New Species and Revision of *Myrmosicarius* (Diptera: Phoridae) that Parasitize Leaf-cutter Ants (Hymenoptera: Formicidae)

by

R. Henry L. Disney[1], Luciana Elizalde[2] & Patricia J. Folgarait[2]

ABSTRACT

The genus *Myrmosicarius* Borgmeier is revised. *M. brandaoi* n. sp., *M. cristobalensis* n. sp., *M. gonzalezae* n. sp. and *M. longipapis* n. sp. from Argentina, with *M. cristobalensis* from Paraguay also, are described. *M. diabolicus* is synonymized with *M. crudelis* and *M. cuspidatus* is synonymized with *M. catharinensis*. A new key to the females is provided and new host records reported.

Keywords: new species, revision, *Myrmosicarius*, Phoridae, parasitic fly, leaf-cutter ant.

INTRODUCTION

The larvae of most species of the genus *Myrmosicarius* Borgmeier parasitize leaf-cutter ants (Myrmicinae), with one species being also recorded over *Solenopsis* (fire ants) and one being associated with the army ant *Labidus praedator* (Ecitoninae) (Borgmeier 1929). Our knowledge of the genus is largely based on females procured while observed pursuing or attacking ants. The females of a *Myrmosicarius* species have even been observed flying backwards when pursuing their ant hosts (Feener & Brown, cited by Orr *et al.* 1997).

The females of the genus are readily recognized by the front tarsus being reduced to two segments only (e.g. Fig. 2), the sternite of abdominal segment 6 being vestigial or absent and by the characteristic ovipositor tube formed from segments 7 and 8 (e.g. Figs. 4, 9, 13, 14, 22 and 34). *Dacnophora* Borgmeier has a similarly modified front tarsus, but its sternite 6 is strongly developed and its ovipositor segments are more elaborate (Borgmeier 1961). The males of most species remain undescribed.

[1]Museum of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, ENGLAND. Email: rhld2@hermes.cam.ac.UK

[2]Centro de Estudios e Investigaciones, Universidad Nacional de Quilmes, R.S. Peña No. 352 (ex180) (1876) Bernal B1876BXD, Bs. As. ARGENTINA

Under the supervision of PF, collections by LE in Argentina and Paraguay produced numerous specimens of this genus associated with leaf-cutter ants.

The Neotropical species were last keyed by Borgmeier (1931) with an addition by Borgmeier & Prado (1975). The single Nearctic species was covered by Borgmeier (1963). However, when using these publications, the identifications of the species collected proved to be problematical. When samples were examined by RHLD, these collections were found to include undescribed species and they further revealed the need for a revised key, as the diagnostic measurements and ratios employed by Borgmeier were found to be more variable than he had supposed. This variation seems to be partly a function of a variation in size, which may be due to variation in the sizes of their ant hosts.

In our study the specimens were preserved in 70% alcohol and then mounted on slides in Berlese Fluid (Disney 2001). Through the cooperation of Dr. Carlos Roberto Ferreira Brandão (Museum de Zoologia, Universidade de São Paulo, Brazil) (MZSP) Borgmeier's type series, preserved in alcohol, were borrowed. The holotypes, and four lectotypes designated below, have been mounted on slides (by RHLD). Without this we would have been unable to assign the correct names to our newly collected specimens. For example, we have split Borgmeier's *M. grandicornis* into three species. Furthermore, it became apparent that Borgmeier's recorded measures often apply to a paratype and differ from those we have recorded for the holotype or lectotype of the same species that we have measured. We therefore provide the ranges that we have recorded for each species. Borgmeier's specimens were preserved in alcohol and his descriptions were based examinations at low magnifications, but with the detachment of a wing, and in some cases of some legs, for examination at higher magnifications. However, these detached parts were not always from the holotype. On two occasions we obtained two species in a single sample procured with the same colony of ants on the same occasion. Some of Borgmeier's type series probably include more than one species.

The new species are described below and a new key to females is provided. Where latitudes and longitudes are given for localities these employ the decimal system and the Southern and Western hemispheres are indicated by the use of the minus sign.

REVIEW OF SPECIES

The females of the species are distinguished in the key below. The splitting of *M. grandicornis* into three species and both *M. infestans* and *M. gracilipes* into two species means that earlier host records, other than those for the holotypes and lectotypes of the original three species, require confirmation. The affinities of the new species are indicated in the keys below.

Holotypes and most paratypes of the new species have been deposited in the Museum Bernardino Rivadavia, Buenos Aires, Argentina (MBR). Otherwise duplicates have been deposited in the Museum of Zoology, University of Cambridge, Cambridge, England (MZUC) and in the collection of PJF, at the Universidad Nacional de Quilmes. Ant specimens were also deposited in the Museum Bernardino Rivadavia as well as in PJF's collection.

Myrmosicarius biarticulatus Borgmeier
Fig. 2

Myrmosicarius biarticulatus Borgmeier 1931: 225.

Female (Fig. 2). Front tarsus as Fig. 2. Ratio of length of fore tarsus to that of the tibia 1.25 : 1. Ratio of basitarsus to last tarsal segment of front leg (Fig. 2) is 1.24 : 1. Ratio of length of mid basitarsus to segments 2-3 is 1.2 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 0.96 : 1. Wing length 1.83 mm. Costal index 0.38. Costal cilia 0.1 mm long.

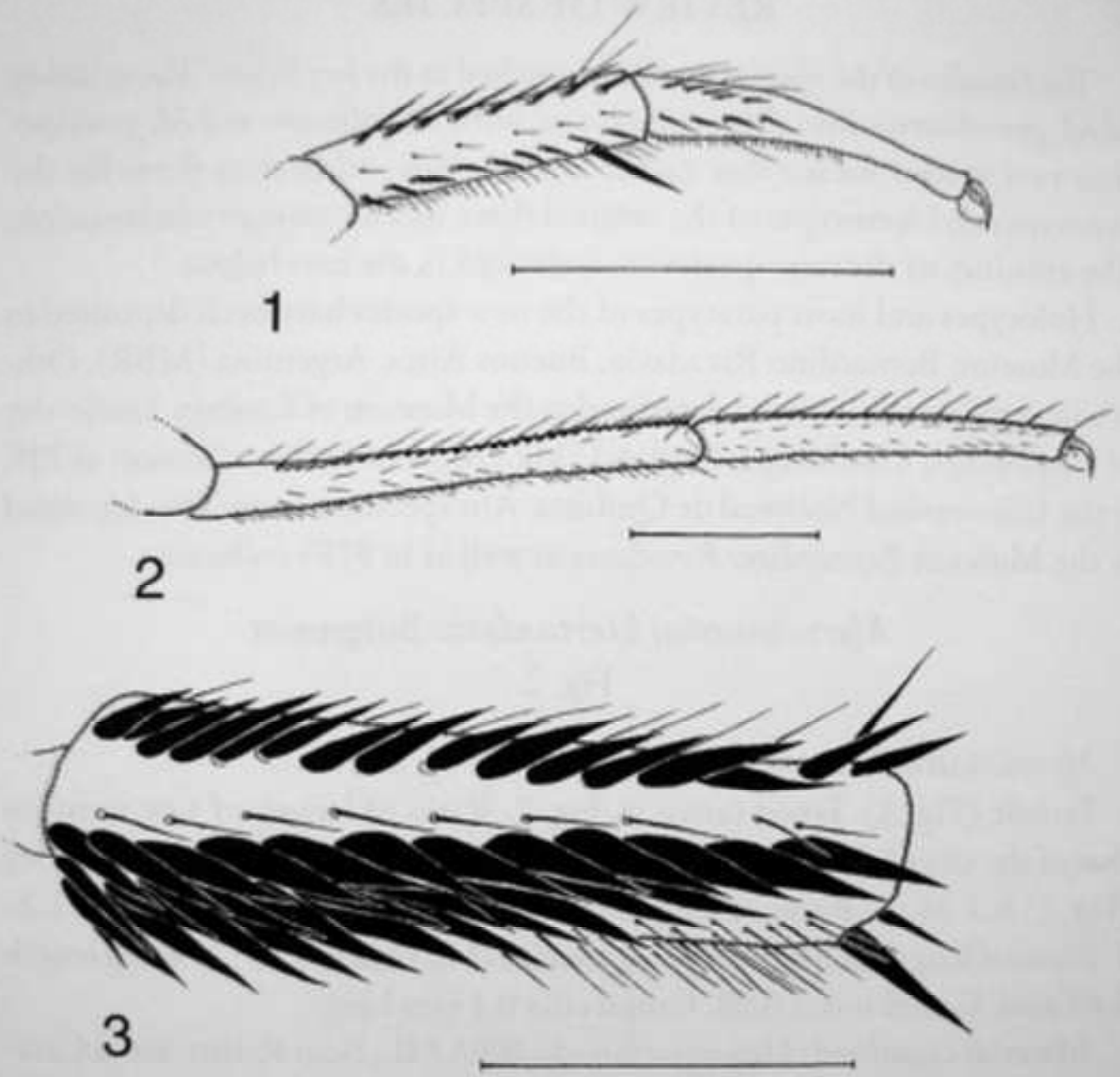
Material examined: Holotype female, BRAZIL, Bom Retiro, Santa Catarina, 22 October 1928, with *Labidus praedator*, C. Prade (MZSP).

Recorded host. *Labidus praedator*.

***Myrmosicarius brandaoi* new species**
Figs. 4-6

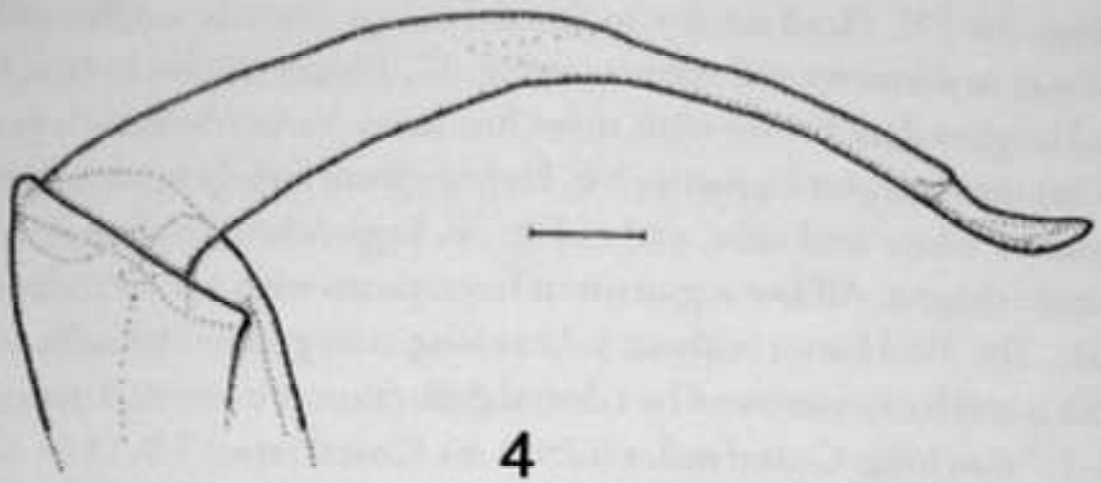
The females exhibit an unusual variation in size that can be confusing when viewing a sample at low magnification. For example, the length of the hind femur ranges from 0.45 to 0.79 mm (mean 0.62 mm).

Female (Figs. 4-6). Eyes with lowermost ommatidia 0.02-0.03 mm in diameter but uppermost ones are <0.02 mm. Anterior ocellus about 0.05 mm in diameter. Frons brown with 20-60 hairs. Bristles arranged as Fig. 11 except the SAs (supra antennal) are closer together. Antenna brown and as Fig. 5. Palp



Figs. 1-3. *Myrmosicarius* females, details of tarsi. Fig. 1. *M. persecutor*, anterior face of tarsal segments 4 and 5 of hind leg; Fig. 2. *M. biarticulatus*, posterior face of front tarsus; Fig. 3. M. tarsipennis, anterior face of hind basitarsus. (Scale bars = 0.1 mm)

brown in distal two thirds and as Fig. 6. Proboscis straw yellow and as Fig. 6. Thorax brown, with three strong bristles on notopleuron. Anterior scutellars reduced to minute hairs or absent. Abdominal tergites dark brown. Venter brown with short hairs on segment 6 only. Ovipositor tube as Fig. 4. Legs essentially straw yellow but hind femur and tibia in part tinged brown. Ratio of length of fore tarsus to that of the tibia 0.63-0.84 : 1. Ratio of basitarsus to last tarsal segment of front leg is 0.48-0.58 : 1. Ratio of length of mid basitarsus to segments 2-3 is 1.04-1.36 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 0.99-1.16 : 1. Wing length 1.21-2.05 mm. Costal index 0.26-0.3. Costal ratios 6.2-15.3 : 1.6-3 : 1. The wide variation reflects the fact that



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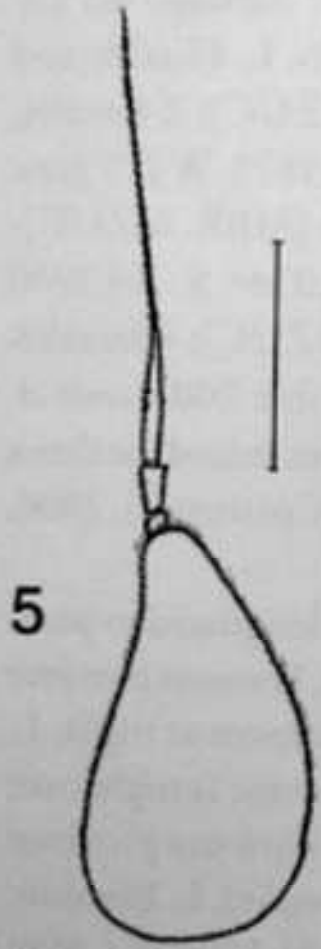

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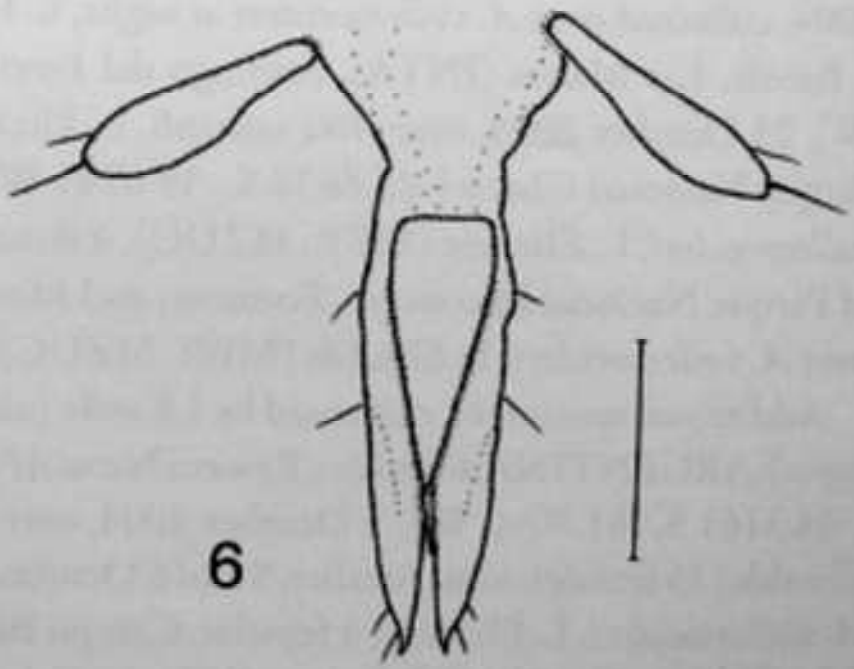

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Figs. 4-6. *Myrmonicarius brandaoi* female. Fig. 4. Left face of ovipositor tube; Fig. 5. Inner face of left postpedicel; Fig. 6. Palps and proboscis (Scale bars = 0.1 mm)

sometimes veins 2 and 3 are so closely approximated that the space between the two branches of the fork tends to be occluded (in the extreme vein 3 may appear to be unforked). Costal cilia 0.04-0.06 mm long. Vein Sc (sub costal) fades away as it approaches vein 1. No hair at base of vein 3. Axillary ridge with 3-4 bristles, the outermost one being longer than costal cilia of section 1. Veins grey and membrane lightly tinged grey. Haltere brown.

Male (Figs. 36-37). Head similar to female, except anterior ocellus only about 0.04 mm in diameter and antenna as Fig. 37. Thorax similar to female. Abdominal tergites dark brown with short fine hairs. Venter brownish grey with a few minute hairs on segments 3-6. Hypopygium largely brown, apart from the almost white anal tube, and as Fig. 36. Legs colored as female but generally more slender. All five segments of front tarsus with a posterodorsal hair palisade. The hind femur is about 4.3x as long as its greatest breadth and its basal fifth is suddenly narrowed by a dorsal deflection of its ventral margin. Wings 1.3-1.7 mm long. Costal index 0.29-0.40. Costal ratios 7.9-13.0 : 1.8-3.1 : 1. Costal cilia 0.05-0.06 mm long. Otherwise it and haltere as female.

Material examined: Holotype female, ARGENTINA, Santiago del Estero, near Brea Pozo, March 2002, over *Atta vollenweideri*, L. Elizalde and P. Folgarait (MBR). Paratypes, 1 female as holotype (MZUC); 2 females, Parque Nacional Pilcomayo, Formosa [-25.1187 S, -58.1675 W], 9 June 2004, collected over *A. vollenweideri* at night, L. Elizalde (MBR, MZUC); 1 female, Las Marias (INTA), Santiago del Estero [-28.0344 S, -64.2930 W], 23 October 2004, over *Atta saltensis*, L. Elizalde (MZUC); 4 females, Parque Nacional Chaco [-26.8638 S, -59.6245 W], October 2003, over *A. vollenweideri*, L. Elizalde (MBR, MZUC). 4 females, from mixed localities of Parque Nacional Pilcomayo, Formosa, and Mercedes, Corrientes), 2004, over *A. vollenweideri*, L. Elizalde (MBR, MZUC).

Additional specimens examined by LE only (and not designated as paratypes): ARGENTINA, 6 females, Reserva Natural Formosa, Formosa province [-24.3161 S, -61.8050 W], 3 October 2004, over *Atta saltensis* at night, L. Elizalde; 25 females, same locality, 5 and 6 October 2004, some at night over *A. vollenweideri*, L. Elizalde; 4 females, Campo Bandera, Formosa province [-24.0091 S, -61.8718 W], January 2004, over *A. vollenweideri*, L. Elizalde; 4 females, San Cristóbal, Santa Fe province [-30.2073 S, -61.1506 W], May and November 2004, over *A. vollenweideri*, L. Elizalde; 4 females, Mercedes Aguaceritos (30 km NW from Mercedes), Corrientes province [-29.1526, -57.9906], September 2004 February 2002, P. Folgarait; 3 females, Noetinger, Córdoba province [-32.3174 S, -62.3608 W], March 2003, over *A. vollenweideri*, G. Azzimonti; PARAGUAY, 3 females Parque Nacional Defensores del Chaco, Chaco Alto Paraguay and Boquerón departments [-20.4388 S,

-60.3198 W], 11 December 2004, over *A. vollenweideri*, L. Elizalde; 10 females, same locality, 6 December 2004, over *A. saltensis*, L. Elizalde.

Etymology: The species is named after Dr. Carlos Roberto Ferreira Brandão (Museum de Zoologia, Universidade de São Paulo, Brazil) who arranged the loan of the type specimens of Borgmeier's species, and allowed RHLD to remount them on slides.

Recorded hosts. *Atta saltensis* and *A. vollenweideri*.

Field observations. This species was found over the nests and the foraging trails of *Atta vollenweideri* and *A. saltensis*. They fly very fast along the foraging trails searching for suitable hosts, periodically pausing for some seconds to rest on leaves or sticks at the sides of the trails. Sometimes, after flying for a while, they rest for a longer time, between one to several minutes. Oviposition attempts occur during flight. They last less than a second and are aimed at the lateral area of the ant's head, probably at the insertion of a mandible. Victims may be carrying a leaf or not.

Ants under attack generally cease walking and curve the abdomen ventrally, between the hind legs. They remain still with the head in a downward position. This behavior is very frequently displayed by the ants after being attacked by any of the species of *Myrmosicarius*. Some ants that are next to a victim, if not carrying a load, may approach and touch her with their antennae. Ants that detect approaching flies try to catch them with their mandibles. In fact, groups of ants may remain with their mandibles extended for several minutes after a phorid has attacked a nearby ant. When under attack, workers riding on leaves carried by ants, called hitchhikers, are commonly seen on the foraging trails of *A. vollenweideri*, but infrequently with *A. saltensis*. This behavior was demonstrated to be a defensive response against phorids (Feener & Moss 1990).

M. brandaoi also attacks ants at their nest entrances; even with *Atta vollenweideri*, where some nest entrances are covered by a small roof, some will attack beneath these roofs. In addition, it has been observed attacking ants of both *Atta* species at night, when leaf cutter ants are very active. At the Campo Bandera and Estero Poi (Parque Nacional Pilcomayo) localities *M. brandaoi* and *M. gonzalezae* were observed attacking ants from the same nest of *Atta vollenweideri* on the same occasion.

Myrmosicarius catharinensis Borgmeier
Figs. 7-9

Myrmosicarius catharinensis Borgmeier 1928: 124.

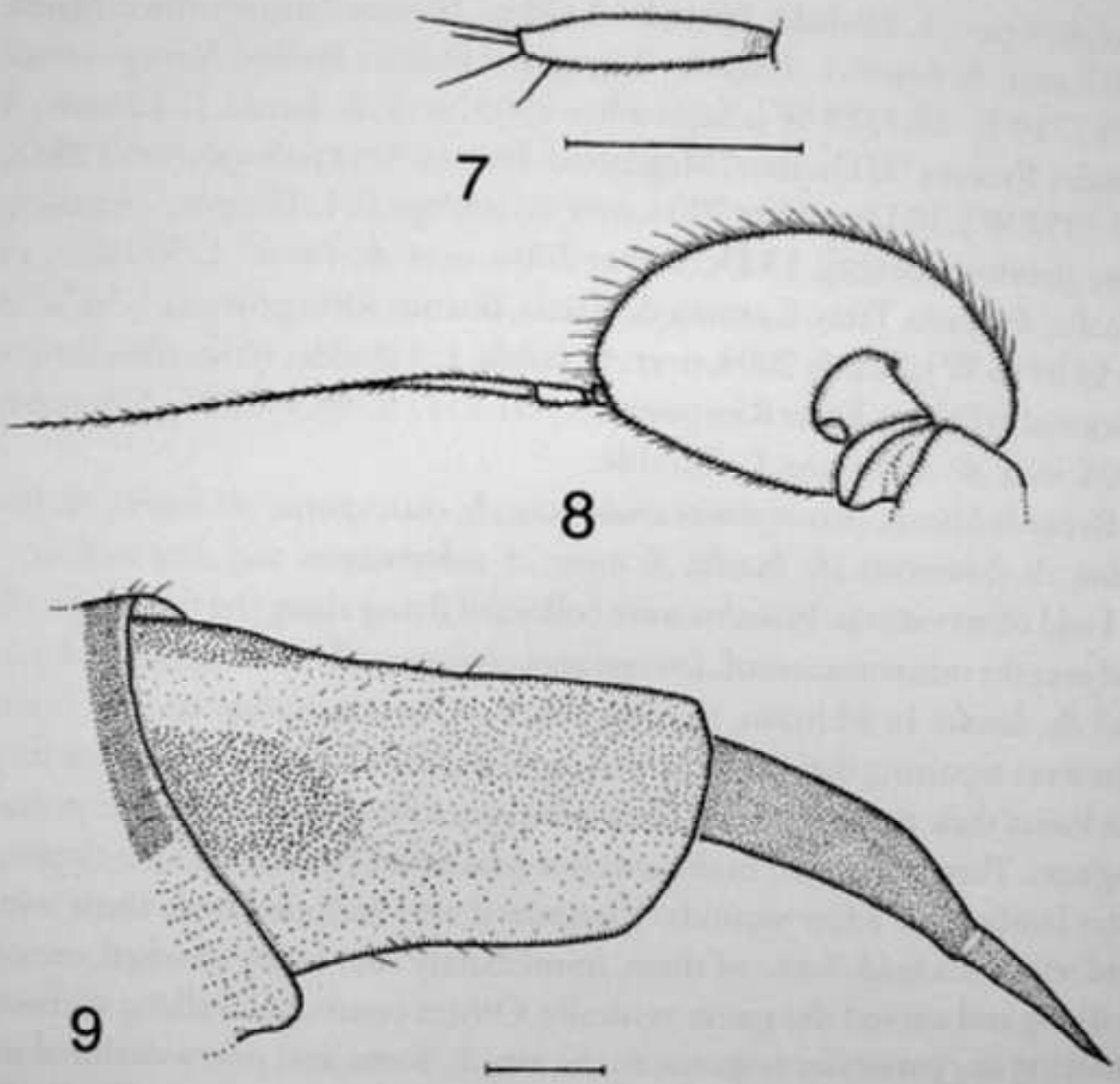
Myrmosicarius cuspidatus Borgmeier 1928: 124. Syn. nov.

We have discovered no consistent differences between *M. catharinensis* and *M. cuspidatus*. The two holotypes represent different extremes of the variation evident in the large series of fresh specimens we have examined. For example the wing length of the holotype of *M. cuspidatus* is the largest measured but that of the holotype of *M. catharinensis* is near the lower end of the range of variation. It seems that Borgmeier separated the supposedly two species mainly on the basis of their different host ants. We therefore propose that *M. cuspidatus* is a junior synonym of *Myrmosicarius catharinensis*, as it is described lower on the same page than the latter species.

The males A and B are both candidates for being this species (see below).

Female (Figs. 7-9). Antenna as Fig. 8. Palp as Fig. 7. Ovipositor as Fig. 9. Ratio of length of fore tarsus to that of the tibia 1.1 : 1. Ratio of basitarsus to last tarsal segment of front leg is 0.70 : 1. Ratio of length of mid basitarsus to segments 2-3 is 0.8-0.91 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 0.85-0.93 : 1. Wing length 1.19-1.60 mm. Costal index 0.31-0.32. Costal ratios 5.4-6.2 : 1.1-1.7 : 1. Costal cilia 0.04-0.07 mm long.

Material examined: Holotype female, BRAZIL, Bom Retiro, Santa Catarina, 28 November 1927, with *Acromyrmex* sp., C. Prade (MZSP). Holotype female of *M. cuspidatus*, Brazil, Petropolis, March 1926, with *Acromyrmex niger* (= *muticinodus*), C. Prade (MZSP). 1 female, Brazil, Tocantins, Tupiratins, 7 January 2001, with *Atta sexdens*, M. Bragança (MZUC); 1 female, ARGENTINA, Parque Nacional Chaco [-26.8638 S, -59.6245 W], October 2003, over *Acromyrmex hispidus*, L. Elizalde (MBR); 4 females, Parque Nacional El Palmar, Entre Ríos [-31.8527 S, -58.3029 W], 10 November 2004, over *Ac. crassispinus*, L. Elizalde (MBR, MZUC); same locality, 12 November 2004, over *Ac. ambiguus*, L. Elizalde (MZUC); 1 female, San Cristobal, Santa Fe [-30.2073 S, -61.1506 W], 18 November 2004, over *Ac. lobicornis*, L. Elizalde (MZUC); 2 females, Azul, Buenos Aires [-36.6646 S, -59.6801 W], 4 December 2004, over *Ac. lundii*, L. Elizalde (MBR, MZUC);



Figs. 7- 9. *Myrmosicarius catharinensis* female. Fig. 7. Left palp from above; Fig. 8. Left antenna; Fig. 9. Left face of rear of abdominal segment 5, segment 6 and ovipositor tube. (Scale bars = 0.1 mm)

7 females, Magdalena, Buenos Aires [-35.1384 S, -57.3952 W], 11 December 2004, over *Ac. heyeri*, L. Elizalde (MBR, MZUC);

Additional specimens examined by LE only (and not designated as paratypes): ARGENTINA; 2 females, Río Pilcomayo National Park, Formosa province [-25.1187 S, -58.1675 W], May 2005, over *Ac. lundii*; 1 female, San Cristóbal, Santa Fe province[-30.2073 S, -61.1506 W], 18 November 2004, over *Ac. heyeri*, L. Elizalde; 1 female, same locality, 19 November 2004, over *Ac. lundii*, L. Elizalde; 2 females, Azul, Buenos Aires province [-36.6646 S, -59.6801 W], over *Ac. ambiguus*, L. Elizalde; 8 females, Reserva Natural Otamendi, Buenos Aires province [-34.2366 S, -58.8914 W], March 2004,

over *Ac. heyeri*, L. Elizlade; 2 females, La Plata, Buenos Aires province, March 2002, over *Ac. heyeri*, L. Elizalde; 2 females, Hudson, Buenos Aires province [-34.7710 S, -58.1329 W], September 2003, over *Ac. lundii*, L. Elizalde; 4 females, Reserva "El Destino", Magdalena, Buenos Aires province [-35.1384 S, -57.3952 W], 10 December 2004, over *Ac. ambiguus*, L. Elizalde; 2 females;, same previous locality, 13 December 2004, over *Ac. lundii*, L. Elizalde; 15 females, Estancia Tatay, Carmen de Areco, Buenos Aires province [-34.3278 S, -59.8975 W], March 2004, over *Ac. lundii*, L. Elizalde; 10 females, Parque Nacional El Palmar, Entre Ríos province [-31.8527 S, -58.3029 W], November 2004, over *Ac. ambiguus*, L. Elizalde.

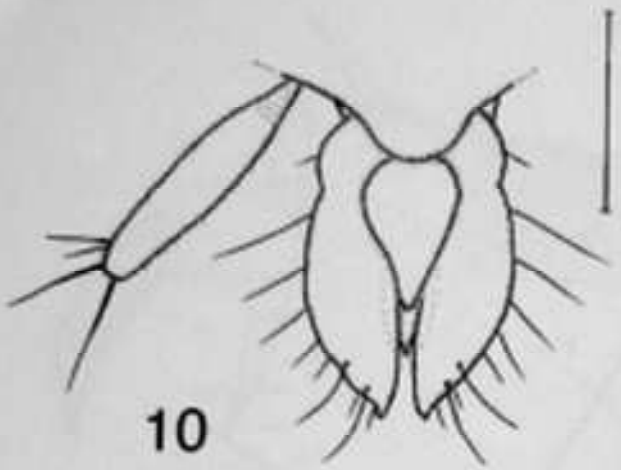
Recorded hosts. *Acromyrmex ambiguus, Ac. crassispinus, Ac. heyeri, Ac. hispidus, Ac. lobicornis, Ac. lundii, A. niger, A. subterraneus* and *Atta sexdens*.

Field observations. Females were collected flying along the foraging trails and over the nest entrances of *Acromyrmex ambiguus, Ac. crassispinus, Ac. heyeri* and *Ac. lundii*. In addition, they approached *Ac. crassispinus* and *Ac. heyeri* that were repairing their nests as well as *Ac. lundii* while in places where they cut leaves their foraging areas. They sometimes flew backwards when pursuing ants. They oviposited in the anterior part of the head, under the clypeus, after landing for a few seconds. Victimized ants included both those with and without a load. Some of them, immediately after being attacked, ceased walking and curved the gaster ventrally. Others continued walking without showing any particular response to the attack. Some ants near a victim of an attack, touched the latter with their mandibles and antennae or remained still with the jaws directed upwards. In fact, when a phorid was flying over a trail it was common to see ants with their mandibles open and the head pointing upwards as they tried to catch the fly. Hitchhikers were common on the ant loads when *M. catharinensis* was present.

Myrmosicarius cristobalensis new species

Figs. 10-12, 14-15, 43

Female (Figs. 10-12, 14-15). Eyes with lowermost ommatidia 0.02-0.03 mm in diameter but uppermost ones are at most only about 0.015 mm. Anterior ocellus typically about 0.06-0.07 mm in diameter. Frons brown with 34-64 hairs. Bristles arranged as Fig. 11. Antenna light brown and as Fig. 12. Palp straw yellow and as Fig. 10. Proboscis paler and as Fig. 10. Thorax brown on



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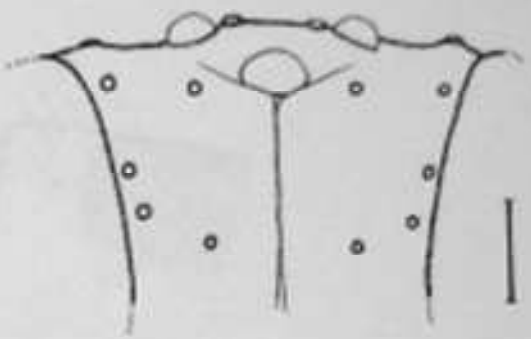

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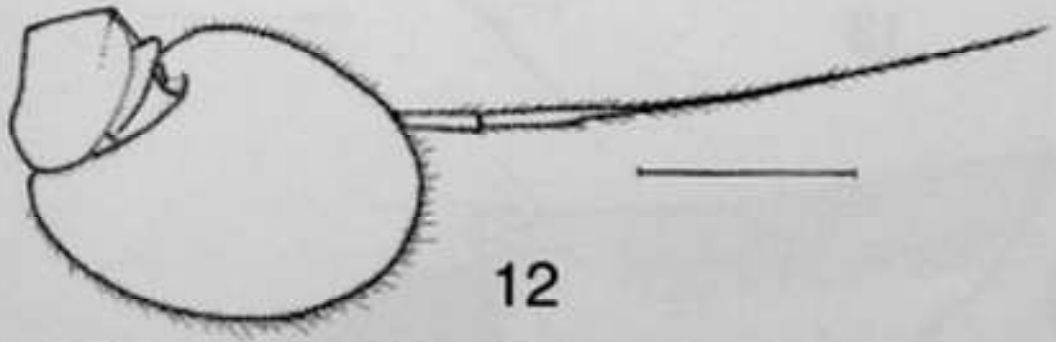

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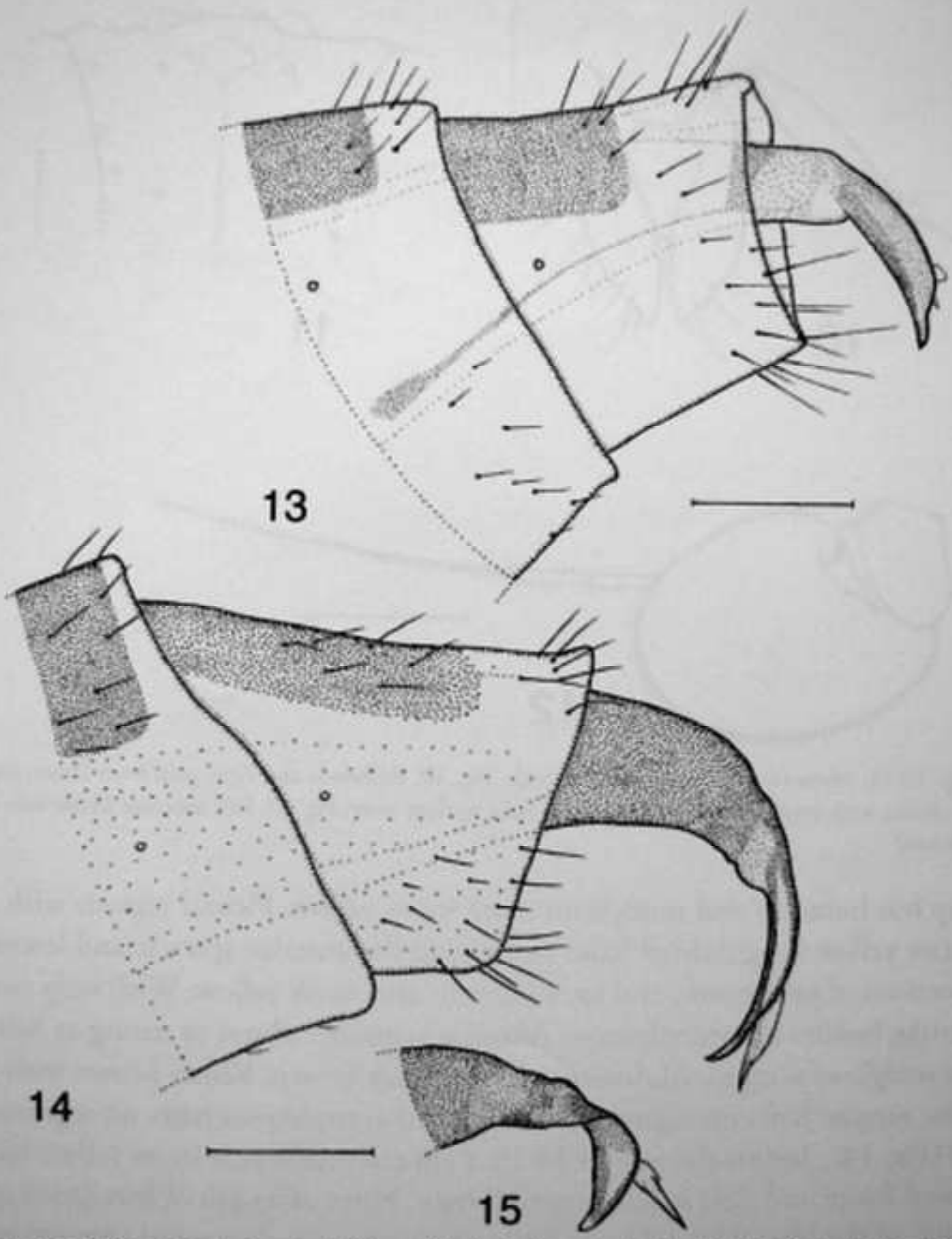
Figs. 10-12. *Myrmosicarius cristobalensis* female. Fig. 10. Proboscis and right palp from above; Fig. 11. Frons, with bristles represented by their basal sockets only; Fig. 12. Left antenna. (Scale bars = 0.1 mm)

top but humerus and notopleuron are straw yellow. Pleural regions with a straw yellow longitudinal band embracing the anterior spiracle and lowest portions of propleuron and mesopleuron also straw yellow. With only two strong bristles on notopleuron. Anterior scutellars about as strong as hairs in middle of scutum. Abdominal tergites dark brown. Venter brown with a few minute hairs on segment 5 and several conspicuous hairs on segment 6 (Fig. 14). Terminalia as Figs 14-15. Legs essentially pale straw yellow but hind femur and tibia in part tinged brown. Ratio of length of fore tarsus to that of the tibia 0.89-1.21 : 1. Ratio of basitarsus to last tarsal segment of front leg is 0.39-0.77 : 1. Ratio of length of mid basitarsus to segments 2-3 is 0.95-1.26 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 0.97-1.1 : 1. Wing length 1.2-1.75 mm. Costal index 0.28-0.31. Costal ratios 6.2-9 : 1.3-2.3 : 1. The wide variation reflects the fact that sometimes veins 2 and 3 are so closely approximated that the space between the two branches of the



Figs. 13-15. *Myrmosicarius* females, left faces of abdominal terminalia. Fig. 13. *M. infestans* from rear of segment 5 onwards; Figs 14-15. *M. cristobalensis*; Fig. 14. From rear of segment 5 onwards; Fig. 15. Apical piece of ovipositor tube and protruding subula viewed from another angle. (Scale bars = 0.1 mm)

fork tends to be occluded (in the extreme vein 3 may appear to be unforked). Costal cilia 0.05-0.07mm long. Vein Sc fades away as it approaches vein 1. No hair at base of vein 3. Axillary ridge with two bristles, the outermost one

being longer than costal cilia of section 1. Veins grey and membrane very lightly tinged grey. Haltere brown.

Male (Fig. 43). Frons brown with 48-56 hairs. Bristle arrangement similar to Fig. 11. Postpedicels yellowish brown, ovoid, 0.17-0.18mm long and 0.13-0.14 mm maximum breadth. Palps straw yellow with five short bristles. Proboscis paler. Thorax similar to female. Abdominal tergites dark brown with small hairs. Venter yellowish brown with minute hairs below segments 2-6. Hypopygium brown, with a straw yellow anal tube, and as Fig. 43. Legs essentially pale straw yellow but hind femur with a brown tip. Front tarsus with a posterodorsal hair palisade on all five segments and segment 5 a little longer than 4. Wing length 1.4 mm. Costal index 0.30-0.31. Costal ratios 7.8 : 1.9 : 1. Costal cilia 0.07 mm long. Otherwise it and haltere similar to female.

Material examined: Holotype female, ARGENTINA, San Cristobal, Santa Fe [-30.2073 S, -61.1506 W], 28 April 2004, over *Acromyrmex fracticornis*, L. Elizalde (MBR). Paratypes, 2 females, as holotype except 20 November 2004, L. Elizalde (MBR, MZUC); 1 female, Parque Nacional Chaco [-26.8638 S, -59.6245 W], 15 May 2004, over *Ac. subterraneus*, L. Elizalde (MZUC); 1 female, same locality, 17 May 2004, over *Ac. lundii*, L. Elizalde (MZUC); 1 male, 2 females, Reserva Natural Formosa [-24.3161 S, -61.8050 W], 4 October 2004, over *Ac. hispidus*, L. Elizalde (MBR, MZUC); 7 females, the same locality, October 2004, over *Ac. striatus*, L. Elizalde (MBR, MZUC); 1 female, Mercedes, Corrientes [-29.1526 S, -57.9906 W], 31 October 2004, over *Ac. heyeri*, L. Elizalde (MZUC). 1 female, BRAZIL, Tocantins, Porto Nacional, 8 May 2005, with *Acromyrmex* sp., C. A. Nogueira (MZUC). 2 females, PARAGUAY, Benjamín Aceval, Presidente Hayes department [-25.0389 S, -57.5472 W], 16 January 2004, over *Ac. fracticornis*, L. Elizalde (MBR, MZUC).

Additional specimens examined by LE only (and not designated as paratypes): ARGENTINA, 8 females, Reserva Natural Formosa, Formosa province [-24.3161 S,, - 61.8050 W], 5 October 2004, over *Ac. lobicornis*, L. Elizalde; 4 females, San Cristóbal, Santa Fe province [-30.2073 S, -61.1506 W], November 2004, over *Ac. lobicornis*, L. Elizalde.

Etymology: The species is named after the type locality.

Recorded hosts. *Acromyrmex fracticornis*, *Ac. heyeri*, *Ac. hispidus*, *Ac. lundii*, *Ac. striatus* and *Ac. subterraneus*.

Field observations. The behavioral observations of this species were made over all six of the recorded hosts. Both sexes were collected flying along foraging trails and nest entrances. Females oviposited rapidly, aiming at the end of the host's gaster. They pursued walking ants for up to 50 cm before starting to pursue another host. They rarely rested while searching for ants prior to oviposition. When present on the foraging trails of *Ac. lobicornis* and *Ac. lundii* these ants carried hitchhikers, and exhibited a defensive posture with their mandibles opened and directed upwards in attempts at catching a fly.

Myrmosicarius crudelis Borgmeier
Figs. 16-19

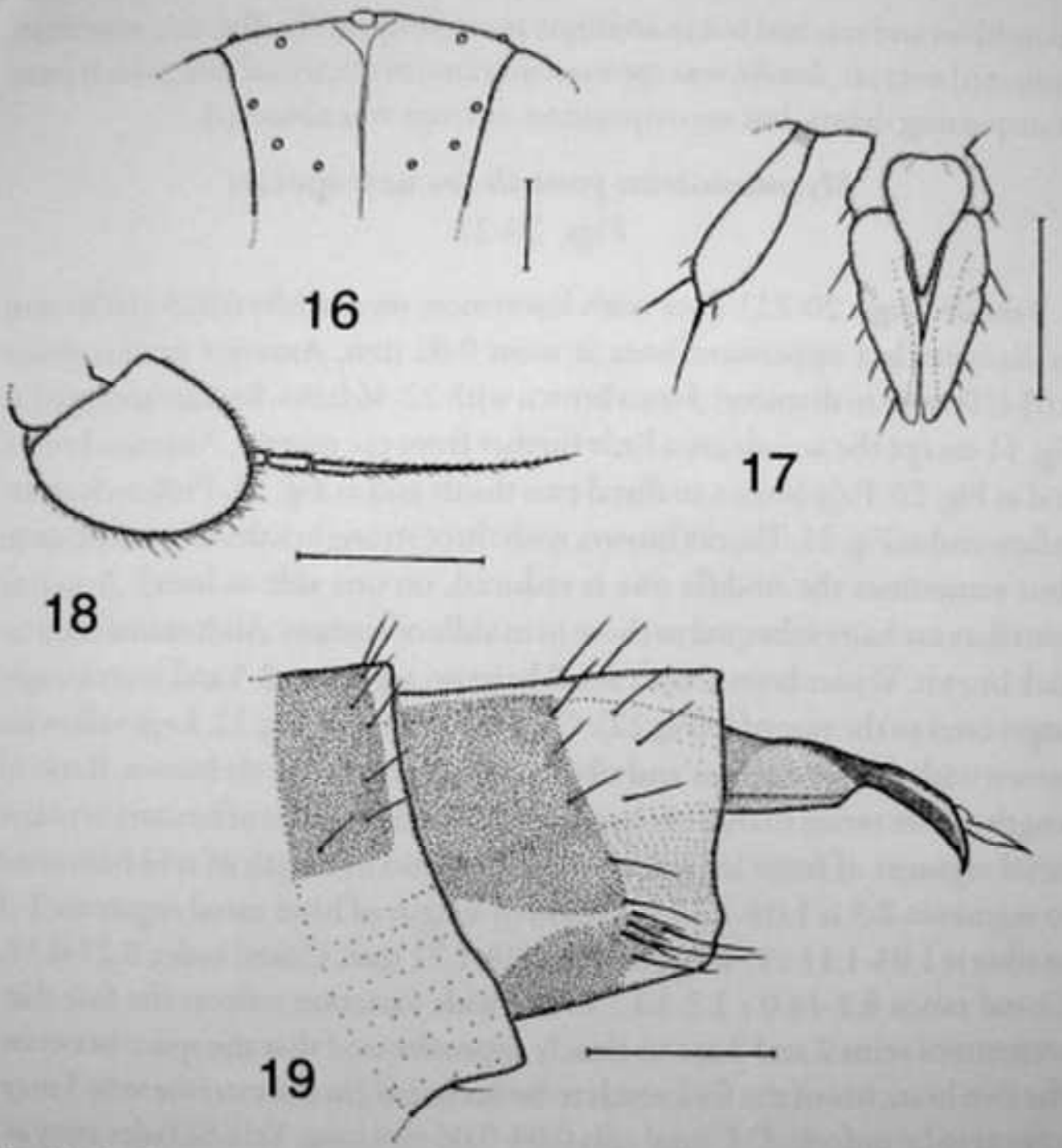
Myrmosicarius crudelis Borgmeier 1928: 123.
Myrmosicarius diabolicus Borgmeier 1931: 222. Syn. nov.

We have designated a slide mounted female as the lectotype of *M. diabolicus*. The supposed differences between *M. crudelis* and *M. diabolicus* are found to lie within the ranges of variation given below. We have concluded that *M. diabolicus* is a synonym of *M. crudelis*.

Female (Figs. 16-19). Frons as Fig. 16. The anterior ocellus is at most 0.03mm in diameter. Antenna as Fig. 18. Proboscis and palp as Fig. 17. Ovipositor as Fig. 19. Ratio of length of fore tarsus to that of the tibia 0.85-0.94 : 1. Ratio of basitarsus to last tarsal segment of front leg is 0.50-0.63 : 1. Ratio of length of mid basitarsus to segments 2-3 is 1.08-1.24 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 0.98-1.04 : 1. Wing length 1.02-1.09 mm. Costal index 0.30-0.33. Costal ratios 4.1-6.7 : 1.2-2.0 : 1. Costal cilia 0.04-0.05 mm long.

Material examined: Holotype female, BRAZIL, Bom Retiro, Santa Catarina, with *Atta sexdens*, 1927, C. Prade (MZSP). Holotype female of *M. diabolicus*, Brazil, Bom Retiro, Sta. Catarina, 29 August 1927, with *Solenopsis saevissima*, C. Prade (MZSP). 1 females, ARGENTINA, Isla Martin Garcia, Buenos Aires, 29 April 2004, with *Acromyrmex lundii*, L. Elizalde (MZUC): 6 females, Noetinger, Córdoba [-32.3174 S, -62.3608 W], 23 November 2004, with *Ac. crassispinus* L. Elizalde (MBR, MZUC).

Recorded hosts. *Acromyrmex crassispinus* and *Ac. lundii*. The holotype was recorded with *Atta sexdens* (Borgmeier, 1929) and this host subsequently



Figs. 16-19. *Myrmosicarius crudelis* female. Fig. 16. Frons, with bristles represented by their basal sockets only; Fig. 17. Proboscis and right palp from above; Fig. 18. Left antenna; Fig. 19. Left face of rear of abdominal segment 5, segment 6, ovipositor tube and protruding subula. (Scale bars = 0.1 mm)

confirmed (Eidmann 1937, Prado 1976). This species has also been recorded over fire ants, *Solenopsis saevissima* complex (Borgmeier, 1928, 1931).

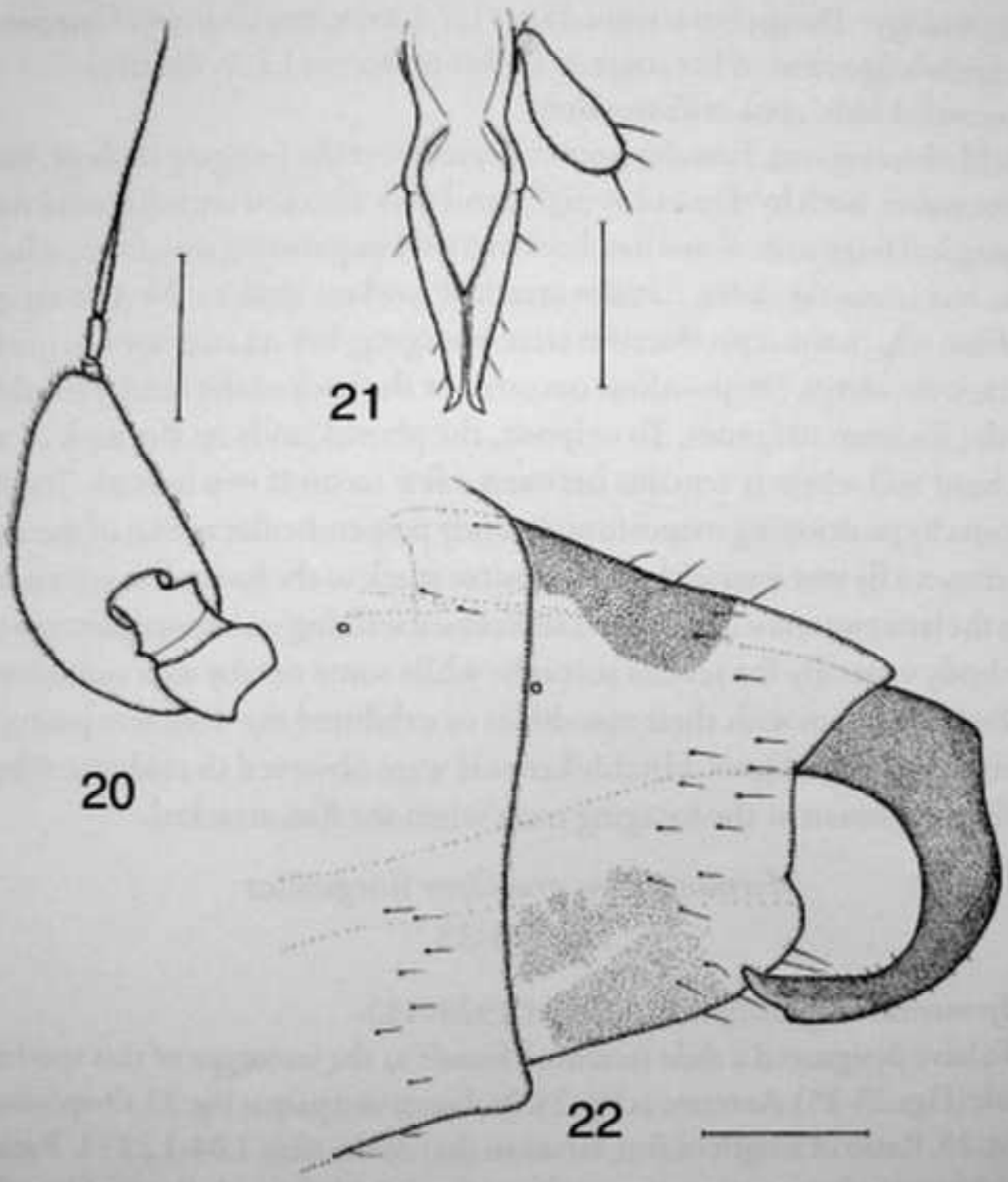
Field observations. *M. crudelis* was collected only over *Acromyrmex crassispinus*. It attacked ants in their refuse piles and on their foraging trails. Females followed ants without a load, flying fast, and periodically landing on the sides of the trail to rest. They oviposited in the rear part of the host's abdomen, landing on the gaster for about a second. Nearby ants frequently opened their

mandibles and reached out in attempts at catching the fly. The only specimen collected over *Ac. lundii*, was approaching ants in the refuse pile, which were transporting debris, but no oviposition attempt was observed.

Myrmosicarius gonzalezae new species
Figs. 20-22

Female (Figs. 20-22). Eyes with lowermost ommatidia 0.025-0.030 mm in diameter but uppermost ones at most 0.02 mm. Anterior ocellus about 0.05-0.06 mm in diameter. Frons brown with 22-46 hairs. Bristles arranged as Fig. 11 except the antials are a little further from eye margin. Antenna brown and as Fig. 20. Palp brown in distal two thirds and as Fig. 21. Proboscis straw yellow and as Fig. 21. Thorax brown, with three strong bristles on notopleuron (but sometimes the middle one is reduced, on one side at least). Anterior scutellars are hairs subequal to those in middle of scutum. Abdominal tergites dark brown. Venter brown with small hairs on segments 2-5 and increasingly larger ones to the rear of 6 (Fig 22). Ovipositor tube as Fig. 22. Legs yellowish brown with the hind femur and tibia being most extensively brown. Ratio of length of fore tarsus to that of the tibia 0.91-1.03 : 1. Ratio of basitarsus to last tarsal segment of front leg is 0.49-0.58 : 1. Ratio of length of mid basitarsus to segments 2-3 is 1.03-1.35 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 1.03-1.11 : 1. Wing length 1.38-1.71 mm. Costal index 0.27-0.31. Costal ratios 8.2-14.0 : 2.2-3.1 : 1. The wide variation reflects the fact that sometimes veins 2 and 3 are so closely approximated that the space between the two branches of the fork tends to be occluded (in the extreme vein 3 may appear to be unforked).Costal cilia 0.04-0.06 mm long. Vein Sc fades away as it approaches vein 1. No hair at base of vein 3. Axillary ridge with 3-5 bristles, the outermost one being longer than costal cilia of section 1. Veins yellowish grey and membrane only very lightly tinged grey. Haltere brown.

Material examined: Holotype female, ARGENTINA, Parque Nacional Pilcomayo, Formosa, May 2004, L. Elizalde (MBR). Paratypes, 1 female as holotype except 9 June 2004, over *Atta vollenweideri* (MZUC); 1 female, Parque Nacional Chaco, October 2003, over *A. vollenweideri*, L. Elizalde (MBR); 1 female, Mercedes, Corrientes, [-29.1526 S, -57.9906 W], 5 November 2004, over *A. vollenweideri*, L. Elizalde (MZUC); 2 females, San



Figs. 20-22. *Myrmosicarius gonzalezae* female. Fig. 20. Left antenna; Fig. 21. Proboscis and left palp; Fig. 22. Left face of rear of abdominal segment 5, segment 6 and ovipositor tube. (Scale bars = 0.1 mm)

Cristobal, Santa Fe, [-30.2073, -61.1506], 18 November 2004 and 26 June 2005, over *A. vollenweideri*, Elizalde (MBR, MZUC).

Additional specimens examined by LE only (and not designated as paratypes): ARGENTINA, 3 females, Campo Bandera, Formosa province [-24.0091 S, -61.8718 W], January 2004, over *Atta vollenweideri*, L. Elizalde; 3 females, San Cristóbal, Santa Fe province [-30.2073 S, -61.1506 W], April 2004, over *Atta vollenweideri*, L. Elizalde.

Etymology: The species is named after Lic. Constanza Gonzalez Campero in acknowledgement of her support to this project of LE in the field.

Recorded host. *Atta vollenweideri*.

Field observations. Females were collected over the foraging trails of *Atta vollenweideri*, both by day and at night, and over attacked ants that were not carrying leaf fragments. Some flew backwards while pursuing ants. Once, when a nest was releasing alates, females attacked workers close to the nest openings from which the reproductives were emerging, but no attempt was made to attack the alates. Ovipositions occurred at the back of the head, probably into the foramen magnum. To oviposit, the phorid lands on the back of an ant's head and where it remains between a few seconds to a minute. The fly oviposits by positioning ovipositing its body perpendicular to that of the ant. Sometimes a fly was seen with its ovipositor stuck to the back of an ant's head when the latter was raised. Attacked ants ceased walking and sometimes curved their body ventrally for several seconds; while some nearby ants sometimes touched the victim with their mandibles or exhibited the defensive posture, opening their raised jaws. Hitchhiker ants were observed in evidence when this fly was present at the foraging trails when the flies attacked.

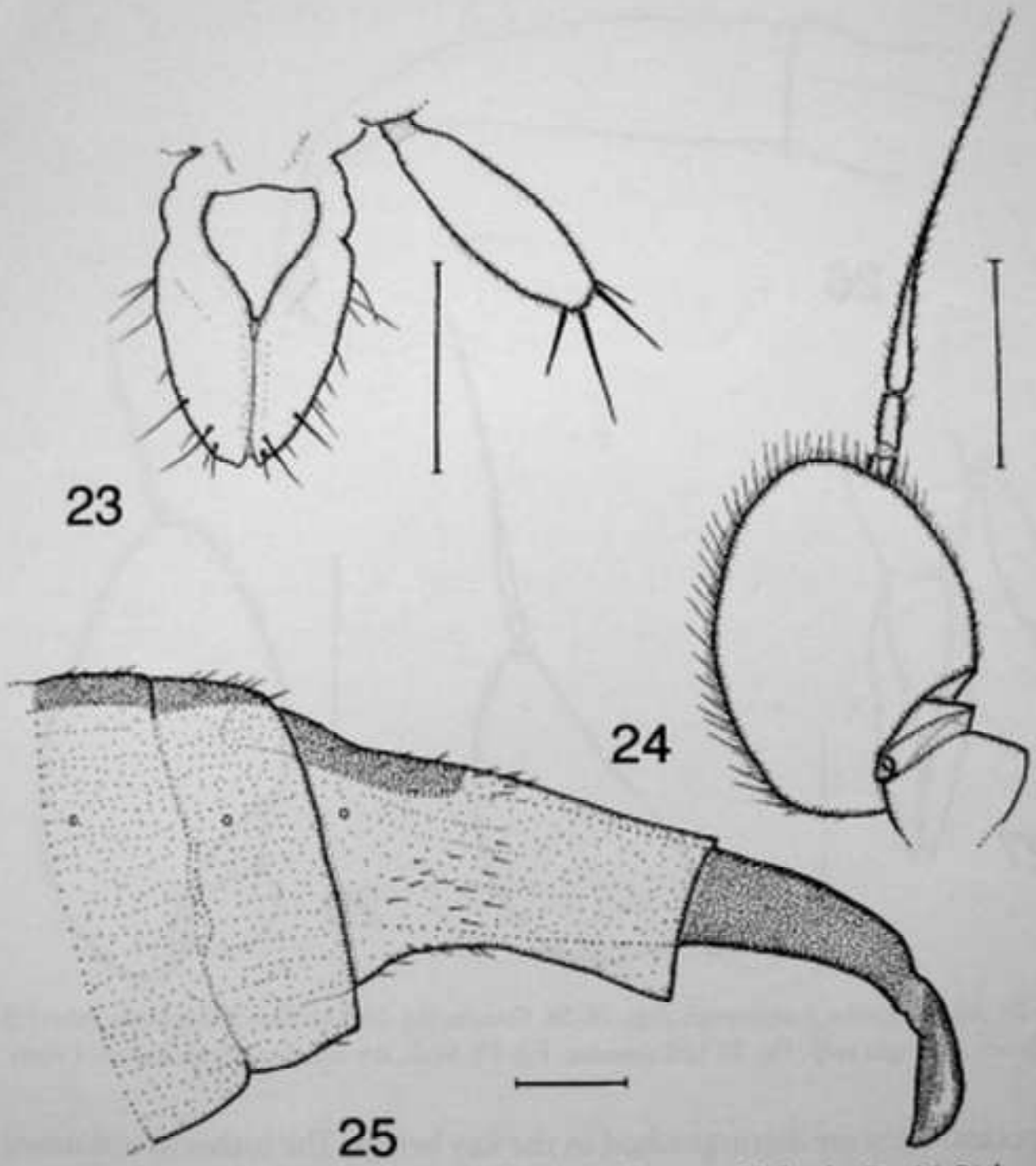
Myrmosicarius gracilipes Borgmeier
Figs. 23-25

Myrmosicarius gracilipes Borgmeier 1928: 123.

We have designated a slide mounted female as the lectotype of this species. Female (Figs. 23-25). Antenna as Fig. 24. Proboscis and palp as Fig. 23. Ovipositor as Fig. 25. Ratio of length of fore tarsus to that of the tibia 1.04-1.22 : 1. Ratio of basitarsus to last tarsal segment of front leg is 0.51-0.64 : 1. Ratio of length of mid basitarsus to segments 2-3 is 1.15-1.16 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 0.87-0.91 : 1. Wing length 1.30-1.54 mm. Costal index 0.32-0.35. Costal ratios 6.1-6.8 : 1..6-1.8 : 1. Costal cilia 0.06-0.07 mm long.

Material examined: Lectotype female, BRAZIL, Rio Negro (Paraná), 13 March 1924, over *Acromyrmex subterraneus*, W. Frey (MZSP). 2 females, ARGENTINA, Noetinger, Córdoba [-32.3174 S, -62.3608 W], 23 November 2004, over *Ac. crassispinus*, L. Elizalde (MBR, MZUC).

Recorded hosts. *Acromyrmex subterraneus* (Borgmeier, 1929, 1931) and *Ac. crassispinus*.



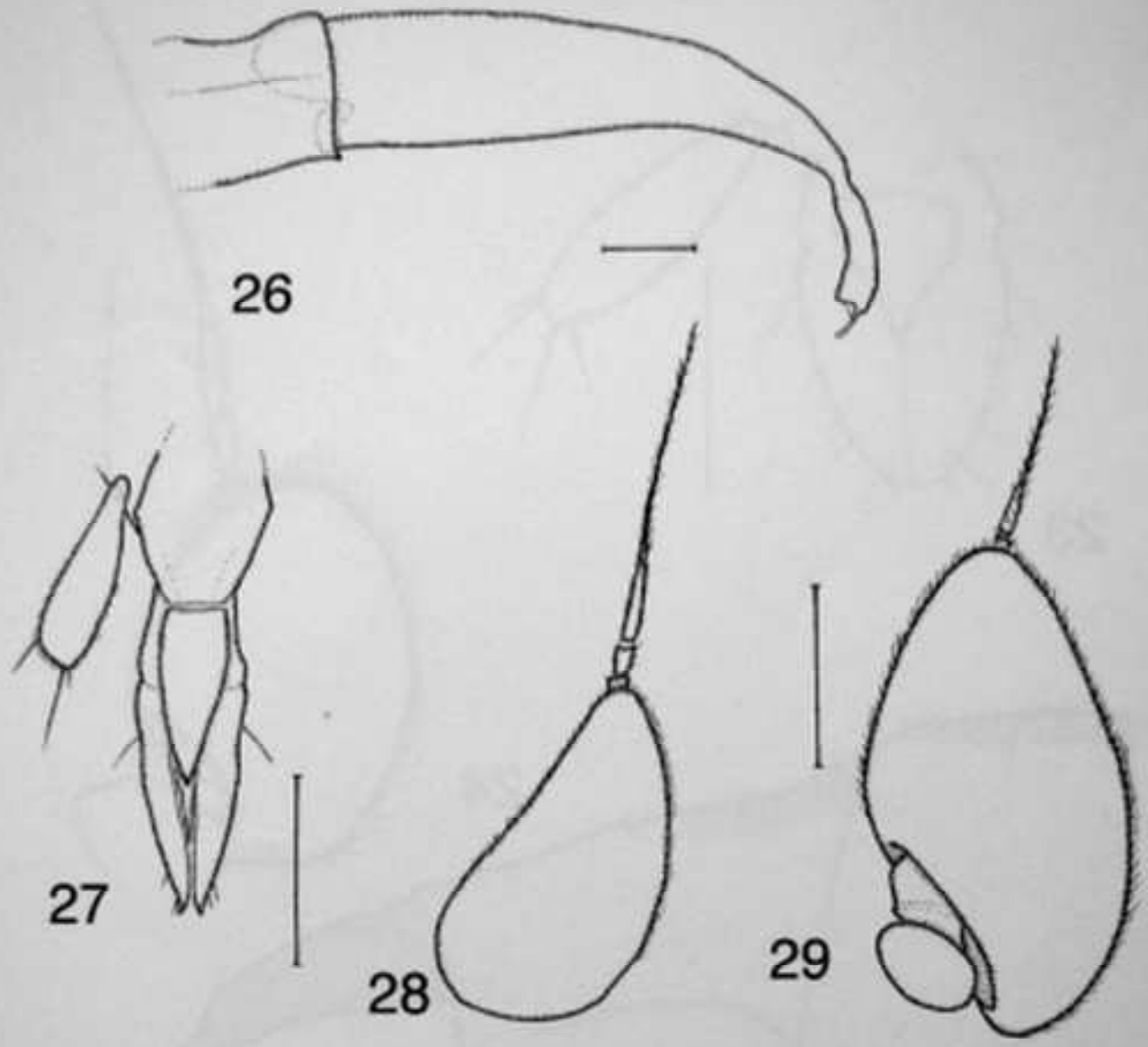
Figs. 23-25. *Myrmosicarius gracilpes* female. Fig. 23. Proboscis and left palp; Fig. 24. Right antenna; Fig. 25. Left face of rear of abdominal segment 4, segments 5-6 and ovipositor tube. (Scale bars = 0.1 mm)

Field observations. Two females were collected flying along the foraging trails of *Acromyrmex crassispinus*, near the nest entrance. Ovipositions were not observed.

Myrmosicarius grandicornis Borgmeier
Figs. 26-28 and 38

Myrmosicarius grandicornis Borgmeier 1928: 124.

In Borgmeier's (1931) key to females two other species will run down to



Figs. 26-29. *Myrmosicarius grandicornis*. Figs. 26-28. Female; Fig. 26. Left face of ovipositor tube; Fig. 27. Proboscis and right palp; Fig. 28 Left antenna. Fig. 29, Male, left antenna. (Scale bars=0.1 mm)

this species. They are distinguished in the key below. The hitherto unknown male is described below.

Female (Figs. 26-28 and 38). Antenna as Fig. 28. Proboscis and palp as Fig. 27. Ovipositor as Figs 26 and 38. Ratio of length of fore tarsus to that of the tibia 0.91-1.07 : 1. Ratio of basitarsus to last tarsal segment of front leg is 0.40-0.61 : 1. Ratio of length of mid basitarsus to segments 2-3 is 1-1.34 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 1.05-1.21 : 1. Wing length 1.44-1.95 mm. Costal index 0.28-0.31. Costal ratios 9.2-13 : 2-3.6 : 1. Costal cilia 0.035-0.05 mm long.

Male (Figs. 29, 39 and 44). Antenna as Fig. 29. Part of thorax as Fig. 44. Hypopygium as Fig. 39.

Material examined: Holotype female, BRAZIL, Raiz da Serra (Est. do Rio de Janeiro, August 1923, flying over *Atta sexdens*, W. S. Bristowe (MZSP). 1 female, Tocantins, Tupiratins, September 2000, with *A. sexdens*, M. Rodrigues (MZUC); 2 females, same locality, 7 January 2001, with *A. sexdens*, M. Bragança (MZUC); 8 females, Tocantins, Porto Nacional, October 2000, 6 December 2000, May 2002, October 2004, with *A. sexdens*, M. Bragança, Z. C. Medeiros, C. A. Nogueira, M. Rodrigues, (MZUC); 11 females, R. J., Campos dos Goytacazes, 8 November 1994, 22 June, 1995, 16 August 1996, 17 June 1998, with *A. sexdens rubropilosa*, A. Tonhasca (MZUC); 1 male, 2 females, same locality, 8 July and 19 December 2004, with *A. laevigata*, C. A. Nogueira (MZUC); 1 female, M. G., Viçosa, September 1999, with *A. bisphaerica*, M. Bragança (MZUC); 6 males, 6 females, same locality, October 1999, with *A. sexdens*, M. Bragança (MZUC). 2 females, PARAGUAY, Asunción City, 21 January 2004, with *A. sexdens*, L. Elizalde (MBR, MZUC).

Recorded hosts. Previous studies report the hosts of this fly to include *Atta bisphaerica* (Braganca *et al.* 2003), *A. laevigata* (Erthal *et al.* 1999) and *A. sexdens* (Borgmeier 1929, Eidmann 1937, Prado 1976, Erthal *et al.* 1999, Tonhasca *et al.* 2001). Fowler *et al.* (1995) reported it over *A. sexdens* on eight different occasions; and it has been caught around the nest entrance also (Disney & Kistner 1998). Fowler & Schlittler (1997) report it attacking a population of the subspecies *A. sexdens rubropilosa*, with a preference for the smaller workers. Our new record is for *A. sexdens*.

Field observations. Following an oviposition attack an ant victim was promptly groomed by several minor workers (Fowler & Schlittler 1997). Tonhasca *et al.* (2001) reported that the presence of this fly causes *A. sexdens* workers to abandon their loads and to retreat to the nest. The flies hover above the ants and attack them from above. The mature larvae pupariate inside the hosts' head capsules, which are detached from the rest of the corpse and deposited in the nest's refuse middens. The adult flies subsequently emerge through the host's mouth cavity about a month after oviposition. The females attacking *A. bisphaerica* hover above an ant before landing on it and inserting an egg in the side of it's head (Braganca *et al.* 2003). LE observed females rapidly attacking the heads of *A. sexdens* workers while they were walking along their foraging trail.

Myrmosicarius infestans Borgmeier
Fig. 13

Myrmosicarius infestans Borgmeier 1931: 223.

We have slide mounted five females from the type series and designated one of them the lectotype; and a sixth from the type locality but collected on a later date.

Female (Fig. 13). Ovipositor as Fig. 13. Ratio of length of fore tarsus to that of the tibia 0.87-1.00 : 1. Ratio of basitarsus to last tarsal segment of front leg is 0.55-0.66 : 1. Ratio of length of mid basitarsus to segments 2-3 is 1.05-1.20 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 1.00-1.10 : 1. Wing length 0.8-1.5 mm. Costal index 0.30-0.34. Costal ratios 5.0-6.5 : 1.5-2.0 : 1. Costal cilia 0.03-0.06 mm long.

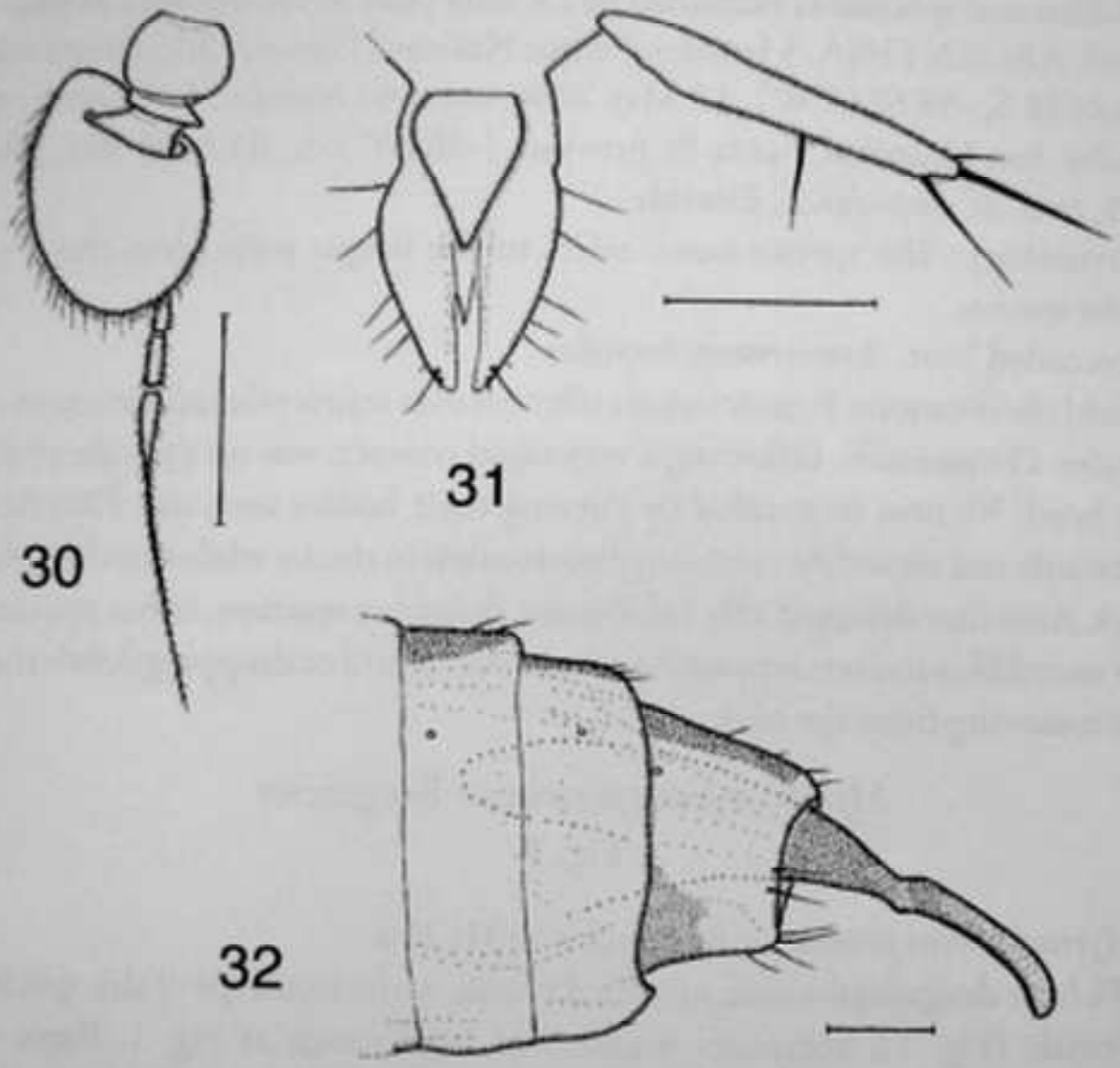
Material examined: Lectotype female, BRAZIL, Itatiaya (Estação Biologica), 12 September 1930, with *Acromyrmex disciger*, W. C. Zikan (MZSP). 4 paratypes as lectotype. 1 female, as lectotype except date was 16 September 1926.

Recorded hosts. *Acromyrmex aspersus mesonotalis*, *Ac. disciger* (Borgmeier, 1931) and *Ac. subterraneus* (Borgmeier, 1929, 1931).

***Myrmosicarius longipalpis* new species**
Figs. 30-32

The males B and C are both candidates for being this species (see below).

Female (Figs. 30-32). Eyes with lowermost ommatidia 0.015 mm in diameter but uppermost ones at most 0.025 mm. Anterior ocellus about 0.035 mm in diameter. Frons brown with 52-84 hairs. Bristles arranged as Fig. 11. Antenna light brown and as Fig. 30. Proboscis and palps as Fig. 31, both being pale straw yellow. Thorax brown, but a little paler in vicinity of anterior spiracle, with only two strong bristles on notopleuron. Anterior scutellars are small hairs subequal to those in middle of scutum. Abdominal tergites dark brown. Venter brown and with conspicuous hairs at the rear of segment 6 (Fig 32). Abdominal terminalia as Fig. 32. Legs essentially straw yellow but hind femur and tibia in part tinged brown. Ratio of length of fore tarsus to that of the tibia 0.8-1.0 : 1. Ratio of basitarsus to last tarsal segment of front leg is



Figs. 30-32. *Myrmosicarius longipalpis* female. Fig. 30. Left antenna; Fig. 31. Proboscis and left palp; Fig. 32. Left face of abdominal segments 4-6 and ovipositor tube. (Scale bars = 0.1 mm)

0.55-0.80 : 1. Ratio of length of mid basitarsus to segments 2-3 is 1.14-1.33 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 0.80-0.91 : 1. Wing length 1.24-1.44 mm. Costal index 0.31-0.34. Costal ratios 5.5-9.6 : 1.3-2.0 : 1. Costal cilia 0.06-0.08 mm long. Vein Sc fades away as it approaches vein 1. No hair at base of vein 3. Axillary ridge with 1-2 bristles, the outermost or single one being longer than costal cilia of section 1. Veins light brown and membrane only very lightly tinged grey. Haltere brown.

Material examined: Holotype female, ARGENTINA, Parque Nacional Pilcomayo, Formosa [-25.1187 S, -58.1675 W], 9 June 2004, over *Acromyrmex hispidus*, L. Elizalde (MBR). Paratypes, 1 female, same data as holotype; 5 females, same data as holotype except over *Ac. hispidus* (MBR, MZUC).

Additional specimens examined by LE only (and not designated as paratypes): ARGENTINA, 5 females, Parque Nacional Chaco, Chaco province [-26.8638 S, -59.6245 W], 17 May 2004, over *Ac. hispidus*, L. Elizalde; 4 females, San Cristóbal, Santa Fe province [-30.2073 S, -61.1506 W], July 2005, over *Ac. hispidus*, L. Elizalde.

Etymology: The species name refers to the longer palps than those of similar species.

Recorded host. *Acromyrmex hispidus*.

Field observations. Females were collected over refuse piles of *Acromyrmex hispidus*. Oviposition, following a very rapid contact, was on the side of the ant's head. Victims responded by curving their bodies ventrally. Flies flew backwards and sometimes remained motionless in the air while searching for a host. Ants that detected a fly exhibited a defensive reaction, either opening their mandibles and attempting capture of the phorid or dropping debris they were removing from the nest.

Myrmosicarius persecutor Borgmeier
Fig. 1

Myrmosicarius persecutor Borgmeier 1931: 224.

We have designated a slide mounted female as the lectotype of this species.

Female (Fig. 1). Segments 4 and 5 of hind tarsus as Fig. 1. Ratio of length of fore tarsus to that of the tibia 1.08 : 1. Ratio of basitarsus to last tarsal segment of front leg is 0.54 : 1. Ratio of length of mid basitarsus to segments 2-3 is 1.03 : 1. Ratio of length of hind tarsal segments 1-3 to tibia is 0.9 : 1. Segments 4 and 5 as Fig. 1. Wing length 1.52 mm. Costal index 0.31. Costal ratios 5.6 : 1.5 : 1. Costal cilia 0.065 mm long. Material examined: Holotype female, BRAZIL, Bom Retiro, Santa Catarina, 22 October 1928, with *Acromyrmex lundii*, C. Prade (MZSP).

Recorded hosts. *Acromyrmex lundii* (Borgmeier, 1931).

Myrmosicarius simplex Borgmeier & Prado

Myrmosicarius simplex Borgmeier & Prado 1975: 58.

No specimen has been examined as the holotype female has apparently been mislaid by Prado. Its data are BRAZIL: São Paulo, Campinas, 1 October 1971, black light trap, A. P. Prado.

Myrmosicarius tarsipennis Borgmeier
Fig. 3

Myrmosicarius tarsipennis Borgmeier 1928: 124.

Female (Fig. 3). Hind basitarsus as Fig. 3.

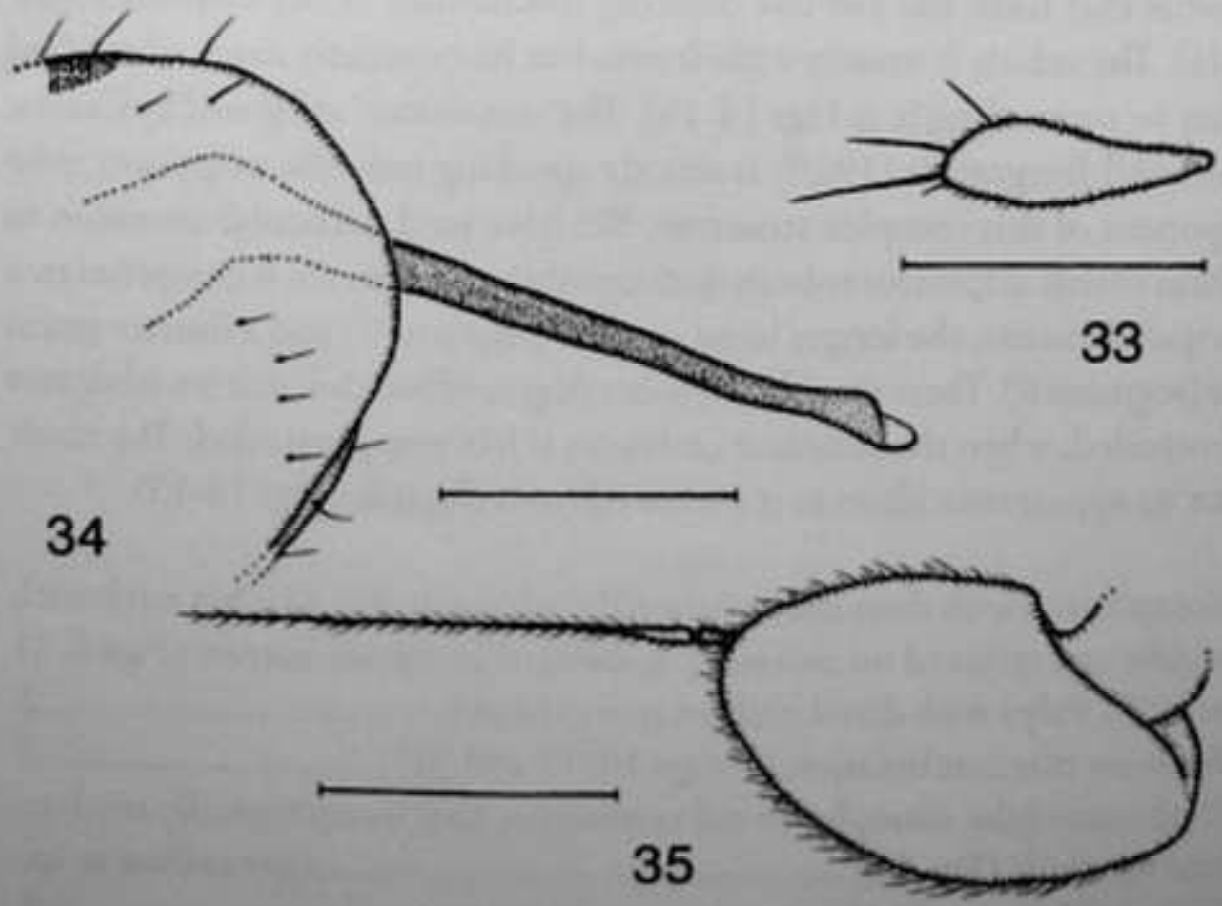
Material examined: Holotype female, BRAZIL, Petropolis, 23 December 1926, with *Acromyrmex niger* (= *muticinodus*), C. Prade (MZSP).

Recorded host. *Acromyrmex niger* (Borgmeier, 1928, 1931).

Myrmosicarius texanus Greene
Figs. 33-35

Myrmosicarius texanus Greene 1938: 182.

Female (Figs. 33-35). Antenna as Fig. 35. Palp as Fig. 33. Ovipositor as Fig. 34. Ratio of length of fore tarsus to that of the tibia 1.0-1.3 : 1. Ratio of basitarsus to last tarsal segment of front leg is 0.4 : 1. Ratio of length of mid basitarsus to segments 2-3 is 1.0 : 1. Ratio of length of hind tarsal segments



Figs. 33-35. *Myrmosicarius texanus* female. Fig. 33. Right palp; Fig. 34. Left face of rear of abdominal segment 6 and ovipositor tube; Fig. 35. Right antenna. (Scale bars=0.1 mm)

1-3 to tibia is 0.8 : 1. Wing length 1.1-1.3 mm. Costal index 0.27-0.32. Costal ratios 6.3-18.0 : 3.5-6.3 : 1. Costal cilia 0.04-0.05 mm long.

Material examined: 2 females, U. S. A., Texas, Austin, 5-7 August 1979, over workers of *Atta texana*, D. Waller (MZUC). [The type material came from Provencal, Louisiana, 13 July 1937, attacking *Atta texana*].

Recorded host. *Atta texana* , the females oviposit into the back of the head (Greene, 1938, Disney, 1980)

REVISED KEY TO FEMALES OF *MYRMOSICARIUS*

Borgmeier's (1931) key mainly relied on differences in the wings and legs. While some of the leg characters have proved reliable, his use of the ratios of various lengths of the parts, and of similar ratios and measurements of the wings, frequently took insufficient account of the variations in size within a species (see above). We have therefore given greater attention to the ovipositor. This comprises abdominal segment 7 onwards, with 7 and 8 (and their extended intersegments) forming the ovipositor tube which embraces the remaining segments that form the awl-like piercing mechanism of the ovipositor (the subula). The subula is usually withdrawn, but its extremely sharp sclerotized tip may be protruding (e.g. Figs 14-15). The 'ovipositor' as figured by Greene (1938) and Borgmeier (1929) is strictly speaking only the ovipositor tube component of this complex structure. We have paid particular attention to the form of this ovipositor tube in distinguishing the species. It comprises two principal elements, the longer basal section (segment 7) and a shorter apical piece (segment 8). There is evidently some degree of rotation as it is withdrawn or protruded, when the subula it embraces is likewise protruded. The result is that its appearance alters as it is viewed from the side (Figs 14-15).

1. Notopleuron with three differentiated bristles (as in Fig. 44) (but rarely with middle one reduced on one side). Labella of proboscis narrow (Figs 6, 21 and 27). Palps with distal half (or more) brown.....2
   Without this combination (cf Figs 10, 17 and 31).....4
2. Ovipositor tube strongly curved ventrally so that its tip typically tends to face forwards (Fig. 22) .....*gonzalezae* n. sp.
   - Not so (Figs. 4 and 26).....3
3. Ovipositor tube gently curved ventrally and ending in a pale narrow finger

(Fig. 26), which appears rounded at its tip or pointed depending on the angle of view (Fig. 38) ..... *grandicornis* Borgmeier

- Ovipositor tube more sinuous and apical piece gradually narrowing to a blunt point (Fig. 4) (note: the expanded anterior portion may be largely withdrawn within the embrace of the preceding segments) ..... *brandaoi* n. sp.

4. Hind basitarsus with a single anteroventral row of spinules 5
- Hind basitarsus as Fig. 3 ..... *tarsipennis* Borgmeier

5. Segment 5 of hind tarsus with hairs extending almost to tip (one usually needs about x100 magnification to see these hairs) 6
- Segment 5 of hind tarsus with last third bare (and strongly tapered) (Fig. 1) ..... *persecutor* Borgmeier

6. Second segment of front tarsus as Fig. 2 7
- Second segment of front tarsus strongly tapered (similar to Fig. 1) 8

7. Front tarsus with basal segment longer than apical segment (Fig.2) ..... *biarticulatus* Borgmeier
- Front tarsus with apical segment longer than basal segment ..... *simplex* Borgmeier & Prado

8. Ovipositor tube (segments 7 and 8) with apical piece long and very slender (Fig. 34, note that in this figure the expanded basal section is entirely withdrawn within the embrace of the preceding segments) ..... *texanus* Greene
- Ovipositor tube with apical piece relatively short (Figs. 9, 13, 14, 19, 25 and 32) 9

9. Palps relatively long (Fig. 31), being longer than postpedicel (Fig. 30). Apical piece of ovipositor tube almost parallel sided with a rounded tip (in side view) (Fig. 32) ..... *longipalpis* n. sp.
- Not so 10

10. Hairs at rear of abdominal segments 5 and 6 relatively short (Figs. 9 and 25). Thorax almost uniformly brown 11
- Hairs at rear of segments 5 and 6 longer (Figs. 13, 14 and 19). Thorax usually with at least humerus and parts of pleural regions pale straw yellow.. 12

11. Apical piece of ovipositor tube strongly tapered and pointed at tip (Fig. 9) ..... *catharinensis* Borgmeier
- Apical piece of ovipositor tube as Fig. 25 ..... *gracilipes* Borgmeier

12. Antials distinctly further from eye margin than ALs and anterior ocellus relatively small, being <0.04 mm wide (Fig. 16). Palps <0.13 mm long.... *crudelis* Borgmeier

- Antials typically closer to eye margin (e.g. Fig. 11), but sometimes a little-more distant. Anterior ocellus larger, being at least 0.04 mm wide. Palps >0.13 mm long 13

Note: the posterior ocelli are situated on the vertex (Fig. 11) and may lie on the back of the head when it is detached and mounted under a coverslip (e.g. Fig. 16).

13. Hairs of abdominal sternum 6 relatively long, those of T6 confined to last third and beyond rear margin of tergite, and apical piece of ovipositor tube relatively short (Fig.13)..... *infestans* Borgmeier

- Hairs at rear of sternum 6 shorter, those on T6 extending further forward, and apical piece of ovipositor tube longer (Figs 14-15)..... .....*cristobalensis* n. sp.

Note: observation of these hairs may require at least x100 magnification.

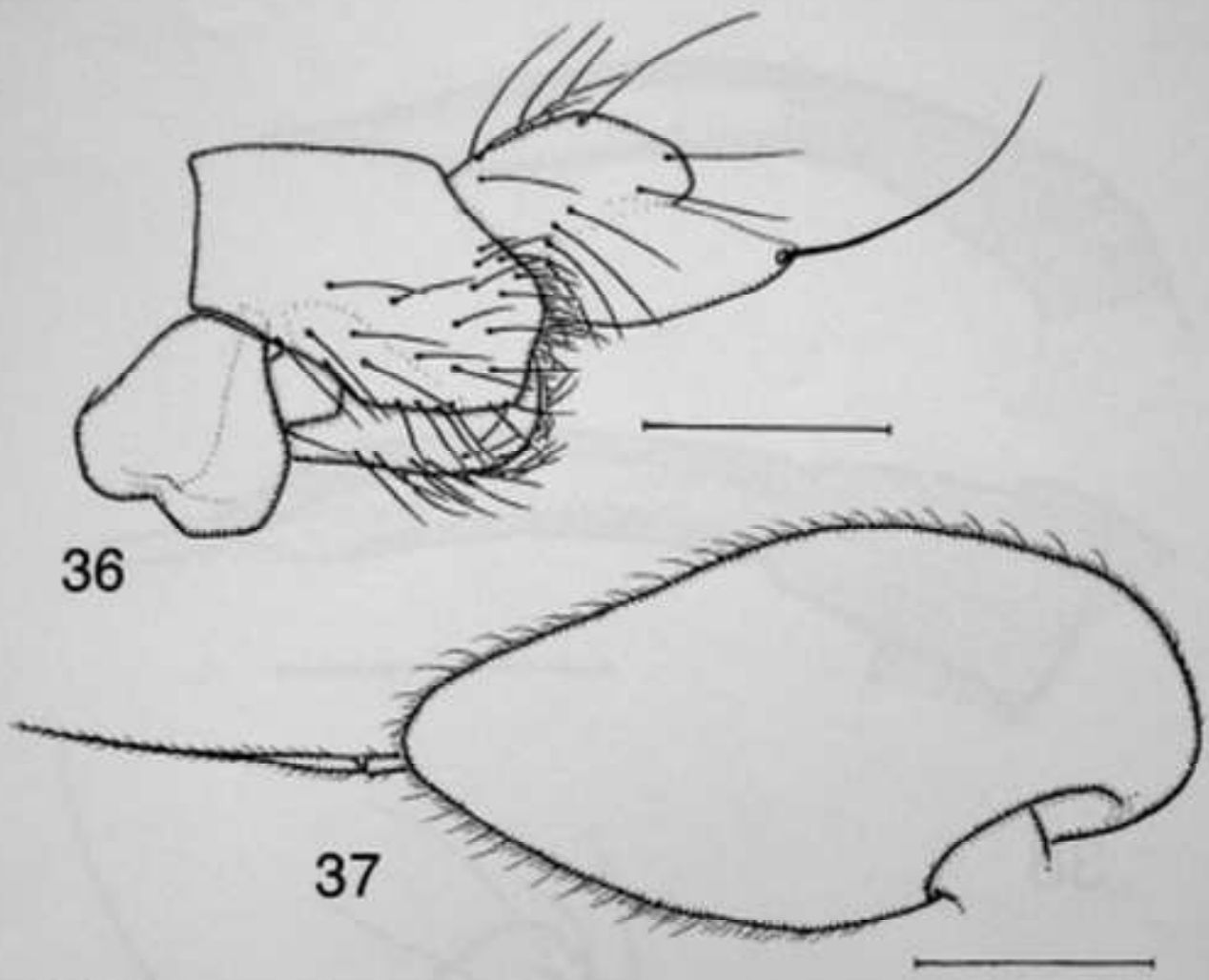
UNASSIGNED MALES

The following males are given code letters only as their specific assignments remain unresolved.

Myrmosicarius Species A
Fig. 40

This is possibly the male of *M. catharinensis*, but such an attribution conflicts with a specimen attributed to this species by Borgmeier (see Species B below).

Male (Fig. 40). Frons brown with 64-68 hairs. Bristle arrangement similar to Fig. 16. Postpedicels light brown, similar in shape to Fig. 24, 0.22 mm long and 0.17 mm maximum breadth. Palps pale straw yellow with six short bristles. Thorax entirely brown, with two bristles on notopleuron and the anterior scutellars subequal to hairs in middle of scutum. Abdominal tergites dark brown with small hairs. Venter brown with minute hairs below segments 5 and 6. Hypopygium brown, with a straw yellow anal tube, and as Fig. 40. Legs essentially pale straw yellow but mid femur and hind femur and tibia partly tinged brown. Front tarsus with a posterodorsal hair palisade on all five



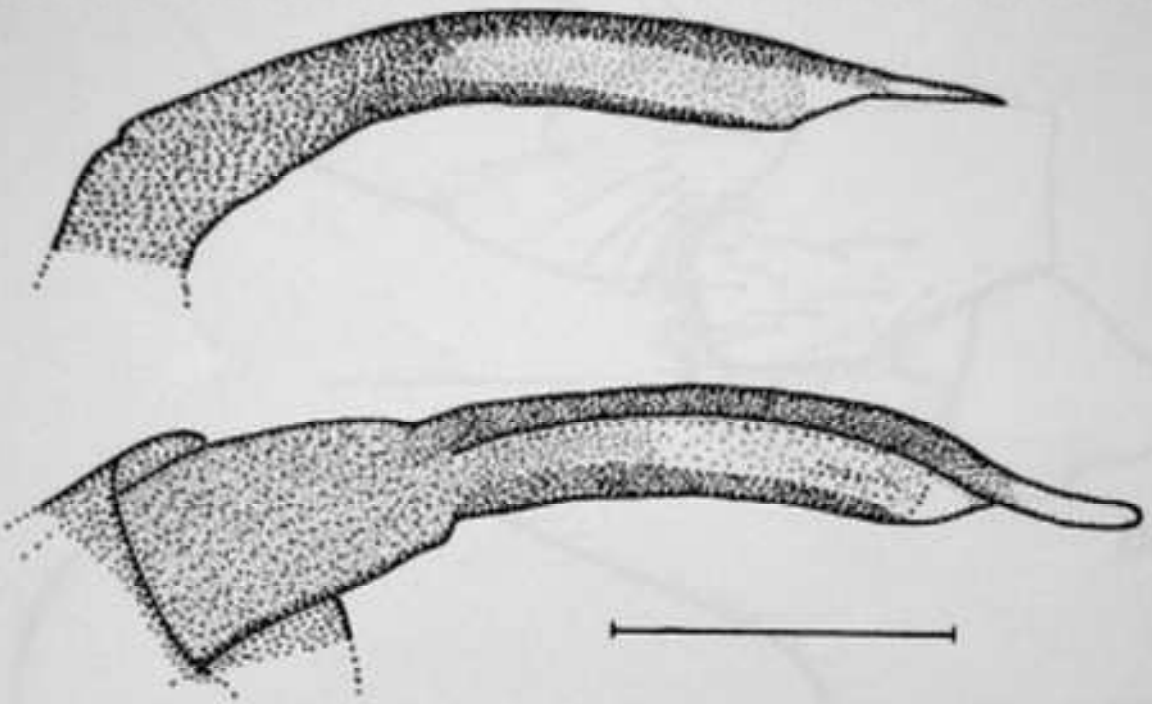
Figs. 36-37. *Myrmosicarius brandaoi* male. Fig. 36. Left face of hypopygium; Fig. 37. Left antenna. (Scale bars = 0.1 mm)

segments and segment 5 a little longer than 4. Wing length 1.4 mm. Costal index 0.33-0.34. Costal ratios 8.9 : 1.7 : 1. Costal cilia 0.05-0.06 mm long. Vein Sc fades away as it approaches vein 1. No hair at base of vein 3. Axillary ridge with 2 bristles, the outermost being longer than costal cilia of section 1. Thick veins yellowish grey, 4-6 pale grey and 7 obscure. Membrane almost colorless. Haltere brown.

Material examined: Male, ARGENTINA, La Plata, Buenos Aires, April 2003, over *Acromyrmex heyeri*, L. Elizalde (MBR).

Myrmosicarius Species B
Fig. 41

This is possibly the male of *M. catharinensis*, if one accepts the attribution by Borgmeier of a male that we mounted on a slide. Furthermore, we have recorded females of this species over *Acromyrmex hispidus*. Otherwise it is a candidate for being the male of *M. longipalpis*.



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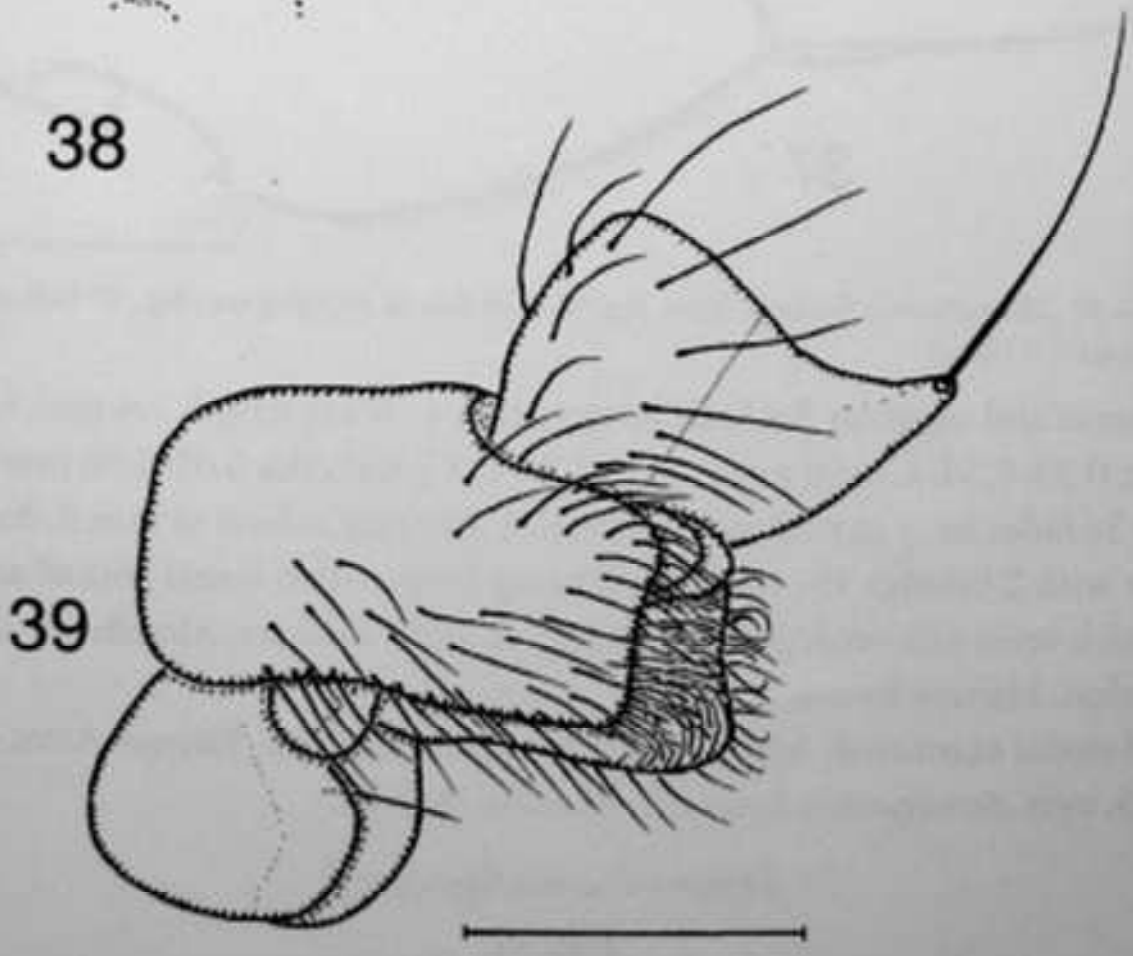

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Figs. 38-39. *Myrmoicarius grandicornis*. Fig. 38. Female, left face of ovipositor tube viewed from two different angles; Fig. 39. Male, left face of hypopygium. (Scale bars=0.1 mm)

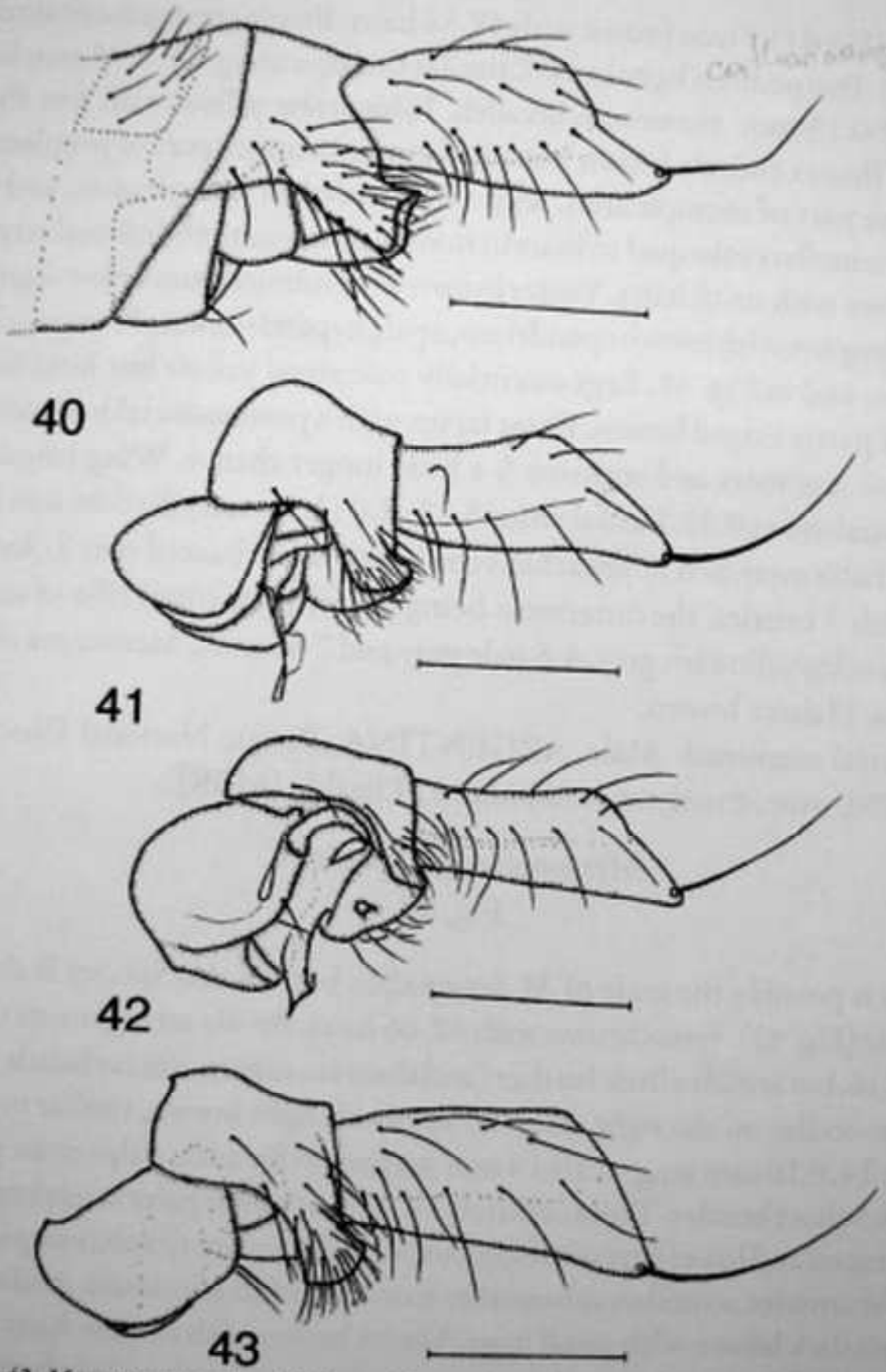
Male (Fig. 41). Frons brown with 48-56 hairs. Bristle arrangement similar to Fig. 11. Postpedicels light brown, similar in shape to fig. 24, 0. 15 mm long and 0.12-0.13 mm maximum breadth. Palps straw yellow with five short bristles. Thorax entirely brown but a little paler in upper part of propleuron and lower part of mesopleuron, with two bristles on notopleuron, and the anterior scutellars subequal to hairs in middle of scutum. Abdominal tergites dark brown with small hairs. Venter brown with minute hairs below segment 6. Hypopygium with brown epandrium, a pale hypandrium and a straw yellow anal tube, and as Fig. 41. Legs essentially pale straw yellow but hind femur and tibia partly tinged brown. Front tarsus with a posterodorsal hair palisade on all five segments and segment 5 a little longer than 4. Wing length 1.2 mm. Costal index 0.32. Costal ratios 5.23 : 1.0 : 1. Costal cilia 0.06 mm long. Vein Sc fades away as it approaches vein 1. No hair at base of vein 3. Axillary ridge with 3 bristles, the outermost being longer than costal cilia of section 1. Thick veins yellowish grey, 4-6 pale grey and 7 obscure. Membrane almost colorless. Haltere brown.

Material examined: Male, ARGENTINA, Parque Nacional Chaco, 12 May 2004, over *Acromyrmex hispidus*, L. Elizalde (MBR).

Myrmosicarius Species C
Fig. 42

This is possibly the male of *M. longipalpis*, but see also Species B above.

Male (Fig. 42). Frons brown with 62-66 hairs. Bristle arrangement similar to Fig. 16, but antials a little further (and there is a supernumeray bristle below the pre-ocellar on the right side). Postpedicels light brown, similar in shape to Fig. 24, 0.16 mm long and 0.14 mm maximum breadth. Palps straw yellow with 4-5 short bristles. Thorax entirely brown but a little paler in upper part of propleuron and lower part of mesopleuron, with two bristles on notopleuron, and the anterior scutellars subequal to hairs in middle of scutum. Abdominal tergites dark brown with small hairs. Venter brown with minute hairs below segment 6. Hypopygium with brown epandrium, a partly pale hypandrium and a straw yellow anal tube, and as Fig. 42. Legs pale straw yellow but hind femur partly tinged brown. Front tarsus with a posterodorsal hair palisade on all five segments and segment 5 a little longer than 4. Wing length 1.2 mm. Costal index 0.32. Costal ratios 5.4-5.5 : 0.9-1.0 : 1. Costal cilia 0.06



Figs. 40-43. *Myrmoticarius* males, left faces of hypopygia. Fig. 40. Species A; Fig. 41. Species B; Fig. 42. Species C; Fig. 43. *M. cristobalensis*. (Scale bars = 0.1 mm)

mm long. Vein Sc fades away as it approaches vein 1. No hair at base of vein 3. Axillary ridge with 2 bristles, the outermost being longer than costal cilia

of section 1. Thick veins pale grey, 4-6 paler grey and 7 obscure. Membrane almost colorless. Haltere brown.

Material examined: Male, ARGENTINA Parque Nacional Chaco, 20 May 2004, over *Acromyrmex hispidus*, L. Elizalde (MBR).

PARTIAL KEY TO MALES

The males of most species remain unknown. The male of *M. infestans* was described by Borgmeier (1931) but without any figures. In the most recent keys to world genera (Disney 1994) this male was run out at couplet 164. However, the lengths of the anal tubes in some of the species keyed below will take them to couplet 170, to *Apocephalus* and *Anaclinusa*, but the latter has since been synonymized with *Apocephalus* (Brown 2000). The species in the latter genus running to this couplet have the anal tube even longer and the vein Sc obscure.

1. Notopleuron with three differentiated bristles (Fig. 44) (but rarely with middle one reduced on one side). Palps with distal half (or more) brown ..2
   Without this combination 3
2. Fewer than 100 hairs on frons. Hypopygium as Fig. 36 .... *brandoai* n. sp.
- At least 100 hairs on frons. Hypopygium as Fig. 39 ..... *grandicornis* Borgmeier

Note: the unknown male of *M. gonzalezae* will also run to this couplet.

3. The hypandrial bristles are about as strong and long as those on the left side of the epandrium (Fig. 43) ..... *cristobalensis* n. sp.
- These bristles are much shorter and also finer 4
4 With fewer than 15 bristly hairs on each cercus. The dorsal hair palisade of mid tibia extends at most three quarters of length 5
- With more than 15 hairs on each cercus (Fig. 40). The hair palisade of mid tibia extends almost to tip ..... Species A
5 Hypopygium as Fig. 41. The hair palisade of mid tibia extends less than half length. The antial bristles about as close to eye margin as anterolaterals ..... Species B
- Hypopygium as Fig. 42. The mid tibia hair palisade extends more than half length. Antials distinctly a little further from eye margin than ALs.. ..... Species C

DISCUSSION

This paper reports a user-friendly key that requires entomological knowledge from the user in the sense that he or she can easily recognize body parts of a parasitic fly. Most of the characters can be observed with a stereoscope using alcohol-preserved specimens, although mounting them on slides and using a microscope facilitates greatly the accuracy of observations. Species identifications can be done accurately by using females which can be easily collected directly from leaf-cutter nests entrances, trails or cutting places. Malaise traps have not added more diversity information in comparison with direct observation of those attracted to ants at their nests. Relatively few males were collected. The use of water (pan) traps placed near ant nests might procure more males.

This paper summarizes ecological data which should help to characterize the life history of these flies as well as help their identification in the field, for at least 8 of the 14 described species. We have found that 5 of the species (*M. brandaoi*, *M. gonzalezae*, *M. catharinensis*, *M. grandicornis*, *M. longipalpis*) oviposit into the head (lateral, posterior or clypeus) whereas 2 target the abdomen (*M. cristobalensis* and *M. crudelis*). Brown (1999) suggested that different oviposition sites within the body of the same host could benefit different phorids species because their larvae can thereby avoid competition for the same resources. Although the idea is interesting, the single phorid reared so far (*M. grandicornis* in Thonasca *et al.* 2001) showed that puparation occurs in the head which, if true for the sympatric parasitoid species that use the same leaf-cutter host, would still lead to spatial competition. In the records presented here we have observed many cases in which 2 species of phorids (*M. brandaoi* and *M. gonzalezae* on *Atta vollenweideri*; *M. crudelis* and *M. gracilipes* on *Ac. crassispinus*; *M. cristobalensis* and *M. catharinensis* on *Ac. lobicornis*) were attacking at the same foraging trail and at the same time suggesting the possibility of competition. It can occur, however, as it does in parasitoids of other ants, that different sizes of phorids use different sizes of hosts (Morrison & Gilbert 1998, Folgarait *et al.* 2002, 2005). If this is the case with leaf-cutter ants, 2 of the 3 pairs mentioned above comprise a large and a small phorid species, which could be avoiding competition by partitioning the resource by size.

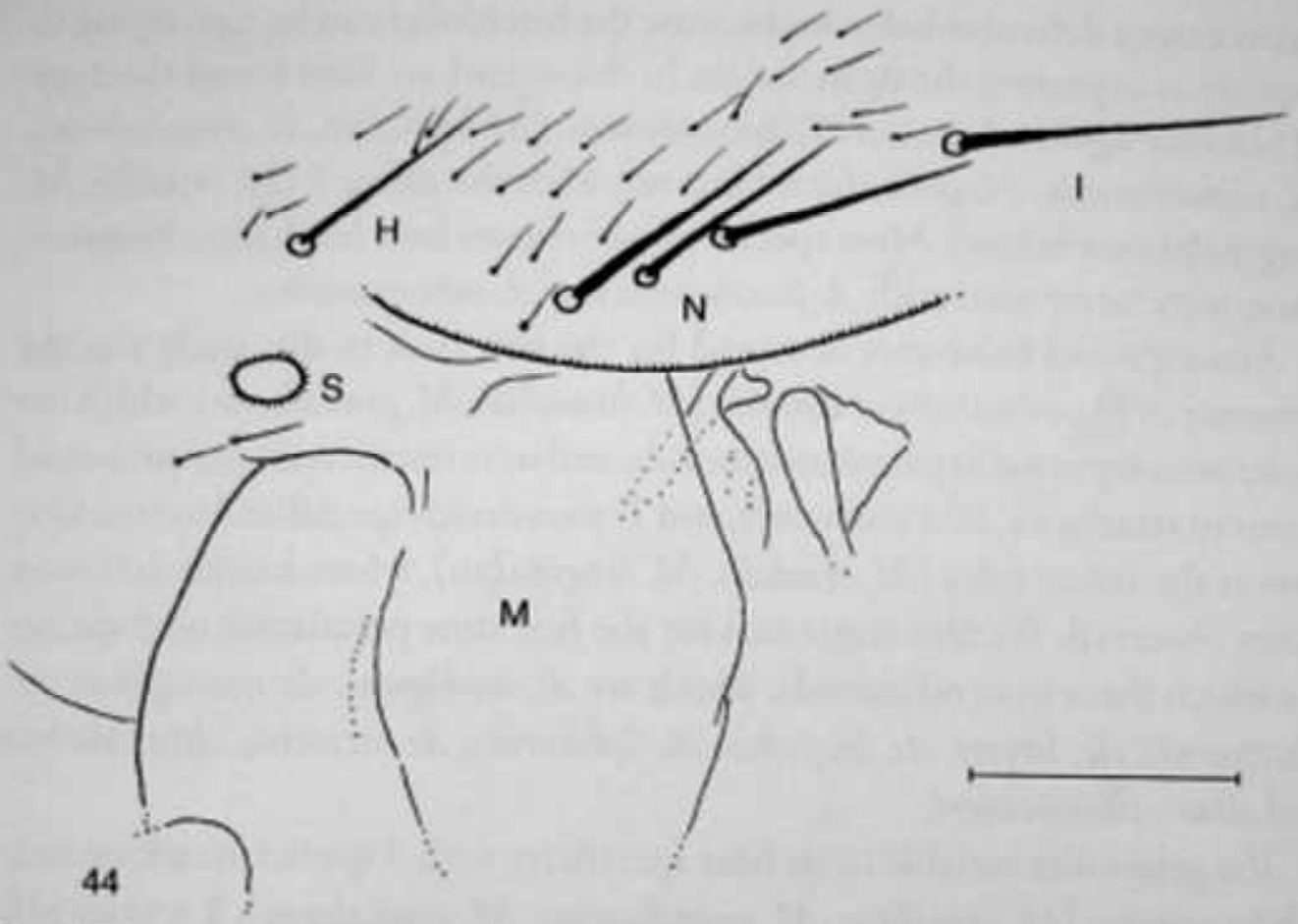


Fig. 44. *Myrmosicarius grandicornis* male, left mesopleuron and notopleuron (S = prothoracic spiracle, H = humeral bristle, N = notopleural bristles, I = intra-alar bristle, M = mesopleuron). (Scale bar=0.1 mm)

Ant parasitic phorids are quite diverse in their strategies for approaching their hosts. This variation probably is related to their preferred sites for injecting the egg. All *Myrmosicarius* observed are "chasing after" types of parasitoids. However another classification can be made with respect to whether the phorid lands or not on the host for oviposition. Thus we have found 3 species that oviposited while in flight (*M. brandaoi*, *M. cristobalensis*, *M. grandicornis*) and 4 that landed on the body of the ant to oviposit (*M. catharinensis*, *M. crudelis*, *M. gonzalezae*, *M. longipalpis*). The enlargement of the lower ommatidia of the eyes, which is a typical characteristic of this genus, is a feature that in other parasitoid phorids is correlated with the habit of approaching their hosts on the wing, as opposed to those that first land and then approach the host on foot (Disney & Schroth 1989).

A characteristic of leaf-cutter ants is the presence of hitchhikers which were shown in one species (from another genus, *Apocephalus*) to protect the host against parasitism (Feener & Moss 1990). The presence of a minor ant, on the top of a leaf that a major worker is carrying, on the foraging trail is in

many cases a defensive behavior because the hitchhiker can be seen trying to capture or capturing the fly in the air. In this regard, we have found this type of behavior against 4 species of *Myrmosicarius* (*M. brandaoi*, *M. cristobalensis*, *M. catharinensis*, *M. gonzalezae*) but not with the other 2 (*M. crudelis*, *M. longipalpis*; see below). Most species of leaf-cutters have hitchikers, however, these were never seen with *A. fracticornis* nor *A. subterraneous*.

Among novel behaviors observed for the first time in this study was the presence of 1) nocturnal parasitoids (*M. brandaoi*, *M. gonzalezae*), which has never been reported in parasitoid phorids, and were restricted in this parasitoid genus to attacks on *Atta* hosts only, and 2) parasitoids specialized in attacking ants at the refuse piles (*M. crudelis*, *M. longipalpis*), where hitchhikers were never observed. We also registered for the first time parasitoids on 9 species for which there were no records, which are *Ac. ambiguus*, *Ac. crassispinus*, *Ac. fracticornis*, *Ac. heyeri*, *Ac. hispidus*, *Ac. lobicornis*, *Ac. stricatus*, *Atta saltensis* and *Atta vollenweideri*.

The genus was variable in its host specificity with 3 species attacking only 1 host species (*M. gracilipes*, *M. grandicornis*, *M. gonzalezae*), 2 species (*M. brandaoi*, *M. crudelis*) attacking 2 host species, with *M. catharinensis* attacking 9 host species and with *M. cristobalensis* ovipositing on 6 leaf-cutter hosts. In no case we found the same parasitoid species attacking an *Atta* and an *Acromyrmex* host, except for *M. crudelis* and *M. catharinensis* which are records published previously (Borgmeier 1929) and some new records from Brazil for *Atta sexdens*. Tables 1 and 2 show that there is at least one record of an attacked host for each of the *Myrmosicarius* species already described, except for *M. simplex*.

Our study reports a previously unexpected diversity of the genus and its host associations. Intriguing and preliminary aspects of the life cycle of these parasitoids were detected and deserve further study. Future research on any aspect of these parasitoids or their associations with their hosts will require accurate identifications of the flies, for which we hope our new key will prove useful.

ACKNOWLEDGMENTS

Without the loan of the type material arranged by Dr. Carlos Roberto Ferreira Brandao (Museum de Zoologia, Universidade de São Paulo, Brazil) this

Table 1. Records of *Myrmosicarius* recorded with species of *Acromyrmex*. (*am.* = *Ac. ambiguus*, *as.* = *Ac. aspersus*, *cr.* = *Ac. crassispinus*, *di.* = *Ac. disciger*, *fr.* = *Ac. fracticornis*, *be.* = *Ac. heyeri*, *hi.* = *Ac. hispidus*, *lo.* = *Ac. lobicornis*, *lu.* = *Ac. lundii*, *ni.* = *Ac. niger*, *st.* = *Ac. striatus*, *su.* = *Ac. subterraneus*).

	Ant species											
	am.	*as.*	*cr.*	*di.*	*fr.*	*be.*	*hi.*	*lo.*	*lu.*	*ni.*	*st.*	*su.*
Fly species												
catharinensis	+	-	+	-	-	+	+	+	+	+	-	+
cristobalensis	-	-	-	-	+	+	+	-	+	-	+	+
crudelis	-	-	+	-	-	-	-	-	+	-	-	-
gracilipes	-	-	+	-	-	-	-	-	-	-	-	+
infestans	-	+	-	+	-	-	-	-	-	-	-	+
longipalpis	-	-	+	-	-	-	+	-	-	-	-	-
persecutor	-	-	-	-	-	-	-	-	+	-	-	-
tarsipennis	-	-	-	-	-	-	-	-	-	+	-	-
TOTALS	1	1	4	1	1	2	3	1	4	2	1	4

Table 2. Records of *Myrmosicarius* recorded with other species of ant. (*At. bi.* = *Atta bisphaerica*, *At. la.* = *A. laevigata*, *At. sa.* = *A. saltensis*, *At. se.* = *A. sexdens*, *At. te.* = *A. texana*, *At. vo.* = *A. vollenweideri*, *La. pr.* = *Labidus praedator*, *So. sa.* = *Solenopsis saevissima* complex).

	Ant species							
	At. bi.	*At. la.*	*At. sa.*	*At. se.*	*At. te.*	*At vo.*	*La. pr.*	*So. sa*
Fly species								
biarticulatus	-	-	-	-	-	-	+	-
brandaoi	-	-	+	-	-	+	-	-
catharinensis	-	-	-	+	-	-	-	-
crudelis	-	-	-	+	-	-	-	+
gonzalezae	-	-	-	-	-	+	-	-
grandicornis	+	+	-	+	-	-	-	-
texanus	-	-	-	-	+	-	-	-
TOTALS	1	1	1	3	1	2	1	1

work would have been impossible. RHLD's continuing work on Phoridae has benefited from a grant from the Professor Hering Memorial Research Fund (British Entomological & Natural History Society). Constanza González Campero, Sebastián Lorenzatti and Diego Meier helped with the field work. Thanks for the logistic help and/or permits given by the following people or organizations that allowed field work to be done and to the following people who allowed LE to work on their land or helped with accommodation and logistics: Estancia Tatay in Carmen de Areco, Sr. Moyano in Otamendi, familia Noetinger in "Montesgrandes", familia Capovilla and owners of "La Cautiva" in San Cristóbal, familia Guzmán in Azul, familia Cassini in San Pedro, Guardaparques from Parque Nacional El Plamar, Parque Nacional

Pilcomayo, Reserva Natural Formosa, Parque Nacional Chaco, Reserva Natural Otamendi, Parque Nacional El Copo, Parque Nacional Defensores del Chaco (Paraguay), Rafael Pizzio (INTA Mercedes), Carlos Kunst and Luis Cejas (INTA Santiago del Estero), Ing. Parmigiani (INTA del Centro) and Guillermo Chiossone (INTA San Cristóbal). PF and LE thank the National Geographic Society and CONICET for financial support and Universidad Nacional de Quilmes Field and laboratory work of LE and PJF was financially supported to PF by National Geographic. Lab work was financially supported to PF (grant 7539-03) and LE by Universidad Nacional de Quilmes (grant 0340-03), both granted to PJF. PJF and LE thank CONICET.

REFERENCES

Borgmeier, T. 1928. Nota prévia sobre alguns Phorideos que parasitam formigas cortadeiras dos generos *Atta* e *Acromyrmex*. Boletim Biologico Laboratorio de Parasitologia, São Paulo 14: 119-26.

Borgmeier, T. 1929. Ueber attophle Phoriden. Zoologischer Anzeiger 80: 493-517.

Borgmeier, T. 1931. Sobre alguns Phorideos que parasitam a saúva e outras formigas cortadeiras (Diptera - Phoridae). Archivos do Instituto Biologico de Defesa Agricola e Animal, São Paulo 4: 209-28.

Borgmeier, T. 1961. Weitere Beitraege zur Kenntnis der neotropischen Phoriden, nebst Beschreibung einiger Dohrniphora-Arten aus der indo-australischen Region (Diptera, Phoridae). Studia Entomologica, Petropolis 4: 1-112.

Borgmeier, T. 1963. Revision of the North American phorid flies. Part I. The Phorinae, Aenigmatiinae and Metopininae, except *Megaselia* (Diptera, Phoridae). Studia Entomologica, Petropolis 6: 1-256.

Borgmeier, T. & A.P. do Prado 1975. New or little-known Neotropical Phorid flies, with description of eight new genera (Diptera, Phoridae). Studia Entomologica, Petropolis 18: 3-90.

Bragança, M.A.L., T.M.C. Della Lucia & A. Tonhasca 2003. First record of phorid parasitoids (Diptera: Phoridae) of the leaf-cutting ant *Atta bisphaerica* Forel (Hymenoptera: Formicidae). Neotropical Entomology 32: 169-171.

Brown, B.V. 1999. Differential host use by neotropical phorid flies (Diptera: Phoridae) that are parasitoids of ants (Hymenoptera: Formicidae). Sociobiology 33: 95-103.

Brown, B.V. 2000. Revision of the "*Apocephalus miricauda*-group" of ant-parasitizing flies (Diptera: Phoridae). Contributions in Science (Natural History Museum of Los Angeles County) 482: 1-62.

Disney, R.H.L. 1980. A new species of *Apocephalus* (Diptera: Phoridae) that parasitises *Atta texana* (Hymenoptera: Formicidae) in Texas. Zeitschrift für angewandt Zoologie 67: 47-50.

Disney, R.H.L. 2001. The preservation of small Diptera. Entomologist's Monthly Magazine 137: 155-159.

Disney, R.H.L. 1994. Scuttle Flies: The Phoridae. Chapman & Hall: London.

Disney, R.H.L. & D.H. Kistner 1998. New species and new records of myrmecophilous Phoridae (Diptera). Sociobiology 31: 291-349.

Disney, R.H.L. & M. Schroth 1989. Observations on *Megaselia persecutrix* Schmitz (Diptera: Phoridae) and the significance of ommatidial size-differentiation. Entomologist's Monthly Magazine 125: 169-174.

Eidmann, H. 1937. Die Gäste und Gastverhältnisse der Blattschneideramiese *Atta sexdens* L. Zeitschrift für Morphologie und Ökologie der Tiere 32: 391-462.

Erthal, M., D. Moreira, M.A.L. Bragança & A. Tonhasca 1999. Variações sazonais nas taxas de parasitismo dos forideos (Diptera: Phoridae) associados com saúvas *Atta sexdens* e *Atta laevigata* (Hymenoptera: Formicidae). Naturalia, São Paulo 24: 2

Feener, D.H. & K.A.G. Moss 1990. Defense against parasites by hitchhikers in leaf-cutting ants: a quantitative assessment. Behav. Ecol. Sociobiol. 26: 17-29.

Folgarait, P.J., O. Bruzzone & L. Gilbert 2002. Development of *Pseudacteon cultellatus* (Diptera: Phoridae) on *Solenopsis invicta* and *Solenopsis richteri* fire ants. Environmental Entomology, 31: 403-410.

Folgarait, P.J., M.G. Chirino & L. Gilbert 2005 Development of *Pseudacteon obtusus* (Diptera: Phoridae) on *Solenopsis invicta* and *Solenopsis richteri* (Hymenoptera: Formicidae). Environmental Entomology 34 : 308-316.

Fowler, H.G., M.A. Pesquero, S. Campiolo & S.D. Porter 1995. Seasonal activity of species of *Pseudacteon* (Diptera: Phoridae) parasitoids of fire ants (*Solenopsis saevissima*) (Hymenoptera: Formicidae) in Brazil. Cientifica, São Paulo 23: 367-71.

Fowler H.G. & F.M. Schlitter 1997. Worker size discrimination and worker behavioral modifications induced by two phorid parasitoids (Diptera: Phoridae) of the leaf-cutting ant *Atta sexdens rubropilosa* (Hymenoptera: Formicidae). Ciência e Cultura 49: 264-6.

Greene, C.T. 1938. A new genus and two new species of the *Dipterous* family Phoridae. Proceedings of the United States National Museum 85: 181-185.

Morrison, L.W. & L.E. Gilbert 1998. Parasitoid-host relationships when host size varies: the case of *Pseudacteon* flies and *Solenopsis* fire ants. Ecological Entomology. 23: 409-416.

Orr, M.R., S.H. Seike & L.E. Gilbert 1997. Foraging ecology and patterns of diversification in dipteran parasitoids of fire ants in south Brazil, genus *Pseudacteon* (Phoridae). Ecological Entomology 22: 305-314.

Prado, A.P. do 1976. Records and descriptions of phorid flies, mainly of the Neotropical Region (Diptera; Phoridae). Studia Entomologica, Petropolis 19: 561-609.

Tonhasca, A., M.A.L. Bragança & M. Erthal 2001. Parasitism and biology of *Myrmosicarius grandicornis* (Diptera, Phoridae) in relationship to its host, the leaf-cutting ant *Atta sexdens* (Hymenoptera, Formicidae). Insectes Sociaux 48:154-8.