REPORT OF THE VIRGINIA
DEPARTMENT OF AGRICULTURE
AND CONSUMER AFFAIRS ON

The Use of Beneficial Insects in Virginia

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

HOUSE DOCUMENT NO. 34

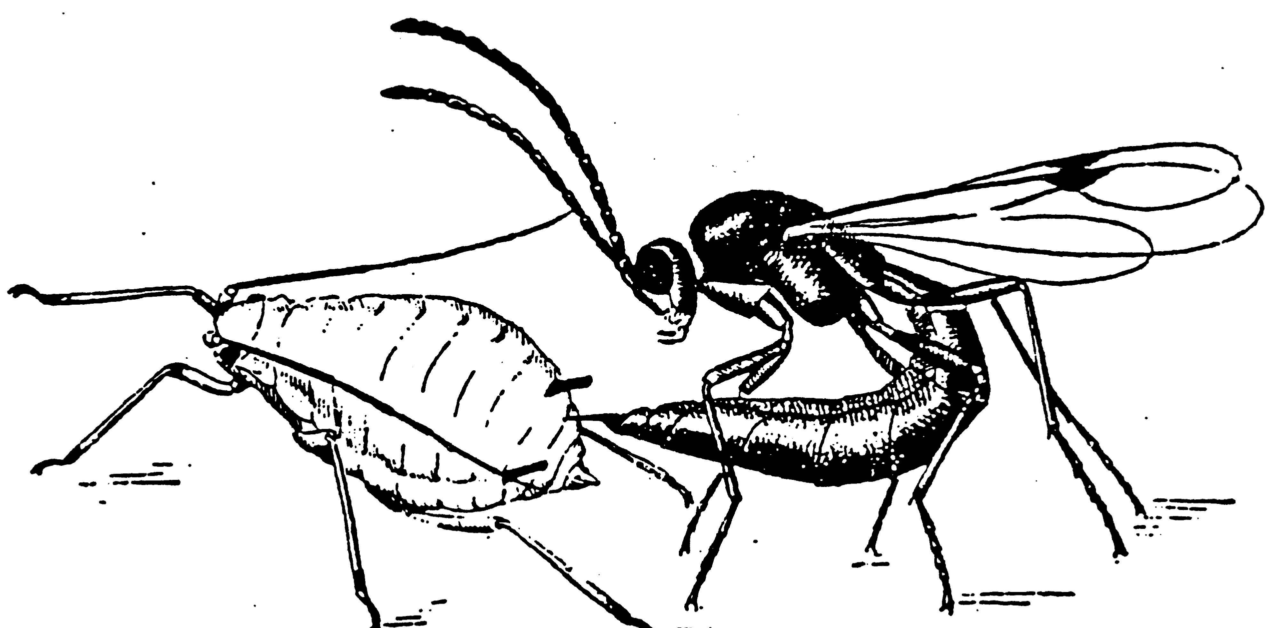
COMMONWEALTH OF VIRGINIA
RICHMOND
1989

The Use of
BENEFICIAL INSECTS IN VIRGINIA

A Study Requested
by the

1988 VIRGINIA GENERAL ASSEMBLY

House Joint
Resolution No. 98



VIRGINIA DEPARTMENT OF AGRICULTURE
AND CONSUMER SERVICES
RICHMOND, VIRGINIA

HP4194510

1988 SESSION
ENGROSSED

HOUSE JOINT RESOLUTION NO. 98

House Amendments in [ ] - February 15, 1988

Requesting the Department of Agriculture and Consumer Services to study expanding the use of beneficial insects for agricultural purposes.

Patrons--McClanan; Senator: Nolen

Referred to the Committee on Agriculture

WHEREAS, the use of beneficial insects reduces the need for chemical pesticide application; and

WHEREAS, reducing the use of pesticides results in a reduced cost to the producer and greater protection of our ground water resource; and

WHEREAS, the use of beneficial insects is a method of pest control that once established is permanent; and

WHEREAS, the use of beneficial insects will result in the establishment of pest control practices that utilize biological agents in lieu of chemical control; and

WHEREAS, more beneficial insects which can be utilized for pest control are being identified, and increased emphasis should be given to this area of pest control; and

WHEREAS, the United States Department of Agriculture and several eastern states are promoting and increasing the use of beneficial insects; and

WHEREAS, the Virginia Department of Agriculture and Consumer Services has been producing and distributing a limited number of beneficial insects for the control of the cereal leaf beetle, gypsy moth, Mexican bean beetle and the musk and curled thistle; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Department of Agriculture and Consumer Services study the use of beneficial insects in agriculture. The study shall consider the potential for expanding the current program, how best to implement such expansion, how to produce and distribute the insects, [from the public and private sector,] and cost estimates for a new beneficial insect program.

The Department of Agriculture and Consumer Services shall report its findings and recommendations to the 1989 Session of the General Assembly.

Official Use By Clerks

Agreed to By The House of Delegates		Agreed to By The Senate	
without amendment	☐	without amendment	☐
with amendment	☐	with amendment	☐
substitute	☐	substitute	☐
substitute w/amdt	☐	substitute w/amdt	☐

Date: ______________________ Date: ______________________

Clerk of the House of Delegates | Clerk of the Senate

P R E F A C E

This report is submitted by the Department of Agriculture and Consumer Services in response to House Joint Resolution No. 98, requesting that the Department of Agriculture and Consumer Services study the use of beneficial insects in agriculture and report its findings and recommendations to the 1989 session of the General Assembly.

Members of the Steering Committee, appointed by Commissioner, S. Mason Carbaugh, to assist in design of the study, provide direction for the study and review the final report, include:

William Metterhouse, Director, Division of Plant Industry, New Jersey Department of Agriculture Trenton, New Jersey

Thomas Burger, Director, Niles Michigan Beneficial Insect Rearing Laboratory, USDA/APHIS-PPQ, Niles, Michigan

Madeline Grulich, Scientist, Environmental Defense Fund, Richmond, Virginia

Alex Hamilton, Director of Public Affairs, Virginia Farm Bureau Federation, Richmond, Virginia

Dr. Geoffrey Zehnder, Assistant Professor/Entomology, VPI & SU, Eastern Shore Agricultural Experiment Station, Painter, Virginia

Donald H. Kludy, State Entomologist & Bureau Chief, Virginia Department of Agriculture & Consumer Services, Richmond, Virginia

F. Raymond Brush, Retired, American Association of Nurserymen Secretary and Director of Technical Services, Madison, Virginia, was retained to assist the Department in the preparation of the report.

Also assisting on the report:

Dr. Peter B. Schultz, Associate Professor/Entomology, VPI & SU, Hampton Roads Agriculture Experiment Station, Virginia Beach, Virginia

John Keeling, Assistant Director of Public Affairs, Virginia Farm Bureau Federation, Richmond, Virginia

John Tate, Assistant Supervisor, Biological Control, Virginia Department of Agriculture and Consumer Services, Richmond, Virginia

C O N T E N T S

RECOMMENDATIONS

1) The committee supports the need for the development and expansion of the biological control component of Integrated Pest Management in the Commonwealth of Virginia as a means of addressing environmental concerns and decreasing the proliferation of chemical use as well as production costs.

2) The committee recommends that the 1989 General Assembly appropriate $160,000 for site analysis and planning for a beneficial insect rearing facility.

3) The committee further recommends that sufficient monies in F.Y. 1990 be appropriated to construct and operate a beneficial insect rearing facility sufficient to meet current and future needs in support of biological control programs.

4) The committee recommends that The Virginia Department of Agriculture and Consumer Services cooperate with private industry and governmental agencies in the development of its biological control programs.

EXECUTIVE SUMMARY

The expansion of government's role in biological control activities is both appropriate and warranted as a means to reduce pesticide use in urban and rural communities, reduce production cost, improve the competitiveness of Virginia farmers in national and international markets, and reduce environmental contamination of Virginia's land, streams, groundwater, and the Chesapeake Bay.

Despite the fact that over five million pounds of pesticides (active ingredients) are applied in Virginia each year, Virginia producers still suffer losses of approximately 300 million dollars yearly due to plant pests. Rather than employ a single control tactic (chemical), the coordinated use of multiple control tactics, known as Integrated Pest Management (IPM) is used by the growers to keep pest populations below damaging levels.

Among the pest control strategies utilized in an IPM system, biological control has the greatest potential for further development; however, the current facilities which house the Virginia Department of Agriculture and Consumer Services' (VDACS) biological control programs were not designed for that use and are inadequate for a major biological control effort. New facilities and program staff are essential if present programs are to be upgraded and expanded, and new programs implemented. Currently, VDACS is involved in biological control of the musk and curled thistle, Mexican bean beetle, cereal leaf beetle, Japanese beetle, and gypsy moth. A state biological control facility would give the Commonwealth the opportunity and ability to establish additional

biological control programs for corn earworm, multiflora rose, European corn borer, white peach and euonymus scale, Colorado potato beetle, oriental fruit moth, spider mites, tobacco budworm, house and stable flies, and spotted knapweed. Its central location and proximity to major crop growing and urban areas caused the steering committee to favor the Richmond area as the proposed laboratory site.

Commercial laboratories, universities, and state and federal laboratories all have a role to play in biological control programs. The universities provide basic research and distribute information through the Extension Division. The state or federal laboratories develop mass rearing techniques, field test and implement the biological control programs, demonstrate the economic feasibility and environmental compatibility of biological control strategies, and provide insects for research. Commercial laboratories can produce and distribute biological agents when economically feasible or profitable to growers or special interest groups after the control agents have been proven effective.

The United States Department of Agriculture, Agricultural Research Service (USDA-ARS) is the lead federal agency which locates, imports, and screens potential biological control agents. ARS currently maintains overseas laboratories for the collection of natural enemies and forwards them to quarantine facilities in the United States. The USDA Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ) maintains biological control laboratories in Niles, MI; Bozeman MT; and

Mission, TX. These laboratories are used to rear biological control agents for use in cooperative federal and state suppression programs of weed and insect pests.

The states of Arizona, California, Colorado, Florida, Hawaii, Maine, Maryland, Michigan, New Jersey, New York, North Carolina, Oregon, South Dakota, and Wisconsin currently conduct biological control programs. Arizona, California, Colorado, Florida, Hawaii, Maryland, New Jersey, and North Carolina have biological control facilities. North Carolina and Colorado, like Virginia, seek to expand their biological control facilities.

WHY BIOLOGICAL CONTROL IS NEEDED

Between 1982 and 1984 an average of 2,879 tons of active ingredients of pesticides were applied annually to cropland in Virginia. This figure does not include the tons of pesticides applied annually by homeowners, nurseries, and other pesticide users in the Commonwealth. Even with the use of pesticides Virginia producers still lost crops valued at $300 million. Losses would have increased to an estimated $1 billion without chemical control.[1] Clearly, the use of chemical controls has benefited the Commonwealth.

Unfortunately, despite their usefulness, pesticides are also associated with environmental contamination, long term public health effects, adverse impacts on non-target organisms including mammals and aquatic species. Target species have demonstrated time and again an amazing ability to adapt to and resist pesticides. In 1982, Virginia farmers spent 41% more for pesticides to treat 5% more acres than in 1978. Also, due to the adverse effects of pesticides, the Environmental Protection Agency has made it more difficult to register new pesticides and many of those currently registered are being withdrawn from the market. These factors are forcing reevaluation of our use of chemicals to control pests.

Rather than continuing to employ a single control strategy, the coordinated use of multiple control tactics or Integrated Pest Management (IPM), is gaining acceptance as an economically, environmentally sound, effective pest control strategy. An IPM system allows for a wide selection of pest control strategies which include cultural controls, chemical use and biological agents. Among the pest control strategies of an IPM system, the strategy with the most potential for further development is biological control.

Biological control agents such as beneficial insects pose little or no threat to the environment. Unlike pesticides, these agents do not contribute to the pollution of our streams, rivers, lakes, ground water, or coastal waters. Air quality is unaffected and there are no adverse effects on humans and non-target animals. Beneficial insects can be economically raised and distributed. Pest species rarely develop a resistance to a beneficial insect. Once established, the control is permanent, and producers and consumers save as pesticide use is reduced.

To reduce the dependence on pesticides, the Commonwealth of Virginia should promote the use of biological controls as an alternative to the chemical control of pests. Reduced use of pesticides is consistent with the objectives of the Chesapeake Bay Agreements and the improvement of environmental quality throughout the state. The benefits of biological controls accrue not only to pesticide users but to all citizens for generations to come.

THE ROLE OF PRIVATE AND PUBLIC SECTORS IN BIOLOGICAL CONTROL

The opportunity for the current and future use of biological agents is enormous. To maximize the efficiency and effectiveness of biological control programs, the public and private sectors must cooperate in their efforts. Participation of legitimate and reputable commercial companies that produce biological agents for the control of pests should be encouraged by the Commonwealth.

Commercial laboratories belong in the biological control programs as do the universities and the state and federal laboratories. Universities provide necessary basic research on the effectiveness of biological agents as well as the economic evaluation to measure the success or failure of a program. State or federal laboratories develop mass rearing procedures and demonstrate to producers the economic feasibility and environmental compatibility of biological agents to control pests over a wide area. Commercial laboratories have a unique role in that they can produce and distribute successful biological agents directly to producers or special interest groups after the agents have been proven economically effective. When commercial laboratories produce effective and viable natural enemies for sale to the public in sufficient quantities, public laboratories will have more opportunity to work on the identification and rearing of other biological control agents.

The Department has, in the past, provided material and information to private laboratories and to universities; however, the demand for parasites from the private sector has been variable due to severe annual fluctuations of the pest populations and the fact that orders for parasites must be placed several months prior to appearance of the pest. Private laboratories need a reliable and stable demand for their product; however, most growers or users prefer not to purchase a product until there is a need, and then, only when proven to be economically or environmentally beneficial to them.

Past dealings with commercial laboratories by the Department and other agencies have revealed problems which must be addressed to insure a successful program and a quality product. These problems include excessive claims and exaggerations regarding the effectiveness of biological agents, biological agents of poor quality or predominately males, and the unreliability of commercial laboratories as a supplier of biological agents.

A Review of the Biological Control Program of the Virginia Department of Agriculture and Consumer Services conducted in 1984 by Dr. Peter B. Schultz states: "To rely solely on commercial enterprise brings the risk of reduced effectiveness due to fluctuations in supply and demand, etc. ......The expenditure of state funds for biological control is certainly justified, as the reduced use of pesticides benefits all citizens of the Commonwealth. Biological control programs have a very low potential for financial success for commercial enterprise. An effective parasite introduction would not require re-introduction after establishment. Private enterprise would be most likely to succeed in a situation of a widespread pest problem that requires a continuous flow of easily mass produced parasites. The state should not compete with the private sector, but rather, it should utilize its resources to produce effective parasites which, for economic or scientific reasons are not available on a commercial basis."[2]

OVERVIEW

A) VIRGINIA'S OFFICIAL POLICY TOWARD THE ENVIRONMENT

The state of Virginia's increasingly strong stand on environmental matters was heightened by Governor Baliles in his inaugural address on January 11, 1986. He emphasized the importance of environmental conservation with these words: "We serve as trustees of our resources of air, land and water. They are ours to use -and enjoy- while we are here on earth, but we must recognize certain limits, respect the conservation ethic and resolve that the legacy we leave to future generations is not one of despoiled air, toxic waste, contaminated lands and polluted waters."[3]

In his address to the General Assembly on Monday, January 13, 1986, he emphasized the importance of the continued well-being of Virginia's agricultural and forestry industries. In regard to natural resources he stated: "We know that our land is finite, and the air and water vulnerable. By your actions you have made preservation of our natural resources one of our clear priorities. I'll work with you to keep it there." In further explanation he clearly indicated one of the top priorities in this area would be continued efforts toward restoration of the Chesapeake Bay.[4]

In a written statement submitted to the U.S. Senate Subcommittee on Governmental Efficiency and the District of Columbia dated June 24, 1986, the Governor reaffirmed his interest in expanding the Commonwealth's efforts to help restore the Bay. He indicated the Commonwealth had initiated programs called the Chesapeake Bay Initiatives which were funded in the 1984-86 budget. The 1986-88 budget was increased for these activities. Included in these activities were programs to reduce the runoff from agricultural land through a combination of cost - share grants and education efforts designed to encourage farmers to use "Best Management Practices." He further stated: "We also urge citizens to do what they can both collectively and as individuals, to help clean up the Bay by actions in their homes, on the farm and at work."[5]

The Future of Virginia Agriculture Studies Subunit Pests, Pesticides and Pest Management committee final report included the following statement:

> "Agricultural pest management is based on an integrated pest management (IPM) concept which has been extremely valuable in optimizing the use of pesticides in crop and animal production. IPM integrates an array of control practices, including cultural, biological, and chemical into comprehensive crop and animal management strategies which maximize economic returns while minimizing undesirable environmental impacts. The practice of IPM often results in an overall reduction in pesticide usage; however, the concept stresses the optimization of pest control. Existing agricultural pest management programs in Virginia have significantly improved the profitability of crop production through management practices and reduction of pesticide applications. The expansion of existing programs, the development of new programs, and implementation of new IPM strategies will greatly enhance the profitability of Virginia's agriculture as well as reduce or eliminate undesirable environmental impacts."

The report's recommendation further states: "Virginia should place major emphasis on the development of agricultural and suburban pest management systems that are economically sound, integrated with the best production practices, and in the long-term interest of the public and the environment."[1]

The Future of Agriculture, Forestry, Food Industries, and Rural Communities in Virginia states: "Some specific research thrusts have been identified that may result in decreased reliance on agricultural chemicals. For example, Integrated Pest Management (IPM) research and extension programs should be expanded to encompass all major pests affecting the production of major crops in Virginia.......In particular, biological control of pests must be better supported in the Commonwealth."[6]

In the August 1988 publication *Virginia Nonpoint Pollution Management Plan* the Virginia Department of Conservation and Historic Resources, Division of Soil and Water Conservation stated that a goal for agriculture is to "implement effective nutrient (both fertilizer and animal wastes) and pesticide management programs by 1990 such that use of these products is managed to optimize benefits and reduce potential for water quality impacts." Among the recommendations to achieve this goal, the report recommended that the Department of Agriculture and Consumer Services "research beneficial insect pest management potential by promoting the development of an insect breeding facility in Virginia."[7]

A VDACS objective is to encourage alternatives to the use of chemicals. In concert with Virginia Polytechnic Institute and

State University (VPI & SU), the Department strongly endorses Integrated Pest Management to Virginia citizens. In cases where pests are a threat to large geographical areas of the Commonwealth and control is beyond any individual landowner, the Department has assumed the leadership in the use of biological control agents to reduce the pest population density to below economic levels. The Department cooperates with USDA, VPI & SU, Virginia Farm Bureau Federation as well as other farm and citizen groups in implementing biological control programs. USDA support is in the form of dollars, manpower, technical guidance and biological control agents. VPI & SU provides research, technical information on use, assistance in the distribution of available biological control agents, and information to the citizens of the Commonwealth on biological control programs.

B) CROP LOSS

The 1986 report by <u>The Future of Agriculture Studies Subunit Pest, Pesticides and Pest Management</u> committee states: "Agricultural pests, including insects, mites, pathogens, and weeds, cost Virginia farmers more than $300 million annually in crop and animal losses in addition to the more than $175 million spent annually for purchase and application of pesticides. Fungicides, herbicides, insecticides, miticides, and nematicides are used extensively in an effort to alleviate losses, which would be in excess of $1 billion annually if no pesticides were used."[1]

The USDA suggests the estimate of $300 million annually in crop and animal losses may even be low. The Department's estimate of pest losses, in cash receipts for crops alone, is estimated at better than $275 million annually. This estimate is based on the assumption that despite the use of pesticides there is an average annual loss in cash receipts for crops due to pest injury equal to 33% of the potential cash receipts. The estimated 33% loss breaks out as 12% due to insect damage, 11% to diseases and 10% to weed competition. The breakout by crops for the 1978-87 ten year average is shown in Table 1.

C) PESTICIDE USAGE

Estimate of pesticide usage from the 1982 Census of Agriculture, Table 2, lists the five general classes of pesticides: insecticides, nematicides, fungicides, herbicides and defoliant and growth control chemicals. For each of these five groups the data shows the number of farms and the acreage in those farms treated in both 1978 and 1982. The number of farms using pesticides decreased for all classes of pesticides except fungicides. The acreages treated increased for all classes of pesticides except nematicides. The total number of acres treated increased 5% in 1982 over 1978. The decrease in number of acres treated with nematicides was the result of several nematicides having been taken off the market.

The 1982 census also indicates that Virginia farmers reported having spent $50.3 million for pesticides in comparison to $35.6

million reported four years earlier in the 1978 census. In 1982, farmers in Virginia spent 41% more for pesticides to treat 5% more acres. The continuing increase in cost of pesticides is a strong incentive for agriculture both to use pesticides more efficiently and to find other means of pest control which are more economical.

An estimate for the actual acreage treated and the pounds of active ingredients applied in Virginia was obtained from Resources for the Future, a private non-profit, nonadvocacy research organization that specializes in studies of natural resource issues. The information provided estimates that 5,757,883 pounds of active ingredients of pesticides were applied to 4,506,262 acres each year between 1982-1984, Table 3. The averages stated were assembled from publicly available reports released by state governments, USDA, and U.S. Environmental Protection Agency and through contacts with the Cooperative Extension Service.[8]

COST BENEFITS

The expansion of government into biological control activities is appropriate and warranted. The use of such programs which reduce pesticide use in urban and rural communities, reduce production cost, improve the competitiveness of Virginia farmers in national and international markets, and reduce the environmental contamination of Virginia's land, waterways, groundwater, and the Chesapeake Bay is justified. The benefits of biological control in terms of decreased environmental contamination are now recognized by both the agricultural community and the public.

Agriculture in Virginia applied in excess of 5,757,000 pounds of pesticides (active ingredients) on 4,500,000 acres of Virginia crops in the average year 1982 - 1984. Crop losses of nearly $300 million occurred even though 4.5 million acres were treated. If no pesticides were applied, the crop losses in Virginia would exceed $1 billion annually.

<u>BENEFITS OF VIRGINIA BIOLOGICAL CONTROL PROGRAMS</u>

<u>SOYBEANS:</u>

A study by Edwin G. Rajotte, Harry S. Baumes Jr., Robert M. McPherson, and W. A. Allen published in 1985 states: "It is estimated that pest management would have cost soybean producers in Virginia $3.7 million under traditional chemical regime, but the cost would be significantly reduced to only $430.7 thousand under the IPM program....Therefore, Virginia producers would grow soybeans at less cost but receive the same price as producers in other states."[9] During 1979 and 1980 Mexican bean beetles (MBB) reached defoliating populations in the Northern Neck of Virginia. The populations were so high in some areas that migrating beetles falling into the Chesapeake Bay were washing up in large numbers along the shore.

A cooperative Mexican bean beetle biocontrol demonstration project was undertaken in 1980 with the USDA, New Jersey, Maryland, Delaware and Virginia. The goal was to demonstrate and evaluate biological control of MBB using releases of the parasite, *Pediobius foveolatus*. Since completion of the demonstration program, the Mexican bean beetle has not been a serious pest of soybeans. Since the parasite does not overwinter in Virginia, it has been necessary to continue rearing and making annual releases to insure that MBB populations are kept in check and do not reach the proportions that they reached in 1979-80.

SMALL GRAINS:

The small grain acreage sprayed for cereal leaf beetle (in Virginia) decreased from 62,768 acres in 1982 to 19,950 acres in 1985 as follows:

1982	-	62,768 acres
1983	-	44,110 acres
1984	-	19,340 acres
1985	-	19,950 acres

The reduction in acreage sprayed from 1982 to 1985 can be partially attributed to the distribution and establishment of cereal leaf beetle parasites. The reduction in the acreage sprayed resulted in a savings of $428,000.00 to the small grain grower in 1985 (1982 acreage sprayed - 1985 acreage sprayed X $10.00/acre treatment).

PASTURES:

There is no study relating to the reduced acreage sprayed for thistle or to the monetary savings resulting from biological control programs; however, thistle weevils were recovered during 1988 in the Shenandoah Valley and Northern Virginia. The Department treated a total of 1,229 acres in five counties under the musk and curled thistle law currently in force in those counties. The thistle populations in some areas of Southwest Virginia are showing increased stress. Thistle populations in fields used as collection sites have declined dramatically, to the point that they are no longer used for collection sites due to low thistle populations.

HARDWOOD FOREST:

Gypsy moth evaluation is conducted to determine the establishment of released parasites and to determine economic or monetary benefits derived from parasite releases for gypsy moth in Virginia. The parasites have their greatest effect after the gypsy moth populations have reached defoliating levels and the populations have collapsed. A collapse of the overall gypsy moth population has not occurred in Virginia to date. The evaluation has resulted in the recovery of several of the introduced species of parasites as well as the identification of numerous native parasites.

COST BENEFITS FROM OTHER STATES AND USDA:

COLORADO:

The Colorado Department of Agriculture is supplying a parasitic wasp for peach growers to place in their orchards. When released, the wasp seeks out and parasitizes larvae of the oriental fruit moth giving an entire season's control of the moth.

Colorado alfalfa growers are saving up to $3.5 million per year in chemical cost by the use of alfalfa weevil parasites. In addition to the savings in pesticides and application costs, the growers are reducing the pesticide pressures on the environment.

Colorado estimates that a new beneficial insect rearing laboratory plus additional full-time personnel would result in pest control cost savings in excess of $13 million over five years.

MARYLAND:

The Maryland Department of Highways estimates biological thistle control has reduced their thistle pesticide usage by 90%. Because of this savings, $100,000 is transferred annually from the Department of Highways to the Maryland Department of Agriculture for continued biological control.

Maryland has found that the parasitic wasp, *Pediobius foveolatus*, has saved soybean growers on the lower eastern shore $1.5 million per year from reduced cost of production and yield loss due to Mexican bean beetle damage.

CALIFORNIA:

Biological control of St. Johnswort (Klamath weed) saved California farmers $3.5 million annually from 1953 -1959.[10]

NEW JERSEY:

The use of the parasitic wasp, *Edovum puttleri*, in addition to strategically timed sprays of insecticides, has obtained nearly 100% control of the Colorado potato beetle in eggplant fields. Although the Department was not able to obtain a cost benefit figure, the increase in percentage of marketable eggplant fruits again makes eggplant an economic crop for New Jersey vegetable growers. They also report that ladybird beetles and other natural enemies of the Colorado potato beetle are now more common in the eggplant fields under biological control.

In 1987, biological control programs were estimated to have saved New Jersey agricultural and forestry producers just under $5 million in reduced pesticide cost. An explanation is to be found in Table 4. New Jersey's modern 21,000 sq. ft. beneficial insects rearing laboratory, completed in 1984, has enabled the state to greatly expand its control activities.

UNITED STATES DEPARTMENT OF AGRICULTURE/ANIMAL PLANT HEALTH INSPECTION SERVICE-PLANT PROTECTION AND QUARANTINE (USDA/APHIS-PPQ):

USDA/APHIS-PPQ cooperative programs, in which Virginia has participated or is currently participating, are showing substantial savings. A list of USDA/APHIS-PPQ National Biological Control Program current and completed programs, as well as the states involved, is to be found in Table 5. The alfalfa weevil program is saving $50 million a year in twelve states. The cereal leaf beetle program is saving $14 million annually in 17 states.

A major component in the use of biological control, in addition to the monetary savings, is the reduction in the pounds and/or gallons of pesticide released into the environment. Any reduction in the application or use of pesticides benefits not only the producer but also the public, due to less environmental pollution.

POTENTIAL FOR EXPANSION OF EXISTING PROGRAMS IN VIRGINIA

Since VDACS initiated its first biological control program in 1940, there has been considerable scientific progress in biological control. In the past 48 years, the Department has increased its service to the Commonwealth in this important area. The current study has enabled the Department to look at what other states are doing to compare its current program with their programs.

Table 6 lists the biological control programs of Virginia plus those of 18 other state Departments of Agriculture and Agriculture Canada (the Canadian Department of Agriculture). From those states which responded with the number of species of biological control agents they have released and the number which have become established, the Department can evaluate additional biological control agents to use in expanding the existing programs.

In both the cereal leaf beetle and Mexican bean beetle programs, there is one additional natural enemy that has proven satisfactory in other states which should be tried in Virginia; *Anaphes flavipes* for cereal leaf beetle and *Uga menone* for Mexican bean beetle. In the alfalfa weevil program, *Anaphes luna* and *Anaphes pratensis* may be considered. In the musk and curled thistle program, Dr. Kok at VPI & SU has been in contact with weed researchers in Canada and other states and has new information on additional agents to try in Virginia. In the gypsy moth program, both North Carolina and Virginia are interested in re-examining some of the natural enemies that were tried in years past in the New England area but which failed to establish there. The climate in these two states is milder than New England and more comparable to the climate in some other countries of the world where gypsy moth exists but is kept under economic control by natural enemies.

The existing Japanese beetle program should be expanded into the concept of a white grub complex program to include, in addition to Japanese beetle, May beetles and other soil grubs which are pests of pastures, lawns, golf greens and reproduction nurseries. The program expansion would be through the introduction of parasitic nematodes.

The Colorado potato beetle program has potential for expansion through two new agents; *Lebia spp.*, a predator beetle and *Chreyeo labdidonerae*, a parasitic mite. The techniques of using these are in the late stage of development with experimental introductions in Rhode Island to be made in 1989. Also, the augmentation of native parasites or predators should be carefully examined.

POTENTIAL FOR NEW BIOLOGICAL CONTROL PROGRAMS IN VIRGINIA

In examining the potential for new biological control programs in Virginia, factors considered were: (1) the impact of the pest on crop production in Virginia, (2) whether natural enemies of a given pest have cleared USDA screening, and (3) the current availibility of information for the biological agent being considered.

Information on cash receipts by crop or crop group and animal and animal products is shown in Table 7. Also, in Table 8 is the list of the number of species of natural enemies which have been cleared for use by the USDA Beneficial Insect Introductory Laboratory in Newark, Delaware. In the case of nursery and greenhouse crops, the additional factor of quarantine or special regulation to prevent the artificial spread of hazardous pests must be considered. Special regulations are in effect in all states for this group of plants because the whole living plant is moving in commerce. Consequently, the potential for inadvertently moving hazardous insects and diseases is greater than with other crops such as fruits, vegetables or grains.

To date very little has been done in biological control activities for Virginia's livestock and poultry enterprises with the exception of thistle control in pastures. Sixty-one percent (61%) of Virginia's agricultural sales are from sales of livestock and poultry according to the 1982 Census of Agriculture. One of the serious problems with livestock and poultry enterprises is flies which breed and live in the manure. Flies are also problems in residential areas adjacent to animal enterprises. Contacts made with other state Departments of Agriculture revealed that both New York and Florida have extensive biological control programs for house and stable flies. These flies may be likely candidates for a new program.

Heliothis spp. are serious pests of several important Virginia cash crops. Tobacco budworm is one of these and continues to be a serious pest of tobacco, Virginia's leading cash crop. A closely related species known by different names, corn earworm, bollworm, and tomato fruitworm, is a serious pest of corn being grown for grain. Virginia's second leading cash crop. This same species (Heliothis zea) is a serious pest of garden crops such as sweet corn and sometimes tomatoes. It was because of such a pest of cotton that most Virginia farmers discontinued growing cotton until an intensive IPM program in early 1980 brought it under control.

Another candidate pest for a new program would be European red mite. This is primarily a pest of fruit crops that attacks apples and pears. Apples are the primary income producing fruit in the crop grouping "fruits, nuts, and berries" in Table 7.

Virginia's nursery and greenhouse plant production, especially the nursery plant portion, is on the increase. In Table 7, nursery and greenhouse crops account for at least 3% of Virginia's agricultural sales. Biological control programs for the control of Euonymus scale has shown promise in other states.

Because of the importance of corn in Virginia; for grain, for silage and for the table (sweetcorn), a biological control program for European corn borer may be warranted.

Spotted knapweed is a relatively new pest in Virginia found only recently along I-81 in southwestern Virginia. This weed has been a serious pest in Oregon, Washington, Idaho and British Columbia. Its primary avenue of spread appears to be transportation routes. Early efforts to control this pest and prevent its rapid spread throughout the state appear worthwhile. States in the Northwest, as well as British Columbia, Canada, have indicated that biological control programs implemented there are very beneficial.

Other pests which warrant consideration at some future time as additional biological data becomes available are imported cabbageworm, coddling moth, white peach scale, multiflora rose, dark sided cutworm, brown stinkbug and southern green stinkbug.

The Department obtained from USDA, ARS Beneficial Insect Introduction Laboratory in Newark, Delaware, a list of imported natural enemies of 23 common pests in Virginia. Table 8 indicates the number of natural enemies imported and cleared for use as biological agents, the number of states to which the biological agents have been shipped, and the number of species which have been released by those states. This is another indication of the potential for expansion of biological control activities in the Commonwealth.

FACILITY JUSTIFICATION

The 1984 report, A REVIEW OF THE BIOLOGICAL CONTROL PROGRAM OF THE VIRGINIA DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES, by Dr. Peter B. Schultz, Associate Professor, VPI&SU, states the facilities occupied by the Virginia Department of Agriculture and Consumer Services "are adequate for a minimal biological control effort.......New facilities are mandatory for rearing gypsy moth primarily due to associated occupational allergies." The report further states: "The construction of new facilities for biological control is essential for the upgrading of the present program and flexibility in adjusting to meet the needs of pests not yet established in Virginia and/or pests for which biological control is still under study.........Present facilities have limited room for expansion."[2]

The Virginia Department of Agriculture and Consumer Services' biological control activities are currently housed in two separate facilities located at the Hampton Roads Agriculture Experiment Station in Virginia Beach and at the Consolidated Laboratories in Richmond. Land for a field insectary is leased from Mobil Oil Company in Hanover County.

The laboratory space in the Consolidated Laboratory Building, Richmond, was designed during the mid-1960's as a diagnostic facility for plant disease and insect identification. The laboratory space is inadequate, both in the amount of space, as well as, the design for the rearing of biological control agents.

The space utilized at Virginia Beach includes a basement laboratory and one-half of a greenhouse at the Hampton Roads Agriculture Research Station. In addition to being an aging facility designed for research, it has the same space, design and environmental constraints as the laboratory in Richmond.

The biological control facilities are now located in either a research facility or a laboratory facility containing analytical equipment used in forensic, pesticide, residue, and food laboratories.

They were never designed for the purpose for which they are being used. Some of the deficiencies are as follows:

Environmental conditions (light, temperature and humidity) that are essential for the rearing of biological agents cannot be regulated or maintained. Because of the large open rooms, it is impossible to keep insect colonies free of disease.

A quarantine room to isolate field collected host material and biological control agents is needed. Neither facility at Richmond or Virginia Beach has the capability to isolate or quarantine field collected material.

Greenhouse facilities for the culture host plants are needed. There is no greenhouse facility at Richmond. Greenhouse space was planned in Richmond at the time the Consolidated Laboratory was constructed, but the greenhouse was not built due to monetary constraints. Limited greenhouse facilities are available at Virginia Beach; however, the greenhouse is obsolete with limited controls to maintain proper environmental conditions.

Laboratories must have smooth walls and ceilings. The walls of both laboratories are cinder block and, therefore, provide places for accumulation of dust and other contaminants, which may harbor diseases that can affect the laboratory colonies.

There is a potential for accidental deaths to beneficial insects due to pesticide testing being conducted across the hall from the rearing rooms in the Richmond Laboratory.

The basic equipment that is necessary for a successful biological control program that is lacking at both facilities include:

Walk-in environmental rooms

Walk-in freezer of cold storage boxes

Steam generator and cleaning equipment

Central monitoring and alarm system

Electrostatic, spun glass, and charcoal filters in duct work

Drying ovens

Exhaust fans and hoods

Maintaining proper temperature, humidity and ventilation is of the highest priority in the rearing of biological agents. Both VDACS facilities have heating and air conditioning systems that are central for the entire building. Adequate individual controls are lacking for the rooms and there is no way to regulate the relative humidity at either facility.

ALTERNATIVES CONSIDERED FOR EXPANDING PROGRAM

A) LEASE, RENOVATE, OR CONSTRUCT A NEW FACILITY

Lease laboratory space:

The state could have a laboratory constructed to specifications for lease to the state. The long term cost of this alternative would likely be higher than outright ownership.

Another alternative would be to lease existing space. Laboratory space to meet the requirements for the rearing of biological agents is not available in Richmond or in the state, especially with the land requirements for an insectary and a greenhouse. Facilities could be modified to specifications, but the cost of the renovation would be amortized during the term of the lease.

Renovate existing facilities:

As previously stated, the current facilities were not designed for the purpose for which they are now being used. To renovate these facilities would cost in excess of $500,000 for the Richmond laboratory and in excess of $100,000 for the Virginia Beach laboratory. Even then, production will remain the same or increase only slightly due to space limitations.

Construct a new facility:

Based on an analysis of the alternatives, construction of a biological control rearing facility is an economical alternative to support statewide biological control activities and to carry out the objectives of VDACS. Construction of a 20,000 sq. ft. rearing facility and greenhouses that would house 21 full time employees could assure that VDACS would provide the most efficient production of biological agents for the control of pests in Virginia. This would reduce the amount of pesticides introduced into the environment and reduce the cost of production for farmers.

B) FACILITY LOCATION

The clientele of the biological control laboratory will come from all areas of the state. A location within close proximity major urban and agricultural areas of the state is important for the agency to conduct its work efficiently. There should be easy access to a major highway system because much of the work at the lab is done in conjunction with other states or federal agencies. Also, the site should be close to a major airport, to allow for prompt shipping and receiving of intrastate and international shipments.

<u>LOCATIONS CONSIDERED</u>

<u>Southwest:</u>

The Southwest area of the state, although in close proximity to a major highway system and the state land grant university, is removed from the major agricultural and urban areas of the state.

<u>Tidewater:</u>

The Tidewater area of the state, although in a major urban area with a major interstate highway and airport, is not centrally located to the state's agricultural areas.

Central:

From the point of convenience, cost, production, efficiency, availability and adequacy of land, proximity to I-95, I-64 and I-295, central location within major urban and agricultural areas, and proximity to Richmond International Airport the laboratory facility could be built on the state-owned Elko tract in Eastern Henrico County. The 1988 land use plans for development of the Elko tract recommend that the Department be appropriated land for the construction of laboratories. The construction of the biological control laboratory would allow the Department to vacate space in the Consolidated Laboratory building that is needed by the Department of General Services, Division of Consolidated Laboratory Services.

A new laboratory as proposed will ensure that the people of the Commonwealth are provided with biological control agents as they are discovered and determined suitable for distribution. The new facility would provide for the production and distribution of numerous new or different species. With approved quarantine facilities, direct shipments could be received from foreign countries for evaluation and rearing, thus reducing the time from introduction to release from 4 to 6 years to 1 or 2 years.

STATISTICAL AND TABULATED INFORMATION REFERENCED

TABLE 1

AVERAGE ANNUAL VALUE OF VIRGINIA CROP PRODUCTION
1978-1987 and Estimated Loss in Production
Caused by Insect, Disease, and Weed Pests

Virginia Crops	Average Crop Cash Receipts 1978-1987 ($1,000)	Estimated Cash Receipts Lost Due to Pests ($1,000)
Food Grains (wheat etc.)	$ 31,557	$ 15,543
Feed Crops (barley, corn, hay)	$ 73,016	$ 35,963
Cotton	$ 202	$ 99
Tobacco	$174,439	$ 85,918
Oil Crops (soybeans/peanuts)	$147,396	$ 72,598
Vegetable Crops	$ 46,369	$ 22,838
Fruits, Nuts & Berries	$ 50,897	$ 25,069
Nursery & Greenhouse	$ 40,718	$ 20,055
All Other Crops	$ 870	$ 429
Total 10 Year Average	$565,464	$278,512

Ten year averages derived from annual cash receipts for Virginia crop groupings reported by Economic Research Service, USDA.

TABLE 2

THE 1978 AND 1982 CENSUS DATA ON VIRGINIA CROP ACREAGE TREATED WITH PESTICIDES

Sprays, Dusts, Granuler, Fumigents, Etc.

To Control:	Farms 1978	Farms 1982	Acreage Treated 1978	Acreage Treated 1982
Insects on hay & other crops	13,349	11,781	668,559	731,928
Nematodes	5,325	3,802	191,363	163,290
Diseases in crops and orchards	2,682	4,311	132,632	143,271
Weeds, grass and brush in crops and potatoes	2,400	1,498	1,207,034	1,276,528
Chemicals for defoliation or for growth control of crops or thinning of fruit	2,536	2,152	70,253	87,325

1982 Census of Agriculture (AC 82 - A-51)
Bureau of Census, U.S. Department of Commerce, page 194

TABLE 3

USE OF SELECTED PESTICIDES IN VIRGINIA

CROP	ACTIVE INGREDIENT	CROP ACRES	PERCENT OF ACRES TREATED	RATE AI LBS/AC/YR	ACRES TREATED	TOTAL AI LBS/YR
Alfalfa	Carbofuran	136889	19	0.55	26009	14305
Alfalfa	Malathion	136889	9	1.86	12320	22915
Apples	2,4-D	29972	20	2.00	5994	11988
Apples	Captafol	29972	5	7.00	1499	10493
Apples	Carbaryl	29972	50	2.00	14986	29972
Apples	Dinozeb	29972	2	1.90	599	1138
Apples	Methyl Parathion	29972	60	6.00	17983	107898
Apples	Metiram	29972	50	15.00	14986	224790
Barley	2, 4-D	86152	30	0.50	25846	12923
Beans	Carbaryl	4449	10	3.80	445	1691
Beans	Trifluralin	4449	29	0.50	1290	645
Cabbage	Carbaryl	1887	29	4.13	547	2259
Cabbage	Chlorothalonil	1887	4	2.84	75	213
Cabbage	Methamidophos	1887	30	2.33	566	1319
Cabbage	Parathion	1887	21	0.49	396	194
Cabbage	Trifluralin	1887	46	0.53	868	460
Corn	Alachlor	821125	40	1.70	328450	558365
Corn	Atrazine	821125	100	1.50	821125	1231688
Corn	Carbaryl	821125	1	1.00	8211	8211
Corn	Carbofuran	821125	29	1.73	238126	411958
Corn	Cyanazine	821125	30	1.00	246338	246338
Corn	Diazinon	821125	1	1.00	8211	8211
Corn	Ethoprop	821125	5	1.00	41056	41056
Corn	Glysophate	821125	8	1.00	65690	65690
Corn	Metolachlor	821125	35	1.30	287394	373612
Corn	Paraquat	821125	42	0.50	349072	174536
Cucumbers	Bensulide	6130	5	4.00	306	1224
Cucumbers	Captafol	6130	50	2.00	3065	6130
Cucumbers	Carbaryl	6130	14	3.50	858	3003
Cucumbers	Chlorothalonil	6130	6	3.20	368	1178
Cucumbers	Diazinon	6130	5	1.00	306	306
Cucumbers	Dinoseb	6130	80	1.00	4904	4904
Oats	2,4-D	11524	12	0.50	1383	692
Pasture	2,4-D	3392000	10	0.50	3392000	169600
Peaches	2,4-D	4899	20	0.80	980	784
Peaches	Carbaryl	4899	50	1.30	2450	3185
Peaches	Chlorothalonil	4899	5	2.00	245	490
Peaches	Dinoseb	4899	2	1.90	98	186
Peaches	Parathion	4899	50	1.80	2450	4410

TABLE 3 continued

CROP	ACTIVE INGREDIENT	CROP ACRES	PERCENT OF ACRES TREATED	RATE AI LBS/AC/YR	ACRES TREATED	TOTAL AI LBS/YR
Peanuts	Acifluorfen	100465	9	0.50	9042	4521
Peanuts	Alachlor	100465	30	2.10	30140	63294
Peanuts	Carbaryl	100465	23	2.10	23107	48525
Peanuts	Carbofuran	100465	31	1.90	31144	59174
Peanuts	Chlorothalonil	100465	7	1.20	7033	8440
Peanuts	Dinoseb	100465	90	0.90	90418	81376
Peanuts	Disulfoton	100465	1	1.00	1005	1005
Peanuts	Ethoprop	100465	25	2.30	25116	57767
Peanuts	Metolachlor	100465	30	1.10	30140	33154
Peanuts	Phorate	100465	33	1.50	33153	49730
Peanuts	Vernolate	100465	48	2.80	48223	135024
Potatoes	Captafol	15986	1	3.00	160	480
Potatoes	Carbaryl	15986	12	3.50	1918	6713
Potatoes	Carbofuran	15986	50	1.60	7993	12789
Potatoes	Chlorothalonil	15986	10	5.00	1599	7995
Potatoes	Dinoseb	15986	20	3.00	3197	9591
Potatoes	Disulfoton	15986	5	3.40	799	2717
Potatoes	Methamidophos	15986	2	1.60	320	512
Potatoes	Metolachlor	15986	65	1.80	10391	18704
Potatoes	Phorate	15986	1	3.00	160	480
Seed Crops	2,4-D	2185	72	0.70	1573	1101
Seed Crops	Dinoseb	2185	8	0.10	175	18
Soybeans	Acifluorfen	612399	13	0.50	79612	39806
Soybeans	Alachlor	612399	34	1.93	208216	401856
Soybeans	Carbaryl	612399	8	0.78	48992	38214
Soybeans	Carbofuran	612399	2	1.82	12248	22291
Soybeans	Dinoseb	612399	3	0.91	18372	16719
Soybeans	Ethoprop	612399	5	2.49	30620	76244
Soybeans	Glysophate	612399	12	0.75	73488	55115
Soybeans	Malathion	612399	17	1.10	104108	114519
Soybeans	Metolachlor	612399	18	1.10	110232	121255
Soybeans	Paraquat	612399	48	0.38	293951	110231
Soybeans	Trifluralin	612399	15	0.69	91860	63383
Soybeans	Vernolate	612399	5	2.14	30620	65527
Sweet Potatoes	Carbaryl	2619	10	2.00	262	524
Sweet Potatoes	Diazinon	2619	10	3.00	262	786
Sweet Potatoes	Ethoprop	2619	60	3.70	1571	5813
Tobacco	Carbaryl	64005	3	1.00	2048	2048
Tobacco	Carbofuran	64005	21	3.00	13185	39555
Tobacco	Disulfoton	64005	17	4.00	11137	44548
Tobacco	Ethoprop	64005	25	6.00	16257	97542
Tobacco	Malathion	64005	1	1.20	640	768
Tobacco	Methyl Parathion	64005	2	1.00	960	960
Tobacco	Parathion	64005	1	0.70	640	448

TABLE 3 continued

CROP	ACTIVE INGREDIENT	CROP ACRES	PERCENT OF ACRES TREATED	RATE AI LBS/AC/YR	ACRES TREATED	TOTAL AI LBS/YR
Tomatoes	Carbaryl	3398	96	4.23	3262	13798
Tomatoes	Chlorothalonil	3398	49	8.65	1665	14402
Tomatoes	Trifluralin	3398	35	0.75	1189	892
Watermelons	Bensulide	2512	6	0.40	151	60
Watermelons	Carbaryl	2512	1	2.60	25	65
Watermelons	Chlorothalonil	2512	18	2.10	452	949
Wheat	2, 4-D	296840	40	0.40	118736	47494
TOTAL					**4,506,262**	**5,757,883**

These numbers are meant to characterize an average year during 1982-1984.

Compiled by Resources for the Future, Washington, D.C.

TABLE 4

ESTIMATED PESTICIDE SAVINGS
FOR NEW JERSEY BIOLOGICAL CONTROL PROGRAMS

Pest	Crop	Acreage		Cost/Acre	Savings
Mexican Bean Beetle	Soybean	99,000	60%-1 app 32%-2 app	$12.50	$779,625
Cereal Leaf Beetle	Grains	55,000	85%-1 app	$10.00	$467,500
Alfalfa Weevil	Alfalfa	40,000	50%-2 app	$14.00	$560,000
Musk Thistle	Pasture Roadsides	40,000	10%-1 app	$10.00	$ 40,000
Gypsy Moth	Forested Areas	1,120,000	Susceptible Acreage		
		-94,000	Defoliation 1987		
		1,106,000			
		-162,265	Acreage Treated		
		1,043,735	Stable Acreage		
		20%	Acreage/Savings		
		208,747			
		x$15			
		$3,131,205	Treat/Savings		
	Total Estimated Pesticide Savings				$4,978,330

Notes:

A - Savings vary each year resulting from parasite population changes and crop acreage planted.

B - Savings does not include increases in crop yield.

C - Savings does not include board feet value of timber saved, property values, dead tree removal, recreational values or ecological benefits.

Estimates provided by William Metterhouse, Director of Plant Industry
New Jersey Department of Agriculture, Trenton, New Jersey (unpublished data)

TABLE 5

USDA/APHIS-PPQ National Biological Control Program
(Cooperative State Projects)

Pest Project	Number States Involved	Number Species Natural Enemies Released
*Cereal Leaf Beetle	18	4
*Mexican Bean Beetle	5	1
Alfalfa Weevil	38	7
Aphid Biological Control (select spp.)	31	9
*Citrus Whitefly	8	1
European Corn Borer	30	3
Colorado Potato Beetle	5	1
Leafy Spruge	12	5
*Silver-leaf Nightshade	5	1
Diffuse and Spotted Knapweed	6	9

*Denotes projects which have been completed or phased out and turned over to States.

Information supplied by USDA/APHIS-PPQ, Niles, Michigan.

TABLE 6

BIOLOGICAL CONTROL PROGRAMS OF 18 OTHER STATES AND VIRGINIA

	AZ	CA	CO	FL	HI	IN	ME	MD	MI	MN	NJ	NY	NC	OR	SD	VA	WI	DE	IA	Canada
Alfalfa Weevil	X	X	2/2X 3	X		X	X	X 4	X	X	X 5/5	X	X 4/3		X 7	X 5/3	X 6/5		X	X
Russian Wheat Aphid	X 4/	X	X 2/											X	X 3					X
Asparagus Beetle							X 6/1		X		X 4/									
Brown Stink Bug				X																
Cereal Leaf Beetle						X		X 3/2	X	X	X 2/2	X	X 1			X /	X	X		X
Citrus Whitefly				X									X 1/1							
Codling Moth													X							X
Corn Ear Worm				X												X /				
Corn Root Worm										X										
Col. Potato Beetle							X 1/1	X 1	X		X 1/1					X /				
Cutworm (darksided)																				
European Corn Borer						X		X	X	X 1	X 1/1		X 2/2			X	X	X	X	X
European Pine Sawfly																	X 1			
Euonymus Scale						X					X 4		X 2/2							
Fall Armyworm																				
Fire Ant																				
Gypsy Moth								X 28	X 5/5		X					X 3/				
Imported Cabbage Worm							X 1/0									X /	X 1			
Japanese Beetle							X 1					X 2/2	X 2/2			X 2/2				
Lygus Bug																				
Mexican Bean Beetle				X			X 1	X 1			X 1					X 1		X		
Mite E. Red							X 1/1				X 1/1	X 2/2					X 1			X
White Peach Scale													X 1/1							
Pink Bollworm																				
Tobacco Budworm				X																
Face Fly										X 1										
House Fly				X								10/X 10								
Little House Fly																				
Stable Fly				X																
Horn Fly				X																
Alligator Weed				X																
Elodea																				
Hydrilla		X		X																
Leafy Spurge			X											X 3/0	X 2/2					X 9/6
Lythrum						X														
Multiflora Rose													X							
Spotted Knapweed														X 3/2	X					X 6/6
St. Johnswort														X 4/2						X 7/4
Tansy Ragwort		X												X 3/3						X 5/5
Thistle		X	X 5/5			X		X 3/3			X 2/2			X 3/3	X 1/1	X				X 10/6
Yellow Nut Sedge				X																
Southern Green Stink Bug				X																

X - indicates current or past involvement in programs
3/ - no. of parasite species released
/3 - no. of parasite species established

TABLE 7

MARKET VALUE OF VIRGINIA AGRICULTURAL CROPS SOLD
1978 AND 1982 BY COMMODITY GROUP

	1982 Value $1,000	%	1978 Value $1,000	%
Total Sales	$1,606,915	100%	$1,261,255	100%
Subtotal: Crop Sales	629,303	39%	503,579	40%
Grains	229,742	14%	160,485	13%
Cotton	98	0%	36	0%
Tobacco	184,819	12%	157,687	13%
Hay, Silage, & Field Seeds	17,342	1%	17,640	1%
Vegetables, Sweet Corn, and Melons	27,409	2%	24,808	2%
Fruits, Nuts, & Berries	42,391	3%	38,408	3%
Nursery & Greenhouse Crops	43,858	3%	30,977	2%
Other Crops	83,644	5%	73,538	6%
Subtotal: Livestock, Poultry, and Their Products	977,612	61%	757,676	60%
Poultry & Poultry Products	293,291	18%	211,730	17%
Dairy Products	278,293	17%	195,292	15%
Cattle and Calves	277,255	17%	235,465	19%
Hogs and Pigs	82,309	5%	77,590	6%
Sheep, Lambs, and Wool	6,814	0%	6,518	1%
Other Livestock and Livestock Products	39,650	3%	31,081	2%

Source: 1982 Census of Agriculture, Volume 1, Part 51, Pages 154 and 161.

TABLE 8

Imported Natural Enemies of 23 Selected Pests Cleared For Use as Biological Agents t
USDA, ARS Beneficial Insect Introduction Laboratory, Newark, Delaware

Common Name	Scientific Name	Number Species	Number Receiving States	Number Species Released
Alfalfa Weevil	Hypera postica (Gyllenhal)	13	47	9
Aphid	Aphids sp.	37	31	19
Russian Wheat Aphid	Diuraphis noxia (Mordvilko)	9	10	8
Asparagus Beetle	Crioceris asparagi (Linnaeus)	5	8	3
Spotted Asparagus Beetle	Crioceris duodecimpunctata (Linnaeus)	4	7	1
Cereal Leaf Beetle	Ouelma melanopus (Linnaeus)	8	18	5
Citrus Whitefly	Dialeurodes citri (Ash mead)	2	10	1
Codling Moth	Cydia pomonella (Linnaeus)	6	6	4
Colorado Potato Beetle	Leptinotarsa decemlineata (Say)	10	7	7
Euonymus Scale	Unaspis euonymi (Comstock)	15	19	9
European Corn Borer	Ostrinia nubilalis (Hubner)	16	8	4
Gypsy Moth	Lymantria dispar (Linnaeus)	77	18	62
Heliothis	Heliothis sp.	28	14	11
Mexican Bean Beetle	Epilachna varivestis Mulsant	8	20	7
Imported Cabbage Worm	Artogeia rapae (Linnaeus)	4	5	1

Common Name	Technical Name	Number Species	Number Receiving States	Number Species Released
Tobacco Budworm	Heliothis virescens (Fabricius)	3	1	0
Southern Green Stink Bug	Nezara viridula (Linnaeus)	7	2	3
Pink Bollworm	Pectinophora gosypiella (Saunders)	7	3	7
Oriental Fruit Moth	Cydia molesta (Busck)	1	0	0
Two spotted Spider Mite	Tetranychus urticae Koch	9	9	4
White Peach Scale	Pseudaulacaspis pentagona (Targioni-Tozzetti)	2	1	2
Tansy Ragwort	Senecio jacobaeae (Linnaeus)	2	3	1
Canada Thistle	Cirsium arvense (Linnaeus)	2	2	0

Information provided by USDA Beneficial Insect Laboratory, Newark, Delaware.

LITERATURE CITED

(1) Allen, W. A. 1986. The Future of Virginia Agriculture Studies Think Tank Subunit - pests, pesticides, and pest management. Entomology Department, VPI & SU. :1-3.

(2) Schultz, Peter B. November 1985. A Review of the Biological Program of the Virginia Department of Agriculture and Consumer Servcies.

(3) Baliles, Gerald L. 1986. Inaugural address (1/11/86):4.

(4) Baliles, Gerald L. 1986. Address to General Assembly (1/13/86) :7-9.

(5) Baliles, Gerald L. 1986. Written statement submitted to the U.S. Senate subcommittee on Governmental Efficiency and the District of Columbia. (6/24/86) :1-2.

(6) 1987. The future of agriculture, forestry, food industries and rural communitites in Virginia -supplementary report. Virginia Polytechnic Institute and State University. :30.

(7) 1988. Virginia - nonpoint source pollution management plan. Virginia Department of conservation and Historic resources. :2-2 and 2-11, 2-12.

(8) Resources for the Future - Estimates of the Use of Selected Pesticide Active Ingredient for Virginia. 1988, 1-4

(9) Bernat Jr., G. Andrew; Norton, George W.; Ragotte, Edwin G.; Drake, Charles R.; and Holliman, Mary C. - Interdisciplinary Evaluation of Pest Management Systems. VPI & SU Bulletin. 85-5, pp. 301-330.

(10) DeBach, P. 1964. Biological Control of Insect Pest and Weeds, Reinhold Publishing Corporation, NY. 844 pages.

PERSONS CONTACTED FOR BIOLOGICAL CONTROL INFORMATION

Name

Backus, Richard R., APHIS, USDA, Washington, DC

Barrett, Ronald O., New York Department of Agri., Albany, NY

Bradley, Linda, Delaware Department of Agri., Dover, DE

Brener, William D., Wisconsin Department of Agri., Madison, WI

Bruckert, William, ARS, USDA, Ferderick, MD

Burger, Thomas, APHIS, USDA, Niles, MI

Carlson, Carl, Iowa Dept. of Agri., Des Moines, IA

Casagrande, Richard A., University of Rhode Island, Kingston, RI

Combs, Eric, Oregon Dept. of Agri., Salem, OR

Coulson, J. R., ARS, USDA, Beltsville, MD

Davis, Donald, Utah State University, Logan, UT

Dickerson, William A., North Carolina Dept. of Agri., Raleigh, NC

Dreves, John, Michigan Dept. of Agri., Lansing, MI

Elder, A. S., APHIS, USDA, Brownsville, TX

Elliott, Donald, Applied Bionomics Ltd, Sidney, British Columbia

Ertle, L. P., ARS, USDA, Newark, DE

Forer, Lyle, Pennsylvania Dept. of Agri., Harrisburg, PA

Gaskallan, Richard, Florida Dept. of Agri. and Consumer Services
Gainsville, Fl

Gimpel, William, Maryland Dept. of Agri., Annapolis, MD

Glenister, Carol, IPM Laboratories, Locke, NY

Hagenbuck, Brian, West Virginia Dept. of Agri., Charleston, WV

Harris, Peter, Canada Dept. of Agri., Regina, Saskatchewan

Herbert, Ames, VPI & SU, Painter, VA

Hoelscher, Clifford E., Texas A&M University, College Station, TX

Hunter, Charles, California Dept. of Agri., Sacramento, CA

Karpati, Joseph, APHIS, USDA, Mexico City, Mexico

Keeling, John, Virginia Farm Bureau Federation, Richmond, VA

Knodel, Janet, NYSAES, Geneva, NY

Kok, L. T., VPI & SU, Blacksburg, VA

Krsnak, James, South Dakota Dept. of Agri., Pierre, SD

Krysan, James, ARS, USDA, Yakima, WA

Lagasa, Eric, Washington State University, Pullman, WA

Lawson, James, NASS, USDA, Richmond, VA

Luna, John, VPI&SU, Blacksburg, VA

Mair, Donald, Maine Dept. of Agri., Augusta, ME

Mason, Arthur, Minnesota Dept. of Agri., St. Paul, MN

Mason, Charles, University of Delaware, Newark, DE

McCafrey, Joseph, University of Idaho, Moscow, ID

McMullen, R., Canada Dept. of Agri., Summerland, British Columbia

Metterhouse, William, New Jersey Dept. of Agri., Trenton, NJ

Meyer, Karl F., Arizona Comm. of Agri. and Hort., Phoenix, AZ

Mowrer, Kent, Colorado Dept. of Agri., Palisade, CO

Obeycki, John, Iowa State University, Ames, IA

Piper, Gary L., Washington State University, Pullman, WA

Priest, Ronald, Michigan Dept. of Agri., Lansing, MI

Puffinberger, Charles W., Maryland Dept. of Agri., Annapolis, MD

Rebhan, Robert, Washington Dept. of Agriculture, Olympia, WA

Reid, Roy, Mississippi State University, Stoneville, MS

Remington, Norman, Michigan Dept. of Agriculture, Lansing, MI

Robert, Kenneth P., Wisconsin Dept. of Agriculture, Madison, WI

Schultz, Peter B., VPI & SU, Virginia Beach, VA

Schwalbe, C.P., APHIS, USDA, Otis, MA

Simons, Edward, Pennsylvania Dept. of Natural Resources, Harrisburg, PA

Soper, Richard S., ARS, USDA, Beltsville, MD

Stewart, Jeff, Canada Dept. of Agriculture, Charlottstown, Prince Edward Island

Teramoto, K. k., Hawaii Dept. of Agriculture, Honolulu, HI

Tette, James, NYSAES, Geneva, NY

Ticehurst, Mark, Nat'l Gypsy Moth Management Group, Landisburg, PA

Villani, Michael, NYSAES, Geneva, NY

Waltz, Robert, Indiana Dept. of natural Resources, Indianapolis, IN

Whittington, Billie, ERS, USDA, Washington, DC

Williams, Robert, ERS, USDA, Washington, DC

Wolf, William, Necessary Trading Co., New Castle, VA

Wright, B.D., Oregon Department of Agriculture, Salem, OR

Abbreviations used in this list:

APHIS - Animal and Plant Health Inspection Service
ARS - Agricultural Research Service
ERS - Economic Research Service
NASS - National Agricultural Statistical Service
USDA - United States Department of Agriculture
VPI&SU - Virginia Polytechnic Institute and State University
NYSAES - New York State Agricultural Experiment Station

Cover: *Lysiphlebus testaceipes*, a universal aphid parasite, in the act of depositing eggs in the body of a grain aphid. (courtesy USDA)