

THE PIONEERING WORK OF GEORGE N. WOLCOTT:  
IMPLICATIONS FOR U.S.-CARIBBEAN ENTOMOLOGY  
IN THE 21ST CENTURY

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This paper is dedicated to the memory of Dr. George Norton Wolcott (Fig. 1), a most distinguished entomologist in the Caribbean. I am pleased that Dr. Wolcott's daughter, Mrs. Ann Wolcott-Martínez, and her son, Mr. David Wolcott-Martínez, are with us today to celebrate the accomplishments of Dr. Wolcott. I thank Dr. Sivinski and the Florida Entomological Society for making this occasion possible.

My objectives are to give abbreviated insights into Dr. Wolcott's educational and personal background, and highlight aspects of his contributions to Puerto Rican and Caribbean entomology. These highlights exemplify Dr. Wolcott's pioneering and visionary work in the region. I will also address Dr. Wolcott's legacy, embodied in part in his many publications describing the Puerto Rican and Caribbean entomofauna that serve as essential research references to numerous entomologists. Dr. Wolcott's extensive collaborative efforts with Caribbean entomologists and agriculturists serve as the model which many should emulate and have important implications for U.S.-Caribbean linkages as we enter the 21st century. His successes in biocontrol then, challenge us now to develop innovative approaches to solving pest problems affecting both the U.S. mainland and the countries within the Caribbean Basin [the region of the Americas inclusive of all the nations washed by the Caribbean Sea and those states of the U.S. abutting the Gulf of Mexico (USAID 1990)].

EDUCATIONAL AND PERSONAL BACKGROUND

George Norton Wolcott was born in Utica, New York, a town located near Yorkville and Whitesboro, on July 12, 1889, to David Clinton Wolcott and Marion Benedict. Upon graduation from Utica Free Academy in Utica, New York, in 1905, he obtained the Bachelor's degree in 1909 in Economic Entomology from the then New York State College of Agriculture at Cornell University and the M.S. in 1915 while studying scientific illustration under Professor W. C. Baker, *Illustrator of Bailey's Encyclopedia of Agriculture*. In 1925, under the guidance of Professor Needham at Cornell University, Wolcott obtained the Ph.D.

In 1919, he married Magdalen Hall (Fig. 2). They had three children: Ann (Fig. 2), David and Oliver. Ann recalls her early years in Puerto Rico and her stories suggest that her father was a wonderful curiosity and a source of amusement to his children and grandchildren.

Dr. Wolcott had a great love for the Puerto Rican outdoors. He also loved gardening and made calendars with twelve black-and-white drawings of flowers and nature scenes, which he gave to friends each year. One can only guess that his earlier training in the illustration of insects at Cornell University had an influence here. Dr. Wolcott was partial to drawing with black ink, an unusual preference in the eyes of his young daughter ("who wouldn't want calendars with brightly colored flowers?" she must have thought).

Her father's frequent pastime was walking, strolling in open fields and hiking to the top of any hill or peak on the island, particularly El Yunque, often with a well-provisioned picnic basket. His frequent hilltop picnics often brought him face to face with



Fig. 1. George N. Wolcott. Year unknown.

the many nuisances and discomforts of living in the tropics: he endured numerous mosquito bites, tropical rainstorms, and even lightning strikes. I am told that once, while he was enjoying lunch under a tree, lightning struck the tree but Wolcott held his

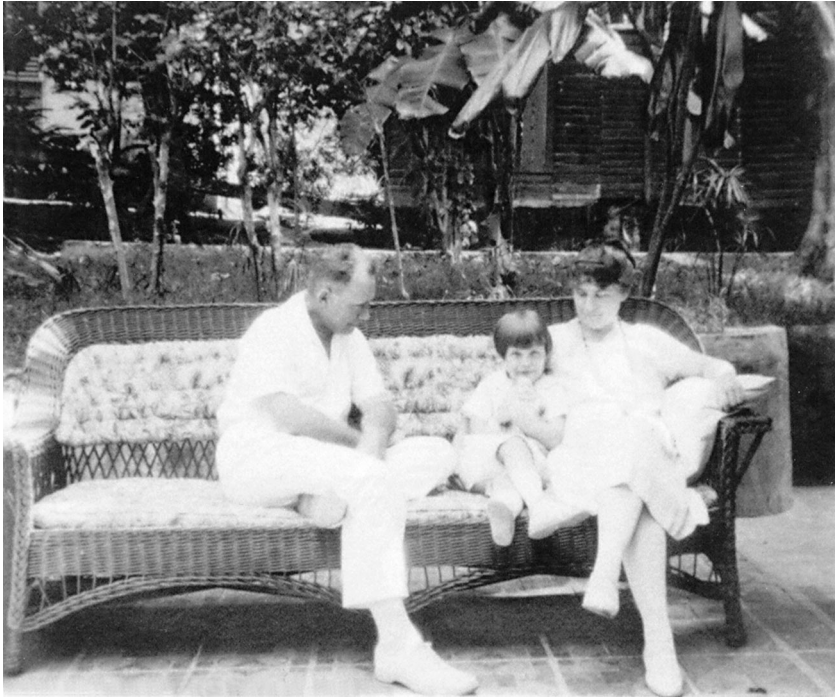


Fig. 2. From left: Dr. George Norton Wolcott, Ann (6 years old), and Mrs. Magdalen Wolcott. Photographed about 1926.

ground and finished his lunch. Whether it was out of bravery or hunger, we will never know. At picnic's end, he nonchalantly set off for home and, on arrival, casually mentioned the incident only after a family member remarked that he smelled of smoke.

Ann fondly remembers her father losing the heel of one shoe during a hiking trip to Mount Britton and sliding down the hill with one good shoe and her, perched on his shoulder, "clinging for dear life to his eye sockets". This surely is evidence that Dr. Wolcott was a loving father who shared many enjoyable experiences with his family while in Puerto Rico. His grandchildren, David and Marie, were fascinated by his orange peeling perfection, especially the cascading, unbroken orange rind falling over his sharp knife and nimble fingers. David recalls thrusting one orange after another at his grandfather, never uttering a word, in desperate effort to keep the "ribbon" in continuous motion.

#### WOLCOTT THE AVID ENTOMOLOGIST

His father was a lawyer, his mother adept at painting in water color, and his sister and brother were architects. So why did George become an entomologist? We may never know why, but I am told that at three or four years old he discovered some insects in a bag of rancid nuts that a grocer tried to pass off on his unsuspecting mother. While she was not amused, little George asked the grocer for more of his bugged nuts. No one knows for sure what George did with his large cache of nuts but we now know

that this boyhood avocation with insects became the lifelong occupation of George Wolcott. Later in life, he bought a cabin and named it the "Entomo-lodge". His daughter Ann reports that her father never doubted that entomology would be his life's work. It was during one of his entomological escapades (catching insects one night) that George met his future wife Magdalen, so it is probably no surprise that he never "shook the bug" habit.

#### CONTRIBUTIONS TO PUERTO RICAN AND CARIBBEAN ENTOMOLOGY

Dr. Wolcott had entomological appointments on the U.S. mainland and in Puerto Rico between 1910 and 1956. In Puerto Rico he worked at the Experiment Station of the Sugar Producers Association from 1910-1912, rising through the ranks from Assistant to Associate Entomologist then to Entomologist. He then served as Director of the Entomology Department of the Insular Experiment Station, Rio Piedras, from 1914-1916 and again from 1932-1956 when he retired.

Between 1919 and 1929 he held various positions as Entomologist, initially in Puerto Rico, then in the Dominican Republic, Haiti and Peru, returning each time to Puerto Rico, the place he seemed to love. In fact, in 1946 he wrote to Dr. John Allen of the Department of Education in Albany, New York, saying, "My work here is most pleasant and psychologically satisfying". From 1932 to 1956, Dr. Wolcott worked for one final time at Rio Piedras then retired and returned to the mainland.

One of his most notable undertakings was to control the lesser sugarcane borer, *Diatraea saccharalis* (F.) (Lepidoptera: Pyralidae) in Puerto Rico. Adults oviposit on sugarcane leaves and the larvae tunnel into the stalks, eating the soft tissue, thereby causing a decrease in sugar content and sugar yield (Wolcott 1915). Additionally, secondary microbial infection occurs in the larval tunnels, tainting the juice and weakening the stalks. The larvae then pupate in the tunnels from which the adults emerge. *D. saccharalis* attacks sugarcane throughout the West Indian archipelago from Guyana, Trinidad and Barbados through St. Kitts, Puerto Rico and Santo Domingo, to Jamaica, Cuba, and the southern United States.

Wolcott (1915) demonstrated that there was an inverse relationship between increased rainfall and the number of young *D. saccharalis* instars found in the field, presumably because the larvae drown in the flooded tunnels. However, the use of this information for *D. saccharalis* control was less practicable than his finding that borer infestations in fields that were burned to remove trash were 100% higher than in fields that were not burned. He presumed that the egg parasitoid *Trichogramma minutum* Riley (Hymenoptera: Trichogrammatidae), as reported by scientists in Louisiana, was being destroyed by the fire. Thus, he recommended that the burning (presumably pre-harvest burning) of trash in sugarcane fields be discontinued. Dr. Wolcott also made augmentative releases of *T. minutum* for the successful suppression of *D. saccharalis* (Wolcott 1915). His extensive collections of parasitized borer egg clusters, and studies of the development and emergence behavior of *T. minutum* adults in Texas (DeBach & Hagen 1964, Wolcott 1918), probably also contributed to his successful rearing and augmentative releases of the parasite for *D. saccharalis* suppression in Puerto Rico and later in Haiti.

The sugarcane root weevil (= sugarcane root stock weevil), *Diaprepes abbreviatus* L. (Coleoptera: Curculionidae), one of several coleopteran pests of sugarcane in Puerto Rico, was studied in great detail by Dr. Wolcott, who developed a protocol for rearing it in the laboratory in order to better understand its biology during its subterranean development. His diagrams of *Diaprepes* larvae and accounts of the life cycle of this pest (Wolcott 1937) not only provide evidence of his talents as an illustrator but of his keen observational skills and meticulous documentation of the insect's biology.

The larvae of several Coleoptera, including the sugarcane rhinoceros beetle, *Strategus barbigerus* Chapin, and the white grubs *Lachnosterna* sp. and *Phyllophaga* sp. (Coleoptera: Scarabaeidae), were exceedingly intractable pests in Puerto Rico (Wolcott 1950). In an effort to develop effective control strategies for these pests, Wolcott (1950) performed a detailed review and assessment of the effectiveness of natural enemies of grub populations on the island. These beneficials included the parasitoids *Cryptomiegia aurifacies* Walton and *Eutrixoides jonesii* Walton (Diptera: Tachinidae), and the predacious wireworm ("cucubano") *Pyrophorus luminosus* Illiger [= *Ignelater luminosus* (Illiger)] (Coleoptera: Elateridae). His detailed analysis of the role of insect parasitoids and predators, as well as vertebrate predators, in white grub control is evidence of the thoroughness and enthusiasm with which he approached his work.

Dr. Wolcott's commitment to controlling insect pests in Puerto Rico appeared to be accompanied by the realization that pest control problems and solutions on that island were influenced by related events in neighboring islands in the Caribbean archipelago. Thus, he traveled to Guyana, Barbados, and Trinidad in 1912 to review the control strategies used there for white grubs. He developed collaborations with entomologists in those countries and imported the parasitic wasp, *Tiphia parallela* Smith (Hymenoptera: Scoliidae), from Barbados into Puerto Rico for *Lachnosterna* control (Wolcott 1950).

#### WOLCOTT: A VISIONARY AND PIONEER

One of Wolcott's most noteworthy undertakings was the biological control of mole crickets (Fig. 3). *Scapteriscus didactylus* (Latreille) (Orthoptera: Gryllotalpidae) ("La changa"), then presumed to be *S. vicinus* Scudder (Frank 1990), was a pervasive agricultural pest in Puerto Rico, having apparently spread from South America via the Lesser Antilles (Wolcott 1938). In 1922 Dr. Wolcott foresaw the need to improve bio-control efforts against mole crickets in Puerto Rico. Consequently, he secured funding and organized expeditions to Trinidad and South America to find parasites. He successfully introduced the wasp *Larra americana* Saussure (Hymenoptera: Sphecidae), later identified as *L. bicolor* F. (Frank 1990) (Figs. 4 & 5), into Puerto Rico from Belem, Pará, Brazil (Wolcott 1938, 1941). This single classical biological control effort by Dr. Wolcott laid the foundation for future biological control successes against mole crickets within the Caribbean Basin region.

Efforts to import *L. bicolor* from Brazil for mole cricket control in Florida in the 1940s were unsuccessful. In 1978, however, a partial solution to the problem was found in Puerto Rico where populations of the wasp previously introduced by Wolcott were well established. The late Dr. Reece Sailer, then Graduate Research Professor in the Department of Entomology, University of Florida (UF), Gainesville, collected and released these parasitoids into five Florida locations, including Ft. Lauderdale, Tampa, and Gainesville, between 1981 and 1983 (Fig. 6). To date, *L. bicolor* is established in Ft. Lauderdale where it seems mainly to attack *S. abbreviatus* (Frank 1990, Frank et al. 1995).

Subsequently, *L. bicolor* imported directly from Santa Cruz, Bolivia, in 1988 and 1989 by Dr. F. D. Bennett, then Graduate Research Professor of Entomology at UF (Frank et al. 1995), was established in Alachua County (Gainesville) (Fig. 6) (Frank et al. 1995). The population has since spread to nearby Clay County (Fig. 6) (Frank, personal communication). No doubt, earlier success with the Puerto Rican introductions into Florida served as an incentive for the additional efforts. Thus, Dr. Wolcott's work laid the foundation for the work of Drs. Sailer and Bennett, both pioneers of biological control in Florida. The *Larra* parasitoid is now well established in Florida (Fig. 6), and this work continues under Dr. Howard Frank, UF Institute of Food and Agricultural Sciences (IFAS) Mole Cricket Control Program (Frank 1994).



Fig. 3. A mole cricket *Scapteriscus vicinus* (unparasitized), a pest of turfgrass in Florida. Slide (lent by Dr. J. H. Frank) was taken by Dr. J. Castner and reprinted with permission.



Fig. 4. An adult mole cricket being parasitized by *Larra bicolor*. Slide taken by Dr. J. Castner (lent by Dr. J. H. Frank) and reprinted with permission.

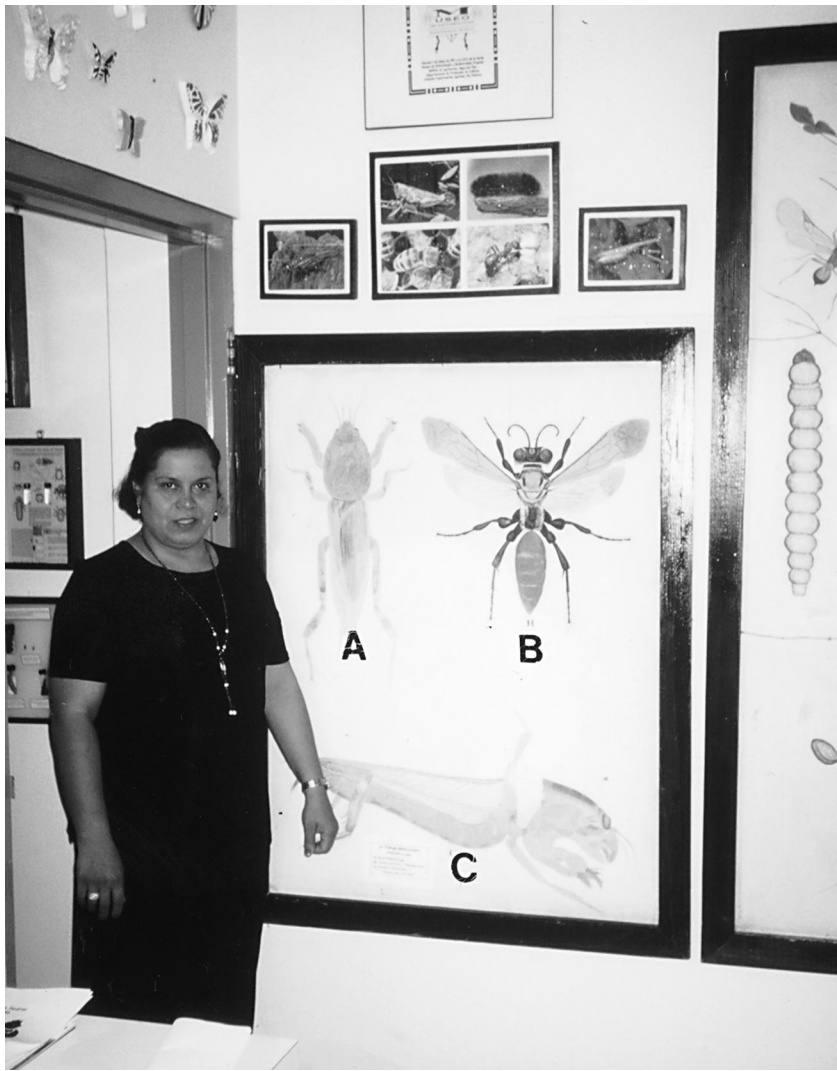


Fig. 5. Original drawing of (A) *Scapteriscus didactylus* (labeled as *S. vicinus*), (B) *Larra americana* (now known as *L. bicolor*), and (C) larva of *Larra* on *Scapteriscus* mole cricket (drawn by Francisco Sein), hangs in the collection of the Institute of Entomology, University of Puerto Rico, Rio Piedras. At left is Dr. Rosa Franqui, Curator of the Insect Collection. Photograph taken by Dr. J. H. Frank, 1999.

Wolcott not only pioneered the introduction of *L. bicolor* into Puerto Rico but also discovered that *Scapteriscus* spp. are hosts to the parasitic fly *Ormia* (= *Euphasiapteryx*) *depleta* (Wiedemann) (Diptera: Tachinidae) which he encountered in Brazil (Wolcott 1940). While this latter parasitoid apparently did not become established in

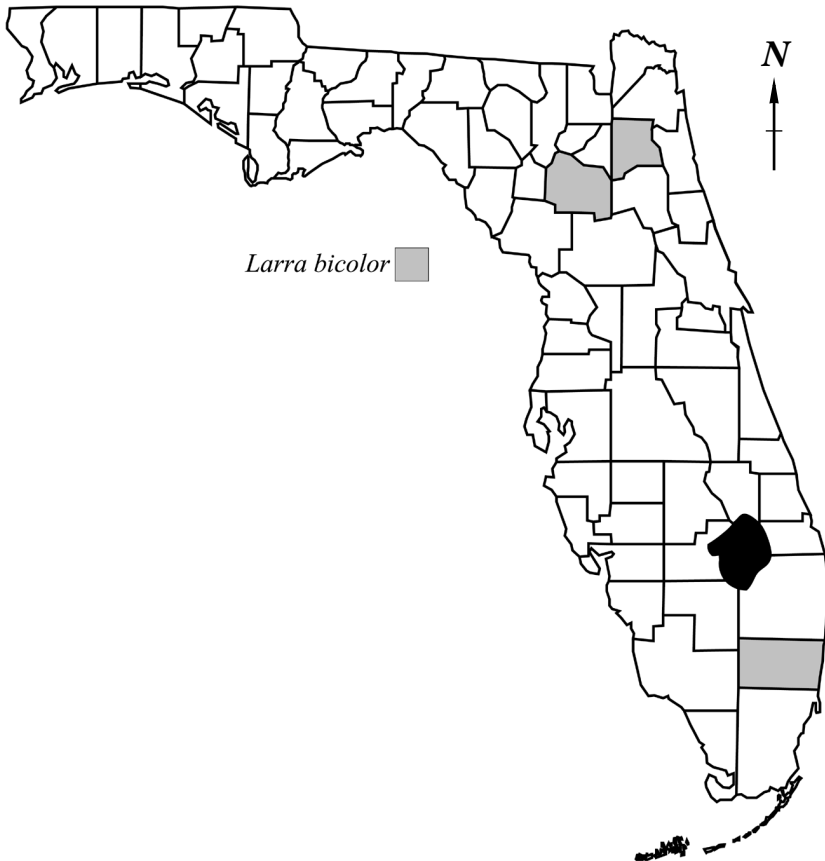


Fig. 6. Map of Florida showing the sites of *L. bicolor* establishment from the initial introduction from Puerto Rico by Dr. Reece Sailer in 1981-1983 in the south (Ft. Lauderdale, Broward County) and from subsequent introductions from Santa Cruz, Bolivia by Dr. Fred D. Bennett in 1988-1989 in the north (Gainesville, Alachua County) that later spread northeast to Clay County. Slide lent by Dr. J. H. Frank.

Puerto Rico (Frank et al. 1995), its potential as a biocontrol agent for mole crickets has since been realized. *O. depleta* was released in 1988 and 1999 against mole crickets in several Florida counties (Frank 1994).

Thus, through his knowledge of the incidence of mole crickets in Cuba, Jamaica, the Lesser Antilles, and other countries (Wolcott 1941) within the Caribbean Basin, Wolcott recognized the role of the Archipelago in the northward migration of insect pests. He collaborated with scientists in other countries and capitalized on the availability of beneficial insects like *Larra* and *Ormia* from countries within the region to address the mole cricket problem in Puerto Rico. His foresight and prior work therefore pioneered future efforts for mole cricket control in Florida.

Wolcott's pioneering work was also evidenced by his educational outreach and teaching activities. From 1924-1928, as Entomologist in the Agricultural Technical

Service of Haiti, Dr. Wolcott trained many Haitians in entomological practices, several of whom reportedly continued in the discipline. These are but a few of his many lasting accomplishments in support of the entomological sciences in the region.

#### HIS LEGACY

Dr. Wolcott's legacy is embodied not only in the entomological careers he fostered but also in his 200-plus scientific publications and manuscripts which serve as a constant reference for scientists within and outside the Caribbean region. His seminal work "Insectae Borinquenses" (Wolcott 1936) is a revised annotated check-list of Puerto Rican insects that has been a classic. His books were adopted as texts by the Polytechnic Institute of San German, Puerto Rico, the College of Agriculture at Mayaguez, and the Imperial College of Tropical Agriculture in Trinidad, now the College of Agriculture, University of the West Indies.

In 1933 Dr. Wolcott revived the once defunct Entomological Society of Puerto Rico founded by Dr. Van Dine. The society continues to function to this day.

#### IMPLICATIONS OF HIS WORK FOR U.S.-CARIBBEAN ENTOMOLOGY IN THE 21ST CENTURY

One of the accomplishments of George Wolcott was the extent to which he familiarized himself with the entomologists, other agricultural scientists, entomological problems and their solutions in the neighboring countries of the Caribbean. Through this knowledge, he apparently recognized the essential role of the Caribbean as the northward conduit for insect pest infestations in Puerto Rico and the U.S. mainland. Thus, he sought to forge collaborations with other scientists and train local personnel to help solve the pest problems in Puerto Rico and the Caribbean Basin as a whole.

Given Florida's location within the Caribbean Basin and Wolcott's example of cooperation, it behooves us to renew our collective efforts in pest curtailment within the region for the 21st Century. Thus, U.S. and Caribbean agencies should (1) more aggressively foster cooperation among scientists within the region, (2) train students and entomological practitioners to help identify and decrease pest infestations that threaten agriculture in the Caribbean and the U.S., and (3) provide the needed infrastructure for detection, analysis, forecast, and communication of pest population outbreaks within the Caribbean Basin. Only through such efforts can we hope to more effectively stem the rising tide of exotic pest invasions and the resulting crop damage.

As a daughter of the Caribbean who, in some ways, is a beneficiary of the work of pioneers like Dr. George Wolcott, I see new challenges for biological control in the 21st Century within the Caribbean Basin. It is in this context that I share a snapshot of my own research on yet another Caribbean pest that has also invaded the U.S. mainland.

The Caribbean fruit fly, *Anastrepha suspensa* (Loew) (Diptera: Tephritidae), attacks various fruits and vegetables in several islands, including Cuba and Jamaica. Flies were first found in Key West, Florida, in 1931. The parasitic wasp *Diachasmimorpha longicaudata* (Ashmead) (Dl) (Hymenoptera: Braconidae), a biological control agent that attacks fruit fly larvae, suppressed the fly populations in Florida by about 40% (Baranowski 1987). Nearly 95% of the fly populations in southern Florida are attacked by the wasp but those north of Lake Okeechobee are parasitized by *D. longicaudata* to a lesser extent (Sivinski et al. 1996).

Biocontrol approaches should not only involve the use of existing parasitoid species but also a search for new ones. To that end, the research in my laboratory focuses on a parasitic wasp and an unusual virus that, respectively, are potential candidates for Caribbean control. The wasp *Fopius arisanus* Sonan (Hymenoptera: Braconidae) is

an egg-pupal parasitoid of Old World tephritids, including the Mediterranean fruit fly (Medfly), *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), and the Oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Harris & Bautista 1996). We have reared *F. arisanus* for the first time on the Caribfly, a New World tephritid (Lawrence et al. 2000), with the goal of mass-rearing and releasing the Caribfly-compatible strain of the wasp into the field.

The second possible biocontrol agent is the symbiotic entomopoxvirus (EPV) found in the accessory glands of the female *D. longicaudata* reproductive system (Lawrence & Akin 1990) and named here DIEPV (Fig. 7). The virus enters the fruit fly's hemocytes (blood cells) upon injection with the wasp egg into the Caribfly larva. Viral infection induces disruption of host blood cells and, thus, could likely cause "anemia" and compromise resistance to microbial infection. Given its large genome of 290-300 kb, DIEPV is also a potential vector for the insertion of specific genes that disrupt fruit fly egg production or other important biological functions. However, a basic understanding of DIEPV genes is needed in the near-term before the feasibility and practicality of such novel control strategies can be explored.

Numerous pests have invaded the continental U.S. via the Caribbean islands and little is known of their biology, ecology or natural control agents. Greater collaboration among scientists in the region would advance our efforts to document pest migrations and biology, and develop proactive strategies for their control.

Dr. George Norton Wolcott left a rich legacy of scientific collaboration and promotion of entomological education in the Caribbean. Through his work, as exemplified by his research on the mole cricket, white grub, and other pests, we know that solutions to entomological problems in the Caribbean have a direct beneficial impact on agriculture in Florida and the rest of the continental U.S. It is therefore fitting that the Florida Entomological Society has elected to honor him.

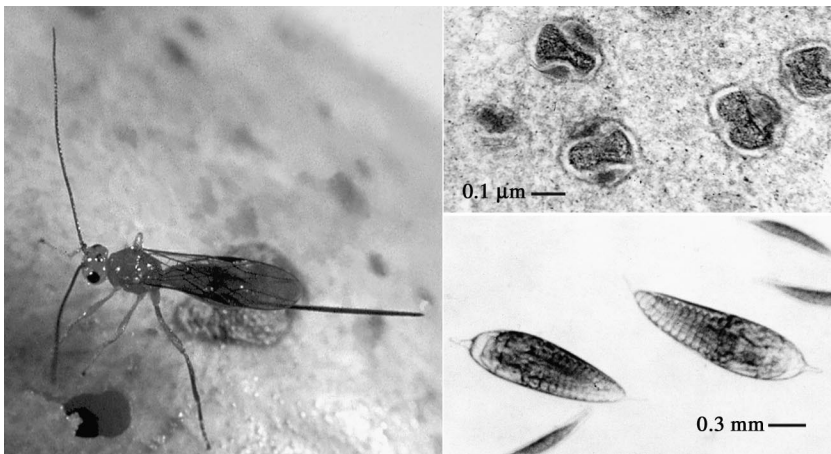


Fig. 7. Left panel: *Diachasmimorpha longicaudata* (Dl), a solitary endoparasitoid of tephritid fruit flies. Females attack larvae of the Caribbean fruit fly, *Anastrepha suspensa* in fruits. Right lower panel: Eggs of *D. longicaudata*. Top: newly oviposited egg (<24 h old); Bottom: fully embryonated egg (36-48 h after oviposition). Wasp and eggs were photographed by Dr. P. D. Greany. Right upper panel: Transmission electron micrograph (TEM) of the entomopoxvirus DIEPV injected into fruit fly larvae with wasp eggs.

As a product of the Caribbean, born and raised, and one who received her early education in Jamaica and worked on Caribbean entomological problems, I feel that in some small way I embody the Pan-Caribbean vision Dr. Wolcott tried to foster. Like Dr. Wolcott, I live in an adopted country, yet my work benefits agriculture throughout the Caribbean Basin. Thus, as we embark on the 21st Century, let us resolve to follow his outstanding example of Pan-Caribbean cooperation and promotion of entomological education in the islands and territories of the Caribbean and in neighboring U.S. mainland states. It is only through cooperation that we can hope to solve the burgeoning agricultural problems we are sure to face in the 21st Century.

Thank you for this honor.

#### ACKNOWLEDGMENTS

I thank Dr. Norm Leppla, Chairman, and members of the Pioneer Lecture Committee of the Florida Entomological Society for inviting me to make this presentation in honor of Dr. Wolcott. I am also indebted to Dr. Howard Frank and Mr. Ignacio Baez, who translated from Spanish to English documents dedicated to the work of Dr. Wolcott and prepared by Drs. José Mari-Mutt and Angel Berríos, University of Puerto Rico, Mayaguez. Their "Dedicatoria" to Dr. Wolcott were originally presented at the meeting of the Entomological Society of Puerto Rico in October 1983. Dr. Frank also provided several slides, from which I made photographs, and reprints, and for serving as a limitless resource of information on mole cricket control by *Larra bicolor* and explaining the relationship of mole cricket research in Florida to Dr. Wolcott's earlier work. I am grateful to Drs. Frank and Leppla for reviewing this manuscript. Special thanks are also due to Mrs. Ann Wolcott-Martínez and her children, David and Marie, for sharing old letters, photographs of Dr. and Mrs. Wolcott, and their wonderful memories of him with me. Dr. Alberto Pantoja deserves my special appreciation for opening communication between the Wolcott-Martínez family and me. I thank David Wolcott-Martínez for his email messages and his efforts to make copies of original photographs and letters for my use. Thanks are due to Ms. Flora MacColl and Mr. Niklaus Hostettler for their preparation of visual aids used herein and in my oral presentation. My special thanks to Ms. Pamela Howell for typing and formatting this manuscript.

I am grateful to my very supportive husband, Dr. Carlton Davis, for sharing his ideas with me and for patiently listening to and reading my many different renditions of this presentation.

Aspects of my research reported herein were supported by grants from the National Science Foundation (IBN9514583) and the Florida Department of Citrus. Florida Agricultural Experiment Station Journal Series No. R-07642.

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