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Toxoptera citricida (Kirkaldy), Brown Citrus Aphid - Identification, Biology, and Management Strategies[1]

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INTRODUCTION: The brown citrus aphid (BrCA), *Toxoptera citricida* (Kirkaldy), is one of the world's most serious pests of citrus. Although BrCA alone can cause serious damage to citrus, it is even more of a threat to citrus because of its efficient transmission of citrus tristeza closterovirus (CTV). One of the most devastating citrus crop losses ever reported followed the introduction of BrCA into Brazil and Argentina: 16 million citrus trees on sour orange rootstock were killed by CTV (Carver 1978). The aphid was first reported in Venezuela in 1976, and by 1987, 6 million citrus trees on sour orange rootstock had been killed (Roca-Peña *et al.* 1995). BrCA is also a major pest in Asia where it is native (Carver 1978; Tao and Tan 1961).

BrCA was first detected in Florida in early November of 1995 in metropolitan Dade and Broward counties. BrCA was discovered early after its introduction (probably about 4 months). The initial distribution of the pest implicated introduction on infested plant material rather than natural spread from the Caribbean. One year after BrCA was detected, infestations could be found south and east of a line from Melbourne (Brevard Co.) to Ft. Myers (Lee Co.). This is consistent with Wellings' (1994) estimate that aphids colonize at a rate of 250 km/yr. By the end of 1997, the entire Florida citrus production area had been colonized.

IDENTIFICATION: Worldwide, 16 species of aphids are reported to feed regularly on citrus, and four more species may be occasional pests (Blackman and Eastop 1984; Stoetzel 1994). Of these 20 species, five are found consistently in Florida groves, including *Aphis craccivora* Koch (cowpea aphid), *Aphis gossypii* Glover (cotton or melon aphid), *Aphis spiraecola* Patch (spirea aphid), *Toxoptera aurantii* (Boyer de Fonscolombe) (black citrus aphid), and BrCA, which has become common in infested areas. An additional three species, *Aphis nerii* Boyer de Fonscolombe (oleander aphid), *Macrosiphum euphorbiae* (Thomas) (potato aphid) and *Myzus persicae* (Sulzer) (green peach aphid) are rarely collected on citrus in Florida and are not considered pests of the crop.

BrCA (Figs. 1 and 2) is larger than other species occurring on citrus. Adult wingless forms (apterae) (Fig. 1) are very shiny black, and nymphs are dark reddish-brown. However, field identification of BrCA can be difficult because four of the five regularly collected species can be dark in color, and all five species colonize new growth. Additionally, mixed colonies of two or more species are common. Winged forms (alatae) (Fig. 2) of BrCA are distinctive. They can be recognized by the conspicuous black antennal segments I, II and III. Identification is easier with alatae than with adult apterae or nymphs, but alatae are less common in the field because they tend to leave the colony soon after they emerge. The following key to adult apterae will separate most colonies in the field with the aid of a hand lens. Characters that require microscopic examination are included in parentheses. It will not always be possible to separate BrCA from *A. craccivora* in the field, but the latter species is not very common. Identification of alatae of most species of aphids on Florida citrus has been covered earlier (Denmark 1990). Another excellent source of identification using microscopic characters is Stroyan (1961). Please refer to Fig. 1 for illustration of aphid terminology for field identification.

Field Key to Adult Wingless Forms (Apterae) of Common Aphids on Citrus in Florida

1. Aphids yellow or green; adults with cauda as dark as siphunculi; (6-13 setae on the cauda; ultimate rostral segment [the terminal segment of the mouthparts] 0.07-0.13 mm long) ..... *Aphis spiraecola*
1'. Aphids black, grey or tan; other characters variable 2
2. Cauda of adults significantly paler than siphunculi; aphids variable in color but not shiny black; antennae not with stripes; "knees" pale; (cauda with two or three pairs of setae; setae on antennal segment III not longer than the diameter of the segment) ..... *Aphis gossypii*
2'. Cauda of adults black, just as dark as the siphunculi; aphids dark, sometimes very shiny black; at least "knees" of hind legs black; (setae variable) 3

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3. Antennae of adults and larger nymphs with joints of most segments darkened so that they appear striped; adult apterae matte black in color, nymphs reddish brown or grey (stridulatory organ present[3]; cauda with 10-20 setae; setae on antennal segment III shorter than the diameter of the segment) ..... *Toxoptera aurantii*

3'. Antennae of adults and larger nymphs not striped, but dark on the distal 1/3-1/2 its length; adult apterae shiny black, nymphs red-brown or grey; other characters variable 4

4. "Knees" of all three pairs of legs very dark; dark portion of the antenna about 1/2 of its length; siphunculi only slightly longer than the cauda; (stridulatory organ present; cauda with about 30 setae; setae on antennal segment III at least as long as the diameter of the segment; antennal segment III slightly swollen). ..... *Toxoptera citricida* (BrCA)

4'. "Knees" usually dark only on hind legs; dark portion of the antenna only about 1/3 of its length; siphunculi much longer than the cauda; (stridulatory organ absent; cauda with about 7 setae; setae on antennal segment III not nearly as long as the diameter of the segment; antennal segment III never swollen) ..... *Aphis craccivora*

DISTRIBUTION: The current distribution of BrCA includes Southeast Asia, Africa south of the Sahara, Australia, New Zealand, the Pacific Islands, South America, the Caribbean and most recently, Florida. So far, the remainder of U.S. citrus-producing areas and the Mediterranean, except (since 1994) for the island of Madeira (Aguilar *et al.* 1994), have remained free of the pest (Blackman and Eastop 1994).

HOST PLANTS: Most aphidologists believe that the preferred host range of BrCA is limited to citrus and a few close relatives (Aguiar 1994; Blackman and Eastop 1984, 1994; Carver 1978; Stoetzel 1994; Stroyan 1961; Yokomi 1994). However, BrCA has been reported to form large colonies on the new growth of other plants in several families. It is not known which, if any, of these reports are the result of misidentifications or collections of incidental specimens. It is possible that under some environmental conditions, BrCA can colonize the new growth of plants that are not its normal hosts. Alternatively, it is not known how genetically variable world populations of BrCA are; thus, it is possible that variants exist that regularly colonize host plants outside the Rutaceae. In particular, van Harten and Ilharco (1975) note a tendency for BrCA to feed on Rosaceae in southern Africa and Mauritius. The host range of BrCA in Florida is not known clearly; however, to date, colonies have been found only on citrus and close citrus relatives.

BIOLOGY: The life cycle of BrCA is much less complex than that of most aphids. In most areas of the world, BrCA is permanently anholocyclic, meaning that there is no sexual cycle in the autumn, and thus, no males, no oviparae, and no eggs. All individuals throughout the year are viviparous parthenogenetic females. In Japan, there is a functional holocycle on citrus (Komazaki 1988). It is expected that BrCA will be permanently anholocyclic in the major citrus production areas of Florida.

Populations of BrCA increase very rapidly under favorable conditions. Nymphs mature in 6-8 days at temperatures of 20° C or higher (Komazaki 1988). Komazaki (1988) calculated the r_c (capacity for increase) for brown citrus aphid to be 0.4 at about 25° C - a single aphid could produce a population of over 4,400 in three weeks in the absence of natural enemies.

BrCA initially colonizes new growth of citrus. As leaves expand and harden off, large colonies develop that cover stems and backs of leaves, particularly along veins. Leaf maturation and/or crowding induce the formation of a winged generation. Most individuals develop wings and leave; however, small colonies may persist for several weeks under poor food quality conditions.

IMPLICATIONS FOR EPIDEMIOLOGY OF CTV: CTV is a phloem-limited virus. This aspect of its biology limits its vectors, for all practical purposes, to those aphid species that colonize the crop (though not all crop colonizers are vectors). BrCA is much more efficient at transmitting CTV than other aphids that infest citrus. It is 6-25 times as efficient as *A. gossypii*, the most efficient vector of CTV in Florida prior to 1995 (Yokomi *et al.* 1994). Besides its intrinsic efficiency, two other factors contribute to the important vector status of BrCA. These include its relatively narrow host range and its tendency to produce winged forms as colonized new growth matures. *A. gossypii* has a very wide host range, including hundreds of plant species in Florida. Thus, a viruliferous winged *A. gossypii* that leaves a citrus tree is less likely to feed immediately on another citrus tree (and transmit the virus) than on some other plant, where the virus meets a dead end. BrCA on the other hand, because of its narrow host range, is

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[3] Aphids in the genus *Toxoptera* have a series of pegs on their hind tibiae and corresponding roughened patches on the posterior ventral area of the abdomen. When disturbed, the aphids rub these together vigorously. BrCA stridulation is inaudible to humans, but large colonies of black citrus aphids make an audible scraping noise (Blackman and Eastop 1994). The stridulatory organ cannot be seen without microscopic examination, but the behavior is easily observed in living colonies.

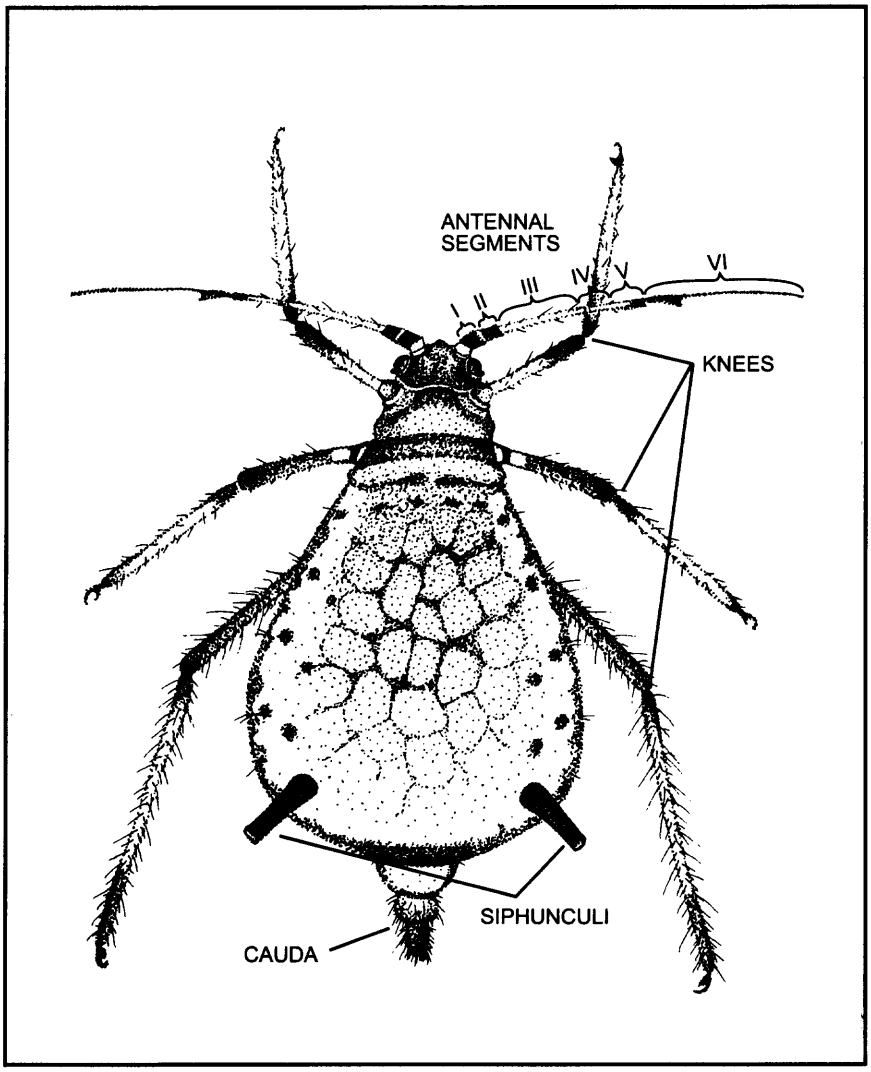

Fig. 1. *Toxoptera citricida* (Kirkaldy), brown citrus aphid (BrCA) - adult wingless form

most likely to feed on another citrus tree, potentially infecting it with CTV. BrCA also transmits some strains of CTV that are not transmissible by other species (Yokomi *et al.* 1994; Yokomi 1995). This increases the likelihood that there will be a gradual increase in severity of citrus tristeza in Florida (Schoulties *et al.* 1987).

INTEGRATED PEST MANAGEMENT:

Cultural control. It is clear that CTV-induced quick decline of citrus trees propagated on sour orange and other susceptible rootstocks has become a fact of life in areas where BrCA has become established. In Florida, strains of CTV that cause quick decline are widespread in citrus on CTV-tolerant rootstocks. Field evaluation of alternate rootstocks will enable a smoother transition away from sour orange (Rocha-Peña *et al.* 1995).

Citrus is propagated vegetatively, which greatly increases the possibility for spreading disease because CTV is graft transmissible. Man can quickly spread citrus tristeza virus faster and further than any aphid. One pickup truck of infected nursery stock can spread the virus several hundred miles in a few hours from nursery sites to grove plantings.

The first step in any integrated management program should be to ensure that budwood and nursery stock are free of disease (with the possible exception of mild strains of CTV used for cross-protection). DPI's Quality Tree Program will periodically test all sources of propagating material for several graft-transmissible pathogens of citrus including CTV, psorosis, cachexia, exocortis and tatterleaf. Mandatory budwood certification will require source trees to have annual tests for CTV, and sources testing positive for severe strains of CTV will no longer be permitted to be used for propagation. Having a known clean pool of propagating material and protecting that pool will help ensure that we are not introducing or intentionally moving pathogens within Florida.

Protection of propagation sources is the most important measure that can be taken to protect the citrus industry from effects of BrCA and spread of severe CTV. Incidence of severe CTV has increased very rapidly in areas where BrCA has become established (Gottwald *et al.* 1996, Stansly 1996, Yokomi *et al.* 1996). Observed BrCA populations in Florida suggest that it will be no different here. Thus, infectivity levels for naturally occurring alate BrCA are likely to be very high, requiring isolation (either geographical or physical) of propagation sources. Chemical protection and strict sanitation measures also are necessary. Contaminated plants never should be brought into propagation screenhouses. Other important sanitation measures for screenhouses include minimizing trips in and out and ensuring that aphid-contaminated employees do not enter.

Another aspect of cultural control is inoculum suppression. Although aphids can fly 30 km or more, most flight is probably local (Loxdale *et al.* 1993). Thus, nearby sources of inoculum are much more important than distant ones (Bishop 1965, 1967; Bishop and Guthrie 1964). Abandoned and/or volunteer crop plants can become reservoirs of pests and disease (Bishop *et al.* 1992; Plumb and Johnstone 1995). Likewise, urban areas may be reservoirs of crop viruses and vectors (Bishop and Guthrie 1964). As much as it is feasible, it is essential to protect propagation source trees from nearby sources of aphid infestation and virus infection.

Biological Control. Aphids in general are attacked by several kinds of natural enemies including parasites, predators and pathogens. BrCA is no exception, but the degree to which natural enemies can suppress BrCA populations is not well known. It is also not known whether suppression of BrCA populations will reduce spread of CTV. In any case, BrCA is also a direct pest, and establishment of effective parasites and predators that will reduce BrCA populations would be beneficial. Under humid Florida conditions, fungi applied as bio-insecticides may be useful for BrCA population suppression. Aphids are also susceptible to viral pathogens, but caution with this approach for control of BrCA is suggested because at least one viral pathogen of aphids (*Rhopalosiphum padi* virus) may enhance transmission of a plant virus (barley yellow dwarf virus) (Damsteegt *et al.* 1992).

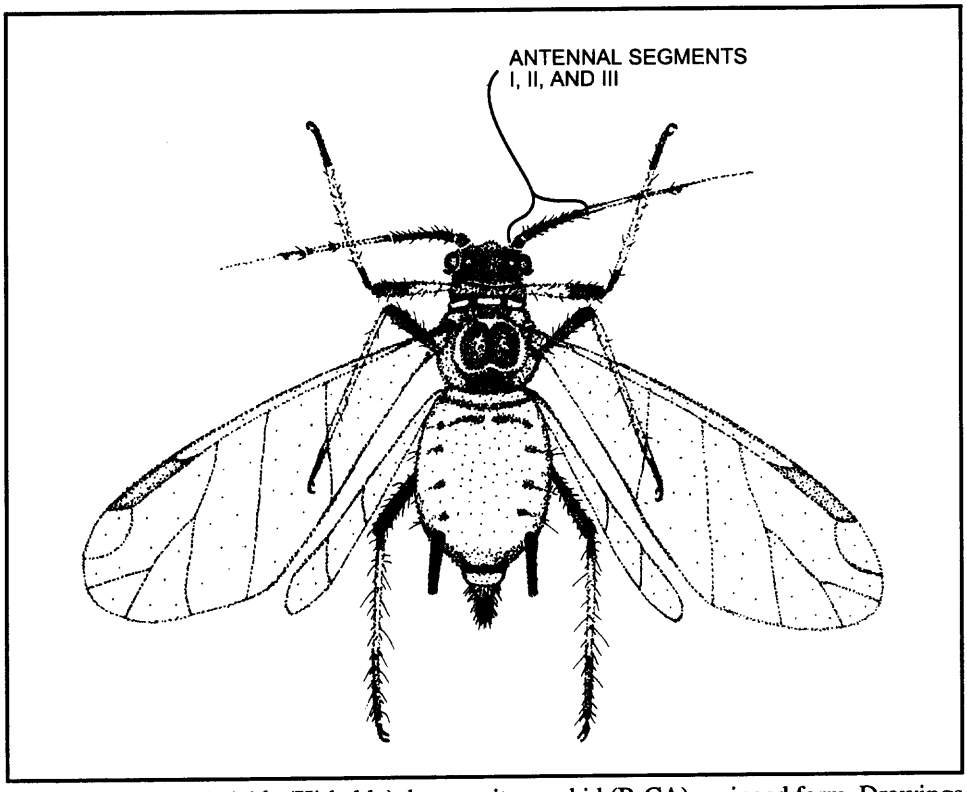

Fig. 2. *Toxoptera citricida* (Kirkaldy), brown citrus aphid (BrCA) - winged form. Drawings by Amie Smith, DPI.

Chemical Control. It is not known whether controlling aphids will reduce spread of CTV in production situations, but insecticides may be beneficial in protecting nursery stock and valuable budwood sources. Consult IFAS extension offices for specific recommendations.

Host Plant Resistance. It is very difficult to breed horticulturally-useful citrus trees. Some of our favorite fruit plants (grapefruit, for example) may be derived from hybrids. Thus, standard crossing may not produce acceptable fruit. Additionally, it may take 10 years or more before production characteristics can be evaluated reliably. Because of these difficulties, there has been active research on the possibilities for genetic engineering.

Cross-protection. Cross-protection is the practice of deliberately infecting trees with a mild strain of CTV in order to prevent or delay infection or symptom expression by severe strains of the pathogen. The technique has been used successfully in Australia (Broadbent *et al.* 1995) and South Africa (van Vurren 1995) and is in limited use in Florida (Lee *et al.* 1995). Deliberately infecting a crop with a pathogen should be done with great caution. Experience in Australia and South Africa indicates that cross-protection will prolong the economic life of a grove; nevertheless, the performance of cross-protected plantings is not equivalent to that of virus-free plantings. Thus, permanent genetic resistance to CTV is still an important goal.

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