Biological control of *Aulacaspis yasumatsui*

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Classical biological control of cycad aulacaspis scale (CAS) began in 1998 when Dr. Richard Baranowski, of the UF Tropical Research & Education Center at Homestead, imported and released a parasitoid (*Coccobius fulvus*) and a predator (*Cybocephalus nipponicus*) from Thailand against *A. yasumatsui* (Howard *et al*. 1999). Although these natural enemies are established in south Florida, they seem not to provide much control (personal observation). The ladybird beetle *Rhyzobius lophanthae* was introduced into Hawaii 1894 for control of other armored scales but reportedly provides some control of CAS (Hara *et al*. undated). Recently, this same beetle was released in Guam.

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Rhyzobius lophanthae is a coccoidophagous predator native to Australia. This beetle is considered by many to be one of the most economically important natural enemies of armored scale insects (Yus 1973, Rosen 1990, Stathas 2001). This beetle has been released all over the world to control a plethora of scale species (Honda & Luck 1995). There are many examples of successful control of scale insects using *R. lophanthae* especially in the Mediterranean region. Then again there have been some very high profile failures as well such as the inability of *R. lophanthae* to control the California red scale.

My research on the biological control of CAS currently focuses on the following areas:

1. Study of population dynamics of CAS and parasitism by *Coccobius fulvus*

A 2.5-year study to look at the population dynamics of CAS on a per plant basis is drawing to a close. The study also examines rates of parasitism by *C. fulvus* in relation to pest density and time of year. In general, overall parasitism is about 30-40%, which is insufficient to provide adequate control of CAS. Cooperation from UF extension agents is allowing us to collect samples to examine geographic variation in parasitism. Also being studied, in the laboratory, are the developmental times of the scale and *C. fulvus* at different temperatures.

2. Study of taxonomy, biology and pesticide susceptibility of the predator *Cybocephalus nipponicus*

At the time of its introduction by Dr. Baranowski, the predatory beetle *Cybocephalus* was being called *C. binotatus*.

As part of a Ph.D. dissertation, my graduate student Trevor Smith has done a revision of this genus in North America and found that the beetles introduced by Dr. Baranowski were actually *C. nipponicus*, a species already present in Florida since at least 1990. Trevor has studied the life history of *C. nipponicus* with CAS as prey and has conducted an experiment to determine the susceptibility of *C. nipponicus* and *R. lophanthae* to pesticides commonly applied for control of CAS.

3. Exploration and screening of exotic parasitoids

Dr. Hui Ren, an insect taxonomist retired from the Guangdong Entomological Institute, where he specializes in the study of minute parasitoid wasps of the families Aphelinidae and Encyrtidae, has collaborated with University of Florida (UF) and DPI scientists the past two years to find parasitoids with potential for release into Florida. During 2003-2005, Dr. Ren collected and sent the following parasitoid species to Dr. Ru Nguyen of the DPI quarantine in Gainesville:

Arrhenophagus chionaspidis Aurivillius *Pteroptrix chinensis* (Howard)

Aphytis lepidosaphes Compere *Thomsonisca sankarani* Subba Rao

Additionally, Dr. Nguyen recently observed the following species parasitizing CAS in Vietnam:

Aprostocetus sp. possibly *purpureus* Girault

Encarsia sp.

All these parasitoids are general armor scale parasitoids, but the most promising is *A. chionaspidis* because it causes high levels of parasitism of male scales in China. Current research with this insect is on-going in the quarantine facilities in Gainesville and Ft. Pierce. The species of *Aprostocetus* from Vietnam also looks interesting because it appears to cause significant mortality in that area. The taxonomy and biology of these parasitic wasps need thorough study before a release permit can be solicited from USDA PPQ.

Funds were recently received from USDA APHIS to conduct exploration in Asia and screen any new natural enemies discovered. Plans are for R. Cave and R. Nguyen to travel to China and Vietnam in spring 2006 (exploration in fall 2005 could not be arranged). *Cycas revoluta* and *C. rumphii* are favored hosts for the CAS. The native homes for these plants are the Ryukyu Islands and Indonesia, respectively. If suitable natural enemies are not found in China and Vietnam, then the Ryukyu Islands and Indonesia may be alternate areas for exploration.

Coccobius fulvus not only parasitizes CAS but also attacks the arrowhead scale, *Unaspis yanonensis (Kuwana*) (Furuhashi & Nishino 1983), which is a pest of citrus in China and Japan. Arrowhead scale is also parasitized by the wasp *Aphytis yanonensis* DeBach & Rosen. Researchers in Japan report that arrowhead scale is effectively controlled where *C. fulvus* and *U. yanonensis* work in tandem. There is no report of CAS being exposed to and parasitized by *U. yanonensis*. However, since *C. fulvus* attacks both CAS and arrowhead scale, it is possible that *U. yanonensis* will do the same, *i.e.* attack arrowhead scale and CAS. This needs to be tested in the laboratory.

4. Entomopathogenic nematodes for control of CAS

Aulacaspis yasumatsui not only infests the leaves of cycads, but also penetrates minute sites on the trunk and roots of the plant. Scales in these microhabitats are inaccessible to parasitoids and predators. Recent research in Ft. Pierce has examined the capability of tiny entomopathogenic nematodes to infect nymphal and female scales on the trunk and roots of cycads. Preliminary observations showed that nematodes in the genera *Steinernema* and *Heterorhabditis* will attack and kill second instar and adult female CAS. Laboratory and field experiments are being carried out in 2005 to determine the best nematode species and efficacy in the field.

Additional research

Further research needs to be continued on the following projects:

1. Nematode research: More laboratory studies and field trials need to be conducted.
   $15,000 for 2 years

2. Studies on *Rhyzobius lophanthae* behavior and feeding: This predator is reported to be a voracious consumer of CAS in Hawaii, and we have seen it destroy populations of CAS on laboratory plants. In Florida, it has only been seen in the Tampa area. We do not understand why it has not dispersed throughout south Florida. Feeding studies need to be conducted and predator release technologies should be developed.
   $50,000 for 2.5 years including M.Sc. student stipend

3. Exploration to other areas of Asia, such as Hainan (China), Ryukyu Islands, Okinawa, Malaysia, Indonesia, and Philippines, needs to be conducted to find all possible biological control agents. After general observation in the field, candidates must be more thoroughly studied in the quarantine laboratory.
   $180,000 for 5 years including Ph.D. student stipend

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