

Type material of Platyhelminthes (Monogenoidea) housed in the Helminthological Collection of the Oswaldo Cruz Institute/ FIOCRUZ (CHIOC), Rio de Janeiro, Brazil, from 1979 to 2016

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Abstract

A catalogue of type material of monogenoids deposited in the Helminthological Collection of the Oswaldo Cruz Institute, FIOCRUZ (CHIOC), between 1979 and 2016, is presented, given that the last list of types was produced in 1979. The monogenoid collection comprises type lots for 203 species, distributed across 14 families and 68 genera. Specific names are listed systematically, followed by type host, infection site, type locality, specimens with the collection numbers and references. The classification and the nomenclature of the species have been updated.

Keywords

Catalogue, helminths, holotype, monogenoids, paratype

Introduction

Natural history collections provide important documentary evidence of biodiversity and the information that they contain is very useful. In the case of helminthological collections, the specimens acquired have been a source not only for knowledge of helminth biodiversity, but also for parasitological studies on taxonomy, systematics and identification of causes of zoonoses. The century-old Helminthological Collection of the Oswaldo Cruz Institute, FIOCRUZ (CHIOC), Rio de Janeiro, Brazil, contains helminths that form part of the fauna of Brazil and other countries, from a wide range of hosts that were caught in different biomes. The samples are holotypes, paratypes and representative specimens of Platyhelminthes (Trematoda, Cestoda and Monogenoidea), Acanthocephala, Nematoda and other non-helminth phyla, such as Annelida and Arthropoda. Recently, a large number of species of Monogenoidea were deposited in the CHIOC, which reflects the increased number of taxonomists working on this group in Brazil.

History and composition of the collection

The CHIOC celebrated its centenary in 2013. Its history is intertwined with that of the Laboratory of Helminth Parasites of Vertebrates of the Oswaldo Cruz Institute (LHPV–IOC), which began with the fieldwork of Gomes de Faria and his student Lauro Travassos (Faria and Travassos 1913). The Collection also received important contributions from other researchers at that time and, since then, it has increased in size through incorporation of private and institutional collections of the late nineteenth and early twentieth centuries (Noronha 2004, Noronha et al. 2004, 2009).

Today, the CHIOC holds around 38.400 samples of helminth parasites from South America and other continents. It is the biggest collection in Latin America and it is among the largest collections at a worldwide reference level (Rego 1982, Knoff et al. 2010), not only because of the number of types, but also because of the number of representative specimens (vouchers) that it contains. The collection has been constantly expanding through the large numbers of deposits made by Brazilian and foreign researchers. Some samples of arthropods (mainly pentastomids) and annelids (parasitic leeches) have also been accepted for inclusion in the collection, thus expanding its original nature of focusing on helminthological parasites of vertebrates, and resulting in a diversified parasitological collection.

All the material is organized according to the lots, which are numbered, recorded in an entry book, and digitized into a database. They are maintained in modern steel sliding closets and in a freezer that maintains some specimens and eggs of *Schistosoma mansoni* Sambon, 1907 (Trematoda) at -30 °C. Most of the information on the sample collections is available on the CHIOC web page (<http://chioc.fiocruz.br/>) and through the *speciesLink* network of the Environmental Information Reference Center (CRIA). Deposits and loans of specimens, permission for visits to examine samples *in loco*,

loans of books and reprints, mini-courses and lectures focusing on the history of the CHIOC, and professional capacitation courses are included among the facilities of this Collection.

The first and only catalogue of the type material held in the CHIOC was published by Rego et al. (1979). They recorded 719 types (only holotypes or type series) of helminths, including 408 of nematodes, 227 of trematodes (Digenea and Monogenoidea), 52 of acanthocephalans, 28 of cestodes and four of pentastomids. Subsequent to this publication, the collection has grown substantially and the number of types has increased significantly as well. The purpose of this article is to inform the scientific community about the acquisitions of the CHIOC by publishing a catalogue of types deposited up to August 1, 2016. Because of the large number of types, we are starting with the species of Monogenoidea. We have followed the articles 73–75 of the Code (ICZN 1999).

Material and methods

The specimens are stored in glass or plastic vials in 70% ethanol or as microscope slide preparations. All the material is available for consultation, but holotypes are not loaned. Unless otherwise stated, all type material is in good condition.

The catalogue is arranged taxonomically as subclasses, families, genera and species, under the original spelling and combinations. Subclasses are arranged following phylogenetic order. Families, genera and species are arranged alphabetically. The information on each entry is presented in the following format:

1. Original genus-species combination with author(s) and year of publication. Asterisk (*) denotes the type species of the genus.
2. Type host: species, author(s) and principal taxonomic group in brackets.
3. Infestation or infection site in the host.
4. Type locality: country, province or state, department, specific locality and coordinates (if available).
5. Primary type status: CHIOC catalogue number. The categories for the types used followed articles 73–75 of the Code (ICZN 1999).
6. Remark sections are inserted when necessary and include additional information about host, locality or status of the types.
7. References include publications in which the species was described and those that mention type specimens in the CHIOC.

The valid names adopted for parasitized hosts follow the most recent bibliography. Fish names are present in accordance with Froese and Pauly (2016) and turtle names, in accordance with Fritz and Havaš (2007, 2013). Mention of the monogenoids and host species in this list does not imply that the authors of the present report agree with their validity or taxonomy. Some monogenoids species catalogued have been

synonymized and the comments about their taxonomy are in the Remarks sections. The higher classification of Monogenoidea follows Boeger and Kritsky (1993), and for families and genera follows specific references.

The following abbreviations are used in the text:

AHC SAMA	Australian Helminthological Collection of the South Australian Museum, North Terrace, Adelaide, Australia;
BMNH	British Museum of Natural History, Collection at the Department of Zoology, Natural History Museum, London, England;
CHIOC	Helminthological Collection of the Oswaldo Cruz Institute, FIOCRUZ, Rio de Janeiro, Brazil;
CHMLP	Helminthological Collection of the Museum of La Plata, La Plata, Buenos Aires, Argentina;
CNHE	National Collection of Helminths, Institute of Biology, National Autonomous University of Mexico, Mexico City, Mexico;
HWML	Harold W. Manter Laboratory, University of Nebraska State Museum, Lincoln, Nebraska, USA;
INPA	National Institute for Amazon Research, Manaus, Amazonas, Brazil;
IPCAS/IPCR/ASCR	Institute of Parasitology, Academy of Sciences of the Czech Republic, České Budějovice, Czech Republic;
MNHN	National Museum of Natural History, Paris, France;
MPEG	Invertebrate Collection of the Emílio Goeldi Museum, Belém, Pará, Brazil;
MPM	Meguro Parasitological Museum, Meguro-ku, Tokyo, Japan;
MZUSP	Helminthological Collection of the Zoology Museum, University of São Paulo, São Paulo, Brazil;
PC–IBPRAS	Parasitological Collection of the Institute of Biology and Pedology, Russian Academy of Sciences, Vladivostok, Russia;
QM	Queensland Museum, Brisbane, Queensland, Australia;
UNICAMP	Collection of the Natural History Museum of the University of Campinas, Campinas, São Paulo, Brazil;
USNM	United States National Museum, Beltsville, Maryland, USA;
USNPC	United States National Parasitological Collection, Beltsville, Maryland, USA;
ZIAC	Zoological Institute of the Russian Academy of Sciences, Saint Petersburg, Russia.

Results and discussion

This database and bibliographic survey presents the diversity of Monogenoidea types in CHIOC, from Brazil and other countries in the world, covering more than 35 years of parasitological studies. This catalogue is the second list of type species held in

this Collection. The only previous checklist recorded only 11 type species of monogenoids, without considering paratypes (Rego et al. 1979). Now, there is a total of approximately 1100 primary types of Monogenoidea, represented by 203 species distributed across 14 families and 68 genera. Dactylogyridae is the most representative family, with 141 species, followed by Gyrodactylidae, with 29. These numbers illustrate the importance of the parasitological collection of the CHIOC, which is among the most significant in Latin America, together with other collections in Mexico and Argentina (Lamothe-Argumedo et al. 2010, Tablado and Tricárico 2010, Lunaschi et al. 2012).

It was observed that 93% of the type species of monogenoids catalogued in this Collection were parasites of bony fish. Only 12 species were parasites of cartilaginous fishes (Potamotrigonidae) and two monogenoids were parasites of turtles (Kinosternidae and Chelidae). All those samples were collected mainly in Brazil (95%), from all regions of this country. This situation could be a reflection of the large number of studies carried out on fish from Brazilian rivers and the Atlantic Ocean, and especially, of the increase in knowledge of monogenoids in Brazil that has been achieved since the late 1960s (Cohen et al. 2013).

List of type species

Phylum Platyhelminthes Gegenbaur, 1859

Class Monogenoidea Bychowsky, 1937

Subclass Polyonchoinea Bychowsky, 1937

Capsalidae Baird, 1853

Caballerocotyla Price, 1960

Caballerocotyla lenti Mogrovejo & Santos, 2002

Type host. *Auxis thazard* (Lacépède, 1800) (Osteichthyes: Scombridae).

Infection site. Gills.

Type locality. Brazil, coastal zone of Rio de Janeiro State (22°55'S, 40°18'W).

Holotype. CHIOC 34938.

Paratypes. CHIOC 34939, 34940, 34941.

Remarks. The species is referred to as *Caballerocotyla magronum* (Ishii, 1936) by Cohen et al. (2013). Gibson and Bray (2016) consider the species to be a synonym of *Capsala magronum* (Ishii, 1936).

References. Mogrovejo and Santos (2002), Gibson and Bray (2016).

Caballerocotyla llewelyni Kohn & Justo, 2006

Type host. *Katsuwonus pelamis* (Linnaeus, 1758) (Osteichthyes: Scombridae).

Infection site. Gills.

Type locality. Brazil, coastal zone of Rio de Janeiro State (22°55'S, 40°18'W).

Holotype. CHIOC 36611 a.

Paratype. CHIOC 36611 b.

Remarks. The species is referred to as *Caballerocotyla katsuwoni* (Ishii, 1936) by Cohen et al. (2013). Gibson and Bray (2016) consider the species to be a synonym of *Capsala katsuwoni* (Ishii, 1936).

References. Kohn and Justo (2006), Gibson and Bray (2016).

Encotylabe Diesing, 1850

Encotyllabe souzalimae Carvalho & Luque, 2012

Type host. *Trichiurus lepturus* (Linnaeus, 1758) (Osteichthyes: Trichiuridae).

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Guanabara Bay (23°1'52"S, 43°11'56"W).

Holotype. CHIOC 37382.

Paratypes. CHIOC 37383, 37384, 37385.

Reference. Carvalho and Luque (2012).

Nasicola Yamaguti, 1968

Nasicola brasiliensis Kohn, Baptista-Farias, Santos & Gibson, 2004

Type host. *Thunnus obesus* (Lowe, 1839) (Osteichthyes: Scombridae).

Infection site. Nasal cavities.

Type locality. Brazil, Rio de Janeiro State, off Cabo Frio (22°52'46"S, 42°01'07"W).

Holotype. CHIOC 34924 a.

Paratypes. CHIOC 34924 b, 34925 a–b, 34935.

Remarks. Other paratypes deposited in the BMNH collection.

Reference. Kohn et al. (2004).

Sprostoniella Bychowsky & Nagibina, 1967

Sprostoniella micrancyra Cezar, Luque & Amato, 1999

Type host. *Chaetodipterus faber* (Broussonet, 1782) (Osteichthyes: Ephippidae).

Infection site. Gills.

Type locality. Brazil, coastal zone of Rio de Janeiro State (21–23°S, 41–45°W).

Holotype. CHIOC 34000 a.

Paratypes. CHIOC 34000 b–d.

Remarks. Other paratype deposited in CNHE.

Reference. Cezar et al. (1999).

Dactylogyridae Bychowsky, 1933

***Ameloblastella* Kritsky, Mendoza-Franco & Scholz, 2000**

***Ameloblastella paranaensis* (França, Isaac, Pavanelli & Takemoto, 2003) Mendoza-Franco & Scholz, 2009**

Type host. *Iheringichthys labrosus* (Lütken, 1874) (Osteichthyes: Pimelodidae).

Infection site. Gills.

Type locality. Brazil, upper Paraná River floodplain (22°43'S, 53°10'W).

Holotype. CHIOC 34598 a.

Paratypes. CHIOC 34598 b, 34588 a–d.

Remarks. Material deposited as *Pseudovancleaveus paranaensis*. Mendoza-Franco and Scholz (2009) transferred *Pseudovancleaveus* to *Ameloblastella*.

References. França et al. (2003), Mendoza-Franco and Scholz (2009), Monteiro et al. (2010a).

***Anacanthoroides* Kritsky & Thatcher, 1976**

***Anacanthoroides sanctifrancisci* Monteiro & Brasil-Sato, 2014**

Type host. *Prochilodus argenteus* Spix & Agassiz, 1829 (Osteichthyes: Prochilodontidae).

Infection site. Gill filaments.

Type locality. Brazil, Minas Gerais State, São Francisco River near Três Marias Reservoir (18°12'32"S, 45°14'41"W).

Holotype. CHIOC 37914.

Paratypes. CHIOC 37915, 37916 a–b, 37917, 37918 a–c, 37919, 37920 a–b.

Reference. Monteiro and Brasil-Sato (2014a).

***Anacanthorus* Mizelle & Price, 1965**

***Anacanthorus acuminatus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus angulatus* (Spix & Agassiz, 1829) (Osteichthyes: Triportheidae).

Infection site. Gills.

Type locality. Brazil, Amazonas State, Furo do Catalão near Manaus.

Paratype. CHIOC 33369.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus adkruidenieri* Monteiro, Cohen & Brasil-Sato, 2015**

Type host. *Salminus franciscanus* Lima & Britski, 2007 (Osteichthyes: Bryconidae).

Infection site. Gills.

Type locality. Brazil, Minas Gerais State, São Francisco River near Três Marias Reservoir (18°12'32"S, 45°15'41"W).

Holotype. CHIOC 38018 a.

Paratypes. CHIOC 38017 a–b, 38018 b–e, 38019 a–d, 38020 a–d

Reference. Monteiro et al. (2015).

***Anacanthorus alatus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus albus* Cope, 1872

Infection site. Gills.

Type locality. Brazil, Amazonas State, Furo do Catalão near Manaus.

Paratype. CHIOC 33365.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus amazonicus* Van Every & Kristky, 1992**

Type host. *Serrasalmus rhombeus* (Linnaeus, 1766) (Osteichthyes: Serrasalminidae).

Infection site. Gills.

Type locality. Brazil, Amazonas State, Água Branca stream, Pitinga River.

Paratypes. CHIOC 33389 a–b.

Remarks. Specimens from CHIOC collected in the Uatamã River. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kristky (1992).

***Anacanthorus bellus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus albus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Furo do Catalão near Manaus.

Paratype. CHIOC 33366.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus bicuspidatus* Cohen, Kohn & Boeger, 2012**

Type host. *Salminus brasiliensis* (Cuvier, 1816)

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River, below and above of the reservoir of Itaipu Hydroelectric Power Station, in the locality of Guaíra (24°04'48"S, 54°15'21"W).

Holotype. CHIOC 37595.

Paratypes. CHIOC 37587, 37588, 37598 a–b, 37600, 37604, 37612, 37613, 37623, 37631, 37722, 37730.

Reference. Cohen et al. (2012).

***Anacanthorus brevicirrus* Monteiro, Kritsky & Brasil-Sato, 2010**

Type host. *Brycon orthotaenia* (Günther, 1864) (Osteichthyes: Bryconidae).

Infection site. Gills.

Type locality. Brazil, Minas Gerais State, São Francisco River near Três Marias Reservoir (18°12'32"S, 45°15'41"W).

Holotype. CHIOC 37333 a.

Paratypes. CHIOC 37333 b–c, 37334.

Remarks. Other paratypes deposited in the collections of INPA, IPCAS and USNM.

Reference. Monteiro et al. (2010b).

***Anacanthorus calophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus elongatus* (Günther, 1864)

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratype. CHIOC 33377.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus carinatus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus angulatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Paratype. CHIOC 33370.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus catoprioni* Kristky, Boeger & Van Every, 1992**

Type host. *Catoprion mento* (Cuvier, 1819) (Osteichthyes: Serrasalminidae).

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, Balbina.

Paratype. CHIOC 33383.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus chelophorus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus angulatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Paratype. CHIOC 33371.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus cinctus* Van Every & Kristky, 1992**

Type host. *Pristobrycon striolatus* (Steindachner, 1908)

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, Samaumã Lake.

Paratypes. CHIOC 33605 a–b.

Remarks. Specimens deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kritsky (1992).

***Anacanthorus cladophallus* Van Every & Kristky, 1992**

Type host. *Serrasalmus spilopleura* Kner, 1858

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratypes. CHIOC 33393 a–b.

Remarks. Specimens deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kritsky (1992).

***Anacanthorus contortus* Cohen, Kohn & Boeger, 2012**

Type host. *Salminus brasiliensis*

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River, below and above of the reservoir of Itaipu Hydroelectric Power Station, Guaíra (24°04'48"S, 54°15'21"W).

Holotype. CHIOC 37662 a.

Paratypes. CHIOC 37583, 37601 a–c, 37605, 37615, 37620 a–b, 37621 a–b, 37626, 37632, 37660 a–c, 37662 b, 37705, 37706, 37707, 37714, 37716, 37718 a–b, 37721, 37724, 37727 a–b, 37729.

Reference. Cohen et al. (2012).

***Anacanthorus cornutus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus angulatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Paratype. CHIOC 33372.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus crytocaulus* Van Every & Kristky, 1992**

Type host. *Pristobrycon striolatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, Samaumã Lake.

Paratypes. CHIOC 33606 a–b.

Remarks. Specimens deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kritsky (1992).

***Anacanthorus daulometrus* Cohen, Kohn & Boeger, 2012**

Type host. *Salminus brasiliensis*

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River, below and above of the reservoir of Itaipu Hydroelectric Power Station, Guaíra (24°04'48"S, 54°15'21"W).

Holotype. CHIOC 37681.

Paratypes. CHIOC 37596, 37602, 37614, 37630, 37636, 37641, 37659, 37663, 37666 a–c, 37668, 37671, 37683, 37684, 37709 a–b, 37711 a–c, 37713 a–b, 37717, 37726, 37728.

Reference. Cohen et al. (2012).

***Anacanthorus dipelecinus* Kristky, Boeger & Van Every, 1992**

Type host. *Roeboides myersii* Gill, 1870 (Osteichthyes: Characidae).

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratype. CHIOC 33600.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus douradensis* Cohen, Kohn & Boeger, 2012**

Type host. *Salminus brasiliensis*

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River, below and above of the reservoir of Itaipu Hydroelectric Power Station, Guaíra (24°04'48"S, 54°15'21"W).

Holotype. CHIOC 37594.

Paratypes. CHIOC 37584, 37599 a–b, 37610, 37611, 37616, 37654, 37679.

Reference. Cohen et al. (2012).

***Anacanthorus euryphallus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus angulatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Furo do Catalão near Manaus.

Paratype. CHIOC 33373.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus formosus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus elongatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Furo do Catalão near Manaus.

Paratype. CHIOC 33378.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus franciscanus* Monteiro, Kritsky & Brasil-Sato, 2010**

Type host. *Brycon orthotaenia*

Infection site. Gills.

Type locality. Brazil, Minas Gerais State, São Francisco River near Três Marias Reservoir (18°12'32"S, 45°15'41"W).

Holotype. CHIOC 37330.

Paratypes. CHIOC 37331 a–e, 37332.

Remarks. Other material deposited in the collections of INPA, IPCAS and USNM.

Reference. Monteiro et al. (2010b).

***Anacanthorus furculus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus elongatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Solimões River near Manaus.

Paratype. CHIOC 33379.

Remarks. Specimen from CHIOC collected in the Manaus Fish market. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus glyptophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus angulatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Paratype. CHIOC 33374.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kritsky et al. (1992).

***Anacanthorus gravihamulatus* Van Every & Kristky, 1992**

Type host. *Serrasalmus rhombeus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, Água Branca stream, Pitinga River.

Paratypes. CHIOC 33391 a–b.

Remarks. Specimens deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kristky (1992).

***Anacanthorus jegui* Van Every & Kristky, 1992**

Type host. *Serrasalmus rhombeus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, a tributary of Amazonas River.

Paratype. CHIOC 33390.

Remarks. Specimen from CHIOC collected in the Pitinga River, Água Branca stream (Amazonas State). Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kristky (1992).

***Anacanthorus lasiophallus* Van Every & Kristky, 1992**

Type host. *Pristobrycon striolatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Água Branca stream, Pitinga River.

Paratypes. CHIOC 33607 a–b.

Remarks. Specimens from CHIOC collected in the Samaumã Lake, Uatumã River (Amazonas State). Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kristky (1992).

***Anacanthorus lepyrophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Serrasalmus elongatus* Kner, 1858

Infection site. Gills.

Type locality. Brazil, Amazonas State, Negro River near Manaus.

Paratype. CHIOC 33385.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus mastigophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Pristobrycon eigenmanni* Norman, 1929

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, Nazaré.

Paratype. CHIOC 33602.

Remarks. Specimen from CHIOC collected in Santa Luzia, Uatumã River. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus mesocondylus* Van Every & Kristky, 1992**

Type host. *Serrasalmus elongatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratypes. CHIOC 33384 a–b.

Remarks. Specimens deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kristky (1992).

***Anacanthorus nanus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus angulatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Paratype. CHIOC 33375.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus palamophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Pristobrycon eigenmanni*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, Nazaré.

Paratype. CHIOC 33603.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus paradouradensis* Monteiro, Cohen & Brasil-Sato, 2015**

Type host. *Salminus franciscanus*

Infection site. Gills.

Type locality. Brazil, Minas Gerais State, São Francisco River near Três Marias Reservoir (18°12'32"S, 45°15'41"W).

Holotype. CHIOC 38023 a.

Paratypes. CHIOC 38021 a–d, 38022 a–c, 38023 b–d, 38024 a–d.

Reference. Monteiro et al. (2015).

***Anacanthorus parakruidenieri* Cohen, Kohn & Boeger, 2012**

Type host. *Salminus brasiliensis*

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River, below and above of the reservoir of Itaipu Hydroelectric Power Station, Guaíra (24°04'48"S, 54°15'21"W).

Holotype. CHIOC 37656.

Paratypes. CHIOC 37603 a–b, 37617, 37624, 37633 a–b, 37639, 37661 a–b, 37697.

Reference. Cohen et al. (2012).

***Anacanthorus paraspathulatus* Kristky, Boeger & Van Every, 1992**

Type host. *Mylossoma duriventre* (Cuvier, 1818) [= *Mylossoma duriventris*] (Osteichthyes: Serrasalminidae).

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratype. CHIOC 33396.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus pedanophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Myelus rubripinnis* (Müller & Troschel, 1844) [= *Myelus rubripinnus*] (Osteichthyes: Serrasalminidae).

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, Nazaré.

Paratype. CHIOC 33397.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus pelorophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus elongatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratype. CHIOC 33380.

Remarks. Specimen from CHIOC collected in the Manaus Fish market. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus penilabiatus* Boeger, Husak & Martins, 1995**

Type host. *Piaractus mesopotamicus* (Holmberg, 1887) (Osteichthyes: Serrasalminidae).

Infection site. Gills.

Type locality. Brazil, São Paulo State, Jaboticabal, Aquaculture Center of the Paulista State University.

Holotype. CHIOC 33268 a.

Paratypes. CHIOC 33268 b–j.

Remarks. Other paratypes deposited in the collections of HWML and USNM.

Reference. Boeger et al. (1995b).

***Anacanthorus periphallus* Kristky, Boeger & Van Every, 1992**

Type host. *Serrasalmus* sp.

Infection site. Gills.

Type locality. Brazil, Amazonas State, Furo do Catalão near Manaus.

Paratype. CHIOC 33395.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus pithophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus angulatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Paratype. CHIOC 33376.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus prodigiosus* Van Every & Kristky, 1992**

Type host. *Serrasalmus elongatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Negro River near Manaus.

Paratypes. CHIOC 33386 a–b.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kristky (1992).

***Anacanthorus quinqueramus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus albus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Furo do Catalão near Manaus.

Paratype. CHIOC 33367.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus ramosissimus* Van Every Boeger & Kristky, 1992**

Type host. *Serrasalmus elongatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratypes. CHIOC 33387 a–b.

Remarks. Specimens deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kristky (1992).

***Anacanthorus ramulosus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus albus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Furo do Catalão near Manaus.

Paratype. CHIOC 33368.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and

USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus scapanus* Van Every & Kristky, 1992**

Type host. *Serrasalmus spilopleura*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratype. CHIOC 33394.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kristky (1992).

***Anacanthorus sciponophallus* Van Every & Kristky, 1992**

Type host. *Serrasalmus elongatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratypes. CHIOC 33388 a–b.

Remarks. Specimens deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kristky (1992).

***Anacanthorus serrasalmi* Van Every & Kristky, 1992**

Type host. *Serrasalmus rhombeus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Água Branca stream, Pitinga River.

Paratypes. CHIOC 33392 a–b.

Remarks. Specimens from CHIOC collected in the Uatumã River (Amazonas State). Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Van Every and Kristky (1992).

***Anacanthorus spinatus* Kristky, Boeger & Van Every, 1992**

Type host. *Myleus rubripinnis*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, Nazaré.

Paratype. CHIOC 33398.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus stachophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Pygocentrus nattereri* Kner, 1858 (Osteichthyes: Serrasalminidae).

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratype. CHIOC 33601.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus stigmophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Myleus rubripinnis*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, Nazaré.

Paratype. CHIOC 33399.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus strongylophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus elongatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratype. CHIOC 33381.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus toledoensis* Leão, São Clemente & Cohen, 2015**

Type host. *Piaractus mesopotamicus*

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River, in the locality of Toledo (24°44'29.0"S, 53°44'51.2"W).

Holotype. CHIOC 37905 a.

Paratypes. CHIOC 37905 b–c.

Remarks. Other paratypes deposited in the INPA collection.

Reference. Leão et al. (2015).

***Anacanthorus tricornis* Kristky, Boeger & Van Every, 1992**

Type host. *Triportheus elongatus*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Solimões River near Marchantaria Island.

Paratype. CHIOC 33382.

Remarks. Specimen deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Anacanthorus xaniophallus* Kristky, Boeger & Van Every, 1992**

Type host. *Pristobrycon eigenmanni*

Infection site. Gills.

Type locality. Brazil, Amazonas State, Uatumã River, Nazaré.

Paratypes. CHIOC 33604 a–c.

Remarks. Specimens deposited in CHIOC collected from the type host/locality. Holotype deposited in the INPA collection. Other paratypes deposited in HWML and USNM. The CHIOC was cited in the original description as one of those collections of deposit, but its number was not informed there.

Reference. Kristky et al. (1992).

***Annulotrematoides* Kritsky & Boeger, 1995**

****Annulotrematoides amazonicus* Kritsky & Boeger, 1995**

Type host. *Psectrogaster rutiloides* (Kner, 1858) (Osteichthyes: Curimatidae).

Infection site. Gills.

Type locality. Brazil, Amazonas State, Manaus, Furo do Catalão.

Holotype. CHIOC 33364.

Remarks. Collection number referred to as CHIOC “33664” in the original description due to a mistake. Paratypes deposited in HWML and USNPC.

Reference. Kritsky and Boeger (1995).

***Annulotrematoides bryconi* Cuglianna, Cordeiro & Luque, 2003**

Type host. *Brycon cephalus* (Günther, 1869)

Infection site. Gills.

Type locality. Brazil, São Paulo State, ponds in Pirassununga.

Holotype. CHIOC 36276.

Paratypes. CHIOC 36272, 36273 a–b, 36274 a–b, 36275.

Remarks. Four paratypes deposited in UNICAMP.

Reference. Cuglianna et al. (2003).

***Annulotrematoides glossophallus* Cohen, Kohn & Boeger, 2012**

Type host. *Salminus brasiliensis*

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River below and above of the reservoir of Itaipu Hydroelectric Power Station, Guaíra (24°04'48"S, 54°15'21"W).

Holotype. CHIOC 37607.

Paratypes. CHIOC 37586, 37618, 37625, 37627, 37629, 37642, 37657 a–b, 37669, 37682.

Reference. Cohen et al. (2012).

***Annulotrematoides parisellei* Cohen, Kohn & Boeger, 2012**

Type host. *Salminus brasiliensis*

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River below and above of the reservoir of Itaipu Hydroelectric Power Station, Guaíra (24°04'48"S, 54°15'21"W).

Holotype. CHIOC 37689.

Paratypes. CHIOC 37585, 37589, 37590, 37591, 37592, 37593, 37597, 37608, 37619, 37622 a–b, 37634, 37643, 37648, 37649 a–b, 37652, 37658, 37664 a–b, 37667, 37676, 37677, 37680, 37685, 37686, 37692 a–b, 37694, 37698 a–b, 37701, 37715, 37725.

Reference. Cohen et al. (2012).

***Apedunculata* Cuglianna, Cordeiro & Luque, 2009**

****Apedunculata discoidea* Cuglianna, Cordeiro & Luque, 2009**

Type host. *Prochilodus lineatus* (Valenciennes, 1837)

Infection site. Gills.

Type locality. Brazil, São Paulo State, ponds in Pirassununga.

Holotype. CHIOC 36904.

Paratypes. CHIOC 36905, 36906, 36907, 36908.

Reference. Cuglianna et al. (2009).

***Aphanoblastella* Kritsky, Mendoza-Franco & Scholz, 2000**

***Aphanoblastella juizforense* Carvalho, Tavares & Luque, 2009**

Type host. *Rhamdia quelen* (Quoy & Gaimard, 1824) (Osteichthyes: Heptapteridae).

Infection site. Gills.

Type locality. Brazil, Minas Gerais State, Juiz de Fora, Paraibuna River (21°41'20"S, 43°20'40"W).

Holotype. CHIOC 37175 a.

Paratypes. CHIOC 37175 b–e.

Reference. Carvalho et al. (2009).

***Cacatuocotyle* Boeger, Domingues & Kritsky, 1997**

***Cacatuocotyle guaibensis* Gallas, Calegari-Marques & Amato, 2014**

Type host. *Astyanax* aff. *fasciatus* (Cuvier, 1819) (Osteichthyes: Characidae).

Infection site. External surface.

Type locality. Brazil, Rio Grande do Sul State, Guaíba Lake, Barra do Ribeiro (30°17'11"S, 51°18'01"W).

Holotype. CHIOC 37965 a.

Paratypes. CHIOC 37965 b–c.

Reference. Gallas et al. (2014).

****Cacatuocotyle paranaensis* Boeger, Domingues & Kritsky, 1997**

Type host. *Characidium lanei* Travassos, 1967 (Osteichthyes: Crenuchidae).

Infection site. Gills.

Type locality. Brazil, Paraná State, Antonina, Cacatu River.

Holotype. CHIOC 33682 a.

Paratypes. CHIOC 33683 a–b, 33684 a–c, 33685 a–d.

Remarks. All paratypes were collected from *C. pterostictum* Gomes, 1947, except CHIOC 33685 b, which was collected from the type host. Other paratypes deposited in HWML and USNPC.

Reference. Boeger et al. (1997).

***Chaubanellus* Bychowsky & Nagibina, 1969**

***Chaubanellus boegeri* Domingues & Fehlaue, 2006**

Type host. *Genidens barbatus* (Lacepède, 1803) (Osteichthyes: Ariidae).

Infection site. Gills.

Type locality. Brazil, Paraná State, Guaratuba, Guaratuba Bay (25°52'16.73"S, 48°39'07.32"W).

Paratypes. CHIOC 36821 a–c.

Remarks. Specimens deposited in CHIOC collected from the type host/locality. Holotype deposited in MZUSP. Other paratypes deposited in MZUSP and USNPC.

Reference. Domingues and Fehlaue (2006).

***Chaubanellus hamatopeduncularoideum* Domingues, Soares & Watanabe, 2016**

Type host. *Amphiarus rugispinis* (Valenciennes, 1840) (Osteichthyes: Ariidae).

Infection site. Secondary lamellae of the gills.

Type locality. Brazil, Pará State, Bragança, Fishing village of Ajuruteua (0°49'31"N, 46°36'29"W).

Holotype. CHIOC 38240 a.

Paratypes. CHIOC 38240 b–h.

Remarks. Other paratypes deposited in the collections of INPA and MPEG.

Reference. Domingues et al. (2016).

***Chauhanellus hypenocleithrum* Domingues, Soares & Watanabe, 2016**

Type host. *Sciades proops* (Valenciennes, 1840) (Osteichthyes: Ariidae).

Infection site. Secondary lamellae of the gills.

Type locality. Brazil, Pará State, Bragança, Fishing village of Ajuruteua (0°49'31"N, 46°36'29"W).

Holotype. CHIOC 38247.

Paratypes. CHIOC 38248 a–b, 38249 a–b, 38250 a–b.

Remarks. Other paratypes deposited in the collections of INPA and MPEG.

Reference. Domingues et al. (2016).

***Chauhanellus neotropalis* Domingues & Fehlaue, 2006**

Type host. *Aspistor luniscutis* (Valenciennes, 1840) (Osteichthyes: Ariidae).

Infection site. Gills.

Type locality. Brazil, Paraná State, Paranaguá, Fish market.

Paratypes. CHIOC 36823 a–b.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in MZUSP and USNPC.

Reference. Domingues and Fehlaue (2006).

***Chauhanellus susamlimae* Domingues, Soares & Watanabe, 2016**

Type host. *Sciades herzbergii* (Bloch, 1794)

Infection site. Secondary lamellae of the gills.

Type locality. Brazil, Pará State, Bragança, Fishing village of Ajuruteua (0°49'31"N, 46°36'29"W).

Holotype. CHIOC 38251 a.

Paratypes. CHIOC 38251 b–h.

Remarks. Other paratypes deposited in the collections of INPA and MPEG.

Reference. Domingues et al. (2016).

***Chauhanellus velum* Domingues, Soares & Watanabe, 2016**

Type host. *Sciades couma* (Valenciennes, 1840)

Infection site. Internal borders of the primary lamellae of the gills.

Type locality. Brazil, Pará State, Bragança, Fish market.

Holotype. CHIOC 38261.

Remarks. Paratype deposited in the INPA collection.

Reference. Domingues et al. (2016).

***Demidospermus* Suriano, 1983**

***Demidospermus araguaiaensis* Cepeda & Luque, 2010**

Type host. *Brachyplatystoma filamentosum* (Lichtenstein, 1819) (Osteichthyes: Pimelodidae).

Infection site. Gill lamellae.

Type locality. Brazil, Mato Grosso State, Araguaia River (13°23'07.3"S, 50°39'58.1"W).

Holotype. CHIOC 37326.

Paratype. CHIOC 37327.

Remarks. Other paratype deposited in the INPA collection.

Reference. Cepeda and Luque (2010).

***Demidospermus brachyplatystomae* Cepeda & Luque, 2010**

Type host. *Brachyplatystoma filamentosum*

Infection site. Gill lamellae.

Type locality. Brazil, Mato Grosso State, Araguaia River (13°23'07.3"S, 50°39'58.1"W).

Holotype. CHIOC 37320.

Paratypes. CHIOC 37321 a–b, 37322 a–d.

Remarks. Other paratypes deposited in the INPA collection.

Reference. Cepeda and Luque (2010).

***Demidospermus ceccarellii* Cepeda & Luque, 2010**

Type host. *Brachyplatystoma filamentosum*

Infection site. Gill lamellae.

Type locality. Brazil, Mato Grosso State, Araguaia River (13°23'07.3"S, 50°39'58.1"W).

Holotype. CHIOC 37323.

Paratypes. CHIOC 37324 a–d, 37325 a–e.

Remarks. Other paratypes deposited in the INPA collection.

Reference. Cepeda and Luque (2010).

***Demidospermus labrosi* França, Isaac, Pavanelli & Takemoto, 2003**

Type host. *Iheringichthys labrosus*

Infection site. Gills.

Type locality. Brazil, upper Paraná River floodplain (22°43'S, 53°10'W).

Holotype. CHIOC 34594 a.

Paratypes. CHIOC 34587 a–c, 34594 b–c, 34595, 34596, 34597.

Remarks. Some authors considered the species to be a synonym of *Demidospermus cornicinus* Kritsky & Gutiérrez, 1998 (Cohen and Kohn 2008a, Monteiro et al. 2010a). Takemoto et al. (2009) referred to it as *D. labrosi*.

References. França et al. (2003), Cohen and Kohn (2008a), Takemoto et al. (2009), Monteiro et al. (2010a).

***Demidospermus mandi* França, Isaac, Pavanelli & Takemoto, 2003**

Type host. *Iheringichthys labrosus*

Infection site. Gills.

Type locality. Brazil, upper Paraná River floodplain (22°43'S, 53°10'W).

Holotype. CHIOC 34586 a.

Paratypes. CHIOC 34586 b, 34589, 34590, 34591, 34592, 34593 a–b.

Remarks. Some authors considered the species to be a synonym of *Demidospermus leptosynophallus* Kritsky & Gutiérrez, 1998 (Cohen and Kohn 2008a, Monteiro et al. 2010a). Takemoto et al. (2009) referred to it as *D. mandi*.

References. França et al. (2003), Cohen and Kohn (2008a), Takemoto et al. (2009), Monteiro et al. (2010a).

***Demidospermus osteomystax* Tavernari, Takemoto, Lacerda & Pavanelli, 2010**

Type host. *Auchenipterus osteomystax* Miranda-Ribeiro, 1918 (Osteichthyes: Auchenipteridae).

Infection site. Gills.

Type locality. Brazil, upper Paraná River floodplain (22°50'–22°70'S, 53°15'–53°40'W).

Holotype. CHIOC 37252 a.

Paratypes. CHIOC 37252 b, 37253, 37254.

Reference. Tavernari et al. (2010).

***Demidospermus paranaensis* Ferrari-Hoeninghaus, Bellay, Takemoto & Pavanelli, 2010**

Type host. *Loricariichthys platymetopon* Isbrücker & Nijssen, 1979 (Osteichthyes: Loricariidae).

Infection site. Gill filaments.

Type locality. Brazil, upper Paraná River floodplain (22°43'S, 53°10'W).

Holotype. CHIOC 37255 a.

Paratypes. CHIOC 37255 b–e.

Reference. Ferrari-Hoeninghaus et al. (2010).

***Euryhaliotrema* Kritsky & Boeger, 2002**

***Euryhaliotrema dontykoleos* Fehlaue & Boeger, 2005**

Type host. *Pachyurus junki* Soares & Casatti, 2000 (Osteichthyes: Sciaenidae).

Infection site. Gills.

Type locality. Brazil, Tocantins State, Santa Rosa, São Valério River (11°21'57"S, 48°28'35"W)

Paratypes. CHIOC 36497, 36498, 36499 a–c, 36500.

Remarks. Paratypes collected in different localities of the Tocantins River (Tocantins State): CHIOC 36498 (Peixe, 11°46'19"S, 48°27'26"W), 36499 a–c (Ipueiras, 11°18'50"S, 48°27'26"W) and 36500 (Porto Nacional, 10°41'45"S, 48°21'43"W). Holotype deposited in MZUSP. Other paratypes deposited in MNHN, MZUSP and USNPC.

Reference. Fehlaue and Boeger (2005).

***Hamatopeduncularia* Yamaguti, 1953**

***Hamatopeduncularia cangatae* Domingues, Soares & Watanabe, 2016**

Type host. *Aspistor quadriscutis* (Valenciennes, 1840)

Infection site. Secondary lamellae of the gills.

Type locality. Brazil, Pará State, Bragança, Fish market.

Holotype. CHIOC 38264.

Paratypes. CHIOC 38265 a–b, 38266.

Remarks. Other paratypes deposited in the INPA collection.

Reference. Domingues et al. (2016).

***Jainus* Mizelle, Kritsky & Crane, 1968**

***Jainus iocensis* Cohen, Kohn & Boeger, 2012**

Type host. *Salminus brasiliensis*

Infection site. Gills.

Type locality. Brazil, Paraná River below and above of the reservoir of Itaipu Hydroelectric Power Station, Guaíra (24°04'48"S, 54°15'21"W).

Holotype. CHIOC 37647 a.

Paratypes. CHIOC 37606, 37635, 37637 a–c, 37638, 37640 a–b, 37644, 37645, 37646, 37647 b, 37650, 37651, 37653, 37655, 37670, 37672 a–c, 37673 a–b, 37675, 37687 a–b, 37690, 37695 a–c, 37700, 37702, 37703, 37704, 37708, 37710 a–b, 37712, 37723.

Reference. Cohen et al. (2012).

Jainus piava Karling, Bellay, Takemoto & Pavanelli, 2011

Type host. *Schizodon borellii* (Boulenger, 1900) (Osteichthyes: Anostomidae).

Infection site. Gill filaments.

Type locality. Brazil, upper Paraná River floodplain (22°50'–22°70'S, 53°15'–53°40'W).

Holotype. CHIOC 37235 a.

Paratypes. CHIOC 37235 b–c, 37236.

Reference. Karling et al. (2011a).

Kritskyia Kohn, 1990

Kritskyia annakohnae Boeger, Tanaka & Pavanelli, 2001

Type host. *Serrasalmus marginatus* Valenciennes, 1836

Infection site. Urinary bladder and ureters.

Type locality. Brazil, Paraná State, upper Paraná River, Baía River near Porto Rico.

Holotype. CHIOC 34243 a.

Paratypes. CHIOC 34243 b–m, 34244, 34245 a–b.

Remarks. Paratypes CHIOC 34244 and 34245 a–b collected from *S. spilopleura* Kner, 1858. Other paratypes deposited in the collections of INPA, HWML, MNHN and USNPC.

Reference. Boeger et al. (2001).

Kritskyia boegeri Takemoto, Lizama & Pavanelli, 2002

Type host. *Prochilodus lineatus*

Infection site. Urinary bladder.

Type locality. Brazil, upper Paraná River floodplain.

Holotype. CHIOC 34701.

Paratypes. CHIOC 34599, 34700.

Reference. Takemoto et al. (2002).

***Kritskyia eirasi* Guidelli, Takemoto & Pavanelli, 2003**

Type host. *Leporinus lacustris* Campos, 1945 (Osteichthyes: Anostomidae).

Infection site. Urinary bladder and ureters.

Type locality. Brazil, upper Paraná River floodplain (22°50'–22°70'S, 53°15'–53°40'W).

Holotype. CHIOC 36401.

Paratypes. CHIOC 36396, 36397, 36398 a–b, 36399, 36400.

Reference. Guidelli et al. (2003).

****Kritskyia moraveci* Kohn, 1990**

Type host. *Rhamdia quelen*

Infection site. Urinary bladder and ureters.

Type locality. Brazil, Rio Grande do Sul State, reservoir of the Hydroelectric Power of Passo Fundo, São Valentim (27°32'S, 52°44'W).

Holotype. CHIOC 32443 c.

Paratypes. CHIOC 32443 a–b, d–r, 32444 a–b.

Reference. Kohn (1990).

***Kritskyia salmini* Cepeda, Ceccarelli & Luque, 2011**

Type host. *Salminus brasiliensis*

Infection site. Urinary bladder.

Type locality. Brazil, Mato Grosso State, Pantanal wetlands, Cuiabá River (17°50'48"S, 57°24'6"W)

Holotype. CHIOC 37533 a.

Paratypes. CHIOC 37533 b–j.

Remarks. Other paratypes deposited in the INPA collection.

Reference. Cepeda et al. (2011).

Ligophorus* Euzet & Suriano, 1977**Ligophorus brasiliensis* Abdallah, Azevedo & Luque, 2009**

Type host. *Mugil liza* Valenciennes, 1836 (Osteichthyes: Mugilidae).

Infection site. Gill lamellae.

Type locality. Brazil, Rio de Janeiro State, Guandu River (22°48'32"S, 43°37'35"W).

Holotype. CHIOC 37180 a.

Paratypes. CHIOC 37180 b–d.

Reference. Abdallah et al. (2009).

***Ligophorus guanduensis* Abdallah, Azevedo & Luque, 2009**

Type host. *Mugil liza*

Infection site. Gill lamellae.

Type locality. Brazil, Rio de Janeiro State, Guandu River (22°48'32"S, 43°37'35"W).

Holotype. CHIOC 37181 a.

Paratypes. CHIOC 37181 b–d.

Reference. Abdallah et al. (2009).

***Ligophorus lizae* Abdallah, Azevedo & Luque, 2009**

Type host. *Mugil liza*

Infection site. Gill lamellae.

Type locality. Brazil, Rio de Janeiro State, Guandu River (22°48'32"S, 43°37'35"W).

Holotype. CHIOC 37178 a.

Paratype. CHIOC 37178 b.

Reference. Abdallah et al. (2009).

***Ligophorus tainhae* Abdallah, Azevedo & Luque, 2009**

Type host. *Mugil liza*

Infection site. Gill lamellae.

Type locality. Brazil, Rio de Janeiro State, Guandu River (22°48'32"S, 43°37'35"W).

Holotype. CHIOC 37179 a.

Paratypes. CHIOC 37179 b–d.

Reference. Abdallah et al. (2009).

***Marumbius* Boeger, Ferreira, Vianna & Patella, 2014**

***Marumbius amplexus* Boeger, Ferreira, Vianna & Patella, 2014**

Type host. *Characidium lanei*

Infection site. Gills.

Type locality. Brazil, Paraná State, Morretes, Marumbi River (25°29'27"S, 45°49'67"W).

Holotype. CHIOC 37897.

Paratype. CHIOC 37896.

Remarks. Other paratypes deposited in the collections of IPCAS and USNPC.

Reference. Boeger et al. (2014).

****Marumbius dorsivaginat* Boeger, Ferreira, Vianna & Patella, 2014**

Type host. *Characidium pterostictum* Gomes, 1947

Infection site. Gills.

Type locality. Brazil, Paraná State, Morretes, Marumbi River (25°29'27"S, 45°49'67"W).

Holotype. CHIOC 37893.

Paratypes. CHIOC 37884, 37885, 37886, 37887, 37888, 37889, 37890, 37891, 37892, 37894, 37895.

Remarks. Other paratypes deposited in the collections of IPCAS, HWML and USNPC.

Reference. Boeger et al. (2014).

Mexicana Caballero & Bravo-Hollis, 1959

***Mexicana anisotremum* Cezar, Paschoal & Luque, 2012**

Type host. *Anisotremus virginicus* (Linnaeus, 1758) (Osteichthyes: Haemulidae).

Infection site. Gills.

Type locality. Brazil, coastal zone of Rio de Janeiro State (21–23°S, 42–45°W).

Holotype. CHIOC 37767.

Paratypes. CHIOC 37768, 37769.

Remarks. Paratype CHIOC 37769 collected from *A. surinamensis* (Bloch, 1791).

Reference. Cezar et al. (2012).

***Mexicana atlantica* Luque, Amato & Takemoto, 1992**

Type host. *Haemulon steindachneri* (Jordan & Gilbert, 1882) (Osteichthyes: Haemulidae).

Infection site. Distal portion of gill filaments.

Type locality. Brazil, Rio de Janeiro State, Sepetiba Bay, Itacuruçá (22°51'S, 43°56'W).

Paratypes. CHIOC 33109, 33110.

Remarks. Holotype and other paratypes deposited in the USNM collection.

Reference. Luque et al. (1992).

***Mymarothecium* Kritsky, Boeger & Jégu, 1996**

***Mymarothecium boegeri* Cohen & Kohn, 2005**

Type host. *Colossoma macropomum* (Cuvier, 1816) (Osteichthyes: Serrasalminidae).

Infection site. Gills.

Type locality. Brazil, Ceará State, Pentecoste, Aquaria of the Research Center in Aquiculture “Rodolfo von Ihering, DNOCS”.

Holotype. CHIOC 36453.

Paratypes. CHIOC 36454, 36455, 36456, 36457.

Reference. Cohen and Kohn (2005).

***Mymarothecium ianwhittingtoni* Leão, São Clemente & Cohen, 2015**

Type host. *Piaractus mesopotamicus*

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River, Toledo (24°44'29.0"S, 53°44'51.2"W).

Holotype. CHIOC 37906 a.

Paratypes. CHIOC 37906 b–d.

Remarks. Other paratypes deposited in the INPA collection.

Reference. Leão et al. (2015).

***Mymarothecium viatorum* Boeger, Piasecki & Sobecka, 2002**

Type host. *Piaractus brachypomus* (Cuvier, 1818)

Infection site. Gills.

Type locality. Poland, Szczecin, Odra River.

Holotype. CHIOC 35041.

Paratypes. CHIOC 35042 a–i.

Remarks. Other paratypes deposited in the collections of INPA, HWML and USNPC.

Reference. Boeger et al. (2002).

***Notozothecium* Boeger & Kritsky, 1988**

***Notozothecium lamotheargumedoi* Cohen & Kohn, 2008**

Type host. *Rhaphiodon vulpinus* Spix & Agassiz, 1829 (Osteichthyes: Cynodontidae).

Infection site. Gills.

Type locality. Brazil, Paraná State, inside and outside of the reservoir of Itaipu Hydroelectric Power Station, Foz do Iguaçu (25°32'52"S, 54°35'17"W).

Holotype. CHIOC 36895.

Paratypes. CHIOC 36896 a–b, 36897 a–d, 36898, 36899 a–d, 36900 a–s, 36901 a–e.

Remarks. Paratypes collected in different localities of the reservoir of Itaipu Hydroelectric Power Station: CHIOC 36897 a–d and 36898 (Santa Helena, 24°51'37"S, 54°19'58"W), and 36899 a–d, 36900 a–d and 36901 a–e (Guaíra, 24°04'48"S, 54°15'21"W).

Reference. Cohen and Kohn (2008b).

***Paracylodiscoides* Caballero & Bravo-Hollis, 1960**

***Paracylodiscoides caballerobravorum* Cezar, Luque & Amato, 1999**

Type host. *Chaetodipterus faber*

Infection site. Gill filaments.

Type locality. Brazil, coastal zone of Rio de Janeiro State (21–23°S, 41–45°W).

Holotype. CHIOC 34001 a.

Paratypes. CHIOC 34001 b–d.

Remarks. Collection numbers were not cited in the original description. Other paratypes deposited in CNHE. Kritsky (2012) considered the species to be a synonym of *Paracylodiscoides longiphallus* (MacCallum, 1915).

References. Cezar et al. (1999), Kritsky (2012).

***Pavanelliella* Kritsky & Boeger, 1998**

***Pavanelliella laertei* Aguiar, Ceccarelli & Luque, 2011**

Type host. *Pimelodus microstoma* Steindachner, 1877 (= *Pimelodus heraldoi* Azpelicue-ta, 2001) (Osteichthyes: Pimelodidae).

Infection site. Nasal cavity.

Type locality. Brazil, São Paulo State, Pirassununga, Cachoeira de Emas, Mogi Guaçu River (21°58'S, 47°26'W).

Holotype. CHIOC 37561.

Paratypes. CHIOC 37562, 37563, 37564, 37565, 37566.

Reference. Aguiar et al. (2011).

***Pavanelliella takemotoi* Aguiar, Ceccarelli & Luque, 2011**

Type host. *Pimelodus maculatus* Lacepède, 1803

Infection site. Nasal cavity.

Type locality. Brazil, São Paulo State, Pirassununga, Cachoeira de Emas, Mogi Guaçu River (21°58'S, 47°26'W).

Holotype. CHIOC 37567 a.

Paratypes. CHIOC 37567 b, 37568 a–f, 37569, 37570 a–b, 37571, 37572, 37573, 37574, 37575 a–b, 37576 a–b, 37577 a–b, 37578, 37579 a–b, 37580, 37582 a–c.

Reference. Aguiar et al. (2011).

***Philocorydoras* Suriano, 1986**

***Philocorydoras longus* Yamada, Brandão, Yamada & Silva, 2015**

Type host. *Hoplosternum littorale* (Hancock, 1828) (Osteichthyes: Callichthyidae).

Infection site. Gills.

Type locality. Brazil, São Paulo State, Taquarituba, upper Paranapanema River, Jurumirim Reservoir (23°12'17"S, 49°13'19"W).

Holotype. CHIOC 38205.

Paratype. CHIOC 38206.

Reference. Yamada et al. (2015).

***Protyrodactylus* Johnston & Tiegs, 1922**

***Protyrodactylus ethiopicus* Boeger, Diamaka, Pariselle & Patella, 2012**

Type host. *Gerres nigri* Günther, 1859 (Osteichthyes: Gerreidae).

Infection site. Gills.

Type locality. Senegal, Bamboung, Sine–Saloum River (13°49'30.5"N, 16°31'44"W).

Paratypes. CHIOC 37744 a–n.

Remarks. Holotype deposited in the MNHN collection. Other paratypes deposited in MNHN and USNPC.

Reference. Boeger et al. (2012).

***Protyrodactylus kritskyi* Boeger, Diamaka, Pariselle & Patella, 2012**

Type host. *Gerres nigri*

Infection site. Gills.

Type locality. Senegal, Bamboung, Sine–Saloum River (13°49'30.5"N, 16°31'44"W).

Paratypes. CHIOC 37743 a–k.

Remarks. Holotype deposited in the MNHN collection. Other paratypes deposited in MNHN and USNPC.

Reference. Boeger et al. (2012).

Protorhinoxenus* Domingues & Boeger, 2002***Protorhinoxenus prochilodi* Domingues & Boeger, 2002**

Type host. *Prochilodus lineatus*

Infection site. Gill filaments.

Type locality. Brazil, Paraná State, metropolitan area of Curitiba, Campina Grande do Sul, reservoir of Capivari–Cachoeira.

Holotype. CHIOC 34542.

Paratype. CHIOC 34543.

Remarks. Other paratypes deposited in the collections of INPA and IPCR.

Reference. Domingues and Boeger (2002).

Pseudempleurosoma* Yamaguti, 1965**Pseudempleurosoma gibsoni* Santos, Mourão & Cárdenas, 2001**

Type host. *Paralonchurus brasiliensis* (Steindachner, 1875) (Osteichthyes: Sciaenidae).

Infection site. Oesophagus.

Type locality. Brazil, São Paulo State, off Ubatuba (23°35'S, 045°06'W).

Holotype. CHIOC 34337 a.

Paratypes. CHIOC 34337 b–e, 34338 a–b.

Reference. Santos et al. (2001).

***Pseudempleurosoma guanabarensis* Carvalho & Luque, 2012**

Type host. *Trichiurus lepturus*

Infection site. Oesophagus.

Type locality. Brazil, Rio de Janeiro State, Guanabara Bay (23°1'52"S, 43°11'56"W).

Holotype. CHIOC 37389.

Paratypes. CHIOC 37390 a–c, 37391.

Reference. Carvalho and Luque (2012).

Rhinonastes* Kritsky, Thatcher & Boeger, 1988**Rhinonastes curimatae* Monteiro & Brasil-Sato, 2014**

Type host. *Prochilodus argenteus*

Infection site. Nasal cavity.

Type locality. Brazil, Minas Gerais State, São Francisco River near Três Marias (18°12'32"S, 45°14'41"W).

Holotype. CHIOC 37953 a.

Paratypes. CHIOC 37953 b–c, 37954 a–f, 37955.

Reference. Monteiro and Brasil-Sato (2014b).

***Rhinoxenus* Kritsky, Thatcher & Boeger, 1988**

***Rhinoxenus anaclaudiae* Domingues & Boeger, 2005**

Type host. *Triportheus* cf. *nematurus* (Kner, 1858)

Infection site. Nasal cavity.

Type locality. Brazil, Mato Grosso do Sul State, Miranda River, Passo do Lontra.

Holotype. CHIOC 36300.

Paratypes. CHIOC 36301 a–e.

Remarks. Other paratypes deposited in INPA, MZUSP, MNHN and USNPC.

Reference. Domingues and Boeger (2005).

***Rhinoxenus bulbovaginatus* Boeger, Domingues & Pavanelli, 1995**

Type host. *Salminus brasiliensis*

Infection site. Nasal cavities.

Type locality. Brazil, Paraná State, Paraná River basin near Porto Rico.

Holotype. CHIOC 33269 a.

Paratypes. CHIOC 33269 b–e.

Remarks. Other paratypes deposited in the collections of HWML and USNM.

Reference. Boeger et al. (1995a).

***Rhinoxenus curimbatae* Domingues & Boeger, 2005**

Type host. *Prochilodus* cf. *lineatus*

Infection site. Nasal cavity.

Type locality. Brazil, Paraná State, metropolitan area of Curitiba, Campina Grande do Sul, reservoir of Capivari–Cachoeira.

Holotype. CHIOC 36303.

Paratypes. CHIOC 36304 a–b.

Remarks. Other paratypes deposited in the collections of INPA and MNHN.

Reference. Domingues and Boeger (2005).

***Rhinoxenus euryxenus* Domingues & Boeger, 2005**

Type host. *Serrasalmus marginatus*

Infection site. Nasal cavity.

Type locality. Brazil, Mato Grosso do Sul State, Paraná River, Medalha Bay.

Holotype. CHIOC 36293.

Paratypes. CHIOC 36294 a–g.

Remarks. Other paratypes deposited in the collections of INPA and MNHN.

Reference. Domingues and Boeger (2005).

***Rhinoxenus guianensis* Domingues & Boeger, 2005**

Type host. *Curimata cyprinoides* (Linnaeus, 1766) (Osteichthyes: Curimatidae).

Infection site. Nasal cavity.

Type locality. French Guiana, Degrad Forian, Iracoubo.

Holotype. CHIOC 36305.

Paratypes. CHIOC 36306 a–d.

Remarks. Other paratypes deposited in the collections of INPA, MNHN and USNPC.

Reference. Domingues and Boeger (2005).

Sciadicleithrum* Kritsky, Thatcher & Boeger, 1989**Sciadicleithrum araguariensis* Paschoal, Scholz, Tavares-Dias & Luque, 2016**

Type host. *Crenicichla labrina* (Spix & Agassiz, 1831) (Osteichthyes: Cichlidae).

Infection site. Gills.

Type locality. Brazil, Amapá State, Ferreira Gomes, Araguari River (0°52'N, 51°12'W).

Holotype. CHIOC 38091 a.

Paratypes. CHIOC 38091 b–d.

Remarks. Other paratype deposited in the IPCA collection.

Reference. Paschoal et al. (2016).

***Sciadicleithrum edgari* Paschoal, Scholz, Tavares-Dias & Luque, 2016**

Type host. *Satanoperca jurupari* (Heckel, 1840) (Osteichthyes: Cichlidae).

Infection site. Gills.

Type locality. Brazil, Amapá State, Ferreira Gomes, Araguari River (0°52'N, 51°12'W).

Holotype. CHIOC 38092 a.

Paratypes. CHIOC 38092 b–c.

Remarks. Other paratype deposited in the IPCA collection.

Reference. Paschoal et al. (2016).

***Sciadicleithrum frequens* Bellay, Takemoto, Yamada & Pavanelli, 2008**

Type host. *Geophagus brasiliensis* (Quoy & Gaimard, 1824) (Osteichthyes: Cichlidae).

Infection site. Gills.

Type locality. Brazil, Paraná State, Ivaí River basin, Mourão Reservoir (24°02'S, 52°22'W).

Holotype. CHIOC 36924.

Paratypes. CHIOC 36921 a–c, 36922, 36923.

Remarks. Paratypes collected in other reservoirs: CHIOC 36921 a–c (Iguaçu River basin, Iraí, 25°25'S, 49°06'W) and 36922 (Piriqui River basin, Melissa, 24°48'S, 53°18'W). Other paratype deposited in the BMNH collection.

Reference. Bellay et al. (2008).

***Sciadicleithrum guanduensis* Carvalho, Tavares & Luque, 2008**

Type host. *Geophagus brasiliensis*

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Seropédica, Guandu River (22°48'32"S, 43°37'35"W).

Holotype. CHIOC 36989 a.

Paratypes. CHIOC 36989 b–f.

Reference. Carvalho et al. (2008).

***Sciadicleithrum joanae* Yamada, Takemoto, Bellay & Pavanelli, 2009**

Type host. *Crenicichla niederleinii* Holmberg, 1891

Infection site. Gill filaments.

Type locality. Brazil, Paraná, Paraná River (22°50'–22°70'S, 53°15'–53°40'W).

Holotype. CHIOC 37161.

Paratypes. CHIOC 37162, 37163 a–b, 37164.

Reference. Yamada et al. (2009).

***Sciadicleithrum jurupari* Melo, Santos & Santos, 2012**

Type host. *Satanoperca jurupari*

Infection site. Gills.

Type locality. Brazil, Pará State, Belém, Guamá River (01°27'21"S, 48°30'14"W).

Holotype. CHIOC 37766 a.

Paratypes. CHIOC 37766 b–f.

Reference. Melo et al. (2012).

***Sciadicleithrum kritskyi* Bellay, Takemoto, Yamada & Pavanelli, 2009**

Type host. *Geophagus proximus* (Castelnau, 1855)

Infection site. Gill filaments.

Type locality. Brazil, Paraná State, upper Paraná River floodplain, Porto Rico (22°50'–22°70'S, 53°15'–53°40'W).

Holotype. CHIOC 37188.

Paratypes. CHIOC 37189, 37190, 37191.

Reference. Bellay et al. (2009).

***Sciadicleithrum paranaensis* Bellay, Takemoto, Yamada & Pavanelli, 2009**

Type host. *Geophagus proximus*

Infection site. Gill filaments.

Type locality. Brazil, Paraná State, upper Paraná River floodplain, Porto Rico (22°50'–22°70'S, 53°15'–53°40'W).

Holotype. CHIOC 37183.

Paratypes. CHIOC 37184, 37185, 37186, 37187.

Reference. Bellay et al. (2009).

***Sciadicleithrum satanopercae* Yamada, Takemoto, Bellay & Pavanelli, 2009**

Type host. *Satanoperca pappaterra* (Heckel, 1840)

Infection site. Gill filaments.

Type locality. Brazil, Paraná State, upper Paraná River floodplain (22°50'–22°70'S, 53°15'–53°40'W).

Holotype. CHIOC 37165 a.

Paratypes. CHIOC 37165 b, 37166 a–b, 37167.

Reference. Yamada et al. (2009).

***Susanlimae* Boeger, Pariselle & Patella, 2015**

****Susanlimae ianwhittingtoni* Boeger, Pariselle & Patella, 2015**

Type host. *Pseudeutropius moolenburghae* Weber & de Beaufort, 1913 (Osteichthyes: Schilbeidae).

Infection site. Gill rakers.

Type locality. Indonesia, Jambi Province, Pemayung Subdistrict, Batang Hari River, near Kubu Kandang village (1°36'17.51"S, 103°19'16.65"E).

Holotype. CHIOC 38202 a.

Paratypes. CHIOC 38202 b–c.

Remarks. Two paratypes deposited in MNHN and one paratype kept in the private collection of Antoine Pariselle.

Reference. Boeger et al. (2015).

***Telethecium* Kritsky, Van Every & Boeger, 1996**

****Telethecium nasalis* Kritsky, Van Every & Boeger, 1996**

Type host. *Osteoglossum bicirrhosum* (Vandelli, 1829) (Osteichthyes: Osteoglossidae).

Infection site. Nasal cavity.

Type locality. Brazil, Amazonas State, Furo do Catalão near Manaus.

Holotype. CHIOC 33639.

Remarks. Paratypes deposited in HWML and USNPC.

Reference. Kritsky et al. (1996).

***Telethecium paniculum* Kritsky, Van Every & Boeger, 1996**

Type host. *Pellona flavipinnis* (Valenciennes, 1837) (Osteichthyes: Pristigasteridae).

Infection site. Nasal cavity.

Type locality. Brazil, Amazonas State, Solimões River, Marchantaria Island near Manaus.

Holotype. CHIOC 33640.

Remarks. Paratypes deposited in HWML and USNPC.

Reference. Kritsky et al. (1996).

Tereancistrum* Kritsky, Thatcher & Kayton, 1980**Tereancistrum arcuatus* Cohen, Kohn & Boeger, 2012**

Type host. *Salminus brasiliensis*

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River below and above of the reservoir of Itaipu Hydroelectric Power Station, Guaíra (24°04'48"S, 54°15'21"W).

Holotype. CHIOC 37628.

Paratypes. CHIOC 37609, 37665, 37674 a–b, 37678.

Reference. Cohen et al. (2012).

***Tereancistrum curimba* Lizama, Takemoto & Pavanelli, 2004**

Type host. *Prochilodus lineatus*

Infection site. Gills.

Type locality. Brazil, upper Paraná River floodplain (22°43'S, 53°10'W).

Holotype. CHIOC 36224.

Paratypes. CHIOC 36225, 36226, 36227 a–b, 36228.

Remarks. Other paratypes deposited in BMNH and USNPC.

Reference. Lizama et al. (2004).

***Tereancistrum paranaensis* Karling, Lopes, Takemoto & Pavanelli, 2014**

Type host. *Schizodon borellii*

Infection site. Gill filaments.

Type locality. Brazil, upper Paraná River floodplain (22°50'–22°70'S, 53°15'–53°40'W).

Holotype. CHIOC 37868.

Paratypes. CHIOC 37866, 37867.

Reference. Karling et al. (2014).

***Tereancistrum pirassununguensis* Cepeda, Ceccarelli & Luque, 2012**

Type host. *Prochilodus lineatus*

Infection site. Gills.

Type locality. Brazil, São Paulo State, Pirassununga, Mogi Guaçu River (21°55'32.49"S, 47°22'13.76"W).

Holotype. CHIOC 37816 a.

Paratypes. CHIOC 37816 b–j.

Reference. Cepeda et al. (2012).

***Tereancistrum toksonum* Lizama, Takemoto & Pavanelli, 2004**

Type host. *Prochilodus lineatus*

Infection site. Gills.

Type locality. Brazil, upper Paraná River floodplain (22°43'S, 53°10'W).

Holotype. CHIOC 36229.

Paratypes. CHIOC 36230 a–b, 36231.

Remarks. Other paratypes deposited in BMNH and USNPC.

Reference. Lizama et al. (2004).

***Trinibaculum* Kritsky, Thatcher & Kayton, 1980**

***Trinibaculum rotundus* Karling, Lopes, Takemoto & Pavanelli, 2011**

Type host. *Schizodon borellii*

Infection site. Gill filaments.

Type locality. Brazil, upper Paraná River floodplain (22°50'–22°70'S, 53°15'–53°40'W).

Holotype. CHIOC 37529 a.

Paratypes. CHIOC 37529 b–e.

Reference. Karling et al. (2011b).

***Trinigyrus* Hanek, Molnar & Fernando, 1974**

***Trinigyrus mourei* Boeger & Belmont-Jégu, 1994**

Type host. *Squaliforma emarginata* (Valenciennes, 1840) [= *Hypostomus emarginatus*] (Osteichthyes: Loricariidae).

Infestation site. Body surface.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Holotype. CHIOC 33052 a.

Paratypes. CHIOC 33052 b–d.

Remarks. Other paratypes deposited in the collections of HWML and USNM.

Reference. Boeger and Belmont-Jégu (1994).

***Unilatus* Mizelle & Kritsky, 1967**

***Unilatus irae* Branches & Domingues, 2014**

Type host. *Leporacanthicus galaxias* Isbrücker & Nijssen, 1989 (Osteichthyes: Loricariidae).

Infection site. Gills.

Type locality. Brazil, Pará State, Guamá River, Capitão Poço (1°34.465'S, 47°02.063'W).

Holotype. CHIOC 37861 a.

Paratypes. CHIOC 37861 b–k.

Remarks. Other paratypes deposited in INPA, MPEG and USNPC.

Reference. Branches and Domingues (2014).

Urocleidoides Mizelle & Price, 1964

Urocleidoides aimarai Moreira, Scholz & Luque, 2015

Type host. *Hoplias aimara* (Valenciennes, 1847) (Osteichthyes: Erythrinidae).

Infection site. Gills.

Type locality. Brazil, Pará State, Xingu River around Altamira (3°12'S, 52°12'W).

Holotype. CHIOC 38001 a.

Paratypes. CHIOC 38001 b–d.

Remarks. Two paratypes deposited in the IPCAS collection.

Reference. Moreira et al. (2015).

Urocleidoides brasiliensis Rosim, Mendoza-Franco & Luque, 2011

Type host. *Hoplias malabaricus* (Bloch, 1794)

Infection site. Gill lamellae.

Type locality. Brazil, Mato Grosso State, Cuiabá (16°58'N, 56°25'W).

Holotype. CHIOC 37470 a.

Paratypes. CHIOC 37470 b–f.

Reference. Rosim et al. (2011).

Urocleidoides cuiabai Rosim, Mendoza-Franco & Luque, 2011

Type host. *Hoplias malabaricus*

Infection site. Gill lamellae.

Type locality. Brazil, Mato Grosso State, Cuiabá (16°58'N, 56°25'W).

Holotype. CHIOC 37469 a.

Paratypes. CHIOC 37469 b–e.

Remarks. Other paratypes deposited in CNHE.

Reference. Rosim et al. (2011).

***Urocleidoides malabaricus* Rosim, Mendoza-Franco & Luque, 2011**

Type host. *Hoplias malabaricus*

Infection site. Gill lamellae.

Type locality. Brazil, Mato Grosso State, Cuiabá (16°58'N, 56°25'W).

Holotype. CHIOC 37466 a.

Paratypes. CHIOC 37466 b–c.

Reference. Rosim et al. (2011).

***Urocleidoides naris* Rosim, Mendoza-Franco & Luque, 2011**

Type host. *Hoplias malabaricus*

Infection site. Nasal cavities.

Type locality. Brazil, Mato Grosso State, Cuiabá (16°58'N, 56°25'W).

Holotype. CHIOC 37468 a.

Paratypes. CHIOC 37468 b–k.

Remarks. Other paratypes deposited in CNHE.

Reference. Rosim et al. (2011).

***Urocleidoides xinguensis* Moreira, Scholz & Luque, 2015**

Type host. *Hoplias aimara*

Infection site. Gills.

Type locality. Brazil, Pará State, Xingu River around Altamira (3°12'S, 52°12'W).

Holotype. CHIOC 38002 a.

Paratypes. CHIOC 38002 b–d.

Remarks. Two paratypes deposited in the IPCAS collection.

Reference. Moreira et al. (2015).

***Whittingnocotyle* Santos Neto, Rodrigues & Domingues, 2015**

****Whittingnocotyle caetei* Santos Neto, Rodrigues & Domingues, 2015**

Type host. *Hoplerythrinus unitaeniatus* (Agassiz, 1829) (Osteichthyes: Erythrinidae).

Infection site. Gills.

Type locality. Brazil, Pará State, Augusto Corrêa, Caeté River (01°3'58.21"S, 46°40'3.65"W).

Holotype. CHIOC 38012 a.

Paratypes. CHIOC 38012 b–d.

Remarks. Other paratypes deposited in INPA and MPEG.

Reference. Santos Neto et al. (2015).

***Whittingnocotyle jeju* Santos Neto, Rodrigues & Domingues, 2015**

Type host. *Hoplerythrinus unitaeniatus*

Infection site. Gills.

Type locality. Brazil, Pará State, Irituia, Guamá River (01°51'59.8"S, 47°24'17.2"W).

Holotype. CHIOC 38014 a.

Paratypes. CHIOC 38014 b–e.

Remarks. Other paratypes deposited in INPA and MPEG.

Reference. Santos Neto et al. (2015).

Diplectanidae Monticelli, 1903***Acleotrema* Johnston & Tiegs, 1922*****Acleotrema lamothei* Santos, Bianchi & Gibson, 2008**

Type host. *Kyphosus incisor* (Cuvier, 1831) (Osteichthyes: Kyphosidae).

Infection site. Gills.

Type locality. Brazil, off Rio de Janeiro State, Ilha Grande Bay (23°00'–23°40'S, 44°00'–44°40'W)

Holotype. CHIOC 36926 a.

Paratypes. CHIOC 36926 b–d.

Reference. Santos et al. (2008).

Anoplectanum* Boeger, Fehlaue & Marques, 2006***Anoplectanum haptorodynatum* Boeger, Fehlaue & Marques, 2006**

Type host. *Petilipinnis grunniens* (Jardine & Schomburgk, 1843) (Osteichthyes: Sciaenidae).

Infection site. Gills.

Type locality. Brazil, Tocantins State, Tocantins River, Porto Nacional (10°41'45"S, 48°25'54"W).

Paratypes. CHIOC 36504 a–b.

Remarks. Paratypes from CHIOC collected in the Tocantins River, Santa Helena (Tocantins State). Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, MNHN and USNPC.

Reference. Boeger et al. (2006).

***Anoplectanum microsoma* Boeger, Fehlaue & Marques, 2006**

Type host. *Pachyurus junki*

Infection site. Gills.

Type locality. Brazil, Tocantins State, Tocantins River, Santa Helena.

Paratypes. CHIOC 36503 a–b.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, MNHN and USNPC.

Reference. Boeger et al. (2006).

***Darwinoplectanum* Domingues, Diamanka & Pariselle, 2011**

***Darwinoplectanum amphiatlanticus* Domingues, Diamanka & Pariselle, 2011**

Type host. *Eucinostomus melanopterus* (Bleeker, 1863) (Osteichthyes: Gerreidae).

Infection site. Gills.

Type locality. Senegal, Sine Saloum, Bamboung (13°49'30.5"N, 16°31'44"W).

Holotype. CHIOC 37546 a.

Paratypes. CHIOC 37546 b–d.

Remarks. Other paratypes deposited in INPA, MPEG and USNPC.

Reference. Domingues et al. (2011).

****Darwinoplectanum figueiredoi* Domingues, Diamanka & Pariselle, 2011**

Type host. *Eucinostomus argenteus* Baird & Girard, 1855

Infection site. Gills.

Type locality. Brazil, Paraná State, Pontal do Paraná (25°35'28.27"S, 48°21'10.70"W).

Holotype. CHIOC 37545 a.

Paratypes. CHIOC 37545 b–f.

Remarks. Other paratypes deposited in INPA, MPEG and USNPC.

Reference. Domingues et al. (2011).

***Diplectanum* Diesing 1858**

***Diplectanum copiosum* Boeger, Fehlaue & Marques, 2006**

Type host. *Pachyurus junki*

Infection site. Gills.

Type locality. Brazil, Tocantins State, Tocantins River, Santa Helena.

Paratypes. CHIOC 36501 a–m.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP and USNPC.

Reference. Boeger et al. (2006).

***Diplectanum monticelli* Domingues & Boeger, 2003**

Type host. *Cynoscion leairchus* (Cuvier, 1830) (Osteichthyes: Sciaenidae).

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Itacuruçá (22°55'S, 43°55'W).

Holotype. CHIOC 34962.

Paratypes. CHIOC 34963 a–b, 34964 a–c.

Remarks. Other paratypes deposited in HWML and USNPC.

Reference. Domingues and Boeger (2003).

***Diplectanum squamatum* Santos, Timi & Gibson, 2002**

Type host. *Cynoscion guatucupa* (Cuvier, 1830)

Infection site. Gills.

Type locality. Argentina, off Mar del Plata (38°08'S, 57°32'W).

Holotype. CHIOC 34538 a.

Paratypes. CHIOC 34538 b–d.

Remarks. Other paratype deposited in the BMNH collection.

Reference. Santos et al. (2002).

***Pseudorhabdosynochus* Yamaguti, 1958**

***Pseudorhabdosynochus jeanloui* Knoff, Cohen, Cárdenas, Cárdenas-Callirgos & Gomes, 2015**

Type host. *Paranthias colonus* (Valenciennes, 1846) (Osteichthyes: Serranidae).

Infection site. Gill arches.

Type locality. Peru, Lima, off Chorrillos (12°13'25"S, 76°43'49"W).

Holotype. CHIOC 38016 a.

Paratypes. CHIOC 38016 b–i.

Remarks. Other paratype deposited in the MNHN collection.

Reference. Knoff et al. (2015).

***Pseudorhabdosynochus sulamericanus* Santos, Buchmann & Gibson, 2000**

Type host. *Hyorthodus niveatus* (Valenciennes, 1828) [= *Epinephelus niveatus*] (Osteichthyes: Serranidae).

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Rio de Janeiro, off Cagaras Islands (23°02'S, 43°12'W).

Holotype. CHIOC 33985 a.

Paratypes. CHIOC 33985 b–i.

Remarks. Other paratype deposited in the BMNH collection.

Reference. Santos et al. (2000).

***Rhabdosynochus* Mizelle & Blatz, 1941**

***Rhabdosynochus bargisi* Kritsky, Boeger & Robaldo, 2001**

Type host. *Centropomus undecimalis* (Bloch, 1792) (Osteichthyes: Centropomidae).

Infection site. Gills.

Type locality. Brazil, Pernambuco State, Itamaracá, earthen ponds (7°41'S, 34°53'W).

Paratypes. CHIOC 34298 a–d.

Remarks. Holotype deposited in the INPA collection. Other paratypes deposited in INPA, MPM, HWML and USNPC.

Reference. Kritsky et al. (2001).

***Rhabdosynochus hudsoni* Kritsky, Boeger & Robaldo, 2001**

Type host. *Centropomus undecimalis*

Infection site. Gills.

Type locality. Brazil, Pernambuco State, Itamaracá, earthen ponds (7°41'S, 34°53'W).

Paratypes. CHIOC 34297 a–d.

Remarks. Holotype deposited in the INPA collection. Other paratypes deposited in INPA, MPM, HWML and USNPC.

Reference. Kritsky et al. (2001).

***Spinomatrix* Boeger, Fehlaue & Marques, 2006**

****Spinomatrix penteormos* Boeger, Fehlaue & Marques, 2006**

Type host. *Pachyurus adpersus* Steindachner, 1879

Infection site. Gills.

Type locality. Brazil, Minas Gerais State, Vau-Açú, Piranga River, Cachoeirinha da Brecha downstream (20°32'S, 42°57'W).

Paratypes. CHIOC 36502 a–f.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, MNHN, HWML and USNPC.

Reference. Boeger et al. (2006).

Gyrodactylidae Van Beneden & Hesse, 1863

***Diechodactylus* Vianna, Boeger & Silva-Souza, 2008**

***Diechodactylus joaberi* Vianna, Boeger & Silva-Souza, 2008**

Type host. *Gymnotus carapo* (Linnaeus, 1758) (Osteichthyes: Gymnotidae).

Infestation site. Body surface.

Type locality. Brazil, São Paulo State, São Carlos, Córrego do Feijão stream (22°06'10.7"S, 47°44'36.7"W).

Holotype. CHIOC 36854 a.

Paratypes. CHIOC 36854 b–e.

Remarks. Other paratypes deposited in INPA and USNPC.

Reference. Vianna et al. (2008).

***Gyrodactylus* Nordmann, 1832**

***Gyrodactylus anisopharynx* Popazoglo & Boeger, 2000**

Type host. *Corydoras paleatus* (Jenyns, 1842) (Osteichthyes: Callichthyidae).

Infestation site. Body surface.

Type locality. Brazil, Paraná State, Piraquara, Piraquara River (25°29'59"S, 49°02'40"W).

Holotype. CHIOC 34215.

Paratypes. CHIOC 34217 a–d, 34218 a–b, 34219, 34220, 34221 b, g–j, 34222.

Remarks. Other paratypes deposited in IPCR, MNHN, HWML and USNPC. CHIOC 34216, 34221 a, c–f and 32223 were cited as paratypes in the original description, but they are paratypes of *G. corydori* Bueno-Silva & Boeger (2009).

References. Popazoglo and Boeger (2000), Bueno-Silva and Boeger (2009).

***Gyrodactylus carolinae* Boeger, Ferreira, Vianna & Patella, 2014**

Type host. *Characidium lanei*

Infestation site. Body surface.

Type locality. Brazil, Paraná State, Morretes, Marumbi River (25°29'27"S, 45°49'67"W).

Holotype. CHIOC 37880.

Paratypes. CHIOC 37875, 37876, 37877, 37878, 37879, 37900.

Remarks. Other paratypes deposited in IPCAS, HWML and USNPC.

Reference. Boeger et al. (2014).

Gyrodactylus corydori Bueno-Silva & Boeger, 2009

Type host. *Corydoras paleatus*

Infestation site. Body surface.

Type locality. Brazil, Paraná State, São José dos Pinhais, Miringuava River (25°38'06"S, 49°05'07"W).

Paratypes. CHIOC 34216, 34221 a, c–f, 34223 a–b, 36911, 36912.

Remarks. Paratypes from CHIOC collected in the Piraquara River (25°29'59"S, 49°02'40"W), Piraquara (Paraná State). Holotype deposited in MZUSP. Other paratypes deposited in MZUSP, MNHN, IPCR, HWML and USNPC.

Reference. Bueno-Silva and Boeger (2009).

Gyrodactylus geophagensis Boeger & Popazoglo, 1995

Type host. *Geophagus brasiliensis*

Infestation site. Body surface.

Type locality. Brazil, Rio de Janeiro State, Itaguaí, Da Guarda River.

Holotype. CHIOC 33144 a.

Paratypes. CHIOC 33144 b–e

Remarks. Other paratypes deposited in the collections of HWML and USNM.

Reference. Boeger and Popazoglo (1995).

Gyrodactylus inesperatus Boeger, Ferreira, Vianna & Patella, 2014

Type host. *Characidium* sp.

Infestation site. Body surface.

Type locality. Brazil, São Paulo State, Ribeirão Bonito, Das Almas River (24°8'52"S, 48°20'52"W).

Holotype. CHIOC 37869.

Paratypes. CHIOC 37870, 37871, 37872, 37873, 37874.

Remarks. Other paratypes deposited in IPCAS, HWML and USNPC.

Reference. Boeger et al. (2014).

***Gyrodactylus samirae* Popazoglo & Boeger, 2000**

Type host. *Corydoras ehrhardti* Steindachner, 1910

Infestation site. Body surface.

Type locality. Brazil, Paraná State, Piraquara, Piraquara River.

Holotype. CHIOC 34226 a.

Paratypes. CHIOC 34226 b, 34227, 34228, 34229 a–g.

Remarks. Other paratypes deposited in IPCR, MNHN, HWML and USNPC.

Reference. Popazoglo and Boeger (2000).

***Gyrodactylus trairae* Boeger & Popazoglo, 1995**

Type host. *Hoplias* aff. *malabaricus*

Infestation site. Body surface.

Type locality. Brazil, Rio de Janeiro State, Nova Iguaçu, Guandu River.

Holotype. CHIOC 33215 a.

Paratypes. CHIOC 33215 b–i.

Remarks. Other paratypes deposited in the collections of HWML and USNM.

Reference. Boeger and Popazoglo (1995).

***Hiperopletes* Boeger, Kritsky & Belmont-Jégu, 1994**

****Hiperopletes malmbergi* Boeger, Kritsky & Belmont-Jégu, 1994**

Type host. *Rhineloricaria* sp. (Osteichthyes: Loricariidae).

Infestation site. Body surface.

Type locality. Brazil, Amazonas State, Manaus, Candiru stream.

Holotype. CHIOC 33050 a.

Paratypes. CHIOC 33050 b–l.

Remarks. Other paratypes deposited in the collections of HWML and USNM.

Reference. Boeger et al. (1994).

***Nothogyrodactylus* Kritsky & Boeger, 1991**

***Nothogyrodactylus amazonicus* Kritsky & Boeger, 1991**

Type host. *Ancistrus* sp. (Osteichthyes: Loricariidae).

Infestation site. Skin.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Paratype. CHIOC 32706.

Remarks. Holotype deposited in the INPA collection. Other paratypes deposited in BMNH, HWML, USNM and ZIAC.

Reference. Kritsky and Boeger (1991).

****Nothogyrodactylus clavatus* Kritsky & Boeger, 1991**

Type host. *Ancistrus* sp.

Infestation site. Skin.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Paratype. CHIOC 32705.

Remarks. Holotype deposited in the INPA collection. Other paratypes deposited in BMNH, HWML, USNM and ZIAC.

Reference. Kritsky and Boeger (1991).

***Nothogyrodactylus plaesiophallus* Kritsky & Boeger, 1991**

Type host. *Ancistrus* sp.

Infestation site. Skin.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Paratype. CHIOC 32707.

Remarks. Holotype deposited in the INPA collection. Other paratypes deposited in BMNH, HWML, USNM and ZIAC.

Reference. Kritsky and Boeger (1991).

***Phanerothecium* Kritsky & Thatcher, 1977**

***Phanerothecium harrisi* Kritsky & Boeger, 1991**

Type host. *Hypostomus plecostomus* (Linnaeus, 1758) [= *Plecostomus plecostomus*] (Osteichthyes: Loricariidae).

Infestation site. Skin.

Type locality. Brazil, Amazonas State, Manaus, Bairro São Jorge.

Paratype. CHIOC 32704.

Remarks. Holotype deposited in the INPA collection. Other paratypes deposited in BMNH, HWML, USNM and ZIAC.

Reference. Kritsky and Boeger (1991).

***Phanerothecium spinatus* Boeger, Kritsky & Belmont-Jégu, 1994**

Type host. *Hypostomus punctatus* Valenciennes, 1840 (Osteichthyes: Loricariidae).

Infestation site. Body surface.

Type locality. Brazil, Rio de Janeiro State, Nova Iguaçu, Guandú River.

Holotype. CHIOC 33051 a.

Paratypes. CHIOC 33051 b–k.

Remarks. Other paratypes deposited in the collections of HWML and USNM.

Reference. Boeger et al. (1994).

Polyclithrum* Rogers, 1967**Polyclithrum boegeri* Ernst, Whittington & Jones, 2000**

Type host. *Mugil liza* (= *Mugil platanus* Günther, 1880)

Infestation site. Body washings.

Type locality. Brazil, Rio de Janeiro State, Itaguaí, Da Guarda River.

Holotype. CHIOC 33988 a.

Paratype. CHIOC 33988 b.

Remarks. Other paratypes deposited in the QM collection.

Reference. Ernst et al. (2000).

Monocotylidae Taschenberg, 1879***Heterocotyle* Scott, 1904*****Heterocotyle sulamericana* Santos, Santos, Cunha & Chisholm, 2012**

Type host. *Dasyatis guttata* (Bloch & Schneider, 1801) (Osteichthyes: Dasyatidae).

Infection site. Gills, between secondary lamellae.

Type locality. Brazil, Rio de Janeiro State, off Angra dos Reis (23°00'24"S, 44°19'05"W).

Holotype. CHIOC 37551 a.

Paratypes. CHIOC 37551 b–d.

Remarks. Collection numbers referred to as “3751” in the original description due to a mistake. Other paratypes deposited in AHC SAMA.

Reference. Santos et al. (2012).

Monocotyle* Taschenberg, 1878**Monocotyle guttatae* Santos, Santos & Gibson, 2006**

Type host. *Dasyatis guttata*

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, off Angra dos Reis (23°00'24"S, 44°19'05"W).

Holotype. CHIOC 36577.

Paratypes. CHIOC 36578 a–c.

Remarks. Other paratype deposited in the BMNH collection.

Reference. Santos et al. (2006).

***Potamotrygonocotyle* Mayes, Brooks & Thorson, 1981**

***Potamotrygonocotyle aramasae* Domingues, Pancera & Marques, 2007**

Type host. *Paratrygon aiereba* (Müller & Henle, 1841) (Chondrichthyes: Potamotrygonidae).

Infection site. Gills.

Type locality. Brazil, Amazonas State, Barcelos, Negro River (0°58'11"S, 62°55'13"W)

Paratypes. CHIOC 36886, 36887 a–c.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, IPCR, HWML and USNPC.

Reference. Domingues et al. (2007).

***Potamotrygonocotyle auriculocotyle* Domingues & Marques, 2011**

Type host. *Potamotrygon motoro* (Müller & Henle, 1841) (Chondrichthyes: Potamotrygonidae).

Infection site. Gills.

Type locality. Brazil, Pará State, Cachoeira do Arari, Arari River, Urubu stream (1°00'36"S, 48°57'36"W).

Paratype. CHIOC 37399.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA and MZUSP. Paratypes collected in a different site along the Urubu stream (0°59'58.2"S, 48°57'52.5594"W).

Reference. Domingues and Marques (2011).

***Potamotrygonocotyle chisholmae* Domingues & Marques, 2007**

Type host. *Potamotrygon motoro*

Infection site. Gills.

Type locality. Brazil, Mato Grosso do Sul State, Miranda, Salobra River (20°14'26"S, 56°22'42"W).

Paratypes. CHIOC 36699 a–e.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, HWML and USNPC.

Reference. Domingues and Marques (2007).

***Potamotrygonocotyle dromedarius* Domingues & Marques, 2007**

Type host. *Potamotrygon motoro*

Infection site. Gills.

Type locality. Brazil, Mato Grosso do Sul State, Miranda, Salobra River (20°14'26"S, 56°22'42"W).

Paratype. CHIOC 36802.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, HWML and USNPC.

Reference. Domingues and Marques (2007).

***Potamotrygonocotyle eurypotamoxenus* Domingues & Marques, 2007**

Type host. *Potamotrygon* cf. *motoro*

Infection site. Gills.

Type locality. Brazil, Mato Grosso do Sul State, Miranda, Salobra River (20°14'26"S, 56°22'42"W).

Paratype. CHIOC 36803.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, HWML and USNPC. Domingues and Marques (2011) considered this species to be a synonym of *P. tsalickisi* Mayes, Brooks & Thorson, 1981.

References. Domingues and Marques (2007), Domingues and Marques (2011).

***Potamotrygonocotyle quadracotyle* Domingues, Pancera & Marques, 2007**

Type host. *Potamotrygon* sp.

Infection site. Gills.

Type locality. Brazil, Amazonas State, Barcelos, Negro River (0°58'11"S, 62°55'13"W).

Paratypes. CHIOC 36883 a–d.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, IPCR, HWML and USNPC.

Reference. Domingues et al. (2007).

***Potamotrygonocotyle rionegrense* Domingues, Pancera & Marques, 2007**

Type host. *Potamotrygon* sp.

Infection site. Gills.

Type locality. Brazil, Amazonas State, Barcelos, Negro River (0°58'11"S, 62°55'13"W).

Paratypes. CHIOC 36885 a–d.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, IPCR, HWML and USNPC.

Reference. Domingues et al. (2007).

***Potamotrygonocotyle septemcotyle* Domingues & Marques, 2011**

Type host. *Potamotrygon scobina* Garman, 1913

Infection site. Gills.

Type locality. Brazil, Pará State, Colares, Marajó Bay, Tocantins River (0°55'45"S, 48°17'29"W).

Paratypes. CHIOC 37397 a–b.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP and USNPC.

Reference. Domingues and Marques (2011).

***Potamotrygonocotyle tatianae* Domingues & Marques, 2011**

Type host. *Paratrygon* sp.

Infection site. Gills.

Type locality. Brazil, Amazonas State, Benjamin Constant, Yavari River (4°18'15.1194"S, 70°4'19.56"W).

Paratype. CHIOC 37404.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, HMWL and USNPC. Paratypes collected in a different site along the Yavari River (4°18'25"S, 70°4'31"W).

Reference. Domingues and Marques (2011).

***Potamotrygonocotyle tocantinsense* Domingues & Marques, 2011**

Type host. *Potamotrygon* cf. *scobina*

Infection site. Gills.

Type locality. Brazil, Tocantins State, Ipueiras, Tocantins River (11°18'36"S, 48°27'36"W).

Paratypes. CHIOC 37405 a–c.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP and USNPC. Paratypes collected from a different site along the Tocantins River (11°15'48.52"S, 48°26'56.79"W).

Reference. Domingues and Marques (2011).

***Potamotrygonocotyle umbella* Domingues, Pancera & Marques, 2007**

Type host. *Potamotrygon* sp.

Infection site. Gills.

Type locality. Brazil, Amazonas State, Barcelos, Negro River (0°58'11"S, 62°55'13"W).

Paratypes. CHIOC 36884 a–b.

Remarks. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, IPCR, HWML and USNPC.

Reference. Domingues et al. (2007).

***Potamotrygonocotyle uruguayensis* Domingues & Marques, 2007**

Type host. *Potamotrygon brachyura* (Günther, 1880)

Infection site. Gills.

Type locality. Brazil, Rio Grande do Sul State, Porto Xavier, Uruguay River (27°54'00"S, 55°08'00"W).

Paratypes. CHIOC 36807 a–d.

Remarks. Domingues and Marques (2011) considered this species to be a synonym of *P. chisholmae*. Holotype deposited in MZUSP. Other paratypes deposited in INPA, MZUSP, HWML and USNPC.

References. Domingues and Marques (2007), Domingues and Marques (2011).

Subclass Polystomatoinea Lebedev, 1986

Polystomatidae Gamble, 1896

***Neopolystoma* Price, 1939**

***Neopolystoma fentoni* Platt, 2000**

Type host. *Cryptochelys leucostoma* (Duméril & Bibron, 1851) (Testudines: Kinosternidae)

Infection site. Conjunctival sac.

Type locality. Costa Rica, Guanacaste, Santa Rosa, Guanacaste Conservation Area, Quebrada Costa Rica (10°49.666'N, 85°38.216'W).

Paratypes. CHIOC 34292, 34293 a–b, 34294.

Remarks. CHIOC 34292 and 34293 a–b were collected from *Rhinoclemmys pulcherrima* (Gray, 1856) (Testudines: Geoemydidae) in Quebrada El Duende (10°50.236'N, 85°36.724'W), Guanacaste Conservation Area. Holotype and other paratypes deposited in USNPC.

Reference. Platt (2000).

***Polystomoides* Ward, 1917**

***Polystomoides brasiliensis* Vieira, Novelli, Sousa & SouzaLima, 2008**

Type host. *Hydromedusa maximiliani* (Mikan, 1825) (Testudines: Chelidae).

Infection site. Buccal and pharyngeal cavities.

Type locality. Brazil, Minas Gerais State, Juiz de Fora, lake of Mariano Procópio Museum (21°41'20"S, 43°20'40"W).

Holotype. CHIOC 36902.

Paratypes. CHIOC 36903 a–d.

Reference. Vieira et al. (2008).

Subclass Oligochoinea Bychowsky, 1937

Allodiscocotylidae Tripathi, 1959

***Metacamopiella* Kohn, Santos & Lebedev, 1996**

****Metacamopiella euzeti* Kohn, Santos & Lebedev, 1996**

Type host. *Trachinotus carolinus* (Linnaeus, 1766) (Osteichthyes: Carangidae).

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Guanabara Bay (23°48'S, 43°10'W).

Holotype. CHIOC 33059.

Remarks. Paratypes deposited in PC–IBPRAS.

Reference. Kohn et al. (1996).

***Metacamopia oligoplites* Takemoto, Amato & Luque, 1996**

Type host. *Oligoplites palometa* (Cuvier, 1833) (Osteichthyes: Carangidae).

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Itacuruça, Sepetiba Bay (22°51'S, 43°56'W).

Holotype. CHIOC 33623 a.

Paratypes. CHIOC 33623 b–c, 33624, 33625.

Remarks. Other paratypes deposited in USNPC.

Reference. Takemoto et al. (1996).

Anoplodiscidae Tagliani, 1912***Anoplodiscus* Sonsino, 1890*****Anoplodiscus longivaginus* Paraguassú, Luque & Alves, 2002**

Type host. *Pagrus pagrus* (Linnaeus, 1758) (Osteichthyes: Sparidae).

Infection site. Mouth and gills.

Type locality. Brazil, coastal zone of Rio de Janeiro State (21–23°S, 41–45°W).

Holotype. CHIOC 34905.

Paratypes. CHIOC 34906 a–d, 34907.

Remarks. Other paratypes deposited in MPM and USNPC.

Reference. Paraguassú et al. (2002).

Diclidophoridae Cerfontaine, 1895***Absonifibula* Lawler & Overstreet, 1976*****Absonifibula estuarina* Santos & Timi, 2009**

Type host. *Cynoscion guatucupa*

Infection site. Gills.

Type locality. Argentina, Buenos Aires Province, Mar del Plata (38°08'S 57°32'W).

Paratypes. CHIOC 37205 a–d.

Remarks. Holotype and other paratypes deposited in CHMLP.

Reference. Santos and Timi (2009).

Choricotyle* van Beneden & Hesse, 1863**Choricotyle brasiliensis* Luque, Amato & Takemoto, 1993**

Type host. *Orthopristis ruber* (Cuvier, 1830) (Osteichthyes: Haemulidae).

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Sepetiba Bay (22°51'S, 43°56'W).

Paratypes. CHIOC 33105, 33106.

Remarks. Holotype and other paratypes deposited in the USNM collection.

Reference. Luque et al. (1993a).

***Choricotyle orthopristis* Luque, Amato & Takemoto, 1993**

Type host. *Orthopristis ruber*

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Sepetiba Bay (22°51'S, 43°56'W).

Paratypes. CHIOC 33108 a–b.

Remarks. One of the collection numbers is referred to as “38108b” in the original description due to a mistake. Holotype and other paratypes deposited in the USNM collection.

Reference. Luque et al. (1993a).

***Choricotyle rohdei* Cohen, Cárdenas, Fernandes & Kohn, 2011**

Type host. *Ctenosciaena gracilicirrhus* (Metzelaar, 1919) (Osteichthyes: Sciaenidae).

Infection site. Gill lamellae.

Type locality. Brazil, Rio de Janeiro State, Angra dos Reis (23°00'24"S, 44°19'05"W).

Holotype. CHIOC 37473 a.

Paratypes. CHIOC 37473 b, 37474 a–b, 37475, 37476 a–b, 37477 a–b, 37478, 37479 a–b, 37480, 37481, 37482, 37483 a–c, 37484 a–b, 37485, 37486, 37487, 37488 a–b, 37489 a–c, 37490 a–c, 37491.

Reference. Cohen et al. (2011).

Heteraxinidae Unnithan, 1957

***Probursata* Bravo-Hollis, 1984**

***Probursata brasiliensis* Takemoto, Amato & Luque, 1993**

Type host. *Oligoplites palometa*

Infection site. Gill filaments.

Type locality. Brazil, Rio de Janeiro State, Sepetiba Bay, Itacuruçá (22°61'S, 43°56'W).

Holotype. CHIOC 33069.

Paratypes. CHIOC 33053 a–b, 33054, 33055, 33056, 33057.

Remarks. Other paratypes deposited in the USNM collection.

Reference. Takemoto et al. (1993).

Macroalvitrematidae Yamaguti, 1963

***Pseudotagia* Yamaguti, 1963**

***Pseudotagia rubri* Luque, Amato & Takemoto, 1993b**

Type host. *Orthopristis ruber*

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Sepetiba Bay, Itacuruçá (22°51'S, 43°56'W).

Paratypes. CHIOC 33100, 33101, 33102.

Remarks. Holotype and other paratypes deposited in the USNM collection.

Reference. Luque et al. (1993b).

Mazocraeidae Price, 1936

***Cribomazocraes* Mamaev, 1981**

***Cribomazocraes travassosi* Santos & Kohn, 1992**

Type host. *Harengula clupeola* (Cuvier, 1829) (Osteichthyes: Clupeidae).

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Rio de Janeiro, Ilha do Governador.

Holotype. CHIOC 32758.

Remarks. No paratype deposited, only vouchers.

Reference. Santos and Kohn (1992).

Microcotylidae Taschenberg, 1879

***Microcotyle* van Beneden & Hesse, 1863**

***Microcotyle pseudopercis* Amato & Cezar, 1994**

Type host. *Pseudopercis numida* Miranda-Ribeiro, 1903 (Osteichthyes: Pinguipedidae).

Infection site. Gill filaments.

Type locality. Brazil, coast of Rio de Janeiro State (21–23°S, 41–45°W).

Paratypes. CHIOC 33290 a–b.

Remarks. Holotype and other paratype deposited in the USNM collection.

Reference. Amato and Cezar (1994).

***Paranaella* Kohn, Baptista-Farias & Cohen, 2000**

****Paranaella luquei* Kohn, Baptista-Farias & Cohen, 2000**

Type host. *Hypostomus* sp.

Infection site. Gills.

Type locality. Brazil, Paraná State, Paraná River, reservoir of the Itaipu Hydro-electric Power Station.

Holotype. CHIOC 33954 a.

Paratypes. CHIOC 33954 b–h.

Remarks. There is no paratype “i”, as informed in the original description. That was a mistake.

Reference. Kohn et al. (2000).

Plectanocotylidae Poche, 1926

***Octoplectanocotyla* Yamaguti, 1937**

***Octoplectanocotyla travassosi* Carvalho & Luque, 2012**

Type host. *Trichiurus lepturus*

Infection site. Gills.

Type locality. Brazil, Rio de Janeiro State, Guanabara Bay (23°1'52"S, 43°11'56"W).

Holotype. CHIOC 37386.

Paratypes. CHIOC 37387 a–b, 37388 a–b.

Reference. Carvalho and Luque (2012).

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References

- Abdallah VD, Azevedo RK, Luque JL (2009) Four new species of *Ligophorus* (Monogenea: Dactylogyridae) parasitic on *Mugil liza* (Actinopterygii: Mugilidae) from Guandu River, Southeastern Brazil. *Journal of Parasitology* 95(4): 855–864. doi: 10.1645/GE-1914.1
- Aguiar JC, Ceccarelli PS, Luque JL (2011) Two new species of *Pavanelliella* (Monogenea, Dactylogyridae) parasitic on pimelodid fishes from Mogi Guaçu river, southeastern Brazil, and notes on the morphology of *P. pavanellii*. *Neotropical Helminthology* 5(2): 213–224.
- Amato JFR, Cezar AD (1994) A new species of *Microcotyle* Van Beneden and Hesse, 1863, parasitic on “namorado”, *Pseudopercis numida* Ribeiro, 1903 and *P. semifasciata* (Cuvier, 1829), from the coast of the state of Rio de Janeiro, Brazil. *Revista Brasileira de Parasitologia Veterinária* 3(1): 41–44.

- Bellay S, Takemoto RM, Yamada FH, Pavanelli GC (2008) A new species of *Sciadicleithrum* (Monogenea: Ancyrocephalinae), gill parasite of *Geophagus brasiliensis* (Quoy and Gaimard) (Teleostei: Cichlidae) from reservoirs in the State of Paraná, Brazil. *Zootaxa* 1700: 63–68.
- Bellay S, Takemoto RM, Yamada FH, Pavanelli GC (2009) Two new species of *Sciadicleithrum* (Monogenea: Dactylogyridae), gill parasites of *Geophagus proximus* (Castelnau) (Teleostei: Cichlidae), from the upper Parana River floodplain, Brazil. *Zootaxa* 2081: 57–66.
- Boeger WA, Belmont-Jégu E (1994) Neotropical Monogenoidea. 21. *Trinigyrus mourei* sp. n. (Dactylogyridae) from the gills of the Amazonian catfish *Hypostomus emarginatus* (Loricariidae). *Amazoniana* 13(1): 13–16.
- Boeger WA, Diamanka A, Pariselle A, Patella L (2012) Two new species of *Protogyrodactylus* (Monogenoidea: Dactylogyridae) from the gills of *Gerres nigri* (Teleostei: Gerreidae) from Senegal. *Folia Parasitologica* 59(1): 59–63. doi: 10.14411/fp.2012.009
- Boeger WA, Domingues MV, Kritsky DC (1997) Neotropical Monogenoidea. 32. *Cacatuocotyle paranaensis* n. g., n. sp. (Dactylogyridae, Ancyrocephalinae) from *Characidium* spp. (Teleostei, Characidae) from the State of Paraná, Brazil. *Systematic Parasitology* 36: 75–78. doi: 10.1023/A:1005796027406
- Boeger WA, Domingues MV, Pavanelli, GC (1995a) Neotropical Monogenoidea. 24. *Rhinoxenus bulbovaginatus* n. sp. (Dactylogyridae, Ancyrocephalinae) from the nasal cavity of *Salminus maxillosus* (Osteichthyes, Characidae) from the Rio Paraná, Paraná, Brazil. *Memórias do Instituto Oswaldo Cruz* 90(6): 695–698. doi: 10.1590/S0074-02761995000600007
- Boeger WA, Fehlaue KH, Marques EE (2006) Neotropical Monogenoidea. 49. Four new species of the Diplectanidae (Dactylogyridae) from the gills of some pachyurines (Teleostei: Sciaenidae) from the Rio Tocantins and Rio Doce Basins, with the proposal of *Anoplectanum* n. g. and *Spinomatrix* n. g. *Systematic Parasitology* 64: 57–68. doi: 10.1007/s11230-005-9021-7
- Boeger WA, Ferreira RC, Vianna RT, Patella L (2014) Neotropical Monogenoidea 59. Polyonchoineans from *Characidium* spp. (Characiformes: Crenuchidae) from southern Brazil. *Folia Parasitologica* 61(2): 120–132. doi: 10.14411/fp.2014.010
- Boeger WA, Husak WS, Martins ML (1995b) Neotropical Monogenoidea. 25. *Anacanthorus penilabiatus* n. sp. (Dactylogyridae, Anacanthorinae) from *Piaractus mesopotamicus* (Osteichthyes, Serrasalminae), cultivated in the State of São Paulo, Brazil. *Memórias do Instituto Oswaldo Cruz* 90(6): 699–701. doi: 10.1590/S0074-02761995000600008
- Boeger WA, Kritsky DC (1993) Phylogeny and a revised classification of the Monogenoidea Bychowsky, 1937 (Platyhelminthes). *Systematic Parasitology* 26: 1–32. doi: 10.1007/BF00009644
- Boeger WA, Kritsky DC, Belmont-Jégu E (1994) Neotropical Monogenoidea. 20. Two new species of oviparous Gyrodactylidae (Polyonchoinea) from loricariid catfishes (Siluriformes) in Brazil and the phylogenetic status of Oeogyrodactylidae Harris, 1983. *Journal of the Helminthological Society of Washington* 61(1): 34–44.
- Boeger WA, Pariselle A, Patella L (2015) *Susanlimae ianwhittingtoni* gen. nov., sp. nov. (Monogenoidea: Dactylogyridae), a dweller of the gill rakers of *Pseudeutropius moolenburghae* (Siluriformes: Schilbeidae) from Sumatra. *Zoologia* 32(6): 532–537. doi: 10.1590/S1984-46702015000600011

- Boeger WA, Piasecki W, Sobecka E (2002) Neotropical Monogenea. 44. *Mymarothecium viatorium* sp. n. (Ancyrocephalinae) from the gills of *Piaractus brachipomus* (Serrasalminae, Teleostei) captured in a warm-water canal of a power plant in Szczecin, Poland. *Acta Ichthyologica et Piscatoria* 32(2): 157–162.
- Boeger WA, Popazoglo F (1995) Neotropical Monogenea. 23. Two new species of *Gyrodactylus* (Gyrodactylidae) from a cichlid and an erythrinid fish of Southeastern Brazil. *Memórias do Instituto Oswaldo Cruz* 90(6): 689–694. doi: 10.1590/S0074-02761995000600006
- Boeger WA, Tanaka LK, Pavanelli GC (2001) Neotropical Monogenea. 39: a new species of *Kriskyia* (Dactylogyridae, Ancyrocephalinae) from the ureters and urinary bladder of *Serrasalmus marginatus* and *S. spilopleura* (Characiformes, Serrasalminae) from southern Brazil with an emended generic diagnosis. *Zoosystema* 23(1): 5–10.
- Branches B, Domingues MV (2014) A new species of *Unilatus* (Platyhelminths: Monogenea) from the gills of *Leporacanthicus galaxias* Isbrücker et Nijssen (Siluriformes: Loricariidae) from Brazil. *Acta Parasitologica* 59(1): 91–97. doi: 10.2478/s11686-014-0213-7
- Bueno-Silva M, Boeger WA (2009) Neotropical Monogenea. 53. *Gyrodactylus corydori* sp. n. and redescription of *Gyrodactylus anisopharynx* (Gyrodactylidae: Gyrodactylidae), parasites of *Corydoras* spp. (Siluriformes: Callichthyidae) from southern Brazil. *Folia Parasitologica* 56(1): 13–20. doi: 10.14411/fp.2009.003
- Carvalho AR, Luque JL (2012) Three new species of monogeneans parasitic on Atlantic cutlassfish *Trichiurus lepturus* (Perciformes: Trichiuridae) from Southeastern Brazil. *Acta Scientiarum* 34(3): 359–365. doi: 10.4025/actasciobiolsci.v34i3.10360
- Carvalho AR, Tavares LER, Luque JL (2008) A new species of *Sciadicleithrum* (Monogenea, Dactylogyridae) parasitic on *Geophagus brasiliensis* (Perciformes, Cichlidae) from Guandu River, Southeastern Brazil. *Acta Parasitologica* 53(3): 237–239. doi: 10.2478/s11686-008-0035-6
- Carvalho AR, Tavares LER, Luque JL (2009) A new species of *Aphanoblastella* (Monogenea: Dactylogyridae) parasitic on *Rhamdia quelen* (Siluriformes: Heptapteridae) from Southeastern Brazil. *Acta Scientiarum* 31(3): 323–325. doi: 10.4025/actasciobiolsci.v31i3.4917
- Cepeda PB, Ceccarelli PS, Luque JL (2011) A new species of *Kriskyia* (Monogenea, Dactylogyridae) parasitic in the urinary bladder of *Salminus brasiliensis* (Characiformes) from the Pantanal wetlands, Brazil. *Acta Parasitologica* 56(3): 270–273. doi: 10.2478/s11686-011-0055-5
- Cepeda PB, Ceccarelli OS, Luque JL (2012) A new species of *Tereancistrum* (Monogenea, Dactylogyridae) parasitic on *Prochilodus lineatus* (Valenciennes, 1837) (Characiformes) from Mogiguaçu river, Brazil. *Neotropical Helminthology* 6(2): 205–210.
- Cepeda PB, Luque JL (2010) Three new species of *Demidospermus* (Monogenea: Dactylogyridae) parasitic on *Brachyplatystoma filamentosum* (Siluriformes: Pimelodidae) from the Araguaia River, Brazil. *Journal of Parasitology* 96(5): 869–873. doi: 10.1645/GE-2331.1
- Cezar AD, Luque JL, Amato JFR (1999) Two new species of Monogenea (Platyhelminths: Cercomeridae) parasitic on *Chaetodipterus faber* (Teleostei: Ephippidae) from the Brazilian coastal zone. *Revista de Biología Tropical* 47(3): 393–398.
- Cezar AD, Paschoal F, Luque JL (2012) A new species of *Mexicana* (Monogenea: Dactylogyridae) parasitic on two species of *Anisotremus* (Perciformes: Haemulidae) from the Brazilian coastal zone. *Neotropical Helminthology* 6(1): 25–29.

- Cohen SC, Cárdenas MQ, Fernandes BMM, Kohn A (2011) A new species of *Choricotyle* (Monogeneoidea: Diclidophoridae) from *Ctenosciaena gracilicirrhus* (Teleostei: Sciaenidae), a marine fish occurring in the littoral zone from the state of Rio de Janeiro, Brazil. *Comparative Parasitology* 78(2): 261–264. doi: 10.1654/4506.1
- Cohen SC, Justo MCN, Kohn A (2013) South American Monogeneoidea parasites of fishes, amphibians and reptiles. Oficina de Livros, Rio de Janeiro, 663 pp.
- Cohen SC, Kohn A (2005) A new species of *Mymarothecium* and new host and geographical records for *M. viatorum* (Monogenea: Dactylogyridae), parasites of freshwater fishes in Brazil. *Folia Parasitologica* 52(4): 307–310. doi: 10.14411/fp.2005.042
- Cohen SC, Kohn A (2008a) New data on species of *Demidospermus* (Dactylogyridae, Monogenea) parasitizing fishes from the Reservoir of the Itaipu Hydroelectric Power Station, Paraná State, Brazil, with new synonymies. *Revista Brasileira de Parasitologia Veterinária* 17(3): 167–170. doi: 10.1590/S1984-29612008000300011
- Cohen SC, Kohn A (2008b) A new species of the genus *Notozothecium* (Monogenea, Dactylogyridae) parasitizing the gills of *Rhaphiodon vulpinus* (Cynodontidae, Characiformes) from the Paraná River, State of Paraná, Brazil. *Revista Mexicana de Biodiversidad* 79: 95S–98S.
- Cohen SC, Kohn A, Boeger WA (2012) Neotropical Monogeneoidea. 57. Nine new species of Dactylogyridae (Monogeneoidea) from the gill of *Salminus brasiliensis* (Characidae, Characiformes) from the Paraná River, State of Paraná, Brazil. *Zootaxa* 3049: 57–68.
- Cuglianna AM, Cordeiro NS, Luque JL (2003) *Annulotrematoides bryconi* sp. n. (Monogenea: Dactylogyridae) parasitic on *Brycon cephalus* (Osteichthyes: Characidae) from Brazil. *Folia Parasitologica* 50: 272–274. doi: 10.14411/fp.2003.046
- Cuglianna AM, Cordeiro NS, Luque JL (2009) *Apendiculata discoidea* gen. n., sp. n. (Monogenea: Dactylogyridae) parasitic on *Prochilodus lineatus* (Valenciennes, 1837) (Characiformes: Prochilodontidae) from southeastern Brazil. *Brazilian Journal of Zoology* 69(3): 895–898. doi: 10.1590/S1519-69842009000400018
- Domingues MV, Boeger WA (2002) Neotropical Monogeneoidea. 40. *Protorhinoxenus prochilodi* gen. n., sp. n. (Monogeneoidea: Ancyrocephalinae), parasite of *Prochilodus lineatus* (Characiformes: Prochilodontidae) from South Brazil. *Folia Parasitologica* 49: 35–38. doi: 10.14411/fp.2002.009
- Domingues MV, Boeger WA (2003) Neotropical Monogeneoidea. 43. *Diplectanum monticellii* n. sp. (Diplectanidae) from the gills of *Cynoscion leiarchus* (Perciformes: Sciaenidae) in Brazil. *Journal of Parasitology* 89(4): 698–700. doi: 10.1645/GE-55R
- Domingues MV, Boeger WA (2005) Neotropical Monogeneoidea. 47. Phylogeny and coevolution of species of *Rhinoxenus* (Platyhelminths, Monogeneoidea, Dactylogyridae) and their Characiformes hosts (Teleostei, Ostariophysi) with description of four new species. *Zoosystema* 27(3): 441–467.
- Domingues MV, Diamanka A, Pariselle A (2011) Monogenoids (Diplectanidae, Polyonchoinea) from the gills of mojarras (Perciformes, Gerreidae) with the resurrection of *Neodiplectanum* Mizelle and Blatz, 1941 and the proposal of *Darwinoplectanum* n. gen. *Zootaxa* 3010: 1–19.
- Domingues MV, Fehlaue KH (2006) New species of *Chauhanellus* (Monogeneoidea, Platyhelminths) from the gills of Southern Atlantic marine catfishes (Siluriformes, Ariidae) of the Neotropical region. *Zootaxa* 1365: 61–68.

- Domingues MV, Marques FPL (2007) Revision of *Potamotrygonocotyle* Mayes, Brooks and Thorson, 1981 (Platyhelminths: Monogenea: Monocotylidae), with descriptions of four new species from the gills of the freshwater stingrays *Potamotrygon* spp. (Rajiformes: Potamotrygonidae) from the La Plata river basin. Systematic Parasitology 67: 157–174. doi: 10.1007/s11230-006-9086-y
- Domingues MV, Marques FPL (2011) Phylogeny and taxonomy of *Potamotrygonocotyle* Mayes, Brooks and Thorson, 1981 (Monogenea: Monocotylidae) with a description of four new species. Journal of Helminthology 85(4): 353–380. doi: 10.1017/S0022149X10000684
- Domingues MV, Pancera NCM, Marques FPL (2007) Monogenean parasites of freshwater stingrays (Rajiformes: Potamotrygonidae) from the Negro River, Amazon, Brazil: species of *Potamotrygonocotyle* (Monocotylidae) and *Paraheteronchocotyle* (Hexabothriidae). Folia Parasitologica 54(3): 177–190. doi: 10.14411/fp.2007.025
- Domingues MV, Soares GB, Watanabe A (2016) Monogenea (Polyonchoinea: Dactylogyridae) parasitizing the gills of marine catfish (Siluriformes: Ariidae) inhabiting the Atlantic Amazon Coast of Brazil. Zootaxa 4127(2): 301–326. doi: 10.11646/zootaxa.4127.2.4
- Ernst I, Whittington ID, Jones MK (2000) Three new species of *Polyclithrum* Rogers, 1967 (Gyrodactylidae: Monogenea) from mugilid fishes from Australia and Brazil, with a redescription of *P. mugilini* Rogers, 1967. Systematic Parasitology 45: 61–73. doi: 10.1023/a:1006285425710
- Faria JG, Travassos L (1913) Nota sobre a presença de larva de *Linguatula serrata* Froelich no intestino do homem, seguida de notas sobre os linguatulídeos da Coleção do Instituto. Memórias do Instituto Oswaldo Cruz 5: 123–128. doi: 10.1590/S0074-02761913000200002
- Fehlauer KH, Boeger WA (2005) Neotropical Monogenea: *Euryhaliootrema dontykoleos* n. sp. (Dactylogyridae) from the gills of the freshwater sciaenid, *Pachyurus junki* (Perciformes). Journal of Parasitology 91(5): 1025–1027. doi: 10.1645/GE-486R.1
- Ferrari-Hoeninghaus AP, Bellay S, Takemoto RM, Pavanelli GC (2010) A new species of *Demi-dospermus* Suriano, 1983 (Monogenea, Dactylogyridae) parasitic on *Loricariichthys platymetopon* Isbrücker et Nijssen (Loricariidae, Siluriformes) from the Upper Paraná River floodplain, Brazil. Acta Parasitologica 55(1): 16–19. doi: 10.2478/s11686-010-0007-5
- França JG, Isaac A, Pavanelli GC, Takemoto RM (2003) Dactylogyridae (Monogenea) from the gills of *Iheringichthys labrosus* (Osteichthyes: Pimelodidae) from the upper Paraná River floodplain, Brazil, with the proposal of *Pseudovancleaveus* n. g. Systematic Parasitology 54: 25–31. doi: 10.1023/A:1022113626634
- Fritz U, Havaš P (2007) Checklist of Chelonians of the World. Vertebrate Zoology 57(2): 149–368.
- Fritz U, Havaš P (2013) Order Testudines: 2013 update. Zootaxa 3703(1): 12–14. doi: 10.11646/zootaxa.3703.1.4
- Froese R, Pauly D (2016) Fish base. World Wide Web Electronic Publication. Version 01/2016. <http://www.fishbase.org> [01 March 2016]
- Gallas M, Calegari-Marques C, Amato SB (2014) A new species of *Cacatuocotyle* (Monogenea, Dactylogyridae) parasitizing two species of *Astyanax* (Ostariophysi, Characidae) in southern Brazil. Acta Parasitologica 59(4): 638–642. doi: 10.2478/s11686-014-0283-6
- Gibson D, Bray R (2016) WoRMS Monogenea: World list of Monogenea. Version Feb 2013. In: Roskov Y, Abucay L, Orrell T, Nicolson D, Kunze T, Flann C, Bailly N, Kirk P, Bourgoin T, DeWalt RE, Decock W, De Wever A (Eds) Species 2000 and ITIS Catalogue

- of Life, 23rd December 2015. Species 2000 (ISSN 2405–8858), Naturalis, Leiden. <http://www.catalogueoflife.org/col> [29 January 2016]
- Guidelli GM, Takemoto RM, Pavanelli GC (2003) A new species of *Kritskyia* (Dactylogyridae, Ancyrocephalinae), parasite of urinary bladder and ureters of *Leporinus lacustris* (Characiformes, Anostomidae) from Brazil. *Acta Scientiarum Biological Sciences* 25(2): 279–282. doi: 10.4025/actascibiolsci.v25i2.2010
- ICZN (International Commission on Zoological Nomenclature) (1999) International code of zoological nomenclature. Fourth Edition. The International Trust for Zoological Nomenclature, London.
- Karling LC, Bellay S, Takemoto RM, Pavanelli GC (2011a) A new species of *Jainus* (Monogenea), gill parasite of *Schizodon borellii* (Characiformes, Anostomidae) from the upper Paraná river floodplain, Brazil. *Acta Scientiarum* 33(2): 227–231. doi: 10.4025/actascibiolsci.v33i2.6168
- Karling LC, Lopes LPC, Takemoto RM, Pavanelli GC (2011b) *Trinibaculum rotundus* n.sp. (Monogenea, Ancyrocephalinae), a parasite of *Schizodon borellii* (Characiformes, Anostomidae) from the upper Paraná River floodplain, Brazil. *Helminthologia* 48(2): 85–87. doi: 10.2478/s11687-011-0014-6
- Karling LC, Lopes LPC, Takemoto RM, Pavanelli GC (2014) New species of *Tereancistrum* (Dactylogyridae) monogenean parasites of *Schizodon borellii* (Characiformes, Anostomidae) from Brazil, and emended diagnosis for *T. parvus*. *Acta Scientiarum* 36(3): 365–369. doi: 10.4025/actascibiolsci.v36i3.20216
- Knoff M, Cohen SC, Cárdenas MQ, Cárdenas-Callirgos JM, Gomes DC (2015) A new species of diplectanid (Monogenoidea) from *Paranthias colonus* (Perciformes, Serranidae) off Peru. *Parasite* 22(11): 1–6. doi: 10.1051/parasite/2015011
- Knoff M, Noronha D, Magalhães-Pinto R, Sanches M, Siqueira LR, Mattos FB, Côrrea-Gomes D (2010) Coleção Helminológica do Instituto Oswaldo Cruz (CHIOC). In: Lamothe-Argumedo R, Damborenea C, García-Prieto L, Lunaschi LI, Osorio-Sarabia D (Comps) Guide to Helminthological Collections of Latin America. Publicaciones Especiales 22, Instituto de Biología, Universidad Nacional Autónoma de México and Museo de La Plata, Universidad Nacional de La Plata, Buenos Aires and Mexico City, 15–27.
- Kohn A (1990) *Kritskyia moraveci* n. g., n. sp. (Monogenea: Dactylogyridae) from the urinary bladder and ureters of *Rhamdia quelen* (Quoy and Gaimard, 1824) (Pisces: Pimelodidae) in Brazil. *Systematic Parasitology* 17: 81–85. doi: 10.1007/BF00009794
- Kohn A, Baptista-Farias MD, Cohen SC (2000) *Paranaella luquei* gen. et sp. n. (Monogenea: Microcotylidae), a new parasite of Brazilian catfishes. *Folia Parasitologica* 47(4): 279–283. doi: 10.14411/fp.2000.048
- Kohn A, Baptista-Farias MF, Santos AL, Gibson DI (2004) A new species of *Nasicola* Yamaguti, 1968 (Monogenea: Capsalidae) from the nasal cavities of *Thunnus obesus* and a redescription of *N. klawei* (Stunkard, 1962) from *T. albacores* off Brazil. *Systematic Parasitology* 57: 51–58. doi: 10.1023/B:SYPA.0000010685.91891.5e
- Kohn A, Justo MCN (2006) *Caballerocotyla llewelinyi* n. sp. and *Caballerocotyla neothunni* (Yamaguti, 1968) (Monogenea; Capsalidae) parasites of Brazilian tunas (Scombridae). *Zootaxa* 1139: 19–26.

- Kohn A, Santos CP, Lebedev B (1996) *Metacamopiella euzeti* gen. n., sp. n., and *Hargicola oligoplites* (Hargis, 1957) (Monogenea: Allodiscocotylidae) from Brazilian fishes. Journal of the Helminthological Society of Washington 63(2): 176–180.
- Kritsky DC (2012) Revision of *Parancylodiscoides* Caballero y C. and Bravo-Hollis, 1961 (Monogenea: Dactylogyridae), with a redescription of *P. longiphallus* (MacCallum, 1915) from the Atlantic spadefish *Chaetodipterus faber* (Broussonet) (Acanthuroidei: Ephippidae) in the Gulf of Mexico. Systematic Parasitology 81: 97–108. doi: 10.1007/s11230-011-9327-6
- Kritsky DC, Boeger WA (1991) Neotropical Monogenea. 16. New species of oviparous Gyrodactylidae with proposal of *Nothogyrodactylus* gen. n. (Oogydactylidae). Journal of the Helminthological Society of Washington 58(1): 7–15.
- Kritsky DC, Boeger WA (1995) Neotropical Monogenea. 26. *Annulotrematoides amazonicus*, a new genus and species (Dactylogyridae: Ancyrocephalinae), from the gills of *Psectrogaster rutiloides* (Kner) (Teleostei: Characiformes: Curimatidae) from the Brazilian Amazon. Proceedings of the Biological Society of Washington 103(3): 528–532.
- Kritsky DC, Boeger WA, Robaldo RB (2001) Neotropical Monogenea. 38. Revision of *Rhabdosynochus* Mizelle and Blatz, 1941 (Polyonchoinea: Dactylogyridae: Diplectanidae), with descriptions of two new species from Brazil. Comparative Parasitology 68(1): 66–75.
- Kritsky DC, Boeger WA, Van Every LR (1992) Neotropical Monogenea. 17. *Anacanthorus* Mizelle and Price, 1965 (Dactylogyridae, Anacanthorinae) from characoid fishes of the Central Amazon. Journal of the Helminthological Society of Washington 59(1): 25–51.
- Kritsky DC, Van Every LR, Boeger WA (1996) Neotropical Monogenea. 27. Two new species of *Telethecium* gen. n. from the nasal cavities of Central Amazonian fishes and a redescription of *Kritskyia moraveci* Kohn, 1990 (Dactylogyridae, Ancyrocephalinae). Journal of the Helminthological Society of Washington 63(1): 35–41.
- Lamothe-Argumedo R, García-Prieto L, Osorio-Sarabia D, Ponce de León GP (2010) Colección Nacional de Helminthos (CNHE). In: Lamothe-Argumedo R, Damborenea C, García-Prieto L, Lunaschi LI, Osorio-Sarabia D (Comps) Guide to Helminthological Collections of Latin America. Publicaciones Especiales 22, Instituto de Biología, Universidad Nacional Autónoma de México and Museo de La Plata, Universidad Nacional de La Plata, Buenos Aires and Mexico City, 48–55.
- Leão ML, São Clemente SC, Cohen SC (2015) *Anacanthorus toledoensis* n. sp. and *Mymarothecium ianwhittingtoni* n. sp. (Dactylogyridae: Monogenea) parasitizing cage-reared *Piaractus mesopotamicus* (Characiformes, Characidae) in the State of Paraná, Brazil. Comparative Parasitology 82(2): 269–274. doi: 10.1654/4759.1
- Lizama MAP, Takemoto RM, Pavanelli GC (2004) New species of *Tereancistrum* Kritsky, Thatcher and Kayton, 1980 (Monogenea: Dactylogyridae: Ancyrocephalinae) from the gills of *Prochilodus lineatus* (Osteichthyes: Prochilodontidae) from the upper Paraná River floodplain, Brazil. Systematic Parasitology 57(1): 45–49. doi: 10.1023/B:SYPA.0000010684.67784.6e
- Lunaschi LI, Álvarez VHM, Damborenea C (2012) Type material housed in the Helminthological Collection of the Museo de La Plata, Buenos Aires, Argentina. Zootaxa 3199: 1–59.
- Luque JL, Amato JFR, Takemoto RM (1992) A new species of *Mexicana* (Monogenea: Dactylogyridae) parasitic on *Haemulon steindachneri* (Jordan and Gilbert) (Osteichthyes: Haemulidae) from the Brazilian coast. Revista Brasileira de Parasitologia Veterinária 1(2): 85–88.

- Luque JL, Amato JFR, Takemoto RM (1993a) Four species of *Choricotyle* Van Beneden and Hesse (Monogenea: Diclidophoridae: Choricotylinae) parasitic on *Orthopristis ruber* (Cuvier) (Osteichthyes: Haemulidae) from the Brazilian coast, with description of two new species. *Revista Brasileira de Parasitologia Veterinária* 2(2): 15–24.
- Luque JL, Amato JFR, Takemoto RM (1993b) A new species of *Pseudotagia* Yamaguti, 1963 (Monogenea: Macrovalvitrematidae) parasitic on *Orthopristis ruber* (Cuvier) (Osteichthyes: Haemulidae) from the Brazilian coast. *Revista Brasileira de Parasitologia Veterinária* 2(2): 111–114.
- Melo MFC, Santos JN, Santos CP (2012) *Sciadicleithrum juruparii* n. sp. (Monogenea: Ancyrocephalidae) from the gills of *Satanoperca jurupari* (Heckel) (Osteichthyes: Cichlidae) in the Guamá River, Amazon Delta, Brazil. *Systematic Parasitology* 82: 125–129. doi: 10.1007/s11230-012-9353-z
- Mendoza-Franco EF, Scholz T (2009) New dactylogyrids (Monogenea) parasitizing the gills of catfishes (Siluriformes) from the Amazon River Basin in Peru. *Journal of Parasitology* 95: 865–870. doi: 10.1645/GE-1820.1
- Mogrovejo CD, Santos CP (2002) *Caballerocotyla lenti* n. sp., a capsalid monogenean from *Auxis thazard* (Scombridae) from off the Southeastern coast of Brazil. *Memórias do Instituto Oswaldo Cruz* 37(7): 1067–1071. doi: 10.1590/S0074-02762002000700023
- Monteiro CM, Brasil-Sato MC (2014a) A new species of *Anacanthoroides* and redescription of *Apedunculata discoidea* (Monogenoidea) parasitizing *Prochilodus argenteus* (Actinopterygii) from the São Francisco River, Brazil. *Zootaxa* 3784: 259–266. doi: 10.11646/zootaxa.3784.3.5
- Monteiro CM, Brasil-Sato MC (2014b) A new species of *Rhinonastes* (Monogenoidea, Dactylogyridae), nasal parasite of *Prochilodus argenteus* (Actinopterygii, Characiformes) from Brazil. *Acta Parasitologica* 59(3): 540–543. doi: 10.2478/s11686-014-0278-3
- Monteiro CM, Cohen SC, Brasil-Sato MC (2015) New species and reports of dactylogyrids (Monogenoidea) from *Salminus franciscanus* (Actinopterygii: Bryconidae) from the upper São Francisco River, Brazil. *Zootaxa* 3941(1): 137–143. doi: 10.11646/zootaxa.3941.1.9
- Monteiro CM, Kritsky DC, Brasil-Sato MC (2010a) Neotropical Monogenoidea. 55. Dactylogyrids parasitising the pintado-amarelo *Pimelodus maculatus* Lacépède (Actinopterygii: Pimelodidae) from the Rio São Francisco, Brazil. *Systematic Parasitology* 76: 179–190. doi: 10.1007/s11230-010-9250-2
- Monteiro CM, Kritsky DC, Brasil-Sato MC (2010b) Neotropical Monogenoidea. 56. New species of *Anacanthorus* (Dactylogyridae) from the gills of matrinhã, *Brycon orthotaenia* (Characiformes: Characidae), in the Rio São Francisco, Brazil. *Folia Parasitologica* 57(3): 164–168. doi: 10.14411/fp.2010.022
- Moreira J, Scholz T, Luque JL (2015) First data on the parasites of *Hoplias aimara* (Characiformes): description of two new species of gill monogeneans (Dactylogyridae). *Acta Parasitologica* 60(2): 254–260. doi: 10.1515/ap-2015-0036
- Noronha D (2004) Correção de dados sobre a Coleção Helmintológica do Instituto Pasteur de São Paulo. *Revista Brasileira de Zoologia* 21: 1033. doi: 10.1590/S0101-81752004000400041

- Noronha D, Bragança R, Vicente JJ, Muniz-Pereira LC (2004) Coleções particulares incorporadas à Coleção Helminológica do Instituto Oswaldo Cruz (CHIOC). I: Coleção do Instituto Pasteur de São Paulo. Revista Brasileira de Zoologia 21(2): 303–305. doi: 10.1590/S0101-81752004000200023
- Noronha D, Sá MR, Knoff M, Muniz-Pereira LC, Pinto RM (2009) Adolpho Lutz and the Helminthological Collection of the Oswaldo Cruz Institute. Museu Nacional, Rio de Janeiro, 154 pp.
- Paraguassú AR, Luque JL, Alves DR (2002) A new species of *Anoplodiscus* (Monogenea: Anoplodiscidae) parasitic on *Pagrus pagrus* (Osteichthyes: Sparidae) from the coastal zone of the State of Rio de Janeiro, Brazil. Memórias do Instituto Oswaldo Cruz 97(8): 1197–1199. doi: 10.1590/S0074-02762002000800022
- Paschoal F, Scholz T, Tavares-Dias M, Luque JL (2016) Dactylogyrids (Monogenea) parasitic on cichlids from northern Brazil, with description of two new species of *Sciadicleithrum* and new host and geographical records. Acta Parasitologica 61(1): 158–164. doi: 10.1515/ap-2016-0021
- Platt TR (2000) *Neopolystoma fentoni* n. sp. (Monogenea: Polystomatidae) a parasite of the conjunctival sac of freshwater turtles in Costa Rica. Memórias do Instituto Oswaldo Cruz 95(6): 833–837. doi: 10.1590/S0074-02762000000600014
- Popazoglo F, Boeger WA (2000) Neotropical Monogenea 37. Redescription of *Gyrodactylus superbus* (Szidat, 1973) comb. n. and description of two new species of *Gyrodactylus* (Gyrodactylidae: Gyrodactylidae) from *Corydoras paleatus* and *C. ehrhardti* (Teleostei: Siluriformes: Callichthyidae) of Southern Brazil. Folia Parasitologica 47: 105–110. doi: 10.14411/fp.2000.022
- Rego AA (1982) Helminthological Collection of the Oswaldo Cruz Institute. In: Lichtenfels JR, Pritchard MH (Eds) A Guide to Parasite Collections of the World. American Society of Parasitologists, Special Publications, Lawrence, 9 pp.
- Rego AA, Vicente JJ, Gomes DC (1979) List of holotypes in the Helminthological Collection of the Oswaldo Cruz Institute. Atas da Sociedade de Biologia do Rio de Janeiro 19 (Supl): 1–29.
- Rosim DF, Mendoza-Franco EF, Luque JL (2011) New and previously described species of *Urocleidoides* (Monogenea: Dactylogyridae) infecting the gills and nasal cavities of *Hoplias malabaricus* (Characiformes: Erythrinidae) from Brazil. Journal of Parasitology 97(3): 406–417. doi: 10.1645/GE-2593.1
- Santos CP, Bianchi LG, Gibson DI (2008) *Acleotrema lamothei* n. sp. (Monogenea: Diplectanidae) from the gills of *Kyphosus incisor* in Brazilian waters. Revista Mexicana de Biodiversidad 79: 69S–73S.
- Santos CP, Buchmann K, Gibson DI (2000) *Pseudorhabdosynochus* spp. (Monogenea: Diplectanidae) from the gills of *Epinephelus* spp. in Brazilian waters. Systematic Parasitology 45: 145–153. doi: 10.1023/A:1006232029426
- Santos CP, Kohn A (1992) Description of *Cribomazocraes travassosi* n. sp. (Monogenea: Mazocraeidae), a fish parasite from the Atlantic Ocean. Memórias do Instituto Oswaldo Cruz 87(1): 247–250. doi: 10.1590/S0074-02761992000500046
- Santos CP, Mourão ED, Cárdenas MQ (2001) *Pseudempleurosoma gibsoni* n. sp., a new Ancyrocephalid monogenean from *Paralichthys brasiliensis* (Sciaenidae) from off the Southeast-

- ern Coast of Brazil. *Memórias do Instituto Oswaldo Cruz* 96(2): 215–219. doi: 10.1590/S0074-02762001000200013
- Santos CP, Santos AL, Cunha R, Chisholm LA (2012) A new species of *Heterocotyle* Scott, 1904 (Monogenea: Monocotylidae) from the gills of *Dasyatis guttata* (Dasyatidae) in southwestern Atlantic waters off Rio de Janeiro, Brazil. *Systematic Parasitology* 81: 65–70. doi: 10.1007/s11230-011-9328-5
- Santos CP, Santos AL, Gibson DI (2006) A new species of *Monocotyle* Taschenberg, 1878 (Monogenea: Monocotylidae) from *Dasyatis guttata* (Dasyatidae). *Journal of Parasitology* 92(1): 21–24. doi: 10.1645/GE-603R.1
- Santos CP, Timi JT (2009) *Absonifibula estuarina* sp. n. (Monogenea: Diclidophoridae) parasite of juvenile *Cynoscion guatucupa* (Osteichthyes) from southwestern Atlantic Ocean. *Memórias do Instituto Oswaldo Cruz* 104(7): 964–969. doi: 10.1590/S0074-02762009000700004
- Santos CP, Timi JT, Gibson DI (2002) *Diplectanum squamatum* n. sp. (Monogenea: Diplectanidae) from the gills of *Cynoscion guatucupa* (Sciecidae) in southwest Atlantic waters. *Systematic Parasitology* 52(3): 199–204. doi: 10.1023/A:1015737719326
- Santos Neto JF, Rodrigues ARO, Domingues MV (2015) Proposal of *Whittingtonocotyle* n. gen. (Dactylogyroidea: Dactylogyridae), with the description of two new species from the gills of *Hoplerthrinus unitaeniatus* (Characiformes: Erythrinidae) in Brazil. *Zootaxa* 3937(1): 191–200. doi: 10.11646/zootaxa.3937.1.10
- Tablado A, Tricárico F (2010) Colección Nacional de Parasitología (MACN-PA). In: Lamothe-Argumedo R, Damborenea C, García-Prieto L, Lunaschi LI, Osorio-Sarabia D (Comps) *Guide to Helminthological Collections of Latin America*. Publicaciones Especiales 22, Instituto de Biología, Universidad Nacional Autónoma de México and Museo de La Plata, Universidad Nacional de La Plata, Buenos Aires and Mexico City, 11–14.
- Takemoto RM, Amato JFR, Luque JL (1993) A new species of *Probursata* Bravo-Hollis, 1984 (Monogenea: Heteraxinidae: Heteraxininae) parasite of *Oligoplites* spp. (Osteichthyes: Carangidae) from the coast of the state of Rio de Janeiro, Brazil. *Memórias do Instituto Oswaldo Cruz* 88(2): 285–288. doi: 10.1590/S0074-02761993000200017
- Takemoto RM, Amato JFR, Luque JL (1996) Monogeneans of leatherjackets, *Oligoplites* spp. (Osteichthyes: Carangidae), with the description of a new species of *Metacamopia* (Monogenea: Allodiscocotylidae) from the coast of the State of Rio de Janeiro, Brazil. *Memórias do Instituto Oswaldo Cruz* 91(2): 165–172. doi: 10.1590/S0074-02761996000200008
- Takemoto RM, Lizama MAP, Pavanelli GCA (2002) New species of *Kritskyia* (Dactylogyridae, Ancyrocephalinae) parasite of urinary bladder of *Prochilodus lineatus* (Prochilodontidae, Characiformes) from the floodplain of the high Paraná River, Brazil. *Memórias do Instituto Oswaldo Cruz* 97(3): 313–315. doi: 10.1590/S0074-02762002000300006
- Takemoto RM, Pavanelli GCA, Lizama MAP, Lacerda ACF, Yamada FH, Moreira LHA, Ceschini TL, Bellay S (2009) Diversity of parasites of fish from the Upper Paraná River floodplain, Brazil. *Brazilian Journal of Biology* 69(2, Suppl.): 691–705. doi: 10.1590/S1519-69842009000300023
- Tavernari FC, Takemoto RM, Lacerda ACF, Pavanelli GC (2010) A new species of *Demi-dospermus* Suriano, 1983 (Monogenea) parasite of gills of *Auchenipterus osteomystax*

- (Auchenipteridae), from the upper Paraná river floodplain, Brazil. *Acta Scientiarum* 32(1): 79–81. doi: 10.4025/actascibiolsci.v32i1.3368
- Van Every LR, Kritsky DC (1992) Neotropical Monogenea. 18. *Anacanthorus* Mizelle and Price, 1965 (Dactylogyridae, Anacanthorinae) from piranha (Characoidea, Serrasalminae) from the Central Amazon, their phylogeny, and aspects of host-parasite coevolution. *Journal of the Helminthological Society of Washington* 59(1): 52–75.
- Vianna RT, Boeger WA, Silva-Souza AT (2008) Neotropical Monogenea. 52. *Diechodactylus joaberi* n. g., n. sp. from the banded knifefish *Gymnotus carapo* (Gymnotiformes: Gymnotidae) in southeastern Brazil. *Systematic Parasitology* 69: 45–50. doi: 10.1007/s11230-007-9107-5
- Vieira FM, Novelli IA, Sousa BM, SouzaLima S (2008) A new species of *Polystomoides* Ward, 1917 (Monogenea: Polystomatidae) from freshwater chelonians (Testudines: Chelidae) in Brazil. *Journal of Parasitology* 94(3): 626–630. doi: 10.1645/GE-1417.1.
- Yamada FH, Brandão H, Yamada POF, Silva RJ (2015) *Philocorydoras longus* sp. n. (Monogenea, Dactylogyridae) from the gills of *Hoplosternum littorale* (Siluriformes, Callichthyidae) in Southeastern Brazil and the reassignment of two species from the genus *Urocleidoides* to *Philocorydoras*. *Helminthologia* 52(4): 331–335. doi: 10.1515/helmin-2015-0052
- Yamada FH, Takemoto RM, Bellay S, Pavanelli GC (2009) Two new species of *Sciadicicleithrum* (Monogenea, Dactylogyridae) parasites of Neotropical cichlid fishes from the Paraná River, Brazil. *Acta Parasitologica* 54(1): 6–11. doi: 10.2478/s11686-009-0004-8

Tardigrada of Ireland: a review of records and an updated checklist of species including a new addition to the Irish fauna

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Abstract

The phylum Tardigrada was not recorded in Ireland until the Clare Island Survey of 1909–1911, with only rare subsequent reports on Irish tardigrade species. In recent decades, significant taxonomic revision has occurred within Tardigrada. This has resulted in the need for a review of all known historical records from Ireland and Northern Ireland in order to produce an updated checklist of valid taxa. The new checklist includes fifty-one tardigrade species and subspecies including a new addition to the Irish fauna reported herein, *Echiniscus quadrispinosus quadrispinosus* Richters, 1902 from Newtown, Ballyvaughan, Co. Clare.

Keywords

Tardigrada, Ireland, species list, historical records

Introduction

Tardigrades, commonly known as “water bears”, are microscopic metazoans with body lengths typically between 0.1–1.2 mm. They are obligate aquatic organisms, occurring in marine, freshwater and damp terrestrial habitats such as soils, mosses and lichens. The body is cylindrical with four pairs of lobopodous appendages ending in claws or

“toed” digits in many marine forms. Tardigrades are best known for the remarkable survival capabilities of many species through cryptobiosis, a type of quiescence that is also seen among other groups of microscopic animals found in similar habitats, notably Rotifera and Nematoda (for further information on tardigrade cryptobiosis see e.g. Guidetti et al. 2011, Møbjerg et al. 2011, Welnicz et al. 2011).

Phylum Tardigrada has had a history of rearrangement, both in terms of its relative taxonomic position as well as its internal structure. Traditionally, Tardigrada was ranked as a class of Arthropoda until being recognised as a separate phylum by Ramazzotti (1962). Morphological and genetic analyses place the phylum within Ecdysozoa (Aguinaldo et al. 1997), most closely allied to Nematoda (e.g. Meusemann et al. 2010) or to Arthropoda with Onychophora as a sister group (e.g. Campbell et al. 2011). This phylogenetic relationship is, however, not considered completely resolved (Nielsen 2012, Börner et al. 2014).

The main intra-phylum division occurs between the classes Heterotardigrada Marcus, 1927 and Eutardigrada Richters, 1926. The heterotardigrades are a group of species that possess a particular cephalic structure known as cirrus A, they also have a separate gonopore and anus, and often have plated cuticles. Eutardigrade species lack cirrus A, have a cloaca, and cuticles without structures homologous to the sclerified plates present among heterotardigrades. A third monospecific class, Mesotardigrada, was described by Rahm (1937) from a Japanese hot spring. However, both the type specimen and locality are no longer extant and there is some doubt of the validity of the class (Nelson 2002).

The Heterotardigrada are divided into two orders, the marine Arthrotardigrada Marcus, 1927 and Echiniscoidea Richters, 1926. Echiniscoidea comprises four families: Echiniscoididae Kristensen & Hallas, 1980; Carphaniidae Binda & Kristensen, 1986; Orellidae Puglia, 1959; and the speciose Echiniscidae Thulin, 1928. Of these, only Echiniscoididae is generally regarded as marine. Species of the other three families occur in limnic or limno-terrestrial environments.

There has been significant taxonomic rearrangement of the Eutardigrada including the establishment of many new genera and families, as well as many new species additions. Pilato (1969) contributed to this reorganization of Eutardigrada with the recognition of four familial lineages, Calohypsibiidae and Hypsibiidae (with subfamilies Diphasconinae Dastych, 1992 and Hypsibiinae Pilato, 1969); Milnesiidae Ramazzotti, 1962; and Macrobiotidae Thulin, 1928. Not in total agreement with the ranking of these families, Schuster et al. (1980) later established the orders Apochela for Milnesiidae (on the basis of the unique cephalic papillae and four separate and distinctive claws), and Parachela for all other eutardigrade families (in which cephalic papillae are not present and with the typical double claw formation).

Within Parachela, the use of morphological analyses and molecular data by Sands et al. (2008) and Marley et al. (2011) supported the creation of four superfamilies: Eohypsibioidea Bertolani & Kristensen, 1987 in Marley et al. 2011; Hypsibioidea Pilato, 1969 in Sands et al. (2008) (amended by Bertolani et al. 2014); Isohypsibioidea Sands, McInnes, Marley, Goodall-Copestake, Convey & Linse, 2008 (amended by Bertolani

et al. 2014); and Macrobiotidea Thulin, 1928 in Sands et al. (2008). The Parachela has undergone the most internal reshuffling at lower taxonomic levels, and species listed in early records may have been known under several names since.

The purpose of the following review is to address the taxonomic changes that have occurred for each Irish species since the time of their original recording. This review facilitated the creation of a valid checklist of Tardigrada species for Ireland and Northern Ireland.

Review of existing irish literature

There has been very little investigation into the status of Tardigrada in Ireland. Studies that included Irish tardigrades are limited to: Murray (1911), Crisp and Hobart (1954), Le Gros (1959), Boaden (1966), Mitchell (1973), Morgan (1975, 1976 (includes unpublished data from Morgan's doctoral thesis (1974) with further distribution notes from this study in Morgan and King 1976)), Baxter (1979), Morgan (1980), Kinchin (1990, 1992), Tumanov (2005) and Guidetti et al. (2015). Past work has been generally faunistic with little inference into ecology. Most species records for Ireland and Northern Ireland occurred prior to major taxonomic revisions within the phylum and so require clarification. The 2009 Inventory of Irish Fauna, by the Irish National Parks and Wildlife Service, included the Tardigrada (Smith 2009) but did not consider all literature pertaining to Irish tardigrades and only listed numerical values for species per family.

We updated the checklist of Irish species, which is presented in Table 1A–B, and have included a new record. The species list is in accordance with the latest version of the internationally recognised species list (Guidetti and Bertolani 2005, Degma and Guidetti 2007, Degma et al. 2015) and follows the amended classification for the Eutardigrada (Bertolani et al. 2014). Irish species that have not undergone alterations of their taxonomic position since their original recording in Ireland are not discussed in detail. Rather, the reader may be directed to the original sources for more information on these taxa.

James Murray and the Clare Island survey

The study of Irish tardigrades began with the work of the Scottish biologist and explorer, James Murray, as part of the multidisciplinary survey of Clare Island located off the west coast of County Mayo, Ireland (Murray 1911). The Clare Island Survey, 1909–1911, carried out by an international team of leading naturalists and scholars, aimed to describe the natural and archaeological history of the island. Murray completed two separate chapters on bdelloid rotifers and tardigrades. The great majority (approx. 70%) of the known Irish species to date are still those recorded by Murray (1911). In this initial survey thirty-five species of tardigrade were collected from thirteen sampling points on

Table 1. A–B An updated checklist of Irish tardigrade species with primary and subsequent records for: **A** Heterotardigrada **B** Eutardigrada. * Indicates type specimen.

1A Class Heterotardigrada Marcus, 1927

Species	Original Irish Record	Additional Irish records
Order Arthrotardigrada Marcus, 1927		
Family Batillipedidae Ramazzotti, 1962		
<i>Batillipes mirus</i> Richters, 1909b	Boaden 1966, Strangford, Lough, Co. Down	0
<i>Batillipes phreaticus</i> Renaud-Debyser, 1959	Morgan 1980, Brittas Bay, Co. Wicklow	0
<i>Batillipes tubernatis</i> Pollock, 1971	Morgan 1980, Belmullet and Achill Island, Co. Mayo; Gowlaun, Co. Galway; Brittas Bay, Co. Wicklow	0
Order Echiniscoidea Richters, 1926		
Family Echiniscoididae Kristensen and Hallas, 1980		
<i>Echiniscoides</i> sp.	Murray 1911, Achill Island, Co. Mayo	0
<i>Echiniscoides sigismundi</i> cf. <i>sigismundi</i>	Crisp and Hobart 1954, Cos. Waterford, Cork, Kerry, Sligo, Leitrim, and Donegal	Morgan 1980
Family Echiniscidae Thulin, 1928		
<i>Bryodelphax parvulus</i> Thulin, 1928	Murray 1911, Castlebar, Co. Mayo	0
<i>Cornechiniscus cornutus</i> (Richters, 1907)	Le Gros 1959, Kilsallagh, Co. Mayo	0
<i>Echiniscus columinis</i> * Murray, 1911	Murray 1911, Achill Island, Co. Mayo	0
<i>Echiniscus granulatus</i> (Doyère, 1840)	Murray 1911, Castlebar, Co. Mayo	Le Gros 1959
<i>Echiniscus militaris</i> * Murray, 1911	Murray 1911, Castlebar, Co. Mayo	0
<i>Echiniscus quadrispinosus quadrispinosus</i> Richters, 1902	Present study, Newtown, Ballyvaughan, Co. Clare	0
<i>Echiniscus testudo</i> (Doyère, 1840)	Murray 1911, Castlebar, Co. Mayo	Morgan 1976
<i>Echiniscus trietostus</i> Cuénot, 1932	Murray 1911, Castlebar, Co. Mayo	0
<i>Pseudoechiniscus</i> cf. <i>suillus</i>	Murray 1911, Achill Island; Inishurk; Beldare, Co. Mayo	0
<i>Hypechiniscus gladiator gladiator</i> (Murray, 1905a)	Murray 1911, Achill Island, Co. Mayo	0
<i>Hypechiniscus exarmatus</i> (Murray, 1907a)	Murray 1911, Achill Island; Clare Island; Inishurk; Beldare, Co. Mayo	0
Total= 16 taxa		

Table 1. Continue. 1B Class Eutardigrada Richters, 1926

Species	Original Irish Record	Additional Irish records
Order Apochela Schuster, Nelson, Grigarick, and Christenberry, 1980		
Family Milnesiidae Ramazzotti, 1962		
<i>Milnesium</i> sp.	Murray 1911, Achill Island; Louisburgh; Westport; Castlebar, Co. Mayo	0
<i>Milnesium</i> cf. <i>tardigradum tardigradum</i>	Morgan 1976, "Galway"	Baxter 1979 Kinchin 1990
Order Parachela Schuster, Nelson, Grigarick, and Christenberry, 1980		
Superfamily Hypsibioidae Pilato, 1969 in Sands, McInnes, Marley, Goodall-Copestake, Convey, and Linse, 2008 (amended by Berrolani et al. 2014)		
Family Calohypsibiidae Pilato, 1969		
<i>Calohypsibius ornatus</i> (Richters, 1900)	Murray 1911, Achill Island; Clare Island; Louisburgh, Co. Mayo	0
<i>Calohypsibius verrucosus</i> (Richters, 1900)	Murray 1911, Clare Island, Co. Mayo	0
Family Hypsibiidae Pilato, 1969		
Subfamily Diphasconinae Dasguch, 1992		
<i>Diphascon</i> cf. <i>chilenense</i>	Murray 1911, Clare Island, Co. Mayo	0
<i>Diphascon</i> cf. <i>pingue</i>	Mitchell 1973, Avoca, Co. Wicklow	0
Subfamily Hypsibiinae Pilato, 1969		
<i>Hypsibius arcticus</i> (Murray, 1907b)	Murray 1911, Clare Island; Inishurk; Louisburgh, Co. Mayo	0
<i>Hypsibius</i> cf. <i>dujardini</i>	Murray 1911, Achill Island, Co. Mayo	Morgan 1975, Baxter 1979 Kinchin 1990
Subfamily Itaquasconinae Bartoš in Rudescu, 1964		
<i>Adropion scoticum scoticum</i> (Murray, 1905b)	Murray 1911, Achill Island; Clare Island; Belclare, Co. Mayo.	Baxter 1979
<i>Mesocrista spitzbergensis</i> (Richters, 1903)	Le Gros 1959, Kilsallagh, Co. Mayo	0
<i>Platycrista angustata</i> (Murray, 1905a)	Murray 1911, Achill Island; Belclare, Co. Mayo	0
Subfamily Pilatobinae Berrolani, Guidetti, Marchioro, Altiero, Rebecchi and Cesari, 2014		
<i>Pilatobius bullatus</i> (Murray, 1905b)	Morgan 1975, Termoncarragh, Co. Mayo	0
<i>Pilatobius ocellatus ocellatus</i> (Murray, 1906b)	Baxter 1979, Crawfordsburn; Helen's Bay, Co. Down	0

Species	Original Irish Record	Additional Irish records
Family Microhypsibiidae Pilato, 1998		
<i>Fractonotus caelatus</i> (Marcus, 1928)	Murray 1911, Clare Island Survey (precise location not given)	0
<i>Microhypsibius truncatus</i> Thulin, 1928	Morgan 1975, Annagh Head, Co. Mayo	0
Family Ramazzottiidae Sands, McInnes, Marley, Goodall-Copestake, Convey, and Linse, 2008		
<i>Hebesuncus conjugens</i> (Thulin, 1911)	Morgan 1975, Belmullet, Co. Mayo	0
Superfamily Isohypsibioidea Sands, McInnes, Marley, Goodall-Copestake, Convey and Linse, 2008 (amended by Bertolani et al. 2014)		
Family Isohypsibiidae Sands, McInnes, Marley, Goodall-Copestake, Convey and Linse, 2008		
<i>Isohypsibius annulatus annulatus</i> (Murray, 1905a)	Murray 1911, Clare Island and Castlebar, Co. Mayo	0
<i>Isohypsibius panovi*</i> Tumanov, 2005	Tumanov 2005, Bellharbour, Co. Clare	0
<i>Isohypsibius papillifer bulbosus</i> (Marcus, 1928)	Murray 1911 Clare Island, Co Mayo	0
<i>Isohypsibius prosostomus prosostomus</i> Thulin, 1928	Morgan 1975, Belmullet, Co. Mayo	Morgan 1976
<i>Isohypsibius prosostomus cambrensis</i> (Morgan, 1976)	Morgan 1976, Belmullet, Co. Mayo	0
<i>Isohypsibius schaudinni</i> (Richters, 1909b)	Murray 1911, Achill Island; Westport, Co. Mayo	Morgan 1975
<i>Isohypsibius tuberculatus</i> (Plate, 1888)	Murray 1911, Beldare; Castlebar, Co. Mayo	Baxter 1979
<i>Thulinius augusti</i> (Murray, 1907a)	Murray 1911 Louisburgh, Co. Mayo	0
Superfamily Macrobioitoidea Thulin, 1928 in Sands, McInnes, Marley, Goodall-Copestake, Convey and Linse, 2008		
Family Macrobioitidae Thulin, 1928		
<i>Macrobiotus crenulatus</i> Richters, 1904c	Murray 1911, Achill Island; Clare Island, Co. Mayo	0
<i>Macrobiotus ehnigenitus</i> Richters, 1903	Murray 1911, Achill Island; Louisburgh; Beldare, Co. Mayo	0
<i>Macrobiotus</i> cf. <i>harnsworthi</i>	Murray 1911, Achill Island; Inishurk; Westport, Co. Mayo	Morgan 1975 Baxter 1979
<i>Macrobiotus</i> cf. <i>infelandi</i>	Murray 1911, Achill Island; Clare Island; Inishurk; Louisburgh, Beldare; Westport; Castlebar, Co. Mayo	Le Gros 1959 Morgan 1975 Morgan 1976 Baxter 1979
<i>Macrobiotus occidentalis occidentalis</i> Murray, 1910	Murray 1911, Westport, Co. Mayo	0
<i>Macrobiotus virgatus</i> Murray, 1910	Murray 1911, Achill Island, Co. Mayo	0
<i>Mimbionus</i> cf. <i>intermedius</i>	Murray 1911 Achill Island; Clare Island; Inishurk; Beldare; Castlebar, Co. Mayo	Morgan 1975 Baxter 1979

Species	Original Irish Record	Additional Irish records
<i>Paramacrobiontus areolatus</i> (Murray, 1907b)	Murray 1911 Achill Island, Co. Mayo	Morgan 1976
<i>Paramacrobiontus richersi</i> * (Murray, 1911)	Murray 1911, Clare Island, Co. Mayo	Le Gros 1959 Morgan 1975 Morgan 1976
Family Murrayidae Guidetti, Rebecchi and Bertolani, 2000		
<i>Murrayon hastatus</i> (Murray, 1907a)	Murray 1911, Achill Island, Co. Mayo	0
<i>Murrayon hibernicus</i> * (Murray, 1911)	Murray 1911, Achill Island	0
Total= 35 taxa		

Clare Island and other nearby locations on mainland County Mayo. Four of these were new species. Unfortunately, while some of Murray's other collections survive (see van der Land 1966, Greaves 1996, Dastych et al. 1998), his Clare Island material has not, and so re-examination of his collected specimens is not possible.

Murray (1911) collected both heterotardigrades and eutardigrades during the survey. All ten heterotardigrades recorded are Echiniscoidea (Table 1A). The only marine species was *Echiniscoidea sigismundi* M. Schultze, 1865 (Echiniscoididae). Murray noted that his single specimen, obtained from sediment washed from seaweed, was morphologically different from both the description of *Ech. sigismundi* by Schultze (1865) and the material of Richters (1909a). Once considered to be a single cosmopolitan species, Kristensen and Hallas (1980) recognized *Ech. sigismundi* as a species complex that shows variation particularly in cuticular structure, claws, and gamete morphology over geographical area. Compared to the amended definition of *Ech. sigismundi sensu stricto* by Kristensen and Hallas (1980), Murray's specimen differed in claw arrangement with seven claws on leg pair IV, as opposed to the typical 8–10 claws on pair IV. This claw configuration can indicate *Ech. sigismundi groenlandicus* Kristensen and Hallas, 1980 but Murray (1911) also noted that his specimen had unusually large spines (25µm length) at the cirrus A position, large sense organs on leg pair four, and translucent papillae on the dorsum and body sides. This combination of features set Murray's specimen apart from all known subspecies of *Ech. sigismundi*. As the original specimen cannot be re-examined, a more detailed diagnosis cannot be made, and this record should be added to the Irish checklist as *Echiniscoidea* sp.

The nine other heterotardigrade species reported by Murray (1911) are Echiniscidae (see Kristensen 1987 for a review of the family), two of which were new species. The Clare Island report includes Murray's description of *Echiniscus militaris* Murray, 1911 from moss collected at a lakeshore in Castlebar, mainland Co. Mayo. The other new heterotardigrade, *Echiniscus columinis* Murray, 1911 was collected from the summit of Slievemore, a 671m mountain on Achill Island. In addition to the type, Murray also reported three forms that he suspected were related to *E. columinis*, but differed from the new species in lacking one or more of the lateral filaments and having different lengths of the filament in the Cd position. *E. militaris* and *E. columinis* have not undergone any taxonomic change, and are included in our Irish checklist as originally described by Murray.

Murray (1911) recorded *Echiniscus testudo* (Doyère, 1840) from Castlebar, Co. Mayo. He noted that the Irish *E. testudo* lacked filament B and exhibited a finer granulation than original figures of the type, yet the original text describing the type population stated that most specimens also lacked filament B. This species has been reported as showing variation in the arrangement of the lateral filaments (Ramazzotti and Maucci 1983). This variation in appendages reported by Murray for *E. columinis* and *E. testudo* is common among *Echiniscus* species, such as those in the *E. blumicanadensis* series (Guil 2008). The difficulties in identifying individuals of such species is further complicated by the lack of supporting genetic data for the delineation of species in these series (Guil and Giribet 2009). There is a possibility that similar

results might be seen in other *Echiniscus* species groups. Murray's record for *E. testudo* is included in our list without any reference to the arrangement of the lateral appendages as the varieties 'trifilis' (lacking lateral B) and 'quadrifilis' (with lateral B) are not considered valid subspecies.

Other heterotardigrades that were recorded by Murray (1911) as *Echiniscus* C. A. S. Schultze, 1840 species were later moved to other genera of Echiniscidae mainly as a result of differences in the configuration of the dorsal cuticular plates. Murray recorded *Echiniscus suillus* (Ehrenberg, 1853) from four Mayo locations (two on Achill Island, two on the mainland). The genus *Pseudechiniscus* was erected by Thulin (1911) and more recently emended by Kristensen (1987). The species *suillus* was moved to this genus, which contains many morphologically similar species including the *P. suillus* complex. The species in this complex can be very difficult to identify, even using modern criteria (Fontoura and Morais 2011). *Pseudechiniscus* has recently been included in an integrative taxonomic study by Vecchi et al. (in press). Their morphological and molecular data provided evidence for emending *Pseudechiniscus*, and the movement of some species (not *suillus*) into a new genus. Murray (1911) provided no notes for his record of this species, so the exact identity remains unclear and should be added to the Irish checklist as *Pseudechiniscus* cf. *suillus*.

Murray (1911) recorded *Echiniscus gladiator* (Murray, 1905a) and its variety *exarmatus* (Murray, 1907a). A single individual of the type was collected from Achill Island while *exarmatus* was noted as abundant among three sampling sites, including Clare Island. Thulin (1928) described the genus *Hypechiniscus* into which he moved both *E. gladiator* and the *exarmatus* variety. Kristensen (1987) favoured species rank for *exarmatus* as a result of its dissimilar claw morphology, and this ranking is now accepted (Guidetti and Bertolani 2005). These two records are included in the Irish checklist as *Hypechiniscus exarmatus* and *H. gladiator gladiator* in order to specify the type from three subspecies described by Iharos (1973).

The last three heterotardigrade records by Murray (1911) from the Clare Island Survey underwent later re-identification by Marcus (1936). Based on the literature, Marcus (1936) moved all Murray's records for *Echiniscus granulatus* (Doyère, 1840) to *E. trisetosus* Cuénot, 1932, and synonymised *Echiniscus crassus* Richters, 1904a with *E. granulatus*. Also based on literature, Marcus (1936) deemed Murray's northern hemisphere specimen of *Echiniscus intermedius* Murray, 1910 (= *Bryochoerus intermedius intermedius*) to be *E. (Bryodelphax) parvulus* (Thulin, 1928). While Thulin (1928) had previously erected the genus *Bryodelphax* for the species *parvulus*, Marcus (1936) only recognized *Bryodelphax* as a subgenus and continued to refer to the species as *E.(B). parvulus*. Both *Bryodelphax* and *Hypechiniscus*, remained as *Echiniscus* subgenera until re-elevated to genera (see: Ramazzotti and Maucci 1983; Kristensen 1987). Using Marcus' (1936) interpretation for the three species identified by Murray (1911), we include, *Echiniscus trisetosus*, *E. granulatus* and *Bryodelphax parvulus* in the Irish checklist.

Murray recorded twenty-five eutardigrade species in the Clare Island Survey (Table 1B). Within Apochela, for over 150 years the genus *Milnesium* Doyère, 1840 was considered monospecific, despite a large degree of morphological variation observed

across the highly cosmopolitan distribution of *M. tardigradum*. As a result of the newly recognized diversity within the genus (e.g. Tumanov 2006, Michalczyk et al. 2012a), historical records for ‘*Milnesium tardigradum*’ that lack notes on taxonomic features currently in use for species identification, require further confirmation. Murray (1911) states that the Irish *M. tardigradum*, collected from four separate sampling sites, had three points on each of the secondary claws of all legs (i.e. a claw formula of [3-3]–[3-3]). With great foresight, Murray recognized that it would be important to note this, as he suspected that the variation in claw morphology in *Milnesium* might subsequently be used in the delineation of new taxa; though he was likely thinking in terms of distinguishing local varieties rather than distinct species. Unfortunately, no further details for the *Milnesium* specimens were included in his description, yet on the basis of the claw configuration it can be concluded that Murray’s Irish specimens are not *M. tardigradum sensu stricto* or its subspecies and so this record must be listed in our Irish checklist as *Milnesium* sp. sensu Michalczyk et al. (2012a, 2012b) and Morek et al. (2016).

The rest of Murray’s eutardigrade records are for Parachela. Following the convention of the time, Murray ascribed these species to only two long-standing genera, *Diphascon* Plate, 1888, differentiated by the presence of a flexible pharyngeal tube, or *Macrobiotus* C.A.S. Schultze, 1834. However, under the most current taxonomic scheme (Guidetti and Bertolani 2005, Degma and Guidetti 2007, Degma et al. 2015) including the amendments of Bertolani et al. (2014), twelve parachelan genera are represented in Murray’s (1911) Clare Island collection (Table 1B).

The specimens recorded by Murray (1911) as *Diphascon* species were: *D. angustatum* Murray, 1905a, *D. chilense* Plate, 1888 and *D. scoticum* Murray, 1905b. This genus has been considerably revised in recent years, and is now placed within the family Hypsibiidae Pilato, 1969, with a number of subfamilies including: Diphasconinae Dastych, 1992 and Itaquasconinae Bartoš in Rudescu, 1964, into which Murray’s (1911) taxa fall. Pilato (1987) recognized major divergence in the details of the buccal-pharyngeal apparatus and separated three additional genera from *Diphascon*: *Hebesuncus*, *Mesocrista*, and *Platicrista*. The two subgenera (from Pilato 1987): *Diphascon* and *Adropion* have now been elevated to genera (Bertolani et al. 2014). From Murray’s (1911) work, *Diphascon chilense* now comes under the Diphasconinae and the genus name remains unchanged. However, this species is a member of the “*alpinum-pingue* group” and it is important to note that the lack of detail in original species descriptions for this group has made later identifications difficult. Several authors have discussed these difficulties (e.g. Dastych 1984, McInnes 1995, and Pilato and Binda 1977, 1998, 1999), with Pilato and Binda (1977, 1998) re-describing members of this group (*D. alpinum* Murray, 1906a, *D. chilense*, *D. pingue* and *D. pinguiforme* Pilato and Binda, 1998). As Murray (1911) did not provide notes on his Irish *D. chilense* material we cannot interpret the correct species diagnoses. It is possible the Clare Island *D. chilense*, collected only from the summit of Croaghmore [Knockmore] (462m), was a similar species within the species-group. Murray’s (1905a) “*D. angustatum*” was used by Pilato (1987) to erect the genus *Platicrista*, within the subfamily Itaquasconinae,

and is the genus type. Therefore, Murray's (1911) reference is now, with the corrected suffix, *P. angustata*. The third species "*D. scoticum*" Murray, 1905b has become the genus type for *Adropion*, and is now *Adropion scoticum scoticum*. As a result of the above amendments, we are modifying Murray's (1911) *Diphascon* records for the Irish checklist to be: *D. cf. chilense*, *Adropion scoticum scoticum* and *Platicrista angustata*.

Of the twenty-two other species attributed to *Macrobiotus* that were recorded by Murray (1911) for the Clare Island Survey, only six remain in that genus today. Some of these taxa have been repositioned several times. Four of Murray's (1911) records were: all three of Richters' (1900) *Macrobiotus ornatus* Richters, 1900 varieties (i.e. *spinnifer*, *spinosissimus*, and *verrucosus*) from western Ireland (Murray 1911), and *Macrobiotus scabrosus* Murray, 1911, which Murray (1911) described from Clare Island itself. These species have been associated to the genera *Calohypsibius* Thulin, 1928 and *Microhypsibius* Thulin, 1928. Initially, Thulin (1911) re-instated *Hypsibius* Ehrenberg, 1848 and moved both "*M. ornatus*" and "*M. scabrosus*" into this genus, and raised "*M. ornatus* v. *verrucosus*" to species rank ("*H. verrucosus*"). Upon further consideration of the type material, Thulin (1928) erected the genus, *Calohypsibius*, with *C. ornatus* as the genus type, into which the species "*H. ornatus*", "*H. scabrosus*", and "*H. verrucosus*" were moved. According to Marcus (1936) *Calohypsibius* was a sub-genus and as Richters' (1900) failed to designate which of the three described varieties of *ornatus* was the type specimen, nominated *spinnifer* for this position. More recently, Pilato (1969) upheld the validity of *Calohypsibius* as a genus, and proposed its placement into a new family, Calohypsibiidae Pilato, 1969 (amended by Bertolani et al. 2014). Pilato (1989) and Pilato et al. (1989) further discussed the wide variation of morphologies reported for *C. ornatus*, and the associated varieties, and the resulting need for taxonomic revision of the species. Pilato (1998) erected the genus *Fractonotus* (in the family Microhypsibiidae Pilato, 1998) for the species *caelatus*, as the claws were determined to be closer to that of *Microhypsibius* Thulin, 1928 than of *Calohypsibius* Thulin, 1928. From Murray's (1911) list, in Marcus' (1936) opinion Murray misinterpreted "*M. ornatus* v. *verrucosus*", which he moved to "*Hypsibius (Calohypsibius) ornatus* v. *caelata* Marcus, 1928". This subspecies has subsequently been elevated to species and moved to the genus *Fractonotus*. Marcus (1936) also concluded from the literature that Murray's (1911) species "*scabrosus*" was actually "*M. ornatus* v. *verrucosus*" moving it to "*Hypsibius (Calohypsibius) verrucosus*". Following these revisions, we are adding Murray's (1911) records for these taxa to the Irish checklist as: *Calohypsibius ornatus* (Richters, 1900) (from "*Macrobiotus ornatus* var. *spinnifer*" and "*Macrobiotus ornatus* v. *spinosissimus*" (no longer considered valid subspecies: see: Bartoš, 1940)); *Calohypsibius verrucosus* (Richters, 1900) (from "*Macrobiotus scabrosus* sp. nov."); and *Fractonotus caelatus* (Marcus, 1928).

Four of the "*Macrobiotus*" taxa Murray (1911) recorded have been moved into the genus *Isohypsibius* Thulin, 1928. These are: "*M. annulatus* Murray, 1905a"; "*M. schaudinni* Richters, 1909b"; "*M. tuberculatus* Plate, 1888"; and "*M. papillifer* Murray, 1905a". Murray's (1911) record of "*M. papillifer*" from Clare Island was not for the type itself, but a variety that he had previously encountered in Scotland, though

had not described. Marcus (1936) elevated this to subspecies but reduced the genus to subgenus: “*Hypsibius (Isohypsibius) papillifer bulbosus* Marcus, 1928”. *Isohypsibius* has been returned to generic ranking (Pilato 1969), and is now the most speciose genus of family Isohypsibiidae, Sands, McInnes, Marley, Goodall-Copestake, Convey, and Linse, 2008. We include in the Irish checklist the four taxa from Murray’s (1911) list as: *Isohypsibius papillifer bulbosus*, *I. annulatus annulatus*, *I. schaudinni* and *I. tuberculatus*.

Another of Murray’s (1911) Clare Island ‘*Macrobiotus*’ records, that for “*M. augusti* Murray, 1907a”, is also now in the family Isohypsibiidae. There has been much confusion about “*augusti*”, which is detailed in Bertolani et al. (1999) and Bertolani (2003). In summary, Thulin (1928) moved “*Macrobiotus augusti*” into the genus *Isohypsibius* and Marcus (1929) from the literature re-described the species as *Hypsibius (I.) augusti*, adding characters that were not present in the type specimen. Subsequent use of erroneous re-descriptions of the species by later authors perpetuated the confusion (for details see also Marley et al. 2008). The genus *Pseudobiotus* Nelson, 1980 in Schuster et al. 1980, with the genus type *Pseudobiotus augusti*, was established upon such a re-description. Later re-examinations of “*Macrobiotus augusti*” type material led Nelson et al. (1999) to re-describe *Pseudobiotus* with the designation of a different type species, and Bertolani et al. (1999) to move “*augusti*” to the genus *Thulinia* Bertolani, 1982 (NB. Bertolani (2003) substituted the genus name with *Thulinus*, as *Thulinia* was already in use for a genus of trematodes). Thus, we are adding Murray’s (1911) record for “*Macrobiotus augusti*” to the Irish taxa as: *Thulinia augusti* (Murray, 1907a).

Two of Murray’s (1911) “*Macrobiotus*” records are now *Hypsibius* species. Murray (1911) recorded both “*Macrobiotus lacustris* Dujardin, 1851” and “*Macrobiotus arcticus* Murray, 1907b” from multiple Clare Island Survey sites. Thulin (1911, 1928) and Marcus (1936) agreed that *M. lacustris* was synonymous with *Hypsibius dujardini* (Doyère 1840). This species is now known to be morphologically very similar to others in the *convergens-dujardini* complex (Miller et al. 2005, Kaczmarek and Michalczyk 2009). As Murray (1911) made no descriptive notes on his specimens we include this record in the Irish checklist as: *Hypsibius* cf. *dujardini*. The second species, “*M. arcticus*”, was initially described by Murray (1907b) from juveniles and eggs collected from Prince Charles Foreland, Franz Josef Land and Loch Ness (Scotland), noting that the eggs were similar to “*Macrobiotus hastatus*”, but he later emended the description with details of adult animals and similar eggs found at Cape Royds (Antarctica) (Murray 1910). The later were *Acutuncus antarcticus* (Richters, 1904b) (see: Dastyh 1991), leaving “*M. arcticus*” with scant information and inadequate data for species identification (Dastyh 1991). However, Thulin (1911) transferred “*arcticus*” into *Hypsibius*, and despite the shortcomings of the original description (see: Dastyh 1991), the species is still valid. We include *M. arcticus* in the Irish checklist as: *Hypsibius arcticus*.

The remaining nine species from Murray’s (1911) Clare Island list are all from the superfamily Macrobiotioidea. Only six now remain in the genus *Macrobiotus* as originally recorded: *M. crenulatus* Richters, 1904c; *M. harmsworthi* Murray, 1907b; *M. hufelandi* C. A. S. Schultze, 1834; *M. echinogenitus* Richters, 1903; *M. occidentalis* Murray, 1910; and *M. virgatus* Murray, 1910. *Macrobiotus hufelandi* and *M. harms-*

worthi are now known to represent large species-groups. It is notoriously difficult to differentiate between species within these groups, even with modern microscopy, and identification usually requires observation of the egg (Bertolani and Rebecchi 1993). Therefore, the records for these species can at present only be listed as *Macrobiotus* cf. *hufelandi* and *M.* cf. *harmsworthi*. However, the position of the *Macrobiotus harmsworthi* group in the genus *Macrobiotus* will soon be revised as a result of new morphological and molecular analyses (Vecchi et al. in press). Murray's (1911) records for *M. crenulatus*, *M. echinogenitus*, *M. occidentalis*, and *M. virgatus* remain unchanged in the Irish checklist. In addition to these records, Murray (1911) collected an egg with an embryonic tardigrade within. He was not able to identify this further than '*Macrobiotus* species' and his notes and figures do not provide for a definitive conclusion. This record has been omitted from our Irish checklist.

Three of Murray's (1911) records have been transferred from *Macrobiotus* into other Macrobiotidae genera. One of these, "*Macrobiotus intermedius* Plate, 1888", became the type species for the genus *Minibiotus* differentiated by Schuster et al. 1980 from *Macrobiotus* by a lack of peribuccal lamellae and an enclosing egg membrane. Recognizing some difficulties with the original diagnoses, including the fact that not all *Minibiotus* eggs share this membrane, the genus and the species *intermedius* were re-described by Claxton (1998). Her study also discussed a species group within *Minibiotus* of morphologically similar adults that includes "*intermedius*". As Murray (1911) did not provide morphological notes on his "*Macrobiotus intermedius*" specimens, this record must be listed as *Minibiotus* cf. *intermedius*.

The two other species, recorded from Clare Island itself, *Macrobiotus areolatus* Murray, 1907b and *Macrobiotus richtersi* Murray, 1911 (Murray 1911) have been moved into the genus, *Paramacrobiotus* by Guidetti et al. (2009) based upon combined morphological and molecular evidence. Murray's (1911) "*richtersi*", described from a salt marsh on Clare Island, was used as the type species for the new genus. In addition to the type, Murray (1911) also recorded a variety of "*richtersi*" from the mainland, which differed from the type mainly in the formation of the egg processes and in the relative lengths of the macropylacoids. This variety was not recorded in Ireland subsequently and we have omitted it from our Irish checklist. *Paramacrobiotus areolatus* and *P. richtersi* are included, however integrative analyses by Guidetti et al. (2015) of *P. richtersi* specimens from the type location on Clare Island and various Italian localities suggest the presence of a cryptic species complex, highlighting the potential importance of integrated taxonomy, incorporating alpha taxonomy and DNA-barcoding, in future identifications of this species.

The last two of Murray's (1911) records, *Macrobiotus hastatus* Murray, 1907a and *Macrobiotus hibernicus* Murray, 1911, have been moved into the genus *Murrayon* Bertolani & Pilato, 1988, which was named in honour of James Murray. The "*hastatus*" species, described by Murray from material collected during the Scottish Loch Survey (Murray 1905a, 1907a) was moved into *Murrayon* at the time of the creation of the genus (Bertolani and Pilato 1988). The species "*hibernicus*", which was described during the Clare Island survey from a tarn on Slievemore, Achill Island (Murray 1911),

was moved later by Guidetti (1998) following a reanalysis of material from Italy and Greenland. A detailed comparison of the cuticular structure and claw formation of some genera of Macrobiotidae led Guidetti et al. (2000) to suggest the split of the family into two subfamilies, Macrobiotinae and Murrayinae with *Murrayon* as the type genus for the latter. Further phylogenetic analysis using morphological and molecular data by Guidetti et al. (2005) gave further support for the division of the Murrayinae line from other macrobiotid taxa. The group was then raised to family level (Murrayidae Guidetti, Rebecchi and Bertolani, 2000). Although recent molecular evidence suggests that Murrayidae may be polyphyletic, no morphological support has yet been found (Bertolani et al. 2014). We include Murray's (1911) two species in the Irish Checklist as: *Murrayon hibernicus* and *Murrayon hastatus*.

Records by later authors

Following Murray's (1911) work for the original Clare Island Survey, the study of tardigrades was neglected in Ireland. No further references to Tardigrada in Ireland can be found in the literature until Crisp and Hobart's (1954) investigation into the distribution of *Echiniscoides sigismundi* on Irish and British coasts. This paper (Crisp and Hobart 1954) was the first strictly ecological study on tardigrades in Ireland, which identified the host, zonation, and seasonal variables of *Ech. sigismundi* at several sites around the Irish coast. *Echiniscoides sigismundi* was recorded from beaches in counties: Waterford, Cork, Kerry, Sligo, Leitrim, and Donegal, suggesting a widespread distribution of the species on Irish intertidal shores. The authors (Crisp and Hobart 1954) did not comment in detail on the morphology of Irish specimens beyond that these matched well with the original description. The differing morphology of the *Echiniscoides sigismundi* specimens of Murray (1911) to those of Crisp and Hobart (1954) supports the inclusion of two separate *Echiniscoides* records in the Irish checklist. As none of the known subspecies had been described at the time of Crisp and Hobart's (1954) study and no variation was reported, it cannot be certain which subspecies they encountered and so is accounted for in the Irish the checklist as *Ech. sigismundi* cf. *sigismundi*.

New species records for Ireland did not occur until Le Gros (1959), nearly fifty years after the Clare Island Survey. A small quantity of moss and lichen samples collected from Kilsallagh, County Mayo, yielded five species of tardigrade, two of which had not been previously recorded. Le Gros' (1959) new additions, *Pseudechiniscus cornutus* (Richters, 1907) and *Hypsibius spitzbergensis* (Richters, 1903) (originally described as *Diphascon spitzbergense*) were both later moved into new genera. *Pseudechiniscus cornutus* became the type species for the genus *Cornechiniscus* Maucci and Ramazzotti 1981 (revised by Kristensen (1987)), for those echiniscids belonging to what was then known as the '*Pseudechiniscus cornutus* group' of species possessing distinctive cirri A in the form of short, recurved spines and with particular features of the cuticular plates. *Hypsibius spitzbergensis* (or *Diphascon spitzbergense*) became the species type for the ge-

nus *Mesocrista* Pilato, 1987. As a result, we include these records in the Irish checklist as: *Cornechiniscus cornutus* and *Mesocrista spitzbergensis*.

The heterotardigrade order, Arthrotardigrada, was not recorded from Ireland until Boaden's (1966) investigation of the interstitial fauna of the area surrounding Strangford Lough in County Down, Northern Ireland. *Batillipes mirus* Richters 1909b (*Batillipedidae* Ramazzotti, 1962) was the only tardigrade species reported by Boaden (1966), who found an unspecified number of individuals among fine sand from the northern end of the lough. The record for *B. mirus* was one among many other taxa from a variety of phyla, and there is no specific discussion of the tardigrade specimen.

Mitchell (1973) was next to make a new addition to the Irish fauna from samples of cherry tree bark from Avoca, Co. Wicklow. Mitchell (1973) recorded an unknown number of specimens, though certainly more than one, of '*Hypsibius (Diphascon) pinguis*' (i.e. *Diphascon pingue*). The species was later considered to belong to genus *Diphascon* (subgenus *Diphascon*) until the aforementioned amendments to Diphasconinae by Bertolani et al. 2014. Le Gros is acknowledged as confirming Mitchell's identification, though Mitchell (1973) noted that the Irish specimens have longer body lengths and narrower placoid rows than the original figures of Marcus (1936). There has been some uncertainty with the "*alpinum-pingue*" species group, as discussed above, and there is some possibility that Mitchell (1973) may have collected *D. pinguiforme*. Mitchell's (1973) notes on the width:length ratio of the pharyngeal bulb and larger body size are closer to the values given for the re-described *D. pingue* (Pilato and Binda 1998). However, slide pressure can change these ratios and as there was no figure or mention of the drop-shaped thickening between the buccal and pharyngeal tubes this record must remain questionable. We include this record in the Irish checklist as *D. cf. pingue*.

Along with Murray (1911), Clive Morgan has perhaps been the greatest contributor to the study of Tardigrada in Ireland. Morgan (1974) included Irish sites in a survey of the British Isles as part of his doctoral thesis research. These were given in Appendix II of Morgan's (1974) thesis as "Belmullet Peninsula" (four sites) and "Galway Bay" (seven sites). The Galway Bay sites, were listed as: "Aran Island" (assumed to be Inishmore judging by Figure 1 in Morgan 1976), Ardfry, Galway [City], Spiddal, and Mweenish Island, Co. Galway, and Finavarra and Doolin Point, [Co. Clare]. Morgan's (1974) thesis does not specify precisely which of the "Galway Bay" locations contained which species. His results (Morgan 1974; table 6) are for 14 taxa belonging to "Galway" (three species) or "Mayo" (eleven species and one variety). There is also an omission from the table corresponding to the notes on species distribution in the main text, as *Paramacrobiotus areolatus* (then *Macrobiotus areolatus*) was recorded from moss from Belmullet, Mayo but was not marked as present in the table's column for Mayo.

Further details on species locations are given in two of Morgan's subsequent works (Morgan 1975, 1976) in which the results from his thesis were published, and in Morgan and King's (1976) "Synopsis of the British Fauna-Tardigrada". Morgan (1975) states that the material for his notes on the Tardigrada from the Mullet Peninsula was obtained as part of the survey of the area conducted by the University of Reading (1971–1972), but this material was probably used as part of his doctoral research. Along with seven pre-

viously reported species, with details on sampling sites and a key to the Irish species, Morgan (1975) added four new records for Ireland (identified in his thesis (Morgan 1974)) as: *Hypsibius* (*Diphascon*) *bullatus* (Murray, 1905b); *Hypsibius* (*Hypsibius*) *conjungens* Thulin, 1911; *Hypsibius* (*Isohypsibius*) *prosostomus* (Thulin, 1928); and, *Hypsibius* (*Calohypsibius*) *truncatus* (Thulin, 1928). All these subgenera have been elevated to genera. *Hypsibius* (*D.*) *bullatus* having a drop-shaped thickening on the bucco-pharyngeal tube was moved to *Diphascon* (*D.*) *bullatum* with the amended suffix, but has since moved to the genus *Pilatobius* Bertolani, Guidetti, Marchioro, Altiero, Rebecchi & Cesari, 2014, and the suffix corrected back to ‘*bullatus*’. *Hypsibius* *conjungens* was used as the type species for the genus *Hebesuncus* Pilato 1987. Morgan’s (1975) record for *Hypsibius* (*Isohypsibius*) *prosostomus* has been elevated to the genus *Isohypsibius* and remains unchanged. The species “*truncatus*” had been the species type for the genus *Microhypsibius* Thulin 1928, but was suppressed by Marcus (1929) as *Hypsibius* (*Calohypsibius*) *truncates*. The genus *Microhypsibius* was later re-instated and re-described by Kristensen (1982) and since moved (along with the genus, *Fractonotus*) into the family, Microhypsibiidae Pilato 1998. We therefore, include Morgan’s (1975) records in the Irish checklist as: *Pilatobius bullatus*, *Hebesuncus conjungens*, *I. prosostomus prosostomus* and *Microhypsibius truncatus*.

Further results from Morgan’s earlier Irish collections were published in 1976 (Morgan 1976) along with data from mainland Britain and offshore islands. Only three species were recorded for “Galway” (Morgan 1976, table 1): *Macrobiotus hufelandi*, *Macrobiotus richtersi* (now *Paramacrobiotus*), and *Milnesium tardigradum*. However, a new Irish record is listed in the systemic account of species, which gives Belmullet, Co. Mayo as secondary location for the new subspecies *Hypsibius* (*Isohypsibius*) *prosostomus cambrensis* (now *Isohypsibius prosotomus cambrensis*), first described by Morgan (1976) from moss collected at the University of Swansea. Morgan (1976) described *I. prosostomus cambrensis* as similar to the type but with fine cuticular granulation present on the sides of the body and upper portions of all legs. Pending a re-examination of the type material, the presence of this granulation may warrant the elevation of *I. prosostomus cambrensis* to species rank. The only other reference from this survey to a specific Irish location is found in Morgan and King’s Synopsis of the British Fauna (1976) in which Mweenish Island (Co. Galway) is named in the distribution notes for *Milnesium tardigradum*. Morgan’s (1976) record for this species is included in our Irish checklist as *Milnesium* cf. *tardigradum*, as no morphological notes were provided.

More recently, Morgan (1980) sampled the marine habitat in Counties Galway, Mayo and Wicklow. Eighteen samples yielded three marine species, two of which had not previously been recorded in Ireland, *Batillipes phreaticus* Renaud Debyser, 1959 and *Batillipes tubernatis*, Pollock 1971. Irish *B. phreaticus* and *B. tubernatis* populations were reported to have some differences in the morphometric values for several appendage lengths compared with those of the type locations (Morgan 1980). Morgan (1980) also recorded *Echiniscoides sigismundi*, which showed some variation in punctuation of the cuticle between the Irish sampling locations but was reported to match well with the then current species descriptions. We include these in the Irish list as: *Batillipes phreaticus*, *B. tubernatis*, and *Echiniscoides sigismundi* cf. *sigismundi*.

Baxter (1979) carried out sampling in north County Down, Northern Ireland, producing the first records of terrestrial tardigrades for the region. The mosses and lichens obtained there were found to contain eight species of tardigrade which Baxter (1979) recorded as: *Hypsibius (Diphascon) oculatus* (Murray, 1906b), *Hypsibius (Diphascon) scoticus*, *Hypsibius (H.) dujardini*, *Hypsibius (I.) tuberculatus*, *Macrobiotus harmsworthi*, *M. hufelandi*, *M. intermedius*, and *Milnesium tardigradum*. One of these records, *Hypsibius (Diphascon) oculatus*, was new for Ireland. Having a drop-shaped thickening on the bucco-pharyngeal tube, “*oculatus*” became *Diphascon (D.) oculatus* before being transferred to *Pilatobius*. As an additional note (E.D. – personal notes and observations): representative material for each species collected by Baxter (1979) was deposited in the National Museum of Ireland - Natural History, Dublin, and was available for study. The specimens of the Baxter Collection are in general, not well-preserved. Some specimens are in better condition but are situated along the coverslip margins. These would require specialist long working distance lenses at higher magnifications for clear observation due to a raised lip of sealant. However, some additional observations of the specimens were possible.

Baxter (1979) recorded *Milnesium tardigradum* but presented no details of claw morphology. Upon examination of Baxter’s museum material, it was not possible to ascertain the claw formula for one specimen but, assuming all specimens on a single slide were the same species, the claw formula was [2-3]–[3-2] with accessory points present on the primary branches indicating *Milnesium* cf. *tardigradum* (in contrast to Murray (1911)). In the Baxter Collection are specimens recorded as ‘*Hypsibius (Hypsibius) dujardini*’ from two separate populations. The specimens of one population are morphologically similar to *H. dujardini* but the presence or absence of characters that separate this species from others in the *dujardini*-group could not be confirmed. The specimens from the other population appeared to have more granular macropylacoids than the species of the *dujardini* group. These were more similar in appearance to those of *H. microps* Thulin, 1928 or *H. pallidus* Thulin, 1911. It is possible that this population represents one of these species but this could not be confirmed. In addition to the eight species recorded, a single degraded specimen of an unidentified *Isohypsibius* species was observed among the Baxter Collection but was not included in the Irish checklist due to a lack of further information. Consequently we included the results of Baxter’s (1979) collection in the Irish checklist as: *Pilatobius oculatus oculatus* (as two other subspecies of *P. oculatus* are known (Murray 1910, Mihelčič 1964)), *Adropion scoticum scoticum*, *Hypsibius* cf. *dujardini*, *Isohypsibius tuberculatus*, *Macrobiotus* cf. *harmsworthi*, *M. cf. hufelandi*, *Minibiotus* cf. *intermedius*, and *Milnesium* cf. *tardigradum*.

The most recent published data on Irish tardigrades are Kinchin (1990) and Tumanov (2005). Kinchin (1990) recorded *Milnesium tardigradum* and *Hypsibius dujardini* associated with lichens from the Giant’s Causeway, Co. Antrim, Northern Ireland. Morphological notes on the specimens were not provided so it was not possible to confirm these records. Kinchin (1992) recording microfauna from various locations in Britain and Ireland included his previous data from Co. Antrim, and reported Rotifera and Nematoda in moss and lichen from Dingle, Co. Kerry but found no Tardigrada. Tumanov (2005) described a new tardigrade species, *Isohypsibius panovi* from Bellharbour, County Clare.

A new addition to the Irish fauna

Echiniscus quadrispinosus quadrispinosus Richters, 1902

A specimen, found in a sample of moss collected from a tree trunk along a rural road in Newtown, Ballyvaughan, Co. Clare (53°6.28'N; 9°10.18'W) in January 2013, was a new record for Ireland and is added to our checklist. The specimen was mounted with Polyvinyl Alcohol medium and identified using an Olympus BX53 microscope with magnification up to x1000 oil immersion. All measurements were taken using Olympus cellSens imaging software (Standard Version 1 CS-ST-V1).

A single adult individual was found (Figure 1). Body length excluding fourth pair of legs, 174 µm. Double granulation present, clearly different from *E. merokensis* Richters, 1904c type. Scapular plate with small accessory plates. Terminal plate faceted, visible is a thin lateral band without granulation. Internal claws 10 µm long, with basal spurs. Fourth pair of legs bear dentate collar with eight well-separated teeth of irregular lengths. Lateral filaments; A 33 µm, B 28 µm, C 30 µm, D 38 µm, E 54 µm. Dorsal spines; Cd 24 µm, Dd 18 µm. Specimen laterally positioned, thus gonopore morphology is not discernible, sex unknown.



Figure 1. *Echiniscus quadrispinosus quadrispinosus* Richters, 1902, habitus.

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References

- Aguinaldo AMA, Turbeville JM, Linford LS, Rivera MC, Garey JR, Raff RA, Lake JA (1997) Evidence for a clade of nematodes, arthropods and other moulting animals. *Nature* 387: 489–493. doi: 10.1038/387489a0
- Argue CW (1972) Tardigrades from New Brunswick, Canada. 2. *Canadian Journal of Zoology* 50: 87–94. doi: 10.1139/z72-016
- Bartoš E (1940) Über die variation der art *Hypsibius ornatus* Richters (Tardigrada). *Zoologische Jahrbücher* 73(4): 369–384.
- Baxter WH (1979) Some notes on the Tardigrada of North Down, including one new addition to the Irish fauna. *Irish Naturalists' Journal* 19(11): 389–391.
- Bertolani R (1982) A new genus and five new species of Italian fresh-water tardigrades. *Bollettino del Museo Civico di Storia Naturale di Verona* 8: 249–254.
- Bertolani R (2003) *Thulinus*, new generic name substituting for *Thulinia* Bertolani, 1981 (Tardigrada, Eutardigrada). *Zootaxa* 314: 1–4.
- Bertolani R, Kristensen RM (1987) New records of *Eohypsibius nadjae* Kristensen, 1982, and revision of the taxonomic position of two genera of Eutardigrada (Tardigrada). In: Bertolani R (Ed.) *Biology of Tardigrades. Selected Symposia and Monographs UZI*. Vol. 1, Mucchi, Modena, 359–372.
- Bertolani R, Pilato G (1988) Struttura dell unghie nei Macrobiotidae e descrizione di *Murrayon* n. gen. (Eutardigrada). *Animalia* 15: 17–24.
- Bertolani R, Rebecchi L (1993) A revision of the *Macrobiotus hufelandi* group (Tardigrada, Macrobiotidae), with some observations on the taxonomic characters of eutardigrades. *Zoologica Scripta* 22(2): 127–152. doi: 10.1111/j.1463-6409.1993.tb00347.x
- Bertolani R, Marley NJ, Nelson DR (1999) Re-description of the genus *Thulinia* (Eutardigrada, Hypsibiidae) and of *Thulinia augusti* (Murray 1907) comb. n. *Zoologischer Anzeiger* 238: 139–145.
- Bertolani R, Guidetti R, Marchioro T, Altiero T, Rebecchi L, Cesari M (2014) Phylogeny of Eutardigrada: new molecular data and their morphological support lead to the identification of new evolutionary lineages. *Molecular Phylogenetics and Evolution* 76: 110–126. doi: 10.1016/j.ympev.2014.03.006
- Binda MG, Kristensen RM (1986) Notes on the genus *Oreella* (Oreellidae) and the systematic position of *Carphania fluviatilis* Binda 1978 (Carphaniidae fam. nov. Heterotardigrada). *Animalia* 13: 9–20.

- Boaden PJS (1966) Interstitial Fauna from Northern Ireland. Veröffentlichungen des Instituts für Meeresforschung in Bremerhaven I: 125–130.
- Borner J, Rehm P, Schill RO, Ebersberger I, Burmester T (2014) A transcriptome approach to ecdysozoan phylogeny. *Molecular Phylogenetics and Evolution* 80: 79–87. doi: 10.1016/j.ympev.2014.08.001
- Campbell LI, Rota-Stabelli O, Edgecombe GD, Marchioro T, Longhorn SJ, Telford MJ, Philippe H, Rebecchi L, Peterson KJ, Pisani D (2011) MicroRNAs and phylogenomics resolve the relationships of Tardigrada and suggest that velvet worms are the sister group of Arthropoda. *Proceedings of the National Academy of Sciences* 108(38): 15920–15924. doi: 10.1073/pnas.1105499108
- Claxton S (1998) A revision of the genus *Minibiotus* (Tardigrada: Macrobiotidae) with descriptions of eleven new species from Australia. *Records of the Australian Museum* 50(2): 125–160. doi: 10.3853/j.0067-1975.50.1998.1276
- Crisp DJ, Hobart J (1954) A note on the habitat of the marine tardigrade *Echiniscoides sigismundi* (Schultze). *Journal of Natural History Series* 12 7(79): 554–560. doi: 10.1080/00222935408651753
- Cuénot L (1932) Tardigrades. In: Lechevalier P (Ed.) *Fauna de France*. Volume 24, 1–96.
- Dastych H (1984) The Tardigrada from Antarctica with descriptions of several new species. *Acta Zoologica Cracoviensia* 27(19): 3774–436.
- Dastych H (1991) Redescription of *Hypsibius antarcticus* (Richters, 1904), with some notes on *Hypsibius arcticus* (Murray, 1907) (Tardigrada). *Mitteilungen Hamburgisches Zoologisches Museum und Institut* 88: 141–159.
- Dastych H (1992) *Paradiphascon manningi* gen. n. sp. n., a new water-bear from South Africa, with the erecting of a new subfamily Diphasconinae (Tardigrada). *Mitteilungen Hamburgisches Zoologisches Museum und Institut* 89: 125–139.
- Dastych H, McInnes SJ, Claxton SK (1998) *Oreella mollis* Murray, 1910 (Tardigrada): a redescription and revision of *Oreella*. *Mitteilungen Hamburgisches Zoologisches Museum und Institut* 95: 89–113.
- Degma P, Guidetti R (2007) Notes to the current checklist of Tardigrada. *Zootaxa* 1579: 41–53.
- Degma P, Bertolani R, Guidetti R (2015) Actual checklist of Tardigrada species (2009–2015, Ver 29 15-12-2015). <http://www.tardigrada.modena.unimo.it/miscellanea/Actual%20checklist%20of%20Tardigrada.pdf>
- Doyère M (1840) Mémoire sur les tardigrades. *Annales des Sciences Naturelles* 2(14): 269–361.
- Dujardin F (1851) Observations zoologiques, II: Sur les Tardigrades et sur une espèce à longs pieds vivant dans l'eau de mer. *Annales des Sciences Naturelles* 3(15): 161–166.
- Ehrenberg CG (1848) Fortgesetzte beobachtungen über jetzt herrschende atmosphärische mikroskopische etc. mit Nachtrag und Novarum specierum Diagnosis. Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin 13: 335–359.
- Ehrenberg CG (1853) Diagnoses novarum formarum. Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin: 526–533.
- Fontoura P, Morais P (2011) Assessment of traditional and geometric morphometrics for distinguishing cryptic species for the *Pseudechiniscus suillus* complex (Tardigrada, Echin-

- iscidae). Journal of Zoological Systematics and Evolutionary Research 49: 26–33. doi: 10.1111/j.1439-0469.2010.00594.x
- Greaves PM (1996) The ill-fated James Murray. Quekett Journal of Microscopy 37: 606–620.
- Guidetti R (1998) Two new species of Macrobiotidae (Tardigrada: Eutardigrada) from the United States of America, and some taxonomic considerations of the genus *Murrayon*. Proceedings of the Biological Society of Washington 111(3): 663–673.
- Guidetti R, Bertolani R (2005) Tardigrade taxonomy: an updated checklist of the taxa and a list of characters for their identification. Zootaxa 845: 1–46.
- Guidetti R, Rebecchi L, Bertolani R (2000) Cuticle structure and systematics of the Macrobiotidae (Tardigrada, Eutardigrada). Acta Zoologica 81: 27–36. doi: 10.1046/j.1463-6395.2000.00034.x
- Guidetti R, Gandolfi A, Rossi V, Bertolani R (2005) Phylogenetic analysis of Macrobiotidae (Eutardigrada, Parachela); a combined morphological and molecular approach. Zoologica Scripta 34(3): 235–244. doi: 10.1111/j.1463-6409.2005.00193.x
- Guidetti R, Schill RO, Dandekar T, Wolf M (2009) New molecular data for tardigrade phylogeny, with the erection of *Paramacrobiotus* gen. nov. Journal of Systematics and Evolutionary Research 47(4): 315–321. doi: 10.1111/j.1439-0469.2009.00526.x
- Guidetti R, Altiero T, Rebecchi L (2011) On dormancy strategies in tardigrades. Journal of Insect Physiology 57: 567–576. doi: 10.1016/j.jinsphys.2011.03.003
- Guidetti R, Cesari M, Rebecchi L, Altiero T, Bertolani R (2015) Integrative taxonomy approach to the *Paramacrobiotus richtersi* group (Eutardigrada, Macrobiotidae). Abstract in: 13th International Symposium on Tardigrada 2015, 23–26 June, Modena, Italy.
- Guil N (2008) New records and within-species variability of Iberian tardigrades (Tardigrada), with comments on the species from the *Echiniscus blumi-canadensis* series. Zootaxa 1757: 1–30.
- Guil N, Giribet G (2009) Fine scale population structure in the *Echiniscus blumi-canadensis* series (Heterotardigrada, Tardigrada) in an Iberian mountain range- when morphology fails to explain genetic structure. Molecular Phylogenetics and Evolution 51(3): 606–613. doi: 10.1016/j.ympev.2009.02.019
- Iharos G (1973) Angaben zur geographischen Verbreitung der Tardigraden. Opuscula Zoologica 12: 73–86.
- Kaczmarek Ł, Michalczyk Ł (2009) Redescription of *Hypsibius microps* Thulin, 1928 and *H. pallidus* Thulin 1911 (Eutardigrada: Hypsibiidae) based on the type material from the Thulin collection. Zootaxa 2275: 60–68.
- Kinchin IM (1990) The cosmopolitan tardigrade *Milnesium tardigradum* Doyère: An observation from Northern Ireland. Microscopy 36: 412–414.
- Kinchin IM (1992) An introduction to the invertebrate microfauna associated with mosses and lichens with observations from maritime lichens on the west coast of the British Isles. Microscopy 36: 721–731.
- Kristensen RM (1982) New aberrant Eutardigrades from homothermic springs on Disko Island, West Greenland. Proceedings of the Third International Symposium on Tardigrada, East Tennessee State University Press, Johnson City (USA), 205–220.
- Kristensen RM (1987) Generic revision of the Echiniscidae (Heterotardigrada) with a discussion of the origin of the family. In: Bertolani R (Ed.) Biology of Tardigrades. Selected Symposia and Monographs, Unione Zoologica Italiana 1: 261–335.

- Kristensen RM, Hallas TE (1980) The tidal genus *Echiniscoides* and its variability with the erection of a Echiniscoididae fam. n. (Tardigrada). Zoological Scripta 9: 113–127. doi: 10.1111/j.1463-6409.1980.tb00657.x
- Le Gros AE (1959) *Pseudechiniscus cornutus* (Richters) and *Hypsibius spitbergensis* (Richters), tardigrades new to Ireland. Irish Naturalists' Journal 13: 44.
- Marcus E (1927) Zur anatomie und ökologie mariner Tardigraden. Zoologische Jahrbücher 53: 487–588.
- Marcus E (1928) Bärtierchen (Tardigrada). In: Dahl F (Ed.) Die Tierwelt Deutschlands 12(8): 1–230.
- Marcus E (1929) Tardigrada. In: Bronn HG (Ed.) Klassen and Ordnungen des Tierreichs 5: 1–608.
- Marcus E (1936) Tardigrada. Das Tierreich 66: 1–340.
- Marley NJ, Bertolani R, Nelson DR (2008) Designation of *Pseudobiotus kathmanae* Nelson, Marley & Bertolani, 1999 as the type species for the genus *Pseudobiotus* Nelson, 1980 (Tardigrada). Zootaxa 1940: 41–47.
- Marley NJ, McInnes SJ, Sands CM (2011) Phylum Tardigrada: a re-evaluation of the Parachela. Zootaxa 2819: 51–64.
- Maucci W, Ramazzotti G (1981) *Cornechiniscus* gen. nov.: nuova posizione sistematica per i cosiddetti “*Pseudechiniscus* gruppo *cornutus*” con descrizione di una nuova specie (Tardigrada, Echiniscidae). Memorie dell'Istituto Italiano di Idrobiologia 39: 147–151.
- McInnes SJ (1995) Tardigrades from Signy Island, South Orkney Islands, with particular reference to freshwater species. Journal of Natural History 29: 1419–1445. doi: 10.1080/00222-939500770601
- Michalczyk Ł, Welnicz W, Frohme M, Kaczmarek Ł (2012a) Redescription of three *Milnesium* Doyère 1840 taxa (Tardigrada: Eutardigrada: Milnesiidae), including the nominal species for the genus. Zootaxa 3154: 1–20.
- Michalczyk Ł, Welnicz W, Frohme M, Kaczmarek Ł (2012b) Corrigenda of Zootaxa, 3154: 1–20 Redescriptions of three *Milnesium* Doyère, 1840 taxa (Tardigrada: Eutardigrada: Milnesiidae), including the nominal species for the genus. Zootaxa 3393: 66–68.
- Mihelčič F (1964) Eine neue Subspecies der Tardigradenart *Hypsibius (Diphascon) oculatus* John Murray 1906. Zoologischer Anzeiger: 172 (2): 138–139.
- Miller WR, McInnes SJ, Bergstrom AM (2005) Tardigrades of the Australian Antarctic: *Hypsibius heardensis* (Eutardigrada: Hypsibiidae: *dujardini* group) a new species from sub-Antarctic Heard Island. Zootaxa 1022: 5764.
- Mitchell D (1973) *Hypsibius (Diphascon) pinguis* Marcus, a tardigrade new to the British Isles. Irish Naturalists' Journal 17: 395.
- Meusemann K, von Reumont BM, Simon S, Roeding F, Strauss S, Kück P, Ebersberg I, Walz M, Pass G, Breuers S, Achter V, von Haeseler A, Burmester T, Hadrys H, Wägele W, Misof B (2010) A phylogenomic approach to resolve the arthropod tree of life. Molecular Biology and Evolution 27: 2451–2464. doi: 10.1093/molbev/msq130
- Møbjerg N, Halberg KA, Jørgensen A, Presson D, Bjørn M, Ramløv H, Kristensen RM (2011) Survival in extreme environments-on the current knowledge of adaptations in tardigrades. Acta Physiologica 202: 409–420. doi: 10.1111/j.1748-1716.2011.02252.x

- Morek W, Gąsiorek P, Stec D., Blagden B, Michalczyk Ł (2016) Experimental taxonomy exposes ontogenetic variability and elucidates the taxonomic value of claw configuration in *Milnesium* Doyère, 1840 (Tardigrada: Eutardigrada: Apochela). *Contributions to Zoology* 85(2): 173–200.
- Morgan CI (1974) Studies on the biology of tardigrades. PhD thesis, University of Swansea, Swansea, Wales, 1–376.
- Morgan CI (1975) Some notes on the Tardigrada of the Mullet Peninsula, including four additions to the Irish fauna, and a key to the Irish species. *Irish Naturalists' Journal* 18(6): 165–177.
- Morgan CI (1976) Studies on the British tardigrade fauna, some zoogeographic and ecological notes. *Journal of Natural History* 10: 607–632. doi: 10.1080/00222937600770491
- Morgan CI (1980) Notes on the Distribution and Abundance of the Irish Marine Tardigrada, including two new additions to the Irish fauna. *Irish Naturalists' Journal* 20(4): 148–152.
- Morgan CI, King PE (1976) British Tardigrades, Synopses of the British Fauna (New Series) vol. 9. Academic Press, London.
- Murray J (1905b) Tardigrada of the Forth Valley. *Annals of Scottish Natural History* 55: 160–164.
- Murray J (1905a) Tardigrada of the Scottish Lochs. *Transactions of the Royal Society of Edinburgh* 41: 677–698. doi: 10.5962/bhl.title.12517
- Murray J (1906a) Scottish alpine Tardigrada. *Annals of Scottish Natural History*, 25–30.
- Murray J (1906b) Tardigrada of the Forth Valley. Part II. *Annals of Scottish Natural History* 60: 214–217.
- Murray J (1907b) Arctic Tardigrada collected by WM. S. Bruce, *Transactions of the Royal Society of Edinburgh* 45(3): 669–681. doi: 10.1017/s0080456800011789
- Murray J (1907a) Scottish Tardigrada, collected by the Lake Survey. *Proceedings of the Royal Society of Edinburgh* 45(3): 641–688. doi: 10.1017/s0080456800011777
- Murray J (1910) Part V Tardigrada. In: *British Antarctic Expedition 1907–, under the command of Sir E. H. Shackleton, C.V.O. Reports on the Scientific Investigations. Vol. 1, Biology.* William Heinemann Publisher, London. doi: 10.5962/bhl.title.22427
- Murray J (1911) Arctiscoida. *Proceedings of the Royal Irish Academy* 31(37): 1–16. doi: 10.5962/bhl.title.64352
- Nelson DR (2002) Current status of the Tardigrada: ecology and evolution. *Integrative and Comparative Biology* 42(3): 653–659. doi: 10.1093/icb/42.3.652
- Nelson DR, Marley NJ, Bertolani R (1999) Re-description of the genus *Pseudobiotus* (Eutardigrada, Hypsibiidae) and of the new type species *Pseudobiotus kathmanae* sp. n. *Zoologischer Anzeiger* 238: 311–317.
- Nielsen C (2012) *Animal Evolution: Interrelationships of the Living Phyla*, third ed. Oxford University Press.
- Pilato G (1969) Evoluzione e nuova sistemazione degli Eutardigrada. *Bollettino di Zoologia* 36(3): 327–345. doi: 10.1080/11250006909436925
- Pilato G (1987) Revision of the genus *Diphascon* Plate, 1889, with remarks on the subfamily Itaquasconinae (Eutardigrada, Hypsibiidae) In: Bertolani R (Ed.) *Biology of Tardigrades. Selected Symposia and Monographs, U.Z.I. Vol. 1., Mucchi, Modena*, 337–357.

- Pilato G (1989) Phylogenesis and systematic arrangement of the family Calohypsibiidae Pilato, 1969 (Eutardigrada). Zeitschrift für Zoologische Systematik und Evolutionsforschung 27: 8–13. doi: 10.1111/j.1439-0469.1989.tb00433.x
- Pilato G (1998) Microhypsibiidae, a new family of Eutardigrades, with the description of the new genus *Fractonotus*. Spixiana 21(2): 129–134.
- Pilato G, Binda MG (1977) Precisazioni e rettifiche alla descrizione di alcune specie di Tardigradi (seconda nota). Animalia 4: 35–51.
- Pilato G, Binda MG (1997/98) A comparison of *Diphascion* (*D.*) *alpinum* Murray, 1906, *D.* (*D.*) *chilenense* Plate, 1889 and *D.* (*D.*) *pingue* Marcus, 1936 (Tardigrada), and description of a new species. Zoologischer Anzeiger 236: 181–185.
- Pilato G, Binda MG (1999) Three new species of *Diphascion* of the *pingue* group (Eutardigrada, Hypsibiidae) from Antarctica. Polar Biology 21: 335–342. doi: 10.1007/s003000050370
- Pilato G, Claxton S, Binda MG (1989) Tardigrades from Australia. II The evaluation of *Calohypsibius ornatus* (Richters, 1900) *caelatus* (Marcus, 1928) as a valid species and description of *Minibiotus fallax* n. sp. (Eutardigrada). Animalia 16: 21–27.
- Plate LH (1888) Beiträge zur Naturgeschichte der Tardigraden. Zoologische Jahrbücher 3: 487–550. doi: 10.5962/bhl.part.1265
- Pollock LW (1971) On some British marine Tardigrada, including two new species of *Batillipes*. Journal of the Marine Biological Association of the United Kingdom 51: 93–103. doi: 10.1017/s0025315400006482
- Puglia CR (1959) Some aspects of the taxonomy, ecology, and distribution of tardigrades with emphasis on the tardigrades of east central Illinois. PhD thesis, Urbana, Illinois: University of Illinois, 1–125.
- Rahm G (1937) A new ordo of Tardigrades from the hot springs of Japan (Furu-Yu Section, Unzen). Annotationes Zoologicae Japonenses 16(4) 345–353.
- Ramazzotti G (1945) Nuovi tardigradi della fauna italiana. Atti della Società Italiana di Scienze Naturali 34: 98–104.
- Ramazzotti G (1962) Il Phylum Tardigrada. Memorie dell'Istituto Italiano di Idrobiologia, 14, 1–595.
- Ramazzotti G, Maucci W (1983) Il Phylum Tardigrada. Terza edizione riveduta e corretta. Memorie dell'Istituto Italiano di Idrobiologia Dott. Marco Marchi 41: 1–1012.
- Renaud-Debyser J (1959) Sur quelques tardigrades du Bassin d' Arcachon. Vie Milieu, 10: 135–146.
- Richters F (1900) Beiträge zur Kenntnis der fauna der Umgebung von Frankfurt a. M. Bericht der Senckenbergischen Naturforschenden Gesellschaft in Frankfurt am Main, 21–44.
- Richters F (1902) Beiträge zur Kenntnis der fauna der Umgebung von Frankfurt am Main Erste Fortsetzung. Bericht der Senckenbergischen Naturforschenden Gesellschaft in Frankfurt am Main 34: 3–21.
- Richters F (1903) Nordische Tardigraden. Zoologischer Anzeiger 27: 168–172.
- Richters F (1904c) Arktische Tardigraden. Fauna Arctica 3: 493–508.
- Richters F (1904a) Isländische Tardigraden. Zoologischer Anzeiger 28 (9): 347352.
- Richters F (1904b) Vorläufiger Bericht über die antarktische Moosfauna. Verhandlungen der Deutschen Zoologischen Gesellschaft 14: 236–239.

- Richters F (1907) Zwei neue *Echiniscus*-Arten. Zoologischer Anzeiger 31: 197–202.
- Richters F (1909a) Marine Tardigraden. Verhandlungen der Duetschen Zoologischen Gesellschaft 19: 84–94.
- Richters F (1909b) Tardigraden-Studien. Bericht der Senckenbergishcen Naturforschenden Gesellschaft in Frankfurt am Main 40: 28–48.
- Richters F (1926) Tardigrada. In: Kükenthal W, Krumbach T (Eds) Handbuch der Zoologie 3, Walter de Gruyter & Co., Berlin and Leipzig, 58–61.
- Rudescu L (1964) Tardigrada. Fauna Republicii Populare Române, Arthropoda, Volume 4(7), Editura Academiei Republicii Populare Române, București, 1–400.
- Sands CJ, McInnes SJ, Marley NJ, Goodall-Copestake WP, Convey P, Linse K (2008) Phylum Tardigrada: an “individual” approach. Cladistics 24: 861–871. doi: 10.1111/j.1096-0031.2008.00219.x
- Schultze CAS (1834) *Macrobiotus hufelandii* animal e crustaceorum classe novum, reviviscendi post diuturnam asphixiam et aridiatem potens, etc. 8, 1 tab. C. Curths, Berlin, 6 pp., I Table.
- Schultze CAS (1840) *Echiniscus Bellermanni*; animal crustaceum. Berolini, apud G. Reimer, 1–8.
- Schultze M (1865) *Echiniscus sigismundi* ein Arctiscoide der Nordsee. Archiv für mikroskopische anatomie 1: 428–436. doi: 10.1007/bf02961427
- Schuster RO, Nelson DR, Grigarick AA, Christenberry D (1980) Systematic Criteria of the Eutardigrada. Transactions of the American Microscopical Society 99(3): 284–303. doi: 10.2307/3226004
- Smith KG (2009) Phylum Tardigrada. In: Ferris SE, Smith KG, Skipp TP (Eds) Irish Biodiversity: A Taxonomic Inventory of Fauna, Irish Wildlife Manuals No. 38, National Parks and Wildlife Service, Department of Environment, Heritage, and Local Government, Dublin, 76–77.
- Thulin G (1911) Beiträge zur Kenntniss der Tardigraden fauna Schwedens. Arkiv för Zoologi 7: 1–60. doi: 10.5962/bhl.part.1270
- Thulin G (1928) Über die phylogenie und das system der Tardigraden. Hereditas 11: 207–266. doi: 10.1111/j.1601-5223.1928.tb02488.x
- Tumanov DV (2005) *Isohypsibius panovi*, a new species of Tardigrada from Ireland (Eutardigrada, Hypsibiidae). Zootaxa 812: 1–4.
- Tumanov DV (2006) Five new species of the genus *Milnesium* (Tardigrada, Eutardigrada, Milnesiidae). Zootaxa 1122: 1–23.
- van der Land J (1966) The Tardigrada of the Scottish Lake Survey described as new species by James Murray. Proceeding of the Royal Society of Edinburgh, Section B, Biology 69(3–4): 298–20. doi: 10.1017/S0080455X0000120X
- Vecchi M, Cesari M, Bertolani R, Jönsson IK, Rebecchi L, Guidetti R (in press) Integrative systematic studies on tardigrades from Antarctica identify new genera and new species within Macrobiotioidea and Echiniscoidea. Invertebrate Systematics.
- Węlnicz W, Grohme MA, Kaczmarek L, Schill RO, Frohme M (2011) Anyhydrobiosis in tardigrades- the last decade. Journal of Insect Physiology 57: 577–583. doi: 10.1016/j.jinsphys.2011.03.019

A new species of *Neoperla* from China, with a redescription of the female of *N. mnong* Stark, 1987 (Plecoptera, Perlidae)

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Abstract

A new species of the *Neoperla clymene* group (Plecoptera, Perlidae), *N. chebalinga* **sp. n.** from Guangdong Province of southern China is described, illustrated, and compared with related taxa. The new species is characterized by the slender aedeagal tube, strongly sclerotized dorsally, and weakly sclerotized ventrally with an upcurved, medial, finger-like membranous lobe. Additionally the aedeagal sac gradually tapers to a blunt apex with a dorsoapical patch of spines. A supplementary description of the female of *N. mnong* Stark, 1987 from Guangdong Province, China is also given.

Keywords

China, *Neoperla*, new species, Perlidae, Plecoptera

Introduction

Neoperla Needham (1905) is the most species-rich perlid genus in China with at least 57 species (DeWalt et al. 2016). Contributions to Chinese species of *Neoperla* were made by Chu (1929), Wu and Claassen (1934), Wu (1935, 1938, 1948, 1962, 1973), Yang and Yang (1992, 1995, 1998), Du (1998, 1999, 2000a, 2000b), Du et al. (1999,

2001), Du and Sivec (2004, 2005), Du and Wang (2005, 2007), Sivec and Zwick (1987), Li and Wang (2011), Li et al. (2011a, 2011b, 2012a, 2012b, 2013a, 2013b, 2014a, 2014b), Qin et al. (2013), Wang et al. (2013a, 2013b), Li and Zhang (2014), Kong et al. (2014), Wang et al. (2014), Chen and Du (2015, 2016). Herein, a new species of this genus is described from Guangdong Province, a coastal region of southern China. Additionally, a supplementary description and new illustrations for the female of *N. mnong* Stark, 1987 from Guangdong Province are provided to indicate the variation of the female subgenital plate and head pattern as compared to the original description of Vietnamese material.

Material and methods

Specimens used in this study were collected from riparian areas by hand and preserved in 75% ethanol. Abdomens were cleared in 10% NaOH. Details of the morphology were studied with a Leica MZAPO microscope, and color illustrations were taken by Leica SZ45 and S4800 FESEM, both in Yangzhou, Jiangsu Province, China. All studied material, including the holotype and paratypes of the new species, are deposited in the Insect Collection of Yangzhou University, China.

Taxonomy

Neoperla chebalinga sp. n.

<http://zoobank.org/960227BF-2234-483D-9363-3C7A40D0F32D>

Figs 1–10

Type material. Holotype male: China: Guangdong Province, Chebaling Nature Reserve, 114.1320E, 24.7128N, 17 June, 2009, leg. Hai-Yang Xue and Bo Yu. Paratypes: 4 males and 2 females, same data as holotype.

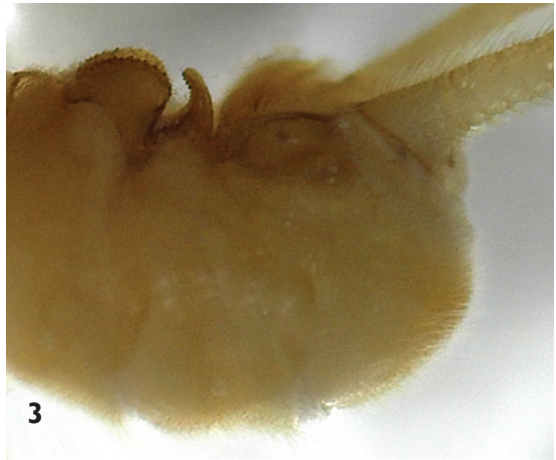
Diagnosis. Distinguishing characteristics of this species include a slender aedeagal tube that has an upcurved, medial, finger-like, membranous lobe on the ventral surface, and a short, blunt, ventrally curved aedeagal sac with a dorsoapical patch of spines.

Adult habitus. General body color yellow patterned with brown. Head slightly wider than pronotum with a brown stigma on anterior frons and a subtriangular dark brown area covering ocelli; compound eyes dark and antennae brown (Figs 1, 9–10). Pronotum disc yellow with pale brown rugosities (Fig. 1). Wing membrane subhyaline, veins brown; legs yellow, femora grading to brown distally. Cerci pale (Figs 9–10).

Male (Figs 1–5, 9). Forewing length 13.5–14.0 mm, hindwing length 11.5–12.0 mm ($n = 5$). The posterior margin of tergum 7 with a raised process densely covered with sensilla basiconica. Tergum 8 bears a recurved oval process with small spines at the distal margin (Figs 2–3). Tergum 9 without sensilla basiconica. Hemitergal processes of tergum 10 slightly curved anteriorly (Fig. 2). Aedeagal tube slender, strongly



Figure 1. *Neoperla chebalinga* sp. n. Male head and pronotum, dorsal view.



Figures 2–3. *Neoperla chebalinga* sp. n. Male terminalia: **2** dorsal view **3** lateral view.

sclerotized dorsally, weakly sclerotized ventrally except for the basal bulb and an up-curved, ventromedial, finger-like membranous lobe. Aedeagal sac short and gradually tapered to a blunt apex, curved ventrally with a dorsoapical patch of spines (Figs 4–5).

Female (Figs 6–7, 10). Forewing length 15.5–16.0 mm, hindwing length 13.0–13.5 mm ($n = 2$). General color and pattern similar to males. Subgenital plate of sternum 8 slightly produced and lightly sclerotized posteromedially (Figs 6, 10). Va-

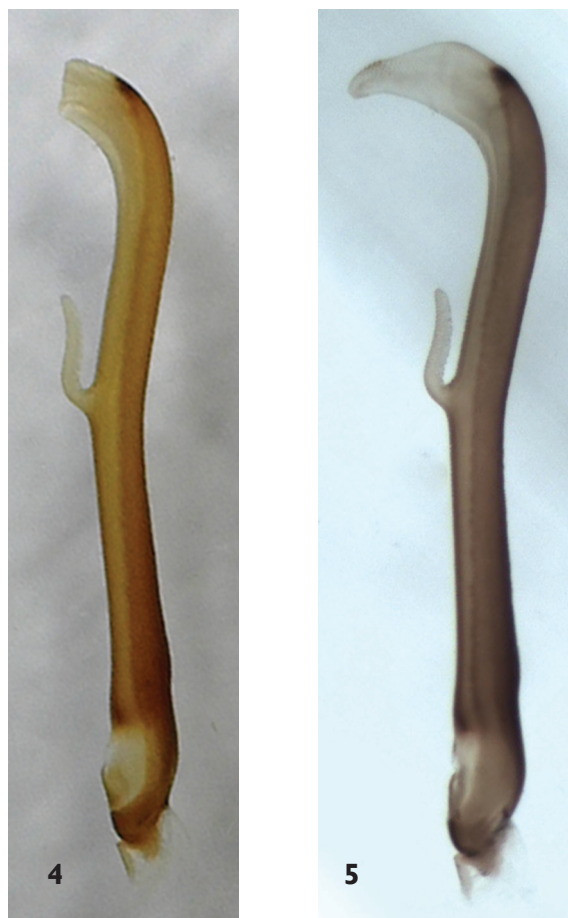


Figure 4–5. *Neoperla chebalinga* sp. n. Aedeagus: **4** *In situ*, lateral view **5** Everted, lateral view.

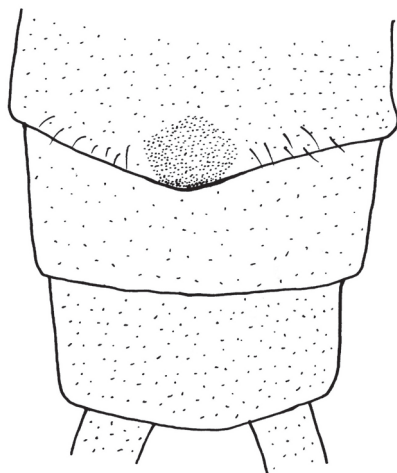


Figure 6. *Neoperla chebalinga* sp. n. Female terminalia, ventral view.

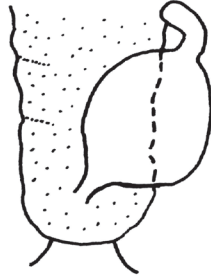


Figure 7. *Neoperla chebalinga*, sp. n. Female genitalia, vagina and spermathecum, lateral view.

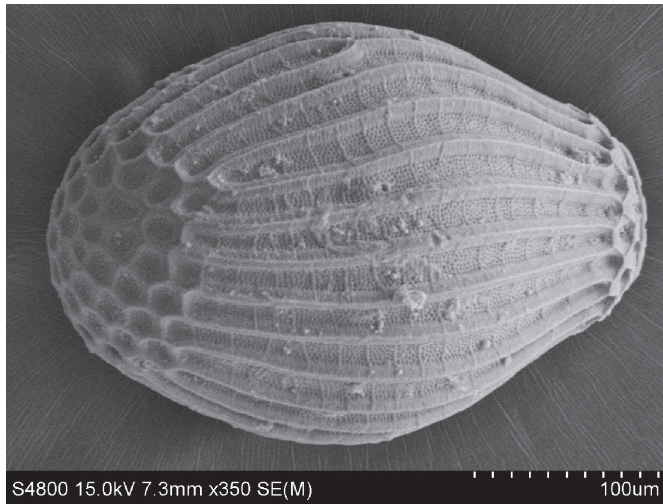


Figure 8. *Neoperla chebalinga* sp. n. Egg, lateral view.

gina elongate-oval, lined sparsely along lateral margins. Spermathecal stalk short, spermatheca oval and curled at tip (Fig. 7).

Eggs (Fig. 8). Outline oval. Collar short and surrounded by 1–2 irregular rows of follicle cell impressions. Primary striae join rim on sides of collar, narrow and widely spaced; each pair of primary striae enclose many secondary striae; sulci with dense pits. Lid small consisting of follicle cell impressions (Fig. 8).

Etymology. The species is named after the type locality, Chebaling Nature Reserve.

Remarks. The new species is a member of the *N. clymene* group possessing a slender and mostly sclerotized aedeagal tube. The processes of terga 7–8 and aedeagus of the new species are similar to those of *N. furcostyla* Li & Qin, 2013 (in: Li et al. 2013b) and *N. forcipata* Yang & Yang, 1992 (Yang and Yang 1992). However, in *N. furcostyla* and *N. forcipata*, the aedeagal tube has a subapical fork instead of the medial finger-like lobe as in *N. chebalinga*. In addition, the aedeagal sacs of *N. furcostyla* and *N. forcipata* are not curved ventrally (see Figs 1–2 in: Li et al. 2013b and fig. 1 in Yang and Yang 1992).

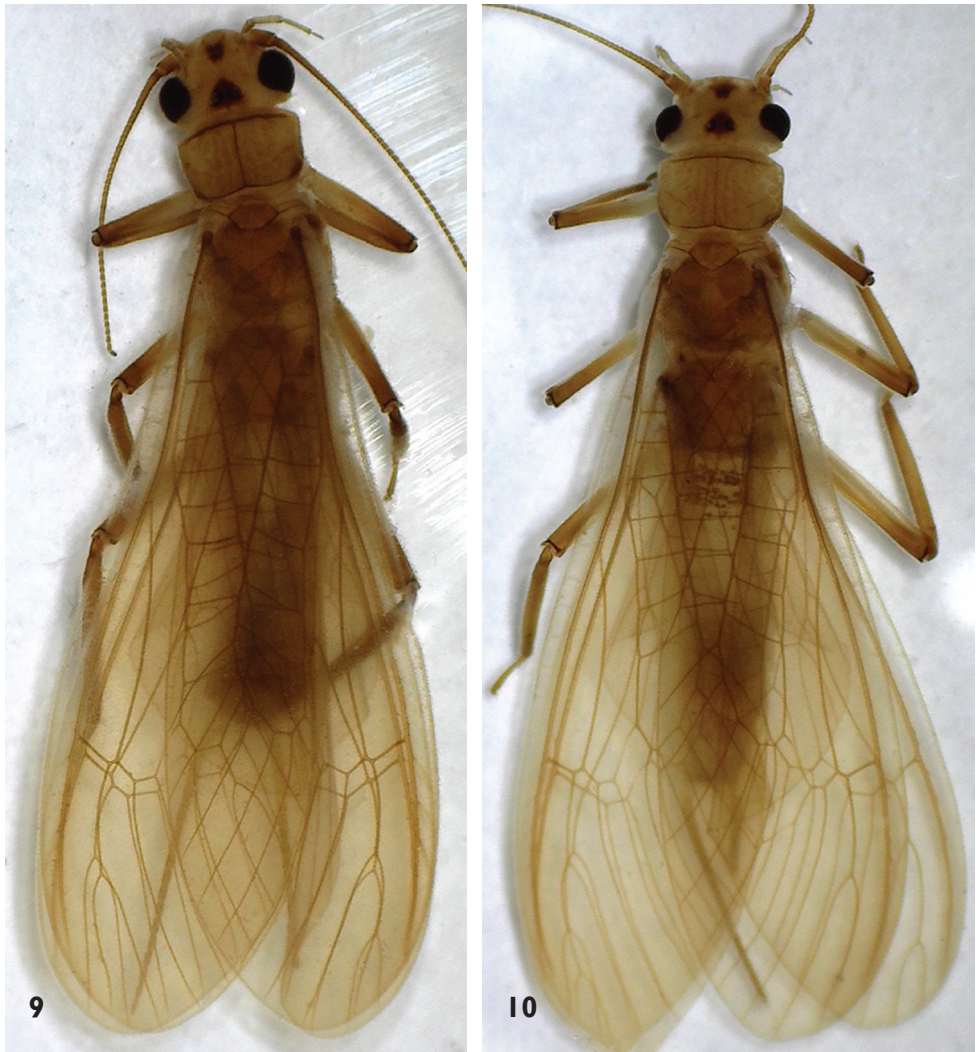


Figure 9–10. *Neoperla chebalinga* sp. n. Habitus: **9** Male habitus, dorsal view **10** Female habitus, dorsal view.

***Neoperla mnong* Stark, 1987**

Figs 11–13

Neoperla mnong Stark, 1987: 48; Stark & Sivec 2008: 33; Du 1998: 393; Li et al. 2012: 22; Wang et al. 2013b: 87.

Material examined. 1 male, 4 females, China: Guangdong Province, Chebaling Nature Reserve, 114.1320E, 24.7128N, 17 June, 2009, leg. Hai-Yang Xue and Bo Yu.

Description of the female Chinese specimens. Female (Figs 11–13). Forewing length 12.0–12.5 mm, hindwing length 10.0–10.5 mm (n = 4). General color yel-



Figure 11. *Neoperla mnong* Stark. Female habitus, dorsal view.

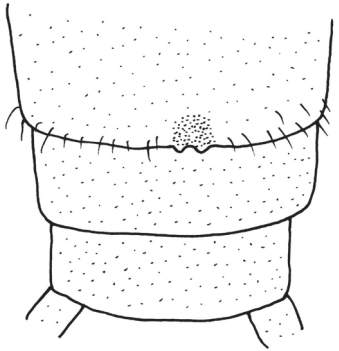


Figure 12. *Neoperla mnong* Stark. Female terminalia, ventral view.



Figure 13. *Neoperla mnong* Stark. Female genitalia, vagina and spermathecum, lateral view.

low to brown. Head nearly as wide as pronotum, with a subtriangular dark brown area covering ocelli; compound eyes dark and antennae pale brown. Pronotum disc yellow with pale brown rugosities. Wing membrane subhyaline, veins pale brown; legs yellow without darker markings. Cerci pale brown (Fig. 11). Subgenital plate of sternum 8 forming a small rounded sclerite with a posteromedial notch (Fig. 12). Vagina oval, lined densely around base of spermathecal stalk. Spermathecal stalk and spermatheca short, slender and curled at tip; a single accessory gland occurs near spermatheca tip (Fig. 13).

Distribution. China (Guangdong Province: Conghua County, Liuxi River; Shixing County, Chebaling Nature Reserve. Guangxi Province: Jinxiu suburb; Tianlin County, Pinglang). Vietnam (Di Linh, Dak Song, Gia Lai, Nghe An, Pleiku). Thailand (Chanthaburia).

Remarks. This species is expected to be widespread in southern Asia. The male of *N. mnong* has been described from Vietnam by Stark (1987) and well-illustrated by Stark and Sivec (2008) from Vietnamese material. This species has been previously recorded from China by Du (1998) and Li et al. (2012b). Females of *N. mnong* from Vietnam were described as *Javanita costalis* by Navás (1932) and later described by Stark and Sivec (2008). In this study, females collected from Guangdong Province of China in 2009 are described and illustrated for the first time. The subgenital plate of these specimens is smaller and pigment patch over the ocelli is larger (for comparison see Figs 40, 43 in Stark and Sivec 2008).

Acknowledgments

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References

- Chu YT (1929) Descriptions of four new species and one new genus of stone-flies in the family Perlidae from Hangchow. *The China Journal* 10: 88–92.
- Chen ZT, Du YZ (2015) The first record of a species of Perlidae from Jiangsu Province, China: a new species of *Neoperla* (Plecoptera: Perlidae). *Zootaxa* 3974(3): 424–430. doi: 10.11646/zootaxa.3974.3.9
- Chen ZT, Du YZ (2016) A new species of *Neoperla* (Plecoptera: Perlidae) from Zhejiang Province of China. *Zootaxa* 4093(4): 589–594. doi: 10.11646/zootaxa.4093.4.12
- DeWalt RE, Maehr MD, Neu-Becker U, Stueber G (2016) Plecoptera Species File Online. <http://Plecoptera.SpeciesFile.org> [accessed 23 Mar 2016]
- Du YZ (1998) Two new record species of genus *Neoperla* Needham (Plecoptera: Perlidae) from China. *Journal of Zhejiang Agricultural University* 24(4): 393.
- Du YZ (1999) Plecoptera. In: Huang BK (Ed.) *Fauna of Insects in Fujian Province of China*. Vol. 3. Fujian Science and Technology Publishing house, Fujian, 301–335.
- Du YZ (2000a) *Neoperla magisterchoui*, a new species of the genus *Neoperla* Needham (Plecoptera: Perlidae) from China. In: Zhang YL (Ed.) *Systematic and Faunistic Research on Chinese Insects*. Proceedings of the 5th National Congress of Insect Taxonomy. China Agriculture Press, Beijing, 1–3.
- Du YZ (2000b) Two new species of the genus *Neoperla* Needham (Plecoptera: Perlidae: Perlinae) from Guizhou, China. *Entomotaxonomia* 22(1): 1–5.
- Du YZ, Sivec I (2004) Plecoptera: Perlidae, Nemouridae, Leuctridae. In: Yang XK (Ed.) *Insects from Mt. Shiwandashan Area of Guangxi*. China Forestry Publishing House, Beijing, 39–45.
- Du YZ, Sivec I (2005) Plecoptera. In: Yang XK (Ed.) *Insect Fauna of Middle-west Qinling Range and South Mountains of Gansu Province*. Science Press, Beijing, 38–54.
- Du YZ, Sivec I, He JH (1999) A checklist of the Chinese species of the family Perlidae (Plecoptera: Perloidea). *Acta Entomologica Slovenica* 7: 59–67.
- Du YZ, Sivec I, Zhao MS (2001) Plecoptera. In: Wu H, Pan CW (Eds) *Insects of Tianmushan National Nature Reserve*. Science Press, Beijing, 69–80.
- Du YZ, Wang ZJ (2005) Plecoptera: Leuctridae, Nemouridae, Perlidae and Peltoperlidae. In: Yang MF, Jin DC (Eds) *Insects from Dashahe Nature Reserve of Guizhou*. Guizhou People Press, Guizhou, 51–57.
- Du YZ, Wang ZJ (2007) Nemouridae and Perlidae. In: Li ZZ, Yang MF, Jin DC (Eds) *Insects from Mountain Leigongshan Landscape of Guizhou*. Guizhou Science and Technology Publishing House, Guizhou, 84–90.
- Kong FB, Lv JF, Li WH (2014) Three new species of *Neoperla* in the *montivaga* group (Plecoptera: Perlidae) from China. *Zootaxa* 3841(3): 429–438. doi: 10.11646/zootaxa.3841.3.7
- Li WH, Liang HY, Li WL (2013a) Review of *Neoperla* (Plecoptera: Perlidae) from Zhejiang Province, China. *Zootaxa* 3652: 353–369. doi: 10.11646/zootaxa.3652.3.4
- Li WH, Li S, Feng GW, Wang YB (2014a) Species of *Neoperla* (Plecoptera: Perlidae) from Henan Province, China. *Zootaxa* 3838(2): 174–182. doi: 10.11646/zootaxa.3838.2.2
- Li WH, Murányi D, Wang RF (2014b) Species of *Neoperla* (Plecoptera: Perlidae) from Yunnan Province, China. *Zootaxa* 3753(1): 1–9. doi: 10.11646/zootaxa.3753.1.1

- Li WH, Wang GQ, Lu WY (2012a) Species of *Neoperla* (Plecoptera: Perlidae) from Hubei, China. Zootaxa 3478: 32–37.
- Li WH, Wang GQ, Li WL, Murányi D (2012b) Review of *Neoperla* (Plecoptera: Perlidae) from Guangdong Province of China. Zootaxa 3597(4): 15–24.
- Li WH, Wang GQ, Qin XF (2013b) Two new species of *Neoperla* (Plecoptera, Perlidae) from China. ZooKeys 290: 21–30. doi: 10.3897/zookeys.290.4568
- Li WH, Wang HL, Lu WY (2011a) Species of the genus *Neoperla* (Plecoptera: Perlidae) from Henan, China. Zootaxa 2735: 57–63.
- Li WH, Wu LM, Zhang HR (2011b) A new species of the genus *Neoperla* (Plecoptera: Perlidae) from Henan, China. Acta Zootaxonomica Sinica 36(1): 33–35.
- Li WH, Wang RF (2011) A new species of *Neoperla* (Plecoptera: Perlidae) from China. Entomological News 122(3): 261–264. doi: 10.3157/021.122.0308
- Li WH, Zhang SQ (2014) Two new species of *Neoperla* (Plecoptera, Perlidae) from Dabie Mountains of China. ZooKeys 438: 45–55. doi: 10.3897/zookeys.438.8230
- Needham JG (1905) New genera and species of Perlidae. Proceedings of the Biological Society of Washington 17: 107–110.
- Navas L (1932) Insecta Orientalis. Memorie della Pontificia Accademia Romana dei Nuovi Lincei 16: 917–918, 923–926, 952–954.
- Qin XF, Murányi D, Wang GQ, Li WH (2013) Stoneflies of the genus *Neoperla* (Plecoptera, Perlidae) from Wuyi Mountain National Nature Reserve, Fujian of China. ZooKeys 326: 1–16. doi: 10.3897/zookeys.326.5911
- Stark BP (1987) Records and descriptions of oriental Neoperlini (Plecoptera: Perlidae). Aquatic insects 9(1): 45–50. doi: 10.1080/01650428709361270
- Stark BP, Sivec I (2008) New species and records of *Neoperla* (Plecoptera: Perlidae) from Vietnam. Illiesia 4: 19–54.
- Sivec I, Zwick P (1987) Some *Neoperla* (Plecoptera) from Taiwan. Beiträge zur Entomologie 37: 391–405.
- Wu CF (1935) New species of stoneflies from East and South China. (Order Plecoptera). Bulletin of the Peking Society of Natural History 9(3): 227–243.
- Wu CF (1938) Plecopterorum sinensium: A monograph of stoneflies of China (Order Plecoptera). Yenching University, Beijing, 225 pp.
- Wu CF (1948) Fourth supplement to the stoneflies of China (Order Plecoptera). Peking Natural History Bulletin 17(1): 75–82.
- Wu CF (1962) Results of the Zoologico-Botanical expedition to Southwest China, 1955–1957 (Plecoptera). Acta Entomologica Sinica 11: 139–153.
- Wu CF (1973) New species of Chinese stoneflies (Order Plecoptera). Acta Entomologica Sinica 16(2): 97–118.
- Wu CF, Claassen PW (1934) New species of Chinese stoneflies. Bulletin of the Peking Society of Natural History 9: 111–129.
- Wang GQ, Li WH, Yang J (2013a) New species and records of the stonefly genus *Neoperla* (Plecoptera, Perlidae) from Jinhuacha Nature Reserve, Guangxi of China. ZooKeys 351: 37–48. doi: 10.3897/zookeys.351.6259

- Wang HL, Wang GQ, Li WH (2013b) Two new species in the subfamily Perlinae (Plecoptera, Perlidae) from China. *ZooKeys* 313: 81–90. doi: 10.3897/zookeys.313.5460
- Wang GQ, Murányi D, Li WH (2014) Two new species of dark *Neoperla* (Plecoptera: Perlidae) from Oriental Realm of China. *Zootaxa* 3872(1): 22–30. doi: 10.11646/zootaxa.3872.1.2
- Yang D, Yang CK (1992) Plecoptera: Perlidae. In: Huang FS (Ed.) *Insects of Wuling Mountains area, Southwestern China*. Science Press, Beijing, 62–64.
- Yang D, Yang CK (1995) Plecoptera: Perlidae. In: Wu H (Ed.) *Insects of Baishanzu Mountain, Eastern China*. China Forestry Publishing House, Beijing, 59–60.
- Yang D, Yang CK (1998) Plecoptera: Styloperlidae, Perlidae and Leuctridae. In: Wu H (Ed.) *Insects of Longwangshan*. China Forestry Publishing House, Beijing, 40–46.

A new genus and species of Rhizoecidae (Hemiptera, Sternorrhyncha, Coccoomorpha) associated with *Acropyga yaeyamensis* (Hymenoptera, Formicidae, Formicinae)

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Abstract

Ishigakicoccus **gen. n.** *shimadai* **sp. n.** is described based on the adult female morphology. This new species was found in the nest of a rare Japanese ant, *Acropyga yaeyamensis* Terayama & Hashimoto, 1996, in Ishigaki Is., Japan. It resembles *Capitisetella migrans* (Green, 1933) and *Pseudorhizoecus proximus* Green, 1933. However, the new species differs from those two species in having small multilocular pores, large 3-5 locular pores on the medial area of ventral abdomen, and two different-sized body setae. This new species is also the first record of a potential trophobiont of *A. yaeyamensis*. A key to Japanese species of Rhizoecidae is also provided.

Keywords

Ant trophobiont, ground mealybug, new genus, root mealybug, taxonomy

Introduction

Rhizoecidae is a family of Coccoomorpha (Hemiptera: Sternorrhyncha) which members mostly live underground, feeding on plant rootlets (Williams 1998), and are known as “root mealybugs” or “ground mealybugs”. The family is composed of 240 nominal

species distributed in 18 genera (García et al. 2016), and 11 species distributed in five genera have been recorded from Japan (Tanaka 2016). Some species of the family are regarded as potentially or actually important plant pests (Danzig et al. 2008; Hambleton 1976; Kawai 2003; Williams 1996), and they are investigated from biological in addition to agricultural and/or economic perspectives.

Some genera and species placed in Rhizoecidae, especially those classified in the tribe Xenococcini, show very close trophobiotic relationships with ants that belong to the genus *Acropyga* (Hymenoptera: Formicidae: Formicinae) (Kishimoto-Yamada et al. 2005; LaPolla et al. 2002; LaPolla et al. 2008). Trophobiosis is commonly observed in interactions among many ants and honeydew-producing insects, including some scale insects, but the relationship between *Acropyga* ants and their trophobiont Rhizoecidae species is known as one of the most peculiar examples. Virgin queens of *Acropyga* ants grasping and carrying a root mealybug by their mandibles emerge from their nests for their mating flight and subsequent colony founding (LaPolla et al. 2002; LaPolla et al. 2008), the mealybugs are maintained in the ant's nest (Flanders 1957; Kishimoto-Yamada et al. 2005; LaPolla et al. 2002), and the ants feed on the honeydew excreted by the mealybugs, which in turn feed on root-sap (Johnson et al. 2001; Smith et al. 2007). This obligatory relationship has greatly interested many researchers, and as a result mealybugs and other scale insects associated with *Acropyga* ants have been relatively well studied systematically and/or taxonomically (LaPolla et al. 2008; Maruyama et al. 2013; Schneider and LaPolla 2011; Williams 1998; Williams 2004; Williams and LaPolla 2004; Williams and Terayama 2000). Nevertheless, a mutualistic partner or associate of a rare Japanese ant species, *A. yaeyamensis*, have not been hitherto detected nor described.

Recently, the author had an opportunity to examine several interesting mealybug specimens that were collected from the nest of *A. yaeyamensis* which showed a close association with the ant (Figure 2), being a potential mutualistic trophobiont. The species is quite peculiar and distinctive among known Rhizoecidae species, although it is somewhat similar to *Capitisetella migrans* and *Pseudorhizoecus proximus*.

This paper describes and illustrates this mealybug as a new genus and species on the basis of adult female morphology. A key to Japanese species of Rhizoecidae is also given.

Materials and methods

Specimens of the root mealybug species used in this study were originally collected by a collaborator of this study, Mr. Taku Shimada, on 16 February 2015, from a nest of *A. yaeyamensis* Terayama & Hashimoto, 1996, in Mt. Omoto, Ishigaki Is., Japan. The mounting method used for these specimens followed that described by Tanaka (2014). Morphology of the slide-mounted specimens was examined under a phase-contrast light microscope (Olympus BH2-PH). The terminology used to describe the adult females followed that of Kozár and Konczné Benedicty (2007). All examined type materials in this study are deposited in the National Museum of Nature and Science, Tsukuba, Japan (NSMT).

Taxonomy

Tribe Rhizoecini Williams, 1969

Type genus. *Rhizoecus* Künckel d'Herculais, 1878

Diagnosis. Same as for the family, except the characters related to Xenococcini (adopted and modified from Kozár and Konczné Benedicty 2007).

Subtribe Rippersiellina Kozár, 2007

Type genus. *Rippersiella* Tinsley, 1899 in Cockerell 1899

Diagnosis. Same as the family, except the characters related to Xenococcini, Geococcina and Rhizoecina. Most of the species have bitubular pores, and 5–6 segmented antennae. In some monotypic genera, included tentatively, the anal ring and/or the antennae are reduced (adopted and modified from Kozár and Konczné Benedicty 2007).

Ishigakicoccus gen. n.

<http://zoobank.org/0F3B70B0-9BF3-4C46-B9D8-0DC17AC12C5F>

Figures 1–3

Type species. *Ishigakicoccus shimadai* sp. n., here designated.

Diagnosis. Body elongate oval, slightly pyriform. Eye spot absent. Antennae 5 segmented. Legs well-developed. Two types of body setae present on both dorsal and ventral body surface. Small sized multilocular pores present, each with 5–6 loculi. Tritubular and bitubular pores absent. Oral collar tubular ducts absent. Ostioles absent. Anal ring irregular oval; anal pores and anal ring setae absent. Large 3–5 locular pore without central hub, present on medial area of ventral abdomen. A circulus present.

Etymology. Named after the island (*Ishigaki*) where the type species was collected first. The suffix *coccus* is commonly used in naming Coccoomorpha genera. Gender: masculine.

Ishigakicoccus shimadai sp. n.

<http://zoobank.org/A2DC112B-D63E-4D50-A0BB-080822CDF0CB>

Figures 1–3

Type series. Holotype, adult female. Japan, Okinawa-pref., Ishigaki Is., Mt. Omoto, 16.II.2015. coll. T. Shimada 1♀ (NSMT-I-Ho 00073). Paratypes, same data as Holotype, 3♀ (NSMT-I-Ho 00074–76).



Figure 1. A mature adult female of *Ishigakicoccus shimadai* sp. n.

Slide-mounted specimens. Body elongate oval, slightly pyriform, 721–895 μm long, 379–632 μm wide. Eye spot absent. Antennae 5 segmented, 1st: 18.4–29.5 μm long, 2nd: 13.7–18.4 μm long, 3rd: 15.8–26.3 μm long, 4th: 17.1–22.1 μm long and 5th: 36.8–41.3 μm long. The fifth segment with three fleshy setae. Anterior spiracles each 20.8–28.7 μm wide across atrium; posterior spiracles each 16.8–29.7 μm wide across atrium. Legs well developed, length of posterior pair: coxa 45.8–55.2 μm long, trochanter + femur 123–133 μm long, tibia + tarsus 112–122 μm long, claw 33.4–39.4 μm long. Ratio of lengths of tibia + tarsus to trochanter + femur 1.05–1.11. Claw digitules setose, each 3.2–6.1 μm long.

Dorsum: Two types of body setae present. Type I: relatively well developed setae, 19.7–58.9 μm long, some setae with a bent or rarely with a knobbed apex. Type II: relatively slender setose setae, 11.0–32.8 μm long, each with a pointed apex. Both types of setae distributed in transverse segmental rows. Multilocular pores each about 2.9–3.7 μm in diameter, each with 5–6 loculi, present on head and thorax, but rarely present on abdomen (Figure 3). Tritubular and bitubular pores absent. Oral collar tubular ducts absent. Ostioles absent. Anal opening 38.9–52.6 μm long and 55.2–61.8 μm wide. Anal ring irregular oval. Anal pores, and anal ring setae absent, but type I and II setae densely present around the opening.

Venter: Labium appearing 2 segmented, 100–107 μm long, 48.4–62.0 μm wide. Two types of body setae present: type I, relatively well developed setae, 18.4–65.3 μm long, some setae with a bent and a rarely knobbed apex.; type II, relatively slender



Figure 2. An adult female of *Ishigakicoccus shimadai* sp. n. being carried by *Acropyga yaeyamensis*.

setose setae, 10.5–37.4 μm long, each with a pointed apex. Both setae distributed in transverse segmental bands. Multilocular pores each about 2.9–3.7 μm in diameter, each with 5–6 loculi, frequently present and evenly distributed on all areas of venter. 3–5 locular pores, each 5.8–7.9 μm in diameter, without central hub, present on medial area of abdominal segments III–VI in transverse rows. A circulus, 10.5–18.4 μm long and 21.0–33.2 μm wide present on medial anterior border of abdominal segment II. Tritubular and bitubular pores absent. Oral collar tubular ducts absent.

Etymology. Named after the collector of the type specimens.

Host plant. Unknown.

Identification key to Japanese Rhizoecidae species (adopted and modified from Kozár and Konczné Benedicty 2007, Schneider and LaPolla 2011)

- 1 Ostioles present 2
- Ostioles absent..... 9
- 2 Anal lobes well-developed, with stout spine-like setae **3 (Genus *Geococcus*)**
- Anal lobes not well-developed, without stout spine-like setae..... 4
- 3 Stout, spine-like setae on dorsum present. Multilocular pores with 7–10 loculi, present on ventral surface (around vulva) ***Geococcus oryzae* (Kuwana, 1907)**

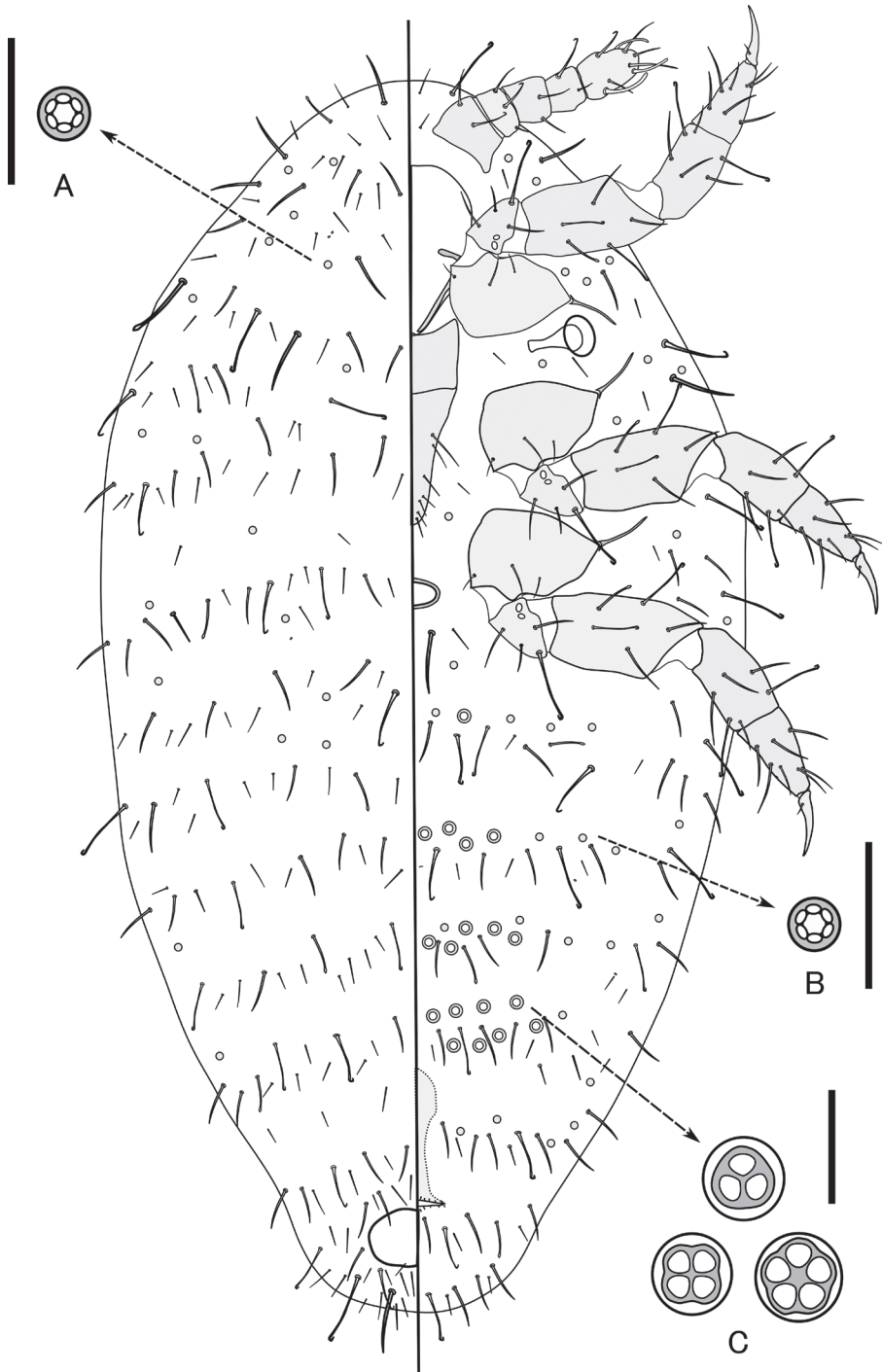


Figure 3. *Ishigakicoccus shimadai* Tanaka, sp. n. adult female. **A** Small multilocular pore on dorsal surface **B** Small multilocular pore on ventral surface **C** 3–5 locular pores on medial area of venter. Scale bars: 10 μ m.

- Stout, spine-like setae on dorsum absent. Multilocur pores with 6 loculi present on all segments of venter and most segments of dorsum ***G. citrinus* Kuwana, 1923**
- 4 Tritubular pores present. Bitubular pores absent..... **5 (Genus *Rhizoecus*)**
- Tritubular duct absent. Bitubular pores present..... **6 (Genus *Ripersiella*)**
- 5 Multilocular pores absent on venter....***Rhizoecus cacticans* (Hambleton, 1946)**
- Multilocular pore present on ventral surface of posterior abdominal segments..... ***Rh. advenoides* Takagi & Kawai, 1971**
- 6 Multilocular pores absent on venter.....
.....***Ripersiella sasae* (Takagi & Kawai, 1971)**
- Multilocular pores present at least on ventral surface of posterior abdominal segments.....**7**
- 7 Multilocular pores present on venter and dorsum (at least on medial part of two segments of dorsum)***Ri. hibisci* (Kawai & Takagi, 1971)**
- Multilocular pores pores only on venter (often some on dorsum, but only on medial part of segment VII) **8**
- 8 With two circuli ***Ri. kondonis* (Kuwana, 1923)**
- With one circulus ***Ri. theae* (Kawai & Takagi, 1971)**
- 9 Disc pores present on venter and dorsum. Antennae 5 segmented
..... ***Ishigakicoccus* gen. n. *shimadai* sp. n.**
- Disc pores absent. Antennae with 2 to 4 segments..... **10**
- 10 Antennae 4 segmented.....
..... ***Xenococcus kinomurai* (Williams & Terayama, 2000)**
- Antennae 2 segmented..... **11 (Genus *Eumyrmococcus*)**
- 11 Circulus absent. Body with flagellate setae only, sensory setae absent on body surface ***Eumyrmococcus smithii* Silvestri, 1926**
- A small circulus present on abdominal segment III. Sensory setae present on body surface..... ***E. nipponensis* Terayama, 1986**

Discussion

The genus and species described in this paper slightly resembles two other species of the monotypic genera of Rhizoecidae, *Capitisetella migrans* (Green, 1933) and *Pseudorhizoecus proximus* Green, 1933, in lacking ostioles and tritubular and/or bitubular pores, and having a pyriform to round body shape. However, the former is clearly distinguishable from those two species by having small multilocular pores on both surfaces of the body, 3–5 large locular pores on the medial area of the ventral abdomen, and two different-sized body setae. These morphological differences are here considered as good for the establishment of a new genus. Based on some morphological similarity, the genus and species is tentatively placed in the subtribe Ripersiellina Kozár 2007 of the tribe Rhizoecini Williams, 1969, in which *C. migrans* and *P. proximus* are also placed (Kozár and Konczné Benedicty 2007).

In east and southeast Asia, many species in tribe Xenococcini have been frequently found in *Acropyga* ants' nests (Williams 1998), and the xenococcine species appear to be the main mutualistic partners of *Acropyga* ants. However, the new species described in this paper is clearly different from all of them in having small multilocular pores, 3–5 locular pores, and 5 segmented antennae. Although the exact phylogenetic position of this new species is still unclear, but morphological features of the specimens indicate that this species apparently does not belong to tribe Xenococcini.

The collector of the species, Mr. Taku Shimada, observed some *A. yaeyamensis* workers grabbing and carrying the root mealybug individuals by their mandibles when he collected the species (Figure 2). This behavioral observation, the collecting site of the species, i.e. inside a nest of *A. yaeyamensis* and the morphological features of the species, i.e. the lack of wax on the body surface (Figure 1 and Figure 2), which is usually observed in most myrmecophilous scale insects (LaPolla et al. 2008) indicates that the species is a potential trophobiont of *A. yaeyamensis*, even though it does not appear to be a xenococcine species. Similar associations between *Acropyga* ants and scale insects that are not members of the tribe Xenococcini have been sometimes, but not commonly, observed in the neotropics, the United States, and Australia (LaPolla et al. 2002; LaPolla et al. 2008; Jonson et al. 2001; Williams 1998; Williams and LaPolla 2004). One of the most extraordinary cases was observed in Australia; an ortheziid scale insect, *Acropygorthesia williamsi* LaPolla & Miller, 2008, which belongs to the family Ortheziidae, not Rhizoecidae, showed a close trophobiotic association with *Acropyga myops* (LaPolla et al. 2008). Intensive molecular phylogenetic analysis of scale insects having trophobiotic associations with *Acropyga* ants, including non-xenococcine trophobiont and/or potential trophobiont species of *Acropyga* ants, related co-evolution and co-speciation analyses and behavioral ecological studies may provide new insights into the evolution and maintenance of this unique obligate mutualism.

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References

Cockerell TDA (1899) Tables for the determination of the genera of Coccidae. Canadian Entomologist 31: 273–279, 330–333. doi: 10.4039/Ent31330-11

- Danzig EM, Gavrilov IA, Trapeznikova IV (2008) A new pest from a greenhouse of St. Petersburg, *Rhizococcus dianthi* Green (Homoptera, Pseudococcidae), with karyotype data. Entomologicheskoe Obozrenie 87: 600–603. doi: 10.1134/s0013873808060067
- Flanders SE (1957) The complete interdependence of an ant and a coccid. Ecology 38: 535–536. doi: 10.2307/1929902
- García Morales M, Denno BD, Miller DR, Miller GL, Ben-Dov Y, Hardy NB (2016) *ScaleNet*: A literature-based model of scale insect biology and systematics. Database. doi: 10.1093/database/bav118. <http://scalenet.info>
- Green EE (1933) Notes on some Coccidae from Surinam, Dutch Guiana, with descriptions of new species. Stylops 2: 49–58. doi: 10.1111/j.1365-3113.1993.tb00969.x
- Hambleton EJ (1946) Studies of hypogeic mealybugs. Revista de Entomologia. Rio de Janeiro 17: 1–77.
- Hambleton EJ (1976) A revision of the new world mealybugs of the genus *Rhizococcus* (Homoptera: Pseudococcidae). United States Department of Agriculture Technical Bulletin 1522: 1–88.
- Johnson C, Agosti D, Delabie JH, Dumpert K, Williams DJ, Tschirnhaus MV, Maschwitz U (2001) *Acropyga* and *Azteca* Ants (Hymenoptera: Formicidae) with scale insects (Sternorrhyncha: Coccoidea): 20 million years of intimate symbiosis. American Museum Novitates 3335: 1–18. doi: 10.1206/0003-0082(2001)335<0001:AAAAHF>2.0.CO;2
- Kawai S, Takagi S (1971) Descriptions of three economically important species of root-feeding mealybugs in Japan (Homoptera: Pseudococcidae). Applied Entomology and Zoology 6: 175–182.
- Kawai S (2003) Coccoidea. In: Umeya K, Okada T (Eds) Agricultural Insect Pest in Japan. Zenkoku Noson Kyouiku Kyoukai, Tokyo, 1203 pp. [In Japanese]
- Kishimoto-Yamada K, Itioka T, Kawai S (2005) Biological characterization of the obligate symbiosis between *Acropyga sauteri* Forel (Hymenoptera: Formicidae) and *Eumyrmococcus smithii* Silvestri (Hemiptera: Pseudococcidae: Rhizoecinae) on Okinawa Island, southern Japan. Journal of Natural History 39: 3501–3524. doi: 10.1080/00222930500393145
- Kozár F, Konczné Benedicty Z (2007) Rhizoecinae of the World. Plant Protection Institute, Hungarian Academy of Sciences, Budapest, 617 pp.
- Künckel d’Herculais J (1878) Historie de la cochenille vivant sur les racines des palmiers de la section des Seaforthia. Exposé des caractères du genre *Rhizococcus*. Annales de la Société Entomologique de France 8: 161–164. [In French]
- Kuwana SI (1907) Coccidae of Japan, I. A synoptical list of Coccidae of Japan with descriptions of thirteen new species. Bulletin of the Imperial Central Agricultural Experiment Station, Japan 1: 177–212.
- Kuwana SI (1923) I. Descriptions and biology of new or little-known coccids from Japan. Bulletin of Agriculture and Commerce, Imperial Plant Quarantine Station, Yokohama 3: 1–67.
- LaPolla JS, Cover SP, Mueller UG (2002) Natural history of the mealybug-tending ant, *Acropyga epedana*, with descriptions of the male and queen castes. Transactions of the American Entomological Society 128: 367–376.
- LaPolla JS, Burwell C, Brady S, Miller DR (2008) A new ortheziid (Hemiptera: Coccoidea) from Australia associated with *Acropyga myops* Forel (Hymenoptera: formicidae) and a key to Australian Ortheziidae. Zootaxa 1946: 55–68.

- Maruyama M, Komatsu T, Kudo SG, Shimada T, Kinomura K (2013) The Guests of Japanese Ants. Tokai University Press, Hatano, Kanagawa, 208 pp. [In Japanese]
- Schneider SA, LaPolla JS (2011) Systematics of the mealybug tribe Xenococcini (Hemiptera: Coccoidea: Pseudococcidae), with a discussion of trophobiotic associations with *Acropyga* Roger ants. Systematic Entomology 36: 57–82. doi: 10.1111/j.1365-3113.2010.00546.x
- Silvestri F (1926) Descrizione di un novo genere di Coccidae (Hemiptera) mirmecofilo della cina. Bollettino del Laboratorio di Zoologia Generale e Agraria della R. Scuola Superior Agricoltura. Portici 18: 271–275. [In Italian]
- Smith CR, Oettler J, Kay A, Deans C (2007) First recorded mating flight of the hypogeic ant, *Acropyga epedana*, with its obligate mutualist mealybug, *Rhizoecus colombiensis*. Journal of Insect Science 7: 1–5. doi: 10.1673/031.007.1101
- Takagi S, Kawai S (1971) Two new hypogeic mealybugs of *Rhizoecus* from Japan (Homoptera: Coccoidea). Kontyû 39: 373–378.
- Tanaka H (2014) How to make slide-mounted specimens of scale insects, a method of a Japanese Coccidologist. Shokubutsu Boeki 68: 483–488. [In Japanese]
- Tanaka H (2016) Coccoidea. In: Editorial Committee of Catalogue of the Insects of Japan (Ed.) Catalogue of the Insects of Japan. Vol. 4, Paraneoptera. Touka Shobo, Tokyo, 174–230.
- Terayama M (1986) A new species of the anomalous ant-attended mealybug *Eumyrmococcus* (Homoptera, Pseudococcidae) from Japan. Kontyû 54: 509–512.
- Terayama M, Hashimoto Y (1996) Taxonomic studies of the Japanese Formicidae, part 1. Introduction to this series and descriptions of four new species of the genera Hypoponera, *Formica* and *Acropyga*. Nature and Human Activities 1: 1–8.
- Williams DJ (1969) The family-group names of the scale insects (Hemiptera: Coccoidea). Bulletin of the British Museum (Natural History) Entomology 23: 315–341. doi: 10.5962/bhl.part.15136
- Williams DJ (1996) Four related species of root mealybugs of the genus *Rhizoecus* from east and southeast Asia of importance at quarantine inspection (Hemiptera: Coccoidea: Pseudococcidae). Journal of Natural History 30: 1391–1403. doi: 10.1080/00222939600771291
- Williams DJ (1998) Mealybugs of the genera *Eumyrmococcus* Silvestri and *Xenococcus* Silvestri associated with the ant genus *Acropyga* Roger and a review of the subfamily Rhizoecinae (Hemiptera, Coccoidea, Pseudococcidae). Bulletin of the Natural History Museum. Entomology Series (London) 67: 1–64.
- Williams DJ (2004) A synopsis of the subterranean mealybug genus *Neochavesia* Williams and Granara de Willink (Hemiptera: Pseudococcidae: Rhizoecinae). Journal of Natural History 38: 2883–2899. doi: 10.1080/00222930310001657856
- Williams DJ, LaPolla JS (2004) The subterranean mealybug, *Rhizoecus colombiensis* (Hambleton) (Hem., Pseudococcidae), described originally from Colombia, now found associated with the ant *Acropyga epedana* Snelling (Hym., Formicidae) in Arizona, U.S.A. Entomologist's Monthly Magazine 140: 106.
- Williams DJ, Terayama M (2000) A new species of the mealybug genus *Eumyrmococcus* Silvestri (Hemiptera: Pseudococcidae: Rhizoecinae) associated with the ant *Acropyga* (*Rhizomyrma*) *kinomurai* Terayama et Hashimoto (Hymenoptera: Formicidae) in the Ryukyu Islands, Japan. Entomological Science 3: 373–376.

Taxonomy of Malagasy *Nesomyrmex brevicornis* species-group using conventional morphology-based approach

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Abstract

Here we describe the diversity of the Malagasy *Nesomyrmex brevicornis*-group as the final installment of series describing the complete Malagasy *Nesomyrmex* fauna. In the current paper introduce the *N. brevicornis*-group, a newly outlined species group. We split this group from one of the four former groups, *N. madecassus*-group (sensu Csősz and Fisher 2015). The relatively small number of individuals available within the *N. brevicornis*-group relative to the large number of OTUs hampers the use of sophisticated statistical techniques to evaluate the morphological data. Instead, we assess the diversity of the *N. brevicornis*-group via a conventional morphology-based approach relying upon non-numeric characters (shape, sculpture, color etc.) recorded by simple eye inspection. Morphometric data are used as secondary data to confirm the most probable boundaries between species, but without employing statistical analyses. We rejected prior species hypotheses imposed by the primary approach if a non-overlapping range of a single index calculated from continuous numeric traits was found between two hypothesized species. Our methods render every species in this revisionary work separable via both salient features and morphometric traits. Our approach reveals the existence of nine morphologically distinct species, *Nesomyrmex brevicornis* sp. n., *N. brunneus* sp. n., *N. cingulatus* sp. n., *N. edentates* sp. n., *N. flavigaster* sp. n., *N. longiceps* sp. n., *N. minutus* sp. n., *N. punctaticeps* sp. n., and *N. sellaris* sp. n.. Geographic maps showing the distribution of each species are provided, along with an updated key to workers of Malagasy *Nesomyrmex* species groups that includes the newly outlined *N. brevicornis*-group.

Keywords

Madagascar, taxonomy, morphometry, species delimitation, biogeography

Introduction

The ant genus *Nesomyrmex* has been the subject of intensive systematic research in recent years, and contributes to efforts to explore the ant fauna of the Malagasy zoogeographical region, i.e. Madagascar and surrounding islands (Bolton 1994). Thanks to earlier explorations of the region's biodiversity, our knowledge of the Malagasy *Nesomyrmex* fauna has increased considerably. The Malagasy members of the genus *Nesomyrmex* were split into four remarkable species groups by Csősz and Fisher (2015): *N. angulatus*-group (Csősz and Fisher 2016a), *N. hafahafa*-group (Csősz and Fisher 2015), *N. madecassus*-group (Csősz and Fisher 2016c) and *N. sikorai*-group (Csősz and Fisher 2015). Their classifications were revised using combined algorithmic approaches to evaluate numeric morphological data. The total species number has climbed to 24 of which 20 are new to science, underpinning earlier assumptions about the extreme species richness of the region.

In the current paper we complete the reexamination of Malagasy *Nesomyrmex* with a revision of the fifth species group, *N. brevicornis*-group, and by describing the nine species that are new to science. This group is subsequently split from the *N. madecassus*-group (sensu Csősz and Fisher 2015) based on several features, such as the remarkably deep mesopropodeal depression, the short scape (SL/CS: 0.49–0.72, in contrast to SL/CS of *madecassus*-group species: 0.72–0.83), the short and high petiole (PEL/CS: 0.34–0.49, in contrast to that of *madecassus*-group species: 0.44–0.58), the relatively long petiolar node (NOL/CS: 0.20–0.34, in contrast to that of *madecassus*-group species: 0.28–0.39, and the shorter mesosoma (ML/CS: 1.08–1.36, in contrast to that of *madecassus*-group species: 1.26–1.50) that distinguish workers of *brevicornis*-group from those of *madecassus*-group species.

All species of the *brevicornis*-group are arboreal; most nest in twigs or hollow branches, but some have very specialized associations with live stems or particular species of trees. *Nesomyrmex cingulatus* sp. n., for example, is known only from live stems from spiny thicket near Tsimanampetsotsa. *N. minutus* sp. n. is unique in nesting only in the stems of *Macphersonia gracilis* (Sapindaceae) and represents one of the few known ant plants in Madagascar. The specialized nesting habits of the *brevicornis*-group may explain why collections of this group are minimal compared to other *Nesomyrmex* species.

As the material available within this species group is insufficiently large for statistical evaluation, morphological diversity is assessed via evaluation of qualitative traits or trait-combination. Species are believed to have characteristic shapes, sizes, pigmentation patterns, sculpture, and other external features that may help in species separation and subsequent identification (Strauss and Bond 1990), hence qualitative morphological traits have often been the primary source for taxonomic studies (see e.g. Hita-Garcia and Fisher 2014, Snelling et al. 2014, Prebus 2015 etc.). An obvious advantage of this approach that it does not require large sample sizes to set species hypotheses. However, the often smaller number of available specimens hampers statistically supported hypothesis testing, and without morphometric analyses cryptic taxa may re-

main undiscovered. Overall, conventional morphology-based taxonomy remains the primary approach to outline species boundaries when small sample size precludes more complex research.

Qualitative evaluation of morphological data has revealed the existence of nine morphologically distinct species within *N. brevicornis* species-group in the Malagasy zoogeographical region, *Nesomyrmex brevicornis* sp. n., *N. brunneus* sp. n., *N. cingulatus* sp. n., *N. edentates* sp. n., *N. flavigaster* sp. n., *N. longiceps* sp. n., *N. minutus* sp. n., *N. punctaticeps* sp. n., and *N. sellaris* sp. n.. We provide a traditional, character-based key supported by simple numeric data based on body size ratios. Geographic maps showing the distribution of these species where populations of particular species were collected are also provided.

Material and methods

In the present study, 21 continuous morphometric traits were recorded in 146 worker individuals belonging to 111 nest samples and 35 further single individuals collected in the Malagasy region.

The material is deposited in the following institutions, abbreviations after Evenhuis (2013): CASC (California Academy of Sciences, San Francisco, California, U.S.A.), MCZC (Museum of Comparative Zoology, Cambridge, Massachusetts, U.S.A.) and PSWC (Phil S. Ward's collection, University of California Davis, Davis, California, U.S.A.). Type material and samples that were morphometrically investigated is presented in "Type material investigated" and "Material examined" sections in the format as follows: **CASENT code**, collection code, verbatim locality, longitude, latitude, elevation in meter, collector, date in MM.DD.YYYY format, (gender, abbreviation of depository). For genders (queen, worker, male) the first letter (Q, w, m) is used.

All images of specimens used in this study are available online on AntWeb (<http://www.antweb.org>). Images are linked to their specimens via the unique specimen code affixed to each pin (CASENT0027494). Online specimen identifiers follow this format: <http://www.antweb.org/specimen/CASENT0027494>.

Digital color montage images were created using a JVC KY-F75 digital camera and Syncroscopy Auto-Montage software (version 5.0), or a Leica DFC 425 camera in combination with the Leica Application Suite software (version 3.8). Distribution maps were generated in R (R Core Team 2015) via 'phylo.to.map' function using package phytools (Revell 2012).

Measurements were taken with a Leica MZ 12.5 stereomicroscope equipped with an ocular micrometer at a magnification of 100 $\times$. Measurements and indices are presented as arithmetic means with minimum and maximum values in parentheses. Body size dimensions are expressed in μm . Due to the abundance of worker individuals available relative to queen and male specimens, the present revision is based on worker caste only. Worker-based revision is further facilitated by the fact that the name-bearing type specimens of the vast majority of existing ant taxa belong to the worker caste.

All measurements were made by the first author. For the definition of morphometric characters, earlier protocols (Csősz et al. 2015, Csősz and Fisher 2015, 2016a, 2016b) were considered. Explanations and abbreviations for measured characters are as follows:

- CL** Maximum cephalic length in median line. The head must be carefully tilted to the position providing the true maximum. Excavations of hind vertex and/or clypeus reduce CL.
- CW** Maximum width of the head. Includes compound eyes.
- CWb** Maximum width of head capsule without the compound eyes. Measured just posterior of the eyes.
- CS** Absolute cephalic size. The arithmetic mean of CL and CWb.
- Cdep** Antero-median clypeal depression. Maximum depth of the median clypeal depression on its anterior contour line as it appears in fronto-dorsal view.
- EL** Maximum diameter of the compound eye.
- FRS** Frontal carina distance. Distance of the frontal carinae immediately caudal of the posterior intersection points between frontal carinae and the torular lamellae. If these dorsal lamellae do not laterally surpass the frontal carinae, the deepest point of scape corner pits may be taken as the reference line. These pits occupy the inner corner of the scape base when the scape is directed caudally and produce a dark triangular shadow in the lateral frontal lobes immediately posterior to the dorsal lamellae of the scape joint capsule.
- ML (Weber length)** Mesosoma length from caudalmost point of propodeal lobe to transition point between anterior pronotal slope and anterior pronotal shield. Preferentially measured in lateral view; if the transition point is not well defined, use dorsal view and take the center of the dark-shaded borderline between pronotal slope and pronotal shield as anterior reference point. In gynes: length from caudalmost point of propodeal lobe to the most distant point of steep anterior pronotal face.
- MW** Mesosoma width. In workers MW is defined as the longest width of the pronotum in dorsal view excluding the pronotal spines.
- MPST** Maximum distance from the center of the propodeal stigma to the antero-ventral corner of the ventrolateral margin of the metapleuron.
- NOH** maximum height of the petiolar node. Measured in lateral view from the uppermost point of the petiolar node perpendicular to a reference line set from the petiolar spiracle to the imaginary midpoint of the transition between dorso-caudal slope and dorsal profile of caudal cylinder of the petiole.
- NOL** Length of the petiolar node. Measured in lateral view from the center of petiolar spiracle to dorso-caudal corner of caudal cylinder. Do not erroneously take as the reference point the dorso-caudal corner of the helcium, which is sometimes visible.

PEH	maximum petiole height. The chord of the ventral petiolar profile at node level is the reference line perpendicular to which the maximum height of petiole is measured.
PEL	Diagonal petiolar length in lateral view; measured from anterior corner of subpetiolar process to dorso-caudal corner of caudal cylinder.
PEW	Maximum width of petiole in dorsal view. Nodal spines are not considered.
PoOC	Postocular distance. Use a cross-scaled ocular micrometer and adjust the head to the measuring position of CL. Caudal measuring point: median occipital margin; frontal measuring point: median head at the level of the posterior eye margin.
PPH	Maximum height of the postpetiole in lateral view. Measured perpendicularly to a line defined by the linear section of the segment border between dorsal and ventral petiolar sclerite.
PPL	Postpetiole length. The longest anatomical line that is perpendicular to the posterior margin of the postpetiole and is between the posterior postpetiolar margin and the anterior postpetiolar margin.
PPW	Postpetiole width. Maximum width of postpetiole in dorsal view.
SL	Scape length. Maximum straight line scape length excluding the articular condyle.
SPST	Spine length. Distance between the center of propodeal stigma and spine tip. The stigma center refers to the midpoint defined by the outer cuticular ring but not to the center of the real stigma opening, which may be positioned eccentrically.
SPTI	Apical spine distance. The distance of spine tips in dorsal view; if spine tips are rounded or truncated, the centers of spine tips are taken as reference points.

In verbal descriptions of taxa based on external morphological traits, recent taxonomic papers (Csősz and Fisher 2015, 2016) were considered. Definitions of surface sculpturing are linked to Harris (1979). Body size is given in μm , and means of morphometric ratios as well as minimum and maximum values are given in parentheses with up to three digits. Inclination of pilosity and cuticular spines is given in degrees. Definitions of species-groups as well as descriptions of species are surveyed in alphabetic order.

Hypothesis formation. The present paper aims to reveal diversity of *N. brevicornis* species-group, including a number of very rare species represented only by three to four individuals. This high level of asymmetry in data, coupled with the extremely low average number of individuals per species, prevents employment of statistical analyses in hypothesis formation and testing. Instead, the conventional morphology-based approach (i.e., individuals are sorted into clusters using simple eye inspection based on salient morphological features, e.g., shape, sculpture etc.) is used as the primary technique for recognizing species. Morphometric data are given for each species as secondary data for confirmation and in order to improve identification.

Results

Based on the applied conventional morphology-based approach, nine remarkably different morphologies are recognized to be considered species. These species can also be characterized by, and separated from each other using, at least one non-overlapping body-size ratio. Morphometric indices are provided for all species in Table 1. To the best of our knowledge, all are endemic to Madagascar.

Key to species-groups

- 1 Anterodorsal spines on petiolar node present ***bafabafa*-group**
- Anterodorsal spines on petiolar node absent **2**
- 2 Petiolar node globular in dorsal view, sides strongly convex. Postocular distance vs. petiole width (PoOc/PEW): ≤ 1.2 [0.72, 1.17]. Sculpture of head, mesosoma, petiole and postpetiole areolate, appears dull. Main sculpture homogenous reticulate, or rugoso-reticulate ***angulatus*-group**
- Petiolar node long and narrow in dorsal view, sides nearly parallel. Postocular distance vs. petiole width (PoOc/PEW): ≥ 1.2 [1.2, 2.01]. Ground sculpture on head, dorsum of mesosoma, petiole and postpetiole often, but not exclusively inconspicuous, shiny. Main sculpture variable, coarse to absent **3**
- 3 Petiolar node in lateral view higher, (MPST/NOH): 2.41 [1.89, 2.87], propodeal spines moderately long, always present, mesopropodeal depression conspicuous, deep ***sikorai*-group**
- Petiolar node in lateral view lower, (MPST/NOH): 3.54 [2.71, 5.63], propodeal spines very short to absent, mesopropodeal depression variable **4**
- 4 Mesopropodeal depression absent (except for *N. gibber* where a mesothoracic hump is conspicuous). Scape longer (SL/CS): 0.72–0.83. Petiole longer (PEL/CS): 0.44–0.58) ***madecassus*-group**
- Mesopropodeal depression present and conspicuous (often shallow in *N. flavigaster*). Scape shorter (SL/CS): 0.49–0.72. Petiole shorter and higher (PEL/CS): 0.34–0.49 ***brevicornis*-group**

Synopsis of Malagasy members of the *Nesomyrmex brevicornis* species group

brevicornis Csősz & Fisher, sp. n.
brunneus Csősz & Fisher, sp. n.
cingulatus Csősz & Fisher, sp. n.
edentatus Csősz & Fisher, sp. n.
flavigaster Csősz & Fisher, sp. n.
longiceps Csősz & Fisher, sp. n.
minutus Csősz & Fisher, sp. n.
punctaticeps Csősz & Fisher, sp. n.
sellaris Csősz & Fisher, sp. n.

Table 1. Mean of morphometric ratios calculated species-wise on individual level. Morphometric traits are divided by absolute cephalic size (CS), $\pm$ SD are provided in the upper row, minimum and maximum values are given in parentheses in the lower row.

	<i>brevicornis</i> (n = 3)	<i>brunneus</i> (n = 36)	<i>cingulatus</i> (n = 26)	<i>edentatus</i> (n = 3)	<i>flavigaster</i> (n = 14)	<i>longiceps</i> (n = 4)	<i>minutus</i> (n = 29)	<i>punctaticeps</i> (n = 17)	<i>sellaris</i> (n = 15)
CS	506 $\pm$ 33	721 $\pm$ 58	459 $\pm$ 25	546 $\pm$ 13	637 $\pm$ 51	531 $\pm$ 36	472 $\pm$ 31	473 $\pm$ 30	449 $\pm$ 36
	[472, 536]	[620, 808]	[419, 515]	[535, 560]	[546, 740]	[478, 556]	[405, 549]	[424, 549]	[410, 557]
CL/CW	1.32 $\pm$ 0.05	1.12 $\pm$ 0.03	1.34 $\pm$ 0.04	1.19 $\pm$ 0.00	1.21 $\pm$ 0.02	1.42 $\pm$ 0.02	1.29 $\pm$ 0.05	1.17 $\pm$ 0.04	1.16 $\pm$ 0.04
	[1.28, 1.37]	[1.07, 1.19]	[1.26, 1.39]	[1.18, 1.19]	[1.16, 1.25]	[1.40, 1.44]	[1.17, 1.36]	[1.11, 1.23]	[1.09, 1.25]
CL/CW/b	1.33 $\pm$ 0.02	1.14 $\pm$ 0.02	1.37 $\pm$ 0.04	1.20 $\pm$ 0.01	1.24 $\pm$ 0.02	1.43 $\pm$ 0.02	1.29 $\pm$ 0.05	1.20 $\pm$ 0.04	1.18 $\pm$ 0.03
	[1.32, 1.35]	[1.09, 1.21]	[1.30, 1.45]	[1.19, 1.21]	[1.21, 1.29]	[1.42, 1.46]	[1.20, 1.36]	[1.14, 1.26]	[1.13, 1.25]
POoC/CL	0.52 $\pm$ 0.01	0.44 $\pm$ 0.03	0.51 $\pm$ 0.01	0.48 $\pm$ 0.01	0.43 $\pm$ 0.01	0.44 $\pm$ 0.01	0.52 $\pm$ 0.01	0.49 $\pm$ 0.01	0.51 $\pm$ 0.01
	[0.51, 0.52]	[0.39, 0.47]	[0.49, 0.52]	[0.47, 0.49]	[0.41, 0.45]	[0.42, 0.45]	[0.51, 0.54]	[0.47, 0.51]	[0.49, 0.53]
FRS/CS	0.36 $\pm$ 0.02	0.33 $\pm$ 0.01	0.31 $\pm$ 0.01	0.30 $\pm$ 0.01	0.34 $\pm$ 0.01	0.26 $\pm$ 0.01	0.35 $\pm$ 0.02	0.33 $\pm$ 0.01	0.29 $\pm$ 0.01
	[0.34, 0.37]	[0.31, 0.35]	[0.30, 0.33]	[0.29, 0.31]	[0.33, 0.36]	[0.25, 0.28]	[0.30, 0.39]	[0.32, 0.35]	[0.27, 0.30]
SL/CS	0.54 $\pm$ 0.01	0.64 $\pm$ 0.02	0.63 $\pm$ 0.01	0.66 $\pm$ 0.01	0.62 $\pm$ 0.02	0.63 $\pm$ 0.02	0.57 $\pm$ 0.02	0.66 $\pm$ 0.02	0.69 $\pm$ 0.02
	[0.53, 0.55]	[0.60, 0.67]	[0.60, 0.65]	[0.65, 0.67]	[0.59, 0.66]	[0.61, 0.65]	[0.49, 0.61]	[0.62, 0.70]	[0.65, 0.72]
EL/CS	0.25 $\pm$ 0.01	0.22 $\pm$ 0.01	0.24 $\pm$ 0.01	0.25 $\pm$ 0.01	0.23 $\pm$ 0.01	0.22 $\pm$ 0.01	0.25 $\pm$ 0.01	0.24 $\pm$ 0.01	0.24 $\pm$ 0.01
	[0.24, 0.26]	[0.20, 0.24]	[0.22, 0.26]	[0.23, 0.26]	[0.21, 0.25]	[0.21, 0.23]	[0.22, 0.28]	[0.22, 0.26]	[0.23, 0.26]
MW/CS	0.59 $\pm$ 0.02	0.60 $\pm$ 0.01	0.55 $\pm$ 0.01	0.56 $\pm$ 0.02	0.59 $\pm$ 0.01	0.53 $\pm$ 0.03	0.56 $\pm$ 0.01	0.61 $\pm$ 0.02	0.58 $\pm$ 0.01
	[0.57, 0.60]	[0.56, 0.62]	[0.52, 0.57]	[0.54, 0.58]	[0.58, 0.61]	[0.50, 0.55]	[0.54, 0.58]	[0.58, 0.64]	[0.56, 0.59]
PEW/CS	0.23 $\pm$ 0.02	0.20 $\pm$ 0.01	0.22 $\pm$ 0.01	0.20 $\pm$ 0.01	0.22 $\pm$ 0.01	0.19 $\pm$ 0.00	0.22 $\pm$ 0.01	0.22 $\pm$ 0.01	0.21 $\pm$ 0.01
	[0.21, 0.25]	[0.19, 0.22]	[0.21, 0.24]	[0.20, 0.22]	[0.20, 0.22]	[0.19, 0.19]	[0.20, 0.23]	[0.21, 0.24]	[0.20, 0.23]
ppw/CS	0.31 $\pm$ 0.01	0.26 $\pm$ 0.01	0.32 $\pm$ 0.01	0.28 $\pm$ 0.01	0.31 $\pm$ 0.01	0.27 $\pm$ 0.01	0.33 $\pm$ 0.01	0.34 $\pm$ 0.02	0.29 $\pm$ 0.01
	[0.30, 0.33]	[0.24, 0.30]	[0.28, 0.35]	[0.27, 0.28]	[0.29, 0.33]	[0.26, 0.28]	[0.29, 0.35]	[0.30, 0.36]	[0.26, 0.31]
ML/CS	1.30 $\pm$ 0.01	1.18 $\pm$ 0.03	1.30 $\pm$ 0.02	1.27 $\pm$ 0.04	1.21 $\pm$ 0.02	1.14 $\pm$ 0.03	1.29 $\pm$ 0.03	1.26 $\pm$ 0.02	1.23 $\pm$ 0.02
	[1.29, 1.31]	[1.08, 1.23]	[1.26, 1.36]	[1.23, 1.31]	[1.17, 1.23]	[1.12, 1.19]	[1.23, 1.36]	[1.22, 1.32]	[1.19, 1.26]
PEL/CS	0.42 $\pm$ 0.01	0.38 $\pm$ 0.02	0.46 $\pm$ 0.02	0.41 $\pm$ 0.01	0.42 $\pm$ 0.01	0.39 $\pm$ 0.01	0.45 $\pm$ 0.02	0.43 $\pm$ 0.01	0.41 $\pm$ 0.02
	[0.41, 0.43]	[0.34, 0.42]	[0.41, 0.49]	[0.39, 0.42]	[0.40, 0.43]	[0.38, 0.40]	[0.42, 0.47]	[0.41, 0.47]	[0.38, 0.44]
NOL/CS	0.26 $\pm$ 0.01	0.23 $\pm$ 0.01	0.32 $\pm$ 0.01	0.26 $\pm$ 0.01	0.23 $\pm$ 0.01	0.24 $\pm$ 0.02	0.26 $\pm$ 0.02	0.28 $\pm$ 0.01	0.25 $\pm$ 0.02
	[0.25, 0.27]	[0.20, 0.25]	[0.28, 0.34]	[0.25, 0.26]	[0.22, 0.25]	[0.22, 0.26]	[0.22, 0.29]	[0.26, 0.31]	[0.22, 0.27]

	<i>brevicornis</i> (n = 3)	<i>brunneus</i> (n = 36)	<i>cingulatus</i> (n = 26)	<i>edentatus</i> (n = 3)	<i>flavigaster</i> (n = 14)	<i>longiceps</i> (n = 4)	<i>minutus</i> (n = 29)	<i>punctaticeps</i> (n = 17)	<i>sellaris</i> (n = 15)
MPST/CS	0.42 ±0.01	0.39 ±0.01	0.41 ±0.01	0.40 ±0.02	0.41 ±0.01	0.37 ±0.01	0.41 ±0.01	0.40 ±0.01	0.40 ±0.01
	[0.41, 0.43]	[0.37, 0.41]	[0.37, 0.43]	[0.38, 0.41]	[0.40, 0.41]	[0.36, 0.38]	[0.38, 0.45]	[0.39, 0.42]	[0.38, 0.43]
PEH/CS	0.28 ±0.02	0.27 ±0.01	0.27 ±0.01	0.27 ±0.01	0.31 ±0.01	0.24 ±0.01	0.31 ±0.02	0.28 ±0.01	0.27 ±0.01
	[0.26, 0.30]	[0.24, 0.30]	[0.26, 0.30]	[0.25, 0.28]	[0.29, 0.33]	[0.22, 0.25]	[0.26, 0.34]	[0.27, 0.31]	[0.25, 0.29]
NOH/CS	0.10 ±0.01	0.12 ±0.02	0.10 ±0.01	0.10 ±0.01	0.13 ±0.00	0.09 ±0.01	0.13 ±0.01	0.11 ±0.01	0.09 ±0.01
	[0.08, 0.10]	[0.10, 0.15]	[0.09, 0.12]	[0.09, 0.11]	[0.12, 0.14]	[0.08, 0.09]	[0.11, 0.15]	[0.09, 0.13]	[0.07, 0.11]
PPH/CS	0.25 ±0.01	0.23 ±0.02	0.27 ±0.01	0.22 ±0.01	0.28 ±0.01	0.21 ±0.01	0.26 ±0.01	0.28 ±0.01	0.22 ±0.01
	[0.24, 0.26]	[0.18, 0.27]	[0.25, 0.30]	[0.22, 0.23]	[0.26, 0.30]	[0.21, 0.22]	[0.23, 0.29]	[0.26, 0.29]	[0.19, 0.24]
PPL/CS	0.20 ±0.02	0.18 ±0.02	0.29 ±0.01	0.19 ±0.01	0.21 ±0.01	0.21 ±0.00	0.24 ±0.01	0.28 ±0.02	0.21 ±0.01
	[0.18, 0.22]	[0.15, 0.21]	[0.26, 0.31]	[0.18, 0.21]	[0.18, 0.23]	[0.21, 0.21]	[0.22, 0.26]	[0.26, 0.31]	[0.19, 0.23]

Key to workers of the *Nesomyrmex madecassus* group species

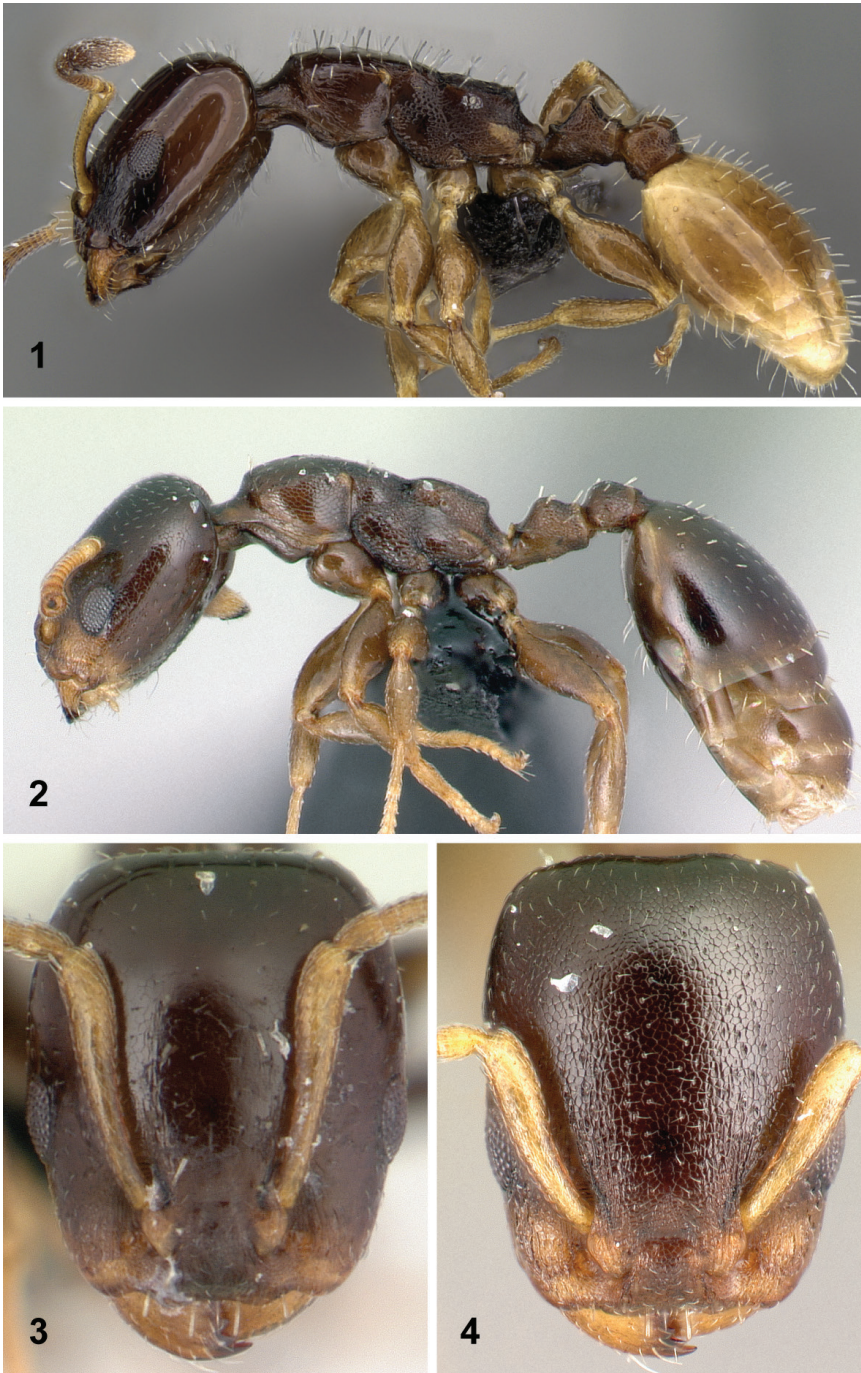
- 1 Head and mesosoma dark brown to black..... **2** (*brevicornis*, *brunneus*, *edentatus*, *flavigaster*)
- Head and mesosoma yellow **5** (*cingulatus*, *longiceps*, *minutus*, *punctaticeps*, *sellaris*)
- 2 Gaster pale yellow, the rest of the body dark brown to black (Fig. 1) **flavigaster**
- Body—including gaster—concolorous, dark brown to black (Fig. 2) **3** (*brevicornis*, *brunneus*, *edentatus*)
- 3 Large species, cephalic size (CS) > 620 µm [620, 808] **brunneus**
- Smaller species, cephalic size (CS) < 560 µm [472, 560] **4** (*brevicornis*, *edentatus*)
- 4 Head feebly imbricate, appears shiny (Fig. 3). Scape longer (SL/CS) > 0.65 [0.65, 0.67] **edentatus**
- Head coarsely imbricate, appears dull (Fig. 4). Scape shorter (SL/CS) < 0.55 [0.53, 0.55] **brevicornis**
- 5 First gaster tergite brown, conspicuously darker than the rest of the body (Fig. 5) **6** (*cingulatus*, *minutus*)
- Body concolorous, gaster light yellow **7** (*longiceps*, *punctaticeps*, *sellaris*)
- 6 On the median area of frons foveae around setal pits larger (Fig. 6), the largest diameter of pits 15–20 µm. Frontal carina distance (FRS/CS): 0.31 [0.30, 0.33], scape length (SL/CS): 0.63 [0.60, 0.65] **cingulatus**
- On the median area of frons foveae around setal pits inconspicuous (Fig. 7), the largest diameter of pits ≤ 10 µm. Frontal carina distance (FRS/CS): 0.36 [0.33, 0.39], scape length (SL/CS): 0.57 [0.53, 0.61] **minutus**
- 7 Head longer (CL/CWb) > 1.40 [1.42, 1.46], postocular area relatively shorter (PoOC/CL) < 0.45 [0.42, 0.45] **longiceps**
- Head shorter (CL/CWb) < 0.30 [1.14, 1.26], postocular area relatively longer (PoOC/CL) > 0.47 [0.47, 0.53] **8** (*punctaticeps*, *sellaris*)
- 8 Frontal carina distance larger (FRS/CS) > 0.33 [0.32, 0.35]. On the median area of frons foveae around setal pits larger (Fig. 8), the largest diameter of pits 10–15 µm **punctaticeps**
- Frontal carina distance smaller (FRS/CS) < 0.29 [0.27, 0.30]. On the median area of frons setal pits are not embedded by foveae (Fig. 9) **sellaris**

***Nesomyrmex brevicornis* Csősz & Fisher, sp. n.**

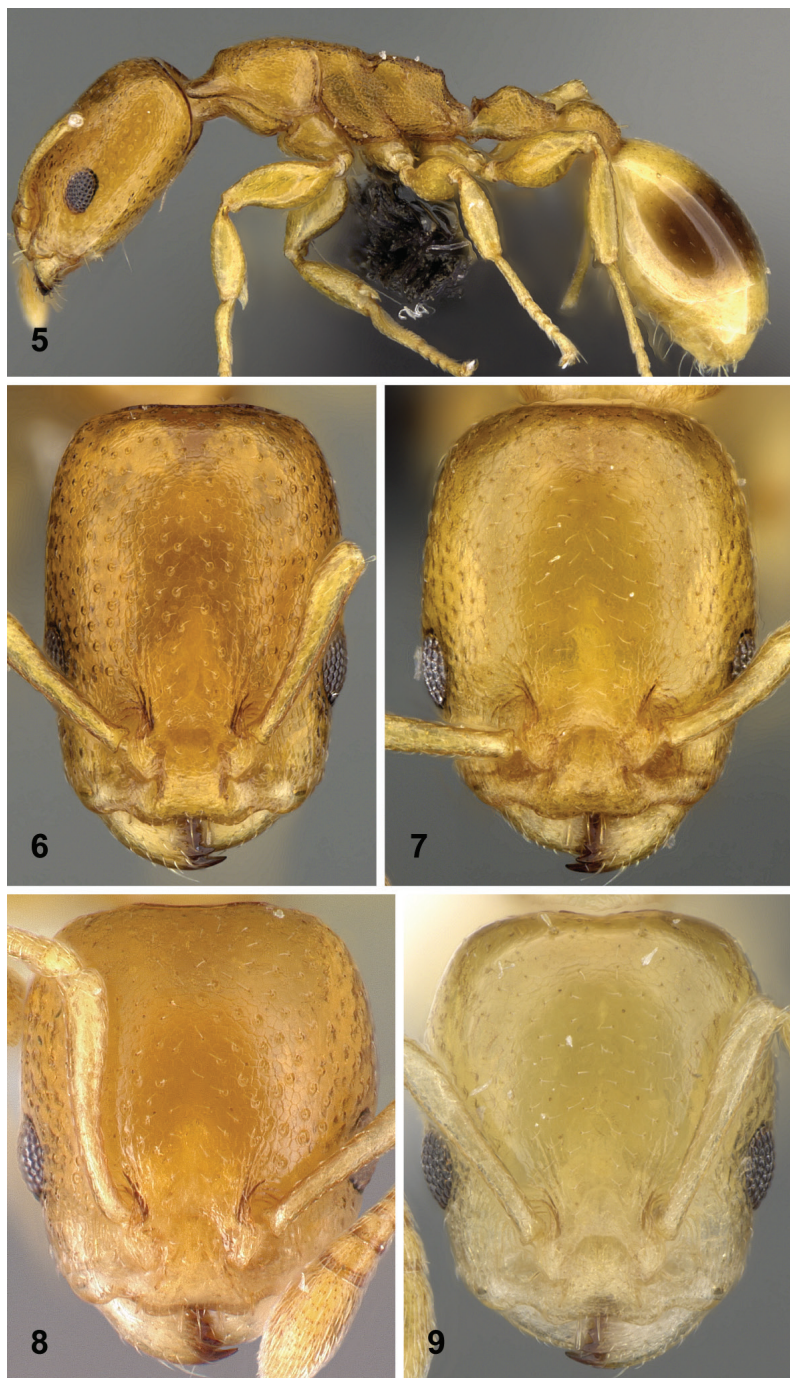
<http://zoobank.org/0DA355E3-6F8F-41AC-B04D-CED946D108B7>

Figs 10–13, Table 1

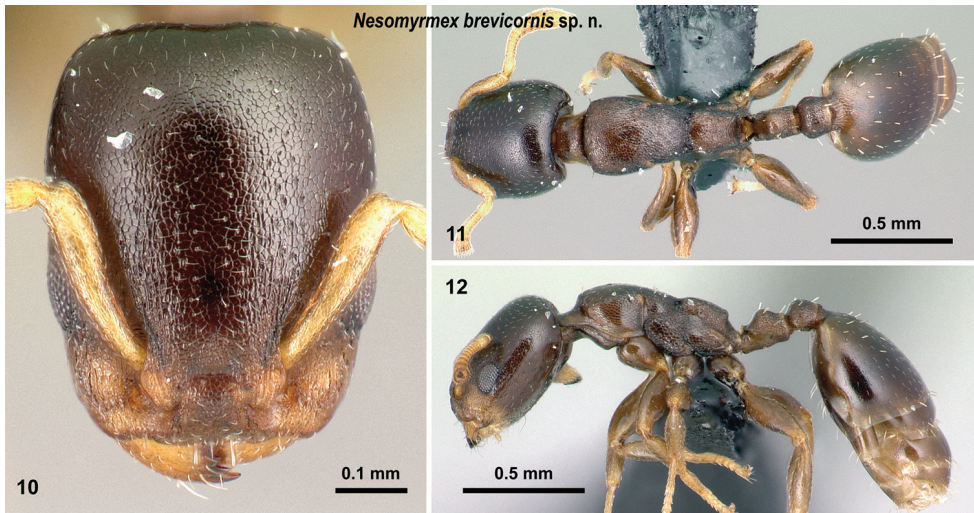
Type material investigated. Holotype: CASENT0027494, collection code: BLF07507, Parc National de Zombitse, 19.8 km 84° E Sakaraha, N -22.84333°, 44.71°, alt 770 m, Fisher, Griswold et al., 02.05.2003, (1w, CASC, CASENT0027494);



Figures 1–4. Diagnostic traits for black *Nesomyrmex brevicornis*-group workers. Lateral view of mesosoma, petiole, postpetiole, and gaster of *N. flavigaster* sp. n. (1), lateral view of mesosoma, petiole, postpetiole, and gaster of *N. brunneus* sp. n. (2), frontal view of head of *N. edentatus* sp. n. (3), frontal view of head of *N. brevicornis* sp. n. (4). For details see main text.



Figures 5–9. Diagnostic traits for yellow *Nesomyrmex brevicornis*-group workers. Lateral view of mesosoma, petiole, postpetiole and gaster of *N. cingulatus* sp. n. (5), frontal view of head of *N. cingulatus* sp. n. (6), frontal view of head of *N. minutus* sp. n. (7), frontal view of head of *N. punctaticeps* sp. n. (8), frontal view of head of *N. sellaris* sp. n. (9). For details see main text.

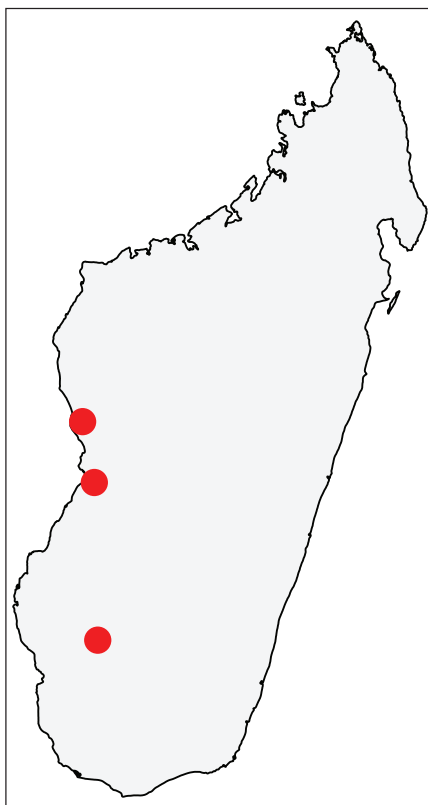


Figures 10–12. *Nesomyrmex brevicornis* sp. n. holotype worker (CASENT0027494). Head in full-face view (**10**), dorsal view of the body (**11**), lateral view of the body (**12**).

Paratypes: **CASENT0195104**, collection code: DMO-CS7, 48 km ENE Morondava, Kirindy, -20.06667°, 44.65°, alt 30 m, D.M.Olson, 01.05.1991, (1w, PSWC); **CASENT0482280**, collection code: BLF04508, Forêt de Tsimembo, 11.0 km 346° NNW Soatana, N -18.99528°, 44.4435°, alt 50 m, Fisher-Griswold Arthropod Team, 11.21.2001, (1w, CASC);

Etymology. The name (*brevicornis*) refers to the short antennal scape that distinguishes this species from other taxa treated in this revisionary work.

Diagnosis in key. Description of workers. Body color: dark brown; black. Body color pattern: concolorous. Absolute cephalic size: 506 [472, 536]. Cephalic length vs. maximum width of head capsule (CL/CWb): 1.33 [1.32, 1.35]. Postocular distance vs. cephalic length (PoOc/CL): 0.52 [0.51, 0.52]. Postocular sides of cranium contour frontal view orientation: converging posteriorly. Postocular sides of cranium contour frontal view shape: broadly convex. Vertex contour line in frontal view shape: straight. Vertex sculpture: main sculpture absent, ground sculpture areolate. Setal pits on head dorsum: inconspicuous with obscure demarcation. Gena contour line in frontal view shape: convex. Genae contour from anterior view orientation: converging. Gena sculpture: ground sculpture areolate, main sculpture absent. Concentric carinae laterally surrounding antennal foramen: present. Eye length vs. absolute cephalic size (EL/CS): 0.25 [0.24, 0.26]. Frontal carina distance vs. absolute cephalic size (FRS/CS): 0.36 [0.34, 0.37]. Longitudinal carinae on median region of frons: absent. Smooth median region on frons: present. Antennomere count: 12. Scape length vs. absolute cephalic size (SL/CS): 0.54 [0.53, 0.55]. Median clypeal notch: present. Ground sculpture of submedian area of clypeus: present. Median carina of clypeus: absent. Metanotal depression: present. Dorsal region of mesosoma sculpture: ground sculpture areolate, main sculpture absent. Lateral region of pronotum sculpture: ground sculpture areolate, main sculpture absent. Mesopleuron sculpture: ground sculpture areolate, main sculpture absent. Metapleuron



Figures 13. Geographic distribution of *Nesomyrmex brevicornis* sp. n.. The known localities of *N. brevicornis* sp. n. in Madagascar.

sculpture: ground sculpture areolate, main sculpture absent. Petiole width vs. absolute cephalic size (PEW/CS): 0.23 [0.21, 0.25]. Dorsal region of petiole sculpture: ground sculpture areolate, main sculpture absent. Postpetiole width vs. absolute cephalic size (PPW/CS): 0.31 [0.30, 0.33]. Dorsal region of postpetiole sculpture: ground sculpture areolate, main sculpture absent. Surface of first gastral tergite: continuously imbricate.

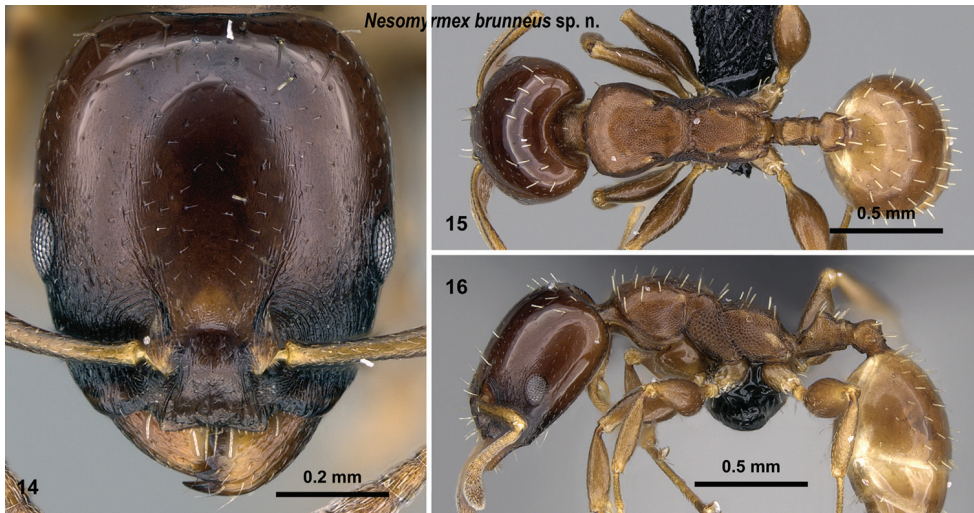
Distribution. This species is known to occur in the southwestern part of Madagascar from 30–770 m (Fig. 13). The known samples are collected from sifted litter (leaf mold, rotten wood) in tropical dry forest.

***Nesomyrmex brunneus* Csősz & Fisher, sp. n.**

<http://zoobank.org/AE916393-5BC3-4511-8D5A-DF045F391A45>

Figs 14–17, Table 1

Type material investigated. Holotype: CASENT0919844, collection code: ANTC1302, P.N. Masoala, 40 km 154° SSE Maroantsetra, -15.72667°, 49.95667°, alt 150 m, A. Dejean et al., 10.14.2001 (1w, CASC, CASENT0919844);



Figures 14–16. *Nesomyrmex brunneus* sp. n. holotype worker (CASENT0919844). Head in full-face view (14), dorsal view of the body (15), lateral view of the body (16).

Paratypes: eight workers and two gynes from the same locality under CASENT codes: CASENT0004957, collection code: ANTC1302, (2w, CASC); CASENT0004958, collection code: ANTC1302, (1Q, CASC); CASENT0004959, collection code: ANTC1302, (1Q, CASC); CASENT0008660, collection code: ANTC1302, (2w, CASC, CASENT0008660); CASENT0008661, collection code: ANTC1302, (2w, CASC); CASENT0008662, collection code: ANTC1302, (2w, CASC);

Material examined. MADAGASCAR: **CASENT0066844**, collection code: BLF13087, Ile Sainte Marie, Forêt Kalalao, 9.9 km 34° Ambodifotatra, -16.9225°, 49.88733°, alt 100 m, B.L.Fisher et al., 11.26.2005, (1w, CASC); **CASENT0082404**, collection code: MA-01-01D-07, Parc National Montagne d'Ambre [Petit Lac road], -12.52028°, 49.17917°, alt 1125 m, R. Harin'Hala, 04.05.2001, (1w, CASC, CASENT0082404); **CASENT0083199**, collection code: MA-01-01D-09, Parc National Montagne d'Ambre [Petit Lac road], -12.52028°, 49.17917°, alt 1125 m, R. Harin'Hala, 04.26.2001, (1w, CASC); **CASENT0107525**, collection code: BLF11668, Nosy Be Airport, 10.3 km 30° Hell Ville, -13.32017°, 48.31083°, alt 25 m, B.L.Fisher, 12.11.2004, (1w, CASC, CASENT0107525); **CASENT0138300**, collection code: BLF20144, Manerinerina, 76.6 km N Antsohihy, -14.10744°, 48.11046°, alt 247 m, B.L.Fisher et al., 04.11.2008, (1w, CASC, CASENT0138300); **CASENT0195102**, collection code: PSW11939, 9km NNW Ranohira, P.N. Isalo, -22.48333°, 45.38333°, alt 800 m, P.S.Ward, 2.16.1993, (2w, PSWC); **CASENT0195103**, collection code: PSW11943, 9km NNW Ranohira, P.N. Isalo, -22.48333°, 45.38333°, alt 800 m, P.S.Ward, 02.16.1993, (2w, PSWC); **CASENT0418178**, collection code: BLF04708, Parc National de Masoala, 39.4 km 150° SSE Maroantsetra, -15.71°, 49.97°, alt 200 m, B.L.Fisher, H.J.Ratsirarson, 11.28.2001, (2w, CASC); **CASENT0418217**, collection code: BLF04724, Parc National de Masoala, 39.4 km 150° SSE Maroantsetra, -15.71°, 49.97°, alt 200 m, B.L.Fisher,

H.J.Ratsirarson, 11.28.2001, (1w, CASC); **CASENT0418218**, collection code: BLF04723, Parc National de Masoala, 39.4 km 150° SSE Maroantsetra, -15.71°, 49.97°, alt 200 m, B.L.Fisher, H.J.Ratsirarson, 11.28.2001, (1w, CASC); **CASENT0418234**, collection code: BLF04696, Tampoalo, Masoala Peninsula, 40.4 km 154° SSE Maroantsetra, -15.73°, 49.96°, alt 30 m, B.L.Fisher, H.J.Ratsirarson, 11.28.2001, (2w, CASC); **CASENT0418244**, collection code: BLF04711, Parc National de Masoala, 39.4 km 150° SSE Maroantsetra, -15.71°, 49.97°, alt 200 m, B.L.Fisher, H.J.Ratsirarson, 11.28.2001, (2w, CASC); **CASENT0418285**, collection code: BLF04710, Parc National de Masoala, 39.4 km 150° SSE Maroantsetra, -15.71°, 49.97°, alt 200 m, B.L.Fisher, H.J.Ratsirarson, 11.28.2001, (2w, CASC); **CASENT0428256**, collection code: BLF02660, Réserve Spéciale d'Ambre, 3.5 km 235° SW Sakaramy, -12.46889°, 49.24217°, alt 325 m, Fisher, Griswold et al., 01.26.2001, (1w, CASC); **CASENT0488569**, collection code: BLF06584, Parc National de Namoroka, 16.9 km 317° NW Vilanandro, -16.40667°, 45.31°, alt 100 m, Fisher, Griswold et al., 11.12.2002, (1w, CASC, CASENT0488569); **MCZENT0576251** 9km NNW Ranohira, P.N. Isalo, -22.48333°, 45.38333°, alt 800 m, P.S.Ward, 02.16.1993, (2w, MCZC); **MCZENT0576252**, collection code: 11939, 9km NNW Ranohira, P.N. Isalo, -22.48333°, 45.38333°, alt 800 m, P.S.Ward, 02.16.1993, (2w, MCZC); **MCZENT0576253**, collection code: 11939, 9km NNW Ranohira, P.N. Isalo, -22.48333°, 45.38333°, alt 800 m, P.S.Ward, 02.16.1993, (2w, MCZC).

Etymology. This name (brunneus) refers to the concolorous dark brown appearance of the workers of this species.

Diagnosis in key. Description of workers. Body color: dark brown; black. Body color pattern: concolorous. Absolute cephalic size: 721 [620, 808]. Cephalic length vs. maximum width of head capsule (CL/CWb): 1.14 [1.09, 1.21]. Postocular distance vs. cephalic length (PoOc/CL): 0.44 [0.39, 0.47]. Postocular sides of cranium contour frontal view orientation: converging posteriorly. Postocular sides of cranium contour frontal view shape: broadly convex. Vertex contour line in frontal view shape: straight. Vertex sculpture: main sculpture absent, ground sculpture absent, smooth and shiny. Setal pits on head dorsum: inconspicuous with obscure demarcation. Gena contour line in frontal view shape: convex. Genae contour from anterior view orientation: converging; strongly converging. Gena sculpture: ground sculpture areolate, main sculpture absent. Concentric carinae laterally surrounding antennal foramen: present. Eye length vs. absolute cephalic size (EL/CS): 0.22 [0.20, 0.24]. Frontal carina distance vs. absolute cephalic size (FRS/CS): 0.33 [0.31, 0.35]. Longitudinal carinae on median region of frons count: absent. Smooth median region on frons: present. Antennomere count: 12. Scape length vs. absolute cephalic size (SL/CS): 0.64 [0.60, 0.67]. Median clypeal notch: present. Ground sculpture of submedian area of clypeus: present. Median carina of clypeus: absent. Metanotal depression: present. Dorsal region of mesosoma sculpture: ground sculpture areolate, main sculpture absent. Lateral region of pronotum sculpture: ground sculpture areolate, main sculpture absent. Mesopleuron sculpture: ground sculpture areolate, main sculpture absent. Metapleuron sculpture: ground sculpture areolate, main sculpture absent. Petiole width vs. absolute cephalic size (PEW/CS): 0.20 [0.19, 0.22]. Dorsal region of petiole sculpture: ground sculpture

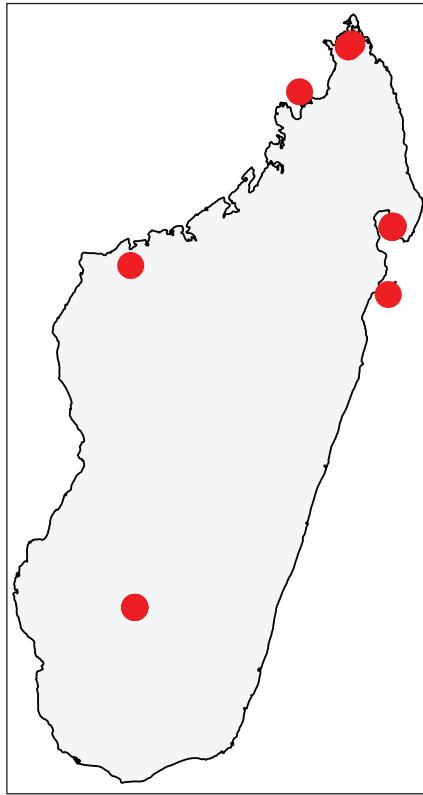


Figure 17. Geographic distribution of *Nesomyrmex brunneus* sp. n.. The known localities of *N. brunneus* sp. n. shown in Madagascar.

areolate, main sculpture absent. Postpetiole width vs. absolute cephalic size (PPW/CS): 0.26 [0.24, 0.29]. Dorsal region of postpetiole sculpture: ground sculpture areolate, main sculpture absent. Surface of first gastral tergite: continuously imbricate.

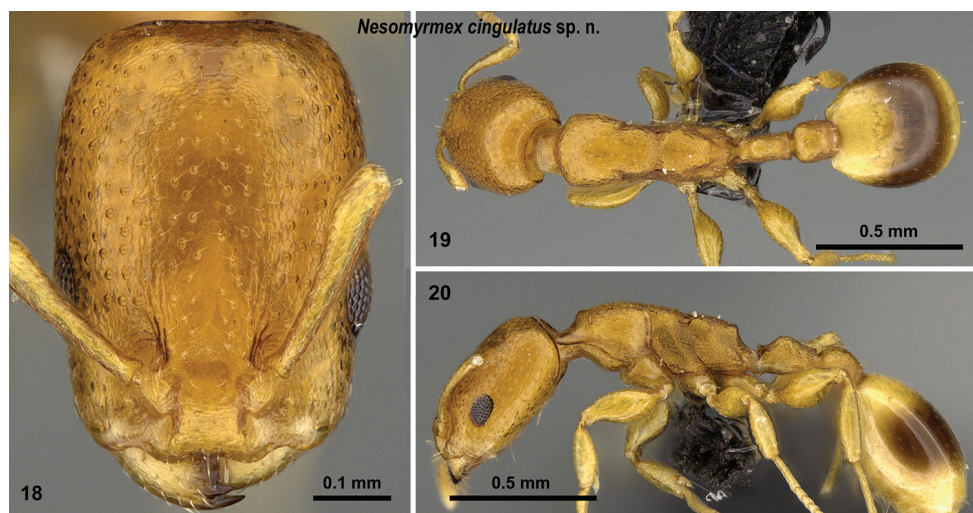
Distribution. This species occurs predominantly in rainforests of northern Madagascar from 25–800 m. The only southern population is reported from a rain forest of Isalo National Park (Fig. 17). The known samples are collected from canopy: canopy moss and leaf litter or rotten pockets of live branches.

***Nesomyrmex cingulatus* Csősz & Fisher, sp. n.**

<http://zoobank.org/E91068C9-E12A-4824-A56A-DF1CA89F2A79>

Figs 18–21, Table 1

Type material investigated. Holotype: CASENT0919845, collection code: BLF06205, Parc National de Tsimanampetsotsa, Mitoho Cave, 6.4 km 77° ENE Efoetse, 17.4 km 170° S Beheloka, -24.04722°, 43.75317°, alt 40 m, Fisher-Griswold Arthropod Team, 03.18.2002, (1w, CASC, CASENT0919845);



Figures 18–20. *Nesomyrmex cingulatus* sp. n. holotype worker (CASENT0919845). Head in full-face view (18), dorsal view of the body (19), lateral view of the body (20).

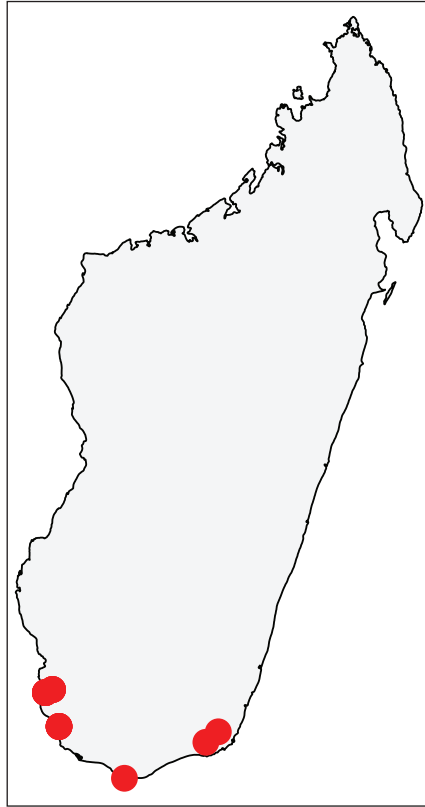
Paratypes: 22 workers and a gyne from the same locality under CASENT codes: **CASENT0455751**, collection code: BLF06204, (2w, CASC); **CASENT0455757**, collection code: BLF06205, (2w, CASC); **CASENT0455756**, collection code: BLF06205, (3w, CASC); **CASENT0455755**, collection code: BLF06205, (3w, CASC); **CASENT0455759**, collection code: BLF06205, (1Q, CASC); **CASENT0455750**, collection code: BLF06204, (3w, CASC); **CASENT0455752**, collection code: BLF06204, (3w, CASC); **CASENT0455753**, collection code: BLF06204, (3w, CASC); **CASENT0455754**, collection code: BLF06204, (3w, CASC);

Material examined. **MADAGASCAR:** **CASENT0003993**, collection code: BLF05832, Mahafaly Plateau, 6.2 km 74° ENE Itampolo, -24.65361°, 43.99667°, alt 80 m, Fisher-Griswold Arthropod Team, 02.21.2002, (2w, CASC); **CASENT0061872**, collection code: MA-02-20-12, Tsimelahy - Parcel II, Andohahela National Park, transitional forest, Tulear Province, -24.93683°, 46.62667°, alt 180 m, M.E. Irwin, F.D. Parker, R. Harin'Hala, 01.06.2003, (1w, CASC); **CASENT0393137**, collection code: BLF36793, Anosy Region, Parc National Andohahela, Col de Tanatana, -24.74969°, 46.84949°, alt 400 m, B.L. Fisher, F.A. Esteves et al., 03.09.2015, (1w, CASC); **CASENT0418656**, collection code: BLF05760, Mahafaly Plateau, 6.2 km 74° ENE Itampolo, -24.65361°, 43.99667°, alt 80 m, Fisher-Griswold Arthropod Team, 02.21.2002, (2w, CASC); **CASENT0418658**, collection code: BLF05760, Mahafaly Plateau, 6.2 km 74° ENE Itampolo, -24.65361°, 43.99667°, alt 80 m, Fisher-Griswold Arthropod Team, 02.21.2002, (2w, CASC); **CASENT0427196**, collection code: BLF06256, Parc National de Tsimanampetsotsa, Forêt de Bemanateza, 20.7 km 81° E Efoetse, 23.0 km 131° SE Beheloka, -23.99222°, 43.88067°, alt 90 m, Fisher-Griswold Arthropod Team, 03.22.2002, (1w, CASC); **CASENT0427197**, collection code: BLF06256, Parc

National de Tsimanampetsotsa, Forêt de Bemanateza, 20.7 km 81° E Efoetse, 23.0 km 131° SE Beheloka, -23.99222°, 43.88067°, alt 90 m, Fisher-Griswold Arthropod Team, 03.22.2002, (1w, CASC); **CASENT0440935**, collection code: BLF06159, Parc National de Tsimanampetsotsa, Mitoho Cave, 6.4 km 77° ENE Efoetse, 17.4 km 170° S Beheloka, -24.04722°, 43.75317°, alt 40 m, Fisher-Griswold Arthropod Team, 03.18.2002, (2w, CASC); **CASENT0445101**, collection code: BLF06320, Parc National de Tsimanampetsotsa, Forêt de Bemanateza, 20.7 km 81° E Efoetse, 23.0 km 131° SE Beheloka, -23.99222°, 43.88067°, alt 90 m, Fisher-Griswold Arthropod Team, 03.22.2002, (1w, CASC); **CASENT0445102**, collection code: BLF06320, Parc National de Tsimanampetsotsa, Forêt de Bemanateza, 20.7 km 81° E Efoetse, 23.0 km 131° SE Beheloka, -23.99222°, 43.88067°, alt 90 m, Fisher-Griswold Arthropod Team, 03.22.2002, (1w, CASC); **CASENT0445936**, collection code: BLF05502, Réserve Spéciale de Cap Sainte Marie, 12.3 km 262° W Marovato, -25.58167°, 45.16833°, alt 200 m, Fisher-Griswold Arthropod Team, 02.11.2002, (2w, CASC); **CASENT0449258**, collection code: BLF05824, Mahafaly Plateau, 6.2 km 74° ENE Itampolo, -24.65361°, 43.99667°, alt 80 m, Fisher-Griswold Arthropod Team, 02.21.2002, (1w, CASC); **CASENT0449268**, collection code: BLF05833, Mahafaly Plateau, 6.2 km 74° ENE Itampolo, -24.65361°, 43.99667°, alt 80 m, Fisher-Griswold Arthropod Team, 02.21.2002, (1w, CASC); **CASENT0455014**, collection code: BLF06240, Parc National de Tsimanampetsotsa, Mitoho Cave, 6.4 km 77° ENE Efoetse, 17.4 km 170° S Beheloka, -24.04722°, 43.75317°, alt 40 m, Fisher-Griswold Arthropod Team, 37333, (2w, CASC); **CASENT0455831**, collection code: BLF06192, Parc National de Tsimanampetsotsa, Mitoho Cave, 6.4 km 77° ENE Efoetse, 17.4 km 170° S Beheloka, -24.04722°, 43.75317°, alt 40 m, Fisher-Griswold Arthropod Team, 03.18.2002, (2w, CASC);

Etymology. The name (cingulatus) refers to the conspicuous dark brown transversal patch on the first gastral tergite of workers of this species.

Diagnosis in key. Description of workers. Body color: yellow; brown. Body color pattern: concolorous, first gaster tergite darker. Absolute cephalic size: 459 [419, 515]. Cephalic length vs. maximum width of head capsule (CL/CWb): 1.37 [1.30, 1.45]. Postocular distance vs. cephalic length (PoOc/CL): 0.51 [0.49, 0.52]. Postocular sides of cranium contour frontal view orientation: converging posteriorly. Postocular sides of cranium contour frontal view shape: broadly convex. Vertex contour line in frontal view shape: straight. Vertex sculpture: main sculpture absent, ground sculpture areolate. Setal pits on head dorsum: surrounded by conspicuous foveae with well-demarcated margins. Diameter of foveae on head dorsum: 15–20 µm. Gena contour line in frontal view shape: straight. Genae contour from anterior view orientation: converging. Gena sculpture: rugoso-reticulate with areolate ground sculpture; ground sculpture areolate, main sculpture absent. Concentric carinae laterally surrounding antennal foramen: present. Eye length vs. absolute cephalic size (EL/CS): 0.24 [0.22, 0.26]. Frontal carina distance vs. absolute cephalic size (FRS/CS): 0.31 [0.30, 0.33]. Longitudinal carinae on median region of frons: absent. Smooth median region on



Figures 21. Geographic distribution of *Nesomyrmex cingulatus* sp. n.. The known localities of *N. cingulatus* sp. n. in Madagascar.

frons: absent. Antennomere count: 12. Scape length vs. absolute cephalic size (SL/CS): 0.63 [0.60, 0.65]. Median clypeal notch: present. Ground sculpture of submedian area of clypeus: present. Median carina of clypeus: absent. Metanotal depression: present. Dorsal region of mesosoma sculpture: ground sculpture areolate, main sculpture absent. Lateral region of pronotum sculpture: ground sculpture areolate, main sculpture absent. Mesopleuron sculpture: ground sculpture areolate, main sculpture absent. Metapleuron sculpture: ground sculpture areolate, main sculpture absent. Petiole width vs. absolute cephalic size (PEW/CS): 0.22 [0.21, 0.24]. Dorsal region of petiole sculpture: ground sculpture areolate, main sculpture absent. Postpetiole width vs. absolute cephalic size (PPW/CS): 0.32 [0.28, 0.35]. Dorsal region of postpetiole sculpture: ground sculpture areolate, main sculpture absent. Surface of first gastral tergite: continuously imbricate.

Distribution. This species is known to occur in the spiny forests of the southern part of Madagascar from 40–400 m (Fig. 21). The known samples are collected from live stems.

***Nesomyrmex edentatus* Csősz & Fisher, sp. n.**

<http://zoobank.org/FF26C1C3-2ADA-45F6-8825-AA60267D0304>

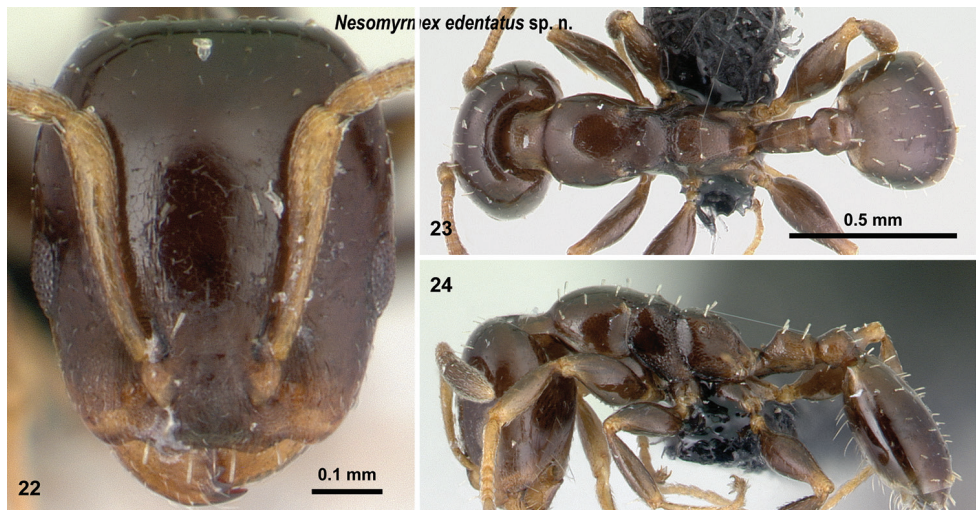
Figs 22–25, Table 1

Type material investigated. Holotype: CASENT0067086, collection code: BLF12553, Forêt d'Analava Mandrisy, 5.9 km 195° Antananambe, -16.48567°, 49.847°, alt 10 m, B.L.Fisher et al., 11.13.2005, (1w, CASC, CASENT0067086);

Paratypes: CASENT0004811, collection code: ANTC1302, P.N. Masoala, 40 km 154° SSE Maroantsetra, -15.72667°, 49.95667°, alt 150 m, A. Dejean et al., 10.14.2001, (1w, CASC); CASENT0121563, collection code: BLF15678, Forêt Mandena 8.5 km N Tolagnaro, -24.95267°, 47.0025°, alt 20 m, B.L.Fisher et al., 12.05.2006, (1w, CASC);

Etymology. The name (*edentatus*) refers to the absence of propodeal teeth in this species.

Diagnosis in key. Description of workers. Body color: black. Body color pattern: concolorous. Absolute cephalic size: 546 [535, 560]. Cephalic length vs. maximum width of head capsule (CL/CWb): 1.20 [1.19, 1.21]. Postocular distance vs. cephalic length (PoOc/CL): 0.48 [0.47, 0.49]. Postocular sides of cranium contour frontal view orientation: converging posteriorly. Postocular sides of cranium contour frontal view shape: broadly convex. Vertex contour line in frontal view shape: straight. Vertex sculpture: main sculpture absent, ground sculpture imbricate, shiny. Setal pits on head dorsum: inconspicuous with obscure demarcation. Gena contour line in frontal view shape: straight. Genae contour from anterior view orientation: converging. Gena sculpture: rugoso-reticulate with areolate ground sculpture. Concentric carinae laterally surrounding antennal foramen: present. Eye length vs. absolute cephalic size (EL/



Figures 22–24. *Nesomyrmex edentatus* sp. n. holotype worker (CASENT0067086). Head in full-face view (22), dorsal view of the body (23), lateral view of the body (24).

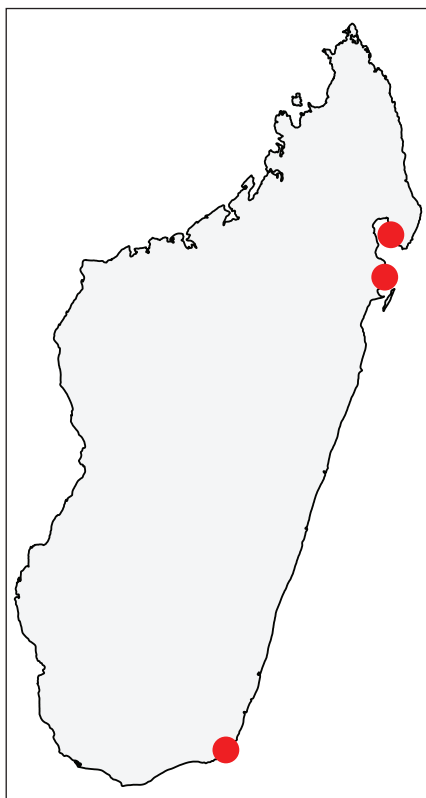


Figure 25. Geographic distribution of *Nesomyrmex edentatus* sp. n.. The known localities of *N. edentatus* sp. n. in Madagascar.

CS): 0.25 [0.23, 0.26]. Frontal carina distance vs. absolute cephalic size (FRS/CS): 0.30 [0.29, 0.31]. Longitudinal carinae on median region of frons: absent. Smooth median region on frons count: present. Antennomere count: 12. Scape length vs. absolute cephalic size (SL/CS): 0.66 [0.65, 0.67]. Median clypeal notch: present. Ground sculpture of submedian area of clypeus: present. Median carina of clypeus: absent. Metanotal depression: present. Dorsal region of mesosoma sculpture: imbricate, main sculpture absent. Lateral region of pronotum sculpture: imbricate, main sculpture absent. Mesopleuron sculpture: ground sculpture areolate, main sculpture absent. Meta-pleuron sculpture: ground sculpture areolate, main sculpture absent. Petiole width vs. absolute cephalic size (PEW/CS): 0.20 [0.20, 0.22]. Dorsal region of petiole sculpture: ground sculpture areolate, main sculpture absent. Postpetiole width vs. absolute cephalic size (PPW/CS): 0.28 [0.27, 0.28]. Dorsal region of postpetiole sculpture: ground sculpture areolate, main sculpture absent. Surface of first gastral tergite: imbricate sculpture absent.

Distribution. This species is known to occur in the littoral rainforests of eastern coastal Madagascar (Fig. 25). All samples were collected via beating low vegetation.

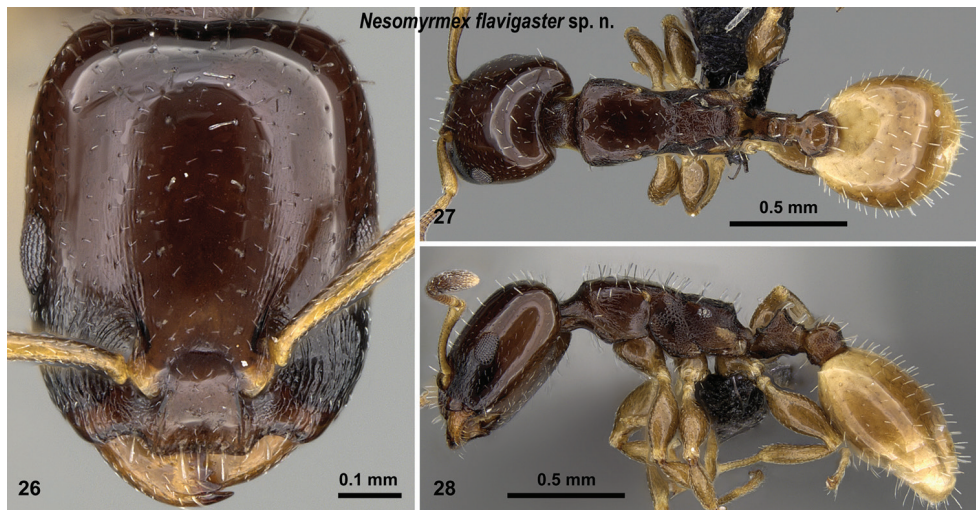
***Nesomyrmex flavigaster* Csősz & Fisher, sp. n.**

<http://zoobank.org/CBB5252E-4A1D-437C-ABC9-884F6BC99F48>

Figs 26–29, Table 1

Type material investigated. Holotype: CASENT0453374, collection code: BLF05530, Réserve Spéciale de Cap Sainte Marie, 12.3 km 262° W Marovato, -25.58167°, 45.16833°, alt 200 m, Fisher-Griswold Arthropod Team, 02.11.2002, (1w, CASC, CASENT0453374);

Paratypes: 25 workers from the same locality under CASENT codes: **CASENT0453367**, collection code: BLF05530, (1w, CASC); **CASENT0453368**, collection code: BLF05530, (1w, CASC); **CASENT0453369**, collection code: BLF05530, (1w, CASC); **CASENT0453370**, collection code: BLF05530, (1w, CASC); **CASENT0453371**, collection code: BLF05530, (1w, CASC); **CASENT0453372**, collection code: BLF05530, (1w, CASC); **CASENT0453373**, collection code: BLF05530, (1w, CASC); **CASENT0453376**, collection code: BLF05530, (1w, CASC); **CASENT0453377**, collection code: BLF05530, (1w, CASC); **CASENT0453378**, collection code: BLF05530, (1w, CASC); **CASENT0453379**, collection code: BLF05530, (1w, CASC); **CASENT0453380**, collection code: BLF05530, (1w, CASC); **CASENT0453381**, collection code: BLF05530, (1w, CASC); **CASENT0453382**, collection code: BLF05530, (1w, CASC); **CASENT0453383**, collection code: BLF05530, (1w, CASC); **CASENT0453384**, collection code: BLF05530, (1w, CASC); **CASENT0453385**, collection code: BLF05530, (1w, CASC); **CASENT0453386**, collection code: BLF05530, (1w, CASC); **CASENT0453387**, collection code: BLF05530, (1w, CASC); **CASENT0453388**, collection code: BLF05530, (1w, CASC); **CASENT0453389**, collection code: BLF05530, (2w, CASC); **CASENT0453390**, collection code: BLF05530, (3w, CASC, CASENT0453390).



Figures 26–28. *Nesomyrmex flavigaster* sp. n. holotype worker (CASENT0453374). Head in full-face view (26), dorsal view of the body (27), lateral view of the body (28).

Material examined. MADAGASCAR: CASENT0136889, collection code: BLF20382, Nosy Be airport, -13.3138°, 48.31509°, alt 25 m, B.L.Fisher et al., 04.015.2008, (1w, CASC); **CASENT0453655**, collection code: BLF05644, Réserve Spéciale de Cap Sainte Marie, 12.3 km 262° W Marovato, -25.58167°, 45.16833°, alt 200 m, Fisher-Griswold Arthropod Team, 02.11.2002, (1w, CASC); **CASENT0453659**, collection code: BLF05644, Réserve Spéciale de Cap Sainte Marie, 12.3 km 262° W Marovato, -25.58167°, 45.16833°, alt 200 m, Fisher-Griswold Arthropod Team, 02.11.2002, (1w, CASC); **CASENT0453661**, collection code: BLF05526, Réserve Spéciale de Cap Sainte Marie, 12.3 km 262° W Marovato, -25.58167°, 45.16833°, alt 200 m, Fisher-Griswold Arthropod Team, 02.11.2002, (1w, CASC); **CASENT0453665**, collection code: BLF05526, Réserve Spéciale de Cap Sainte Marie, 12.3 km 262° W Marovato, -25.58167°, 45.16833°, alt 200 m, Fisher-Griswold Arthropod Team, 02.11.2002, (1w, CASC); **CASENT0453685**, collection code: BLF05586, Réserve Spéciale de Cap Sainte Marie, 12.3 km 262° W Marovato, -25.58167°, 45.16833°, alt 200 m, Fisher-Griswold Arthropod Team, 02.11.2002, (1w, CASC); **CASENT0453687**, collection code: BLF05586, Réserve Spéciale de Cap Sainte Marie, 12.3 km 262° W Marovato, -25.58167°, 45.16833°, alt 200 m, Fisher-Griswold Arthropod Team, 02.11.2002, (1w, CASC); **CASENT0477291**, collection code: BLF05504, Réserve Spéciale de Cap Sainte Marie, 12.3 km 262° W Marovato, -25.58167°, 45.16833°, alt 200 m, Fisher-Griswold Arthropod Team, 02.11.2002, (1w, CASC).

Etymology. The name (flavigaster) refers to the light yellow gaster of this species, which is in sharp contrast to the dark brown color of the rest of the body.

Diagnosis in key. Description of workers. Body color: dark brown; black. Body color pattern: body concolorous, gaster pale yellow. Absolute cephalic size: 629 [546, 740]. Cephalic length vs. maximum width of head capsule (CL/CWb): 1.23 [1.13, 1.29]. Postocular distance vs. cephalic length (PoOc/CL): 0.43 [0.41, 0.46]. Postocular sides of cranium contour frontal view orientation: converging posteriorly. Postocular sides of cranium contour frontal view shape: broadly convex. Vertex contour line in frontal view shape: straight. Vertex sculpture: main sculpture absent, ground sculpture absent, smooth and shiny. Setal pits on head dorsum: inconspicuous with obscure demarcation. Gena contour line in frontal view shape: convex. Genae contour from anterior view orientation: converging. Gena sculpture: ground sculpture areolate, main sculpture absent; ground sculpture areolate, main sculpture costulate. Concentric carinae laterally surrounding antennal foramen: present. Eye length vs. absolute cephalic size (EL/CS): 0.23 [0.21, 0.25]. Frontal carina distance vs. absolute cephalic size (FRS/CS): 0.34 [0.33, 0.36]. Longitudinal carinae on median region of frons: absent. Smooth median region on frons: present. Antennomere count: 12. Scape length vs. absolute cephalic size (SL/CS): 0.62 [0.59, 0.66]. Median clypeal notch: present. Ground sculpture of submedian area of clypeus: present. Median carina of clypeus: absent. Metanotal depression: present. Dorsal region of mesosoma sculpture: imbricate, main sculpture absent. Lateral region of pronotum sculpture: imbricate, main sculpture absent; inconspicuous areolate ground sculpture, main sculpture

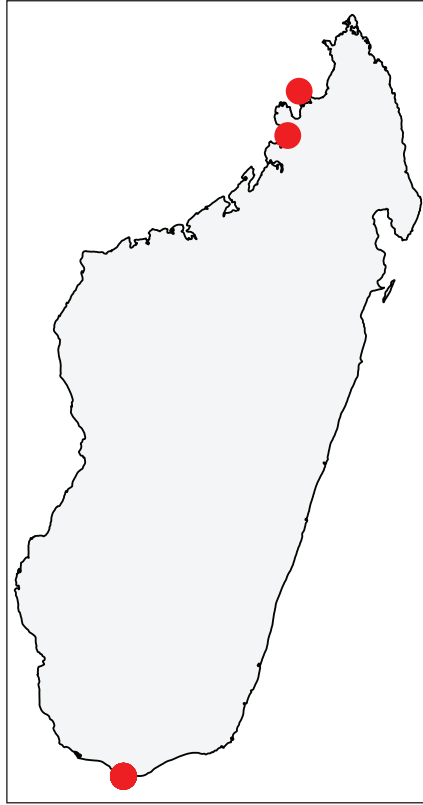


Figure 29. Geographic distribution of *Nesomyrmex flavigaster* sp. n.. The known localities of *N. flavigaster* sp. n. in Madagascar.

dispersed costate. Mesopleuron sculpture: ground sculpture areolate, main sculpture absent. Metapleuron sculpture: ground sculpture areolate, main sculpture absent. Petiole width vs. absolute cephalic size (PEW/CS): 0.22 [0.20, 0.22]. Dorsal region of petiole sculpture: ground sculpture areolate, main sculpture dispersed rugose. Postpetiole width vs. absolute cephalic size (PPW/CS): 0.31 [0.29, 0.33]. Dorsal region of postpetiole sculpture: ground sculpture smooth, main sculpture absent. Surface of first gastral tergite: imbricate sculpture absent.

Distribution. This species is known from Madagascar's most remote spots (Fig. 29). The southern locality (Réserve Spéciale de Cap Sainte Marie, near Marovato), where it can be found in low vegetation of spiny forests in lowlands (200 m), seems the only known natural occurrence of this species. The known northern samples were most probably introduced by humans in Nosy Be airport (urban garden) and Manerinerina (disturbed forest).

***Nesomyrmex longiceps* Csösz & Fisher, sp. n.**

<http://zoobank.org/FA8BB966-98EF-403F-B7B1-3D62C36E3B1C>

Figs 30–33, Table 1

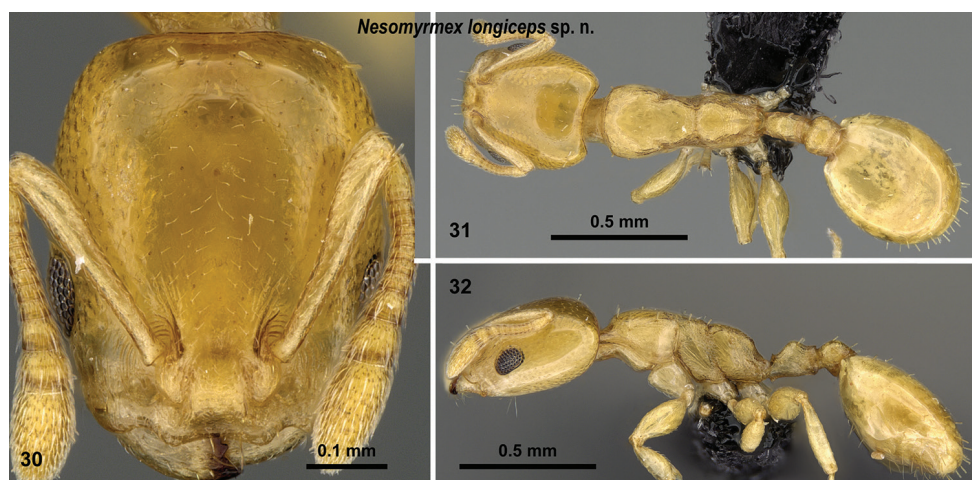
Type material investigated. Holotype: CASENT0488528, collection code: BLF06584, Parc National de Namoroka, 16.9 km 317° NW Vilanandro, -16.40667°, 45.31°, alt 100 m, Fisher, Griswold et al., 11.12.2002, (1w, CASC, CASENT0488528);

Paratype: CASENT0488529, collection code: BLF06584, Parc National de Namoroka, 16.9 km 317° NW Vilanandro, -16.40667°, 45.31°, alt 100 m, Fisher, Griswold et al., 11.12.2002, (1w, CASC);

Material examined. MADAGASCAR: CASENT0400876, collection code: BLF02660, Réserve Spéciale d'Ambre, 3.5 km 235° SW Sakaramy, -12.46889°, 49.24217°, alt 325 m, Fisher, Griswold et al., 01.26.2001, (1w, CASC); CASENT0422685, collection code: BLF02660, Réserve Spéciale d'Ambre, 3.5 km 235° SW Sakaramy, -12.46889°, 49.24217°, alt 325 m, Fisher, Griswold et al., 01.26.2001, (1w, CASC);

Etymology. This name (*longiceps*) refers to the relatively elongated head of workers of this species.

Diagnosis in key. Description of workers. Body color: yellow. Body color pattern: concolorous. Absolute cephalic size: 531 [478, 556]. Cephalic length vs. maximum width of head capsule (CL/CWb): 1.43 [1.42, 1.46]. Postocular distance vs. cephalic length (PoOc/CL): 0.44 [0.42, 0.45]. Postocular sides of cranium contour frontal view orientation: converging posteriorly. Postocular sides of cranium contour frontal view shape: broadly convex. Vertex contour line in frontal view shape: straight. Vertex sculpture: main sculpture absent, ground sculpture absent, smooth and shiny. Setal pits on head dorsum: inconspicuous with obscure demarcation. Gena contour line in frontal view



Figures 30–32. *Nesomyrmex longiceps* sp. n. holotype worker (CASENT0488528). Head in full-face view (30), dorsal view of the body (31), lateral view of the body (32).

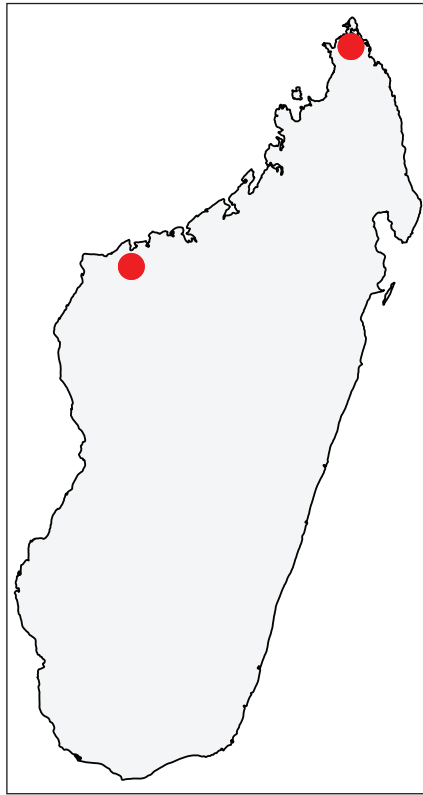


Figure 33. Geographic distribution of *Nesomyrmex longiceps* sp. n.. The known localities of *N. longiceps* sp. n. in Madagascar.

shape: straight. Genae contour from anterior view orientation: converging. Gena sculpture: ground sculpture areolate, main sculpture costulate. Concentric carinae laterally surrounding antennal foramen: present. Eye length vs. absolute cephalic size (EL/CS): 0.22 [0.21, 0.23]. Frontal carina distance vs. absolute cephalic size (FRS/CS): 0.26 [0.25, 0.28]. Longitudinal carinae on median region of frons: absent. Smooth median region on frons: present. Antennomere count: 12. Scape length vs. absolute cephalic size (SL/CS): 0.63 [0.61, 0.65]. Median clypeal notch: present. Ground sculpture of submedian area of clypeus: present. Median carina of clypeus: absent. Metanotal depression: present. Dorsal region of mesosoma sculpture: imbricate, main sculpture absent. Lateral region of pronotum sculpture: ground sculpture areolate, main sculpture absent. Mesopleuron sculpture: ground sculpture areolate, main sculpture absent. Metapleuron sculpture: ground sculpture areolate, main sculpture absent. Petiole width vs. absolute cephalic size (PEW/CS): 0.19 [0.19, 0.19]. Dorsal region of petiole sculpture: ground sculpture areolate, main sculpture dispersed rugose. Postpetiole width vs. absolute cephalic size (PPW/CS): 0.27 [0.26, 0.28]. Dorsal region of postpetiole sculpture: ground sculpture smooth, main sculpture absent. Surface of first gastral tergite: imbricate sculpture absent.

Distribution. This species is known to occur in northwestern Madagascar from 100–325 m (Fig. 33). The known samples were collected in tropical dry forests.

***Nesomyrmex minutus* Csősz & Fisher, sp. n.**

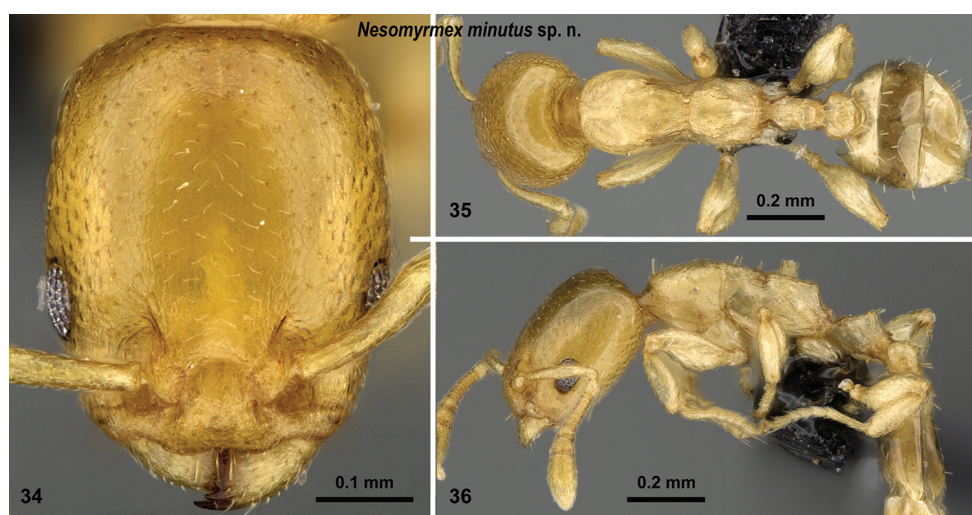
<http://zoobank.org/786E5C5E-8DAA-4A60-BCEB-03E56B27CD3A>

Figs 34–37, Table 1

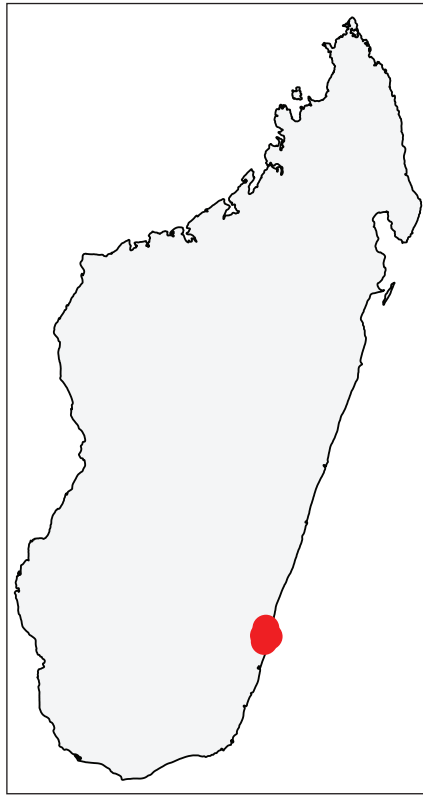
Type material investigated. Holotype: CASENT0071633, collection code: BLF14082, Réserve Speciale Manombo 24.5 km 228° Farafangana, -23.01583°, 47.719°, alt 30 m, B.L. Fisher et al., 04.22.2006, (1w, CASC, CASENT0071633);

Paratypes: 21 workers, 16 gynes, and one male from the same locality under CASENT codes:

CASENT0071611, collection code: BLF14077, (1w, 1Q, CASC); **CASENT0071616**, collection code: BLF14066, (1w, CASC, CASENT0071616); **CASENT0071632**, collection code: BLF14076, (1w, 1Q, CASC); **CASENT0071639**, collection code: BLF14100, (1w, CASC); **CASENT0071640**, collection code: BLF14081, (1w, 1Q, CASC); **CASENT0071644**, collection code: BLF14073, (1w, 1Q, CASC); **CASENT0071646**, collection code: BLF14074, (1w, 1Q, CASC); **CASENT0071647**, collection code: BLF14071, (1w, 1Q, CASC); **CASENT0071650**, collection code: BLF14111, (1w, CASC); **CASENT0071657**, collection code: BLF14083, (1w, 1Q, CASC); **CASENT0071658**, collection code: BLF14067, (1w, CASC); **CASENT0071662**, collection code: BLF14064, (1w, 1Q, CASC); **CASENT0071667**, collection code: BLF14078, (1w, CASC); **CASENT0071668**, collection code: BLF14079, (1w, 1Q, CASC); **CASENT0071673**, collection code: BLF14072, (1w, 1Q, CASC); **CASENT0071676**, collection code: BLF14070, (1w, CASC); **CASENT0071714**, collection code: BLF14084, (1w, 1Q, CASC); **CASENT0071720**, collection code: BLF14069, (1w, CASC); **CASENT0071721**, collection code: BLF14080, (1w, 1Q, CASC); **CASENT0071725**, collection code: BLF14075, (1w, CASC); **CASENT0071656**, collection code: BLF14068,



Figures 34–36. *Nesomyrmex minutus* sp. n. holotype worker (CASENT0071633). Head in full-face view (34), dorsal view of the body (35), lateral view of the body (36).



Figures 37. Geographic distribution of *Nesomyrmex minutus* sp. n.. The known localities of *N. minutus* sp. n. in Madagascar.

(1w, 1m, CASC); **CASENT0071675**, collection code: BLF14063, (1Q, CASC); **CASENT0071645**, collection code: BLF14073, (1Q, CASC); **CASENT0071636**, collection code: BLF14076, (1Q, CASC); **CASENT0071659**, collection code: BLF14083, (1Q, CASC);

Etymology. The name (*minutus*) refers to the small tiny appearance of workers of this species.

Diagnosis in key. Description of workers. Body color: yellow. Body color pattern: body concolorous, first gaster tergite darker. Absolute cephalic size: 469 [405, 530]. Cephalic length vs. maximum width of head capsule (CL/CWb): 1.30 [1.22, 1.36]. Postocular distance vs. cephalic length (PoOc/CL): 0.52 [0.51, 0.54]. Postocular sides of cranium contour frontal view orientation: converging posteriorly. Postocular sides of cranium contour frontal view shape: broadly convex. Vertex contour line in frontal view shape: straight. Vertex sculpture: main sculpture absent, ground sculpture imbricate, shiny. Setal pits on head dorsum: inconspicuous with obscure demarcation. Gena contour line in frontal view shape: convex. Genae contour from anterior view orientation: converging. Gena sculpture: rugoso-reticulate with areolate ground sculpture; ground sculpture areolate, main sculpture costulate. Concentric carinae laterally

surrounding antennal foramen: present. Eye length vs. absolute cephalic size (EL/CS): 0.25 [0.22, 0.28]. Frontal carina distance vs. absolute cephalic size (FRS/CS): 0.36 [0.33, 0.39]. Longitudinal carinae on median region of frons: absent. Smooth median region on frons: present. Antennomere count: 12. Scape length vs. absolute cephalic size (SL/CS): 0.57 [0.53, 0.61]. Median clypeal notch: present. Ground sculpture of submedian area of clypeus: present. Median carina of clypeus: absent. Metanotal depression: present. Dorsal region of mesosoma sculpture: imbricate, main sculpture absent. Lateral region of pronotum sculpture: imbricate, main sculpture absent; inconspicuous areolate ground sculpture, main sculpture dispersed costate. Mesopleuron sculpture: ground sculpture areolate, main sculpture absent. Metapleuron sculpture: ground sculpture areolate, main sculpture absent. Petiole width vs. absolute cephalic size (PEW/CS): 0.22 [0.20, 0.23]. Dorsal region of petiole sculpture: ground sculpture areolate, main sculpture absent. Postpetiole width vs. absolute cephalic size (PPW/CS): 0.33 [0.30, 0.35]. Dorsal region of postpetiole sculpture: ground sculpture smooth, main sculpture absent. Surface of the first gastral tergite: imbricate sculpture absent.

Distribution. This species is known from rainforests of a single locality in the southeastern coast of Madagascar (Fig. 37), where it appears to be exclusively associated with the host plant *Macphersonia gracilis* (Sapindaceae). We know little about the ecology of the association. Unlike other tropical regions, very few ant plant associations are known from Madagascar. The only known ant associations are from northeastern Madagascar, where three species in the plant genus *Gravesia* Naudin, 1851 (Melastomataceae) are often occupied by *Tetramorium silvicola* Hita Garcia & Fisher, 2014 and *Vitsika breviscapa* Bolton & Fisher, 2014.

***Nesomyrmex punctaticeps* Csősz & Fisher, sp. n.**

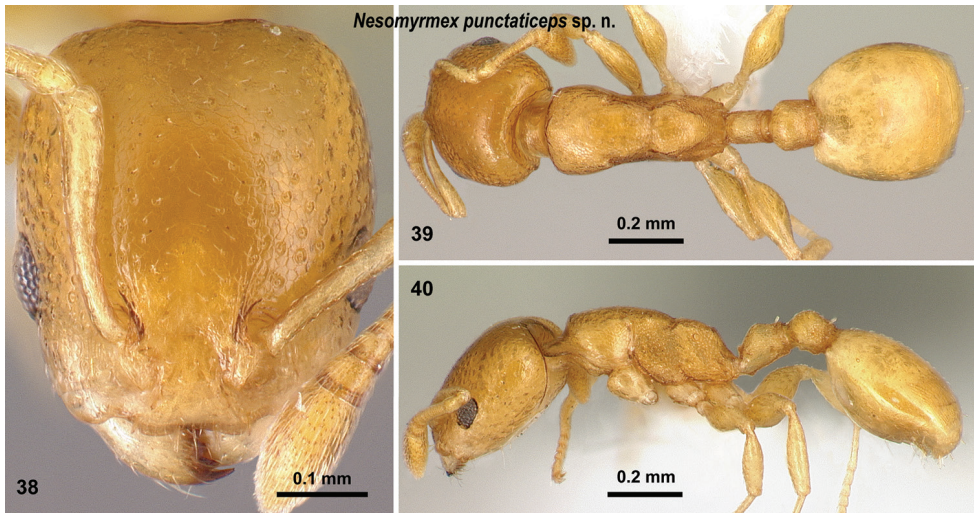
<http://zoobank.org/0E95F739-536E-4ED2-9AEA-ED70E7620038>

Figs 38–41, Table 1

Type material investigated. Holotype: CASCENT0418448, collection code: BLF04604, Forêt de Kirindy, 15.5 km 64° ENE Marofandilia, -20.045°, 44.66222°, alt 100 m, Fisher-Griswold Arthropod Team, 11.28.2001, (1w, CASC, CASCENT0418448);

Paratypes: four workers from the same locality under CASCENT codes: CASCENT0418445, collection code: BLF04604, (3w, CASC); CASCENT0418446, collection code: BLF04604, (1w, CASC);

Material examined. MADAGASCAR: CASCENT0002644, collection code: BLF06141, Forêt de Beroboka, 5.9 km 131° SE Ankidranoka, -22.23306°, 43.36633°, alt 80 m, Fisher-Griswold Arthropod Team, 03.12.2002, (2w, CASC, CASCENT0002644); CASCENT0004025, collection code: BLF05637, 6.1 km 182° S Marovato, -25.58167°, 45.295°, alt 20 m, Fisher-Griswold Arthropod Team, 02.14.2002, (1w, CASC); CASCENT0156889, collection code: BLF23048, Réserve forestière Beanka, 50.7 km E Maintirano, -17.88021°, 44.46877°, alt 140 m,



Figures 38–40. *Nesomyrmex punctaticeps* sp. n. holotype worker (CASENT0418448). Head in full-face view (38), dorsal view of the body (39), lateral view of the body (40).

B.L.Fisher et al., 10.30.2009, (2w, CASC); **CASENT0206506**, collection code: MG-33-03, Sofia Region, District of Port-Berger, Ambovomamy 20Km N of Port-Berger, Mahajanga, -15.45117°, 47.61333°, alt 86 m, M.F. Rin'ha, 01.21.2007, (1w, CASC); **CASENT0447338**, collection code: BLF05968, Forêt de Tsinjoriaky, 6.2 km 84° E Tsifota, -22.80222°, 43.42067°, alt 70 m, Fisher-Griswold Arthropod Team, 03.06.2002, (2w, CASC); **CASENT0484806**, collection code: BLF07511, Parc National de Zombitse, 19.8 km 84° E Sakaraha, -22.84333°, 44.71°, alt 770 m, Fisher, Griswold et al., 02.05.2003, (3w, CASC); **MCZENT0576250**, Ranomafana National Park, -21.32°, 47.39°, alt 900 m, W.E. Steiner, 01.02.1990, (1w, MCZC);

Etymology. This name (*punctaticeps*) refers to conspicuously foveolate head dorsum of workers of this species.

Diagnosis in key. Description of workers. Body color: yellow. Body color pattern: concolorous. Absolute cephalic size: 473 [424, 549]. Cephalic length vs. maximum width of head capsule (CL/CWb): 1.20 [1.14, 1.26]. Postocular distance vs. cephalic length (PoOc/CL): 0.49 [0.47, 0.51]. Postocular sides of cranium contour frontal view orientation: converging posteriorly. Postocular sides of cranium contour frontal view shape: broadly convex. Vertex contour line in frontal view shape: straight. Vertex sculpture: main sculpture absent, ground sculpture imbricate, shiny. Setal pits on head dorsum: surrounded by conspicuous foveae with well demarcated margins. Diameter of foveae on head dorsum: 10 μ m. Gena contour line in frontal view shape: convex. Genae contour from anterior view orientation: converging. Gena sculpture: rugoso-reticulate with areolate ground sculpture. Concentric carinae laterally surrounding antennal foramen count: present. Eye length vs. absolute cephalic size (EL/CS): 0.24 [0.22, 0.26]. Frontal carina distance vs. absolute cephalic size (FRS/CS): 0.33 [0.32, 0.35]. Longitudinal carinae on median region of frons: absent. Smooth median region

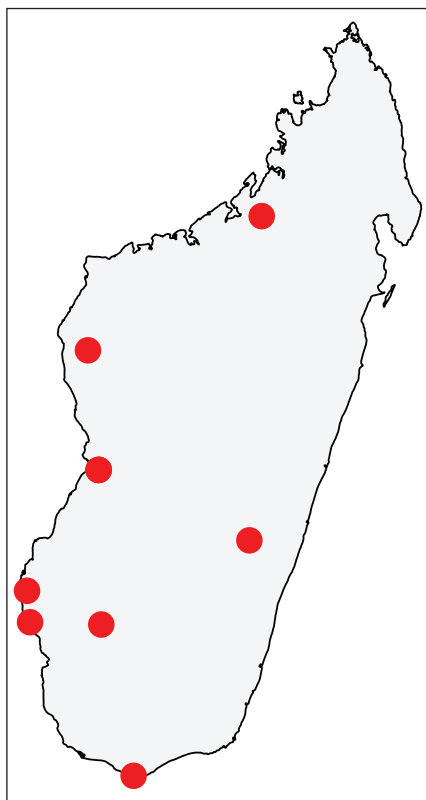


Figure 41. Geographic distribution of *Nesomyrmex punctaticeps* sp. n.. The known localities of *N. punctaticeps* sp. n. in Madagascar.

on frons: present. Antennomere count: 12. Scape length vs. absolute cephalic size (SL/CS): 0.66 [0.62, 0.70]. Median clypeal notch: present. Ground sculpture of submedian area of clypeus: present. Median carina of clypeus: absent. Metanotal depression: present. Dorsal region of mesosoma sculpture: ground sculpture areolate, main sculpture absent. Lateral region of pronotum sculpture: ground sculpture areolate, main sculpture absent. Mesopleuron sculpture: ground sculpture areolate, main sculpture absent. Metapleuron sculpture: ground sculpture areolate, main sculpture absent. Petiole width vs. absolute cephalic size (PEW/CS): 0.22 [0.21, 0.24]. Dorsal region of petiole sculpture: ground sculpture areolate, main sculpture absent. Postpetiole width vs. absolute cephalic size (PPW/CS): 0.34 [0.30, 0.36]. Dorsal region of postpetiole sculpture: ground sculpture areolate, main sculpture absent. Surface of the first gastral tergite: incontinuously imbricate.

Distribution. This species is widely distributed in Madagascar's tropical dry forests and spiny forests (Fig. 41) in lower elevations between 20–770 m. Only one sample is known to be collected from rainforest of Ranomafana National Park in higher elevation (900 m). The known samples were collected by beating low vegetation.

***Nesomyrmex sellaris* Csősz & Fisher, sp. n.**

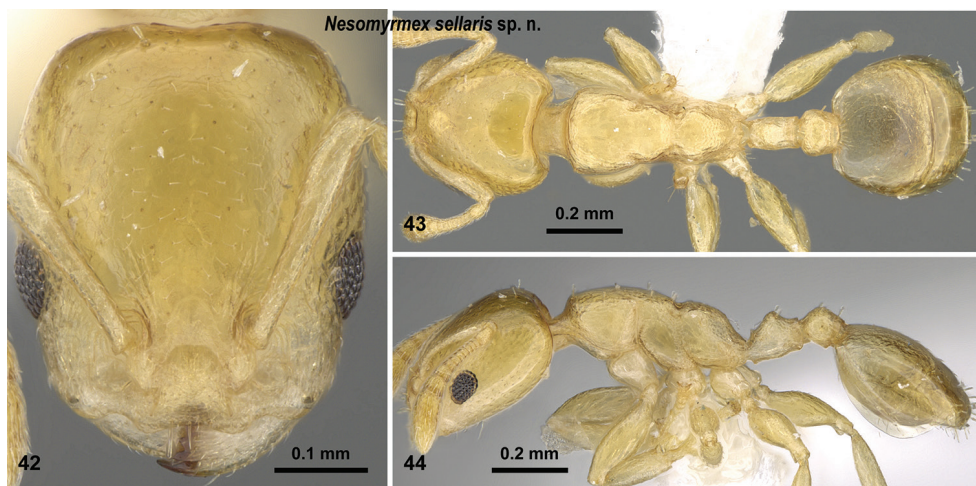
<http://zoobank.org/C87A166F-4CC1-4A74-AA7A-39CDE98104AC>

Figs 42–45, Table 1

Type material investigated. Holotype: CASENT0428261, collection code: BLF02859, Réserve Spéciale de l'Ankarana, 22.9 km 224° SW Anivorano Nord, -12.90889°, 49.10983°, alt 80 m, Fisher, Griswold et al., 02.10.2001, (1w, CASC, CASENT0428261);

Paratypes: four workers from the same locality under CASENT codes: **CASENT0422623**, collection code: BLF02859, (1w, CASC); **CASENT0422624**, collection code: BLF02859, (1w, CASC); **CASENT0428262**, collection code: BLF02859, (1w, CASC); **CASENT0422621**, collection code: BLF2859, (1w, CASC);

Material examined. MADAGASCAR: **CASENT0004813**, collection code: ANTC1302, P.N. Masoala, 40 km 154° SSE Maroantsetra, -15.72667°, 49.95667°, alt 150 m, A. Dejean et al., 10.14.2001, (2w, CASC); **CASENT0053591**, collection code: MA-02-09B-53, radio tower, Ranomafana National Park, Fianarantsoa Prov., -21.25083°, 47.40717°, alt 1130 m, M. Irwin, R. Harin'Hala, 02.18.2003, (1w, CASC); **CASENT0068333**, collection code: BLF12740, Res. Ambodiriana, 4.8 km 306° Manompana, along Manompana river, -16.67233°, 49.70117°, alt 125 m, B.L.Fisher et al., 11.18.2005, (1w, CASC); **CASENT0070953**, collection code: BLF13926, Réserve Forestière d'Agalazaha, Mahabo, 42.9 km 215° Farafangana, -23.19383°, 47.723°, alt 20 m, B.L. Fisher et al., 04.19.2006, (1w, CASC); **CASENT0071722**, collection code: BLF14065, Réserve Speciale Manombo 24.5 km 228° Farafangana, -23.01583°, 47.719°, alt 30 m, B.L. Fisher et al., 04.22.2006, (1w, CASC); **CASENT0189193**, collection code: BLF01998, R.S. Manongarivo, 10.8 km 229° SW Antanambao, -13.96167°, 48.43333°, alt 400 m, B.L.Fisher, 11.08.1998,



Figures 42–44. *Nesomyrmex sellaris* sp. n. holotype worker (CASENT0428261). Head in full-face view (42), dorsal view of the body (43), lateral view of the body (44).

(1w, CASC); **CASENT0262171**, collection code: MG-58-30, SAVA Region, District of Vohemar, Antsahabelela Rain Forest, 9 km SW of Daraina, -13.2505°, 49.61667°, alt 182 m, Mike, Rin'ha, 04.27.2011, (1w, CASC); **CASENT0422618**, collection code: BLF02660, Réserve Spéciale de l'Ankarana, 22.9 km 224° SW Anivorano Nord, -12.90889°, 49.10983°, alt 80 m, Fisher, Griswold et al., 02.10.2001, (1w, CASC); **CASENT0422620**, collection code: BLF02660, Réserve Spéciale d'Ambre, 3.5 km 235° SW Sakaramy, -12.46889°, 49.24217°, alt 325 m, Fisher, Griswold et al., 01.26.2001, (1w, CASC); **CASENT0494407**, collection code: BLF09906, Forêt de Bekaraoka, 6.8 km 60° ENE Daraina, -13.16667°, 49.71°, alt 150 m, B.L. Fisher, 12.07.2003, (1w, CASC, CASENT0494407);

Etymology. The name (*sellaris*) refers to the deep mesopropodeal depression in workers resembling a saddle (=sella Lat.).

Diagnosis in key. Description of workers. Body color: yellow. Body color pattern: concolorous. Absolute cephalic size: 449 [410, 557]. Cephalic length vs. maximum width of head capsule (CL/CWb): 1.18 [1.13, 1.25]. Postocular distance vs. cephalic length (PoOc/CL): 0.51 [0.49, 0.53]. Postocular sides of cranium contour frontal view orientation: converging posteriorly. Postocular sides of cranium contour frontal view shape: broadly convex. Vertex contour line in frontal view shape: straight. Vertex sculpture: main sculpture absent, ground sculpture imbricate, shiny. Setal pits on head dorsum: surrounded by conspicuous foveae with well demarcated margins. Diameter of foveae on head dorsum: 10–15 µm. Gena contour line in frontal view shape: straight. Genae contour from anterior view orientation: converging. Gena sculpture: rugoso-reticulate with areolate ground sculpture. Concentric carinae laterally surrounding antennal foramen: present. Eye length vs. absolute cephalic size (EL/CS): 0.24 [0.23, 0.26]. Frontal carina distance vs. absolute cephalic size (FRS/CS): 0.29 [0.27, 0.30]. Longitudinal carinae on median region of frons: absent. Smooth median region on frons: present. Antennomere count: 12. Scape length vs. absolute cephalic size (SL/CS): 0.69 [0.65, 0.72]. Median clypeal notch: present. Ground sculpture of submedian area of clypeus: present. Median carina of clypeus: absent. Metanotal depression: present. Dorsal region of mesosoma sculpture: imbricate, main sculpture absent. Lateral region of pronotum sculpture: imbricate, main sculpture absent; inconspicuous areolate ground sculpture, main sculpture dispersed costate. Mesopleuron sculpture: ground sculpture areolate, main sculpture absent. Metapleuron sculpture: ground sculpture areolate, main sculpture absent. Petiole width vs. absolute cephalic size (PEW/CS): 0.21 [0.20, 0.23]. Dorsal region of petiole sculpture: ground sculpture areolate, main sculpture absent. Postpetiole width vs. absolute cephalic size (PPW/CS): 0.29 [0.26, 0.31]. Dorsal region of postpetiole sculpture: ground sculpture smooth, main sculpture absent. Surface of the first gastral tergite: inconspicuously imbricate; continuously imbricate.

Distribution. This species is widely distributed in East Madagascar (Fig. 45). The known samples were collected in diverse habitats from tropical dry forests to rainforests, typically at lower elevation from 20–1130 m.

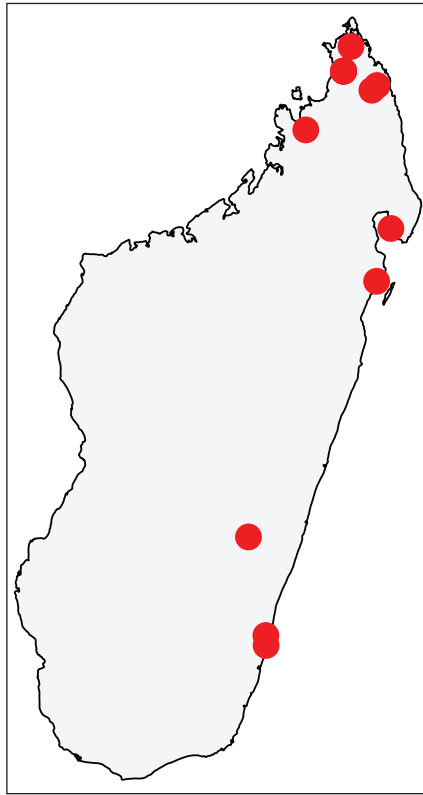


Figure 45. Geographic distribution of *Nesomyrmex sellaris* sp. n.. The known localities of *N. sellaris* sp. n. in Madagascar.

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References

- Bolton B (1994) Identification Guide to the Ant Genera of the World. Harvard University Press, Cambridge, 222 pp.
- Bolton B, Fisher BL (2013) The Malagasy endemic myrmicine ants related to *Eutetramorium* (Hymenoptera: Formicidae): taxonomy of the genera *Eutetramorium* Emery, *Malagidris* nom. n., *Myrmisaraka* gen. n., *Royidris* gen. n., and *Vitsika* gen. n. Zootaxa 3791: 1–99. doi: 10.11646/zootaxa.3791.1.1
- Csősz S, Fisher BL (2015) Diagnostic survey of Malagasy *Nesomyrmex* species-groups and revision of *hafahafa* group species via morphology-based cluster delimitation protocol. Zookeys 526: 19–59. doi: 10.3897/zookeys.526.6037
- Csősz S, Fisher BL (2016a) Toward objective, morphology-based taxonomy: a case study on the Malagasy *Nesomyrmex sikorai* species group (Hymenoptera: Formicidae). PLoS ONE 11(4): e0152454. doi: 10.1371/journal.pone.0152454
- Csősz S, Fisher BL (2016b) Taxonomic revision of the Malagasy members of the *Nesomyrmex angulatus* species group using the automated morphological species delineation protocol NC-PART-clustering. PeerJ 4:e1796. doi: 10.7717/peerj.1796
- Csősz S, Fisher BL (2016c) Taxonomic revision of the Malagasy *Nesomyrmex madecassus* species-group using a quantitative morphometric approach. ZooKeys 603: 105–130. doi: 10.3897/zookeys.603.8271
- Evenhuis NL (2013) The insect and spider collections of the world website. <http://hbs.bishop-museum.org/codens/> [Accessed: 3 Mar 2014]
- Harris RA (1979) A glossary of surface sculpturing. California Department of Food and Agriculture, Bureau of Entomology 28: 1–31.
- Hita Garcia F, Fisher BL (2014) The hyper-diverse ant genus *Tetramorium* Mayr (Hymenoptera, Formicidae) in the Malagasy region taxonomic revision of the *T. naganum*, *T. pleiarum*, *T. schaufussii*, and *T. severini* species groups. ZooKeys 413: 1–170. doi: 10.3897/zookeys.413.7172
- Prebus M (2015) Palearctic elements in the old world tropics: a taxonomic revision of the ant genus *Temnothorax* Mayr (Hymenoptera, Formicidae) for the Afrotropical biogeographical region. ZooKeys 483: 23–57. doi: 10.3897/zookeys.483.9111
- R Core Team (2015) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org/> [Accessed: 20 January 2015]
- Revell LJ (2012) phytools: an R package for phylogenetic comparative biology (and other things). Methods in Ecology and Evolution 3.2 (2012): 217–223. doi: 10.1111/j.2041-210X.2011.00169.x
- Snelling RR, Borowiec ML, Prebus MM (2014) Studies on California ants: a review of the genus *Temnothorax* (Hymenoptera, Formicidae). ZooKeys 372: 27–89. doi: 10.3897/zookeys.372.6039
- Strauss RE, Bond CE (1990) Taxonomic methods: morphology In: Moyle P, Schreck C (Eds) Methods for Fish Biology. American Fisheries Society, Special Publication, 109–140.

