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# BIOLOGICAL CONTROL OF ARTHROPOD PESTS: TRADITIONAL AND EMERGING TECHNOLOGIES

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Biological control of arthropod pests has a long history of useful practical application. Parasites, predators, and pathogens have been employed in many cases to control pest arthropods in an efficient, effective and permanent manner. The traditional tactics used in biological control (classical, augmentation, and conservation) remain vital and valuable tools in the biological control of pests for agricultural crops New technologies offer promise. One emerging technique involves the genetic improvement of natural enemies of arthropods through selection, hybridization, or recombinant DNA technology. Crop yields is reduced by the impact of a variety of pests. Insect pests, weeds, plant pathogens and nematodes are very important limiting factors. Control of pest insects has been achieved through chemical, cultural, and biorational controls, but biological control has unique advantages over the other tactics. Biological control has been defined as the "actions of parasites, predators, and pathogens in maintaining another organism's density at a longer average than would occur in their absence". It also includes host plant resistance, autocidal control, and pheromones under the category of biological control. Generally, biological control has been achieved by the use of one of three approaches—classical, augmentation, or conservation.

**Classical biological control:**

"Classical" biological control is based on the importation of exotic natural enemies (parasites, predators, or pathogens) and their long-term establishment in the new environment, a strategy which may then provide long-term control of the target pest. In addition, once a successful program is achieved in one location, the same natural enemies are frequently used to control the same pests elsewhere in other climatically similar locations. Natural enemy importation thus remains an important and effective tactic in pest management, particularly in the management of those arthropod and weed pests that are exotic. This approach to biological control, unfortunately, has received less support than it deserves. Classical biological control has been actively practiced for about 100 years in the India. Worldwide, approximately 2300 introductions directed against insect pests have provided complete biological control in about 100 cases. Substantial control was provided in an additional 140 cases. Many factors affect success in classical biological control programs, including climate, natural enemies, habitat type, genetics, host compatibility, host phenology, and operational procedures. Thus, while classical biological control is effective and has yielded complete and lasting control in many important situations, there are several aspects of this pest management tactic that require additional work to be done.The cottony cushion scale threatened the citrus industry in California in the late 1800s. This exotic species was suspected to have come from Australia. A very small amount of funding ($2000) was obtained to support a field agent's search for natural enemies in Australia in 1888. A parasite and a small lady beetle (then called Vedalia) were found attacking the scale in the Adelaide area of Australia, and 129 beetles were shipped to California. There they were placed on a small infested citrus tree enclosed in a mesh tent in January, 1889. By early April the scales were controlled on the caged tree and by early June over 10,000 beetles had been distributed to various southern California groves. By the end of 1889 the Vedalia beetle had cleared the scale pest from hundreds of acres of citrus.

**Augmentation:**

Augmentation involves efforts to increase populations or beneficial effects of natural enemies of both native and exotic pests. Periodic releases may be labeled inundative or inoculative, depending upon the numbers of natural enemies released and the interval during which they are expect  to provide control. Environmental manipulation may include provision of alternative, factitious hosts or prey, use of semiochemicals to improve natural enemy performance, provision of environmental requisites such as food or nesting sites, and modification of cropping practices to favor natural enemies). Inundative releases are designed to control a pest by the actions of the released natural enemies, not by the actions of their progeny, and thus can be considered "biotic insecticides." Inundative releases are currently hampered by our limited ability to produce high quality, inexpensive, mass-reared natural

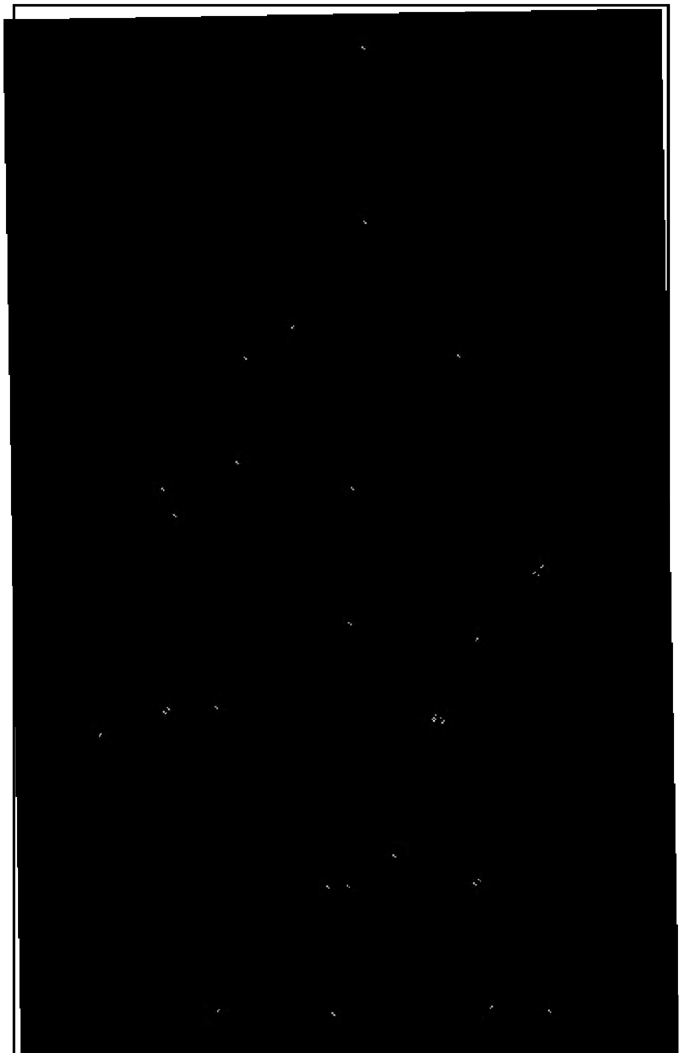

**Fig. 1 : Component of a genetic improvement with anthropod naturla enemia. Dashed lines indicate consideration if recombination DNA methods are used as the method of genetic manipulation**

enemies. Thus, advances in current research on synthetic diets, artificial hosts, quality control, and genetic manipulation could result in increased of this tactic. Another emerging technology is the use of semiochemicals to improve the efficacy of natural enemies in augmentation schemes. Parasitic insects use various chemical cues to locate their hosts. Recent reports, indicate that learning can modify the responses of parasites to these chemicals. The complexity of host seeking behavior exhibited by arthropod natural enemies is only beginning to be understood and could lead to the more sophisticated use of natural enemy augmentation.

**Conservation:**

Conservation involves protecting and maintaining natural enemy population. Conservation is crucial if both native and exotic natural enemies are to be maintained in agricultural ecosystems. Most commonly, conservation involves modifying pesticide application practices so that they occur only when the pest population exceeds specified levers. In some cases, conservation of natural enemies can be achieved by changing the active ingredient, rates, formulations, timing, and location of pesticide applications or existing populations of natural enemies can be protected by maintaining refuges.

**Emerging technologies:**

Genetic manipulation of natural enemies of arthropods offers promise of enhancing their efficacy in agricultural cropping systems. Genetic manipulation of other beneficial arthropods, such as silkworms and honey bees, has been conducted for hundreds of years. Such manipulation of biological control agents seems to be a logical extension of the domestication of crop plants and animals that has been part of agriculture for thousands of years, since many agricultural systems are artificial. As in crop breeding, three potential genetic manipulation tactics exist, *i.e.,* artificial selection, hybridization (use of heterosis), and recombinant DNA (rDNA) techniques. To date, only artificial selection of arthropod natural enemies has been successfully employed and the potential role of heterosis or rDNA technologies remains to be documented. There are some of the constraints to initiating a genetic improvement of arthropod natural enemies- First, the factors limiting the efficacy of the natural enemy must be identified. This means that a great deal must be known about the biology, ecology, and behavior of the natural enemy. This first step is extremely crucial, since improper identification of the trait needing improvement could lead to an expensive and time-consuming. Second, genetic variability must be available upon which one can select if using artificial selection. If such variability does not occur in natural populations, it must be provided for through mutagenesis or, perhaps, through recombinant DNA methods. Third, the "improved" natural enemy must be documented to be effective in the field. Finally, one must assume that the cost of the project will be justified by the benefits achieved. The potential for using rDNA technology in genetic manipulation of natural enemies of arthropods has a great value. This technology offers the possibility that genetic manipulation could become more efficient and more creative, beneficial genes isolated from one species could be transferred to many if efficient transformation systems can be found. This research has a many steps, desirable genes must be identified cloned, inserted into natural enemies, be incorporated into their genome, be stable, be expressed in the appropriate tissues and at the appropriate time and transmitted to the progeny.

The transformed natural enemy strain must then be fit and able to perform well in agricultural systems. Issues relating to the safety of releasing rDNA manipulated arthropod natural enemies remain to be resolved. Safety questions will probably focus on three issues: 1) whether the transformed strain is stable, 2) whether the improved strain retains its host/prey specificity and 3) whether the ecological range of the transformed strain has been altered. It will be important to remember that genetic improvement of arthropod natural enemies of insect pests will be initiated because there is a serious pest problem.

**Conclusions:**

In practice, effective biological control may require that several tactics be combined to achieve effective pest management. Thus, once an exotic natural enemy is established, specific efforts may be needed to conserve it. Alternatively, it may have to be released augmentatively if it is unable to persist in sufficient numbers, perhaps because it lacks a diapause or alternative hosts. Classical, augmentation, and conservation tactics should not be considered to be mutually exclusive. Arthropods have been pests in agriculture for more than 10,000 years, it is likely that they will remain serious pests of agriculture, even as it changes and evolves. New technologies should be examined to determine whether they can result in improved biological control. Biological control is not being fully exploited as a method for the control of pest arthropods in many fields. Additional and continuing efforts should be made in the traditional classical, augmentation and conservation approaches to biological control because the benefits associated with these approaches are already known to be substantial and can probably be improved. In addition, research efforts should be continued to combine and develop new and innovative approaches to biological control, including the genetic manipulation of natural enemies, the manipulation of natural enemy behavior through semiochemicals and the development of improved artificial diets and improved rearing methods so that mass production for augmentative releases becomes economical.