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SILVERLEAF WHITEFLY

Bemisia argentifolii **(Homoptera:Aleyrodidae)**

Studies on
Host Plants, Life Cycle and Parasitoids on Guam

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SUMMARY

Agricultural field sites were surveyed on Guam to identify the host range of the silverleaf whitefly (*Bemisia argentifolii* Bellows & Perring). Thirteen plant species were identified as hosts of this pest. Among agricultural crops, *B. argentifolii* was found frequently on eggplant (*Solanum melongena* L.), tomato (*Lycopersicon esculentum* Mill.), cucumber (*Cucumis sativus* L.), and watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai), while *Euphorbia hirta* L., *Physalis angulata* L. and *Stachytarpheta jamaicensis* (L.) Vahl were the host plants among farmland weeds. The developing time from egg to adult ranged between 16 to 20 days on tomato seedlings grown in a screenhouse. Two larval parasitoids were collected from silverleaf whitefly infesting eggplant and tomato foliage. They were identified as *Encarsia nigricephala* Dozier and *Eretmocerus* sp.

INTRODUCTION

In the summer of 1993, a new whitefly was found on foliage of cucumbers (*Cucumis sativus* L.), yard-long beans (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc.) and tomatoes (*Lycopersicon esculentum* Mill.) at two farms in the southern part of Guam (F. Cruz, personal communication). It is now distributed throughout the island, infesting a variety of vegetable crops. This whitefly differs from the well-established sweet potato whitefly (*Bemisia tabaci* Gennadius) in host colonization. *B. tabaci* has been found in Guam for more than 20 years, but it has never been described as a major pest of agricultural crops (I. Schreiner, personal communication).

In a laboratory, when seedlings of zucchini (*Cucurbita pepo* L. cv. Ambassador) were grown in the same screenhouse with tomato seedlings heavily infested with these new whiteflies, silvering and netting of veins occurred on zucchini leaves. This "silverleaf" phenomenon was previously described as a characteristic of a new strain or B type of *B. tabaci* (Brown et al., 1992) or silverleaf whitefly, *Bemisia argentifolii* Bellows & Perring (Jimenez et al., 1995; Bellows et al., 1994; Bharathan et al.., 1990; Schuster et al., 1991; Yokomi et al., 1990). This whitefly was also documented on the island of Saipan in the Northern Marianas, located 206 km northeast of Guam (A. Moore, personal communication).

B. argentifolii has been reported to have a wide range of hosts, causing various plant disorders (Bellows et al., 1994; Costa et al., 1993; Hokama et al., 1993). Cucurbits were preferred vegetable hosts for oviposition of *B. argentifolii* (Blua et al, 1995; Chu et al., 1995). Hokama et al (1993) described plant damages in over 30 species and cultivars of eight families in a laboratory and in the field. Among Cucurbitaceae, pumpkin, *Cucurbita maxima* Duch cv. Ebisu was one of the most severely affected plants exhibiting silverleaf, chlorotic leaf spot, vein clearing, and discoloration of leaf, stem and fruit. However, watermelon, *Citrullus lanatus* (Thunb.) Matsum. et Nakai cv. Kodama, karimori, *Cucumis melo* L. var. *utilissimus* Duthie et Fuller cv. Karimori, and bittermelon, *Momordica charantia* L., were the least affected, displaying a slight disorder of chlorotic leaf spot. Plant damage varied among cultivars of *C. melo* L. var. (reticulatus group) (Hokama et al., 1993). Other important vegetable hosts included *Brassica* spp. (Brown et al., 1992; Hokama et al., 1993; Costa et al., 1993), lettuce, *Lactuca sativa* L. (Costa et al., 1993), tomato, *Lycopersicon esculentum* (Schuster et al., 1991) and several species of Umbelliferae (Hokama et al., 1993).

Longevity and fecundity of the silverleaf whitefly depends on temperature and host plants

(Enkegaard, 1993; Wagner, 1995). On cotton, a developmental time from the egg to the adult stage varied between 16 to 20 days at the temperature range of 23 °C to 32 °C (Wagner, 1995). The number of eggs oviposited on tobacco was the highest with 86.4 per adult female at 22° C while on poinsettia it was highest (263.0 per adult female) at 28 °C (Enkegaard, 1993).

Several natural enemies have been identified as prospective biological control agents of the silverleaf whitefly. Heinz and Parrella (1994a) evaluated one predator (*Delphastus pusillus* Leconte) and four parasitoids (*Encarsia* spp.) of the silverleaf whitefly infesting two cultivars of poinsettia (*Euphorbia pulcherrima* Wild.) in a laboratory. They suggested that a greater success of biocontrol may be achieved by releases of *D. pusillus* if the pest population was high, and by releases of *E. formosa* (Gahan) or mated *E. pergandiella* (Howard) regardless the pest density. In another report, Heinz and Parrella (1994b) suggested weekly releases of *E. luteola* Howard with additional releases of *D. pusillus* to control *B. argentifolii* infesting greenhouse-grown poinsettia. Recently, Headrick et al. (1995) described in detail, the behaviors of female *Eretmocerus* sp. nr. *californicus* Howard feeding *B. argentifolii* on sweet potato, *Ipomoea batatas* (L.) Lam.

On Guam, the tropical climate allows *B. argentifolii* to find its host plants throughout the year in continuous cropping or natural vegetation. The purpose of this study was to identify the host range, the life cycle, and parasitoids of the *B. argentifolii* present on Guam.

MATERIALS AND METHODS

Host plants: Several farms on Guam with crops infested by the new whitefly were surveyed to determine its host range between February to June, 1995 on Guam. The presence of adult whiteflies on crops and weeds in the fields was noted. Weeds in areas adjacent to crop growing fields were also examined. If eggs and nymph stages of the whiteflies were observed, whole plants or leaves of crops and weeds were sampled and examined under a dissecting microscope. The degree of host preference was determined by (1) the presence or absence of whitefly on a plant, (2) the developing stages of the insect found on plant and, (3) visual observation on the degree of infestation on foliage.

Life cycle of whitefly on tomato: Potted tomato seedlings (cv 'N-63') were exposed for 24 hrs from midday to midday to a field of cultivated eggplants which were heavily infested with silverleaf whiteflies. This pest infestation was started on March 20, 1995. Seedlings were then isolated in a insect screen cage where plants received ambient temperature (23-32 °C) and partial sunlight. Daily average relative humidity ranged from 63 to 87% during the experiment (NOAA Climatological Data, March and April, 1995). Five to ten leaflets with whiteflies were sampled daily and examined to reveal the rate of insect development at each observation date.

All whiteflies on sampled leaflets were investigated and the number of insect in each stage was counted.

Isolation of parasitoids: Heavily infested eggplant and tomato foliage from farm fields was collected in sealed polyethylene bags and incubated for a week at room temperature in a laboratory. Emerged parasitoids from larva were collected and identified.

RESULTS

Host plants of silverleaf whitefly: During the survey, eight major vegetable farms throughout Guam were found to be infested by the silverleaf whitefly. Among the 10 vegetable species surveyed, cucurbits and solanaceous crops were preferred host plants of silverleaf whitefly (Table 1). Various stages of the insect development (eggs, larvae and pupae) were found on the undersides of leaves, especially along the midrib and veins of leaves. Among Cucurbitaceae, bittermelon had few whiteflies underside of leaves. In contrast, many whiteflies in all stages occurred on cucumber and watermelon leaves. In Solanaceae, eggplant was the most infested crop, followed by tomato. However, no infestation of hot peppers was observed during the survey. Taro and yam (two common tropical root crops) also did not show any infestation of whiteflies. Although a few adults of the silverleaf whitefly were found on foliage of pak choi and yardlong beans, we did not confirm that *B. argentifolii* completed its life cycle on these plant species. Among the 12 weed species from the 12 families examined (Table 2), *Euphorbia hirta* L.(Euphorbiaceae), *Physalis angulata* L. (Solanaceae), and *Stachytarpheta jamaicensis* (L.) Vahl. (Verbinaceae) were more often the infested host plants than *Synedrella nodiflora* L. Gaertn. (Asteraceae), *Ipomoea obscura* (L.) Ker (Convolvulaceae), *Commelina benghalensis* L.(Commelinaceae), *Malachra capitata* L. (Malvaceae), *Passiflora foetida* L. (Passifloraceae). *Mimosa pudica* L. (Fabaceae) and *Antigonon leptopus* H. & A. (Polygonaceae) were not colonized and only a few adults were observed on *Pennisetum purpureum* Schum. (Poaceae) and *Portulaca oleracea* L. (Portulacaceae).

Life cycle of whitefly on tomato: The average of 25 whiteflies from sampled leaflets were investigated on each observation date. Six distinct development stages of *B. argentifolii* were recognized: (1) eggs, (2) first instar (crawler), (3) second instar, (4) third instar, (5) pupa, and (6) adult. Newly laid eggs were light green in color and within 1 to 3 days those eggs became brown before hatching. The first nymphs were observed three days after the plants were infested. The first instar stage (crawler stage) was very short (< 1 day). The first pupae were observed on the 14th day and the life cycle was completed within 16 to 20 days.

Isolation of parasitoids: Two parasitic wasps emerged from larval silverleaf whiteflies infesting tomato and eggplant foliage in several farms. They were identified as *Encarsia nigricephala* Dozier and *Eretmocerus* sp. No predators were found feeding on whiteflies during the survey.

Table 1. Incidence of silverleaf whitefly, *B. argentifolii* among agricultural crops on Guam during the survey from February–June, 1995.

Plant observed on leaves[z]	Stages of whitefly	Incidence [y]
Araceae:		
Taro, *Colocasia esculenta* (L.) Schott	None	-
Brassicaceae:		
Pak choi, *Brassica* sp.	A (few)	+/-
Cucurbitaceae:		
Cucumber, *Cucumis sativus* L.	E, L, P, A	++
Watermelon, *Citrullus lanatus* (Thunb) Matsum. & Nakai	E, L, P, A	++
Bittermelon, *Momordica charantia* L.	E, L, P, A	+
Dioscoreaceae:		
Yams, *Dioscorea* spp.	None	-
Fabaceae:		
Yardlong beans, *Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc.	A (few)	+/-
Solanaceae:		
Eggplant, *Solanum melongena* L.		
A hybrid (cv. Nitta X cv. Waimanalo)	E, L, P, A	+++
Cv. Takii Long Black	E, L, P, A	+++
Tomato, *Lycopersicon esculentum* Mill.	E, L, P, A	++
Hot pepper, *Capsicum* spp.	None	-

z E=eggs; L=larvae, P=pupae, A=adults.

y The number of positive sign (+) indicates the degree of incidence. The negative sign (-) indicates that whitefly was not found on plants. The sign of +/- indicates that adult whitefly and/or few eggs were found on plants, but it was not certain that the whitefly could complete its life cycle.

Table 2. Incidence of silverleaf whitefly, *B. argentifolii* among weeds on Guam during the survey from February–June, 1995.

Plant	Stages of whitefly observed on leaves[z]	Incidence [y]
Asteraceae:		
Synedrella nodiflora L. Gaertn.	E, L, P, A	+
Convolvulaceae:		
Ipomoea obscura (L.) Ker	E, L, P, A	+
Commelinaceae:		
Commelina benghalensis L.	E, L, P, A	+
Euphorbiaceae:		
Euphorbia hirta L.	E, L, P, A	++
Fabaceae:		
Mimosa pudica L.	None	-
Malvaceae:		
Malachra capitata L.	E, L, P, A	+
Solanaceae:		
Physalis angulata L.	E, L, P, A	++
Verbinaceae:		
Stachytarpheta jamaicensis (L.) Vahl	E, L, P, A	++
Passifloraceae:		
Passiflora foetida L.	E, A	+
Poaceae:		
Pennisetum purpureum Schum.	A (few)	+/-
Polygonaceae:		
Antigonon leptopus H. & A.	None	-
Portulacaceae:		
Portulaca oleracea L.	A (few)	+/-

z E=eggs, L=larvae, P=pupae, A=adults.

y The number of positive sign (+) indicates the degree of incidence . The negative sign (-) indicates that whitefly was not found on plants. The sign of +/- indicates that adult whitefly and/or few eggs were found on plants, but it was not certain that whitefly could complete its life cycle.

Synedrella nodiflora L. Gaertn.

Stachytarpheta jamaicensis (L.) Vahl

DISCUSSION

On Guam, *B. argentifolii* was found colonizing on six agricultural crops and eight farmland weeds in 16 families (Tables 1 and 2). The silverleaf whitefly has become a new insect pest of major vegetable crops including eggplant, watermelon, tomato, and cucumber. The plant host colonization varied due to a combination of crops grown at a site. However, eggplant appeared to be the most heavily infested crop by silverleaf whitefly on Guam. No differences were found in the colonization of the pest between two long purple eggplant cultivars, a hybrid (cv. Nitta x cv. Waimanalo) and cv. Takii Long Black, which were grown side by side in the same farm filed (Table 1). The wide host range of *B. argentifolii* observed in this study was similar to that observed elsewhere (Hokama et al., 1993; Schuster et al., 1991).

The development time (16-20 days) from egg to adult on tomato foliage at the ambient temperature range of 23 to 32 °C was the same as the report on cotton by Wagner (1995). Disregarding other climatic factors, like tropical storms, we expect that silverleaf whitefly completes its life cycle within three weeks on Guam with the air temperature range of 23-32 °C year around. Population density of the pest may be affected by the difference in precipitation between the dry months and the rainy months. During the 30 years from January 1965 to December 1994, March was the month with the least precipitation having the average rainfall of 10.4 cm. August, the wettest month, had the average rainfall of 38.1 cm (NOAA Climatological Data, 1994).

This is the first report of *Encarsia nigricephala* on Guam. In 1993, on the island of Hawaii, *E. nigricephala*, *E. formosa*, *E. pergandiela*, *E. transvena* and *Eretmocerus* sp. were recovered from greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), infesting tomatoes in greenhouses (Kajita, 1994). It is not certain that *Eretmocerus* sp. isolated from Guam in the present study is identical to the species of *Eretmocerus* found in Hawaii. Since a lot of produce and

ornamentals are imported from Hawaii and California to Guam, the presence of *E. nigricephala* may be due to its accidental entry with some host pests from these origins. There are no records of *T. vaporariorum* on Guam. It appears that *E. nigricephala* came to Guam with a different homopteran host species than *T. vaporariorum*.

The population of *B. argentifolii* can easily build up within a short period of time due to Guam's environmental condition. Frequent usage of pesticides against the pest may contribute to the creation of resistance problems. Efficacy of *E. nigricephala* and *Eretmocerus* sp. found on Guam as natural enemies should be evaluated in more detail. The introduction of additional effective biocontrol agents should be considered to prevent further damages to agricultural crops.

In recent years, the number of accidental introduction of insect pests to Guam has rapidly increased (Schreiner, 1991). Whiteflies which came to Guam with hibiscus plants from Hawaii in 1990, were described as *B. tabaci* then (Schreiner, 1991), but were probably *B. argentifolii* (Schreiner, personal communication). There is a great possibility of spreading *B. argentifolii* to other parts of Micronesia and to other areas of the Pacific region within a short time.

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