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Pediobius cajanus sp. n. (Hymenoptera, Eulophidae), an important natural enemy of the Asian fly (*Melanagromyza obtusa* (Malloch)) (Diptera, Agromyzidae) in the Dominican Republic

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Abstract

Pediobius cajanus **sp. n.** is described based on material from the Dominican Republic, where it is widespread, and it is anticipated to have a much larger distribution in tropical America. It is compared to other species of *Pediobius* from the New World, and is also compared to *P. vignae* (Risbec), a similar species from Africa with similar biology. The new species is a gregarious endoparasitoid of the pupae of the Asian fly, *Melanagromyza obtusa* (Malloch), an agromyzid that causes major damage to pigeon pea, *Cajanus cajan* (L). Millspauh. In the Dominican Republic *P. cajanus* **sp. n.** is the most important parasitoid of this pest. Details on its biology are provided.

Keywords

Guandul, potential biocontrol agent, Neotropics

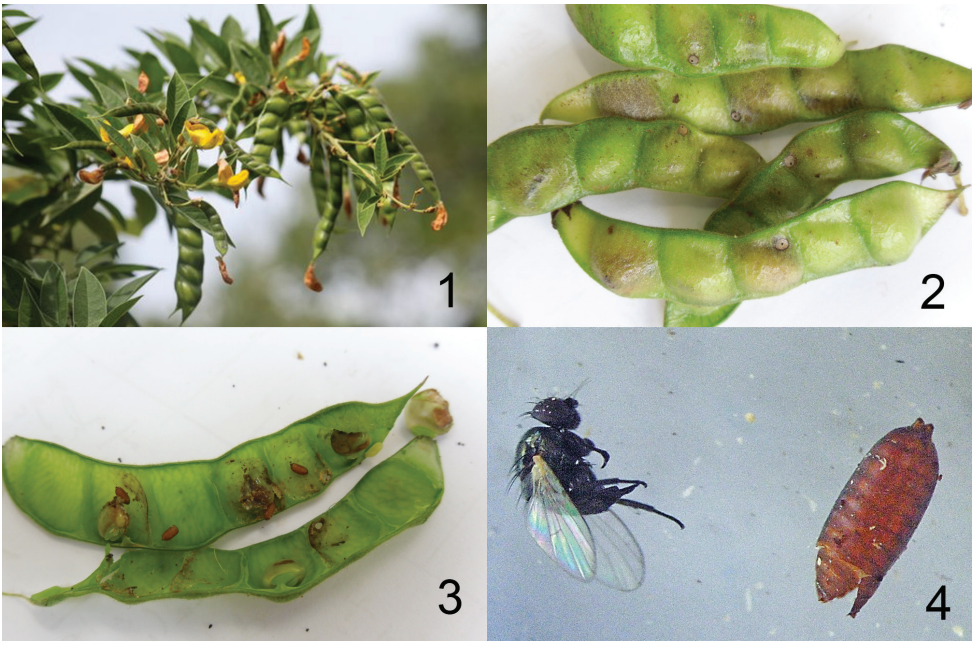
Introduction

Pediobius is a cosmopolitan genus with 217 described species (Noyes 2015), 25 of which have been recorded from the Neotropical region (Hansson 2002). Species of *Pediobius* develop as primary or secondary endoparasitoids in eggs, larvae or pupae of other insects, and the host range is extensive (Bouček 1988). The host species belong mainly to Coleoptera, Diptera, Hymenoptera and Lepidoptera. Some species have been reared from egg sacks of spiders, but then act as secondary parasitoids of ichneumonid larvae (Hymenoptera) feeding on the spider eggs. In the Neotropical region *Pediobius* species have been recorded from Coleoptera, Hymenoptera, and Lepidoptera but not from Diptera (Hansson 2002). Some *Pediobius* species have been used in biological control, most notable is perhaps *P. foveolatus* (Crawford), which has been used successfully to control populations of the Mexican bean beetle, *Epilachna varivestis* Mulsant, 1850 (Coleoptera: Coccinellidae) in North America (Barrows and Hooker 1981). Here we describe a new species of *Pediobius* that is the main enemy and a potential biocontrol agent of the Asian fly, *Melanagromyza obtusa* (Malloch, 1914) (Diptera: Agromyzidae). The Asian fly is an invasive pest in tropical America that causes extensive damage to pigeon pea, *Cajanus cajan* (L) Millspauh. Pigeon pea is an important source of food in tropical America, and as processed food is an important source of income from export.

The components of the tritrophic system including *Pediobius cajanus* sp. n.

The pigeon pea, "guandúl" in Spanish (Fig. 1), is a legume native to tropical India, and it has been grown in the Dominican Republic and other countries in tropical America since the late 15th century, when the Spanish came to the Americas. It is a very important source of nutrition: Miquilena and Higuera Moros (2012) gave a protein value of 17.52%, and compared it to lentil and soy, with 18 and 35% protein values respectively. The plant is very tolerant to heat and drought and in dry areas without access to irrigation, it is a valuable alternative to less tolerant crops. In addition to its usefulness as food for humans the plant fixates nitrogen and thus contributes to the fertilization of the soil; the empty seedpods are an important food source for livestock, the remaining plant parts can be used as firewood, and it also has some medicinal properties (Cedano 2006).

In the Dominican Republic, the study area for this paper, the pigeon pea is grown in approximately 25,000 hectares, by nearly 3,000 farmers (statistics from the Ministry of Agriculture 2013). However, this figure is underestimated because much of the production is in small lots, along paths and road edges, and it is used as property borders, and these areas are not included in the statistics. Thus, the total area of cultivation is unknown, but the unrecorded areas are significant and contribute to the diet of some of the country's population. In the Dominican Republic its cultivation has also been developed as a source of income for farmers who process the bean as canned or freshly



Figures 1–4. 1 pigeon pea, *Cajanus cajan* (L). Millspauh **2** seed pods of pigeon pea with marks indicating windows created by larvae of the Asian fly, *Melanagromyza obtusa* (Malloch), prior to pupation, a window that facilitates the emergence of the adult fly from the pod **3** opened seed pods of pigeon pea with pupae of the Asian fly **4** imago of the Asian fly with pupa.

frozen beans for export. The export of pigeon pea has diversified and today it is being exported to many countries, including countries in Europe, but the largest importers are in the arc of the Antilles.

The pigeon pea is attacked by a complex of insect pests, mainly from the orders Lepidoptera, Diptera, Hemiptera and Coleoptera (Schmutterer 1990). One of the major pests is the Asian fly (Fig. 4) which causes great damage to the crops of pigeon pea, considerably reducing the production and export volumes.

Studies in India have shown that the damage caused by the Asian fly affects 25.5 to 36% of the crop (Sharma et al. 2011). These data are in accordance with those found in the Dominican Republic, where the Asian fly was detected in 2000 (Phytosanitary Alert system 2004, and Etienne et al. 2004). An investigation in the Dominican Republic by Guzman et al. (2010) indicated that the percentage of damage, even though the crops were treated with insecticides every 21 days, reached a level of 27%. However, the amount of damage varies considerably between different localities and the state of crop development in the Dominican Republic. In 2012 the level of damage was evaluated in 122 localities and in the town of Rancho Los Vargas, Puerto Plata, it reached 76% (Taveras and Guzman 2013).

Yadaf and Yadaf (2011) conducted a review of the parasitoids of the Asian fly in India and listed 21 Hymenoptera parasitoids in 10 genera. They found that *Euderus*

lividus (Ashmead, 1886) (Eulophidae) and *Ormyrus orientalis* Walker, 1871 (Ormyridae) were the main parasitoids, and these two species were also the most studied parasitoids for control of the fly. Species of *Pediobius* have, prior to this paper, not been recorded from the Asian fly.

In the Dominican Republic *Ormyrus orientalis* and an unidentified species of *Pediobius* have been reared from the Asian fly on pigeon pea. In a paper by Taveras and Guzman (2013) the presence of these beneficial parasitoids was recorded from 103 sites that included 25 of the 31 provinces in the country. The level of parasitism was 27.8%, with the *Pediobius* species responsible for 25.8%, and *Ormyrus orientalis* for 2%. This information clearly indicates that these parasitoids are distributed throughout the country, which is also supported by this investigation, and very probably have a far larger distribution outside the Dominican Republic. It also indicates that the *Pediobius* species is an important natural enemy of the Asian fly, and as such might be considered as a biocontrol agent against this invasive pest.

Because of the economic importance of the pigeon pea, and because the unidentified *Pediobius* species obviously is an eminent natural enemy of its main pest, the Asian fly, in the Dominican Republic, it is important to identify this *Pediobius* species. After a close examination of several specimens of *Pediobius* we found that it belongs to an undescribed species. To facilitate the identification of this new species it is described and diagnosed here, and given a scientific name so that future information can be linked to it.

Methods

The color photos were made with a Nikon SMZ 1000 stereomicroscope and a Nikon DS-5M camera. To eliminate reflections from the metallic and shiny body, a dome light manufactured as described by Kerr et al. (2008), was used as the light source for photography. Photos were taken at different focus levels and Helicon Focus Pro version 4.75 was used to merge them into a single image. The SEM photos were made from uncoated specimens on their original cardboard mounts. These were taken in low vacuum mode on a JEOL® JSM 5600LV scanning electron microscope.

Pods of pigeon pea were collected in several different parts of the Dominican Republic and were placed in plastic bags with holes for ventilation and prevention of condensation inside the bags. The samples were brought to the laboratory where the pods were opened and fly larvae, pupae and adults were counted. The larvae and pupae were placed in plastic containers (9 × 9 cm) with a piece of cloth at the opening to facilitate aeration. The emerging parasitoids and imagines of the Asian fly were killed and stored in vials with ethanol.

Measurements were taken using the Nikon stereomicroscope mentioned above, using a eyepiece micrometer at 80 times magnification. The female holotype and ten paratypes of each sex were measured.

Morphological terms follow Gibson (1997). For illustrations of the morphological terms see also Hansson (2015).

Results

***Pediobius cajanus* sp. n.**
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Figures 6–19

Material examined. Type material: HOLOTYPE ♀ labelled "DOMINICAN REPUBLIC: San Juan Province, San Juan de la Maguana, 20.x.2014, Rosina Taveras", "Ex pupae of *Melanagromyza obtusa* on pigeon pea (*Cajanus cajan*)" (in the Natural History Museum, London, United Kingdom). PARATYPES: 42♀ 15♂ with same label data as holotype (in the Natural History Museum, London, United Kingdom; Canadian National Collection of Insects and Arachnids, Ottawa, Canada; Museo Nacional de Historia Natural, Dominican Republic; Museum of Biology (Entomology), Lund, Sweden; United States National Museum of Natural History, Washington, D.C., USA). Additional material: 42♀ 12♂ from the Dominican Republic: Luperon Province, Puerto Plata, v.2013 (in the Museum of Biology (Entomology), Lund, Sweden).

Diagnosis. Hind leg with tibial spur 0.4 times as long as length of hind tarsus; propodeum with strong submedian carinae that diverge towards posterior part (Fig. 18); propodeal callus with four setae; female gaster elongate (Figs 13, 19), 2 times as long as wide; small species (0.9–1.5 mm).

In the most recent keys to the Neotropical species of *Pediobius* (see Hansson 2002) and in the key to Nearctic species (Peck 1985), *P. cajanus* runs to *P. pyrgo* (Walker, 1839). It differs from *P. pyrgo* in having median third of scutellum smooth (Fig. 17) (completely reticulate in *P. pyrgo*), posterior margin of dorsellum tridentate (Fig. 18) (rounded in *P. pyrgo*), and petiole in female 0.7 times as long as wide (1.0 times as long as wide in *P. pyrgo*).

Pediobius cajanus sp. n. also appears to be morphologically similar to *P. vignae* (Risbec, 1951) from Nigeria, as described in Kerrich (1973). The host of *P. vignae*, *Melanagromyza vignalis* Spencer, 1959 in seeds of *Vigna unguiculata* (L.) Walp. (Fabaceae), is also similar to the host of *P. cajanus*. When Kerrich (1973) revised the tropical and subtropical species of *Pediobius* he was unable to find the type material of *P. vignae* and designated a neotype for the species, to be deposited in BMNH. However, this neotype, or the series it was pulled from, cannot be located in BMNH (Natalie Dale-Skey, pers. comm.). Thus we rely totally on the redescription of *P. vignae* in Kerrich (1973) for the interpretation of this species. *Pediobius cajanus* sp. n. differs from *P. vignae* in having eyes bare (Figs 15, 16) (setose in *P. vignae*), scutellum smooth in median third (Fig. 17) (reticulate throughout in *P. vignae*), female first gastral tergite 0.5 times as long as length of gaster (Figs 13, 19) (well over half the length of gaster in *P. vignae*), female with first gastral tergite with very weak and superficial reticulation posteromedially (Figs 13, 19) (this part with strong and very distinct reticulation in *P. vignae*).

Description. Female: length of body 1.1–1.5 mm.

Antenna dark and metallic (Figs 6, 11). Frons dark golden-purple with bluish tinges (Fig. 8). Vertex shiny with dark golden and blue tinges (Fig. 10). Pronotum

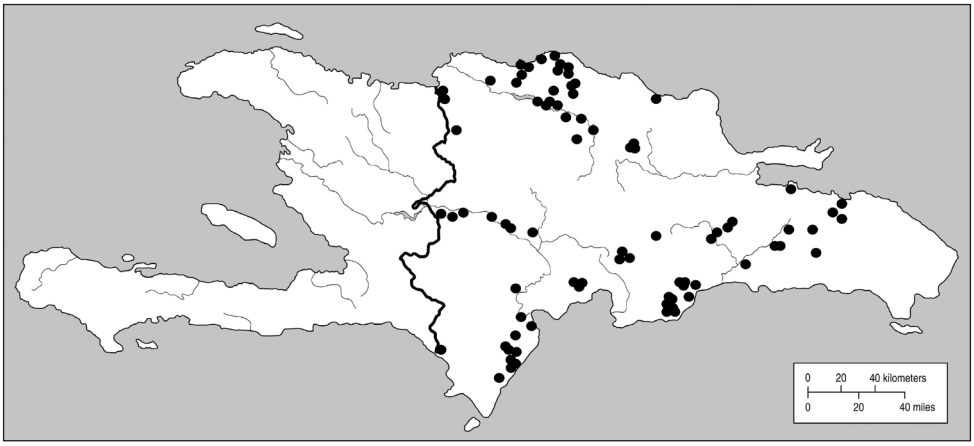
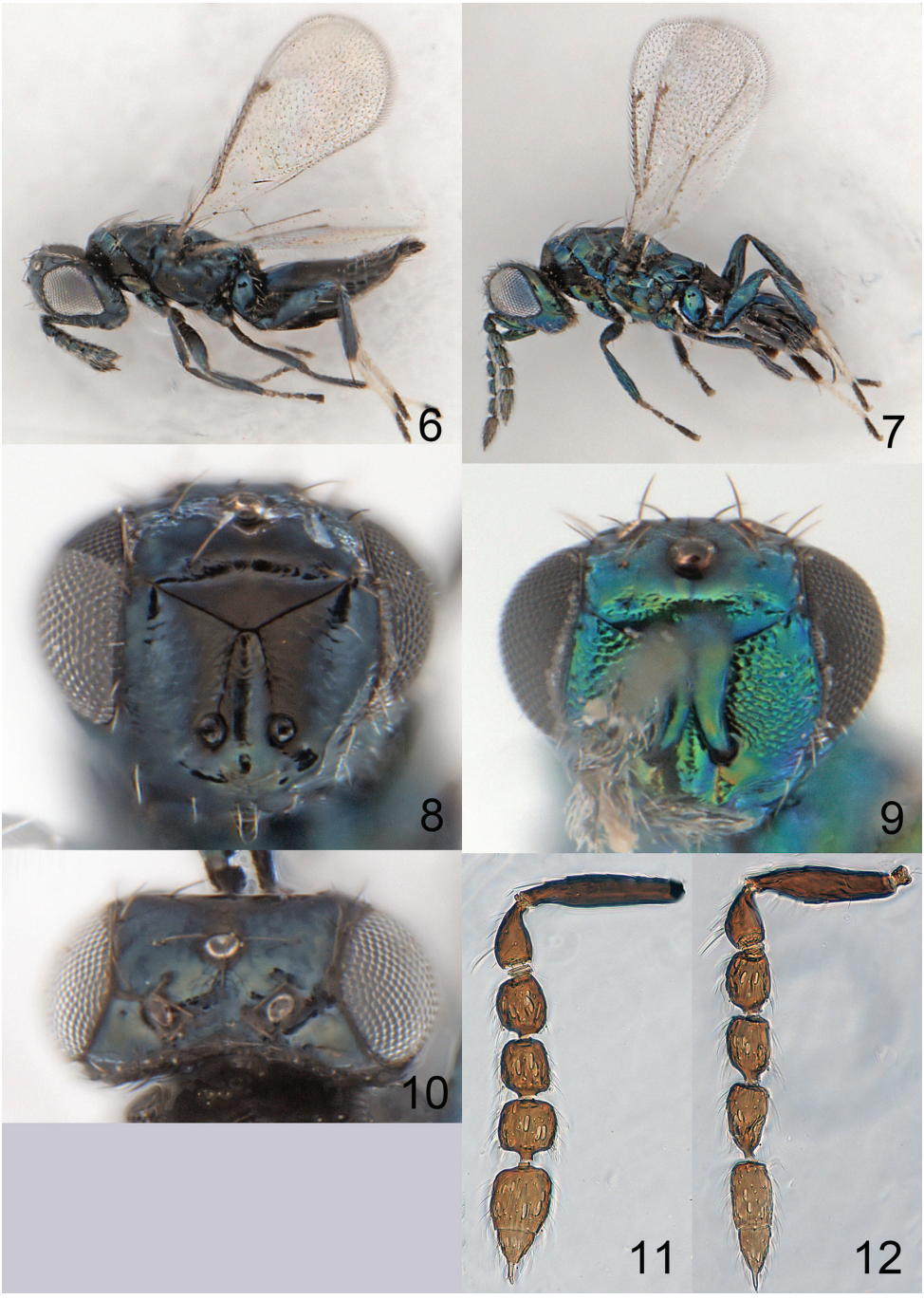


Figure 5. Map of the island of Hispaniola showing localities in the Dominican Republic where *Pediobius cajanus* sp. n. has been reared from *Melanagromyza obtusa* during this investigation. Specific names of localities and coordinates are provided in Table 1.

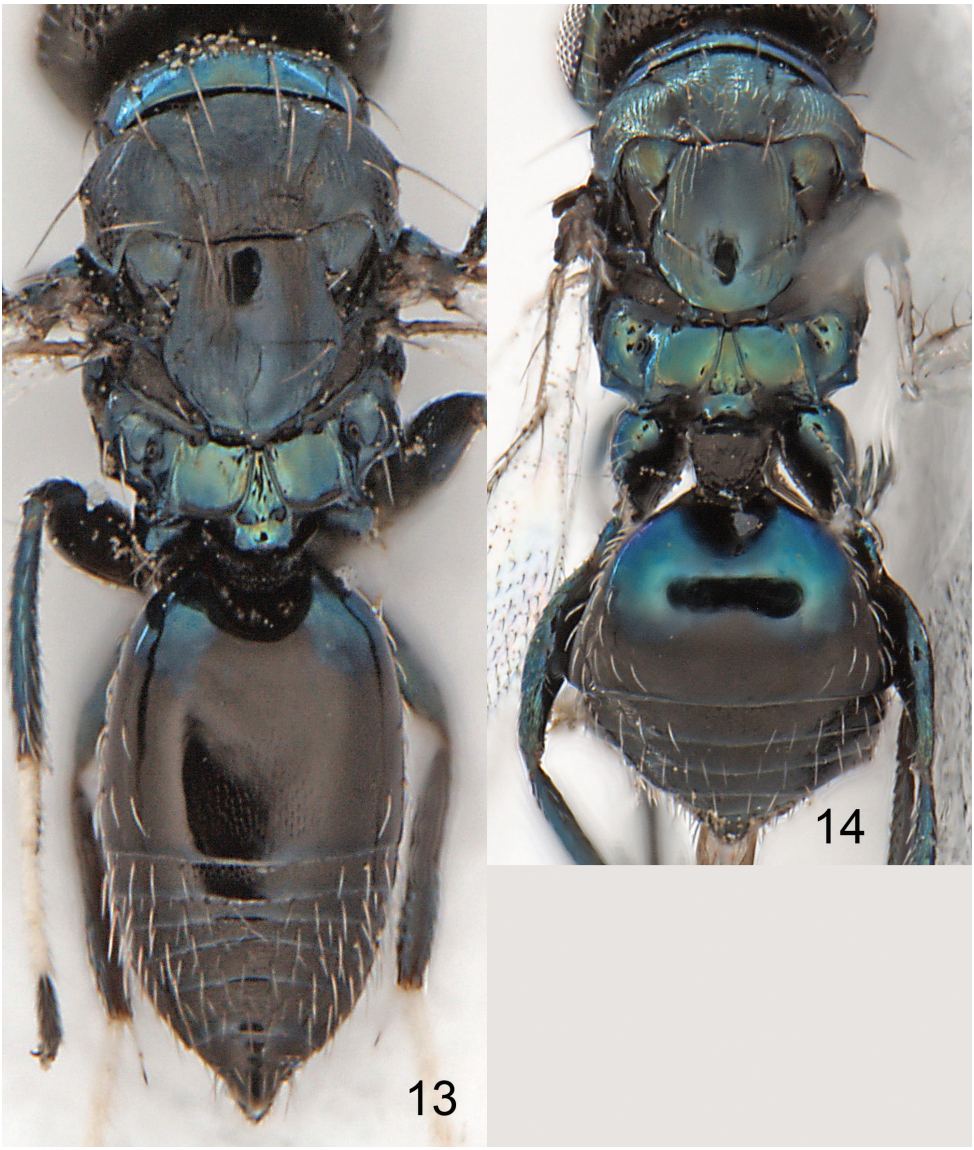
with part in front of transverse carina dark golden-purple, part behind transverse carina metallic bluish-green (Fig. 13). Mesoscutum dark golden-purple (Fig. 13). Scutellum dark golden-purple with lateral and posterior parts with greenish tinges (Fig. 13). Propodeum golden-green (Fig. 13). Coxae, femora and tibiae dark and metallic (Fig. 6); tarsal segments 1–3 dusky on fore leg and white on mid and hind legs, fourth segment dark brown on all legs. Wings hyaline. Petiole dark golden-purple. Gaster with first tergite metallic bluish-green in anterior fourth, posterior three quarters and remaining tergites dark golden-purple (Fig. 13).

Antenna as in Figs 6, 11. Frons smooth and shiny below level of toruli and above frontal suture, between these parts with very weak reticulation (Fig. 16); antennal scrobes join frontal suture separately (Fig. 8). Vertex inside and behind ocellar triangle with weak, small-meshed reticulation, outside ocellar triangle smooth (Fig. 15). Occipital margin with a weak carina behind posterior ocelli, otherwise rounded (Fig. 15). Eyes bare (Figs 15, 16). Ratios: length of head (in dorsal view)/width of head (measured at widest part): holotype 0.49, paratypes 0.46–0.52; height of eye in frontal view/malar space: holotype 2.06, paratypes 1.87–2.33; height of eye in frontal view/width of mouth opening: holotype 1.45, paratypes 1.29–1.46; distance between posterior ocelli/distance between eye and posterior ocellus: holotype 2.38, paratypes 1.75–2.40

Mesoscutum with weak reticulation (Fig. 17), meshes isodiametric in anteromedian part but otherwise elongate; notauli distinct and narrow in anterior two thirds, indistinct in posterior third. Scutellum convex with median third smooth, lateral parts to either side of smooth, median part reticulate with elongate meshes (Fig. 17). Posterior margin of dorsellum with a prominent medial projection and with weak and blunt lateral projections (Fig. 18). Transepimeral sulcus strongly curved. Fore wing speculum closed below; 12 admarginal setae. Hind leg with tibial spur 0.4 times as long as length of hind tarsus. Propodeum with strong submedian carinae that diverge towards



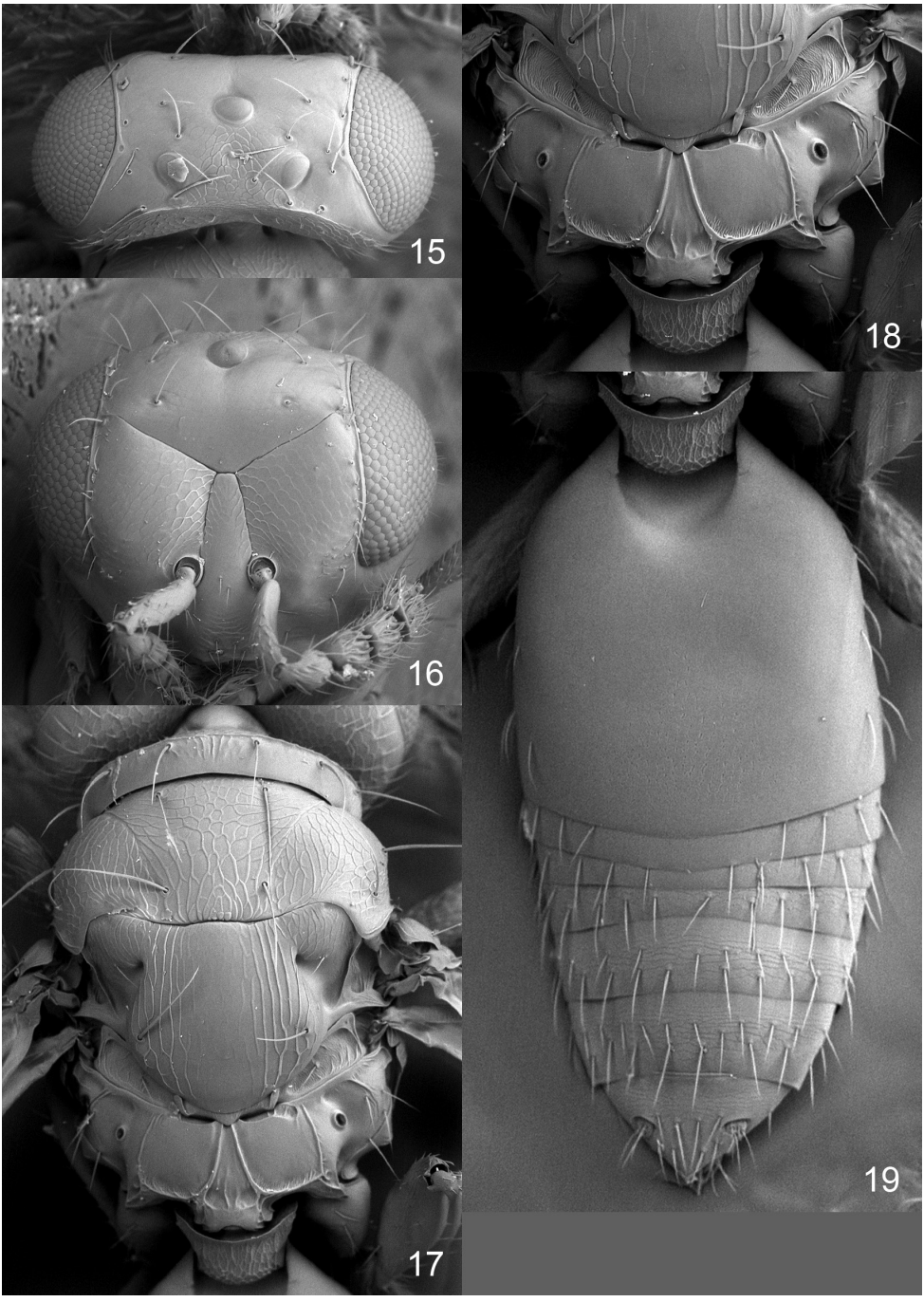
Figures 6–12. *Pediobius cajanus* sp. n. **6–7** habitus in lateral view **6** female **7** male **8–9** head in frontal view **8** female **9** male **10** vertex, female **11–12** antenna in lateral view **11** female **12** male.



Figures 13–14. *Pediobius cajanus* sp. n., habitus in dorsal view **13** female **14** male.

posterior part (Fig. 18); with a short but distinct nucha; callus with four setae. Petiolar foramen rounded. Ratios: length of fore wing/length of marginal vein: holotype 1.98, paratypes 1.85–2.04; length of fore wing/height of fore wing: holotype 1.67, paratypes 1.63–1.75; length of postmarginal vein/length of the stigmal vein: holotype 0.96, paratypes 0.63–1.00.

Petiole 0.7 times as long as wide, with strong irregular sculpture (Fig. 19). Gaster with first tergite smooth (Fig. 19), posteromedially with very weak and superficial reticulation, meshes incomplete; first tergite covers 0.5 times the length of gaster in both



Figures 15–19. *Pediobius cajanus* sp. n., female **15** vertex **16** head in frontal view **17** thoracic dorsum **18** propodeum in dorsal view **19** petiole and gaster in dorsal view.

sexes (Figs 13, 14, 19). Ratio length of the mesosoma (measured along the median mesosoma from the pronotal collar carina to posterior margin of the propodeum)/ length of gaster: holotype 0.88, paratypes 0.81–0.93.

Male: length of body 0.9–1.3 mm.

Similar to female except as follows. Frons bright metallic bluish-green (Fig. 9). Mesoscutum golden-green (Fig. 14). Scutellum golden-green (Fig. 14). Gaster with first tergite metallic bluish-green in anterior half, posterior half and remaining tergites dark golden-purple (Fig. 14).

Antenna as in Figs 7, 12. Ratios: height of eye in frontal view/malar space: 1.75–1.94; height of eye in frontal view/width of mouth opening: 1.30–1.60.

Petiole 1.1 times as long as wide. Gaster with first tergite completely smooth. Ratio length of the mesosoma (measured along the median mesosoma from the pronotal collar carina to posterior margin of the propodeum)/length of gaster: 1.09–1.58.

Etymology. Named after the host plant.

Distribution. The Dominican Republic. The first author of this paper has reared this new species from its host from 90 sites (Fig. 5, Table 1).

Biology. *Pediobius cajanus* sp. n. is a gregarious endoparasitoid in pupae of *Melanagromyza obtusa*. The female wasps lay 3–15 eggs per fly pupa (mean = 7.6, n = 50). In laboratory conditions, with 25 °C, the development time from egg to pupa of the parasitoid was 21 days. Without food the female wasps lived for four days and males for two days. The sex ratio female to male is 5:1 (n = 50).

Biology of the Asian fly. The female fly lays eggs on immature pods, and the emerging larvae feed in the developing seeds, initially feeding externally but after the first molt feed inside the seed, which they eventually destroy (Fig. 3). A single seed may be enough for a larva to complete its development, but usually more than one seed is devoured. The larva goes through three stages prior to pupation. Before pupating in the seed pod the larva emerges from the seed and opens a window in the wall of the pod (Fig. 2).

Conclusions. *Pediobius cajanus* sp. n. is so far known only from the Dominican Republic, but its distribution throughout this country suggests a larger distribution. It is certainly found over the entire island of Hispaniola, of which the Dominican Republic constitutes the larger part. It is possibly also found on neighboring islands in the Caribbean, e.g. Cuba, and perhaps also in tropical parts of the mainland in the Americas. Some *Pediobius* species have a very large distribution (Kerrich 1973, Hansson 2002), thus indicating a strong dispersal ability. If this ability is present also in *P. cajanus* sp. n. future investigations must establish.

In the Dominican Republic *P. cajanus* sp. n. is an important natural enemy of the Asian fly, killing on average 25% of the fly larvae in investigated areas. The fly is found in many tropical countries, in Asia, its native area, as well as in other tropical parts of the World, and is a serious pest on economically valuable crops in these areas. The record of parasitism of *P. cajanus* sp. n. in the Dominican Republic makes it worthwhile to investigate the potential of this parasitoid as a biocontrol agent of the Asian fly.

Table 1. List of localities in the Dominican Republic where *Pediobius cajanus* sp. n. has been reared from *Melanagromyza obtusa*.

Locality	Province	Decimals	Degrees
13 de Azua	Azua	18.459420, -70.853738	18°27'33.9"N, 70°51'13.5"W
Guanábano, Azua	Azua	18.447210, -70.790729	18°26'50.0"N, 70°47'26.6"W
Los Jovillos	Azua	18.449151, -70.801853	18°26'56.9"N, 70°48'06.7"W
Santana	Bahoruco	18.417995, -71.193348	18°25'04.8"N, 71°11'36.0"W
Pizarrete, Bani	Peravia	18.290396, -70.229342	18°17'25.4"N, 70°13'45.6"W
Barahona	Barahona	18.201356, -71.093906	18°12'04.9"N, 71°05'38.1"W
Caballero, Cachón	Barahona	18.248869, -71.195371	18°14'55.9"N, 71°11'43.3"W
Caletón, Enriquillo	Barahona	17.960965, -71.266760	17°57'39.5"N, 71°16'00.3"W
Charco Prieto, Higuero	Barahona	18.024770, -71.210300	18°01'29.2"N, 71°12'37.1"W
El Puerto, Polo	Barahona	18.052038, -71.280082	18°03'07.3"N, 71°16'48.3"W
Enriquillo	Barahona	17.895977, -71.238366	17°53'45.5"N, 71°14'18.1"W
Higuero,	Barahona	18.055723, -71.287129	18°03'20.6"N, 71°17'13.7"W
La Cueva, Polo	Barahona	18.159054, -71.251670	18°09'32.6"N, 71°15'06.0"W
Naranjal, Enriquillo	Barahona	17.902976, -71.237133	17°54'10.7"N, 71°14'13.7"W
Paraíso	Barahona	18.031771, -71.198618	18°01'54.4"N, 71°11'55.0"W
Polo	Barahona	18.093777, -71.283545	18°05'37.6"N, 71°17'00.8"W
San Rafael de Los Patos	Barahona	17.956199, -71.190141	17°57'22.3"N, 71°11'24.5"W
Cañongo,	Dajabón	19.623469, -71.692030	19°37'24.5"N, 71°41'31.3"W
Monte Grande, Loma de C.	Dajabón	19.395277, -71.617351	19°23'43.0"N, 71°37'02.5"W
Sangre Linda, La Ceiba	Dajabón	19.589494, -71.703911	19°35'22.2"N, 71°42'14.1"W
El Seibo	El Seibo	18.770027, -69.059393	18°46'12.1"N, 69°03'33.8"W
Miches	El Seibo	18.980588, -69.051765	18°58'50.1"N, 69°03'06.3"W
Pedro Sánchez	El Seibo	18.865925, -69.111536	18°51'57.3"N, 69°06'41.5"W
Corozito	Elías Piña	18.845685, -71.712592	18°50'44.5"N, 71°42'45.3"W
Km 5	Elías Piña	18.878255, -71.663325	18°52'41.7"N, 71°39'48.0"W
Matayaya	Elías Piña	18.888584, -71.590058	18°53'18.9"N, 71°35'24.2"W
Gaspar Hernández	Espaillat	19.633862, -70.284616	19°38'01.9"N, 70°17'04.6"W
Hoyoncito	Hato mayor	18.743150, -69.413553	18°44'35.3"N, 69°24'48.8"W
Las Cañas	Hato mayor	19.013698, -69.382548	19°00'49.3"N, 69°22'57.2"W
Los Cocos de Los López	Hato mayor	18.764635, -69.264540	18°45'52.7"N, 69°15'52.3"W
Villa Tapia,	Hermanas Mirabal	19.304531, -70.423018	19°18'16.3"N, 70°25'22.9"W
Barranca Sección Jamo	La Vega	19.265503, -70.462317	19°15'55.8"N, 70°27'44.3"W
Toro Cenizo,	La Vega	19.267749, -70.435889	19°16'03.9"N, 70°26'09.2"W
Guanuma	Monte Plata	18.695502, -69.923678	18°41'43.8"N, 69°55'25.2"W
La luisa Blanca	Monte Plata	18.741184, -69.897959	18°44'28.3"N, 69°53'52.6"W
Monte Plata	Monte Plata	18.795157, -69.775756	18°47'42.6"N, 69°46'32.7"W
Monte Plata	Monte Plata	18.811407, -69.772323	18°48'41.1"N, 69°46'20.4"W
Doña Antonia	Montecristi	19.673590, -71.230963	19°40'24.9"N, 71°13'51.5"W
El Cerro Gordo	Montecristi	19.758288, -71.211732	19°45'29.8"N, 71°12'42.2"W
Juan Gómez	Montecristi	19.702509, -71.409304	19°42'09.0"N, 71°24'33.5"W
Juancho, Oviedo	Pedernales	17.859494, -71.290455	17°51'34.2"N, 71°17'25.6"W
La Colonia, Villa Esperanza	Pedernales	17.851947, -71.331894	17°51'07.0"N, 71°19'54.8"W

Locality	Province	Decimals	Degrees
Pedernales	Pedernales	18.042637, -71.740322	18°02'33.5"N, 71°44'25.2"W
Altamira Puerto Plata	Puerto Plata	19.667481, -70.831862	19°40'02.9"N, 70°49'54.7"W
Canada Bonita	Puerto Plata	19.623430, -70.841566	19°37'24.4"N, 70°50'29.6"W
Cruce Guanabano-Navarrete	Puerto Plata	19.645546, -70.831922	19°38'44.0"N, 70°49'54.9"W
El Clavo, Altamira	Puerto Plata	19.688241, -70.838275	19°41'17.7"N, 70°50'17.8"W
El Corral, La Isabella	Puerto Plata	19.889946, -71.078641	19°53'23.8"N, 71°04'43.1"W
El estrecho de Luperon	Puerto Plata	19.811370, -70.927220	19°48'40.9"N, 70°55'38.0"W
Llano de Perez	Puerto Plata	19.735383, -70.836076	19°44'07.4"N, 70°50'09.9"W
Los pilones Estero Hondo	Puerto Plata	19.850299, -71.194336	19°51'01.1"N, 71°11'39.6"W
Los Saballos	Puerto Plata	19.762564, -70.852450	19°45'45.2"N, 70°51'08.8"W
Luperón, Puerto Plata	Puerto Plata	19.888215, -70.965599	19°53'17.6"N, 70°57'56.2"W
Ranchito de los Vargas	Puerto Plata	19.800079, -70.951472	19°48'00.3"N, 70°57'05.3"W
Tiburcio, Estero Hondo	Puerto Plata	19.824297, -71.169407	19°49'27.5"N, 71°10'09.9"W
Boruga	San Cristobal	18.467846, -70.111334	18°28'04.2"N, 70°06'40.8"W
Dona Ana	San Cristobal	18.367099, -70.172548	18°22'01.6"N, 70°10'21.2"W
Hato Viejo, Nigua	San Cristobal	18.375388, -70.054718	18°22'31.4"N, 70°03'17.0"W
Juan Barón	San Cristobal	18.254917, -70.178947	18°15'17.7"N, 70°10'44.2"W
La Pared Haina	San Cristobal	18.459363, -70.050263	18°27'33.7"N, 70°03'00.9"W
Limón Dulce	San Cristobal	18.476587, -70.102365	18°28'35.7"N, 70°06'08.5"W
Najayo Arriba	San Cristobal	18.393321, -70.167548	18°23'36.0"N, 70°10'03.2"W
Nizao	San Cristobal	18.251518, -70.215143	18°15'05.5"N, 70°12'54.5"W
Palenque	San Cristobal	18.259212, -70.146696	18°15'33.2"N, 70°08'48.1"W
Pedro Caballero	San Cristobal	18.486706, -70.085832	18°29'12.1"N, 70°05'09.0"W
Santana, Nizao	San Cristobal	18.277117, -70.216288	18°16'37.6"N, 70°12'58.6"W
Yaguate	San Cristobal	18.340808, -70.189547	18°20'26.9"N, 70°11'22.4"W
IDIAF, Sabana Larga	San Jose de Ocoa	18.592277, -70.492133	18°35'32.2"N, 70°29'31.7"W
La ciénaga	San Jose de Ocoa	18.605390, -70.461812	18°36'19.4"N, 70°27'42.5"W
Los Naranjos	San Jose de Ocoa	18.582174, -70.424650	18°34'55.8"N, 70°25'28.7"W
Arroyo Loro	San Juan de la Maguana	18.815161, -71.274463	18°48'54.6"N, 71°16'28.1"W
El llanito, Pedro Corto	San Juan de la Maguana	18.843386, -71.411901	18°50'36.2"N, 71°24'42.8"W
Perfecto Socorro, Santomé	San Juan de la Maguana	18.813673, -71.268493	18°48'49.2"N, 71°16'06.6"W
Sabana Alta	San Juan de la Maguana	18.729593, -71.111594	18°43'46.5"N, 71°06'41.7"W
Batey Los Chicharrones	San Pedro de Macorís	18.619355, -69.265162	18°37'09.7"N, 69°15'54.6"W
San José de los llanos	San Pedro de Macorís	18.630262, -69.488109	18°37'48.9"N, 69°29'17.2"W
San José de los llanos	San Pedro de Macorís	18.632422, -69.487457	18°37'56.7"N, 69°29'14.8"W
Gurabo Abajo	Santiago	19.487863, -70.671401	19°29'16.3"N, 70°40'17.0"W
Navarrete	Santiago	19.563186, -70.892973	19°33'47.5"N, 70°53'34.7"W
Villa González	Santiago	19.535330, -70.788074	19°32'07.2"N, 70°47'17.1"W
El Toro, Guerra	Santo Domingo	18.550604, -69.697820	18°33'02.2"N, 69°41'52.1"W
Engombe	Santo Domingo	18.457893, -70.006814	18°27'28.4"N, 70°00'24.5"W

Locality	Province	Decimals	Degrees
Engombe	Santo Domingo	18.458875, -70.005151	18°27'31.9"N, 70°00'18.5"W
Batey Libertad, Mao	Valverde	19.622122, -70.988046	19°37'19.6"N, 70°59'17.0"W
Boca de Mao	Valverde	19.588610, -71.042608	19°35'19.0"N, 71°02'33.4"W
Damajagua, Mao	Valverde	19.650145, -70.994961	19°39'00.5"N, 70°59'41.9"W
Damajagua, Mao	Valverde	19.651787, -70.995733	19°39'06.4"N, 70°59'44.6"W
Jicomé	Valverde	19.629866, -70.953735	19°37'47.5"N, 70°57'13.4"W
Mao	Valverde	19.562764, -71.087287	19°33'46.0"N, 71°05'14.2"W
Los Mogotes, Villa Altagracia	San Cristobal	18.738189, -70.245321	18°44'17.5"N, 70°14'43.2"W
Navarrete	Santiago	19.563186, -70.892973	19°33'47.5"N, 70°53'34.7"W
Villa González	Santiago	19.535330, -70.788074	19°32'07.2"N, 70°47'17.1"W
El Toro, Guerra	Santo Domingo	18.550604, -69.697820	18°33'02.2"N, 69°41'52.1"W
Engombe	Santo Domingo	18.457893, -70.006814	18°27'28.4"N, 70°00'24.5"W
Engombe	Santo Domingo	18.458875, -70.005151	18°27'31.9"N, 70°00'18.5"W
Batey Libertad, Mao	Valverde	19.622122, -70.988046	19°37'19.6"N, 70°59'17.0"W
Boca de Mao	Valverde	19.588610, -71.042608	19°35'19.0"N, 71°02'33.4"W
Damajagua, Mao	Valverde	19.650145, -70.994961	19°39'00.5"N, 70°59'41.9"W
Damajagua, Mao	Valverde	19.651787, -70.995733	19°39'06.4"N, 70°59'44.6"W
Jicomé	Valverde	19.629866, -70.953735	19°37'47.5"N, 70°57'13.4"W
Mao	Valverde	19.562764, -71.087287	19°33'46.0"N, 71°05'14.2"W
Los Mogotes, Villa Altagracia	San Cristobal	18.738189, -70.245321	18°44'17.5"N, 70°14'43.2"W

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