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Host range findings on *Beauveria bassiana* and *Metarhizium anisopliae* (Ascomycota: Hypocreales) in Argentina

A. V. TOLEDO[1*], A. M. M. De REMES LENICOV[2] y C. C. LÓPEZ LASTRA[3]

Resumen: Espectro de hospedadores hallado en *Beauveria bassiana* y *Metarhizium anisopliae* (Ascomycota: Hypocreales) en Argentina. El espectro natural de hospedadores de los hongos entomopatógenos (HEP) *Beauveria bassiana* (*Bb*) y *Metarhizium anisopliae* (*Ma*) fue investigado en Argentina desde el invierno de 2003 hasta la primavera de 2004. Las muestras de insectos con infecciones fúngicas (153) fueron recolectadas a partir de campos de maíz y las áreas no cultivadas circundantes a los mismos, en diferentes localidades de las provincias de Buenos Aires (7), Tucumán (2) y Corrientes (3). El espectro de hospedadores infectados con *Bb* varió entre los Coleoptera (37%), Hemiptera (27%) y Dermaptera (1,3%). Mientras que el espectro de hospedadores infectados con *Ma* varió entre los Coleoptera (0,7%) y los Hemiptera (34%). El mayor espectro lo presentó *Bb*, encontrado en ocho especies de Coleoptera (cuatro familias), una especie de Dermaptera y cuatro especies de Hemiptera (tres familias), mientras que *Ma* fue encontrado infectando una especie de Coleoptera y tres especies de Hemiptera (dos familias). Nosotros obtuvimos 75 aislamientos fúngicos puros (48 de *Bb* y 27 de *Ma*), de los cuales 56 (33 de *Bb* y 23 *Ma*) fueron caracterizados morfológicamente.

Palabras clave: *Beauveria bassiana*, control biológico, Coleoptera, Dermaptera, Hemiptera, hongos entomopatógenos, *Metarhizium anisopliae*.

Summary: The natural insect host range of the entomopathogenic fungi (EPF) *Beauveria bassiana* (*Bb*) and *Metarhizium anisopliae* (*Ma*) was investigated in Argentina during the winter of 2003 through spring of 2004. Fungi- infected insect samples (153) were collected from cornfields and the surrounding uncultivated areas in different localities of Buenos Aires (7), Tucumán (2), and Corrientes (3) provinces. The rates of *Bb*-infected host range varied among the Coleoptera (37%), Hemiptera (27%) and Dermaptera (1.3%). While the rates of *Ma*-infected host range varied between the Coleoptera (0.7%) and Hemiptera (34%). The greater host range resulted with *B. bassiana* found from eight species of Coleoptera (four families), one species of Dermaptera and four species of Hemiptera (three families), than the host range of *M. anisopliae* found infecting one species of Coleoptera and three species of Hemiptera (two families). We obtained 75 pure fungal isolates (48 *Bb*-isolates and 27 to *Ma*-isolates), and 56 of them (33 *Bb*-isolates and 23 *Ma*-isolates) were morphologically characterized.

Key words: *Beauveria bassiana*, biological control, Coleoptera, Dermaptera, Hemiptera, entomopathogenic fungi, *Metarhizium anisopliae*.

Introduction

Beauveria (Ascomycota: Hypocreales) is one of the earliest entomopathogenic fungi (EPF) ever discovered (Rehner, 2005); it is considered as one of the principal organisms on fungal insect pathology research (Steinhaus, 1963). Among its most relevant characteristics are the cosmopolitan distribution, easy recognition and isolation, frequent occurrence in nature and the wide broad host range including more than 700 insect species (Goettel *et al.*, 1990; Rehner, 2005). On the other hand, *Metarhizium* spp. (Ascomycota: Hypocreales) are known to infect more than 200 insect species, many of which are major agricultural pests such as spittlebugs, sugar cane borer, termites, scarab grubs, and grasshoppers (St. Leger, 1993). Since *Metarhizium* EPF species have the potential to be of economic importance, several commercial companies have registered several strains

[1*]Centro de Investigaciones de Fitopatología (CIDEFI). Facultad de Ciencias Agrarias y Forestales, UNLP. Calle 60 y 119 s/n, (1900) La Plata, Buenos Aires, Argentina. *E-mail*: atoledo@cepave.edu.ar
[2] División Entomología, Facultad de Ciencias Naturales y Museo, UNLP, Paseo del Bosque s/n, (1900) La Plata, Buenos Aires, Argentina.
[3]Centro de Estudios Parasitológicos y de Vectores (CEPAVE), UNLP-CONICET. Calle 2 Nro. 584, (1900) La Plata, Buenos Aires, Argentina.

for insect pest management (Rehner, 2005). Currently, the natural host range of *B. bassiana* (Bals.) Vuill. and *M. anisopliae* (Metsch.) Sorokin in Argentina, include several species of insects such as *Diatraea sacharalis* (Fabricius) (Lepidoptera: Pyralidae), *Spilosoma virginica* (Fabricius) (Lepidoptera: Lymantriidae), *Doru lineare* (Eschscholtz) (Dermaptera: Forficulidae), *Musca domestica* L. (Diptera: Muscidae), *Nezara viridula* L. (Hemiptera: Pentatomidae), *Phyrdenus muriceus* Germar (Coleoptera: Curculionidae), *Diabrotica speciosa* (Germar) (Coleoptera: Chrysomelidae), *Cycloneda sanguinea* L. (Coleoptera: Coccinellidae), *Diloboderus abderus* Sturm (Coleoptera: Scarabeidae), *Aleuas lineatus* Stal, *Dichroplus elongatus* Giglio Toss, *Rhammatocerus pictus* (Bruner) (Orthoptera: Acrididae) and *Triatoma infestans* Klug (Hemiptera: Reduviidae) (Fresa, 1979; López Lastra, 1988; Mariani *et al*., 1996; Lecuona & Díaz, 2001; Luna Rodríguez & Lecuona, 2002; Marti *et al*., 2005; Siri *et al*., 2005).

The objectives of this paper were to search for new insect host of *B. bassiana* and *M. anisopliae* and to provide morphological characterization of some of the native isolates from Argentina.

Materials and Methods

Sampling and identification of insects and fungi

The sample localities were not only the cornfields but also the surrounding uncultivated field with *Eryngium* sp. L. (Apiaceae) plants growing as predominant weed. Samples were obtained from localities with different agroecological characteristics of Argentina during the winter of 2003 through the spring of 2004. These localities were from the provinces of Buenos Aires (Abasto, Berazategui, Colonia Urquiza, La Plata, Los Hornos, San Antonio de Areco and San Vicente), Tucumán province (El Manantial and Horco Molle), and Corrientes province (Bella Vista, Esteros del Iberá and Mercedes). Dead insects covered by cottony mycelia were collected, placed in sterilized plastic containers and then processed in the laboratory. Healthy insects were also collected, fixed in 70% ethanol, and taken to the laboratory for their taxonomic identification.

Isolation and characterization of fungi

Infected insects were mounted on sterile glass microscope slides, and with the aid of an sterilized insect pin (number 000) a small portion of mycelium was transferred from the surface of the cadaver onto malt extract agar (MEA) with penicillin G 40,000 units/ml (Merck, Germany) and streptomycin 80,000 units/ml (Parafarm®, Argentina). Cultures were incubated at 25° C in darkness. After 7 days they were transferred to MEA medium in glass tubes and stored at 4° C. Some isolates were deposited at the Mycological Collection of the Centro de Estudios Parasitológicos y de Vectores (CEPAVE, La Plata, Buenos Aires, Argentina), while others were deposited at the Instituto de Botánica Carlos Spegazzini (LPSC, La Plata, Buenos Aires, Argentina) and at the USDA-ARS Collection of Entomopathogenic Fungal Cultures (ARSEF, Ithaca, New York). Macroscopic and microscopic observations of *B. bassiana* and *M. anisopliae* isolates were made from cultures on MEA and potato dextrose agar (PDA), respectively. Monosporic isolates of each fungal species were obtained as reported by Lecuona (1996) and incubated in Petri dishes at 25º C in darkness. After 72 hours of incubation, three colony-forming units (CFU) from each plate were removed and transferred to three sterile Petri dishes containing MEA and PDA and incubated for 14 days in darkness at 23 and 25º C, respectively. Growth rates, aspect, and pigmentation of the colony were recorded. The radial growth of the colony was measured from two orthogonal diameters at 14 days after incubation. Micromorphological characteristics were recorded from 14 d-old colonies by using and mounting young colony structures in lactophenol cotton blue (0.01% w/v). Twenty-five conidia, of each isolate, were individually measured under the microscope and their mean ± standard error was calculated. Morphological descriptions were made according to Brady (1979a, b) and De Hoog (1972) monographs. To estimate conidial germination, 100ml of MEA medium were added to sterile glass microscope slides, which were placed inside Petri dishes containing sterile moistened filter paper. Three slides per isolate, each containing culture media was inoculated with 100μl of conidial suspension at a concentration of 1×10^4 conidia/ μl. Spore germination was estimated by examining microscopically at least 200 conidia per isolate, three times from each disk after 24 hours of incubation at 25° C in darkness.

Results and Discussion

Sampling and identification of fungi and host insects

A total of 153 infected insects were collected from different hosts (56 Coleoptera, 42 Hemiptera and 2 Dermaptera infected with *B. bassiana*, and 1 Coleoptera and 52 Hemiptera with *M. anisopliae*) from July 13, 2003 to November 15, 2004. Samplings were done between July to November due to previous results indicated that fungi were more prevalent in that period of time. All insect cadavers were covered with mycelia, and some of them had sporulated. The rates of *Bb*-infected host range varied among the Coleoptera (37%), Hemiptera (27%) and Dermaptera (1.3%). The rates of *Ma*-infected host range varied between the Coleoptera (0.7%) and Hemiptera (34%). The greater host range resulted with *B. bassiana* which was found infecting eight species of Coleoptera (four families: Chrysomelidae, Coccinellidae, Curculionidae, and Lampyridae), one species of Dermaptera (Forficulidae) and four species of Hemiptera (three families: Cicadellidae, Membracidae, and Pentatomidae), than the host range of *M. anisopliae* which was found infecting one species of Coleoptera (Cantharidae) and three species of Hemiptera (Cercopidae and Pentatomidae). Data regarding fungal species, species and number of insect hosts, origin locality, and collection date are given in Table 1.

Isolation and characterization of fungi

Seventy-five fungal isolates (48 isolates corresponding to *B. bassiana* and 27 to *M. anisopliae*), out of 153 insects, were isolated in pure cultures. Additionally, 33 isolates of *B. bassiana* and 23 of *M. anisopliae* were morphologically characterized. Data of fungal species, host, and locality of origin, and CEPAVE, LPSC and ARSEF collection accession numbers of each isolate are given in Table 2.

Beauveria bassiana colony diameters ranged from 1.3 x 1.4 to 3.5 x 3.6 cm (Mean ± SE: 2.2 ± 0.09 x 2.2 ± 0.08 cm) after 14 days of incubation on MEA at 23º C in darkness (Table 3). Some morphological differences, as to mycelia growth, coloration, and the presence or absence of exudate drops were observed (Fig. 1a). Most of the isolates showed regular colony borders, white cottony and powdery mycelium without exudate drops, and colorless or pale yellow colony reverse. In contrast, the isolates *B. bassiana* CEP 073 and CEP 074 showed irregular colony borders; CEP 150 and CEP 175 showed colorless exudate drops; while CEP 075, CEP 091 and CEP 175 showed synnemata formation. This structure was rarely observed in *B. bassiana* when De Hoog (1972) and Brady (1979a) describe this species. In the field survival and transmission of *B. bassiana* and other pathogenic fungi could be enhanced by the production of synnemata, such as were observed by Meyer *et al*. (2007) in natural infections caused by *Hirsutella citriformis* Speare (Ascomycota: Hypocreales).

Conidia were hyaline, smooth, and globose to broadly ellipsoidal, measuring 2.0 - 2.8 x 1.9 - 2.4 µm (average: 2.4 ± 0.04 x 2.1 ± 0.02 µm) (Table 3). The morphology and conidial measurements of the isolates fit the descriptions of Brady (1979a). Most of *B. bassiana* isolates showed 90% or higher spore germination. The lower spore viabilities were found in isolates: CEP 153 (61.9%), CEP 154 (68.9%), CEP 152 (72.0%), CEP 151 (80.5%), and CEP 115 (82.4%) (Table 3).

Metarhizium anisopliae colony diameters ranged from 2.2 x 2.2 to 4.2 x 4.1 cm (Mean ± SE: 3.2 ± 0.12 x 3.1 ± 0.12 cm) after 14 days of incubation on PDA at 25º C in darkness (Table 3). Some morphological differences related to mycelia growth, coloration, and the presence or absence of exudate drops were noted (Fig. 1 b-f). Colony borders of the majority of isolates were regular, with white mycelia bearing clumps of conidiophores which became colored with the development of conidia, varying from yellow green or olivaceous green to dark herbage green, with the presence of colorless exudate drops; the reverse was pale yellow. In contrast, *M. anisopliae* isolates CEP 094, CEP 096, CEP 097, CEP 095, CEP 120, CEP 121 and CEP 122 showed irregular colony borders; CEP 093, CEP 090, CEP 159, CEP 160, CEP 178 and CEP 179 lacked exudate drops; while CEP 078, CEP 084 and CEP 087 showed orange to brownish colony reverse. In all the cases the sporulation started after the sixth or seventh day of incubation. *M. anisopliae* conidia were cylindrical, tapering and truncate at both ends, olivaceous to green and aseptate, measuring 6.5 - 9.2 x 2.4 - 2.9 µm (average: 7.1 ± 0.12 x 2.8 ± 0.03 µm). However, some conidia were longer (usually 5 - 8 x 1.5 – 3.5 µm) than those measurements reported by Brady (1979b) (Table 3). The conidial germination in the majority of isolates was 100%, although only two isolates presented of 85.3% (CEP 078) and 90.8% (CEP 079) (Table 3).

Our results show new insect host range findings for these indigenous fungal isolates, which exhibit some morphological differences among *B. bassiana* and *M. anisopliae* isolates in Argentina.

Further studies, including molecular examinations,

Table 1. Data of *Beauveria bassiana* and *Metharrhizium anisopliae* found on different insect host species in Argentina: Note: Asterisk (*) shows new records from Argentina.

Fungal species	Host insect	# of infected insects	Locality of origin	Collection date
Beauveria bassiana	Unidentified species of Coleoptera: Curculionidae (adults)	1	San Vicente, Buenos Aires 35º 0.1’ 49.5’’ S - 58º 26’ 56.9’’ W	07/13/2003
		4	Berazategui, Buenos Aires 34º 51’ S - 58º 06’ W	12/30/2003 07/21/2004
		32	Abasto, Buenos Aires 34º 57’ 59’’ S - 58º 04’ 42’’ W	04/07/2004 04/13/2004 04/28/2004 05/12/2004 06/09/2004 06/22/2004
		2	La Plata, 11 Country road Km 15, Buenos Aires 35º 01’ 27.6’’ S - 57º 51’ 26.0’’ W	08/18/2004 10/06/2004
	Unidentified species of Coleoptera (adult)	1	Horco Molle, Tucumán 26º 47’ 33.4’’ S - 65º 19’ 05.3’’ W	03/09/2004
	Heilipodus erythropus (Klug) (Coleoptera: Curculionidae) (adult) *	1	La Plata, 11 Country road, Buenos Aires 35º 01’ 27.6’’ S - 57º 51’ 26.0’’ W	08/18/2004
	Unidentified species of Coleoptera (adult)	1	Berazategui, Buenos Aires 34º 51’ S - 58º 06’ W	08/25/2004
	Cratomorphus diaphanus (Germar) (Coleoptera: Lampyridae) (adults)*	2	Mercedes, Corrientes 29º 11’ 43.5’’ S - 58º 02’ 0.8’’ W	11/15/2004
	Diabrotica speciosa (Coleoptera: Chrysomelidae) (adult)	1	El Manantial, Tucumán 26° 49’ 50.2’’ S - 65° 16’ 59.4’’ W	03/11/2004
	Cycloneda sanguinea (Coleoptera: Coccinellidae) (adults)	3	El Manantial, Tucumán 26° 49’ 50.2’’ S - 65° 16’ 59.4’’ W	03/11/2004
	Plagiodera erythroptera Blanchard (Coleoptera: Chrysomelidae) (adults)*	8	San Vicente, Buenos Aires 35º 0.1’ 49.5’’ S - 58º 26’ 56.9’’ W	07/18/2004
	Doru lineare (Dermaptera: Forficulidae) (adults)	2	El Manantial, Tucumán 26° 49’ 50.2’’ S - 65° 16’ 59.4’’ W	03/11/2004 04/15/2004
	Euchistus sp. (Hemiptera: Pentatomidae) (adult) *	1	Abasto, Buenos Aires 34º 57’ 59’’ S - 58º 04’ 42’’ W	04/07/2004
	Balacha melanocephala (Signoret) (Hemiptera: Cicadellidae) (adults and nymphs)*	8	Colonia Urquiza, Buenos Aires 34º 56’ 19.2’’ S - 58º 0.6’ 3.8’’ W	09/11/2003 09/17/2003 12/09/2003 02/10/2004
		8	Berazategui, Buenos Aires 34º 51’ S - 58º 06’ W	12/30/2003 04/20/2004 07/21/2004 08/25/2004

Table 1. Cont.

		1	Los Hornos, Buenos Aires 34º 57’ 29.5’’ S - 58º 5’ 26.6’’ W	02/24/2004 03/30/2004
		13	San Vicente, Buenos Aires 35º 0.1’ 49.5’’ S - 58º 26’ 56.9’’ W	10/05/2003 03/20/2004 05/09/2004
		2	La Plata, 11 Country road Km 15, Buenos Aires 35º 01’ 27.6’’ S - 57º 51’ 26.0’’ W	08/18/2004
	Kronides sp. (Hemiptera: Membracidae) (adults and nymphs) *	4	San Vicente, Buenos Aires 35º 0.1’ 49.5’’ S - 58º 26’ 56.9’’ W	03/20/2004
		1	Mercedes, Corrientes 29º 11’ 43.5’’ S - 58º 02’ 0.8’’ W	11/15/2004
	Pawiloma victima (Germar) (Hemiptera: Cicadellidae) (adults)*	3	Berazategui, Buenos Aires 34º 51’ S - 58º 06’ W	08/25/2004
		1	San Vicente, Buenos Aires 35º 0.1’ 49.5’’ S - 58º 26’ 56.9’’ W	09/29/2004
Metarhizium anisopliae	*Chauliognathus scriptus* Germar (Coleoptera: Cantharidae) (adult) *	1	San Antonio de Areco, Buenos Aires 34º 10’ 27’’ S - 58º 59’17.7’’ W	03/03/2004
	Unidentified species of Hemiptera: Pentatomidae (nymph)	1	Abasto, Buenos Aires 34º 57’ 59’’ S - 58º 04’ 42’’ W	04/07/2004
	Kanaima fluvialis (Lallemand) (Hemiptera: Cercopidae) (adults) *	3	Los Hornos, Buenos Aires 34º 57’ 29.5’’ S - 58º 5’ 26.6’’ W	02/24/2004 03/30/2004
	Unidentified species of Hemiptera: Cercopidae (adults)	29	Abasto, Buenos Aires 34º 57’ 59’’ S - 58º 04’ 42’’ W	04/07/2004 04/13/2004 04/28/2004 05/18/2004 06/01/2004
	K. fluvialis (adults)	2	Abasto, Buenos Aires 34º 57’ 59’’ S - 58º 04’ 42’’ W	05/12/2004
	Unidentified species of Hemiptera: Cercopidae (adults)	5	San Antonio de Areco, Buenos Aires 34º 10’ 27’’ S - 58º 59’17.7’’ W	03/03/2004
	Unidentified species of Hemiptera: Cercopidae (adults and nymphs)	7	Esteros del Iberá, Corrientes 28º 24’ S - 57º 07’ W	10/06/2004
	K. fluvialis (adults)	5	Bella Vista, Corrientes 28º 26’ 58.1’’ S - 58º 55’ 38’’ W	11/10/2004

Table 2. List of *B. bassiana* and *M. anisopliae* isolates found on different insect hosts, origin localities, repository agencies and their accession numbers.

Fungal species	Host	Origin locality	CEPAVE Collection* #	LPSC Collection* #	ARSEF Collection* #
B. bassiana	*Balacha melanocephala*	Colonia Urquiza, Buenos Aires	69	883	8459
			70	-	-
			72	781	7464
			73	-	-
		Berazategui, Buenos Aires	74	884	7465
			99	-	-
			110	889	-
			111	-	8460
			137	891	8370
			145	895	-
		Los Hornos, Buenos Aires	77	885	7467
		San Vicente, Buenos Aires	81	887	7469
			82	-	-
			115	890	-
			153	899	-
			154	-	-
		La Plata, 11 Country road Km 15, Buenos Aires	139	892	8529
			140	893	8529
	Pawiloma victima	Berazategui, Buenos Aires	142	894	8371
			143	-	-
			144	-	-
		San Vicente, Buenos Aires	152	-	-
	Kronides sp.	San Vicente, Buenos Aires	80	886	7468
	Euchistus sp.	Abasto, Buenos aires	91	888	-
	Unidentified species of Coleoptera	Berazategui, Buenos Aires	146	-	-
	Unidentified species of Coleoptera	Horco Molle, Tucumán	83	-	7470
	Unidentified species of Coleoptera: Curculionidae	Berazategui, Buenos Aires	75	-	7466
			136	-	-
		Abasto, Buenos Aires	92	-	7471
			98	-	-
			112	-	8520
			113	-	8521
			114	-	8522
			116	-	8523
			117	-	8524
			118	-	8525
			119	-	8526
		La Plata, 11 Country road Km 15, Buenos Aires	141	-	8530
			156	-	-

Table 2. Cont.

	Heilipodus erythropus	La Plata, 11 Country road Km 15, Buenos Aires	138	-	-
	Plagiodera erythroptera	San Vicente	135	-	-
	Cycloneda sanguinea	El Manantial, Tucumán	147 148 149	896 - -	8372 8462 8463
	Diabrotica speciosa	El Manantial, Tucumán	150	897	8373
	Doru lineare	El Manantial, Tucumán	151	898	8374
	Cratomorphus diaphanus	Mercedes, Corrientes	175 176	900 901	- -
M. anisopliae	Unidentified species of Hemiptera: Pentatomidae	Abasto, Buenos Aires	90	-	-
	Unidentified species of Hemiptera: Cercopidae	Los Hornos, Buenos Aires	76	905	7474
	Kanaima fluvialis	Los Hornos, Buenos Aires	85	-	-
	Unidentified species of Hemiptera: Cercopidae	San Antonio de Areco, Buenos Aires	78 79	906 -	7475 -
	Unidentified species of Hemiptera: Cercopidae	Abasto, Buenos Aires	86 87 88 89 93 94 95 96 97	907 - - - - - - - -	7476 - - - - - - - -
	Kanaima fluvialis	Abasto, Buenos Aires	120	-	-
	Unidentified species of Hemiptera: Cercopidae	Abasto, Buenos Aires	121 122	- -	- -
	Unidentified species of Hemiptera: Cercopidae	Esteros del Iberá, Corrientes.	157 158 159 160 161 162	- - - 908 - -	- - - 8376 - -
	K. fluvialis	Bella Vista, Corrientes	177 178 179	- 909 -	- - -
	Chauliognathus scriptus	San Antonio de Areco, Buenos Aires	84	-	-

Table 3. Radial growth, conidia size and conidial germination of *B. bassiana* and *M. anisopliae* isolates from different host insects and localities.

Isolate	Colony diameter (Mean ± SE) (cm)	Conidia size (Mean ± SE) (μm)	Conidial germination (Mean ± SE) (%)
Bb CEP 069	1.6 ± 0.02 x 1.6 ± 0.01	2.5 ± 0.5 x 2.0 ± 0.2	90.0 ± 5.1
Bb CEP 070	2.2 ± 0 x 2.1 ± 0.01	2.8 ± 0.1 x 2.4 ± 0.1	87.4 ± 1.5
Bb CEP 072	1.5 ± 0.02 x 1.5 ± 0.02	2.2 ± 0.1 x 1.9 ± 0.04	94.8 ± 2.6
Bb CEP 073	2.4 ± 0.1 x 2.4 ± 0.1	2.7 ± 0.1 x 2.1 ± 0.04	97.8 ± 0.1
Bb CEP 074	1.5 ± 0.01 x 1.3 ± 0.01	2.6 ± 0.1 x 2.3 ± 0.1	98.0 ± 0.7
Bb CEP 075	2.6 ± 0.02 x 2.2 ± 0.04	2.0 ± 0 x 2.0 ± 0	92.7± 1.8
Bb CEP 077	2.8 ± 0.04 x 2.7 ± 0.03	2.7 ± 0.1 x 2.1 ± 0.1	91.3 ± 4.0
Bb CEP 080	2.3 ± 0.03 x 2.2 ± 0.01	2.6 ± 0.1 x 2.2 ± 0.04	100
Bb CEP 081	1.9 ± 0 x 1.7 ± 0.04	2.7 ± 0.1 x 2.3 ± 0.1	95.4 ± 2.3
Bb CEP 083	3.1 ± 0.03 x 2.9 ± 0.01	2.6 ± 0.1 x 2.2 ± 0.1	89.5 ± 0.5
Bb CEP 091	2.8 ± 0.02 x 2.6 ± 0.02	2.2 ± 0.1 x 2.1 ± 0.1	97.9± 0.8
Bb CEP 092	1.9 ± 0.01 x 1.9 ± 0.01	2.7 ± 0.1 x 2.3 ± 0.1	86.1 ± 3.3
Bb CEP 098	1.9 ± 0.01 x 1.9 ± 0.01	2.4 ± 0.1 x 2.0 ± 0.03	94.3 ± 1.9
Bb CEP 110	1.7 ± 0 x 1.6 ± 0.01	2.5 ± 0.1 x 2.1 ± 0.04	100
Bb CEP 113	1.9 ± 0.02 x 1.7 ± 0.03	2.4 ± 0.1 x 2.2 ± 0.1	96.8 ± 1.3
Bb CEP 115	1.4 ± 0.02 x 1.4 ± 0.02	2.3 ± 0.08 x 2.1 ± 0.04	82.4 ± 3.1
Bb CEP 116	1.8 ± 0 x 1.8 ± 0.02	2.2 ± 0.1 x 2.0 ± 0.02	96.3 ± 1.1
Bb CEP 136	1.6 ± 0.1 x 1.8 ± 0.01	2.6 ± 0.04 x 2.2 ± 0.04	100
Bb CEP 137	3.6 ± 0.1 x 3.5 ± 0.1	2.4 ± 0.1 x 2.1 ± 0.04	99.2 ± 0.8
Bb CEP 138	2.9 ± 0.04 x 2.8 ± 0.03	2.5 ± 0.1 x 2.0 ± 0.04	96.6 ± 2.9
Bb CEP 140	2.7 ± 0.04 x 2.7 ± 0.	2.2 ± 0.1 x 2.0 ± 0	94.6 ± 1.5
Bb CEP 141	1.8 ± 0.02 x 1.7 ± 0	2.3 ± 0.04 x 2.0 ± 0	89.4 ± 1.6
Bb CEP 142	2.1 ± 0.04 x 2.2 ± 0.1	2.1 ± 0.04 x 2.0 ± 0	99.6 ± 2.7
Bb CEP 145	2.1 ± 0.02 x 2.0 ± 0.02	2.8 ± 0.1 x 2.3 ± 0.06	88.7 ± 3.4
Bb CEP 146	1.9 ± 0.02 x 1.8 ± 0.02	2.6 ± 0.1 x 2.1 ± 0.04	99.6 ± 0.6
Bb CEP 147	2.3 ± 0.04 x 2.2 ± 0.02	2.4 ± 0.1 x 2.1 ± 0.04	96.5 ± 1.6
Bb CEP 150	2.9 ± 0.1 x 2.8 ± 0.02	2.1 ± 0.1 x 2.0 ± 0	98.2 ± 0.5
Bb CEP 151	2.6 ± 0.04 x 2.5 ± 0.01	2.3 ± 0.1 x 2.0 ± 0	80.5 ± 5.5
Bb CEP 152	2.3 ± 0.01 x 2.1 ± 0.02	2.3 ± 0.1 x 2.0 ± 0.02	72.0 ± 1.9
Bb CEP 153	2.3 ± 0.02 x 2.2 ± 0.02	2.3 ± 0.1 x 2.0 ± 0.02	61.9 ± 7.5
Bb CEP 154	2.3 ± 0.02 x 2.1 ± 0.01	2.4 ± 0.1 x 2.1 ± 0.04	68.9 ± 8.5
Bb CEP 175	2.7 ± 0.03 x 2.5 ± 0.01	2.1 ± 0.04 x 2.0 ± 0.02	99.9 ± 0.16
Bb CEP 176	2.4 ± 0.01 x 2.3 ± 0.02	2.0 ± 0.02 x 2.0 ± 0	100
Ma CEP 076	2.7 ± 0.01 x 2.7 ± 0.01	7.1 ± 0.2 x 2.6 ± 0.07	100
Ma CEP 078	2.5 ± 0.01 x 2.5 ± 0.01	7.3 ± 0.1 x 2.6 ± 0.1	85.3 ± 9.4
Ma CEP 079	2.4 ± 0.02 x 2.4 ± 0.02	7.5 ± 0.04 x 2.8 ± 0.01	90.8 ± 8.0
Ma CEP 084	2.5 ± 0.02 x 2.5 ± 0.02	6.7 ± 0.1 x 2.9± 0	100
Ma CEP 085	3.3 ± 0.03 x 3.3 ± 0.02	6.7 ± 0.1 x 2.8 ± 0.1	100
Ma CEP 086	3.7 ± 0 x 3.7 ± 0.01	7.3 ± 0.1 x 2.9± 0	100
Ma CEP 087	2.2 ± 0x 2.2 ± 0	7.0 ± 0.1 x 2.8 ± 0.1	100
Ma CEP 088	2.4 ± 0.1 x 2.4 ± 0.1	7.0 ± 0.2 x 2.6 ± 0.1	100

Table 3. Cont.

Ma CEP 089	2.8 ± 0.1 x 2.4 ± 0.03	7.1 ± 0.2 x 2.7 ± 0.1	100
Ma CEP 090	3.8 ± 0.04 x 3.7 ± 0.1	6.8 ± 0.1 x 2.9± 0	100
Ma CEP 093	2.8 ± 0 x 2.8 ± 0	7.3 ± 0.1 x 2.9± 0	100
Ma CEP 094	3.1 ± 0.1 x 3.1 ± 0.1	6.6 ± 0.1 x 2.9± 0	100
Ma CEP 095	3.6 ± 0.1 x 3.5 ± 0.1	7.1 ± 0.1 x 2.9± 0	100
Ma CEP 096	4.2 ± 0.01 x 4.0 ± 0.03	6.6 ± 0.1 x 2.8 ± 0.1	100
Ma CEP 097	3.4 ± 0.1 x 3.1 ± 0.03	6.5 ± 0.1 x 2.6 ± 0.1	100
Ma CEP 120	3.5 ± 0.1 x 3.4 ± 0.12	6.6 ± 0.2 x 2.9 ± 0.04	100
Ma CEP 121	4.1 ± 0.1 x 4.1 ± 0.04	7.1 ± 0.1 x 2.8 ± 0.1	100
Ma CEP 122	3.9 ± 0.1 x 3.9 ± 0.1	6.5 ± 0.1 x 2.9± 0	100
Ma CEP 158	3.5 ± 0.02 x 3.3 ± 0.04	6.9 ± 0.1 x 2.4 ± 0.1	100
Ma CEP 159	3.2 ± 0.1 x 3.0 ± 0.1	7.4 ± 0.2 x 2.9 ± 0.04	100
Ma CEP 160	3.2 ± 0.02 x 3.0 ± 0.04	7.2 ± 0.1 x 2.8 ± 0.04	100
Ma CEP 178	3.0 ± 0.04 x 2.9 ± 0.02	8.1 ± 0.2 x 2.9 ± 0.1	100
Ma CEP 179	3.4 ± 0.02 x 3.3 ± 0.04	9.2 ± 0.2 x 2.9 ± 0.1	100

will determine their genetic variability among isolates from different host and origin and their potential as biocontrol agents against insect pests.

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