Chilo suppressalis

Scientific name
Chilo suppressalis Walker

Synonyms
Jartheza simplex, Chilo oryzae, Chilo simplex, and *Crambus suppressalis*

Common names
Asiatic rice borer, striped rice stem borer, striped rice stalk borer, rice stem borer, rice chilo, purple-lined borer, rice borer, sugarcane moth borer, pale-headed striped borer, and rice stalk borer.

Figure 1. *Chilo suppresalis* egg masses. Image courtesy of International Rice Research Institute Archive. www.bugwood.org

Type of pest
Moth

Taxonomic position
Class: Insecta, Order: Lepidoptera, Family: Crambidae

Reason for Inclusion in Manual
CAPS Target: AHP Prioritized Pest List – 2009 & 2010

Pest Description
Eggs: Eggs (Fig. 1) are fish scale-like, about 0.9 x 0.5 mm, turning from translucent-white to dark-yellow as they mature. They are laid in flat, overlapping rows containing up to 70 eggs. Eggs of other *Chilo* spp. are quite similar and cannot be easily distinguished (UDSA, 1988).

Larvae: First-instar larvae are grayish-white with a black head capsule and are about 1.5 mm long (CABI, 2007). The head capsule of later instars becomes lighter in color, changing to brown. Last instar larvae (Fig. 2) are 20-26 mm long, taper slightly toward each end, and are dirty-white, with five longitudinal purple to brown stripes running down the dorsal surface of the body (Hill, 1983).

Figure 2. *Chilo suppresalis* larva. Image courtesy of Probodelt, SL.

Pupae: Pupae are reddish-brown, 11-13 mm long, 2.5 mm wide (Hill, 1983) and have two ribbed crests on the pronotal margins and two short horns on the head. The cremaster (the terminal spine of the abdomen) bears several small spines (Hattori and Siwi, 1986).

Adults: In general, *C. suppressalis* forewings are 11-15 mm long with a wingspan of 20-30 mm (Hill, 1983) with a color varying from dirty-white to yellow-brown (Fig. 3), sprinkled with gray-brown scales. The hindwings are white to yellowish-brown (Hattori and Siwi, 1986).

Figure 3. *Chilo suppressalis* adult. Photos courtesy of International Rice Research Institute Archive www.bugwood.org.

Adult male: Forewing straw colored, variably or often uniformly suffused with light brown, with brown to dark-brown specks scattered irregularly, sometimes forming small patches; sometimes with broken, diffuse, oblique brown median band between middle of wing and apex; outer margin with row of small dark spots; fringe not metallic, of a lighter shade distally. Hindwing whitish, faintly shaded with brown; fringe uniformly whitish. Front of head conical, strongly protruding forward beyond eye, with very distinct corneous point and a protruding ridge along lower margin; front between point and ventral margin appears concave in profile. These features made visible by brushing away scales from face between the eyes. Labial palp 3 times as long as diameter of eye. Wing expanse ranges from 20-30 mm. Male genitalia bifurcate juxta symmetrical, the arms bowed, equally long, distinctively swollen, and without subapical teeth; aedeagus with long, thin, ventral arm (USDA, 1988).

Adult female: Larger than male, with paler forewing and fewer dark flecks. Hindwing nearly white. Ridge along lower margin of front of head only about half as prominent as that of male, sometimes barely apparent, but still useful for recognizing this species, as so many others lack it entirely. Labial palp 3.5 times as long as diameter of eye. Wing expanse ranges from 24-30 mm Female genitalia have heavily sclerotized ostial pouch, slightly demarcated from ductus bursae; the latter distinctly swollen posterior to ostial pouch, with heavily sclerotized band; Signum distinct, elongate, with median ridge (USDA, 1988).

Biology and Ecology

C. suppressalis is mainly a pest of rice and most of its phenology reflects observations taken on rice.

C. suppressalis is adapted to temperate climatic conditions; larvae survive low winter temperatures in Japan, China and other northern areas. This is in marked contrast to most other species of *Chilo*, which are restricted to tropical or sub-tropical regions (CABI, 2007). In favorable (tropical) conditions, up to six generations develop in a year, often overlapping where rice cropping is continuous. In colder climates, final instars remain dormant during the winter. It seems that photoperiod is more important than temperature for diapause; a facultative diapause has been observed when the photoperiod drops below 14 hours (Cho et al., 2005).

Adults are nocturnal and survive up to a week under field conditions, with females generally living longer than males. Although there is minor temporal isolation in the development of *C. suppressalis* developing on rice and other hosts, significant overlap and mating exists among these groups (Ueno et al., 2006). Eggs are laid in batches of 60-70, mainly on the basal halves of leaves and occasionally on leaf sheaths (the part of the blade that wraps around the stem). The optimum temperature for hatching is 21-33°C (71-91°F).

After hatching, larvae cluster between the leaf sheaths and stems, then burrow into the stems to feed. Some early larval instars may move to other plants by wind aided dispersal. Several larvae may feed together within a single internode, living in a moist pulp of chewed plant debris and frass. They pupate within stems, having first prepared an exit hole from which the adult will emerge. In the tropics and on rice, normal development times are: egg (5 to 6 days), larva (30 days), pupa (6 days). The life cycle is completed in 35-60 days.

Degree-day models have been calculated for *C. suppressalis*. At 25°C (77°F) with a 14L:10D photoperiod, the average degree days for eggs, larvae, and male and female pupae were 124, 521, 111, and 103 day-degrees, respectively (Tsumuki et al, 1994).

Pest Importance

C. suppressalis is considered one of the most serious pests of rice in the Far East (Grist and Lever, 1969). For example, up to 100% loss have been reported from individual fields in Japan, but normally 4-7% yearly losses have been attributed to this pest overall in Asia (Cho et al., 2005).

Figure 4. Dead heart symptom. Photo courtesy of the Purdue Extension Entomology (J. Obermeyer).

Historically, organophosphates have been used to control this pest in rice and other cropping systems. Due to increasing regulation and resistance in certain populations, pyrethroids are now being studied for their effectiveness (He et al., 2007).

A pheromone dispensor (Selibate CS™) has been developed for both the monitoring and control of *C. suppressalis* in Spain. Studies to control the cost of using pheromone disruption by streamlining the density and placement within and around rice fields are in their fourth year (Alfaro et al., 2009). These studies have shown that treatments provide effective control even with reduced pheromone dispenser densities.

Transgenic lines of rice expressing toxin genes from *Bacillus thuringiensis* have been developed with great success against stem borers (*ex.*, cryIA coding sequences, Cheng et al., 1998). Corn has been similarly transformed with equivalent coding sequences; although there are no published reports quantifying control of *C. suppressalis* with these transgenic lines of maize, the protection these genes provide rice yields would also have a high likelihood of being successful in corn.

Symptoms/Signs

Infested leaf sheaths first show transparent patches, late turning yellow brown and drying. Stems weaken and easily break as a result of larval feeding inside the stem around the nodes. Seedlings attacked at the base show "dead hearts" (Fig. 4) or drying of the central shoot produced when stem borer larvae kill the growing points of young shoots. Infested plants bear "whiteheads" (empty panicles or with a few filled grains). There are other possible causes of these symptoms (other insects, fungi, and etc.) and samples of stems should be dissected to establish that *C. suppressalis* is responsible for the damage.

Known Hosts

Major hosts

Oryza sativa (rice), *Poaceae* spp. (grasses), *Sorghum bicolor* (sorghum), and *Zea mays* (corn).

Wild/Minor hosts

Andropogon sorghum (broomcorn), *Brachiaria mutica* (para Grass), *Brassica oleracea* (broccoli), *Chaetochloa verticillata* (bristlegrass), *Coix lacryma-jobi* (job's tears), *Cymbopogon citratus* (lemongrass), *Echinochloa* spp., *Eleusine* spp., *Oryza* spp. (rice), *Panicum miliaceum* (millet), *Paspalum conjugatum* (sour grass), *Paspalum distichum* (knotgrass), *Pennisetum americanum* (pearl millet), *Pennisetum glaucum* (pearl millet)*Phragmites australis* (common reed), *Phragmites communis* (common reed)*Saccharum fuscum*, *Saccharum officinarum* (sugarcane), *Sclerostachya fusca*, *Solanum lycopersicon* (tomato), *Setaria verticillata* (bristly foxtail), *Solanum melongena* (eggplant), *Typha latifolia* (cattail), *Triticum* spp. (wheat), *Zizania aquatica* (annual wildrice), and *Zizania latifolia.*

Known Vectors (or associated organisms)

Chilo suppressalis is not a known vector and does not have any associated organisms.

Known Distribution

Asia: Bangladesh, Brunei, Burma, Cambodia, China, India, Indonesia, Iran, Japan, Korea, Laos, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam. **Europe:** France, Portugal, Russian Federation, and Spain. **North America:** Mexico and United States (Hawaii). **Oceania:** Australia and Papua New Guinea.

Potential Distribution within the United States

Chilo suppressalis is present in Hawaii and was first found in 1927. Rice production was already starting to decline in Hawaii prior to this discovery. This discovery, however, is thought to have hastened the decline of the rice industry in Hawaii (USDA, 1957). Yasumatsu et al. (1968) stated that the Asiatic rice borer became extinct in Hawaii sometimes between 1939 and 1962. On October 31, 1968, *Chilo suppressalis* was identified on rice at Wailalua, Kauai. It was not known whether the infestation resulted from progeny of borers from those discovered in 1929 or from the progeny of a new borer introduction (addendum to Yasumatsu et al. (1968)).

Survey

Preferred Method: Male moths may be monitored with the female sex pheromone traps. The sex pheromone of female *C. suppressalis* was initially identified in 1975 as a binary mixture of (Z)-11-hexadecenal (Z11-16:AL) and Z)-13-octodecenal (Z13-18:AL). The pheromone was present in the female ovipositor extract (Nesbitt et al., 1975; Ohta et al., 1975, 1976). In 1983, another active component of the the sex pheromone from C. suppressalis, (*Z)*- 9-hexadecenal (Z9-16:AL), was discovered (Tatsuki et al, 1983). The three-component blend with aldehyde stabilizing agents has been the primary compounds for commercial development of controlled release formulations.

A pheromone lure is available from the CPHST- Otis lab. The lure is loaded with 0.308 mg of Z11-16:AL, Z13-18:AL, and Z9-16:AL in a 73:10:8 ratio. BHT at 9% was added as a stabilizer.

Goh et al. (1983) compared trap catches when using synthetic pheromones [4.5:1 mixture of (Z)-11-hexadecenal and (Z)-13-octodecenal] to those using virgin females. Circular water traps located 100 cm above the ground level were used in paddy fields (three pheromone traps per 30 acres or three pheromone traps plus one virgin female trap per 20 acres). In this study, virgin female traps attracted a higher number of males than synthetic pheromone traps, but the use of synthetic pheromones was warranted for monitoring *C. suppressalis* and for mating disruption.

Ishida et al. (2000) used sticky traps (24 x 25 cm) baited with a 0.6 mg synthetic sex pheromone mixture of the three component sex pheromone [(Z)-11-hexadecenal, (Z)-13-octodecenal, and (Z)-9-hexadecenal] in a 48:6:5 ration and 0.06 mg butylated hydroxytoluene soaked into a rubber septa. Each septa was changed monthly and the traps were placed 0.8 meters above the ground with four traps per location. Trapped moths were detached with xylene. Mochida et al. (1984) showed that the three component pheromone trapped males at a much greater rate than traps with virgin females. Kanno et al. (1985) compared traps baited with the three component sex pheromone to light traps. The pheromone trap catch was very high in both the first and second flight seasons. The number of moths caught in the pheromone traps was about three to five times greater than that of light traps.

Alternative Method: Visually look or of “deadhearts” in younger plants and "whiteheads" and broken stems on older plants. Examine stalks for borer entry and exit holes. Cut open suspect stems and look for larvae or pupae near the middle or the basal internode. In corn, feeding damage in whorl stage corn should be examined for the presence of larvae. Proper identification of these larvae is important to discriminate between stem borer species.

Key Diagnostics

Hattori and Siwi (1986) published an account of the morphology together with field keys for the identification of adults, larvae and pupae. One key diagnostic of larvae are the five longitudinal stripes, which can be purple to brown in color. The head of larvae also appear to have two short horns. A key to commonly intercepted larvae of Pyraloidea, which includes *Chilo suppressalis* is available (Solis, 2006).

Chilo suppressalis resembles many other species of *Chilo* in external adult and larval characters, but can be distinguished by examination of the male and female genitalia. Bleszynski (1970) is the best reference for genitalic identification, because his work gives illustrations of the genitalia of both sexes for all known *Chilo* spp. Peng (1971) compare morphological characteristics of *C. suppressalis* with those of the paddy borer (*Tyrporyza incertulas*), another important stem borer in Taiwan.

The one most useful external adult feature for recognition of *C. suppressalis* males is the profile of the head, or face, showing the conical front and the ridge along the lower edge of the front between the eyes. Although a conical front is common in this group of moths, few other species have the ridge on the lower margin, and the only other Old World *Chilo* spp. known to have such a ridge is *C. phragmitellus*, which is a stem borer in *Phragmites australis* and *Glyceria aquatica* across Eurasia from western Europe to China and Japan. Although the frontal ridge is obvious and works well for identification of males of *C. suppressalis*, it is less developed in females and may sometimes leave one guessing as to whether it is actually present (USDA, 1988).

Easily Confused Pests

Larva of the indigenous North American species, *Chilo plejadellus* (rice stalk borer), appears almost indistinguishable, insofar as can be determined from specimens preserved in alcohol. *C. plejadellus* is a widespread species of the eastern United States from the Gulf Coast to Canada and is a stem borer in various coarse grasses, including rice in the south. The pupa of *C. plejadellus*, however, differs from *C. suppressalis* in that it lacks a separate pair of small points or ridges on the dorsal side of the caudal segment immediately anterior to the cremaster that always seem to be present in *C. suppressalis.* The adult is about the same size, shape, and color as *C. suppressalis*, but it has a scattering of gold metallic scales on the forewing, including the fringe, lacks the ridge along the lower margin of the front between the eyes, and differs in the genitalia of both sexes. The male genitalia of *C. plejadellus* have the arms of the juxta similarly bowed but less swollen, slightly unequal in length, and each with a short, sharp, subapical tooth (USDA, 1988).

E. loftini is a somewhat similar corn and sugarcane borer of Mexico and adjacent States of the United States. The adult is smaller than that of *C. suppressalis*, often grayer, and lacks the frontal ridge; the larva has one rather than two subventral setae on the meso- and metathorax; and the pupa has numerous enlarged, sharp, thornlike setae on the abdominal segments (USDA, 1988).

In North American corn, there are other stem borers that tend to be polyphagous and could potentially be confused with *C. suppressalis. Papaipema nebris* (Lepidoptera: Noctuidae) can be found, and this larva has 5 white stripes that gradually fade during maturity. Fall armyworm may also be found in the whorl of corn plants, and has 3 yellow longitudinal lines on larval bodies. *Diatraea crambidoides,* sometimes found in the whorls before entering the rootstock, is yellowish in color with spots (no longitudinal stripes). The European corn borer (*Ostrinia nubilalis)* larva is without longitudinal stripes. *Hydraecia immanis*, the hop vine borer can also be found in corn stalks, but also does not have longitudinal stripes.

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