Brasilianische Pilzzüchter-Ameisen der Gattung *Mycetophylax* - Lebensweise und Taxonomie

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Inhalt

1. Einleitung

Zu den pilzzüchtenden Ameisen, den Attini, zählen 12 Gattungen mit ca. 250 Arten. Vor ungefähr 50 Millionen Jahren entstand ihre enge Symbiose mit Pilzen, heute Grundlage ihrer Ernährung. Attini kommen nur in der Neotropis vor, ihre Verbreitung reicht bis in den Süden der USA (Weber 1972, Fowler 1983, Hölldobler & Wilson 1990).

Der Symbiose-Komplex der Attini umfasst nach neueren Studien insgesamt vier Komponenten (Abbildung 1), die in gegenseitiger Abhängigkeit leben. Die Ameisen (1) züchten ihre Pilze aus der Gruppe der Agaricales (2). Diese werden von einem weiteren Pilz (*Escovopsis* sp.) parasitiert (3). Den parasitischen Pilz halten die Ameisen mit Hilfe von Bakterien (*Streptomyces*) (4) in Schach, die auf ihrer Körperoberfläche leben und ein Antibiotikum produzieren, das nur für den parasitischen Pilz schädlich ist, nicht aber für die Pilzkultur der Ameisen. Das Zusammenwirken dieser 4 Symbiose-Komponenten wird derzeit intensiv analysiert (Chapela 1994, North 1997, Mueller et al. 1998, Currie et. al 1999a, 1999b, 2003, Schultz 1999, Munkacsi et al. 2004, Villesen et al. 2004).

Wesentlich für das Verständnis der Lebensweise der Pilzzüchter-Ameisen sind die Kastenstrukturen der Arbeiterinnen, die nur bei den sog. höheren Attini extrem polymorph ausgeprägt sind und weitgehend funktionell spezialisierte Subkasten darstellen.

Im Allgemeinen werden die Attini in drei Gruppen (Tabelle 1) eingeteilt: die polymorphen „höheren“ Attini, die monomorphen „intermediären“ und die monomorphen „basalen“ Attini (Weber 1956, Wilson 1971, Garling 1979, Hölldober & Wilson 1990).

Am besten untersucht sind die Blattschneider-Ameisen der Gattungen *Atta* und *Acromyrmex*. Ihre oft riesigen Kolonien können in Monokulturen erhebliche Schäden anrichten (Cherret 1986), vor allem in Plantagen von Eukalyptus, Zitrus und Zuckerrohr sowie auf Viehweiden. In Waldhabitaten sind ihre Nester eher selten. Die Blattschneider wurden bereits im 18. Jahrhundert als landwirtschaftliche Schädlinge bezeichnet (Wilson, 1971, Hölldober & Wilson 1990, Schultz 1999), bis heute sind sie Gegenstand kostspieliger Bekämpfungsmaßnahmen. In Brasilien hat vor allem Mario Autuori die Kolonieentwicklung bei *Atta*-Arten untersucht, sowohl in Feldstudien als auch in Laborexperimenten (Autuori 1940 a, b, 1941, 1942, 1947, 1950).

Die „intermediären" Attini (*Trachymyrmex* und *Sericomyrmex*) teilen bestimmte Eigenschaften mit den „höheren" Attini. Ihre Arbeiterinnen tragen fakultativ frisches pflanzliches Material, vor allem Blüten, als Pilzsubstrat ein (Hölldober & Wilson 1990, Feldmann et al. 2000). In der Hauptsache kultivieren sie ihre Pilze jedoch auf totem pflanzlichem Material, Insektenfezes und Fruchtfleisch. Ihre Kolonien sind mit bis zu 5.000 Arbeiterinnen zwar kleiner als die der echten Blattschneiderameisen, aber größer als die der ursprünglichen Attini (Weber 1972, Hölldobler & Wilson 1990).

Über die „basalen" Attini ist erst relativ wenig bekannt. Ihre kleinen Nester enthalten selten mehr als 300 Individuen. Über Koloniegründung und Nestarchitektur gibt es nur für einzelne Arten Informationen, beschrieben wurden semi-klaustrale Verhältnisse (Hölldobler & Wilson 1990). Die Pilzgärten werden ausschließlich auf totem Material pflanzlicher oder tierischer Herkunft kultiviert.

Die Arten der Gattung *Apterostigma* sind Teil dieser Gruppe, aber der symbiotische Pilz stammt aus der Gruppe der Tricholomatacea und hat die Fähigkeit, verrottendes Holz weiter zu zersetzen. Damit unterscheidet er sich von den anderen bekannten Pilzsymbionten (z. B. Villesen et al. 2004).

Allen Attini gemeinsam ist also das Pilzzüchten. Außerdem kommt nur bei ihnen eine charakteristische Borste median am oberen Rande des Clypeus vor, die sich von den medianen Borsten anderer Ameisen-Gruppen unterscheidet (Brandão & Mayhé-Nunes, 2000).

Pilzsymbiose

Zum Ursprung der Pilzsymbiose gibt es seit über hundert Jahren Überlegungen, ohne dass bislang eine der Hypothesen verifiziert werden konnte (Belt 1874 and Müller 1874 in Wilson 1971, Forel 1902, Weber 1956, Garling 1979, Schultz 1999).

Neu sind zwei alternative Modelle (Mueller et al. 2001): das „consumption first“ Modell geht davon aus, dass die Pilze zunächst nur einen Teil der Ameisen-Diät ausmachten, die Ameisen dann die Pilzkultur entwickelten, diese zur hauptsächlichen Nahrung wurde und dann Pilmycel an Folgegenerationen weiter gegeben wurde. Beim alternativen „transmission first“ Modell wird dagegen angenommen, dass die Pilze zunächst die Ameisen als Vektoren für ihre Verbreitung nutzten. Erst später fraßen die Ameisen die Pilze und schließlich wurden diese von ihnen kultiviert. Bisher sind beide Annahmen rein hypothetisch.

Jedenfalls werden die monomorphen Attini als ursprünglicher als die polymorphen angesehen. Es ist anzunehmen, dass Untersuchungen ihrer Lebensweise zur Aufklärung der Evolution des Pilzzüchtens beitragen können. Ihre verwandtschaftlichen Beziehungen werden auch durch Studien an den symbiotischen und parasitischen Pilzen analysiert (Chapela et al. 1994, Currie et al. 2003) sowie anhand morphologischer Merkmale der Larven diskutiert (Schultz & Meier 1995).

Die Pilzsymbionten der basalen Attini weisen stets eine enge Verwandtschaft zu frei lebenden Formen auf, was bei den Pilzen der polymorphen Blattschneider-Ameisen *Atta* und *Acromyrmex* nicht der Fall ist (Chapela et al. 1994).

Sozioevolution

Die molekularen Techniken erlauben heute Aussagen über die Patri- und Matri-Linien eines Volkes sozialer Insekten. Bei einigen Blattschneider-Arten ist inzwischen Polyandrie nachgewiesen worden. Über die intermediären und basalen Gruppen liegen kaum Daten vor. Mit molekulargenetischem Ansatz können außerdem Informationen über die systematische Einordnung der Gattungen ursprünglicher Attini erhalten werden.

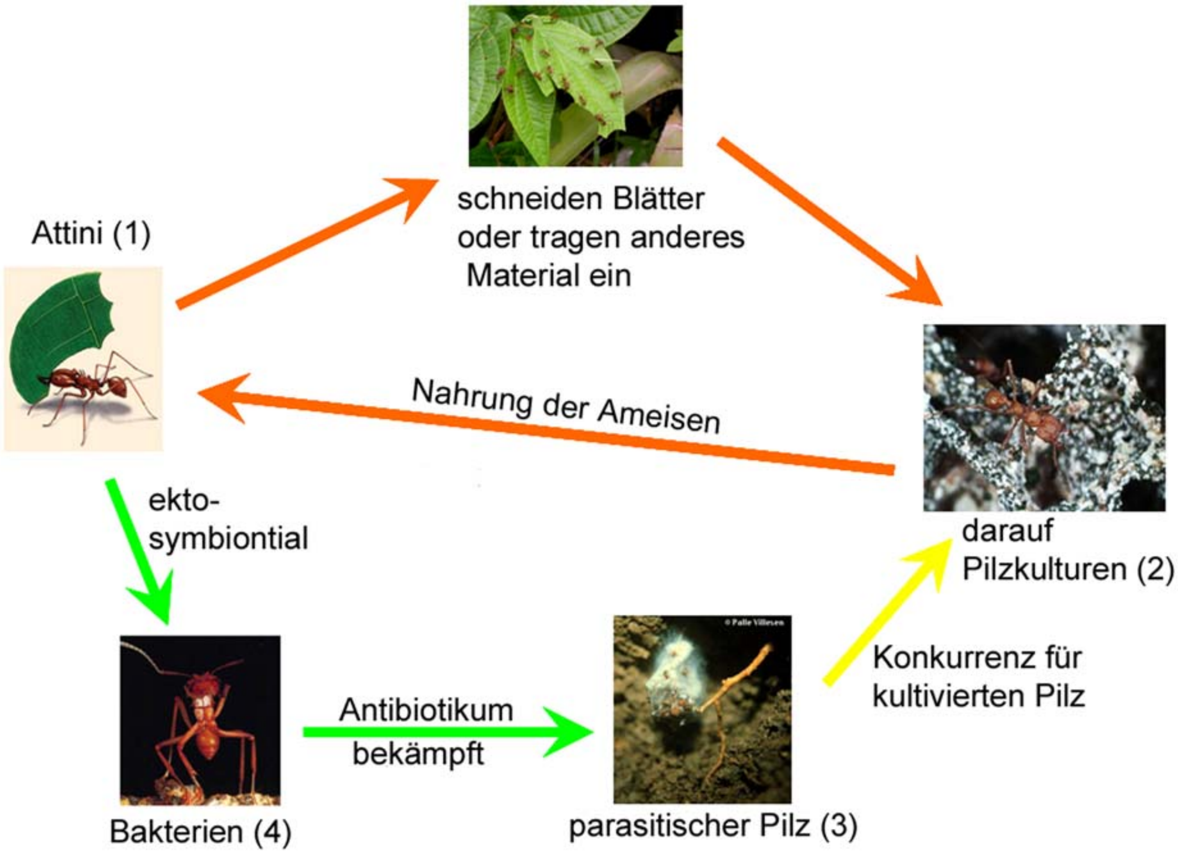

Abb. 1: Beziehungen des Symbiose-Komplexes der pilzzüchtenden Ameisen.

Tabelle 1: Charakteristika der drei Gruppen von Attini

Attini-Gruppen	höhere	intermediäre	basale
Gattungen	*Atta, Acromyrmex*	*Sericomyrmex, Trachymyrmex*	*Apterostigma, Cyphomyrmex, Mycetosoritis, Mycetophylax, Mycocepurus, Mycetarotes, Myrmicocrypta, Mycetagroicus*
Sammelgut	nur frisch geschnittene Blätter	teilweise frisch geschnittene Blüten, mehr totes pflanzliches Material, Fruchtfleisch	totes pflanzliches Material, Insektenfeces, tote Insekten, verrottendes Holz (nur *Apterostigma*)
Arbeiterinnen-Kaste	stark polymorph	monomorph	monomorph
Koloniegröße maximal	mehreren Millionen	ca. 5000	ca. 500
Neststruktur	große Nester mit bis zu 3500 Kammern (Atta) im Erdreich	mittelgroße Nester im Erdreich	kleine Nester, eine oder zwei Kammern, im Erdreich, bzw. verrottendem Holz (*Apterostigma*)
Nestgründung	klaustral (*Atta*), semi-klaustral (*Acromyrmex*)	semi-klaustral	semi-klaustral
Paarungssystem	polyandrisch	oligoandrisch	monoandrisch

2. Arbeitsprogramm

Da über die ursprünglichen Attini erst so wenige Studien vorliegen, könnten zahlreiche Aspekte untersucht werden. Ich habe für mein Promotionsvorhaben die Gattung *Mycetophylax* ausgewählt und folgende Fragen bearbeitet:

2.1 Nestarchitektur und Lebensweise am Beispiel von drei Arten (Ms 4.1).

Ziel der Untersuchungen war es zunächst, die Neststandorte von den zwei *Mycetophylax*-Arten und einer *Cyphomyrmex*-Art an den Stränden des atlantischen Ozeans zu beschreiben. Dazu gehört die Definition der einzelnen besiedelten Strand-Abschnitte wie der eigentliche Spülsaum-nahe Strand, die Vordünen und die Dünen bzw. Restinga. Eine weitere Zielsetzung war die Untersuchung der Nestarchitektur und das Sammeln der Kolonien für weitere Untersuchungen im Labor. Zur Erhebung der Architektur-Daten wurde eine Grabungsmethode für die in sandigen Habitaten lebenden Arten entwickelt, die es zum einen erlaubt, die Position der Nestkammern zu bestimmen, zum anderen aber auch den Verlauf der Tunnel zu beschreiben. Bei der Entnahme der Kolonien ist eine gewisse Vorsicht geboten, um den Pilzgarten nicht zu zerstören und die Königin nicht zu verlieren oder zu verletzen. Mit dieser Grabungsmethode konnte ich zahlreiche Nester der verschiedenen Arten ausgegraben und dabei auch erstmals exakte Daten zur Nestarchitektur erheben. Beim Vergleich der Neststandorte stellte sich heraus, dass die Arten in definierten Strandabschnitten leben und es nur in Ausnahmefällen zu einer Überlappung der Mikrohabitate kommt. Die Verbreitung der beiden *Mycetophylax*-Arten unterscheidet sich also feintopographisch, aber beide nisten in den gleichen Strandabschnitten. Die dritte Art, *Cyphomyrmex morschi*, kommt hingegen vorwiegend in den mehr landeinwärts gelegenen Abschnitten der Strände vor, also den bereits bewachsenen Dünen und Restingas. Die Nestarchitektur ist bei allen drei Arten ähnlich. Die Nester bestehen meist nur aus eine Kammer, bis zu drei Kammern sind jedoch möglich. Angaben über die Koloniegröße sind problematisch, da das Alter eines Nestes nicht verlässlich bestimmt werden kann. Die Zahl der gesammelten Arbeiterinnen schwankt je nach Art zwischen 120 bis 250. Die Kolonien sind stets monogyn.

Zusätzlich wurde noch die Haltung von Kolonien in künstlichen Labornestern getestet. Da es in der Literatur kaum Angaben hierüber zu basalen Attini gibt, sollen diese Beobachtungen bei der Planung fortführender Studien mit diesen Arten helfen.

2.2 Analyse der Patrilinien, um Aussagen über die Anzahl der Kopulationspartner der Königinnen und auch über die Verwandtschaftsbeziehungen innerhalb einer Kolonie treffen zu können (Ms 4.2).

Wie alle anderen Hymenopteren zeichnen sich die Ameisen durch Haplodiploidie aus. Das bedeutet, dass die Männchen im Gegensatz zu den Arbeiterinnen und Königinnen nur den einfachen Chromosomensatz haben. Bei den eusozialen Hymenopteren kommt es dadurch in der Regel zu folgender Kolonie- und Kastenstruktur: es gibt die diploide Königin, die allein für die Produktion der Nachkommen verantwortlich ist, Arbeiterinnen, die ebenfalls diploid sind, normalerweise aber nicht reproduzieren, hingegen für alle in der Kolonie anfallenden Arbeiten zuständig sind. Und die Männchen, die sich aus unbefruchteten Eiern entwickeln und daher haploid sind. Die Arbeiterinnen besitzen noch kleine Ovarien und unter bestimmten Bedingungen, vor allem in Königein-losen Nestern, können sie unbefruchtete Eier produzieren, aus denen sich ebenfalls Männchen entwickeln. Die Verwandtschaftsstrukturen innerhalb einer Kolonie sind abhängig von der Anzahl der Kopulationen der Königin mit verschiedenen Männchen. Oder, anders ausgedrückt, abhängig von der Anzahl der Väter sämtlicher Arbeiterinnen, was deren Verwandtschaftsgrad bestimmt: Arbeiterinnen können Vollschwerstern oder Halbschwestern sein. Trotz dieser geregelten Arbeitsverteilung kann es innerhalb eines Volkes zwischen der Königin und den Arbeiterinnen zu Konflikten über die Männchen-Produktion kommen. Dieser Fall tritt vorwiegend dann ein, wenn die Arbeiterinnen mit ihren eigenen Söhnen ein näheres Verwandtschaftsverhältnis haben mit ihren Brüdern. Solche Konflikte können die fitness des gesamten Volkes, die so genannte inklusive fitness, beeinträchtigen. Das ist dann der Fall, wenn die Königin nur mit einem einzigen Männchen kopuliert hat, somit Monandrie vorliegt und alle Arbeiterinnen also

Vollschwestern sind. Ob eine solche Situation vorliegt, kann man durch molekulare Analyse der in einer Kolonie vorhandenen Patrilinien der Arbeiterinnen feststellen, womit ihre Verwandtschaftsverhältnisse bechrieben werden können.

Innerhalb der Attini sind bei den beiden Gattungen der echten Blattschneiderameisen Mehrfach-Kopulationen der Königinnen auf dem Hochzeitsflug üblich. Man nimmt an, dass es eine Korrelation zwischen Koloniegröße und Kopulationsfrequenz der Königin gibt. Um diese Hypothese zu testen, habe ich bei drei Arten der basalen Attini die Paarungshäufigkeit von Königinnen mit molekulargenetischen Techniken bestimmt. Die Ergebnisse zeigen, dass alle untersuchten Kolonien monogyn waren, also durchweg Monandrie vorlag.

2.3 Untersuchung taxonomisch verwertbarer morphologischer Merkmale der Arten der Gattung *Mycetophylax* und Hinweise zum Typusmaterial des Museu de Zoologia da USP (MS 4.3 und 4.4).

Die Gattung *Mycetophylax* besteht derzeit aus sechs Arten mit 11 Unterarten, Rassen bzw. Varietäten. Der Vergleich von morphologischen Merkmalen und den jeweiligen Originalbeschreibungen ergibt ein extrem heterogenes Gattungs-Bild, so dass sich die Notwendigkeit einer taxonomischen Revision als dringend darstellte. Trotz zahlreicher spezifischer Merkmale ergab der Vergleich aller Unterarten, Rassen und Varietäten morphologisch betrachtet ein recht einheitliches Bild. Dies wird bestärkt durch einzelne Subspezies-Beschreibungen, wenn darin beispielsweise für zwei Unterarten der gleiche Fundort angegeben wird. Merkmale wie Färbung und die Behaarung können nicht als immer taxonomisch so relevant eingestuft werden, dass zur Unterscheidung von Arten dienen können. Die eingehende Untersuchung des vorhandenen Typus-Materials ergab daher, dass es sich durchweg bei den beschriebenen zahlreichen Unterarten, Rassen und Varietäten um Synonyme der einzelnen Arten handelt. Auf Art-Niveau konnten somit nur vier der sechs etablierten Taxa bestätigt werden. Dabei musste zudem eine Spezies der Gattung *Cyphomyrmex* in das Genus *Mycetophylax* überstellt werden. Letztendlich wurde die Gattung *Mycetophylax* in drei verschiedene Genera aufgeteilt. Dabei handelt es sich nunmehr um *Mycetophylax* mit drei Arten, *Paramycetophylax* (stat. rev.) mit einer Art und *Kalathomyrmex* als neue Gattung (in litt.) mit einer Art.

Da zur taxonomischen Revision die Untersuchung von Typus-Material unumgänglich ist, wurde gleichzeitig eine komplette Liste aller im Zoologischen Museum der Universität von São Paulo, Brasilien, hinterlegten Attini-Typen erstellt. Diese Liste soll bei zukünftigen Revisionen der Attini als Hilfestellung bei Auffinden von Typus-Material in den verschiedenen Museen dienen.

2.4 Zusammenfassung relevanter Informationen über Ameisen, die im Internet verfügbar sind (Ms 4.5).

Das Internet ist in der heutigen Zeit ein wichtiger Informationsträger zu Themen aller Art. Auch die Myrmekologie bedient sich zunehmend dieses Mediums. Bereits im Promotionsplan war die Erstellung einer eigenen Homepage über Ameisen anvisiert worden, was auch realisiert werden konnte (http://www.ameisen-net.de). Um einen noch besseren und aktuellen Überblick der frei zugänglichen Informationen zu bekommen, entstand daher eine Zusammenstellung relevanter Internetseiten zum Thema Myrmekologie. Der Informationsgehalt aller vom Internetsuchdienst Google gefundenen Webseiten ist selbstverständlich von unterschiedlicher Qualität. Eine Auswertung hat ergeben, dass man zwischen wissenschaftlich relevanten und in regelmäßigen Abständen aktualisierten Seiten und Webseiten mit weniger relevantem Informationsgehalt unterscheiden muß. Die relevanten Seiten kann man in folgende Kategorien einteilen: Internet Portale mit allgemeinen Informationen über Ameisen, Ameisen-Taxonomie und Systematik, Ameisen-Sammlungen und Typen-Kataloge, Ameisen-Literatur, Informationen über regionale Myrmekofaunen, spezielle Ameisengruppen, invasive Arten und Schädlingskontrolle, rote Listen und Ameisenschutz, Glossare und Informationen zur Morphologie, Ameisen-Bilder, Ameisen-Haltung und Diskussionsforen. Das von uns zusammengestellte Manuskript spricht jede dieser Kategorien an und bietet kommentierte Beispiel-Seiten.

Alle Feldarbeiten führte ich in Brasilien durch. Die Laboruntersuchungen liefen am Zoologischen Museum der Universität von São Paulo und im Labor für Evolution und Genetik der Bienen am Institut für Biowissenschaften der Universität von São Paulo.

3. Material und Methoden

Die verwendeten Materialien und Untersuchungsmethoden sind in den einzelnen Publikationen angeführt.

4. Ergebnisse

Die Ergebnisse meiner Untersuchungen sind in folgenden Publikationen bzw. Manuskripten dargestellt:

4.1 Klingenberg, C., Brandão, C. R. F. & Engels, W. Nest architecture and colony structure of three basal Attini species inhabiting dunes and salt marshes in Southern Brazil (eingereicht)

4.2 Klingenberg, C. & Arias, M. C. Monandry in three ant species of the basal genera *Mycetophylax* and *Cyphomyrmex* (Attini, Formicidae).

4.3 Klingenberg, C. & Brandão, C. R. F. Revision of the fungus-growing ant genera *Mycetophylax* and *Paramycetophylax* stat. rev. and description of a new fungus growing ant genus, *Kalathomyrmex* gen. nov. (Hymenoptera: Formicidae)

4.4 Klingenberg, C. & Brandão, C. R. F. (2005) The type specimens of fungus growing ants, Attini (Hymenoptera, Formicidae, Myrmicinae), deposited in the Museu de Zoologia da Universidade de São Paulo, Brazil. Papéis Avulsos de Zoologia, 45 (4):41-50.

4.5 Klingenberg, C. & Verhaagh, M. 2005: Myrmecology in the internet: Possibilities of information gathering (Hymenoptera, Formicidae). Beitr. Entomol. 55 (2): 485-498, with 12 tables.

5. Eigenanteil

Der Eigenanteil der in meiner Dissertation vorgestellten Ergebnisse beträgt bei den Manuskripten

4.1 = 85%

4.2 = 85%

4.3 = 80%

4.4 = 70%

4.5 = 70%

6. Diskussion

Zwar gehören die Ameisen des Tribus Attini zu den am besten untersuchten Gattungen und Arten, allerdings stehen dabei die so genannten Blattschneiderameisen der Genera *Atta* und *Acromyrmex* im Mittelpunkt. Über die Gattung *Mycetophylax* mit den zunächst sechs beschriebenen Arten ist dagegen erst wenig bekannt. In meiner Dissertation habe ich für diese Gattung Befunde erhoben, die eine Reihe neuer Blickwinkel über basale monomorphe Attini eröffnen.

Bei meiner taxonomischen Revision habe ich *Mycetophylax* in drei verschiedene Gattungen aufgeteilt. Von den ursprünglich sechs Arten habe ich drei in meine molekularbiologischen Untersuchungen einbezogen. Dazu kamen für dieselben Arten zahlreiche Ergebnisse über die Lebensweise. Über die neu etablierten Gattungen ist erst wenig bekannt, speziell fehlen für die einzelnen Taxa Kenntnisse über die Lebensweise. Es wäre daher interessant, ähnliche Datensätze über *Paramycetophylax* und *Kalathomyrmex* zu erarbeiten. Sich dabei ergebende Unterschiede würden voraussichtlich die Abtrennung von der Gattung *Mycetophylax* noch unterstreichen.

Im Allgemeinen bestätigen und ergänzen die von mir erarbeiteten Fakten die Literaturangaben. Trotz sind noch immer viele Aspekte ungeklärt. So weiß man bisher noch nichts über das das Verhalten einzelner Arbeiterinnen in der Kolonie, auch zur Verhaltensökologie liegen noch keine Daten vor. Im Weiteren hat mein kurzer Vergleich von morphologischen Merkmalen mit Arten anderer Gattungen gezeigt, dass die von *Mycetophylax* abgetrennten wahrscheinlich nicht einmal als Schwestergruppen einzustufen sind. Dies dürfte unter anderem mit der offenen Radialzelle des Vorderflügels bei den Geschlechtstieren, aber auch an den langen Borsten am Clypeus begründet werden können. Um eine solche Hypothese zu bestätigen, müssten weiterführende Studien der morphologischen Merkmalsausprägungen an Vertretern aller Gattungen des Tribus durchgeführt werden.

Letztendlich ist darauf hinzuweisen, dass in der letzten Zeit einige Publikationen über die Lebensweise bei basalen Attini erschienen sind (Fernandez-Marin et al. 2004, 2005, Solomon et al. 2004). Insofern ergänzen meine Studien das langsam vollständiger werdende Bild der basalen Attini um wichtige Details.

7. Zusammenfassung

Die Untersuchungen zur Lebensweise von *Mycetophylax*-Arten (Hymenoptera: Formicidae: Attini) haben gezeigt, dass die drei Arten, die auch nach der taxonomischen Revision noch zu *Mycetophylax* gehören, vorwiegenden in Brasilien an den Stränden und Restingas des südatlantischen Ozeans vorkommen. Doch gibt es keine direkte Überlappung in der Besiedlung von Mikrohabitaten. Die Arten *M. conformis* und *M. simplex* sind zudem in verschiedenen geographischen Breiten zu finden. *Mycetophylax morschi* (früher *Cyphomyrmex*) lebt zwar in den gleichen Zonen, die Nester befinden sich aber in der Restinga und nur in solchen Dünen, die bereits von Pflanzenbewuchs geprägt sind. Nester der Arten *M. conformis* und *M. simplex* findet man dagegen nur in den Vordünen, ohne oder mit nur sehr wenig Bewuchs. Die Nestarchitekturen sind ähnlich mit einigen artspezifischen Unterschieden. Die Kolonien sind monogyn und enthalten in der Regel weniger als 300 Arbeiterinnen. Mit der Haltung von Labornestern hatte ich nur bei Kolonien von *M. conformis* über einen längeren Zeitraum Erfolg.

Die Ergebnisse der molekularbiologischen Untersuchungen haben Monandrie für die Königinnen aller drei Arten *M. conformis*, *M. simplex* und *C. morschi* ergeben. Die Königinnen haben also nur einmal kopuliert, und der Verwandtschaftsgrad unter den Arbeiterinnen einer Kolonie ist mit 0.75 maximal. Diese Daten entsprechen den wenigen Literaturangaben zur Kopulationsfrequenz bei monomorphen Attini. Im Gegensatz hierzu ist für die polymorphen Gattungen *Atta* und *Acromyrmex* Polyandrie belegt.

Die Gattung *Mycetophylax* umfasste bisher sechs Arten. Meine taxonomische Revision hat ergeben, dass sie in drei Gattungen aufzuspalten ist: *Mycetophylax* mit den Arten *M. conformis*, *M. simplex* und *M. morschi* (davor *Cyphomyrmex*), *Paramycetophylax* rev. stat. mit der Art *P. bruchi* und *Kalathomyrmex* als neue Gattung mit der Art *K. emeryi*. Alle Arten wurden neu beschrieben und mit Zeichnungen, Rasterelektronenmikroskopischen Aufnahmen und AutoMontage-Bildern illustriert. Da es für die Geschlechtstiere einiger Arten noch keine Beschreibungen gab, wurden diese mit in die Revision aufgenommen.

Im Internet gibt es bereits eine sehr große Zahl von Seiten, die sich mit dem Thema Ameisen befassen. Ein Großteil dieser Portale wurde von amerikanischen Wissenschaftlern initiiert oder zumindest mit ihrer Unterstützung aufgebaut. Es gibt aber noch keine spezielle Seite über die pilzzüchtenden Ameisen, auch nicht in deutscher Sprache. Hier präsentiere ich eine Übersicht der wichtigsten Internet-Seiten zu Ameisen. Außerdem habe ich ein Internet-Portal (www.ameisen-net.de) etabliert. Das soll regelmäßig aktualisiert werden und Informationen sowie Verknüpfungen zu bereits bestehenden Webseiten anderer Myrmekologen beinhalten.

Resumo

As observações sobre a biologia das espécies de *Mycetophylax* (Hymenoptera: Formicidae: Attini) mostraram que vivem exclusivamentemente nas praias e restingas do oceano Atlântico Sul, no Brasil. Mostrou ainda que as espécies não sobrepõem sua distribuição geográfica local. Duas espécies possuem uma distribuição geográfica similar (*M. conformis* e *M. simplex*) e só a terceira espécie (*M. morschi,* antes *Cyphomyrmex)* vive em locais nas mesmas latitudes como as outras. Mesmo assim, *M. morschi* habita áreas nas dunas e restingas com vegetação, enquanto as outras espécies vivem nas dunas nuas, geralmente sem ou com apenas muito pouca vegetação. A arquitetura dos seus ninhos é semelhante mas mostra ainda algumas diferenças específicas. As colônias são, com poucas exceções, monogínicas e contêm geralmente menos de 300 operárias. A manutenção de colônias sob condições de laboratório por mais de algumas semanas obteve sucesso apenas para *M. conformis*.

Os resultados das análises de biologia molecular mostraram monandria para as rainhas das espécies *M. conformis*, *M. simplex* e *C. morschi*. Elas copularam apenas uma única vez e, com isto, o grau de parentesco entre as operárias da mesma colônia é muito alto. Estes resultados estão de acordo com os poucos dados existentes na literatura sobre a freqüência de cópulas de Attini monomórficos. Contrariamente, para os gêneros de *Atta* e *Acromyrmex* foi encontrada poliandria.

O gênero *Mycetophylax* apresentava, até o momento, seis espécies nominais. A revisão taxonômica mostrou que cinco dessas espécies são válidas e que as espécies antes aceitas em *Mycetophylax* na verdade podem ser divididas em três gêneros: *Mycetophylax*, com as espécies *M. conformis*, *M. simples* e *M. morschi* (antes *Cyphomyrmex*), *Paramycetophylax*, com a espécie *P. bruchi*, e *Kalathomyrmex*, como gênero novo com uma espécie, *P. emeryi*. Todas as espécies foram redescritas detalhadamente e ilustradas através de desenhos, imagens REM ou imagens submetidas ao programa AutoMontage. Como para algumas espécies ainda não haviam sido descritas formas aladas, apresentamos também descrições detalhadas das gines e machos. Além disso, são apresentados mapas de distribuição geográfica conhecida de todos os táxons.

Existem muitas páginas na internet com todo o tipo de informação sobre formigas. A grande maioria destes sites é criado e pelo menos apoiado por pesquisadores americanos. Como não existe um site específico sobre formigas criadoras de fungo e muito menos na língua alemã, apresento uma visão crítica geral sobre as diferentes páginas disponíveis na rede. Além disso, iniciei uma página de internet (www.ameisen-net.de) que será atualizada regularmente e que contém informações sobre formigas criadoras de fungo, além de "links" para outras páginas sobre mirmecologia.

Abstract

The biological survey on species of *Mycetophylax* (Hymenoptera: Formicidae: Attini) shows that the three species now accepted for *Mycetophylax* inhabit mainly Brazilian beaches and restingas of the South Atlantic Ocean.

Two species show different geographic distributions (*M. conformis* and *M. simplex*). The third species, *M. morschi* (formerly *Cyphomyrmex*) lives at the same latitude but occurs at different locations at the beach. Whereas *M. conformis* and *M. simplex* prefer the naked dunes near to the shore, *M. morschi* nests mainly at the restinga area with at least some kind of vegetation covering. The nest architecture follows a common structural design in all species, but displays some specific differences. Colonies are monogynous with up to 300 workers. I maintained colonies of *M. conformis* for several weeks and report behavioral observations.

Through molecular analysis, I demonstrated that *M. conformis*, *M. simplex* and *Cyphomyrmex morschi* are monandrous. Queens copulate only once and consequently the degree of kinship among workers of the same colony is very high. The results of my studies confirm the existing data on mating frequencies of monomorphic Attini.

The taxonomic revision of *Mycetophylax* (Hymenoptera: Formicidae: Attini) resulted in the division of the six species currently accepted in *Mycetophylax* into three genera and one synonymy: *Mycetophylax* with the species *M. conformis*, *M. simplex* and *M. morschi* (formerly *Cyphomyrmex*), *Paramycetophylax* with the species *P. bruchi* and the newly described genus *Kalathomyrmex* with the species *K. emeryi*. I present here detailed descriptions of all species, illustrated with drawings, REM images or AutoMontage images. As there are no descriptions for several alate forms, they are described here, too. Maps of the geographic distribution are presented as well.

There are many sites at the internet with different kinds of information about ants. Most of these sites are maintained by north-american researchers, or at least with their support. As there is no specific internet portal on Attini ants and even less in German language, I give a summary about some of the most important internet sites related to ants. Besides that, I launched a internet-portal during my research (www.ameisen-net.de) regularly updated and that will contain information about fungus growing ants and links to other related web sites about myrmecology.

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Nest architecture and colony structure of three basal Attini species inhabiting dunes and salt marshes in Southern Brazil

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Abstract

Mycetophylax conformis, *M. simplex* and *Cyphomyrmex morschi* belong to the so-called basal Attini and live exclusively on beaches along the Atlantic shores of South America. We found species-specific nesting site preferences resulting in a zonal distribution within dune and salt marsh habitats in Brazil. From excavations of subterraneous nests we describe details of the architecture, especially on the number and position of the fungus chambers. Colony size and structure differ among species. Colonies transferred to the laboratory and maintained for up to twelve months in artificial nest provided observations on some of the intranidal habits of the ants. Most of our data represent the first behavioral records on the studied taxa.

Resumo

As espécies *Mycetophylax conformis*, *M. simplex* e *C. morschi* fazem parte do grupo dos Attini chamados de basais e vivem exclusivamente em praias do Atlântico na América do Sul. Registramos preferências específicas quanto à distribuição zonal nas dunas e restingas no Brasil. A partir de excavações cuidadosas de um número representativo de ninhos obtivemos detalhes sobre a arquitetura, em especial o número e posição das câmaras de fungo. O tamanho da população e estrutura diferem entre as espécies. Colônias transferidas para o laboratório e mantidas em ninhos artificiais permitiram observações dos hábitos dos indivíduos. Grande parte das nossas observações representam os primeiros dados para estas espécies.

Keywords: *Attini, Mycetophylax, Cyphomyrmex, coastal sand habitats, marshs, nest architecture, colony structure, South Brazil*

Introduction

The fungus growing ants (tribe Attini) live exclusively in the Neotropics (Weber, 1972, Fowler, 1983, Hölldobler & Wilson, 1990, Wirth et al., 2003). Most species inhabit regions with dense plant cover, like rainforests or other inland vegetation (Schultz, 1999).

The leaf cutting species of the genera *Atta* and *Acromyrmex* form colonies populated by up to millions of polymorphic workers and their nests can comprise more than thousand fungus chambers (Autuori, 1941). These ants cut exclusively fresh leaves as fungus substrate and for so doing they are considered as major agriculture pests where hey occur. As the leaf cutting ants are highly specialized for their fungus substrate and present polymorphic workers which perform different tasks within the nest, they are classified as higher Attini. By contrast, the so called lower Attini are monomorphic and colony populations are smaller to medium sized (Hölldobler & Wilson, 1990). The nest architecture of the lower Attini was described only for a few species (e. g. Mueller & Wcislo, 1998, Schultz et al., 2002). As fungus substrate they collect dry plant matter, faeces of other insects or insect carcasses. A group of Attini considered intermediate includes only two genera (*Trachymyrmex* and *Sericomyrmex*) which are also monomorphic or weakly polymorphic and forage facultatively for fresh flowers. Generally all material listed thus far as fungus substrate is plenty available in non-desert regions.

It is common that the nuptial flights of most Attini ants occur during early Spring, at the onset of the rainy season (Fernandez-Marín et al*.,* 2004), when soil conditions are more adequate; a moist soil favours colony foundation and digging the first fungus chamber by the founding queen.

At the Atlantic beaches and dunes the local conditions differ from those of inland habitats. The constant wind, the non-consolidate sandy soil, lack of dense vegetation, low density of other insects and animals may hamper the survival of the Attini ants. In spite of that, there are some Attini species which nest preferably or exclusively under such conditions. We focus our observations on three species belong to the so-called basal Attini: two *Mycetophylax*: *M. conformis* and *M. simplex* and one of *Cyphomyrmex*: *C. morschi*. Information on their natural history, colony structure and nest architecture is scarse. As far as we know only data on nest density and distribution of *M. simplex* was recorded in the northern coast of Rio Grande do Sul, Brazil (Albuquerque et al., 2005).

In our study we addressed the following questions:

1. Are there differences in the preference for particular nesting microhabitats among the three studied species?
2. How are the subterraneous nests structured?
3. Are there species-specific peculiarities in nest populations?

As these Attini are believed to compose the most basal group of all fungus-growing ants, special studies on behavior like on task partitioning or individual social behavior are important, although are still lacking. A protocol to maintain colonies of the leaf cutting ant genera under laboratory conditions is established and publications about behavior patterns observed in the lab are revised (Weber, 1976, Mintzer et al., 1991). We also tested the maintenance of colonies.

Materials and Methods

Field studies were carried out at Cabo Frio, Maricá and Araruama, Rio de Janeiro state (22° S, 42° W), and Joaquina and Pântano do Sul beaches, Florianópolis, Santa Catarina state (27° S, 48° W). Colonies of *M. conformis* were collected at Cabo Frio, Maricá and Araruama in February and July 2002, nests of *M. simplex* at Joaquina in September 2003, and those of *C. morschi* at Joaquina and Pântano do Sul in April 2003.

Nests were located by searching for entrances and excavated according to the following protocol. The entrance is marked with a stick. Some 0.5 m apart from the entrance, a hole of about 1 m depth is dig out. Then the sand towards the assumed position of the nest tunnel is carefully removed until parts of the nest structure are exposed. We try to evidence the complete entrance tunnel that ends in the chamber containing the fungus garden. The whole content of the chamber is transferred into a plastic container (ø 10 cm, 8 cm high) with a spoon. We also attempt to collect all the ants disturbed during our digging. The details of the nest architecture were documented and measured.

At the Zoological Museum of the University São Paulo the colonies were maintained at 25°C in containers with a plaster layer on the bottom, regularly moistened. In the laboratory the number of workers, queens, gynes and males was recorded as soon as they reach the laboratory, but for some of the *M. conformis* colonies, that were censured a few days after collection. As the ants occupy the whole fungus garden, it was necessary to "destroy" it in order to count the ants. Unfortunately the ants were often not able to restore the fungus garden in its original appearance. Due to that, all further colonies where counted after their death.

The daily maintenance included the check of a queen, males and gynes, presence of brood, disposal of different kinds of fungus substrates and waste removal. As fungal substrate we offered triturated corn, dry grass and plant matter from the collection sites. During the first days in the laboratory the material collected by the foragers was determined only by examining the remnants in the waste heap.

Results

Nesting site

Nests of all the three species were found in dunes of Atlantic beaches. *Mycetophylax conformis* and *M. simplex* nested relatively closer to the sea shore, where vegetation cover was sparse. The distance from the nests to the seawater was just large enough to prevent flooding of the colonies. The actual distances between the nests and the shore differ in different beaches. Nests of *C. morschi* were found on the lee side of the dunes, in the so called restinga area (a drier salty marsh). Only once a *C. morschi* fungus chamber was found when excavating a *M. simplex* colony. In general both species did not occupy exactly the same area at the beaches (Fig. 1). Nests of *M. conformis* were found near small freshwater pools in the dunes, which occasionally caused flooding of the fungus chamber floors. However, as the fungus mycel was usually suspended in the roof of the chamber by grass roots, there was no direct contact with the water.

Nest architecture

In all three species the nest entrances were formed by a small opening measuring about 0.5 cm, surrounded by a round or semi-circular crater of sand (Figure 2a, b). Only at Araruama some *M. conformis* nests had their entrance hole located on a little tumulus of sand *circa* 1 cm high. Nest entrances may be closed at windy weather or on days without foraging activity. Depending on the length of the entrance tunnel, the excavated sand sometimes differed in color from the surface layer. In *M. conformis* and *M. simplex* we observed that after rainfalls a new tunnel was built up to 15 cm aside of the old one.

The tunnels to the nest chambers had species-specific characteristics. In *M. conformis* and *C. morschi* they were narrow (ca. 3 mm) and therefore hard to follow at excavation. In nests of *M simplex* the diameter was wider (5 mm) and so the entrance easier to detect (Fig. 3). Consequently in nests of *M. conformis* and *C. morschi* the exact position of the tunnel in the sand was only ascertain when ants were passing through them during excavation. Usually the tunnel was straightly directed towards the fungus chamber located about 20 to 40 cm laterally and below the nest entrance. In nests of *M. simplex* small empty chambers (2 cm high, 5 cm wide) were found. The first chamber was always located only 3 to 5 cm under the nest entrance and in a horizontal distance of up to 10 cm (Fig. 3b) and mostly contained some workers and rarely males. From these first chambers tunnels of 5 mm width were directed slightly downwards, making some curves and passing through two to three other empty chambers that were distributed in an irregular manner on the way from the nest entrance to the fungus chamber, finally ending in the fungus chamber.

Position and size of the fungus chamber varied with species, season and colony size (Tab. I). In nests of *M. conformis* the fungus chamber was found up to 40 cm deep in summer but only 20 cm deep in winter time. In winter, the summer chamber contained only waste and roots. In actively cultivated chambers, the fungus garden always occupied almost the whole volume without any empty space. Only one nest had three fungus chambers, the biggest of which (350ml in volume) contained the queen and fresh fungus while the smaller ones (45ml in volume) housed some workers, males and old fungus.

In nests of *M. simplex* and *C. morschi* the fungus gardens filled only about two thirds of the chamber (Fig. 4). In two *M. simplex* nests also some partially decomposed substrate was found. However, in these cases, the expected contamination by the parasitic fungus *Escovopsis* was not observed. Only once we found mainly decaying material and small rests of intact fungus in the fungus chamber of *M. simplex*. In three *C. morschi* nests there was a second chamber of the same size near the fungus chamber containing merely accumulated waste. In another nest the waste was accumulated in the fungus chamber.

Contrary to *M. conformis*, in *M. simplex* we found waste accumulated in the fungus chamber in almost all excavated nests. In nests of *C. morschi* with only one fungus chamber, the waste was accumulated beneath the fungus garden. In nests with two chambers (N = 3), one chamber contains only fungus garden and in the second chamber waste was accumulated.

Foraged material for the fungus garden

The examination of the waste heaps showed that the workers of the observed three species foraged mainly for plant material. Additionally, *M. conformis* workers foraged for substrate of animal origin, like insect corpses or body parts (e. g. *Notoxus* spp., Coleoptera, Anthicidae). We observed that the ants sometimes used dead conspecifics as fungus substrate. In nests of *M. simplex* and *C. morschi* we never found dead insects in the waste heap. In all species the waste also contained many live mites and nematodes.

Colony size

Colony size varied with species (Table II). *Mycetophylax simplex* attained the largest colonies.

Behavior and survival of formicars

During the first days after laboratory nests establishment, the ants cleaned the fungus gardens from sand contamination resulting from the excavation (Fig. 5). Only in *M. conformis* workers showed an apparent “normal” foraging behavior under laboratory conditions. After five days, they began to forage for the given fungus substrate. The mean survival age from most of the colonies under laboratory conditions was three month, and one colony survived for more than a year. Under laboratory conditions, the colonies raised new alate forms, mainly males. When the queen was lost during excavation or died later in the laboratory, the workers begun ovipositing and males emerged.

The colonies of *M. simplex* and *C. morschi* did not adapt well to laboratory conditions. Their workers either did not accept the offered substrate or, when foraged, fungus growth was not sufficient to maintain the colonies. Even dried and triturated plant material from the collection sites was not accepted. Half of the colonies of *M. simplex* did not even start foraging and these colonies soon died. In these cases the fungus volume decreased quickly and the last surviving ants were found dead after 10 weeks.

Discussion

Nesting sites

The three species studied nest exclusively and abundantly at the South Atlantic sea beaches where only a few other Attini species was found until today. Kempf (1964) already commented that colonies of *C. morschi* occur on the Atlantic shore from Buenos Aires, Argentina, to Cabo Frio, Rio de Janeiro State, southeastern Brazil. Also, *M. simplex* seems to be common at the beaches of Rio Grande do Sul State, southern Brazil (Diehl Fleig et al., 2003, Albuquerque et al., 2005). Nests of *M. conformis* were even found numerous at beaches highly frequented by tourists where the nest entrances are at risk to be destroyed.

Also we were able to distinguish genus-specific microhabitats with a zonal distribution in the dunes and restinga (Fig. 1). Probably this generic specific preferences help to prevent competition for substrate material forage in the sandy environment scarce of vegetation, which results in low availability of plant and insect remnants.

Nest architecture

The nest entrances of the three species are very much similar and can easily confounded with those of *Brachymyrmex* sp., *Pheidole* sp. or *Dorymyrmex* sp. (unpublished own observations). In case of doubt, nests of the three Attini species can be distinguished by their worker's behavior. Upon disturbance at the nest entrances, the Attini species show a more discrete behavior than non-Attini species, which quickly run out of their nests in order to defend the colony. The observed Attini species did not react so readily to disturbance.

Only in one nest of *M. conformis* at Araruama beach we recorded a distinct entrance in the form of small sand tubes. The described nest entrances, with a species-particular architecture as seen in *Cyphomyrmex longiscapus* (Mueller & Wcislo 1998) or *C. muelleri* (Schultz *et al.* 2002) was not found. Probably the dry sand at the surface and the constant wind do not allow the construction of more elaborated nest entrances.

We suspect that shifting of fungus between summer and winter chamber by the ants of *M. conformis* is performed, allowing the cultivation of the fungus under more or less constant climatic conditions. In summers characteristic strong insolation of the almost bare soil might heat up the upper soil layer too much, whereas during winter it might be desirable to elevate the temperature in the fungus by moving it to a more superficial chamber warmed by the mild winter sun. This hypothesis could be tested by measuring temperature variation in the soil and in the fungus chamber and by determining the relation between fungal growth and temperature.

In contrast to our findings, Diehl Fleig et al. (2003) reported on nests of *M. simplex* with three fungus chambers. It should be further tested whether this variability is due to the different geographic locations were the studies where conducted.

The data on colony size and fungus chamber size presented in table I and II should not be directly interpreted as a correlation between colony size and nest size. This is because the fungus chamber and not the garden volume was measured. In nests of species of *M. simplex* and *C. morschi* the fungus garden occupies nearby two thirds of the chamber. Estimating now the fungus garden size of the two species, the correlation between fungus garden volume and colony size is still not positive. The fact is that the nests of *M. simplex* are the most populous and with the biggest fungus chamber volume and consequently with the biggest fungus garden. Even though we observed, that fungus chambers of all species contain proportionally bigger fungus gardens.

Small empty chambers along the tunnel in front of the fungus chambers as seen in *M. simplex* nests are also known from *Mycocepurus* species (C. Rabeling, pers. comm.). We suppose that these chambers serve as a kind of interim storage for fungus substrate. As we observed in one case some males in this chamber, it could also be an anteroom for the foragers and the alate ants. This makes sense taking into account that the fungus chambers can be at a distance of up to 1 m to the nest entrance. The lack of these chambers in *M. conformis* and *C. morschi* may then be due to the fact that the fungus chamber is closer to the nest entrances in these two species.

Colony structure

Because nothing is known about the age of the colonies analyzed by us, since their founding, the data on colony size must be interpreted cautiously. It seems that the species studied form only quite small colonies, as typical for the basal Attini (Hölldobler & Wilson, 1990). However, it seems unlikely that our sample included preferably recently founded nests with still relatively low populations. In no case the colonies of the species we studied here showed such a high number of individuals as in colonies of *Sericomyrmex*, *Trachymyrmex*, *Acromyrmex* or *Atta*. However it is evident that the colonies we studied are more populous than colonies of *Cyphomyrmex longiscapus* and *C. muelleri* which have 22.7 (range 4 - 48) and 43.8 (range 6 - 109) workers respectively (Schultz et al., 2002). Notwithstanding, only few studies of population size of the monomorphic Attini ants are available and it seems that in some cases the colony size has been underestimated. Colonies of *Mycocepurus,* for example may contain more than a thousand workers living in several fungus chambers (C. Rabeling, pers. comm.). This example and the published data on *M. conformis*, *M. simplex* and *C. morschi* show that ant nest architecture of the monomorphic Attini genera are not that similar as suggested by the classification by Hölldobler & Wilson (1990).

Most colonies we studied of these three species are monogynous, except for one colony of

M. conformis and two of *C. morschi* (the colony-members were not counted and do not appear in table II). However, we do not know whether both queens were functional or are unmated gynes. Only with molecular studies the true number of queens can be confirmed.

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Table I. Comparison of nest features (mean, range) of three species of basal Attini in sandy beaches along the Atlantic coast in Southern Brazil.

Nest features	*Mycetophylax conformis*	*M. simplex*	*Cyphomyrmex morschi*
no. of colonies collected	18	8	15
no. of fungus chambers	1-3	1	1-2
Depth of fungus chamber (cm)	43 (summer) 18 (winter)	54 (35-80)	27 (7-40)
fungus chamber volume (ml)	250	1.300 (300-2464)	950 (120-2550)
horizontal distance to entrance (cm)	20-40	60	20-40

Table II: Detailed analysis of collected colonies of the three species of basal Attini in sandy beaches along the Atlantic coast in Southern Brazil.

	M. conformis				*M. simplex*				*C. morschi*			
Colony No.	workers	queens	males	gynes	workers	queens	males	gynes	workers	queens	males	gynes
1	31	1	0	0	252	1	37	0	39	1	0	0
2	337	1	0	0	365	1	21	2	148	1	29	30
3	9	0	0	0	63	0	5	0	58	1	1	0
4	71	0	0	11	245	0	3	2	167	1	4	103
5	231	1	0	15	129	1	5	0	252	1	5	12
6	46	1	0	8	535	1	14	59	41	1	0	0
7	104	0	1	5	33	0	0	0	38	0	0	0
8	-	-	-	-	335	1	3	3	150	1	0	0
9	-	-	-	-	-	-	-	-	106	1	1	0
10	-	-	-	-	-	-	-	-	227	1	24	12
Mean	118.4		0.14	5.57	245		11	8.25	123		6.4	15.7

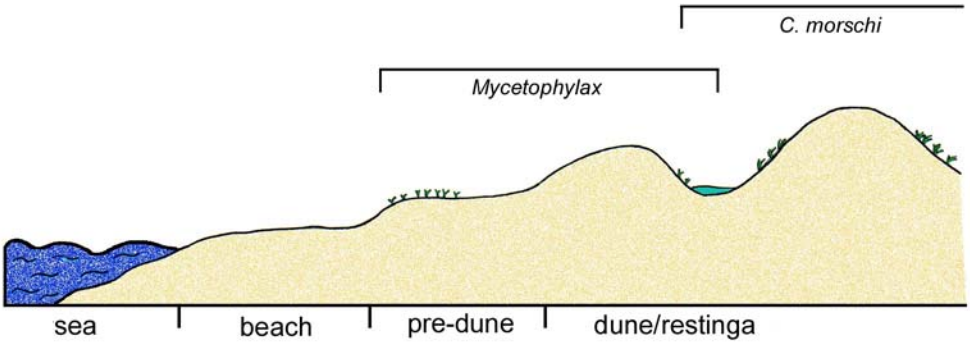

Figure 1. Nesting microhabitats of the ants *Mycetophylax conformis*, *M. simplex* and *C. morschi* in the dunes at shores of the Atlantic ocean in southern Brazil.

Figure 2. Entrance structure of nests in the sandy soil, a *Cyphomyrmex morschi*, b *Mycetophylax simplex*.

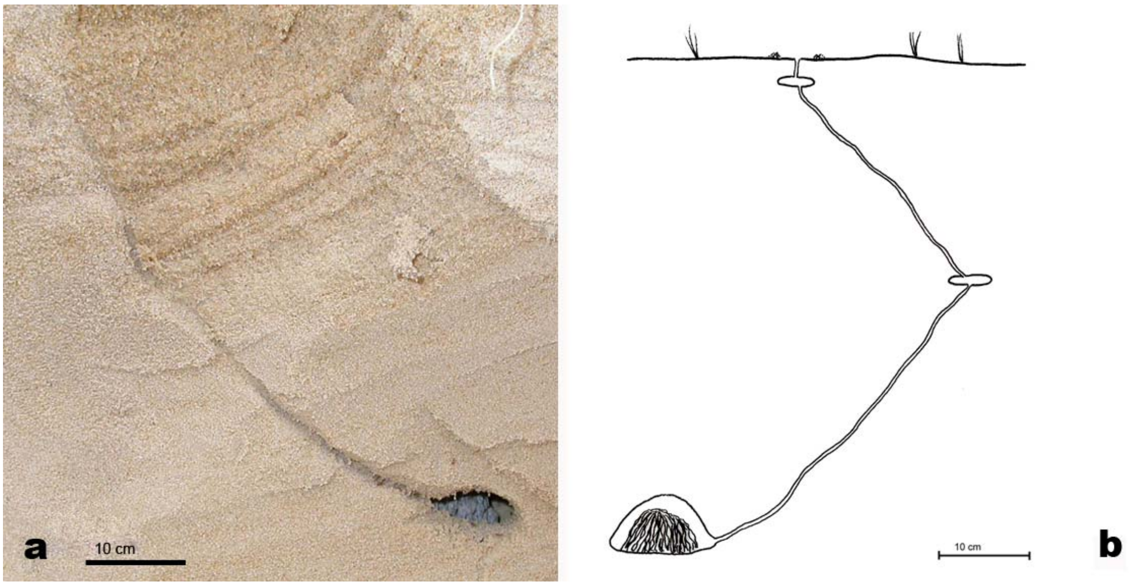

Figure 3. Subterraneous nests of *M. simplex*, a tunnel ending in the fungus chamber, b system of tunnel with intermediate empty chambers and terminal chamber with fungus garden.

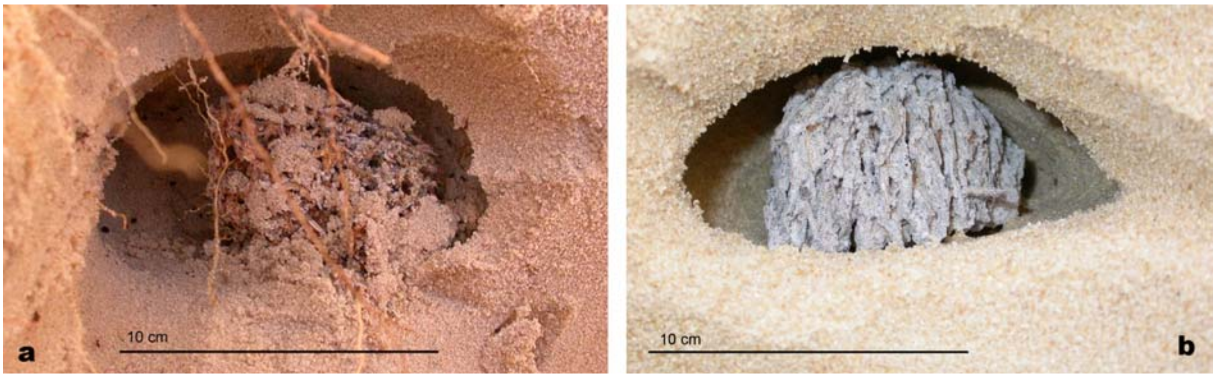

Figure 4. Fungus chamber in the nests of *C. morschi* and *M. simplex*.

Figure 5. Formicar containing a laboratory colony of *C. morschi*, a few days after excavation. The fungus garden was split in three parts.

Monandry in three species of the basal ant genera *Mycetophylax* and *Cyphomyrmex* (Attini, Formicidae)

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Abstract

We analyzed with microsatellite technique the number of patrilines in colonies of three species of basal Attini, *Mycetophylax conformis*, *M. simplex* and *Cyphomyrmex morschi*. All the colonies were monogyneous with only one patriline represented in the worker progeny. This indicates monandry. We assume that single mating of the queen has to be regarded normal in the basal Attini. Our colonies were collected at two sites, and the data show that the microsatellite allele frequency varies between distinct populations.

Keywords

Basal Attini, monogyneous colonies, microsatellite analysis, monandry, single mating of queens, allele frequency

Introduction

The evolution of sociality occurred several times in the haplo-diploid Hymenoptera because of the extreme level of relatedness of r = 0.75 between female progeny of the same parents (Hamilton 1964a, b, Ratnieks 1988). Within a monogyneous colony this depends on the mating frequency of the queen. Only monandry results in workers all being full sisters, whereas polyandry produces half sister cohorts. However, this also increases the intranidal genetic variability. Strassmann (2001) gave a detailed overview about benefits and constraints of multiple and single mating for hymenopteran colonies.

Recent studies on leaf cutting ants revealed polyandry in the genera *Atta* and *Acromyrmex*, all living in large colonies with populations of up to several millions of polymorphic workers (Hölldober & Wilson 1990). Perhaps such colonies of the so-called higher Attini have profit from the high degree of genetic diversity in their worker force. Only little is known on the mating system in the intermediate and basal groups of Attini with colonies of only some thousand and a few hundred workers, respectively.

Villesen *et al.* (1999) examined some monomorphic Attini species (*Myrmicocrypta ednaella*, *Apertostigma collare* and *Cyphomyrmex longiscapus*) and found that their queens were single mated. Murakami *et al.* (2000) confirmed this observation in *M. ednaella* and estimated the number of queen matings in several more species. They stated single mating in *Apterostigma mayri*, *Cyphomyrmex costatus*, *C. rimosos*, *Trachymyrmex isthmicus*, double mating in *Sericomyrmex amabilis* and double or multiple mating in *Acromyrmex octospinosus* and *Atta colombica*. Later on the double mating in *S. amabilis* was corrected into single mating; therefore, within the fungus cultivating ants, multiple mating is so far proved only for the higher Attini (Villesen et al. 2002b).

Using the microsatellite technique, we analyzed the number of patrilines in three species of basal Attini, all inhabiting sandy habitats in the beaches of Southern Brazil. We compared species collected at sites with about two thousand km in between and found differences in the frequency of some microsatellite alleles within the colonies of the same species. The revealed mating systems are discussed under aspects of within-colony relatedness and nestmate numbers, considering the impact of colony size in different ecosystems. All the species of basal Attini for which data on the mating system are available inhabit diverse aboreal habitats (Weber 1956, Hölldobler & Wilson 1990), mainly rain forests (Villesen et al. 1999, 2002b). Up to now no species living in such uniform environment as the sandy dunes inhabited by the ants studied by us have been subject to molecular analysis. We suppose that under more stable conditions selection will not favor genetic variability and, consequently, no constraints against monandry should exist.

Material and Methods

Collection sites

Colonies of *M. conformis* were sampled February and July 2002 in Cabo Frio (22°53`S 42°0´W), Maricá (22°57`S 42°49`W) and Araruama (22°56`S 42°17`W), Rio de Janeiro state, those of *M. simplex* at Joaquina beach (27°37`S 48°27`W) in September 2003 and of

C. morschi in April 2003 at Joaquina beach and Pântano do Sul beach (27°46´S 48°30`W), both in Florianopolis, Santa Catarina state.

Colony sampling

Located colonies were excavated and transported into the Museu de Zoologia da Universidade de São Paulo. Nests were digged out after the nest entrance was marked with a small stick. About 40 cm aside the nest entrance, the sand was removed up to 80 cm depth. Thin slices of sand were cut out with a small spade in order to find chambers without destroying the fungus garden. When ants in tunnels were detected, their direction was followed. Once the fungus chamber was found, the hole towards the fungus chamber was carefully enlarged with a spoon and the entire fungus garden was collected in a plastic container. Ants which where lost during the procedure were carefully picked up.

DNA extraction

From each colony 15 to 20 workers and if present some males were stored in a freezer at -80°C. The CHELEX protocol was used for total DNA extraction (Walsh *et al.* 1991, modified by Villesen 2001). The extractions were made using only legs and/or head of one individual per tube.

PCR reaction

The primer pair Cypho15B_16B was used to amplify a microsatellite region. According to Villesen *et al.* (2002a) this microsatellite is the most variable locus across the lower Attini. The PCR conditions were as follows: initial denaturation at 94° C for 5 min, and 35 cycles of 94° C/5 min for denaturing, 60°C/ 50 sec. for annealing and 72°/ 40 sec. for elongation. The PCR mix consisted of 2 µl of DNA extraction, 1 µl of PCR buffer, 0.2 µl of each primer (20 mM), 0.5 µl of dNTP's (2 mM each), 0.3 µl of $MgCl_2$ (50mM), 2 U of *Taq* polymerase, and sterile water to achieve a final volume of 10 µl. The amplified products were analyzed in 5.6 % polyacrylamide gels and stained with silver.

Sequencing

The amplified alleles were cloned in the pGEM T-Easy vector (Promega) and used to transform *Escherichia coli* cells DH 5α. The selection of positive clones was done by using LB culture plates with ampicillin and X-Gal (Sambrook *et al.* 1989). The recombinant plasmids were extracted from positive colonies, following the protocol described in "Automated DNA Sequencing Chemistry Guide" of Perkin Elmer Corporation (http://www.appliedbiosysmtems.com). The check for cloning success was done by plasmid digestion with *Eco* RI followed by electrophorosis in 2% agarose gels where the size of the fragment, its concentration and purity could be verified. The positive clones (showing the expected insert size) were sequenced using the primers M13 forward and reverse, which are complements to the plasmid, flanking the insertions. The Big Dye Terminator kit (Applied Biosystem) was used for sequencing reaction and the fragments of single stranded DNA were analyzed by an automatic ABI-PRISM 3100 sequencer (Perkin Elmer).

Statistical analysis

The statistics used by Fjerdingstad *et al.* (1998), Boomsma *et al.* (1999), Bekkevold *et al.* (1999) and Villesen *et al.* (1999; 2002b) in their studies on mating strategy in Attini ants were adopted. We determined the number of patrilines present in the workers for each colony. In addition the effective number of queen matings was calculated (Pedersen & Boomsma 1999), using MateSoft (Moilanen *et al.* 2004).

For comparison of population allele frequency we used Genepop (Raymond & Rousset 1995) based on one worker per colony because in case of full sisters, all worker progeny of one fathering male share the same allele. For estimating F_{ST} we used the "IBD" software (Bohonak 2002).

Results

Origin of the samples

We used worker samples from a number of nests collected (Table 1) at different sites: 10 colonies of *M. conformis* at two beaches (Cabo Frio/RJ and Barra de Maricá/RJ, ca. 80 km apart), 8 colonies of *M. simplex* at one beach (Praia da Joaquina, Florianopolis/SC) and 10 colonies of *C. morschi* at two beaches (Praia da Joaquina and Pântano do Sul, both in Florianópolis/SC, ca. 20 km apart).

Microsatellites

We sequenced two alleles of the microsatellite locus Cypho15B_16B (GenBank accession numbers DQ166133 and DQ166134): of *M. simplex* and of *C. morschi*, respectively. Unfortunately it was not possible to sequence any allele of *M. conformis*. The microsatellite region comprises TC repeats, with 15 duplicates in *Cyphomyrmex longiscapus* and in *M. simplex* 21. In *C. morschi* the TC repeats in the allele are interrupted, typical for an imperfect repeat.

Allele frequency

In *M. conformis* and in *M. simplex* 8 and in *C. morschi* 7 alleles were detected, with 115 to 155 bp in *M. conformis,* 118 to 160 bp in *M. simplex* between and 160 to 190 bp in *C. morschi*. Allele frequency varied between the collection sites, some cases alleles were specific for only one site (Table 2). Alleles measuring exactly 130 and 140 bp occur in *M. conformis* and *M. simplex*, and the 160 bp allele was found in the genome of *M. simplex* and *C. morschi*.

The average allele frequency per collection site varied in correlation with the geographical distance in between (Table 2). However, our samples were taken from merely two locations per ant species.

Patriline and matriline numbers per colony

According to our analysis, all colonies were monogyneous because only two maternal alleles were present in the worker progeny. At the same time, just one paternal allele could be detected. These data indicate single mating of the queen (Table 3), resulting in high intranidal worker relatedness of $r \geq 0.7$.

Besides this common result, we found some exceptions. In one colony of *C. morschi* two patrilines were represented (Table 4). Because the sample of one *M. conformis* nest showed four maternal alleles, the colony must have contained two queens. Accordingly more than one patriline was detected. This colony was excluded from our kinship calculation. Furthermore, the worker progeny of one *C. morschi* colony carried two paternal alleles with quite different frequency. One contributed to about 90% of the worker population (Table 4). This remarkable skew might result from shifting workers.

Discussion

Experimental design

In this study we analyzed patrilines of 479 workers of 28 colonies from three species of basal Attini. *Mycetophylax conformis* and *C. morschi* were represented from 10 colonies each and *M. simplex* with 8 colonies. For each colony we analyzed 10 to 20 workers. Therefore, the median sample size of this study is comparable to the studies of Villesen at al. (1999, 2002b) and Murakami et al. (2002). Boomsma & Ratnieks (1996) suggested using at least 20 workers for effective paternity analyses. We increased the sample size when there were hints for a possible double mating of the queen.

The microsatellite locus Cypho15B_16B, originally developed for ants of the species *Cyphomyrmex longiscapus* (Villesen at al. 2002a), is variable enough to detect the same microsatellite region in the species we studied. We obtained a sufficient resolution in terms of visualizing numerous bands in the gels. The accuracy was high enough to identify the two alleles of each worker without doubts.

Villesen et al. (1999, 2000b) did not observe a single case of double mating after analyzing 269 workers of 29 colonies of three species of basal Attini and 476 workers of 40 colonies of five species of intermediate Attini. Only in one colony we detected possible double mating and another colony was polygynous with two queens. Presumably this was due to worker drifting or colony fusion. In laboratory experiments we observed that different colonies can mix up and that the queen or workers of a joining colony do not suffer any kind of aggression.

Boomsma & Ratnieks (1996) discussed if sperm clumping as known for honey bees is also occurring in multiply mated ant queens. Our data are based on merely one case of two worker cohorts. To test this problem, it would be necessary to maintain colonies during a longer period under laboratory conditions and do kinship analyses at regular intervals. Another possibility is the examination of the queen's spermatheca. Fournier *et al.* (2002) succeeded in confirming a single mating of queens of *Pheidole pallidula* with this technique and proved that sperm clumping does not occur in this species. Strassmann (2001) underlined that in general Hymenoptera show little evidence for sperm clumping but she also recognized that until now only a few studies have been done with ants.

As we did not detect any double mated queens, in our statistical analysis we had to use a hypothetical value of paternity skew, i. e. for the distribution of patrilines within the colony when the mating frequency would be higher than one. The estimate we used is based on the average sperm bias of 19 ant species with the value of c = 0.77 (Boomsma & Ratnieks 1996, Villesen *et al.* 2002b).

We showed that essentially all nestmate workers in our colonies of *M. conformis*, *M. simplex* and *C. morschi* had a single father. Consequently, the queens must by monandrous in their mating. Furthermore, our results indicate that the colonies of basal Attini are generally monogynous.

Our study with samples of three species resulted in a satisfactory data set, though we analyzed only one microsatellite locus. Certainly it would be favorable to increase the number of microsatellite loci screened. This would give stronger evidence for the mating frequency of queens and the genetic distance of the sampled populations.

Mating strategies in basal Attini ants

Information about mating strategies in ants is scarse. It is known that species of the higher leaf cutting ants perform multiple mating (Fjerdingstad & Boomsma 1998, 2000, Fjerdingstad et al. 1998, Bekkevold et al. 1999, Boomsma et al. 1999). Only a few species of basal Attini were also analyzed (Villesen 1999, 2002b, Murakami et al. 2000), and in all studies the queens had monandrous mating behaviour. Our results confirm these published results.

Benefits and constraints of monandry *versus* polyandry

Advantages and disadvantages of multiple mating in social hymenoptera were discussed by Strassmann (2001). Boomsma et al. (2000) hypothesized that mating frequency in fungus growing ants correlates with colony size. Therefore, the polyandrous genera *Atta* and *Acromyrmex* possess big colonies with up to millions of workers, and the nests have a live expectancy of several years (Hölldober & Wilson, 1990).

Small colonies of the basal Attini need for survival constant environment conditions without to much seasonal change in abiotic factors; ambient situations given in the sandy soil habitats of the south Brazilian Atlantic dunes. The resources available for foraging material used as substrate for fungus culture need no sophisticated collection behavior of the workers as leaf cutting does. Consequently a high genetic variability within the worker population of a colony should not be necessary.

Multiple mating guarantees a heterogeneous gene pool in the colony and progeny of a less fit male could be balanced by workers of a more effective patriline. Furthermore, another possible reason for monandry could be the low life expectancy of the nests. The spermatozoids of only one male are enough to fertilize all worker eggs during the queen's life time. Certainly a high nest density (Albuquerque *et al.* 2005) on the basal Attini species results in a genetically heterogeneous local community. The colonies are headed by many queens all with varying genomes, and all mated with different males. This must assure sufficient intercolonial genetic variability at the population level. Male fitness selection during nuptial flight or multiple mating and therefore pressure on evolution of other (multiple) mating strategies was presumably not operating.

Monandry in Hymenoptera is accepted as the original mating system. In wasps and bees both monandry and polyandry occur in eusocial species whereas in solitary species monandy is prevalent. Because all extant ants are eusocial, comparison with solitary species is not possible with the recent material. Multiple mating in ants is up to date only known for a few species of higher Attini, the leaf cutting ants *Atta* and *Acromyrmex*, *Pogonomyrmex* and, in addition. for some species of the genera *Formica* and *Lasius* all with large colonies. Strassmann (2001) discussed possible reasons why multiple mating is not the only mating system in social Hymenoptera. Taking in account her arguments, we suppose that higher intranidal genetic variability in colonies of basal Attini would not result in advantages by increased inclusive fitness. This means that the basal Attini could conserve the assumed original single mating strategy of their solitary extinct ancestors.

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Table 1: Collected ant colonies and their origin.

species	n individuals	collection site	N colonies
M. conformis	176	Barra do Maricá/RJ	7
		Cabo Frio/RJ	3
M. simplex	120	Joaquina / SC	8
C. morschi	183	Joaquina/SC	5
		Pântano do Sul/SC	5

Table 2: Frequency of the microsatellite allele Cypho15B_16B in our sample of different origin in Brazil.

allele (bp)	*M. conformis*		*M. simplex*	*C. morschi*	
	Barra de Maricá (RJ)	Cabo Frio (RJ)	Praia da Joaquina (SC)	Praia da Joaquina (SC)	Pântano do Sul (SC)
115	0.143				
118			0.188		
120	0.071				
125	0.286				
128			0.125		
130	0.143	0.167	0.062		
135	0.286	0.167			
140		0.167	0.125		
145		0.5	0.125		
148			0.188		
150			0.125		
155	0.071				
160			0.062	0.3	
168				0.1	0.1
170					0.4
175				0.1	0.1
180				0.3	0.1
185				0.1	0.1
190				0.1	0.2

Table 3: Synopsis of our patriline analyses with kinship calculation.

	Mycetophylax conformis	*Mycetophylax simplex*	*Cyphomyrmex morschi*
double mating assumed (D_{obs})	0	0	0.1
number of microsatellite loci	1	1	1
number of colonies analyzed	10	8	10
number of workers genotyped	17. 6 ± 5.72	15 ± 2.76	18.1 ± 7.14
estimated double mating (D_{est})	0	0	0.129
error for identification of double mating (f)[a]	0.160	0.171	0.222
maximal effective paternity of nest-mate workers (m_{ep}) [b]	1.0	1.0	1.048
minimal inferred relatedness among nest-mate workers [c]	0.75	0.75	0.727
F_{ST}	0.121	-	0.056

[a] Estimated by MateSoft

[b] Calculated as $1/m_e = (1 - D_{est}) \times 1.0 + D_{est} \times \Sigma p_i^2 = 0.646$ based on $p_1 = 0.77$, $p_2 = 0.23$ from Boomsma & Ratnieks, see also Villesen *et a*l. 2002

[c] Calculated as $r = 0.25 + (0.5 / m_e)$ (Pamilo 1993)

Table 4: Nest populations and sample size of our genotyping in the three species of basal Attini.

species	colony/location	queen(s)	male	offspring (with no. of analyzed genotypes)
M. conformis	M1/Maricá	120/130	125	120/125 (5) 130/125 (14)
	M2/Maricá	120/130 120/140 130/140	130 155 140	120/130 (7) 120/140 (4) 120/155 (1) 130/130 (3) 130/155 (2) 130/140 (1) 140/155 (14)
	M3/Maricá	125/135	135	125/135 (10) 135/135 (5)
	M4/Maricá	125/125	115	115/125 (19)
	M5/Maricá	115/125	120	115/120 (8) 120/125 (9)
	M6/Maricá	125/135	125	125/125 (3) 125/135 (9)
	M7/Maricá	135/145	125	125/135 (14) 125/145 (5)
	CF1/Cabo Frio	140/145	130	130/140 (8) 130/145 (5)
	CF2/Cabo Frio	130/135	145	130/145 (1) 135/145 (12)
	CF3/Cabo Frio	135/145	140	135/140 (4) 140/145 (13)
M. simplex	MS1/Joaquina	118/150	160	118/160 (8) 150/160 (6)
	MS2/Joaquina	145/150	145	145/145 (9) 145/150 (5)
	MS3/Joaquina	118/148	148	118/148 (4) 148/148 (10)
	MS4/Joaquina	128/148	140	128/140 (7) 140/148 (7)
	MS5/Joaquina	118/128	148	118/148 (10) 128/148 (4)
	MS6/Joaquina	130/140	140	130/140 (4) 140/140 (8)
	MS7/Joaquina	118/128	118	118/118 (9) 118/128 (10)
	MS8/Joaquina	128/150	150	128/150 (11) 150/150 (8)
C. morschi	Jo1/Joaquina	175/190	180	175/180 (9) 180/190 (9)
	Jo3/Joaquina	160/175	180	160/180 (5) 175/180 (9)
	Jo4/Joaquina	175/185	160 175	160/175 (18) 160/185 (16) 175/175 (4)
	Jo5/Joaquina	168/180	190	168/190 (8) 180/190 (8)
	Jo7/Joaquina	160/168	180	160/180 (9) 168/180 (6)
	Pa1/Pantano	170/180	170	170/170 (8) 170/180 (10)
	Pa2/Pantano	170/175	180	170/180 (10) 175/180 (7)
	Pa4/Pantano	185/190	170	170/185 (5) 170/190 (12)
	Pa6/Pantano	160/185	160	160/160 (9) 160/185 (7)
	Pa7/Pantano	170/175	190	170/190 (6) 175/190 (8)

Revision of the fungus-growing ant genera *Mycetophylax* and *Paramycetophylax* stat. rev. and description of a new fungus growing ant genus, *Kalathomyrmex* gen. nov. (Hymenoptera: Formicidae)

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Abstract

There are six nominal species currently accepted in the fungus-growing ant genus *Mycetophylax*, but our study indicates that these taxa do not belong to the same clade. In our proposal, *Mycetophylax* includes *Myrmicocrypta brittoni* (type species of *Mycetophylax*, by designation of Emery 1913 and synonym of *M. conformis* by Kempf 1962), *M. simplex* and *Cyphomyrmex morschi,* now in combination of *Mycetophylax*. For *Mycetophylax bruchi* we are resurrecting from synonymy *Paramycetophylax* Kusnezov, 1956 (*Mycetophylax bruchi* as type species, by original designation, with *M. cristulatus* as its new synonym. *M. emeryi*, formerly described as *Myrmicocypta emery*i (Forel, 1907) is the type species of genus here described *Kalathomyrmex* gen. nov. We redescribe and describe workers of all species in all three genera, and describe for the first time gynes of *Mycetophylax conformis* and *M. simplex*, males of *M. simplex* and *M. morschi.* Furthermore we present SEM pictures and high resolution photographs of the species, along with maps of collection records and a summary of biological observations.

Introduction

Mycetophylax is currently one of the most poorly known genera of the fungus-growing myrmicine ant tribe Attini. Until today six species, and 9 subspecies and varieties have been described and are nomenclaturaly valid (Kempf, 1972; Brandão, 1991; Bolton, 1995), but there is no recent and reliable taxonomic revision of the genus. Already in 1962, Kempf commented that *Mycetophylax* "certainly is an ill-defined assembly of heterogeneous forms, a residue of classification. Whereas some of its members, such as *emeryi*, *cristulatus* and *bruchi*, are quite distinct from C*yphomyrmex s. str.*, the type species *brittoni* (= *conformis*) is dangerously close to *Cyphomyrmex morschi*, as Emery already pointed out in 1922, (p. 343). The only good generic difference for workers consists in the absence of a clearly defined and circumscribed antennal scrobe in *Mycetophylax*."[1]

Mayr described in 1884 the first species nowadays included in *Mycetophylax Cyphomyrmex conformis*. In 1907, Forel and Wheeler described two species in *Myrmicocrypta* now accepted as *Mycetophylax* (respectively *M. emeryi* and *M. brittoni*), both already suspecting that these species might not belong to *Myrmicocrypta*.[2] Wheeler (1911) described the alate forms of *M. brittoni* (junior synonym of *M. conformis* by Kempf, 1962) and reinforced the argument for their inclusion in a different genus. Only in 1913, Emery recognized *Mycetophylax* as a taxon, but as a subgenus of *Cyphomyrmex*, designating *M. brittoni* Wheeler (1907) as type-species. Notwithstanding, Gallardo (1916) recognized *Mycetophylax* as a subgenus of *Myrmicocrypta*. Only in 1923, *Mycetophylax* was raised to generic level by Santschi. The same author, in 1922, published a comprehensibly but now very much outdated key for the species, subspecies and varieties of the genus.

Paramycetophylax was described by Kusnezov in 1956, with *Sericomyrmex bruchi* as type

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[1] Actually *C. morschi* do show an antennal scrobe, but distinctly less developed than in other *Cyphomyrmex* species.

[2] As *Mycetophylax* was never properly described, most authors accept the sum of these species descriptions as the definition of the genus.

species by original designation. Weber (1958) synonymized *Paramycetophylax* with *Mycetophylax*, but was unable to justify his decision with clear differences in the morphological characters of the genus that also included *M. bruchi*.

In 1962 Kempf transferred *Cyphomyrmex conformis* Mayr (1884), *Myrmicocrypta brittoni* Wheeler (1907), and *Myrmicocrypta emeryi* Forel (1907) to *Mycetophylax*.

In 2002, Villesen *et al.* presented a phylogenetic hypothesis for the tribe Attini. In their analysis *Mycetophylax* appears as a paraphyletic taxon. Also in the phylogenetic hypothesis on the fungus symbiosis with Attini ants (Mueller et al. 1998, Mueller 2002) there is no support for the monophyly of the genus.

Moreover, the very imprecise descriptions of the species now included in *Mycetophylax* do not afford easy separation from other Attini genera, and we found ground to question the present taxonomic status of the species grouped under *Mycetophylax*, justifying its revision.

A careful examination of all species of *Mycetophylax* led us to conclude that the genus as accepted until now is not monophyletic and we suggest its division in three taxa, as fully explained below. The genus *Mycetophylax,* in the new sense, includes *M. conformis, M. simplex* and *Cyphomyrmex morschi* (hereby transferred to *Mycetophylax*). The species *M. bruchi* and *M. cristulatus* are hereby transferred to *Paramycetophylax* Kusnezov (1956), here revalidated. The species *M. emeryi* is designated as type species of a new monotypic genus, *Kalathomyrmex* gen. nov..

The different authors that described *Mycetophylax* species (Emery 1888; Wheeler 1907, 1911; Forel 1912; Santschi 1916, 1922, 1923, 1925, 1929; Weber 1948 and Kempf 1962) used always different character traits for diagnosing these ants. Here we present a taxonomic revision of the genera *Mycetophylax,* and *Paramycetophylax* stat. rev. and the description of a new fungus growing ant genus *Kalathomyrmex,* with illustrated redescriptions and descriptions of the workers, gynes and males, along with drawings, digital photographs and electron micrographs (SEM). We also provide maps showing the known geographic distribution of all species and a discussion of their habits.

Material and Methods

For this revision we used the specimens deposited in the Museu de Zoologia da Universidade de São Paulo (MZSP, curator C. R. F. Brandão), that includes recent collections of *Myctophylax* specimens and donations by Eduardo Diehl-Fleig, Alex Wild and Scott Solomon, along with specimens loaned from research institutions listed below. Collection acronyms follow Arnett *et al.* (1993), and are cited followed by the names of the curators of the respective collections or responsible for the loans.

AMNH: American Museum of Natural History, New York, USA, Dr. James M. Carpenter.
MCSN: Museo Civico di Storia Naturale “G. Doria”, Genova, Italy, Dr. V. Raineri.
SMNK: Staatliches Museum für Naturkunde Karlsruhe, Germany, Dr. Manfred Verhaagh.
INPA: Instituto Nacional de Pesquisas de Amazônia, Manaus, Brazil, Dr. Heraldo Vasconcelos.
NHMB: Naturhistorisches Museum Basel, Switzerland, Dr. Daniel Burckhardt.
USNM: United States National Museum, Smithsonian Institution, Washington, USA, Dr. Ted Schultz.

In the list of examined specimens, the adopted abbreviations are: w (worker), q (queen/gyne) m (male).

The specimens were analyzed under a binocular stereomicroscope Wild M8® with ocular lens 10 to 16 X. Digital photos were taken with a Leica MZ 6 binocular, coupled to a high resolution JVC KY-F70B camera. To produce a single image with extended focus of a series of in-focus images, we used the software package AutoMontage©. REM photographs were taken using the scanning electron microscope (SEM) model Zeiss Leo 444® of the MZSP. For this, the specimens were previously cleaned with 99% alcohol and kept in an ultrasonic bath (Thornton) for three minutes in a frequency of 40 kHz. After that, a series of washings were made, reducing the alcohol and increasing the acetone part in steps of 25%. At the last step, the specimens were submersed in a 100% acetone solution for at least 20 minutes. Posteriorly the ants were glued on aluminum triangles, which were fixed on a stub support for the SEM. Finally the specimens were metalized with gold using a Bal-Tec SCD 050 sputter.

Morphometric measurements follow Bolton (2000) and were obtained using micrometric reticule adapted to a binocular stereomicroscope. The following measurements and indices were taken and calculated for each measured specimen.

Head width (HW): maximum width of the head in full-face view, not considering the compound eyes.

Head length (HL): maximum length of the head in full-face view, from the midpoint of the clypeal border, in a transverse line, to the midpoint of the occipital margin of the head, including the occipital corners.

Cephalic Index (CI): HW/HL x 100.

Scape length (SL): maximum cord length of the scape, excluding its basal articulation condyle.

Scape Index (SI): SL/HW x 100.

Mandible length (ML): maximum length of the mandible in full-face view, from the tip of the apical tooth, in a transverse line, to the midpoint of the clypeus, including the mandible insertions.

Mandibular Index (MI): ML/HL x 100

Pronotal width (PrW): maximum width of the pronotum in dorsal view

Weber's length of the mesosoma (WL): diagonal length of the mesosoma in lateral view, measured from the anteriormost collar of pronotum to the posterior ventral corner of the mesosoma

Petiole length (PL): maximum length of the petiole in lateral view

Post petiole length (PPL): maximum length of the post petiole

Gaster length (GL): maximum cord length of the gaster from the division of tergum and sternum at its anterior border to the most posterior point at the last segment.

Metafemural length (FL): maximum length of metafemura.

Total length (TL): sum of ML, HL, WL, PL, PPL and GL.

The terminology of the wing cells follows Klingenberg & Dietz (2004).

Results and Discussion

The apomorphies of *Mycetophylax* (absence of deeply impressed antennal scrobes, the typical shape of mandibles, head, frontal lobes and postpetiole) are absent in the species *M. bruchi*, *M. cristulatus* and *M. emeryi* and we then propose to transfer them to another genus. The species hereby included in the genus *Paramycetophylax* (*M. bruchi* and *M. cristulatus* with their subspecies) present as apomorphic characters wide triangular frontal lobes, long setae at the mandibles and at the inferior margin of clypeus, forming a kind of psammophore and distinct pronotal spines. The newly described genus *Kalathomyrmex* with *Kalathomyrmex emeryi* as type species presents as apomorphic characters the subquadrate head shape, reduced arched frontal lobes, subtriangular mandibles with five teeth and a triangular clypeus, with long setae at its middle portion, lack of a median clypeal seta (otherwise universal in Attini), slenderer body, and the metapropodeal depression with a median spine. Also, contrariwise to the species of *Mycetophylax* as accepted here, the species of *Paramycetophylax* and *Kalathomyrmex* share apomorphic morphological female character states such as postpetiole with a large impression, almost dividing it in two lobes. Besides this, the open radial cell of the forewing is a unique character trait for the Attini (Klingenberg & Dietz 2004). Even though, we believe the species belong to different genera due to their distinct apomorphical characters as cited above. The fact that the species of both genera present a psammophore is no argument to unite them in a unique genus because of the different origin of those setae (in *P. bruchi* the setae set off at the inferior margin of the clypeus, whereas the setae of *Kalathomyrmex emeryi* originate at the middle portion of the clypeus). See also table 1 for comparison of the main morphological differences between the genera.

Recent publications on the Attini phylogeny strongly suggest that some genera as traditionally treated are paraphyletic (Villesen *et al.* 2002). A phylogeny for the basal Neoattini is in preparation and will be published elsewhere.

However, our comparative studies of the here accepted species of *Mycetophylax*, *Paramycetophylax* and *Kalathomyrmex* revealed the phylogenetic signal of morphological characters, supporting their division in three different genera.

Mycetophylax bruchi was described by Santschi in 1916 as *Sericomyrmex*, and so Kusnezov while describing *Paramycetophylax* in 1956, designated *S. bruchi* as type species. The name *Paramycetophylax* is available and is hence hereby revalidated to accommodate *Sericomyrmex bruchi.* We then propose the exclusion of synonyms from *Mycetophylax* in this new sense, besides the cited taxa, *Mycetophylax bruchi* var. *pauper* (Santschi 1923), *Mycetophylax cristulata* (Santschi 1922), and its variety *M. cristulata* var. *emmae* (Santschi, 1929).

Mycetophylax emeryi (Forel, 1907) is also excluded from *Mycetophylax* and is now designated as type species of the new genus *Kalathomyrmex*. Here we propose the synonymy of its varieties and subspecies (*M. emeryi* var. *arenicola* (Forel, 1912), *M. emeryi* var. *argentinus* (Santschi 1916), *M. emeryi* var. *fortis* (Forel 1912), *M. emeryi boliviari* (Weber 1948), *M. emeryi gallardoi* (Santschi 1922), *M. emeryi hubrichi* (Santschi 1925), *M. emeryi weiseri* (Santschi 1929), *M. hummelincki* (Weber 1948) and *M. glaber* (Weber 1948). The synonymy of the above cited species *M. cristulata* and its variety *M. cristulata* var. *emmae* and the subspecies and varieties of *M. emeryi* we justify with the clearly defined apomorphies for both genera and the lack of distinct morphological character traits on species and subspecies/variety level which allow a clear separation of the taxa. The lack of apomorphies on subspecies level becomes evident by analyzing the original descriptions of them (see comments at species description below).

A further argument for the division of the genus *Mycetophylax* as traditionally accepted is the biogeographical data set. Contrary to the species of *Mycetophylax,* the species of *Paramycetophylax* and *Kalathomyrmex* as here proposed are never found in the "restingas" (dunes) of the South Atlantic Ocean beaches. *Paramycetophylax* seems to occur only in South America, with *P. bruchi* known only in Argentina until know. Biological data or life history observations are to scant to afford any interpretation.

In collections, specimens of *Mycetophylax*, *Paramycetophylax* and *Kalathomyrmex* are rare. Apparently this is due to the habitat choice of these ants, as few myrmecologists collected in the beaches of the sea coast or in river margins (but see Gonçalves & Mayhé-Nunes 1984, Bonnet & Lopes 1993, Diehl-Fleig *et al.* 2000, Albuquerque *et al.* 2005). Even in the few available studies, most *Mycetophylax* species are listed only as morpho-types. Bonnet & Lopes (1993) did not list *M. simplex* for the Praia da Joaquina beach in the Isle of Santa Catarina in their survey, but this species is quite common there. By our experience, the three known species of *Mycetophylax* may be locally abundant in the dunes and restingas of the Brazilian Atlantic coast.

Mycetophylax Emery, 1913

(Figs. 1 - 4a, 5 -11a)

Cyphomyrmex (in part) Mayr, 1884: 9

Myrmicocrypta (in part) Wheeler, 1907: 728; Forel 1907: 144

Cyphomyrmex (*Mycetophylax*) Emery 1913: 251; key to species, Santschi, 1922: 357; raised to genus by Santschi 1923: 268

Myrmicocrypta (*Mycetophylax*) Santschi, 1916: 383, Gallardo, 1916: 320

Sericomyrmex (in part) Santschi, 1916: 383

Type species: *Myrmicocrypta brittoni* (Mayr, 1884) (original designation) (junior synonym of *Mycetophylax conformis*)

Worker:

Monomorphic. Integument areolate, smooth and shiny at metapleural gland. Hairs short, appressed. Head longer than wide, slightly triangular, the greatest wide of head at posterior third. Compound eyes at the anterior third of head (not considering the mandibles), convex, surpassingsurpassing the lateral margin in frontal view. Mandibles triangular with seven to ten teeth. Dorsal sculpture of the mandible varying among the species. Masticatory margin smooth without any trace of sculpture. Apical teeth bigger than the others that reduce in size basally, the most basal tooth as a denticle. Anterior margin of clypeus with a small impression. Median portion of clypeus elevated until the antennae insertions. Posterior border of clypeus visible by means of a distinct suture forming the frontal area as a shallow triangular impression. Clypeal suture bends at anterior tentorial pit. Area between preocular carina and frontal carina free of hairs, distinct, but never deeply impressed or forming an antennal scrobe. Frontal lobes laterally produced, covering the antennal insertions. Lobes reaching posterior third of head. Occipital margin concave and occipital lobes without spines or protuberances.

Mesosoma without spines, smooth or with rounded protuberances only. Shoulders of pronotum rounded, without acute spines or angles. Mesonotum without projections. Propodeal spiracle clearly visible, so is the opening of the metapleural gland. Petiole longer than high, in lateral view peduncle very short, with an undifferentiated node. In all species, the apex of the subpetiolar process ends with an acute angle. In dorsal view, postpetiole always wider and long and as longer than petiole. Posterior margin straight, without impression or distinct lobes. Gaster never with tubercles or protuberances and somewhat smaller than head.

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Gyne:

Colour, pilosity and sculpture like workers. The head conspecific with the workers, but with three equally developed ocelli in the middle of the posterior third of head. Alitrunk differs due to flight sclerites with a well developed scutum, scutum-scutellar sulcus and scutellum. Prescutellum perfectly straight but axilla well developed. In dorsal view, scutum rounded at anterior and has its widest part at the tegulae. Parapsides almost indistinct, set between parapsidial lines and latero-posterior margin of the scutum which is limited by a carina. Scutum-scutelar sulcus concave anteriorly. Anepisternum and katepisternum divided by a suture. Katepisternum with anterior border sinuous. Petiole, postpetiole and gaster like those of the workers. Gaster with the same width as the head.

Male:

Pilosity like workers and queens. Mandibles triangular, with five to seven teeth, the most apical always larger than the others. Clypeus elevated till frontal area between the antennal insertions. Head without antennal scrobes and antennal scapes almost of double length of the funiculus, always surpassing the occipital corners. Big rounded compound eyes situated at anterior half of head and occupying one third of its lateral expansion. At posterior third of head with three equally developed ocelli. Anterior part of scutum with a median furrow, hairless and with smooth sculpture. Parapsidial lines in parallel direction to the main body axis. In dorsal view prescutellum slender and scutellum becoming narrow at posterior. Posterior boarder of scutellum concave, with two protuberances pointing backwards. Katepisternum and anepisternum divided by a distinct suture. Petiole and postpetiole like workers. Gaster slender of only double width of postpetiole, having the same width as the head including compound eyes. Legs long and filamentous.

Paramycetophlax (Kusnezow, 1956) stat. rev.

(Figs. 4b, 11b, 12, 13))

Myrmicocrypta (in part) Wheeler, 1907: 728; Forel 1907: 144

Cyphomyrmex (Mycetophylax) Emery 1913: 251; key to species, Santschi, 1922: 357; raised to genus by Santschi 1923: 268

Myrmicocrypta (Mycetophylax) Santschi, 1916: 383, Gallardo, 1916: 320

Sericomyrmex (in part) Santschi, 1916: 383

Paramycetophylax Kusnezov, 1956: 23; synonym of *Mycetophylax* Weber, 1958: 263 (removed from synonymy, new revalidation)

Type species: *Sericomyrmex bruchi*, Santschi, 1916 (original designation) (junior subjective synonym of *Paramycetophylax bruchi*)

Worker:

Monomorphic. Antenna with 11 segments. Integument reticulate, with appressed hairs. Head with quadratic aspect. Compound eyes positioned at the middle of head. Mandibles subtriangular, with irregular teeth. Anterior margin of clypeus straight, median portion elevated up to the antennal insertions. Long setae at the inferior margin of clypeus, forming a kind of psammophore, mandibles without such setae. Median seta at clypeus present. Without antennal scrobes. Well developed triangular frontal lobes. Occipital margin concave. Ventral face of head flat. Mesosoma slender, pronotum with defined blunt angles, mesonotum with uneven. Metapropodeal impression distinct. Propodeum armed with a pair of small spines. Petiole without distinct node and postpetiole at posterior portion with a large impression, dividing the postpetiole in two lobes. Gaster smooth, without spines or protuberances.

Male:

Colour brown. Head with quadratic aspect. Big compound eyes, occupying anterior half of lateral extension of head. Mandibles elongated. Anterior margin of clypeus straight with long seta, posterior margin elevated. Without antennal scrobes. Frontal lobes reduced, covering only half of antennal insertions. At posterior portion of frons three ocelli. Occipital margin straight. Antenna with 13 segments, antennal scapes surpassing the occipital margin. In lateral view alitrunk compact, scutum covering pronotum. In lateral view anepisternum and katepisternum distinctly divided. Postpetiole at posterior with median impression, gaster smooth. Wing with open radial cell.

Kalathomyrmex new genus

(Figs. 4c, 11c, 15 – 17)

Myrmicocrypta (in part) Forel 1907: 144

Cyphomyrmex (Mycetophylax) Emery 1913: 251; key to species, Santschi, 1922: 357; raised to genus by Santschi 1923: 268

Myrmicocrypta (Mycetophylax) Santschi, 1916: 383, Gallardo, 1916: 320

Etimology: from latinized Greek *kalathos* = basket, referring to the psamophore; *myrmekos* = ant.

Worker:

Monomorphic. Colour brownish. Body densely sculptured and covered with short, appressed hairs. Masticatory margin of mandibles smooth, without any trace of sculpture. Head subquadrate. Compound eyes at anterior half of head. Mandibles subtriangular. Clypeus in a triangular shape. Frontal lobes reduced, in frontal view forming a triangle. Antenna with 11 segments ,scape sursurpassing the occipital corners. Alitrunk slender, pronotum without defined spines, only dorsal margin undulated. Anterior mesonotal spines vestigial, occasionally developed. Propodeum armed with a pair of small spines. Petiole without distinct node and postpetiole at posterior portion with a wide impression, dividing the postpetiole in two distinct lobes. Gaster smooth, without spines or protuberances.

Gyne:

Colour and pilosity same as the workers, so the main morphological character traits. Posterior portion of head with three ocelli. Alitunk compact, scutum flat and in dorsal view rounded at anterior and posterior. At anterior portion of scutum a median lone without hairs. Parapsidial lines visible and impressed, prescutum reduced, axillaries in triangular form. Propodeum with small blunt spines. Radial cell of forewing open.

Male:

Colour brown. Body covered with short appressed hairs. Head with quadratic aspect. Big compound eyes big, almost occupying anterior half of lateral extension of head. At posterior portion of frons three ocelli. Mandibles slender and elongated. Anterior margin of clypeus straight with long seta, one of the median, only visible at REM-images. Posterior margin elevated up to half of antennal insertions. Frontal lobes reduced. Without antennal scrobes. Occipital margin convex, occipital corners rounded. Antenna with 13 segments, antennal scapes surpassing the occipital margin. In lateral view alitrunk compact. In dorsal view anterior margin of scutum rounded. At anterior portion a median lone without hairs. In dorsal view scutum and prescutum of the same width. Scutellem with triangular aspect, having the major width at anterior. In lateral view anepisternum and katepisternum distinctly divided. Postpetiole with a median impression at posterior, gaster smooth. Forewing with open radial cell.

Identification keys

Identification keys to the genera based on workers

1) Colour light to dark brown, head slightly triangular, mandibles triangular with seven toten teeth, deeply impressed antennal scrobes absent, frontal lobes laterally produced reaching half of the width of the head, covering the antennal insertions. Occipital margin concave. Mesosoma without spines or protuberances, mesonotum

without projections. Posterior margin of postpetiole straight, without any impression. Lives exclusively at dunes and restingas of the Atlantic Ocean, prefers arid habitats with sandy soil

Mycetophylax

1´) Colour reddisch-brown or brownish. Head with quadratic or subquadrate aspect, posterior margin of postpetiole not straight, with and median impression, long setae at clypeus forming a psammphore.

2) Colour brownish, clypeal setae originated at inferior margin of clypeus, frontal lobes triangular and well developed, covering a third of median head line and lateral margin of head. Mesonotum at dorsal face with a small blunt median protuberance.

Paramycetophylax

2´) Colour reddisch-brown, clypeal setae originated at posterior margin of triangular clypeus, median clypeal seta lacking. Frontal lobes reduced, only covering antennal insertions, mesosoma with elongated aspect. Metapropodeal depression with a median spine

Kalathomyrmex

Identification key for the workers and gynes of *Mycetophylax*

1) Colour light to dark brown and black. Total length or worker normally more than 3 mm and of gynes more than 4 mm. Head as long as wide as or somewhat longer than wide. Frontal area smooth, without vertexal carina. Mesosoma smooth without spines or protuberances, dorsal profile even.

(2)

1') Total length of workers normally less than 3 mm and of gynes less than 3,5 mm. Head longer than wide. Vertexal carina present. Antennal scape surpassing the occipital corners. Mesosoma with uneven dorsal profile. Gynes: scutum covering only half of the pronotum.

Mycetophylax morschi

2) Colour brownish to yellow. Total length of workers about 3,75 mm and gynes 5,2 mm. Mandibles with eight to nine teeth. Integument of the frontal lobes semitransparent, resulting in a round transparent structure at each side, above the antennal insertions. Without spines at propodeum. Gaster without ventral keel.

Mycetophylax simplex

2') Colour dark brown to black. Total length of workers about 3,05 mm and of gynes 4,3 mm. Mandibles with nine to ten teeth. No transparent integument on frontal lobes. Anterior margin of pronotum inclined. Propodeum armed with a pair of spines.

Mycetophylax conformis

Identification key to the males of *Mycetophylax*

1) Head wider than long, occipital margin convex or straight, frontal lobes not fully covering the antennal insertions. Scutum covering the pronotum in dorsal view. Katepisternum quadratic. Propodeum unarmed

(2)

1') Head longer than wide, occipital margin concave to straight. In bigger specimens, occipital corners with protuberances. Frontal lobes covering antennal insertions. Scutum covering pronotum only at two posterior thirds in dorsal view. Posterior margin of scutellum convex, with distinct short projections. Propodeum armed with a pair of spines.

Mycetophylax morschi

2) Antenna with 13 segments. Posterior border of clypeus without distinct suture. In lateral view, scutum higher than pronotum. Posterior margin of scutum slightly convex.

Mycetophylax simplex

2') Antennae with 12 segments. Posterior border of frontal triangle rounded. Scutum and pronotum in lateral view with the same hight. Posterior margin of scutum straight.

Mycetophylax conformis

Mycetophylax conformis (Mayr, 1884)

(Figs. 1-3, 4a))

Cyphomyrmex conformis Mayr, 1884: 38; (worker) Holotype, French Guiana, Cayenne (NHMW, not examined); Kempf, 1962: 34 (combination in *Mycetophylax*); Kempf, 1972: 145 (catalogue); Jaffe, 1993: 183, Bolton, 1995: 268 (catalogue)

Myrmicocrypta brittoni Wheeler, 1907: 728 (worker) Syntype, "Porto Rico (sic), Santurce (Wheeler), no coll. date" (AMNH, examined); Wheeler, 1911: 170 (male); *Cyphomyrmex* (*Mycetophylax*) *brittoni* Emery, 1913: 251; Santschi, 1922: 355 (key); Kempf, 1962: 34 (synonym of *Mycetophylax conformis*)

Mycetophylax brittoni var. *littoralis* Weber, 1937: 401 (worker) Syntype, "Trinidad, B. W. I. Mayaro Bay, 11.iii.1935, N. A. Weber" (MZSP, examined); Kempf, 1962: 34 (synonym of *Mycetophylax conformis*).

Worker (Figs 1 and 4 a)

For syntype measurements and indices see table 2.

Measurements (in mm) and indices of examined specimens (range, N = 80)

HW 0.58-0.78; HL 0.63-0.82; CI 91-101; SL 0.49-0.70; SI 76-98; ML 0.28-0.43; MI 39-59; WL 0.78-1.13; PrW 0.37-0.58; PL 0.10-0.20; PPL 0.17-0.29; GL 0.53-0.78; FL 0.64-0.92; TL 2.62-3.41

Colour dark brown to black, legs brownish. Entire body covered with short golden hairs, sparse and appressed. Legs and antennae covered by the same type of hairs, only area between the preocular carinae and frontal carinae without hairs. Masticatory border of mandibles with longer hairs. Sculpture shiny and areolate. Mandible sculpture faintly reticular. Head slightly longer than wide (see CI). Compound eyes situated at anterior fourth of head with eleven ommatidia at major length and nine ommatidia at major width. Mandibles triangular with nine to ten regular teeth, the most basal one only as denticule. Anterior margin of clypeus slightly concave in the middle. Median portion of clypeus elevated till posterior level of antennal insertions and ends with a rounded suture followed by a small but distinctly impressed frontal triangle. External margin of frontal lobes rounded, but failing to attain half of the distance between the median line and external border of the head. Lateral carinae following the compound eyes, at posterior level of compound eyes curved towards median head line and joining the posterior end of the frontal lobes, describing a rounded arch. Frons with a smooth longitudinal median impression which reaches the occipital margin. Antennal scapes slightly curved, reaching the occipital corners and surpassing them by a distance smaller than its diameter at apex. Antenna ending in a two-segmented club, Last antennal segment as long as the two anterior together. Occipital margin with median impression, forming distinct lobes without spines.

Mesosoma compact, in lateral view profile of dorsal surface convex and continuous. Promesonotum without spines or protuberances laterally. When present, pronotal inferior spine variable in size. Metapropodeal impression distinct. Basal face of propodeum slightly convex and armed with a pair of small but conspicuous spines, directed up- and backwards. Declivous face of propodeum concave, having nearly the same length as basal face. Propodeal spiracle distinguished with rounded opening in circa 30 ° in relation of the main body axis. Node of petiole twice as wide as the peduncle and, in lateral view, as wide as high. Postpetiole wider than long. The posterior area presents a slight impression, however the posterior margin is straight. Gaster with a small median ventral keel at first sternite.

Gyne (undescribed) (Figs. 2 and 4 a)

Measurements (in mm) and indices of examined specimens (range, N = 10)
HW 0.82-0.96; HL 0.84-0.95; CI 96-102; SL 0.66-0.78; SI 77-87; ML 0.36-0.50; MI 36-46; WL 1.28-1.46; PL 0.22-0.30; PPL 0.22-0.26; GL 1.06-1.24; TL 4.00-4.65

Colour yellowish to brown, depending on age. Compound eyes at major lenght with 18 ommatidia and at major width with 17 ommatidia. In lateral view scutum covering almost the whole pronotum, scutum flattened. Pronotum with inferior pronotal spines. Parapsidial lines smooth, shining and free of hairs, almost parallel to the median line of the body. Notaulices almost indistinct, differentiated only by the lighter colour of the integument. Axillaries subtriangular. Scutum-scutellar sulcus distinct and prescutellum well developed with longitudinal rugae. Scutellum with reduced width posteriorly; posterior margin slightly concave with two small protuberances at the posterior angles. At propodeum a pair of blunt spines, directed back- and upwards. Anepisternum subtriangular, both divided by a groove.

Male (Figures 3, 4 a and 11 a)

Measurements (in mm) and indices of examined specimens (range, N = 13)
HW 0.46-0.52; HL 0.46-0.53; CI 90-104; SL 0.44-0.52; SI 92-108; ML 0.18-0.22; MI 36-46; WL 1.02-1.18; PL 0.20-0.22; PPL 0.16-0.19; GL 0.82-0.94; TL 2.87-3.16

Colour brown. Mandibles, legs and apical funiculars of antenna yellowish. Integument areolate-imbricate, gaster imbricate. Head with quadratic aspect, occipital corners rounded. Occipital margin without median impression. Compound eyes with 25 ommatidia at major length and 20 ommatidia at major width. Number of teeth at mandibles variable, maximum seven. The two apical teeth bigger than the following, having the same size. Anterior clypeal margin concave with median part straight, with three fine and long seta. Median portion of clypeus elevated till posterior level of antennal insertions. Posterior clypeal margin rounded, followed by a small impressed frontal triangle. Clypeal suture ends at anterior tentorial pit. Frontal lobes reduced, not covering the antennal insertions but elevated till posterior level of compound eyes. Lateral carinae following compound eyes till posterior level, than curved in direction to the middle of the head, joining the posterior portion of frontal lobes, forming a rounded arch. Antennal scapes at apical part somewhat wider than at basis. Antenna with 12 segments, ending with a three-segmented club, the last funicle of the same length than the two anterior together. In lateral view scutum covering almost the whole pronotum. Anterior inferior spines only indicated. Notaulices shallowly impressed. Prescutellum reduced, triangular axillaries small. Scutum-scutellar sulcus distinct and impressed. Scutum subtriangular, at anterior margin straight and at posterior margin convexly rounded. Anepisternum and katepisternum subtriangular, anterior-inferior corner of katepisternum rounded. At propodeum a small pair of spines.

Examined material: PUERTO RICO: Tortuguera Camp, x1950 (W. F. Buren) 17 w (AMNH), 12 w (USNM), 20ix,27x1950, (W. F. Buren) 17 w (MZSP); Santurce, no coll. data (W. M. Wheeler) 28 w (AMNH); TRINIDAD: Mayaro Bay, no coll. data (N. A. Weber) 1 w (*Syntype*) (MZSP); VENEZUELA: Miranda, Higuerote, xii1983 (K. Jaffe) 4 w, 1 q (MZSP); BRAZIL: Pará: Salinópolis, 13,19xi1953 (C. R. Gonçalves) 4 w (MZSP); Bahia: Mangue Seco, 31xii1999 (C. Klingenberg), 3 w (MZSP); Caravelas, 5x1993 (B. H. Dietz) 3 w (MZSP); Rio de Janeiro: Muriqui, 3-8ii2002 (C. Klingenberg & D. Couto-Lima) 6 w (MZSP); Cabo Frio, Praia das Dunas, 3-8ii2002 (C. Klingenberg & D. Couto-Lima) 53 w, 15 q, 17 m (MZSP); Maricá, Barra da Marica, 3-8ii2002 (C. Klingenberg & D. Couto-Lima), 48 w, 4 q, 7 m (MZSP); Macaé, 3v1970 (W. W. Kempf) 6 w (MZSP); São Paulo: Caraguatatuba v-vi1962 (Exp. Dept. Zool.), 20 w (MZSP); no coll. data, 1 w (MCSN) [C. Emery collection]

Comments

Mycetophylax conformis is the type species of the genus *Mycetophylax*. The morphological character traits are very similar all over the know distribution of the species, much improved by recent collections. Only the size of the anterior-inferior spines and propodeal spines can vary. Alate forms were collected in all seasons of the year in the state of Rio de Janeiro, Brazil. The species was first described by Mayr in 1884 as *Cyphomyrmex*. Posteriorly Wheeler (1907) described *Myrmicocrypta brittoni,* synonymized with *M. conformis* by Kempf (1962), with whom we agree. Wheeler's description can be considerate rather complete; he already suggests the species might belong to a new genus, that should also include *M. emeryi* described by Forel (1907). He recognized that these species actually do not fit in any other described Attini genus, but did not realize that *M. brittoni* and *M. emeryi* should actually belong to two different genera.

In 1962 Kempf redescribed *M. conformis*, comparing it with *Cyphomyrmex morschi*. He showed up the differences between the species and discussed the validity of the genus *Mycetophylax*, taking into account the striking similarity between *M. conformis* and *C. morschi*.

Mycetophylax simplex (Emery, 1888)

(Figs. 4a, 5 – 7, 11b)

Cyphomyrmex simplex Emery, 1888 (“1887”): 361; (worker) Syntype Brazil, Rio Grande do Sul, São Lourenço; Emery, 1922: 343; Kempf, 1972: 146: combination in *Mycetophylax*; Kempf 1972 :145 (catalogue); Fowler, 1980: 184, Bolton, 1995: 269 (catalogue), Albuquerque *et al.* 2005; (type specimens not localized).

Worker (Figs. 4 a and 5)

Measurements (in mm) and indices of examinatedexamined specimens (range, N = 36)

HW 0.83-1.03; HL 0.85-1.01; CI 96-106; SL 0.49-0.82; SI 58-82; ML 0.34-0.48; MI 39-52; WL 1.05-1.30; PrW 0.52-0.69; PL 0.19-0.26; PPL 0.22-0.27; GL 0.70-0.92; FL 0.92-1.14; TL

3.30-4.05

Colour yellow to brownish, masticatory border median portion of clypeus, frontal area and coronal suture darker. Sculpture with opaque appearance, reticulate. Mandibular sculpture of dorsal disc with slight longitudinal rugae. Area between preocular carinae and frontal carinae free of hairs. Surface of frons with small irregular pores, a single seta coming out of each of them (only visible with higher magnifications). At REM magnifications, there appears a thin layer of "dirt", detritus adhering at the integument, which leaves the sculpture with a punctate appearance. Whole body covered with short hairs, sparse and appressed, brighter than integument. Legs and antennae covered with the same type of hairs, only at the area between preocular carinae and frontal carinae pilosity more sparsly. Masticatory border of mandibles with somewhat longer hairs. Integument of the frontal lobes semitransparent at the area above the antennal insertions, where appears a rounded spot at each side, which differs from the rest of the integument of the frontal lobes due to the darker colour. Head as long as wide (see CI), almost heart-shaped. Occipital margin concave and angles of occipital corners rounded. Compound eyes with eleven ommatidia at major length and nine ommatidia at major width. Masticatory border of mandibles with seven to eight triangular teeth, the three most apical of the same size, the others a little bit smaller. Anterior margin of clypeus concave, with a slight impression in the middle. Frontal lobes slender, covering insertions of antennae. External margin of frontal lobes slightly rounded, but failing to attain more than a fourth than half of the distance between the median line and external border of the head. Frontal and lateral carinae reaching posterior margin of the eyes. Antennal scape slightly curved at its apical part, only reaching the occipital corners without surpassing them. Antenna ending in a two segmented club, the last antennal segment as long as the two before together.

Pronotum convex with a pair of pointed pronotal inferior spines. In lateral view mesonotum differentiated from pronotum by a accentuated suture and mesonotum projected. Metapropodeal impression shallow. Basal face of propodeum convex, somewhat longer than the straight declivous face, without spines or protuberances. Inferior margins of pronotum, anepisternum and propodeum present a broad carina. Propodeal spiracle small, with rounded opening in 45° in relation to the main body axis. In dorsal view, node of petiole twice as wide as peduncle and wide as high. Postpetiole wider than high.

Gyne (undescribed) (Figs. 4 a and 6)

Measurements (in mm) and indices of examined specimens (range, N = 10)
HW 1.14-1.20; HL 1.00-1.12; CI 104-116; SL 0.82-0.9; SI 71-78; ML 0.48-0.56; MI 44-52; WL 1.64-1.68; PL 0.30-0.36; PPL 0.24-0.32; GL 1.32-1.40; TL 5.10-5.30.

Colour yellow to brownish. Depending on age, masticatory border of mandibles, middle portion of clypeus, area in front of ocelli and parapsidial lines brownish. Compound eyes with 18 ommatidia at major length and 14 ommatidia at major width. In lateral view scutum flattened, almost covering two thirds of pronotum. Pronotum with blunt anterior inferior spines. Parapsidial lines shallowly impressed. Scutellum subquadrate, at anterior margin concave and wider than at posterior. Posterior margin concave with indicated spines. Anepisternum subtriangular, katepisternum subquadrate, both at posterior with distinct suture. First gastral tergite with well visible spiracle at anterior fourth.

Male (undescribed) (Figs 4 a, 7 and 11 b)

Measurements (in mm) and indices of examined specimens (range, N = 9)
HW 0.56-0.68; HL 0.56-0.68; CI 97-103; SL 0.58-0.76; SI 100-112; ML 0.24-0.30; MI 40-45; WL 1.30-1.70; PL 0.20-0.30; PPL 0.18-0.24; GL 0.94-1.34; TL 3.50-4.56.

Colour dark brown. Mandibles, antennae and legs yellowish. Integument reticulate with golden appressed shiny hairs. Hairs at external margin of mandible with double length of the others. Mandibles with six to seven teeth, all triangular and decreasing in size from apical to basal, sometimes with irregular distances between them. Clypeus concave, with a distinct convex median impression. One median seta with the same site of mandible hairs visible. Median portion of clypeus elevated till half of antennal insertions. Frontal carina elevated till posterior margin of compound eyes. Lateral carina following compound eyes, at posterior third in straight posterior direction. Compound eyes with 18 ommatidia at major length and 14 ommatidia at major width. Antenna with 13 segments. Antennal scapes straight, surpassing occipital corners by half of its length. Apical antennal segment as long as the two anterior.

Scutum puissant, in lateral view higher than pronotum. In dorsal view, scutum uneven, posterior margin almost straight. Parapsidial lines distinct, shiny, without hairs and connected directly to the posterior margin of scutum. Area around them impressed. Lateral margin at the area at the tegulae limited by a carina. Prescutellum wide, axillaries subtriangular. Scutum-scutellar sulcus with transversal rugae. At anterior scutellum wide, at posterior with two short acute spines. In lateral view katepisternum quadratic, anepisternum subtriangular. Median coxa set only at the posterior fourth of katepisternum. Both with a distinct suture at posterior. Propodeal spiracle distinct, with rounded opening in parallel direction to the main body axis.

Petiole with reduced peduncle and strong developed node. With very ill developed ventral process. Anterior margin of note elevated in 90° angle, dorso-posterior portion concave. In dorsal view petiole subrectangular, somewhat wider anteriorly than at posterior end. Post-petiole in dorsal view wider than petiole. Spiracle of first gastral tergite well visible.

Examined material: BRAZIL: Santa Catarina: Florianópolis, Praia da Joaquina, 17ix2003 (C. Klingenberg & B. H. Dietz) 16 w, 1 q, 9 m (MZSP); Rio Grande do Sul: Praia do Cassino, 16km S, duna costa, 27v1992 (N. M. Giannuca), 20 w, 7 q (MZSP); Torres, Praia Grande, 18ii1998 (Ed. Diehl-Fleig), 29 w, 10 q, 3 m (MZSP).

Comments

In the literature we found no information on the biology of this species. Until now the geographic distribution included the State of Rio Grande do Sul, Brazil, but we collected for the first time colonies of this species at the Isle of Florianópolis, Santa Catarina State, Brazil. Fowler (1980) recorded *M. simplex* in Paraguay, but as this species is known only along the Atlantic beaches, this information should be handled carefully; we had no chance to examine this material. Alate forms are here described by the first time. The species can be easily recognized from other *Mycetophylax* due to its yellow-brownish colour and unarmed propodeum.

Mycetophylax morschi (Emery, 1888) new combination

(Figs. 4a, 8 – 10, 11c)

Cyphomyrmex morschi Emery, 1888 ("1887"): 9, (worker) Syntypes, Brazil, Rio Grande do Sul, São Lourenço (von Ihering), (MZSP, examined); Kempf, 1972: 93 (catalogue); Bolton, 1995: 168 (catalogue) **new combination in *Mycetophylax*.**

Cyphomyrmex sp. Mayr 1887: 556 (key)

Cyphomyrmex (*Mycetosoritis*) *personatus* Santschi, 1923: 268: (queen) Argentina: Prov. de Buenos Aires, Monte Hermose, no coll. data (C. Bruch); Kempf, 1964: 25: synonym of *Cyphomyrmex morschi*; (type specimens not localized).

Worker (Figs. 4 a and 8)

For syntype measurements (mm) and indices see table 3.

Measurements (in mm) and indices of examined specimens (range, N = 10)

HW 0.53-0.67; HL 0.6-0.71; CI 82-97; SL 0.49-0.60; SI 79-98; ML 0.20-0.28; MI 32-42; WL 0.80-1.00; PrW 0.40-0.50; PL 0.10-0.20; PPL 0.20-0.30; GL 0.54-0.70; FL 0.66-0.93; TL 2.54-3.03

Colour brown to clear brown. Mandibles, antennae and legs brownish to yellowish. Sculpture with opaque areolate appearance. Surface of frons with small irregular pores, a single seta coming out of each of them (only visible with higher magnifications). Whole body covered with short appressed hairs, bright and sparse. Legs and antenna covered by the same type of hair; only area between frontal carinae and preocular carinae hairless. Masticatory border of mandible with hairs somewhat longer than in other areas. Sculpture of mandibular discs with slight longitudinal rugae. Head longer than wide, subrectangular; posterior portion somewhat wider than anterior. Compound eyes with eight ommatidia at major length and six ommatidia at major width. Masticatory border of mandible with nine triangular teeth, the four most apical bigger and the following only a bit smaller. Last teeth only as a denticle. Anterior margin of clypeus concave and a median seta present, but short and hardly visible. Frontal lobes slender, external margin rounded and failing to attain more than half of the distance between the median line and external border of the head. Frontal and lateral carinae reaching the occipital margin, forming an impressed area where the ants accommodate the antennal scapes. Lateral carina distinct untill half of head length, posterior part of carina discrete, faintly developed. Antennal scape straight, surpassing the occipital corners by a distance length similar to its diameter. Antenna ending in a three-segmented club, last antennal segment as long as the three before together. Occipital margin with a concave impression, occipital corners rounded.

Pronotum uneven laterally, convex with short, blut pronotal inferior spines. Anterior pronotal protuberances present and in dorsal view a median elevation present. Metapropodeal impression ditinct. Propodeum at basal face convex, declivous face concave, armed with a pair of small blunt spines, occasionally these spines appear as protuberances. Peduncle of petiole reduced, node of petiole as long as high, forming two lateral lobes. In dorsal view, posterior portion of postpetiole with an impression, posterior margin straight, only slightly convex.

Gyne (Figs. 4a and 9)

Measurements (in mm) and indices of examined specimens (range, N = 13)
HW 0.66-0.72; HL 0.74-0.78; CI 87-92; SL 0.54-0.64; SI 79-94; ML 0.35-0.40; MI 47-52; WL 1.04-1.14; PL 0.20-0.24; PPL 0.26-0.30; GL 0.84-0.98; TL 3.45-3.90.

Colour brownish to dark brown. Mandibles, antenna and legs yellowish, depending on age. Compound eyes at major length with 15 ommatidia and at major width with eleven ommatidia. In lateral view scutum flattened, covering only half of pronotum. Pronotum with distinct blunt inferior pronotal spines, anterior pronotal protuberances and median elevation. Parapsidial lines indistinct, free of hairs, and in parallel direction to the main body axis. Notaulices shallowly impressed. Scutum-scutellar sulcus distinctly impressed. Scutellum concave at anterior margin and of double width than at posterior. Posterior margin pointed out at angles. Propodeum with small blunt spines, directed back- and upwards. Katepisternum subtriangular, anepisternum subrectangular, both divided by a suture.

Male (undescribed) (Figures 4a, 10 and 11c)

Measurements (in mm) and indices of examined specimens (rangeN = 10)
HW 0.44-0.52; HL 0.52-0.62; CI 79-87; SL 0.54-0.68; SI 117-113; ML 0.22-0.28; MI 38-48; WL 0.84-1.04; PL 0.18-0.22; PPL 0.18-0.24; GL 0.70-0.84; TL 2.69-3.15

Colour yellowish to brownish. Mandibles, antenna and legs yellowish, depending on age. Sculpture like workers, only at gastral tergits of gaster faintly. Antenna with 13 segments. Antennal scapes slightly curved, at basal flattened, at apical rounded and thicker. Apical segment of funicle as long as the two anterior together.

Head longer than wide, compound eyes occupying a fourth of its lateral expansion with 18 ommatidia at major length and 16 ommatidia at major width. Anterior margin of clypeus concave. One median seta with the same size of mandible hairs visible. Middle portion elevated and ending above the level of antennal insertions. Frontal lobes covering half of antennal insertions. Mandibles with three apical teeth followed by a diatsemma and then two to three smaller teeth. Last tooth only as a denticle. Frontal carinae surpassing the posterior margin of compound eyes, reaching the level of the median ocellus, than descrete, reaching the occipital margin. Lateral carinae following compound eyes, at level of posterior margin of them straightly directed posterior. Occiput flattened, not convexly rounded, shallowly impressed. At posterior with defined angles, appearing as indicated blunt spines. Area between frontal and lateral carina impressed and free of hairs. In lateral view scutum covering half of pronotum. Pronotum with small acute pronotal inferior spines and well developed acute pronotal anterior spines. In dorsal view notaulices as wide impressed lines with slightly transversal rugae at posterior portion. Parapsidial lines indistinct. Prescutellum wide, axillaries subtriangular. Scutum-scutellar sulcus deep with transversal rugae. Scutellum rounded at anterior margin, at posterior only of half of the width of anterior margin and with pointed angles. In lateral view katepisternum and anepisternum divided by a suture with transversal rugae. Katepisternum subquadrate, anterior inferior angles sinous. Anepisternum subtriangular. Mesocoxa occupying only posterior third of katepisternum. Propodeum with short spines directed backwards.

Examined material: BRAZIL: Rio de Janeiro: Cabo Frio, viii1926 (T. Borgmeier), 1 w (MZSP); São Paulo: Itanhaém, vi1914 (Luederwaldt), [18862, 18867], 3 w (MZSP); Itanhaém, 15-19vii1961 (A. Guedes & F. Grossmann), 3 w (MZSP); Mongagúa, Praia Grande, 18vi1960 (W. W. Kempf), 1 w (MZSP); São Sebastião, 30i1955 (B. Fleddermann), 1 w [# 4]; São Vincente, Praia Grande, 18xii1955 (W. W. Kempf) [# 1496], 1 w (MZSP); Caraguatatuba, 22v-1vi1962 (K. Lenko) 1 q (MZSP); Santa Catarina: Florianópolis, Praia da Joaquina, 3v1991 (A. Bonnet & B. C. Lopes) 2 w (MZSP), 8iv2003 (C. Klingenberg , R. R. Silva & B. C. Lopes) 29 w, 16 q, 9 m (MZSP); Pântano do Sul, 9iv2003 (C. Klingenberg, R. R. Silva & B. C. Lopes) 9 w, 2 q, 4 m (MZSP); Rio Grande do Sul: Morrete, Fazenda Oliveira, xii1975 (V. P. Daniel) [# 12212], 1 w (MZSP); without data, (H. v. Ihering)

[11419], 1 w (Syntype), (MZSP).

Comments

We propose the new combination of this species in the genus *Mycetophylax* based on apomorphic character states shared with the other species of *Mycetophylax.* Kempf (1962, 1964) already commented the similarity of *M. conformis* and *C. morschi*, citing the lack of defined antennal scrobes in *C. morschi*, a typical character trait for all species of *Cyphomyrmex*. Another apomorphy of *Mycetophylax* is the lack of defined spines or protuberances at the mesosoma, the triangular head shape with triangular mandibles, and the typical shape and expansion of the frontal lobes. The straight posterior margin of the postpetiole and the shallow impression in dorsal view are other morphological character traits. Another argument for transferring *C. morschi* to *Mycetophylax* is the nesting biology and habitat choice of the ants. As *M. conformis* and *M. simplex* do, the nests of *C. morschi* are found in the sandy soil of the Atlantic beaches. The nest architecture and colony size are similar in the three species also (average of 120 workers per colony, Klingenberg, unpublished data). It is known that other *Cyphomyrmex* species have smaller colonies (see Müller & Wcislo, 1988; Murakami *et al.* 2000, Schultz et al. 2002).

Paramycetophylax bruchi (Santschi, 1916) reviewed status

(Figs. 4b, 12 – 14a)

Sericomyrmex bruchi Santschi, 1916: 383, (worker) Holotype, Argentine: Puerto Madryn (Biraben) (NHMB, examined). Santschi 1922: 355 combination in *Myrmicocrypta* (*Mycetophylax*); Santschi 1923: 268 combination in *Mycetophylax*; Kusnezov 1956: 24 combination in *Paramycetophylax*; Weber 1958: 262 combination in *Mycetophylax*; Kempf, 1972: 145 (catalogue); Bolton 1995: 268 (catalogue) **new synonym.**

Mycetophylax bruchi var. pauper Santschi, 1923: 268 junior secondary homonym of *Mycetophylax bruchi* var. *simplex* Santschi, 1922: 355 (worker) Type, Argentina: Neuquén, (Dr. Carette col.) (MZSP, NHMB examined); Kempf 1972: 145 (catalogue);

Bolton 1995: 269 (catalogue) **new synonym**.

Myrmicocrypta (*Mycetophylax*) *cristulata* Santschi 1922: 356 (worker, queen, male) Syntypes, Argentina: Tucumán, El Bañado, Valle Santa Maria, Ing. Weiser col. (NHMB, examined; queen was missing); Santschi 1929: 304 combination in *Myetophylax*; Bucher, 1974: 63, Kempf 1972: 145 (catalogue), Bolton 1995: 268 (catalogue) **new synonym**.

Mycetophylax cristulatus var. *emmae* Santschi 1929: 304 (worker) Syntypes, Argentina, Catamarca, Nacimientos, (Weiser col.) (NHMB, MZSP examined); Kempf 1972: 145 (catalogue), Bolton 1995: 268 (catalogue) **new synonym.**

Worker (Figs. 4b and 12)

For syntype measurements and indices see table 4.

Measurements (in mm) and indices of examined specimens (range, N = 13)

HW 0.88-1.18; HL 0.82-1.10; CI 101-113; SL 0.67-0.87; SI 57-80; ML 0.47-0.58; MI 47-58; WL 1.25-1.73; PrW 0.53-0.70; PL 0.25-0.37; PPL 0.23-0.37; GL 0.90-1.18; FL 0.93-1.39; TL 3.93-5.82

Colour yellow to reddish-brown. Masticatory boarder of mandibles brownish. Under optical scope body sculpture densely reticulate with exception of lateral mandible discs, where sculpture is striate. Whole body with golden shiny appressed hairs. Clypeal seta fine and stiff with length of the most apical funiculus. Inferior margin of clypeus with five to nine long setae, reaching half of the length of the mandibles. The three median setae longer than the lateral. Head wider than long (see CI). Compound eyes situated somewhat under the middle of head, at major width with 11 ommatidia and at major length with eight ommatidia. Mandibles with eight to ten teeth, the two most apical teeth bigger than all the others, followed by five to seven smaller triangular teeth. Last teeth only as denticule. Anterior margin of clypeus slightly convex, almost straight. In frontal view, clypeus elevated up to half of the frontal lobes, with posterior margin rounded, followed by a little impressed frontal triangle. Frontal lobes in triangular form, covering the antennal insertions and a third between median head line and lateral margin of head, ending posteriorly at level of posterior margin of compound eyes. Lateral carinae marginating anterior of compound eyes. Occipital margin concave, with a median impression, forming two lobes. Antennal scape flattened, occasionally slightly curved; depending on degree of curving, reaching or surpassing the occipital corners. First funicular segment as long as the second and half of the third. Apical end of funiculus with club, comprised of three most apical segments which are wider than the others. The most apical funicular segment is long as the two anterior together. Ventral face of head flat.

Mesosoma without anterior inferior pronotal spines. Anterior pronotal spines present, blunt and obliquely directed upwards and forward. Dorsal face of mesonotum at anterior with a small blunt median protuberance. Inferior margin of pronotum and metapleuron with a carina. Dorsal face of metanotum concave, declivous face straight. Propodeum with a pair of diverged, short, blunt spines, directed obliquely upwards. In lateral view petiole compact, peduncle almost high as node, with a ill developed ventral process. In dorsal view petiole straight, with an longitudional shallow impression at the upper, posterior portion. Postpetiole in dorsal view subquadrate, with a large impression at posterior margin. In lateral view, sternit of post petiole well defined, but covering only a third of tergit surface.

Male (Figs. 4b, 13 and 14a)

Measurements (in mm) and indices of examined specimens (N = 2)

HW 0.88-1.18; HL 0.82-1.10; CI 101-113; SL 0.67-0.87; SI 57-80; ML 0.47-0.58; MI 47-58; WL 1.25-1.73; PrW 0.53-0.70; PL 0.25-0.37; PPL 0.23-0.37; GL 0.90-1.18; FL 0.93-1.39; TL 3.93-5.82

Colour dark brown. Integument and pilosity like workers. Head somewhat wider than long (see CI). Compound eyes with 21 ommatidia at major length and 20 ommatidia at major width. Mandibles slender and elongated with only two visible apical teeth. Anterior margin of clypeus straight with three long setae, one of them median. Clypeus elevated up to half of antennal insertions. Epistomal suture distinct. Frontal lobes reduced, covering only half of antennal insertions. Lateral carinae reaching level of posterior margin of compound eyes. Occipital margin straight, occipital corners distinct, not rounded. Antennal scapes straight, with half of the length of all other antennal segments.

In lateral view alitrunk compact, scutum covering pronotum. In dorsal view anterior margin of scutum rounded and with a median lone without hairs. Posterior margin of scutum convex. Parapsidial lines in parallel direction to the median body line. Prescutum with median portion very narrow, axillaries in triangular form. Scutum-scutellar sulcus distinct. Scutellum with anterior margin slightly convex, posterior margin rounded. Propodeum with a pair of small spines. In lateral view anepisternum and katepisternum divided by a groove. Superior part of anepisternum subtriangular with transversal rugae. Petiole without spines, only with two lobes in dorsal view.

Examined material: ARGENTINE: Neuquén, no coll. data 2 w (NHMB), v1925 (Dr. Carette), [#1425], 1 w (MZSP); Nascimiento, 2.xii1922 (Weiser), 3 w (NHMB) 1 w (MZSP) (Cotype); Puerto Madryn (Biraben), 1 w (NHMB); El Banado, Valle Sta. Maria (Weiser), 2 w, 2 m (NHMB); Tucumán, Siete de Abril, Depto. Burruyacú, 2vi1965 (E. Bucher), 2 w (MZSP).

Comments

As there are no available queen specimen of *P. bruchi*, we have to rely on the detailed description of the queen of *M. cristulatus* by Santschi (1922), here synonymized with *P. bruchi*.

The antennal scapes form of the workers vary. It is not possible to determine a typical form for the species. Some specimens have straight scapes, surpassing the occipital corners while others have curved scapes, only reaching the occiptal corners. Santschi (1922) commented the existence of the variation in *P. simplex* (=*Mycetophylax bruchi var.*

pauper Santschi, 1923) with some individuals with somewhat longer antennal scapes and without greyish powder covering ("pruinosité"). We suspect that he actually observed in some individuals the bacteria symbiont *Streptomyces* covering of the Attini ants, which can cause such an appearance. Currie (1999) described this phenomenon in *Acromyrmex* ants.

In his description of *Myrmicocrypta* (*Mycetophylax*) *cristulatus* Santschi mentioned bigger dimensions in comparison with *M. bruchi*. But he was not able to define any clear morphological differences between the species, except for the shape of the postpetiole, erroneously, as show below. In 1929 Santschi published the description of *Mycetophylax cristulatus* var. *emmae*. Again he justified the description of the variety because of its different dimensions and colour.

In his key, published in 1922, Santschi recognized differences between *M. bruchi* and *M. cristulatus* and he based his arguments on the dimensions of the postpetiole. In *M. cristulatus* the postpetiole seems to be wider than long meanwhile in *M. bruchi* the postpetiole seems be as long as wide. The measurements of all available specimens showed that this character is no efficient for species separation. The same is true for separation of *M. bruchi* and its variation *simplex*. In the description of *M. cristulatus* Santschi (1922) comments several times the high similarity with *M. bruchi*.

Santschi never was able to show distinct morphological apomorphies between the species *bruchi* and *cristulatus* and the variations of them in all his descriptions. Our observations show, that all the examined individuals presented variations in body dimensions and colour, especially the length and shape of the antennal scape. These variations are gradually, so that a differentiation in two distinct species was not possible. In that way, the synonymization of *M. cristulatus* and all variations is justified.

Kalathomyrmex emeryi (Forel, 1907) new combination

(Figs. 4c, 14b, 15 – 17)

Myrmicocrypta emeryi Forel, 1907:144 (worker) Syntypes, Colombia, Dibulla, Santo Antonio, Forel col. (MCSN, examined); Forel 1912: 189 (queen, male) Allotypes; Emery 1913: 251 combination in *Cyphomyrmex* (*Mycetophylax*); Santschi 1916: 383 combination in *Myrmicocrypta* (*Mycetophylax*); Weber 1958: 263 senior synonym of *M. hummelincki*. Kempf 1972: 145 (catalogue); Bolton 1995: 268 (catalogue) **combination**.

Mycetophylax hummelincki Weber, 1948: 84 (worker) Syntypes, Venezuela, Stat. 121, Cabo Blanco, 19.viii.1936 (P. Wagenaar Hummelinck col.); Weber 1958: 263 synonym of *Mycetophylax emeryi*; Kempf 1972: 145 (catalogue); Bolton 1995: 268 (catalogue), (not examined) **new synonym**.

Myrmicocrypta emeryi var. *arenicola* Forel, 1912: 189 (worker, queen) Synytpes, Argentina, Huasan, 1300 m, (Bruch col.); Emery 1922: 343 combination in *Cyphomyrmex* (*Mycetophylax*); Santschi 1922: 355 combination in *Myrmicocrypta* (*Mycetophylax*); Kempf 1962: 34 combination in *Mycetophylax* (not examined); Kempf 1972: 145 (catalogue); Bolton 1995: 268 (catalogue) Bestelmeyer & Wiens 1996. **new synonym**.

Myrmicocrypta (Mycetophylax) emeryi var. *argentina* Santschi, 1916: 383 (worker) Syntypes, Argentina, Santiago del Estero, Rio Salado, (Wagner col.), Buenos Aires, (Bruch col.) (NHMB, examined); Emery 1922: 343 combination in *Cyphomyrmex* (*Mycetophylax*); Kempf 1972: 146 combination in *Mycetophylax* ; Bolton 1995: 268 (catalogue) **new synonym**.

Myrmicocrypta emeryi var. *fortis* Forel, 1912: 189 (worker) Synype, Argentina, Huasan, 1300 m, (Bruch col.); Santschi 1922: 355 combination in *Myrmicocrypta* (*Mycetophylax*); Bucher, 1974: 63; Kempf 1972: 146 in *Mycetophylax*¸; Bolton 1995: 268 (catalogue); (not examined) **new synonym**.

Mycetophylax bolivari Weber, 1948: 84 (worker) Syntypes, Venezuela, Llanos 17 km N of Soledad, 27.i.1935, across the Orinoco River from Cuidad Bolivar in the State of Anzoategui, (Weber col.); Weber 1958: 263 *Mycetophylax emeryi* ssp. *bolivari*, Kempf 1972: 145 (catalogue); Bolton 1995: 268 (catalogue) (not examined) **new synonym**.

Myrmicocrypta (Mycetophylax) emeryi st. *gallardoi* Santschi, 1922: 354 (worker)

Syntypes, Argentina, Province de Buenos-Ayres, Sierra de la Ventana (Bruch, leg) (*sic.*) (NHMB, examined); Kempf 1972: 146 combination in *Mycetophylax*; Bolton 1995: 268 (catalogue) **new synonym**.

Mycetophylax emeryi st. *hubrichi* Santschi, 1925: 163 (worker) Syntypes, Argentina, Santa Fe, Rosario, (Hubrich, col.) (NHMB, examined); Kempf 1972: 145 (catalogue); Bolton 1995: 268 (catalogue) **new synonym**.

Mycetophylax emeryi st. *weiseri* Santschi, 1929: 303 (worker) Syntypes, Argentina, Catamarca, Corral Quemado, (Weiser, col.) (NHMB, examined); Kempf 1972: 145 (catalogue); Bolton 1995: 268 (catalogue) **new synonym**.

Mycetophylax glaber Weber, 1948: 85 (worker) Holotype, Bolivia, Tumupasa, (W.M. Mann col.); Kempf 1972: 145 (catalogue); Bolton 1995: 268 (catalogue) (not examined) **new synonym**.

Worker (Figs. 4c and 15)

For type measurements (mm) and indices see table 5.

Measurements (in mm) and indices of examined specimens (range, N = 76)

HW 0.49-0.83; HL 0.54-0.83; CI 85-106; SL 0.48-0.8; SI 84-112; ML 0.23-0.48; MI 34-77; WL 0.70-1.26; PrW 0.26-0.60; PL 0.16-0.30; PPL 0.19-0.35; GL 0.57-0.92; FL 0.52-0.98; TL 2.42-4.03.

Colour yellow to reddish-brown. Apex of funiculus, clypeus, masticatory boarder of mandibles, head vertex, postpetiole, gaster and femura brownish. Mandibles and tarsi yellowish. Rest of body light reddish brown. Under optical scope body sculpture densely punctuated with exception of lateral of pronotum, where sculpture is more superficial. Mandible discs shiny with piligerous punctuations. Mesosoma covered by a fine layer of “dirt”, visible only at REM images. Sculpture of integument is “reprinted” in the dirt-layer. Whole body with golden shiny appressed hairs. Head with longer flexuous hairs (length of the first funicular segment), psammophore hairs fine and stiff with length of the most apical funiculus. Clypeal vertex with six long setae, reaching or surpassing the anterior limit of the mandibles. Same kind of setae at inferior part of external margin of mandibles. Head shape with quadratic aspect (see CI). Mandibles with five teeth, apical teeth bigger than all the others, followed by a smaller second teeth and a triangular third teeth. After the diastema a small fourth teeth and a small denticule follows. Anterior margin of clypeus straight. In lateral view clypeus in triangular form, with six seta of the psammophore at vertex of the triangle. In frontal view, clypeus elevated to a trenched ridge, dividing it in two rounded folds. Posterior wing of clypeus elevated till posterior limit of antennal insertions, followed by a little impressed frontal triangle, sometimes rounded posteriorly. From the frontal triangle to vertex a shallowly impressed median line. Frontal lobes reduced, only covering the antennal insertions, but covering less than a fourth of median head line and lateral margin of head, ending posteriorly at level of anterior margin of compound eyes. Lateral carinae marginating anterior of compound eyes, fading a little bit over posterior margin of compound eyes. Compound eyes situated somewhat under the middle of head, at major width with ten ommatidia and at major length with 14 ommatidia. Occipital margin straight, but occasionally with a median impression, forming two lobes. Antenna with flattend scape, surpassing the occipital corners. First funicular segment so long as the second and the third. Apical end of funiculus with club, comprised of three most apical segments which are wider than the others. The most apical funicular segment is long as the two anterior together. Ventral face of head flat.

Mesosoma with elongated aspect without anterior inferior pronotal spines. Anterior pronotum occasionally with a blunt spine, in obliquely forward direction (specimens from Paraguay and Argentina). Dorsal face of mesonotum with shallow median impression. Katepisternum with dorsal carina. Metapropodeal depression with a median spine. Declivous face of propodeum in lateral view concave and one half shorter than basal face. Mesothoracal spiracle visible with rounded opening. Propodeal spiraculum distinguished, opening in an angle of 45° in relation to the main body axis. Propodeum with a pair of diverged, short, blunt spines, directed obliquely upwards. In dorsal view petiole straight, wider at three fourth of its length. With a very ill developed ventral process. Postpetiole in dorsal view subtriangular, with a large impression at posterior margin forming two distinct lobes, heart-shapened and flattend dorsoventrally. Gaster smooth without protuberances.

Gyne (Figs. 4c and 16)

Measurements (in mm) and indices of examined specimens (range, N = 10)
HW 0.54-0.64; HL 0.56-0.63; CI 90-107; SL 0.5-0.56; SI 83-100; ML 0.26-0.34; MI 43-61; WL 0.94-1.02; PL 0.16-0.24; PPL 0.2-0.24; GL 0.84-0.98; TL 3.01-3.36

Colour and pilosity similar as in the workers. Main morphological character traits of head, propodeal spiracle, petiole, post petiole and gaster same as in the workers. Mandibles with five teeth, apical tooth bigger than all the others, followed by smaller second and third triangular teeth; fourth tooth triangular and smaller than the second and third, a small denticule follows. Compound eyes at major width with 15 ommatidia and at major length with 17 ommatidia. Posterior portion of head with three ocelli, the median superficially impressed at frons. The most apical funicular segment is as long as the three anterior together.

Alitrunk compact due to flight muscles. In lateral view scutum dorsally flattend initiating after first third of the pronotum. In dorsal view anterior margin of scutum rounded. Posterior margin in dorsal view rounded and ending in a carina. In dorsal view, parapsidial lines shallowly impressed. Prescutum reduced, only represented by triangular axillaries. Scutum-scutellar sulcus deeply impressed. Scutellum subquadrate, anterior third wider than posterior one, posterior margin rounded. Metanotum reduced, appearing only as small, flattened disc in dorsal view. Propodeum with a small blunt obliquely upwards directed spine. Katepisternum rectangular; anepisternum half of size of katepisternum, subquadrate, divided by a distinct groove and ending posteriorly in a carina. Petiole, postpetiole and gaster same as in the workers.

Male (Figs. 4c, 14b and 17)

Measurements (in mm) and indices of examined specimens (range, N = 10)
HW 0.21-0.34; HL 0.24-0.34; CI 88-100; SL 0.32-0.42; SI 110-152; ML 0.13-0.18; MI 38-53; WL 0.76-0.92; PL 0.10-0.18; PPL 0.12-0.20; GL 0.68-0.82; TL 2.31-2.58

Colour brownish to dark brown. Masticatory boarder of mandible, petiole and alitrunk reddish brown. Vertex and gaster brownish, mandibles, clypeus, antenna, anterior part of frontal carinae and legs yellowish. Under optical scope body sculpture densely punctuated with exception of gaster, where sculpture is more superficial. Gaster shiny. Whole body with golden shiny appressed hairs. Psammophore hairs fine and stiff with the length of the two most apical segments of funiculus. Clypeal vertex with four long setae, reaching the anterior limit of the mandibles. Head shape with quadratic aspect (see CI). Mandibles with three teeth, apical teeth longer than the others, followed by a smaller second triangular teeth and a denticle. Teeth like a saw, only visible at higher magnifications. Anterior margin of clypeus straight. In lateral view clypeus in triangular form, with four seta of the psammophore at middle of the triangle. In frontal view, clypeus elevated, contrariwise to the workers, without forming a trenched ridge. Posterior wing of clypeus elevated untill middle of antennal insertions, followed by a little impressed frontal triangle, posteriorly rounded. Clypeal suture bends at anterior tentorial pit. Frontal lobes reduced, only covering half of the antennal insertions, ending posteriorly at level of anterior margin of compound eyes. Lateral carinae marginating anterior of compound eyes. Compound eyes situated at antertior part of head, at major width with 19 ommatidia and at major length with 23 ommatidia. Vertex with three big ocelli, all pronounced from the level of the integument. Occipital margin with median impression resulting from the lateral ocelli shape, occipital corners rounded. Antenna with 13 segments, scapes rounded, surpassing the occipital corners by the length of the three most apical segments of the funiculus. First funicular segment as long as the second. Apical end of funiculus with club, comprised by the three most apical segments which are wider than the others. The most apical funicular segment is as long as the two anterior together. Ventral face of head flat. Alitrunk compact. In dorsal view, scutum rounded and almost covering the whole pronotum. Scutum having ist major width at tegula. Parapsidial lines distinct and in parallel direction to the whole body axis. Axillaries subtriangular and scutum-sctutellar sulcus deeply impressed. Scutellum subquadrate to subtriangular, anterior third wider than posterior, posterior margin rounded. Propodeum only with indicated spines, declivous face of propodeum in lateral view straight occasionally slightly concave and as long as the basal face. Katespisternum subquadrate with superior and posterior margins accompanied by a wide sulcus. Anepisternum subtriangular, the coxa of the pronotal pair of legs shorter than anterior margin of katepisternum. In lateral view petiole of triangular form, anterior face with double the length of the basal face, node rounded. In dorsal view petiole with a shallowly median wide impression. Post petiole laterally flattened, heart-sharped. Gaster elongated, smooth without any protuberances.

Legs long and filamentous.

Examined material: BRAZIL: São Paulo: São Manoel, 10ii, 6xi, 8xii1988, (E.S. Zanetti), 2 q, 1 w (MZSP); Agudos, ix, 10x1958 (R. Mueller), [2752, 2661], 4 w (MZSP), Agudos, 26xi1955 (W. Kempf), 2 w, 1 q (MZSP); Itirapina, 18iii1966 (W. Kempf), [4422], 1 w (MZSP); Mato Grosso: Porto Murtinho, vii1960 (B. Kelber), [4680, 3803], 3 w (MZSP); Rondonópolis, 6iii1971 (W. Kempf), [6263], 7 w (MZSP); Tocantins: Goiatins, 9xi1999 (C. R. F. Brandao & C. I. Yamamoto), 1 w (MZSP); Bahia: Juazeiro, x-8xii1948 (C. R. Gonçalves), 5 w, 1 q (MZSP); Piaui: Canto do Buriti, 18-22xi1991 (C. R. F. Brandão) 23 q, 17 m; 20 km S Floriano, Buriti Sol, 5-12xi1991 (C. R. F. Brandão & P. Moutinho), 10 km N Corrente, Faz. Maracuja, 23-27xi1991 (C. R. F. Brandão) 1q, 1m (MZSP); Rio Uruçui-Preto, 20ii1976 (R. Negrett), [12857], 3 w (MZSP); Pernambuco: Araripina, 2-4i1973 (R. Montenegro), [8424, 8426, 8434, 8445], 8 w, 2 q (MZSP); Paraíba: Juazeirinho, Soledade, 28i1956 (C. R. Gonçalves), 4 w (MZSP); Pará: Altér do Chao, 2°30'S 54°57W, 15vii1998

(M. F. Leite), 2 w (Heraldo Vasconcelos); Piaui: Amazonas: Manaus, Praia de Tupé (Rio Negro), 3iii2002 (C. Rabeling), 32 w (MZSP), 20iv2002 (C. Klingenberg), 14 w (MZSP); Praia Paricatuba (Rio Negro), 20iv2002 (C. Klingenberg) 4 w (MZSP); ARGENTINA: Buenos Aires, Sierra de la Ventana, no coll. data (C. Bruch), 3 w (NHMB); Córdoba, no coll. data (C. Bruch), 2 w, 1 q (MZSP); Tucumán: no coll. data. (Weiser), 1 w; 5xii1956 (NK 10018) [Nicolas Kusnezov], 3 q (MZSP); Siete de Abil, Dpto. Burruyacu, 8vi1965 (E. Bucher) 2 w (MZSP); Santiago del Estero, no. coll. data (Merkle), 1 w (MZSP); Chaco de Santiago del Estero, Rio Salado, no coll data, 1 w (NHMB) (Holotype of *M. emeryi argentina*); Rosário, no coll. data (Hubrich), 1 w (MZSP), 3 w (NHMB); La Soledad (Canete), Cruz Alta, 30v1965 (E. Bucher), 1 w (MZSP), *Mendoza*, Chileiro, no coll. data (Duzione), 3 w (NHMB)(Cotype), *Catamarca*, no coll. data. (Coronel Weiser), 2 w (NHMB) (Types); *Chaco*, Chaco National Park, 26°48,522' S 59°36.395' W, 4-6iV2003, Scott Solomon col., 2 w, 2 q, 2 m (SMNK); VENEZUELA: Barquisimeto to Carora km 19, 29vi1971 (W. L. Brown), 15 w (MZSP); Paraguay: *Boquerón*: Parque Nacional Tte. Enciso, Zona Administrativa, 21°13'S 61°40'W, 6-7viii1994 (B. Garcete), 1 w (MZSP); PERU: *Huánuco* ("Panguana"), Rio Yuyapidris, 16xii1984 (M. Verhaagh), 3 w (SMNK), GUYANA: Pirara, nest in soil, 4iv1996 (Ted Schultz & U. G. Mueller), 4 w [#00303800] (USNM).

Comments

Authors often based their descriptions of subspecies and varieties of this species on morphological character traits regarded today as local minor variations. It is known that characters like colour and pilosity can vary within the same species and colony. Examples of the use of these traits can be seen in Forel (1912) in his descriptions of *Myrmicocrypta emeryi var. arenicola* and *M. emeryi var. fortis*. The two variations differ only by their colour but were collected at the same locality. Another example is given by Santschi (1922) when he says, that *M. emeryi* var. *fortis* seems to be a transitional form between *arenicola* and *argentina*. This example shows that the validity of the majority of the described subspecies and variations is doubtful. The examination of all available specimens shows that there are variations in colour and pilosity, but sometimes gradual and sometimes aleatory and thus does not afford for reliable species or subspecies differentiation. Although we were no able to lacate and examine the type of M. glaber, the description of the species given by Weber (1948) led us to conclude that *M. glaber* is identical to *K. emeryi*. Also Weber was not able to name clear morphological differences in relation to the other described species of *Mycetophylax* (now *Kalathomyrmex*) described in the same publication. As observations indicate that the species presents a high variation in colour, pilosity and development of spines and protuberances, but these variations are gradual and we were not able to define any morphological character that could justify the recogntion of the describe infraspecific ranks.

Comments about biology

All species of *Mycetophylax* nest exclusively in the restinga area marked by dunes with sandy soil. *M. conformis* and *M. simplex* nest in the middle of the naked dunes, without any protection of plants or bushes. The nests can be found near the shore, but never in direct contact with sea water. In contrast, *M. morschi* construct their nest more inland, where the dunes are covered by a constant layer of vegetation, composed by typical plants and sometimes bushes. Detailed information on nesting biology and nest architecture will be published elsewhere.

The species of the genera *Paramycetophylax* and *Kalathomyrmex* prefer sandy soil for nesting, too. Bucher (1974) described the architecture of *P. bruchi* and *K. emeryi*; both species nest in sandy soil, in places devoid of any vegetation. We confirmed this observation for *K. emeryi*, as we found this species nesting at the beaches of the Rio Negro (AM), Brazil. The nests can be easily located because they are quite common at the sandy beaches of the river. For some periods of the year the nests become flooded with water. This was also observed by Dr. M. Verhaagh (pers. comm.) in Peru. There he collected *K. emeryi* nearby a river bank covered by high water for several days. When the river got back to its normal water level, the ants reopened the entrance and came out of the nest. According Bucher (1974), the fungus chambers are located from 60 to 100 cm depth, but can be found deeper due to temperature changes within along the year. For fungus substrate, the species forage for faeces of other insects, mainly from Lepidoptera. The ants showed their highest activity during the night. In *K. emeryi* we could observe a high activity during the day, even with high temperatures and sun incidence.

Geographic distribution

The maps (fig. 4 a- c) show the known geographic distribution of the recognized species of *Mycetophylax, Paramycetophylax* and *Kalathomyrmex.* The species of *Mycetophylax* live exclusively in the Atlantic coast beaches, from Rio Grande do Sul up to the Caribbean's. Only once *M. conformis* was found inland in the French Guiana (U. Mueller, pers. comm.), nesting also, however, in sandy soil. At the Isle of Florianópolis, *M. simplex* and *M. morschi* occur at the same beaches, but do not concur for fungus substrate. *M. simplex* build their nests in the naked sandy area, while *M. morschi* choose areas covered with permanent vegetation.

The species of *Paramycetophylax* and *Kalathomyrmex* live in open and arid habitats inland. None of the species live near the shore. Ants of the species *P. bruchi* are known only from Argentine, while *K. emeryi* is distributed all over the South American continent.

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We would like to thank Antonio Mayhé-Nunes for helpful comments on the manuscript, Dr. Rudolf Fischer (Universität Münster) for the translation of the original description of *Myrmicocrypta emeryi* (Forel 1907) from esperanto to german and the Staatliches Museum für Naturkunde Karlsruhe, Germany for allowing the use of the AutoMontage equipment. C. K. received partly financial support from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto of the University of São Paulo (FFCLRP-USP), Brazil and GRAFÖG

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Synonymy Index

valid names as here proposed	synonymies
Mycetophylax conformis	*Cyphomyrmex conformis, Myrmicocrypta brittoni, Cyphomyrmex (Mycetophylax) brittoni, Mycetophylax brittoni* var. *littoralis*
Mycetophylax simplex	*Cyphomyrmex simplex*
Mycetophylax morschi	*Cyphomyrmex morschi, Cyphomyrmex (Mycetosoritis) personatus*
Paramycetophylax bruchi	*Sericomyrmex bruchi, Myrmicocrypta (Mycetophylax) bruchi* *Mycetophylax bruchi, Mycetophylax bruchi* var. *pauper* *Mycetophylax bruchi* var. *simplex, Myrmicocrypta (Mycetophylax) cristulata* *Myetophylax cristulata, Mycetophylax cristulatus var. emmae*
Paramycetophylax emeryi	*Mycetophylax emeryi, Myrmicocrypta emeryi, Cyphomyrmex (Mycetophylax) emeryi, Myrmicocrypta (Mycetophylax) emeryi, Mycetophylax hummelincki* *Myrmicocrypta emeryi* var. *arenicola, Cyphomyrmex (Mycetophylax) emeryi* var. *arenicola, Mycetophylax emeryi* var. *arenicola* *Myrmicocrypta (Mycetophylax) emeryi* var. *argentina, Cyphomyrmex (Mycetophylax) emeryi* var. *argentina, Mycetophylax emeryi* var. *argentina* *Myrmicocrypta emeryi* var. *fortis, Myrmicocrypta (Mycetophylax) emeryi* var. *fortis, Mycetophylayx fortis* *Mycetophylax bolivari, Mycetophylax emeryi* ssp. *bolivari* *Myrmicocrypta (Mycetophylax) emeryi* st. *gallardoi, Mycetophylax emeryi* st. *gallardoi* *Mycetophylax emeryi* st. *hubrichi* *Mycetophylax emeryi* st. *weiseri* *Mycetophylax glaber*

Tables

Table 1: Main morphological character traits of the here described genera

	apomorphies
Mycetophylax	subtriangular head shape, triangular mandibles, median clypeal seta present, mesonotum without spines or protuberances, posterior margin of post-petiole straight without any impression, at alate forms radial cell of forewing closed, geographic distribution only at Atlantic beaches.
Paramycetophylax	subquadrate head shape, subtriangular mandibles, long clypeal setae originating at anterior margin of clypeus, median clypeal seta present, frontal lobes expanded in triangular form, post-petiole with a distinct impression at posterior margin, already dividing it in two lobes, alate forms with open radial cell at forewing, only known from Argentina.
Kalathomyrmex	subquadrate head shape, subtriangular mandibles, clypeal setae originating at posterior margin of triangular clypeus, median clypeal seta absent, frontal lobesreduced, mesonotum slender, metapropodeal depression with a median spine, post-petiole with a distinct impression at posterior margin, already dividing it in two lobes, alate forms with open radial cell at forewing, known from Brazil, Argentina, Paraguay, Colombia, Peru, Venezuela.

Table 2: Syntype measurements (mm) and indices of *M. conformis* workers

	locality	HW	HL	CI	ML	MI	SL	SI	WL	PrW	PL	PPL	GL	FL	TL
MZSP	Trinidad, Mayaro Bay	0.67	0.7	95.7			0.59	88.1	0.93	0.48	0.12	0.17	0.65	0.81	
AMNH	Puerto Rico, Santurca	0.67	0.72	93.1	0.35	48.61	0.6	89.6	1		0.2	0.25	0.63	0.67	3.15
AMNH	Puerto Rico, Santurca	0.68							1.03		0.13	0.2	0.68	0.67	
AMNH	Puerto Rico, Santurca		0.7		0.32	45.71	0.58		0.92		0.13	0.22	0.78	0.79	3.07
AMNH	Puerto Rico, Santurca	0.68					0.52	76.5	0.95	0.45	0.15	0.19	0.78	0.76	
AMNH	Puerto Rico, Santurca	0.63	0.68	92.61	0.35	51.5	0.58	92.1	1.05		0.15	0.22	0.65	0.83	3.1

Table 3: Syntype measurements (mm) and indices of *M. morschi,* worker.

	locality	HW	HL	CI	ML	MI	SL	SI	WL	PrW	PL	PPL	GL	FL	TL
MZSP	Brasil, RS, Esta. Rio Grande do Sul	0.67	0.71	94.4	0.27	38.0	0.53	79.1	0.9	0.48	0.2	0.25	0.67	0.83	3

Table 4: Syntype measurements (mm) and indices of *P. bruchi,* worker, without gaster.

	locality	HW	HL	CI	ML	MI	SL	SI	WL	PrW	PL	FL
NHMB	Argentina, Biraben, Puerto Madryn	1	0.91	109.9	0.53	58.24	0.76	76	1.48	0.62	0.3	0.93

Table 5: Syntype measurements (mm) and indices of *K. emeryi,* worker.

	locality	HW	HL	CI	ML	MI	SL	SI	WL	PrW	PL	PPL	GL	FL	TL
MCSN	Colombia, Cienaga	0.63	0.65	96.9	0.33	50.8	0.59	93.7	0.95	0.45	0.22	0.3	0.77	0.7	3.22
NHMB	Argentina, Catamarca, Corral Quemado								1.15	0.52	0.25	0.3	0.85	0.92	
NHMB	Argentina, Catamarca, Corral Quemado	0.72	0.77	93.5			0.77	106.9	1.12	0.54	0.27	0.25	0.87	0.93	

Figure 1: AutoMontage images of *M. conformis* worker in frontal, lateral and dorsal view.

Figure 2: AutoMontage images of *M. conformis* queen in frontal, lateral and dorsal view.

Figure 3: AutoMontage images of *M. conformis* male in frontal and lateral view and REM image of dorsal view

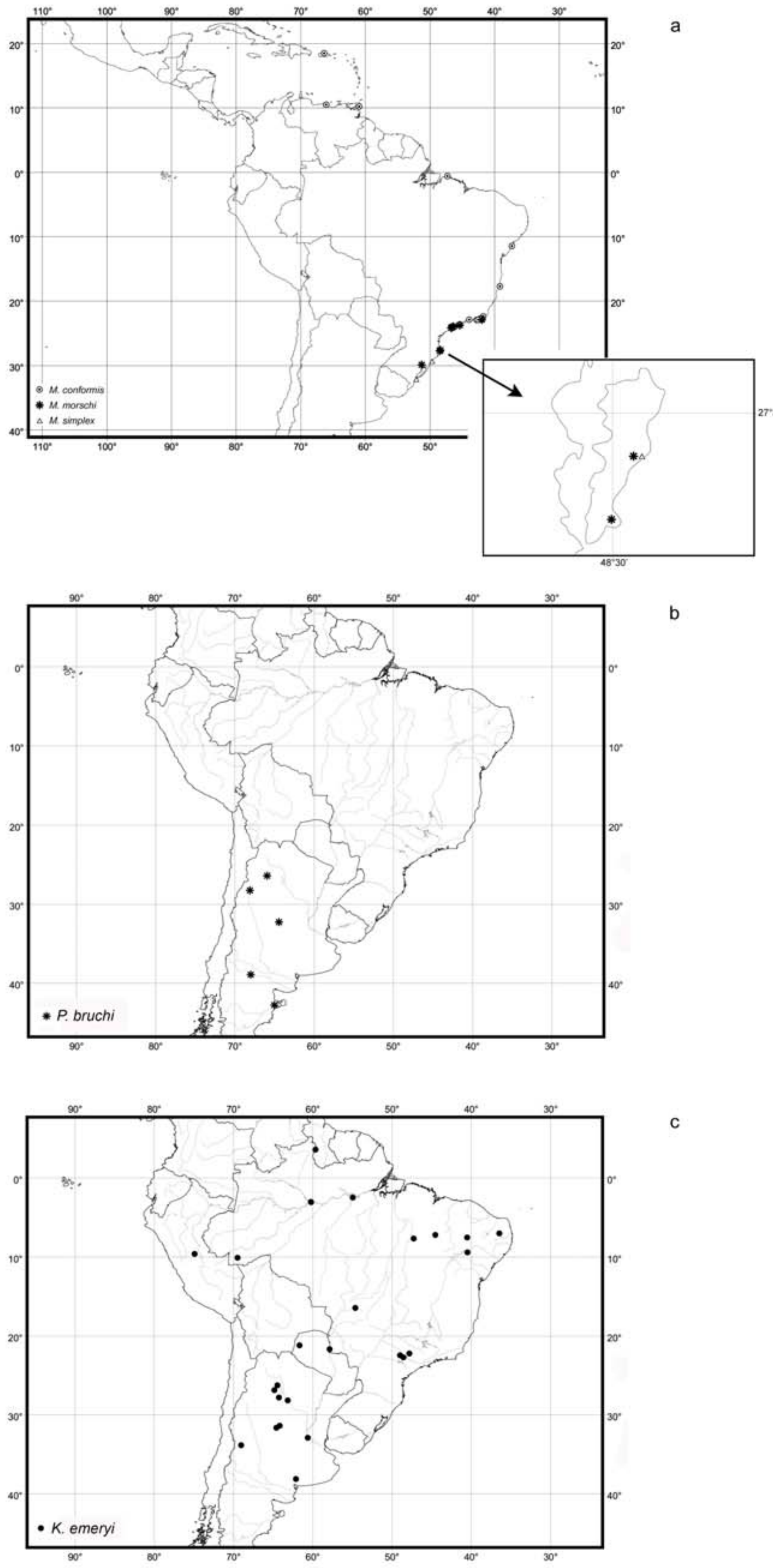

Figure 4: Geographic distribution maps of the species of the genera a) *Mycetophylax*, b) *Paramycetophylax* and c) *Kalathomyrmex*.

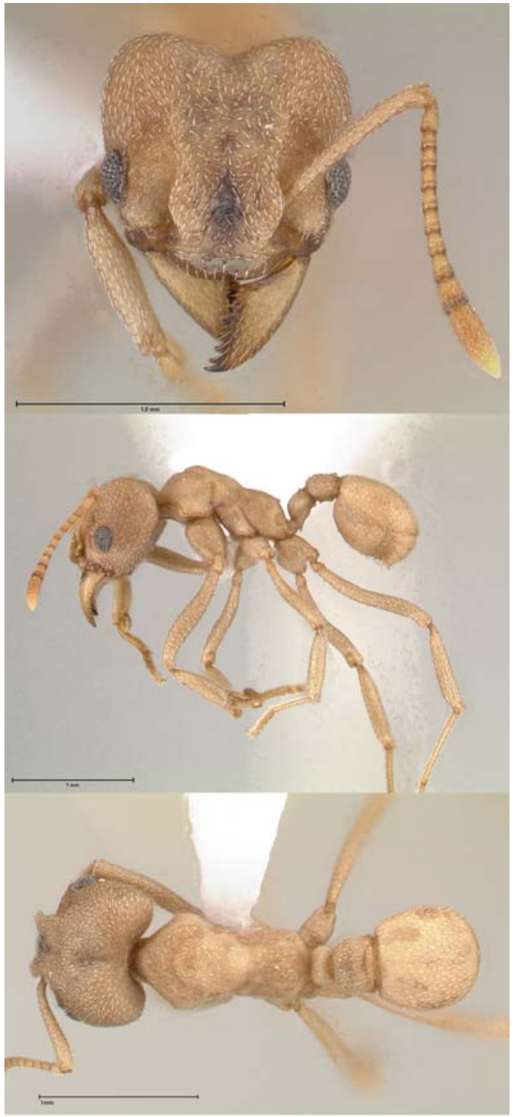

Figure 5: AutoMontage images of M. simplex worker in frontal, lateral and dorsal view

Figure 6: AutoMontage images of *M. simplex* queen in frontal, lateral and dorsal view.

Figure 7: AutoMontage images of *M. simplex* male in frontal and lateral view and REM image of dorsal view.

Figure 8: AutoMontage images of *M. morschi* worker in frontal, lateral and dorsal view.

Figure 9: AutoMontage images of *M. morschi* queen in frontal, lateral and dorsal view.

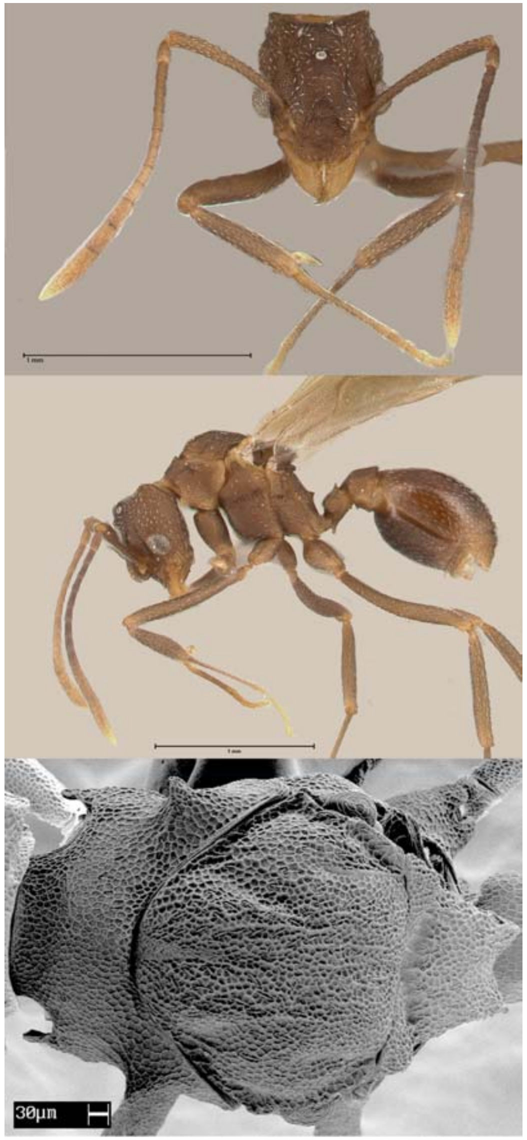

Figure 10: AutoMontage images of *M. morschi* male in frontal and lateral view and REM image of dorsal view.

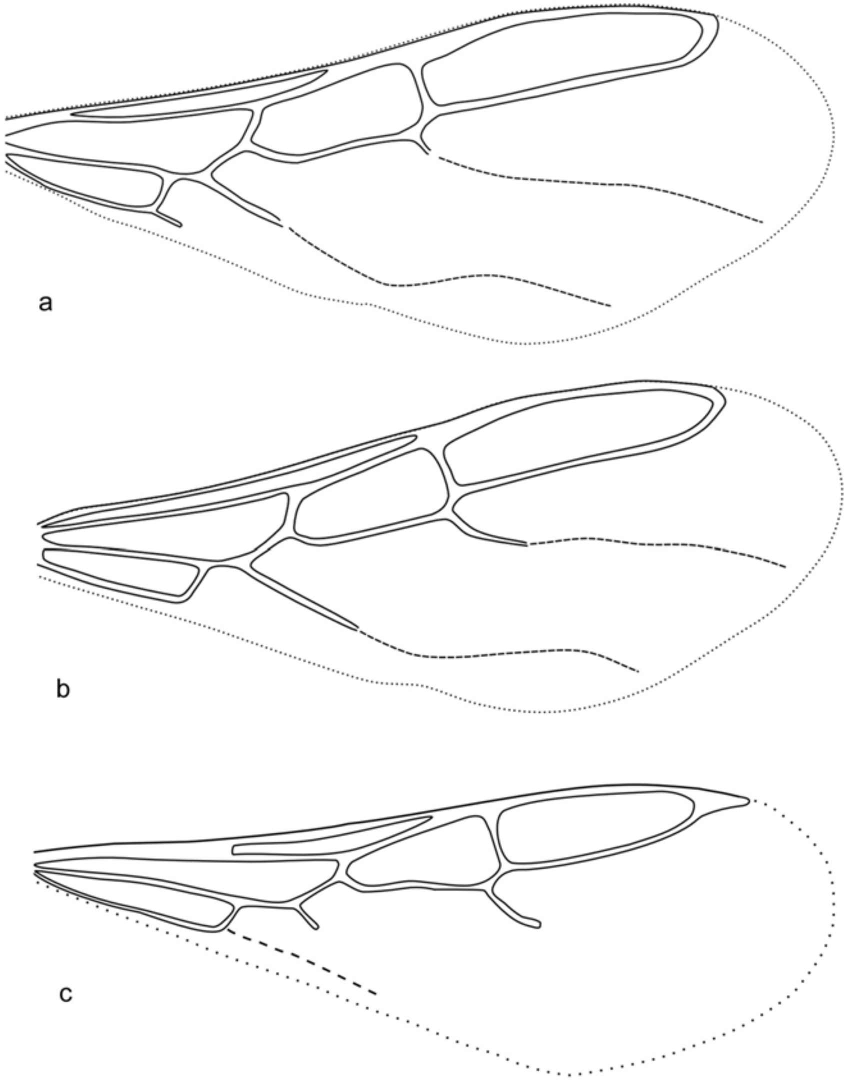

Figure 11: Drawings of the male forewings of a) *M. conformis*, b) *M. simplex* and c) *M. morschi*.

Figure 12: AutoMontage images of *P. bruchi* worker in frontal, lateral and dorsal view.

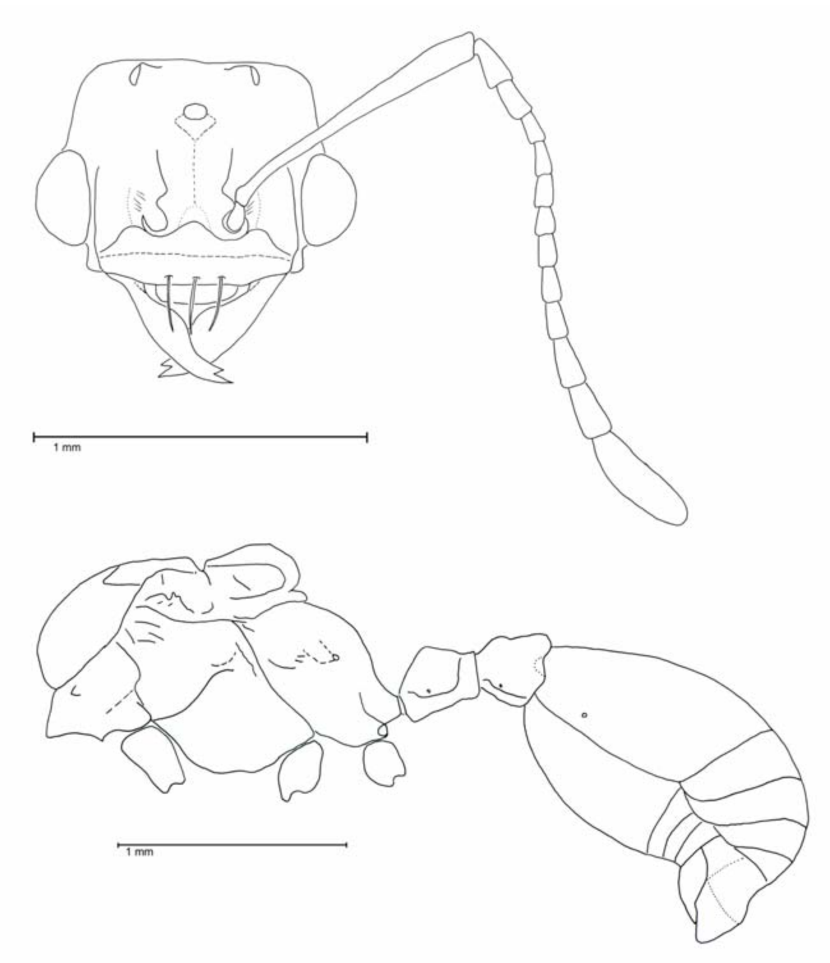

Figure 13: Drawings of *P. bruchi* male in frontal and lateral view.

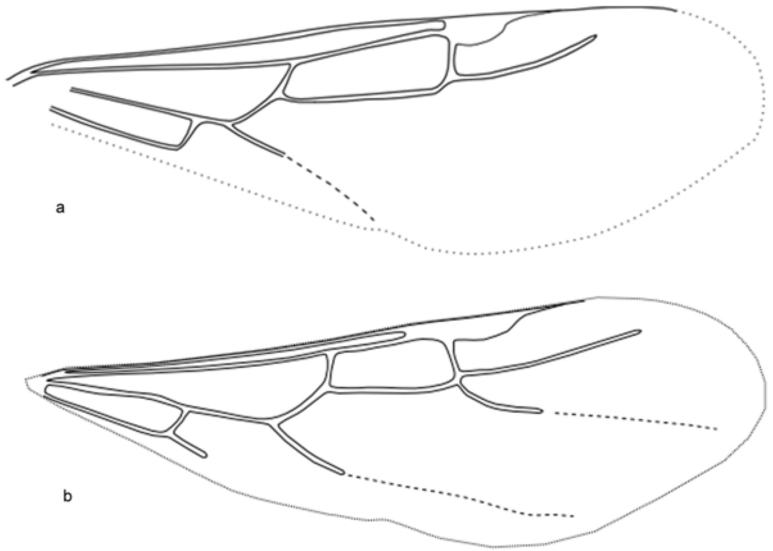

Figure 14: Drawings of the male forewings of a) *P. bruchi* and b) *K. emeryi*.

Figure 15: AutoMontage images of *K. emeryi* worker in frontal, lateral and dorsal view.

Figure 16: AutoMontage images of *K. emeryi* queen in frontal, lateral and dorsal view.

Figure 17: AutoMontage images of *K. emeryi* male in frontal and lateral view and REM image of dorsal view.

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THE TYPE SPECIMENS OF FUNGUS GROWING ANTS, ATTINI (HYMENOPTERA, FORMICIDAE, MYRMICINAE) DEPOSITED IN THE MUSEU DE ZOOLOGIA DA UNIVERSIDADE DE SÃO PAULO, BRAZIL

CHRISTIANA KLINGENBERG[1,2]
CARLOS ROBERTO F. BRANDÃO[1]

ABSTRACT

We present here a list of the Attini type material deposited in the Formicidae collection of the Museu de Zoologia da Universidade de São Paulo (MZSP), Brazil. In total, the Attini (fungus-growing and leaf-cutting ants) collection includes types of 105 nominal species, of which 74 are still valid, whereas 31 are considered synonyms. The majority of the types in the MZSP collection are syntypes (74), but in the collection there are 4 species represented only by holotypes, 12 by holotypes and paratypes, 13 species only by paratypes, and 2 species by the lectotype and one paralectotype as well. All holotypes and paratypes refer to valid species. The aim of this type list is to facilitate consultation and to encourage further revisionary studies of the Attini genera.

KEYWORDS: Insects, Hymenoptera, Myrmicinae, Attini, types, MZSP.

INTRODUCTION

The Formicidae collection housed in the Museu de Zoologia da Universidade de São Paulo (MZSP) is one of the most representative for the Neotropical region in number of types and ant species, as well as for the geographic coverage. The earliest records correspond to material collected by Hermann von Lüderwaldt and Hermann von Ihering, at the beginning of the XX century, when the collections still belonged to the Museu Paulista da Universidade de São Paulo (also known as Museu do Ipiranga), as part of its Zoological Section. These specialists maintained strong ties with colleagues from abroad, sending and exchanging material to/with Carlo Emery, Auguste Forel, F. Santschi, and in a lesser extent, to/with William M. Wheeler, Gustav Mayr, Carlo Menozzi, and Marion R. Smith. Several species collected in Brazil were named by these authors, who often sent back to São Paulo type specimens. In 1939, the Zoological section of the Museu Paulista was transferred to the São Paulo State Secretary of Agriculture and Commerce, as its Zoological Department, to a building planned to receive the collections and laboratories, in the same block where the Museu Paulista is located.

At this time, Karol Lenko (1914-1975) worked for the MZSP as curator of the ant collection, trading specimens with Thomas Borgmeier (1892-1975) and Walter Wolfgang Kempf (1920-1976), both Franciscan friars that published important revisionary works,

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including the descriptions of several fungus growing ant taxa. In 1969, the Department was transferred to the University of São Paulo, as its Museu de Zoologia; K. Lenko retired at this time.

After Father Kempf returned for his Ph. D. studies in Cornell University, in the late 1940's, Father Borgmeier gave him his personal collection and library on ants, publishing afterwards mostly on Phoridae (Diptera) ant parasites. The collection of reprints came from Hermann von Ihering, who once offered to sell it to Borgmeier, who did not have the means to buy it at the time. One year later, Borgmeier got a large box from the mail, containing the entire reprint collection, bought by a donator who insisted in remaining anonymous. Much later, Borgmeier learned that Julius Arp, an amateur lepidopterologist and industrialist, had paid for the collection and sent it to him. Borgmeier founded the *Revista de Entomologia* in 1931, where he published most of his contributions; publishing the last volume (22) in 1951.

Kempf and Borgmeier founded in 1958 the scientific magazine *Studia entomologica,* edited by Kempf until volume 19, published in 1976. The last volume (20) was edited by Lauro Travassos Filho, and published in 1978. Father Kempf lived in many cities, mostly in southern Brazil, before retiring from his duties in the Church, in 1973. He then moved to Brasília, and was nominated Visiting Professor of the Universidade de Brasília in 1975. Kempf lived there until his unexpected death while attending an International Congress of Entomology, in Washington, D.C. in August, 1976, the night before he was scheduled to present a paper on a biogeographical account on the ants of the São Paulo State.

The Borgmeier-Kempf ant collection and library was bought by the MZSP from the Franciscan order, by means of a Brazilian agency CNPq grant (Conselho Nacional de Desenvolvimento Científico e Tecnológico), in the name of Dr. Nelson Papavero, then head of the Entomology section of the MZSP, in 1977, The State of São Paulo Foundation for the Endowment of Sciences (FAPESP) financed the transport of the collection, library and optical equipment from Brasília to the city of São Paulo.

Since then, the ant collection has been receiving material from many projects, in special those conducted by Carlos Roberto F. Brandão, hired as curator in 1981, and collaborators. Many colleagues have also contributed extensively, depositing much material in the MZSP, including numerous types.

Brandão (1982) published a very crude list of the MZSP Attini type material (at least specimens labeled as such) in the newsletter *Attini.* Since this publication ceased some years ago, and several colleagues still ask for loans based on this publication, we decided to update and complete the list. Readers may find in the literature references to other type specimens supposedly deposited here, although the list we present corresponds to the actual specimens we found in the collection.

In order to avoid unnecessary duplication, we follow, throughout this paper, the same reference listing adopted by Ward *et al.* (1996), including the notations employed to differentiate publications by the same authors in the same year, citing only the references that do not appear in Ward *et al.* (*op. cit.*). The names are listed as they were published originally, but under the genera the species are now accepted to belong to, and in alphabetical order of species. To facilitate consultation, we added a list with the names as accepted nowadays followed by the respective cited synonyms.

We use the following codes to identify sexes and castes of the type individuals: w = worker, m = male, g = gyne. We copied the labels, including between parentheses or brackets further information not given in the lables, but that we were able to complete from original descriptions or field book notes, providing comments whenever necessary. Numbers given between parentheses correspond to handwritten catalogues also deposited in the MZSP, listing specimens deposited originally in the collections of the Museum itself (MP # referring to Museu Paulista), T. Borgmeier (Coll. Borgmeier), K. Lenko and W.W. Kempf collections. Sometimes we were not able to determine from which collections the numbers came from, although we are sure they do not belong either to Museu Paulista or Borgmeier collections.

Genus *Acromyrmex* Mayr, 1865

Atta (Acromyrmex) aspersa dimidiata Forel, 1911e:292. Syntypes, 5 w, 1 g. Brazil, São Paulo, São Paulo, Ipiranga. [H. Lüderwaldt col.; 8.xii.1908], (MP # 14190/Coll. Borgmeier # 2720) (combination in *Acromyrmex;* Emery, 1922). Junior synonym of *Acromyrmex laticeps nigrosetosus* (Forel, 1908), (see Gonçalves, 1961:146).

Acromyrmex aspersus var. *insularis* Santschi, 1925d:242. Syntype, 1 w. Brazil, São Paulo, Ilha São Sebastião; [Günther coll.; iv.1906], (MP2489/Coll. Borgmeier 1994). [mislabeled as *Acromyrmex mesonotalis* var. *insularis* Santschi]. Junior synonym of *Acromyrmex crassipinus* Forel, 1909a (see Gonçalves 1961:139).

Acromyrmex (Moellerius) balzani var. *senex* Santschi, 1925b("1924"):19. Syntypes, 3 w. Brazil, Minas Gerais, Pirapora, E. Garbe col.; vi.1912, MP # 18463. Junior synonym of *Acromyrmex (Moellerius) landolti landolti* (Forel, 1885), (see Gonçalves, 1961:120).

Acromyrmes bucki Wasmann, 1931:106. Syntypes, 4 w. Brazil, Rio Grande do Sul, Porto Alegre; Buck, col. 27.viii.1924. Junior synonym of *Acromyrmes lobicornis* (Emery, 1888c), (see Gonçalves, 1961:148).

Acromyrmes coronatus st. *andicola* var. *flavescens* Santschi 1925d:239. Syntype 5 w. Brazil, Goiás, Grinas. Dietz col.; [19.iii.1908], (MP # 10868/Coll. Borgmeier # 1992/2723). Unavailable name Bolton (1995b:55); material referred to *Acromyrmex coronatus* (Fabricius, 1804), (see Gonçalves 1961:135).

Acromyrmex coronatus st. *moellei* var. *obscurior* Santschi. 1925d:240. Syntype 1 w. Brazil, Santa Catarina, Itajai; [xii.1914], (MP # 18993/Coll. Borgmeier # 2722). Unavaiable name Bolton 1995b:56; material referred to *Acromyrmex coronatus* (Fabricius, 1804), (see Gonçalves, 1961:135).

Acromyrmex diasi Gonçalves 1983a("1982"):483. Syntypes, 3 g. Brazil, Distrito Federal, Reserva Ecológica IBGE, Brasília; D. Dias col.; 2.xi.1978; (Coll. Borgmeier # 2305).

Acromyrmex (Moellerius) landolti var. *nivalis* Santschi 1922c; 362. Syntypes, 5 w. Brazil, Mato Grosso, São Luiz, Cáceres, [Campo]; [xi.1917], (MP # 19601/Coll. Borgmeier # 2902). Junior synonym of *Acromyrmes (Moellerius) landolti landolti* (Forel, 1884), see Gonçalves, 1961:120); of *Acromyrmes (Moellerius) balzani,* Fowler 1988:284.

Acromyrmex lundi st. *boliviensis* var. *nigripes* Santschi, 1929d. Syntypes, 9 w, 2 g. Argentina, Tucumán, Santa Ana; Dr. Rempski col. (no col. date), (Coll. Borgmeier # 5463). Unavaiable name Bolton (1995b:56).

Acromyrmex rugosus st. *bigener* Santschi 1925d:243. Syntypes, 1 w, 1 g, 1 m. Brazil, Pará, Monte Alegre; P. Mones O.F.M. col.; (no date), (Coll. Borgmeier # 559/ Ex. Coll. Reichensperger). Junior synonym of *Acromyrmex rugosus rugosus* (Smith, 1858), (see Gonçalves, 1961:159).

Acromyrmex rugosus var. *navarroi* Borgmeier, 1937b:249. Syntypes, 5 w. Brazil, São Paulo, Descalvado. Navarro de Andrade col.; v.1935. Junior synonym of *Acromyrmex rugosus rochai* (Forel, 1904), (see Gonçalves, 1961:162).

Acromyrmex rugosus var. *vestitus* Santschi 1925a:380. Syntypes, 3 w. Brazil, Minas Gerais, Pirapora; E. Garbe col.; vi.1912. (MP # 20648, although this number corresponds to a different specimen/Coll. Borgmeier # 2269). Junior synonym of *Acromyrmex rugosus rugosus* (Smith, 1858), (see Gonçalves, 1961:159).

Atta (Acromyrmex) subterranea var. *brunnea* Forel, 1912f:181. Syntypes, 1 w, 1 g. Brazil, São Paulo, São Paulo, Ipiranga; H. Lüederwaldt col.; [18.i.1908], (MP # 10506/Coll. Borgmeier # 1970). (see Gonçalves, 1961:167).

Acromyrmex subterranea var. *depressoculis* Forel 1913 m:237. Syntypes, 6 w. Brazil, Santa Catarina, Ibirama; Lüderwaldt col.; viii.1910. (MP # 15478/Coll. Borgmeier # 2869). Junior synonym of *Acromyrmex muticinodus* (Smith, 1858), (see Gonçalves, 1967a:20).

Acromyrmex subterraneus var. *eidmanni* Santschi, 1937f:232 Syntypes, 4 w, 1 g, 1 m. Brazil, Rio de Janeiro, Mendes; H. Eidmann col.; 1933. (Coll. Borgmeier # 5882). Junior synonym of *Acromyrmex subterraneus* st. *molestans* Santschi, 1925 (Gonçalves, 1961:168).

Acromyrmex subterraneus var. *peruvianus* Borgmeier, 1940:606. Syntypes, 9 w. 5 m. Peru, [La Libertad], Cartabo; Weyrauch col.; 1939.

Genus *Apterostigma* Mayr, 1865

Apterostigman acre Lattke, 1997:133. Holotype w, Paratypes 1 g, 1 m (no. 416). Brazil, São Paulo; I.P. Noguiera (sic) col.; (no date).

Apterostigma angustum Lattke, 1997:138. Paratype, 1 w. Venezuela. Tá[chira], 1100 m, Uribante, Caparo, *ca.* Siberia, 7°50'N, 71°49'W; J. Lattke col.; 28.viii.1988.

Apterostigma auriculatum Wheeler, 1925a:49. Syntypes, 3 w. Trinidad, Port of Spain, 4 Roads Pt.; R. Thaxter col.; (no date).

Apterostigma bruchi Santschi, 1919f:49. Syntype, w. [Argentina], La Plata; Bruch col.; (no date).

Apterostigma carinatum Lattke, 1997:145. Paratype, w. Colombia, Valle, Rio Tatabro; P. Chacón col.; 5.ix.1993.

Apterostigma convexum Lattke, 1997:149. Paratype, 1 w. Venezuela, Am[zonas], Cerro Marawaka; J.E. Lattke col.; 8.iii.1985.

Apterostigma fallax Borgmeier, 1934:105. Syntypes, 6 w, 1 g. Suriname, Paramaribo; Buenzli, col.; (no date). Junior synonym of *Apterostigma urichii* Forel, 1893 (see Lattke, 1997:217).

Apterostigma jubatum Wheeler, 1925a:47. Syntypes, 3 w. British Guiana, Kartabo; W.M. Wheeler col.; vii/viii.1920. Junior synonym of *Apterostigma robustum* Emery 1896 Weber 1958d), revived from synonymy (Lattke, 1997:158).

Apterostigma luederwaldti Santschi, 1923d:66. Syntype, w. Brazil, São Paulo, São Paulo, Horto Botânico; H. Lüderwaldt, col.; (no date); (no. 2959). Junior synonym of *Apterostigma steigeri* (Lattke, 1997:171).

Apterostigma reburrum Lattke, 1997:166. Paratype, 1 w. Colombia, Ant[ioquia]. Providencia Est. Biologica, Zona Buenos Aires; C. Kugler col.; 30/31.xii.1977.

Apterostigma serratum Lattke, 1997:168. Holotype, w, Paratypes 1 g, 1 m. Brazil, Minas Gerais, Viçosa; A. Mayhé-Nunes col.; 12.ii.1993.

Apterostigma tholiforme Lattke, 1997:173. Paratype, 1 w. Equador, Pichincha, Centro Cient. R. Palenque; S. Sandoval col.; 20.xii.1980.

Apterostigma tropicoxa Lattke, 1997:175. Holotype, w. Brazil, Amazonas, Manaus, BR 174; G.A.R. [Melo]. col.; 5.ix.1991.

Note: We found in the MZSP collection specimens of *Apterostigma andense* and *Apterostigma goniodes* labeled as paratypes, although they were not listed in the respective original descriptions (Lattke, 1997), and hence can not be treated as type specimens.

Genus *Atta* Fabricius 1804

Atta silvai Gonçalves, 1983b:174. Syntypes, 9 w. Brazil, Bahia, Maraú; Pedrito Silva, col.; 4.ix.1969. Junior synonym of *Atta laevigata* (F. Smith) (Delalie, 1998:340).

Genus *Cyphomyrmex* Mayr, 1862

Cyphomyrmex bruchi Santschi, 1917f:282. Paratype, 1 w. Argentina, Buenos Aires, La Plata; C. Bruch col.; no. 631.

Cyphomyrmex cornutus Kempf, 1968a:35. Paratypes, 20 w, 4 g. Colombia, Valle, 3,2 km E Rio Aguaclara on old Cali Road; R.B. Root, W.L. Brown cols.; 1967. Paratypes, 10 w, 2 g. Colombia, Valle, Mun. Buenaventura. R.B. Root, W.L. Brown cols.; 16/17.iii.1967.

Cyphomyrmex daguerrei Santschi, 1933f:118. Paratype, 1 w. Argentina, Buenos Aires, Rosas, F.C. Sud; Juan B. Daguerre col.; (no date).

Cyphomyrmex kirbyi Mayr, 1887:557. Paratypes, 2 w. Colombia, N. Granada; G. Mayr col.; (no date).

Cyphomyrmex morschi, Emery, 1888c("1887"):360. Syntype, w. Brazil, Rio Grande do Sul; v. Ihering col.; (no date), (MP # 11419).

Cyphomyrmex nemei Kusnezov, 1957e:7. Syntypes, 2 m. Paratypes, 1 g, 5 m. Argentina, Salta, Reserva Nacional Estancia El Rey; N. Kusnezov col.; 17.ii.1953.

Cyphomyrmex occultus Kempf, 1964d:41. Holotype, g. Paratypes, 1 m, 4 g. Brazil, Santa Catarina, Nova Teutônia; F. Plaumann, col.; 1960 (col. Kempf 3918). Paratypes, 4 g, 4 m. Brazil, São Paulo, Barueri; K. Lenko col.; 17.x.1958. (no. 698).

Cyphomyrmex olitor Forel 1893h:605. Syntypes, 6 w. 1 g. Argentina, Tucumán, Quebrada Cainzo, Tafi Viejo; N. Kusnezov col.; iv.1948; (no. 1595).

Atta (Cyphomyrmex) olitrix lectus Forel, 1911e:295. Syntypes, 11 w. Brazil, São Paulo, São Paulo, Ipiranga; H. Lüderwaldt col.; [18.iv.1903], (MP # 12714/Coll. Borgmeier # 290).

Cyphomyrmex paniscus Wheeler, 1925a:42. Paratypes, 1 w, 1 g. Brazil; (no further data).

Cyphomyrmex peltatus Kempf, 1966("1965"):181. Holotype, w. Brazil, Santa Catarina, Ibicaré; F. Plaumann, col.; ix.1960 (no. 3654). Paratypes, 5 w, 1 g. Brazil, Santa Catarina, Ibicaré; F. Plaumann, col.; ix.1960. (no. 3654). Paratypes, 2 w, 2 g. Brazil, Rio Grande do Sul, B. Cotejipe; F. Plaumannm, col.; vii.1960. (no. 3768). Paratypes, 2 w. Brazil, Rio Grande do Sul, Boqueirão; F. Plaumann, col.; ix.1960. (no. 3610). Paratype, 1 w. Brazil, Santa Catarina, Chapecó; F. Plaumann, col.; v.1957. Paratypes, 5 w, 1 g. Brazil, Santa Catarina, Seara; F. Plaumann, col.; vii.1958. (no. 2704). Paratypes, 15 w. Brazil, Santa Catarina, Nova Teutônia, F. Plaumann, col.; x.1953, iv.1954, x.1955, vi.vii.1959, vi.1960, vi.1963, 195?.

Cyphomyrmex plaumanni Kempf, 1962b:31. Holotype, w. Brazil, Santa Catarina, Nova Teutônia; F. Plaumann col.; x.1955. Paratype, 1 w. Brazil, Rio Grande do Sul, Erechim; F. Plaumann col.; vii.1960. Paratypes, 2 w. Brazil, Paraná, Rio Azul; F. Plaumann col.; ix.1960.

Cyphomyrmex rimosus breviscapus Weber, 1940b:412. Syntypes, 2 w. Panama, Barro Colorado, Canal Zone, NO; N.A. Weber col.; 1938. Junior synonym of *Cyphomyrmex minutus* Mayr, 1862 (Snelling & Longino 1992:489).

Cyphomyrmex rimosus cochunae Kusnezov, 1949d:439. Syntypes, 5 w. Argentina, Tucumán, Quebrada de la Sosa; N. Kusnezov col.; (no date). Junior synonym of *Cyphomyrmex rimosus* Spinola 1851, (Snelling & Longino 1992:489).

Cyphomyrmex rimosus r. dentatus Forel, 1901d:124. Syntype, 1 w. Mexico, Morelos, Cuernavaca; W.M. Wheeler col.; (no date). Junior synonym of *Cyphomyrmex flavidus* Pergande, 1896 (Snelling & Longino 1992:485).

Cyphomyrmex rimosus venezuelensis Weber, 1938b:188. Syntypes, 2 w. Venezuela, Ciudad Bolivar; N.A. Weber col.; 30.i.1935. Junior synonym of *Cyphomyrmex rimosus* Spinola 1851, (Snelling & Longino 1992:489).

Cyphomyrmex wheeleri Forel 1900h:282. Syntypes, 3 w. USA, Texas, Austin; W.M. Wheeler; (no date). (no. 1-3 9225).

Genus *Mycetagroicus* Brandão & Mayhé-Nunes, 2001

Mycetagroicus cerradensis Brandão & Mayhé-Nunes, 2001:644. Holotype, w. Paratypes, 38 w. São Paulo, Rancharia. E. Amante; 5.x.1969. Brazil, Paratypes, 2 w. Brazil, Distrito Federal: Brasília, W.L. & Brown, D.E. 13-14.v.1971. Paratypes, 20 w. Brazil, Goiás: Faz. Cachoeirinha, Jataí, Exp. Dept. Zool. 20.vii.1964. Paratypes, 3 w. Brazil, Mato Grosso do Sul: Fazenda Fortaleza, J.L.M. Diniz, 19.ii.1976. Paratypes, 2 w. Brazil, Minas Gerais: Paraopeba, J.A. Barcelos, iii.1990. Paratypes, 2 w. Brazil, Minas Gerais: Lassance, P. Pacheco, 18.ix.1985.

Mycetagroicus triangularis Brandão & Mayhé-Nunes, 2001:649. Holotype w, Paratypes, 2 w. Brazil, Mato Grosso, Gustavo Dutra; C.R. Gonçalves, col.; 25.x.1953. Paratype g. Brazil, Distrito Federal: Brasília, Fazenda Água Limpa, T. Schultz, 2.viii.1988. Paratype, g, Brazil, Bahia, Encruzilhada, Seabra & Alvarenga col.; xi.1972 (Kempf # 8869).

Mycetagroicus urbanus Brandão & Mayhé-Nunes 2001:657. Holotype w, Paratypes, 3 w. Brazil, São Paulo, São Paulo, Ibirapuera Park; C.R. Gonçalves, col.; 15.iii.1968.

Genus *Mycetarotes* Emery, 1913c

Mycetarotes acutus Mayhé-Nunes, 1995. Holotype, w. Brazil, Amazonas, Manaus; E.F. Morato col.; iii.; 1991.

Mycetarotes carinatus Mayhé-Nunes, 1995. Holotype, w. Paratypes, 6 w. Brazil, Rio Grande do Sul, Paulo de Frontin; A. Mayhé-Nunes col.; 29.xii.1997.

Atta (Mycocepurus) lüderwaldti Forel, 1911e. Syntypes, 6 w. Brazil, São Paulo: São Paulo, Ipiranga; H. Lüderwaldt col.; 23.iii.1909, MP 12692. Junior synonym of *Mycetarotes parallelus* (Emery, 1906), (Kempf 1960d:279).

Mycetarotes senticosus Kempf, 1960d:282. Holotype, w. Brazil, São Paulo: Federal Highway São Paulo-Curitiba, km 40; W.W. Kempf col.; 7.v.1960. Paratypes, 2 w. Brazil, Santa Catarina: Chapecó; F. Plaumann col.; xii.1957. Brazil, Rio de Janeiro: Petrópolis; W.W. Kempf col.; 21.iv.1945.

Genus *Mycetophylax* Emery 1913c

Mycetophylax brittoni var. *littoralis* Weber, 1937:401. Syntype, w. Trinidad, Mayaro Bay, B.W.I.; N.A. Weber col.; [1.iii.1935]. Junior synonym of *Mycetophylax conformis* (Mayr, 1884), (Kempf 1962b:34).

Mycetophylax cristulatus var. *emmae* Santschi, 1929d:304. Syntype, w. Argentina, Catamarca, Nascimiento; Weiser col.; (no date).

Genus *Mycetosoritis* Wheeler, 1907d

Mycetosoritis explicata Kempf, 1968b:401. Holotype, w. Brazil, Goiás: Anápolis; W.W. Kempf col.; 15.iii.1968.

Genus *Mycocepurus* Forel, 1893h

Trachymyrmex attaxenus Menozzi in Eidmann 1936b:85. Syntypes, 2 w, 2 g. Brazil, Rio de Janeiro, Mendes; Dr. Eidmann col.; 19.ix.1933. Junior synonym of *Mycocepurus smithii* Forel, 1893 (Kempf, 1963b:425).

Mycocepurus bolivianus Weber 1938b:155. Syntype, w. Bolivia, Beni, Rurrenabaque; W.H. Mann col.; x.1921. Junior synonym of *Mycocepurus smithii* Forel, 1893 (Kempf 1963b:425).

Mycocepurus curvispinosus MacKay. 1998:423. Paratype, 1 w. Mexico, Chiapas. 24 km SW Cintalpa, 710 m; W. MacKay col.; 2 vi.1988.

Mycocepurus goeldii st. *gentiles* Santschi, 1925b ("1924"). Syntype, w. Brazil, Minas Gerais, Pirapora; E. Garbe col.; (no date). Junior synonym of *Mycocepurus goeldii* Forel 1893 (Kempf 1963b:420).

Mycocepurus reconditus Borgmeier 1937b:246. Syntypes, 2 w, 1 g. Brazil, Bahia, Água Preta [= Uruçuca] G. Bondar col.; v.1936. Junior synonym of *Mycocepurus smithii* Forel 1893 (Kempf 1963b:425).

Atta (Mycocepurus) smithi var. *borinquenensis* Wheeler, 1907d:718. Syntype, w. Puerto Rico, [Vega Beja, Arecibo], Utuado, [Monte Mandios]; W.M. Wheeler col.; (no date). Junior synonym of *Mycocepurus smithii* Forel, 1893 (Kempf 1963b:425).

Atta (Mycocepurus) smithi var. *tolteca* Wheeler, 1907d:718. Syntypes, 4 w. Mexico, Jalisco, Tuxapan. J.F. McClendon col. (no date). Junior synonym of *Mycocepurus smithii* Forel, 1893 (Kempf 1963b:425).

Mycocepurus smithi var. *trinidadensis* Weber, 1937:378. Syntype, w. Trinidad, Northern Rage B.W.I.; N.A. Weber col.; 23.vi.1935. Junior synonym of *Mycocepurus smithii* Forel, 1893 (Kempf 1963b:425).

Mycocepurus tardus Weber, 1940b:416. Syntype, w. Panama, Barro Colorado, Canal Zone; N.A. Weber col.; 1938.

Genus *Myrmicocrypta* Smith, 1860c

Myrmicocrypta buenzlii Borgmeier, 1934:134. Syntype, w. Suriname, Paramaribo; Buenzli col.; (no date) (see Kempf 1961b:517).

Myrmicocrypta microphthalma Borgmeier, 1948a:202. Syntypes, 50 w, 1 g. Peru, Valle Chanchamayo; Weyrauch col.; 1.viii.1939.

Myrmicocrypta spinosa Weber 1937:382. Syntypes, 2 w. British Guiana, betw[een] R. Cuyuni & R. Mararuni; N.A. Weber col.; 7.ix. 1935; (no. 354).

Myrmicocrypta urichi Weber, 1937:379. Syntypes, 2 w. Trinidad, Mayaro Bay, B.W.I.; N.A. Weber col.; [9.iii.1935], (no. 55).

Myrmicocrypta weyrauchi Borgmeier 1948a:204. Syntypes, 11 w. 1 g. Peru, Valle Chanchamayo; Weyrauch col.; 1.viii.1939, (no. 28).

Genus *Sericomyrmex* Mayr, 1865

Sericomyrmex amabilis Wheeler, 1925e:166. Syntypes, 3 w. Panama, Barro Colorado, Canal Zone; W.M. Wheeler col.; 8.iii.1924, (no. 838).

Sericomyrmex beniensis Weber, 1938b:182. Syntypes, 2 w. Brazil, GB [Rio de Janeiro], Rio de Janeiro; Werneck col.; iii.1923; (Coll. Borgmeier # 4203).

Sericomyrmex bondari Borgmeier, 1937b:248. Syntypes, 4 w. Brazil, Bahia, Água Preta [= Uruçuca]; G. Bondar col.; [v.1936]; (Coll. Borgmeier # 5779).

Sericomyrmex diego Forel, 1912f:192. Syntype, w. Colombia; (no further data), (Coll. Borgmeier # 3813).

Sericomyrmex harekulli arawakensis Weber, 1937:399. Syntypes, 2 w. British Guiana, R. Mazaruni; N.A. Weber col.; viii-ix.1935.

Sericomyrmex luederwaldti Santschi, 1925b("1924"):15. Syntypes, 4 w. Brazil, Minas Gerais, Pirapora; [E. Garbe col.]; (no date).

Sericomyrmex lutzi Wheeler, 1916c:9. Syntypes, 1 w. 1 g. British Guiana, Roraima, Kauwa Creek; A. Crampton col.; 13.viii.1911; (no. 3907).

Sericomyrmex moreirai Santschi, 1925b:16. Syntype. w. Brazil, Rio de Janeiro; Moreira col.; (no date); (Coll. Borgmeier # 3803); Syntypes, 3 w. Brazil, Rio de Janeiro; Werneck col.; iii.1923; (Coll. Borgmeier # 4203).]

Sericomyrmex scrobifer Forel, 1911e:296. Syntypes, 6 w. Brazil, São Paulo, [São Paulo] Ipiranga; [H.Lüderwaldt col.]; (no date).

Sericomyrmex zacapanus Wheeler, 1925a:54. Syntypes, 3 w. Guatemala, Zacapa; W.M. Wheeler, col.; 15.xii.1911.

Genus *Trachymyrmex* Forel, 1893h

Trachyrmex agudensis Kempf, 1967a("1966"):124. Holotype, w; Paratype, w. Brazil, São Paulo, Agudos; C. Gilbert col.; v.1959.

Atta (Trachymyrmex) arizonensis Wheeler, 1907d:710. Syntypes, 3 w. USA, Arizona, Hunters Canon; (no date).

Trachymyrmex carib Weber, 1945:61. Syntype, w. Panama, Barro Colorado, Canal Zone; N.A. Weber col.; 1938; (no. 829).

Trachymyrmex compactus Mayhé-Nunes & Brandão, 2002:673. Holotype, w. Suriname, Maripaheuvel; J. van der Drift col.; [September] 1959.

Myrmicocrypta cucumis Mann, 1922:45. Syntypes, 2 w. Honduras, Progresso, W.M. Mann col; (no col. date). Weber, 1958b. Junior synonym of *Trachymyrmex bugnioni* Forel 1912 (see Weber, 1967, p. 273).

Trachymyrmex dichrous Kempf, 1967a("1966"):126. Holotype, w; Paratypes, 5 w. Brazil, Goiás, Anápolis, W. Kempf, col.; 4-7.i.1966. (Kempf # 4230, 4199). Paratype, w. Brazil, Mato Grosso, Chapada; Fr. Canuto col.; v.1959. Paratype, w. Brazil, São Paulo, Agudos; W. Kempf col.; 13.xii.1955 (Kempf # 1493).

Trachymyrmex (Acromyrmex) iheringi var. *cordovanus* Bruch, 1921:202. Syntype, w. Argentina; Cordoba Alta Gracia; Bruch col.; [25.iii.1921]; (no. 3878). combination in *Trachymyrmex;* Kempf, 1972; combination in *T. tucumanus;* Santschi, 1922.

Trachymyrmex morgani Weber, 1940b: Syntype, w. Panama, Barro Colorado, canal Zone, N.A. Weber col. 14; 22, vi, 1938. Junior synonym of *Trachymyrmex bugnioni* Weber, 1945 (see Weber, 1967, p. 237).

Trachymyrmex nogalensis Byars, 1951:109. Paratypes, 3 w. [USA, Arizona], Nogales Ariz; Nogales col.; 10.i.1946.

Atta (Trachymyrmex) oetkeri Forel, 1908h:352. Syntype, g. (no date). Syntypes, 7 w. Brazil, São Paulo, [São Paulo] Ipiranga; (no date) (# 593, 313, 5593). (combination in *Trachymyrmex,* Gallardo 1916).

Sericomyrmex opulentus Mann, 1922:48. Lectotype, w. Paralectotypes, 11 w. (designated by Mayhé-Nunes & Brandão, 2002). Honduras, San Juan Pueblo; W.M. Mann col.; 2.iii.1920. (combination in *Trachymyrmex* Weber, 1958).

Trachymyrmex papulatus Santschi, 1922c:359. Syntype, w. Argentina, Cordoba, Tantiviejo (Durione); (no date) (no. 3815).

Trachymyrmex phaleratus Wheeler, 1925a:39. Syntypes, 3 w. British Guiana, Kartabo; W.M. Wheeler col.; vii-viii.1930.

Trachymyrmex phippsi Weber, 1937:405. Syntypes, 2 w. British Guiana, Oronoque R. 2°42'N; N.A. Weber col.; 30.vii.1936. Junior synonym of *Trachymyrmex diverus* Mann, 1916 (see Weber 1967:274).

Trachymyrmex pruinosus spinosior Santschi, 1922c:359. Syntype, w. Argentina, Cordoba, Alta Gracia, Bruch col.; (no date); (no. 3879).

Trachymyrmex relictus Borgmeier, 1934:107. Paratypes, 42 w. 2 g, 1 m. Suriname, Paramaribo; G.H. Bünzli col.; 1930/1931. Syntypes, 4 w. Trinidad, B.W.I., Nariva Swamp; N.A. Weber, col.; 22.iv.1935.

Trachymyrmex ruthae Weber, 1937:402. Syntypes, 1 w. 1 g. Trinidad, B.W.I., Foothills, N of Tunapuna; N.A. Weber col.; [24.vii.1935]; (no. 245).

Trachymyrmex smithi Buren, 1944b:5. Paratypes, 12 w. Mexico, Coahuila, La Rosa; E. Buren col.; 8.xi.1942.

Trachymyrmex smithi neomexicanus Cole, 1952a:159. Paratypes, 3 w. USA, New Mexico, Las Cruces; A.C. Cole col.; 15.ix.1951.

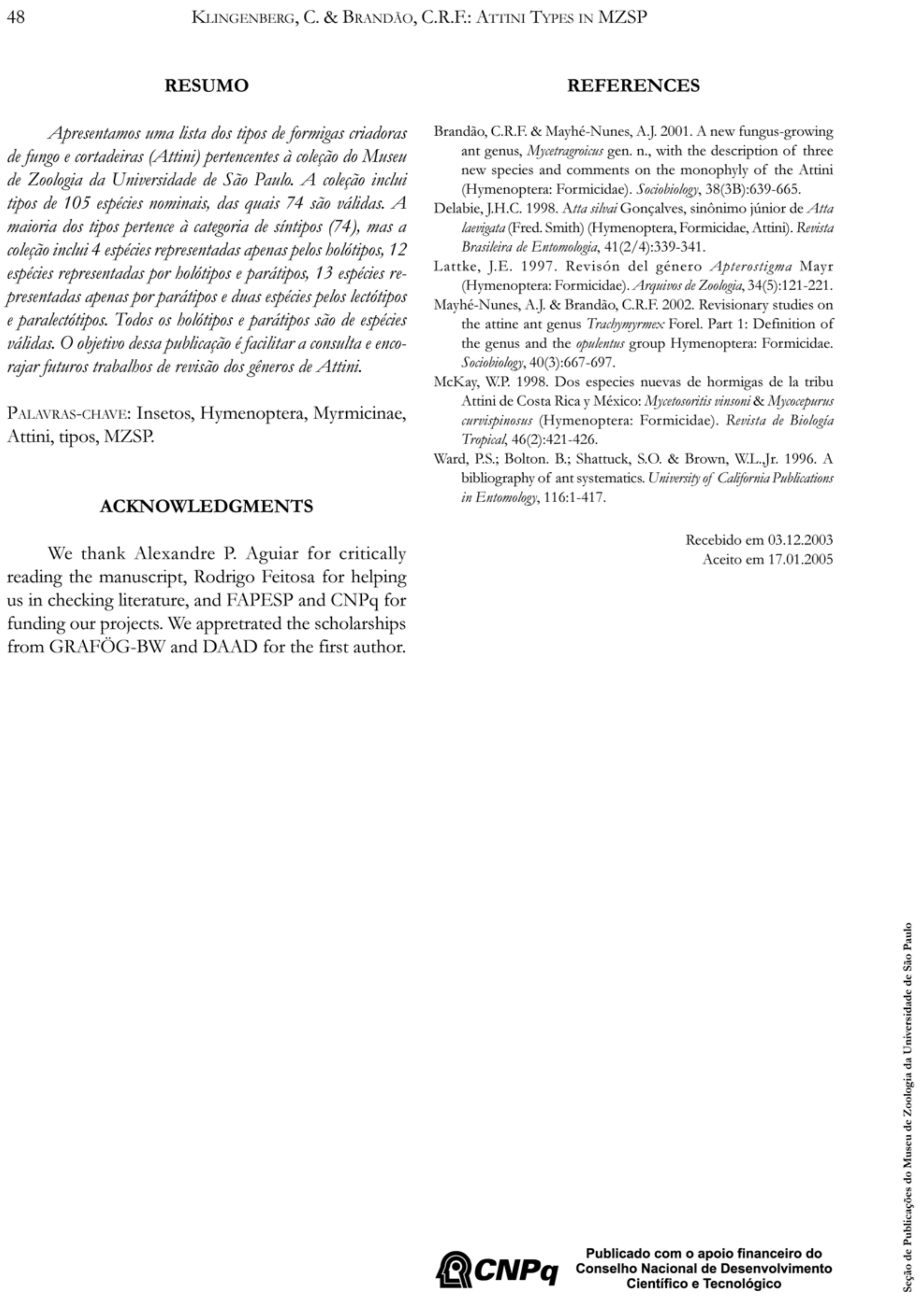
Trachymyrmex tucuche Weber, 1938b:197. Syntype, w. Trinidad, B.W.I., Northern Range, El. Tucuche; N.A. Weber col.; 15.xii.1934; (no. 29a). Junior synonym of *Trachymyrmex bugnioni* Forel, 1912 (see Weber, 1967).

Trachymyrmex tucumana var. *weiseri* Santschi, 1925e:164. Syntype, w. Argentina, Santa Fé, Fives Lilles; Weiser col. (no date); (no. 3810).

Atta (Trachymyrmex) turrifex Wheeler, 1903c:100. Syntypes, 3 w. USA, Texas, Austin, [W.M. Wheeler col.]; 9.v.1902.

Trachymyrmex verrucosus Borgmeier, 1948a:205. Syntypes, 4 w, 1 g. Suriname, Lelydorp. 20.v.1938, Geyskes col.

Trachymyrmex zeteki Weber, 1940b:422. Syntype, w. Panama, Barro Colorado, Canal Zone, N.A. Weber col.; [13.vi]1938; (no. 162).



RESUMO

Apresentamos uma lista dos tipos de formigas criadoras de fungo e cortadeiras (Attini) pertencentes à coleção do Museu de Zoologia da Universidade de São Paulo. A coleção inclui tipos de 105 espécies nominais, das quais 74 são válidas. A maioria dos tipos pertence à categoria de síntipos (74), mas a coleção inclui 4 espécies representadas apenas pelos holótipos, 12 espécies representadas por holótipos e parátipos, 13 espécies representadas apenas por parátipos e duas espécies pelos lectótipos e paralectótipos. Todos os holótipos e parátipos são de espécies válidas. O objetivo dessa publicação é facilitar a consulta e encorajar futuros trabalhos de revisão dos gêneros de Attini.

PALAVRAS-CHAVE: Insetos, Hymenoptera, Myrmicinae, Attini, tipos, MZSP.

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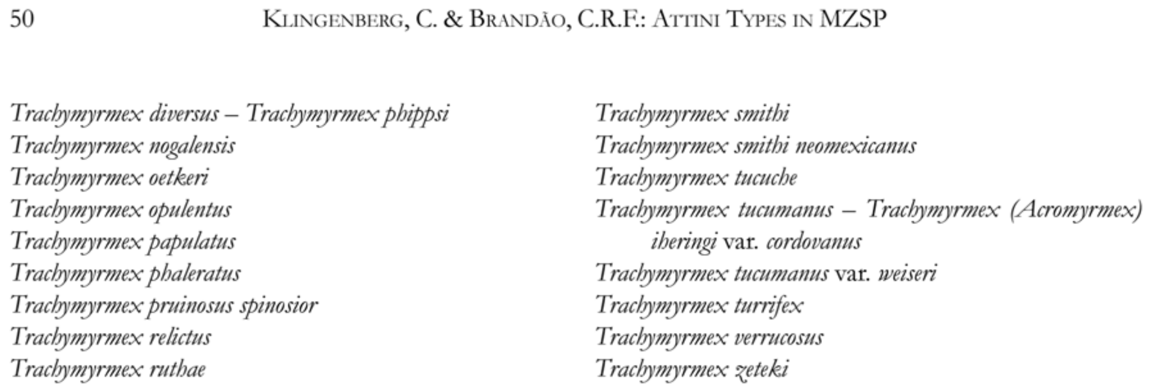
APPENDIX

Index of currently valid taxa cited in this list followed, when it is the case, by their cited synonyms.

Acromyrmex (Moellerius) landolti landolti – *Acromyrmex (Moellerius) balzani* var. *senex, Acromyrmex (Moellerius) landolti* var. *nivalis*
Acromyrmex coronatus – *Acromyrmex coronatus* st. *andicola* var. *flavescens, Acromyrmex coronatus* st. *moelleri* var. *obscurior*
Acromyrmex crassispinus – *Acromyrmex aspersus* var. *insularis*
Acromyrmex diasi
Acromyrmex laticeps nigrosetosus – *Atta (Acromyrmex) aspersa dimidiata*
Acromyrmex lobicornis – *Acromyrmex bucki*
Acromyrmex lundi st. *boliviensis* var. *nigripes – unavailable name*
Acromyrmex muticinodus – *Acromyrmex subterraneus* var. *depressoculis*
Acromyrmex rugosus rugosus – *Acromyrmex rugosus* st. *bigener, Acromyrmex rugosus* var. *vestitus*
Acromyrmex rugosus rochai – *Acromyrmex rugosus* var. *navarroi*
Acromyrmex subterraneus brunneus – *Acromyrmex subterraneus* var. *eidmanni*
Acromyrmex subterraneus st. *molestans* – *Acromyrmex subterraneus eidmanni*
Acromyrmex subterraneus var. *peruvianus*
Apterostigma acre
Apterostigma angusutm
Apterostigma auriculatum
Apterostigma bruchi
Apterostigma carinatum
Apterostigma convexum
Apterostigma reburrum
Apterostigma robustum – *Apterostigma jubatum*
Apterostigma serratum
Apterostigma steigeri – *Apterostigma luederwaldti*
Apterostigma tholifome
Apterostigma tropicoxa
Apterostigma urichii – *Apterostigma fallax*
Atta laevigata – *Atta silvai*
Cyphomyrmex bruchi
Cyphomyrmex cornutus
Cyphomyrmex daguerrei
Cyphomyrmex flavidus – *Cyphomyrmex r. dentatus*
Cyphomyrmex kirbyi
Cyphomyrmex minutus – *Cyphomyrmex rimosus breviscapus*
Cyphomyrmex morschi
Cyphomyrmex nemei
Cyphomyrmex occultus
Cyphomyrmex olitor
Cyphomyrmex olitrix letus
Cyphomyrmex paniscus
Cyphomyrmex peltatus
Cyphomyrmex plaumanni
Cyphomyrmex rimosus rimosus – *Cyphomymrex rimosus cochunae, Cyphomyrmex rimosus venezuelanis*
Cyphomyrmex wheeleri
Mycetagroicus cerradensis
Mycetagroicus triangularis
Mycetagroicus urbanus
Mycetarotes acutus
Mycetarotes carinatus
Mycetarotes senticosus
Mycetarotes paralellus – *Atta (Mycocepurus) lüderwaldti*
Mycetophylax conformis – *Mycetophylax brittoni* var. *littoralis*
Mycetophylax cristulaus var. *emmae*
Mycetosoritis explicata
Mycocepurus curvispinosus
Mycocepurus goeldii – *Mycocepurus goeldii* st. *gentiles*
Mycocepurus smithii – *Atta (Mycocepurus) smithi* var. *borinquenensis, Atta (Mycocepurus) smithi* var. *tolteca, Atta (Mycocepurus) smithi* var. *trinidadensis, Mycocepurus bolivianus, Mycocepurus reconditus, Trachymyrmex attaxenus*
Mycocepurus tardus
Myrmicocrypta buenzli
Myrmicocrypta microphthalma
Myrmicocrypta spinosa
Myrmicocrypta urichi
Myrmicocrypta weyrauchi
Sericomyrmex amabilis
Sericomyrmex beniensis
Sericomyrmex bondari
Sericomyrmex diego
Sericomyrmex harekulli arawakensis
Sericomyrmex luederwaldti
Sericomyrmex lutzi
Sericomyrmex moreirai
Sericomyrmex scrobifer
Sericomyrmex zacapanus
Trachymyrmex agudensis
Trachymyrmex arizonensis
Trachymyrmex bugnioni – *Trachymyrmex cucumis, Trachymyrmex morgani, Trachymyrmex tucuche*
Trachymyrmex carib
Trachymyrmex compactus
Trachymyrmex cornetzi – *Trachymyrmex cornetzi* var. *bivittatus*
Trachymyrmex dichrous



Trachymyrmex diversus – *Trachymyrmex phippsi*
Trachymyrmex nogalensis
Trachymyrmex oetkeri
Trachymyrmex opulentus
Trachymyrmex papulatus
Trachymyrmex phaleratus
Trachymyrmex pruinosus spinosior
Trachymyrmex relictus
Trachymyrmex ruthae
Trachymyrmex smithi
Trachymyrmex smithi neomexicanus
Trachymyrmex tucuche
Trachymyrmex tucumanus – *Trachymyrmex (Acromyrmex) iheringi* var. *cordovanus*
Trachymyrmex tucumanus var. *weiseri*
Trachymyrmex turrifex
Trachymyrmex verrucosus
Trachymyrmex zeteki

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Myrmecology in the internet: Possibilities of information gathering

(Hymenoptera, Formicidae)

with 12 tables

Christiana Klingenberg and Manfred Verhaagh

Summary

A well advanced information system about ants exists on the internet. Many myrmecologists all over the world offer useful information as text files, images or databases. A good part of the information focuses on regional faunas and biogeographic regions, with updated species checklists and geographic distribution maps. Many internet sites deal with specific ant groups or single genera and provide dichotomous and sometimes interactive identification keys, extensive information about the biology and/or geographic distribution of the species. Text information is often illustrated with images of living or dry mounted ants. Additionally, detailed pages about anatomy, mounting of ants, colony husbandry or ant conservation (red lists) can be found. In discussion forums it is possible to exchange facts and thoughts about all myrmecological facets with other interested people. A special offer for taxonomists is the increasing number of databases about museum collections and their type catalogues.

Zusammenfassung

Für Ameisen gibt es mittlerweile ein sehr gut entwickeltes Informationssystem im Internet. Weltweit bieten zahlreiche Myrmekologen brauchbare Informationen in Form von Textbeiträgen, Bildern und Datenbanken an. Ein guter Teil der Information beschäftigt sich mit regionalen Faunen bzw. biogeographischen Regionen, z.B. in Form von Artenlisten und Verbreitungskarten. Viele Internetseiten handeln auch spezielle Ameisentaxa ab, stellen dichotome oder gar interaktive Bestimmungsschlüssel vor und offerieren ausführliche Informationen zur Biologie und Verbreitung der Arten. Die Texte werden häufig durch Bilder präparierter oder lebender Ameisen ergänzt. Es lassen sich auch detaillierte Seiten über Anatomie, Präparation, Haltung und Schutz finden. Diskussionsforen bieten die Möglichkeit, sich über alle Aspekte der Myrmekologie mit Gleichgesinnten auszutauschen. Ein wichtiges Angebot speziell für taxonomisch Interessierte ist die zunehmende Zahl von Sammlungs- und Typenlisten.

Keywords

ants, Formicidae, internet based information, database, type images

Introduction

The World Wide Web is the most dynamic information source about any given topic. Performing internet searches about "ants" in different languages, the popular search engine "Google®" presents close to 3.5 million records. But not all of the recorded internet sites are dealing in a reliable or useful manner with ants (Baroni Urbani & Andrade 2003). The aim of this publication is to give a list of major and helpful internet sites about ants within a broad spectrum of themes that, however, will be far from exhaustive.

Results

We distinguish different categories of sites, the limits, however, are often far from being sharply drawn. There are some sites that serve as kind of internet portals about ants (table 1). Beside own information, these sites offer links to other pages with many different topics. The main site in this category is "Antbase", initiated and maintained by Donat Agosti and Norman F. Johnson. It is the pilot site of the Social Insects World Wide Web (SIWeb) and aims to give all available information about ant names (via "Hymenoptera Name Server") and primary taxonomic literature (citations and full text copies); there are links to important other databases, a glossary about morphological terms and the directory of world's ants taxonomists.

The main topic of another category of highly useful internet pages is taxonomy and systematics (table 2). These pages are partly integrated into the ant portals. "Antweb" initiated by Brian Fisher of the California Academy of Sciences provides superb high resolution Automontage® images of nearly all ant genera of the world. The "Hymenoptera Name Server" offers the actual taxonomic status of any given species name with its synonymies and original descriptions, often available for download in PDF file format. In this category also fits the webpage of the "Tree of Live"-project. This site deals with phylogenetic (cladistic) relationships among all taxa on earth and also gives a short description of the natural history of the requested organism, with useful links to sites with more specific information and images.

Sites about the content of collections and type catalogues are available in growing number. Some examples are given in table 3. The homepage of the Museum of Comparative Zoology at Harvard University is a very good example because the authors provide high resolution images of deposited ant types. The German project "Digital information on ant collections in Germany and their types (FoCol)" within the GBIF-D program has the same focus (Verhaagh & Klingenberg 2004). High resolution images of the ant types in German collections and any other available information such as taxonomic status and original literature will be available on the international GBIF homepage from 2006 on.

Very important and helpful are websites with ant literature (table 4). The database "Formis" has a key function in this respect; one can search for ant literature published since 1650. Weblogs have a message board character containing also links to new publications. "Notes from Underground" is an informal ant newsletter established since three years in the internet, formerly published in paper prints. It also offers a message board.

There are many websites related to regional ant faunas (table 5). A majority of pages is dealing with the North American ant fauna. The Japanese Image Database gives detailed information about the ant fauna of each Japanese island. Similar pages are available about the ant fauna of other countries and continents, but in very different completeness. Most of these pages are providing checklists, identification keys, distribution maps, images often in excellent quality, literature, glossaries, hints for specimen preparation and link lists. In a few cases information about natural history is given, too. Outstanding in this category are the web pages of John Longino about Costa Rican ants and of Steve Shattuck about Australian ants.

For several ecologically important ant groups such as leaf cutting ants or fire ants web sites with detailed information on their natural history are available (table 6). They often include images of living ants and links to related sites.

A category of ant related web sites of growing importance deals with invasive ants (table 7). In most of the presented sites those ants are not only treated as pests in the context of human activities, but also as ants which are dangerous for the native ant fauna. Identification guides are given, often illustrated with images. Geographic distribution maps on regional level are also available in some cases. Useful information on the biology of invasive species may also be found on some sites about controlling pest ants. But we made no attempt to check the very high number of websites that deal with pest ant control.

There are a few web sites about endangered ants (table 8). The IUCN red list is also linked to antbase.org. The German "Ameisenschutzwarte" deals mainly with *Formica* spp. and provides information about activities in red wood ant conservation and literature, and maintains a discussion forum.

Glossaries are helpful especially for beginners in myrmecology (table 9). At some of the web sites related to regional ant fauna and internet portals (e.g. "Antbase") glossaries are given. Two other sites listed here not only give a list of explained terms, but the main structures are illustrated and detailed descriptions of each structure with links to the main morphological complex are given.

URLs to images of mounted and living ants are given in table 10. To our opinion the web page of Alex Wild "myrmecos.net" shows the best images of living ants we have seen in the web. The superb pictures of mounted specimens of all ant genera at "Antweb" have already been mentioned above under the taxonomic category. The Australian Ant Image Database is actually a subsite of the Japanese Ant Image Database. Both sites provide very good images of mounted and living ants. Many other pages, especially on sites of regional ant fauna (see above) also provide images of ants in high resolution quality.

For people who like to maintain living colonies at home or under laboratory conditions useful hints are given on the sites listed in table 11. Discussion forums about ant husbandry are available, too. The ecological risks for the environment and the native fauna in the case that exotic ant species escape from captivity should be kept in mind (Buschinger 2004). Serious precautions against escapement should accompany any rearing of exotic ant species that nevertheless should be restricted to responsible scientific investigations.

Discussion forums in different languages are the last category of our ant related web sites (table 12). There is more than one discussion forum in German. Links to them can be found on other sites, such as "Ameisenschutzwarte" or "Ameisenhaltung".

Conclusion

The links presented here are only a small subset of all available web sites which deal with ants. We have chosen these sites, because they seem to be maintained regularly and all URLs have been verified by us. Many of these sites hold links to other sites and bear more information than we have commented.

It became evident that most web sites are maintained by US-American colleagues, or at least with support of them. European or German web sites about ants with comparative quality are still quite rare.

A difference to printed information is that web sites are more or less always under construction and sometimes not available (there are also many "dead" links). The contributions are not peer-reviewed – except for information copied from peer-reviewed texts. Thus, one should be ready to read really silly ideas like "Preventive measures [against ants]: Destroy all Hymenoptera´s nests around your home" (from the site "Poisonous animals and plants – Ants"; http://library.thinkquest.org/C007974/2_4ant.htm) Internet sites offer today only a small part of all the information available on ants. They cannot replace traditional information sources as already stated by BARONI URBANI & ANDRADE (2003) but can complement them to growing extent.

Acknowledgement

We thank Jochen Bihn for critical reading of the manuscript and the hint to the link "Poisonous animals and plants".

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After submission of our paper the following publication appeared which offers few additional web resources about ants: NASH, D. R. 2005: Web resources for myrmecologists. - Myrmecologische Nachrichten 7: 95-102.

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Tab. 1: Internet portals and general information on ants

URL	site title	content
http://antbase.org	Antbase	Is the pilot site of the Social Insects World Wide Web (SIWeb) and aims to give all available information about ant names (via Hymenoptera Name Server) and primary taxonomic literature (citations and full text copies); links included to ground living ant database, to a distribution database, to red lists and the extensive literature database FORMIS; contents a term glossary and the directory of world's ants taxonomists.
http://www.myrmecology.info/portal/news.php	Myrmecology Portal	Provides links to the main web pages about ants and is directly linked to the Hymenopter Name Server; ant discussion forum; books about ants available at Amazon and other book sellers. Search engine "ant dig". For full access to register.
http://ant.edb.miyakyo-u.ac.jp/	Japanese Ant Image Database and World Ant Link	Since 1995 online. Introduction to myrmecology, gives a world distribution map of ant genera, links to Australian ant image database, Hymenoptera Name Server, FORMIS literature database, Australian ants online etc.
http://www.discoverlife.org/nh/tx/Insecta/Hymenoptera/Formicidae/	Discover Life	Gives check lists of world ant genera and species lists of a number of countries in America, Asia and Africa; interactive identification guides for a number of countries, information about invasive ants and leafcutter ants with geographic distribution maps; ant images with Automontage® software.

Tab. 2: Ant taxonomy and systematics

URL	site title	content
http://iris.biosci.ohio-state.edu/hymenoptera/hym_db_form.html	Hymenoptera Online Database	Gives information about ant taxa and other Hymenoptera taxa including their "parent" and "children" taxa, provides literature, images, maps and links to other databases if available.
http://atbi.biosci.ohio-state.edu/	Hymenoptera Name Server	Gives all information about taxonomy and systematics about ants, with synonymies, links to original descriptions with pdf-documents for download. Is directly linked with the Hymenoptera Online Database.
http://tolweb.org/tree?group=Formicidae&contgroup=Vespoidea	Tree of Life	Presents phylogenetic relationships between ants themselves and other insects groups. Images of living ants and references are given.
http://www.cs.unc.edu/~hedlund/ants/catalog/BoltonUpdates.html	Update to Boltons Ant Catalog	Taxonomic updates to Bolton, B. (1995): A new general catalogue of the ants of the world - Harvard University Press.
http://www.antweb.org/index.jsp	Antweb	Provides high resolution Automontage® images of all ant genera of the world.

Tab. 3: Ant collections and type catalogues

URL	site title	content
http://mcz-28168.oeb.harvard.edu/mcz/FMPro?-db=Species.fm&-lay=web&-format=search.htm&-view	Museum of Comparative Zoology, Type Database	Provides Automontage® images of type specimens deposited at the Museum of Comparative Zoology Harvard.
http://ant.edb.miyakyo-u.ac.jp/E/GUIDE/TYPES.HTM	Type specimen of Japanese ants	Links to type specimen of Japanese ants in the MCZ of Harvard University and the Smith Collection in the Natural History Museum London.
http://www.calacademy.org/research/entomology/types/insecta/hymenop/formicid.htm	California Academy of Sciences, Formicidae type collection	Provides a list of ant types deposited at California Academy of Sciences.
http://iris.biosci.ohio-state.edu/types/hyms/formicid.html	Ohio State University, primary types of Formicidae	Provides a list of ant types deposited at Ohio State University.
http://insects.ummz.lsa.umich.edu/species_lists/Formicidae.html	University of Michigan, Formicidae in the UMMZ insect division	Provides a list of ant species deposited at University of Michigan.
http://www.zsm.mwn.de/hym/ressources.htm	Zoologische Staatssammlung München Online Resourcen der Sektion Hymenoptera	Provides a list of ant species and ant types deposited at Zoologische Staatssammlung München.
http://www.gbif.org/	GBIF	Provides taxonomic information about organisms in zoological and botanical institutions, often with images.

Tab. 4: Literature on ants

URL	site title	content
http://cmave.usda.ufl.edu/~formis/	Formis	Extensive ant bibliography data base with last update 2003. Literature data base is for download and can be opened with Endnote.
http://www.oegef.at/	Myrmecological News/ Österreichische Gesellschaft für Entomofaunistik	Registered Online-Journal about myrmecology. Paper reprints available.
http://www.notesfromunderground.org/	Notes from Underground	Online-Journal about myrmecology, but no ISSN. Message board.
http://pogonomyrmex.blogspot.com/	Ant News	Weblog, different kind of ant notes, often with links to research articles.

Tab. 5: Information on regional ant faunas

URL	region	checklist	identification key/taxonomy	distribution maps	literature	natural history	images	glossary morphology	collection guide/specimen preparation	links	observations
http://www.antweb.org/	USA (Arizona, Califonia, Florida, Louisiana), Mexico (Baja California), Madagascar	+		+			+ (Automontage)				combines distribution maps with Google Earth
http://www.antdata.org/	USA	+								+	
http://www.cs.unc.edu/~hedlund/ants/catalog/index.html	USA	+		+	+	+	+				
http://www.desertants.org/	USA		+			+		+			still under construction
http://www.tightloop.com/ants/	USA (Arizona)	+				+	+			+	

URL	region	check-list	identi-fication key/taxo-nomy	distribu-tion maps	litera-ture	natu-ral his-tory	images	glossary morpho-logy	collection guide/speci-men prepa-ration	links	observations
http://www.msstate.edu/org/mississippientmuseum/Researchtaxapages/Formicidaehome.html	USA (Missisipi and Alabama)	+	+				+	+		+	Discover Lifeimages
http://www.acad.carleton.edu/curricular/BIOL/resources/ant/	USA (Cowling Arboretum & McKnight Prarie)	+	+	+	+		+		+	+	
http://insects.ummz.lsa.umich.edu/fauna/MICHANTS.html	USA (Michigan)	+									
http://www.sunfoundation.org/prod/Reference/antsSunFoundation.asp	USA (Sun Foundation, Illinois)	+			+	+	+ (REM pictures)				
http://www.npwrc.usgs.gov/resource/1999/ants/ants.htm	USA (Tallgrass Prairie)	+	+		+	+					
http://www.utep.edu/leb/antgenera.htm	North, Central and South America		+	+ (in the keys)	+		+ (in the keys)			+	keys in MS Word format for download
http://faculty-staff.ou.edu/K/Michael.E.Kaspari-1/K/Michael.E.Kaspari-1/bcnm_ants_home.htm	North and Central America (Barro Colorado, Panama)	+					+			+	

URL	region	check-list	identification key/taxonomy	distribution maps	literature	natural history	images	glossary morphology	collection guide/specimen preparation	links	observations
http://www.naturalsciences.be/cb/ants/projects/ibisca_ants.htm	Panama				+	+	+ (videos)				Ibisca-project site about insect diversity in Panamanian rain forest
http://www.evergreen.edu/ants/AntsofCostaRica.html	Costa Rica	+	+		+	+	+		+	+	
http://www.bdt.fat.org.br/zoologia/formiga/index.html	Brazil				+				+	+	still under construction
http://antbase.org/ants/africa/	Africa	+	+	+	+		+				
http://www.museums.org.za/bio/ants/#Classification	South-Africa		+								
http://www.ento.csiro.au/science/ants/default.htm	Australia	+	+	+	+	+	+ (REM-images	+	+		
http://ant.edb.miyakyo-u.ac.jp/AZ/index.html	Australia	+			+		+				
http://ant.edb.miyakyo-u.ac.jp/E/index.html	Japan	+	+	+	+	+	+	+		+	
http://www.hormigas.org/	Spain	+	+		+	+		+		+	

URL	region	check-list	identification key/taxonomy	distribution maps	literature	natural history	images	glossary morphology	collection guide/specimen preparation	links	observations
http://www.agr.hr/hed/hrv/ento/inventar/formica.htm	Croatia	+ (genera)			+						
http://www.antnest.co.uk/	United Kingdom	+	+			+	+	+		+	with introduction to myrmecology
http://www.anthill.org.uk/index.htm	United Kingdom					+	+			+	with introduction to myrmecology
http://perso.wanadoo.fr/jean-yves.bichaton/ecran.htm	France	+		+	+	+					
http://www.antbase.de/	Germany, Borneo, Malaysia, Mongolia	+			+		+				

Tab. 6: Special ant groups

URL	ant group	content
http://entomology.ucdavis.edu/faculty/ward/pseudo.html	Subfamily Pseudomyrmecinae	Taxonomy, identification guides, Automontage® images, phylogeny, natural history.
http://www.blueboard.com/leafcutters/	Leafcutter ants (Attini)	Natural history, image gallery, related publications for download as pdf, link to Attini researchers.
http://www.armyants.org/	New World army ants (Ecitoninae)	Identification key, images, taxonomy, distribution maps, natural history.
http://www.projectlinks.org/ants/	Carpenter ants (*Camponotus*)	Link list to *Camponotus* web pages.

URL	ant group	content
http://www.allabouthome.com/tips/pests/carpenter_ants.html#Anchor-Reinfestation-59546	Carpenter ants (*Camponotus*)	Commercial website about *Camponotus*, treating these ants only like house invading ants and pest.
http://fireant.tamu.edu/index.html	Fire ants (*Solenopsis*)	Natural history, identification, habitat and impact of fire ants, distribution maps.
http://fireant.ifas.ufl.edu/	Fire ants (*Solenopsis*)	Site of the US-Department of Agriculture in Florida reporting on projects for areawide fire ant suppression.
http://msa.ars.usda.gov/ms/stoneville/bcpru/bcpruhome_001.htm	Fire ants (*Solenopsis*)	Natural history, link to research institutions.
http://www.ento.okstate.edu/fireants/fireants.html	Fire ants (*Solenopsis*)	Site offers links to recent research projects at the Oklahoma State University, gives general information about fire ants, image gallery, links to related web sites.
http://ipmworld.umn.edu/chapters/lockley.htm	Fire ants (*Solenopsis*)	Offers information about history, biology and control.
http://www.bluesquaregroup.de/projekte/ameisen/index.html	Red wood ants (*Formica*)	Experiments to investigate strength of wood ants.
http://www.natur-lexikon.com/Texte/MZ/001/00071-Ameise/MZ00071-Waldameise.html	Red wood ants (*Formica*)	Image gallery with information about natural history.
http://www.wald.gr.ch/download/ameise.pdf	Red wood ants (*Formica*)	Downloadable newsletter about *Formica*.
http://www.bursztyn.px.pl/b_systematyka/formicidae.html	Ants in amber	Image gallery and identification guide.

Tab. 7: Invasive ants and control

URL	region	content
http://home.sandiego.edu/~tmcglynn/exotic.htm	worldwide	Distribution maps, natural history, information about native locality and non-native habitats.
http://www.extento.hawaii.edu/kbase/urban/type/antsmenu.htm	USA (Hawaii) and worldwide	Information about natural history, damage and control.
http://www.hear.org/AlienSpecies InHawaii/ants/index.html	USA (Hawaii)	Image gallery, distribution, control and identification key.

URL	region	content
http://www.forestandbird.org.nz/biosecurity/argentineants.asp	New Zealand	Information about *Linepithema humile* (argentine ant) in New Zealand.
http://ohioline.osu.edu/hyg-fact/2000/2064.html	USA	Description of the most common invasive ants.
http://lancaster.unl.edu/enviro/pest/factsheets/003-97.htm	USA	Description of (invasive) pest ants and control.
http://doyourownpestcontrol.com/antask.htm	USA	Commercial site about (invasive) ant control.
http://www.pestproducts.com/antindex.htm	USA	(Invasive) ant lists, description of damage and control.

Tab. 8: Red lists and protection of ants

URL	content
http://www.redlist.org	International red list of the IUCN.
http://www.naturschutz-planung.de/html/tiere/391ameisen.html	Ants as possible bioindicators in German environment projects.
http://www.ameisenschutzwarte.de/	German web page about ant protection, especially *Formica* ants, with links to related pages.

Tab. 9: Glossaries of ant morphology

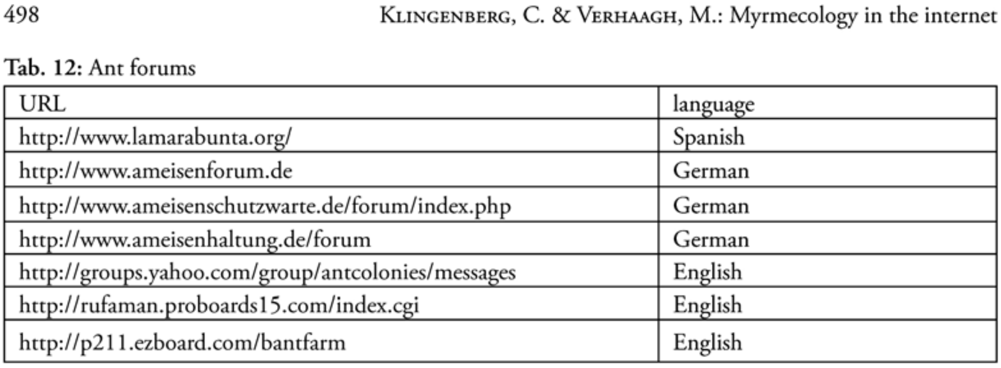
URL	content
http://antbase.org/databases/glossary_files/glossary_A.htm	A glossary of entomological terms based on Torre Bueno's Glossary, from which all terms relevant to ants, wasps, bees and termites were extracted.
http://flrec.ifas.ufl.edu/entomo/ants/ant_anatomy.htm	Ant anatomy illustrated with photographs.
http://jlibsch.web.wesleyan.edu/Ant/Morphology/index.html	Ant anatomy illustrated with photographs.

Tab. 10: Ant images

URL	content
http://www.myrmecos.net/	Fabulous images of living ants.
http://www.antweb.org/index.jsp	Provides excellent high resolution Automontage® images of all ant genera of the world.
http://ant.edb.miyakyo-u.ac.jp/E/index.html	Japanese ant image database with much other information.
http://ant.edb.miyakyo-u.ac.jp/AZ/index.html	Australian ant image database, with checklists and bibliography.

Tab. 11: Ant husbandry

URL	content
http://www.zooscape.com/cgi-bin/maitred/ZooRide?fountainhead=yellow&zooride=ant+farm&r=01	Commercial site for ant farms and related toys.
http://www.antcolony.org/index.htm	Rearing and exhibiton of ants, casts of ant nests, many links to other parts of myrmecology.
http://www.antnest.co.uk/index.html	Instructions for ant keeping and ant colony dietary, images.
http://home.tiscalinet.ch/tao/Gipsnest.htm	Instruction for building artificial plaster ant nests and maintaining the colonies.
http://www.sasionline.org/antsfiles/pages/dino/dinobio.html	Husbandry of *Dinoponera* ants.
http://www.ameisenhaltung.de/	Information and German discussion forum about ant husbandry.
http://www.fourmis.org/	French web site about ant husbandry.
http://www.antsalive.com	Living harvester ants and supply for ant keeping.
http://shop.apocrita.de/	Living ant colonies and supply for ant keeping.
http://www.antstore.net	Living ant colonies and supply for ant keeping.
http://www.antsnature.de/catalog/	Living ant colonies and supply for ant keeping.



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Tab. 12: Ant forums

URL	language
http://www.lamarabunta.org/	Spanish
http://www.ameisenforum.de	German
http://www.ameisenschutzwarte.de/forum/index.php	German
http://www.ameisenhaltung.de/forum	German
http://groups.yahoo.com/group/antcolonies/messages	English
http://rufaman.proboards15.com/index.cgi	English
http://p211.ezboard.com/bantfarm	English

Lebenslauf

Christiana Klingenberg

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Geboren am 21. Mai 1972 in Esslingen am Neckar
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1978 – 1982	Justinus-Kerner-Schule in Ruit auf den Fildern, Ostfildern 1
1982	Heinrich-Heine-Gymnasium in Nellingen, Ostfildern 2
1982 – 1984	Städtisches Gymnasium Oerlinghausen
1984 – 1991	Felix-Fechenbach-Gesamtschule Leopoldshöhe, Abitur

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1992 – 1994	im Sozialwerk „Obra Social Nossa Senhora da Glória, Fazenda da Esperança", Brasilien

Studium

1994 – 2000	Studium der Biologie (Diplom) an der Eberhard-Karls-Universität Tübingen,
1997 – 1998	Internationaler Studentenaustausch mit der Universidade de São Paulo, Brasilien, gefördert durch ein IAS-Stipendium des DAAD
2000	Diplom-Biologin, Diplomarbeit über Sammel-Präferenzen von Blattschneider-Ameisen, insbesondere für Araukarien-Nadeln. Im Reservat Pró-Mata und an der UNESP Botucatu im Staat São Paulo Betreuer Prof. Dr. Wolf Engels und Prof. Dr.Luis Carlos Forti
seit 2000	Doktorandin an der Eberhard-Karls-Universität Tübingen und der Universidade de São Paulo im Rahmen des Partnerschaftsabkommens, Betreuer Prof. Dr. Wolf Engels (Tübingen) und Prof. Dr. Carlos Roberto Ferreira Brandão (Brasilien)
2001 - 2002	Stipendiatin der „Coordenação de Aperfeiçoamento de Pessoal de Nível Superior" (CAPES, Brasilien)
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2004 – 2005	wissenschaftliche Angestellte am Staatlichen Museum für Naturkunde Karlsruhe in der Abteilung Entomologie