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Threecornered Alfalfa Hopper *Spissistilus festinus* (Say) (Insecta: Hemiptera: Membracidae)[1]

Rafia Khan, Dakshina Seal, Victoria Adeleye, and Garima Garima[2]

The Featured Creatures collection provides in-depth profiles of insects, nematodes, arachnids and other organisms relevant to Florida. These profiles are intended for the use of interested laypersons with some knowledge of biology as well as academic audiences.

Introduction

Spissistilus festinus (Figure 1) was first described by Thomas Say in 1831 and belongs to the insect order Hemiptera under the family Membracidae. The species' common name "threecornered alfalfa hopper" was coined by farmers after observing large infestations in alfalfa. The presence of three corners on the pronotum (a prominent plate-like structure that covers all or part of the thorax of some insects), one at each shoulder and one at the apex, also confers the common name. *Spissistilus festinus* prefers to feed on leguminous plants and is a common insect in the southeastern United States (Wildermuth 1915).

Synonym

Spissistilus festinus was first named *Membracis festina* in 1831 by Thomas Say. The genus was changed by Stal to *Stictocephala* and described as *Stictocephala festina* (Wildermuth 1915). Caldwell changed the tribe (taxonomic rank above genus) to Ceresini in 1949 and established the new binomial name *Spissistilus festinus* (Davis 1969).

Ceresa festina Say 1830

Membracis festina Say 1830:243

Stictocephala festina, Funkhouser, 1927:224-225

Spissistilus festinus, Metcalf and Wade, 1965:809-814

Figure 1. Adult female three-cornered alfalfa hopper, *Spissistilus festinus* Say, (Lateral view).
Credits: Rafia A. Khan, UF/IFAS Entomology and Nematology Department

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2. Rafia Khan, UF/IFAS Tropical Research and Education Center; Dakshina Seal; Victoria Adeleye; and Garima Garima; UF/IFAS Extension, Gainesville, FL 32611.

Distribution

The native range of *Spissistilus festinus* is transcontinental, from Canada to Central America and West Indies (Wildermuth 1915). *Spissistilus festinus* is frequently found in the southern and southwestern United States. The species is less abundant in the northern United States and southern Canada (Osborn 1911, Wildermuth 1915, Caldwell 1949, Moellenbeck et al. 1993, Deitz and Wallace 2012).

Description and Identification

The adult *Spissistilus festinus* is light green and 6-7 mm long, with an elongated pronotum extending to the abdomen's tip (Wildermuth 1915). The dried specimen appears a deep orange to straw color with suprahumerals and dorsal crest light red (Kopp and Yonke 1973). The pronotum has three corners, one at each shoulder and one at the apex. The male *Spissistilus festinus* can be differentiated from the females by observing a red tint on the dorsal surface of the pronotum. The female *Spissistilus festinus* is marginally bigger than the male (Wildermuth 1915) (Figure 2).

Figure 2. Adult male (A) and female (B) three-cornered alfalfa hopper, *Spissistilus festinus* Say, (Dorsal view).
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Spissistilus festinus is a hemimetabolous insect with three life stages, including eggs, nymphs, and adults. Eggs are white in color, and oblong in shape, with one end more expansive than the other, ranging from 0.9 to 1.3 mm long. The broader part of the egg is covered in papillae to secure the egg within the plant tissue (Wildermuth 1915). The female *Spissistilus festinus* inserts the eggs under the epidermis of the host plants in a slit. *Spissistilus festinus* oviposits near the base of the main stem early in the season in soybean (*Glycine max* L) (Wildermuth 1915) and softer tissues such as terminals and nodes in the later of the season (Mitchell and Newsom 1984, Rice and Dress 1985). The number of eggs laid in each slit varies, averaging six eggs in each slit in soybean and 1-to 2 eggs per slit in alfalfa (Wildermuth 1915, Jordan 1952).

Figure 3. Adult three-cornered alfalfa hopper, *Spissistilus festinus* Say, (A, Ventral view) and female ovipositor (B).
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The number of nymphal instars (Figure 4) of *Spissistilus festinus* depends on nutrition and weather conditions. There are four to six nymphal instars, while five are more usual (Wildermuth 1915, Moore and Muller 1976, Deitz and Wallace 2012). The first and second instars are 1.6 mm and 2.1 mm in length, pale green or straw-colored with a series of dorsal spine-like protrusions. The dorsal spines grow and develop divergent lateral spurs that occur along the length of each spine after each successive nymphal stage. The third nymphal instars appear with wing pads and pronounced development of the pronotum. The third nymphal instars of *Spissistilus festinus* are darker yellow-brown with green markings and are about 2.9 mm in length. The fourth and fifth instars are similar in appearance and grow progressively greener with pronounced wing pads, dorsal spikes, and pronotum. The third through fifth instars are more mobile than the first and second instars (Wildermuth 1915). Nymphs can produce a globule from the abdomen as a defense mechanism and quickly move to the opposite side of the stem if disturbed. The adults have the same defensive manner as nymphs. Adults generally fly within 33 cm above the soil or the plant canopy (Johnson and Mueller 1989, 1990).

Figure 4. Fourth instar nymph (A) and different nymphal instars (B) of three-cornered alfalfa hopper, *Spissistilus festinus* Say, (Lateral view). Credits: Rafia A. Khan, UF/IFAS Entomology and Nematology Department

Life History

Depending on the favorable weather and food availability from the host plants, *Spissistilus festinus* can have multiple generations per year (Wildermuth 1915, Mitchell and Newsom 1984). The adult *Spissistilus festinus* undergoes a reproductive diapause in the winter (Newsom et al. 1983, Mitchell and Newsom 1984). However, Wildermuth (1915) found continued reproduction during mid-winters. Male *Spissistilus festinus* usually die soon after copulation but females live for 38.6 d post copulation (Mitchell and Newsom 1984). The sex ratio varies throughout the season (Mitchell and Newsom 1984, Newsom et al. 1983). However, some research shows that the *Spissistilus festinus* population consists of more males than females (Wildermuth 1915). A female *Spissistilus festinus* can produce more than 220 eggs during her reproductive period of 38 d (Mitchell and Newsom 1984). The incubation period ranges from 6 to 27 days (Meisch and Randolph 1965). *Spissistilus festinus* completes the first three instars in 3-5 days each and the last two instars in 4-8 days each (Wildermuth 1915, Jordan 1952, Meisch and Randolph 1965, Spurgeon and Mack 1990). Wildermuth (1915) reported that the total development time from egg hatching to adult was 69 days at 16°C and 32 days at 30°C.

Hosts

Spissistilus festinus has a wide range of feeding and reproductive hosts. However, plant species in the Fabaceae family are the most favorable as *Spissistilus festinus* infest those plants for their reproduction and development (Caviness and Miner 1962, Tugwell et al. 1972, Mitchell and Newsom 1984, Johnson et al. 1988). *Spissistilus festinus* was first recognized as a potential pest of tomato in 1888 in Georgia (Oemler 1888) and alfalfa in 1899 (Cockerell 1899). The host range of *Spissistilus festinus* includes tomato (*Solanum lycopersicum* L.), cowpeas (*Vigna unguiculata* L.), soybean (*Glycine max* L.), alfalfa (*Medicago sativa* L.), sugarcane (*Saccharum offinarum* L.), potato (*Solanum tunerosum* L.), cotton (*Gossypium hirsutum* L.), field pea (*Pisum sativum* L.), peanut (*Arachis hypogaea* L.), Bermuda grass (*Cynodon dactylon* L.), Johnson grass (*Sorghum halepense* L.), wheat (*Triticum spp.* L.), barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.), bur clover (*Medicago polymorpha* L.), red clover (*Trifolium pratense* L.), sweet clover (*Melilotus officinalis* L.), sunflower (*Helianthus spp*. L.), mesquite (*Prosopis glandulosa* Torr.), Spanish clover (*Acmispon americanus* L.), subterranean clover (*Trifolium subterraneum* L.), crimson clover (*Trifolium incarnatum* L.), dandelion (*Taraxacum officinale* F. H. Wigg.), birdsfoot trefoil (*Lotus corniculatus* L.), common groundsel (*Senecio vulgaris* L.), field bindweed (*Convolvulus arvensis* L.), magnus peas (*Pisum sativum* L.), bell beans (*Vicia faba* L.), blando brome (*Bromus hordeaceus* L.), black medick (*Medicago lupulina* L.) (Wildermuth 1915, Van Zwaluwenburg 1926, Swezey 1937, Kopp and Yonke 1973, Anderson et al. 2002, Rahman et al. 2007). *Spissistilus festinus* was also found to overwinter and reproduce on a variety of alternative hosts, including weeds, pine (*Pinus* spp. L.), and vetch (*Vicia* spp. L.) (Wildermuth 1915, Osborn 1911, Mueller and Dumas 1987, Newsom et al. 1983).

Figure 5. Adult female and nymphs of three-cornered alfalfa hopper, *Spissistilus festinus* Say, (Lateral view).
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Economic Importance

Spissistilus festinus is a phloem feeder with piercing-sucking mouthparts. Both adults and nymphs show two distinct feeding behaviors, sporadic probing of stems and

consumption of phloem sap (Anderson et al. 2002); and the formation of a continuous series of lateral punctures around the circumference of a stem, resulting in a girdle (gall-like growth) around the stem (Wildermuth 1915). Studies showed that insoluble salivary sheaths are left in the plant tissue after insect feeding, which disorganizes and disrupts the vascular bundles of the phloem (Smith 1933, Johnson et al. 1988). Mainly third, fourth, and fifth nymphal instars and adults can create stem girdles leading to lodging, stem breakage, and stand reduction (Caviness and Miner 1962, Meich and Randolph 1965, Bailey 1975, Tugwell et al. 1972, Moore and Muller 1976, Mueller and Jones 1983, Mitchel and Newsom 1984, Anderson et al. 2002). The nutrient flow becomes interrupted, and photosynthates accumulate in the area above the girdle leading to the breakage of the stem (Osborn 1911, Wildermuth 1915, Mitchel and Newsom 1984, Anderson et al. 2002). With the progression of plant age, the proportion of the feeding injury by *Spissistilus festinus* shifts from main stems to petioles (Rice and Dress 1985). The long-term adverse growth effects occur on the leaves and stem due to the temporary changes on the girdled stems. Nymphs of *Spissistilus festinus* were observed within 5 mm above the girdle and fed up to 7 days (Moellenbeck and Quisenberry 1991, Anderson et al. 2002). Heavy girdling reduces the forage quality, lowers carbohydrates and amino acids, and increases detergent fibers in alfalfa and soybean (Wilson and Quisenberry 1987, Mollenbeck and Quisenberry 1991). At the early vegetative stages of the host, *Spissistilus festinus* makes girdles mainly on the hypocotyl and first internode of the main stem which causes the thickness of the stem to increase and increased woodiness. Then hoppers shift to the petioles of leaves, small lateral branches, pods, pedicels, and peduncles, and even at the pod-filling stage (Mitchell and Newsom 1984). Recently, *Spissistilus festinus* was identified as a vector of Grapevine red blotch virus (GRBV) (Bahder et al. 2016). The infestation of GRBV delays maturity and reduces the accumulation of sugar in grapes. The disease also affects the production of secondary metabolites that impair grape quality in the form of color, flavor, and aroma (Blanco-Ulate et al., 2017). The grape growers and wine producers in the United States are very concerned about this vector-borne disease (Calvi 2011, Wallis and Sudarshana 2016). Nymphs and adults were observed in tomato and pepper fields infesting the seedlings and making girdles on the stems in South Florida (Khan and Seal personal communication 2021) (Figure 5, Figure 6, Figure 7). Adults and nymphs were also observed in nearby pepper and eggplant fields feeding on plants and making girdles on the stems (Adeleye and Garima, personal communication 2021) (Figure 9, Figure 10). Stems of some plants were completely broken because of the feeding injury (girdling) close to the root leading to the eventual death of the plant (Figure 11).

Figure 6. Nymphs of three-cornered alfalfa hopper, *Spissistilus festinus* Say, fed on tomato plant (Green circle) (A and B).
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Figure 7. Injured tomato seedlings (Girdle) (A and B) by nymphs and adults of three-cornered alfalfa hopper, *Spissistilus festinus* Say (Green circle).
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Figure 8. Injured tomato seedlings (A and B) (Girdle) by nymphs and adults of three-cornered alfalfa hopper, *Spissistilus festinus* Say, on tomato plant (Green circle).
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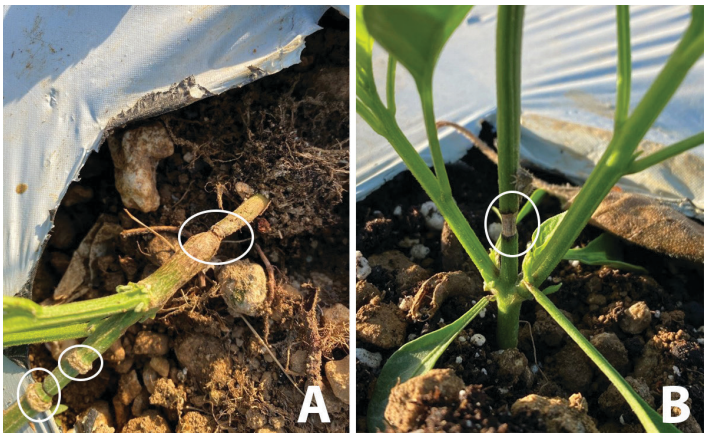

Figure 9. Injury (Girdle) by nymphs and adults of three-cornered alfalfa hopper, *Spissistilus festinus* Say, on pepper plant (Green circle).
Credits: Victoria Adeleye, UF/IFAS Entomology and Nematology Department

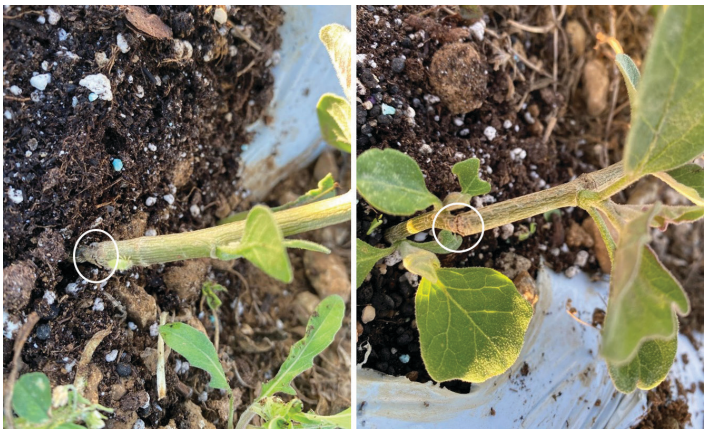

Figure 10. Feeding injury of three-cornered alfalfa hopper, *Spissistilus festinus* Say, on eggplant (Green circle).
Credits: Garima Garima, UF/IFAS Entomology and Nematology Department

Figure 11. Stem breakage caused by three-cornered alfalfa hopper, *Spissistilus festinus* Say, on pepper plant.
Credits: Victoria Adeleye, UF/IFAS Entomology and Nematology Department

Management

Sampling

Spissistilus festinus females are found randomly distributed throughout the field in soybean and peanut Plant injury can be assessed within 10 m of field borders to adequately estimate whole field injury levels (Sparks and Boethel 1987, Rahman et al. 2007). The observation of the entire plant can provide an accurate assessment of the nymphal population but is time-consuming. Beat sheet sampling is less time-consuming but not ideal for detecting the younger, smaller nymphs in soybean (Spurgeon and Mueller 1991). The beat-net and vertical beat sheet techniques are alternatives to the beat sheet for sampling nymphs (Sparks and Boethel 1987, Dress and Rice 1985). The sweep net effectively assesses the adult population in soybean and peanut (Kogan and Herzog 1980, Rahman et al. 2007). Yellow sticky traps effectively monitor adults when placed 33 cm above the ground or plant canopy level (Johnson and Mueller 1988, Johnson and Mueller 1989).

Cultural Control

Spissistilus festinus cannot survive nor reproduce on some cover cops like orchard grass (*Dactylis glomerata* L.), creeping red fescue (*Festuca rubra* L.), fawn tall fescue (*Festuca arundinacea* Schreb.), hard fescue (*Festuca ovina* L.), and California poppy (*Eschscholzia californica* Cham.). Cultivating these cover crops next to the crop field can reduce the

migration of adult *Spissistilus festinus* to the crops (Kron and Sisterson 2020).

Biological Control

Nickerson et al. (1977) found that the ant species of *Solenopsis germinata* Fabricius and *Conomyrma insana* Buckley were the most abundant and tended nymphs of *Spissistilus festinus* in Florida. He also reported the workers of ant species *Conomyrma insane* Buckley, *C. flavopecta* M.R. Smith, *Iridomyrmex pruinosus* Roger, and *Pheidole morris* Forel along with the previous two mentioned were observed to tend *Spissistilus festinus* in the soybean field. The entomopathogenic fungus *Erynia delphacis* (Hori) Humberwas found to be effective in controlling adult *Spissistilus festinus* in Alabama. The adults were found infected under laboratory conditions, where sporulation of fungi started through the intersegmental folds of the abdomen and the joint of frons and pronotum (Miller and Harper 1987). In Arkansas, *Geocoris punctipes* (Say) (Hemiptera: Geocoridae) and *Nabis roseipennis* (Reuter) (Hemiptera: Nabidae) were found to predate on *Spissistilus festinus* nymphs of 33% to 83% and 33% to 100%, respectively under laboratory conditions (Medal et al. 1997). Daigle et al. (1988) found *Polynema* spp. (Hymenoptera: Mymaridae) as the egg parasitoid of *Spissistilus festinus*. A strepsipteran parasite, *Membracixenos jordani* Pierce, was reported as a parasite of the Family Membracidae in America (Pierce 1952).

Chemical Control

Insecticides of various modes of action (e. g. pyrethroids, carbamates, diamides) are an effective tool to reduce the *Spissistilus festinus* population. The third, fourth, and fifth nymphal instars cause most of the feeding injuries. Thus, management strategies need to reduce the population of those damaging stages (Beyer et al. 2017). However, the adult *Spissistilus festinus* can re-infest the field shortly after less effective chemical treatments (Sparks and Boethel 1987).

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