FIELD-BASED RATES OF POPULATION INCREASE FOR *OXYOPS VITIOSA* (COLEOPTERA: CURCULIONIDAE), A BIOLOGICAL CONTROL AGENT OF THE INVASIVE TREE *MELALEUCA QUINQUENERVIA*

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Melaleuca quinquenervia (Cav.) S. T. Blake (melaleuca) is a large (~30 m tall) broad-leaved tree indigenous to eastern Australia and was introduced into south Florida as an ornamental plant in 1906 (Meskimen 1962). Since introduction, melaleuca has aggressively invaded >200,000 ha of natural areas in southern Florida, including ecologically sensitive habitats such as the Everglades National Park (Turner et al. 1998).

Instigated by ecological damage resulting from the melaleuca invasion, a classical weed biological control program was initiated in 1986 (Balciunas et al. 1994). Of the >400 herbivores associated with melaleuca in Australia, the weevil *Oxyops vitiosa* Pascoe became the first candidate introduced into US quarantine facilities for host specificity screening (Balciunas et al. 1994). After extensive testing the weevil was approved for release into south Florida, where it subsequently established at 9 of 13 initial release sites (Center et al. 2000).

Once established, populations of a classical weed biological control agent are expected to increase rapidly in response to the seemingly ubiquitous resource (Grevstad 1999), resulting in eventual suppression of the target plant (Marohasy 1997). Therefore, an important component of post-release evaluations of biological control agents includes an assessment of population increase in the introduced habitat. The intrinsic rate of increase and the finite rate of population increase are commonly used to quantify growth rates of insect populations (Carey 1993, Price 1997). These estimates of population growth are typically calculated from fecundity bioassays conducted under controlled environmental conditions. While estimating population growth rates under laboratory conditions is useful for inter and intraspecific comparisons (Evans 1982), the extrapolation of these data to the field is limited because environments in nature continuously vary. Therefore, laboratory based estimates may not describe the actual rates of increase in heterogeneous (realistic) environments.

Herein we quantify population growth rates for *O. vitiosa* under environmental conditions experienced in its adventive range and compare these estimates with those of other successful weed biological control agents. Ultimately, these data will be used in the development of mathematical models to describe population dynamics of the weevil in south Florida.

For this study, the finite rate of population increase for *O. vitiosa* was defined as the multiplication factor that converts one population size to another, one time step later or:

$$\bar{\lambda} = \frac{\sum_{t=1}^{n-1} \frac{N_{t+1}}{N_t}}{(n-1)}$$

where N is the population density at time interval t and n represents the number of sample intervals (Carey 1993, Southwood 1975). To estimate λ under field conditions we quantified the number of adult weevils/ha monthly for a year and calculated the mean multiplication factor ($\bar{\lambda}$) over all sample dates (Bellows & Van Driesche 1999). To provide an annual estimate we raised $\bar{\lambda}$ to the 12th power. This annual estimate of $\bar{\lambda}$ /yr was used to calculate the field-based intrinsic rate of population increase as:

$$r = \ln(\lambda)$$

(Carey 1993). Caution should be used when drawing inferences from comparisons with our estimates and laboratory or field-based population growth rates of other species due to differing environmental parameters under which data were collected.

To quantify population densities of *O. vitiosa* in the field, a 1 ha study site was delineated within an existing melaleuca stand under a power line right of way near Weston, Broward Co., FL (N 26.035483 and W 80.43495). Land managers cut melaleuca trees near their bases within the plot prior to 1997, resulting in multistemmed coppices regrowing from the stumps. Within this plot, transects were arranged in a grid pattern with 8 transects oriented east to west at 10-m intervals and points on each transect spaced 10 m apart. In June, July and September of 1997 40, 171 and 240 adult *O. vitiosa* weevils were liberated near the center of the plot, respectively.

Beginning in July 2000 through June 2001, melaleuca clumps were sampled at 20 randomly selected transect points monthly. Plants at each sampling point were selected using the quarter

method of vegetation sampling (Smith, 1966). The area was divided into four quarters at each sampling point based on the four cardinal directions. The nearest clump to the sample point in each quarter was reviewed to determine the number of *O. vitiosa* adults per plant.

The finite rate of increase ($\bar{\lambda}$) for *O. vitiosa* when averaged over all sample dates was 1.23 (SD = 0.84), resulting in an annual estimate for λ of 11.5. The most probable explanation for the variability associated with $\bar{\lambda}$, as is evident in the SD, is resource stochasticity. *Oxyops vitiosa* larvae are obligate flush-feeders, attacking expanding leaves from foliar buds. In undisturbed systems of south Florida, this seasonal growth occurs primarily during late fall and early winter whereas melaleuca leaves mature and rarely support larval development during the remainder of the year (Center et al. 2000). Although plant phenology appears to be an important predictor for population growth of *O. vitiosa*, the effect of temperature, humidity and plant quality on λ remains unclear.

Impact of a weed biological control agent on the target plant is dependent, in part, on increases in the herbivore's population densities (Parker et al. 1999, Marohasy 1997). Therefore, an important characteristic of an effective biological control agent may include a high rate of population increase (Pratt & Croft 2000, Huffaker 1971). The intrinsic rate of increase for *Cactoblastis cactorum* Bergroth, a widely acclaimed weed biological control agent, was estimated as 3.38/year (Caughley & Lawton 1981). Schooler (1998) reported a composite estimate of r = 2.24/yr for the successful purple loosestrife (*Lythrum salicaria* L) biological control agents *Galerucella calmariensis* (L.) and *G. pusilla* (Duftschmidt). The intrinsic rate of increase for *O. vitiosa* under the field conditions tested herein was 2.44/yr. These data suggest that *O. vitiosa* is capable of increasing population densities at a rate comparable to that of other successful weed biological control agents.

Summary

The classical weed biological control agent *Oxyops vitiosa* was introduced into south Florida in 1997 to aid in the suppression of the invasive weed *Melaleuca quinquenervia*. As part of our ongoing post release evaluations, we estimated the population growth rate of *O. vitiosa* under field conditions. The intrinsic rate of increase, r, was estimated as 2.44 and the time required for an *O. vitiosa* population to double is 3.41 months.

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