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SYSTEMATICS, MORPHOLOGY AND PHYSIOLOGY

Feltia submontana (Noctuidae, Noctuinae): Redescription, Taxonomy, Life Cycle, and Spatial Distribution of a Neglected South American Potential Pest Species

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Abstract

Feltia submontana (Köhler, 1961) is redescribed based on specimens from Northwestern Argentina and Central and Southeastern Brazil. Taxonomic comments, photographs of the adults, characters of taxonomic importance, and illustrations of structures of the labial palpus, legs, and male and female genitalia are provided. The species is compared with similar-looking and supposedly closely related species, such as *F. hispidula* (Guenée, 1852) and *F. lilacina* (Zerny, 1916). The species, originally described for Argentina, is reported for Brazil for the first time. Most Brazilian specimens come from the "Cerrado" but also from Southeastern Atlantic Forests. The life cycle of *F. submontana* specimens collected in Planaltina, Distrito Federal, Brazil, is described; the species probably has only a single generation per year and imagines are on the wing in the late autumn and early winter months; the last instar prepupa and pupa pass through aestival diapause. The abundance of *F. submontana* relative to other species of *Agrotis* Ochsenheimer, 1816, and *Feltia* Walker, 1856, in the above-cited locality is accessed through 4 years of standardized collecting with light trap; the species is the second most abundant species of these genera in the area, with about one fifth of the captures, second only to *A. ipsilon* (Hufnagel, 1766), with about two thirds of the captures, and about two times more abundant than *F. subterranea* (Fabricius, 1794); the latter two are regarded as important pest species in South America.

Introduction

Feltia Walker, 1856, is a genus of owlet moths widely distributed throughout the Nearctic and Neotropical Americas (Lafontaine 2004, San Blas 2014), of a group of moths popularly known as "cutworms" in the USA and Canada, "cortadoras" in Spanish Latin America, and "lagartas-roscas" in Brazil (Costa Lima 1950). Most species currently included in *Feltia* were associated with species of the large and cosmopolitan *Agrotis* Oschenheimer, 1816, a genus that served as a catch-all to lump several species of agrotine moths.

Even though Poole (1989) synonymized several genera with *Agrotis*, he recognized *Feltia* as valid, but included in the genus only 11 species of exclusively Nearctic distribution. Lafontaine (2004), revising the Nearctic Agrotini, recognized *Trichosilia* Hampson, 1918, as a subgenus of *Feltia* and included in the nominate subgenus a number of Neotropical

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species formerly included in *Agrotis* by Poole (1989), in addition to the Nearctic species. Lafontaine (2004) distinguished the subgenus *Feltia* from *Trichosilia* by the relatively long, thin clasper; the apically expanded, foot-shaped cucullus of the male; the apically enlarged uncus; the male doubly biserrate antenna present in most species; and the larvae epicranial suture very reduced or absent.

Lafontaine (2004) further recognized two species groups in the subgenus *Feltia*: the Nearctic "*subgothica*-group," with long, saber-like papilla analis and streaked forewing patterns; and the mostly Neotropical "*subterranea*-group," with bullet-shaped papilla analis and an *Agrotis*-like appearance. The lack of a spiny subbasal bar and a sclerotized band on the vesica, the longer ampulla and clavus, and the doubly biserrate or doubly bifasciculate antenna distinguishes species of the "*subterranea*-group" from species of *Agrotis* (Lafontaine & Fibiger 2004).

San Blas (2014), revising the South American *Agrotis*, studied all names (sensu Poole 1989) occurring in the area, including those previously combined with *Feltia* by Lafontaine (2004). San Blas (2014) further transferred to *Feltia* several other taxa formerly included in *Agrotis* by Poole (1989). Therefore, the subgenus *Feltia* currently comprises 36 species: six restricted to the Nearctic, 28 restricted to the Neotropics and two widely distributed in both realms.

Feltia submontana (Köhler, 1961), a little-known taxon originally described from Argentina, was one of the species transferred to *Feltia* from *Agrotis* by San Blas (2014). San Blas (2014) further recognized *F. maldonadoi* (Köhler, 1961), also described from Argentina, as a junior subjective synonym of *F. submontana*. This species is superficially similar to several other species of the genus, including the widespread and abundant *F. subterranea* (Fabricius, 1794).

Although *F. submontana* was further cited and illustrated by Köhler (1967), there is no additional data about the species elsewhere. Therefore, the aim of this paper are to redescribe *F. submontana*, providing taxonomic comments, distribution maps, illustration of head, thorax and its appendages and male and female genitalia, comparing it with supposedly closed related species; to describe its life cycle under controlled conditions; and its abundance relative to other species of *Feltia* and *Agrotis* occurring in central Brazil.

Material and Methods

Taxonomy

Specimens examined are deposited in the following collections: **EMBRAPA:** Coleção Entomológica da Embrapa Cerrados, Planaltina, Distrito Federal, Brazil; **ESALQ/USP:** Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Piracicaba, Brazil; **DZUP:** Coleção Entomológica Padre Jesus Santiago Moure, Curitiba, Brazil; **HT:** Coleção Hubert Thöny, Camacan, Brazil; **IFML:** Instituto y Fundación Miguel Lillo, Tucumán, Argentina; **IPCN:** former Instituto Patagónico de Ciencias Naturales, now on loan to the Instituto Argentino de Investigaciones de las Zonas Áridas, Mendoza, Argentina; **MZUSP:** Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil; **OUMNH:** Oxford University Museum of Natural History, Oxford, United Kingdom; **VOB:** Coleção Vitor Osmar Becker, Camacan, Brazil; **USNM:** National Museum of Natural History, Washington D.C., USA.

Dissected specimens (marked with an asterisk in the Material Examined section) had their body parts detached and soaked in 10% potassium hydroxide solution in a test tube heated in a bain-marie in a beaker for approximately 5–10 min; the abdomen was further dissected and the genitalia removed. All dissections were kept in glycerin in vials with the dissected specimen.

The genitalia were examined under a stereoscopic microscope, and illustrations were prepared with the aid of a camera lucida and digital photographic camera attached to the stereoscopic microscope, by focus stacking system. In the illustrations full lines represent sclerotized structures, thinner full lines membranous structures, dashed lines structures visible through transparent body parts, and dotted lines areas of different sclerotization. The valva was flattened for examination and illustration. Scale bars are provided for all illustrated structures.

As males and females are generally similar, the diagnosis and the description were based on males, except for the few features that are sexually dimorphic. The terminology of Lafontaine (2004) is employed for structures of the genitalia and areas and elements of wing pattern. Higher level taxonomy follows Lafontaine & Schmidt (2010) and Zahiri *et al* (2011); genus- and species-level taxonomy follows Lafontaine (2004) (Nearctic taxa) and San Blas (2014) (Neotropical taxa); the diagnosis of the "*subterranea*-group" follows San Blas (2014, 2015). Distribution maps were prepared in SimpleMappr (Shorthouse 2010), extrapolated from the georeferenced labels of examined specimens.

Standardized Collections

To access the abundance of *F. submontana* relative to other species of *Agrotis* and *Feltia*, specimens were collected at the Estação Experimental da Embrapa Cerrados (Embrapa Cerrados Experimental Station), in Planaltina, Distrito Federal, Brazil (15°35′30″S, 47°42′30″W, 1007 m). The area is located in the Brazilian Savanna, also known as the "Cerrado" (Ab'Saber 2003), where the climate is characterized by a dry and mild season that starts in May and ends in September and a hot and rainy summer (Silva *et al* 2014); the crop season starts in July and ends in June of the following year.

Imagines were attracted to a "Pennsylvania" light trap (Frost 1957) set with a black fluorescent light model BL T8 15W (Tovalight), with wavelengths varying between 290 and 450 nm, peaking around 340 nm. A plastic cone was attached to the lower portion of the trap, with the widest diameter of 32 cm and narrowest of 16 cm, to which a plastic bucket with three liters of 96% ethanol was attached. The trap was set on a pole 3.5 m above the ground and lit for 12 h a day from sunset to sunrise. The trap was lit monthly for 5 days at and about the new moon (Zanuncio *et al* 1995) during 4 years, totaling 48 collection events from July 2013 to June 2017. The month of November 2013 was excluded from the analyses, as the excess rainfall and the large number of specimens of Coleoptera, Hymenoptera and Isoptera attracted to the trap damaged the specimens preventing species identification.

Specimens of *Agrotis* and *Feltia* were retained and identified; representative specimens of each taxon were mounted on insect pins and deposited at the EMBRAPA as vouchers; some specimens will be also deposited at the DZUP.

Life Cycle

The life cycle data was accessed from four females caught in a "Luiz de Queiroz" light trap (Silveira Neto & Silveira 1969), in May 2016, in Planaltina, Distrito Federal, Brazil (15°36′24.52″S, 47°44′42.45″W, 1169 m). Each female was maintained inside cylindrical plastic containers (10 cm in diameter and 15 cm high), stopped by plastic film at the top and a Petri dish lined with filter paper at the bottom; long filter paper strips were attached to the sides of the cylinder to stimulate oviposition. Imagines diet was composed of honey (10 g), sorbic acid (p.a. Sigma-Aldrich) (1 g), methylparaben (p.a. Sigma-Aldrich) (1 g), sucrose (p.a. Merck) (60 g), and distilled water (1000 ml) (Hoffmann-Campo *et al* 1985) and kept under refrigeration (7°C) until use. Pilsner beer was added to the solution daily in the proportion of 1:4 and made available to the imagines in a 5-cm Petri dish lined with cotton wool. Additionally, autoclaved water was provided in another 5-cm cotton-lined Petri dish. Containers were examined daily to record adult survival and to remove the eggs and to count their numbers.

The viability and duration of 626 eggs from three of the females collected in light trap were evaluated. Eggs were individually placed into Petri dishes (10-cm diameter and 1.5-cm height) lined with filter paper moistened with distilled water until eclosion. Larval development and duration was evaluated observing 275 hatched first instars. The artificial diet used to rear the larvae was adapted from Greene *et al* (1976), according to Montezano *et al* (2013, 2014, 2015).

First instars were placed in individual plastic containers (300 ml) with a small wad of cotton (~1 cm in diameter) moistened with distilled water and a ~1 cm^3 piece of artificial diet, both were replaced daily. Larvae were observed daily for development and duration. When reached the prepupal period, characterized by a decrease in size and feeding, the larvae were transferred to a translucent plastic container, with 10-cm diameter and 5-cm height filled with expanded vermiculite moistened with distilled water. The prepupa builds its pupal chamber by the wall of the container, allowing keeping record of the development and duration of the prepupae without disturbing the prepupal chamber. Pupae were kept in the same container and under the same conditions as the prepupae. Moisture was controlled daily. Sex determination was performed on the second day after pupation, when the cuticle was further hardened.

Imagines were kept in pairs ($n = 10$) in the same cylindrical plastic containers and diet as females collected in field. The observed fecundity (number of eggs laid per female), and longevity for females and males, the duration of the pre-oviposition, post-oviposition, and oviposition periods were recorded. All biological parameters and immature stages durations were analyzed using descriptive statistics, means and standard deviations. Some means were compared using a t test assuming unequal variances, at a significance level of 5%.

Results and Discussion

Taxonomy

***Feltia submontana* (Köhler, 1961)** (Figs 1a, b, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11).

Agrotis submontana Köhler, 1961, p. 73.—Köhler 1967, p. 318, fig. 48.— Poole 1989, p. 57.

Agrotis maldonadoi Köhler, 1961, p. 73.—Köhler 1967, p. 329, fig. 49.—Poole 1989, p. 51.

Feltia lilacina [misidentification]; Silveira Neto 1972, p. 71, 94.

Feltia submontana; San Blas 2014, p. 9; ***syn.***: *maldonadoi*.

Type locality. Agrotis submontana Köhler, 1961, holotype female from San Pedro de Colalao, Tucumán, Argentina (see below); paratypes females from San Pedro de Colalao, Tucumán, Argentina and Aguaray, Salta, Argentina. *Agrotis maldonadoi* Köhler, 1961, holotype and paratypes male from Aguaray, Salta, Argentina.

Type material. Feltia submontana (Köhler) holotype female with the following labels (Fig 1a): /ALOTIPO /Tucumán, S[an] Pedro de Colalao, XII.54 /*submontana* K., DET. KOEHLER /Ex. Colección P. Koehler /TLEP283 /, deposited at the IFML; two females paratypes, with the following labels: /PARATYPUS /Tucumán, S[an] Pedro de Colalao, 22.IV.1961 /*submontana* K., DET. KOEHLER/ Ex. Colección P. Koehler /, deposited at the IFML; paratypes from Aguaray, Salta, collected in

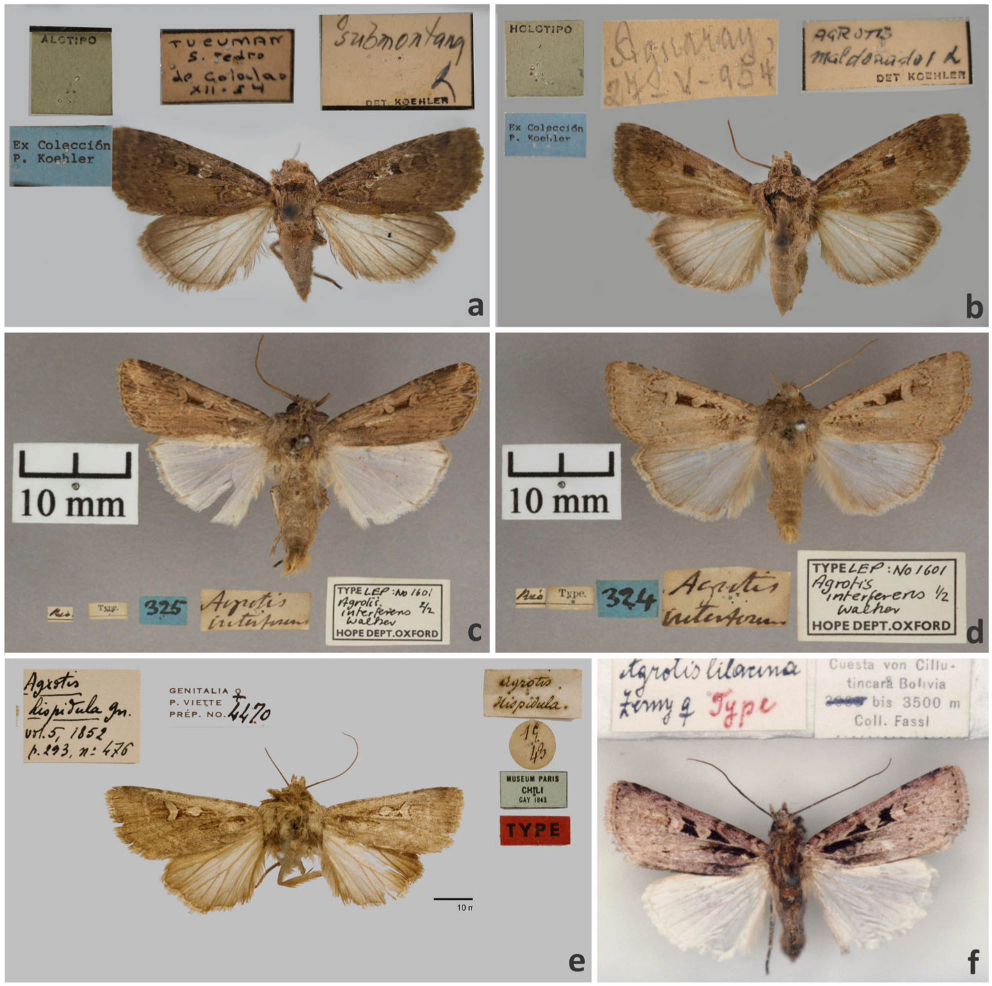

Fig 1 Type specimens and associate labels of species of *Feltia* Walker, 1856 similar to *Feltia submontana* (Köhler, 1961), dorsal (**a**), holotype (mistakenly labeled "allotype", see text) of *Agrotis submontana* Köhler, 1961 (**b**), holotype of *A. maldonadoi* Köhler, 1961 (**c**), lectotype of *A. interferens* Walker, 1858 (**d**), supposedly female syntype of *A. interferens* Walker, 1858, which is conspecific with *F. submontana* (Köhler, 1961) (see text) (**e**), *A. hispidula* Guenée, 1852, holotype (**f**), *A. lilacina* Zerny, 1916, holotype.

20.V.1959 not located. *Feltia maldonadoi* (Köhler) holotype male with the following labels (Fig 1b): /HOLOTIPO /Aguaray, 27-V-954 /*Agrotis maldonadoi* K, DET KOEHLER /Ex. Colección P. Koehler /TLEP266 /, deposited at the IFML; paratypes not located.

Diagnosis. Feltia submontana (Fig 2) differs from other South American congeners by the following combination of characters: beadlike, doubly bifasciculate antenna; forewing subterminal area with small creamy white spots over the veins, close to postmedial line; male genitalia

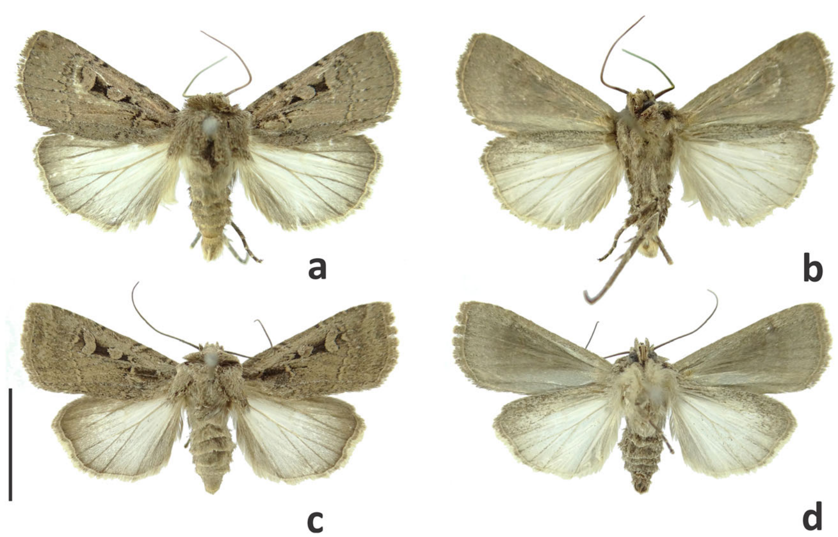

Fig 2 *Feltia submontana* (Köhler, 1961), dorsal and ventral, male (**a**, **b**) and female (**c**, **d**). Scale bar = 1 cm.

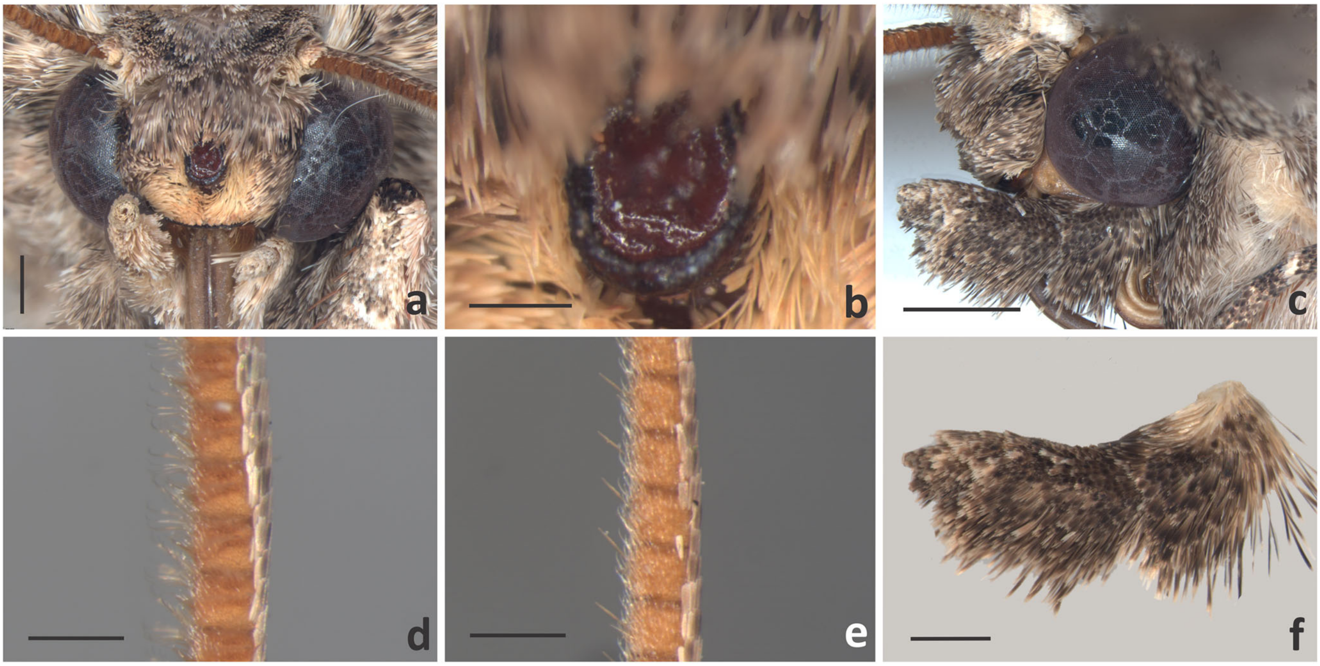

Fig 3 *Feltia submontana* (Köhler, 1961), head and appendages (**a**), head, anterior (**b**), frontal tubercle (**c**), head, lateral (**d**), male antenna, ventral (**e**), female antenna, ventral (**f**), labial palpus, lateral view. Scale bars: **a**, **f** = 0.5 mm; **b**, **d**, **e** = 0.2 mm; **c** = 1 mm.

with vesica two times as long as aedeagus, with subbasal, median, and apical diverticula differentiated, without cornuti; female genitalia with appendix bursae slightly larger than corpus bursae, corpus bursae without signa.

Redescription

Head (Figs 3 and 5a): vertex grayish brown, some creamy white at the tips; frons similarly colored, but yellowish and creamy white ventral to the frontal tubercle,

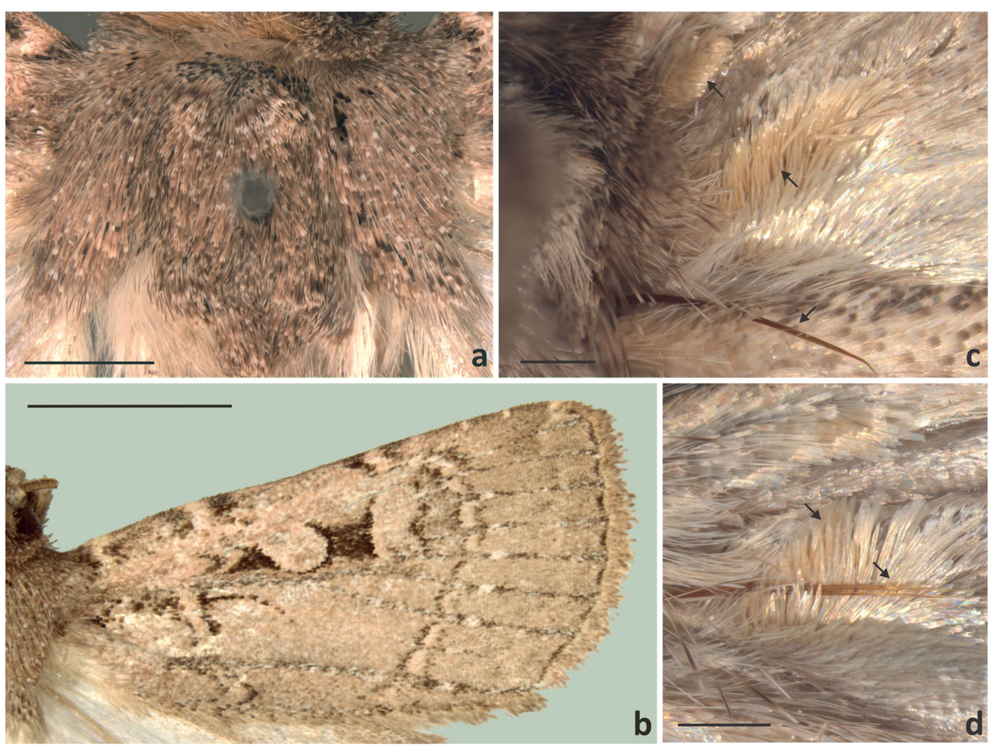

Fig 4 *Feltia submontana* (Köhler, 1961), thorax and wings (**a**), thorax, dorsal (**b**), forewing wing, dorsal (**c**), male wing coupling (**d**), female wing coupling. Scale bars: **a** = 2 mm, **b** = 5 mm, **c**, **d** = 0.5 mm.

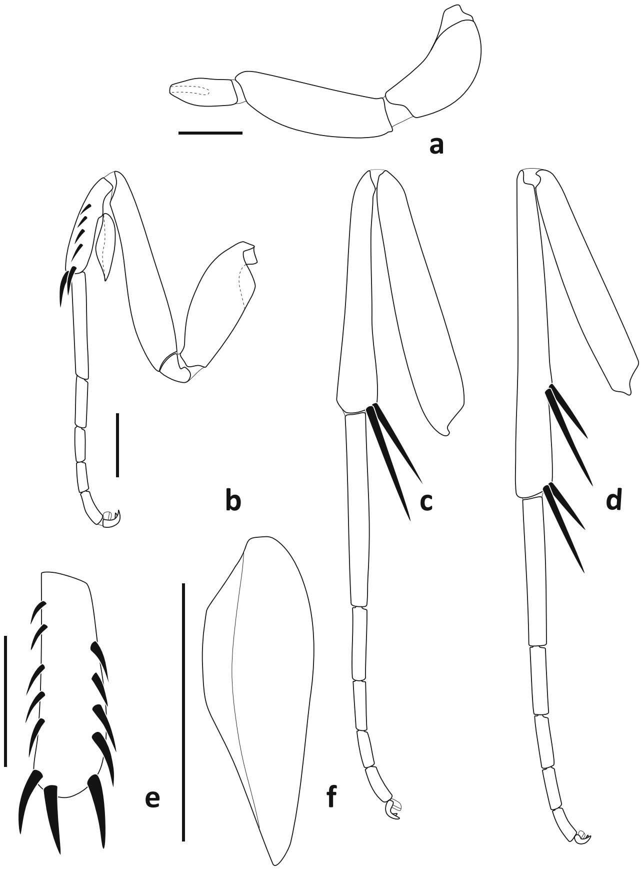

Fig 5 *Feltia submontana* (Köhler, 1961), palpus and legs (**a**), labial palpus, lateral (**b**), male foreleg (**c**), male mid leg (**d**), male hindleg (**e**), foreleg tibia, anterior (**f**), foreleg epiphysis, lateral. Scale bar: **a** = 0.5 mm, **b**–**f** = 1 mm.

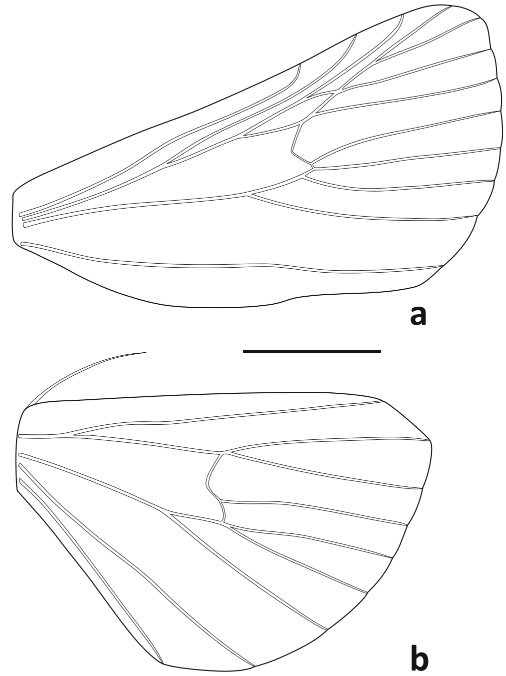

Fig 6 *Feltia submontana* (Köhler, 1961), wing venation (**a**), forewing (**b**), hind wing. Scale bar = 0.5 cm.

tubercle naked, ellipsoidal, flat and ridged, with a central bulge; compound eyes naked, mostly dark brown with brown reticulations; male antenna beadlike, about three fifths the length of the costal margin, scapus and pedicellus covered by grayish brown and creamy white, antennomers slightly tapering towards the tip of the antenna, ventrally naked, dorsally covered by grayish brown and creamy white, doubly bifasciculate; labial palpus grayish brown, some creamy white at the tip, first segment creamy white at the base, first and second segments thick and slightly curved, the latter slightly longer than the former, inner area of first segment rough, with fine scales, third segment oblong, pointed distally, narrower and about half the length of the first segment, vom Rath organ about half of the length of the third segment. Female as in male, but antenna filiform, with bristles.

Thorax (Fig 4a). Patagium, tegula, and meso- and metathorax dorsally grayish brown, some creamy white at the tips; metathorax posteriorly creamy white; thorax ventrally lighter than dorsally, creamy white. Female as in male.

Legs (Fig 5b–f). Mostly grayish brown, speckled with darker and lighter scales, creamy white distally; foreleg coxa thicker than other coxae; trochanter small and curved; femur one and a half longer than the coxa, smooth; tibia dorso-ventrally flattened, about half the length of the femur, wider in anterior view, with strong lateral and distal spines, epiphysis about two thirds the length of the tibia; midleg femur slightly longer than the tibia, smooth; tibia distally wider and with a pair of spines, the outer two thirds the size of the inner; hindleg femur two thirds the length of the tibia, about the same size of the midleg tibia, smooth; tibia with two pairs of spines, one in the distal two thirds and one distal, outer spines about half the size of the inners; mid- and hind femora, and all tibiae and tarsi with three somewhat regular rows of ventral spines, tibiae and first tarsomeres also with sparse additional outer spines; tarsal claws bifid. Female as in male.

Wings size, shape, and venation (Figs 2, 4b–d, and 6). Average size of males 1.3 cm (1.1–1.5 cm; n = 107) and females 1.4 cm (1.2–1.6 cm; n = 47) (measured from the base to the apex of the forewing); wings shape and venation similar to other agrotines.

Forewing, upperside (Figs 2a, c and 4b). Ground color mostly grayish brown with silvery hues; veins slightly marked by speckled darker and lighter scales; basal, antemedial and medial lines as three pairs of dark brown lines along the costal margin to the Subcostal vein; antemedial line doubled,

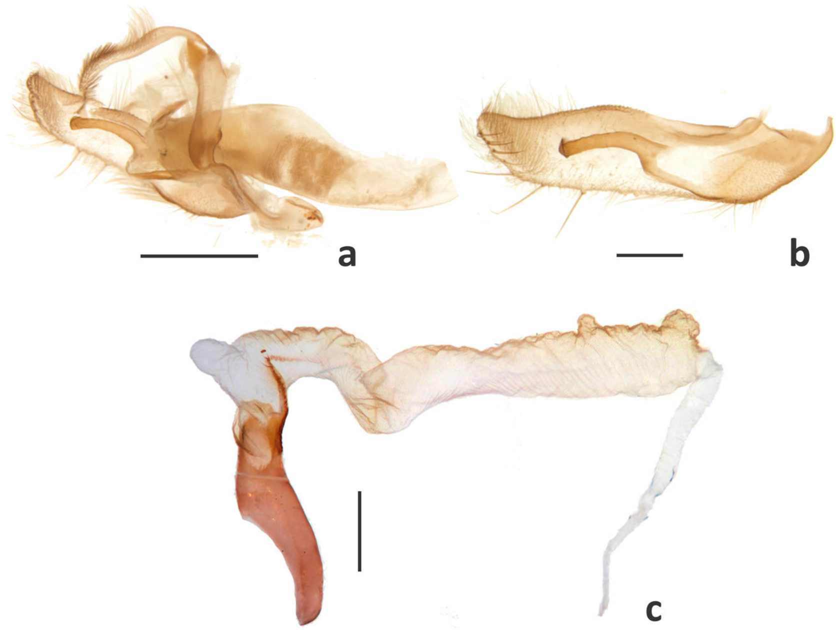

Fig 7 *Feltia submontana* (Köhler, 1961), male genitalia, lateral (**a**), genital capsule with right valva removed (**b**), valva (**c**), aedeagus. Scale bars: **a**, **c** = 1 mm, **b** = 0.5 mm.

curved and close to the orbicular spot in the discal cell, straight between CuA_2–1A+2A and displaced distally from 1A+2A to the outer margin; area between the antemedial line and orbicular spot dark brown; orbicular spot color similar to the ground color, bordered with dark brown except along the Radial vein; orbicular spot not reaching the Cubital vein; area between orbicular and reniform spot dark brown, except near the Radial vein; reniform spot color similar to the ground color, bordered basally and distally with dark brown; basal dash and claviform spot dark brown, but weakly developed; postmedial line slightly marked by dark brown scales, distinctively double on some specimens, wavy but regularly curved from the costal to the outer margin; subterminal area color similar to the ground color, with small creamy white spots over the veins, close to postmedial line; subterminal line indistinct; terminal line slightly marked with dark brown; fringe similar to the ground color. Female as in male.

Forewing, underside (Figs 2b, d and 4c, d). Mostly grayish brown, darker on the discal cell and on the subterminal area and along the outer margin. Female as in male.

Hind wing, upper side (Fig 2a, c). Ground color mostly creamy white with silvery hues; apex, veins and areas along the costal, outer and inner margins grayish brown; discal spot

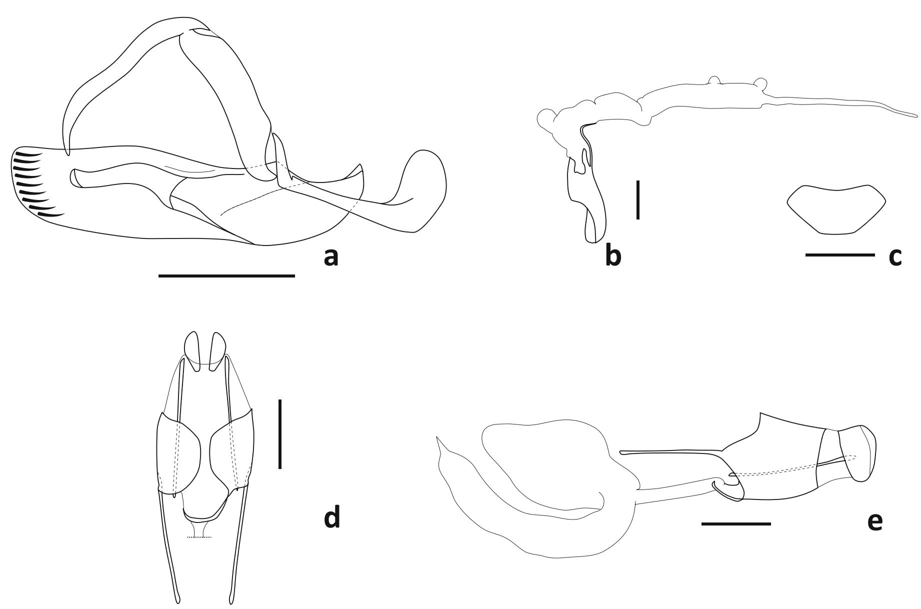

Fig 8 *Feltia submontana* (Köhler, 1961), male and female genitalia (**a**), male genital capsule with right valva and aedeagus removed, lateral (**b**), aedeagus, left view, lateral (**c**), fultura inferior, ventral (**d**), female genitalia, ductus, corpus and appendix bursae hidden, ventral (**e**), female genitalia, lateral. Scale bars: **a**, **b**, d, e = 1 mm; **c** = 0.5 mm.

indistinct; fringe grayish brown. Female as in male, but usually darker.

Hind wing, underside (Figs 2b, d and 4c, d). Similar to the upper side; male frenulum formed by a single strong bristle. Female as in male, but frenulum formed by two stronger and one weaker bristle.

Abdomen (Fig 2). Dorsally, laterally and ventrally grayish brown with silvery hues, speckled with darker and lighter scales, and creamy white along the posterior margin of each segment; male coremata and associated structures absent. Female as in male, but the abdomen is somewhat stouter and abruptly tapering at the last segments.

Male genitalia (Figs 7 and 8a–c). Tegumen strap-like, ventral arm enlarged, connecting to the dorsal arm of the saccus; saccus short, globose and posteriorly projected, dorsal arms thin and more or less straight and angled dorsally, about the same length of the ventral arm of the tegumen; uncus long, with dorsally curved scales, distally ventrally curved and with posteriorly directed spines; subscaphium, slightly sclerotized ventrally; valva basis ventrally rounded, more or less straightly projecting posteriorly in its distal half, distally ventrally blunt and obtusely angled, and dorsally pointed and more acutely angled; sacculus and clavus weakly sclerotized in comparison with the ampulla; ampulla slightly curved, one third the length of the valva, tip reaching three fourths the length of the valva; digitus absent; corona covering two thirds of the valva width; fultura inferior somewhat trapezoidal, narrower close to the sacculus; aedeagus curved; ductus ejaculatorius opening dorsal, about two thirds the length of the aedeagus; vesica of aedeagus everting ventrally, with a sclerotized band in its base, curved at one fifth and three fifths of its length, slightly swollen at the base, about two times the length of the aedeagus, distal two fifths tapered, subbasal diverticulum without cornutus, median diverticulum small, apical diverticulum larger than median diverticulum.

Female genitalia (Fig 8d–e). Lamella antevaginalis strap-like; lamella postvaginalis absent; abdominal segment VIII not fused ventrally, slightly longer than wider in lateral view; apophysis anterioris on the middle of the abdominal segment VIII in lateral view, in its widest area; apophysis posterioris long, slightly longer than the abdomen segment VIII and slightly shorter than the apophysis anterioris; papilla analis oblong, wider than longer; ostium bursae medial; ductus bursae thinner than the corpus bursae and the appendix bursae; corpus bursae irregularly rounded, slightly shorter than the appendix bursae; signa absent; appendix bursae irregularly cylindrical, two times the width of the ductus bursae; abruptly tapering distally to the ductus seminalis.

Distribution and habitat (Fig 9). As far as known, *Feltia submontana* is disjointly distributed in Argentina and Brazil. In Argentina, the species occurs in the northwestern provinces of Catamarca, Santiago del Estero, Tucumán, and Salta, from 190 m to 2000 m of elevation; in Brazil, in the central and southeastern states of Distrito Federal, Espírito Santo, Mato Grosso do Sul, Minas Gerais, São Paulo, and Rio de Janeiro, from 650 m to 1800 m of elevation, although most of the specimens were collected in Planaltina, Distrito Federal, at about 1000 m of elevation.

Comments. As stated by San Blas (2014) for other species described by Köhler, there is some confusion about the sex and identity of the original holotype of *F. submontana*. The original description affirms that "unfortunately, no male specimens have been obtained" of this species, although a male sex symbol is misleadingly included before the species description. A holotype and an unstated number of paratypes were designated from two localities in two different provinces of Argentina, even though the type locality of the holotype cannot be unambiguously established (ICNZ 1999, Art. 76.1).

Six years later, Köhler (1967: fig. 48) illustrated a female specimen of *F. submontana* captioned "allotype, female". No female specimen labeled holotype was located at the IFML. However, a female specimen labeled allotype, which agree with the illustration provided by Köhler (1967: fig. 48) and from one of the localities indicated for the holotype and the paratypes in the original description of *F. submontana* was located at the above-cited collection (Fig 1a). Additionally, one male specimen labeled "holotype" was also located, even though the locality is different from the localities indicated in the original description.

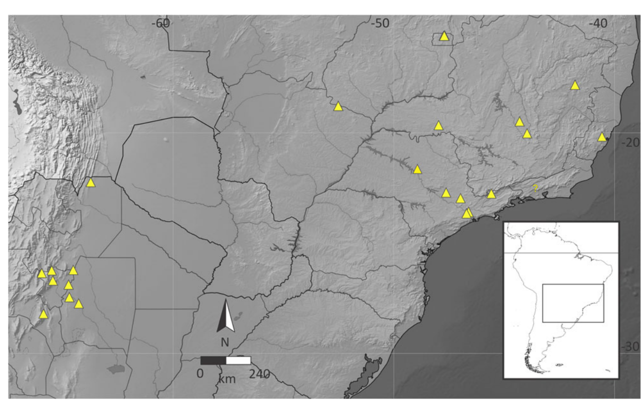

Fig 9 *Feltia submontana* (Köhler, 1961) distributional map, Argentinean provinces and Brazilian states highlighted.

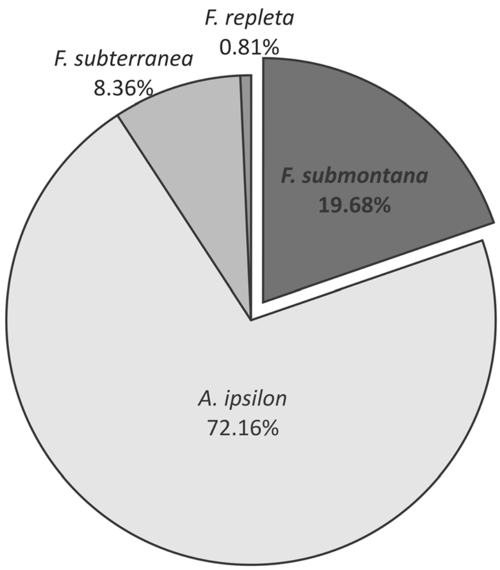

Fig 10 Proportion of species of *Agrotis* and *Feltia* collected monthly with light trap in Embrapa Cerrados Experimental Station from July of 2013 to June 2016.

Probably Köhler originally designated a female specimen as the holotype, but later changed his mind, removed the holotype label of the original holotype and switched it for an allotype label, including a holotype label in a male specimen obtained after the description of the species. This assumption is supported by the fact that 1) Köhler (1961) explicitly stated that he only had females of *F. submontana* in the original description, and 2) the allotype female agrees with one of the type localities provided in the original description, while the male specimen bearing the holotype label does not. Therefore, the female labeled as "allotype" at IFML and illustrated by Koehler (1967: fig. 48) is here recognized as the actual holotype of *F. submontana* and, consequently, San Pedro de Colalao, Tucumán, Argentina, its type locality (Fig 1a). There are six additional specimens with "paratypes" labels at the IFML, three which agree with the localities indicated in the original description, two females and one male (most likely neglected by Köhler, as both sexes of *F. submontana* are quite similar) and three females which does not agree with the localities indicated in the original description: one from Rio Hondo, Santiago del Estero and two from Colalao del Valle, Tucumán (see Material Examined section).

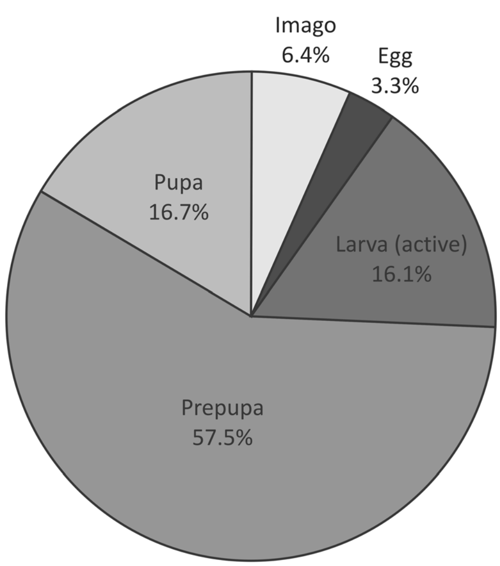

Fig 11 Duration (%) of each developmental stage of *Feltia submontana* reared at 25 ± 1°C, 70 ± 10% RH and 14 h photophase. The larval stage is further divided between active larvae and prepupae.

As the species was described based solely on only females, the male specimen is not recognized here as paratype nor are the three latter "paratypes" which labels does not agree with the localities given in the description. It is important to note that although the term allotype is not regulated by the ICZN (1999) and despite the fact that most specimens designated as allotype are in fact females, the term "allotype" should only be used to designate a specimen of the opposite sex of the holotype in the original description, be the specimen male or female.

Köhler (1961) described *A. maldonadoi* (Fig 1b) in the same paper and immediately following the description of *F. submontana*. While *F. submontana* was supposedly described based only on females, *A. maldonadoi* was described based only on males, a holotype (Fig 1b) and an unstated number of paratypes from Aguaray, Salta, Argentina. Köhler actually described the males and females of the same species as different species, a fact confirmed by the examination of the type material of both taxa. Therefore, as previously proposed by San Blas (2014), *A. maldonadoi* is a junior subjective synonym of *F. submontana*.

Agrotis interferens Walker, 1858 is consistently recognized as a junior subjective synonym of *F. subterranea* (Poole 1989, Lafontaine 2004, San Blas 2014) and only incidentally related to the taxonomy of *F. submontana*. The taxon was proposed based on an unstated number of males and females, although only two syntypes are known, one male and one female from an unstated locality in Rio de Janeiro, Brazil. While the male specimen, designated as lectotype of *F. interferens* by Lafontaine (2004), in fact corresponds to *F. subterranea* (Fig 1c), the supposedly female specimen is actually a male of *F. submontana* (Fig 1d). The lectotype designation by Lafontaine (2004) safeguards the identity of *F. submontana* and avoids disruption on the long-established recognition of *A. interferens* as a junior subjective synonym of *F. subterranea*. The syntype specimen of *F. interferens* wrongly acknowledged as a female by Walker (1858), here recognized as a male of *F. submontana*, has the following labels: /Rio [de Janeiro]/Type /324 /*Agrotis interferens* /Type Lep: No 1601 *Agrotis interferens* 1/2 HOPE DEPT. OXFORD/, deposited at the OUMNH.

Feltia submontana can be differentiated form other South American species of *Feltia* by the wings pattern and beadlike antenna. *Feltia subterranea, F. hispidula* (Guenée, 1852) (Fig 1e) and *F. lilacina* (Zerny, 1916) (Fig 1f) are the most similar species to *F. submontana*, at least superficially. The latter two are distinguishable from *F. submontana* by the absence of the creamy white spots over the veins in the subterminal area of the forewing, and from *F. lilacina* by the wavier transverse lines. The distinction with *F. hispidula* is easier through the examination of the male genitalia: *F. submontana* have a shorter vesica of the aedeagus, with three well differentiated diverticula, while *F. hispidula* have a longer vesica (four and a half times as long as aedeagus), with subbasal diverticulum and sometimes one small median diverticulum; the apical diverticulum is absent. The female genitalia of *F. hispidula* has longer appendix bursae than in the other species, twice as long as the corpus bursae, and *F. lilacina* has an intermediate length of appendix bursae and a differentiated antrum, absent in the other species. The male genitalia of *F. lilacina* was not examined thus far, but the holotype was illustrated by Zerny (1916) in the original description and again by Thöny (2000); the type and the only other specimens known to us, deposited at the VOB, occurs in the high altitudes of the Andes, above 3000 m. Finally, *F. submontana* can be differentiated from *F. subterranea* by the broader and shorter forewing, subcostal band indistinct, ground color mostly grayish brown with silvery hues, and area between the antemedial line and orbicular spot and area between orbicular and reniform spots dark brown; while in *F. subterranea* the forewing is narrower and longer, with distinctly lighter subcostal band, ground color light brown without silvery hues, area between antemedial line and orbicular spot similar in color to the subcostal band, and area between orbicular and reniform spots dark brown only at the posterior half. The male genitalia of *F. subterranea* can be readily differentiated from *F. submontana* by the abruptly dorsally enlarged tip of the valva and the absence of diverticulum of the vesica, and female genitalia can be differentiated by the appendix bursae one third the length of corpus bursae. *Feltia submontana* is redescribed based on 236 specimens, 165 males and 71 females, and a number of additional unspreaded specimens from collections and rearings carried out by Embrapa Cerrados.

Material Examined. (165 males and 71 females). ARGENTINA: *Catamarca*: **El Rodeo**, 1 male and 1 female (IFML). *Salta*: **Aguaray**, 26.V.1954, 1 male (IFML) [with paratype label], 23.V.1954, male (IFML) [with holotype label]; **Río Urueña**, V.1972, 2 females (IFML). *Santiago del Estero*: **La Banda**, 20.IV.1963, 2 males and 2 females (IFML), 1 male (IPCN), 26.IV, 1 male (IFML); **Río Hondo**, 25.IV.1963, 4 males and 4 females (IFML) [one female with paratype label]. *Tucumán*: **Colalao del Valle**, 24.IV.1954, 2 males, Pierrotti *leg.* (IFML) [with paratype labels]; **Las Cejas**, 20.V.1968, 1 male, Köhler *leg.* (IFML), 21.V.1968, 2 females, Köhler *leg.* (IFML); **San Pedro de Colalao**, 22.IV.1961, 2 females (IFML), 1 female (IPCN); **Siambón**, 11.V, 3 males (IFML). BRAZIL: *Distrito Federal*: **Planaltina**, 1000 m, 28.IV.1976, 1 male (USNM), 1 male and 1 female, 20.IV.1982, 1 male, Becker *leg.* 18,821[a], 18,821[b], 39,955 (VOB); 8.V.1976, 1 male, 15.IV.1977, 1 male, 17.V.1976, 2 males and 1 female, 23.III.1977, 1 male, 25.IV.1977 1 male, Becker *leg.* 01054, 01056, 01052*, 01055, 01051, 01057*, 01050 (EMBRAPA); 15°36′19″S 47°42′38″W, 1007 m, 8.IV.2013, 1 female, 24.IV.2013, 3 females, 4.V.2013, 1 male and 1 female, 15.V.2013, 5 males and 3 females, 11.VIII.2013, 1 male, 6.XI.2013, 2 males and 1 female, 24.IV.2014, 18 males and 5 females, 25.IV.2014, 4 males and 1 female, 26.IV.2014, 6 males and 2 females, 27.IV.2014, 8 males and 2 females, 28.IV.2014, 4 males and 5 females, 29.IV.2014, 2 males and 3 females, 30.IV.2014, 2 males and 1 female, 1.V.2014, 1 male and 1 female, 2.V.2014, 2 males and 1 female, 4.V.2014, 1 male and 2 females, 22.V.2014, 1 female, 23.V.2014, 5 males and 2 females, 24.V.2014, 3 males, 25.V.2014, 4 males, 26.V.2014, 2 males, 27.V.2014, 3 males, 28.V.2014, 5 males, 29.V.2014, 2 males, 30.V.2014, 3 males and 1 female, 1.VI.2014, 2 males and 2 females, 21.VI.2014, 1 female, 18.IX.2014, 1 female, 12.IV.2015, 3 males, 13.IV.2015, 2 males, 14.IV.2015, 2 males, 15.IV.2015, 1 male and 3 females, 16.IV.2015, 1 male, 18.IV.2015, 2 males, 19.IV.2015, 1 male and 1 female, 21.IV.2015, 1 male, 18.VI.2015, 1 male, 2.V.2016, 2 males and 1 female, 3.V.2016, 1 male and 3 females, 30.V.2016, 2 males, 31.V.2016, 2 males, 4.V.2016, 6 males and 1 female, 5.V.2016, 4 males, 6.V.2016, 2 males, 7.VI.2016, 1 male, Specht *leg.* 01590, 01636, 01637, 01646, 01576, 01652, 01664, 01666, 01667, 01669, 01670*, 01658, 01659, 01668, 01553, 01592, 01641, 01656, 01537, 01538, 01541, 01542, 01543, 01546, 01547, 01549, 01559, 01560, 01567, 01570, 01603, 01606, 01609, 01610, 01613, 01614, 01544, 01569, 01602, 01611, 01620, 01545, 01554, 01564, 01646, 01596, 01536, 01539, 01548, 01550, 01580, 01608, 01671, 01675, 01551 01555, 01568, 01571, 01612, 01615, 01650, 01654*, 01540, 01589, 01563, 01595, 01597, 01624, 01574, 01607, 01625, 01649, 01672, 01601, 01626, 01558, 01565, 01577, 01552, 01566, 01594, 01579, 01647, 01573, 01561, 01578, 01627, 01562, 01651, 01662, 01581, 01583, 01584, 01640, 01653, 01582, 01634, 01591, 01622, 01644, 01600, 01605, 01616, 01619, 01623, 01629, 01604, 01617, 01645, 01585, 01587, 01588, 01631, 01643, 01556, 01557, 01660, 01663, 01665, 01657, 01598, 01621, 01593, 01618, 01599, 01661, 01633, 01635, 01673, 01532, 01655, 01534, 01630, 01632, 01628, 01638, 01639, 01528, 01531, 01535, 01533, 01530, 01642, 01529, 04274, 04283, 04286, 04269, 04291, 04267, 04275, 04306, 04288, 04276, 04279, 04287, 04271, 04281, 04289, 04278, 04285, 04284, 04272, 04270, 04268, 04282, 04313, 04312, 04277 (EMBRAPA). *Espírito Santo*: **Santa Leopoldina**, Tirol, 650 m, 15.V–15.VI.1998, 1 male, Thöny *leg.* (HT); *Mato Grosso do Sul:* **Chapadão do Sul**, 804 m, 11.VI.2015, 3 males, 12.VI.2016, 1 male, Taira *leg.* 04290, 04214, 04273, 04280 (EMBRAPA); *Minas Gerais*: **Poté**, 500 m, 1–30.X.1997, 1 male, Thöny *leg.* (HT); **Sete Lagoas**, 720 m, 12.IV.1969, 1 female, Becker *leg.* 399,692 (VOB); **Nova Lima**, 1000 m, 20.V.1979 1 female, Pimenta & Becker *leg.* 2674 (VOB); **Uberaba**, 819 m, 12.IV.2015, 1 male, 13.V.2015, 2 males, 14.V.2015, 1 male and 2 females, 15.IV.2016, 1 male, 16.IV.2015, 1 male, 16.VI.2015, 2 males and 1 female, 17.VI.2015, 1 male, Moreira *leg.* 04155, 04164, 04152, 04156, 04153, 04157, 04127, 04158, 04229, 04160, 04163, 04161 (EMBRAPA). *São Paulo*: **Campos do Jordão**, Umuarama, 1800 m, 8–15.III.1937, 1 male and 1 female, Gagarin *leg.* DZ 30.536*, DZ 31.857* (DZUP); **Ibitinga,** 19.V.1988, 1 male, Fernandes leg. (ESALQ/USP); **Piracicaba**, 3.V.1965, 2 males, 17.V.1965, 2 males, Silveira Neto *leg.* (ESALQ/USP); **São Paulo**, Ipiranga, 17.V.1929, 1 male, Spitz *leg.* (MZUSP); Santo Amaro, V.1929, 1 male, Spitz *leg.* (MZUSP).

Abundance and Life Cycle

(Tables 1 and 2, Figs 10 and 11).

In 4 years of collecting, 741 imagines of four cutworms species were collected (in order of abundance): *A. ipsilon* (Hufnagel, 1766), *F. submontana*, *F. subterranea,* and *F. repleta* (Walker, 1857) (Fig 10). Specimens of *F. submontana* comprise 19.68% of the collected specimens (146 specimens), and were captured only in mid to late autumn and early winter months of April, May and June. The abundance of collected specimens of cutworms decreased from the crop season of 2013/2014 onwards.

Additional data from the examined entomological collections and literature (Silveira Neto 1972) revealed that *F. submontana* occurs in several states in Central and Southwestern Brazil, but the bulk of the specimens were collected at or nearby "Cerrado" areas similar to that of the study site.

The survival rates and duration of the immature stages of *F. submontana* are given by Table 1. *Feltia submontana* demands from 164 to 236 days to complete its life cycle in controlled conditions, with an average of 198.2 days. Eggs take from 7 to 8 days to hatch. About three fourths (155.8 days) of the life cycle takes place during the larval stage, mainly as prepupa, when the last instar remains inactive inside the pupal chamber before metamorphosing into pupa (Table 1, Fig 11). The pupal stage was extremely variable with an average of 35.3 days, varying from 27 to 52 days. The overall survival rate was of 10.1%, especially because of the low survival rates of the larval (21.8%) and pupal stages (55%); the survival rate of eggs was considerably higher (84.4%) (Table 1).

Table 1 Survival (%), duration (mean ± standard deviation) and range (minimum and maximum) of the *Feltia submontana* (Köhler, 1961) immature stages, on artificial diet under controlled conditions (25 ± 1°C, 70 ± 10% RH and 14 h photophase).

Stage	*N* (initial-final)	Survival (%)	Duration (days)	Range (days)
Egg	626–532	84.984	7.091 ± 0.292	7–8
Larval	275–125	45.455	34.121 ± 3.516	29–42
Prepupa	125–60	48.000	121.667 ± 18.924	89–152
Pupal	60–33	55.000	35.394 ± 6.514	27–52
Overall	–	10.198	198.273 ± 19.826	164–236

The average longevity of the imagines was of 13.6 days, varying from 1 to 3 weeks; the difference of longevity between males and females was not statistically significant ($p = 0.210$) (Table 2). The pre-ovipostion period was variable, with an average of 3.9 days, varying from 3 to 7 days; the oviposition was likewise variable with an average 10 days, varying from 6 to 16 days. Female imagines died up to 3 days after they stop laying eggs; overall, the post-oviposition period had an average of 0.9 days. The fecundity was on average of 790.2 eggs laid per female, but the number also varied greatly among the ten observed couples, from 217 to 1149 eggs laid per female (Table 2).

The duration of the egg of *F. submontana*, from 7 to 8 days, was similar that reported for *Agrotis malefida* Guenée, 1852 (Villata *et al* 1988), and *Agrotis robusta* (Blanchard, 1852) (misidentified as *A. malefida* by Rizzo *et al* 1995 and Specht *et al* 2013). However, the egg duration of *F. submontana* was relatively long when compared with *F. subterranea* (Vendramin *et al* 1982, 4 days), and several other agrotines reared under lower

Table 2 Mean, standard deviation and range of the longevity, preovipotition, oviposition, post-oviposition periods and fecundity (mean number eggs laid) of *Feltia submontana* (Köhler, 1961) (10 couples), under controlled conditions (25 ± 1°C, 70 ± 10% RH and a 14 h photophase).

Sex	Biological parameter	Mean	SD	Range
Both	Longevity (days)	13.6	3.470	7–21
Females	Longevity (days)	14.6	4.169	9–21
	Pre-oviposition (days)	3.9	1.37	3–7
	Oviposition (days)	10	3.432	6–16
	Post-oviposition (days)	0.6	0.966	0–3
	Fecundity (eggs)	790.6	351.543	217–1149
Males	Longevity (days) ns	12.6	2.413	7–15

Comparisons of male and female mean longevity using a Student *t* test, considering different variances, at 5% level of significance (not significant; $p = 0.210$).

temperatures, such as *A. ipsilon* (Santos & Nakano 1982, 4 days, Bento *et al* 2007, 3.3 days), *Anicla ignicans* (Guenée, 1852) (Foerster & Mello 1996, 4 days at 26°C), *Anicla infecta* (Ochsenheimer, 1816) (Teston *et al* 2001, 3.2 days at 25°C) and *Anicla mahalpa* Schaus, 1898 (Specht *et al* 2008, 6 days at 20°C).

The relatively high egg fertility of circa 85% is probably related to the fact that wild-caught females passed through pheromones and other courtship stimuli under natural conditions. Nevertheless, numerous studies with *Agrotis* and *Feltia* observed high fertility of the eggs, especially when the specimens are in proper conditions of temperature and humidity (Bento *et al* 2007, Specht *et al* 2013).

The relative long duration of the larval stage, especially the long prepupae of *F. submontana* (121.6 days) is similar to the larval duration of *A. malefida* and *A. robusta* (Villata *et al.* 1988, Specht *et al* 2013). This suggests that these species pass through a prepupal diapause (Oku 1984, Fantinou *et al* 1996, Gadenne *et al* 1997, Bentancourt & Scatoni 2006, Eizaguirre *et al* 2008, Feng *et al* 2010, Specht *et al* 2013). Conversely, this long larval duration contrasts with the relatively faster developmental periods of *F. subterranea* (Vendramin *et al* 1982) and several other agrotines and noctuids (Reese *et al* 1972, Foerster & Mello 1996, Teston *et al* 2001, Bento *et al* 2007, Specht *et al* 2008).

The low larval survival rate of *F. submontana*, especially in the prepupal stage, are similar to *A. robusta* (Specht *et al* 2013) and *Sesamia nonagrioides* (Lefèbvre, 1827) (Eizaguirre *et al* 2008), and contrasts with much higher survival rates of *F. subterranea* (Vendramin *et al* 1982) and other agrotines and noctuids with faster development (Reese *et al* 1972, Foerster & Mello 1996, Teston *et al* 2001, Bento *et al* 2007, Specht *et al* 2008). Therefore, species with longer larval stage durations generally also have lower larval stage survival rates. The relatively large variation in the duration of the pupal stage of *F. submontana* indicates that, like *A. robusta* (Specht *et al* 2013) and other noctuids such as *Helicoverpa armigera* (Hübner, [1805]) (Qureshi *et al* 2000), the pupa of *F. submontana* may also pass through diapause. The survival rate of the pupal stage of *F. submontana* was relatively low when compared with other agrotines reared in the laboratory, such as *A. robusta* (Specht *et al* 2013), *F. subterranea* (Vendramin *et al* 1982), *A. ipsilon* (Reese *et al* 1972, Bento *et al* 2007) and *A. mahalpa* (Specht *et al* 2008).

The longevity of imagines of *F. submontana* was similar to that observed for *A. robusta* (Specht *et al* 2013), *F. subterranea* (Vendramim *et al* 1982) and *A. ipsilon* (Bento *et al* 2007). However, the longevity of imagines of *F. submontana* was relatively shorter (6.4%) than most other agrotines, such as *F. subterranea* (Vendramin *et al* 1982, 22.6%) and *A. ipsilon* (Santos & Nakano 1982, 24.3%, Bento *et al* 2007, 24.5%), although somewhat similar to *A. robusta* (Specht *et al* 2013, 7.4%).

The pre-oviposition period of *F. submontana* is at least 3 days longer than *A. robusta* and *A. ipsilon* (Bento *et al* 2007, Specht *et al* 2013) and is similar to *F. subterranea* in artificial diet (Vendramin *et al* 1982, 3 days). Thus, *F. submontana* reaches the sexual maturation quickly after emergence and females are able to lay eggs 4 days after emergence. The duration of the oviposition period was variable but quite similar to the described for *A. robusta* (Specht *et al* 2013). The average fecundity of *F. submontana* was lower than other agrotines and noctuids, where the average fecundity is usually larger than 1000 eggs per female (e.g. Swier *et al* 1976, Archer *et al* 1980, Santos & Nakano 1982, Vendramin *et al* 1982, Bento *et al* 2007, Specht *et al* 2013). Nevertheless, the oviposition of 1149 eggs by one of the females indicates that the species potentially could have higher fecundity in different, more natural conditions.

Some aspects of the life cycle of *A. ipsilon* and *F. subterranea*, the most important species of *Agrotis* and *Feltia* of economic interest in Brazil (Costa Lima 1950), favor their status of agricultural pests. Both *A. ipsilon* and *F. subterranea* develop more than one generation per year (while *F. submontana* develops only one), and have faster development times and higher survival rates than *F. submontana*. It is important to note that *F. subterranea* is quite similar to *F. submontana* and are frequently mixed in entomological collections. Nevertheless, the abundance of *F. submontana* in the study site relative to other species of agrotines and some biotic data (e.g. fertility) indicate that *F. submontana* could be a neglected agricultural pest (though most likely secondary) in several economically relevant annual crops in the "Cerrado", as all species of *Agrotis* and *Feltia* of economic interest are highly polyphagous (Lafontaine 2004).

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