either physically or by the use of insecticides would be unlikely to prevent all flies hatching.

Delimiting surveys would be required (see Section 2.6) however to determine the extent of establishment before the option of eradication or containment was ruled out.

2.7.1 General procedures for control

- Keep traffic out of affected areas and minimize movement in adjacent areas.
- Stop irrigating affected (irrigated crops) areas and use bunding to divert overland flood flows around them (both irrigated and dryland crops).
- Adopt best-practice farm hygiene procedures to retard the spread of the pest between fields and adjacent farms.
- After surveys are completed, destruction of the infected crop is an effective control.
- On-going surveillance of infected paddocks to ensure barley stem gall midge is eradicated.

2.7.2 Control if small areas are affected

No specific information is available for *M. hordei*, but the following control measures for Hessian fly should be applicable.

If pupae are detected before any distribution of the infested product normal quarantine procedures should be followed. It is unlikely that eradication would be achieved after larvae or pupae are detected in-field. If a preliminary survey has indicated that no more than one localised infestation is present, and that no adults have emerged from that area (check for empty puparial cases), then in that isolated area eradication may be achieved if a “scorched earth” policy is followed. Remove all possible host plant material (dry or living) within a 5 m radius of the affected area and dispose through burning. Keep the area within a 10 m radius host plant free by spraying with a selective herbicide. Continue to keep the area bare of any host plants for at least 18 months. If a thorough surveillance campaign (the extent of which to be based on a Cost/Benefit analysis) reveals more than one further point infestations indicated by either eggs (unlikely to see them), larvae or pupae or any clear signs of a emerging or previous Hessian fly infestation located further than 500 m away from the first find, then the eradication campaign should probably be terminated (Botha et al 2005).

2.7.3 Control if large areas are affected

Where large areas are already affected the likelihood of eradication or containment is extremely small. Treatment of large areas with insecticides is unlikely to stop all pupae developing.

2.7.4 Cultural control

- The negative effect of *M. hordei* can be reduced through sowing barley crops after the peak of adult midge emergence.
- Increasing plant vigour through the application of fertiliser will enhance crop tolerance to *M. hordei* infestation.
- Destroy crop residues (stems and stubble) following harvest.
- Remove volunteer crop plants and alternative hosts. This will reduce the carryover of *M. hordei* from one growing season to the next, and will limit the damage on young crops early in the growing season.
- Crop rotation with non-susceptible species can reduce insect numbers.
- Barnes (1956) reviewed the development of control measures and general practices for cultural control including crop rotation, ploughing in stubbles, destruction of volunteer weed plants and soil preparation.

2.7.5 Host plant resistance

Plants bred for host-resistance against *M. destructor* are generally effective against *M. hordei*. Both species are known to overcome host resistance. Currently there are no barley lines with specifically breed resistance to barley stem gall midge, however this objective has been incorporated into breeding programs in Africa (ICARDA Annual Report, 2001). Screenings of barley germplasm for resistance to barley stem gall midge revealed that more Moroccan germplasm was susceptible. However, various levels of tolerance were expressed in this germplasm. Screenings of the wild barley species showed that many accessions were heterogeneous with some selected as having adequate levels of resistance (Lhaloui 1995). The screening of a wild barley collection has yielded four resistant sources. The resistance of these sources is being transferred to cultivated barley through inter specific crosses, and the seeds of these crosses will be tested for transfer of resistance (Lhaloui et al 2000).

2.7.6 Chemical control

The use of chemical control measures (based on the use of systemic or non-systemic insecticides) have been developed for use against Hessian fly, but these are not always effective (Buntin & Hudsen, 1991). Similar outcomes are expected for barley stem gall midge.

2.7.7 Biological control

A number of wasp species are known to parasitise Hessian fly (Barnes, 1956). Although no specific information is known about their relationship with *M. hordei*, these may potentially be used as biological control measures. High levels of natural parasitism have been recorded in many areas overseas where *M .destructor* is a pest, and conservation of these natural enemies is important.

3 Course of action – Eradication methods

Additional information is provided by the IPPC (1998) in Guidelines for Pest Eradication Programmes. This standard describes the components of a pest eradication programme which can lead to the establishment or re-establishment of pest absence in an area. A pest eradication programme may be developed as an emergency measure to prevent establishment and/or spread of a pest following its recent entry (re-establish a pest free area) or a measure to eliminate an established pest (establish a pest free area). The eradication process involves three main activities: surveillance, containment, and treatment and/or control measures.

3.1 Destruction strategy

3.1.1 Destruction protocols

- Disposable equipment, infected plant material or soil should be disposed of by autoclaving, high temperature incineration or deep burial.
- Any equipment removed from the site for disposal should be double-bagged.
- Herbicides could be used to destroy the infected crops or pastures.
- Infected crops or pastures could be ploughed in.
- Insecticides could be used to destroy the pest.
- Farm machinery used in destruction processes need to be thoroughly washed, preferably using a detergent such as Decon 90.

3.1.2 Decontamination protocols

If containment, eradication and/or best practice hygiene measures are implemented, machinery, equipment, vehicles in contact with infected plant material or soil or present within the Quarantine Area, should be washed to remove soil and plant material using high pressure water or scrubbing with products such as a farm degreaser disinfectant or a 1% bleach solution in a designated wash down area. General guidelines for wash down areas are as follows:

- Located away from crops or sensitive vegetation
- Readily accessible with clear signage
- Access to fresh water and power
- Site, including entry and exit points should be mud free (e.g. gravel, concrete or rubber matting)
- Gently sloped to drain effluent away
- Effluent must not enter water courses or water bodies
- Allow adequate space to move larger vehicles
- Away from hazards such as power lines
- Waste water, soil or plant residues should be contained (see PLANTPLAN 2008 Appendix 18).
- All chemicals used according to label.

General guidelines for personnel and equipment are as follows:

- Disposable overalls and rubber boots should be worn when handling infected soil or plant material in the field. Boots, clothes and shoes in contact with infected soil or plant material should be disinfected at the site or double-bagged to remove for cleaning.
- Skin and hair in contact with infested plant material or soil should be washed.
- Decon 90 is a suitable detergent for using to decontaminate equipment or personnel.

3.1.3 Priorities

Specific priorities for eradication

- Confirm the presence of the pest.
- Prevent movement of vehicles and equipment through affected areas.
- Priority of eradication/decontamination of infected host material.
- Control barley stem gall midge populations to prevent further spread.
- Inform all groups within the industry.
- Determine the extent of infection through survey.

3.1.4 Plants, by-products and waste processing

- All infested seedlings and alternate / susceptible host material from the infected site should be destroyed by (enclosed) high temperature incineration, autoclaving or deep burial (in a non-cropping area). Seeds harvested from infected plants will be of poor quality and shrivelled.
- As the barley stem gall midge can be mechanically transmitted, killed crops should be ploughed in or burnt.
- All infested plants, together with all susceptible and alternate host material such as wheat, rye and oats, should be destroyed by burning as pupae can survive for long periods.
- Hay, straw and stubble residues should be collected and destroyed after harvest by burning to reduce carry-over from one season to another.
- Infested paddocks should remain free of susceptible host plants until soil has been shown to be free from the pest.

3.1.5 Disposal issues

- Particular care must be taken to minimize the transfer of infected soil or plant material from the area.
- Raking infected crops is not an option as this procedure is likely to spread the eggs, larvae and pupae greater distances during the raking process.

- No particular issues with resistance of disease to chemicals or physical treatments are known to exist.

3.2 Quarantine and movement controls

3.2.1 Quarantine priorities

- Plant material and soil at the site of infestation to be subject to movement restrictions.
- Machinery, equipment, vehicles and disposable equipment in contact with infected plant material or soil to be subject to movement restrictions.
- Adult barley stem gall midges have wings and *Mayetiola* spp can be dispersed from emergence sites by winds and thermal currents over distances up to 9km (McColloch 1923) making establishment of quarantine difficult.

3.2.2 Movement control for people, plant material and machinery

Once established barley stem gall midge will be difficult to eradicate. Therefore, any zoning, quarantine or movement controls will usually pertain to containment and management unless detection occurs soon after establishment.

If Restricted or Quarantine Areas are practical, movement of equipment or machinery should be restricted and movement into the Area only occurs by permit. The industry affected will need to be informed of the location and extent of the disease occurrence.

Movement of people, vehicle and machinery, from and to affected farms, must be controlled to ensure that infected soil or plant debris is not moved off-farm on clothing, footwear, vehicles or machinery. This can be achieved through:

- Signage to indicate quarantine area and/or restricted movement in these zones.
- Fenced, barricaded or locked entry to quarantine areas.
- Movement of equipment, machinery, plant material or soil by permit only.
- Clothing and footwear worn at the infected site should either be double-bagged prior to removal for decontamination or should not leave the farm until thoroughly disinfected, washed and cleaned.
- Hay, stubble, seed or trash must not be removed from the site or used for feeding stock due to the risk of moving larvae, pupae or eggs. Seed from the affected site should not be used for planting new crops, feeding stock or for human consumption.
- All machinery and equipment should be thoroughly cleaned down with a pressure cleaner prior to leaving the affected farm. The clean down procedure should be carried out on a hard surface, preferably a designated wash-down area, to avoid mud being re-collected from the affected site onto the machine (see Section 3.1.2).

3.3 Zoning

The size of each quarantine area will be determined by a number of factors, including the location of the incursion, biology of the pest, climatic conditions and the proximity of the infected property to other infected properties.

3.3.1 Destruction zone

The size of the destruction zone (i.e. zone in which the pest and all host material is destroyed) will depend on the ability of the pest to spread, distribution of the pest (as determined by delimiting surveys), time of season (and part of the pest life cycle being targeted) and factors which may contribute to the pest spreading.

The entire crop or pasture should be destroyed after the level of infection has been established. The delimiting survey will determine whether or not neighbouring host crops are infected and need to be destroyed. The Destruction Zone may be defined as contiguous areas associated with the same management practices as the infected area (i.e. the entire trial, paddock or farm if spread could have occurred prior to the infection being identified).

If the movement of *M. hordei* to neighbouring crops appears likely through the flight of adults, they will also need to be destroyed. Particular care needs to be taken to ensure that soils and plant material are not moved into surrounding areas not showing symptoms of disease. Where possible, destruction should take place in dry conditions to limit mud being spread within the field on boots and protective clothing.

3.3.2 Quarantine zone

The Quarantine Zone is defined as the area where voluntary or compulsory restraints are in place for the affected property(ies). These restraints may include restrictions or movement control for removal of plants, people, soil or contaminated equipment from an infected property.

3.3.3 Buffer zone

A Buffer Zone may or may not be required depending on the incident. It is defined as the area in which the pest does not occur but where movement controls or restrictions for removal of plants, people, soil or equipment from this area are still deemed necessary. The Buffer Zone may enclose an infested area (and is therefore part of the Control Area) or may be adjacent to an infested area.

3.3.4 Restricted Area

The Restricted Area is defined as the zone immediately around the infected premises and suspected infected premises. The Restricted Area is established following initial surveys that confirm the presence of the pest. The Restricted Area will be subject to intense surveillance and movement control with movement out of the Restricted Area to be prohibited and movement into the Restricted Area to occur by permit only. Multiple Restricted Areas may be required within a Control Area.

3.3.5 Control Area

The Control Area is defined as all areas affected within the incursion. The Control Area comprises the Restricted Area, all infected premises and all suspected infected premises and will be defined as the minimum area necessary to prevent spread of the pest from the Quarantine Zone. The Control Area will also be used to regulate movement of all susceptible plant species to allow trace back, trace forward and epidemiological studies to be completed.

3.4 Decontamination and farm clean up

Decontaminant practices are aimed at eliminating the pest thus preventing its spread to other areas.

3.4.1 Decontamination procedures

General guidelines for decontamination and clean up:

- Refer to PLANTPLAN (Plant Health Australia 2008) for further information.
- Keep traffic out of affected area and minimize it in adjacent areas.
- Adopt best-practice farm hygiene procedures to retard the spread of the pest between fields and adjacent farms.
- Machinery, equipment, vehicles in contact with infected plant material or soil or present within the Quarantine Area, should be washed to remove soil and plant material using high pressure water or scrubbing with products such as Decon 90 detergent, a farm degreaser or a 1% bleach solution in a designated wash down area as described in Section 3.1.2.
- Only recommended materials are to be used when conducting decontamination procedures, and should be applied according to the product label.

3.4.2 General safety precautions

For any chemicals used in the decontamination, follow all safety procedures listed within each MSDS.

3.5 Surveillance and tracing

3.5.1 Surveillance

Detection and delimiting surveys are required to delimit the extent of the outbreak, ensuring areas free of the pest retain market access and appropriate quarantine zones are established.

Initial surveillance priorities include the following:

- Surveying all properties in the pest quarantine area with known hosts.
- Surveying all properties identified in trace-forward or trace-back analysis as being at risk.
- Surveying all host growing properties that are reliant on trade with interstate or international markets which may be sensitive to barley stem gall midge presence.
- Surveying commercial nurseries selling at risk host plants.

- Surveying other host growing properties and backyards.

3.5.2 Survey regions

Establish survey regions around the surveillance priorities identified above. These regions will be generated based on the zoning requirements (see Section 3.3) for barley stem gall midge, and prioritised based on their potential likelihood to currently have or receive an incursion of this pest. Surveillance activities within these regions will either allow for the area to be declared pest free and maintain market access requirements or establish the impact and spread of the incursion to allow for effective control and containment measures to be carried out.

Steps outlined below form a basis for a survey plan. Although categorised in stages, some stages may be undertaken concurrently based on available skill sets, resources and priorities.

Phase 1:

- Identify properties that fall within the buffer zone around the infested premise.
- Complete preliminary surveillance to determine ownership, property details, production dynamics and tracings information (this may be an ongoing action).

Phase 2:

- Preliminary survey of host crops in properties in buffer zone establishing points of pest detection.

Phase 3:

- Surveillance of an intensive nature, to support control and containment activities around points of pest detection.

Phase 4:

- Surveillance of contact premises. A contact premise is a property containing susceptible host plants, which are known to have been in direct or indirect contact with an infested premises or infected plants. Contact premises may be determined through tracking movement of materials from the property that may provide a viable pathway for spread of the disease. Pathways to be considered are:
    - Items of equipment and machinery which have been shared between properties including bins, containers, irrigation lines, vehicles and equipment.
    - The producer and retailer of infected material if this is suspected to be the source of the outbreak.
    - Labour and other personnel that have moved from infected, contact and suspect premises to unaffected properties (other growers, tradesmen, visitors, salesmen, crop scouts, harvesters and possibly beekeepers).
    - Movement of plant material and soil from controlled and restricted areas.
    - Storm and rain events and the direction of prevailing winds that result in air-borne dispersal of the pest during these weather events.

Phase 5:

- Surveillance of nurseries, gardens and public land where plants known to be hosts of barley stem gall midge are being grown.

Phase 6:

- Agreed area freedom maintenance, post control and containment.

3.5.3 Post-eradication surveillance

The period of pest freedom sufficient to indicate that eradication of the pest has been achieved will be determined by a number of factors, including cropping conditions, the previous level of infestation and the control measures applied. As a guide, the following activities should be carried out following the eradication of the pest:

- Establishment of sentinel plants at the site of infection (see Section 2.6.4).
- Maintain good sanitation and hygiene practices throughout the year.
- Sentinel plants should remain in place and inspected on a fortnightly basis for a further 6 weeks and then on a monthly basis.
- Surveys comprising of plant and soil sampling for testing for barley stem gall midge to be undertaken for a minimum of 12 months after eradication has been achieved. The pest has short lifecycle hence surveys may need to be repeated every 3-4 weeks.

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5 Appendices

Appendix 1. Standard diagnostic protocols

For a range of specifically designed procedures for the emergency response to a pest incursion refer to Plant Health Australia's PLANTPLAN.

Appendix 2. Experts, resources and facilities

The following table lists the experts who can be contacted for professional diagnostics and advisory services in the case of an incursion.

Expert	State	Details
Dr Ray Gagne	USA	USDA rgagne@sel.barc.usda.gov
Dr David Yeates	ACT	CSIRO Entomology PO Box 1700 Canberra ACT 2601 David.yeates@csiro.au
Dr Mike Grimm	WA	Western Australian Department of Agriculture and Food mgrimm@agric.wa.gov.au
Dr Darryl Hardie	WA	Western Australian Department of Agriculture and Food dhardie@agric.wa.gov.au

The following table lists the facilities available for diagnostic services in Australia.

Facility	State	Details
DPI Victoria Knoxfield Centre	Vic	621 Burwood Highway Knoxfield VIC 3684 Ph: (03) 9210 9222; Fax: (03) 9800 3521
DPI Victoria Horsham Centre	Vic	Natimuk Rd Horsham VIC 3400 Ph: (03) 5362 2111; Fax: (03) 5362 2187
DPI New South Wales Elizabeth Macarthur Agricultural Institute	NSW	Woodbridge Road Menangle NSW 2568 PMB 8 Camden NSW 2570 Ph: (02) 4640 6327; Fax: (02) 4640 6428
DPI New South Wales Tamworth Agricultural Institute	NSW	4 Marsden Park Road Calala NSW 2340 Ph: (02) 6763 1100; Fax: (02) 6763 1222

Facility	State	Details
DPI New South Wales Wagga Wagga Agricultural Institute	NSW	PMB Wagga Wagga NSW 2650 Ph: (02) 6938 1999; Fax: (02) 6938 1809
SARDI Plant Research Centre - Waite Main Building, Waite Research Precinct	SA	Hartley Grove Urrbrae SA 5064 Ph: (08) 8303 9400; Fax: (08) 8303 9403
Grow Help Australia	QLD	Entomology Building 80 Meiers Road Indooroopilly QLD 4068 Ph: (07) 3896 9668; Fax: (07) 3896 9446
Department of Agriculture and Food, Western Australia (AGWEST) Plant Laboratories	WA	3 Baron-Hay Court South Perth WA 6151 Ph: (08) 9368 3721; Fax: (08) 9474 2658

Appendix 3. Communications strategy

A general Communications Strategy is provided in PLANTPLAN

Appendix 4. Market access impacts

Within the AQIS PHYTO database, no countries appear to have a specific statement regarding area freedom from *M. hordei* (October 2008). Should *M. hordei* be detected or become established in Australia, some countries may require specific declaration. Latest information can be found within PHYTO, using an Advanced search "Search all text" for *Mayetiola hordei.*