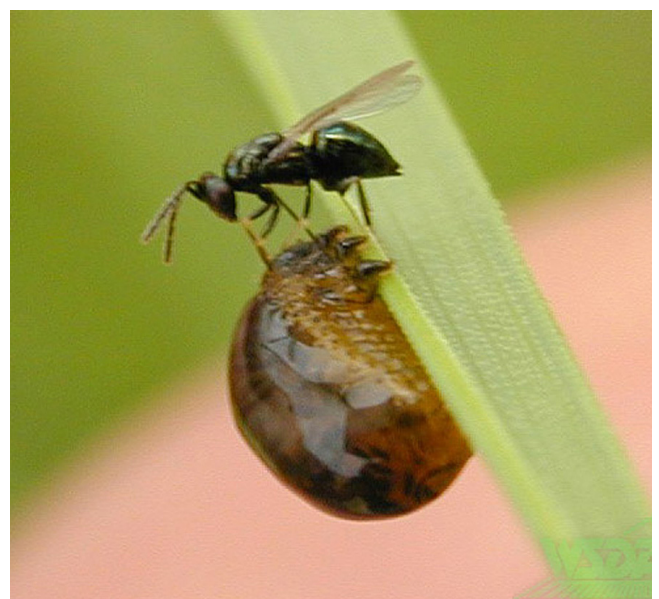
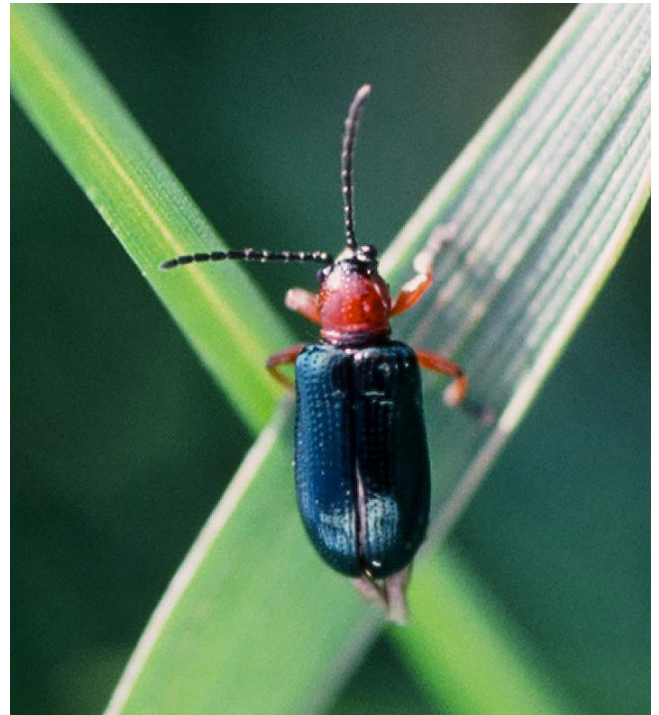


# Integrated Pest Management (IPM) for the Cereal Leaf Beetle in Washington State

WASHINGTON STATE UNIVERSITY EXTENSION • EM054E



# Integrated Pest Management (IPM) for the Cereal Leaf Beetle in Washington State

The cereal leaf beetle (CLB), *Oulema melanopus*, (Coleoptera, Chrysomelidae), is a pest of cereal grains, grass forage/seed crops, and other grass-host species in the Pacific Northwest (PNW) region (Oregon, Washington, Idaho, and Montana). In Washington, the CLB has caused yield losses of 25% in spring wheat (Pike and Gould 2002).

Integrated pest management (IPM) for the CLB should begin with positive pest identification and field scouting to determine infestation rates. Cultural management methods and the use of biological control agents are possible ways to minimize the use of insecticides.

## Distribution of the CLB

The CLB is native to Europe and Asia. The first official record of the CLB in the United States is from southwestern Michigan in 1962 (Castro and Guyer 1963). The insect is now widespread across the eastern and Midwestern states and into Canada. The CLB was first found in Washington State in 1999. As of 2011, the CLB now infests 19 Washington counties (Figure 1). (Consult the National Agricultural Pest Information System (NAPIS) website for up-to-date distribution maps at <http://pest.ceris.purdue.edu/index.php>.)

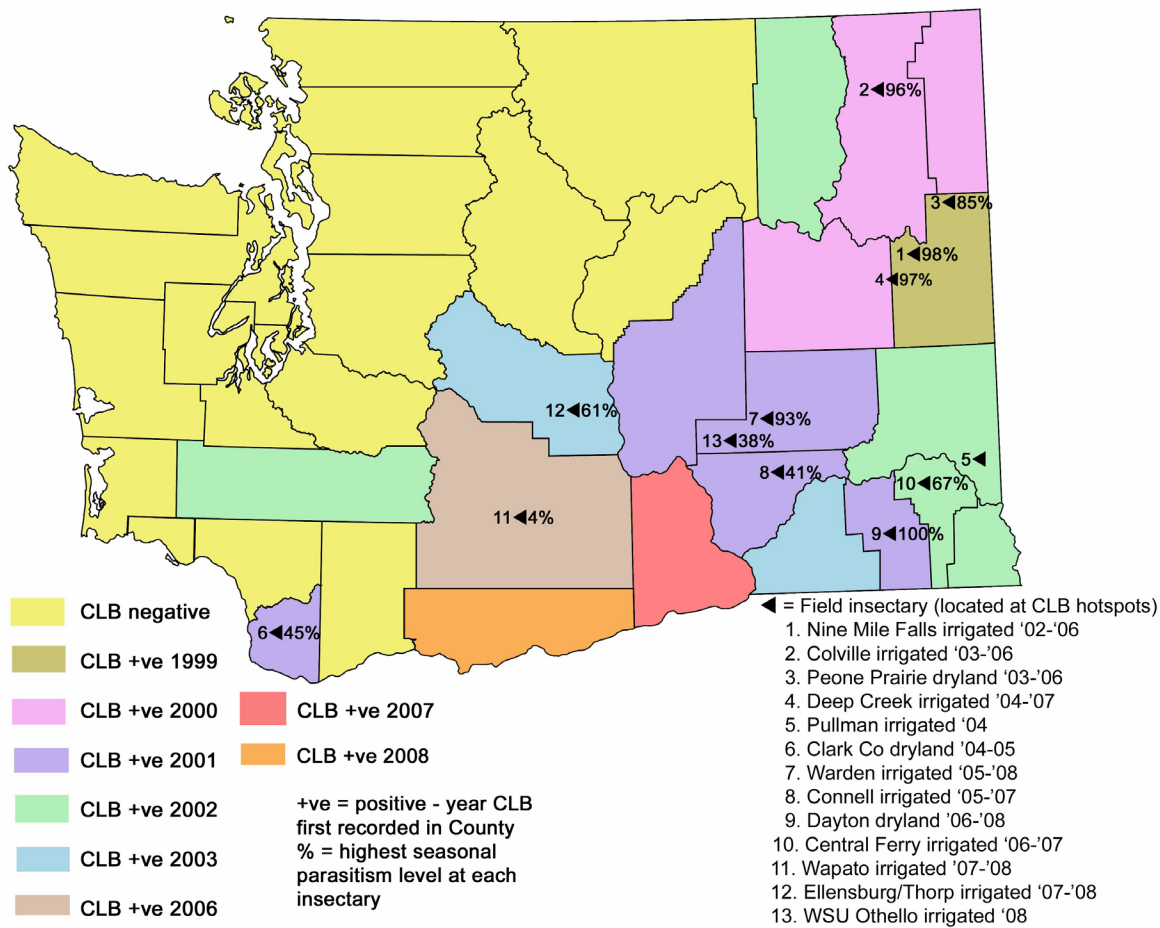


Figure 1. Washington counties with established cereal leaf beetle infestations, plus locations of insectaries for the *T. julis* parasitoid wasp (labeled with their highest recorded seasonal parasitism levels) (Roberts et al. 2010).

## Host Range of the CLB

CLB larvae and adults feed solely on the leaves of cereal crops and grasses. Spring-planted grains, especially oats, are their favorite host and, when available, the insect will move to successively younger crops. Barley and wheat are their secondary choices. The CLB seldom causes yield loss in winter wheat, unless it is the only food source available.

Other occasional hosts—grass crops or weeds—include corn, sorghum, millet, rice, triticale, quackgrass, wild oats, plus brome and foxtail species. The CLB may also use cultivated forage and grass seed crops, such as timothy, orchard grass, perennial/annual ryegrass, tall fescue, Kentucky bluegrass, and fine fescue as hosts. In general, the CLB finds grasses with narrow leaves unattractive for egg-laying compared to spring cereals. However, new spring-planted grasses are at risk for damage by the summer adult CLB after cereal crops have matured and other warm-season grass hosts (e.g., corn) are no longer available (Rao et al. 2004).

Neither CLB larvae nor adults feed on seed/grain kernels or broadleaf plants (Hodgson and Evans 2007). Adults have been found in harvested grain; however, they can survive no more than 14 days in a grain bin. Adults can also survive the compression of baled hay; therefore, any straw exported out of the U.S. through California must be fumigated (see quarantine alert sidebar).

## Life History and Habits of the CLB

The adult CLB overwinters in protected sites, such as grain stubble, grass crowns, wooded areas, and other sheltered places close to grain fields. In spring, adults emerge when air temperatures are above 50°F and feed on available host grasses and cereal grains. Adults are active for approximately 6 weeks, during which time they mate and lay eggs in spring-planted (preferably) and fall-planted cereal grains. Adult activity increases on calm, sunny days, and the beetles will drop to the ground when disturbed. Female CLB adults begin to lay eggs about 2 weeks after emergence and can lay up to 300 eggs over a 6-week period. The time required for hatching depends on temperature, so eggs can hatch from 4 to 23 days after deposition (Philips et al. 2011).

Larvae feed on the host plant for 3 to 4 weeks during which time they go through 4 instars or stages. An estimated 90% of feeding occurs during the last 2 instars. Mature larvae drop to the ground in late June, pupate in earthen cells within the top 2 inches of the soil, and emerge as adults 2 to 3 weeks later,

## Quarantine Alert

The CLB has not been found in grain fields in California. Consequently, the following products are restricted from entering California:

- Small grains, such as barley, oats, and wheat
- Straw and hay, including marsh hay (pelletized hay not listed)
- Grass sod
- Grass and forage seed
- Fodder and plant litter
- Cut or balled Christmas trees of Scotch, red, and Austrian pine (Adults sometimes overwinter in these trees.)
- Used harvesting equipment and machinery

These products cannot enter California if they come from any county known to be infested with the CLB—unless that product shipment has been certified as treated for the CLB. The origin of commodities sourced from uninfested counties must also be certified. There are exemptions to this, however, based on what part of the crop is being transported, how it is packaged, how it was used previously (e.g., for livestock bedding), and even what time of year it was transported.

For more information regarding cleaning or fumigation treatments and county-of-origin certification, or exemption, visit the California Department of Food and Agriculture website at <http://pi.cdafa.ca.gov/pqm/manual/pdf/321.pdf>.

in July. During July, the new summer adults feed but do not mate, which means they produce only one generation per year. After summer aestivation (dormant stage during high heat periods), the adult beetles move to any available grass hosts (such as corn or grass seed crops) to feed for 2 to 3 weeks prior to dispersing to overwintering sites, where they remain inactive until the following spring. In the Midwest, overwintering mortality rates range from 40%–70% due to extreme temperatures and introduced/natural predators (USDA-APHIS 1995).

## Signs of CLB Damage and Yield Impact

CLB larvae and adults feed between the veins of the newest leaves on host plants. Larvae cause the most

## Life Stages of the CLB



*Look-alike Collops sp. (left) and adult CLB (right).*

### Adult

The adult CLB is between 7–9 mm long (approx. ¼") and is slender and cylindrical with metallic, bluish-black wing covers (elytra), a black head, and an orange-red thorax and legs. Adults drop to the ground when disturbed. Look-alike beetles found in the PNW include native predators, such as the soft-winged flower beetle (Coleoptera: Melyridae), which feeds on aphids, alfalfa weevils, and the immature stages of several types of immature insects.

*(Photo by G. Clevenger)*



*CLB eggs laid singly or in clumps of up to 3 on the upper midrib of cereal plant leaves.*

### Egg

The CLB lays its yellow, cylindrical eggs on an upper leaf surface, close to the mid-vein. They are found usually as a single egg, although groups of two or three can occasionally be found. Eggs are about 1-mm (<1/16-inch) long and darken when they are about to hatch.

*(Photo from P. Glogoza, NDSU Extension Bulletin E-1230, Figure 3)*



*Pants smeared with fecal material from CLB larvae after walking in a field is often the first sign of a CLB infestation. (Photo by K. Cutler)*

### Larva

CLB larvae (approx. ¼" at maturity) have black heads and pale yellow bodies that appear black because of their "slimy backpack." This backpack, which gives the larvae a "slug-like" appearance, contains fecal material and mucus that act to protect it from natural enemies, as well as from drying out. Walking through CLB-infested fields may result in "smeared" pants.



*CLB larva on a wheat leaf. (Photo by D. Roberts)*



*CLB larva and leaf damage. (Photo from the WSDA)*



*CLB pupa. (Photo by G. Clevenger)*

### Pupa

CLB larvae pupate in the soil in earthen cells that are difficult to detect.

damage by removing long strips of tissue from the upper leaf surface, while leaving the translucent cuticle of the lower surface intact. This feeding pattern produces a characteristic “frosted” appearance (Figure 2). Tips of damaged leaves frequently turn white, giving heavily infested fields a frost-damaged appearance. Adults will chew completely through the leaf, which results in narrow slits, although the damage they cause is usually insignificant.



Figure 2. CLB larvae and signs of their damage to young oat plants. (Photo by K. Cutler)

Yield losses of 25% have been reported in irrigated spring wheat in Washington State (Pike and Gould 2002). Yield loss is influenced by crop vigor and the timing and duration of the CLB infestation. Stressed growing conditions or poorly developed plants may increase potential damage.

## CLB Scouting and Economic Thresholds

Scouting for adult beetle activity should begin in the spring when air temperatures exceed 50°F for several days. To detect eggs and small larvae, early and frequent scouting is necessary (from the onset of favorable temperatures until the heads of grain are fully emerged). For fall-planted grains, begin scouting when plants have two visible stem nodes. Spring grain scouting should begin soon after emergence, especially for late plantings. Heavy rain or irrigation can wash CLB larvae off the leaves, so scouting during this time may not yield accurate results. To determine if CLB populations have reached economic threshold levels (the infestation level at which the cost of insecticide application is equal to or less than the cost of grain yield loss from the pest), examine a minimum of 100 tillers per field (see Appendix worksheets 1 and 2). Record the number of CLB eggs and larvae per tiller from each of 10 tillers that have been

examined at 10 different sites within the field (10 X 10 method). Indicate the number of eggs/larvae that are located on the flag leaves, if they have developed.

Field edges should be scouted separately. Large fields may need to be subdivided for more thorough scouting. Eggs may be located on leaves near the ground, so careful examination of each tiller is critical. Because these beetles are often randomly distributed within a field, it is possible that only a portion of a field will be above the threshold. In this case, treating only this portion of the field is optimal. At boot stage (when the flag leaf has developed but the grain head has not emerged) in spring wheat, the threshold level of 0.5 larvae per flag leaf may be more accurate if the crop has not developed adequate tiller density and/or is growing under poor conditions (Rao and Walenta 2011).

### Economic threshold levels for small grains:

- PRE-BOOT UNTIL FLAG LEAF FULLY EMERGED (Feekes 1–8) *Average of 3 eggs and/or larvae per tiller*
- BOOT- AFTER FLAG LEAF EMERGED but grain head not emerged (Feekes 9+) *Average of 1 larva per flag leaf*

## Cultural Control of the CLB

Effective cultural controls for the CLB rely on proven agronomic practices that favor well established stands with vigorous, well-tillered plants that can tolerate damage by CLB populations that are below threshold levels.

Resistant varieties of wheat and barley are available in the eastern U.S. (Ruppel and Stehr 1972), but none have been identified in the PNW region. The resistance mechanism in wheat is attributed to leaf hairiness, which deters egg laying and feeding by larvae.

In Oregon, CLB adults showed a strong preference for leaves of small, young oat plants compared to younger tillers on older plants when they were selecting host plants for egg laying (Hoffman and Rao 2006). Such behavior may explain why, in Washington, border strips (1–2 drill strips 45–60 ft wide) seeded to oats 2 weeks after spring wheat were an effective trap crop management strategy (Roberts et al. 2010). The oats then provide areas of refuge (no-spray areas) that enable the survival and proliferation of parasitoid wasps and other natural predators

(Figure 3). Beneficial insects provide the optimal, long-term method of CLB control.

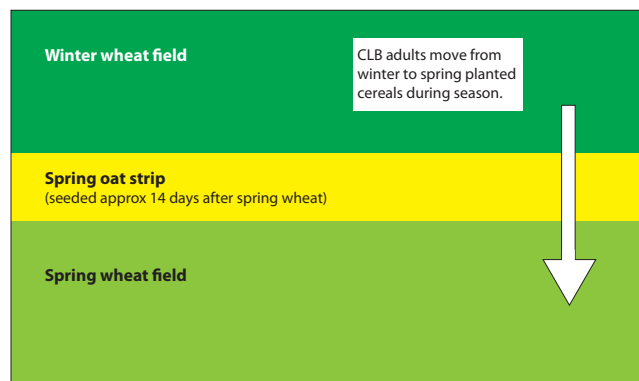


Figure 3. Diagrammatic representation of an oat trap crop for CLB management.

## Biocontrol of the CLB

In the U.S., insecticides were the first line of defense against the CLB, and in 1966, more than 1.6 million acres of small grains were sprayed. Following the introduction of CLB-specific parasitic wasps, and, in areas where this parasite/natural predator complex is well established, biological control can reduce CLB populations by 70%, and drop yield losses to less than 1% (USDA-APHIS 1995).

In the PNW, through collaborative partnerships with the USDA-APHIS, state departments of agriculture, and land grant universities, biocontrol programs were initiated in each state soon after CLB detection. After importing, rearing, and releasing the CLB larval parasitoid wasp, *Tetrastichus julis*, (Hymenoptera: Eulophidae) into commercial fields and managed insectaries, this biocontrol agent has established itself successfully in many areas of the PNW. Due to the successful overwinter recovery of *T. julis* and the consistently high parasitism rates of CLB larvae (>90%) in the commercial fields of eastern Washington, redistribution of parasitized larvae to other CLB-infested areas in the state was possible (Figure 1).

*T. julis* parasitoid wasps are very small (1/8 inch) and produce two generations per year, which are timed with CLB larvae occurrence in the field. The female wasp inserts its eggs into a CLB larva (Figure 4), where several young can complete their development. Upon hatching, the parasitoid larvae feed within the CLB larva and destroy it during pupation in the soil. Although current season CLB control does not occur since CLB larvae continue to feed until pupation, CLB adults emerging in the summer and the following spring are reduced due to the parasitoid wasp.

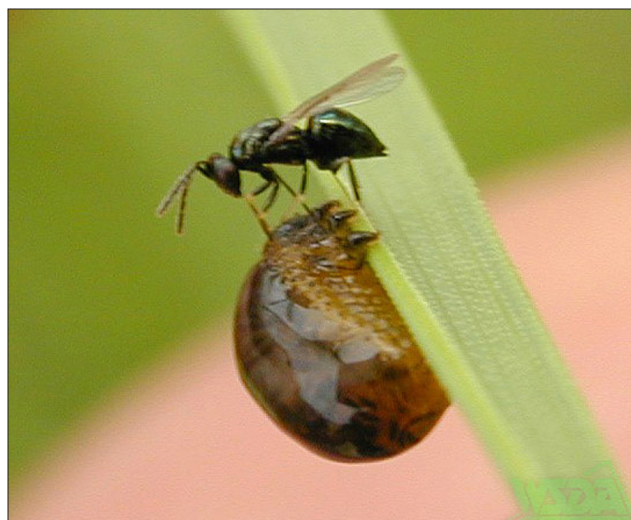


Figure 4. Parasitoid wasp *Tetrastichus julis* and CLB larva. (Photo courtesy of Washington State Department of Agriculture)

The convergent ladybird beetle, *Hippodamia convergens* (Hc), is a native predator species (Figure 5) that overwinters in pine duff in low mountains at 3500 feet or more. Ladybird beetles migrate to grain fields in the spring when temperatures reach 45°F or higher prior to the CLB and other cereal pests becoming active. Hc reduces early season CLB and aphid populations to below economic threshold levels, and they may remain active until soft dough, when the grain is fully formed and starchy (Feekes stage 11.2). The Hc larvae and adults only consume CLB eggs and larvae up to the 3rd instar (thus providing in-crop control). They will not consume CLB larvae beyond this point, so they should not compete with the parasitoid wasp for host insects—so *T. julis* may multiply its own population and its effects on the CLB population (Bragg 2010).



Figure 5. Convergent ladybird beetle (*Hippodamia convergens*). (Photo by D. Roberts)

## Cereal Leaf Beetle Integrated Pest Management

Integrated management of a CLB infestation is a decision-making process (Appendix Figure 1) that involves asking several key questions:

- 1) Does the CLB population meet or exceed economic threshold levels for the crop growth stage?
- 2) Do small larvae (1st and 2nd instar) make up the majority of the population?
- 3) Do eggs make up only a small percentage of the population (<50%)?
- 4) Are parasitoid wasps active in the field and, if so, at what level? (See instructions following.)

Insecticide application targets the cereal leaf beetle's larval stage, and the optimal time to apply is when the majority of CLB eggs have hatched and small larvae are present on foliage (Pike and Gould 2002). Note that insecticides cannot kill the CLB at the egg stage and adults are highly mobile and can avoid control efforts. It is also important to understand that insecticides can also kill parasitoid wasps and other natural predators that are active in the field.

Insecticides applied too early or without consideration for crop growth stage and CLB infestation levels or distribution within a field will not provide effective control. Repeated treatment may then become necessary if the field becomes infested at economic levels, thus increasing the cost of control and the potential for yield loss. Treatment is not needed once larvae have matured and have entered pupation in the soil. So before applying an insecticide, use the Field Data Sheets (Appendix worksheets 1 and 2) to determine whether treatment is needed for the entire field, only parts of the field, or is not required at all. Untreated areas within a field or near field borders will offer refuge to parasitoids and other useful CLB predators (Figure 6).

Using the CLB IPM strategy will maximize insecticide effectiveness, improve parasitoid survival, and help parasitoids and other natural predators keep CLB populations below economic threshold levels within a given field (Philips et al. 2011).

For information on insecticide recommendations, refer to the online PNW Insect Management Handbook, which is updated annually by Oregon State



Figure 6. Untreated areas within fields and near field borders promote survival of introduced parasitoids and natural predators. (Photo by D.L. Walenta)

University, Washington State University, and the University of Idaho. This handbook can be found at <http://pnwpest.org/pnw/insects>.

### Parasitism Levels of the CLB Larvae

Growers in Washington may determine the parasitism rate of CLB larvae (Figure 7) by sending samples to Washington State University's Plant Diagnostic Lab in Pullman. There is a \$40 fee for this service. Call the Lab ahead of time at 509-335-3292 to get updated information.

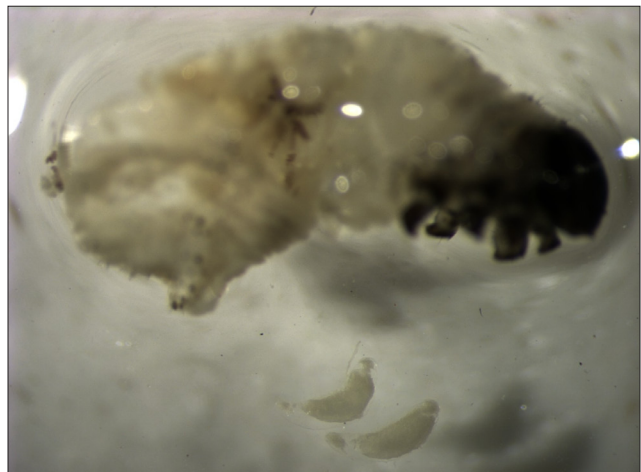


Figure 7. Dissection of CLB larva showing *T. julis* wasp larvae as crescent shapes in lower center of photo. (Photo by G. Clevenger)

For samples, collect 30–50 larvae (at least 1/8-inch long or preferably the most mature larvae, which are approximately 1/4-inch long) by clipping off the leaves that support the larvae and placing them in a plastic container with a lid, for example, a one-pound yogurt container. Place the container in a cardboard box and mail it overnight—timing it to

arrive prior to the weekend as dead insects will not provide accurate results. Mail it to:

Washington State University  
Plant Diagnostic Lab  
Department of Plant Pathology  
345 Johnson Hall  
100 Dairy Rd  
Pullman WA 99164-6430  
Phone: 509-335-3292

### **CLB Biocontrol and Contact Information**

For PNW regional CLB and biological control information, go to:

- CLB Research—Western North America  
<http://clbarchive.wsu.edu>
- Nat. Ag. Pest Information System (NAPIS)  
<http://pest.ceris.purdue.edu/index.php>

To report new CLB infestations, please contact:

- WSDA Pest Program 360-902-2070
- USDA-APHIS 509-535-2932

### **Conclusion**

As this publication goes to press in 2012, the CLB is seen occasionally in the dryland areas of eastern Washington. However, it has not been reported as a pest there for almost 10 years. While there may be seasonal fluctuations in pest populations, we believe the beneficial *T.julis* parasitoid wasp will continue to keep the pest populations at a sub-economic level.

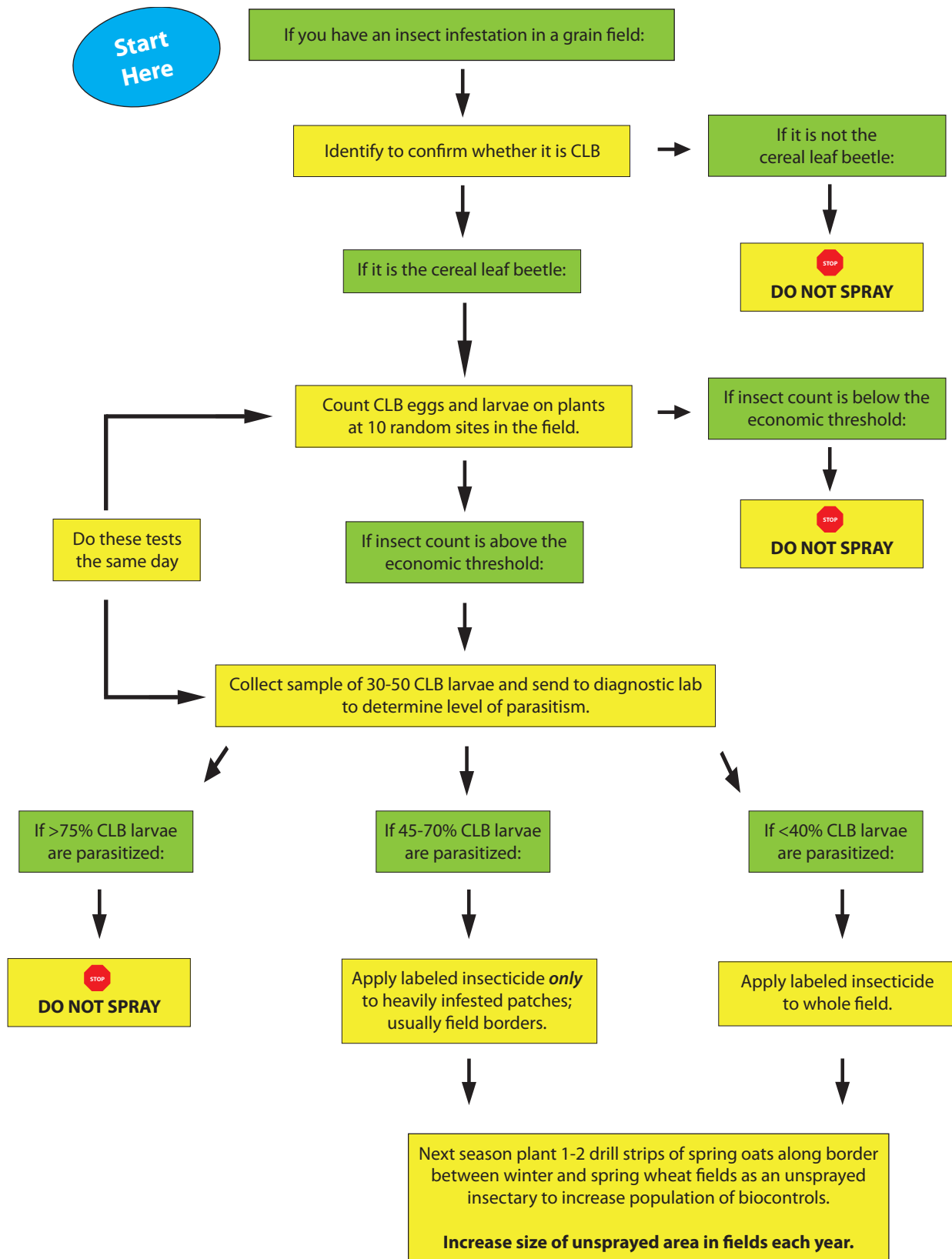
In the irrigated areas of the Columbia Basin, however, the situation is not as positive. Wheat is grown there as a rotation crop and economics of production and pesticide use are different than in the dryland areas. Where insecticides are used routinely, it is a tough environment for the parasitic wasp. Although we know it established itself and survived in insectaries, it has not thrived in commercial fields.

Ultimately the producer chooses which management method to employ. In order to promote the survival of beneficial insects, farmers would benefit from providing them with a non-sprayed refuge area (see section on Cultural Control) adjacent to their grain fields, and maintaining the refuge even after parasitism levels have reduced the CLB populations.

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**Appendix Figure 1. Decision chart for managing CLB infestations.**



## Appendix—Worksheet 1

### CLB Damage Worksheet

Field: \_\_\_\_\_

Date Collected: \_\_\_\_\_

Crop/Growth Stage: \_\_\_\_\_

Sample #	Tiller #	Tiller		Flag Leaf		Sample #	Tiller #	Tiller		Flag Leaf	
		# eggs	# larvae	# eggs	# larvae			# eggs	# larvae	# eggs	# larvae
1	1					6	1				
	2						2				
	3						3				
	4						4				
	5						5				
	6						6				
	7						7				
	8						8				
	9						9				
	10						10				
	subtotal							subtotal			
2	1					7	1				
	2						2				
	3						3				
	4						4				
	5						5				
	6						6				
	7						7				
	8						8				
	9						9				
	10						10				
	subtotal							subtotal			
3	1					8	1				
	2						2				
	3						3				
	4						4				
	5						5				
	6						6				
	7						7				
	8						8				
	9						9				
	10						10				
	subtotal							subtotal			
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	4						4				
	5						5				
	6						6				
	7						7				
	8						8				
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	10						10				
	subtotal							subtotal			
5	1					10	1				
	2						2				
	3						3				
	4						4				
	5						5				
	6						6				
	7						7				
	8						8				
	9						9				
	10						10				
	subtotal							subtotal			

## Appendix—Worksheet 2

### Calculation of CLB infestation level and comparison to known economic thresholds

CLB Economic Thresholds for Small Grains:	
<b>PRE-BOOT</b> (Feekes 1-8)	Average of 3 eggs and/or larva per tiller (refer to Table 1)
<b>BOOT+</b> (flag leaf fully emerged, Feekes 9+)	Average of 1 larva per flag leaf (Table 2)
*Current control recommendations are presented in the PNW Insect Management Handbook which are available online at <a href="http://pnwpest.org/pnw/insects">http://pnwpest.org/pnw/insects</a>	

#### CLB Threshold Evaluation Sheet Instructions

1. Inspect 10 individual tillers in 10 different locations in the field.
2. At each location, record total # of eggs and larvae found on each tiller; if the flag leaf is present then record how many of the total were actually found on the flag leaf.
3. Determine the subtotal for each of the 10 locations to determine variation of infestation levels within the field.
4. Tally the subtotals for each category and record in Table 1 (eggs/tiller and larvae/tiller for PRE-BOOT) and Table 2 (eggs/flag leaf and larvae/flag leaf for BOOT+).
5. Divide each category total by 100 to determine average # for each category and record in appropriate tables below.
6. Divide the **percentage of eggs** to larvae by dividing the total # of eggs per tiller by the total number of eggs + larvae per tiller then multiplying by 100. This number indicates the % of eggs within the population found on a tiller. **Repeat for percentage of larvae.**
7. If flag leaf fully emerged, repeat Step 6 (with flag leaf data) and record in Table 2. Also note # of eggs and larvae on tillers.
8. Refer to threshold levels at top of page to determine if CLB control is needed. NOTE: If a high percentage of eggs per tiller or flag leaf are discovered, delay any insecticide applications until at least 25% or more (preferably 50% or more) of the eggs have hatched and numbers still meet threshold requirements. Control is improved when the majority of the population is in the larval stage.

**Table 1. PRE-BOOT (vegetative growth stage) threshold calculations.**

	<u>Total # per 100 Tillers</u> (refer to Step 4)	<u>Average # per Tiller</u> (refer to Step 5)	<u>Meet or Exceed Threshold?</u> (Yes or No)
# Eggs			
# Larvae			
# Eggs + Larvae			
		% of EGGS in population (Step 6) =	
		% of LARVAE in population (Step 6) =	

**Table 2. BOOT+ (Flag leaf emerged & beyond or Feeks 9+) threshold calculations.**

	<u>Total # per 100 Flag Leaf</u> (refer to Step 4)	<u>Average # per Flag Leaf</u> (refer to Step 5)	<u>Meet or Exceed Threshold?</u> (Yes or No)
# Eggs			
# Larvae			
# Eggs + Larvae			
		% of EGGS in population (Step 7) =	
		% of LARVAE in population (Step 7) =	



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Cover photo of adult CLB is provided courtesy of Lloyd M. Dosdall, University of Alberta, AB, Canada.

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