MODIFYING THE BIOLOGICAL WORLD FOR HUMAN BENEFIT 2. ENTOMOLOGY AND THE BIOLOGICAL CONTROL OF PESTS

Introduction

Insects comprise about 70% of known species of all kinds of animals. Man benefits a great deal from insects (eg. pollinators of crops, producers of useful sbstances such as honey, silk, wax etc; predators of harmful insects; source of food protein in certain parts of the world). Insects have a direct influence on humanity - both beneficial as well as harmful. Most attention in economic entomology is devoted to studies on harmful insects, how they become pests, and how they are controlled. The emphasis on managing harmful insects reflects the immediacy and seriousness of pest problems, particularly the destruction of food and transmission of disease.

Central to the definition of a pest (be it an insect or any other organism) is determination of the economic threshold. Any insect population, when introduced into a favourable environment, increases in numbers until reaching an environmental carrying capacity. In pest insects, there exists a density above which the insect population interferes with human health, comfort, convenience or profits. When this economic threshold is reached, a decision must be made to utilize some control measure to prevent further increase in numbers.

Classical Biological Control

Humans observed the action of predacious insects early in their agricultural history and a few crude attempts to ulilize predators have been carried on for centuries. However, the necessary understanding of biological and ecological principles, especially those of population dynamics, did not begin to emerge until the nineteenth century. The term biological control was proposed in 1919 to apply to the use or role of natural enemies in insect population regulation. The enemies involved are termed parasites (parasitoids) predators or pathogens. Classical biological control is an ecological phenomenon which occurs everywhere in nature, without aid from, or sometimes even understanding by, humans. However, humans have utilized the ecological principles involved to develop the field of applied biological control of insects, and the great majority of practical applications have been achieved with insect pests. Additionally, such diverse types of pest organisms as weeds, mites and certain mammals have been successfully controlled by the use of natural enemies. We shall discuss some of these examples in the lecture.

Most cases of applied biological control involve importation and colonization of new exotic enemies of the insect pest in question. In the majority of cases, the pest was an invader, being native to another country, and its natural enemies had been left behind. By searching the native habitat for effective enemies and sending them to the new home of the invader pest, the biological balance was reconstituted. This method is considered to be classical biological control and its scientific application has been responsible for most of the outstanding results obtained. These are however, two other aspects of biological control. The first, involves the manipulation of the environment to favour survival and reproduction of natural enemies already established in the habitat. Adverse environmental factors (for example, the use of insecticides causing so-called upsets in balance or pest population explosions) are modified or eliminated, and requisites which are lacking such as food or nesting sites may be provided. The second aspect, concerns direct manipulation of established enemies themselves. Potentially, effective enemies may be periodically eliminated by environmental extremes or other adverse factors which are not subject to human control. The major means of solving such problems has involved laboratory mass culture of enemies and their periodic colonization in the field, generally after the adverse period has passed. Various insect parasites, predators and microorganisms have been successfully used in this manner.

Microbial agents have been used for pest control for sometime. A combination of factors have limited the acceptance of bacteria and viruses for large scale pesticidal use. However, due to their simple genetic makeup, and the advances in genetic engineering, the prospects for improving the efficacy of microbial insecticides are promising. From over one hundred bacteria that are naturaly pathogenic to insects, one in particular <u>Bacillus thuringiensis</u>, which produces a toxin that disrupts the gut cells of insect larvae is used worldwide as an insecticide. Current advances in genetic engineering has given man the opportunity to produce variants of this bacterium, which are more potent and have a broad spectrum of activity towards insect pests. Furthermore, the new technolgy has helped to reduce manufacturing costs.

Baculoviruses are a group of viruses that are specific to insects; therefore they are extremely safe and a few have already been registered as commercial insecticides in USA. Once again recent advances in biotechnology have made it possible to introduce foreign genes eg. those toxic to insects, into baculoviruses, making them more potent insecticides. Infection with recombinant bacteria or baculoviruses may being about onset of pathological effects in insects, faster than those caused by the original parent bacterium or virus.

Non-classical Biological Control

Other non-classical methods of biological control have been proposed and developed. In the sterile male technique, mass-produced sterile male insects have been released to mate with wild females in the field, thereby greatly reducing or suppressing the pests' production of progeny.

Studies on insects have rendered invaluable service to science and thus to humanity, as easily reared experimental animals for investigation of basic principles of genetics, biochemistry, development and behaviour. Consequently, the last few decades have seen great advances in the study of insects. We now know that they are highly differentiated invertebrates, whose life cycles, metabolism and behaviour patterns are precisely coordinated and controlled. This knowledge has enabled man to attempt to modify or disrupt these integrated pathways in insects, so as to control the numbers of harmful insects.

Scientists are now attempting to produce novel insecticides based on molecules such as hormones derived from insects. These molecules are so essential in the life of insects, that if they are given at the wrong time in inappropriate quantitites, insect physiology will be disrupted, and the insect will be unable to become a `pest'. Insects produce specific molecules called pheromones for communicating with other members of their species. Synthetic pheromones are used to lure insects to traps, to lead one sex astray, to assess population density, dispersal etc. and disruption of mating. Whole pheromone baits are also used for pathogen dissemination to insect pests.

Molecular Entomology

Geneticists have for decades bred crops with improved characteristics, among them, resistance to insects. At the same time entomologists and chemists have developed new insecticides. Molecular biologists have combined these two approaches into a third new approach, genetic engineering of crops that produce insecticidal or antifeedant proteins continuously in the field. This study is still in a very early stage.

We benefit tremendously from insects that do not compete with man. Honey bees are managed for their honey and bees-wax but their most valued service, together with moths, butterflies, wasps etc is pollination of crops. The silk worm larva is important in silk production. Man has over several decades developed methods of maximising the economic value of silkworms and honeybees. Humans have used silkworms for silk production for several thousand years. Its normal development is extremely rapid. Because of the efficiency of silkworm protein synthesis is extremely high during the larval stage, several milligrams of a specific protein can be synthesised within a day. The silkworm is easily mass-cultured at low cost, even under sterile conditions, by an automated feeding machine and advanced artificial diets.

It is now possible to obtain essentially unlimited quantities of silkworm, larvae. Scientists have been able to successfully express foreign genes via baculoviruses by recombinant DNA technology in silkworm larvae. Since the silkworm is also used as human food, it is considered a safe factory for the production of foreign proteins - eg pharmaceutical products using recombinant DNA technology. Furthermore, the silkworm does not seem as prone to induce allergy as some insects. The use of the baculovirus system in silkworms has also been applied for diagnostic work or the production of vaccines. Peptides of the AIDS virus have been used in this way. One of the products has been tested with success by immunological means with serum from AIDS patients. Envelope proteins of an AIDS virus produced in a cell line of armyworm insects have now been approved for testing in humans for AIDS vaccinaion.