BIOLOGICAL CONTROL OF INSECTS

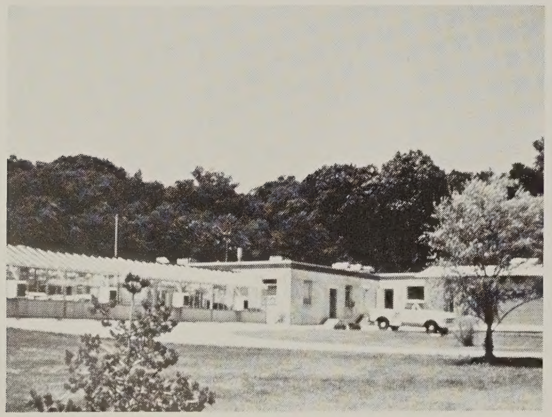
AGRICULTURAL RESEARCH SERVICE
U.S. Department of Agriculture

Biological Control of Insects Research Unit

North Central Region
Agricultural Research Service
U.S. Department of Agriculture
Research Park Box A
Columbia, Missouri
65201

BIOLOGICAL CONTROL OF INSECTS RESEARCH UNIT

Developing ways to prevent insect damage using biological control agents is the primary objective of the U. S. Department of Agriculture scientists at the Biological Control of Insects Research Unit (BCIRU) in Columbia, Missouri. Specifically, their mission is to discover, define, clarify, and implement biological control principles and concepts. Administered by the Agricultural Research Service, the laboratory houses facilities for conducting both basic and applied research on (1) *principles and concepts of biological control,* (2) *methods of using natural insect enemies in the fight against destructive pests,* and (3) *designing biological control systems for various commodities or ecosystems.*



The Biological Control Laboratory is on a 10-acre tract located in the Research Park on the campus of the University of Missouri at Columbia. The main laboratory was opened in February 1967 and covers nearly a quarter acre. A greenhouse, insectary, shop, pond, and about 2½ acres of plot land are also located on the grounds. The site permits close cooperation between other federal and university scientists. Laboratory research scientists at the BCIRU hold staff appointments with the Department of Entomology.

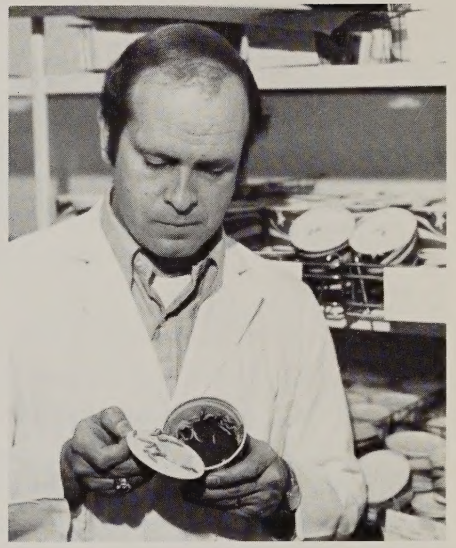
The biological control scientists' raw materials for studies are naturally occurring parasites, predators, and pathogens that attack insects. Insect parasites are organisms that live on or in, and at the expense of, other insects. Predators are organisms that prey on and devour other insects. Insect pathogens are disease-producing microorganisms that attack and cause sickness and eventual death of pest insects. Properly manipulated, these natural biocontrol agents can and have been used to control insect pests. Since parasites, predators, and pathogens only attack specific pests, there is little danger to beneficial insects such as honey bees or to man and the environment. Biocontrol can be generally stated as man's effort to use what nature has provided to his own advantage.

During the relatively short existence of the laboratory, the staff has developed biocontrol systems for cabbage insects and ornamentals and for flies attacking cattle. Research effort at present is focused on developing a biocontrol system for soybeans. Although the BCIRU current effort is in the soybean ecosystem, studies on other ecosystems are also conducted. Major areas of investigation are: (1) *the effects of the environment on parasites, predators, and pathogens;* (2) *in vitro methods of propagating endoparasites and predators;* (3) *microbial control, microbiology, and pathology of target pests, parasites, and predators;* (4) *importation, screening, and biology of native and foreign parasites, predators, and pathogens;* (5) *insect rearing and nutrition;* (6) *population dynamics and manipulation of beneficial and pest insects;* (7) *parasite and predator behavior;* and (8) *studies on selective biocontrol chemicals.*

Staff reviewing manuscripts prior to processing for publication in a scientific journal.

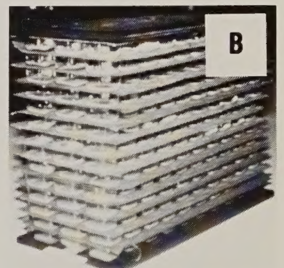
Shop facilities and maintenance personnel permit the construction of unique equipment to be used in both laboratory and field experiments.

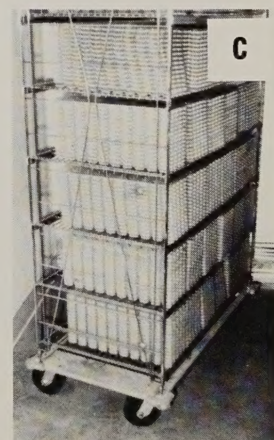
Insect Rearing and Nutrition



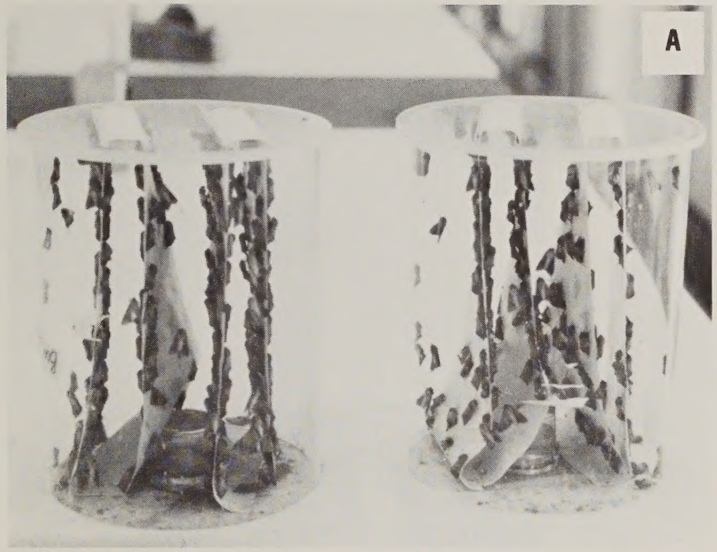
Millions of living insects are needed the year round in order to conduct research on biological control agents. This project is responsible for developing methods and artificial diets for rearing insects and evaluating the nutritional requirements of insects.

Much of the early work to develop artificial diets is first done on plants using small cages. This technician is recording the amount of feeding done on different kinds of plants by the velvetbean caterpillar.

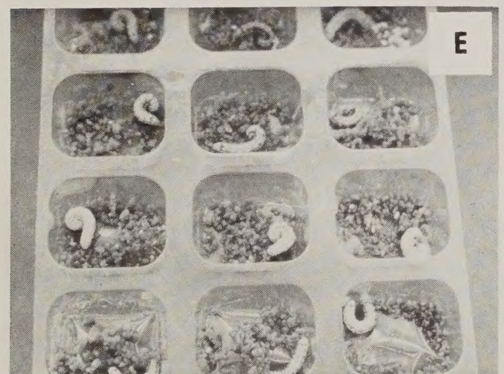




Special man-made diets and not plants are used to annually rear millions of several different kinds of insect pests. To effectively do this, a special machine (A) is used to automatically fill individual cells of a disposable plastic tray (B). Hundreds of these trays filled with larvae are often used to conduct basic and applied research on biological control agents. (C).

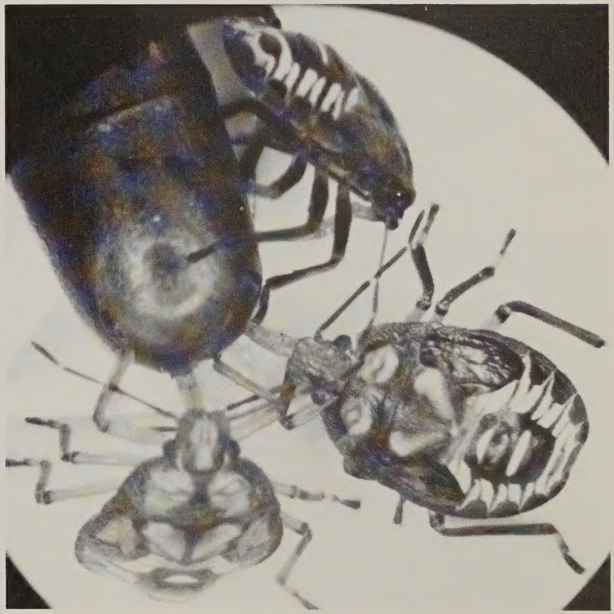


The corn earworm is one of several insect pests reared for over 200 generations in our laboratory on artificial diets. To do this, adult male and female bollworm moths are confined in clear plastic jars called oviposition cages (A). Female moths lay their eggs (B) on sheets of absorbent paper placed inside the cages. The egg sheets are removed daily (C) and incubated. After hatching into larvae, the larvae are transferred to (D) and individually reared in their own little cell (E) until they become pupae (F). One generation has been completed when adult male and female moths emerge from these pupae. (G)



New Methods of Rearing Beneficial Organisms

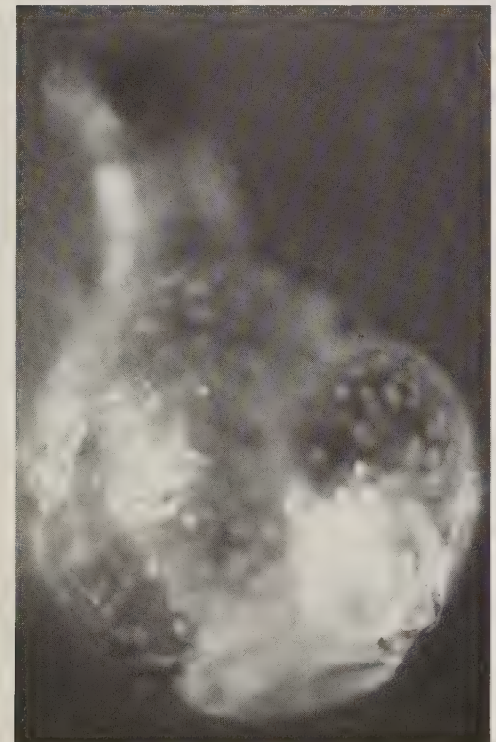
Most beneficial parasites and predators have to be grown on other living insects. This research program is focused on development of artificial diets and test-tube systems for rearing large numbers of parasites and predators so as to increase their possible use for controlling pest insects.



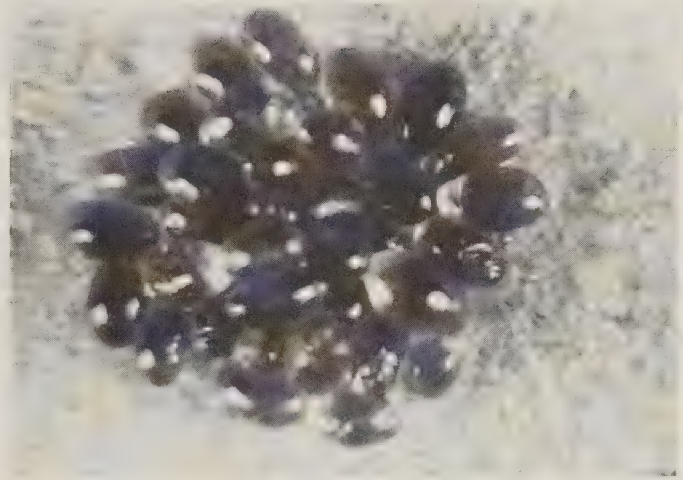
A man-made caterpillar containing an artificial liquid diet on which immature stages of the predacious stink bug *Podisus maculiventris* are feeding.

Sterile liquid feeding medium is being applied to absorbent paper. An egg of a wasp parasite *(Trichogramma pretiosum)* will be placed on each feeding pad and observed for hatch and development.

A man-made insect egg being parasitized by the beneficial wasp parasite *Trichogramma pretiosum*. This parasitic wasp attacks the eggs of many pest moths and butterflies.



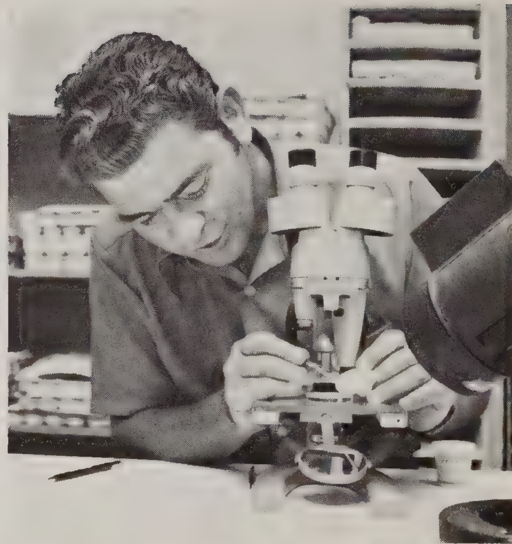
A man-made insect egg containing immature wasp parasites (*Trichogramma pretiosum*). Four wasp larvae (bulges) are developing inside the artificial egg.



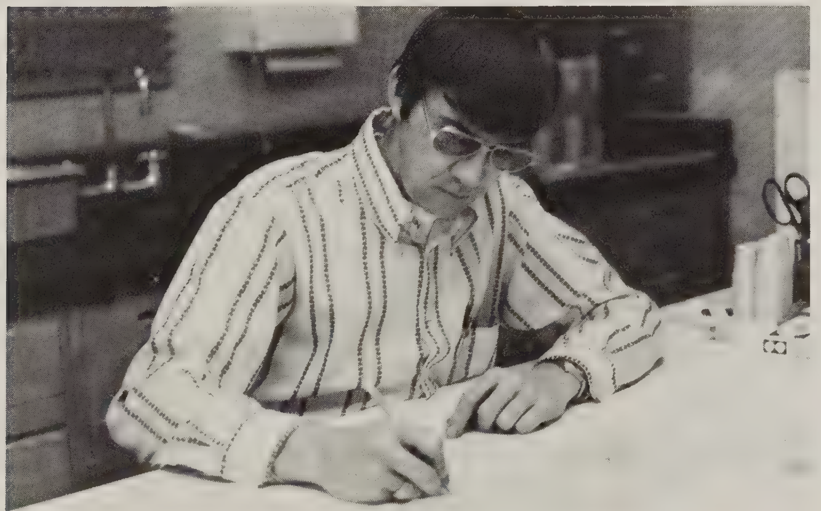
Larvae of a wasp parasite (*Trichogramma pretiosum*) are reared on absorbent paper impregnated with an artificial liquid medium. The larvae in the picture have stopped feeding and are ready to transform into pupae.

An adult of the tiny parasitic wasp is seen escaping from an insect egg in which it developed after its mother had deposited her egg.

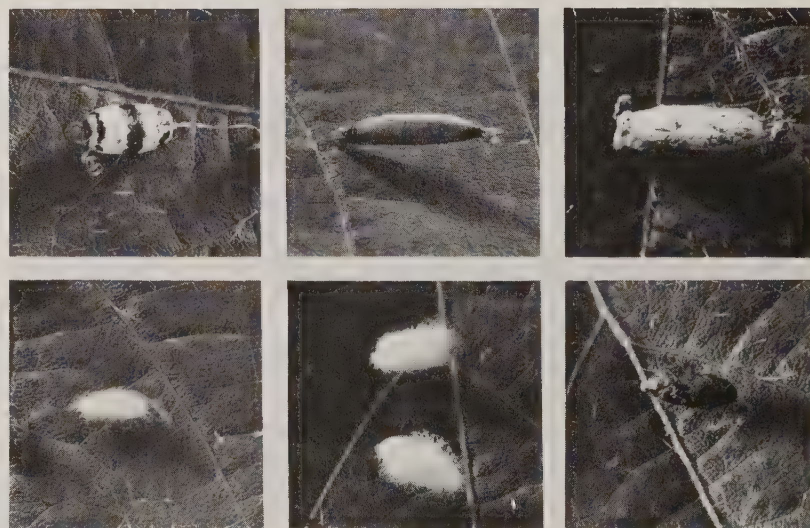
Importation, and Biology of Native and Foreign Parasites, Predators and Pathogens



Research activities of this project concentrate on the bionomics of native and introduced natural enemies of pest insects and their role in reducing pest populations. Exotic natural enemies are obtained through foreign exploration and are then evaluated for potential use in the United States. Studies on the interrelationship between the parasite and its host also are under study.



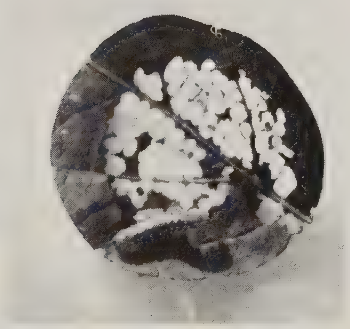
A research technician is recording oviposition using the petri dish method to determine fecundity of a parasite wasp, *Euplectrus* sp., of the velvetbean caterpillar, *Anticarsia gemmatalis*.



Parasitic wasps transform into cocoons after feeding on caterpillar pests. Collectively, the adult wasps of these species in conjunction with other parasites significantly reduce damage caused by pest caterpillars. Top, left to right: *Charops annulipes, Rogas nolophanae, Campoletis flavicincta;* bottom, left to right: *Apanteles marginiventris, Protomicroplitis facetosa, Meteorus autographae.*

Natural Insect Control by Manipulating the Agents and the Environment

Research in this project is directed toward developing methods for controlling pests using naturally occurring field populations of parasites, predators, and diseases and in determining their role in limiting pest populations. Means of artificially increasing populations of beneficial agents and improving their effectiveness through cultural practices or by adding attractants and food are also under study.

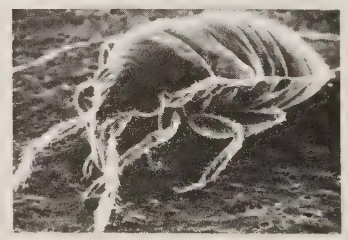


An artificial feeding attractant (placed in the center of the leaf disc) is used to stimulate feeding by a corn earworm larva.

Spiders of various types are some of the most efficient predators of insect pests. A jumping spider, which stalks its prey rather than constructs a web, has caught and is devouring a cabbage looper larva.

Field soybeans are being artificially infested with cabbage looper to evaluate the effectiveness of natural populations of parasites, predators, and pathogens on pest insects.

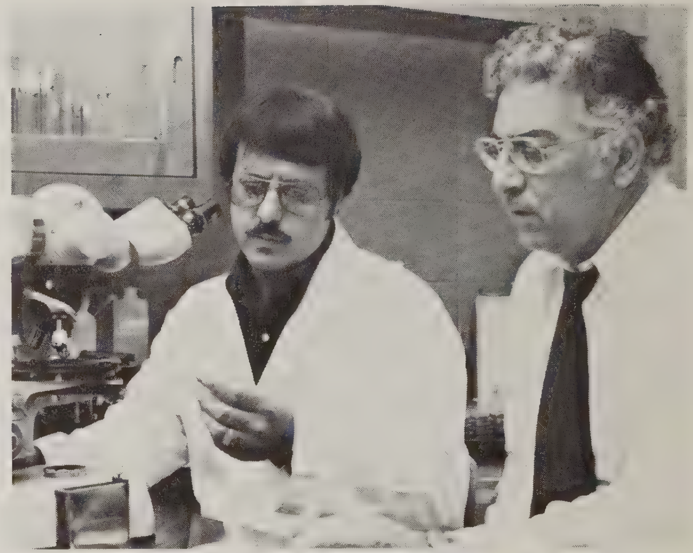
Predatory ground beetles search primarily at night to find prey; their predacious larvae feed on prey captured in soil and debris.



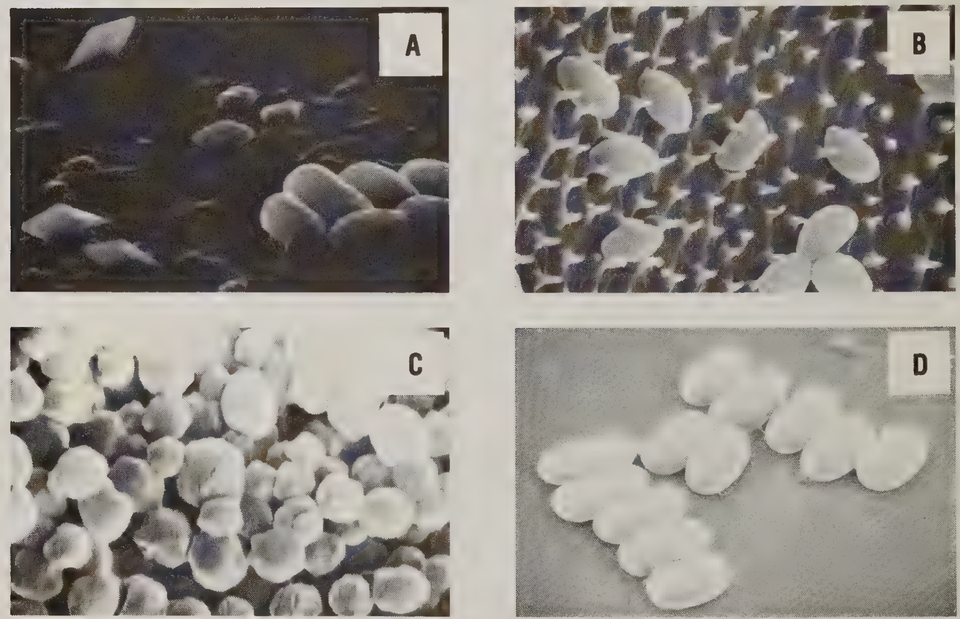
A scanning electron photomicrograph of one of the most numerous predators in soybeans, *Orius insidiosus*.

Using Safe, Selective Microorganisms for Insect Control

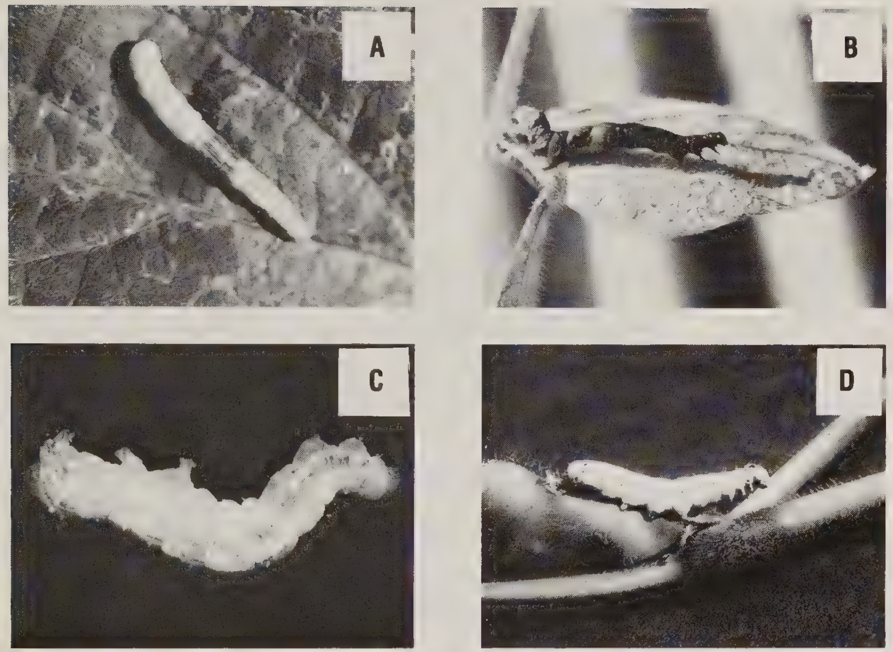
This research effort emphasizes the isolation, identification, specificity, and propagation of pathogenic microorganisms of insect pests with the ultimate utilization of these microorganisms as microbial insecticides. Microbial insecticides made from viruses, bacteria, fungi, and protozoa have been used both in laboratory and field studies.



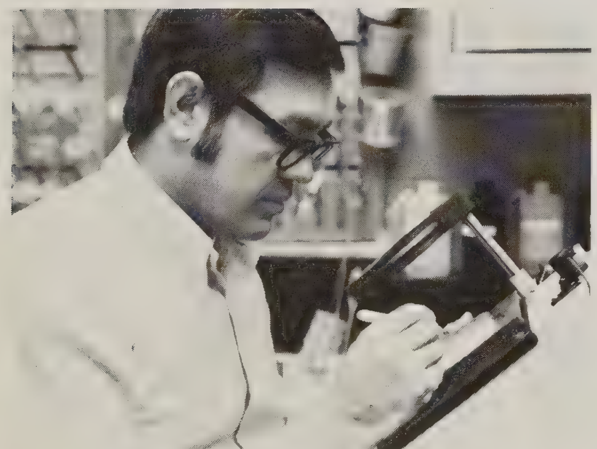
A scanning electron microscope is being used to determine the number of inclusion bodies, crystals, or spores per droplet of formulated microbial insecticide. Estimates are made to determine the relationships between droplet size and expected insect mortality after application in the field.



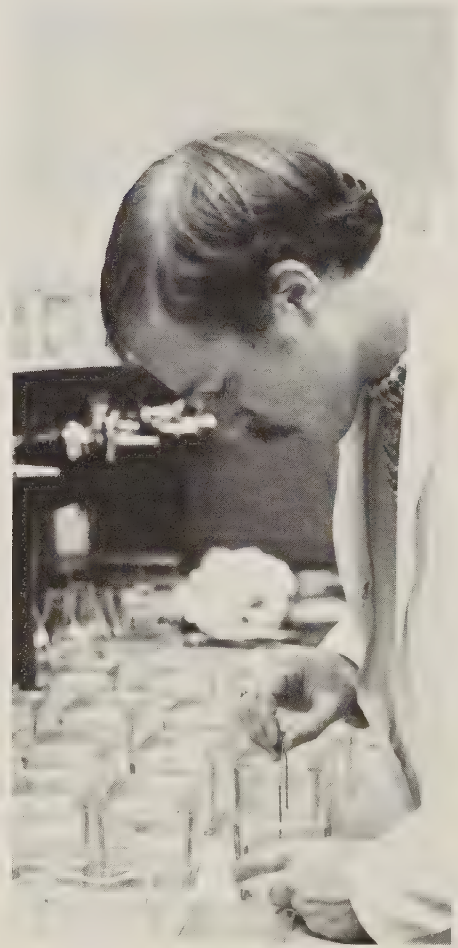
Photomicrographic enlargements of the infective units of four pathogenic microorganisms of insects: A—Bacteria (crystals and spores of *Bacillus thuringiensis*); B—Fungus (conidia of *Nomuraea rileyi*); C—Virus (polyhedral shaped inclusion bodies of *Baculovirus heliothis*); and D—Protozoan (spores of a *Nosema* sp.).



Different kinds of disease symptoms are produced when insect pests are attacked by beneficial microorganisms. For example, the mid-section of a cabbage looper quickly become discolored after it has fed on spores and toxin of the bacterium *Bacillus thuringiensis* (A). The body of a cabbage looper larva is fragile and turns completely black after having been killed by a nucleopolyhedrosis virus (B). In contrast, the body swells, especially at the posterior end, when a cabbage looper larva is infected with the protozoan *Mattesia* (C). The white mycelial growth of the entomopathogenic fungus *Nomuraea rileyi* has invaded the body and completely destroyed this corn earworm larva (D).



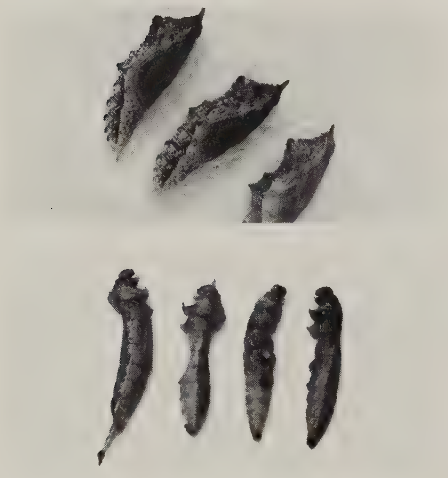
A research technician peers through the magnifier of a colony counter and counts viable fungal spores in an effort to characterize the activity of a potential new microbial insecticide.



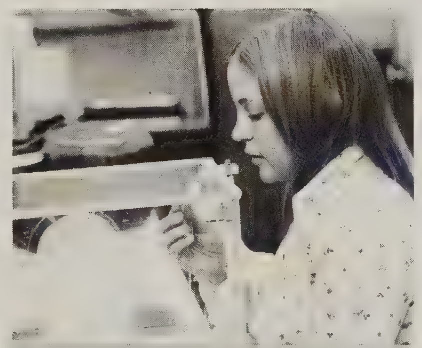
Staining insect tissue for histological studies to investigate how microorganisms cause diseases in insects. The technique delineates the entrance site, infection site, and the progression of disease in the insect.

Environmental Effects on Parasites, Predators, and Pathogens

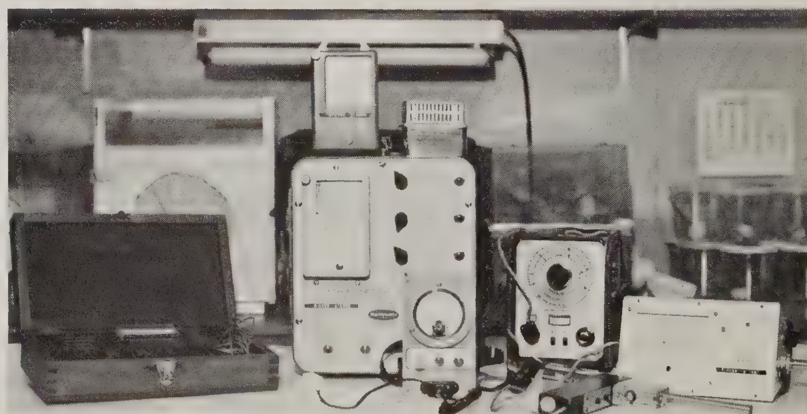
This research project is primarily concerned with evaluating effects of environmental and other factors on biological control agents and the host insects. Specific studies include: (1) the effects of environmental factors on parasites, predators, and pathogens; (2) effects of environmental stress on virulence and transmission of insect pathogens; (3) effects of chemical and microbial pesticides on beneficial insects; and (4) evaluating the use of insect pathogens, insect growth regulators, and pheromones in biocontrol programs.



Pupae of the imported cabbage worm in the upper part of this picture are normal and alive. The individuals in the lower part were treated with an insect growth regulator as larvae and died while transforming to the pupal stage. These chemicals interfere with the normal development of insects.



A research technician collects adults of a parasitic wasp, *Apanteles marginiventris*. These wasps are used to evaluate possible toxicity of chemical and biological pesticides to beneficial insects.

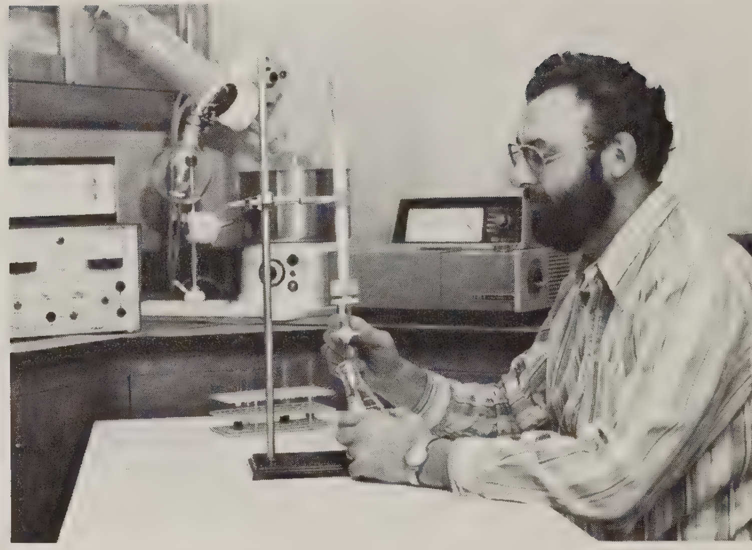


Climatic conditions in the field and in specially constructed cabinets are monitored with automated recording equipment.

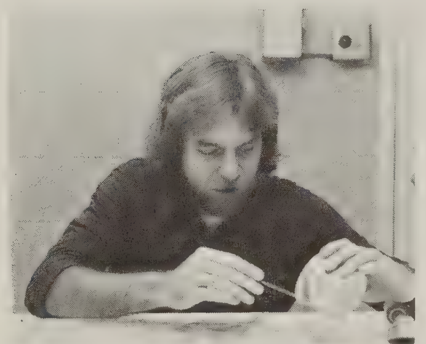
An adult of a beneficial predator, the spined soldier bug (*Podisus maculiventris*), is feeding on a cabbage looper larva, *Trichoplusia ni,* while a group of immature soldier bugs feeds on another larva.

Plants can be protected from damage by using a safe, selective bacterial insecticide (*Bacillus thuringiensis*). Larvae of the cabbageworm, *Pieris rapae,* are serious pests of cabbage and many other related crops.

Host Selection Behavior of Insect Parasitoids and Predators

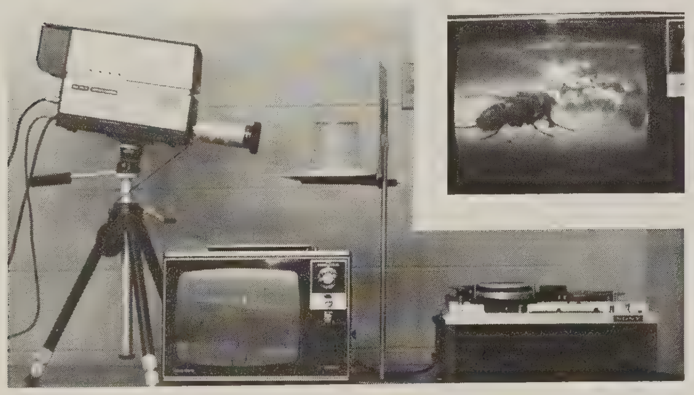


Research in this area focuses on how an insect predator or parasite finds a pest insect. This information is essential to a fuller understanding of predator-prey and parasite-host relationships. It leads to more effective biological control systems and contributes to the rearing of large numbers of beneficial insects. One specific project is the isolation and identification of chemicals which could be used to attract beneficial insects to fields threatened by pest insects.



A research technician collects corn earworm larvae that have been parasitized by a parasitic fly, *Voria ruralis*. (Several colonies of different beneficial insects are maintained for behavioral research studies.)

A beneficial wasp, *Campoletis sonorensis*, attacking the corn earworm. (The wasp is attempting to lay an egg inside the worm.)

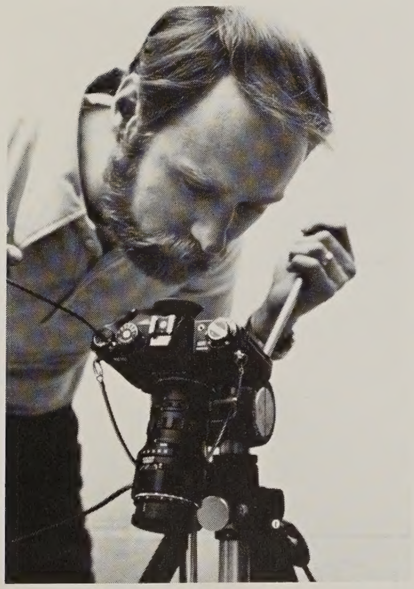


TV is a valuable tool in analyzing insect behavior. Movements of a beneficial parasite, too fast for the human eye to detect, can be recorded and viewed later in slow motion to define each phase of the attack.

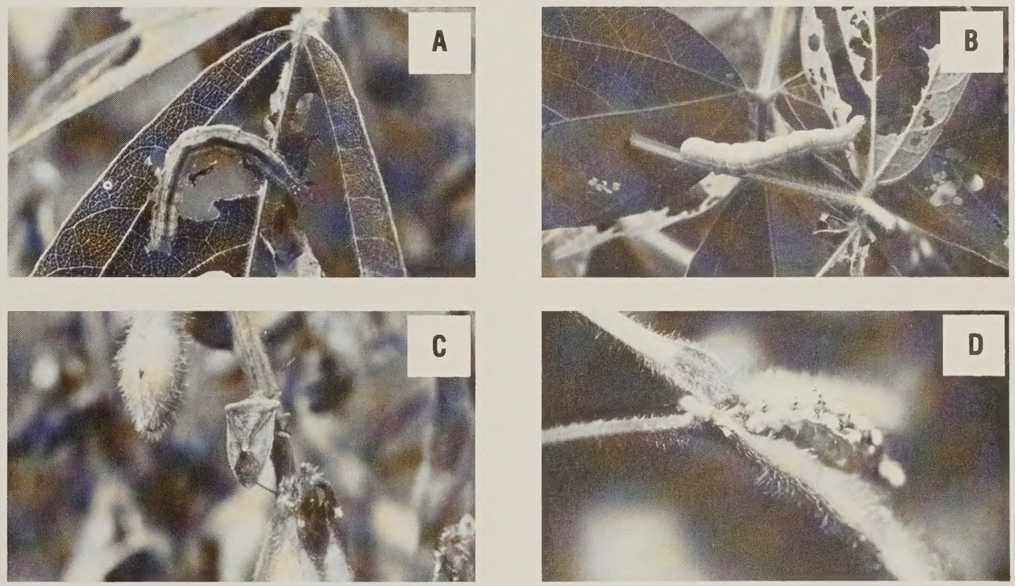
The *Campoletis* wasp is attacking a man-made cotton larva which has been treated with a chemical extracted from the corn earworm.

Population Dynamics of Beneficial and Pest Insects

This project evaluates the effects of environmental factors on insect populations and determines economic injury levels of plants attacked by insect pests. Specific areas of investigation are to: (1) determine economic thresholds using mechanical injury to stimulate insect damage, (2) evaluate the effect of insect pests on yield and quality of the crop, (3) develop efficient sampling methods to estimate beneficial and pest insect populations, and (4) alter the genetic makeup of natural enemies to increase their effectiveness.



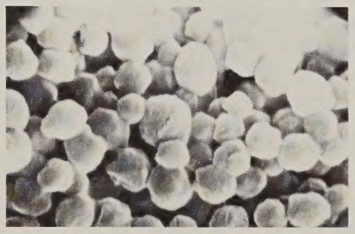
Photography is an important research tool to document insect damage and phenological plant events occurring during laboratory and field experiments.

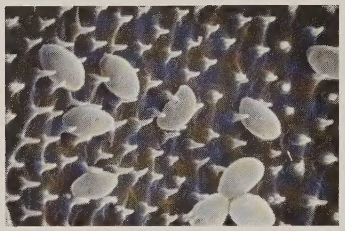
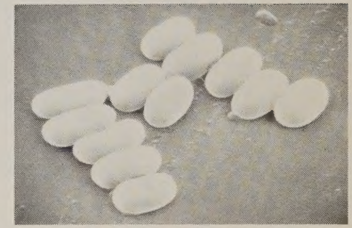


Insects of various kinds can cause damage to plants. The velvetbean caterpillar (A) and cabbage looper larva (B) feed on leaves; a stinkbug rests after piercing several young soybean pods (C); and a corn earworm burrows its head into a soybean pod to feed on the young developing beans (D).

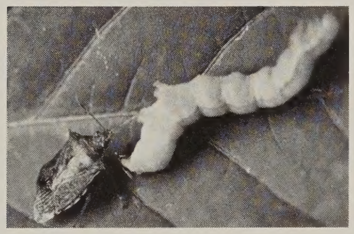
USING NATURE'S OWN

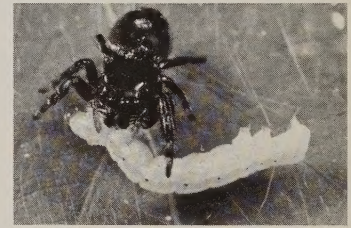
MICRORGANISMS



PREDATORS



PARASITES