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MANAGEMENT OF CYCAD AULACASPIS SCALE, *AULACASPIS YASUMATSUI* TAKAGI

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Abstract. **Since it was first introduced into south Florida in 1995, *Aulacaspis yasumatsui* Takagi (cycad aulacaspis scale) has been attacking popular landscape cycads and spreading rapidly. This pest is now found in Florida, Texas, Hawaii, Puerto Rico, U.S. Virgin Islands, and Guam. Plant death and damage caused by *A. yasumatsui* is having a marked effect on the ornamental cycad industry and has become a major concern for nursery professionals. The spread of *A. yasumatsui* to other countries through plant sale and trade is also a serious concern as it could threaten native cycad populations. Previous research on 1 gallon potted cycads indicated that an insect growth regulator, pyriproxifen, applied as a foliar spray provided excellent control of this pest and did not cause any plant tissue damage. An additional study was conducted to evaluate the effectiveness of pyriproxifen on light and dense infestations of *A. yasumatsui* on cycads ranging in size from 1 foot to approximately 10 feet tall growing in a landscape situation. We observed that pyriproxifen provided excellent control of *A. yasumatsui* on lightly infested plants, adequate control on densely infested plants, and did not cause any plant tissue damage.**

In 1995, residents of south Miami first began to notice a white scale insect infesting *Cycas rumphii* Miq. and *C. revoluta* Thunb. which had, until then, been low maintenance cycads (Walters et al., 1997). By 1996, this pest had infested many *C. rumphii* and *C. revoluta* in an area at least several square kilometers in south Miami (Howard et al., 1996; Weissling et al., 1999). Plants were quickly covered in layers of live and dead scale that looked like a white crust. The cycads rapidly began to lose leaves as the scale infestation continued. Within a year, many large plants in the southern Miami area were dying (Walters et al., 1997). The infected area included Fairchild Tropical Botanic Garden and Montgomery Botanical Center, both of which have collections of rare and endangered cycads. Concern for their collections led these two gardens to seek an identification of this pest so control measures could be established (Howard et al., 1999; Walters et al., 1997).

Initially, the scale insect was thought to be *Psuedaulacaspis cockerelii* (Magnolia white scale), which is common in the area. However, the control methods often used for *P. cockerelii* did not seem to be effective and the infestations of scale appeared to be more intense than in the past (Howard et al., 1996; Walters et al., 1997). Dr. Avas B. Hamon, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, identified the scale pest as *Aulacaspis yasumatsui* Takagi (cycad aulacaspis scale). The identification was confirmed by Dr. Douglas R. Miller Systematic Entomology Laboratory, USDA-ARS-SEL, Beltsville, Md. (Howard et al., 1996).

After the scale's identity was confirmed, a survey of south Miami was conducted in Oct. 1996 to evaluate the extent of the scale infestation (Howard et al., 1999). From Oct. 1996 to June 1998, (Howard et al., 1999) examined hundreds of infested cycads in the south Miami area. By 1997, cycad aulacaspis scale (CAS) infestations had been discovered in Miami Beach and cities north of Miami. By the following year, CAS had spread to Broward County, and by 1999, CAS had been reported in Palm Beach County, Hong Kong, Hawaii, and the Cayman Islands (Weissling et al., 1999). Most recently, CAS has been reported to be attacking cultivated *C. revoluta* on the island of Guam and there is concern that if it is not controlled, it may spread to the native *C. micronesica* (Marler, 2004).

This pest has spread rapidly and has a wide host range among cycads (Howard et al., 1999). If uncontrolled, it is a threat to the ornamental cycad nursery industry as well as a threat to native cycad populations around the world.

Initially, pesticides and oils recommended for armored scales were used to manage CAS. This has included foliar applications of horticultural and fish oils, insecticidal soap, or drenching with dimethoate (previously sold as Cygon) or malathion (Walters et al., 1997; Weissling et al., 1999).

Disadvantages of these methods of control quickly became apparent. Applications of horticultural or fish oils are effective in controlling CAS only when infestations are light and good foliar spray coverage is possible. In addition, oils need to be applied weekly or at least biweekly until the infestation is under control (Hodges et al., 2003; Walters et al., 1997).

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Conversely, dimethoate and malathion can more quickly control a heavy infestation of CAS although use of dimethoate or malathion has its own disadvantages. They are broad-spectrum insecticides, which can be toxic or dangerous if used inappropriately. In addition, many suppliers have stopped carrying dimethoate. Both dimethoate and malathion can cause phytotoxicity to new growth on cycads (Emshousen and Mannion, 2004).

In more recent years, University of Florida, IFAS researchers have evaluated some of the newer classes of insecticides for control of CAS. Research trials conducted at the Tropical Research and Education Center showed that two systemic insecticides recommended for scale control, imidacloprid (Merit or Marathon) and thiamethoxam (Flagship) did not provide adequate control of CAS (C. Mannion, University of Florida, personal communication).

Pyriproxifen (Distance), an insect growth regulator, has also been evaluated and shown to provide excellent control of CAS. There are several main differences between pyriproxifen and broad-spectrum insecticides. Pyriproxifen does not provide a contact kill, but rather inhibits production of viable eggs by females, sterilizes females, and inhibits metamorphosis of immature scale. Since pyriproxifen is a narrowly targeted insect growth regulator rather than a broad-spectrum insecticide, it is less likely to disrupt any control by biological parasitoids. It is also less likely to inadvertently harm either the applicator or the immediate environment. Since pyriproxifen breaks the life cycle of the scale by preventing development, it takes a full life cycle before control of the pest can be established.

C. Mannion and H. Glenn first began evaluating pyriproxifen for control of CAS at TREC in 2002. They initially experimented with foliar applications applied to *C. revoluta* in 1-gallon pots. Female scale on leaf samples were examined under a microscope for mortality of females and eggs. Results indicated that, although pyriproxifen was slower to act in controlling CAS than some broad-spectrum insecticides, 100% of eggs and 99% of female scale examined were dead after eight weeks (Mannion and Glenn, unpublished data). Mannion and Glenn have tested pyriproxifen in subsequent tests and found similar results (C. Mannion, personal communication).

Following the work of Mannion and Glenn, we constructed a study examining the effectiveness of pyriproxifen on large cycads heavily infested with CAS at Montgomery Botanical Center (MBC). The objective of this study was to examine the effectiveness of pyriproxifen in controlling all life stages of CAS on large cycads in a field situation. Cycads in this study were also examined for any signs of phytotoxicity or other negative effects of chemical application.

Materials and Methods

Nine plants that had the heaviest infestations of CAS at MBC were selected for study and sampling. Two samples were taken from each of the nine plants, and scale insects were examined under a microscope. The plants selected for sampling were of varying sizes, ranging from 1 to approximately 10 feet tall and varied in age from 11 to 46 years old. Species selected for sampling included primarily species of *Cycas*, as we have observed that this genera is the most heavily affected. Sampled species included *Cycas thouarsii* R. Br. ex Gaudich, *C. media* R. Br., *C. bougainvilleana* K.D. Hill, *C. riuminiana* Porte ex Regel, *C. angulata* R. Br., *C. taitungensis* C.F. Shen, *C. edentata* De Laub., and *Stangeria eriopus* (Kunze) Baill. With the exception of *C. edentata*, one plant of each species was sampled. *S. eriopus* was included in this study because we have observed heavy infestations of CAS on this species at MBC. MBC was selected for the location of this study because there are more than 3000 cycads in the ground and available for scientific study.

The spray solution was mixed at a rate of 12 fl. oz. product per 100 gal of water in accordance with the Distance label. The mixed solution was applied as a foliar spray to both surfaces of leaves, cones and trunk. The spray was applied with a 300-gal high-pressure sprayer until the point of runoff.

After 40 d, Mannion and Glenn removed two samples from each of the nine plants. One sample from each plant was taken from a heavily infested area, such as a leaf base, and a second sample was taken from an area with a lighter infestation, such as a distal leaflet. Twenty female scale insects were examined on each sample for mortality of the females and eggs.

Results and Discussion

Pyriproxifen's ability to control female scale and eggs was encouraging. One hundred percent of female scale and eggs on the lightly infested sample of *S. eriopus* were dead. Of the nine samples taken from lightly infested portions of the sampled plants, six samples contained 90% or greater female mortality and female scale with all dead eggs. All samples taken from lightly infested portions of sampled plants contained at least 75% female mortality and 75% of females with all dead eggs (Table 1). Based on these results, pyriproxifen broke the scale life cycle and was able to provide a high degree of control on lightly infested areas of the plants.

Pyriproxifen did not control scale as well on densely infested samples. Of the nine samples taken, two samples, *S. eriopus* and *C. media*, showed excellent control of CAS by pyriproxifen (89% or greater female scale mortality and females with all dead eggs). Five samples, *C. bougainvilleana*, *C. angulata*, *C. edentata*, *C. riuminiana*, and *C. taitungensis*, showed moderate control of CAS (70-80% female mortality and females with all dead eggs). Two samples, *C. thouarsii* and *C. edentata*, showed poor control of CAS (less than 65% female mortality and females with all dead eggs) (Table 2). No signs of phytotoxicity were observed on any plants treated with pyriproxifen.

Control of female scale and eggs by pyriproxifen was not as consistent among the densely infested samples as it was among lightly infested samples. Control of CAS seemed to depend on the ability of the applicator to obtain good spray cov-

Table 1. Percent mortality and percent females with all dead eggs from lightly infested cycad species.

Plant	Percent female mortality	Percent females with all dead eggs
S. eriopus	100	100
C. media	95	95
C. taitungensis	95	95
C. bougainvilleana	95	95
C. edentata	95	95
C. edentata	90	90
C. thouarsii	85	84
C. angulata	80	80
C. riuminiana	75	75

Table 2. Percent mortality and percent females with all dead eggs from densely infested cycad species.

Plant	Percent female mortality	Percent females with all dead eggs
C. media	90	90
S. eriopus	90	89
C. angulata	80	80
C. bougainvilleana	80	79
C. edentata	75	74
C. taitungensis	70	70
C. riuminiana	70	70
C. thouarsii	65	65
C. edentata	40	35

erage. Researchers have found that the plant architecture of cycads can sometimes prevent the applicator from being able to direct a spray to all infested portions of a plant (Hodges et al., 2003). We found that plants with branch/leaf architecture or size that made it difficult to spray all parts of the plant showed less control of scale on densely infested areas of the plant such as leaf bases. Similarly, areas of the plant that have become densely infested and have layers of dead scale on top of live scale may have made it difficult for the chemical to penetrate the layers and control the live scale. Pyriproxifen may provide the best control when plants are treated regularly to control scale and dead scale are washed from the plant so layers of dead scale are not allowed to build up.

In the future we need to continue to examine the period of effective control of CAS after a treatment and determine the optimal application times. Additional studies are also needed to establish the effect of pyriproxifen on natural enemies and the level of control that can be obtained by using pyriproxifen and biological control organisms in an integrated pest management system.

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