



Animal and Plant Health Inspection Service
U.S. DEPARTMENT OF AGRICULTURE

Plant Protection and Quarantine Biological Control Program Annual Report Fiscal Year 2023

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Agency Contact:

Office of the Deputy Administrator

Plant Protection and Quarantine

Animal and Plant Health Inspection Service

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Executive Summary

This annual report describes the major accomplishments and activities for the Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ), Biological Control program in fiscal year (FY) 2023. The report highlights the program's mission and operating principles, key program level accomplishments including approval of a comprehensive strategic plan, and completion of a Regulated Domestic Pest Program Evaluation Committee (RDPPEC) program review. The report highlights outreach efforts, subject matter expert committee affiliations, and provides appendices that list current Biological Control targets including agents, and the stage of project development, and a list of Plant Protection Act (PPA), 7721, Plant Pest and Disease Management and Disaster Prevention Program leveraged biological control projects. Key accomplishments and highlights are presented for Field Operations implementation efforts, Science and Technology's (S&T) research and methods development work, and Pest Exclusion and Import Programs recent biological organism permitting actions. In FY23, the program provided national program oversight for both insect and weed biological control activities. Field Operations provided funding and oversight for 31 cooperative agreements with organizations in 22 different states that will rear, release, and monitor the establishment and impact of 16 agents attacking 3 invasive arthropods and 14 exotic weeds. S&T supported the coordination of research projects against 33 targets. Scientific research is focused on advancing research and data collection towards evaluation for U.S. permitting of 19 potential agents, as well as advancing methods development for rearing and release of 24 agents. Taken together, these activities and efforts demonstrate consistent progress towards the future and sustainability of the PPQ Biological Control program and the facilitation of environmentally sustainable pest management solutions that will help mitigate the economic and environmental impacts of invasive plant pest species.

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Biological Control Cross Functional Working Group

The Biological Control cross functional working group's (CFWG) goal is to increase the cohesion, efficiency, and effectiveness of the PPQ Biological Control program. The Biological Control CFWG coordinates activities related to the PPQ Biological Control program across four PPQ Core Functional Areas (CFAs):

- Emergency and Domestic Programs (EDP); Biocontrol, and Forest, Wood, and Rangelands Pests (BFWRP) – Ron Weeks
- Field Operations (FO) – Keith Colpetzer
- Science and Technology (S&T) Domestic and Emergency Scientific Support (DESS) – Tara Holtz and Ashton Leo
- Pest Exclusion and Import Programs (PEIP), Permitting and Compliance Coordination (PCC) – Bob Pfannenstiel

Program Mission and Operating Principles

The PPQ Biological Control program promotes, facilitates, develops, and delivers safe and effective biological control through partnerships with other federal, state, tribal, and private organizations that can be used either alone or in combination with other control tactics to help reduce the economic losses and negative impacts of non-indigenous, invasive pests to America's agricultural production and natural areas.

The program invests in the discovery, development, and deployment of new, non-native agents (i.e., parasitoids, predators, herbivores, or pathogens) and through surveys, basic research, and methods development that locate and exploit biological control agents. The program supports the development of more efficient and improved operational methods for biological control implementation. Permitting and Compliance Coordination manages the compliance activities required under the authority of the Plant Protection Act for approval of PPQ 526 permits for the importation, interstate movement, and environmental release of biological control organisms of plant pests and weeds.

Limited resources and the continued pressure of invasive pests on American agriculture and natural resources make it impractical for PPQ alone to maintain the necessary resources, infrastructure, space, and scientific expertise to effectively sustain the overall Biological Control program. PPQ's Biological Control program actively seeks and maintains partnerships with tribal governments, state agencies, federal agencies, and universities to be better prepared, equipped, and more efficient in carrying out the agency's biological control mission.

PPQ uses cooperative agreements, inter-agency agreements, and Memoranda of Understanding (MOU) to leverage and sustain PPQ's biological control projects. These partnerships establish mutual cooperative relationships which PPQ and interested partners can use to develop, implement, and sustain the Biological Control program. PPQ consultation and active collaboration with these partners include discussions and determinations of cost-sharing,

prioritization of target pests, availability of funding, infrastructure issues, and leveraging of other resources.

The program leverages significant PPA 7721 funding to complete biological control projects. PPA 7721 projects ranged from native natural enemy surveys, completion of host range testing, rearing of non-target hosts for testing, development, and approval of a first-time release permit, rearing and development of rearing systems for targets and/or hosts, initial release and data collection protocols, and field establishment verification studies after first time releases.

In FY23, 25 PPA 7721 biological control projects were approved for \$5,255,706.25 in funding (see Appendix B List of FY23 PPA 7721 biological control projects).

Key Program Highlights

Completed Strategic Plan

PPQ's BC Strategic Plan describes the program's mission, vision, and strategic milestones. The strategic plan includes specific goals, objectives, and deliverables to accomplish the agency's biological control regulatory functions and program mission. These strategic goals provide a traceable framework to ensure that the PPQ Biological Control program is responsive, sustainable, efficient, measurable, and valued by PPQ and its stakeholders. It provides five long term goals with supporting objectives, and deliverables. The plan can be found on the [PPQ Biological Control internet site](#).

Completed Full Review of the Biological Control Program by the Regulated Domestic Pest Program Evaluation Committee (RDPPEC)

The RDPPEC reviewed program documents provided by the Biological Control CFWG and the group's responses to questions raised by the RDPPEC. Based on the information provided by the CFWG, the RDPPEC believes that the Biological Control program provides a beneficial, unique service in researching the feasibility, applicability, and rearing of appropriate biological control agents for targeted pests of concern. The RDPPEC recognized key areas (communication, process, and implementation) within the Biological Control program that could benefit from increased focus and development by the CFWG and support by PPQ Management. In conjunction with the Biological Control strategic plan, these recommendations will help facilitate the development of safe and sustainable biological control options and guide program activities now and into the future. The Recommendations document can be found on the [PPQ Biological Control internet site](#).

Outreach and Education

On November 7, at the Entomological Society of America meeting in National Harbor, MD, PPQ S&T scientist Dr. Juli Gould was presented the Distinguished Scientist award by the International Organization of Biological Control Nearctic Regional Section. This award celebrates a member of the organization who has made significant contributions to biological control. Prior to receiving her award, Dr. Gould gave a seminar on her career's work in developing and implementing biological control; she highlighted her successful work on implementing biological control of ash whitefly and emerald ash borer.

Increasing awareness and understanding of the biological control process and successes, enhance PPQ and stakeholder knowledge and continued use of biological control solutions. The Biological Control CFWG participated in several key stakeholder engagement sessions in FY23 to share information and enhance awareness about PPQ's biological control development and delivery process.

Below are additional outreach and education accomplishments the CFWG completed this year.

- Completed delivery of three biological control intra-agency webinars that covered key program areas such as permitting, operations, and a historical perspective of APHIS Biological Control. Result was increased program information sharing to participants within PPQ that attended the 3-part series.
- Presented "Overview of PPQ's Biological Control Strategic Plan" at National Plant Board meeting in Little Rock AR. Result was communication and stakeholder support of national program goals, objectives, and performance measures to audience of over 100 PPQ and NPB representatives.
- Participated in Colorado Department of Agriculture's (CDA) Palisade Insectary Webinar (Stakeholder engagement and partnership development). Result was initiation of a new cooperative agreement that will support regional rearing and release of a weevil (*Ceratapion basicorne*) to help control yellow starthistle, an invasive weed found in 40 of the lower 48 states. Impact is continued regional collaboration with stakeholders that advance the biological control program and leverages state and federal capabilities.
- Presented an overview of the APHIS Biological Control Program to the National Plant Protection Organization of Taiwan, the Bureau of Animal and Plant Health Inspection and Quarantine, during which we discussed partnering with other organizations and leveraging other organizations' resources to accomplish a shared goal more efficiently.
- Delivered two program presentations to visiting representatives of the Taiwan Bureau of Animal and Plant Health Inspection and Quarantine. Presentations covered; 1) an overview of the biocontrol program including program mission, project types and

selection, project development and facilitation activities, and working with cooperators and 2) APHIS regulation and permitting of biocontrol agents.

- Presentations on the regulatory process for approving the introduction of biological control agents and an updated list of current petitions were given at the Montana Weed Biological Control Meeting and to Biopesticide permitting section of the EPA.
- A section was created on the APHIS environmental compliance process for the North American Invasive Species Management Association Biocontrol 101 Short Course. [NAISMA Biological Control 101 Short Course](#)
- Participated in a meeting with the National Association of State Foresters where we discussed opportunities to partner on shared biological control goals.

Committee and Expert Group Activities

Biological Control CFWG members served as APHIS PPQ Biological Control representatives as part of NAPPO Biological Control Export Group – “Revision of RSPM 26 - Certification of commercial arthropod BCAs or non-Apis pollinators moving into NAPPO member countries”. The CFWG’s work strengthened international collaboration and development of regional standards that support and facilitate the use and development of biological control pest management solutions in North America.

Biological Control CFWG members also served as APHIS PPQ Biological Control experts and TAG members at 2023 Hybrid Annual TAG Meeting. PPQ provided guidance to researchers and expert advice on recommendations for or against the release of biological control agents, based on considerations of potential non-target impacts and conflicts of interest.

FY23 Portfolio of Biological Control Targets, Agents, and Stage of Project Development

See Appendix A

FY23 List of PPA 7721 Biological Control Projects Supported

See Appendix B

Key PPQ Priority Pests and Program Support

PPQ’s Biological Control program provides scientific, practical, and technical support for specific pest biological control programs funded by PPQ under other funding lines. With many

years of experience and partnership connections on these types of programs, the PPQ Biological Control community of scientists can assist in the development and completion of these programs.

Emerald Ash Borer

The emerald ash borer (EAB, *Agrilus planipennis*) is a destructive wood-boring pest of ash trees (*Fraxinus* spp.). EAB was first found in Michigan in 2002. Today EAB is in 36 states and the District of Columbia. Exploration for EAB natural enemies in China, Russia, and Korea has yielded several hymenopteran parasitoids, and four species have been approved for release as biological control agents of EAB in the United States and others are under consideration (see Appendix B).

Releases

During the 2023 season, APHIS, and its biological control partners, released parasitoids in 35 new counties. These releases bring the program’s total number of releases to 453 counties in 32 states and the District of Columbia.

Table 1. Biocontrol Agents Release January 1 - October 31, 2023

Biocontrol Agents Release January 1 - October 31, 2023	Amount
<i>Oobius agrili</i>	207,463
<i>Spathius agrili</i>	8,494
<i>Spathius galinae</i>	107,399
<i>Tetrastichus planipennis</i>	163,268
Total	486,624

Recoveries

To date, parasitoids have been recovered in 23 states: Colorado, Connecticut, Delaware, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Tennessee, Virginia, Wisconsin, and in 2 Canadian provinces: Ontario and Quebec. This means the wasps are establishing, reproducing, and killing EAB.

S&T continues to work with partners to assess the population level impacts on EAB leading to several key publications that illuminate the impact of parasitoid releases in the United States. PPQ S&T and State University of New York, College of Environmental Science and Forestry evaluated insecticide treatments, parasitoid releases, forest regeneration, release efficacy at early- and post-invasion locations. This led to the development of a manuscript documenting regeneration of ash in forest stands where EAB killed most of the mature trees.

- Morris, T. D., Gould, J. R., Drake, J., & Fierke, M. K. (2023). Status of ash forests and regeneration a decade after first detection of emerald ash borer infestation in New York state. *Forest ecology and management*, 549, 121464.

A second publication shows that EAB parasitoids released in forest stands where most mature trees have been killed and EAB densities have collapsed have a significant impact. The impact of EAB parasitoids in such stands is high: as high as in stands where parasitoids were released a decade earlier before EAB collapse.

- Morris, T. D., Gould, J. R., & Fierke, M. K. (2023). Establishment and impacts of emerald ash borer (Coleoptera: Buprestidae) parasitoids released at early-and post-invasion sites. *Journal of Economic Entomology*, 2023 Aug 10;116(4):1155-1164.

Another publication described factors affecting the distribution of EAB parasitoids in an urban environment.

- Morris, T. D., Drake, J. E., Gould, J. R., & Fierke, M. K. (2023). Factors affecting distribution of emerald ash borer parasitoids in an urban environment. *Landscape and Urban Planning*, 237, 104814.

Spotted Lanternfly

PPQ S&T is working in partnership with more than 11 cooperators to pursue biological control for Spotted Lanternfly (SLF; *Lycorma delicatula*). Host specificity testing of three haplotypes of *Anastatus orientalis*, an egg parasitoid attacking SLF, came to conclusion in FY23. The parasitoid attacked squash bug eggs, stink bug eggs, and silk moth eggs. It is insufficiently host specific for release in the United States. Further, completed life-cycle studies show that *Anastatus orientalis* is not well synchronized with the lifecycle of its host.

Work continues for the nymphal parasitoid *Dryinus sinicus*. Improved rearing of tree-of-heaven plants and SLF nymphs led to the development of a robust colony of the *Dryinus sinicus* in quarantine. S&T and cooperators-initiated host specificity testing and studies of *Dryinus sinicus*' life history. To date, we have not observed any non-target attack. Studies are ongoing.

Box Tree Moth

Investigations continue on the parasitoid complex of box tree moth (BTM; *Cydalima perspectalis*) in South Korea lead by CABI Switzerland. Field observations of parasitism were as high as 96% in some areas, with parasitism levels across urban and natural sites ranging from 43 to 55%. Cooperators collected samples of BTM larvae and live parasitoids in South Korea and shipped them to the CABI facility in Switzerland to develop optimal rearing techniques and conduct investigations on their biology and host range testing. Of the eight primary larval parasitoids shipped to the CABI quarantine in Switzerland, two parasitoid species are now established in the quarantine laboratory and undergoing host specificity testing. These first results show that one of them; the ichneumonid wasp, *Eriborus* sp. (Campopleginae), had high levels of parasitism observed in the field and may be a good candidate for introduction for BTM classical biological control in North America (Appendix B). The most promising parasitoids will

be shipped to PPQ S&T to initiate host range testing with native Lepidoptera and assess potential non-target effects.

PPQ S&T established trapping and collecting methods for non-target moths in the families Crambidae and Pyralidae in the United States. Rearing methods for individual non-target species are in development to facilitate host testing of promising candidates.

Asian Citrus Psyllid

PPQ S&T continues to produce *Tamarixia radiata* for release in Texas, Louisiana, and Mexico border areas. Since 2011, PPQ S&T has produced over 15.7 million beneficial insects for field release in Texas, Louisiana, and Mexico border areas, with 283,000 released in FY23. In FY23, S&T completed a comprehensive rearing, release, and monitoring manual for *Tamarixia radiata*, a significant milestone contributing to the accomplishments of the program. Work also continued on additional biological control options to further reduce Asian citrus psyllid (ACP; *Diaphorina citri*) populations. PPQ S&T concluded studies on assessing the impact of entomopathogens for the integrated biological control of the ACP in the Lower Rio Grande Valley of Texas. After thorough primary and secondary screening, BioCeres (ANT03) and Isarid (Ifr9901, previously known as NoFly) emerged as promising candidates for field use. Both candidates are included in the list of approved crop applications in the United States. In California, PPQ S&T and Citrus Research Board conducted augmentative releases of three predator species, *Chrysoperla comanche*, *Rhyzobius lophanthæ*, and *Diomus pumilio* and are evaluating these predators as an additional method of suppressing ACP in residential citrus.

Field Operations

Field Operations provided funding and oversight for 31 cooperative agreements with organizations in 22 different states that will rear, release, and monitor the establishment and impact of 16 agents attacking three invasive arthropods and 14 exotic weeds.

Key Invasive Species Targeted

Olive Psyllid

Olive psyllid (*Euphyllura olivine*) is a serious pest of olives that was first detected in California in 2007 and is known to reduce crop yields by up to 60% in the Mediterranean basin. Our FY23 agreement with the California Department of Food and Agriculture primarily focused on rearing, releasing, and monitoring for the establishment of *Psyllaephagus euphylluræ*, an encyrtid wasp that attacks and kills olive psyllid. This investment, which started in FY21, led to the release of the wasp into California in June 2022 when APHIS first permitted the release of this wasp into the United States, and it financed establishment surveys that began in July 2023.

Russian Wheat Aphid

APHIS partnered with the Agriculture Research Service and Colorado State University to release *Aphelinus hordei* for the first time into the United States. *Aphelinus hordei* is a parasitoid wasp that attacks and kills Russian wheat aphid (*Diuraphis noxia*), a major pest of wheat, barley, and other small grains. APHIS expects this newly permitted parasitoid to establish and compliment *Aphelinus atriplicis*, a biological control agent of Russian wheat aphid that was established in the United States by 1996 and reportedly attacks 13-16% of Russian wheat aphid in Colorado, Nebraska, and Wyoming. This investment is extremely important since the Russian wheat aphid has evolved four virulent strains that are capable surviving and reproducing on resistant wheat cultivars, the industry's primary tool for managing the aphid.

Spotted Wing Drosophila

Spotted wing drosophila (*Drosophila suzukii*) is a vinegar fly that damages healthy berries, cherries, grapes, and other soft tree fruit by cutting slits into the fruit to deposit eggs. APHIS increased our investments in biological control of Spotted wing drosophila in FY23 in response to the fly rapidly spreading throughout the United States, the high economic impacts associated with its spread, the difficulties experienced while trying to control the fly by other methods, and the availability of a newly permitted biological control agent, *Gnaspis brasiliensis*. FY23 agreements focused on rearing and releasing *G. brasiliensis*, a parasitoid wasp that attacks and kills Spotted wing drosophila larvae.

Air Potato

Air potato (*Dioscorea bulbifera*) is a vine that grows rapidly, forms dense mats, and displaces native vegetation in Florida, Hawaii, and parts of Alabama, Georgia, Louisiana, Mississippi, and Texas. FY23 cooperators efforts concentrated on rearing and releasing *Lilioceris egena*, a chrysomelid beetle from southeast Asia that APHIS first permitted for release into the United States in 2021. APHIS anticipates that *L. egena* feeding on the reproductive structures (i.e., bulbils) of air potato will enhance the impacts researchers have already seen from releasing *Lilioceris cheni*, a beetle that feeds exclusively on the leaves of air potato, has established everywhere in the continental United States where air potato is known to occur, and has been shown to inflict moderate to high damage to individual air potato plants growing in the environment and reduce the area of the United States covered by air potato.

Black and Pale Swallowworts

Black and pale swallowworts (*Cynanchum louiseae* and *C. rossicum*) are perennial vines that have invaded fields and forests in the northeastern United States and have been found as far west as Nebraska and Kansas, with satellite populations in California, and as far south as Missouri and Kentucky. These species can form dense stands that displace native vegetation and alter the composition of animal communities. Black swallowwort is an ecological threat because it stimulates monarch butterflies to deposit eggs even though monarch larvae cannot complete

development on this plant. FY23 efforts focused on rearing and releasing *Hypena opulenta*, a Ukrainian moth whose larvae feed exclusively on these plants. APHIS efforts also concentrated on distributing the moth to cooperators for release across the nation and on determining what impact the moth has had on these invasive swallowwort populations since the agency first permitted its release in 2017.

Bohemian, Giant, and Japanese Knotweeds

Bohemian, giant, and Japanese knotweeds (*Fallopia x bohemica*, *F. sachalinensis*, and *F. japonica*) are three robust perennials that occur almost everywhere in the United States, except the arid southwest. They spread rapidly from rhizomes and cuttings, form dense thickets that displace native vegetation, reduce biodiversity, and are difficult to control. In FY23, APHIS cooperators worked primarily on rearing, releasing, and monitoring for the establishment of *Aphalara itadori*, a psyllid that feeds exclusively on these plants and was first permitted for release into the United States in 2020. To date, APHIS cooperators have released two different lines (i.e., the Hokkaido and the Kyushu biotype) into a variety of different habitats where knotweeds grow without seeing any indication of establishment. These results have not deterred biological control efforts, as the psyllids are difficult to detect, and a new promising biotype (i.e., the Murakami biotype) should be approved for field release before the Spring 2024.

Common Crupina

Common crupina (*Crupina vulgaris*) is a federally listed noxious weed that forms dense stands, displaces native vegetation, and reduces the value of range and pastureland, as the mature plants are not palatable to most livestock. FY23 agreements focused primarily on propagating and releasing spores of the fungus, *Ramularia crupinae*, which APHIS first permitted for field release in 2021. Cooperators also investigated factors that could contribute to infection and thus improve future release methods.

Gorse

Gorse (*Ulex europaeus*) is a spiny, woody, perennial that is extremely flammable, has fueled catastrophic fires around the world and in the United States, and has established in the northeastern United States from New York to Virginia and on the west coast from Washington to southern California. In FY23, APHIS cooperators concentrated on rearing, releasing, and confirming establishment of the gorse thrips, *Sericothrips staphylinus*, a biological control agent that was first introduced into the United States in 2020. In the past three years, cooperators have confirmed establishment of gorse thrips in the United States and have seen some minor impacts to the target, as the thrips populations slowly increase in size and density.

Hoary Cress

Hoary cress (*Cardaria draba*) is a long-lived and drought resistant perennial that spreads rapidly, occurs everywhere in the United States, except the southeast, forms dense monocultures that

displace native vegetation, contains chemicals that irritate the mucus membranes of grazing animals, and is difficult to control. This year, APHIS cooperators worked on rearing and releasing *Aceria drabae*, a mite that causes galls to form on the buds and developing flowers of hoary cress. Galls on the buds stunt plant growth, and galls on the flowers prevent seed production. Since the first release into the environment, which occurred in 2019, cooperators have shown that the mite can survive harsh winter conditions, like those that occur in Montana.

Houndstongue

Houndstongue (*Cynoglossum officinale*) is a shade-tolerant perennial that invades disturbed areas and outcompetes native vegetation in rangeland, pastureland, riparian areas, and on forest edges. The plant also causes issues when mixed with hay because it contains phytochemicals that cause liver disease and even liver failure in animals that consume too much of it. Its spiny seeds create problems for ranchers trying to market wool and fur as they must spend extra time and money removing these burs before selling the animal fiber. The burs are also known to damage livestock when they become lodged in the livestock's eyelashes. Our investment, which began in FY22, helped APHIS cooperators map infestations, rank them in terms of suitability for releasing *Mogulones borraginis*, a weevil that feeds exclusively on the flowers and developing seeds of houndstongue, and release the weevil for the first time into the United States.

Puncturevine

APHIS provided a relatively small amount of funding (i.e., \$15,000) in FY23 to investigate whether cold-hardy agents could enhance biological control of puncturevine (*Tribulus terrestris*). In the early 1960s, USDA invested in establishing two agents, *Microthrips lareynii*, a seed weevil, and *M. lypriformis*, a stem weevil, to help control puncturevine, a plant present in nearly every state that when allowed to grow unchecked forms dense mats that create dangerous conditions for livestock, people, and pets. The project is often cited as a partial success because these weevils control puncturevine in some areas of the United States, but there are areas of the United States where these agents have never established. Redistributing these weevils from healthy, existing populations to climatically matched areas where they have never established may, therefore, enhance past investments in puncturevine biological control.

Yellow Starthistle

Yellow starthistle (*Centaurea solstitialis*) is an annual forb present in almost every state that forms dense monocultures, displaces native vegetation, reduces biodiversity, reduces the value of range and pastureland, and is toxic to horses. In FY23, APHIS cooperators focused on rearing, releasing, and monitoring for the establishment of *Ceratopion basicorne*, a weevil whose larvae feed and develop in the root crown of yellow starthistle. Our investment, which began in FY21, supported the first release of this weevil in 2020 and helped improve mass rearing techniques.

Yellow Toadflax

Yellow toadflax (*Linaria vulgaris*) is a short-lived and drought resistant perennial that occurs almost everywhere in the United States. Yellow toadflax, like most invasive plants, can spread rapidly, form dense monocultures, displace native vegetation, and reduce the value of range and pastureland, as cattle generally avoid eating it. In FY23, APHIS cooperators concentrated on rearing, releasing, and confirming establishment of *Rhinusa pilosa*, a weevil that cooperators first released in Montana in 2019, Oregon and South Dakota in 2021, and Idaho and Wyoming in 2022. While it is too early to claim that the weevil has established from most of these releases, the probability of establishment in South Dakota is high, and establishment is confirmed at multiple sites in Montana where the larvae are inducing galls on the stems of yellow toadflax. These galls ultimately stunt plant growth, reduce the number of rhizomes, and reduce seed production.

Science and Technology

Key Research by Target Species

In FY23 the program supported the coordination of research projects against 33 targets. Scientific research is focused on advancing research and data collection to support US permitting of 19 potential agents and on advancing methods development for rearing and release of 24 agents. Below we highlight a handful of PPQ S&T led projects.

Asian Bean Thrips

The Asian bean thrips (*Megalurothrips usitatus*) is a recently established thrips pest of legumes affecting production of snap bean and other legume crops in south Florida. PPQ S&T and University of Florida-Gulf Coast Research and Education Center sampled multiple legume fields and identified associated predators. Overall, sampling revealed a low number of predators under commercial snap bean production conditions. They consisted primarily of *Orius* spp. and *Neoseiulus* predatory mites. A yearlong study of flowers collected from lablab beans, a perineal specialty crop, showed that the predatory mites were always present within the flowers along with the pest. In addition, the group evaluated commercially available predators under laboratory conditions revealing that *Amblyseius swirskii* and *A. cucumeris* caused up to 80% mortality of the first instar larvae within 48 hours.

Bemisia tabaci, *Tuta absoluta*

PPQ S&T, University of Florida Immokalee, and Instituto Valenciano de Investigaciones Agrarias (IVIA), Spain scientists co-authored a paper describing the results of a 4-year study that tested the ability of one established and one native omnivorous plant bugs' (mirids; *Nesidiocoris tenuis* and *Macrolophus praeclarus*) ability to control whiteflies and their ability to persist in

open field tomato production. The group showed the predatory mirids control whiteflies but would leave the field once they consumed all the prey. Intercropping a few sesame plants provided a way to retain the mirids in the absence of prey. This study provides a method to use mirids as biological control agents in open-field tomato production to help manage existing and future invasive pests of tomato such as *Tuta absoluta* and *Helicoverpa armigera*. The publication is available at <https://doi.org/10.3390/plants11202779>

Brazilian Peppertree

In FY23, PPQ S&T began a comprehensive field monitoring initiative, covering 13 locations in Hidalgo County, five in Willacy County, and eight in Cameron County, Texas. This program aims to establish pre-release population data, to assess impact and the persistence of Thrips, (*Pseudophilothrips ichini*) releases to control Brazilian Peppertree. PPQ S&T has established a colony of *P. ichini*, and the first release occurred in Hidalgo County where PPQ S&T released a total of 10,500 Thrips. Parallel projects are also underway by ARS for release in Florida.

Brevipalpus yothersi

In response to the emergence of the citrus leprosis virus, CiLV-C2H, which affects ornamental crops such as hibiscus, PPQ and University of Florida-Tropical Research and Education Center conducted studies to test the role of biological control in the management of viruliferous *Brevipalpus* mites. *Brevipalpus*-transmitted viruses are spread by the feeding and movement of viruliferous *B. yothersi* within and among affected plants. The group found the predatory mite, *Amblyseius largoensis*, to be a promising biological control agent of *B. yothersi*. The effects of acaricides used to control *B. yothersi* were also evaluated on this predator. Researchers also evaluated the commonly used acaricides like abamectin and spiroticlofen, highly effective in controlling *B. yothersi*, are only slightly harmful to *A. largoensis*. Under greenhouse conditions, a combination of predators and acaricide increased suppression of *B. yothersi* from one month to three months after treatment application when compared to acaricides alone. Combining predatory mites with acaricides shows promise in improving *B. yothersi* management.

Phantasma scale

PPQ S&T and Florida Department of Agriculture and Consumer Services evaluated the impact of the Phantasma scale (*Fiorinia phantasma*) at the original detection sites in Miami-Dade County and developed a method to show that the scale was low to non-detectable on most palm species. Two palm species (canary palms and tahina palms) had moderate levels of infestation. The natural enemies known to attack the scale were present on all palm species and at all locations. This information will help identify susceptible palm species and the established biological control agents that could be augmented or conserved to control the scale in the landscape as the pest spreads to new areas.

Roseau cane scale

PPQ S&T research efforts concentrate on identifying key parasitoids in the community of natural enemies on Roseau cane scale across Asia, focusing on species in the genus *Aprostocetus*. Using molecular analyses, PPQ S&T detected a high degree of genetic diversity, suggesting the presence of seven cryptic species within the *Aprostocetus* genus. One of these species, referred to as *Aprostocetus* sp. 7, was detected in autumn 2023 in Louisiana. PPQ S&T developed an *Aprostocetus* rearing protocol and successfully established *Aprostocetus* sp. 7 in colony. PPQ S&T has initiated host range testing and life history studies of *Aprostocetus* sp. 7 to estimate its role on Rosea cane scale in Louisiana.

Shot Hole Borer

PPQ S&T is continuing work to identify an effective biological control agent for shot hole borer (*Euwallacea fornicates*). PPQ S&T successfully reared parasitoid wasps in the genus *Phymastichus* for at least seven generations under laboratory conditions. Methods development work is ongoing to increase parasitism rates in the laboratory. Also, three species of non-target ambrosia beetles are being tested under laboratory conditions for use in host specificity testing. To improve parasitoid rearing, PPQ S&T conducted experiments comparing shot hole borer colonization and reproduction in different host tree species. In Taiwan, cooperators began experiments testing the utility of sentinel logs to attract parasitoids in the field, as well as exclusion experiments to assess impact of parasitoids on field populations of shot hole borers in Taiwan.

Pest Exclusion and Import Programs

In FY23, Pest, Pathogen, and Biological Control Permitting (PPBP) Unit continued to review and process petitions for approval for the release of biological control agents. These petitions were submitted by stakeholders and are at different phases of the review and approval process. The following are highlights:

Four biological control agents were granted Findings of No Significant Impact (FONSI's) for the National Environmental Policy Act (NEPA) environmental assessments between Oct 1, 2022, and Oct 1, 2023. PPQ permitted the release of the Murakami strain of *Aphalara itadori* against giant, Japanese, and bohemian knotweeds throughout the contiguous United States in March 2023. In April and May 2023, three biological control agents were approved specifically for release in Hawaii: the golden sombermark butterfly, *Euselasia chrysippe*, against Miconia, the flea beetle, *Syphraea uberabensis*, against cane Tibouchina, and the parasitoid *Phymastichus coffea* against the coffee berry borer.

APHIS received three petitions for new agents in 2023. *Callopietria exotica* was petitioned as an agent against old-world climbing fern, an invasive weed in the Everglades. Two petitions were received targeting invasive insects: *Apanteles opuntiarum* against the cactus moth in the southern United States, and *Aprostocetis nitens* against the Erythrina gall wasp in Hawaii. These petitions have all been reviewed and recommended for release by the TAG for weeds and the Biocontrol

Review Committee for insects. PPQ is preparing biological assessments and environmental assessments from these petitions to continue through the regulatory process.

Three biological assessments are under review by the U.S. Fish and Wildlife Service; the biological assessments for *Bagous nodulosus* against flowering rush and *Dichrorampha aeratana* against oxeye daisy are nearing completion, and the assessment for *Euchryptorrhynchus brandti* for control of tree of heaven is in review. APHIS also received one Letter of Concurrence from the U.S. Fish and Wildlife Service in September 2023 for a biological assessment for *Ceuthorhynchus scrobicollis* against garlic mustard; the environmental assessment for this has been prepared and the Tribal review package is being prepared.

Tribal review or responses to tribal review are being worked on for four petitions. Two packages are being prepared for review *Aceria salsolae* against Russian thistle and *Bagous nodulosus* against flowering rush (also mentioned above, FWS and Tribal reviews do not have to be sequential). There are two Tribal reviews for which responses to Tribal concerns are being developed, one for *Aceria angustifolia* against Russian olive and another for *Mogulones borraginis* against houndstongue.

Two additional petitions are on hold while additional data is collected. One of these for two agents against Chinese tallow is at the end of the process however, because of resistance from beekeepers a working group has been developed to determine the value of Chinese tallow to beekeepers and determine if the agents might cause any economic impact. The two agents affect seedlings and are unlikely to have any impact on mature trees of value to beekeepers. Lastly, there was a petition that was not recommended by the TAG for *Ceutorhynchus cardariae* against hoary cress; additional research was requested. The response from the petitioners was recently received and is currently under review by APHIS and the TAG chair.

Appendix A: FY23 Biological Control Target, Agent, and Stage of Project Development

TARGET PEST/BC Agent	Pre-Approval Testing	Permitting Review	Approved for Release	Methods Development	Rearing & Release	Field Coll. & Redistribute	Post-release Monitoring	Technology Transfer
INSECTS								
Asian Citrus Psyllid								
<i>Tamarixia radiata</i>			Y		X		X	X
Bagrada bug								
<i>Gryon aetherium</i>	X		N-W			X		
Brown Marmorated Stink Bug								
<i>Trissolcus japonicus</i>	X		N-W			X		X
Coffee Berry Borer								
<i>Phymastichus coffea</i>			Y-H	X	X			
Box Tree Moth								
<i>On-going exploration</i>								
Cactus Moth								
<i>Apanteles opuntiarum</i>	X	X	N					
Emerald Ash Borer								
<i>Oobius agrili</i>			Y	X	X		X	X
<i>Spathius agrili</i>			Y	X	X		X	X
<i>Spathius galinae</i>			Y	X	X		X	X
<i>Tetrastichus planipennis</i>			Y	X	X		X	X
Erythrina Gall Wasp								
<i>Aprostocetus nitens</i>		X	N					
Harrisia Cactus Mealybug								
<i>Anagyrus cachamai</i>	X		N					
<i>Anagyrus lapachosus</i>	X		N					
Invasive Shot Hole Borers								
<i>Phymastichus sp.</i>	X		N	X				

TARGET PEST/BC Agent	Pre-Approval Testing	Permitting Review	Approved for Release	Methods Development	Rearing & Release	Field Coll. & Redistribute	Post-release Monitoring	Technology Transfer
<i>Eucosmophorus</i> sp.	X		N	X				
Japanese Beetle								
<i>Istocheta aldrichi</i>			Y			X	X	X
<i>Tiphia vernalis</i>			Y			X	X	X
<i>Ovavesicula popilliae</i>				X	X			
Olive Psyllid								
<i>Psyllaephagus euphylluræ</i>			Y	X	X			
Roseau Cane Scale								
<i>Aprostocetus</i> sp.	X		N					
Spotted Lantern Fly								
<i>Anastatus orientalis</i>	X		N					
<i>Dryinus sinicus</i>	X		N					
Spotted Wing Drosophila								
<i>Ganaspis brasiliensis</i>			Y	X	X			
Russian Wheat Aphid								
<i>Aphelinus hordei</i>			Y	X	X			
WEEDS								
Air Potato								
<i>Lilioceris egena</i>			Y	X	X			
<i>Lilioceris cheni</i>			Y				X	X
Brazilian Peppertree								
<i>Pseudophilothrips ichini</i>			Y		X		X	
<i>Calophya latiforceps</i>			Y	X				
Canada Thistle								
<i>Puccinia punctiformis</i>		X	Y-R	X				
Cane Tibouchina								
<i>Syphraea uberabensis</i>			Y-H	X	X			
Cape Ivy								

TARGET PEST/BC Agent	Pre-Approval Testing	Permitting Review	Approved for Release	Methods Development	Rearing & Release	Field Coll. & Redistribute	Post-release Monitoring	Technology Transfer
<i>Parafreutreta regalis</i>			Y					
<i>Secusio extensa</i>			Y					
Cheatgrass								
<i>N/A ongoing exploration</i>								
Common Crupina								
<i>Ramularia crupinae</i>			Y-R	X	X			
Common Reed								
<i>Archanara geminipunctata</i>	X		N					
Chinese Tallow								
<i>Bikashi collaris</i> (leaf beetle)		X	N					
<i>Gadirtha fusca</i>		X	N					
Dyer's Woad								
<i>Ceutorhynchus peyerimhoffi</i>	X		N					
<i>Ceutorhynchus rusticus</i>	X		N					
Field Bindweed								
<i>Melanagromyza albocilia</i>	X		N					
<i>Microsphecia brosimiformis</i>	X		N					
Flowering Rush								
<i>Bagous nodulosus</i>	X	X	N					
Garlic Mustard								
<i>Ceutorhynchus constrictus</i>	X		N					
<i>Ceuthorhynchus scrobicollis</i>		X	N					
Giant Reed								
<i>Lasioptera donacis</i>			Y				X	
Giant Salvinia								
<i>Cyrtobagous salviniae</i>			Y					X
Gorse								

TARGET PEST/BC Agent	Pre-Approval Testing	Permitting Review	Approved for Release	Methods Development	Rearing & Release	Field Coll. & Redistribute	Post-release Monitoring	Technology Transfer
<i>Sericothrips staphylinus</i>			Y		X			
Hawkweeds								
<i>Aulacidea pilosellae</i>	X							
<i>Aulacidea subterminalis</i>			Y				X	X
<i>Cheilosia urbana</i>			Y	X				
Hoary Cress								
<i>Aceria drabae</i>			Y	X	X			
<i>Ceutorhynchus cardariae</i>	X		N					
Houndstongue								
<i>Mogulones borraginis</i>	X		N					
<i>Mogulones crucifer</i>	X		N					
Hydrilla								
<i>Bagous hydrillae</i>			Y				X	
<i>Hydrellia balciunasi</i> & <i>pakistanae</i>			Y				X	
Knapweed - Diffuse & Spotted								
<i>Cyphocleonus achates</i>			Y	X			X	X
Knapweed - Russian								
<i>Aulacidea acroptilonica</i>			Y					X
<i>Pseudorchestes sericeus</i>	X		N					
<i>Jaapiella ivannikovi</i>			Y					X
Knotweeds								
<i>Aphalara itadori</i>			Y		X			
Melaleuca								
<i>Lophodiplosis indentata</i>			Y		X			
Old World Climbing Fern								

TARGET PEST/BC Agent	Pre-Approval Testing	Permitting Review	Approved for Release	Methods Development	Rearing & Release	Field Coll. & Redistribute	Post-release Monitoring	Technology Transfer
<i>Callopietria exotica</i>		X	N					
<i>Neostromboceros albicomus</i>		X	N					
Oxeye Daisy								
<i>Dichrorampha aeratana</i>		X	N					
Perennial Pepperweed								
<i>Ceutorhynchus marginellus</i>	X		N					
Puncturevine								
<i>Microlarinus lareynii</i>			Y	X	X	X	X	
<i>Microlarinus lypriformis</i>			Y	X	X	X	X	
Rush Skeletonweed								
<i>Bradyrrhoa gilveollea</i>			Y				X	
Russian Olive								
<i>Aceria angustifoliae</i>		X	N					
Russian Thistle								
<i>Aceria salsolae</i>		X	N					
<i>Uromyces salsolae</i>	X		N					
Scotch Broom								
<i>Bruchidius villosus</i>			Y				X	
<i>Exapion fuscirostre</i>			Y				X	
<i>Leucoptera spartifoliella</i>			Y				X	
Starthistle - Yellow								
<i>Ceratapion basicorne</i>			Y	X	X			
Swallow-wort								
<i>Hypena opulenta</i>			Y			X	X	
Miconia								
<i>Euselasia chrysippe</i>			Y-H	X	X			
Tree of heaven								
<i>Verticillium nonalfalfae</i>	X		N					

TARGET PEST/BC Agent	Pre-Approval Testing	Permitting Review	Approved for Release	Methods Development	Rearing & Release	Field Coll. & Redistribute	Post-release Monitoring	Technology Transfer
<i>Eucryptorrhynchus brandti</i>		X	N					
Toadflax - Dalmation								
<i>Mecinus janthiniformis</i>			Y					X
<i>Rhinusa linariae</i>			Y		X	X		
Toadflax - Yellow								
<i>Mecinus heydeni</i>	X		Y					
<i>Mecinus janthinus</i>			Y					X
<i>Rhinusa pilosa</i>			Y	X	X			
Tropical Soda Apple								
<i>Gratiana boliviana</i>			Y					
Water Lettuce								
<i>Neohydronomus affinis</i>			Y		X	X	X	X
Water Hyacinth								
<i>Megamelus scutellaris</i>			Y		X	X	X	X
<i>Neochetina</i> spp.			Y		X	X	X	X

X= Current stage of support, Y= Yes, N= No, Y-H= Yes - Hawaii only, Y-R= Yes - Research only, N-W = not approved for interstate release -within State movement only

Appendix B: FY23 PPA 7721-funded biological control projects.

State	Project Title
FL	Laurel Wilt Disease Biological Control
FL	Evaluating predatory plant bugs (Miridae) for biological control against the invasive South American tomato leafminer
MD	Regional to National Post-Release Evaluation of Emerald Ash Borer Biological Control
FL	Establishment and evaluation of Brazilian peppertree biological control
HI	Field testing of bait stations containing a fungal pathogen to control invasive fruit flies
DE	Protection of North American ash against emerald ash borer with biological control: Measuring Natural Enemy Impacts
NH	Advancing blueberry plant protection: creating identification and monitoring tools for parasitoids of blueberry gall mid
FL	Biological Control of Cactus Moth, <i>Cactoblastis cactorum</i> (Berg)
TX	Biological Control of Brazilian Peppertree in the United States FY2023
HI	Systems Approach for the Management of Coffee Berry Borer in Hawaii and Puerto Rico with Emphasis on Biological Control
FL	Investigating interactions between multiple biocontrol agents used to control the invasive plant air potato
MD	Field Release and Evaluation of <i>Ramularia crupinae</i> for the Management of Noxious <i>Crupina vulgaris</i> Populations
KY	The Japanese beetle control near airports and cargo transportation facilities: Field Testing
MA	Developing biological control methods for Roseau cane scale
ID	Nez Perce Tribe Bio-control Project-Noxious/Invasive Weed Survey and Control
FL	Establishment and Evaluation of Air Potato Biological Control
NC	Establishing and Assessing Biological Control Agents of Emerald Ash Borer in North Carolina
MA	Classical Biological Control of Boxtree Moth
CA	Biological Control of <i>Bagrada</i> Bug
HI	Management of hala scale in Hawaii, and survey of its potential biological control agents in its native range
TN	Post-Release Aftermath Assessment of Biological Control of Emerald Ash Borer in a Southern Climate (Tennessee)
DE	Preemptive biological control of a high-risk invasive longhorn beetle
OR	Deploying a Rapid Response Biocontrol Strategy against Emerald Ash Borer in Oregon
OR	Biological Control of Spotted Wing <i>Drosophila</i> in Oregon
FL	Registration of <i>Verticillium nonalfalfae</i> to control tree-of-heaven