FOREIGN EXPLORATION: THE KEY TO CLASSICAL BIOLOGICAL CONTROL

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ABSTRACT

Importation and establishment of exotic natural enemies, known as "classical" biological control, is the best alternative to the wholesale use of toxic chemical pesticides. The statistics of worldwide importation projects are discussed, and a plea is made for enhanced foreign exploration for natural enemies.

RESUMEN

La importacion y el establecimiento de enemigos naturales exoticos, conocido como control biologico clasico, es la mejor alternativa a el uso unilateral de pesticidas quimicos toxicos. Se discuten las estadisticas de los projectos de importacion de enemigos naturales a nivel mundial y se hace una peticion para el fomento de exploraciones en el extranjero.

With rising concern about environmental quality, modern agriculture has been experiencing a severe pesticide crisis. While effective pest control is an absolute necessity in most cropping systems, it has become increasingly evident that unilateral reliance on toxic chemicals may involve serious hazards of chemical pollution affecting man, domestic animals, plants and wildlife. Resurgences and upsets of target and non-target pests, triggered by rapid development of resistance coupled with destruction of beneficial natural enemy populations, have become common occurrences, and the ever-mounting cost of chemical pesticides has often become prohibitive. Safer, environmentally compatible and less expensive alternatives to wholesale chemical control are therefore urgently needed.

Of the various alternatives available to us—selective chemicals, cultural, mechanical, physical and autocidal controls, etc.—"classical" biological control, or the importation of exotic natural enemies and their establishment in new habitats, has been by far the most successful to date. Other selective control methods may serve as important components of integrated pest management whenever they are applicable, but classical biological control remains the most promising approach for the foreseeable future. When it works, as it often does, biological control offers effective, permanent, inexpensive and virtually hazard-free solutions to serious pest problems. Worldwide, attempts at classical biological control have been made against 416 species of insect pests belonging to eight orders, and a significant degree of success has been achieved against two-fifths of them: 75 species have been brought under complete control by imported natural enemies, 74 under substantial control, and 15 under partial control in at least one country. Many of these successes have been repeated in other countries, so that altogether there have been at least 384 successful projects worldwide, including 156 that have been rated as complete successes, 164 as substantial, and 64 as partial successes (see DeBach & Rosen 1991). Achievements with biological control of weeds have been as impressive, but this falls beyond the scope of this conference. Outstanding examples in the Caribbean Basin have included the citrus blackfly, *Aleurocanthus woglumi* Ashby (Homoptera: Aleyrodidae), and the sugar-cane borer, *Diatraea saccharalis* (Fabricius) (Lepidoptera: Pyralidae), and—in Florida—the Florida red scale, *Chrysomphalus aonidum* (L.), the purple scale, *Lepidosaphes beckii* (Newman), and the citrus snow scale, *Unaspis citri* (Comstock) (Homoptera: Diaspididae). Several projects are currently addressing other pests.

The benefit-to-cost ratio of classical biological control has been calculated as 30:1 (DeBach & Rosen 1991). Compared with a 3:1 ratio for chemical control (Pimentel et al. 1981), this is indeed remarkable. The cost of researching, developing and marketing a new pesticide is now at least $20 million, and the process may take at least ten years. The cost of discovering a new natural enemy, on the other hand, rarely exceeds several thousand dollars. Repeat projects, where a successful natural enemy is simply transferred to another country, may cost no more than the small amount required for a few airmail shipments; but even new projects, involving foreign exploration "from scratch", may be relatively inexpensive. Unfortunately, unlike augmentative biological control, where natural enemies can be mass-reared and sold to consumers for periodic releases, there is no direct profit incentive for private enterprise to import and establish exotic natural enemies. Such incentives can, however, be provided by government or agro-industry contracts.

Some have cited a low rate of establishment of imported natural enemies as justification for the claim that classical biological control hardly ever works. The rate of establishment is actually very good: Out of a total of 4226 natural enemy importations that have been recorded to date in 153 countries, about 30 percent have resulted in establishment, and the fate of an additional 22 percent is still unknown (DeBach & Rosen 1991). This is an impressive record, considering that, by comparison, only one in 15,000 or 20,000 candidate chemicals ever makes it to the marketing stage as a pesticide (DeBach & Rosen 1991). However, the rate of establishment in itself is, of course, irrelevant as a measure of success of biological control. If nine natural enemies fail to become established and the tenth provides complete, permanent control of a serious pest, it is the benefit-to-cost ratio of the entire project that should be taken as the criterion for its success, and we have already seen that this ratio is excellent.

In view of this outstanding record, it is almost unbelievable that out of about 10,000 insect pest species recorded worldwide, only some 400 species have ever served as targets for classical biological control efforts. In other words, over 95 percent of the world's insect pests have had no biological control importation project directed against them. This is indeed a remarkable indictment against our profession! (DeBach & Rosen 1991).

Exciting breakthroughs in molecular biology should not overshadow the fact that importation of exotic natural enemies is still the best method for controlling a pest. The only alternative, that of creating new superior natural enemies through genetic engineering, is still far from offering practical solutions (Beckendorf & Hoy 1985), and until it does, foreign exploration for exotic natural enemies should always receive the first priority. Thorough ecological study of agro-ecosystems can be most enlightening and improve our understanding of pest-natural enemy interactions. However, with all our simulation, modeling and sophisticated analysis capabilities, classical biological control remains essentially an empirical endeavor: We simply cannot predict the performance of a natural enemy in a new habitat. On the other hand, competition among natural enemy species does not present a threat to the success of a biological control project. Multiple importations may result either in complementary action of several natural enemies coexisting in the same habitat, or in competitive displacement of inferior species by one that is better adapted to that particular habitat, but in each case the outcome is more effective biological control. There is, therefore, no substitute for foreign exploration. Importation of as many exotic natural enemies as can be discovered is the key to success in pest management.

Inasmuch as foreign exploration and importation of natural enemies are basically empirical, there is no need for extensive preliminary research. Knowledge of systematics—both of the target pest and of its natural enemies—and basic biology is an essential prerequisite. In order to be utilized, a natural enemy obviously has to be recognized as distinct, and inadvertent importation of hyperparasites or other noxious organisms should of course be avoided. However, basic ecological research, important as it may be for our understanding of ecosystems, should not delay the actual importation of natural enemies. Time spent in studying existing host-natural enemy complexes, etc., before new natural enemies are imported, can result in real loss to society. The loss an investigator can be credited with may be calculated as the time spent from the start of a project until the actual importation is made, times the annual savings accrued by ultimate success of biological control (DeBach 1966). One could cite quite a few good examples for such unnecessary delays.

The Caribbean Basin has seen one of the very first attempts to use air transportation for the transfer of natural enemies. It was Dr. J. G. Myers who, as early as 1932, used fledgling PanAm flights to ship sugar-cane borer parasites from Cuba to Antigua. With modern air transport, there is really no excuse for not bringing the natural enemies in. In the past, the transfer of live organisms from one continent to another required prolonged odysseys on land and sea, and explorers had to maintain suitable host plants with live cultures of host insects, or make judicial use of whatever refrigerating facilities were available on board ships at the time, for their colonies of natural enemies to survive the long journey. Many importation failures resulted from these formidable difficulties, as well as from poor handling techniques (see van den Bosch 1968, Hoy 1985). Modern-day explorers may still encounter tremendous difficulties and hazards, especially in some so-called developing countries—Dr. Myers' exploits in the Amazon Basin stand out as an excellent example, and conditions have not improved much over there—but the actual transfer of live natural enemies from one corner of the globe to another can usually be accomplished within 24 to 48 h, and improved techniques such as the use of humiditrons (DeBach & Rose 1985) make the task even easier. The rate of successful establishment of imported natural enemies is therefore constantly improving, and explorers can devote most of their energy to the actual search.

Classical biological control is still far from reaching the point of diminishing returns. Not only have the vast majority of pest species never served as targets for importation projects, but the vast majority of natural enemy species still remain to be discovered. The fauna of large world areas is very little known, and it has been estimated that between 70 and 90 percent of all parasitic Hymenoptera—by far the most important group of biological control agents—are still undescribed, and that we have no biological information whatsoever about 97 percent of all existing species (DeBach & Rosen 1991). Most of the task is still ahead of us, and at the current rate of foreign exploration it is anybody's guess how many potentially powerful weapons will become extinct before we even have a chance to discover them!

The title of this conference—"Important Arthropod Pests of the Caribbean Basin Amenable to Biological Control: Homoptera, Coleoptera, Lepidoptera"—is somewhat misleading. It may be misunderstood to imply that other groups of pests are either not important, or not amenable to biological control. If there is one lesson that may be learned from an analysis of past projects, it is that classical biological control is broadly applicable to essentially all pest situations. Successes have indeed been achieved against Homoptera, Coleoptera and Lepidoptera, but also against various other arthropod pests, as well as against diverse organisms such as snails and rabbits, weeds and plant pathogens. In spite of the opinions of some, that biological control may work only under certain favorable conditions, it has been very successful under very diverse circumstances: in continental areas as well as on islands, in temperate as well as tropical climates, on annual as well as perennial crops and in forests, and against direct as well as indirect pests, including species of medical and veterinary importance. In fact, although the prospects may seem better in certain situations than in others, as a general rule the amount of success in biological control has been directly correlated with the amount of research and importation work carried out. Further efforts are likely to yield many further successes (Rosen 1985, DeBach & Rosen 1991).

Both exotic and native pests have proved amenable to classical biological control. The most common scenario is, of course, that of an exotic pest invading a new area, leaving its natural enemies behind. Foreign exploration in the land of origin is, therefore, a logical starting point for any classical biological control project. However, pests may acquire additional natural enemies as they spread into new areas, and natural enemies may also become accidentally established in faraway lands, or may have different strains in different areas. Some climatic matching can be very useful: If the target pest is a problem on a tropical island in the Caribbean, it stands to reason that exploration for its natural enemies should focus on similar areas. However, it should be remembered that natural enemies have been known to surprise us in the past in this respect, and there is no way of predicting their performance in a new habitat. Whenever possible, exploration throughout the range of distribution of the target pest should be carried out, and a broad genetic spectrum of each natural enemy species should be imported from numerous localities.

Some outstanding successes have been achieved by importing the natural enemies of related species, so when all else fails this option should not be discounted. However, the idea should not be carried to extremes: The so-called "new associations theory" (Hokkanen & Pimentel 1984), which claims that natural enemies that have not evolved with the target pest are somehow more likely to effect biological control than do "old associations", is simply not true and is not borne out by the statistics of worldwide importation projects. Thus, although the parasites and predators of related species should certainly not be ignored, those that have evolved with the target pest in its land of origin should continue to be the first choice (DeBach & Rosen 1991).

The main problem with foreign exploration is that, by definition, it has to be performed in foreign lands, and administrators are often reluctant to provide funds for trips abroad. Although only modest funds are sometimes required, some funds are nevertheless always needed. As early as in the cottony-cushion scale project in California, attempts at foreign exploration were at first thwarted by an act of Congress prohibiting employees of the USDA from traveling abroad, and it took some adroit political maneuvering to send Albert Koebele to attend an exposition in Melbourne and bring about what, to paraphrase a contemporary expression, has become "the mother of all biological control projects". Unfortunately, official attitudes have not changed much during the century that has elapsed since then. This, coupled with the rise of rather petty environmental concerns about possible detrimental effects of biological control and the tendency of bureaucrats to over-regulate importation activities, has resulted in a regrettable decline of classical biological control. These adverse trends ought to be reversed.

In many cases, natural enemies can be obtained from knowledgeable colleagues in other countries, without resorting to foreign travel. International organizations may also be of great help—the IIBC, or International Institute of Biological Control, formerly known as the CIBC, is currently the best one, maintaining stations on several continents with trained personnel collecting and shipping natural enemies upon request. However, in the final analysis, there is no substitute for dedicated foreign explorers from the importing country, who are willing to go out there by themselves and search for natural enemies to solve a pest problem back home. There is a great shortage of such trained explorers, and the attitude of many of our universities and research institutions, which prefer so-called basic, paper-oriented scientific research to foreign exploration for biological control agents, is not very helpful. If these trends toward over-scientification and bureaucratization continue unhindered, they may eventually bring about the demise of classical biological control. It is in the better interests of all mankind that foreign exploration for exotic natural enemies be encouraged and adequately funded, and that dedicated foreign explorers be rewarded for their contributions to problem-solving research.

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