Development of a Training Program to Identify Invasive Weevils in the Caribbean Basin and the United States

Authors: Haseeb, Muhammad, Dosunmu, Omotola G., Kanga, Lambert H. B., O'Brien, Charles W., and Zhang, Runzhi

Source: Florida Entomologist, 102(3) : 469-474

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.102.0304

Development of a training program to identify invasive weevils in the Caribbean basin and the United States

Muhammad Haseeb[1,], Omotola G. Dosunmu[2], Lambert H. B. Kanga[1], Charles W. O'Brien[3], and Runzhi Zhang[4]*

Abstract

Numerous weevil species are serious pests on agricultural crops in the Caribbean basin and the USA. These pests include native and exotic weevil (Coleoptera: Curculionoidea) species. Among them, some weevil species are easy to identify, and others need training and expertise in taxonomy in order to identify them properly. Commodity-based identification and training tools are extremely important and critical. For example, the citrus root weevil, *Diaprepes abbreviatus* (L.) (Coleoptera: Curculionidae) was established in the US nearly 50 yr ago, and costs millions of dollars annually in control attempts in Florida alone. Other species such as the red palm weevil, *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Dryophthoridae); the South American palm weevil, *Rhynchophorus palmarum* (L.) (Coleoptera: Dryophthoridae); and the Jamaican weevil, *Exophthalmus vittatus* L. (Coleoptera: Curculionidae), are potential threats to fruits, vegetables, and ornamental crops. Adults of these weevils display various coloration, and patterns of red, blue, black, green, yellow, orange, and white. Some species have more than 2 color forms; male and female weevils may show major variations in their morphological characters. Regulatory agencies at the local, regional, and international levels are strengthening collaboration on offshore mitigation of these pests. Strict enforcement of regulatory guidelines and procedures is being adopted at the ports of entry into the US. Indeed, training on the identification and screening of these species, and other potential crop pests, is critically important for food security in the region. Training and capacity building to design, develop, and deploy keys, tools, and resources are major components of successful implementation of digital identification tools. The team at the Center for Biological Control is part of the digital resource consortium building tools on invasive beetles on economically important crops. To build capacity in digital insect identification, we have not only modified the contents of graduate and undergraduate insect systematics curriculum, but also have trained numerous students in these new skills.

Key Words: Curculionoidea; training; identification; agriculture; commodities; mitigation

Resumen

Numerosas especies de gorgojos son plagas importantes en cultivos agrícolas en la cuenca del Caribe y los Estados Unidos. Estas plagas incluyen especies de gorgojo nativas y exóticas (Coleoptera: Curculionoidea). Entre ellas, algunas especies de gorgojo son fáciles de identificar y otras necesitan capacitación y experiencia en taxonomía para poder identificarlas adecuadamente. Las herramientas de identificación y capacitación basadas sobre la clase de hospedero son extremadamente importantes y críticas. Por ejemplo, el gorgojo de la raíz de los cítricos, *Diaprepes abbreviatus* (L.) (Coleoptera: Curculionidae), se estableció en los EE. UU. hace casi 50 años y ha costado millones de dólares cada año en intentos para controlarlo solamente en la Florida. Otras especies, como el gorgojo de la palma roja, *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Dryophthoridae); el gorgojo de la palma de América del Sur, *Rhynchophorus palmarum* (L.) (Coleoptera: Dryophthoridae); y el gorgojo jamaicano, *Exophthalmus vittatus* L. (Coleoptera: Curculionidae), son amenazas potenciales para las frutas, los vegetales y las plantas ornamentales. Los adultos de estos gorgojos muestran varios colores y patrones de rojo, azul, negro, verde, amarillo, naranja y blanco. Algunas especies tienen más de 2 formas de color; los machos y las hembras de estos gorgojos pueden mostrar grandes variaciones en sus caracteres morfológicos. Las agencias reguladoras a nivel local, regional e internacional están fortaleciendo la colaboración en la mitigación de estas plagas en alta mar. La aplicación estricta de las pautas y procedimientos reglamentarios se está adoptando en los puertos de entrada a los EE. UU. De hecho, la capacitación en la identificación y detección de estas especies y otras posibles plagas de los cultivos es de importancia crítica para la seguridad de alimentos en la región. La capacitación y el desarrollo de capacidades para diseñar, desarrollar e implementar claves, herramientas y recursos son componentes principales de la implementación exitosa de las herramientas de identificación digital. El equipo del Centro para el Control Biológico es parte del consorcio de recursos digitales que construye herramientas sobre escarabajos invasores en cultivos económicamente importantes. Para desarrollar capacidad en la identificación digital de insectos, no solo hemos modificado los contenidos del plan de estudios de sistemática de insectos para graduados y no graduados, sino que también hemos capacitado a numerosos estudiantes en estas nuevas habilidades.

Palabras Clave: Curculionoidea; formación; identificación; agricultura; productos básicos mitigación

[1]Center for Biological Control, College of Agriculture and Food Sciences, Florida A&M University, Tallahassee, Florida 32307-4100, USA; E-mails: muhammad.haseeb@famu.edu (M. H.); lambert.kanga@famu.edu (L. H. B. K.)
[2]Department of Entomology and Nematology, University of Florida, Gainesville, Florida 32611-0620, USA; E-mail: toladosunmu@ufl.edu (O. G. D.)
[3]2313 West Calle Balaustre, Green Valley, Arizona 85622, USA; E-mail: cobrien6@cox.net (C. W. O.)
[4]Institute of Zoology, Chinese Academy of Sciences, #1 Beichen West Road, Chaoyang, Beijing 100101, China; E-mail: zhangrz@ioz.ac.cn (R. Z.)
*Corresponding author; E-mail: muhammad.haseeb@famu.edu

Table 1. Weevil pests of economically important crops in the Caribbean basin and the United States.

Host plant	Common name	Scientific name	Distribution***
Citrus	citrus root weevils	**Diaprepes abbreviatus* (Linnaeus) 1758	Widespread - Greater and Lesser Antilles, *Florida, *Texas (O'Brien & Wibmer 1982)
		Diaprepes balloui Marshall 1916	Dominica (O'Brien & Wibmer 1982)
		Diaprepes doublierii Guérin 1847	Haiti (O'Brien & Wibmer 1982)
		Diaprepes comma Boheman 1834	"America meridionali," Dominica, Grenada (O'Brien & Wibmer 1982)
		Diaprepes famelicus (Olivier) 1790	Dominica, Guadeloupe, Martinique, Nevis
		Diaprepes marginatus (Fabricius) 1775	Guadeloupe, St. Thomas (Virgin Islands)
		Diaprepes rohrii (Fabricius) 1775 [Actually prefers sugar cane]	"West Indies," St. Croix
		Diaprepes spengleri (Linnaeus) 1767	Puerto Rico
		Pachnaeus citri Marshall 1916	Jamaica
		Pachnaeus marmoratus Marshall 1916	Jamaica
		Pachnaeus psittacus (Olivier) 1807	Cuba, Puerto Rico
		Pachnaeus litus (Germar) 1824	Florida, Mexico [Cuba, Jamaica, both believed to be misidentifications of other species]
		Exophthalmus vittatus (Linnaeus) 1758 [Primary citrus pest, rarely on other hosts]	Jamaica
		Exophthalmus similis (Drury) 1773 [Rarely on citrus, a general feeder]	Jamaica
Sugar cane, also attack banana and palms	West Indian cane weevil	***Metamasius hemipterus* (Linnaeus) 1758	*Lesser Antilles and South America
	silky cane weevil	***Metamasius sericeus* (Olivier) 1807	*Greater Antilles, Central and South America
Sweet potato	Sweet potato weevils El Piche de la Batata	***Cylas formicarius* (Fabricius) 1798	Old World, *southern USA, *Greater Antilles, *Central America, *Hawaii
	The "Scarabee"	**Euscepes postfasciatus* (Fairmaire) 1849	South America, Greater and Lesser Antilles, *California, *Hawaii, *Tahiti, *Old World
		Palaeopus costicollis Marshall 1918	Jamaica, (Florida in quarantine)
		Rhyssomatus nigerrimus Fahraeus 1837	St. Vincent, Central America
Rice	rice water weevils	***Lissorhoptrus isthmicus* Kuschel 1952	Panama, *Dominican Republic, *Haiti, *Puerto Rico, *Colombia, *Venezuela
		Lissorhoptrus brevirostris (Suffrian) 1871	Cuba
		**Lissorhoptrus oryzophilus* Kuschel 1952	USA, East Coast to California, southern Canada to Texas, Mexico, Cuba, *Japan, *Korea, *China [mainland], *Taiwan, *Italy
Coconut palm and other palms	South American palm weevil	*Rhynchophorus palmarum* (Linnaeus) 1758	Neotropical, Greater and Lesser Antilles
Cultivated palms	red palm weevil	***Rhynchophorus ferrugineus* (Olivier) 1790	India, Pakistan, Middle East, China, Japan, Aruba, Curacao, etc.
Stored grains	rice weevil	***Sitophilus oryzae* (Linnaeus) 1763	Cosmopolitan
	maize weevil	***Sitophilus zeamais* Motschulsky 1855	Cosmopolitan
	broad-nosed grain weevil	*Caulophilus oryzae* (Gyllenhal) 1838	Southern US, California, Baja, Central America, Cuba, Jamaica, Puerto Rico, Hawaii, Madeira, Europe
Coffee		*Lachnopus coffeae* Marshall 1922	Puerto Rico
Beans (legumes)		*Chalcodermus angulicollis* Fahraeus 1837	Central America, Barbados, Dominican Republic, South America
		Styracopus phaseoli Marshall 1916	Dominica, Guadeloupe, St. Vincent, South America

*Countries or the US states into which species have been introduced. **Species introduced in Caribbean countries. ***Native and introduced ranges.

Table 1. (Continued) Weevil pests of economically important crops in the Caribbean basin and the United States.

Host plant	Common name	Scientific name	Distribution***
Cassava		*Pappista armipes* (Boheman) 1837 [formerly *Coelosternus* and *Sternocoelus*]	Dominican Republic, Puerto Rico, Guadeloupe, St. Vincent
Banana	banana corm weevil, banana root weevil	***Cosmopolites sordidus* (Germar) 1824	Southeast Asia, *Africa, *Central and *South America, *Greater and *Lesser Antilles, *Florida
Pineapple	pineapple weevil	*Cholus spinipes* (Fabricius) 1781	Grenada
	pineapple weevil	*Metamasius ritchiei* Marshall 1916	Cuba and Jamaica
Mango	mango weevil, mango seed weevil	***Sternochetus mangiferae* (Fabricius) 1775	*Dominican Republic, *Haiti, *Guadeloupe, Southeast Asia, Old World, [California, Hawaii (in quarantine)]
Sapodilla		*Conotrachelus sapotae* (Barber) 1924	Cuba, Dominican Republic
Tamarind	tamarind weevil	***Sitophilus linearis* (Herbst) 1797	*Greater and *Lesser Antilles, *Florida, *Louisiana, *Costa Rica, *South America, *Africa, *Old World

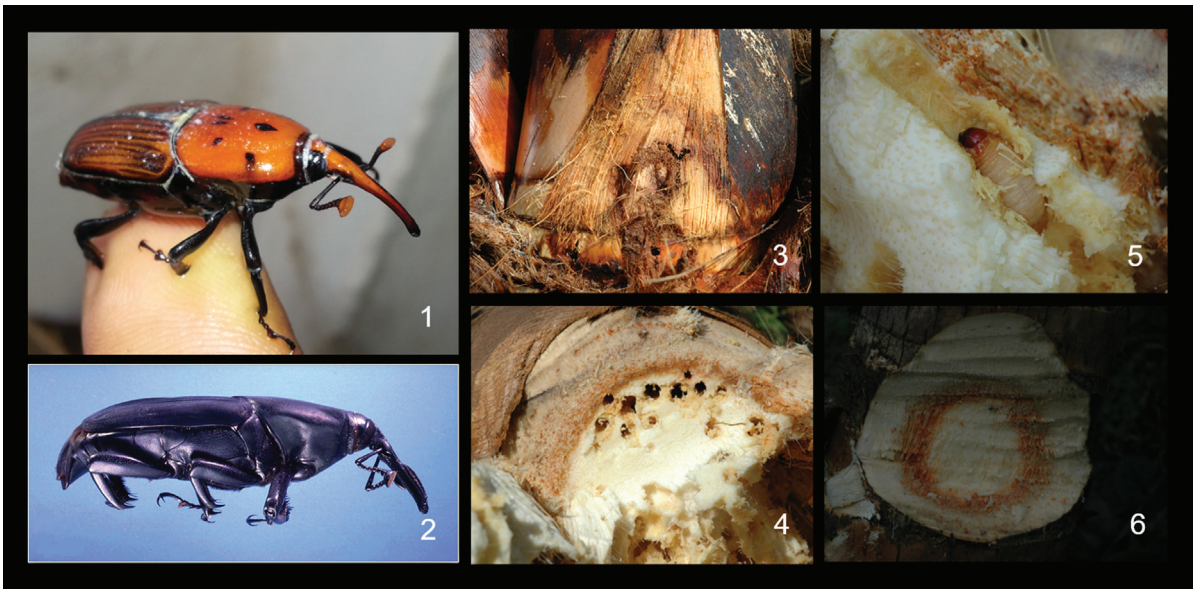
*Countries or the US states into which species have been introduced. **Species introduced in Caribbean countries. ***Native and introduced ranges.

Exotic pest species introduced into the Caribbean generally constitute a regional problem, affecting numerous countries, but potentially the Caribbean region as a whole. Several exotic weevil species are already present in the Caribbean basin. The potential for introductions, deliberate or accidental, is growing through an increase in international economic and cultural links. In the Caribbean, numerous weevil species are serious pests of economically important crops or stored grains. These commodities include citrus, sugar cane, banana, palm, sweet potato, rice, coffee, stored grain, beans, cassava, pineapple, mango, sapodilla, tamarind, and others. Several pests feed on agricultural crops in the field, as well as in storage. When commodities are shipped from an island to another destination, chances of new invasion exist, and pathways are considered important points of geographical expansion of these species. Much of the management time, labor, and money invested in agricultural production is consumed by attempts to manage serious pests. In the past, several pest species (native or exotic to the Caribbean basin) have arrived in the US by either conventional agricultural trade, tourism, or trade of non-agricultural products.

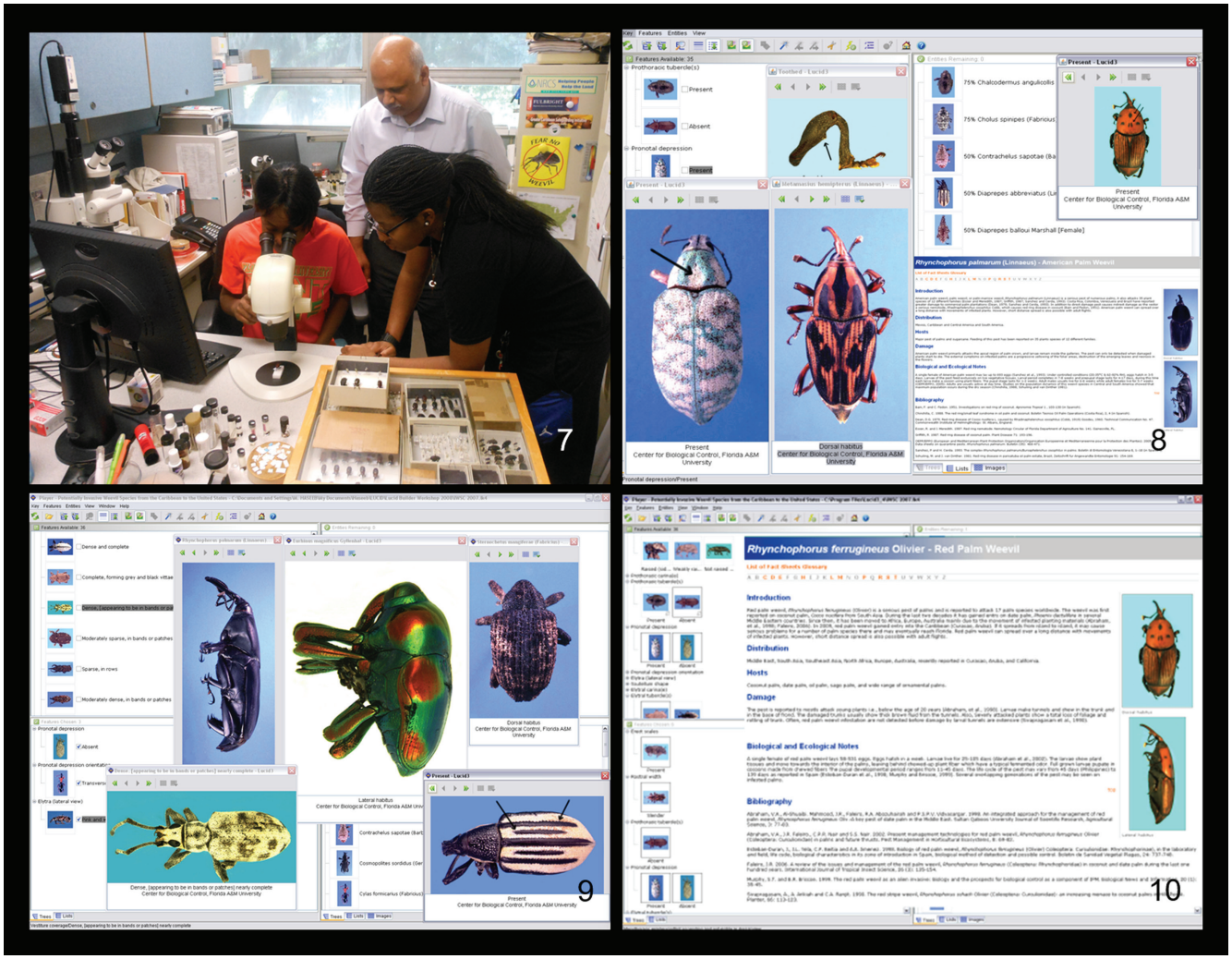
For example, since 2010 the South American palm weevil, *Rhynchophorus palmarum* (L.) (Coleoptera: Dryophthoridae), has been attacking and killing Canary Island date palms, *Phoenix canariensis* Wildpret (Arecaceae), in Tijuana, Baja California, and Mexico adjacent to San Diego, California, USA (Hodel et al. 2016), and has now crossed the border into San Diego where it has killed hundreds of Canary Island date palms (Hodel, personal communication). Similarly, a number of weevil species including *Rhynchophorus ferrugienus* (Olivier) (Coleoptera: Dryophthoridae), *Exophthalmus vittatus* L. (Coleoptera: Curculionidae), *Lissorhoptrus isthmicus* Kuschel (Coleoptera: Brachyceridae), and *Lissorhoptrus brevirostris* (Suffrian) (Coleoptera: Curculionidae), are serious pests in the Caribbean basin, and can cost millions of dollars to control (O'Brien & Haseeb 2014; Fiaboe et al. 2012). Indeed, in recent times, international trade and food security rely on the enforcement of regulatory aspects of pest management. Strategic research work on the identification of potential invasive weevil species and offshore mitigation of potential pests is critical for agricultural productivity and trade (Haseeb et al. 2011a, b). The current study was undertaken to develop a web-based digital identification tool on weevil pests of economically important crops in the Caribbean pathways, and to provide hands-on training and necessary skills to graduate and undergraduate students to achieve rapid identification and detection of these weevil pests.

Material and Methods

This study was conducted in the Caribbean and other parts of the world, relying on weevil collection, loan of material, and specimen exchange(s). Lists of economically important weevils were developed from the existing literature (O'Brien & Wibmer 1982; Wibmer & O'Brien 1986), including the electronic resources available. Survey and collection were carried out in Trinidad and Tobago in summer 2009, and Aruba and Curacao in summer 2013. All specimens were identified before any imaging and digital identification work. For imaging, we have been relying exclusively on museum specimens and Auto-Montage imaging systems (Syncroscopy, http://www.directindustry.com/prod/syncroscopy/product-14153-357875.html) in the Center for Biological Control, College of Agriculture and Food Sciences, Florida A&M University, Tallahassee, Florida, USA. The weevil damage images and plant information were captured with a Nikon SLR camera and software. For identification and diagnostics,



Figs. 1-6. Red palm weevil (1), and South American palm weevil (2), South American palm weevil damage (3, 4, 5), and red ring disease symptom (6). Arrows 3 and 4 show early and late infestation of South American palm weevil, arrow 5 shows a full-grown larva and its damage, arrow 6 shows the cross section of coconut palm with red ring disease.



Figs. 7–10. Hands-on student training (7), and weevil identification process (8 and 9), image-based selection of diagnostic characters that leads to species identification in question (10), spreadsheet on a species with embedded brief introduction, distribution, hosts, damage, biological and ecological notes, and bibliography.

Table 2. Weevil common characters and diagnostic characters of 2 important palm pest weevils in the Caribbean basin.

	Diagnostic characters	
Common characters	*Rhynchophorus ferrugineus*	*Rhynchophorus palmarum*
Body length	24.0–30.0 mm	26.0-44.0 mm
Body shape	Elongate-oval	Elongate-oval
Humeri	Oblique, well developed	Oblique, weakly developed
Predominant color (cuticle)	Reddish brown	Black
Circular scales	Absent	Absent
Strap-like scales	Absent	Absent
Rostrum length	Long	Long
Rostral width	Slender	Slender
Male rostrum setae comb	Present	Present
Antennal morphology	Elbowed	Elbowed
Antennal club	Broad, flattened, asymmetrical	Broad, flattened, asymmetrical
Prothoracic collar	Weakly raised (side view)	Not raised (side view)
Prothoracic carina(e)	Absent	Absent
Prothoracic tubercle(s)	Absent	Absent
Pronotal spots	Present	Absent
Pronotal groove	Present	Present
Pronotal groove orientation	Longitudinal	Longitudinal
Scutellum shape	Triangular	Triangular
Elytral deep striae	Present	Present
Elytral carina(e)	Absent	Absent
Elytral tubercle(s)	Absent	Absent
Elytral spicule(s)	Absent	Absent
Mesothoracic epipleuron	Ascending and visible dorsally	Ascending and visible dorsally
Leg color (cuticle)	Reddish brown to black	Black
Leg color (setae)	Brown	Black
Trochanteral shape and length	Triangular and short	Triangular and short
Femoral armature	Clothed densely with setae	Clothed densely with setae
Tibial armature of apices	All with large spine	All with large spine
Tibial armature (inner row of teeth)	Present	Present
Third tarsus shape	Cordate	Cordate
Vestiture type (scales and setae)	Absent	Absent
Wax like coating	Absent	Absent
Pygidium	Not concealed by elytra	Not concealed by elytra

we used Lucid nutshell (http://www.lucidcentral.com/). The software is unique to design, develop, and deploy web- and compact disc (CD)-based insect identification keys.

Results

A list (Table 1) of 38 weevil species within 20 genera which included the introduced 3 species in Caribbean countries or the US, and introduced into Caribbean countries (10 species), and 25 species native to the Caribbean region is provided. However, most of these weevil species may not be from the Caribbean countries, because of intensive tourism and trade around the world. Central and South America are especially vulnerable, and serve as a hub for further spread of these exotic species to North America. Some of these species are monophagous, others are oligophagous and have narrow host plant range(s), and some are polyphagous. A web-based tool for the identification of these species was developed, and CDs were developed for users who do not have access to the internet. In this digital tool, images of dorsal and lateral habitus of these species were developed and embedded in spreadsheets. Notes on brief introduction, hosts, distribution, biology, and ecology of each species were included. The digital identification tools we have developed are based on simple distinguishing characters of weevils (25 genera and 40 species) linked with images for end-users to properly identity invasive weevil pests on economically important crops. Herein, we have provided examples of 2 exotic species: the red palm weevil, *R. ferrugienus*, and the South American palm weevil, *R. palmarum*; both are serious pests of cultivated palms, and also feed on other hosts (Figs. 1–6). Their appearance, and signs and symptoms of infestation are provided. Common and diagnostic characters of both species are provided in Table 2. Our efforts focused on providing necessary skills and hands-on training to graduate and undergraduate students to develop and deploy such digital identification tools and user-friendly identification processes (Figs. 7–10). Since spring 2009, we have trained 19 graduate and 14 undergraduate students to develop and identify insect pests, including weevil pests, based on the Lucid nutshell. Currently, these digital tools are part of the Systematic Entomology class at Florida Agricultural and Mechanical University to further train incoming students. We have organized symposia and workshops for end-users, including port of entry pest identifiers, pest managers, pest survey experts, and those involved in biodiversity and ecological studies who rely on correct identification of invasive pest species to analyze problems.

Discussion

Agricultural production needs to increase considerably in the foreseeable future to meet food demands of a growing human population.

Productivity of crops grown for human consumption is at risk due to the incidence of economically important crop pests. In the Caribbean, several serious weevil pest species exist that feed on economically important crops. A number of these pest species are native to the region, whereas others are exotic. Several of these species are polyphagous, and others have narrow host ranges. Because several Caribbean countries are important trade partners of the US and play a very significant role in tourism, monitoring the movements of these species in several conventional and non-conventional pathways in the Caribbean is critical to successful mitigation of these pest species. Keys to successful implementation of regionally coordinated strategies, including the development of rapid identification and detection of potential crop pests, are data exchange and joint response strategies.

Insect identifiers confront the challenge of identifying new, existing, and potentially invasive pest species. Accurate identification of insects is required before action can be determined. In the past, end-users used various approaches to identity insects, including matching with type specimens, dichotomous keys, pathway keys, matrices, and multiple entry keys (computer assisted), tabular keys (taxa vs. diagnostic characters), and punch card keys. Currently, computer-based taxonomic programs (Walter & Winterton 2007) comprising taxonomic keys, tools, and resources have become increasingly popular. Therefore, the Entomology program at Florida Agricultural and Mechanical University has been developing and training graduate and undergraduate students in this national need area.

Acknowledgments

Funding supports for this work from the USDA, NIFA Capacity Building Grants Program, and the USDA, APHIS, Center for Plant Health Sciences Technology, are greatly appreciated. We are grateful to Michael Thomas of the Florida Department of Agriculture and Consumer Sciences, Division of Plant Industry, Gainesville, Florida, USA, for weevil specimens and loans. We thank Farzan Hosein of the Ministry of Food Production, Land and Marine Affairs, St. Augustine, Trinidad and Tobago; Lizz Johnson of the CAB International, Caribbean and Central America, Curepe, Trinidad and Tobago; Ministry of Health, Environment, and Nature, Willemstad, Curacao; and Franken Facundo of the Department of Agriculture, Husbandry and Fisheries, Oranjestad, Aruba for assistance during the survey and collections of selected weevil species.

References Cited

Fiaboe KKM, Peterson AT, Kairo MTK, Roda AL. 2012. Predicting the potential of the red palm weevil *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) using ecological niche modeling. Florida Entomologist 95: 659-673.

Haseeb M, Kairo MTK, Flowers RW. 2011a. New approaches and possibilities for invasive pest identification using web-based tools. American Entomologist 57: 223–226.

Haseeb M, O'Brien CW, Kairo MTK. 2011b. Potentially invasive weevil species from the Caribbean countries to the United States. Developed and deployed in cooperation with the CBC, FAMU, USDA, APHIS, PPQ, CPHST, and CSREES. (Beta CD version).

Hodel DR, Marika MA, Ohara LM. 2016. The South American palm weevil, a threat to palms in California and the Southwest. PalmArbor 3: 1–27.

O'Brien CW, Haseeb M. 2014. Revision of the "rice water weevil" genus *Lissorhoptrus* in North America, north of Mexico (Coleoptera: Cuculionidae). The Coleopterists Bulletin 68: 163–186.

O'Brien CW, Wibmer GJ. 1982. Annotated checklist of the weevils (Curculionidae *sensu lato*) of North America, Central America, and the West Indies (Coleoptera: Curculionoidea). Memoirs of the American Entomological Institute 34: 1–382.

Walter ED, Winterton S. 2007. Keys and crisis in taxonomy: extinction or reinvention? Annual Review of Entomology 52: 193–208.

Wibmer GJ, O'Brien CW. 1986. Annotated checklist of the weevils (Curculionidae *sensu lato*) of South America (Coleoptera: Curculionoidea). Memoirs of the American Entomological Institute 39: 1-563.