

AUGMENTATIVE BIOLOGICAL CONTROL IN NORTH AMERICA AS A FOUNDATION FOR AGRICULTURAL PEST MANAGEMENT: ITS POTENTIAL AND LIMITATIONS

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ABSTRACT. Twenty-one North American commercial insectaries produce some 90 species of natural enemies for release in North American agricultural crops, urban landscapes, and interior plantscapes. It appears to represent about a \$10 million dollar industry, but sales figures are difficult to come by for proprietary reasons. A number of North American insectaries also repackage natural enemies supplied by other producers, while others also ship natural enemies to suppliers in Europe for use in the glasshouse industry and to South and Central America. Thus, the North American natural enemy industry increasingly supplies an international market, as do their European and Mediterranean counterparts.

Augmentative biological control, as a pest suppression tactic, began in 1916 with the proliferation of insectaries in southern California to produce the coccinellid *Cryptoleamus montrouzieri* Mulsant to control the citrus mealybug. This coccinellid, known as the mealybug destroyer, was unable to survive the cool, southern California winters. By 1930, 16 insectaries had been built and they produced approximately 20 million beetles annually. Later, in the 1930s, the Fillmore Protective District, one of several such citrus protective districts in southern California, began producing parasitoids of black scale (*Saissetia oleae* [Olivier]), for release in the citrus groves of its grower members. This same protective district also began producing *Aphytis melinus* (DeBach) in the 1960s for release against California red scale by its members. From this initial beginning five or six commercial insectaries now produce this parasitoid for release in various locations within California's citrus growing region. This pest control tactic is often more cost-effective than a pest management program based on broad-spectrum insecticides.

Three other natural enemy production systems have been the focus of intensive development in the last several decades in North America. These include production of *Trichogramma* species for use against lepidopteran pests, the production of phytoseiid mites for use in strawberries and greenhouses, and the production of pteromalid parasitoids for fly control in a variety of livestock and poultry production systems. The experience with the production of phytoseiids and pteromalids and their use are reviewed along with that of an augmentative release program in San Joaquin Valley citrus. The success of a specific augmentative biological control program depends heavily on several factors: (1) how well the ecology of the system is understood, (2) the specific economics of the natural enemy production system, (3) the presence of an established complex of natural enemies in addition to those being released, and (4) the economics of the crop's production. A much under appreciated aspect of pest management is the effect of the prevailing traditions within the cropping system, including the psychology and sociological outlook of the growers involved. Aspects of these factors will be discussed with examples from the three cropping or production systems referred to above.