Wheat Stem Sawfly Biological Control

Cephus cinctus Norton (Hymenoptera: Cephidae)

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FIGURE 1: *Cephus cinctus* female ovipositing in a wheat stem.

FIGURE 2: *Bracon cephi*, an endemic parasitoid of *Cephus cinctus* in North America.

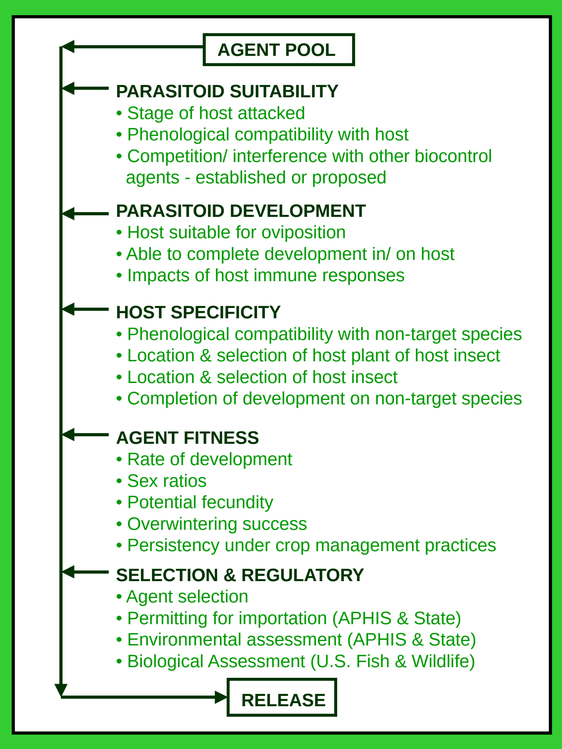


FIGURE 3: Elements to be considered when selecting new biological control agents.

FIGURE 4: *Collyria* sp. n. reared from *Cephus fumipennis* collected in China.

FIGURE 5: Collecting sawfly infested wheat stubs in Gansu Province, China.

Introduction

Several species of grass-mining cephids are pests of wheat and other cereal crops in the northern hemisphere. In North America, three species attack wheat: *Cephus cinctus* in the west (Figure 1), and *C. pygmaeus* and *Trachelus tabidus* in the east. The latter two species were introduced into North America over 100 years ago, while the origin of the first is unclear. Grass-mining cephids are uni-voltine and have an obligate larval diapause. Females oviposit in elongating stems of wheat or other hosts in the spring. Larvae feed within the stem, moving to the basal portion as the plant matures. A groove is cut around the inside of the stem, and the weakened stem breaks forming a structure called a 'stub'. The stub is sealed at the top with a secreted plug, creating a chamber where the diapausing larva spends the winter. Increased temperatures, moisture and/or photoperiod terminates diapause in the spring. Pupation occurs within the stub and the adult sawfly emerges and mates.

Damage/Impact

Cephus cinctus has been the most important and consistent pest of wheat in the northern Great Plains since large-scale cereal crop cultivation began more than 100 years ago. Field infestations of 70 to 80% have been recorded at several locations and in several years. Yield losses are the result of larval feeding which can reduce grain weight by more than 20%, and fallen grain due to stem cutting. Yield losses of up to 35% have been reported in some locations, and across the region, annual losses to wheat and other cereal crops can exceed US$100 million.

Endemic Natural Enemies

The most important sawfly natural enemies are parasitic Hymenoptera, though nematodes and two fungal pathogens have been reported. In wheat, two species of congeneric braconid, *Bracon cephi* (Figure 2) and *B. lissogaster* attack the larvae of the wheat stem sawfly. Morphologically the two species are very similar and have only recently been accurately differentiated. Runyon *et al.* (2001) separated the two using several characters including the texture of the metasomal terga and first metasomal suture. It is likely that these two species have been confused in earlier reports. The impact of these parasitoids has been spatially and temporally variable, and inconsistent. As early as 1923, *B. cephi* was reported to parasitize up to 50% of available *C. cinctus* larva in North Dakota (Criddle, 1924) while more recently, Morrill *et al.* (1998) observed *Bracon* spp. parasitizing 1 to 98% of available hosts over four years in central Montana.

Ecology

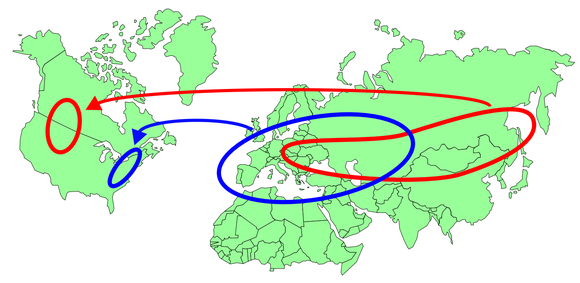
A three year survey indicates that most native and introduced grass species in western North America are used as hosts by the wheat stem sawfly. An apparent limitation to host utilization occurs for thin-stemmed grasses under drought conditions. The literature suggests a complex of up to nine species of natural enemies exploit *C. cinctus* in grasses. Behavioral analysis using Y-tubes shows that both *B. cephi* and *B. lissogaster* use female-produced sex pheromones to attract males. Additional experiments clearly show that there is no attraction towards congeneric females by males of either species. These pheromones may help to maintain species isolation for these important biological control organisms. Efforts are underway to isolate and identify these compounds. In addition, newly-commenced research is aimed at elucidating induced host plant compounds that serve to attract parasitoids towards sawfly-infested wheat. A considerable effort is underway to identify novel compounds produced by larval feeding, and to elucidate the behavioral activity of these compounds in wind tunnel and Y-tube experiments. Preliminary evidence suggests that newly-oviposited wheat may also release a dramatically-altered profile of volatile compounds. Experiments are underway to evaluate the role of these compounds in host location by egg/larval parasitoids that are candidates for introduction for classical biological control of *C. cinctus*.

Selection and Evaluation of New Biological Control Agents

Selection of new wheat stem sawfly natural enemies will be based upon several interrelated factors, including host acceptance, host suitability and host specificity (Figure 3). Prior to introduction of new exotic parasitoids into North America, a risk assessment must be developed to determine direct or indirect environmental impacts, or potential impacts of such introductions on indigenous organisms. This selection process has begun on one parasitoid, *Collyria* sp. n. (Figure 4). This wasp is an egg-larval parasitoid collected from *Cephus fumipennis* from north central China. *Collyria* females oviposit within the developing sawfly egg. The larval parasitoid partially develops within its host during the summer and completes its development the following spring. Preliminary tests indicate that *C. cinctus* may be a suitable host for this parasitoid.

Previous Biological Control Efforts

The first attempt at biological control of *C. cinctus* was in Canada using parasitoids collected from *C. pygmaeus* in England. No biological control agents were permanently established despite nine years (1930-39) of effort and the release of more than 500,000 parasitoids. A second attempt was undertaken in the western US from 1952-55, again using parasitoids from *C. pygmaeus*, though this time collected in France. Nearly 40,000 parasitoids were released but this attempt was also unsuccessful. A biological control program was also conducted against *C. pygmaeus* in eastern North America (1935-40). More than 52,000 parasitoids, collected from *C. pygmaeus* in England, were released resulting in the permanent establishment of *Collyria coxator* (Hymenoptera: Ichneumonidae). This species appears to play an important regulatory role in the sawfly's population dynamics, and has been credited with the successful biological control of *Cephus pygmaeus*.



Distribution and movement of natural enemies for *Cephus pygmaeus* (——) and North American distribution and possible Asian source for *Cephus cinctus* (——) natural enemies.

Foreign Exploration

Previous unsuccessful biological control efforts utilized parasitoids field-collected in northwestern Europe. These failures were attributed to a lack of adaptation to *C. cinctus* or to the lack of proper synchronization with suitable host stages. Recently, further collections and introductions have been reconsidered following the synonomy of *C. cinctus* with the Asian species *C. hyalinatus* Konow (Ivie & Zinovjev, 1996). They suggested that several other Asian species may also be conspecific with *C. cinctus*. At least 10 *Cephus* spp. are reported from Asia, the likely center of diversity for this genus. Little is known of Asian parasitoids (Table 1). In the sparse literature records, the ichneumonid *Collyria* (Figure 4) is frequently the dominant species in reported parasitoid assemblages. Complexes generally include a braconid and one or more chalcidoids. Parasitism from other members of the local complex is relatively low. Literature records suggest many of these species have alternate hosts. Exploration is planned in areas of northern China, Mongolia and Siberian Russia that include wheat-growing areas as well as natural wild grass habitat (Figure 5). In addition to known pest species of *Cephus*, additional species of grass-feeding sawflies not specifically targeted in the past will also be collected and their natural enemies identified and evaluated.

Table 1. Hymenopterous parasitoids reported from *Cephus* spp. in Asia

BRACONIDAE
- *Bracon* (= *Microbracon*) *minutator* F. [= *abscissor* Nees, *rufigaster* Szépligeti]
- *Brcon praetermissus* Marshall
- *Bracon terebella* Wesmael [= *curticaudis* Szépligeti]
- *Ceratobracon stschegolevi* Telenga

ICHNEUMONIDAE
Collyriinae
- *Collyria* sp. n.(?)
- *Collyria coxator* Villers [= *C. coxator* (Gravenhorst), *C. puncticeps* Meyer]

Cryptinae
- *Theroscopus hemipteron* (Riche) [= *Hemiteles hemipterus* F.]

Pimplinae
- *Endromopoda* (= *Pimpla*) *detrita* (Holmgren)

EUPELMIDAE
- *Euplemus atropurpureus* Dalman
- *Eupelmus vesicularis* (Retzius) [= *Eupelminus saltator*, *Eupelmella vesicularis* (Retzius)]

PTEROMALIDAE
- *Homoporous* (= *Merisus*) *febriculosus* (Girault)
- *Norbanus meridionalis* (Masi)
- *Norbanus scabriculus* (Nees) [= *Arthrolysis* (*Picrocystus*) *scabricula* Nees)

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