United States Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine

New Pest Response Guidelines

Oxycarenus hyalinipennis (Costa)
Cotton seed bug

O. hyalinipennis

Contents

Figures and Tables

O. *hyalinipennis*

Figures

Tables

Chapter 1

Introduction

Plant Protection and Quarantine (PPQ) develops New Pest Response Guidelines (NPRGs) in preparation for potential pest introductions. This document is based on the best information available at the time of development and may not reflect the latest state of knowledge at the time the pest is detected. In addition, the PPQ response must be tailored to the specific circumstances of each pest introduction event, which cannot be predicted. Therefore, this document provides only general guidelines that can be used as a basis for developing a situation-specific response plan at the time a new pest is detected.

Program managers of Federal emergency response or domestic pest control programs must ensure that their programs comply with all Federal Acts and Executive Orders pertaining to the environment, as applicable. Refer to the Environmental Compliance section in Appendix A for details.

Chapter 2

Pest Overview

Key Information

- The cotton seed bug (CSB), *Oxycarenus hyalinipennis*, feeds on host plants of the order Malvales (cotton, okra, hibiscus, etc.), although it may attack other plants to obtain moisture and shelter.
- In cotton, CSB populations increase and are most evident when bolls open; in the United States this occurs from July to September.
- There are no specific traps or lures for this species. Examining opened bolls and seed pods is the most efficient way to survey for CSB in the United States. CSB is typically found in aggregated groups.
- Species identification is based on morphology of the adult male internal structures.
- The species is not capable of strong, sustained flight.
- Since 2017, agricultural port inspectors have intercepted 149 CSB at U.S. ports of entry. The majority of the interceptions were on cut flowers or fruit for consumption (USDA, 2020).
- CSB populations in other countries have shown resistance to many pesticides approved for cotton.

Taxonomy

Scientific Name

- *Oxycarenus hyalinipennis* (Costa, 1847)

Taxonomic Position

- Animalia : Arthropoda : Insecta : Hemiptera : Lygaeoidea : Oxycarenidae

Synonym(s)

- *Aphanus tardus hyalinipennis* Costa, 1847
- *Cymus cincticornis* Walker, 1870

- *Oxycarenus castaneus* (Bergevin, 1932)
- *Oxycarenus cruralis* Stål, 1856
- *Oxycarenus leucopterus* (Fieber, 1852)
- *Oxycarenus nigricornis* Samy, 1969

Common Names

- **Cotton seed bug (CSB)**
- Cotton stainer
- Dusky cotton bug
- Egyptian cottonseed bug

Biology and Ecology

Life Cycle

Cotton seed bug must feed on the oils inside Malvales seeds to complete nymphal development, but the species may feed on numerous other plants and plant parts, usually to acquire moisture (Halbert and Dobbs, 2010). Breeding occurs in seed pods or bolls that are ripe, open, or damaged by other pests such as bollworm moth larvae (*Helicoverpa*) (Abbas et al., 2015; Halbert and Dobbs, 2010). As seeds become available, CSB will move to different Malvales hosts, extending the breeding season. Optimum temperatures for CSB reproduction and development are between 22 °C (71 °F) and 35 °C (95 °F) (Khan and Naveed, 2017). A complete generation occurs in about a month. Depending on host availability and temperature, four to seven generations can occur per year (Adu-Mensah and Kumar, 1977; Halbert and Dobbs, 2010).

The eggs are generally laid in cotton boll lint close to the seed, or in seed pods of other hosts. Later in the season, eggs may be found in green bolls near (or at) the base or in holes made by bollworm moth larvae (*Helicoverpa* spp.). Each female lays up to 110 eggs, either singly or in groups. The incubation period generally lasts from 4 to 8 days (Kirkpatrick, 1923; Sweet, 2000).

There are five nymphal stages that last 14–22 days, depending on temperature (Kirkpatrick, 1923). To complete their development, the insects must pierce ripe or almost ripe seeds with their needle-like mouth parts, inject saliva to liquify the contents, and suck the juices out. When dew is present on the cotton plant, nymphs can be found drinking it from nearby bolls or leaves. When dew is unavailable, they may seek moisture by piercing leaves (Kirkpatrick, 1923). Nymphs aggregate on hosts in a feeding swarm, during which they are very conspicuous.

Adults congregate in bolls and begin feeding on seeds as soon as the bolls open. Mating occurs soon afterwards. At the end of the breeding season, adults enter diapause, leave the cotton fields, and walk or take short flights to various shelter locations for overwintering. During this period, CSB generally prefers cryptic locations such as tree trunks, the undersides of living or dead leaves, pods of leguminous plants, or human-made structures (Adu-Mensah and Kumar, 1977; Kirkpatrick, 1923; Smith and Brambila, 2008).

There are two similar looking invasive oxycarenids that have been introduced into the United States: *Metopoplax ditomoides* (A. Costa) and *Microplax albofasciata* (A. Costa).

Metopoplax ditomoides **(**Fig. 2-1) is present in California, Oregon, and Washington (Lattin and Wetherill, 2002; Wheeler and Henry, 2015). Primarily a pest of Asteraceae plants, *M. ditomoides* can be distinguished from CSB because the anterior end of the head is rounded rather than acute.

Microplax albofasciata (Fig. 2-2) was introduced into California from the Mediterranean area (Wheeler and Henry, 2015). Although the host plants are unknown, researchers suspect an association with plants in the Asteraceae family (Wheeler and Henry, 2015). Proper identification will require a dissecting microscope. *Microplax albofasciata* has a rectangular patch of fine white hairs above the third segment of the thorax, which CSB lacks (Wheeler and Henry, 2015).

Figure 2-1 Adult *M. ditomoides* (image courtesy of Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org)

Figure 2-2 Adult *M. albofasciata* (image courtesy of Thomas J. Henry Systematic Entomology Laboratory, ARS-USDA)

Hosts

For CSB to breed and nymphs to mature, seeds within the order Malvales must be present, although one report includes *Cenchrus americanus* (L.) Morrone (Poaceae) and *Cajanus cajan* (L.) Huth (Fabaceae) as exceptions (Ram and Chopra, 1984). As a result, the primary economic host plants of concern in the United States include cotton (*Gossypium* spp.), hibiscus (*Hibiscus* spp.), and okra (*Abelmoschus esculentus* (L.) Moench) (Kirkpatrick, 1923; Sweet, 2000). The preferred reproductive host is cotton.

In addition, CSB causes damage to but does not reproduce on economically valuable fruits such as apricot, peach, persimmon, apple, pear, quince, grapes, dates, figs, and avocados. Cotton seed bugs affect the quality of fruits with their feces, pungent odors, and toxic saliva (Avidov and Harpaz, 1969; Nakache and Klein, 1992; Sweet, 2000).

Natural hosts of CSB are listed in Table 2-1, and experimental hosts are listed in Table 2-2.

Table 2-1 Natural hosts of CSB

Scientific name	Common name	References
Abelmoschus esculentus (L.) Moench	okra	Shah et al., 2016
Abelmoschus moschatus Medik. subsp.	musk okra	Rajashekhargouda et al., 1983

Scientific name	Common name	References
moschatus		
Abelmoschus spp.	okra	El-Rahim et al., 2015
Abutilon fruticosum Guill. & Perr.	Texas Indian mallow	Kirkpatrick, 1923
Abutilon grandifolium (Willd.) Sweet (=*Sida mollis* Ortega)	hairy Indian mallow	Kirkpatrick, 1923
Abutilon incanum (Link) Sweet	pelotazo	Shah et al., 2016
Abutilon indicum (L.) Sweet	monkeybush	Ananthakrishan et al., 1982
Abutilon pictum (Gillies ex Hook. & Arn.) Walp. (=*Abutilon thompsonii* André; *Abutilon venosum* Lem.)	Chinese-lantern	Ananthakrishan et al., 1982; Kirkpatrick, 1923
Alcea spp.	hollyhock	Bolu et al., 2020
Alcea rosea L. (=*Althaea rosea* (L.) Cav.)	common hollyhock	Dimetry, 1971; Kirkpatrick, 1923
Brachychiton populneus (Schott & Endl.) R. Br. (=*Sterculia diversifolia* G. Don)	bottletree	Kirkpatrick, 1923
Cajanus cajan	pigeon pea	Ram and Chopra, 1984
Dombeya spp.		Ram and Chopra, 1984
Gossypium arboreum L	tree cotton	Ram and Chopra, 1984
Gossypium hirsutum L.	upland cotton	Ananthakrishan et al., 1982
Gossypium spp.	Cotton	Atta et al., 2015a
Grewia asiatica L.	phalsa	Shah et al., 2016
Grewia tiliifolia Vahl (=*Grewia subinaequalis* DC.)	raisin bush	Ram and Chopra, 1984
Herissantia crispa (L.) Brizicky (=*Abutilon crispum* (L.) Medik.)	bladdermallow	Ananthakrishan et al., 1982
Hibiscus cannabinus L.	Indian hemp/ kenaf	Kirkpatrick, 1923
Hibiscus mutabilis L.	Dixie rosemallow	Kirkpatrick, 1923
Hibiscus rosa-sinensis L.	China-rose	Ram and Chopra, 1984
Hibiscus schizopetalus (Dyer) Hook. f.	coral hibiscus	Ram and Chopra, 1984
Hibiscus spp.	rosemallow	Shah et al., 2016
Hibiscus syriacus L.	rose-of-Sharon	Ram and Chopra, 1984
Hibiscus trionum L.	flower of an hour	Kirkpatrick, 1923
Lagunaria patersonia (Andrews) G. Don	cow-itch-tree	Beucke, 2021
Malva multiflora (Cav.) Soldano et al. (=*Lavatera cretica* L.)	Cretan-hollyhock	Ribeiro, 1997
Malva parviflora L.	cheeseweed mallow	Kirkpatrick, 1923
Malva spp.	Mallow	Porcelli and Palmieri, 2016
Malva sylvestris L.	high mallow	Kirkpatrick, 1923
Malvaviscus spp.	wax mallow	Ram and Chopra, 1984
Pavonia spinifex (L.)	gingerbush	Kirkpatrick, 1923

Scientific name	Common name	References
Cav.		
Pennisetum glaucum	pearl millet	Ram and Chopra, 1984
Phymosia umbellata (Cav.) Kearney (=*Sphaeralcea umbellata* (Cav.) G. Don)	Mexican bush mallow	Kirkpatrick, 1923
Pterospermum acerifolium (L.) Willd.	bayur tree	Ram and Chopra, 1984
Sida rhombifolia L.	Cuban jute	Ananthakrishan et al., 1982
Sida spp.	fanpetals	Ram and Chopra, 1984
Sphaeralcea miniata (Cav.) Spach	Latin globemallow	Kirkpatrick, 1923
Sphaeralcea spp.	fanpetals	Ram and Chopra, 1984
Thespesia populnea (L.) sol. ex Corrêa	portia tree	Ram and Chopra, 1984
Urena lobata L.	caesarweed	Adu-Mensah and Kumar, 1977
Wissadula amplissima (L.) R.E. Fries	big yellow velvetleaf	Adu-Mensah and Kumar, 1977

Table 2-2 Experimental hosts of CSB

Scientific name	Common name	References
Abutilon guineense (Schumach.) Baker f. ex Exell		Adu-Mensah and Kumar, 1977
Abutilon mauritianum (Jacq.) Medik.	English bush mallow	Adu-Mensah and Kumar, 1977
Corchorus spp.		Adu-Mensah and Kumar, 1977
Gossypium barbadense L.	Creole cotton	Dimetry, 1971
Hibiscus micrathus L. f.	tiny flower hibiscus	Adu-Mensah and Kumar, 1977
Hibiscus sabdariffa L.	roselle	Adu-Mensah and Kumar, 1977
Hibiscus tiliaceus L.	sea hibiscus	Adu-Mensah and Kumar, 1977
Malva pusilla Sm. (=*Malva rotundifolia* L.)	low mallow	Dimetry, 1971
Malvastrum corchorifolium (Desv.) Britton ex Small	false mallow	Adu-Mensah and Kumar, 1977
Malvastrum coromandelianum (L.) Garcke	threelobe false mallow	Adu-Mensah and Kumar, 1977
Malvastrum spp.	false mallow	Adu-Mensah and Kumar, 1977
Sida acuta Burm. f.	common wireweed	Adu-Mensah and Kumar, 1977
Sida cordifolia L.	flannelweed	Adu-Mensah and Kumar, 1977

Dispersal

In recent years, researchers have observed the species steadily extending its distribution northward through the Caribbean (Smith and Brambila, 2008), although no definitive studies have been conducted on the specific mode of spread.

Human-Assisted Spread

Cotton seed bug moves easily in trade, even with commodities that are not known hosts (Henry, 1983). Since 2017, agricultural port inspectors have intercepted 149 CSB at U.S. ports-of-entry. The majority of the interceptions were on cut flowers or fruit for consumption (USDA, 2020).

Natural Dispersal

Natural dispersal to the United States is possible for this pest. While few studies on CSB flight behavior and capability are available, Adu-Mensah and Kumar (1977) observed flight durations of five seconds in dispersal experiments. They summarized that CSB is not an active migrant and cannot sustain flight. The typical flight behavior of CSB is for individual insects to climb to the highest point on a leaf, branch, or terminal bud and make a quick take-off in the direction that the wind is blowing. Cotton seed bugs are then able to control flight towards an object in the downwind direction (Adu-Mensah and Kumar, 1977). Cotton seed bug dispersal may also be wind-assisted, and hurricanes or tropical storms may help spread CSB from the Caribbean islands to the continental United States.

Chapter

3

Pest Identification

Species ID/Diagnostic

Morphological

- Definitive species identification is based on morphology of the adult male internal structures (Brambila, 2020). See Appendix B.

Adults

Newly emerged individuals are pale pink but rapidly turn brown, dark brown, or black (Figs. 3-1 and 3-2). Males are typically 3.82 mm (0.12 in) long and females are 4.41 mm (0.12 in) (Samy, 1969). Male abdomens terminate in a round lobe, while female abdomens are truncated. Other distinguishing characteristics include: three tarsal joints, a pair of red simple eyes situated above and behind the compound eyes, and the second antennal segment is usually partially yellow or pale yellow. The forewings are glassy/translucent and usually whitish. The clavus, base of corium, and costal vein are opaque (Henry, 1983; Kirkpatrick, 1923; Smith and Brambila, 2008).

Figure 3-1 Dorsal, ventral, and lateral views of an adult male *O. hyalinipennis* (image courtesy of Dr. Halil Bolu, Dicle University, Faculty of Agriculture, Diyarbakir, Turkey)

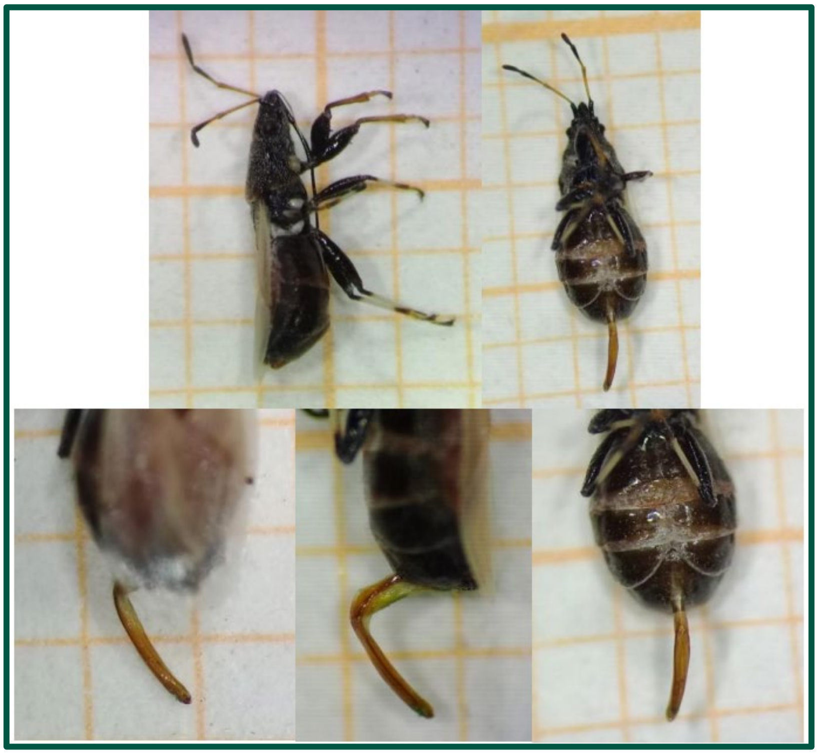

Figure 3-2 Lateral and ventral views of an adult female *O. hyalinipennis*. The female has a curved ovipositor, which may not always be visible (image courtesy of Dr. Halil Bolu, Dicle University, Faculty of Agriculture, Diyarbakir, Turkey)

Eggs

The egg is 0.29 mm (0.01 in) wide by 0.97 mm (0.04 in) long, slender, subcylindrical, with 25 longitudinal ribs or corrugations. The anterior end is broadly rounded and bears six chorionic processes; the posterior is distinctly pointed. During development, the eggs change from straw yellow to orange or pink (Henry, 1983; Sweet, 2000).

Figure 3-3 *Oxycarenus hyalinipennis* eggs (image courtesy of Dr. Halil Bolu, Dicle University, Faculty of Agriculture, Diyarbakir, Turkey)

Nymph

The nymphs are orange-red on hatching and later develop a dark red abdomen that has a greenish tint (Fig. 3-4). There are two abdominal scent glands located dorsally between terga 4 to 5, and 5 to 6. The orifices are close together. Kirkpatrick (1923) measured the average instar lengths as first, 1.20 mm (0.05 in); second, 1.58 mm (0.06 in); third, 2.25 mm (0.09 in); fourth, 2.86 mm (0.11 in); and fifth, 3.7 mm (0.15 in) (Kirkpatrick, 1923).

Figure 3-4 Dorsal, ventral, and lateral views of nymph-stage *O. hyalinipennis* (image courtesy of Dr. Halil Bolu, Dicle University, Faculty of Agriculture, Diyarbakir, Turkey)

Signs and Symptoms

A few visual cues can help detect the presence and infestation level of CSB in an area. A surveyor may be able to find a CSB population more easily when fruits, seeds, and seed pods from plants in Malvales are available, or after a recent rain (Ismail, 2018; Adu-Mensah and Kumar, 1977). Symptoms to look for include the following:

- Feeding damage is not a reliable indicator of CSB presence, but it can help narrow down an area to begin a delimitation survey. Look for brown leaves and stipple marks from feeding (Fig. 3-5) (Bolu et al., 2020;

Kirkpatrick, 1923).

- The cotton plant and cotton seed show no external signs of damage from CSB (Kirkpatrick, 1923; Sweet, 2000). Internally, seeds are shriveled and discolored (Kirkpatrick, 1923).
- Adult and nymph-stage CSBs commonly congregate together in tight clusters, especially in seed pods (Fig. 3-6) (Adu-Mensah and Kumar, 1977; Chin et al., 2009; Smith and Brambila, 2008).
- Populations of CSB do not damage seeds until the bolls open, but if another pest damages the boll, CSB will enter and feed on the internal seeds (Ismail, 2018; Adu-Mensah and Kumar, 1977; Sharma et al., 2010).
- Symptoms in cotton will be most apparent between July and September, when the bolls are open (Ritchie et al., 2004).
- Cotton seed bugs resemble fleas in infested bolls; look for small black or brown bugs running through the cotton (Fig. 3-7) (USDA-APHIS-PPQ-S&T, 2016).
- Aggregated groups produce a pungent odor (Adu-Mensah and Kumar, 1977; Sharma et al., 2010; Smith and Brambila, 2008).

Figure 3-5 *Oxycarenus hyalinipennis* will suck fluids from leaves, stems, and flowers for moisture, but it feeds on seeds (image courtesy of Dr. Halil Bolu, Dicle University, Faculty of Agriculture, Diyarbakir, Turkey)

Figure 3-6 Aggregates of adult and nymph *O. hyalinipennis*. They will cluster inside of dried seed pods. Surveyors should open seed pods if they suspect infestation (image courtesy of Dr. Halil Bolu, Dicle University, Faculty of Agriculture, Diyarbakir, Turkey)

Figure 3-7 Infested cotton bolls on Stock Island, FL (image courtesy of Julieta Brambila, USDA-APHIS-PPQ)

Chapter 4

Delimitation Survey

Delimitation Area

Delimitation surveys determine the extent of the affected area after an infestation has been confirmed. Several factors can influence the delimitation area, including host plant density and distribution, wind direction, and agency resources at the time of introduction. If specific pathways are suspected, this information may also inform the selection of a delimitation area.

Timing of Surveys

The survey should be conducted as soon as possible after a confirmed detection. If possible, surveys should take place during a time when infestation is most apparent. In general, this means CSB surveys should occur during the breeding period, when seed bolls are open.

If no additional pests are detected, delimitation surveys should continue until the end of the CSB breeding season (early fall in the continental United States) and detection surveys and other monitoring for CSB should continue in the area for at least 3 years before confirming eradication.

During the Breeding Period, When Seed Bolls are Open

The breeding period for CSB occurs between late spring and early fall (Kirkpatrick, 1923). Surveyors can detect CSB visually on open cotton bolls (Derksen et al., 2010) during this time. Bolls typically open as early as July, and CSB will remain on the plant until harvest in October (Collins, 2020). During the breeding period, most bugs will be found within the bolls, and only occasionally in leaf litter or on the leaves of cotton plants (Smith and Brambila, 2008). Cotton seed bugs will emerge when the boll is agitated.

During the Quiescent Period, When Seeds of Host Plants are Unavailable

After the breeding period, CSB stops feeding and begins aggregating in old bolls or other hidden areas. This quiescent period begins in the fall and continues until early spring (Kirkpatrick, 1923). For detection purposes, surveying during the quiescent period is not recommended, due to the cryptic nature of CSB.

During the quiescent period, CSB has been observed on tree trunks, on the undersides of both living and dead leaves, pods of leguminous plants, cracks in telephone poles or wooden posts and fences, under bark, in old *Polistes* paper wasp nests, in crevices between strands of barbed wire, on dried flower heads, among roots of grasses, underneath sheath-leaves of maize and sugarcane, in stored cotton, or in unintended artificial traps such as old sacks on poles or in hedges near cotton fields (Kirkpatrick, 1923). It can also be found in leaf litter beneath cotton plants, or occasionally on the leaves (Smith and Brambila, 2008), in dry fruit pods, under tree bark, between planks of wooden structures, or in dry grass and leaf litter (Adu-Mensah and Kumar, 1977).

Trees appear to be a preferred resting location of CSB during the quiescent period. Past observations rarely found CSB moving onto willows, poplars, date-palms, or mulberries. It was more commonly observed on various species of *Ficus*, *Acacia*, and some *Eucalyptus*, suggesting that rough barked trees are more attractive than smooth barked trees. Colonies on the trees may be detected near the ground, up to a height of 6–7 m (19.7–23.0 ft) (Kirkpatrick, 1923).

Outreach efforts to cotton growers and residents in the affected area may be beneficial during this time to help detect cryptic CSB where it occurs in unmanaged and residential areas (See Outreach Program for CSB).

Survey Techniques for Delimitation

The current USDA PPQ CAPS Approved Survey Method for *O. hyalinipennis* can be found at:
https://pest.ceris.purdue.edu/services/approvedmethods/sheet.php?v=675.

Visual Inspection

The most suitable method for detecting and delimiting CSB in the field is through visual inspection. Conduct visual inspections by searching for life stages of CSB (see Signs and Symptoms) and damage symptoms. Cotton plants, other potential malvaceous host plants, and nearby resting places for aggregations of CSB can be inspected.

Delimitation Survey Design

Delimitation surveys are carried out to determine the extent of the infested area after a CSB detection. This survey protocol describes how to inspect areas that are near confirmed CSB detections. For this survey, we are assuming that CSB infestations will be dense enough to be visually detected.

The survey will consist of a core and buffer design where surveyors will visually inspect a core area and certain high-risk areas in the buffer to delimit the pest. An outreach campaign is suggested to spread awareness of CSB and more effectively delimit the pest in hidden or hard to reach areas.

We found little evidence of CSB flight capabilities or the capabilities of closely related species in the literature (see Natural Dispersal). The observed flight duration of CSB under laboratory conditions is reported to be approximately five seconds, which implies primarily short distance migration by adults. For these reasons, we consider this pest a weak flier and recommend a core survey area with a radius of 800 m (0.5 mi) and a buffer area with a radius of 4.8 km (3 mi) to ensure full delimitation of a novel CSB infestation.

To delimit CSB:

1. Identify and survey the core infested area.
    a. Draw a circle that extends 0.8 km (0.5 mi) out from the initial detection (Fig. 4-1).
        i. This core infested area should be surveyed because it is likely to contain dispersing CSB and intensive surveys will identify the size of the starting population.
        ii. If the core infested area is primarily within a cultivated field or fields, proceed to the Surveying in Fields Section.
        iii. If the core infested area is primarily within residential or non-cultivated areas, proceed to the Surveying in Residential Areas Section.
        iv. Core infested areas with roughly equivalent portions of fields and residential areas may require a hybrid survey.

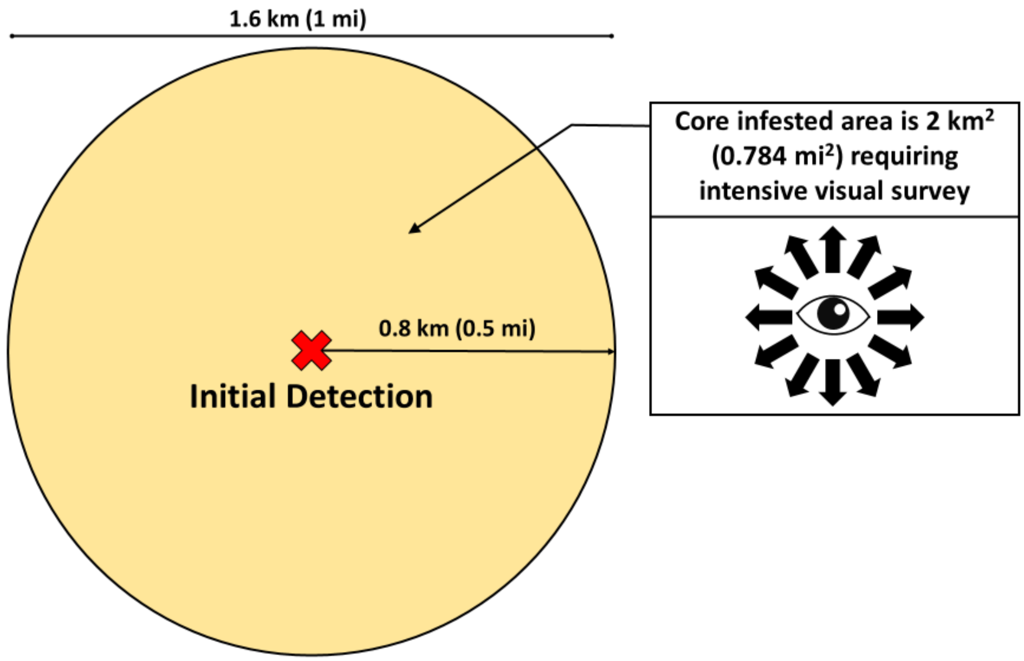

Figure 4-1 Surveying the core infested area

2. Identify and survey the buffer area.
    a. Draw a circle around all points within 4.8 km (3 mi) of the initial detection(s) (or 4 km (2.5 mi) beyond the core area) (Fig. 4-2).
    b. We recommend visual inspections only in high risk areas. Designation of high-risk areas will depend on knowledge of cultivated, wild cotton, and other hosts available in the area (See Surveying in the Buffer Area Section).
    c. In addition to surveys, we recommend developing an outreach program for potentially affected growers and local residents in the buffer area and vicinity to spread awareness of CSB (See Outreach Campaign).

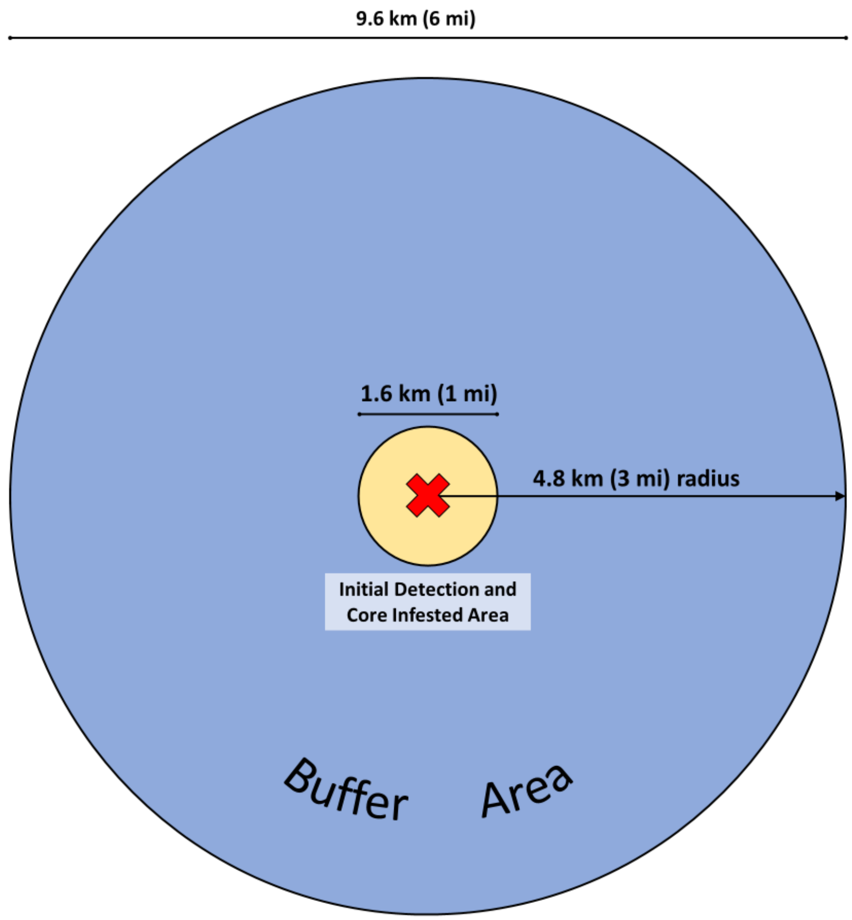

Figure 4-2 Surveying the buffer area

3. If resources are limited, consider developing smaller sentinel sites in the buffer area for surveys.
    a. A sentinel site, in this case, would be a small portion of a cotton field that is easy to reach and regularly inspected along a surveyor's normal route.
    b. We recommend mapping the sentinel site locations to promote even coverage, focusing on high-risk areas near field edges.
    c. If sentinel sites are established for CSB, use GPS to record the perimeter of each sentinel site and draw a map of the immediate area that includes reference points to aid others in finding the areas if necessary.
    d. Once a sentinel site is established, the surveyor should re-inspect it (refer to Timing of Surveys) as frequently as permitted by resources.
4. Consider how to expand survey efforts upon additional detections. Instructions are included for each surveying section below.

Surveying in the Core Area

Surveying in Fields

This section describes how to survey cotton fields within the core infested area, which includes a close inspection of plants within 100 m (328 ft) of the initial detection and a visual walking survey along transects throughout the remainder of the core area. We are working under the assumption that CSB infestations will be easily detectable by eye for this protocol. Surveyors should adapt these instructions to survey for CSB in other hosts.

To survey a field:

1. Within the core area, inspect plants within 100 m (328 ft) of the initial detection (Fig. 4-3)
    a. It is likely that there will be between 300,000 and 400,000 plants in this area, based on the density of cotton plants typically ranging from 30,000 to 50,000 plants per acre and a total area of 40,000 m^2, or 9.88 acres.
    b. Based on the number of cotton plants likely to be present and the hypergeometric sampling table, surveyors will need to inspect at least 298 plants from this area (Table 4-2).
        i. Surveyors may need to adjust this calculation based on plant density information from growers. In these cases, multiply the plant density by the total area surveyed to calculate the number of plants present in the surveyed area and consult Table 4-2 to calculate the number of required samples.
    c. Visually inspect the required number of plants at regular intervals along rows within the 40,000 m^2 (9.88 ac) section.
        i. Surveyors may wish to round up to even numbers (e.g. 300 inspected plants instead of 298) to space the samples more conveniently.
        ii. Inspecting plants for insects may require opening bolls with the fingers or shaking bolls to reveal any insects.
        iii. Attempt to inspect up to 5 bolls per cotton plant.

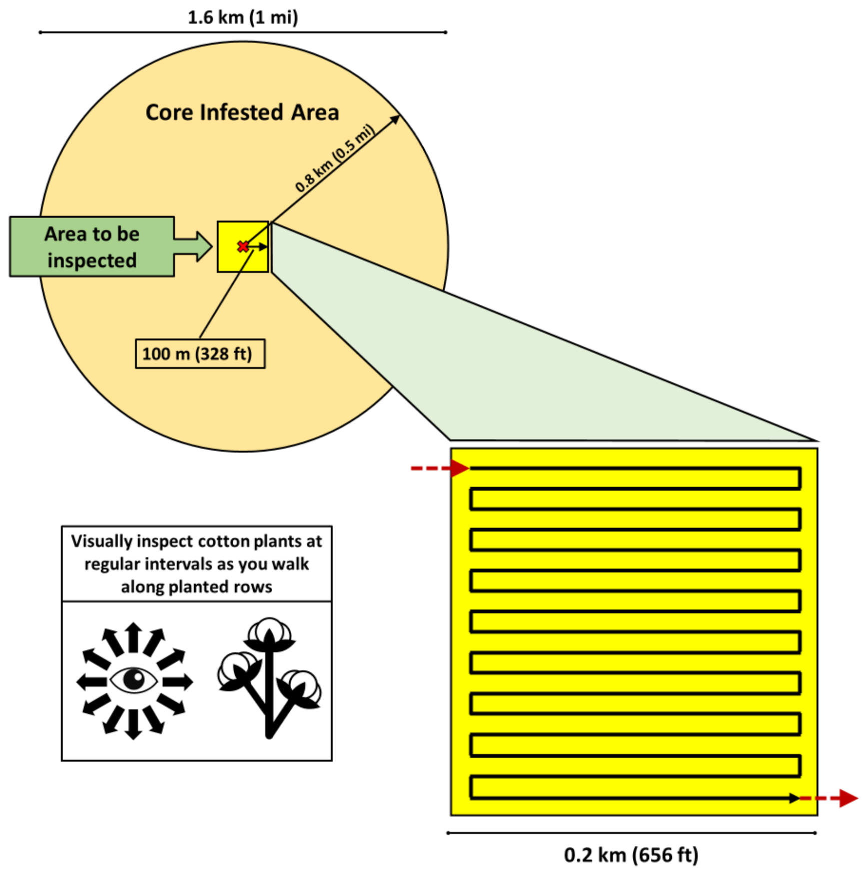

Figure 4-3 Visually inspecting all plants within 100 m of a detection

2. Beyond 100 m (328 ft) from the initial detection, determine the total area to be inspected within the core to calculate the number of transects needed to effectively inspect the entire area.
    a. If the core area is located entirely within a field, the area will be roughly 500 ac.
    b. If the core area includes multiple fields or is only partially cultivated field space, subtract any non-field from the total area.
    c. Field sizes can be acquired from satellite imagery or by asking growers or landowners.
    d. Refer to Table 4-1 to determine the number of transects needed to comprehensively survey the nursery/plantation on foot.
    e. Adhering to this method ensures 95% confidence to detect a 0.1% pest incidence (NSHS, 2019a).
3. Map the survey route by placing transects (as calculated in step 2) equidistantly throughout the core infested area, ensuring field edges are surveyed (an example survey is provided in (Fig. 4-4). Transects should follow the rows of cotton plants and cover the entire core area.
4. Visually inspect plants along each transect for presence of insects.
    a. If insects or symptoms are observed, record the location and collect

any insects (See Sample Collection).

b. Opening or shaking bolls over a tray or white sheet may be necessary to locate and catch insects during inspection.

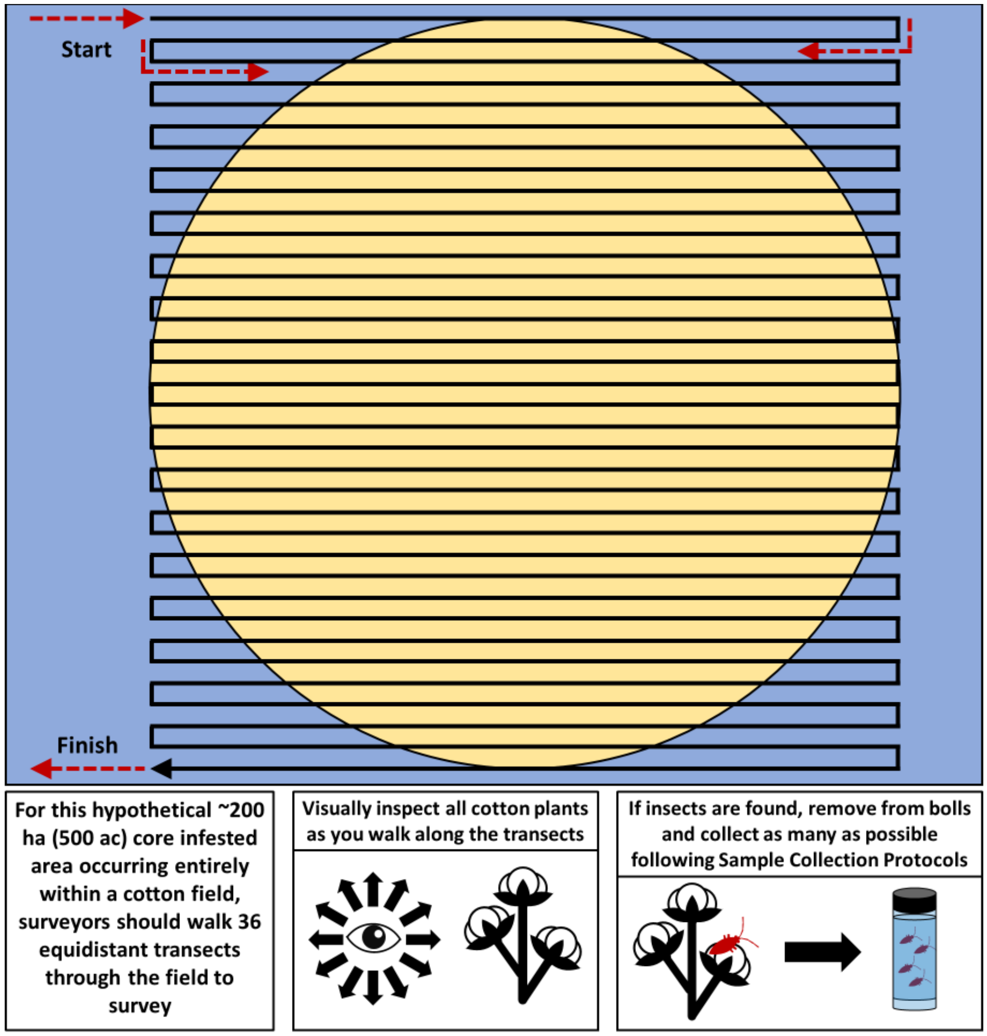

Figure 4-4 An example survey for a 500 ac core infested area within a cotton field based on field inspection guidelines of NSHS (2019b)

5. If the core infested area covers multiple fields, surveyors should place transects evenly throughout both fields to ensure accurate delimitation.

Table 4-1 Minimum number of transects surveyors should walk in cotton fields to effectively inspect plants for CSB based on NSHS Phytosanitary Field Inspection Procedures for non-cereal crops (NSHS, 2019b)

Field Size (Acres)	Minimum # transects
0-1	6
1-5	9
5-10	11
10-20	13
20-50	17
50-100	20
100-200	24
200-500	30
500-1000	36

6. Additional detections of CSB from within the core infested area require no expansions to the delimitation survey.
    a. Surveyors can expect CSB to be found in the core infested area because of proximity to the initial detection, likelihood of multiple introduced bugs, or the potential for a nearby established population.
    b. Use any trapped individuals in the core infested area to map the distribution of CSB in the core area for control and monitoring efforts.

Surveying in Residential Areas

Infestations of CSB in residential areas can be more difficult to survey because of property lines, fences, and other potential barriers. Additionally, the distribution of host plants in these areas is not predictable; therefore, we generalized the instructions for a residential survey. Surveyors will be responsible for modifying the survey to fit their situation.

- Walking linear transects may be difficult on varied terrain but following roads and other natural barriers could facilitate this process.
- Obtaining permission to inspect or walk across private property may be necessary to fully delimit the infestation.
- Unlike in cultivated hosts (e.g. cotton, okra), a wide diversity of host plants may be present in residential areas, requiring surveyors to identify potential hosts.

To survey the residential area:

1. Perform a visual survey to locate all host plants within the core area. Always ask property owners for permission to access the plants. Walking through public areas or driving through the core and buffer areas is suggested (Fig. 4-5).

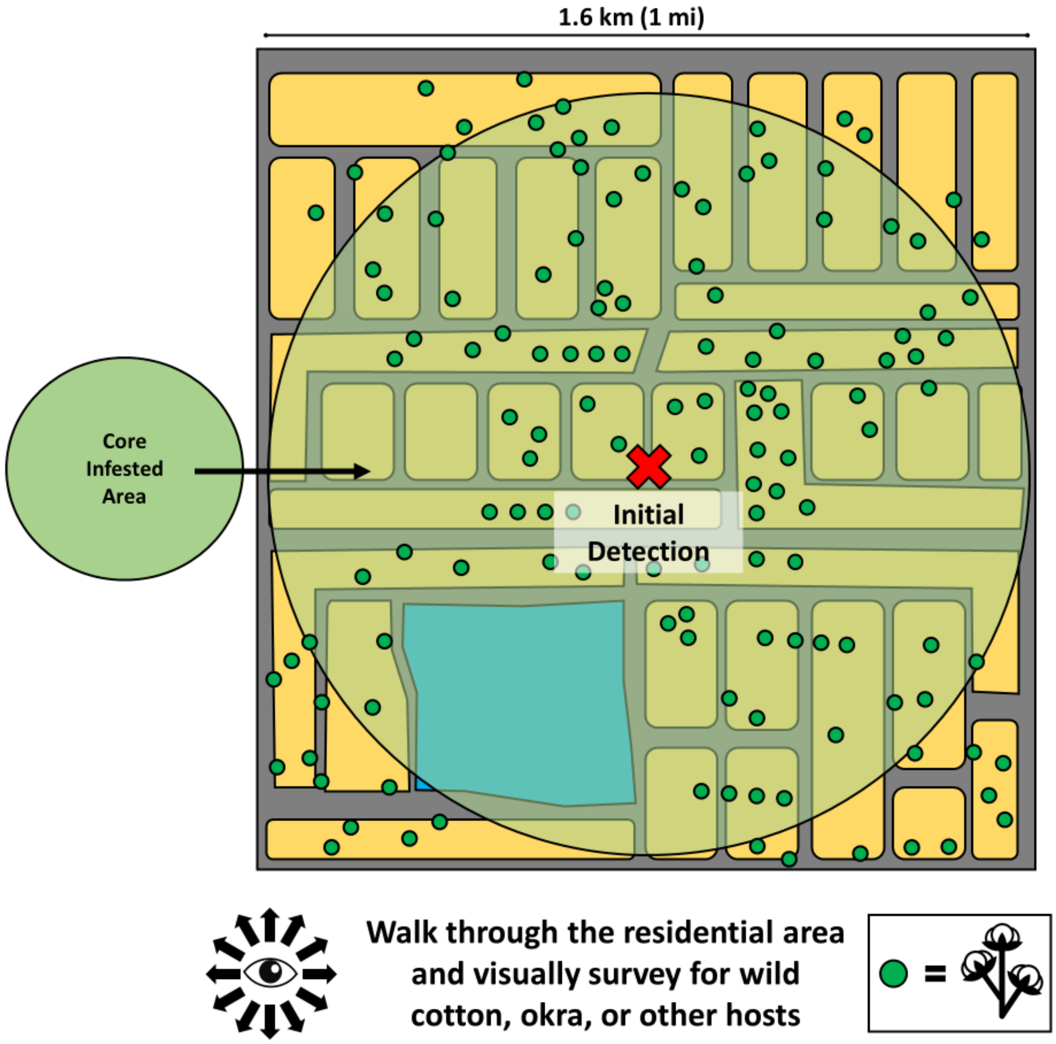

Figure 4-5 Visual survey for CSB host plants in a residential survey area

2. Consult Table 4-2 to determine the appropriate sample size for the core infested area based on the number of host plants located during the visual survey. It is likely that core infested areas with low host plant density will require sampling every individual.

Table 4-2 Minimum sample collected to detect a 1% infestation rate based on survey size with 95% confidence (IPPC, 2016)

Number of host plants in survey	Number of plants that will need inspection
10	10
50	50
100	95
200	155
300	189
400	211
500	225
600	235
700	243
800	249
900	254
1000	258
1500	271
2000	277
4000	288
8000	293
16000	296
30000	297
100000	298

3. Map all visually surveyed host plants and plot a route through the core infested area to survey the appropriate number of host plants identified in step 2.
4. Following the route planned from step 3, visually inspect all potential CSB hosts and collect any insects found during the survey.
5. Detections of CSB from residential areas within the core infested area require no additional surveys.
    a. Cotton seed bugs are expected to be found in this area throughout the survey because of either proximity to the initial detection, likelihood of multiple introduced bugs, or the potential for a nearby established population.
    b. Use individuals found in the core infested area to map the distribution of CSB for control and monitoring efforts.
    c. After detections are made in the core area, completing the remainder of the survey will help accurately delimit the pest population for control or eradication. However, surveyors can choose to stop the survey if the core area is heavily infested. This will allow resources to be re-allocated to other parts of the survey. After surveys are stopped, surveyors may want to pursue control options within the core area to prevent further spread of the pest (See Eradication and Control Options).

Surveying in the Buffer Area

Within the buffer area, surveying efforts should focus on high-risk areas for CSB infestation. This includes cotton fields, okra fields, commercial nurseries propagating known hosts, or any patches of wild cotton that are known to be present in the area (See Fig. 4-6). Consider contacting local extension officials to help locate wild cotton occurring in residential settings or in unmanaged areas.

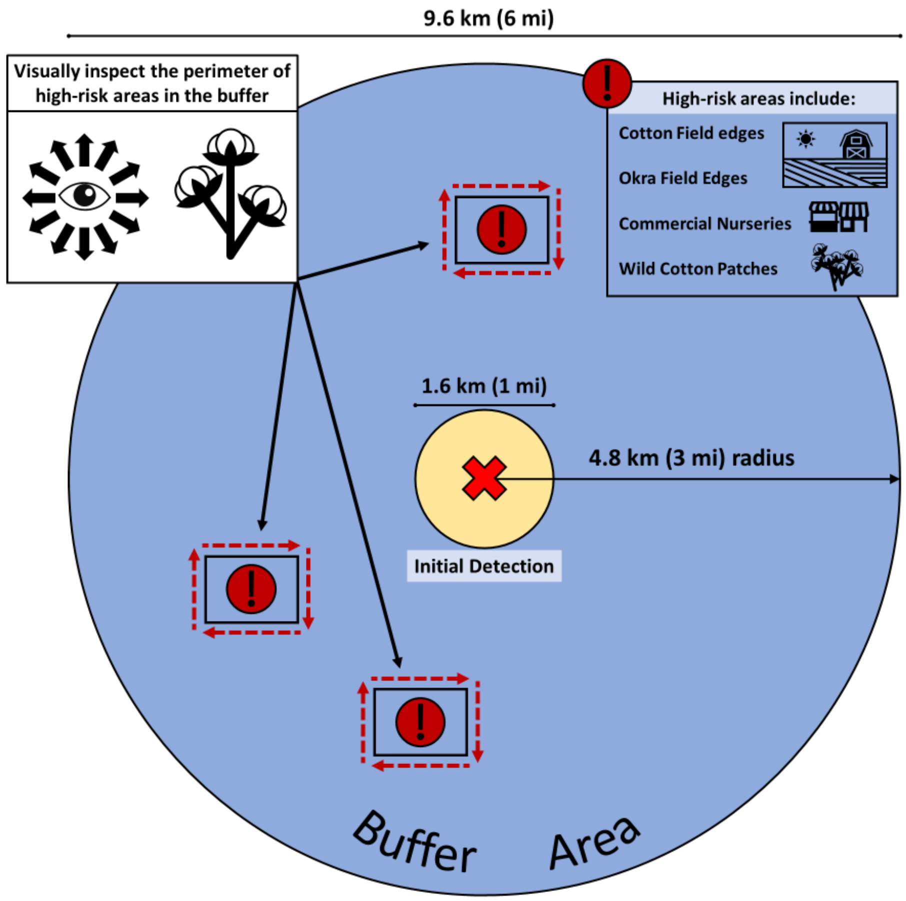

Figure 4-6 Survey high-risk areas in the buffer for CSB

Surveying in Fields

1. For cultivated fields in the buffer, visually inspect along the perimeter of the field and near any entrances for vehicles.
    a. To determine where and how often to sample for each field, first measure the length of its perimeter.
    b. Divide the total perimeter into 10 m (33 ft) sections.
    c. Consult Table 4-2 to assess how many of the 10 m (33 ft) sections will need to be visually inspected.
    d. Fig. 4-7 illustrates a model field that requires surveying in the buffer section.

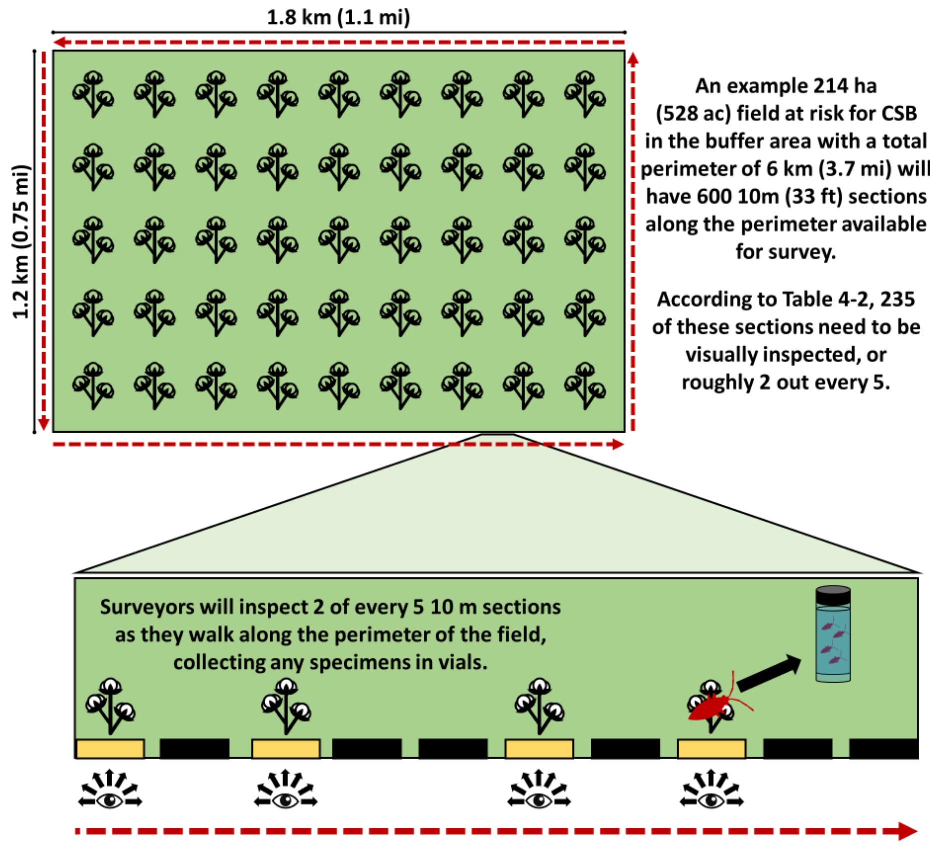

Figure 4-7 A hypothetical survey for CSB around the perimeter of a cotton field designated a high-risk area in the buffer

Surveying in Residential Areas

We do not recommend surveying residential areas in the buffer because they are less likely to contain large numbers of host plants, and efforts to survey larger areas may rapidly consume limited survey resources. In the absence of surveys, outreach programs to educate and encourage residents in affected areas to photograph or collect CSB would benefit the delimitation and monitoring.

If high-risk areas are in residential or other unmanaged areas (e.g., small patches of cotton, wild cotton, or other hosts) and resources are available, surveyors should attempt to inspect at least 20 plants from each high-risk area. Locating these areas may be difficult and require extension or other officials with knowledge of the affected area.

Expanding the Survey After New Detections in the Buffer

A new detection of CSB at high risk locations in the buffer may indicate a new focal point of the infestation and requires the following:

1. If a single CSB is detected at any time during the buffer survey, create a

0.8 km (0.5 mi) core infested area around that detection (Fig. 4-8) and survey in that area following the guidelines from either the Field or Residential Survey section, depending on the location.

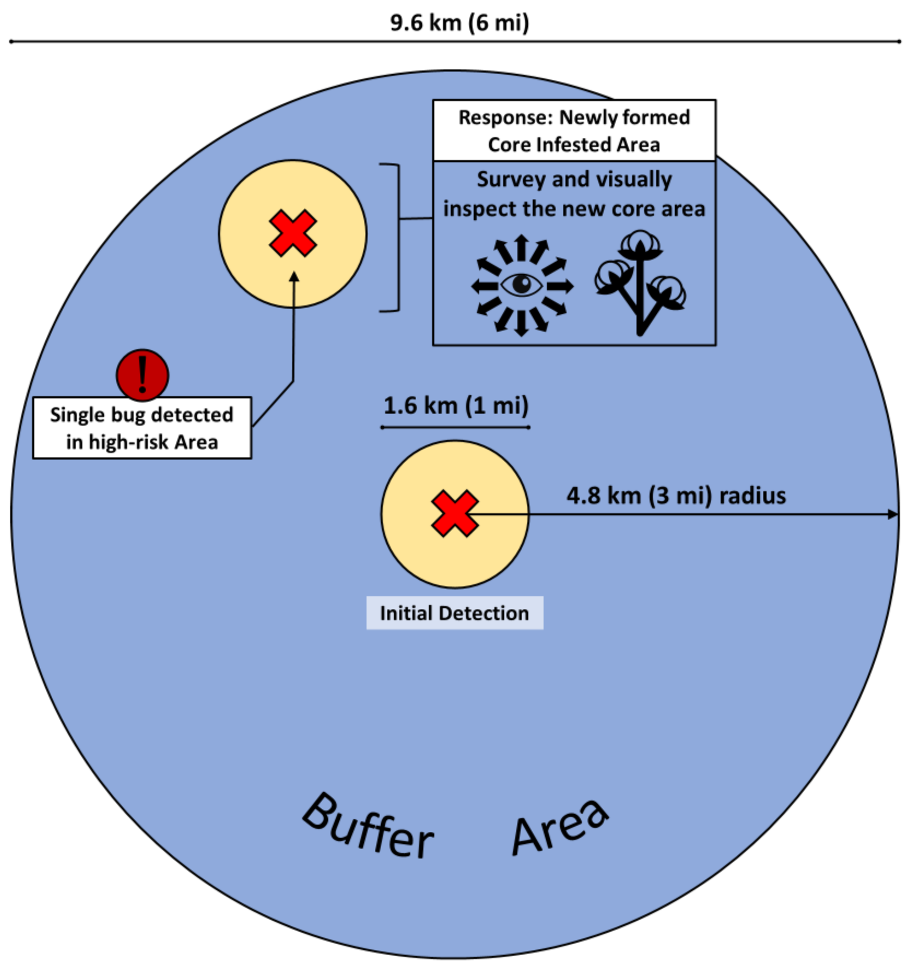

Figure 4-8 Planned survey expansion after detecting a single bug in a high-risk area

2. If two or more CSB are detected at any time during the buffer survey, create a new 0.8 km (0.5 mi) core infested area as well as an expanded buffer area (Fig. 4-9). Buffer areas overlapping with the original survey should be excluded from any expansion.
3. After detections are made in high-risk areas, completing the remainder of the survey will help accurately delimit the pest population for control or eradication. However, surveyors can choose to stop surveys in or around high-risk areas if a heavy infestation is detected. This will allow resources to be re-allocated to other parts of the original or newly expanded survey. If surveys are stopped, surveyors may want to pursue control options where heavy infestations were found to prevent further spread of the pest (See Eradication and Control Options).

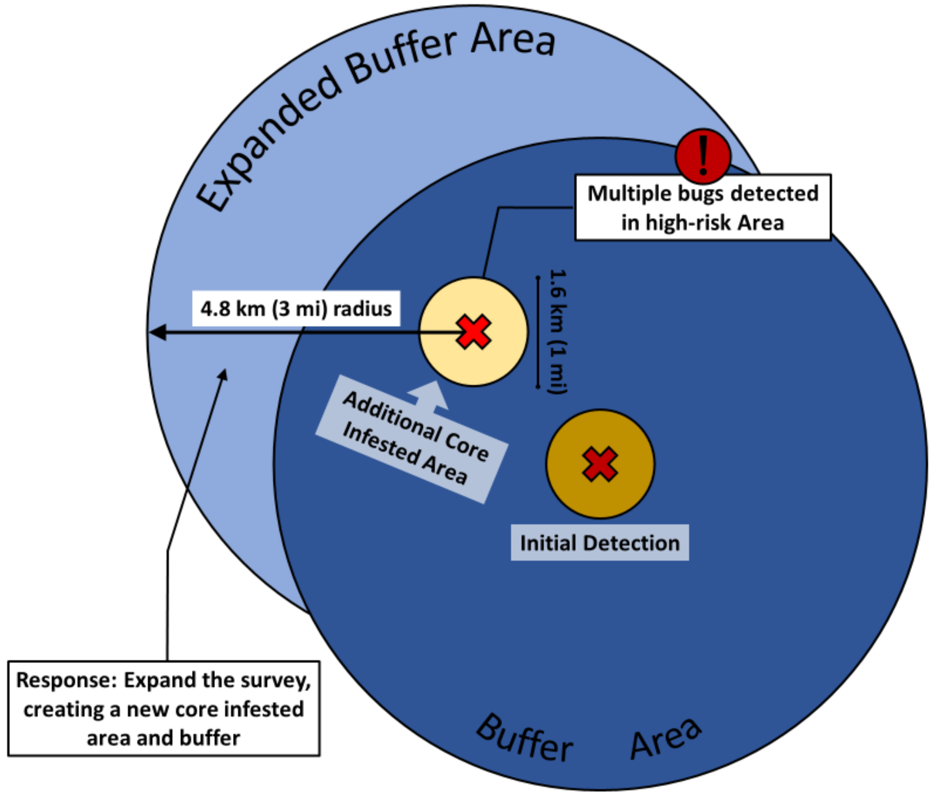

Figure 4-9 Planned survey expansion after detecting multiple CSBs near a high-risk area

Outreach program for CSB in the Buffer Area

Developing an outreach campaign as a supplement for traditional surveys will more effectively detect CSB over a larger area. This campaign should spread awareness of this insect pest and its impacts on cotton and other crops to engage cotton growers in at-risk areas to proactively inspect their crops and report signs and symptoms (see Signs and Symptoms) to the proper authorities. Photographs of insects and collected specimens submitted to local extension agents or PPQ surveyors will help map new detections and/or areas for further investigation.

This outreach should operate side by side with traditional detection surveys by PPQ surveyors or local extension services to communicate to growers when the risk for CSB infestation in their fields is greatest and to investigate detections found by local growers and nursey operators. Extension specialists and local universities should be involved in the planning stages of any outreach program to design a program/survey that caters to the needs of local stakeholders.

Beyond growers, we also recommend developing outreach materials for the nursery industry, the general public, and for school-aged children to help detect CSB in wild cotton plants or other hosts found in unmanaged commercial or residential areas. A central website to disseminate this information, along with presentations to community groups, schools, and other interested parties, will help spread awareness about CSB. E-mail or educational mailers, billboards, radio spots, and television public service announcements could also be used to inform the public.

All communications should include the typical signs and symptoms of CSB infestation, its potential consequences, and instructions and contact information to report a suspected CSB detection.

Assigning a dedicated outreach coordinator may be the most effective way to engage the community and ensure that the proper information is brought to the public. This person could develop outreach materials and manage their dispersal, make presentations to the community, and facilitate interactions between property owners and official surveyors.

Sample Collection

Careful inspection of the newly matured bolls and dry seeds should be conducted to locate CSB. High density infestations are obvious (Fig. 4-10). Cotton seed bugs resemble fleas in infested bolls; look for small black or brown bugs running through the cotton.

Figure 4-10 Cotton seed bug aggregation inside a cotton boll (Picture courtesy of Julieta Brambila USDA-APHIS-PPQ)

Open bolls into a plastic zipper storage bag and spray them gently with a small amount of 70% alcohol (isopropyl works, but ethanol is recommended) from a spray bottle or atomizer (a perfume atomizer purchased at the local dollar store works nicely). Close the bag quickly. The alcohol will irritate CSBs, which will quickly become very active. This technique promptly indicates an infested boll. Since this is a quarantine pest in the United States, do not open the bag; instead freeze the sample and then pick out the bugs (Sharma et al., 2010).

When cotton is not seeding, adults may move to alternative hosts such as dates, figs, avocado and persimmon. General visual surveys could detect CSBs during this period; however, the potential hibernation sites are so varied it is probably not efficient to survey specifically for CSBs when cotton bolls and seeds are not present (Sharma et al., 2010).

Sample Screening

An aid for screening possible CSB (Brambila, 2020) is included in Appendix B and can be found at http://download.ceris.purdue.edu/file/529.

Sample Submission

Contact your State Plant Health Director for sample submission guidance.

Chapter 5

Eradication and Control Options

Overview

This information can be used by PPQ decision-makers after a detection to assess the suitability of potential actions to eradicate, contain, or suppress CSB. The efficacy and feasibility of each control option should depend on the pest situation at the time of detection. Factors including detection location (e.g., natural or urban environment, agricultural crops, greenhouses, orchards), area of spread, the climatic region, the time of year, the phenology of the host, and current practices already in place contribute to determining whether a particular control option is appropriate.

Eradication Options

Host Removal

Burning old cotton stalks with bolls limits future damage by CSB (Odhiambo, 1957). Before burning any material, check the local ordinance for guidelines and required documentation. Cotton seed bugs are not adept at flying; therefore, it is possible to compost, mulch, or till the infested crop into the soil if burning is not an option. Contact your local extension expert to determine the best way to remove/destroy hosts in your area. Removal of all weeds or alternative Malvales host plants near cotton fields is recommended (Adu-Mensah and Kumar, 1977; Kirkpatrick, 1923). Destruction or removal of crop residues after harvest reduces CSB population size (Atwal, 1976).

Chemical Control

Various chemical control measures are available for use against CSB (Tables 5-1 and 5-2), although researchers have found that different populations are developing resistance to insecticides (Ijaz and Shad, 2020; Sweet, 2000). To avoid inherited resistance, combine insecticides with differing modes of action (Insecticide Resistance Action Committee, 2020).

Effective application of insecticides for control of CSB may be difficult due to the tendency of this insect to aggregate in many different areas on or near host plants, and to hide within cotton bolls (Atta et al., 2015b). However, experts in other countries have achieved effective control of CSB by combining contact and systemic chemical insecticides (Smith and Brambila, 2008). Some chemical controls should be applied aerially as ultra-low volume sprays in early morning while the insects are less active (Smith and Brambila, 2008). Sprays or dusts may be applied when the insects are seen on newly opened bolls (Hill, 1983).

In Australia, control of the similar species *Oxycarenus luctuosus* (Montrouzier) is difficult because while the chemicals may kill the pests it contacts, it does not restrict the movement of additional *O. luctuosus* bugs from nearby alternative host plants (Chin et al., 2009).

Many chemicals used against CSB are registered in the United States for use on cotton (Table 5-1) but have not been tested on this pest and host combination in the United States. Also, efficacies in other countries may not be the same in the United States. Other chemicals used against CSB in other countries are not currently registered in the United States for use on cotton (Table 5-2).

Table 5-1 Insecticides registered on cotton in the United States[1]

Chemical Name	Other information/ References
Avermectin	The fungus *Beauveria bassiana* is highly compatible with this insecticide (Ahmed et al., 2020). CDMS, 2021; Greene, 2019
Bifenthrin[2]	CDMS, 2021; Greene, 2019; Ibrahim et al., 1993
Chlorpyrifos	During a study in Pakistan, chlorpyrifos reduced CSB population by 96.2% (Abbas et al., 2014). Another study showed it is the highest performing pesticide against CSB (Irshad et al., 2019). CDMS, 2021; Greene, 2019
Clothianidin[3]	CDMS, 2021; Greene, 2019; Irshad et al., 2019
Deltamethrin[2]	CDMS, 2021; NPIC, 2010
Dimethoate[2]	Kedar et al. (2014) outlines how okra farmers manage CSB in India with specific formulations that may vary in the United States. CDMS, 2021; Ikisan, 2000; Greene, 2019
Emamectin[2] benzoate	CDMS, 2021; Greene, 2019
Fipronil[2]	Highly effective against plant bugs (Shaw and Yang, 1996; Wazir and Shad, 2020). CDMS, 2021

Chemical Name	Other information/ References
Imidacloprid[2]	Kedar et al. (2014) outlines how okra farmers manage CSB in India with specific formulations that may vary in the United States. At the time of sowing, farmers may also smear the seed with imidacloprid. CDMS, 2021; Nazir et al., 2017
Lambda-cyhalothrin[2]	In a comparative study, researchers found this pesticide to be the third most effective pesticide against CSB (Irshad et al., 2019). CDMS, 2021; Greene, 2019
Malathion	CDMS, 2021; Sweet, 2000
Methomyl/ diflubenzuron	CDMS, 2021; Ibrahim et al., 1993
Neem/Neem Oil	CDMS, 2021; Khan and Ahmed, 2000
Oxydemeton-methyl	Kedar et al. (2014) outlines how okra farmers manage CSB in India with specific formulations that may vary in the United States. Restricted use in cotton in AZ and CA (U.S. EPA, 2002).
Profenofos[2]	No residential use of this pesticide. Restricted use in cotton (U.S. EPA, 2000). Abbas et al., 2014
Spinosad[2]	CDMS, 2021; Cleveland et al., 2002
Spirotetramat	CDMS, 2021; Ijaz and Shad, 2020
Thiamethoxam	Used on seeds prior to sowing (Kedar et al., 2014). CDMS, 2021

[1] Many of the chemicals are approved for a wide variety of crops and plants. CSB is frequently found on fruits, leaves, or young stems of a wide variety of plants.

[2] Some populations of CSB show resistance to this pesticide in Pakistan (Ijaz and Shad, 2020; Ullah et al., 2016).

[3] Effective in reducing *Oxycarenus* spp. under field conditions in cotton.

Table 5-2 Insecticides for use against CSB NOT registered on cotton in the United States

Chemical Name	Other information/ References
Imidacloprid + Acetamiprid	Nazir et al., 2017
Imidacloprid + fipronil	Ijaz and Shad, 2020
Metasystox	Ikisan, 2000
Methamidophos[1]	Ibrahim et al., 1993
Triazophos[2]	In a comparative study, researchers found this pesticide to be the second most effective pesticide against CSB (Irshad et al., 2019). Ullah et al., 2016

[1] Listed in Ibrahim et al. (1993) as methamidophos/triflumuron. Triflumuron is not approved for use in the United States.

[2] Some populations of CSB show resistance to this pesticide in Pakistan (Ijaz and Shad, 2020; Ullah et al., 2016).

Insect Growth Regulators

Ibrahim et al. (1993) tested four insect growth regulator/insecticide mixtures and four synthetic pyrethroids in cotton fields and found that all tested insecticides effectively reduced CSB adult and nymph population levels by more than 80 percent. In a similar laboratory experiment, Atta et al. (2015b) tested different concentrations of four insect growth regulators (Table 5-3). These findings concluded that Lufenuron is highly toxic and effective against various life stages of CSB and is recommended for control in integrated pest management programs (Atta et al., 2015b).

Table 5-3 Insect growth regulators effective against CSB (Atta et al., 2015a; Atta et al., 2015b; Greene, 2019)

Active Ingredients of Insect Growth Regulators	Results
Methoxyfenozide	Less toxic to all instars. No sublethal effects on related species in the field.
Triflumuron	Triflumuron is not approved for use in the United States. Less toxic to all instars. Field studies show usage does not minimize insecticide resistance problems in other species.
Pyriproxyfen	Less toxic to all instars. Field studies show resistance over time in other species.
Lufenuron	24 hours after application= 58.3% mortality. 72 hours after application= 83.3% mortality >50% mortality in nymphs in 72 hours

Alternative Control Techniques

Biological Control

Biological control using only parasites or predators for CSB is generally not a practical control tactic (Sweet, 2000). One study found that the fungi *Metarhizium anisopliae* (Metschn.) Sorokīn was effective at killing over 50 percent of adult CSBs (Sahayaraj and Borgio, 2010). This demonstrates the fungi's effectiveness as an integrated pest management component, but its use alone will likely not lead to eradication. A strategy to increase the efficacy of biological controls is combining the application with insecticides.

Mixing the fungal spores with insecticides synergizes the effectiveness. Another study found that the most effective combination included the fungus *Beauveria bassiana* (Bals.-Criv.) Vuill. and the insecticide bifenthrin (Ahmed et al., 2020). *Beauveria bassiana* is also compatible with the insecticides avermectin and pyrethroids. Results from Khan et al. (2014) reiterated that *B. bassiana* isolates showed a higher percent mortality when compared to two other entomopathogenic fungi, *Cordyceps fumosorosea* (Wize) Kepler, B. Shrestha & Spatafora (=*Isaria* *fumosorosea* Wize) and *M. anisopliae* (Khan et al., 2014).

Cultural Control

According to some older literature, the most effective cultural control tactic was the removal of hibernation sites, weed shelters, and alternative Malvales hosts near cotton fields (Adu-Mensah and Kumar, 1977; Kirkpatrick, 1923). Reducing the exposure time of the seeds to CSB attack by picking cotton earlier in the season and at shorter intervals will limit damage to the crop but will not eliminate the pest (Kirkpatrick, 1923; Odhiambo, 1957). Removal of all infested plants, hibernation sites, and alternative hosts, preservation of natural enemies, and subsequent elimination of residual populations are more likely to effectively suppress CSB populations (Kirkpatrick, 1923; Ullah et al., 2016).

Damage to cotton seed significantly increases when the bolls are affected by bollworms (*Helicoverpa*) (Kirkpatrick, 1923). Control of bollworms may reduce early damage to the cotton seed.

Seed cotton is stored in large, compacted modules after harvest before being sent for ginning (Cotton Counts, 2010). These modules should be covered to prevent further infestation (Pearson, 1958).

Sanitary Measures

Removal of all weeds or alternative Malvales host plants near cotton fields is recommended (Adu-Mensah and Kumar, 1977; Kirkpatrick, 1923). Destruction or removal of crop residues after harvest reduces CSB population size (Atwal, 1976).

Behavioral Control

Mass trapping

We found conflicting evidence for the efficacy of mass trapping as a control measure for CSB. Currently, there are no pheromone lures or CSB specific traps (El-Sayed, 2020). UV-light traps are not recommended for surveying for CSB except in cases where there is a need to confirm eradication or enhance detection of a known population. UV-light traps are not pest specific, so they are time-consuming for sorting and identification purposes. In addition, it is unclear whether UV-light traps would be an effective monitoring tool for CSB.

Kirkpatrick (1923) demonstrated CSB's attraction to light in laboratory experiments; however, when light traps were placed at night in the direct path that CSB were known to use between a tree and nearby field, no individuals were captured. It was concluded that CSB either did not migrate at night or were not attracted to lights. Conversely, Nakache and Klein (1992) noted that CSB was strongly attracted to light at night in Israel. Additional research regarding the efficacy of UV-light traps is needed.

Based on the available information, mass trapping is not a recommended tactic for eradicating CSB at this time.

Literature Cited

O. hyalinipennis

Abbas, G., N. Hassan, I. Haq, M. Farhan, and H. Karar. 2014. Relative suitability of various insecticide for early crop management of cotton against sucking insect pest complex especially dusky cotton bug *Oxycarenus hyalinipennis* (Hemiptera: Oxycarenidae). Pakistan Entomology 36:129-133.

Abbas, M., F. Hafeez, M. Farooq, and A. Ali. 2015. Dusky cotton bug *Oxycarenus* spp. (hemiptera: Lygaeidae): Hibernating sites and management by using plant extracts under laboratory conditions. Polish Journal of Entomology 84(3): pp.127-136.

Adu-Mensah, K., and R. Kumar. 1977. Ecology of *Oxycarenus* species (Heteroptera: Lygaeidae) in southern Ghana. Biological Journal of the Linnean Society 9:349-377.

Ahmed, K., S. Freed, R. F. Shoukat, and W. A. Kanwar. 2020. Efficacy of entomopathogenic fungi with insecticides mixtures against *Oxycarenus hyalinipennis* (Costa) (Lygaeidae: Hemiptera). Pakistan Journal of Zoology 52(2):573-583.

Ananthakrishan, T. N., K. Raman, and K. P. Sanjayan. 1982. Comparative growth rate, fecundity, and behavioral diversity of the dusky cotton bug, *Oxycarenus hyalinipennis* Costa (Hemiptera: Lygaeidae) on certain malvaceous host plants. Proceedings of the Indian National Science Academy 48(5B):577-584.

Atta, B., M. D. Gogi, M. J. Arif, F. Mustafa, M. F. Raza, M. J. Hussain, M. A. Farooq, M. J. Nisar, and M. Iqbal. 2015a. Toxicity of some insect growth regulators (IGRs) against different life stages of dusky cotton bugs *Oxycarenus hyalinipennis* Costa (Hemiptera: Lygaeidae: Oxycareninae). Bulgarian Journal of Agricultural Science 21(2):367-371.

Atta, B., M. D. Gogi, F. Mustafa, M. Adil, M. F. Raza, M. A. Farooq, and M. W. Abbas. 2015b. Repellency of some insect growth regulators (IGRs) against dusky cotton bug *Oxycarenus hyalinipennis* Costa (Hemiptera: Lygaeidae: Oxycareninae) under laboratory conditions. Academic Journal of Entomology 8(2):52-55.

Atwal, A. S. 1976. Agricultural Pests of India and South-East Asia. Kalyani Publishers, Ludhiana, India. 502 pp.

Avidov, Z., and I. Harpaz. 1969. Plant Pests of Israel. Israel University Press, Jerusalem.

Beucke, K. 2021. FW: Feedback about revised New Pest Response Guidelines (NPRGs) cotton seed bug. Personal communication to R. Valdez on 1 February 2021, from K. Beucke.

Bolu, H., P. Dioli, and H. Çelik. 2020. Various observations on some biological character of *Oxycarenus hyalinipennis* (A. Costa, 1843) (Hemiptera: Lygaeoidea: Oxycarenidae) in south-eastern Turkey. Munis Entomology and Zoology Journal 15(2):481-488.

Brambila, J. 2020. Field screening aid for the cotton seed bug *Oxycarenus hyalinipennis* (Hemiptera). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Gainesville, FL. 1 pp.

CDMS. 2021. Crop Data Management Systems. http://www.cdms.net/Label-Database/Advanced-Search.

Chin, D., B. Thistleton, and H. Brown. 2009. Factsheet: Swarming bugs (family Lygaeidae) (ENT7). Department of Regional Development, Primary Industry, Fisheries and Resources, Northern Territory Government, Northern Territory Australia. 2 pp.

Cleveland, C. B., M. A. Mayes, and S. A. Cryer. 2002. An ecological risk assessment for spinosad use on cotton. Pest Management Science 58(1):70-84.

Collins, G. 2020. Cotton growing season details. Personal communication to J. Cook on 17 December 2020, from Collins, G.

Cotton Counts. 2010. Cotton: From Field to Fabric. Educational Resources, Memphis, TN. Last accessed December 14, 2020, http://www.cotton.org/pubs/cottoncounts/fieldtofabric/upload/Cotton-From-Field-to-Fabric-129k-PDF.pdf.

Derksen, A., K. Griffiths, and T. R. Smith. 2010. 2009 Florida CAPS *Oxycarenus* survey report (Program Report No. 2009-05-OH-01). Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Florida Cooperative Agricultural Pest Survey.

Dimetry, N. Z. 1971. Studies on the host preference of the cotton seed bug *Oxycarenus hyalinipennis* Costa (Lygaeidae: Hemiptera). Zeitschrift für Angewandte Entomologie 68(1-4):63-67.

El-Rahim, A., H. Gamal, and M. Amro. 2015. Population fluctuations of *Oxycarenus hyalinipennis* and effect of certain compounds on its population on okra in Asyut Governorate. Egyptian Journal of Agricultural Research 93(1):25-34.

El-Sayed, A. M. 2020. The Pherobase: Database of pheromones and semiochemicals. The Pherobase - Extensive Database of Pheromones and Semiochemicals. Last accessed December 15, 2020, http://www.pherobase.com.

Greene, J. 2019. Cotton insect management. South Carolina Pest Management Handbook for Field Crops:108-121.

Halbert, S. E., and T. Dobbs. 2010. Cotton seed bug, *Oxycarenus hyalinipennis* (Costa): A serious pest of cotton that has become established in the Caribbean Basin. Florida Department of Agriculture and Consumer Services, Division of Plant Industry-Pest Alert. FDACS-P-01726 6(04).

Henry, T. J. 1983. Pests not known to occur in the United States or of limited distribution (No. 38: Cottonseed bug). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Raleigh, NC. 6 pp.

Hill, D. S. 1983. Agricultural Insect Pests of the Tropics and their Control. Cambridge University Press, Cambridge. 746 pp.

Ibrahim, S. A., J. A. Ottea, and S. H. Martin. 1993. Field evaluation of certain synthetic pyrethroids and IGR's/insecticide mixtures against cotton pests. Proceedings of the Beltwide cotton Producers Conference 2:769-772.

Ijaz, M., and S. A. Shad. 2020. Genetic basis and realized heritability of laboratory selected spirotetramat resistance for insecticide resistance management in *Oxycarenus hyalinipennis* Costa (Hemiptera: Lygaeidae). Chemosphere:1-8.

Ikisan. 2000. Cotton Insect Management. Last accessed December 18, 2020, http://www.ikisan.com/mh-cotton-insect-management.html.

Insecticide Resistance Action Committee. 2020. IRAC mode of action classification scheme. CropLife International, Brussels, Belgium. 30 pp.

IPPC. 2016. International standard for phyosanitary measures (ISPM No. 31. Methodologies for sampling of consignments). International Plant Protection Convention (IPPC). 21 pp.

Irshad, M., M. M. Saleem, Q. A. Hanif, M. Nasir, M. U. Asif, and R. M. Shamraiz. 2019. Comparative efficacy of different insecticides against dusky cotton bug (*Oxycarenus* spp.) under field conditions. Journal of Entomology and Zoology Studies 7(2):125-128.

Ismail, H. A. 2018. The main sucking insect pests and their associated predators on okra plants. Zagazig Journal of Agricultural Research 45:1257-1271.

Kedar, S. C., K. M. Kumaranag, D. S. Bhujbal, and N. H. Thodsare. 2014. Insect pests of okra and their management. Popular Kheti 2(3):112-119.

Khan, B. A., S. Freed, J. Zafar, and M. Farooq. 2014. Evaluation of three different insect pathogenic fungi for the control of *Dysdercus koenigii* and *Oxycarenus hyalinipennis*. Pakistan Journal of Zoology 46:1759-1766.

Khan, M. F., and S. M. Ahmed. 2000. Toxicity of neem fruit extract and seed oil against *Oxycarenus* (Heteroptera) of cotton crop. Acta Biologica Cracoviensia series Zoologia 42:14-21.

Khan, R. A., and M. Naveed. 2017. Seasonal population dynamics and management of dusky cotton bug (DCB), *Oxycarenus hyalinipennis* Costa in cotton. Journal of Animal and Plant Sciences 27(4):1348-1352.

Kirkpatrick, T. W. 1923. The Egyptian cottonseed bug (*Oxycarenus hyalinipennis* (Costa)). Its bionomics, damage, and suggestions for remedial measures. Bulletin Ministries of Agriculture Egypt Technology Science Service (35):144.

Lattin, J. D., and K. Wetherill. 2002. *Metopoplax ditomoides* (Costa), a species of Oxycarenidae new to North America (Lygaeoidea: Hemiptera: Heteroptera). Pan-Pacific Entomologist 78:63-65.

Nakache, Y., and M. Klein. 1992. The cotton seed bug, *Ocycarenus* [sic] *hyalinipennis*, attacked various crops in Israel in 1991. Hassadeh 72:773-775.

Nazir, T., M. D. Gogi, M. Z. Majeed, W. ul Hassan, A. Hanan, and M. J. Arif. 2017. Field evaluation of selective systemic formulations against sucking insect pests complex and their natural enemies on transgenic *Bt* cotton. Pakistan Journal of Zoology 49(5):1789-1796.

NPIC. 2010. Deltamethrin technical fact sheet. Oregon State University, Corvallis, WA. Last accessed December 1, 2020, http://npic.orst.edu/factsheets/archive/Deltatech.html.

NSHS. 2019a. National Seed Health System. Phytosanitary field inspection procedures (1.3). Ames, IA. USDA-APHIS.

NSHS. 2019b. Phytosanitary field inspection procedures (1.3). USDA-APHIS, Ames, IA. 6 pp.

Odhiambo, T. R. 1957. The bionomics of *Oxycarenus* species (Hemiptera Lygaeidae) and their status as cotton pests in Uganda. The Journal of the Entomological Society of South Africa 20(2):235-249.

Pearson, E. O. 1958. The Insect Pests of Cotton in Tropical Africa. Empire Cotton Growing Corporation and Commonwealth Institute of Entomology, London. 355 pp.

Porcelli, F., and F. A. Palmieri. 2016. Infestazione di *Oxycarenus hyalinipennis* (Costa 1838) (Rhynchota, Lygaeidae) su Kenaf in Basilicata. Entomologica 30:197-205.

Rajashekhargouda, R., M. C. Devaiah, and S. Yelshetty. 1983. New record of insect pests infesting kasuri bhendi, *Hibiscus abelomoschus* Linnaeus, a medicinal plant. Journal of the Bombay Natural History Society 81(1):212-213.

Ram, R., and N. P. Chopra. 1984. Host plant relationships of *Oxycarenus hyalinipennis* Costa (Hemiptera: Lygaeidae: Oxycareninae). Bulletin of Entomological Research 25(2):111-116.

Ribeiro, F. N. 1997. The occurrence of *Oxycarenus hyalinipennis* (Costa, 1847) (Hemiptera: Lygaeidae) in the Alcobaca region. Boletim da Sociedade Portuguesa de Entomologia 6(25):357-363.

Ritchie, G. L., C. W. Bednarz, P. H. Jost, and S. M. Brown. 2004. Cotton growth and development (Bulletin 1252). The University of Georgia Cooperative Extension, Athens, GA. 16 pp.

Sahayaraj, K., and J. F. Borgio. 2010. Virulence of entomopathogenic fungus *Metarhizium anisopliae* (Metsch.) Sorokin on seven insect pests. Indian Journal of Agricultural Research 44(3):195-200.

Samy, O. 1969. A revision of the African species of *Oxycarenus* (Hemiptera: Lygaeidae). Roy. Entomol Soc. London Trans. 121(4):79-165.

Shah, Z. U., A. Ali, I. Haq, and F. Hafeez. 2016. Seasonal history of dusky cotton bug (*Oxycarenus hyalinipennis* Costa). Journal of Entomology and Zoology Studies 4(3):228-233.

Sharma, S., S. Tafel, and A. Hodges. 2010. Cotton seed bug *Oxycarenus hyalinipennis* (presentation). Florida Department of Agriculture and Consumer Services, , Gainesville, FL.

Shaw, R., and H. S. Yang. 1996. Performance summary of fipronil insecticide on cotton. In Beltwide Cotton Conferences (USA).862-865.

Smith, T. R., and J. Brambila. 2008. A major pest of cotton, *Oxycarenus hyalinipennis* (Heteroptera: Oxycarenidae) in the Bahamas. Florida Entomologist 91(3):479-482.

Sweet, M. H. 2000. Seed and chinch bugs (Lygaeoidea). Pages 143-264 *in* C. W. Schaefer and A. R.

Panizzi, (eds.). Heteroptera of Economic Importance. CRC Press, Boca Raton.

U.S. EPA. 2000. Profenofos facts (EPA 738-F-00-005 (7508C)). United States Environmental Protection Agency. Prevention, Pesticides and Toxic Substances, Washington, D. C. 3 pp.

U.S. EPA. 2002. Oxydemeton-methyl facts (EPA 738-F-06-020). United States Environmental Protection Agency. Prevention, Pesticides and Toxic Substances, Washington, D. C. 3 pp.

Ullah, S., S. A. Shad, and N. Abbas. 2016. Resistance of dusky cotton bug, *Oxycarenus hyalinipennis* Costa (Lygaidae: Hemiptera), to conventional and novel chemistry insecticides. Journal of Economic Entomology 109(1):345-351.

USDA-APHIS-PPQ-S&T. 2016. CPHST pest datasheet for Cotton seed bug - *Oxycarenus hyalinipennis*. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Science & Technology, Raleigh, NC. 11 pp.

USDA. 2020. Agriculture Risk Monitoring (ARM). United States Department of Agriculture (USDA).

Wazir, S., and S. A. Shad. 2020. Inheritance mode and properties of fipronil resistance in *Oxycarenus hyalinipennis* Costa (Hemiptera: Lygaeidae). Journal of Asia-Pacific Entomology 23(4):1055-1061.

Wheeler, A. G., and T. J. Henry. 2015. First North American record of the Palearctic *Microplax albofasciata* (Costa)(Hemiptera: Lygaeoidea: Oxycarenidae). Proceedings of the Entomological Society of Washington 117(1):55-61.

Appendix A Environmental Compliance

Introduction

Use Appendix A as a guide to environmental regulations pertinent to *Oxycarenus hyalinipennis*.

Overview

Program managers of Federal emergency response or domestic pest control programs must ensure that their programs comply with all Federal Acts and Executive Orders pertaining to the environment, as applicable. Two primary Federal Acts, the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA), often require the development of significant documentation before program actions may begin. APHIS' Policy and Program Development Staff (PPD), Environmental and Risk Analysis Services (ERAS) is available to provide guidance and advice to program managers and prepare drafts of applicable environmental documentation. In preparing draft NEPA documentation, PPD ERAS may also perform and incorporate assessments that pertain to other Acts and Executive Orders, described below, as part of the NEPA process. The Environmental Compliance Team (ECT), a part of PPQ's Plant Health Programs, sometimes assists ERAS in development of documents and implements environmental monitoring. Program leadership is strongly advised to consult with PPD ERAS and/or ECT early in the development of a program in order to conduct a preliminary review of applicable environmental statutes and to ensure timely compliance.

Environmental monitoring of APHIS pest control activities may be required as part of compliance with environmental statutes, as requested by program managers, or as suggested to address concerns with controversial activities. Monitoring may be conducted with regards to worker exposure, pesticide quality assurance and control, off-site chemical deposition, or program efficacy. Different tools and techniques are used depending on the monitoring goals and control techniques used in the program. Staff from ECT will work with the program manager to develop an environmental monitoring plan, conduct training to implement the plan, provide day-to-day guidance on monitoring, and provide an interpretive report of monitoring activities.

The following is list of pertinent laws and Executive Orders:

National Environmental Policy Act (NEPA) – NEPA requires all Federal agencies to examine whether their actions may significantly affect the quality of the human environment. The purpose of NEPA is to inform the decision-maker prior to taking action and to inform the public of the decision. Actions that are excluded from this examination, actions that normally require an Environmental Assessment, and actions that normally require Environmental Impact Statements are codified in APHIS' NEPA Implementing Procedures located in 7 CFR 372.5.

The three types of NEPA documentation are:

1. **Categorical Exclusion**

   Categorical exclusions are classes of actions that do not have a significant effect on the quality of the human environment and for which neither an environmental assessment (EA) nor an environmental impact statement (EIS) is required. Generally, the means through which adverse environmental impacts may be avoided or minimized have actually been built into the actions themselves (see 7 CFR 372.5(c)).

2. **Environmental Assessment (EA)**

An EA is a public document that succinctly presents information and analysis for the decision-maker of the proposed action. An EA can lead to the preparation of an environmental impact statement (EIS), a finding of no significant impact (FONSI), or the abandonment of a proposed action.

3. **Environmental Impact Statement (EIS)**

   In the event that a major Federal action may significantly affect the quality of the human environment (adverse or beneficial), or, the proposed action may result in public controversy, an EIS is prepared.

Endangered Species Act (ESA) – This statute requires that programs consider their potential effects on federally protected species. The ESA requires programs to identify protected species and their habitat in or near program areas and documentation of how adverse effects to these species will be avoided. The documentation may require review and approval by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service before program activities can begin. Knowingly violating this law can lead to criminal charges against individual staff members and program managers.

Migratory Bird Treaty Act – This statute requires that programs avoid harm to migratory bird species, eggs, and their nests. In some cases, permits may be available to capture birds, which require coordination with the U.S. Fish and Wildlife Service.

Clean Water Act – This statute requires various permits for work in wetlands and for potential discharges of program chemicals into water. This may require coordination with the Environmental Protection Agency, individual states, and the Army Corps of Engineers. Such permits would be required even if the pesticide label allows for direct application to water.

Tribal Consultation – This Executive Order requires formal government to government communication and interaction if a program might have substantial direct effects on any federally-recognized Indian Nation. This process is often incorrectly included as part of the NEPA process, but must be completed prior to general public involvement under NEPA. Staff should be cognizant of the conflict that could arise when proposed federal actions intersect with tribal sovereignty. Tribal consultation is designed to identify and avoid such potential conflict.

National Historic Preservation Act – This statute requires programs to consider potential impacts on historic properties (such as buildings and archaeological sites) and requires coordination with local State Historic Preservation Offices. Documentation under this Act involves inventorying the project area for historic properties and determining what effects, if any, the project may have on historic properties. This process may require public involvement and comment prior to the start of program activities.

Coastal Zone Management Act – This statute requires coordination with states where programs may impact Coastal Zone Management Plans. Federal activities that may affect coastal resources are evaluated through a process called “federal consistency”. This process allows the public, local governments, Tribes, and state agencies an opportunity to review the federal action. The federal consistency process is administered individually by states with Coastal Zone Management Plans.

Environmental Justice – This Executive Order requires consideration of program impacts on minority and economically disadvantaged populations. Compliance is usually achieved within the NEPA documentation for a project. Programs are required to consider if the actions might disproportionally impact minority or economically disadvantaged populations, and if so, how such impact will be avoided.

Protection of Children –This Executive Order requires federal agencies to identify, assess, and address environmental health risks and safety risks that may disproportionately affect children. If such a risk is identified, then measures must be described and implemented to minimize such risks.

Appendix

B Screening Aid

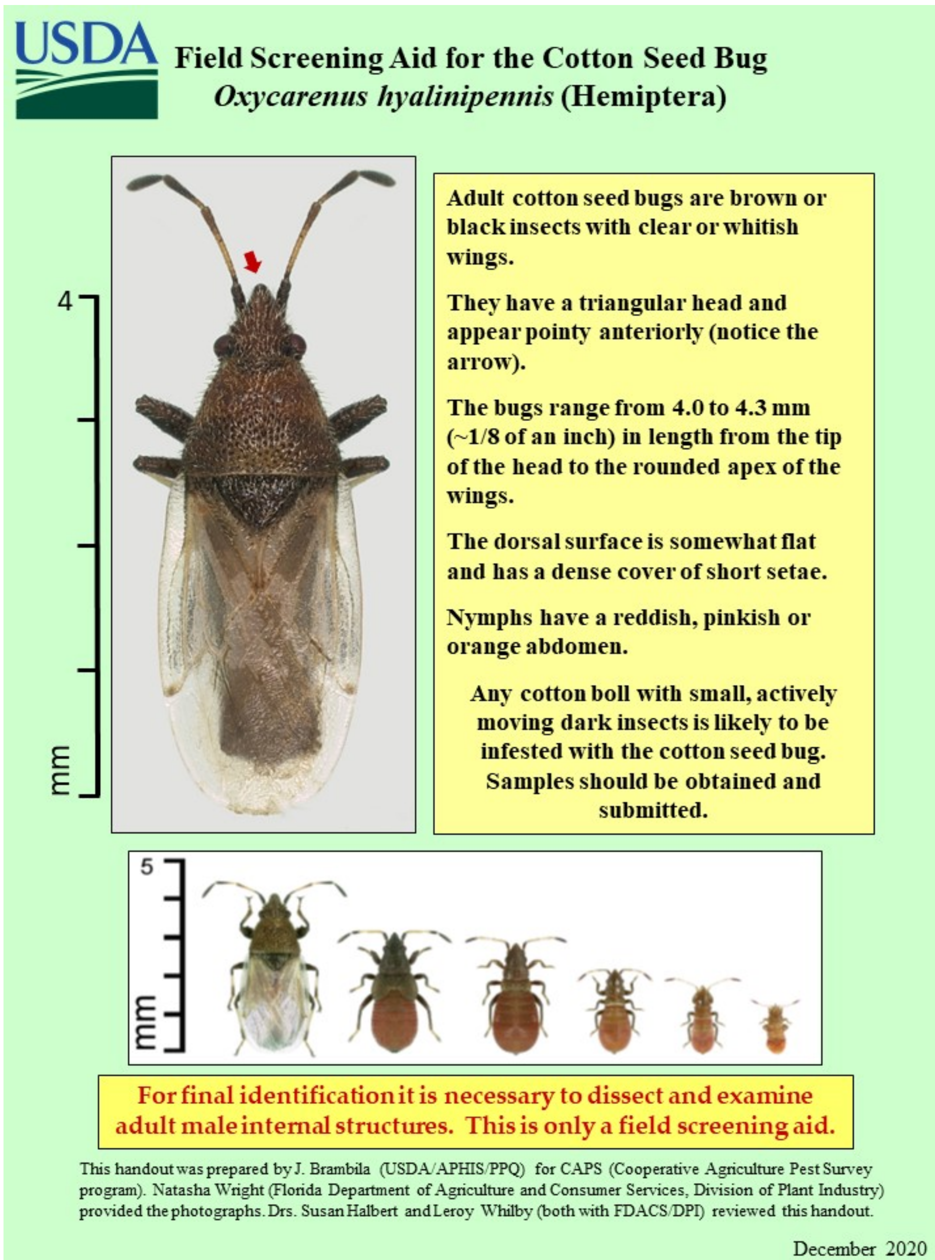

Figure B-1 Field screening aid for CSB (Brambila, 2020)

Authors and Reviewers

O. hyalinipennis

Authors

Jennifer C. Cook, Ph.D., NCSU–CIPM

Colin F. Funaro, Ph.D., NCSU–CIPM

Trace C. Hardin, USDA–APHIS–PPQ–PERAL

Doug McPhie, USDA–APHIS–PPQ–PERAL

Editor

Rosemary Hallberg, NCSU–CIPM

Reviewers

Julieta Brambila, USDA–APHIS–PPQ

Gary L. Cave, Ph.D., USDA–APHIS–PPQ–PERAL

Michelle L. Gray, USDA–APHIS–PPQ–PERAL

Peter T. Hertl, Ph.D., USDA–APHIS–PPQ–PERAL

Wendy G. Marchant, Ph.D., USDA–APHIS–PPQ–PERAL

Alec Ormsby, USDA–APHIS–PPQ–FO

Godshen R. Pallipparambil, Ph.D., NCSU–CIPM

Ricardo Valdez, USDA–APHIS–PPQ–PER

Contributors

Global Pest and Disease Database team

Cover Image

Cotton seed bug, *O. hyalinipennis* (image courtesy of Julieta Brambila, USDA–APHIS–PPQ)