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IMPACTS OF RECENTLY EMERGED INVASIVE EXOTIC SPECIES AND MAJOR THREATS TO THE DOMINICAN AGRICULTURE

Colmar-A. Serra[1], Xiomara Cayetano[1], Andrea Féliz[1,4], Mileida Ferreira[1], Socorro García[3], Graciela Godoy[2], Máximo Halpay[1], Reina Teresa Martínez[1], Rosa María Méndez[1], Juan de Dios Moya[3], Lucía Silverio[1], & Luis Matos[1]

Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF), C/Rafael Augusto Sánchez 89, Santo Domingo, D.N., República Dominicana:
[1] Centro de Technologías Agrícolas (CENTA), Pantoja, Los Alcarrizos, Provincia Santo Domingo, Dominican Republic.
[2] Estación Experimental Arroyo Loro (EEAL), San Juan de la Maguana.
[3] Estación Experimental Mata Larga (EEML), San Francisco de Macorís.
[4] Ministerio de Agricultura-Depto. de Sanidad Vegetal, Santo Domingo, Dominican Republic.
Colmar Serra (contact autor) Telephone 809-564-4401; Email: cserra@idiaf.gov.do.

ABSTRACT

Nearly 20 new registers, interceptions, and phytosanitary problems are presented that correspond to those reported for the Dominican Republic between 2005 and 2011 under the contribution in diagnostics, identification, and/or mitigation by researchers in plant protection of IDIAF. Several of the detected problems are threatening on longer-term specific crops, such as Huanglongbing in the citrus industry, and Red palm mite and Lethal yellowing in the coconut industry. Other species, although causing economic impacts, have been evaluated and practices for their management are being developed and validated, or are already being practiced. The status of some of the species is still unknown. New registers must first be validated and confirmed by the authorities of the Department of Plant Health of the Ministry of Agriculture.

RESUMEN

Alrededor de 20 nuevos registros, detecciones y problemas fitosanitarios para la República Dominicana son presentados, correspondiendo a aquellos reportados entre 2005 y 2011 con la contribución en el diagnóstico, la identificación y/o mitigación por parte de investigadores en protección vegetal del IDIAF. Varios de los problemas detectados están amenazando a largo plazo a cultivos específicos, como la enfermedad Huanglongbing en la industria de cítricos, y como el Ácaro rojo de las palmeras y el Amarillamiento letal en la industria de cocotales. Otras especies o agentes causales, a pesar de causar impactos económicos, han sido evaluadas y las prácticas para su manejo se están desarrollando, validando o ya se practican. El estado de algunas de las especies aún es desconocido. De todos modos, nuevos registros deben ser validados y confirmados por las autoridades del Departamento de Sanidad Vegetal del Ministerio de Agricultura.

INTRODUCTION

The increasing number of travelers and shipment of agricultural commodities from and to the Caribbean, and especially the Dominican Republic (DR), have allowed the introduction and establishment and spread of numerous exotic species, mainly arthropods, and fungal, bacterial, and viral diseases. Thirty of the most important invasive alien species (IAS) reported in the Dominican Republic between 1975 and 2003 with impacts on Dominican agriculture belonged to the following taxonomic groups: 21 arthropods (16 insects, 4 mites, 1 spider); 1 molluscs; 8 pathogenic diseases (3 fungi, 1 bacteria, 1 MLO, 3 virosis) (Serra et al. 2003b; Serra 2005).

Immediate threats by IAS to the agricultural and ornamental crops in the Dominican Republic include exotic fruit flies (several *Anastrepha* spp., and *Bactrocera*, *Dacus*, and *Ceratitis*), Mango seed weevil (*Sternochetus mangiferae*), *'Q biotype'* of sweetpotato whitefly (*Bemisia tabaci*), Cycad scale (*Aulacaspis yatsumatsui*), Lobate lac scale (*Paratachardina lobata lobata*), Pepper weevil (*Anthonomus eugenii*), Avocado seed moth (*Stenoma catenfer*), African giant snail (*Achatina fulica*), Tropical bont tick (*Amblyomma variegatum*), and Tropical soda apple (*Solanum viarum*) (Serra et al. 2003b, 2005).

INVASIVE SPECIES WITH IMPACT ON DOMINICAN PLANT PRODUCTION

Invasive exotic species belonging to a wide variety of taxons, such as insects, mites, fungi, viruses, and viroids, have been reported to have reached the Dominican Republic. Below are examples of those that have been established, presenting a threat to agricultural crops, including some ornamentals.

Arthropods

Until 2011, only one of the listed threats had been widely reported to have entered the Dominican Republic, the pepper weevil.

<u>Pepper weevil</u> (span. Picudo del ají, *Anthonomus eugenii* Cano): It was previously reported on the neighboring island of Puerto Rico. It attacks the pepper fruits during the flowering period with the larvae feeding inside the fruits, causing the abortion of fruits or spoiling them in association with rotting fungi and bacteria. This curculionid is closely related to the native eggplant weevil (*A. oraapis*, syn. *A. pulicarius*), reported on occasions as a severe pest aborting eggplant flowers (Schmutterer 1990; Baltensperger and Serra 2004). It was first mentioned in 2006 in orchards localized in the eastern regions of the island, causing heavy damages in sweet and hot pepper growing areas, such as Ocoa, Baní and the Cibao region, between 2008 and 2010.

<u>Red palm mite (RPM, *Raoiella indica* Hirst):</u> Since its first detection in the Western Hemisphere in Martinique, French West Indies, the RPM has been disseminated throughout the Caribbean islands, having reached the Dominican Republic in 2005; since then, samplings have been carried out, especially on coconut palms and bananas covering 24 provinces of the Dominican Republic, to register the presence and dissemination throughout the country (Roda et al. 2008; Serra 2007). In the southern/southwestern provinces of Santo Domingo, San Cristóbal, Azua, Barahona, and Pedernales (and beyond the Haitian border), as well as the northern/northeastern María Trinidad Sánchez, Samaná, among others, significant outbreaks were observed in coconut palms (*Cocus nucifera*), ornamentals palms (*Aonidia merrillii*, *Phoenix* spp., *Raphis* sp. and others), and edible and ornamental bananas (*Musa* spp.), and in lower intensities in Strelitziaceae, Heliconiaceae, and Zingiberaceae. At the end of 2006, detections were made for the area between Santo Domingo and Azua. By 2007, RPM had already spread widely over the

southwestern, northern, and northeastern coastal areas, and the central Cibao plain, where the typical yellowing and necrotic symptoms on palm leaves were seen, sometimes in mixed infestations with scales, mealybugs, and whiteflies; and by 2010, significant damages were registered on all the island.

The impact of RPM is severe during dry seasons, and less so during rainy seasons (rain reduces the population dramatically). Coconut producers of the main producing areas of the north and northeastern coast have reported losing between 50 and 70 percent of their yields, and obtaining fruits of low quality. In addition, under very dry conditions at the eastern part of the Samaná peninsula, bananas associated to coconut palms are heavily affected by RPM. The obtained data suggest the dissemination starting from the capital along the southwestern coast or crossing the country from Santo Domingo through the Cibao plain to the northern coast of Puerto Plata province and to the northeastern provinces of María Trinidad Sánchez and Samaná. The quick spread was probably enhanced through the transportation of ornamental palms and other host plants from plant nurseries of the capital area to regions with high construction activity due to tourism infrastructure development. The quick spread was encouraged by winds and storms. In spite of a superior tourism infrastructure on the east coast, a delayed RPM infestation was probably due to the production of palms and other ornamentals in the southeastern provinces. Throughout the study, only relatively low amounts of natural enemies, such as predatory mites *Amblyseius largoensis* (Muma), (Acari: Phytoseiidae), *Stethorus* sp. (Coleoptera: Coccinellidae), and chrysopids, have reached the level of biocontrol similar to findings reported by Peña et al. (2009) for Puerto Rico.

Pests on *Ficus* spp.: Several new pests of the genus *Ficus* that have been registered cause severe leaf drop. The Cuban laurel thrips (*Gynaikothrips ficorum* [Marchal]) was first reported in 1927, a heavy outbreak in 2001 was considered to be linked to this species. Since 2008, severe leaf drop in *Ficus* spp. has spread over the island. This was due to a heavy outbreak of the exotic Ficus whitefly, *Singhiella simplex* (Singh) (Hemiptera: Aleyrodidae), in the absence of effective biocontrol mechanisms with parasitism of <<1%. The species was already widespread in Puerto Rico in 2006. The whitefly parasitoid, *Encarsia protransvena* Viggiani, although still not confirmed, has steadily increased its presence, reaching up to 40 percent in 2011 in *F. retusa* in Santo Domingo, which suggests a stabilization of the population on longer terms.

Mango leafhopper: Since 2009, several researchers have reported the presence of a still unidentified leafhopper, similar to the so-called Flat fish hopper (Flatidae), among the inflorescences of mango trees, especially during the bloom period, when it reaches higher populations. No studies have still been realized to clarify the status as potential pest.

Pigeon pea podfly, (span. 'Moscas asiática del guandul', *Melanagromyza obtusa* (Malloch), Diptera: Agromyzidae): After the establishment of this pest of Asian origin, especially on alternative host plants (e.g., *Rhynchosia* spp., Fabaceae) was recorded (e.g., *Habrobracon* sp., Hymenoptera: Braconidae), the impact of up to >80% yield losses has been reduced (Serra et al. 2003a) due to the adoption of control measures by farmers and the adaptation of native and/or introduced parasitoids (*Melittobia* sp. and *Ormyrus* sp., Hym.: Eulophidae or Ormyridae, respectively). In Puerto Rico, Abreu and Almodovar (2005) reported parasitoids of the genus *Callitula* (Hym.: Pteromalidae) and *Melittobia* sp. (Hym.: Eulophidae) obtained from

Rhynchosia spp. For classical biocontrol purposes, *Ormyrus orientalis* from Australia and India was introduced.

Passionvine and Coffee Mealybugs (*Planococcus minor* (Maskell) and *Planococcus lilacinus* (Cockerell), Hemiptera: Pseudococcidae, respectively): A study is being undertaken in Dominican cocoa and coffee plantations to actualize the inventory of mealybugs, host ranges, and associated arthropods (parasitoids and others) and to confirm/not confirm the presence and status of *Planococcus minor* (Maskell) and *Planococcus lilacinus* (Cockerell) as reported for Hispaniola by Ben-Dov (1994) and Watson and Chandler (2000). There were 75 detections reported entering U.S. ports from the Dominican Republic between 1986 and 2005 (Pérez-Gelabert 2008). The difficulty in finding colonies of the species could be due to the presence of effective natural enemies as shown for *P. minor* in Trinidad and Florida (Francis, Kairo, and Roda 2012; Francis et al. 2012).

Classical biocontrol: Three projects on classical biological control (CBC) of IAS have been successfully accomplished in the Dominican Republic since 2000 with support of USDA/APHIS through the Plant Health Department of the Ministry of Agriculture, experts from diverse institutions and universities, and the scientific follow-up by USDA/APHIS and by IDIAF for Papaya mealybug (*Paracoccus marginatus*: liberating *Acerophagus papayae*, *Anagyrus loecki*, *Anagyrus californicus* Compere, and *Pseudaphycus* sp.), Pink hibiscus mealybug (*Maconellicoccus hirsutus* with encyrtid wasps *Anagyrus kamali* and *Gyranosoidea indica*), Fruit flies (mainly *Anastrepha obliqua* and *A. suspensa*: establishing *Doryctobracon areolatus* (Szépl.), a braconid wasp) (Kauffman et al. 2001; Meyerdirk and DeChi 2003; Serra, Nunez, and Garcia 2004; Serra et al. 2011). A dramatic reduction of mealybug populations has been achieved, with only sporadic outbreaks being, and a positive effect on the targeted fruit flies has been confirmed by some commercial growers of mangos and guava of the San Cristobal and Monseñor Nouel provinces, respectively.

Fungal Diseases

Taro leaf blight disease (span. 'Tizón foliar de la yautía', *Phytophthora colocasiae* Racib.): While it was first reported by Ciferri (1954) in the Dominican Republic in New cocoyam (*Xanthosoma* spp., Araceae), Holliday (1980) confirmed the presence of the pathogen in the Dominican Republic and other Caribbean islands, and Erwin and Ribeiro (1996) confirmed the presence in Taro (*Colocasia esculenta*, Araceae) specifically. In 2004, the pathogen was reported by Méndez, Reyes, and Hernandez (2004) as the causal agent of an epidemic, which destroyed the taro crop in the rather humid northeastern Dominican Republic, making it necessary to establish drip irrigation in arid zones in the northwestern and southern areas of the country. Research with resistant materials (originating at the University of Hawaii) is ongoing at CENTA.

Brown leaf spot or ghost spot (span. 'Mancha marrón de las hojas de yautía' *Cladosporium colocasiae* Sawada): This fungal disease of older leaves, which is present in the U.S. state of Louisiana (Holcomb 1989) has only recently been reported in the Dominican Republic (García and Moya 2012). The disease causes spots that are less visible on the lower leaf surface. As the disease progresses, the petiole turns flaccid from the top to the base, making the leaves drop.

Stackburn disease in rice (span. 'Manchado del grano de arroz', *Alternaria padwickii* (Ganguly) M.B. Ellis): This disease was first reported in the Dominican Republic by Méndez and Reyes (2008). It produces blight in rice plants, with circular brown foliar spots that are brighter in the center and darker on the edges. It is reported to be transmissible by seeds (Ou 1985). The leaf spot syndrome is also caused by other pathogens such as *Bipolaris oryzae*, *Curvularia* sp., *Cercospora oryzae*, *Sarocladium oryzae*, *Nigrospora* sp., *Magnaporte* sp., and the bacteria *Burkholderia glumae* and *Erwinia* sp.

Antracnosis of pigeon pea (*Cajanus cajan*): A pod rot that causes yield losses up to 50 percent in the Mayor production zone (San Juan de La Maguana valley) has been analyzed by Segura, Arias, Godoy-Lutz (2010), and the causal agents Collectotrichum gloeosporioides Penz. and Fusarium equiseti (Corda) Saccardo have been identified by sequencing the ITS region (Godoy-Lutz 2004). No resistant varieties are yet available against this seed-borne disease (Lenné 1992).

Emerging mango diseases: The so-called 'Dieback' and gummosis (span. 'Muerte regresiva', *Lasiodiplodia theobromae* (Pat.)) is a fungus (originating in Asia) that affects several fruit trees such as avocado, macadamia, and citrus spp. In affected plants, twigs die from the tips backwards into the old wood. In the Dominican Republic, researchers use sanitation measures combined with copper sulphate (Pérez no date; Leger 2009). In addition, the so-called 'Witches broom' (span. 'Escoba de Bruja del mango') is present in the Dominican Republic. It is consistent with infloresense malformation which is caused by the complex of *Fusarium* spp. and the Mango eriophyid mite *Eriophyes mangiferae* (Leger 2009).

Fusarium oxysporum f. sp *lycopersici* race 3: Méndez, Perez, and Camejo (2010) have confirmed the presence of this race in tomato crops (*Lycopersicum esculentum* Mill.) in the Dominican Republic.

Bacteria

Bacterial panicle blight (BPB)**:** (span. 'Añublo bacterial del arroz'): Rice is cultivated as a main food crop in the Dominican Republic (consumption 45–50 kg/capita/year), producing 450,000 metric tons of polished rice on 93,000 hectares. Based on IDIAF research data, the syndrome of 'empty grains of rice' has caused over US$50 million in losses in the Dominican Republic, reducing yields more than 20 percent, especially in the northeastern and north-central regions. The 'empty rice grains syndrome' (ERGS), is believed to be caused by a combination of the panicle rice mite (*Steneotarsonemus spinki* Smiley), the fungal disease, *Sarocladium oryzae* (Sawada), and non-biotic factors. The disease known as BPB (span. "Añublo Bacterial de la Panícula del Arroz) is caused by the bacteria *Burkholderia glumae* interacting with the panicle rice mite (*Steneotarsonemus spinki* Smiley), which initially colonizes the flag leaf to invade the spikelets during the bloom causing the rot, discoloration, and sterility of the grains (Hummel et al. 2009). Although not officially confirmed in the Dominican Republic, in 2008, symptoms resembling those of the bacterial blight in fields of the provinces of Maria Trinidad Sánchez, Monseñor Nouel, and Montecristi, were noticed on the flag leaf sheaths (Halpay, Silverio, and Camejo 2012). Serological tests (ELISA) run by IDIAF researchers of the CENTA to 32 randomly collected panicles and grains gave 17 percent positives. The further extraction of DNA of positive samples and analysis with a specific primer (Qiagen, Gaithersburg, MD) by PCR confirmed 66 percent positives. This factor (*B. glumae*) is being added to ERGS and is likely to become the most important pathogen associated with the disease complex known as vaneamiento because of its seed-borne transmission capacity (Halpay, Silverio, and Camejo 2012).

Huanglongbing (HLB) or 'citrus greening': *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae), vector of the HLB, has been present in the Dominican Republic since at least 2001 (Serra et al. 2003b). In August 2008, the first detection of HLB symptoms was reported in citrus orchards near Luperón on the northern coast of the Puerto Plata province and confirmed using the PCR technique (Matos, Hilf, and Camejo 2009). Backed by funds from citrus producers, the CENTA laboratory started analyzing samples in 2009. Analyzing 11,568 samples from 27 provinces, 47.5 percent of the samples were positive. HLB has spread from the northern and northwestern provinces to most of the DR areas with citrus trees, and has actually been confirmed for 25 provinces (Matos et al. 2011c). The National Program for Integrated Management of Citrus HLB is coordinating efforts with IDIAF researchers, growers, nurserymen, and the Ministry of Agriculture for the destruction of infected plants and for chemical control of the vector. Some predators and the parasitoid *Tamarixia radiata* (Waterston) (Hymenoptera: Eulophidae) are present, but still no evaluation of their biocontrol has yet been undertaken (Halbert and Nunez 2004).

Phytoplasma, Viruses, and Viroids

Lethal yellowing disease of palms (LY): This phytoplama infects 36 palm species, among those are *Cocos nucifera, Veitchia merrillii,* and *Phoenix dactylifera.* In the Dominican Republic, it was first reported by Carter (1962) in Dajabon in the northeast, having been disseminated very slowly during decades but having reached the region of Cabrera at the western edge of the main coconut growing region in the northeastern and eastern coastal areas. In addition, Martínez et al. (2008) reported for the first time the presence of LY in coconut on the southern coast of Boca Chica. A molecular analysis shows that it is due to the Phytoplasma 16 Sr IV. It has been reported that LY is also approaching the southeastern edge of the main coconut-growing area.

Diverse sucking arthropods potentially associated with coconut groves were listed for the first time in the Dominican Republic by Ferreira, McKamey, and Martinez (2010) as mirid bugs (*Pycnoderes vanduzeei* Reuter, *P. testaceipes* Stål, *Halticus bractatus* Say, *Trigonotylus tenuis* Reuter, *Reuteroscopus hamatus* Kelton, *Taylorilygus apicalis* Fieber) and cicadellid (*Bothriocera undata*). Besides the known cixiid planthopper and LY vector *Haplaxius* (syn. *Myndus*) *crudus* (van Duzee) (Howard, Kramer, and Peralta 1981; Howard, Norris, and Thomas 1983; Howard and Wilson 2001; Ferreira, McKamey, and Guerrero 2012), two other species, *H. jamaicae* (Kramer) of insular Caribbean distribution and the newly described species *H. cabrerensis* has been detected (Ferreira, McKamey, and Martinez 2010). Further studies will be needed to confirm their importance as potential LY vectors.

Virus diseases in vegetables: Several of the viruses present in DR pepper, tomatoes, and cucurbits have presumably not been identified or confirmed on a molecular level yet, so they will need to be targeted in ongoing and proposed projects.

Bean common necrotic mosaic virus (span. Virus del mosaico necrótico común del frijol, BCNMV): It was first detected in the San Juan Valley in 1999/2000 in black and white beans and was probably introduced through seeds of the beans type 'Pinto' or 'Negra' from Africa or the United States, where it is endemic (Godoy-Lutz et al. 2004; Godoy-Lutz, Segura, and Arias 2006). It has been isolated in the Dominican Republic, associated with basic seeds of black-seeded and white-seeded bean varieties distributed for seed production by growers. A study conducted by IDIAF researchers helped to eliminate more than 454 Tm (10,000 qq) of contaminated seeds from stored seed stocks of growers associations. Since seeds of the black-seeded varieties are purchased by non-governmental agencies for distribution among Haitian farmers, there is the probability that the BCMNV present in the DR southwestern region is similar to strains associated with beans in Haiti. In collaboration with Drs. Phil Miklas (USDA) and Flores-Estevez (CINVESTAP/IPN, Mexico), we have determined that the strain present in the Dominican Republic is among the most virulent pathotypes of the BCMNV. By RT/PCR and analysis of the sequence at the amino region at the end terminus of the coat protein gene, the DR strain was assigned to pathogroup VI instead of III, as previously thought, based on ELISA assays inoculation to set of host differentials. The presence of both pathotypes and a recombinant of both should not be ruled out since the latest findings indicate the occurrence of genomic recombination between two distinct virus species within the family *Potyviridae*. Currently, seed testing for potyvirus and the release of new black-seeded varieties such as DPC-40 with both I and bc-3 resistant genes have reduced the spread and severity of the BCMNV in bean production in the Dominican Republic.

Citrus Tristeza Virus (CTV): It has actually spread all over the country The CTV genotype composition in the Dominican Republic is represented by the strains T3, T30, T68, and VT. T30 and VT are widely distributed within the country while T3 is still restricted to only four provinces. T30 and VT were found to be present on all five cultivars sampled. T3 was found in trees of Persian lime (*Citrus latifolia* (Tan.)) and Mexican lime (*Citrus aurantifolia* (Christm. Swingle)) (Matos et al. 2011a).

Citrus Viroids: Matos et al. (2011b), using RT-qPCR to analyze 51 samples from 22 citrus orchards of the main citrus producing areas, reported viroids types II and III for the first time in the Dominican Republic. They confirmed that the cracking of the bark of Persian lime trees is not due to a genetic degeneration, as initially suspected, but to the presence of various types of viroids. No samples were amplified for viroids types IV and V. The results indicate that the presence of viroids type III are widely spread in sampled orchards; nevertheless, the viroids of Exocortis, which were reported in 1996 (Matos et al. 2011a), seem to be rather restricted in terms of distribution compared to viroids types II and III. Only one sample of sweet orange, 'Valencia', of Hato Mayor amplified a viroid type III while the other 19 corresponded to Persian lime, indicating that it is the more sensitive of both cultivars.

CONCLUSIONS

Despite efforts of regulatory authorities in charge of plant quarantine, established international networks, improved infrastructures, and trained staff, IAS belonging to different taxons have entered and become established in the Dominican Republic, causing severe impact on plant production and economic losses to the people involved with the agricultural sector. We will continue researching IAS detection, diagnosis, and/or mitigation activities in the Dominican Republic, especially under the coordination or participation of IDIAF researchers, through CENTA plant protection laboratories and EEAL and EEML experimental stations. In our study, we emphasized the following complexes or races of species: four arthropods (insects and mites), seven fungi, two bacteria, one phytoplasma, three viruses or virus complexes, and one viroid.

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