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BIOLOGICAL CONTROL

Review

Review of Sarcophagidae and Tachinidae (Diptera) Parasitic Flies Associated to *Mocis latipes* (Guenée, 1852) (Lepidoptera: Erebidae), with Novel Parasitism Records for Alagoas and Brazil

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Abstract

Mocis latipes (Guenée, 1852) (Lepidoptera: Erebidae) is the main pest of graminaceous plants in the American Continent, especially in warm areas. Under normal conditions, *M. latipes* populations have their densities maintained at equilibrium by different natural enemies, including microorganisms (viruses, bacteria, and fungi), nematodes, insects, arachnids, birds, and mammals. In the megadiverse insect order Diptera, the families Tachinidae and Sarcophagidae are important natural enemies of various invertebrates, including pests, since several species parasitize insects and other arthropods. In the present work, we report the fly species *Chetogena scutellaris* (Wulp, 1890) (Tachinidae: Exoristinae: Exoristini); *Atacta brasiliensis* Schiner, 1868 (Tachinidae: Exoristinae: Goniini); and *Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830) (Sarcophagidae: Sarcophaginae) parasitizing caterpillars of *M. latipes* collected on pasture, in Alagoas state, Northeast Brazil. This is the first record of *C. scutellaris* parasitizing *M. latipes* in Alagoas, the first report of the occurrence of *P.* (*S.*) *lambens* in Alagoas, and the first report of *P.* (*S.*) *lambens* parasitizing *M. latipes* in Brazil. Additionally, we reviewed the records of Tachinidae and Sarcophagidae parasitizing *M. latipes*, as well as all other hosts reported for them, and discussed the importance of parasitic flies for natural biological control of this and other lepidopteran pests in agrosystems, based on the distribution and host specificity of parasitic flies reported so far.

Keywords Striped grassworm · *Chetogena scutellaris* · *Atacta brasiliensis* · *Peckia lambens* · *Sarcodexia*

Introduction

Owlet caterpillars (Lepidoptera: Noctuoidea) include the largest groups of lepidopterans of agricultural importance, especially Noctuidae and Erebidae, which are the most diverse families and whose species often reach populations of millions of individuals each season. In natural environments, populations are controlled by diverse natural enemies which include vertebrate predators (amphibians, reptiles, birds, and mammals), invertebrate predators (spiders, assassin bugs, lacewings, ladybugs, ground beetles, sand wasps, vespids, and ants), parasitoids (mainly Hymenoptera and Diptera), and microorganisms (viruses, bacteria, fungi, and nematodes) (Wagner et al. 2011). Commonly known as striped grassworm, *Mocis latipes* (Guenée, 1852) (Lepidoptera: Erebidae) is widely distributed in the Americas, from Canada to Argentina. Its caterpillars feed primarily on grasses (Poaceae), infesting several

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important annual crops such as maize [*Zea mays* L.], rice [*Oryza sativa* L.], sorghum [*Sorghum bicolor* (L.) Moench], sugarcane [*Saccharum officinarum* L.], and wheat [*Triticum aestivum* L.] (Claudino et al. 2021). Furthermore, *M. latipes* is considered the main pest of pastures in American tropical areas (Claudino et al. 2021; Torres 2022). The background coloration and the presence of spots and stripes are variable in caterpillars and adults of *Mocis* representatives, requiring the examination of the genitalia for species identification (Zilli 2000). In this sense, it is postulated that in the Americas, *M. latipes* is confused with *Mocis repanda* (Fabricius, 1794), which is restricted to Africa and erroneously referred to America since its description (De Prins and De Prins 2025).

Diptera is one of the four megadiverse orders of holometabolous insects. The order presents varied feeding habits, including parasitoidism, as seen in species from the families Tachinidae and Sarcophagidae, which benefit plant production by biologically controlling agricultural pests, including lepidopterans (Carvalho et al. 2024). Tachinidae has 9626 species (Carvalho et al. 2024), distributed in all geographic regions of the planet, except Antarctica (O'Hara 2013; Stireman et al. 2019; O'Hara et al. 2020). All known tachinid species are endoparasitoids of insects and other arthropods. Although tachinids can attack hosts of 15 different orders of Arthropoda, the vast majority parasitize holometabolic insect larvae (Stireman et al. 2019, 2021). Lepidopterans represent 70% of known host species (Dindo and Grenier 2014; Dindo and Nakamura 2018). The Sarcophagidae family is also cosmopolitan, with 3094 species described, 750 recorded for the Neotropical Region, and 372 for Brazil. The family representatives present varied feeding habits, but some species of the subfamily Sarcophaginae can be facultative parasites of insects and other arthropods (Carvalho et al. 2024).

Identifying natural enemies of pests is essential for designing and establishing management programs, either by directly using them or conserving them through more sustainable practices. Thus, the present work aims to report the parasitism of *M. latipes* by three parasitoid flies in pasture in Alagoas, Northeast Brazil, with novel records for the state and the country. Furthermore, we reviewed the records of Tachinidae and Sarcophagidae flies parasitizing *M. latipes*, as well as all other hosts that have been reported for them. Based on the distribution and host specificity of the parasitic flies reported, we also discussed their importance for natural biological control of *M. latipes* and other lepidopteran pests in agrosystems.

Materials and Methods

In April 24, 2024, an outbreak of *M. latipes* caterpillars was observed in a demonstrative pasture unit in the municipality of Chã Preta, state of Alagoas, Northeast Region of Brazil (9°17′40″S; 36°16′00″W). The climate in the region is tropical without a dry season (Af in Koppe's classification), with rainfall of 1900–2200 mm and an annual mean temperature of 24–26°C (Alvares et al. 2013). The demonstrative unit had pasture varieties of *Andropogon gayanus* Kunth (Poaceae), *Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs, hybrid *M. maximus* × *Megathyrsus infestus* (Andersson) B.K.Simon & S.W.L.Jacobs, *Urochloa brizantha* (Hochst. ex A.Rich.) R.D.Webster, and *Urochloa ruziziensis* (R.Germ. & Evrard) Crins. Thirty caterpillars of late instars and 52 cocoons containing pupae found in the plants in the field were randomly collected, taken to the laboratory, individualized in plastic pots (10 cm in diameter × 6 cm high), kept under environmental conditions, and daily monitored to check the possible emergence of natural enemies.

Initially, caterpillars and pupae of *M. latipes* were identified according to Ogunwolu and Habeck (1979), and emerged adults (including genitalia) were compared with illustrations and descriptions of Forbes (1954), Gregory et al. (1988), and Wagner et al. (2011). Sixteen adult parasitoid flies emerged from the *M. latipes* pupae cocoons and were collected, initially preserved in 70% alcohol, then mounted on pins and dissected for species identification. After being identified, the specimens were deposited in the Zoological Reference Collection of the Universidade Federal de Mato Grosso do Sul (ZUFMS), in Campo Grande, Mato Grosso do Sul, Brazil.

In addition, we carried out a bibliographic review on parasitoid flies already mentioned in previous studies to analyze and discuss the role of dipterans in the natural control of *M. latipes* throughout the Americas. To this end, a list of Tachinidae and Sarcophagidae flies was drawn up, highlighting the authors who referred to each taxon associated with the natural parasitism of *M. latipes*, considering the species and genera. Parasitoid genera names were considered in the list only when there was no identified species of the genus. The taxonomic classification of Sarcophagidae species followed Pape (1996), those of *Peckia* followed Buenaventura and Pape (2013), and those of Tachinidae followed O'Hara et al. (2020). Records of all other hosts reported for these *M. latipes* parasitoids found in the first review were also collected.

Old literature, especially up until the end of the 1970s, greatly confuses the identification of *M. latipes* with *M. repanda*, which is another valid species and at the time considered supposedly sympatric (ex. Arnaud 1978). However, De Prins and De Prins (2025) indicate that the description and indication of provenance "Americae meridionalis Insulis Dr. Pflug" (Fabricius, 1794) should be considered an error, since the type, illustrated in De Prins and De Prins (2025), comes from Congo. Thus, in the present study, all records made for *M. repanda* in America are considered to refer only to *M. latipes*.

For each taxon, especially for Diptera species, we indicated the studies that cited the parasitic association with *M. latipes* and other invertebrates. The taxonomic update of the host organisms of the different flies considered several taxonomic studies, especially Beccaloni et al. (2023, 2024).

Results

The parasitoids emerged from *M. latipes* were identified as belonging to three species: *Chetogena scutellaris* (Wulp, 1890) (Tachinidae: Exoristinae: Exoristini) (Fig. 1) (18.75% of the parasitoids emerged); *Atacta brasiliensis* Schiner, 1868 (Tachinidae: Exoristinae: Goniini) (Fig. 2) (37.5% of the parasitoids emerged); and *Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830) (Sarcophagidae: Sarcophaginae) (Fig. 3) (43.75% of the parasitoids emerged). Adult dipterans were identified according to Aldrich (1925), Parchami-Aragui (2008), Wood and Zumbado (2010), and Buenaventura and Pape (2013).

The bibliographic review recovered 25 taxa, 22 at the species level and three at the genus level, of which 22 belong to Tachinidae and three to Sarcophagidae (Table 1). The representatives of Tachinidae belong to the subfamilies Dexiinae (2), Exoristinae (16), and Tachininae (4). The two representatives of Dexiinae were identified only at the genus level and belong to Campylochetini (*Campylocheta* sp.) and Voriini (*Cyrtophloeba* sp.).

In the subfamily Exoristinae, records of representatives of the tribes Blondeliini [*Eucelatoria armigera* (Coquillett, 1889), *E. rubentis* (Coquillett, 1895)]; Eryciini [*Lespesia affinis* (Townsend, 1927), *L. aletiae* (Riley, 1879), *L. archippivora* (Riley, 1871), *L. lata* (Wiedemann, 1830), *L. parviteres* (Aldrich & Webber, 1924)]; Exoristini [*Chetogena claripennis* (Macquart, 1848), *C. scutellaris* (van der Wulp, 1890)]; Goniini [*Atacta brasiliensis* Schiner, 1868; *Belvosia bicincta* Robineau-Desvoidy, 1830; *Choeteprosopa hedemanni* (Brauer & Bergenstamm, 1891), *Gonia crassicornis* (Fabricius, 1794), *Hyphantrophaga blanda* (Osten Sacken, 1887), *Patelloa similis* (Townsend, 1927)]; and Winthemiini [*Winthemia* Robineau-Desvoidy, 1830, considering only

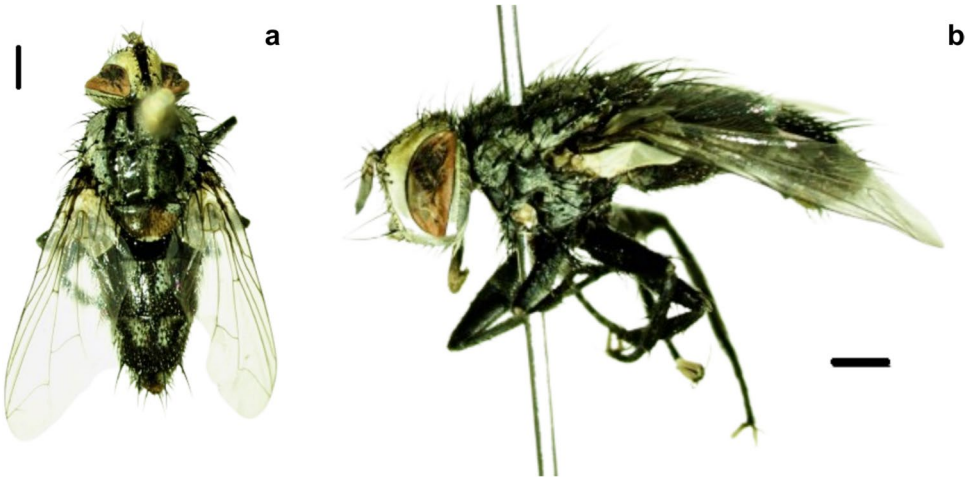

Fig. 1 Male of *Chetogena scutellaris* (Wulp, 1890). **a**) Dorsal view (scale bar = 0.8 mm); **b**) lateral view (scale bar = 1 mm). This figure is in color in the electronic version

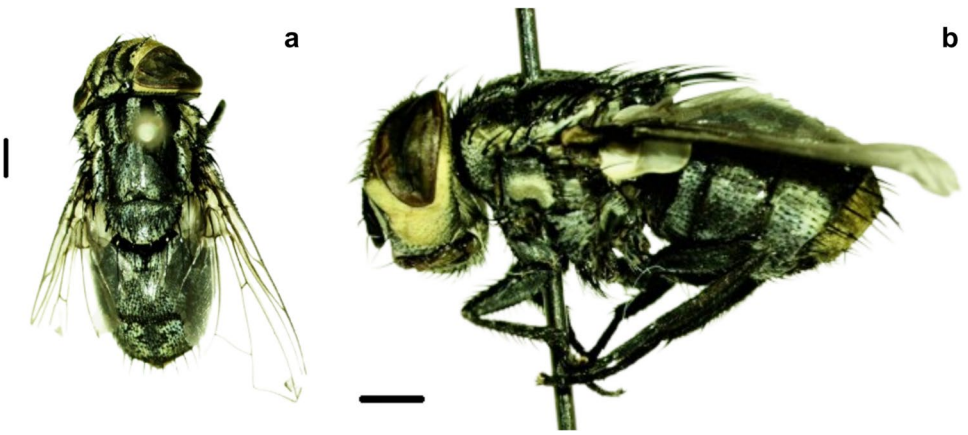

Fig. 2 Female of *Atacta brasiliensis* Schiner, 1868. **a**) Dorsal view; **a**) lateral view. Scale bars = 1 mm. This figure is in color in the electronic version

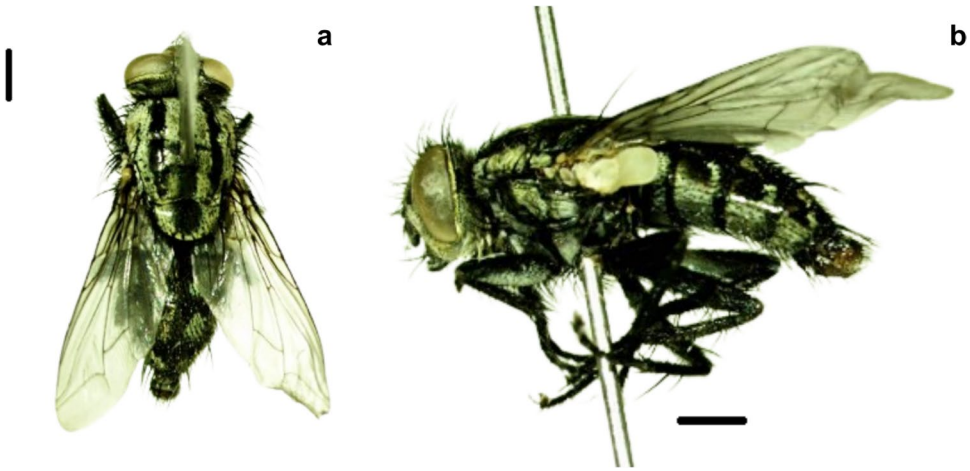

Fig. 3 Male of *Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830). **a**) Dorsal view; **b**) lateral view. Scale bars = 1 mm. This figure is in color in the electronic version

representatives at genus level] were recovered. In the subfamily Tachininae, representatives of the tribes Ernestiini [*Linnaemya comta* (Fallén, 1810), *L. fulvicauda* Walton 1914] and Tachinini [*Archytas incertus* (Macquart, 1851), *A. marmoratus* (Townsend, 1915)] (Table 1) were recovered.

Most of the listed Tachinidae have been shown to be polyphagous, parasitizing several taxa, but are quite restricted to Lepidoptera. In this sense, *C. claripennis*, *C. scutellaris*, *E. armigera*, *E. rubentis*, *G. crassicornis*, *L. aletiae*, *L. archippivora*, *L. parviteres*, and *L. comta* were recorded parasitizing one or a few species of Coleoptera, Hymenoptera, and/or Orthoptera. In contrast, dozens of species were recorded in Lepidoptera (Table 1). The remaining species were recorded only attacking immature Lepidoptera. The three sarcophagids associated with *M. latipes* belong to three distinct genera. Bibliographic records indicate that *Helicobia rapax* (Townsend, 1892) and *P.* (*S.*) *lambens* have records of parasitic association with several hosts, including arthropods such as insects of different orders, scorpions, myriapods, and even mollusks. However, concerning *Oxysarcodexia aura* (Hall, 1937), the only recorded association of parasitism was made with *M. latipes*.

Discussion

Fifteen of the 82 *M. latipes* individuals collected in the field were parasitized, resulting in a parasitism rate of 18.29%. *Peckia* (*S.*) *lambens* was the most prevalent parasitoid fly from *M. latipes* collected in Alagoas, representing 43.75% of the parasitoids emerged, followed by *A. brasiliensis* (37.5%) and *C. scutellaris* (18.75%). The three species showed to be larval-pupal parasitoids, with the parasitization occurring in the last instars of the host caterpillars and the adult parasitoids emerging from the host pupae. Even with the sampling of relatively few caterpillars/pupae done in Alagoas, the parasitic associations between dipterans and *M. latipes* complemented by the expressive number of tachinid and sarcophagid dipterans previously reported in the literature (Table 1) illustrate the diversity and importance of these flies in the biological control of *M. latipes* and other insects (Stireman et al. 2006). Despite the diversity of reported parasitic associations, the literature shows the importance and difficulty of developing in-depth taxonomic studies where, unfortunately, many representatives of both Diptera and Lepidoptera are identified only at the genus level or the identifications generate doubts, greatly restricting the considerations to be made. In this sense, regarding *M. latipes*, the species for a long time was confused, in the American continent, with *M. repanda* (see various examples in Arnaud 1978), which has its distribution restricted to some regions of the African continent (De Prins and De Prins 2025). Regarding Diptera, several studies relate the taxa at the genus level, whose morphotypes were no longer identified later (e.g., Sauer 1946; Mendonça Filho 1972; Gonçalves and Gonçalves 1974; Cave 1992). These morphotypes probably represent undescribed specialist species that fail to be added to the diversity of parasitic associations (see Smith et al. 2007).

In the present study, we failed to infer specific associations because the information was imprecise and probably misleading, as about *Winthemia quadripustulata* (Fabricius, 1794) as described below. *Winthemia quadripustulata* was cited by several authors (Lima 1948; Ribeiro 1954; Silva et al. 1968; Guagliumi 1973; Correia et al. 1999). The first mention of *W. quadripustulata* parasitizing *M. latipes* was made by Lima (1948), who only mentioned that it was obtained from specimens of *M. latipes* collected in rice, without mentioning the location. This mention may refer to the material cited by Sauer (1946) as *Winthemia* sp., reared from pupae of "*Mocis repanda* (Fab.), attacking *Oryza sativa* in Conchal," São Paulo, Brazil 18/II/1941, and identified by Dr. David G. Hall, of the USDA. However, since Dr. Hall was familiar with *W. quadripustulata* from the USA, he

Table 1 Tachinidae and Sarcophagidae (Diptera) parasitoids of *Mocis latipes*, and other host species of these flies recorded so far. The taxonomic classification of Tachinidae species followed O'Hara et al. (2020), of Sarcophagidae followed Pape (1996), and of *Peckia* followed Buenaventura and Pape (2013). References to parasitism of *M. latipes* are given in full between braces, and to parasitism of other taxa are numbered between brackets[a]

TACHINIDAE

DEXIINAE

Campylochetini

1. *Campylocheta* sp. {Cave 1992}

Voriini

2. *Cyrtophloeba* sp. {Sauer 1946; Silva et al. 1968; Guimarães 1977; Lourenção et al. 1982; Santos 1989}

EXORISTINAE

Blondeliini

3. *Eucelatoria armigera* (Coquillett, 1889) {Cardin 1915; Guagliumi 1962; Labrador 1964; Babayan et al. 1975; Arnaud 1978; Urtiaga 2007}

INSECTA: HYMENOPTERA: Diprionidae *Neodiprion* spp. **[13]**; **LEPIDOPTERA: Crambidae** *Herpetogramma licarsisalis* (Walker, 1859) **[13]**; *Omiodes accepta* (Butler, 1877) **[13]**; *Omiodes blackburni* (Butler, 1877) **[13]**; *Spoladea recurvalis* (Fabricius, 1794) **[13]**; **Erebidae** *Achaea janata* (Linnaeus, 1758) **[13]**; *Estigmene acrea* (Drury, 1773) **[13]**; *Polydesma umbricola* Boisduval, 1833 **[13]**; **Geometridae** Unidentified geometrid **[13]**; **Noctuidae** *Agrotis ipsilon* (Hufnagel, 1766) **[13]**; *Amyna natalis* (Walker, 1859) **[13]**; *Autographa californica* (Speyer, 1857) **[13]**; *Chloridea phloxiphaga* (Grote & Robinson, 1867) **[13]**; *Chloridea virescens* (Fabricius, 1777) **[13]**; *Chrysodeixis chalcites* (Esper, 1789) **[13]**; *Helicoverpa zea* (Boddie, 1850) **[13]**; *Helicoverpa hawaiiensis* (Quaintance & Brues, 1905) **[13]**; *Leucania cholica* (Dyar, 1919) **[13]**; *Leucania inconspicua* Herrich-Schaeffer, 1868 **[13]**; *Leucania latiuscula* Herrich-Schaeffer, 1868 **[13]**; *Mythimna unipuncta* (Haworth, 1809) **[13]**; *Spodoptera exempta* (Walker, 1857) **[13]**; *Spodoptera exigua* (Hübner, 1808) **[13]**; *Spodoptera frugiperda* (Smith, 1797) **[13]**; *Spodoptera mauritia* (Boisduval, 1833) **[13]**; *Spodoptera praefica* (Grote, 1875) **[13]**; *Trichoplusia ni* (Hübner, 1803) **[13]**; **Pieridae** *Pieris rapae* (Linnaeus, 1758) **[13]**

4. *Eucelatoria rubentis* (Coquillett, 1895) {Sabrosky 1981}

INSECTA: HYMENOPERA: Diprionidae "a pine sawfly" **[69]**; **LEPIDOPTERA: Crambidae** *Hymenia perspectalis* (Hübner, 1796) **[69]**; *S. recurvalis* **[69]**; **Erebidae** *Anticarsia gemmatalis* Hübner, 1818 **[69]**; *Hypena scabra* (Fabricius, 1798) **[69]**; **Noctuidae** *Anicla infecta* (Ochsenheimer, 1816) **[69]**; *C. virescens* **[69]**; *H. zea* **[69]**; *L. latiuscula* **[39, 69]**; *Litoprosopus futilis* (Grote and Robinson, 1868) **[69]**; *M. unipuncta* **[13, 69]**; *C. includens* (Walker, 1858) **[69]**; *S. exigua* **[13, 69]**; *S. frugiperda* **[69]**; *T. ni* **[69]**

Eryciini

5. *Lespesia affinis* (Townsend, 1927)=*Myiosturmia mixta* Townsend, 1927 {Sauer 1946; Lima 1948, 1950; Ribeiro 1954; Guagliumi 1973; Guimarães 1977; Santos 1989}

INSECTA: LEPIDOPTERA: Dalceridae *Acraga moorei* Dyar, 1898 **[26, 48]**; **Erebidae** *Alysidota* sp. **[30]**; *Cyanopepla alonzo* (Butler, 1876) **[72]**; *Euclystis plusioides* (Walker, 1858) **[54]**; *Eupseudosoma involuta* (Sepp, 1855) **[38]**; *Sarsina violascens* (Herrich-Schäffer, 1856) **[38, 44]**; **Geometridae** *Thyrinteina arnobia* (Stoll, 1782) **[37, 38, 59]**; **Hesperiidae** *Urbanus proteus* (Linnaeus, 1758) **[38]**; **Noctuidae** *Agrotis* sp. **[72]**; *C. includens* **[13]**; *S. frugiperda* **[38]**; **[55]**; **Nymphalidae** *Caligo illioneus* (Cramer, 1775); *Mechanitis lysimnia* (Fabricius, 1793) **[38]**; *Mechanitis polymnia* (Linnaeus, 1758) **[38]**; **Pieridae** *Ascia monuste* (Linnaeus, 1764) **[72]**; *Pereute charops* (Boisduval, 1836) **[82]**; **Saturniidae** *Lonomia obliqua* (Walker, 1855) **[73]**

6. *Lespesia aletiae* (Riley, 1879) {Patton 1958; Labrador 1964; Arnaud 1978}

INSECTA: COLEOPTERA: Coccinellidae *Epilachna varivestis* Mulsant, 1850 **[13]**; **LEPIDOPTERA: Crambidae** *Evergestis rimosalis* (Guenée, 1854) **[13]**; **Erebidae** *Alabama argillacea* (Hübner, 1823) **[13]**; *Antichloris caca* Hübner, 1818=*Eriphia butleri* Möschler, 1878 **[13]**; *Antichloris viridis* Druce, 1884 **[68]**; *E. acrea* **[13]**; *Halisidota harrisii* Walsh, 1864 **[13]**; *Halisidota tessellaris* (Smith, 1797) **[13]**; *H. scabra* **[13]**; *Hypercompe eridanus* (Cramer, 1775) **[68]**; *Hyphantria cunea* (Drury, 1773) **[13]**; *Leucoma salicis* (Linnaeus, 1758) **[13]**; *Lophocampa maculata* Harris, 1841 **[13]**; *Lymantria dispar* (Linnaeus, 1758) **[13]**; *Orgyia leucostigma* (Smith, 1797) **[13]**; *Seirarctia echo* (Smith, 1797) **[13]**; *Spilosoma virginica* (Fabricius, 1798) **[13]**; *S. epilais* **[13]**; *Utetheisa ornatrix* (Linnaeus, 1758) **[13]**; **Nymphalidae** *Opsiphanes tamarindi* C. & R. Felder, 1867 **[13]**; **Geometridae** *Ennomos subsignaria* (Hübner, 1823) **[13]**; **Hesperiidae** *Autochton cellus* (Boisduval & LeConte, 1837) **[13]**; *Epargyreus clarus* (Cramer, 1775) **[13]**; *U. proteus* **[13]**; **Lasiocampidae** *Malacosoma americana* (Fabricius, 1793) **[13]**; **Limacodidae** *Acharia apicalis* (Dyar, 1901) **[13]**; **Megalopygidae** *Megalopyge opercularis* (Smith, 1797) **[13]**; *Megalopyge pyxidifera* (Smith, 1797) **[13]**; **Noctuidae** *C. includens* **[13]**; *H. zea* **[13]**; *M. unipuncta* **[13, 19]**; *Spodoptera androgea* (Stoll, 1782) **[68]**; *Spodoptera dolichos* (Fabricius, 1794) **[68]**; *S. frugiperda* **[13]**; *Spodoptera ornithogalli* (Guenée, 1852) **[13]**; *T. ni* **[13]**; *Xanthopastis timais* (Cramer, 1780) **[13]**; **Notodontidae** *Cerura* spp. **[13]**; *Dasylophia anguina* (Smith, 1797) **[13]**; *Datana ministra* (Drury, 1773) **[13]**; *Heterocampa manteo* (Doubleday, 1869) **[13]**; **Nymphalidae** *Asterocampa* sp. **[13]**; *Caligo telamonius* (C. & R. Felder, 1862) **[68]**; *Nymphalis antiopa* (Linnaeus, 1758) **[13]**; *Nymphalis interrogationis* (Fabricius, 1798) **[13]**; *Vanessa cardui* (Linnaeus, 1758) **[13]**; **Pieridae** *Pontia protodice* (Boisduval & LeConte, 1830) **[13]**; *P. rapae* **[13]**; **Psychidae** *Oiketicus kirbyi* Guilding, 1827 **[68]**; **Pyralidae** *Melitara junctolineella* (Hulst, 1900) **[13]**; **Saturniidae** *Hemileuca maia* (Drury, 1773) **[13]**; **Sphingidae** *Ceratomia catalpae* (Boisduval, 1875) **[13]**; *Pholus* sp. **[13]**

7. *Lespesia archippivora* (Riley, 1871) {Guagliumi 1962; Labrador 1964; Babayan et al. 1975; Maes 1989; Saunders et al. 1998; Urtiaga 2007}

INSECTA: HYMENOPTERA: Tenthredinidae *Pristiphora erichsonii* (Hartig, 1837) **[13, 50]**; **LEPIDOPTERA: Crambidae** *Achyra similalis* (Guenée, 1854) **[13]**; *Diatraea lineolata* (Walker, 1856) **[50]**; *Loxostege commixtalis* (Walker, 1866) **[13]**; *Loxostege sticticalis* (Linnaeus, 1761) **[13, 50]**; *O. accepta* **[13]**; *O. blackburni* **[13]**; **Erebidae** *Anomis hawaiiensis* (Butler, 1882) **[13]**; *Anomis noctivolans* (Butler, 1880) **[13]**; *A. gemmatalis* **[38, 50]**; *E. acrea* **[13, 50]**; *Estigmene* sp.; *Euchaetias egle* (Drury, 1773) **[13]**; *Lophocampa caryae* Harris, 1841 **[13]**; *P. umbricola*; *Syntomeida melanthus* (Cramer, 1779) **[74]**; *Tyria jacobaeae* (Linnaeus, 1758) **[13, 50]**; **Geometridae** *Anacamptodes fragilaria* (Grossbeck, 1909) **[13]**; *Scotorythra paludicola* (Butler, 1879) **[13]**; *Scotorythra rara* (Butler, 1879) **[13]**; **Lasiocampidae** *M. americana* **[13, 50]**; *M. californica* **[13]**; *Malacosoma californica ambisimile* (Dyar, 1893) **[13]**; *Malacosoma californica fragile* (Stretch, 1881) **[13]**; *Malacosoma californica pluvialis* (Dyar, 1893) **[13, 50]**; *Malacosoma californica recenseo* Dyar, 1928 **[13]**; *Malacosoma constricta* (H. Edwards, 1874) **[13, 50]**; *Malacosoma disstria* Hübner, 1820 **[13, 50]**; *Malacosoma incurva discolorata* (Neumoegen, 1893) **[13]**; *Malacosoma incurva incurva* (H. Edwards, 1882) **[13]**; **Lycaenidae** *Lampides boeticus* (Linnaeus, 1767) **[13]**; **Noctuidae** *Agrotis crinigera* (Butler, 1881) **[13]**; *Agrotis dislocata* (Walker, 1856) **[13]**; *A. ipsilon* **[13, 50]**; *Agrotis vestigialis* (Hufnagel, 1766) **[50]**; *Alypia octomaculata* (Fabricius, 1775) **[13]**; *Anarta trifolii* (Hufnagel, 1766) **[13, 50]**; *Athetis nonagrica* (Walker, 1863) **[13]**; *A. californica* **[13]**; *C. virescens* **[50]**; *Feltia* sp. near *subgothica* (Haworth, 1809) **[13]**; *Feltia subterranea* (Fabricius, 1794) **[13, 25, 50]**; *H. hawaiiensis* **[13]**; *H. zea* **[13, 50]**; *Mamestra configurata* Walker, 1856 **[13]**; *Mythimna sequax* (Franclemont, 1951) **[19]**; *M. unipuncta* **[13]**; *Peridroma coniotis* (Hampson, 1903) **[13]**; *Peridroma saucia* (Hübner, 1808) **[13]**; *S. exempta* **[13]**; *S. exigua* **[13, 50]**; *S. frugiperda* **[13. 38, 39, 50, 82]**; *S. mauritia* **[13]**; *S. ornithogalli* **[13, 50]**; *S. praefica* **[13, 50]**; *T. ni* **[13, 50]**; **Notodontidae** *Schizura concinna* (Smith, 1797) **[13, 50]**; **Nymphalidae** *Danaus erippus* (Cramer, 1775) **[37]**; *Danaus gilippus* (Cramer, 1775) **[50]**; *Danaus plexippus* (Linnaeus, 1758) **[50, 82]**; *Dione juno* (Cramer, 1779) **[74]**; *Fountainea glycerium* (Doubleday, 1849) **[13]**; *N. antiopa* **[13, 50]**; *Nymphalis milberti* (Godart, 1819) **[13]**; *Vanessa atalanta* (Linnaeus, 1758) **[13, 50]**; *V. cardui* **[13, 50]**; *Vanessa carye* (Hübner, 1812) **[50]**; **Papilionidae** *Papilio* spp. **[13, 50]**; **Pieridae** *Colias eurytheme* Boisduval, 1852 **[13]**; *Colias philodice* Godart, 1819 **[50]**; *P. rapae* **[13, 50]**; *P. protodice* **[13, 50]**; **Riodinidae** *Cremna thasus* (Stoll, 1780) **[57]**; **Saturniidae** *Citheronia regalis* (Fabricius, 1793) **[13]**; **Scythrididae** *Mapsidius iridescens* Walsingham, 1907 **[13]**

8. *Lespesia lata* (Wiedemann, 1830)=*Prophryno cromobergiae* Blanchard 1963 {Santos 1989}

INSECTA: LEPIDOPTERA: Erebidae *Dinia eagrus* (Cramer, 1779) **[38]**; *H. scabra*; *Hyperstrotia inordinata* Walker, 1864 **[79]**; **Geometridae** *Glena bipennaria* (Guenée, 1852) **[59]**; *Melanolophia apicalis* (Warren, 1900) **[52]**; **Noctuidae** *Cromobergia teichii* (Berg, 1885) **[17]**; **Nymphalidae** *D. erippus* **[4]**; **Papilionidae** *Parides ascanius* (Cramer, 1775) **[4]**; *Parides zacynthus* (Fabricius, 1793) **[4]**; *Battus polystictus* (Butler, 1874) **[4]**

Table 1 (continued)

TACHINIDAE

9. *Lespesia parviteres* (Aldrich & Webber, 1924) {Maes 1989; Cave 1992; Saunders et al. 1998; Smith et al. 2007}

INSECTA: HYMENOPTERA: Crabronidae *Crabro rufibasis* (Banks, 1921) **[50]**; **LEPIDOPTERA: Erebidae** *H. scabra* **[13]**; **Geometridae** *Melanchroia cephise* (Stoll, 1782) **[13]**; **Hesperiidae [79]**; **Pieridae** *A. monuste* **[13]**; *Eurema nicippe* (Cramer, 1779) **[43]**; *Ganyra* sp. **[79]**; *Itaballia* sp. **[79]**; *Phoebis sennae* (Linnaeus, 1758) **[43]**; **Riodinidae [79]**

Exoristini

10. *Chetogena claripennis* (Macquart, 1848) { Jones and Wolcott 1922, Wolcott 1923, 1948; Fennah 1947; Labrador 1964; Guimaraes 1977; Arnaud 1978; Saunders et al. 1998}

INSECTA: COLEOPTERA: Chrysomelidae *Calligrapha multipunctata* (Say, 1824) **[13]**; **Coccinellidae** *Epilachna borealis* (Fabricius, 1775) **[13]**; *E. varivestis* **[13]**; **HYMENOPTERA: Diprionidae** *Diprion similis* (Hartig, 1836) **[13]**; *Neodiprion abbotii* (Leach, 1817) **[13]**; *Neodiprion lecontei* (Fitch, 1858) **[13]**; *Neodiprion sertifer* (Geoffroy, 1785) **[13]**; *Neodiprion virginianus* Rohwer, 1918 **[13]**; **ORTHOPTERA: Acrididae** *Melanoplus differentialis* (Thomas, 1865) **[13]**; **LEPIDOPTERA: Crambidae** *Fissicrambus mutabilis* (Clemens, 1860) **[13]**; *L. sticticalis* **[13]**; **Erebidae** *A. argillacea* **[13]**; *E. egle* **[13]**; *Euproctis chrysorrhoea* (Linnaeus, 1758) **[13]**; *Grammia phyllira* (Drury, 1773)=*Apantesis oithona* Strecker, 1878 **[13]**; *H. tessellaris* **[13]**; *H. scabra* **[13]**; *H. cunea* **[13]**; *L. salicis* **[13]**; *L. dispar* **[13]**; *Lymire edwardsii* (Grote, 1881) **[13]**; *Notarctia proxima* (Guérin-Méneville, 1844) **[13]**; *O. leucostigma* **[13]**; *Virbia rubicundaria* (Hübner, 1831) **[13]**; *U. ornatrix* **[13]**; **Gelechiidae** *Anarsia lineatella* Zeller, 1839 **[13]**; **Geometridae** *Cingilia catenaria* (Drury, 1773) **[13]**; *Digrammia neptaria* (Guenée, 1857) **[13]**; *Philtraea elegantaria* (H. Edwards, 1881) **[13]**; *Speranza sulphurea* (Packard, 1873) **[13]**; **Hesperiidae** *E. clarus* **[13]**; **Lasiocampidae** *M. americana* **[13]**; *M. disstria* **[13]**; **Limacodidae** *Acharia stimulea* (Clemens, 1860) **[13]**; **Megalopygidae** *Megalopyge crispata* (Packard, 1864) **[13]**; *M. opercularis* **[13]**; *M. pyxidifera* **[13]**; **Noctuidae** *Acronicta hamamelis* Guenée, 1852 **[13]**; *Actebia fennica* (Tauscher, 1806) **[13]**; *A. ipsilon* **[13]**; *A. trifolii* **[13]**; *C. virescens* **[13]**; *Euxoa auxiliaris* (Grote, 1873) **[13]**; *Dargida diffusa* (Walker, 1856) **[13]**; *Feltia herilis* (Grote, 1873) **[13]**; *Feltia jaculifera* (Guenée, 1852)=*Feltia ducens* Walker, 1856 **[13]**; *Feltia subgothica* (Haworth, 1809) **[13]**; *H. zea* **[13]**; *Hydroecia immanis* Guénee, 1852 **[13]**; *Lithophane disposita* Morrison, 1874 **[13]**; *Lithophane innominata* (Smith, 1893) **[13]**; *Lithophane petulca* Grote, 1874 **[13]**; *M. unipuncta* **[13]**; *P. saucia* **[13]**; *Spodoptera eridania* (Stoll, 1782) **[13]**; *S. frugiperda* **[13]**; *S. praefica* **[13]**); *Xestia c-nigrum* (Linnaeus, 1758) **[13]**; **Notodontidae** *Clostera inclusa* (Hübner, 1831) **[13]**; *Datana angusii* Grote & Robinson, 1866 **[13]**; *Datana contracta* Walker, 1855 **[13]**; *Datana integerrima* Grote & Robinson, 1866 **[13]**; *D. ministra* **[13]**; *Datana perspicua* Grote & Robinson, 1865 **[13]**; *S. concinna* **[13]**; *Schizura unicornis* (Smith, 1797) **[13]**; **Nymphalidae** *Agraulis vanillae* (Linnaeus, 1758) **[13]**; *Asterocampa clyton* (Boisduval & Le Conte, 1835) **[13]**; *Chlosyne lacinia* (Geyer, 1833) **[13]**; *N. antiopa* **[13]**; *Nymphalis comma* (Harris, 1842) **[13]**; *N. interrogationis* **[13]**; **Pieridae** *C. eurytheme* **[13]**; *P. rapae* **[13]**; **Psychidae** *Thyridopteryx ephemeraeformis* (Haworth, 1803) **[13]**; **Saturniidae** *Anisota senatoria* (Smith, 1797); *Automeris io* (Fabricius, 1775) **[13]**; *Callosamia promethea* (Drury, 1773) **[13]**; *Dryocampa rubicunda* (Fabricius, 1793); *Hemileuca electra* Wright, 1884 **[13]**; *Hemileuca lucina* H. Edwards, 1887 **[13]**; *H. maia* **[13]**; *Hemileuca nevadensis* Stretch, 1872 **[13]**; *Hemileuca oliviae* Cockerell, 1898 **[13]**; *Hyalophora cecropia* (Linnaeus, 1758) **[13]**; **Sphingidae** *C. catalpae* **[13]**; *Ceratomia undulosa* (Walker, 1856) **[13]**; *Sphinx chersis* (Hübner, 1823) **[13]**; **Zygaenidae** *Harrisina americana* (Guérin-Méneville, 1832) **[13]**

11. *Chetogena scutellaris* (van der Wulp, 1890)=*Euphocera floridensis* Townsend, 1916 {Maes 1989; Saunders et al. 1998; Present work}

INSECTA: COLEOPTERA: Cerambycidae *Saperda* sp. **[13]**; **Coccinellidae** *E. varivestis* **[13]**; **LEPIDOPTERA: Crambidae** *Cnaphalocrocis trapezalis* (Guenée, 1854) **[39]**; **Erebidae** *A. argillacea* **[13, 37, 40, 50]**; *Ammalo helops* (Cramer, 1775) **[10]**; *A. gemmatalis* **[13, 50]**; *Eulepidotis rectimargo* (Guenée, 1852) **[22]**; *G. phyllira* **[13]**; *H. scabra* **[13]**; *H. cunea* **[13]**; *L. edwardsii* **[13]**; *Syntomeida epilais* (Walker, 1854) **[13]**; **Geometridae** *E. subsignaria* **[13]**; *M. cephise* **[13]**; *M. apicalis* **[52]**; **Hesperiidae** *E. clarus* **[13]**; *Mysoria barcastus ambigua* (Mabille & Boullet, 1908) **[76]**; *Staphylus vulgata* (Möschler, 1879) **[12]**; *Urbanus simplicius* (Stoll, 1790) **[64]**; **Lycaenidae** *Strymon acis bartrami* (Comstock & Huntington, 1943) **[71]**; **Noctuidae** *C. includens* **[13]**; *H. zea* **[13, 37]**; *M. unipuncta* **[13]**; *Spodoptera albula* (Walker, 1857) sic *S. sunia* (Guenée) **[50]**; *S. eridania* **[50]**; *S. frugiperda* **[13, 50]**; **Notodontidae** *Clostera apicalis* (Walker, 1855) **[13]**; *C. inclusa* **[13]**; *D. integerrima* **[13]**; *Datana major* Grote & Robinson, 1866 **[13]**; *D. ministra* **[13]**; *Elasmia mandela* (Druce, 1887) **[62]**; **Nymphalidae** *Anaea troglodyta floridalis* (Johnson & Comstock, 1941) **[70]**; *Brassolis sophorae* (Linnaeus, 1758) **[44]**; *D. juno* **[66]**; *Euptoieta hortensia* (Blanchard, 1852) **[37]**; *Opsiphanes invirae* (Hübner, 1808) **[44]**; **Papilionidae** *Protographium epidaus* (Doubleday, 1846) **[53]**; **Pieridae** *Colias lesbia* (Fabricius, 1775) **[37]**; *P. protodice* **[13]**; **Pyralidae** *Elasmopalpus lignosellus* (Zeller, 1848) **[39]**; **Saturniidae** *A. subangulata* **[59]**; *Agapema galbina* (Clemens, 1860) **[13]**; *D. rubicunda* **[13]**; *Hylesia metabus* (Cramer, 1775) **[41]**; *Rothschildia lebeau* (Guérin-Méneville, 1868) **[6]**; **Sphingidae** *C. catalpae* **[13]**; *Erinnyis ello* (Linnaeus, 1758) **[37]**; **Stenomiidae** *Stenoma impressella* (Busck, 1914)=*Stenoma cecropia* Meyrick, 1916 **[32]**; **Zygaenidae** *H. americana* **[13]**

Goniini

12. *Atacta brasiliensis* Schiner, 1868 {Aldrich 1925; Mendonça Filho 1972; Guagliumi 1973; Gonçalves and Gonçalves 1974; Guimarães 1977; Arnaud 1978; Maes 1989; Santos 1989; Cave 1992; Saunders et al. 1998; Present work}

INSECTA: LEPIDOPTERA: Erebidae *Coenipeta bibitrix* (Hübner, 1823) **[65]**; **Noctuidae** *C. includens* **[16]**; **Sphingidae** *Manduca* spp. **[13]**

13. *Belvosia bicincta* Robineau-Desvoidy, 1830 {Rica 1953, 1954; Arnaud 1978}

INSECTA: LEPIDOPTERA: Notodontidae *Hemiceras pallidula* Guenée, 1852 **[37]**; **Nymphalidae** *Brassolis astyra* Godart, 1824 **[37]**; **Saturniidae** *Eacles imperialis* (Drury, 1773) **[18]**; *Eacles magnifica* Walker, 1855 **[37, 44]**; *Hylesia nanus* (Walker, 1855) **[37]**; **Sphingidae** *Hyles lineata* (Fabricius, 1775) **[42]**; *E. ello* **[37, 67]**; *Pachylia ficus* (Linnaeus, 1758) **[37]**; *Pachylia syces* (Hübner, 1819) **[37]**

14. *Choeteprosopa hedemanni* (Brauer & Bergenstamm, 1891) {Saunders et al. 1998}

INSECTA: LEPIDOPTERA: Noctuidae *S. eridania* **[3]**; *S. ornithogalli* **[31]**

15. *Gonia crassicornis* (Fabricius, 1794)=*Gonia texensis* Reinhard, 1924 {Arnaud 1978}

INSECTA: COLEOPTERA: Scarabaeidae *Phyllophaga* spp. **[13]**; **LEPIDOPTERA: Noctuidae** *A. ipsilon* **[45]**; *F. subterranea* **[13]**; *S. albula* **[13]**; *S. eridania* **[13, 37]**=*Spodoptera peruviana*; *S. exigua* **[13]**; *S. frugiperda* **[13, 25, 37]**

16. *Hyphantrophaga blanda* (Osten Sacken, 1887) {Arnaud 1978}

INSECTA: LEPIDOPTERA Crambidae *A. similalis* **[13]**; *Alatuncusia canalis* (Walker, 1866)=*Alatuncusia bergii* (Möschler, 1890) **[13]**; *Dichogama redtenbacheri* Lederer, 1863 **[13]**; **Depressariidae** *Depressaria radiella* (Goeze, 1783)=*Depressaria pastinacella* (Duponchel, 1823) **[13]**; *Psilocorsis cryptolechiella* (Chambers, 1872)=*Psilocorsis faginella* (Chambers, 1872) **[13]**; *Psilocorsis reflexella* Clemens, 1860=*Psilocorsis fletcherella* Gibson, 1909 **[13]**; **Erebidae** *A. argillacea* **[13]**; *Catocala* spp. **[13]**; *E. chrysorrhoea*=*Nygmia phaeorrhoea* (Donovan, 1813) **[13]**; *Hypena humuli* Harris, 1841 **[13]**; *H. scabra*; *H. cunea*=*Hyphantria textor* (Harris, 1847) **[13]**; *L. salicis* **[13]**; *Orgyia antiqua* (Linnaeus, 1758) **[13]**; **Gelechiidae** "gelechiid webber(-s)" **[13]**; **Geometridae** *C. catenaria* **[13]**; *E. subsignaria* **[13]**; *Epelis truncataria* (Walker, 1862) **[13]**; *Nepytia phantasmaria* (Strecker, 1899) **[13]**; *Rheumaptera undulata* (Linnaeus, 1758) **[13]**; **Hesperiidae** *C. ethlius* **[13]**; *E. clarus* **[13]**; *Erynnis brizo* (Boisduval & LeConte, 1834) **[13]**; **Limacodidae** *Euclea cippus* (Cramer, 1775) **[13]**; *Euclea delphinii* (Boisduval, 1832) **[13]**; **Noctuidae** *H. zea* **[33]**; *F. subterranea* **[25]**; *Phosphila turbulenta* Hübner, 1813 **[13]**; *S. frugiperda* **[13, 25]**; **Nymphalidae** *N. antiopa* **[13]**; *N. interrogationis* **[13]**; *V. atalanta* **[13]**; *V. cardui* **[13]**; **Psychidae** *T. ephemeraeformis* **[13]**; **Pyralidae** *Acrobasis comptoniella* Hulst, 1890 **[13]**; *Sciota subcaesiella* (Clemens, 1860) **[13]**; *Sciota subfuscella* (Ragonot, 1887) **[13]**; *Tetralopha robustella* Zeller, 1848 **[13]**; **Saturniidae** *D. rubicunda* **[13]**; **Sphingidae** *Smerinthus jamaicensis* (Drury, 1773) **[13]**; *Sphecodina abbottii* (Swainson, 1821) **[13]**; **Tortricidae** *Archips argyrospila* (Walker, 1863) **[13]**; *Archips cerasivoranus* (Fitch, 1856) **[13]**; *Archips fervidana* (Clemens, 1860) **[13]**; *Argyrotaenia mariana* (Fernald, 1882) **[13]**; *Choristoneura rosaceana* (Harris, 1841) **[88]**; *Gretchena bolliana* (Slingerland, 1896) **[13]**

17. *Patelloa similis* (Townsend, 1927) {Blanchard 1963; Guimarães 1977}

INSECTA: LEPIDOPTERA: Crambidae *Omiodes indicata* (Fabricius, 1775) **[20]**; **Erebidae** *A. argillacea* **[37, 40]**; *A. gemmatalis* [37]; **Geometridae** *Parallelia bistriaris* Hübner, 1818 **[37]**; *Semiothisa* sp. **[20]**; *T. arnobia* **[59]**; **Noctuidae** *A. ipsilon* **[45]**; *C. teichii* **[37]**; *Helicoverpa gelotopoeon* (Dyar, 1921) **[37]**; *M. sequax* **[35]**; *C. includens* **[56]**; *Rachiplusia nu* (Guenée, 1852) **[37]**; *Spodoptera cosmioides* (Walker, 1858) **[20]**; *S. frugiperda* **[37]**; *Trachea anguliplaga* (Walker, 1858) **[46]**

Table 1 (continued)

TACHINIDAE
Winthemiini
18. *Winthemia* sp. {Sauer 1946; Lima 1948; Ribeiro 1954; Silva et al. 1968; Guagliumi 1973}
Tachininae
Ernestiini
19. *Linnaemya comta* (Fallén, 1810) {Cave 1992}
INSECTA: COLEOPTERA: Melolonthidae *Phyllophaga* sp. **[13]**; **LEPIDOPTERA: Noctuidae** *Agrotis experta* (Walker, 1869) **[72]**; *Agrotis gladiaria* Morrison, 1875 **[13]**; *A. ipsilon* **[13, 25, 72]**; *Agrotis malefida* Guenée, 1982 **[13, 72]**; *Agrotis orthogonia* Morrison, 1876 **[13]**; *Agrotis venerabilis* Walker, 1857 **[13]**; *Copablepharon viridisparsa* Dod, 1916 **[13]**; *E. auxiliaris* **[13]**; *Euxoa messoria* (Harris, 1841) **[13]**; *Euxoa ochrogaster* (Guenée, 1852) **[13]**; *Euxoa tristicula* (Morrison, 1875) **[13]**; *F. subterranea* **[13, 16, 25, 72]**; *P. saucia* **[13]**; *Pseudoleucania bilitura* (Guenée, 1852) **[72]**; *Orthodes goodelli* (Grote, 1875) as *Polia acutermina* (Smith, 1904) **[13]**; *S. exigua* **[16]**; *S. frugiperda* **[13]**; *Spodoptera ochrea* (Hampson, 1909) **[72]**
20. *Linnaemyia fulvicauda* Walton 1914 {Walton 1914; Jones and Wolcott 1922; Fennah 1947; Labrador 1964; Babayan et al. 1975; Arnaud 1978; Saunders et al. 1998}
INSECTA: LEPIDOPTERA: Noctuidae *H. zea* **[13]**
Tachinini
21. *Archytas incertus* (Macquart, 1851) {Blanchard and De Santis 1975; Avalos 1987}
INSECTA: LEPIDOPTERA: Erebidae *A. gemmatalis* **[24, 37]**; *Paracles deserticola* (Berg, 1875) **[37]**; **Noctuidae** *C. virescens* **[37]**; *Dargida albilinea* (Hübner, 1821) **[15, 37]**; *Helicoverpa armigera* (Hübner, 1805) **[49, 87]**; *H. gelotopoeon* **[37]**; *H. zea* **[37]**; *Mythimna adultera* (Shaus, 1894) **[15]**; *S. cosmioides* as *Spodoptera latifascia* (Walker, 1856) **[25]**; *S. frugiperda* **[13, 25, 37, 87]**; *R. nu* **[37]**; **Pieridae** *C. lesbia* **[37]**
22. *Archytas marmoratus* (Townsend, 1915) {Labrador 1964; Arnaud 1978; Maes 1989; Cave 1992}
INSECTA: LEPIDOPTERA: Crambidae *Diatraea saccharalis* (Fabricius, 1794) **[84]**; **Hyblaeidae** *Hyblaea puera* (Cramer, 1777) **[50]**; **Noctuidae** *A. ipsilon* **[13, 50, 58, 81]**; *H. armigera* **[49, 87]**; *H. zea* **[13, 37, 50]**; *L. latiuscula* **[13, 50]**; *Leucania multilinea* Walker, 1856 **[86]**; *Leucania subpunctata* (Harvey, 1875) **[86]**; *M. unipuncta* **[13, 50, 86]**; *S. cosmioides* as *S. latifascia* **[25]**; *S. frugiperda* **[13, 25, 37, 50, 87]**; *S. latifascia* **[13, 50]**
SARCOPHAGIDAE
Sarcophaginae
23. *Helicobia rapax* (Townsend, 1892) = *Sarcophaga helicis* Townsend, 1892 {Jones and Wolcott 1922; Fennah 1947; Labrador 1964; Saunders et al. 1998}
MOLLUSCA: GASTROPODA: Ampullariidae *Marisa cornuarietis* (Linnaeus, 1758) **[80]**; **Polygyridae** *Mesodon thyroidus* (Say, 1817) **[2]**; **MYRIAPODA [1]**; **INSECTA: MEGALOPTERA: Corydalidae** *Corydalus cornutus* (Linnaeus, 1758) **[1]**; **ORTHOPTERA: Acrididae** *Melanoplus differentialis* (Thomas, 1865) **[2]**; *Melanoplus sanguinipes* atlanis (Riley, 1875) **[2]**; **HEMIPTERA: Cicadidae** *Neotibicen canicularis* (Harris, 1841) **[34]**; *Neotibicen linnei* (Smith & Grossbeck, 1907) **[36]**; *Neotibicen tibicen* (Linnaeus, 1758) **[2]**; **COLEOPTERA: Bostrichidae** *Dinapate wrightii* Horn, 1886 **[1]**; **Carabidae** *Calosoma* sp. **[1]**, **Tenebrionidae** *Eleodes opaca* (Say, 1824) **[2]**; **Scarabaeidae** *Dynastes tityus* (Linnaeus, 1763) **[63]**; *Phyllophaga fervida* (Fabricius, 1775) = *Lachnosterna arcuata* Smith, 1889 **[1]**; **LEPIDOPTERA: Crambidae** *Conchylodes nolckenialis* (Snellen, 1875) **[28]**; *D. saccharalis* **[61]**; *L. sticticalis* **[2]**; **Erebidae** *Theages xanthura* (Schaus, 1910) **[29]**; **Euteliidae** *Nagara vitrea* (Guenée, 1852) **[51]**; **Geometridae** *E. subsignaria* **[5]**; **Hyblaeidae** *H. puera* **[30]**; **Noctuidae** *M. unipuncta* (Haworth, 1809) **[2]**; **Pieridae** *P. rapae* **[2]**; **Riodinidae** *Hades noctula* Westwood, 1851 **[78]**; **Sphingidae** *Manduca occulta* Rothschild & Jordan, 1903 **[11]**
24. *Oxysarcodexia aura* (Hall, 1937) {Sauer 1946; Lima 1948, 1950; Ribeiro 1954; Santos 1989}
25. *Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830) = *Sarcodexia sternodontis* Townsend, 1892 {Jones and Wolcott 1922; Sauer 1946; Fennah 1947; Lordello and Mariconi 1953; Blanchard 1963; Guagliumi 1962; Labrador 1964; Babayan et al. 1975; Hall 1988; Maes 1989; Cave 1992; Saunders et al. 1998; Urtiaga 2007; Present work}
CHELICERATA: SCORPIONES: Buthidae *Centruroides edwardsii* (Gervais, 1843) **[47]**; **INSECTA: COLEOPTERA: Cerambycidae** *Stenodontes damicornis* (Linnaeus, 1771) **[47]**; **Coreidae** *Coreus confluentus* Say, 1831 **[47]**; **Hydrophilidae** *Hydrophilus foveolatus* Régimbart, 1901 **[47]**; **Melolontidae** *Phyllophaga plaei* Blanchard, 1851 = *Lachnosterna portoricensis* Smyth, 1917 **[47]**; *Strategus* sp. **[47]**; **Scarabaeidae** *Dynastes tityus* (Linnaeus, 1763) **[63]**; **HEMIPTERA: Pentatomidae** *Acrosternum hilare* (Say, 1832) **[47]**; *Euschistus servus* (Say, 1832) **[47]**; *Murgantia histrionica* (Hahn, 1834) **[47]**; *Nezara viridula* (Linnaeus 1758) **[47]**; **Reduviidae** *Triatoma infestans* (Klug, 1834) **[47]**; **LEPIDOPTERA: Cossidae** *Cossula magnifica* (Strecker, 1876) **[47]**; **Crambidae** *Condylorrhiza vestigialis* (Guenée, 1854) **[44]**; *Diaphania hyalinata* (Linnaeus, 1767) **[47, 84]**; *Diatraea busckella* Dyar & Heinrich, 1927 **[84]**; *D. lineolata* **[47]**; *D. saccharalis* **[47, 50, 61, 84]**; **Erebidae** *A. argillacea* **[23, 40, 47, 50, 75, 84]**; *A. gemmatalis* **[50]**; *Chabora rhodogaster* (Guenée, 1852) **[29]**; *E. acrea* **[50]**; *T. xanthura* **[27]**; **Hesperiidae** *Calpodes ethlius* (Stoll, 1782) **[47]**, **[8]**; **Noctuidae** *Acronicta ovata* (Grote, 1873) **[47]**; *C. virescens* **[47, 50]**; *H. zea* **[47]**; *Sacadodes pyralis* Dyar, 1912 **[47, 50]**; *S. cosmioides* as *S. latifascia* **[25]**; *S. eridania* **[50]**; *S. frugiperda* **[25, 47, 50, 82]**; *S. ornithogalli* **[50]**; *T. ni* = *Plusia brassicae* Riley, 1870 **[47, 50]**; **Nymphalidae** *B. sophorae* **[47]**; **Psychidae** *O. kirbyi* **[47, 67]**; **Saturniidae** *Adeloneivaia subangulata* (Herrich-Schäffer, 1855) **[59]**; *Arsenura armida* (Cramer, 1779) **[85]**; *Arsenura xanthopus* (Walker, 1855) **[47]**; *C. regalis* **[47]**; *Dirphia avirosensis* Brechlin & Meister, 2017 **[77]**; *H. metabus* **[41, 83]**; *Rothschildia erycina* (Shaw, 1796) **[7]**; **Sphingidae** *E. ello* **[47, 75]**; *M. sexta* **[47]**; *Pachylioides resumens* (Walker, 1856) **[21]**; *Xylophanes turbata* (Edwards, 1887) **[9]**; **NEUROPTERA: Ascalaphidae** *Albardia furcata* van der Weele, 1903 **[60]**; **ORTHOPTERA: Acrididae** *Schistocerca americana* (Drury, 1773) **[47]**; *Schistocerca cancellata* (Serville, 1838) **[47]**; **Gryllotalpidae** *Scapteriscus vicinus* Scudder, 1869 **[47]**; **Romaleidae** *Romalea microptera* (Palisot de Beauvois, 1817) = *Dictyophorus reticulatus* Thunberg, 1815 **[47]**

[a] **[1]** Aldrich 1915;**[2]** Aldrich 1916;**[3]** Aldrich 1925;**[4]** Almeida et al. 2012;**[5]** Anderson and Kaya 1976;**[6]** Aragón 2015a;**[7]** Aragón 2015b;**[8]** Aragón 2016;**[9]** Aragón 2017;**[10]** Araya 2020;**[11]** Araya 2021;**[12]** Araya 2023;**[13]** Arnaud 1978; **[14]** Benito et al. 2025;**[15]** Bentancourt and Scatoni 2006;**[16]** Bio-Nica 2025; **[17]** Blanchard 1963;**[18]** Bleicher and Melo 1996;**[19]** Bortolotto et al. 2015;**[20]** Bueno et al. 2012;**[21]** Cano 2018;**[22]** Cantillano 2018;**[23]** Carvalho 1941;**[24]** Castiglioni 2006;**[25]** Constantino 2020; **[26]** Constantino et al. 2013; **[27]** Cortes 2017;**[28]** Cortes 2020;**[29]** Cortes 2021;**[30]** Cortes 2023;**[31]** Crumb 1929;**[32]** Delvare and Genty 1992;**[33]** Falcon-Brindis and Villanueva 2024;**[34]** Ferraz and De Abreu 1984;**[35]** Foerster et al. 2001;**[36]** Giroux et al. 2022;**[37]** Guimarães 1977;**[38]** Guimarães 1983;**[39]** Hall 1988;**[40]** Hambleton 1939;**[41]** Hernández et al. 2009;**[42]** Jorgensen 1988;**[43]** Koptur et al. 2015;**[44]** Lemes and Zanuncio 2021;**[45]** Link and Costa 1984;**[46]** Link and Diefenthaler 1979;**[47]** Lordello and Mariconi 1953;**[48]** Lourenção and Sabino 1994;**[49]** Luz et al. 2018;**[50]** Maes 1989;**[51]** Martinez 2021;**[52]** Martins et al. 1984;**[53]** Medina 2021;**[54]** Mendes et al. 1991;**[55]** Molina-Ochoa et al. 2003;**[56]** Moraes et al. 1991;**[57]** Murgas and Jaen 2020;**[58]** Nettles and Burks 1975;**[59]** Pedrosa-Macedo 1993;**[60]** Pereira-Colavite et al. 2018;**[61]** Plank 1929;**[62]** Ramirez 2018;**[63]** Reeves et al. 2000;**[64]** Ríos 2016;**[65]** Ríos 2020;**[66]** Ríos 2023;**[67]** Rodrigues et al. 1983;**[68]** Rodríguez-V et al. 1993;**[69]** Sabrosky 1981;**[70]** Salvato et al. 2009;**[71]** Salvato et al. 2012;**[72]** Sánchez and Raven 1989;**[73]** Santos et al. 2015;**[74]** Santos-Murgas et al. 2020;**[75]** Sauer 1946;**[76]** Sihezar 2020a;**[77]** Sihezar 2020b;**[78]** Sihezar 2020c;**[79]** Smith et al. 2007;**[80]** Stegmaier Jr. 1972;**[81]** Thompson 1946; **[82]** Toma 2010;**[83]** Toma et al. 2017;**[84]** Urtiaga 2007;**[85]** Vergara 1983; **[86]** Vickery 1915;**[87]** Weber et al. 2021;**[88]** Wilkinson et al. 2004

would have identified the species if that were the case. Other authors, such as Ribeiro (1954) and Silva et al. (1968), again mentioned the association between *W. quadripustulata* and *M. latipes*, only citing the study by Lima (1948). Guagliumi (1973) once again associated these two species in sugarcane in Northeastern Brazil, including an illustration of *W. quadripustulata* that he claims to have taken from "Walton 1925" but which is actually "Walton (1916), p. 8" and he must have been confused with the work of Allen (1925) which is only about *W. quadripustulata*. Due to these bibliographical inaccuracies and the associations between *W. quadripustulata* and *M. latipes* having been made in Brazil, we excluded it from the list, because according to O'Hara et al. (2020), *W. quadripustulata* has a Nearctic, Palaearctic, and Oriental (China) distribution and "all citations in the Neotropical Region" are misidentification. Therefore, the references on the associations between representatives of *Winthemia* and *M. latipes* made in Brazil must be revised. In this sense, in addition to the erroneous citation of *W. quadripustulata*, the studies cite another species belonging to the same genus (Mendonça Filho 1972; Guimarães 1977; Santos 1989).

In the same way, Fonseca (1934, p. 284) recorded the parasitism of *M. repanda* (=*M. latipes*) by a species identified as *Sarcophaga chrysophora* Schiner (*ipsis litteris*) in São Paulo, Brazil. However, this taxon name had not been formally described in the literature, likely originated from erroneous records in earlier publications, such as *Sarcophaga chrysophora* Schiner (Lima 1922, p. 164; Carvalho 1941) and *Sarcophaga chrysophora* Sahiner (Pio Correa 1926). Lima (1948), citing prior studies, possibly to correct the species name, changed it to *Sarcophaga chrysostoma* (Wiedemann, 1830) (=*Peckia* (*Peckia*) *chrysostoma*). Despite this revision, the name *Sarcophaga chrysophora* persisted in later works (Bertels 1956; Gravena et al. 1985). Recent literature lacks reference to these early reports associating *P.* (*Peckia*) *chrysostoma* (Wiedemann, 1830) (Sarcophagidae) with lepidopteran hosts. Therefore, this species will not be considered in the present work.

Based on the characteristics shared in the different phylogenetic groups, we will consider each taxon, at the species or genus level, associated with *M. latipes*, making comments related to biology, distribution, and importance for natural balance, based on knowledge available in the literature.

Tachinidae

Dexiinae

Representatives of the genera *Cyrtophloeba* Rondani, 1856 and *Campylocheta* Rondani, 1859 (Dexiinae, Voriini) have been recorded parasitizing *M. latipes* (Sauer 1946; Cave 1992) (Table 1). Hosts known for species of these two genera are lepidopterans of different families, including Aegiriidae, Erebidae, Geometridae, Noctuidae, and Tortricidae (Arnaud 1978). Members of Voriini lay incubated eggs directly onto their hosts (Herting 1957; Stireman et al. 2006).

Exoristinae

Blondeliini The genus *Eucelatoria* Townsend, 1909 is composed of approximately 70 species (O'Hara et al. 2020). *Eucelatoria armigera* was associated with *M. latipes* in Cuba (Cardin 1915). However, the report of the association between *E. rubentis* and *M. latipes*, established by Sabrosky (1981), does not provide information on the collection site. Representatives of *Eucelatoria* are known as ovolarviparous, i.e., deposit incubated eggs directly into the hosts' body (Shekharappa and Jairao, 1988; Stireman et al. 2006). This ability to directly infect hosts with their larvae, associated with a wide variety of lepidopteran pest hosts (Guimarães 1977; Arnaud 1978) and the great parasitism capacity of several representatives, including *E. armigera* and *E. rubentis*, led some species to be studied for possible inundative release strategies aimed at managing lepidopteran pests in the USA (Jackson et al. 1969; Bryan et al. 1970; Bratti and Nettles 1992; Gross and Rogers 1995; Reitz and Adler 1996).

Eryciini The genus *Lespesia* Robineau-Desvoidy, 1863, also represented by approximately 70 species (O'Hara et al. 2020), has five species associated as parasites of *M. latipes* (Table 1). These species have a broad host range, especially Lepidoptera, including several families (Table 1). The success of Eryciini is associated with parasitism that relies on incubated eggs oviposited directly on the cuticle of their hosts (Stireman et al. 2006). Seconds after oviposition, the maggot hatches and pierces the host, leaving behind the collapsed chorion that covers the entry point and serves to seal the wound and minimize the loss of host body fluid, initiating the development process inside the parasitized insect (Bryan et al. 1968; Etchegaray and Nishida 1975). Despite the great diversity and importance of representatives of this genus in the control of several species of lepidopteran agricultural pests (Guimarães 1977; Arnaud 1978; Gurrola-Pérez et al. 2018), with up to 65% parasitism (Cardoza et al. 1997), relatively few studies have been carried out to enable laboratory breeding and possible use in biological control programs (Bryan et al. 1968; Etchegaray and Nishida 1975; Cardoza et al. 1997). In addition to the high parasitism rates, there is the specific case of *L. archippivora*, which was introduced to Hawaii to increase natural biological control and can be found parasitizing several lepidopterans on the various islands of the archipelago (Lai 1988). In this sense, Sabrosky (1980) reports that the genus *Lespesia* is among

the largest and most important ones within Tachinidae in the Western Hemisphere. It should be noted that, from the five species of the genus *Lespesia* associated with *M. latipes*, *L. affinis* and *L. lata* are distributed and have observations concentrated in South America, and the others, *L. aletiae*, *L. archippivora*, and *L. parviteres*, have a greater number of associations in North and Central America (O'Hara et al. 2020) (Table 1).

Exoristini The genus *Chetogena* Rondani, 1856, like the previous ones, is quite diverse and contains approximately 70 species (O'Hara et al. 2020). Some of its representatives present the greatest diversity of arthropod hosts, including species such as *C. claripennis* and *C. scutellaris*, also associated with *M. latipes* (Table 1). Like the other representatives of Exoristiini, *Chetogena* females can locate their hosts in the most diverse locations and oviposit their unincubated planoconvex eggs directly on the hosts (Stireman et al. 2006). Because incubation is external, their eggs (and "unincubated larvae") can be eliminated during the ecdysis of their hosts. Thus, to increase the success of parasitism, their representatives need to oviposit in the last instars of the hosts, when the intermolt period is longer (Sourakov and Mitchell 2002). Despite the relatively high success (close to 50%) of *C. scutellaris* parasitism in some species of Noctuidae in the laboratory (Sourakov and Mitchell 2002) and the undeniable biological importance regarding the parasitism of several arthropods in nature (Guimarães 1977; Arnaud 1978), there are no studies on the viability of production and use of *Chetogena* representatives for pest management in the field.

Goniini In the tribe Goniini, six species belonging to six distinct genera were found associated with *M. latipes*: *A. brasiliensis*, *B. bicincta*, *C. hedemanni*, *G. crassicornis*, *H. blanda*, and *P. similis* (Table 1). The tribe is formed by species whose primary oviposition strategy is indirect. They deposit thousands of microscopic eggs on plants where the host insects possibly ingest them accidentally (Stireman et al. 2006).

The genus *Atacta* Schiner, 1868 is represented by only four species, of which *A. brasiliensis* has the widest distribution in the American Continent (O'Hara et al. 2020). The first report of *A. brasiliensis* parasitizing *M. latipes* was done by Aldrich (1925) in the Chiriqui Province, Canal Zone, Panama. However, in recent decades, this association has been reported in several locations in Brazil (Mendonça Filho 1972; Guagliumi 1973; Gonçalves and Gonçalves 1974; present work) and Central America (Maes 1989; Cave 1992; Saunders et al. 1998). Although there are relatively few reports of *A. brasiliensis* hosts, it is noted that this tachinid parasitizes both caterpillars found in open habitats and herbaceous plants, such as *M. latipes*, and caterpillars found in closed formations in the tree canopy, such as *Coenipeta bibitrix* (Hübner, 1823) (Ríos 2020).

The genus *Belvosia* Robineau-Desvoidy, 1830 contains more than 70 species (O'Hara et al. 2020). Its species are generally large flies, associated with Lepidoptera from several families, especially Bombycoidea and Sphingoidea (Guimarães 1977; Arnaud 1978), but *B. bicincta* is associated with *M. latipes* as well as other Lepidoptera belonging to different families (Table 1). A possible explanation for the greater number of "large" Lepidoptera (Bombycoidea and Sphingoidea) being parasitized by these flies can be attributed to the larger leaf area consumed by their larvae, increasing the chance of ingesting the micro eggs. However, there are also several other factors to be considered in the strategies related to host findings, used by the flies so that oviposition is carried out in order to obtain greater success in infecting the hosts, including volatiles from plants, caterpillars, etc. (Stireman et al. 2006).

The genus *Choeteprosopa* Macquart, 1851 is formed by only five species, and *C. hedemanni* is known in Central America, Mexico, and Panama (O'Hara et al. 2020) and the USA (Crumb 1929). Saunders et al. (1998) record the occurrence of the association between *C. hedemanni* and *M. latipes*. However, it was not possible to track the original source of the information. Although there is no biological information, like the other representatives of Goniini already reported, their females must lay eggs (microtype) that are ingested by the hosts, together with the tissues of the host plants. Although the literature associates *C. hedemanni* only with *M. latipes*, *Spodoptera eridania* (Stoll, 1782), and *S. ornithogalli* (Guenée, 1852) (Noctuidae) (Aldrich 1925; Crumb 1929; Saunders et al. 1998) (Table 1), the host range is probably much broader.

The genus *Gonia* Meigen, 1803 is composed of just over 60 species (O'Hara et al. 2020). The association between *M. latipes* and *G. crassicornis* was established in Scaramuzza (1946), in Cuba, cited by Arnaud (1978). Several representatives of the genus *Gonia* are associated, especially with pest noctuoids (Guimarães 1977; Arnaud 1978). Although there are no specific studies focused on their use in inundative biological control programs, the high fertility and the fact that species such as *Gonia cinerascens* Rondani , 1859 can be produced on alternative hosts easily reared in the laboratory and/or cultivated in vitro (Baronio and Sehnal 1980) highlight the possibilities of *Gonia* species in biological control programs.

The genus *Hyphantrophaga* Townsend, 1892 is composed of 15 species (O'Hara et al. 2020). The three best-known species, including *H. blanda*, associated with *M. latipes* (Table 1), have dozens of known hosts (Arnaud 1978). Although the association of *H. blanda* with *M. latipes* has been established in Cuba (Scaramuzza 1946, cited by

Arnaud 1978), it should be noted that *H. blanda* is widely distributed throughout North America (O'Hara and Wood 2004). Larvae of *H. blanda* can emerge from larvae or pupae of their hosts, generally abandoning the host soon after development. However, in overwintering species, the larvae leave their hosts only in the following spring. Generally, *H. blanda* is a solitary parasite, but there may be multiparasitism in large hosts (O'Hara 2005).

The genus *Patelloa* Townsend, 1916 has approximately 20 species (O'Hara et al. 2020). The species whose hosts are known are associated primarily with lepidopterans of agricultural or forestry importance (Guimarães 1977; Arnaud 1978). Studies have shown that representatives of *Patelloa* play an important role in the population control of some lepidopteran pest species (Parry 1995). The record of *P. similis*, a species restricted to South America (Argentina, Brazil, Paraguay, and Uruguay) (O'Hara et al. 2020), parasitizing *M. latipes* was made in Argentina (Blanchard 1963), and the few studies that relate this tachinid to lepidopterans indicate natural parasitism between 6% and 24.2% of caterpillars (Link and Diefenthaler 1979; Moraes et al. 1991).

Winthemiini The genus *Winthemia* Robineau-Desvoidy, 1830 encompasses more than 120 species (O'Hara et al. 2020), of which several have a long list of hosts, preferably lepidopterans (Guimarães 1977; Arnaud 1978). Even with the exclusion of the association between *W. quadripustulata* and *M. latipes* discussed above, it is certain that there are associations between species of *Winthemia* and *M. latipes* (Sauer 1946; Guimarães 1977; Mendonça Filho 1972) that still need to be reviewed and even described.

Regarding the importance of *Winthemia* species, adults oviposit unincubated eggs directly on the host larvae (Hébert and Cloutier 1990), but with high parasitism rates (Marcicano et al. 2009) that can reach 100% of the caterpillars, as described for armyworms in the USA (Allen 1925). This importance is amplified when the number of hosts (Guimarães 1977; Arnaud 1978), fecundity, and ecological plasticity are related, since, depending on environmental conditions, in certain species, the life cycle can vary from 2 weeks to 6 months (Allen 1925). The importance for managing some lepidopteran species drove studies and programs for introducing species such as *Winthemia occidentis* Reinhard, 1931, in Canada (Otvos 1973).

Tachininae

Ernestiini The genus *Linnaemya* Robineau-Desvoidy, 1830 represents more than 140 species (O'Hara et al. 2020), and it has two species associated with *M. latipes* (Table 1). *Linnaemya comta*, which can be considered pseudocosmopolitan and polyphagous, is associated with several species throughout its distribution area (Arnaud 1978; Cave 1992), and *L. fulvicauda*, of Neotropical distribution, appears to be restricted to the Greater Antilles, including Puerto Rico and Jamaica (O'Hara et al. 2020), only referred to as a host of *M. latipes* and *Helicoverpa zea* (Boddie, 1850) (Lepidoptera: Noctuidae) (Table 1). Very little is known about the biology of these species that are ovolarviparous (with incubated eggs) (Stireman et al. 2021). In some known species, females oviposit in locations near the host, which is infected by the vagile and motile first instar larva (Pohjoismäki and Haarto 2015).

Tachinini The genus *Archytas* Jaennicke, 1867 comprises approximately 100 species (O'Hara et al. 2020), most of which have been reported attacking lepidopterans. Of the two species already associated with *M. latipes* (Table 1), *A. incertus* is distributed in the Neotropics, including the Antilles and South America, while *A. marmoratus* is recorded throughout the American continent (O'Hara et al. 2020). Both species are recognized as important parasites of different lepidopteran pests (Blanchard and De Santis 1975; Guimarães 1977; Arnaud 1978). Females of *Archytas* and other Tachinini deposit incubated eggs on host plants close to the hosts (Stireman et al. 2006). Thus, the first instar maggots adhere to the larvae that pass by, entering them, where they complete their development, causing the death of the pupa (see details in Hughes 1975). The high capacity for depositing embryonated eggs and parasitism in species of this genus, especially *A. marmoratus*, determined the development of several biological studies (Hughes 1975), mass production and inundative releases for *H. zea* and *Spodoptera frugiperda* (Smith, 1797) (Lepidoptera: Noctuidae) control in maize (Gross 1988, 1990, 1994; Gross and Young 1984; Gross and Johnson 1985; Gross et al. 1996; Proshold et al. 1997; Carpenter and Proshold 2000). In the case of *M. latipes*, studies of this nature must be carried out so that the possibility of mass production and mass release for managing *M. latipes* can be evaluated, especially in areas where outbreaks are recurrent.

Sarcophagidae

The genus *Helicobia* Coquillett, 1895 is one of the most diverse genera of Neotropical Sarcophagidae, but only a few species have a known larval substrate (Pape and Dahlem 2010). They are generally carcass decomposers and have been associated with forensic entomology studies (Silva et al. 2023). The species *H. rapax* (Table 1) was associated with the parasitism of *M. latipes* on sugarcane for the first time in Puerto Rico (Jones and Wolcott 1922). Reports of parasitic association of *H. rapax* indicate a great diversity of invertebrate hosts (Table 1), and studies often question the real capacity of active infection of these hosts versus the simple "occupation" of weakened or injured hosts (Aldrich 1916;

Reeves et al. 2000; Giroux et al. 2022). Combined with the large number of reported hosts (Table 1), some reports on associations between *Helicobia* representatives and arthropods have reinforced behavioral and biological aspects that confirm the infection and parasitism capacity of these species (Bragança et al. 2020) and perhaps biology and behavior studies can better unravel the role of representatives of these sarcophagids on host populations. They can be considered "useful" insects for managing pests such as *M. latipes*.

The genus *Oxysarcodexia* Townsend, 1917 is restricted to the American Continent and comprises about 90 small- to medium-sized species (Pape and Dahlem 2010). Its representatives include coprophagous species, predators (larvae preying on larvae of other flies), myiasis-causing species in different vertebrates (Pape 1996), and many species associated with vertebrate carcasses, with forensic importance (Lopes et al. 2018; Paseto et al. 2019). The association between *O. aura* and *M. latipes* was established by Sauer (1946) by flies that emerged from pupae obtained from caterpillars collected in rice in Conchal, São Paulo, on 18/ii/1941, identified by the species describer Dr. David G. Hall (USDA-USA). Although no other associations between *O. aura* and insects have been reported, the literature reports that some representatives of *Oxysarcodexia* have highly diversified larval associations. *Oxysarcodexia varia* (Walker, 1836) larvae usually associate with dung (Hernandez 1989; Mendes and Linhares 2002) and adults are largely attracted to and oviposit on feces baits, being considered synanthropic in rural areas (Ferreira 1979; Mariluis et al. 2007; Mulieri et al. 2008, 2010). However, it is also known to parasitize live and dead grasshoppers (Blanchard 1933, 1939). Thus, it is likely that representatives of *O. aura* use *M. latipes* caterpillars and other insects sporadically, depending on availability.

The genus *Peckia* Robineau-Desvoidy, 1830 is distributed throughout the New World and includes flesh-flies, generally large, that usually reproduce in excrement (Marchiori et al. 2010), carrion (Oliveira-Costa et al. 2001; Barros et al. 2008), and can attack living organisms such as vertebrates, causing myiasis in humans, livestock (Neiva and Faria 1913; Almeida 1933; Guimarães et al. 1983; Hall and Wall 1995; Fernandes et al. 2009), several vertebrate animals in nature (Fessl et al. 2001; Hagman et al. 2005; Buenaventura et al. 2009; Bermúdez et al. 2010) and several invertebrates (Table 1), and can be considered a facultative parasitoid (Coupland and Barker 2004; Toma et al. 2017).

General discussion of what the survey represents

Tachinids have been considered one of the most important groups of pest biological control agents, as they are natural enemies of primarily phytophagous groups (Gudin and Messas 2018) in natural environments and managed ecosystems (Stireman et al. 2019). Their impact on host populations is generally reported to be between 10 and 25%, but in some situations, it can exceed 75% (Marcicano et al. 2009; Wagner et al. 2011), with reports of up to 100% (Allen 1925). The rates are certainly underestimated since reports, as in the present study, are generally made sporadically based on observations of a fraction of individuals in the host population. In the case of associations with *M. latipes*, the existence of 21 named species, of three taxa still identified only at the genus level (Table 1), and several species not identified in different studies (Mendonça Filho 1972; Gonçalves and Gonçalves 1974; Guimarães 1977; Arnaud 1978; Lourenção et al. 1982; Santos 1989; Cave 1992) indicates the diversity of these parasites associated with each of the species. Furthermore, it is important to highlight that most of the listed tachinids have already been found parasitizing several species of Lepidoptera, which can be found in entirely different environments, such as *A. brasiliensis* and *B. bicincta*, which were recovered from *M. latipes*, typically found in herbaceous grasses, and *C. bibitrix*, whose larvae are found in arboreal Fabaceae in forested areas (Ríos 2020). Other examples can be seen, such as *C. claripennis*, which, in addition to *M. latipes*, is associated with dozens of other groups, at the level of orders and families, which have epigean habits, most of the species, or hypogean habits, such as *Agrotis* Ochsenheimer, 1816 and *Feltia* Walker, 1856 (Table 1).

The ability to parasitize different organisms in different habitats allows these parasitic flies to maintain their populations over time in different ecosystems, despite the spatiotemporal variability in the availability of their hosts, surviving periods of low availability of optimal hosts. Relatively few species of Tachinidae associated with agricultural pests enter diapause under adverse conditions (Han et al. 2022), accompanying their hosts in diapause. Generally, tachinids that enter diapause are species specialized in synchronizing their cycle to parasitize a host species with a very regular phenology (Pohjoismäki and Haarto 2015). Even in marked climatic variations where hosts enter diapause, species such as *A. marmoratus* (Table 1) do not undergo diapause (Proshold and Carpenter 1999), depending on alternative hosts to maintain their populations in adverse seasons. The distribution of *M. latipes* is predominantly associated with tropical, subtropical, and, to a lesser extent, temperate climates (Claudino et al. 2021). Consequently, the condition that the parasitic dipterans associated with it encounter is a great diversity of native hosts (and alternative hosts in anthropized areas) with gaps in availability, especially in areas cultivated with non-suitable (non-graminaceous) plants or with high use of agrochemicals. Naturally, different factors modulate the variations in the availability of hosts throughout the distribution areas, especially dry and rainy seasons in tropical

zones (Janzen 1987) and periods of intense cold in subtropical and temperate zones (Claudino et al. 2021).

In addition to the unquestionable importance of the role of flies, together with other natural enemies, in maintaining the population densities of host insects in equilibrium in native areas (Stireman et al. 2006), the present study highlights their contribution to the biological control of species associated with plants cultivated by humans, such as *M. latipes* in different crops of forage grasses and others of high commercial value such as barley, maize, oat, rice, sorghum, sugarcane, and wheat. In this sense, the present study relates to *M. latipes*; however, the analysis of Table 1 (even without relating species not reported attacking *M. latipes*) reveals that these same species of flies (collected in the most diverse hosts associated with different plants in different environments—see references of Table 1) parasite several other species of great agricultural importance, such as *Alabama argillacea* (Hübner, 1823), *Anticarsia gemmatalis* Hübner, 1818, *Agrotis ipsilon* (Hufnagel, 1766), *Chrysodeixis includens* (Walker, 1858), *Chloridea virescens* (Fabricius, 1777), *Hypena scabra* (Fabricius, 1798), *H. zea*, *Mythimna unipuncta* (Haworth, 1809), *S. eridania*, and *S. frugiperda*.

This all indicates that, for each assembly of insects (Lepidoptera) associated with native or cultivated vegetation in a given location, there is expected to be a corresponding assembly of natural enemies (including parasitoid Diptera), which oscillates temporally and spatially depending on abiotic variations (especially climatic) and host availability. In the case of *M. latipes*, the occurrence of cyclical population outbreaks is associated, especially in areas occupied by native and/or cultivated grasses, with their great capacity for dispersion and migration (Ferguson et al. 1991; Brou Jr. 2004; Krauel et al. 2018; Alves et al. 2019), high biotic potential (Labrador 1964; Reinert 1975; Cruz and Santos 1983; Ferreira and Parra 1985; Silva and Carvalho 1986; Silva et al. 1991; Piedra and Carrilo 1999; Wagner et al. 2011), and olygophagy (mainly Poaceae). This allows *M. latipes* to occupy new locations with suitable plants and disseminate its progeny over vast areas covered with graminaceous plants. In areas where plants significantly develop in response to seasonal events such as the beginning of the rainy season, with a still small number of natural enemies, or in places where pest management is restrictive to the use of products that limit the occurrence of natural enemies, *M. latipes* populations find ideal conditions for their full development until their biological controllers grow in sufficient number and diversity to reduce their populations.

The interspecific relationships among *M. latipes* and its associated dipteran parasitoids represent a vast compilation of knowledge that has involved many observations and researchers for over a century. The available data can be compared to space-time photographs that can be combined to explain, at least in part, the interactions. However, gathering this knowledge reveals the enormous gap in information still needed to understand the real importance of natural biological control and the potential of applied biological control. Again, it is worth emphasizing that this is a small portion of parasitoid organisms. All other parasites, all groups of predators, and microorganisms (viruses, bacteria, fungi, and nematodes) are still missing. Thus, in nature, the number of interactions between a lepidopteran species and its natural enemies is infinitely greater. Considering the current ease of interaction and movement, it is important to increasingly encourage researchers from different groups to come together to develop broad, multidisciplinary projects to synergize results. In this sense, researchers, research institutions, and funding institutions should be made aware of the need for comprehensive projects capable of producing more consistent results, involving researchers from different areas (taxonomists, biologists, geneticists, ecologists, agronomists, botanists, meteorologists, etc.) with the goal of understanding at least as much as possible most of the biological interactions within ecosystems or agrosystems, including parasitoid dipterans.

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Declarations

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