Cotesia cassina sp. nov. from southwestern Colombia: a new gregarious microgastrine wasp (Hymenoptera, Braconidae) reared from the pest species Opsiphanes cassina Felder & Felder (Lepidoptera, Nymphalidae) feeding on Elaeis oil palm trees (Arecaceae)

Geraldo Salgado-Neto¹, Consuelo Alexandra Narváez Vásquez², Dillon S. Max³, James B. Whitfield³

¹ Pós-graduação em Agronomia, Departamento de Defesa Fitossanitária, Universidade Federal de Santa Maria, 97105-900, Santa Maria, RS, Brazil ² Pós-graduação em Entomologia, Departamento de Entomologia/BIO-AGRO, Universidade Federal de Viçosa, 36570-900, Viçosa, MG, Brazil ³ Department of Entomology, 320 Morrill Hall, 505 South Goodwin Ave., University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA

Corresponding author: James B. Whitfield (jwhitfie@life.illinois.edu)

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Abstract
A new species of microgastrine wasp, Cotesia cassina Salgado-Neto, Vásquez & Whitfield, sp. nov., is described from southwestern Colombia in Tumaco, Nariño. This species is a koinobiont gregarious larval endoparasitoid, and spins a common mass of cocoons underneath the host caterpillars of Opsiphanes cassina (Felder & Felder) (Lepidoptera, Nymphalidae), feeding on oil palm trees (interspecific hybrid Elaeis oleifera × E. guineensis) (Arecaceae). While superficially similar, both morphologically and biologically, to C. invirae Salgado-Neto & Whitfield from southern Brazil, the two species are distinct based on DNA barcodes, host species, geographical range and morphological characters.

Keywords
Butterfly, DNA barcode, integrative taxonomy, morphology, natural enemy, new species

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Introduction

The nymphalid butterfly *Opsiphanes cassina* Felder & Felder occurs from Mexico to the Amazon Basin (Brazil, Bolivia, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname and Venezuela) (Lamas 2004). This species is widespread in Colombia but is most commonly found within the States of Nariño, Cauca and Putumayo (Benavides and Cárdenas 1970; Fuentes 1973; Pava et al. 1983; Posada 1989; Villegas 1993). *Opsiphanes cassina* is considered a pest of oil palm trees (interspecific hybrid *Elaeis oleifera* × *Elaeis guineensis*) (Arecaceae) in southwest Colombia (Genty 1978; Mezón and Chinchilla 1996; Posada and Cárdenas 1996; Loría et al. 2000; González 2011). In southwestern Colombia, the occurrence of the subspecies *O. cassina numatius* Fruhstorfer was recorded by Martínez (1970). We also recorded the presence of three additional subspecies: *O. cassina chiriquensis* Stichel, *Opsiphanes cassina periphetes* Fruhstorfer, and *Opsiphanes cassina caliensis* Bristow.

Five species of Braconidae have been recorded as endoparasitoids of species of *Opsiphanes* (larval stage): *Cotesia biezankoi* (Blanchard), *Cotesia opsiphanis* (Schrottky), *Cotesia alia* (Muesebeck) (Mason 1981; Penteado-Dias 1987; De Santis 1989; Salgado-Neto 2013), *Cotesia invirae* Salgado-Neto & Whitfield (Salgado-Neto et al. 2019), and *Rhyssipolis* sp. (Sauer 1946; Costa Lima 1950, 1962; Silva et al. 1968; Briceño-Vergara 1978; De Santis 1980; Mason 1981; Penteado-Dias 1987; Briceño-Vergara 1997; Mezón 1997; Rodríguez et al. 2006). Here we describe a new species of *Cotesia* Cameron, reared from *O. cassina* feeding on oil palms in southwestern Colombia.

*Cotesia* is easily recognizable morphologically among microgastrine braconids, although the huge variety of species can be difficult to distinguish from each other (Whitfield et al. 2009), especially those without host data. The wasps have a koinobiont habit (Kankare and Shaw 2004) and both solitary and gregarious species are known. *Cotesia* (Braconidae, Microgastrinae) currently contains roughly 300–400 described species (Fernandez-Triana et al. 2020), but this number will certainly increase dramatically, as world estimates range from 1000–2000 species (Mason 1981; Michel-Salzat and Whitfield 2004; Whitfield et al. 2018; Fernandez-Triana et al. 2020), and a relatively small number of studies recording Neotropical species of *Cotesia* and their biology are available so far (Whitfield 1997; Whitfield et al. 2018), particularly in South America.

As *Cotesia* species appear to be highly host specialized (Kankare and Shaw 2004), with many cryptic species and geographically restricted distributions (Fiaboe et al. 2017), the use of an integrative taxonomic approach (combining morphological, molecular, biological and geographical data) is critical for recognizing and distinguishing these parasitoid wasps (Smith et al. 2008; Kaiser et al. 2017).

Using such an integrative taxonomic approach, this paper provides a description of a new species of *Cotesia*, whose brood was produced from caterpillars of *Opsiphanes cassina* (Felder & Felder) (Lepidoptera, Nymphalidae) (Fig. 1) feeding on palm trees (interspecific hybrid *Elaeis oleifera* × *E. guineensis*) (Arecaceae) in Tumaco, Nariño, south-west Colombia. We compare it with the other described species of *Opsiphanes* that have been formally recorded from the Neotropical region, two of which have been well characterized and two of which are of uncertain identity.
New species of *Cotesia* from *Opsiphanes* in Colombia

**Materials and methods**

Between April 2018 and March 2019; we collected 35 larvae of *Opsiphanes cassina* as part of a survey carried out on exotic palms in the Palmeiras plantation A.S., 58 km from San Andrés de Tumaco, Nariño, Colombia (1°47'28.0"N, 78°47'33.9"W, 28 m elev. – see Fig. 1A, B). The larvae of *O. cassina* were found on the interspecific hybrid *Elaeis oleifera × E. guineensis* (Arecaceae). Upon collecting, larvae were kept in the laboratory (25 ± 1 °C; 70% RH; photoperiod of 14 hours of light) and observed daily until the emergence of the butterflies or parasitoids, which were then preserved in 70% ethanol.

Photographs of the caterpillar and parasitoid cocoons (Fig. 1C, D) were taken in the field by CANV. Morphological photographs of the *Cotesia* (Fig. 2A–F) were taken by DSM at the University of Illinois, USA using a Leica M205 C stereo microscope (467 nm resolution) fitted with a 5 megapixel Leica DFC 425 digital microscope camera. Images were stacked using a motor drive on the microscope and Zerene Stacker software. Morphological terms and measurements of structures are mostly those used by Salgado-Neto et al. (2019).

To characterize and compare the new species at the molecular level, the mitochondrial (DNA barcode) gene cytochrome oxidase I (COI) was analyzed. For the amplification of a fragment of approximately 460 bp of this gene, we used the following primer pair: COI-F (5'-GATTTTTTGKAYCCMGAAG-3') and COI-R (5' CRAATACRGCTCCTATWGATAAWAC-3') (Gusmão et al. 2010). DNA extraction of one specimen was performed with the GenElute Mammalian Genomic DNA Miniprep Kit (Sigma-Aldrich) and followed the manufacturer’s protocol. The product was amplified via Polymerase Chain Reaction (PCR) according to the following schedule: 94 °C for 2 minutes, 40 cycles of 94 °C for 30 seconds, 54 °C for 30 seconds, 72 °C for 40 seconds and 72 °C for 4 minutes. Then the PCR product was purified using polyethylene glycol precipitation (PEG; Schmitz and Riesner 2006). These samples were sequenced using the Big Dye 3.1 reagent (Life Technologies) and a 3500 XL automatic sequencer (Life Technologies).

**Descriptive taxonomy**

*Cotesia cassina* Salgado-Neto, Vásquez & Whitfield, sp. nov.

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**Material examined.** *Holotype* Female, Colombia: Nariño, San Andrés de Tumaco (1°47'28.0"N, 78°47'33.9"W, 28 m elev.), March 2019, coll. Consuelo Vásquez, ex larva *Opsiphanes cassina* Felder & Felder (Lepidoptera, Nymphalidae). Deposited in the collection of the National University of Colombia (UNC, Dr Fernando Fernandez, curator). *Paratypes* 2 males, deposited in UNC, same data as holotype. 1 female, also same data as holotype, deposited in the Illinois Natural History Survey (INHS). *Nontypes.* 2 females, in poor condition, also deposited at INHS.
Diagnosis. As discussed above, *Cotesia* is a huge worldwide genus of hundreds of species, with many morphologically similar species. While useful world identification keys are not available, it is currently possible to successfully diagnose species regionally, especially combined with molecular and host data. The closest described species, morphologically, biologically and within the region, is *Cotesia invirae* from southern Brazil, which also parasitizes *Opsiphanes* on palms (different species). The table below provides a diagnostic comparison between the two species.

*Cotesia alia* (Muesebeck), also recorded from *Opsiphanes*, resembles these two species but has a relatively longer first metasomal tergite (see illustration in Muesebeck 1958). Like *C. cassina*, the second tergite has the medial part of the second tergite longer than the lateral portions, and the tergites tend to both be blackish (tending to be mostly orangish in *C. invirae*). The other two named *Cotesia* species recorded from *Opsiphanes*, *C. biezankoi* (Blanchard) and *C. opsiphanis* (Schrottky), are both very poorly characterized in their descriptions and their type locations are unknown (Fernandez-Triana et al. 2020), so they are not compared here. There is a possibility that *C. invirae* might prove to be a junior synonym of *C. biezankoi*, based on shared host and geographic region, if the holotype of the latter were to resurface and be examined. Our understanding of the correct nomenclature for the entire complex would benefit from a full review of the named and putative unnamed species across all of Central and South America, especially if all the types could eventually be located. In the meantime, it is possible to characterize the relationships among the species for which we can clearly establish the identity.

**Description. Female.** Body length 3.1–3.3 mm; fore wing length 2.9–3.1 mm. **Coloration** (Fig. 2A–F). General body coloration black except: scape shading from light to dark brown, palps pale yellow, tegulae brown, fore legs all yellowish, middle legs all yellowish, hind legs all yellowish except distal end of femur brown/black dorsally; distal end of tibia brown, coxae translucent yellowish, laterotergites yellowish ventrally, shading to brown dorsally; sternites and hypopygium translucent yellowish. **Head** (Fig. 2A, E). Facial sculpture weakly punctate; vertex sculpture smooth to very weakly punctate; distance between posterior ocellae nearly identical with distance from outer ocelli to compound eyes. **Mesosoma** (Fig. 2A, B, F). Pronotum with both dorsal and ventral grooves present, ventral groove crenulate. Mesoscutum fully and distinctly but shallowly punctate; scutoscutellar scrobe slightly sunken groove and formed by 8 pits.

| Character          | *C. invirae*                                      | *C. cassina*                                      |
|--------------------|---------------------------------------------------|--------------------------------------------------|
| Color              | Generally lighter. T3 and all tergites posterior to T3 mostly bright yellow orangish. Mesopleuron with some light yellow/brown on ventral side | Generally darker. T3 and all tergites posterior to T3 are more brown to black rather than orangish. Mesopleuron almost entirely black |
| T2 Sculpture       | Mostly smooth. Sculpture is more uniform across width; less punctate laterally | More punctate laterally, smooth medially |
| T2 Shape           | Posterior margin/groove straight                  | Posterior margin slightly convex apically, with length greatest medially |
Scutellum shield-shaped to subtriangular (anteriorly straight and posteriorly rounded) and weakly convex, weakly punctate. Mesopron smooth and polished throughout. Propodeum generally finely rugose/punctate with indistinct longitudinal medial carina. Legs (Fig. 2A–C). Hind coxa mostly smooth with faint sculpture on dorsal face; inner hind tibial spurs slightly longer than outer. Wings (Fig. 2B, C). Fore wing hyaline with dark brownish vein pigmentation; stigma more than 2x as long as broad, without obvious pale spot at proximal end. Metacarp extending 0.60–0.70 to end of 3Rs fold along wing edge; r approximately same length as 2RS vein and meeting it at a distinct shallow angle; vannal lobe edge roughly semicircular with distal end slightly flattened;
vannal lobe fringe even and dense. **Metasoma** (Fig. 2B–D, F). Tergite 1 roughly as long as broad, evenly widening from anterior margin then rounding over posterior half, mostly rugulose; tergite 2 very weakly rugulose peripherally, mostly smooth and slightly raised centrally, roughly twice as broad as long, subrectangular with posterior margin slightly longer medially than laterally. Hypopygium with angled but blunt tip, not extending past dorsal end of metasoma; ovipositor with very sparse setae at tip.
Male. Similar to female except with slightly narrower metasoma.

Molecular data. COI barcode deposited in GenBank (MW405620). Using the identification tools in the Barcode of Life Database (Ratnasingham and Hebert 2007), *C. cassina* is closest to *C. salebrosa* (Marshall), a primarily Eurasian species attacking geometrid larvae, at a similarity level of 97.4%. Interestingly, *C. invirae* appears closest (97.02% similarity) to *Cotesia* Whitfield78 and *Cotesia* Whitfield20, two apparently conspecific sets of rearings of an undescribed species from the Lepidoptera Inventory of the Guanacaste Conservation Area (ACG) in northwest Costa Rica (Janzen et al. 2009); these rearings are from another species of *Opsiphanes*. It thus appears that there is a complex of at least four closely related species attacking different *Opsiphanes* species in a variety of geographically dispersed Neotropical habitats, as suggested by Salgado-Neto et al. (2019). BOLD and NCBI use slightly different criteria to make cutoffs in sequence comparisons, and to calculate % similarity. They also contain different sets of sequences. We checked the BOLD investigations of related species by using BLASTn (Altschul et al. 1990) to query the NCBI nucleotide database (NCBI 1988). The same most closely related species to *Cotesia cassina* and *C. invirae*, respectively, were recovered, with the exception that for *C. cassina*, *C. melitaearum* (Wilkinson) and *C. koebelei* (Riley), both attacking other genera of Nymphalidae but in the Holarctic region, joined *C. salebrosa* as closest, at roughly 94.6–95.6% similarity for all of them. In neither the BOLD nor the NCBI search did *C. cassina* come within 2.5% similarity of any other known *Cotesia* species.

Host. *Opsiphanes cassina* (Felder & Felder) (Lepidoptera, Nymphalidae) (Fig. 1C, D).

Biology/ecology. *Cotesia cassina* is a gregarious parasitoid wasp that occurs mainly in the wet season (March-May); however, their host, *O. cassina*, occurs throughout the year, mainly in the rainy season (March-July). *Cotesia cassina* larvae kill the host larva before the end of the last instar and form their cocoons in a regular mass of dirty whitish cocoons, regularly arranged disposed under the host (Fig. 1B). The larvae of this gregarious species all emerge from the host in a short time through many different holes in the host cuticle and spin a common woolly cocoon mass within which the individual cocoons can be distinguished.

Distribution. Known so far from San Andrés de Tumaco, Nariño, Colombia (Neotropical Region).

Etymology. The specific epithet *cassina*, is a reference to *Opsiphanes cassina* (Felder & Felder) (Lepidoptera, Nymphalidae), the host caterpillar name. The word cassina is the feminine of cassino which in Italian means playhouse.

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References

Altschul SF, Gish W, Miller W, Myers EW, Lipman DJ (1990) Basic Local Alignment Search Tool. Journal of Molecular Biology 215: 403–410. https://doi.org/10.1016/S0022-2836(05)80360-2

Benavides M, Cárdenas R (1970) Visita al corregimiento de Pueblo Tapiado, Municipio de Montenegro, Quindío. Cabrito del plátano *Opsiphanes* sp. Informe. Programa de Entomología ICA. Regional 5, 4 pp.

Briceño-Vergara AJ (1997) Perspectivas de un manejo integrado del gusano verde del plátano, *Opsiphanes tamarindi* Felder (Lepidoptera: Brassolidae). Revista de la Facultad de Agronomía 14(5): 475–590.

Briceño-Vergara AJ (1978) Algunos parasitos y depredadores de *Opsiphanes tamarindi* Felder (Lepidoptera: Brassolidae) en Venezuela. Revista de la Facultad de Agronomía 26: 117–128.

Bristow R (1991) A revision of the brassoline genus Opsiphanes (Lepidoptera: Rhopalocera). Zoological Journal of the Linnean Society 101: 203–293. https://doi.org/10.1111/j.1096-3642.1991.tb00282.x

Cameron P (1911) On a collection of parasitic Hymenoptera (chiefly bred) made by Mr. W.W. Frogsatt, F.L.S., in New South Wales, with description of new genera and species. Part i. Proceedings of the Linnean Society of New South Wales 36: 333–346. https://doi.org/10.5962/bhl.part.21902

Costa Lima AM (1950) Insetos do Brasil, Lepidopteros. 6º tomo, 2ª parte, Série Didática da Escola Nacional de Agronomia, Universidade Rural, Rio de Janeiro, 420 pp.

Costa Lima AM (1962) Insetos do Brasil, Himenópteros. 12º tomo, 2ª parte, Escola Nacional de Agronomia, Rio de Janeiro, 393 pp.

De Santis L (1980) Catalogo de los Himenópteros Brasilenos de la Serie Parasitica: Incluyendo Bethyloidea. Editora da Universidade Federal do Paraná, Curitiba, 395 pp.

De Santis L (1989) Catalogo de de los Himenópteros Calcidoïdes (Hymenoptera) al sur de los Estados Unidos, segundo suplemento. Acta Entomologica Chilena 15: 1–12.

Felder C, Felder R (1862) Specimen faunae lepidopterologicae riparum fluminis negro superioris in Brasilia septentrionali. Wiener entomologische Monatschrift 6: 175–192.

Fernandez-Triana JL, Shaw MR, Boudreault C, Beaudin M, Broad GR (2020) Annotated and illustrated world of Microgastrinae parasitoid wasps (Hymenoptera, Braconidae). Zootaxa 920: 1–1089. https://doi.org/10.3897/zookeys.920.39128.figure159

Fernandez-Triana JL, Whitfield JB, Rodriguez JJ, Smith MA, Janzen DH, Hallwachs W, Hajibabaei M, Burns JM, Solis MA, Brown J, Cardinal S, Goulet H, Hebert PDN (2014) Review of *Apaneles* (Hymenoptera, Braconidae, Microgastrinae) from Area de Conservacion Guanacaste, Costa Rica, with keys to all described species from Mesoamerica. ZooKeys 383: 15–65. https://doi.org/10.3897/zookeys.383.6418

Ferreira JMS, Lima MF, Santana DLQ, Moura JIL, Souza LA (1998) Pragas do coqueiro. In: Ferreira, JMS, Warwick DRN, Siqueira LA (Eds) A cultura do coqueiro no Brasil (2nd edn. rev. ampl.). Brasília, Embrapa-SPI/Aracaju, Embrapa CPATC, 189–267.

Fiaboe KKM, Fernandez-Triana JL, Nyamu FW, Agbodzavu KM (2017) *Cotesia icipe* sp. nov., a new Microgastrinae wasp (Hymenoptera, Braconidae) of importance in the biological
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control of Lepidopteran pests in Africa. Journal of Hymenoptera Research 61: 49–64. https://doi.org/10.3897/jhr.61.21015

Fruhstorfer H (1912) Family: Brassolidae. In: Seitz A (Ed.) Die Gross-Schmetterlinge der Erde (Vol. 5). Alfred Kernen, Stuttgart, 285–332.

Fruhstorfer H (1912) Brassolidae, in Seitz-Macrolep. do Mundo 5: 285–332.

Fuentes R (1973) Dípteros parásitos de larvas de lepidópteros en algunos municipios del Valle del Cauca. Acta agronomica (Palmira) 23(1/2): 7–50. [+ 9 pls., 7 tabs]

Genty P et al. (1978) Las plagas de la palma aceitera en América Latina. Oléagineux 33: 324–594.

González GR et al. (2011)Metodología para muestrear las fases inmaduras del defoliador *Op- siphanes cassina* Felder (1862) (Lepidoptera: Nymphalidae) en palma aceitera. Revista Científica UDO Agrícola 11(1): 104–108.

Greeney HF, Whitfield JB, Stireman JO, Penz CM, Dyer LA (2011) Natural History of *Ery-phanis greeneyi* (Lepidoptera: Nymphalidae) and Its Enemies, With a Description of a New Species of Braconid Parasitoid and Notes on Its Tachinid Parasitoid. Annals of the Entomological Society of America 104(6): 1078–1090. https://doi.org/10.1603/AN10064

Gusmão FA, Harakava R, Campos AEC (2010) Fire-ants of the *Solenopsis saevissima* species-group (Hymenoptera: Formicidae) nesting in parks in the city of São Paulo: identification based on mtDNA sequences and morphological characters. Sociobiology 56: 353–362.

Janzen DH, Hallwachs W, Blandin P, Burns JM, Cadiou J-M, Chacon I, Dapkey T, Deans AR, Epstein ME, Espinoza B, Francelmont JG, Haber WA, Hajibabaei M, Hall JPW, Hebert PDN, Gauld ID, Harvey DJ, Hausmann A, Kitching IJ, LaFontaine D, Landry J-F, Lemaire C, Miller JY, Miller JS, Miller L, Miller SE, Montero J, Munroe E, Rab Green S, Ratnasingham S, Rawlins JE, Robbins RK, Rodriguez JJ, Rougerie R, Sharkey MJ, Smith MA, Solis MA, Sullivan JB, Thiacciourt P, Wahl DB, Weller SJ, Whitfield JB, Willmot KR, Wood DM, Woodley NE, Wilson JJ (2009) Integration of DNA barcoding into an ongoing inventory of complex tropical diversity. Molecular Ecology Resources 9(suppl. 1): 1–26. https://doi.org/10.1111/j.1755-0998.2009.02628.x

Kaiser L, Fernandez-Triana J, Capdevielle-Dulac C, Chantre C, Bodet M, Kaoula F, Benoist R, Calatayud PA, Dupas S, Herniou EA, Jennette R, Obonyo J, Silvain JF, Ru BL. (2017) Systematics and biology of *Cotesia typhae* sp. n. (Hymenoptera, Braconidae, Microgastrinae), a potential biological control agent against the noctuid Mediterranean corn borer, *Sesamia nonagrioides*. ZooKeys 682: 105–136. https://doi.org/10.3897/zookeys.682.13016

Kankare M, Shaw MR (2004) Molecular phylogeny of *Cotesia* Cameron, 1891 (Insecta: Hy- menoptera: Braconidae: Microgastrinae) parasitoids associated with Melitaeini butterflies (Insecta: Lepidoptera: Nymphalidae: Melitaeini). Molecular Phylogenetics and Evolution 32: 207–220. https://doi.org/10.1016/j.ympev.2003.11.013

Lamas G (2004) Checklist: Part 4A, Hesperioidea-Papilionoidea. In: J. Heppner (Ed.) Atlas of Neotropical Lepidoptera, Association for Tropical Lepidoptera, Scientific Publishers, 439–439.

Link D, Alvarez Filho A (1979) Palmeiras atacadas por lagartas de Brassolidae (Lepidoptera) em Santa Maria, RS. Revista do Centro Ciências Rurais 9(2): 221–225.

Link D, Biezanko CM, Carvalho S, Tarragó MFS (1980) Lepidoptera de Santa Maria e Arre- dores. III. Morphidae e Brassolidae. Revista do Centro de Ciências Rurais 10(2): 191–195.
Loría R, Chinchilla CM, Domínguez J, Mexzón RG (2000) An effective trap to capture adults of *Opsiphanes cassina* F. (Lepidoptera, Nymphalidae) and observations on the behavior of the pest in oil palm. Una trampa efectiva para capturar adultos de *Opsiphanes cassina* F. (Lepidoptera; Nymphalidae) y observaciones sobre el comportamiento de la plaga en palma aceitera. ASD Oil Palm Papers 21: 1–12.

Martínez E (1970) Informe anual de progreso 1969. Programa Entomología. C.N.I.A. “Marconía”. Informes anuales. Programa Entomología. ICA. Regional 3, 9 pp.

Mason WRM (1981) The polyphyletic nature of *Apanteles* Foerster (Hymenoptera: Braconidae): a phylogeny and reclassification of Microgastrinae. Memoirs of the Entomological Society of Canada 115: 1–147. https://doi.org/10.4039/entm113115fv

Mexzón RG (1997) Entomofauna prejudicial, enemigos naturales y malezas útiles en palma aceitera en América Central. Manejo Integrado de Plagas (C.R.) 20/21: 1–7.

Mexzón RG, Chinchilla CM (1996) Natural enemies of harmful arthropods in oil palm (*Elaeis guineensis* Jacq.) in Tropical America. Enemigos naturales de los artrópodos perjudiciales a la palma aceitera (*Elaeis guineensis* Jacq.) en América Tropical. ASD Oil Palm Papers 13: 9–33. [+ 9 figs., 6 tabs]

Michel-Salzat A, Whitfield JB (2004) Preliminary evolutionary relationships within the parasitoid wasp genus *Cotesia* (Hymenoptera: Braconidae: Microgastrinae): combined analysis of four genes. Systematic Entomology 29: 371–382. https://doi.org/10.1111/j.0307-6970.2004.00246.x

Muesebeck CFW (1958) New Neotropical wasps of the family Braconidae (Hymenoptera) in the U.S. National Museum. Proceedings of the United States National Museum 107: 405–461. https://doi.org/10.5479/si.00963801.108-3389.405

NCBI [National Center for Biotechnology Information] [Internet] (1988) Bethesda (MD): National Library of Medicine (US), National Center for Biotechnology Information; [1988]. [accessed 1 Apr 2021]

Pava J, Castillo E, González A, Patiño H (1983) Aspectos de interés fitosanitario de la palma de chontaduro *Bactris gasipaes* H.B.K. en algunas regiones del Valle y Chocó. Acta agronómica (Palmira) 33(1): 25–35.

Penteado-Dias AM (1987) Contribuição para o conhecimento da morfologia e biologia de *Cotesia alius* (Muesebeck, 1958) (Hymenoptera: Braconidae, Microgastrinae). Revista Brasileira de Entomologia 31(3): 439–443.

Penz CM (2008) Phylogenetic revision of *Eryphanis* Boisduval, with a description of a new species from Ecuador (Lepidoptera, Nymphalidae). Insecta Mundi 0035: 1–25.

Posada FJ (1989) Todos en palma. Notas y Noticias entomológicas (Bogotá) 1989(7/8): e63.

Posada FJ (1989) Enemigos eficientes. Notas y Noticias entomológicas (Bogotá) 1989(7/8): e63.

Posada FJ, Cárdenas R (1996) Gusanos en otra palma. MIP – Notas y Noticias (Bogotá) 2(6): e15.

Ratnasingham S, Hebert PDN (2007) BOLD: The Barcode of Life Data System. Molecular Ecology Notes 7: 355–364. https://doi.org/10.1111/j.1471-8286.2007.01678.x

Rodríguez G, Fariñas J, Díaz A, Silva-Acuña R, Piña E (2006) Plantas atrayentes de enemigos naturales de insectos plaga en palma aceitera. Revista Digital CENIAP HOY Número 10, 2006. Maracay, Aragua, Venezuela. ISSN 1690-4117, Depósitolegal: 00302AR1449.
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www.ceniap.gov.ve/ceniaphoy/articulos/n10/arti/rodriguez_g/arti/rodriguez_g.htm  [Accessed: 05/11/2007]

Salgado-Neto G (2013) Aspects of biology of *Cotesia alius* (Muesebeck 1958) (Hymenoptera: Braconidae: Microgastrinae) on *Opsiphanes invirae amplificatus* Stichel (Lepidoptera: Nymphalidae) for Rio Grande do Sul, Brazil. Estudos de Biologia 35(84): 35–41. https://doi.org/10.7213/estud Biol.7854

Salgado-Neto G, Whitfield JB, Mello Garcia FR (2019) *Cotesia invirae*, sp. nov., from South Brazil: a new gregarious microgastrine wasp (Hymenoptera: Braconidae) reared from *Opsiphanes invirae* (Nymphalidae) feeding on palms. Revista Brasileira Entomologia 63: 136–140. https://doi.org/10.1016/j.rbe.2019.02.003

Sauer HFG (1946) Constatação de himenópteros e dipteros Entomófagos no Estado de São Paulo. Boletim Fitossanitário 3(1): 7–23.

Schmitz A, Riesner D (2006) Purification of nucleic acids by selective precipitation with polyethylene glycol 6000. Analytical Biochemistry 354: 311–313. https://doi.org/10.1016/j. ab.2006.03.014

Shaw MR, Huddleston T (1991) Classification and biology of braconid wasps (Hymenoptera, Braconidae). Handbooks for the Identification of British Insects. Royal Entomological Society of London 7: 1–126.

Silva AG de, Gonçalves CR, Galvão DM, Gonçalves AJL, Gomes J, Silva MN, Simoni L (1968) Quarto catálogo dos insetos que vivem nas plantas do Brasil; seus parasitas e predadores. Rio de Janeiro, Ministério da Agricultura, tomo 1, part. 2, 622 pp.

Smith MA, Rodriguez JJ, Whitfield JB, Deans AR, Janzen DH, Hallwachs W, Hebert PDN (2008) Extreme diversity of tropical parasitoid wasps exposed by iterative integration of natural history, DNA barcoding, morphology, and collections. Proceedings of the National Academy of Sciences of the United States of America 105(35): 12359–12364. https://doi. org/10.1073/pnas.0805319105

Sousa-Lopes B, Bächtold A, Del-Claro K (2016) Biology, natural history and temporal fluctuation of the geometrid *Oospila pallidaria* associated with host plant phenology. Studies on Neotropical Fauna and Environment 51(2): 135–143.

Sousa-Lopes B, Whitfield JB, Salgado-Neto G, Del-Claro K (2018) *Cotesia itororensis*, sp. nov., from Brazilian savanna: a new reared microgastrine wasp (Hymenoptera: Braconidae) described using an integrative taxonomic approach. Zootaxa 4544(3): 437–445. https://doi.org/10.11646/zootaxa.4544.3.9

Souza LA, Lemos WP (2007) Sistema de produção do açaí. Embrapa Amazônia Oriental. http://sistemasdeproducao.cnptia.embrapa.br/FontesHTML/Acai/SistemaProducaoAcai_2ed/paginas/pragas.htm [Access 03/11/2007]

Stichel H (1904) Lepidoptera, Rhopalocera, Fam. Nymphalidae, Subfam. Brassolinae. In: Wytssman P (Ed.) Genera Insectorum (Vol. 20), 48 pp.

Stichel H (1909) Brassolidae. Das Tierreich, 25, [xiv.] 244 pp.

Stichel H (1932) Lepidopterorum Catalogus (Vol. 51): Brassolidae. W. Junk, Berlin. https://doi.org/10.5962/bhl.title.124190

Villegas D (1993) Más benéficos. Notas y Noticias entomológicas (Bogotá) 1992(11/12): e75.
Whitfield JB (1997) Subfamily Microgastrinae. In: Wharton RA, Marsh PM, Sharkey MJ (Eds) Identification Manual to the New World Genera of the Family Braconidae (Hymenoptera). International Society of Hymenopterists Special Publication, 333–364.

Whitfield JB, Austin AD, Fernandez-Triana JL (2018) Systematics, biology and evolution of microgastrine parasitoid wasps. Annual Review of Entomology 63: 389–406. https://doi.org/10.1146/annurev-ento-020117-043405

Whitfield JB, Rodriguez JJ, Masonick PK (2009) Reared microgastrine wasps (Hymenoptera: Braconidae) from Yanayacu Biological Station and environs (Napo Province, Ecuador): diversity and host specialization. Journal of Insect Science 9(1): e31. https://doi.org/10.1673/031.009.3101

Yu DSK, Van Achterberg C, Horstmann K (2016) Taxapad, Ichneumonoidea 2015. Ottawa, Ontario. http://www.taxapad.com