BIODIVERSITY STUDIES IN AFROTROPICAL MOTH FLIES (DIPTERA: PSYCHODIDAE)

Gunnar Mikalsen Kvifte

Master thesis in biology - Biodiversity, Evolution and Ecology

University of Bergen 2011

I found it and I named it, being versed
in taxonomic latin, thus became
Godfather of an insect, and its first
describer, *and I want no other fame.*

-Vladimir Nabokov

ACKNOWLEDGEMENTS

First of all I would like to thank my supervisors Trond Andersen and Richard Telford for their excellent guidance and encouragement through the thesis process. Trond was the first to suggest Psychodidae as a worthy subject for study, and has remained extremely helpful in writing, labwork and illustration throughout my education. Richard helped me planning fieldwork and has shared his considerable methodological expertise generously. I can not thank them enough for their contributions to this project.

I am very grateful to everybody involved in the MATRIX project for support during the fieldwork in Uganda. Without all the advice and technical help I received from Vigdis Vandvik, Josephine Esaete and Brooke Wilkerson I would have had a considerably harder time in Uganda. I also could not have done without my field assistant Afeku Alfred, whose wide ecological and botanical knowledge of Budongo forest was crucial in my site selection. For further help, advice and company during my stay at the Budongo Conservation Field Station I thank Roman M. Wittig, Zephyr Kiwede, Tonny Kidega and all the students and staff of the BCFS. Asanti sana!

The staff at the natural history museums in Makerere: Robert Kityo, Perpetra Akite and Fabiano Ebonga and Bergen: Per Djursvoll, Katrine Kongshavn, Gladys Ramirez and Steffen Roth were very helpful in solving technical and/or administrative problems. I also want to thank Marc de Meyer and Eliane de Coninck of the Royal Museum for Central Africa, Tervuren for the loan of the *Trichomyia congoensis* holotype, and Erica McAlister at the British Museum of Natural History, London for guidance during my visit in the entomology collections in London.

Discussions with Gregory R. Curler were of great help in resolving some difficult taxonomical issues; I am especially grateful for his comments on an earlier draft of chapter 2. I also appreciated good advice from Torbjørn Ekrem, Jan Ježek, Bjarte Jordal, Lawrence Kirkendall, Humberto F. Mendes, Torstein Solhøy, Gaute Velle and Endre Willassen. Furthermore, I want to thank Louis Boumans, Freddy Bravo, Cínthia Chagas, Øyvind Håland, Jan Ježek and Salih Krek for providing me with copies of some of the more obscure taxonomic publications.

Less academic kinds of support from my friends and family has been of great help – writing a thesis is a stressful and largely lonely process which I would have great difficulties with if it was not for you. Svein, Lasse, Inge, the entire «fagpils» community, my fellow Klubb Fantoft-ers – you are all greatly appreciated. See you at Baran for the thesis celebration!

Finally I have to thank my lovely Aleksandra for her everlasting patience and loving support, which has been and remains very important to me.

TABLE OF CONTENTS

Front page: *Clogmia albipunctata* (Williston, 1893), a common cosmopolitan synanthropic Psychodine species, photographed in Nyabyeya, Uganda.

PREFACE

We are living in an age of extinction. Currently, species are disappearing at rates that are believed to be hundreds or even thousands of times higher than the «natural» rate of extinction; principally because of habitat loss induced by changes in land use and climate (Pimm *et al.* 1995; Sala *et al.* 2000). A majority of the extinctions are likely to go unnoticed as most of the endangered biodiversity consists of unknown or poorly known tropical insect species (Lewis & Basset 2007). Our ignorance of tropical insect diversity is immense - up to 95% of the multicellular species on Earth may remain unknown, and for most of the described species the only available information is basic data about the morphology and geographical origin of a few specimens (Stork 2007). Even less is known about species assemblages and biological communities and of the processes that shape them (Godfray *et al.* 1999).

Accompanying the alarming rates of species extinction is a severe loss of taxonomic knowledge and know-how; the so-called taxonomic impediment (Hoagland 1996). The number of active taxonomic specialists has decreased steadily the last 50 years, both among amateurs and professionals (Hopkins & Freckleton 2002; Wheeler 2004). Within the same time frame, however, the relevance of taxonomy has, if anything, increased! Firstly, our ignorance has been proven to be even more extensive than previously thought. This has been revealed both by new sampling methods (e.g. canopy fogging; Erwin 1982; Thunes *et al.* 2004) and methodological advances in species identification (e.g. use of DNA to resolve cryptic species complexes: Hebert *et al.* 2004; Smith *et al.* 2006). Just as notably, taxonomy provides an important basis for most other subdisciplines of biology, including but not limited to conservation biology (e.g. Dubois 2003; Mace 2004), forestry science (e.g. Eidt 1995), agricultural sciences (e.g. Rosen 1986), palaeoecology (e.g. Birks 1994), disease vector control (e.g. Brooks & Hoberg 2001; Van Bortel *et al.* 2001) and biomonitoring (e.g. Terlizzi *et al.* 2003).

In this thesis I am attacking one of the biggest unsolved science questions of our time – the magnitude and formation of tropical insect biodiversity. Following the recommendations of Godfray *et al.* (1999) and Gotelli (2004), I will do this using a combination of revisionary alpha taxonomy and statistical interpolation from species inventories. My focus group is the Psychodidae, a species-rich family of small, hairy flies with a near-cosmopolitan distribution.

In chapter 1, I provide a systematic context for the work; reviewing the diversity, morphology, systematics and classification of Psychodidae of the world. Six subfamilies Bruchomyiinae, Phlebotominae, Psychodinae, Sycoracinae, Trichomyiinae and Horaiellinae are recognised. The chapter gives an overview of their characteristics, species diversity and known biology. The chapter also includes a broad review of the morphological characters used in the taxonomy of Psychodidae with an emphasis on the most species-rich subfamily Psychodinae.

Chapter 2 catalogues the Afrotropical fauna of non-phlebotomine Psychodidae. A total of 175 species in 27 genera are listed, all with full bibliographic citations and distributional data. *Cryptotelmatoscopus* Vaillant, 1982 is placed as a subgenus of *Clogmia* Enderlein, 1935, **stat. nov.**; *Karakovounimerus* Ježek, 1990 is placed as a subgenus of *Panimerus* Eaton, 1904, **stat. nov.**; *Orgaoclogmia* Ježek & van Harten, 1996 is synonymised with *Cryptotelmatoscopus* Vaillant, 1982, **syn.nov.**; and *Rhipidopsychoda* Vaillant, 1991 is synonymised with *Threticus* Eaton, 1904 **syn.nov.** *Telmatoscopus flagellifer* Freeman, 1949, *Mormia soelii* Wagner & Andersen, 2007 and *Rhadinoscopus triangulatus* Wagner, 1979 are transferred to *Hemimormia* Krek, 1971, **comb.nov.**; *Orgaoclogmia caboverdeana* Ježek & van Harten, 1996 is transferred to *Clogmia* Enderlein, 1937, **comb.nov.**; *Telmatoscopus pilosternatus* Satchell, 1955 is transferred to *Mormopericomiella* Ježek & van Harten, 2002, **comb.nov.**; *Copropsychoda bulbosa* Ježek & van Harten, 2005, *Falsologima verrucosa* Ježek & van Harten, 2005, *Psychana rujumensis* Ježek & van Harten, 2005 and *Psychodocha khoralkhwairensis* Ježek & van Harten, 2009 are transferred to *Psychoda* Latreille, 1796 **comb.nov.**; and *Psychoda boettgeri* Wagner, 1979 is transferred to *Threticus* Eaton, 1904 **comb.nov.**

Chapter 3 investigates the habitats of Psychodidae in Budongo forest, Uganda, based on Malaise trap samples in the forest's four different vegetation types: Colonizing forest, mixed mature forest, *Cynometra alexandrei*-dominated climax forest and swamp forest. A total of 546 specimens were collected, of which 103 specimens of 38 morphospecies in eight genera could be identified. One of the genera appears to be new to science and five other genera are recorded for the first time from Uganda. The genus *Neotelmatoscopus* Tonnoir, 1933, is recorded for the first time from the Afrotropical region. The dominant genus both in species richness and in total abundance is *Psychoda*. The colonizing and mixed mature forest types had quite similar species assemblages and an apparently much higher diversity than both the swamp forest and the *Cynometra* forest. The results are briefly discussed and compared to a similar study in Brazil.

Chapter 4 is a review of the Afrotropical species of *Trichomyia* Haliday *in* Curtis, 1839. *Trichomyia piricornis* Freeman, 1949 and *Trichomyia congoensis* Satchell, 1956 are redescribed based on type material. *Trichomyia nodosa* Duckhouse, 1980, *Trichomyia dlinzae* Duckhouse, 1980 and *Trichomyia brochata* Quate, 1957 are diagnosed. *Trichomyia anderseni,* **sp.nov.,** *Trichomyia budongoensis* **sp.nov.,** *Trichomyia cornifera* **sp.nov.,** *Trichomyia cynometrae* **sp.nov.** and *Trichomyia telfordi* **sp.nov.** are described as new to science. A key to the males of Afrotropical *Trichomyia* is provided and the genus' biogeography and phylogeny is briefly discussed.

The results presented in this thesis are only a small step towards a more thorough understanding of Afrotropical Psychodidae diversity. As indicated in chapter 2, many taxa are in need of revision; notably *Threticus, Telmatoscopus s.l., Psychoda* and Mormiina. Chapter 3 makes it clear that taxonomy of female Psychodidae should be given priority – both exploring their morphology more closely both for genus- and species-level characters and associating females and males using e.g.

DNA techniques or rearing. As shown in chapter 4 the species groups of Afrotropical *Trichomyia* show a relatively clear biogeographic pattern, which can be tested through further sampling and phylogenetic studies of African and other *Trichomyia*.

Ecological questions worth pursuing further include the specific natural history of the immature stages of individual species, which would facilitate the search for autecological patterns in diversity. Furthermore, species inventories should be made along comparable land use gradients in other tropical sites, both in the Afrotropics and in other regions. Comparing and contrasting Psychodids with other semiaquatic decomposer taxa (e.g. Chironomidae: Orthocladiinae) could be interesting to see whether the observed patterns given in chapter 3 can be linked to feeding guilds.

DISCLAIMER

In line with the International Code of Zoological Nomenclature (ICZN) articles 8.2 and 8.3, this thesis is *not* published for nomenclatural purposes. The nomenclatural acts in this thesis are therefore not yet valid by ICZN criteria and should be considered mere suggestions rather than actual scientific names. The taxonomic decisions herein will be validated in later publications satisfying the criteria in ICZN art. 8.

REFERENCES

Birks, H. J. B. (1994) The importance of pollen and diatom taxonomic precision in quantitative palaeoenvironmental reconstructions. *Review of Palaeobotany and Palynology, 83*, 107-117.

Brooks, D. R. & Hoberg, E. P. (2001) Parasite systematics in the 21st century: opportunities and obstacles. *Trends in Parasitology, 17*, 273-275.

Dubois, A. (2003) The relationships between taxonomy and conservation biology in the century of extinctions. *Comptes Rendus Biologies, 326, supplement 1*, 9-21.

Eidt, D. C. (1995) The Importance of Insect Taxonomy and Biosystematics to Forestry. *Forestry Chronicle, 71*, 581-583.

Erwin, T. L. (1982) Tropical Forests: Their Richness in Coleoptera and Other Arthropod Species. *The Coleopterists Bulletin, 36*, 74-75.

Godfray, H. C. J., Lewis, O. T. & Memmott, J. (1999) Studying insect diversity in the tropics. *Philosophical Transactions of the Royal Society of London (B), 354*, 1811-1824.

Gotelli, N. J. (2004) A taxonomic wish-list for community ecology. *Philosophical Transactions of the Royal Society of London (B), 359*, 585-597.

Hebert, P. D. N., Penton, E. H., Burns, J. M., Janzen, D. & Hallwachs, W. (2004) Ten species in one: DNA barcoding reveals cryptic species in the neotropical skipper butterfly Astraptes fulgerator. *Proceedings of the National Academy of Sciences of the United States of America,* *101*, 14812-14817.

Hoagland, K. E. (1996) The taxonomic impediment and the Convention of Biodiversity. *Association of Systematics Collections Newsletter, 24*, 61-62, 66-67.

Hopkins, G. W. & Freckleton, R. P. (2002) Declines in the numbers of amateur and professional taxonomists: implications for conservation. *Animal Conservation, 5*, 245-249.

International Commission for Zoological Nomenclature (1999). International Code of Zoological Nomenclature. 4th edition. Available online from http://www.nhm.ac.uk/hosted-sites/iczn/code/, assessed august 16th 2011

Lewis, O. T. & Basset, Y. (2007) Insect Conservation in Tropical Forests. *In:* A. J. A. Stewart, T. R. New & O. T. Lewis (Eds), *Insect Conservation Biology*. Royal Entomological Society of London, London, pp. 34-56.

Mace, G. M. (2004) The role of taxonomy in species conservation. *Philosophical Transactions of the Royal Society of London (B), 359*, 711-719.

Pimm, S. L., Russell, G. J., Gittleman, J. L. & Brooks, T. M. (1995) The Future of Biodiversity. *Science, 269*, 347-350.

Rosen, D. (1986) The Role of Taxonomy in Effective Biological-Control Programs. *Agriculture Ecosystems & Environment, 15*, 121-129.

Sala, O. E., Chapin, F. S., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., et al. (2000) Global biodiversity scenarios for the year 2100. *Science, 287*, 1770-1774.

Smith, M. A., Woodley, N. E., Janzen, D. H., Hallwachs, W. & Hebert, P. D. N. (2006) DNA barcodes reveal cryptic host-specificity within the presumed polyphagous members of a genus of parasitoid flies (Diptera: Tachinidae). *Proceedings of the National Academy of Sciences of the United States of America, 103*, 3657-3662.

Stork, N. E. (2007) Biodiversity - World of insects. *Nature, 448*, 657-658.

Terlizzi, A., Bevilacqua, S., Fraschetti, S. & Boero, F. (2003) Taxonomic sufficiency and the increasing insufficiency of taxonomic expertise. *Marine Pollution Bulletin, 46*, 556-561.

Thunes, K. H., Skartveit, J., Gjerde, I., Starý, J., Solhøy, T., Fjellberg, A., et al. (2004) The arthropod community of Scots pine (Pinus sylvestris L.) canopies in Norway. *Entomologica Fennica, 15*, 65-90.

Van Bortel, W., Harbach, R. E., Trung, H. D., Roelants, P., Backeljau, T. & Coosemans, M. (2001) Confirmation of Anopheles varuna in Vietnam, previously misidentified and mistargeted as the malaria vector Anopheles minimus. *American Journal of Tropical Medicine and Hygiene, 65*, 729-732.

Wheeler, Q. D. (2004) Taxonomic triage and the poverty of phylogeny. *Proceedings of the Royal Society of London (B), 359*, 571-583.

Chapter 1

Introduction to the Psychodidae

The moth flies (Diptera: Psychodidae) are a species-rich family of small, fuzzy gnats found all over the world. Most known species are considered to be aquatic or semiaquatic, but the family exhibits a large and still poorly explored ecological diversity. About 2900 species are described this far, but as the fauna in most parts of the world remains poorly studied the actual number of species is clearly much higher (see Curler & Courtney 2009).

The only area that has been investigated thoroughly for moth flies is the West Palearctic, but even here new species are still discovered at a fairly regular rate (e.g. Withers 2003; Salmela & Piirainen 2005; Wagner & Schrankel 2005; Ježek 2006; Ježek & Hájek 2007; Beran *et al.* 2010). More research is clearly needed to improve our knowledge of Psychodid diversity. Wagner & Ibañez-Bernal (2009) estimate that the total world fauna may comprise as many as 20 000 species.

Most authors recognize the Psychodidae as a single family comprising six extant subfamilies: Bruchomyiinae, Phlebotominae, Psychodinae, Sycoracinae, Horaiellinae and Trichomyiinae. Some authors, however, treat the group as a superfamily Psychodoidea; comprising two families (e.g. Williams 1993, Azar *et al.* 1999). Under this scheme Phlebotomidae consists of the two subfamilies Bruchomyiinae and Phlebotominae while Psychodidae s.str. comprises the subfamilies Psychodinae, Horaiellinae, Sycoracinae and Trichomyiinae. As both views seem phylogenetically sound, choosing between them is a matter of personal taste.

Synapomorphies indicating that Psychodidae form a monophyletic group include dense vestiture of the body; antennae with membranous sensory filaments (ascoids); wing with reduced anal area; second basal cell and A_2 vein of wing shortened; distal part of wing without crossveins; reduction from 3 to 2 spermathecae in the female; and male genitalia inverted 180° (Hennig 1972; Quate & Vockeroth 1981). The sister group of the Psychodidae is less clear. Based on characters of the larval mouthparts, Wood & Borkent (1989) suggested that the moth flies' closest relatives are a clade comprising the families Trichoceridae, Anisopodidae, Scatopsidae, Synneuridae and Perissomatidae. Oosterbroek & Courtney (1995) analysed an expanded morphological data set and resolved Psychodidae as the sister grup to a clade consisting of Tipulomorpha, Anisopodidae and

Brachycera. Molecular data suggest a close relationship with Tanyderidae (Bertone *et al.* 2008); a relationship which has long been suspected but without any clear morphological synapomorphies (e.g. Hennig 1972, 1973 cited in Oosterbroek & Courtney 1995).

Because of the morphological and structural diversity within the Psychodidae, each of the six subfamilies are presented separately below.

MORPHOLOGY

The present account is meant as an introduction to the general morphology of psychodid flies, with an emphasis on the Psychodinae. Only adult stages are treated here; for information on the larvae see e.g. Tonnoir (1933), Keilin & Tate (1937), Satchell (1947, 1949, 1953), Vaillant (e.g. 1959, 1963, 1971), Duckhouse (1985, 1994), Mahmood & Alexander (1992) and Leite & Williams (1996). Some aspects of the pupae are treated by e.g. Vaillant (1971), Satchell (1948), Leite *et al.* (1991) and Curler & Courtney (2009).

Morphological terminology varies slightly between different authors. The present work follows Curler & Courtney (2009).

Head (Figs 1.1-1.3)

The taxonomically most important parts of the head are the eyes, the antennae and the mouthparts. The shape and chaetotaxy of the frons (e.g. the *frontal scar patch*; the arrangement of hair scars on the frons), the vertex and the clypeus are occasionally also of some value. In some groups, there are also some accessory organs (e.g. *corniculi*) that are taxonomically useful.

In most Psychodinae the eyes are extended between frons and vertex, creating an eyebridge (Fig. 1.1). The width and extent of this bridge is often an important taxonomic character. Other subfamilies lack this eyebridge completely (e.g. Fig. 4.4).

The sclerotized inner parts surrounding the pharynx, especially the *cibarium*, have been proven useful as a systematic character especially in the Phlebotominae, but has been less used in other subfamilies (Quate 1962).

In some groups the terminal lobes of the labium, called the *labellum*, are of importance. In most Psychodidae these are fleshy and distinctly bulbous. However, in Phlebotominae and Psychodinae: Psychodini they are modified (Quate 1959). The appearance of the labrum and the maxillae seem rather uniform throughout the family. The maxillary palps primitively consist of five segments called *palpomeres*, but in most subfamilies this number is reduced to four (in Psychodinae, Sycoracinae, some Trichomyiinae) or three segments (Horaiellinae, some Trichomyiinae). Functional mandibles are only present in Phlebotominae, Sycoracinae and possibly Horaiellinae.

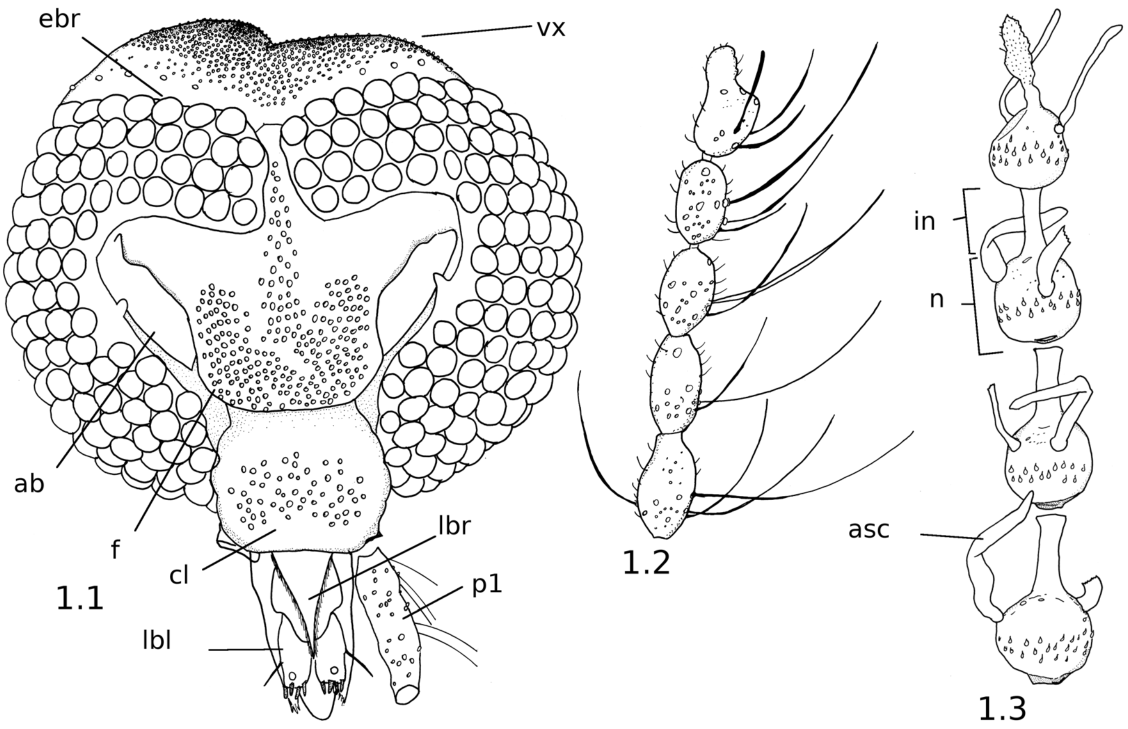

Fig. 1.1-1.3. Morphology of Psychodidae I. (1.1) *Psychoda terskolina* Vaillant & Joost, 1983: Head; (1.2) *Pericoma nielseni* Kvifte, 2010: Flagellomeres 10-14 (fusiform); (1.3) *Telmatoscopus* sp.n.1, Uganda: Flagellomeres 11-14 (nodiform). ab – antennal basis, asc – ascoid, cl – clypeus, ebr – eyebridge, f – frons, in – internode, lbl – labellum, lbr – labrum, n – node, p1 – first palpomere, vrt – verticil, vx – vertex

The antennae of the Psychodidae are divided into three parts: The scape, the pedicel and a flagellum consisting of between 8 and 111 flagellomeres. The vast majority of species have 12-14 flagellomeres. The first flagellomere is occasionally called the *postpedicel,* especially in groups where this segment has a different shape than the other flagellomeres. The distalmost flagellomeres sometimes carry tubercles, spines or other structures of taxonomic value.

A feature unique to the Psychodidae is the presence of *ascoids* – hyaline sensory organs carried on the flagellomeres. The most simple ascoids are digitiform or filamentose, but a large range of variation exists for this character with modifications in branching and/or flattening being the most common changes. Additional types of sensillae are also common in many genera, most conspicuosly the so-called «bullseye organs» in some Mormiini (Vaillant 1974, p. 132) and the postpedicel spines of many Pericomaini. Less conspicuous sensillae have also been found; in a recent study of the antennae of *Psychoda* s.l., Faucheux & Gibernau (2011) detected no less than seven types of antennal sensillae.

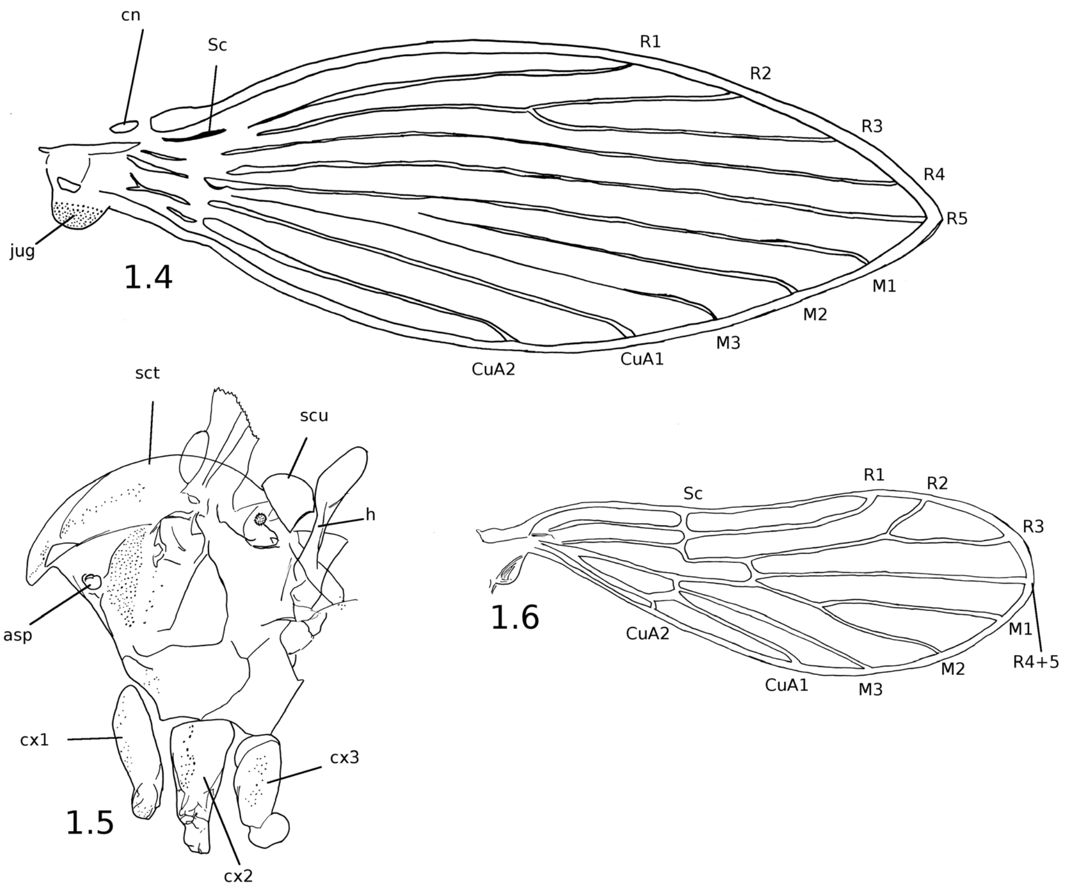

Fig. 1.4-1.6. Morphology of Psychodidae II. (1.4) *Threticus* sp.n.1, Uganda: Wing; (1.5) *Telmatoscopus* sp.n.1, Uganda: Thorax; (1.6) *Sycorax* sp. near *malayensis* Quate, Malaysia: Wing. asp – anterior spiracle, cn – costal node, CuA – cubital / anal veins, cx – coxa, h – haltere, jug – jugum, M – medial veins, R – radial veins, Sc – subcosta, sct – scutum, scu – scutellum.

Thorax (Fig. 1.5)

Few systematic characters are found in the thorax. Some characteristics common for the group include a straight transverse suture in the scutum and the metanotum protruding into the abdomen. The pteropleurites show some variation especially within the Psychodinae and have been suggested as an important character in tribal classification of this subfamily (Ježek 1984).

Some groups within the Psychodinae have developed more or less elaborate organs on the meso- and metanotum. They are most properly called *allurement organs*, although many authors use the Lepidopteran morphological terms *patagia* and *tegulae* instead (Duckhouse 1990). For most taxa the function of these organs is not clear. However, in the European species *Ulomyia fuliginosa* (Meigen, 1804) the anterior mesothoracal allurement organ is involved in secretion of pheromones (Elger 1981).

Wing (Figs 1.4, 1.6)

The ground-plan wing has 10 veins reaching the margin. Five of these are branches of the radial vein (R), three are branches of the medial vein (M) and two are of the cubital vein (CuA). In the subfamilies Sycoracinae, Trichomyiinae and Horaiellinae, the R vein has only four branches (e.g. Fig. 1.6). Also, there is a costal vein (C) surrounding the wing and a reduced subcostal vein (Sc) at the wing basis. The subfamily Psychodinae have a well-developed triangular lobe at the base of the wing; this is occasionally misnamed an *alula,* but is properly called the *neala* or *jugum*.

The wing forks are composed of veins R_2+R_3 (the *R-fork*) and M_1+M_2 (the *M-fork*). They are present in all Psychodidae wings, although they sometimes are incomplete at their bases. Their relative placement to each other and to CuA_2 are in much use as taxonomic characters.

Usually, Psychodid wings and bodies are covered in hair-like scales. Some groups have hairs on the wing membrane, but most moth flies have hairs confined to the wing veins only. The colour patterns formed by these hairs are presumably species-specific, but as the hairs tend to break loose in alcohol preserved material they are not much used as taxonomic characters.

Abdomen and terminalia (Fig. 1.7)

The abdomen consists of 9 sternites and 10 tergites, abbreviated S1-9 and T1-10. The terminal part including the genitalia is inverted 180 degrees in all taxa except the Sycoracine genera *Sycorax* Haliday *in* Curtis, 1839 and *Parasycorax* Duckhouse, 1972.

The male genitalia (Fig. 1.7) carry many of the most important systematic characters within the group, both on species level and in higher classification. They consist of the sternite 9 and tergites 9 and 10 with their appendages; which for all groups include the *gonopods*. Sternite 9 is usually present as a narrow band above the gonopods, called the *hypandrium*.

Primitively, the Psychodidae have a gonopod with two segments: a *gonocoxite* and a *gonostylus.* A few taxa have one or two additional appendages (see e.g. Duckhouse 1978 and chapter 4, this volume). The gonocoxite is articulated posteriorly to the gonostylus and is often expanded basally. On the inner surface of the gonocoxite, its expansions are called the anterior and posterior *gonocoxal apodeme,* respectively (Quate & Brown 2004). In this volume I have adopted the term *outer gonocoxal apodeme* for the ventral (morphologically dorsal) anterior gonocoxal expansions seen in many taxa. The gonocoxal apodeme of Quate & Brown (2004) is thus labelled the *inner gonocoxal apodeme*.

The copulatory organ of the male – the *aedeagus* – is divided into a *basiphallus* (occasionally called an *aedeagal apodeme, ejaculatory apodeme* or *phallapodeme*), a *distiphallus* and a *subgenital plate*. The distiphallus primitively consists of a symmetrical pair of *phallomeres* which often are called *distiphalli*. In many taxa these are fused or secondarily asymmetrical. The phallomeres are often flanked by paired *gonapophyses* and paired or unpaired *parameres.* In some groups, the

1.7

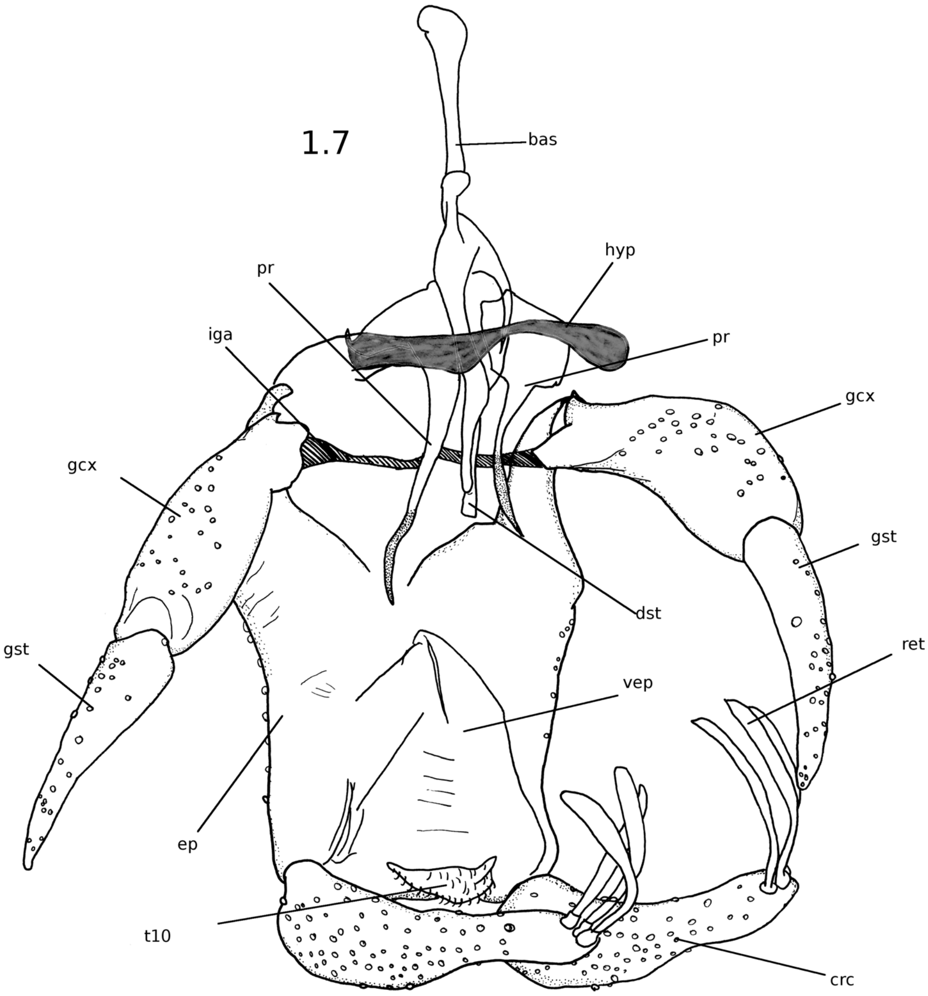

Fig. 1.7. Morphology of Psychodidae III. (1.7) *Threticus* sp.n.1, Uganda: Male genitalia. bas – basiphallus, crc – cercopod, dst – distiphalli, ep – epandrium, gcx – gonocoxite, gst – gonostylus, hyp – hypandrium, iga – inner gonocoxal apodeme, pr – paramere, ret – retinaculum, t10 – The 10th tergite, vep – ventral epandrial plate

parameres form a phallic sheath around the distiphalli. Additional parts of the aedeagus include the *furca* of many Psychodinae: Paramormiini, which articulates the aedeagus to the ventral epandrial plate (Duckhouse 1987).

Tergite 9 is called the *epandrium* and carries on its dorsal surface a *ventral epandrial plate* (ventral prior to genital rotation; Duckhouse (1987)). Posteriorly the ventral epandrial plate articulates with the 10th tergite and the cerci. In Psychodinae, the cerci are modified to form *cercopods*, carrying from 1 to over 100 *retinaculae* usually at their apex. The shape and number of retinaculae is taxonomically important, although intraspecific variation in number is not uncommon in many groups.

The female genitalia of Psychodidae are insufficiently explored for most taxa, with the exception of the Phlebotominae (Curler & Courtney 2009). Vaillant (1971) redescribes the female *Clogmia albipunctata* (Williston, 1893) in considerable detail, and Sæther (1977) illustrates two species of *Psychoda* Latreille, 1796. Still, a review of female genital morphology would be desireable in most Psychodid groups.

CLASSIFICATION

Bruchomyiinae Alexander, 1920

The Bruchomyiinae are often considered to be the most primitive group of Psychodidae, based on plesiomorphies in the wing venation, antennae, mouthparts and lack of eyebridges (Quate & Alexander 2000). The group comprises 41 extant species in tropical and subtropical parts of the world, with most species known from the Neotropical Region (Williams 2003; Wagner 2006; Santos *et al.* 2009b). Three genera *Bruchomyia* Alexander, 1920, *Nemapalpus* Macquart, 1838 and *Eutonnoiriella* Alexander, 1940 are recognized. However, it is likely that at least *Nemapalpus* as presently defined is an artificial assemblage (Quate & Alexander 2000).

Rarely collected, adult Bruchomyiines seem to be mostly restricted to moist forests. *Nemapalpus ledgeri* Stuckenberg, 1978 and *N. davidsoni* Stuckenberg, 1978 were, however collected in the nests of rock hyraxes, *Procavia capensis* (Pallas, 1766), in an arid savanna landscape (Stuckenberg 1978). Immature stages of two species have been described, but their biology remains poorly known (Mahmood & Alexander 1992). A *Nemapalpus* species in New Zealand was found to develop in rotting wood (Duckhouse 1980), and Williams (2003) mentions larvae and pupae in association with ant colonies.

Synapomorphic characters for the Bruchomyiinae include the reduction from two to one spermatheca in the female and from two to one genital opening in the male, as well as non-functional mouthparts in both sexes (Hennig 1972; Wagner 2006). Other characteristic features include the long legs and slender body; maxillary palp with five segments; Sc connected to R_1 and often C; CuA_1, CuA_2 and CuA_3 elongated and gonostyles without thorns (Duckhouse 1965; Wagner 2006). Another possible apomorphy for the clade is a tendency to duplicate antennal segments – whereas *Nemapalpus* has 16 flagellomeres, *Bruchomyia* has around 30 and *Eutonnoiriella* as many as 111 (Williams 2003)! The subfamily has been suspected to be paraphyletic (Fairchild 1955; cited in Hennig 1972), but is now usually regarded as the monophyletic sister group of the Phlebotominae (Hennig 1972; Azar *et al.* 1999; Curler 2009).

Undisputed fossil Bruchomyiinae are from Baltic and Dominican amber; both of which are of Tertiary age (Wagner 2006). In addition, the Jurassic wing fossil *Dacochile microsoma* Poinar & Brown, 2004 has been suggested as a possible member of the group (Woodley 2005).

Phlebotominae Rondani, 1840

More study has been devoted to the Phlebotominae than to all the other Psychodid subfamilies combined. This is due to their medical importance; around 70 species in the genera *Lutzomyia* França, 1924 and *Phlebotomus* Rondani & Berte *in* Rondani, 1840 are important vectors of pathogenic protozoans such as *Leishmania* (Williams 1993; Azar & Nel 2003). Until recently, the Phlebotominae was considered to consist of six extant genera (e.g. Williams 1993). The group has, however, been the focus of several large-scale phylogenetic studies (e.g. Galati 1995; Rispail & Leger 1998) and is currently classified in 31 genera and 35 subgenera (Marcondes 2007).

Phlebotominae are terrestrial breeders with larvae feeding on damp organic matter (Azar & Nel 2003). The larvae are difficult to find in the field, but have been studied in laboratory cultures. Adults of both sexes feed on nectar and honeydew; females additionally feed on vertebrate blood (Azar & Nel 2003).

Synapomorphies of the Phlebotominae include a complete reduction of A_1; the partition of tergite 9 into two long lateral lobes in the male; gonostylus pointed towards T9 and carrying characteristic thorns; and sperm pump without connection to aedeagus (Hennig 1972). Additional characteristics include the slender general appearance, the functional mandibles and maxillae of the female, the five-segmented palp and the elongated proboscis (Williams 1993).

The fossil record of Phlebotominae dates back to the early Cretaceous (e.g. Hennig 1972; Azar *et al.* 1999), and several extant genera are known from Mexican, Dominican and Baltic ambers (Hennig 1972; Poinar 2008). Distributional data, however, point to the phlebotomines as an older group even than this (Ilango 2010). The oldest documented association with parasitic protozoans is from Burmese amber, believed to be from the late Cretaceous (Poinar 2004).

Psychodinae Newman, 1834

The Psychodinae are a highly derived group containing the majority of Psychodid species diversity. About 2000 species have been described in about 100 genera distributed all over the world (Wagner *et al.* 2008). No satisfactory system of classification has yet been developed, and different authors often follow widely different generic and tribal concepts (e.g. Vaillant 1971; Duckhouse 1987; Ježek & van Harten 2005).

The ecology of Psychodinae was summarised by Vaillant (1971), who classified them into 11 functional groups based on habitats. Most species are freshwater detritivores, but there are also species found in fungal fruit bodies, leaf litter and compost, decaying wood, dead snails and vertebrate faeces. A few species are opportunistic myiasis agents, but confirmed cases of this are rare (Smith & Thomas 1979; Taylan-Ozkan *et al.* 2004; Tu *et al.* 2007).

The Psychodinae exhibit a number of synapomorphic characters including a well developed eyebridge (secondarily lost in some genera); reduced mouthparts; both basal cells of wings shortened; a triangular neala at wing bases; cerci of males modified into cercopods carrying retinaculae; gonopods directed at cercopods; tergite 9 fused with sternite 9 to form a ring; sessile spermathecae and elongated cerci present in the females; the larvae with 1-segmented antennae and breathing tube and pupae with basal part of prothoracal horn moveable (Hennig 1972).

Whereas the monophyly of the subfamily is well established, its relationships with other subfamilies remains unclear. Hennig (1972) and Azar *et al.* (1999), based on morphology of mainly fossil species, suggested a clade Trichomyiinae+Sycoracinae+Horaiellinae to be the sister group of the Psychodinae. On the other hand, Curler (2009) found the sister group to be Bruchomyiinae based on morphology of all life stages, and either Trichomyiinae or Trichomyiinae+Horaiellinae based on molecular phylogenies.

Fossil Psychodinae are found in many amber deposits, but remain poorly studied (Evenhuis 1994). A molecular clock analysis based on European species suggested the major radiations in the group to have taken place around 85 million years ago (Espindola 2010). There are, however several reasons to doubt this result as the mitochondrial markers used were putatively saturated and because only European species were included (Espindola 2010). An older age is also suggested by Gondwanan distributions in e.g. the Maruinini (Duckhouse 1990).

Sycoracinae Jung, 1954

The Sycoracinae is a species-poor group, consisting of only 36 described extant species (Santos *et al.* 2009a; Bravo *et al.* 2010). Although sometimes considered monogeneric (Ježek 1999), most authors recognise 3 genera in the subfamily (Duckhouse 1972; Santos *et al.* 2009a). The group has a near cosmopolitan distribution, lacking only in North America.

Females of many species have been found to be haematophagous on amphibians, and the European *Sycorax silacea* Haliday *in* Curtis, 1839 is a vector for microfilarial worms (Desportes 1941; Bravo & Salazar-Valenzuela 2009). Known immature stages are small and aselliform and are found in aquatic mosses or leaf litter (Duckhouse 1972; Wagner 1997).

Proposed synapomorphic characters of Sycoracines include a shortened CuA_2; sternites of the eight abdominal segment of the female present as a narrow ring separated from S9 and hypopygium of male not inverted relative to body axis (Duckhouse 1972). Other characteristic features include developed mandibles in females; R with four branches; basal cell elongated; palp with four segments and gonostylus with a terminal spine (Duckhouse 1972). Most of these non-unique characters are plesiomorphic in the Psychodidae, except the 4-branched R which may or may not be indicative of a relationship with Trichomyiinae. This relationship was hypothesised by Hennig (1972), and was also recovered in an 18S molecular study by Curler (2009). Other molecular analyses have, however, failed to replicate this result (Curler 2009).

The oldest Sycoracine fossils date back to the Cretaceous, and it is generally believed that the group's current diversity is much lower than it was in the past (Azar *et al.* 2007).

Trichomyiinae Tonnoir, 1922

The Trichomyiinae form an ancient and heterogenous group consisting of around 100 described extant species (Bravo 1999). It is cosmopolitan in distribution, with species being found on all continents except Antarctica. The only extant genus is *Trichomyia* Haliday *in* Curtis, 1839; which has not yet been satisfactorily subdivided. Tentative classifications divide it into a «group A» and a «group B» (Duckhouse 1965) and/or into six subgenera (Bravo 2001).

The larvae of several Trichomyiinae have been found to be xylophagous (Keilin 1914; Duckhouse 1978), and it has been speculated that most or all species live this way (Wagner 1982). The adults are often rare in collections, but this is due to inappropriate collecting methods more than actual rarity in nature (Duckhouse 1978). Males of many species are attracted to light and are best collected using light traps (Duckhouse 1978).

Apomorphic characters characterising Trichomyiinae include annulated spermathecal ducts with cup-like sceroterisations connected to the spermathecae and the larva's adaptations to terrestrial, xylophagous feeding (Keilin & Tate 1937; Duckhouse 1980). Other characteristics include reduced mouthparts; palps with three or four segments; the inner part of the first or second palp segment with a group of sensillae; R with four branches; CuA_2 long and cerci similar in males and females (Duckhouse 1972; Hennig 1972; Wagner 1982).

About 20 fossil species of Trichomyiinae are known, belonging to the genera *Trichomyia*, *Eatonisca* Meunier, 1905 and *Eotrichomyia* Nel, Menier & De Ploëg, 2002 (Lak *et al.* 2008). The oldest *Trichomyia* species known is from Cretaceous French amber, but the Gondwanan and Transantarctic distribution of some groups are suggestive of an even older age (Duckhouse 1972, 1980).

Horaiellinae Enderlein, 1936

The subfamily Horaiellinae was erected for the single genus *Horaiella* Tonnoir, 1933, and is known from four obscure species from India, China and Thailand (Curler *et al.* 2006). Like the Sycoracinae and the Trichomyiinae it has R with four branches, but whereas R_4 and R_5 are fused in these subfamilies, *Horaiella* has a fusion between R_2 and R_3 (Hennig 1972). As in the Sycoracinae and the Phlebotominae, the female has functional mouthparts. This is, however, most likely a plesiomorphic condition.

Larval Horaiellinae live in fast-flowing streams and in the splash zones of waterfalls. For attachment, they have large ventral suckers similar to those of the Psychodine genera *Maruina* Müller, 1895, *Neotelmatoscopus* Tonnoir, 1933 and *Neomaruina* Vaillant, 1963. However this similarity is surely superficial (Duckhouse 1985).

REFERENCES

Azar, D. & Nel, A. (2003) Fossil psychodid flies and their relation to parasitic diseases. *Memórias do Instituto Oswaldo Cruz, 98*, 35-37.

Azar, D., Nel, A., Solignac, M., Paicheler, J.-C. & Bouchet, F. (1999) New Genera and Species of Psychodoid Flies from the Lower Cretaceous Amber Lebanon. *Palaeontology, 42*, 1101-1136.

Azar, D., Tahchy, A. & Perrichot, V. (2007) The oldest Sycoracinae (Diptera: Psychodidae) from the French Cretaceous amber. *Alavesia, 1*, 5-10.

Beran, B., Doczkal, D., Pfister, K. & Wagner, R. (2010) Two new species of Psychodidae (subfamilies Trichomyiinae and Psychodinae) from Germany associated with decaying wood. *Zootaxa, 2386*, 59-64.

Bertone, M. A., Courtney, G. W. & Wiegmann, B. M. (2008) Phylogenetics and temporal diversification of the earliest true flies (Insecta: Diptera) based on multiple nuclear genes. *Systematic Entomology, 33 (4)*, 668-687.

Bravo, F. (1999) *Septemtrichomyia*, Subgênero Novo de Trichomyiinae Neotropical (Diptera, Psychodidae). *Revista Brasileira de Entomologia, 43*, 1-7.

Bravo, F. (2001) *Opisthotrichomyia*, Subgênero novo de Trichomyiinae (Diptera, Psychodidae) e descrição de três novas espécies do Brasil. *Sitientibus Série Ciências Biológicas, 1*, 50-55.

Bravo, F., de Souza Rocha, L. & Santos, C. B. d. (2010) A new species of *Sycorax* (Diptera: Psychodidae: Sycoracinae) from the Brazilian Atlantic Forest. *Zoologia, 27*, 834-836.

Bravo, F. & Salazar-Valenzuela, D. (2009) A new species of *Sycorax* Curtis (Diptera, Psychodidae, Sycoracinae) collected on harlequin frogs (Anura: Bufonidae, *Atelopus*) in the Ecuadorian Andes. *Zootaxa, 2093*, 37-42.

Curler, G. R. (2009) *Morphological and Molecular Systematics of Psychodidae (Diptera)*. University of Tennessee: PhD thesis.

Curler, G. R. & Courtney, G. W. (2009) A revision of the world species of the genus *Neotelmatoscopus* Tonnoir (Diptera: Psychodidae). *Systematic Entomology, 34 (1)*, 63-92.

Curler, G. R., Phasuk, J., Chanpaisaeng, J. & Courtney, G. W. (2006) A new species of *Horaiella*

Tonnoir (Diptera: Psychodidae) from Thailand. *Proceedings of the Entomological Society of Washington, 108*, 519-524.

Desportes, C. (1941) *Forcipomyia velox* Winn et *Sycorax silacea* Curtis, vecteurs d'*Icosiella neglecta* (Diesing, 1850) filaire commune de la grenouille verte. *Annals de Parasitologie Humaine et Compareè, 19*, 53-68.

Duckhouse, D. A. (1965) Psychodidae (Diptera, Nematocera) of Southern Australia, subfamilies Bruchomyiinae and Trichomyiinae. *Transactions of the Royal Entomological Society of London, 117*, 329-343.

Duckhouse, D. A. (1972) Psychodidae (Diptera, Nematocera) of South Chile, subfamilies Sycoracinae and Trichomyiinae. *Transactions of the Royal Entomological Society of London, 124*, 231-268.

Duckhouse, D. A. (1978) Taxonomy, phylogeny and distribution of the genus *Trichomyia* (Diptera, Psychodidae) in Australia and New Guinea. *Systematic Entomology, 3*, 197-243.

Duckhouse, D. A. (1980) *Trichomyia* species (Diptera, Psychodidae) from southern Africa and New Zealand, with a discussion of their affinities and the concept of monophyly in Southern Hemisphere biogeography. *Annals of the Natal Museum, 24*, 177-191.

Duckhouse, D. A. (1985) A re-examination of *Neomaruina* (Diptera, Psychodidae), with observations on its life-history and affinities and redefinition of the tribe Psychodini. *Annals of the Natal Museum, 26 (2)*, 601-620.

Duckhouse, D. A. (1987) A revision of Afrotropical *Setomima*, elucidation of their genealogical relationships and descriptions of other Afrotropical Psychodinae (Diptera: Psychodidae). *Annals of the Natal Museum, 28*, 231-282.

Duckhouse, D. A. (1990) The Australasian Genera of Pericomoid Psychodidae (Diptera) and the Status of Related Enderlein Genera in the Neotropics. *Invertebrate Taxonomy, 3*, 721-746.

Duckhouse, D. A. (1994) The final-stage larvae of *Brunettia* (Diptera: Psychodidae: Psychodinae) and their evolutionary significance. *Invertebrate Systematics, 9*, 83-105.

Elger, M. (1981) The ultrastructure of special epidermal organs in Psychodidae (Diptera) 1. Appendages on the mesothorax of male *Ulomyia fuliginosa* (Meigen). *Acta Zoologica (Copenhagen), 62*, 1-16.

Espindola, M. A. (2010) *Inferring reciprocal evolutionary histories in associated species of plants and insects in two European pollination systems*: PhD thesis, Université de Neuchâtel.

Evenhuis, N. L. (1994) *Catalogue of the fossil flies of the world (Insecta: Diptera)*. Leiden: Backhuys Publishers.

Fairchild, G. B. (1955) The relationships and classification of the Phlebotominae (Diptera, Psychodidae). *Annals of the Entomological Society of America, 48*, 182-196.

Faucheux, M. J. & Gibernau, M. (2011) Antennal sensilla in five Psychodini moth flies (Diptera: Psychodidae: Psychodinae) pollinators of *Arum* spp. *Annales de la Société Entomologique de France, 47*, 89-100.

Galati, E. A. B. (1995) Phylogenetic systematics of the Phlebotominae (Diptera: Psychodidae) with emphasis on American groups. *Boletin de la Direción de Malariología y Saneamento Ambiental, 43*, 133-142.

Hennig, W. (1972) Insektenfossilien aus der unteren Kreide IV. Psychodidae (Phlebotominae), mit einer kritischen Übersicht über das phylogenetische System der Familie und die bisher beschriebenen Fossilien (Diptera). *Stuttgarter Beiträge zur Naturkunde, 241*, 1-69.

Ilango, K. (2010) Radiation of the Oriental phlebotomine sand flies (Diptera: Psychodidae). *Insect Science, Early view*, doi:10.1111/j.1744-7917.2010.01378.x.

Ježek, J. (1984) Six new genera of the tribe Psychodini End. (Diptera, Psychodidae). *Acta Faunistica Entomologica Musei Nationalis Pragae, 17*, 133-153.

Ježek, J. (1999) Comments on the correct grammatic gender of *Sycorax* Curt. and *Philosepedon* Eat. (Diptera: Psychodidae) with world catalogue. *Dipterologica bohemoslavica, 9*, 83-87.

Ježek, J. (2006) Psychodidae (Diptera) of the Jeseníky Protected Landscape Area and its environs with descriptions of two new *Berdeniella* species from the Czech Republic. *Acta Entomologica Musei Nationalis Pragae, 46*, 151-192.

Ježek, J. & Hájek, J. (2007) Psychodidae (Diptera) of the Orlické hory Protected Landscape Area and its environs with descriptions of two new species from the Czech Republic. *Acta Entomologica Musei Nationalis Pragae, 47*, 237-285.

Ježek, J. & van Harten, A. (2005) Further new taxa and little-known species of non-biting moth flies (Diptera, Psychodidae) from Yemen. *Acta Entomologica Musei Nationalis Pragae, 45*, 199-220.

Keilin, D. (1914) Sur la biologie d'un Psychodide a Larve xylophage *Trichomyia urbica* CURTIS (Diptère). *Comptes Rendus Hebdomaire des Seances et Memoires de la Societe de Biologie, 76*, 434-437.

Keilin, D. & Tate, P. (1937) A comparative account of the larvae of *Trichomyia urbica* Curtis, *Psychoda albipennis* Zett., and *Phlebotomus argentipes* Ann. & Brun. (Diptera, Psychodidae). *Parasitology, 29*, 247-258.

Lak, M., Azar, D., Nel, A., Néraudeau, D. & Tafforeau, P. (2008) The oldest representative of the Trichomyiinae (Diptera: Psychodidae) from the Lower Cenomanian French amber studied with phase contrast synchrotron X-ray imaging. *Invertebrate Systematics, 22*, 471-478.

Leite, A. C. R. & Williams, P. (1996) Description of the fourth instar larva of *Lutzomyia longipalpis*, under scanning electron microscopy. *Memórias do Instituto Oswaldo Cruz, 91*, 571-578.

Leite, A. C. R., Williams, P. & Dossantos, M. C. (1991) The Pupa of *Lutzomyia longipalpis* (Diptera, Psychodidae - Phlebotominae). *Parassitologia, 33, Suppl. Dec. 1991*, 477-484.

Mahmood, F. & Alexander, B. (1992) Immature stages of *Nemapalpus nearcticus* (Diptera: Psychodidae). *The Florida Entomologist, 75*, 171-178.

Marcondes, C. B. (2007) A proposal of generic and subgeneric abbreviations for phlebotomine sandflies (Diptera: Psychodidae: Phlebotominae) of the World. *Entomological News, 118*, 351-356.

Oosterbroek, P. & Courtney, G. (1995) Phylogeny of the nematocerous families of Diptera (Insecta). *Zoological Journal of the Linnean Society, 115*, 267-311.

Poinar, G., Jr. (2004) *Palaeomyia burmitis* (Diptera: Phlebotomidae), a new genus and species of Cretaceous sand flies with evidence of blood-sucking habits. *Proceedings of the Entomological Society of Washington, 106*, 598-605.

Poinar, G., Jr. (2008) *Lutzomyia adiketis* sp. n. (Diptera: Phlebotomidae), a vector of *Paleoleishmania neotropicum* sp. n. (Kinetoplastida: Trypanosomatidae) in Dominican amber. *Parasites & Vectors, 1*, 1-8.

Quate, L. W. (1959) Classification of the Psychodini (Psychodidae: Diptera). *Annals of the Entomological Society of America, 52*, 444-451.

Quate, L. W. (1962) A taxonomic study of Borneo Psychodidae (Diptera: Psychodidae). *Pacific Insects, 4*, 1-75.

Quate, L. W. & Alexander, J. B. (2000) Synopsis of the New World *Nemapalpus* (Diptera, Psychodidae, Bruchomyiinae) with description of four new species. *Annals of the Entomological Society of America, 93*, 185-193.

Quate, L. W. & Brown, B. V. (2004) Revision of Neotropical Setomimini (Diptera: Psychodidae: Psychodinae). *Contributions in Science, 500*, 1-117.

Quate, L. W. & Vockeroth, J. R. (1981) Psychodidae. *In:* J. F. McAlpine, B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth & D. M. Wood (Eds), *Manual of Nearctic Diptera Vol.1*. Biosystematics Research institute, Ottawa, pp. 293-300.

Rispail, P. & Leger, N. (1998) Numerical taxonomy of Old World Phlebotominae (Diptera: Psychodidae). 2. Restatement of classification upon subgeneric morphological characters. *Memórias do Instituto Oswaldo Cruz, 93*, 787-793.

Salmela, J. & Piirainen, T. (2005) Description of a new Psychodidae (Diptera) species from Estonia. *Entomologica Fennica, 16*, 301-304.

Santos, C. B., Ferreira, A. L. & Bravo, F. (2009a) Taxonomy of the genus *Parasycorax* Duckhouse (Diptera, Psychodidae, Sycoracinae), with description of a new species from Brazil. *Zootaxa, 2174*, 63-68.

Santos, C. B. d., Falqueto, A. & Alexander, B. (2009b) Description of three new species of

Nemapalpus (Diptera, Psychodidae, Bruchomyiinae) from Atlantic Forest in southeastern Brazil. *Zootaxa, 2264*, 58-64.

Satchell, G. H. (1947) The Larvae of the British Species of *Psychoda* (Diptera, Psychodidae). *Parasitology, 38*, 51-69.

Satchell, G. H. (1948) The Respiratory Horns of *Psychoda* Pupae (Diptera, Psychodidae). *Parasitology, 39*, 43-52.

Satchell, G. H. (1949) The early stages of the British species of *Pericoma* Walker. (Diptera: Psychodidae). *Transactions of the Royal Entomological Society of London, 100,* 411-477.

Satchell, G. H. (1953) On the early stages of *Bruchomyia argentina* Alexander (Diptera, Psychodidae). *Proceedings of the Royal Entomological Society of London (A), 28*, 1-12.

Smith, K. G. & Thomas, V. (1979) Intestinal myiasis in man caused by larvae of *Colgmia* [sic!] (= *Telmatoscopus*) *albipunctatus* Williston (Psychodidae, Diptera). *Transactions of the Royal Society of Tropical Medicine and Hygiene, 73*, 349-350.

Stuckenberg, B. R. (1978) Two new species of *Nemopalpus* (Diptera, Psychodidae) found in rock hyrax abodes in South West Africa. *Annals of the Natal Museum, 23*, 367-374.

Sæther, O. A. (1977) Female genitalia in Chironomidae and other Nematocera: morphology, phylogenies, keys. *Bulletin of the Fisheries Research Board of Canada, 197*, 1-211.

Taylan-Ozkan, A., Babur, C., Kilic, S., Nalbantoglu, S., Dalkilic, I. & Mumcuoglu, K. Y. (2004) Urogenital myiasis caused by *Psychoda albipennis* (Diptera: Nematocera) in Turkey. *International Journal of Dermatology, 43*, 904-905.

Tonnoir, A. L. (1933) Descriptions of remarkable Indian Psychodidae and their early stages, with a theory of the evolution of the ventral suckers of Dipterous larvae. *Records of the Indian Museum, 35*, 53-75.

Tu, W. C., Chen, H. C., Chen, K. M., Tang, L. C. & Lai, S. C. (2007) Intestinal myasis caused by larvae of *Telmatoscopus albipunctatus* in a Taiwanese man. *Journal of Clinical Gastroenterology, 41*, 400-402.

Vaillant, F. (1959) The larvae of Three Nearctic Diptera of the Family Psychodidae. *Journal of the New York Entomological Society, 67*, 39-50.

Vaillant, F. (1963) An African psychodid larva with ventral suckers (Diptera, Psychodidae). *Bulletin de la Société Entomologique de France, 68*, 71-91.

Vaillant, F. (1971) Psychodidae - Psychodinae. *In:* E. Lindner (Ed), *Die Fliegen der Palaearktischen Region. Lief. 287*. E. Schweizerbart'scheVerlagsbuchhandlung, Stuttgart, pp. 1-48.

Vaillant, F. (1974) Psychodidae - Psychodinae. *In:* E. Lindner (Ed), *Die Fliegen der Palaearktischen Region. Lief. 305*. E. Schweizerbart'scheVerlagsbuchhandlung, Stuttgart, pp. 109-142.

Wagner, R. (1982) Palearctic moth-flies: a review of the Trichomyiinae (Psychodidae). *Systematic Entomology, 7*, 357-365.

Wagner, R. (1997) Diptera Psychodidae, Moth flies. *In:* A. Nilsson (Ed), *Aquatic Insects of North Europe 2*. Apollo Books, Stensrup, pp. 133-144.

Wagner, R. (2006) Amber Bruchomyiinae: descriptions of already known and new species, and the position of the subfamily within Psychodidae (s.l.) (Diptera). *Studia Dipterologica, 13*, 83-95.

Wagner, R., Barták, M., Borkent, A., Courtney, G., Goddeeris, B., Haenni, J.-P., et al. (2008) Global diversity of dipteran families (Insecta Diptera) in freshwater (excluding Simulidae, Culicidae, Chironomidae, Tipulidae and Tabanidae). *Hydrobiologia, 595*, 489-519.

Wagner, R. & Ibañez-Bernal, S. (2009) Psychodidae (sand flies, and moth flies or owl flies). *In:* B. V. Brown, A. Borkent, J. M. Cumming, D. M. Wood, N. E. Woodley & M. A. Zumbado (Eds), *Manual of Central American Diptera. Volume 1*. NRC Research Press, Ottawa, pp. 319-336.

Wagner, R. & Schrankel, I. (2005) New West Palearctic moth flies (Diptera: Psychodidae). *Studia Dipterologica, 12*, 57-62.

Williams, P. (1993) Relationships of phlebotomine sand flies (Diptera). *Memories do Instituto Oswaldo Cruz, Rio de Janeiro, 88*, 177-183.

Williams, P. (2003) Notes on the subfamily Bruchomyiinae (Diptera: Psychodidae). *Lundiana, 4*, 5-11.

Withers, P. (2003) The British *Trichomyia* Haliday in Curtis (Diptera, Psychodidae), with the description of a new species. *Dipterists Digest, 10*, 107-110.

Wood, D. M. & Borkent, A. (1989) Phylogeny and classification of the Nematocera. *In:* J. F. McAlpine (Ed), *Manual of Nearctic Diptera vol.3*. Biosystematics Research Centre, Ottawa, pp. 1333-1370.

Woodley, N. E. (2005) *Dacochile microsoma* Poinar & Brown, not a tanyderid but a bruchomyiine psychodid (Diptera: Psychodidae, Tanyderidae). *Zootaxa, 1012*, 53-60.

Chapter 2

Catalogue and bibliography of Afrotropical Psychodidae: Bruchomyiinae, Psychodinae, Sycoracinae and Trichomyiinae

INTRODUCTION

The first major contribution to non-phlebotomine Afrotropical Psychodidae were the studies of Tonnoir (1920, 1922, 1939a, 1939b), in which 34 Afrotropical moth fly species were described mostly from East Africa. Another important pioneer of the continent's Psychodidae fauna was Satchell (1955), whose comprehensive key remains useful today despite its outdated nomenclature. To date, the most important studies of the African Psychodidae fauna were conducted by Duckhouse (1975, 1978, 1980, 1985a, 1987), based mostly on collections by G. H. Satchell and B. Stuckenberg housed in the Natal Museum in Pietermaritzburg, South Africa. In addition to describing a total of 40 species, he also described and revised several genera, catalogued the fauna (Duckhouse & Lewis 1980) and shed light on several systematic and biogeographic questions.

Other studies on the taxonomy of Afrotropical Psychodidae include Eaton (1913), Edwards (1929), Freeman (1949), Quate (1957), Stuckenberg (1962, 1978), Hogue (1970), Salamanna (1980), Wagner (1979a, 1983, 1989), Ježek (2004), Ježek & van Harten (1996, 2002, 2005, 2009) and Wagner & Andersen (2007). A total of 173 non-phlebotomine Psychodidae species are currently known from the region, however this is likely only a small fraction of the total fauna. Africa's moth fly fauna remains poorly studied and there is still much to be learned even from small collections (Ježek & van Harten 2005; Wagner & Andersen 2007).

The first check list of Afrotropical Psychodidae was presented in Tonnoir (1939) without bibliographic references for the individual species. Another early catalogue was prepared by Rapp & Cooper (1945), but today this work only has historical value as its nomenclature is outdated and inconsequent. In Duckhouse & Lewis' (1980) treatment of the family in the catalogue of Afrotropical Diptera, some, but not all of the nomenclatural errors were corrected. Since then, many new species and genera have been recorded from the Afrotropics and an updated catalogue will prove useful for future taxonomic endeavors in the region.

Systematic and geographic scope

The present catalogue covers the Afrotropical species of Psychodidae: Bruchomyiinae, Psychodinae, Sycoracinae and Trichomyiinae. Systematics of Psychodidae are generally stable on the subfamily level; however conflicting classifications exist within several of the subfamilies. This catalogue follows Duckhouse's (1987) provisional tribe-level systematics of Psychodinae and is in most cases in accordance with Duckhouse & Lewis (1980) on generic nomenclature. It deviates mainly within the Mormiini and Paramormiini; the systematics of which have been the focus of much recent work by Ježek (e.g. 1983, 1984a, 1989, 1990, 1994, 2004). Some new nomenclatural acts are proposed; these are discussed in further detail below. Subfamilial and tribal autorship is according to Sabrosky (1999).

The geographic scope of this work is the Afrotropical region as defined in Crosskey (1980), modified according to the forthcoming Manual of Afrotropical Diptera (Kirk-Spriggs & Mostovski, *in prep.*). Accordingly, the Afrotropical region is recognized as Africa South of the Sahara (starting for convenience with the Northern boundaries of Mauritania, Mali, Niger, Chad and Sudan), the Cape Verde Islands, Madagascar, the islands of the Southern Indian Ocean and the Southernmost part of the Arabian peninsula including Yemen, Oman and the United Arab Emirates.

Format

The catalogue lists Afrotropical subfamilies, tribes, genera, subgenera and species of Afrotropical Psychodidae exclusive of Phlebotominae. All supraspecific taxa are written in capitals. Valid names are listed in bold, with synonyms and unavailable names in regular typeface. Each entry contains the following bibliographic records: Author, year, title of publication, issue and first page number of taxon description. Type species with type fixation criteria are given for genera. Species are listed with type localities and distributional information based on the published literature. For species described in genera other than those in which they currently placed, the original genus is given in italics.

Type localities are mostly quoted directly from the original descriptions. For a few species described from other zoogeographical regions, the type localities are quoted from previous Psychodidae catalogues, notably Wagner (1990). In cases where names of type localities are ambiguous or outdated the modern names of the respective countries are given in square brackets. The Democratic Republic of Congo is abbreviated D.R. Congo and the United Arab Emirates are abbreviated UAE.

CATALOGUE

Subfamily BRUCHOMYIINAE ALEXANDER, 1921

BRUCHOMYIINAE ALEXANDER, 1921 (as subfamily of Tanyderidae): *Annals of the Entomological Society of America* **13 (1920)**: 402.
NEMOPALPINAE EDWARDS, 1921: *Annals and Magazine of Natural History* **7**: 439

Genus ***EUTONNOIRIA*** ALEXANDER, 1940

EUTONNOIRIA ALEXANDER, 1940: *Revista de Entomologia* **11**: 794. Type species: *Bruchomyia edwardsi* Tonnoir, 1939b (original designation)

edwardsi (TONNOIR, 1939b): *Ruwenzori Expedition* **1:** 38 (*Bruchomyia*). Type locality: [Uganda] «RUWENZORI: Mobuku valley, 7300 ft.» - Distr.: Uganda.

Genus ***NEMAPALPUS*** MACQUART, 1838

NEMAPALPUS MACQUART, 1838*: Mémoires de la Société royale des sciences, de l'agriculture et des arts de Lille* **1:** 85. Type species: *Nemapalpus flavus* Macquart, 1838 (monotypy)
NEMOPALPUS MACQUART, 1839: *Histoire Naturelle des Iles Canaries* **2:** 102. Variant spelling.
NYGMATODES LOEW, 1845: *Dipterologische Beiträge* **1**: 9. Unavailable name.
PALAEOSYCORAX MEUNIER, 1905: *Miscellana Entomologica* **13**: 50. Type species: *Palaeosycorax tertiariae* Meunier, 1905 (monotypy)

capensis EDWARDS, 1929: *Annales and Magazine of Natural History* **3**: 422. Type locality: «S. AFRICA: Port St. John, Pondoland» - Distr.: South Africa
concolor STUCKENBERG, 1962: *Annals of the Natal Museum* **15**: 211. Type locality: [South Africa] «Port St. Johns, Pondoland, Eastern Cape Province» - Distr.: South Africa
davidsoni STUCKENBERG, 1978: *Annals of the Natal Museum* **23:** 372. Type locality: [Namibia] «SOUTH WEST AFRICA. Windhoek District, Daan Viljoen Park, approximate lat. 22°30'S, long. 16°55'E, altitude c. 1 900 m.» - Distr.: Namibia
ledgeri STUCKENBERG, 1978: *Annals of the Natal Museum* **23:** 369. Type locality: [Namibia] «SOUTH WEST AFRICA, Bethanie Dist., Oberndorf farm, approx. lat. 26°22'S, long. 17°09'E» - Distr.: Namibia
transvaalensis STUCKENBERG, 1962: *Annals of the Natal Museum* **15**: 211. Type locality: [South Africa] «Mariepskop, Pilgrims Rest District, Eastern Transvaal» - Distr.: South Africa

Subfamily PSYCHODINAE NEWMAN, 1834

PSYCHODITES NEWMAN, 1834: *Entomological Magazine* **2**: 379.

Tribus MARUININI ENDERLEIN, 1937

MARUININI ENDERLEIN, 1937: *Deutsche Entomologische Zeitsschrift* **1936**: 109
ARISEMINI VAILLANT, 1982a: *Nouvelle Revue d'Entomologie* **12**: 190
SETOMIMINI VAILLANT, 1982a: *Nouvelle Revue d'Entomologie* **12**: 191

Genus ***NEOARISEMUS*** BOTOSANEANU & VAILLANT, 1970

NEOARISEMUS BOTOSANEANU & VAILLANT, 1970: *Travaux du Laboratoire d'Hydrobiologie et de Pisciculture de l'Universite de Grenoble* **61:** 178. Type species: *Psychoda nigra* Banks, 1894 (original designation)

advenus DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 321. Type locality: «SOUTH AFRICA, Cape Province, Grahamstown, Chalmers Waterfall» Distr.: South Africa
anarticulatus DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 315. Type locality: «SOUTH AFRICA, Cape Province, near Knysna, Bracken Hill stream». Distr.: South Africa

angularis DUCKHOUSE, 1987: *Annals of the Natal Museum* **28:** 237. Type locality: «SOUTH AFRICA, Cape Province, Garden of Eden, forest, 342/3AA.» Distr.: South Africa

brevicornis DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 329. Type locality: «SOUTH AFRICA, Cape Province, Stutterheim, Kologha Forest.» Distr.: South Africa

brunneus DUCKHOUSE, 1987: *Annals of the Natal Museum* **28:** 242. Type locality: «TANZANIA, 6,5 miles S of Morogoro, 490 m, wet forest». Distr.: Tanzania

collarti (SATCHELL, 1955b): *Revue de zoologie et de botanique africaines* **51:** 350. *(Telmatoscopus)*. Type locality: [D.R. Congo] «Belgian Congo : Stanleyville». Distr.: D.R. Congo

deviatus (TONNOIR, 1939b): *Ruwenzori Expedition* **1**:46 *(Psychoda).* Type locality: [Uganda] «RUWENZORI: Bwamba Pass (West side) 5500-7500 ft.». Distr.: Uganda.

elongatus DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 317. Type locality: «SOUTH AFRICA, Natal Province, Drakensberg Mts. (2929 Ad), Giant's Castle Reserve, 1 768 m». Distr.: South Africa

impeditus DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 332. Type locality: «SOUTH AFRICA, N.E. Transvaal, Tzaneen, Magoeba's Kloof.» Distr.: South Africa, Zimbabwe

obtusistylus DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 320. Type locality: «SOUTH AFRICA, N.E. Transvaal, Tzaneen, Magoeba's Kloof.» Distr.: South Africa

pectinatus (TONNOIR, 1939b): *Ruwenzori Expedition* **1**:66 *(Telmatoscopus).* Type locality: [Uganda] «RUWENZORI: Namwamba Valley, 10,200 ft..». Distr.: Uganda.

plesius DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 313. Type locality: «SOUTH AFRICA, Cape Province, Ashton, Klaas Vooges Kloof». Distr.: South Africa

pristinus DUCKHOUSE, 1987: *Annals of the Natal Museum* **28:** 239. Type locality: «SOUTH AFRICA, Natal, Pietermaritzburg, Town Bush». Distr.: South Africa

prodigiosus DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 310. Type locality: «SOUTH AFRICA, near Cape Town, Kalk Bay stream». Distr.: South Africa

propensus (JUNG, 1956): *Deutsche Entomologische Zeitschrift, N.F.* **3:** 185 *(Telmatoscopus*, as new name for *Telmatoscopus fuscus* Tonnoir, 1939 nec (Macquart, 1826)). Type locality: [Uganda] «Namwamba Valley, 6500 ft.». Distr.: Uganda.

fuscus (TONNOIR, 1939b) nec Macquart, 1826*: Ruwenzori Expedition* **1**:65 *(Telmatoscopus)*. Type locality: [Uganda] «Namwamba Valley, 6500 ft.». Distr.: Uganda.

satchelli DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 324. Type locality: «SOUTH AFRICA, Cape Town, Kirstenbosch, Skeleton Stream, upper reaches.» Distr.: South Africa

tapetipennis DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 326. Type locality: «SOUTH AFRICA, Cape Town, Kirstenbosch, Skeleton Stream, upper reaches.» Distr.: South Africa

youngi DUCKHOUSE, 1987: *Annals of the Natal Museum* **28:** 240. Type locality: «TANZANIA, 6,5 miles S of Morogoro, 490 m, wet forest». Distr.: Tanzania

Genus ***SETOMIMA*** ENDERLEIN, 1937

SETOMIMA ENDERLEIN, 1937: *Deutsche Entomologische Zeitschrift* **4:** 100.Type species: *Setomima lithocolleta* Enderlein, 1937 (original designation)

PARABRUNETTIA VAILLANT, 1975: *Die Fliegen Der Palearktischen Region* **310:** 165 (as subgenus of *Brunettia* Annandale, 1910). Type species: *Psychoda nitida* Banks, 1901 (original designation)

Subgenus ***OPHRYOSETOMIMA*** DUCKHOUSE, 1987

OPHRYOSETOMIMA DUCKHOUSE, 1987: *Annals of the Natal Museum* **28**: 255 (as subgenus of *Setomima* Enderlein, 1937.Type species: *Setomima spinifera* Duckhouse, 1978 (original designation)

brachiata DUCKHOUSE, 1987: *Annals of the Natal Museum* **28**: 260. Type locality: «KENYA, Rift Valley, Kampi-Ya-Samaki, Lake Baringo, 00°37´N:36°02´E, 980 m.». Distr.: Kenya, South Africa.

longispinosa DUCKHOUSE, 1987: *Annals of the Natal Museum* **28**: 256. Type locality: «SOUTH AFRICA, Natal, Eshowe District, Dlinza Forest, 450». Distr.: South Africa.

pectinata (TONNOIR, 1922a): *Bulletin de la Société Entomologique D'Égypte* **6:** 107 (*Brunettia)*. Type locality: [Ghana] «Nsawam, South Nigeria (Gold Coast)». Distr.: Ghana.

spinifera DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 342. Type locality: «SOUTH AFRICA, Transvaal, Soutpansberg Range, 23°00´s, 30°14´E, Entabeni Forestry Station, Vera Kop Forest». Distr.: South Africa

Subgenus ***SETOMIMA*** ENDERLEIN, 1937

gloriosa (TONNOIR, 1939b): *Ruwenzori Expedition* **1:** 73 (*Brunettia*). Type locality: [Uganda] «RUWENZORI: Kilembe, 4500 ft.» Distr.: Uganda, Democratic Republic of Congo.

grahami (TONNOIR, 1920): *Revue du zoologie Africaine* **8**: 143 (*Brunettia*). Type locality: [Ghana] «Ashanti, Obuasi». Distr.: Ghana

lithocolleta ENDERLEIN, 1937: *Deutsche Entomologische Zeitschrift* **4:** 101.Type locality: [Cameroon] «N. Kamerun, Johann-Albrechtshöhe.» Distr.: Cameroon

pseudosplendens DUCKHOUSE, 1987: *Annals of the Natal Museum* **28**: 249. Type locality: [D.R. Congo] «ZAÏRE, S of Walikale, 700 m.» Distr.: D.R. Congo

senegambica WAGNER, 1983: *Entomologica Scandinavica* **14:** 98. Type locality: «Gambia, Abuko Nature Reserve at Bambo Pool». Dist.: Gambia

splendens (TONNOIR, 1920): *Revue du zoologie Africaine* **8**: 140 (*Brunettia*). Type locality: [Ghana] «Ashanti: Obuasi». Distr.: Ghana

Genus ***TONNOIRIELLA*** VAILLANT, 1976

TONNOIRIELLA VAILLANT, 1971: *Die Fliegen Der Palearktischen Region* **287:** 38. Type species: *Pericoma pulchra* Eaton, 1893 (indication)

cracens DUCKHOUSE, 1987: *Annals of the Natal Museum* **28**: 244. Type locality: «SOUTH AFRICA, Natal, Cathedral Peak.» Distr.: South Africa

drepanopenis (DUCKHOUSE, 1975): *Annals of the Natal Museum* **22:** 424 (*Pericoma*). Type locality: «SOUTH AFRICA, Cape Town, Platteklip stream.» Distr.: South Africa, D.R. Congo

consimilis (SATCHELL, 1956a): *South African Animal Life* **3**: 399 (*Pericoma*). *Nomen nudum*

fasciola WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 298. Type locality: «TANZANIA: Tanga Region, Lushoto District, West Usambara Mts., Mazumbai Forest Reserve, Kaputu Stream, Loc. 7, 1535 m a.s.l.». Distr.: Tanzania

stuckenbergi (DUCKHOUSE, 1975): *Annals of the Natal Museum* **22:** 427 (*Pericoma*). Type locality: «SOUTH AFRICA, Cape Town, Platteklip stream.» Distr.: South Africa

Tribus MORMIINI ENDERLEIN, 1937

MORMIINI ENDERLEIN, 1937: *Deutsche Entomologische Zeitschrift* **4:** 82.

BRUNETTINI VAILLANT, 1971: *Die Fliegen Der Palearktischen Region* **287:** 38.

Genus ***BRUNETTIA*** ANNANDALE, 1910

BRUNETTIA ANNANDALE, 1910: *Records of the Indian Museum* **5**: 141. Type species: *Diplonema superestes* Annandale, 1908 (subsequent designation of Brunetti 1911).

PARABRUNETTIA BRUNETTI, 1911: *Records of the Indian Museum* **4:** 310. Type species: *Psychoda squamipennis* Brunetti, 1908 (subsequent designation of Brunetti 1912)

PARABRUNETTIA ENDERLEIN, 1937: *Deutsche Entomologische Zeitschrift* **4**: 106. Type species: *Brunettia indica* Eaton, 1913 (original designation)

TRICHOBRUNETTIA TONNOIR, 1939b: *Ruwenzori Expedition* **1**: 74 (as subgenus of *Brunettia*). Type species: *Psychoda albonotata* Brunetti, 1908 (original designation).

albonotata (BRUNETTI, 1908): *Records of the Indian Museum* **4**: 373 (*Psychoda*). Type locality: «Calcutta, India.». Distr.: Ghana, Nigeria, the Seychelles, Sierra Leone, Uganda. Oriental, Neotropical.

?indica EATON, 1913: *The Percy Sladen Trust expedition to the Indian Ocean in 1905, under the leadership of Mr. J. Stanley Gardiner, M. A.* **4:** 424. Type locality: «Seychelles. Mahé: Cascade

Estate, about 800 feet.» ***Questionable synonym. See note 1.***
howelli WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 305. Type locality: «TANZANIA: Morogoro Region, Morogoro, Sokoine University of Agriculture, Campus, about 550 m a.s.l.». Distr.: Tanzania
transvaalensis DUCKHOUSE, 1978: *Annals of the Natal Museum* **23**: 338. Type locality: «SOUTH AFRICA, E. Transvaal, Komatipoort». Distr.: South Africa

Genus ***HEMIMORMIA*** KREK, 1971

HEMIMORMIA KREK, 1971: *Travaux du Laboratoire d'hydrobiologie et de pisciculture de l'Université de Grenoble* **62:** 170 (as subgenus of *Mormia* Enderlein, 1935). Type species: *Pericoma albicornis* Tonnoir, 1919 (monotypy, see ICZN art 68.3 and discussion in Ježek 1984). ***See note 2***
PERIMORMIA VAILLANT, 1975: *Die Fliegen der Palearktischen Region* **310:** 143 (as subgenus of *Mormia* Enderlein, 1935. Type species: *Pericoma albicornis* Tonnoir, 1919 (original designation)
AFROMORMIA DUCKHOUSE, 1987: *Annals of the Natal Museum* **28:** 268 (as subgenus of *Mormia* Enderlein, 1935). Type species: *Mormia dycei* Duckhouse, 1978 (original designation).

acrostylis (DUCKHOUSE, 1978): *Annals of the Natal Museum* **23:** 346 *(Mormia)*. Type locality: «SOUTH AFRICA: E. Transvaal, Komatipoort». Distr.: South Africa, ?Cape Verde
dycei (DUCKHOUSE, 1978): *Annals of the Natal Museum* **23:** 345 *(Mormia)*. Type locality: «SOUTH AFRICA: E. Transvaal, Komatipoort». Distr.: South Africa
flagellifer (FREEMAN, 1949): *Proceedings of the Royal Entomological Society of London (B)* **18**: 240 (*Telmatoscopus*). Type locality: [D.R. Congo] «BELGIAN CONGO: Coquilhatville.» Distr.: D.R. Congo, ?South Africa ***comb.nov. See note 2.***
soelii (WAGNER & ANDERSEN, 2007): *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 300 (*Mormia*). Type locality: «TANZANIA: Morogoro Region, Morogoro, Sokoine University of Agriculture, Campus, about 550 m.a.s.l.». Distr.: Tanzania. ***comb.nov. See note 2.***
triangulata (WAGNER, 1979): *Aquatic Insects* **1:** 60 (*Rhadinoscopus*). Type locality: [D.R. Congo] «Kalengo, 10 km westward Lake Kivu (Republic of Zaire)]. Distr.: D.R. Congo. ***comb.nov. See note 2.***

Genus ***LIMOMORMIA*** VAILLANT, 1982b

LIMOMORMIA VAILLANT, 1982b: *Bulletin de la Société Entomologique de France* **87: ??**. Type species: *Telmatoscopus apicealbus* Tonnoir, 1922 (original designation). ***See note 3.***

wadi JEŽEK & VAN HARTEN, 2009: *Arthropod Fauna of the UAE* **2:** 688. Type locality: «United Arab Emirates, Bithnah [25°11'N 56°14'E]». Distr.: UAE.

Tribus PARAMORMIINI ENDERLEIN, 1937

PARAMORMIINA ENDERLEIN, 1937: *Deutsche Entomologische Zeitschrift* **4**: 96.
TELMATOSCOPINI VAILLANT, 1971: *Die Fliegen Der Palearktischen Region* **287:** 39.

Genus ***CLOGMIA*** ENDERLEIN, 1937

CLOGMIA ENDERLEIN, 1937: *Deutsche Entomologische Zeitschrift* **4:** 87. Type species: «*Psychoda albipennis»* Williston, 1893 (original designation, typographical error for *albipunctata*)
ORGAOCLOGMIA JEŽEK & VAN HARTEN, 1996. See below, as subgenus

Subgenus ***CLOGMIA*** ENDERLEIN, 1937

albipunctata (WILLISTON, 1893): *Entomological News and Proceedings of the Entomological Section of the Academy of Natural Sciences of Philadelphia* **4:** 113 (*Psychoda*). Type locality: «Havana, Cuba». Distr.: Angola, Burundi, Cape Verde, D.R. Congo, Ghana, Kenya, Madagascar, Malawi, Mauritius, Nigeria, Senegal, South Africa, Tanzania, UAE, Uganda; Nearctic, Neotropical, Oceanic, Oriental, Palearctic. ***See note 4***
meridionalis (EATON, 1894): *Entomologist's Monthly Magazine* **30:** 194 (*Pericoma*). Type locality:

[Mozambique] «Delagoa Bay».

legnothisa (SPEISER, 1910): *Wissenschaftliche Ergebnisse der Schwedischen zoologischen Expedition nach dem Kilimandjaro, dem Meru und den umgebenden Massaisteppen Deutsch-Ostafrikas 1905-1906* **10**: 44. (*Psychoda*) Type locality: [Tanzania] «ohne nähere Bezeichnung vom *Kilimandjaro*».

bidentata JEŽEK, 2004: *Acta Facultatis Ecologiae (Zvolen)* **12**: 58. Type locality: «Madagascar, Toamasina: small brook 4 km E. of Amboditafonana, 840 m.a.s.l., rain forest 17º27'33''S 48º46'18''E». Distr.: Madagascar

Subgenus ***CRYPTOTELMATOSCOPUS*** VAILLANT, 1982b

CRYPTOTELMATOSCOPUS VAILLANT, 1982b: *Bulletin de la Société Entomologique de France* **87:** 298 (as genus). Type species: *Telmatoscopus vestitus* Vaillant, 1973 (original designation). ***stat. nov. See note 5***

ORGAOCLOGMIA JEŽEK & VAN HARTEN, 1996: *Boletim do Museu Municipal do Funchal (História Natural)* **48**: 67 (as genus). Type species *Orgaoclogmia caboverdeana* Ježek & van Harten, 1996 (original designation). ***syn.nov. See note 5***

caboverdeana (JEŽEK & VAN HARTEN, 1996): *Boletim do Museu Municipal do Funchal (História Natural)* **48**: 68. Type locality: «Cape Verde Islands, Santiago São Jorge dos Orgãos.» Distr.: Cape Verde. ***comb.nov. See note 5.***

Subgenerically unplaced species of ***CLOGMIA*** ENDERLEIN, 1937

coronata DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 352. Type locality: «SOUTH AFRICA, Cape Province, Grahamstown, Fern Kloof.» Distr.: South Africa

odontostylis DUCKHOUSE, 1987: *Annals of the Natal Museum* **28**: 274. Type locality: «MALAWI, Zomba, 1535Ad, 1100 m, at light». Distr.: Malawi.

Genus ***ELSAHOWIA*** DUCKHOUSE, 1978

ELSAHOWIA DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 353. Type species: *Elsahowia natalensis* Duckhouse, 1978 (original designation)

dactyliata (SATCHELL, 1955b): *Revue de zoologie et de botanique africaines* **51:** 349. *(Brunettia)*. Type locality: [Tanzania] «Matengoo Hochland, WSW, village of Songea, Tanganyika Terr.». Distr.: Tanzania

natalensis DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 355. Type locality: «SOUTH AFRICA, Natal, forest 7 miles E. Kranskop.» Distr.: South Africa, Tanzania

oxypages (QUATE, 1957): *La Naturaliste Malgache* **9**: 257 (*Telmatoscopus*). Type locality: «MADAGASCAR CENTRE EST: Périnet.» Distr.: Madagascar

spicocauda (QUATE, 1957): *La Naturaliste Malgache* **9**: 258 (*Telmatoscopus*). Type locality: «MADAGASCAR CENTRE EST: Périnet.» Distr.: Madagascar

zombae DUCKHOUSE, 1987: *Annals of the Natal Museum* **28**: 269. Type locality: «MALAWI, Zomba Plateau, montane forest, 1500 m». Distr.: Malawi.

Genus ***IRANOTELMATOSCOPUS*** JEŽEK, 1987

IRANOTELMATOSCOPUS JEŽEK, 1987: *Acta Entomologica Musei Nationalis Pragae* **42**: 5. Type species: *Iranotelmatoscopus hajiabadi* Ježek, 1988 (original designation)

hajiabadi JEŽEK, 1987: *Acta Entomologica Musei Nationalis Pragae* **42**: 5. Type locality: «Iran, Kerman province, 7 km W. of Kahkom (28 12 N, 55 46 E), 20 km S. W. of Hajiabad». Distr.: UAE, Iran

Genus ***PANIMERUS*** EATON, 1913

PANIMERUS EATON, 1913: *The Percy Sladen Trust expedition to the Indian Ocean in 1905, under the leadership of Mr. J. Stanley Gardiner, M. A.* **4:** 425. Type species: *Pericoma notabilis* Eaton, 1893

(original designation) ***See note 6.***
LEPISEODA ENDERLEIN, 1935: *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin* **1935:** 247. Type species: *Pericoma notabilis* Eaton, 1893 (original designation)
MOGISETIA ENDERLEIN, 1937: *Deutsche Entomologische Zeitschrift* **4**: 91. Type species: *Pericoma albifacies* Tonnoir, 1919 (original designation)

scotti EATON, 1913: *The Percy Sladen Trust expedition to the Indian Ocean in 1905, under the leadership of Mr. J. Stanley Gardiner, M. A.* **4:** 426. Type locality: «Seychelles. Mahé: from near Morne Blanc, about 800 feet.» Distr.: the Seychelles

Subgenus ***KARAKOVOUNIMERUS*** JEŽEK, 1990

KARAKOVOUNIMERUS JEŽEK, 1990: *Acta Entomologica Musei Nationalis Pragae* **43:** 141 (as genus). Type species: *Panimerus sarai* Salamanna, 1975a (original designation). ***stat.nov. See note 7***

sarai SALAMANNA, 1975a: *Entomologica* 11: 197. Type locality: [Italy] «Torre Guaceto (Brindisi), su giunchi presso paludi retrodunali a pochi metri dalla riva del mare». Distr.: Yemen, Palearctic

Genus ***PARAMORMIA*** ENDERLEIN, 1935

PARAMORMIA ENDERLEIN, 1935: *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin* **1935:** 248. Type species: *Pericoma fratercula* Eaton, 1893 (original designation)
DUCKHOUSIELLA VAILLANT, 1972: *Die Fliegen Der Palearktischen Region* **291:** 54. Type species: *Pericoma ustulata* Walker, 1856 (original designation)

fluviatilis JEŽEK, 2004: *Acta Facultatis Ecologiae (Zvolen)* **12:** 61. Type locality: «Madagascar, Fianarantsoa: brook 2,5 km S.E. of Ranomena, approximately 1000 m.a.s.l., montane rain forest, 21º29'36''S, 47º24'11''E.» Distr.: Madagascar

Genus ***PSYCHOMASINA*** JEŽEK, 2004

PSYCHOMASINA JEŽEK, 2004: *Acta Facultatis Ecologiae (Zvolen)* **12:** 64. Type species: *Psychomasina armata* Ježek, 2004 (original designation).

armata JEŽEK, 2004: *Acta Facultatis Ecologiae (Zvolen)* **12**: 64. Type locality: «Madagascar, Toamasina: 2,5 km S. E. of Amboditafoana.». Distr.: Madagascar

Genus ***TELMATOSCOPUS*** EATON, 1904

TELMATOSCOPUS EATON, 1904: *Entomologist's Monthly Magazine* **40:** 58. Type species: *Pericoma advena* Eaton, 1893 (by subsequent designation of Quate 1965). ***See note 8.***
XENAPATES EATON, 1904: *Entomologist's Monthly Magazine* **40:** 59. Type species: *Pericoma fraudulenta* Eaton, 1896 (original designation)
SCIRIA ENDERLEIN, 1935: *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin* **1935:** 247. Type species: *Pericoma advena* Eaton, 1893 (original designation)
SEODA ENDERLEIN, 1935: *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin* **1935:** 247. Type species: *Pericoma labeculosa* Eaton, 1893 (original designation)
KREKIELLA VAILLANT, 1972: *Die Fliegen Der Palearktischen Region* **291:** 54 (As subgenus of *Panimerus* Eaton, 1913). Type species: *Pericoma labeculosa* Eaton, 1893 (original designation)

crassiascoidatus TONNOIR, 1939b: *Ruwenzori Expedition* **1:** 64. Type locality: «KENYA: Mt. Elgon, 12-13 000 ft., on *Lobelia elgonensis*». Distr.: Kenya.
edwardsi TONNOIR, 1939b: *Ruwenzori Expedition* **1:** 64. Type locality: [Uganda] «RUWENZORI: Namwamba Valley, 10,200 ft.» Distr.: Uganda.
fryeri EATON, 1913: *The Percy Sladen Trust expedition to the Indian Ocean in 1905, under the leadership of Mr. J. Stanley Gardiner, M. A.* **4:** 430. Type locality: [The Seychelles] «Aldabra» Distr.: the Seychelles

fuscipennis TONNOIR, 1920: *Revue du zoologie Africaine* **8**: 136. Type locality: «Sierra-Leone: Free Town». Distr.: Sierra Leone

idalimus QUATE, 1957: *La Naturaliste Malgache* **9**: 256. Type locality: «MADAGASCAR CENTRE: Ankaratra, station forestière de Manjakatompo.» Distr.: Madagascar

madagascarensis QUATE, 1957: *La Naturaliste Malgache* **9**: 253. Type locality: «MADAGASCAR CENTRE: Ankaratra, station forestière de Manjakatompo.» Distr.: Madagascar

nsawamensis SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 354. Type locality: [Ghana] «Nsawam, Gol Coast.» Distr.: Ghana

obtusus WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 302. Type locality: «TANZANIA: Morogoro Region, Morogoro, Sokoine University of Agriculture, Campus». Distr.: Tanzania

ochraceus WAGNER, 1989: *Spixiana* **12**: 187. Type locality: [South Africa] «Natal, Karkloof forest, 1500 m». Distr.: South Africa.

pannosus SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 352. Type locality: [Zambia] «Serenje Boma, 4,200 ft. Kaomba, N.Rhodesia.» Distr.: Zambia

pentacus DUCKHOUSE, 1978: *Annals of the Natal Museum* **23:** 349. Type locality: «SOUTH AFRICA, E. Transvaal, Komatipoort» Distr.: South Africa

stuckenbergi QUATE, 1957: *La Naturaliste Malgache* **9**: 255. Type locality: «MADAGASCAR CENTRE EST: Périnet.» Distr.: Madagascar

Genus ***VAILLANTODES*** WAGNER, 2001

VAILLANTODES WAGNER, 2001: *Zoologica Baetica* **12:** 87. Type species: *Vaillantia margaretae* Wagner, 1988 (original designation)

VAILLANTIA WAGNER, 1988: *Stuttgarter Beiträge zur Naturkunde, Serie A (Biologie)* **425:** 10. Type species: *Vaillantia margaretae* Wagner, 1988 (original designation). Junior homonym of *Vaillantia* Jordan & Brayton, 1878, type species: *Boleosoma camurum* Forbes, 1878 nec. Cope, 1870

ypsilon WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 302. Type locality: «TANZANIA: Tanga Region, Lushoto District, West Usambara Mts., Mazumbai Forest Reserve, about 1600 m a.s.l.». Distr.: Tanzania

Tribus PERICOMAINI ENDERLEIN, 1935

PERICOMINI ENDERLEIN, 1935: *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin* **1935:** 246. ***Unavailable name; Junior homonym of Pericominae Burr, 1911, in Dermaptera. The name Pericomaini was suggested by Sabrosky (1999).***

ULOMYIINI ENDERLEIN, 1935: *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin* **1935:** 246

Genus ***MORMOPERICOMIELLA*** JEŽEK & VAN HARTEN, 2002

MORMOPERICOMIELLA JEŽEK & VAN HARTEN, 2002: *Folia Heyrovskyana* **10**: 226. Type species: *Mormopericomiella yemenensis* Ježek & van Harten, 2002 (original designation).

pilosternatus (SATCHELL, 1955b): *Revue de zoologie et de botanique africaines* **51:** 351 (*Telmatoscopus*). Type locality: [D.R. Congo] «Belgian Congo: Stanleyville.» Distr.: D.R. Congo. ***comb.nov. See note 9.***

yemenensis (JEŽEK & VAN HARTEN, 2002): *Folia Heyrovskyana* **10:** 226. Type locality: «SW Yemen, Ta'izz.» Distr.: Yemen, UAE.

Genus ***NOTIOCHARIS*** EATON, 1913

NOTIOCHARIS EATON, 1913: *The Percy Sladen Trust expedition to the Indian Ocean in 1905, under the leadership of Mr. J. Stanley Gardiner, M. A.* **4:** 427. Type species: *Notiocharis insignis* Eaton, 1913 (monotypy)

insignis EATON, 1913: *The Percy Sladen Trust expedition to the Indian Ocean in 1905, under the* *leadership of Mr. J. Stanley Gardiner, M. A.* **4:** 427. Type locality: «Seychelles. Mahé: near Morne Blanc, about 800 feet.» Distr.: the Seychelles

Tribus PSYCHODINI NEWMAN, 1834

PSYCHODITES NEWMAN, 1834: *Entomological Magazine* **2**: 379.

NEOMARUININI VAILLANT, 1990: *Bulletin de la Société Vaudoise des Sciences Naturelles. (Lausanne.)* **80**: 160

Genus *NEOMARUINA* VAILLANT, 1963

NEOMARUINA VAILLANT, 1963a: *Annals of the Natal Museum* **15:** 338. Type species: *Neomaruina stuckenbergi* Vaillant, 1963a (monotypy)

deviata (TONNOIR, 1939b): *Ruwenzori Expedition* **1:**46 (*Psychoda*)**.** Type locality: [Uganda] «RUWENZORI: Bwamba Pass (West side) 5500-7500 ft.». Distr.: Uganda.

pseudomaxima (TONNOIR, 1939b): *Ruwenzori Expedition* **1:** 44 (*Psychoda*)**.** Type locality: [Uganda] «RUWENZORI: Namwamba Valley, 13-14,000 ft.». Distr.: Uganda.

stuckenbergi VAILLANT, 1963a: *Annals of the Natal Museum* **15:** 338. Type locality: «MALAWI, Zomba Mountain (1535AD), Mandala Falls, 1 500 m». Distr.: Malawi

torosa DUCKHOUSE, 1985a: *Annals of the Natal Museum* **26:** 618. Type locality: «MALAWI, Zomba Mountain (1535AD), montane forest, Mandala Falls, 1 500 m». Distr.: Malawi

usambarica WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 293. Type locality: «TANZANIA: Tanga Region, Lushoto District, West Usambara Mts., Mazumbai Forest Reserve, Kaputu Stream, 1600 m a.s.l». Distr.: Tanzania

Genus *PHILOSEPEDON* EATON, 1904

PHILOSEPEDON EATON, 1904: *Entomologist's Monthly Magazine* **40:** 57. Type species: *Psychoda humeralis* Meigen, 1818 (original designation)

TERMITODELPHOS HOLMGREN, 1905: *Zoologischer Anzeiger* **29**: 530. Type species: *Termitodelphos silvestrii* Holmgren, 1905 (monotypy)

LEPIDOPSYCHODA EDWARDS, 1928: *Insects of Samoa and other Samoan terrestrial Arthropoda* **4:**71. Type species: *Lepidopsychoda tineiformis* Edwards, 1928 (original designation)

MINIOCEROS QUATE, 1959: *Insects of Micronesia* **12:** 455 (as subgenus of *Telmatoscopus* Eaton, 1904). Type species: *Telmatoscopus squamalatus* Quate, 1959 (=*Lepidopsychoda tineiformis* Edwards, 1928, original designation)

africanum WAGNER, 1979: *Aquatic Insects* **1:** 62. Type locality: [D.R. Congo] «Kalengo, 10 km westward Lake Kivu (Republic of Zaire). Distr.: D.R. Congo

arabicum JEŽEK & VAN HARTEN, 2002: *Folia Heyrovskyana* **10:** 230. Type locality: «SW Yemen, Ta'Izz.» Distr.: Yemen.

distylum (QUATE, 1957): *La Naturaliste Malgache* **9**: 259 (*Psychoda*). Type locality: «MADAGASCAR CENTRE: Ankaratra, station forestière de Manjakatompo.» Distr.: Madagascar

?humerale MEIGEN, 1818: *Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten* **1:** 106 (*Psychoda*). Type locality: Not given (Germany). Distr.: Seychelles (doubtful record); Palearctic

triangulatum EATON, 1913: *The Percy Sladen Trust expedition to the Indian Ocean in 1905, under the leadership of Mr. J. Stanley Gardiner, M. A.* **4:** 429. Type locality: «Seychelles. Mahé: Cascade Estate, about 800 feet.». Distr.: Seychelles

triastylum (QUATE, 1957): *La Naturaliste Malgache* **9**: 259 (*Psychoda).* Type locality: «MADAGASCAR CENTRE EST: Pèrinet». Distr.: Madagascar

Genus *PSYCHODA* LATREILLE, 1796

PSYCHODA LATREILLE, 1796: *Precis des characters generiques des insectes, disposes dans un ordre naturel:* 152. Type species: *Tipula phalaenoides* Linnaeus, 1758 (monotypy). ***See note 10***

TRICHOPTERA MEIGEN, 1803: *Magazin für Insektenkunde* **2:** 261. Type species: *Tipula phalaenoides* Linnaeus, 1758 (subsequent designation of Coquillett 1910)

Subgenus ***APSYCHA*** JEŽEK, 2007

APSYCHA JEŽEK, 2007: *Acta Zoologica Universitatis Comenianae,* **47:** 146 (as genus). Type species: *Psychoda pusilla* Tonnoir, 1922 (original designation).

consobrina SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 357. Type locality: [D.R. Congo] «Belgian Congo: Rutshuru». Distr.: D.R. Congo

Subgenus ***COPROPSYCHODA*** VAILLANT, 1971.

COPROPSYCHODA VAILLANT, 1971: *Die Fliegen Der Palearktischen Region,* **287:** 30 (as genus). Type species: *Psychoda brevicornis* Tonnoir, 1940 (monotypy)

bulbosa (JEŽEK & VAN HARTEN, 2005): *Acta Entomologica Musei Nationalis Pragae* **45**: 201 (*Copropsychoda)*. Type locality: «YEMEN: Ar Jurum, 15°29'N 43°41'E». Distr.: Yemen. ***comb. nov. See note 10***

dewulfi SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 369. Type locality: [D.R. Congo] «Belgian Congo: Rutshuru». Distr.: D.R. Congo

Subgenus ***FALSOLOGIMA*** JEŽEK & VAN HARTEN, 1996

FALSOLOGIMA JEŽEK & VAN HARTEN, 1996: *Boletim do Museu Municipal do Funchal, História Natural,* **48:** 73 (as genus). Type species: *Psychoda savaiiensis* Edwards, 1928 (original designation)**.**

savaiiensis EDWARDS, 1928: *Insects of Samoa and other Samoan terrestrial Arthropoda* **4:** 74. Type locality: [Samoa Islands] «Savaii: Salailua». Distr.: Cape Verde, D.R. Congo, South Africa, UAE; Australian, Nearctic, Neotropical, Oceanic, Oriental, Palearctic.

rarotongensis SATCHELL, 1953: *Proceedings of the Royal Entomological Society of London, Series B.* **22:** 183. Type locality: «Wigmore's Waterfall, Rarotonga, Cook Islands.»

lucia QUATE, 1954: *Proceedings of the Hawaiian Entomological Society* **15:** 349. Type locality: «Gastries, St.Lucia, West Indies».

verrucosa (JEŽEK & VAN HARTEN, 2005): *Acta Entomologica Musei Nationalis Pragae* **45**: 204 *(Falsologima)*. Type locality: «YEMEN: Ar Jurum, 15°29'N 43°41'E». Distr.: Yemen. ***comb.nov. See note 10***

Subgenus ***LOGIMA*** EATON, 1904

LOGIMA EATON, 1904: *Entomologist's Monthly Magazine* **40:** 58 (as genus). Type species: *Psychoda erminea* Eaton, 1893 (original designation)

albipennis ZETTERSTEDT, 1850: *Diptera Scandinaviæ disposita et discripta* **9**: 3708. Type locality: [Norway] «In Töien prope Christianiam Norwegiae.» Distr.: Gambia, South Africa; Australian, Oriental, Nearctic, Palearctic,

severini TONNOIR, 1922c: *Annales de la Société Entomologique de Belgique* **62:** 78. Type locality: not given (Europe)

parthenogenetica TONNOIR, 1940: *Transactions of the Society for British Entomology* **7:** 53. Type locality: not given (Europe).

sigma KINCAID, 1899: *Entomological news, and proceedings of the Entomological Section of the Academy of Natural Sciences in Philadelphia* **10:** 31. Type locality: [U.S.A] «Olympia, Washington». Distr.: St.Helena; Australian, Nearctic, Neotropic, Palearctic

surcoufi TONNOIR, 1922c: *Annales de la Société Entomologique de Belgique* **62:** 74. Type locality: [France] «Lamballe»

subimmaculata TONNOIR, 1929: *Diptera of Patagonia and South Chile* **2:** 6. Type locality: [Chile] «Ancud».

spatulata SATCHELL, 1950: *Transactions of the Royal Entomological Society of London, Series B.* **101:** 166. Type locality: [New Zealand] «Christchurch»

Subgenus ***PSYCHA*** JEŽEK, 1984b

PSYCHA JEŽEK, 1984b: *Acta faunistica Entomologica Musei Nationalis Pragae* **17:** 136 (as genus). Type species: *Psychoda grisescens* Tonnoir, 1922c (original designation)

calva SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 368. Type locality: [D.R. Congo] «Belgian Congo: Rutshuru». Distr.: D.R. Congo

congruens SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 366. Type locality: [D.R. Congo] «P.N.A. : gite Nyiragongo». Distr.: D.R. Congo

contortula SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 367. Type locality: [Cameroon] «Mount Cameroon, 8,100 ft., Onyanga, Nigeria». Distr.: Cameroon

malleola TOKUNAGA & KOMYO, 1954: *Phillippine Journal of Science* **83:** 310. Type locality: «Honsyo, Japan». Distr.: D.R. Congo, South Africa; Oriental, Palearctic

harrisoni SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 358. Type locality: [D.R. Congo] «Belgian Congo: [...] Rutshuru»

Subgenus ***PSYCHANA*** JEŽEK & VAN HARTEN, 2005

PSYCHANA JEŽEK & VAN HARTEN, 2005: *Acta Entomologica Musei Nationalis Pragae* **45:** 207 (as genus). Type species: *Psychana rujumensis* Ježek & van Harten, 2005 (original designation)

rujumensis (JEŽEK & VAN HARTEN, 2005): *Acta Entomologica Musei Nationalis Pragae* **45:** 207 (*Psychana)*. Type locality: «YEMEN: Ar Jurum, 15°29’N 43°41’E». Distr.: Yemen. ***comb.nov. See note 10***

Subgenus ***PSYCHODA*** LATREILLE, 1796

obscuripennis JEŽEK & VAN HARTEN, 2005: *Acta Entomologica Musei Nationalis Pragae* **45:** 211. Type locality: «YEMEN: Ar Rujum, 15°29’N 43°41’E». Distr.: Yemen

Subgenus ***PSYCHODOCHA*** JEŽEK, 1984b

PSYCHODOCHA JEŽEK, 1984b: *Acta faunistica Entomologica Musei Nationalis Pragae* **17:** 135 (as genus). Type species: *Psychoda cinerea* Banks, 1894 (original designation)

angustisternata SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 364. Type locality: [D.R. Congo] «Belgian Congo: Rutshuru». Distr.: D.R. Congo, ?South Africa

cinerea BANKS, 1894: *Canadian Entomologist* **26:** 331. Type locality: [U.S.A] «Sea Cliff, N.Y.». Distr.: South Africa; Australian, Nearctic, Neotropical, Palearctic

compar (EATON, 1904): *Entomologist's Monthly Magazine* **15:** 57 (*Threticus*). Type localities: «Ireland, England, Algeria, and Madeira».

filipenis SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 362. Type locality: [Cameroon] «Mt. Cameroon, Onyanga, 8,100 ft. Nigeria». Distr.: Cameroon

haematospicula SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 361. Type locality: [D.R. Congo] «Belgian Congo: Rutshuru». Distr.: D.R. Congo

khoralkhwairensis (JEŽEK & VAN HARTEN, 2009): *Arthropod Fauna of the UAE* **2:** 701 (*Psychodocha)*. Type locality: «United Arab Emirates, Khor-al-Khwair [25°58’N 46°03’E]». Distr.: Yemen. ***comb.nov. See note 10***

scuticopenis SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 363. Type locality: [D.R. Congo] «Belgian Congo: Escarpement Kabasha, Chambi». Distr.: D.R. Congo

Subgenus ***PSYCHODULA*** JEŽEK, 1984b

PSYCHODULA JEŽEK, 1984b: *Acta faunistica Entomologica Musei Nationalis Pragae* **17**: 138 (as genus). Type species: *Psychoda minuta* Banks, 1894 (original designation)

harrisi SATCHELL, 1950: *Transactions of the Royal Entomological Society of London, Series B.* **101:** 171. Type locality: . Distr.: Yemen; Australian, Oceanic, Oriental, Palearctic

bifurcata TOKUNAGA, 1958 (female only): *Philippine Journal of Science* **86:** 378. Type locality: [Japan], «Naha vicinity, Okinawa, Ryuku Islands».

haematifera TOKUNAGA, 1958 (male only): *Philippine Journal of Science* **86:** 385. Type locality:[Japan], «Naha vicinity, Okinawa, Ryuku Islands».

Subgenus ***TINEARIA*** SCHELLENBERG, 1803

TINEARIA SCHELLENBERG, 1803: *Genres des Mouches Dipteres, representes en XLII Planches projettees et dessinees par Mr. J. R. Schellenberg et expliquees par deux amateurs de l'Entomologie:* Tab. 40. Type species: *Psychoda alternata* Say, 1824 (subsequent designation of Coquillett 1910)

acanthostyla TOKUNAGA, 1957: *Scientific Reports of the Saikyo University. Agriculture* **9:** 53. Type locality: [Taiwan] «Szechun, near Chaochow, Formosa». Distr.: Cape Verde, UAE; Oriental, Palearctic

alternata SAY, 1824: *Narrative of an expedition to the source of the St. Peter's river, Lake Winnepeek, Lake of the Woods 1823 under the command of Major Long* **2:** 358. Type locality: [U.S.A.] «inhabits Pennsylvania». Distr.: D.R. Congo, Gambia, Ghana, Nigeria the Seychelles, South Africa, Tanzania, UAE; Australian, Nearctic, Neotropical, Oceanic, Oriental, Palearctic. ***See note 11***

lativentris BERDÉN, 1952: *Opuscula Entomologica* **17:** 110. Type locality: [Sweden] «Sk. Åkarp.» Distr.: South Africa; Nearctic, Neotropical, Palearctic. ***See note 12.***

quadesiana VAILLANT, 1963b: *Opuscula Entomologica* **28:** 211. Type locality: «Quades, au sud de Qual'eh Nahou, Afghanistan»

pseudoalternicula SALAMANNA, 1975b: *Bollettino dei Musei e degli Istituti Biologici dell' Universita di Genova* **43:** 84. Type locality: [Italy] «Schivonea». Distr.: Cape Verde; Palearctic

lebanica VAILLANT & MOUBAYED, 1987: *Annales de Limnologie* **23:** 125. Type locality: [Lebanon] «Anjar, Chamsine, entre 900 et 1 000 m d'altitude, en bordure du Ghozayel, qui est un affluent du Litani.»

Subgenerically unplaced species of ***PSYCHODA*** LATREILLE, 1796

acuta TONNOIR, 1939b: *Ruwenzori Expedition* **1:**54. Type locality: [Uganda] «RUWENZORI: Kilembe, 4500 ft.» Distr.: Uganda

adunca WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 295. Type locality: «TANZANIA: Tanga Region, Lushoto District, West Usambara Mts., Mazumbai Forest Reserve, about 1600 m a.s.l,». Distr.: Tanzania

albida TONNOIR, 1939b: *Ruwenzori Expedition* **1:**52. Type locality: [Uganda] «RUWENZORI: Namwamba Valley, 8300 ft.» Distr.: Uganda.

albidonigra TONNOIR, 1939a: *Journal of the East Africa and Uganda Natural History Society* **14:** 12. Type locality: «Chyulu Hills, Kenya.» Distr.: Kenya

amphorica TONNOIR, 1939b: *Ruwenzori Expedition* **1:** 49. Type locality: [Uganda] «RUWENZORI: Namwamba Valley, 8300-10,200 ft.» Distr.: Uganda.

bilobata TONNOIR, 1939b: *Ruwenzori Expedition* **1:**50. Type locality: [Uganda] «RUWENZORI: Namwamba Valley, 13-14,000 ft.» Distr.: Uganda

cylindrica WAGNER, 1989: *Spixiana* **12**: 190. Type locality: [South Africa] «Transvaal, Entabeni Forest, Soutpansberg, 4000-5000 ft.». Distr.: South Africa.

dentata TONNOIR, 1939b: *Ruwenzori Expedition* **1:**53. Type locality: «S.W. UGANDA: in crater of Mt. Muhavura, 13,500 ft.» Distr.: Lesotho, South Africa, Uganda.

flexistyla SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 359. Type locality: [D.R. Congo] «Belgian Congo: N. Kivu, Kibati». Distr.: D.R. Congo

latipennis TONNOIR, 1939b: *Ruwenzori Expedition* **1:**56. Type locality: [Uganda] «RUWENZORI: Kilembe, 4500 ft.» Distr.: Uganda.

latisternata TONNOIR, 1939a: *Journal of the East Africa and Uganda Natural History Society* **14:** 11. Type locality: «Chyulu Hills, Kenya.» Distr.: Kenya

martini HOGUE, 1970: *Contributions in Science* **204:** 1. Type locality: «Kilifi Creek, Kenya, East Africa.» Distr.: Kenya.

maxima TONNOIR, 1939b: *Ruwenzori Expedition* **1:**41. Type locality: [Uganda] «RUWENZORI: Namwamba Valley, 10,200 ft.». Distr.: Uganda.

megale QUATE, 1957: *La Naturaliste Malgache* **9**: 260. Type locality: «MADAGASCAR CENTRE: Ankaratra, sommet du Tsiafajavona.» Distr.: Madagascar

modesta TONNOIR, 1939b: *Ruwenzori Expedition* **1:**43. Type locality: [Uganda] «RUWENZORI: Bwamba Pass (west side) 5500-7500 ft.». Distr.: Uganda.

morogorica WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 293. Type locality: «TANZANIA: Morogoro Region, Morogoro, Sokoine University of Agriculture, Campus, about 550 m a.s.l.». Distr.: Tanzania. ***See note 13***

penicillata SATCHELL, 1950: *Transactions of the Royal Entomological Society of London, Series B.* **101:** 176. Type locality: [New Zealand] «Wellington». Distr.: South Africa; Australian.

perlonga SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 370. Type locality: [D.R. Congo] «Belgian Congo. [...] Envir. Mission Rugari (Lulenga)». Distr.: D.R. Congo

plumosa TONNOIR, 1939b: *Ruwenzori Expedition* **1:**56. Type locality: [Uganda] «RUWENZORI: Kilembe, 4500 ft.» Distr.: Uganda.

reducta TONNOIR, 1939b: *Ruwenzori Expedition* **1:**42. Type locality: [Uganda] «RUWENZORI: Namwamba Valley, 8300 ft.»

sanfillippoi SALAMANNA, 1980: *Aquatic Insects* **2**: 191. Type locality: [Kenya] «Mount Kenya, Teleki Valley, Teleki Kut, 4150 m.» Distr.: Kenya

serrata WAGNER, 1989: *Spixiana* **12**: 189. Type locality: [South Africa] «Transvaal, Entabeni Forest, 4000-5000 ft. Höhe». Distr.: South Africa.

solitaria EATON, 1913: *The Percy Sladen Trust expedition to the Indian Ocean in 1905, under the leadership of Mr. J. Stanley Gardiner, M. A.* **4:** 429. Type locality: «Seychelles. Mahé: Cascade Estate, about 800 feet.» Distr.: The Seychelles. ***See note 14***

subinflata SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 360. Type locality: [Cameroon] «Mt. Cameroon, 8,100 ft., Onyanga, Nigeria». Distr.: Cameroon

trifida WAGNER, 1979: *Aquatic Insects* **1:** 60. Type locality: [D.R. Congo] «Kalengo, 10 km westward Lake Kivu (Republic of Zaire)». Distr.: D.R. Congo

undulata TONNOIR, 1939b: *Ruwenzori Expedition* **1:**47. Type locality: «S.W. UGANDA: Mt. Hgahinga, 8000 ft.» Distr.: Uganda.

Genus ***THRETICUS*** EATON, 1904

THRETICUS EATON, 1904: *Entomologist's Monthly Magazine* **40:** 57. Type species: *Psychoda lucifuga* Walker, 1856 (subsequent designation of Enderlein 1935)

RHIPIDOPSYCHODA VAILLANT, 1991: *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique (Entomologie)* **61:** 209. Type species: *Psychoda nana* Tonnoir, 1922 (original designation) ***syn.nov. See note 15***

boettgeri (WAGNER, 1979): *Aquatic Insects* **1:** 61 (*Psychoda*). Type locality: [D.R. Congo] «Kalengo, 10 km westward Lake Kivu (Republic of Zaire)». Distr.: D.R. Congo ***comb.nov. See note 16***

dubitatus (TONNOIR, 1939b): *Ruwenzori Expedition* **1:**57. Type locality: «KENYA: Mt. Kinangop, 8000 ft., Aberdare Range». Distr.: Kenya, ?South Africa

ingrami (TONNOIR, 1922a): *Bulletin de la Société Entomologique D'Égypte* **6:** 88 (*Psychoda).* Type locality: [Ghana] «Gold Coast, Nsarvan Barana». Distr.: Ghana.

nana (TONNOIR, 1922a): *Bulletin de la Société Entomologique D'Égypte* **6:** 93 (*Psychoda).* Type locality: [Ghana] «Gold Coast, Nsarvan Barana». Distr.: Ghana, D.R. Congo

saetheri WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 296. Type locality: «TANZANIA: Tanga Region, Lushoto District, West Usambara Mts., Mazumbai Forest Reserve, Kaputu Stream, 1600 m a.s.l». Distr.:

Tanzania
tanganicus WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 296. Type locality: «TANZANIA: Tanga Region, Lushoto District, West Usambara Mts., Mponde Forest, Tekwe River, 4º53'S 38º25'E, 1590 m a.s.l.». Distr.: Tanzania

Genus ***TRICHOPSYCHODA*** TONNOIR, 1922

TRICHOPSYCHODA TONNOIR, 1922c: *Annales de la Société Entomologique de Belgique* **62:** 59 (as subgenus of *Psychoda* Latreille, 1796). Type species: *Psychoda hirtella* Tonnoir, 1919 (monotypy)

africana SATCHELL, 1955a: *Proceedings of the Royal Entomological Society of London. Series B, Taxonomy.* **24:** 51. Type locality: [South Africa] «NATAL: Town Bush, Pietermaritzburg». Distr.: South Africa, D.R. Congo

PSYCHODINAE incertae sedis

Genus ***CLYTOCERUS*** EATON, 1904

CLYTOCERUS EATON, 1904: *Entomologist's Monthly Magazine* **40:** 59. Type species: *Clytocerus africanus* Tonnoir, 1920 (subsequent monotypy)
SYNSEODAIS ENDERLEIN, 1937: *Deutsche Entomologische Zeitschrift* **4:** 92. Type species: *Synseodais flavitarsis* Enderlein, 1937 (original designation)
NOTOCLYTOCERUS DUCKHOUSE, 1975: *Annals of the Natal Museum* **22:** 428 (as subgenus of *Clytocerus* Eaton, 1904). Type species: *Clytocerus tauricornis* Duckhouse, 1975 (original designation)

africanus TONNOIR, 1920: *Revue du zoologie Africaine* **8**: 137. Type locality: «South Nigera, Warra». Distr.: D.R. Congo, Nigeria
carbonarius TONNOIR, 1939b: *Ruwenzori Expedition* **1:**62. Type locality: [Uganda] «RUWENZORI: Namwamba Valley, 8300 ft.». Distr.: Uganda.
chyuluensis SATCHELL, 1955b: *Revue de zoologie et de botanique africaines* **51:** 347. Type locality: «Chyulu Hills, Kenya, 5200 feet». Distr.: Kenya, South Africa.
constrictus DUCKHOUSE, 1975: *Annals of the Natal Museum* **22:** 443. Type locality: «SOUTH AFRICA, E. Transvaal, near Nelspruit.» Distr.: South Africa, Zimbabwe
corniculatus DUCKHOUSE, 1975: *Annals of the Natal Museum* **22:** 438. Type locality: [Zimbabwe] «RHODESIA, Chirinda Forest, Mt Selinda». Distr.: Zimbabwe
divaricatus DUCKHOUSE, 1975: *Annals of the Natal Museum* **22:** 440. Type locality: «SOUTH AFRICA, Grahamstown, Fern Kloof». Distr.: South Africa
duckhousei WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 303. Type locality: «TANZANIA: Tanga Region, Lushoto District, West Usambara Mts., Mazumbai Forest Reserve, about 1550 m a.s.l.». Distr.: Tanzania
excelsior DUCKHOUSE, 1987: *Annals of the Natal Museum* **28**: 280. Type locality: «MALAWI, Zomba Plateau, montane forest, 1500 m». Distr.: Malawi.
fasciatus TONNOIR, 1939b: *Ruwenzori Expedition* **1:** 59. Type locality: [Uganda] «RUWENZORI: Mt. Karangora, 8-9000 ft.» Distr.: Uganda
flavitarsis (ENDERLEIN, 1937): *Deutsche Entomologische Zeitschrift* **4:**92.Type locality: [Tanzania] «D. O. Afrika, Kilimandjaro Meruberg». Distr.: Tanzania
haeselbarthi WAGNER, 1989: *Spixiana* **12**: Type locality: [South Africa] «Transvaal, Entabeni Forest, Soutpansberg». Distr.: South Africa.
inequalis DUCKHOUSE, 1975: *Annals of the Natal Museum* **22:** 433. Type locality: «SOUTH AFRICA, Paarl district, W. Cape, Du Toit's Kloof, 900 – 1 370 m». Distr.: South Africa
palliolatus DUCKHOUSE, 1975: *Annals of the Natal Museum* **22:** 441. Type locality: «SOUTH AFRICA, E. Transvaal, near Nelspruit.» Distr.: South Africa
tauricornis DUCKHOUSE, 1975: *Annals of the Natal Museum* **22:** 431. Type locality: «SOUTH AFRICA, Cape Town, Kirstenbosch, upper reaches of Skeleton stream.» Distr.: South Africa
zuluensis DUCKHOUSE, 1975: *Annals of the Natal Museum* **22:** 434. Type locality: «SOUTH AFRICA,

Natal, Pietermaritzburg, Town Bush». Distr.: South Africa

Genus ***MYSTROPSYCHODA*** DUCKHOUSE, 1975

MYSTROPSYCHODA DUCKHOUSE, 1975: *Annals of the Natal Museum* **22:** 444. Type species: *Mystropsychoda rhodesiensis* Duckhouse, 1975 (original designation)

obscura (TONNOIR, 1939b): *Ruwenzori Expedition* **1:** 77. Type locality: [Uganda] «RUWENZORI: Kilembe 4500 ft.». Distr.: D.R. Congo, Uganda

pallida (TONNOIR, 1922a): *Bulletin de la Société Entomologique D'Égypte* **6:** 96 (*Psychoda).* Type locality: [Ghana] «Abhouri (Côte de l'Or)». Distr.: Ghana, Botswana, D.R. Congo, South Africa, Zimbabwe

rhodesiensis DUCKHOUSE, 1975: *Annals of the Natal Museum* **22**: 445. Type locality: [Zimbabwe] «RHODESIA, near Umtali, Vumba Mt.». Dist.: Zimbabwe, Malawi

tansanica WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 290. Type locality: «TANZANIA: Tanga Region, Lushoto District, West Usambara Mts., Mazumbai Forest Reserve, about 1600 m a.s.l.». Distr.: Tanzania

Unplaced species of PSYCHODINAE

coprina SATCHELL, 1956a: *South African Animal Life* **3:** 402 (*Psychoda*). ***nomen nudum***
multimaculatus SATCHELL, 1956a: *South African Animal Life* **3:** 399 (*Clytocerus*). ***nomen nudum***
patersoni SATCHELL, 1956a: *South African Animal Life* **3:** 400 (*Telmatoscopus*). ***nomen nudum***
spatulipenis SATCHELL, 1956a: *South African Animal Life* **3:** 402 (*Psychoda*). ***nomen nudum***

Subfamily SYCORACINAE RONDANI, 1856

SYCORAXIDAE RONDANI, 1856: *Dipterologiae Italicae Prodromus* **1:** 17
SYCORACINAE HENNIG, 1950: *Die Larvenformen der Dipteren* **2:** 20

Genus ***SYCORAX*** HALIDAY IN CURTIS, 1839

SYCORAX HALIDAY IN CURTIS, 1839: *British entomology; being illustrations and descriptions of the genera of insects found in Great Britain and Ireland: containing coloured figures from nature of the most rare and beautiful species, and in many instances of the plants upon which they are found* **16:** 745. Type species: *Sycorax silacea* Haliday in Curtis, 1839 (monotypy)

MICRODIXA MÜLLER, 1927: *Zeitschrift für Morphologie und Ökologie der Tiere* **7:** 535. Type species: *Microdixa scutigera* Müller, 1927 (by original designation, see ICZN art. 68.2.1)

africana TONNOIR, 1920: *Revue du zoologie Africaine* **8**: 146. Type locality: «UGANDA: Nasala Mpumu (forèt) et Victoria Nyanza (rive).». Distr.: Uganda. ***See note 17***

duckhousei WAGNER, 1989: *Spixiana* **12:** 184. Type locality: [South Africa] «Südafrika, Natal, Karkloof-forest, 1500 m». Distr.: South Africa.

kalengoensis WAGNER, 1979: *Aquatic Insects* **1:** 56. Type locality: [D.R. Congo] «Kalengo, 10 km westward Lake Kivu (Republic of Zaire)». Distr.: D.R. Congo

usambarica WAGNER & ANDERSEN, 2007: *Contributions to the Systematics and Ecology of Aquatic Diptera – A Tribute to Ole A. Sæther*: 288. Type locality: «TANZANIA: Tanga Region, Lushoto District, West Usambara Mts., Mazumbai Forest Reserve, about 1600 m a.s.l.». Distr.: Tanzania

Subfamily **TRICHOMYIINAE** TONNOIR, 1922

TERMITODIPTERINAE SPEISER, 1906: *Zoologische Anzeiger* **30:** 717. ***See note 18***
TRICHOMYINAE TONNOIR, 1922b: *Bulletin et Annales de la Société Royale d'Entomologie de Belgique* **62:** 127

Genus ***TRICHOMYIA*** HALIDAY IN CURTIS, 1839

TRICHOMYIA HALIDAY IN CURTIS, 1839: *British entomology; being illustrations and descriptions of the genera of insects found in Great Britain and Ireland: containing coloured figures from nature of the most rare and beautiful species, and in many instances of the plants upon which they are found* **16:** 745. Type species: *Trichomyia urbica* Haliday in Curtis, 1839 (monotypy)
DIPLONEMA LOEW, 1845: *Dipterologische Beiträge* **1**: 7. Type species: *Diplonema buceras* Loew, 1845 (monotypy)
PHALAENOMYIA LOEW, 1845: *Dipterologische Beiträge* **1**: 9. Type species: *Diplonema buceras* Loew, 1845 (subsequent designation of Evenhuis (1994))
TERMITODIPTERON HOLMGREN, 1905: *Zoologischer Anzeiger* **29**: 533. Type species: *Termitodipteron wasmanni* Holmgren, 1905 (monotypy)
LEPRIA ENDERLEIN, 1937: *Deutsche Entomologische Zeitschrift* **1936:** 112. Type species: *Lepria squamosa* Enderlein, 1937 (original designation)
EUBONETIA VARGAS & DIAZ NÀJERA, 1953: *Revista del Instituto de Salubridad y Enfermedades Tropicales* **13**: 155. Type species: *Trichomyia cirrata* Coquillett, 1902 (original designation)

brochata QUATE, 1957: *La Naturaliste Malgache* **9**: 252. Type locality: «MADAGASCAR OUEST: forêt de l'Ankarafantsika, Tsaramandroso.» Distr.: Madagascar
congoensis SATCHELL, 1956b: *Proceedings of the Royal Entomological Society of London (B)* **24:** 154. Type locality: [D.R. Congo] «BELGIAN CONGO: N. Kivu, Kibati». Distr.: D.R. Congo
dlinzae DUCKHOUSE, 1980: *Annals of the Natal Museum* **24:** 187. Type locality: «SOUTH AFRICA, Natal, Eshowe district, Dlinza forest» Distr.: South Africa
nodosa DUCKHOUSE, 1980: *Annals of the Natal Museum* **24:** 184. Type locality: [South Africa] «TRANSKEI, Port St. Johns district, coastal forest.» Distr.: South Africa
piricornis FREEMAN, 1949: *Proceedings of the Royal Entomological Society of London (B)* **18**: 239. Type locality: [D.R. Congo] «BELGIAN CONGO: District of Lake Leopold II, Luna». Distr.: D.R. Congo

NOTES

1. The type specimen of *Psychoda albonotata* Brunetti, 1908 is a female and the male of this species is still not known with certainty. The synonymy of *Brunettia indica* Eaton, 1913 with *P. albonotata* is according to Edwards (1928) and has subsequently been cited by Tonnoir (1939b) and Duckhouse & Lewis (1980). Many species of *Brunettia* are, however, inseparable in the female sex, so Edwards' synonymies should be considered doubtful (Quate 1962).

2. Apart from the *Limomormia wadi* Ježek & van Harten, 2009 from the UAE, all Afrotropical Mormiina belong to a single monophyletic group (Duckhouse, 1987). According to Ježek (1994), *Afromormia* Duckhouse, 1987 is a subjective synonym of *Hemimormia* Krek, 1971 *sensu* Ježek (1984a). *Rhadinoscopus* Quate & Quate, 1967 and *Promormia* Ježek, 1984a have also been mentioned from the continent, but the species in question do not fit the diagnoses of these genera. The present catalogue is the first to recognise that the described Afrotropical Mormiina are congeneric and that the global diversity of Mormiina is best represented as several genera (cf. Ježek 1984a, 1994; Krek 1999, but see Duckhouse 1990). The classification of Mormiina on a global level is still a matter of debate.

3. Krek's (1999) interpretation of *Limomormia* Vaillant, 1982 comprises two subgenera: *Limomormia s.str.* and *Lepimormia* Enderlein, 1937. This interpretation is in violation of the ICZN art. 23.3, as such a genus should be called *Lepimormia* by its oldest name. Pending a generic revision of *Mormia s.l.*, the name *Limomormia* is here used for *Limomormia s.str. sensu* Krek (1999) and *Limomormia (Arabomyia)* Ježek & van Harten, 2009.

4. A complete synonymy of *Clogmia albipunctata* (Williston, 1893) can be found in Ibañez-Bernal (2008).

5. *Cryptotelmatoscopus* Vaillant, 1982 was proposed as a genus to include the Nearctic species *Telmatoscopus vestitus* Vaillant, 1973. This species shares many characteristics with *Clogmia* Enderlein, 1937, mainly differing in whether the ascoids are bifurcate or with multiple branches. Since the polarity of this character is not well understood it is not considered as a suitable genus-level character in the present publication. *Cryptotelmatoscopus* is therefore provisionally placed as a (possibly para- or polyphyletic) subgenus of a broadly conceived *Clogmia*. *Orgaoclogmia* Ježek & van Harten, 1996 was psoposed as a genus to include a large group of species previously placed in *Clogmia*; all with ascoids having multiple branches. As all the diagnostic characters of these two taxa are identical, *Orgaoclogmia* is placed as a subjective junior synonym of *Cryptotelmatoscopus* **syn.nov**.

6. In his original type species designation for *Panimerus*, Eaton (1913, p. 426) wrote «Type: *Panimerus hirtus* (Linn.) (*notabilis* Eaton).» This refers to *Tipula hirta* Linnaeus, 1761, which is a *nomen dubium*; however the status of this species is not relevant for nomenclatural purposes. Eaton (1913) clearly viewed *Pericoma notabilis* Eaton, 1893 as a synonym of *T. hirta*, thus *P. notabilis* will remain the type of the genus even if this synonymy is found to be wrong (see §70.3 in the ICZN). Enderlein's (1937) and Ježek's (1984) citations of *Panimerus scotti* Eaton, 1913 as the type species of *Panimerus* Eaton, 1913 are probably due to a misunderstanding of the ICZN § 68.2.1. This article states that the expression «gen.n., sp.n.» or equivalent can be interpreted as a type species designation for the genus if the type species is not explicitly given otherwise. In the case of *Panimerus* this does not apply, as Eaton (1913) clearly provided such a designation.

7. *Karakovounimerus* Ježek, 1990 differs from *Panimerus* Eaton, 1913 *s.str.* mainly by the round pedicel and the nodiform 13th flagellomere of *Karakovounimerus*; characters likely to be plesiomorphic within the Paramormiini. However, the two taxa share several apomorphies in the structure of the male genitalia, including a broad basiphallus and a pair of crescent-shaped parameres attached laterodistally to the distiphallus. Other similarities include an elongate scape, the presence of corniculi and the wing membrane with darker patches near the apices of the longitudinal veins. Because these taxa probably form a monophyletic unit, *Karakovounimerus* is here treated as a subgenus of *Panimerus*. It is likely that the related genus *Psycmera* Ježek, 1984 also should be moved to the status of subgenus; however this taxon is not known from the Afrotropical region and is therefore not within the scope of the present paper.

8. The type species of *Telmatoscopus* Eaton, 1904 is controversial. The genus was described without any included species; however in the first subsequent publication on the genus three species were mentioned, viz. *T. advena* Eaton, 1893, *T. meridionalis* Eaton, 1893 (=*Clogmia albipunctata* (Williston, 1893)) and *T. rothschildii* Eaton, 1912 (Eaton 1912). Since the type species needs to be selected from the originally included species (ICZN §67.2), *Pericoma morula* Eaton, 1893 is not available for type species designation in *Telmatoscopus*; contrary to e.g. Quate (1955), Duckhouse (1966), Ježek (1984, 1989), Krek (1999) and Bravo *et al.* (2011) 's interpretation of the genus. In the present work I have nevertheless adopted a pragmatic genus concept similar to that used by Bravo *et al.* (2011). This is, however, only provisory as the generic placement of the Afrotropical species placed in *Telmatoscopus* needs to be revised.

9. Duckhouse & Lewis (1980) transferred *Telmatoscopus pilosternatus* Satchell, 1955 to *Notiocharis* Eaton, 1913. However this species lacks several of the diagnostic characters for *Notiocharis* listed by Duckhouse (1966), as the gonostylus is not bifurcate and the eyebridge is not fully reduced. The species is therefore transferred to the closely related genus *Mormopericomiella* Jezek & van Harten, 2002. The only Afrotropical species of *Notiocharis s.str.* is *Notiocharis insignis* Eaton, 1913; which occurs in the Seychelles.

10. *Psychoda* Latreille, 1796 is a large and species-rich genus that eventually will need subdivision. Various classifications have been suggested (Vaillant 1971; Ježek 1977, 1983, 1984b, 2007; Ježek & van Harten 1996, 2005, 2009). However, these subdivisions only seem robust for the holarctic fauna. In this catalogue I follow Withers (1986) and Bravo *et al.* (2006), treating the genera proposed in Ježek (1984b), Ježek & van Harten (2005) and Ježek (2007) as subgenera of a broadly conceived *Psychoda* Latreille, 1796. Assignment of species to subgenera follows the genus nomenclature of the above mentioned articles; I have refrained from placing additional species.

11. For a complete synonymy of *Psychoda alternata* Say, 1824, see Ibañez-Bernal (2008).

12. *Psychoda lativentris* Berdén, 1952 is listed for South Africa by Satchell (1955) and Duckhouse & Lewis (1980) without further information on material and localities.

13. *Psychoda morogorica* Wagner & Andersen, 2007 and some other Afrotropical species described in *Psychoda* Latreille, 1796 may be species of *Quatiella* Botosaneanu & Vaillant, 1970, *Feuerborniella* Vaillant, 1971 or a related genus.

14. Eaton (1913) considered the possibility that *Psychoda solitaria* Eaton, 1913 was a synonym of *Psychoda albipennis* Zetterstedt, 1850. This has yet to be confirmed.

15. *Rhipidopsychoda* Vaillant, 1991 was described for two species previously treated as aberrant species of *Threticus* Eaton, 1904: *Psychoda nana* Tonnoir, 1922a and *Threticus fissiceps* Quate & Quate, 1967. Diagnostic characters differentiating the two genera are insufficiently explored for most African species of *Threticus* and it is here considered more useful to treat *Rhipidopsychoda* as a synonym of *Threticus* than as a full genus.

16. *Psychoda boettgeri* Wagner, 1979 is placed as a *Threticus* because its male genitalia closely resemble those of *Threticus tanganicus* Wagner & Andersen, 2007 and *Psychoda nana* Tonnoir, 1922a.

17. Wagner (1979) lists *Sycorax africana* Tonnoir, 1920 as a *nomen dubium* due to his belief that the type material of the species was lost. There is, however, a type series of three pinned specimens in the Museum of Natural History, London (pers.obs.).

18. Termitodipterinae Speiser, 1906 is the correct name for the subfamily containing *Trichomyia* Haliday in Curtis, 1839 according to ICZN art. 23 (see Sabrosky 1999). However, since the name has not been in use since Speiser (1906) proposed it (although see comment by Edwards *in* Tonnoir 1929), it is here deemed most useful to follow the prevailing useage of Trichomyiinae Tonnoir, 1922b. Ideally, this should be confirmed by the ICZN. However, the synonymy of *Termitodipteron* Holmgren, 1905 with *Trichomyia* Haliday *in* Curtis, 1839 should first be confirmed through a redescription of Holmgren's original type material.

BIBLIOGRAPHY

Alexander, C. P. (1921) A new subfamily of tanyderid flies. *Annals of the Entomological Society of America, 13 (1920)*, 402-407.

Alexander, C. P. (1940) Further observations on the psychodid subfamily Bruchomyinae (Diptera). *Revista de Entomologia, 11*, 793-799.

Annandale, T. N. (1910) A new genus of psychodid Diptera from the Himalayas and Travancore. *Records of the Indian Museum, 5*, 141-144.

Banks, N. (1894) Some Psychodidae from Long Island, N.Y. *Canadian Entomologist, 28*, 329-333.

Berdén, S. (1952) Taxonomical notes on Psychodidae (Dipt. Nem.) 1. *Psychoda lativentris* n.sp., a species hitherto confused with *alternata* Say. *Opuscula Entomologica, 17*, 110-112.

Botosaneanu, L. & Vaillant, F. (1970) Trois Diptères Psychodidae nouveaux de Cuba. *Travaux du*

Laboratoire d'Hydrobiologie et de Pisciculture de l'Universite de Grenoble, 61, 173-183.

Bravo, F., Cordeiro, D. & Chagas, C. (2006) Two new species and new records of *Psychoda* Latreille (Diptera: Psychodidae: Psychodinae) from Brazil, with comments on supraspecific classification of the genus. *Zootaxa, 1298*, 1-15.

Bravo, F., Souza, I., Santos, C. B. d. & Ferreira, A. L. (2011) Three new species of *Telmatoscopus* Eaton, 1904 (Diptera, Psychodidae) from Brazil. *Zootaxa, 2802*, 34-40.

Brunetti, E. A. (1908) Indian Psychodidæ. *Records of the Indian Museum, 2*, 369-384.

Brunetti, E. A. (1911) New Oriental Nemocera. *Records of the Indian Museum, 4*, 259-316.

Brunetti, E. A. (1912) *Diptera Nematocera (excluding Chironomidæ and Culicidæ)*. London: Taylor & Francis.

Crosskey, R. W. (1980) *Catalogue of the Diptera of the Afrotropical Region*. London: British Museum (Natural History).

Curtis, J. (1839) *British entomology: being illustrations and descriptions of the genera of insects found in Great Britain and Ireland: containing coloured figures from nature of the most rare and beautiful species, and in many instances of the plants upon which they are found. Volume 16*. Printed by the author, London.

Duckhouse, D. A. (1966) Psychodidae (Diptera, Nematocera) of Southern Australia: subfamily Psychodinae. *Transactions of the Royal Entomological Society of London, 118*, 153-220.

Duckhouse, D. A. (1975) Non-phlebotomine Psychodidae (Diptera, Nematocera) of southern Africa. I. Subfamily Psychodinae: *Pericoma, Clytocerus* and *Mystropsychoda* gen.n. *Annals of the Natal Museum, 22 (2)*, 421-448.

Duckhouse, D. A. (1978) Non-phlebotomine Psychodidae (Diptera, Nematocera) of southern Africa. II. Subfamily Psychodinae: *Neoarisemus* and the brunettoid and telmatoscopoid genera. *Annals of the Natal Museum, 23 (2)*, 305-359.

Duckhouse, D. A. (1980) *Trichomyia* species (Diptera, Psychodidae) from southern Africa and New Zealand, with a discussion of their affinities and the concept of monophyly in Southern Hemisphere biogeography. *Annals of the Natal Museum, 24*, 177-191.

Duckhouse, D. A. (1985a) A re-examination of *Neomaruina* (Diptera, Psychodidae), with observations on its life-history and affinities and redefinition of the tribe Psychodini. *Annals of the Natal Museum, 26 (2)*, 601-620.

Duckhouse, D. A. (1985b) Type-species designation for *Trichomyia* subgenus *Gondwanotrichomyia* Duckhouse (Diptera: Psychodidae). *Annals of the Natal Museum, 24*, 177-191.

Duckhouse, D. A. (1987) A revision of Afrotropical *Setomima*, elucidation of their genealogical relationships and descriptions of other Afrotropical Psychodinae (Diptera: Psychodidae). *Annals of the Natal Museum, 28*, 231-282.

Duckhouse, D. A. (1990) Morphology and Taxonomy of the Bornean *Mormia maai* (Quate) and Related Forms in Northern Australia (Diptera, Psychodidae). *Aquatic Insects, 12*, 247-256.

Duckhouse, D. A. & Lewis, D. J. (1980) Family Psychodidae. *In:* R. W. Crosskey (Ed), *Catalogue of the Diptera of the Afrotropical Region*. British Museum (Natural History), London, pp. 93-105.

Eaton, A. E. (1894) Description of a new species of *Pericoma* from Delagoa Bay. *Entomologist's Monthly Magazine, 30*, 194-195.

Eaton, A. E. (1904) New Genera of European Psychodidae. *Entomologist's Monthly Magazine, 40*, 55-59.

Eaton, A. E. (1912) *Telmatoscopus rothschildii,* a new species of psychodid Diptera found in London. *Entomologist's Monthly Magazine, 48*, 7-9.

Eaton, A. E. (1913) The Percy Sladen Trust expedition to the Indian Ocean in 1905, under the leadership of Mr. J. Stanley Gardiner, M. A. Vol. 4 No. XXV. - Diptera, Psychodidae. *Transactions of the Linnaean Society of London (2. Zool.), 15*, 423-432.

Edwards, F. W. (1921) A note on the subfamily Bruchomyiinæ (Diptera Nematocera). *Annals and Magazine of Natural History, 7*.

Edwards, F. W. (1928) Nematocera. *Insects of Samoa, British Museum (Natural History), 6*, 23-102.

Edwards, F. W. (1929) The genus *Nemapalpus* in South-Africa (Diptera, Psychodidæ). *Annals and Magazine of Natural History, 10*, 421-423.

Enderlein, G. (1935) Zur Klassifikation der Psychodinen. *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin, 1935*, 246-249.

Enderlein, G. (1937) Klassifikation der Psychodiden (Dipt.). *Deutsche Entomologische Zeitschrift, 4*, 81-112.

Freeman, P. (1949) Two new Ethiopian species of Psychodidae (Diptera). *Proceedings of the Royal Entomological Society of London (B), 18*.

Hennig, W. (1950) *Die Larvenformen der Dipteren. 2. teil*. Berlin: Akad. -Verlag.

Hogue, C. L. (1970) A new moth fly of the genus *Psychoda* from crabholes on the Kenya coast. *Contributions in Science, 204*, 1-5.

Holmgren, N. (1905) Zwei neue Termitomastiden aus Südamerika. *Zoologischer Anzeiger, 29*, 349-356.

Ibáñez-Bernal, S. (2008) New Records and Descriptions of Mexican Moth Flies (Diptera: Psychodidae, Psychodinae). *Transactions of the American Entomological Society, 134*, 87-131.

International Commission on Zoological Nomenclature (1999). International Code of Zoological Nomenclature. 4th edition. Available online from http://www.nhm.ac.uk/hosted-sites/iczn/code/, assessed august 16th 2011

Ježek, J. (1977) Reinstatement of the genus *Tinearia* Schellenberg (Diptera, Psychodidae). *Acta entomologica Bohemoslovaca, 74*, 232-241.

Ježek, J. (1983) Intergeneric relationship of selected tribes of the subfamily Psychodinae. *Acta Entomologica Musei Nationalis Pragae, 41*, 255-259.

Ježek, J. (1984a) Nomenclatorical changes of some higher taxa of palaearctic Psychodinae (Diptera, Psychodidae). *Acta Faunistica Entomologica Musei Nationalis Pragae, 17*, 155-170.

Ježek, J. (1984b) Six new genera of the tribe Psychodini End. (Diptera, Psychodidae). *Acta Faunistica Entomologica Musei Nationalis Pragae, 17*, 133-153.

Ježek, J. (1987) Results of the Czechoslovak-Iranian entomological expeditions to Iran 1973. *Iranotelmatoscopus hajiabadi* gen.n., sp.n. (Diptera, Psychodidae) from the Palearctic region. *Acta Entomologica Musei Nationalis Pragae, 42*, 5-10.

Ježek, J. (1989) Contribution to the taxonomy of the genus *Telmatoscopus* Eat. (Diptera, Psychodidae). *Acta Musei Nationalis Pragae, 44B*, 75-104.

Ježek, J. (1990) Contribution to the taxonomy of some genera of Paramormiine moth flies (Diptera, Psychodidae) with description of a new genus *Karakovounimerus*. *Acta Entomologica Musei Nationalis Pragae, 43*, 129-157.

Ježek, J. (1994) Catalogue of Holarctic and Afrotropical Mormiina End. (Diptera, Psychodidae, Psychodinae, Mormiini). *Casopis Narodniho Muzea Rada Prirodovedna, 162*, 63-66.

Ježek, J. (2004) New taxa of non-biting moth flies (Diptera, Psychodidae, Psychodinae, Paramormiini) from Madagascar. *Acta Facultatis Ecologiae, 12*, 57-68.

Ježek, J. (2007) New Records of Moth Flies (Diptera, Psychodidae) from Poland with description of *Apsycha* gen.nov. *Acta Zoologica Universitatis Comenianae, 47*, 145-160.

Ježek, J. & van Harten, A. (1996) Psychodidae (Diptera) of the Cape Verde Islands, captured with a Johnson-Taylor suction trap. *Boletim do Museu Municipal do Funchal, História Natural, 48*, 63-86.

Ježek, J. & van Harten, A. (2002) New taxa of non-biting moth flies (Diptera: Psychodidae: Psychodinae) from Yemen. *Folia Heyrovskyana, 10*, 225-234.

Ježek, J. & van Harten, A. (2005) Further new taxa and little-known species of non-biting moth flies (Diptera, Psychodidae) from Yemen. *Acta Entomologica Musei Nationalis Pragae, 45*, 199-220.

Ježek, J. & van Harten, A. (2009) Order Diptera, Family Psychodidae. Subfamily Psychodinae (non-biting moth flies). *In:* A. van Harten (Ed), *Arthropod Fauna of the UAE*. Dar Al Ummah Publishing, Abu Dhabi, pp. 686-711.

Jung, H. F. (1956) Beiträge zur Biologie, Morphologie und Systematik der europäischen Psychodiden (Diptera). *Deutsche Entomologische Zeitschrift, 3*, 97-257.

Kincaid, T. (1899) The Psychodidae of the Pacific Coast. *Entomological news, and proceedings of the Entomological Section of the Academy of Natural Sciences in Philadelphia, 10*, 30-37.

Kirk-Spriggs, A. H. & Mostovski, M. (in prep.) *Manual of Afrotropical Diptera*. Publication Unit of the South African National Biodiversity Institute (SANBI): more information on *http://afrotropicalmanual.net*.

Krek, S. (1971) Les Telmatoscopini de la Bosnie (Diptera, Psychodidae, Psychodinae). *Travaux du Laboratoire d'Hydrobiologie et de Pisciculture de l'Universite de Grenoble, 62 (1970)*, 169-188.

Krek, S. (1999) *Psychodidae (Diptera Insecta) Balkanskog Poluotoka*: Studentska Stamparija Univerziteta Sarajevo, Sarajevo.

Latreille, P. A. (1796) Précis des Caractères génériques des Insectes, disposés dans un order naturel par citoyen Latreille. *In*. A. Brive, Bordeaux, p. 201.

Loew, H. (1845) Dipterologische Beiträge. I. *[Progr.] K. Friedrich-Wilhelms-Gymnasiums Posen, 1845*, 1-50.

Macquart, J. (1826) Insectes Diptères du Nord de la France. Tipulaires. *Mémoires de la Société des Sciences, de l'Agriculture et des Arts de Lille, 1823-1824*, 59-224.

Macquart, J. (1838) Dipteres exotiques noveaux ou peu connus. *Mémoires de la Société royale des sciences, de l'agriculture et des arts de Lille, 1*, 9-225.

Macquart, J. (1839) 13. Diptères. *In:* P. B. Webb & S. Berthelot (Eds), *Histoire naturelle des Iles Canaries 2 (2), contenant la zoologie. Entomologie.*, Paris, pp. 97-119.

Meigen, J. W. (1803) Versuch einer neuen Gattungs-Eintheilung der europäischen zweiflügligen Insekten. *Magazin für Insektenkunde, 2*, 259-281.

Meigen, J. W. (1818) *Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten. Erster Teil.* Aachen: F.W. Forstmann.

Meunier, F. (1905) Sur un curieux Psychodid de l'ambre de la Baltique. *Miscellana Entomologica, 13*, 49-51.

Müller, G. W. (1927) *Microdixa* nov. gen. der Dixidae und ihre Verwandlung. *Zeitschrift für Morphologie und Ökologie der Tiere, A, 7*, 535-542.

Newman, E. (1834) Attempted division of British insects into natural orders. *Entomological Magazine, 2*, 379-431.

Quate, L. W. (1954) A revision of the Psychodidae of the Hawaiian Islands (Diptera). *Proceedings of the Hawaiian Entomological Society, 15*, 335-356.

Quate, L. W. (1955) A revision of the Psychodidae (Diptera) in America, north of Mexico. *University of California publications in entomology, 10*, 103-273

Quate, L. W. (1957) Premier etude des Psychodidae de Madagascar. *Le Naturaliste Malgache, 9 (2)*, 251-261.

Quate, L. W. (1959) Diptera: Psychodidae. *Insects of Micronesia, 12*, 435-484.

Quate, L. W. (1962) Psychodidae (Diptera) at the Zoological Survey of India. *Proceedings of the Hawaiian Entomological Society, 18*, 155-188.

Quate, L. W. (1965) Family Psychodidae. *In:* A. Stone, C. W. Sabrosky, W. W. Wirth, R. H. Foote & J. R. Coulson (Eds), *A catalog of the Diptera of America north of Mexico*. Agriculture Research Service, United States Department of Agriculture, Washington DC, pp. 91-97.

Rapp Jr, W. F. & Cooper, J. L. (1945) Check-List of African Psychodidæ. *Journal of the New York Entomological Society, 53*, 247-257.

Rondani, C. (1856) *Dipterologiae Italicae Prodromus. Vol. 1. Genera Italica ....* Parmae: A. Stoschi.

Sabrosky, W. C. (1999) Family-Group Names in Diptera and Bibliography. *Myia, 10*, North American Dipterist's Society. Backhuys Publishers, Leiden. 584 pp.

Salamanna, G. (1975a) Psychodidae Psychodinae della Puglia e della Basilicata con descrizione di due nuove specie (Diptera Nematocera). *Entomologica, 11*, 193-214.

Salamanna, G. (1975b) Psychodinae della Calabria con descrizione di due specie nuove (Diptera Nematocera Psychodidae). *Bollettino dei Musei e degli Istituti Biologici dell'Universita di Genova, 43*, 75-94.

Salamanna, G. (1980) *Psychoda sanfilippoi* sp. n., a brachypterous species from Mount Kenya (Diptera: Psychodidae). *Aquatic Insects, 2*, 191-196.

Satchell, G. H. (1950) The New Zealand Psychodidae: A study based upon the collection and manuscript notes of the late Dr. A. L. Tonnoir. *Transactions of the Royal Entomological Society of London, 101*, 147-178.

Satchell, G. H. (1953) New and little known Samoan Psychodidae and a new species from Rarotonga. *Proceedings of the Royal Entomological Society of London (B), 22*, 181-188.

Satchell, G. H. (1955a) The genus *Trichopsychoda* Tonnoir (Diptera: Psychodidae). *Proceedings of the Royal Entomological Society of London (B), 24*, 49-57.

Satchell, G. H. (1955b) New species of East and Central African Psychodidae. Part 1. *Revue de zoologie et* *de botanique africaines, 51*, 339-372.

Satchell, G. H. (1956a) Diptera (Nematocera): Psychodinae. *In:* B. Hanström, P. Brinck & G. Rudebeck (Eds), *South African Animal Life. Results of the Lund University Expedition. Vol. III*. Almqvist & Wiksell, Stockholm, pp. 399-403.

Satchell, G. H. (1956b) On the genus *Trichomyia* Haliday (Diptera: Psychodidae) with descriptions of four new species. *Proceedings of the Royal Entomological Society of London (B), 24*, 147-156.

Say, T. (1824) Natural History: §1 Zoology. *In:* W. H. Keating (Ed), *Narrative of an expedition to the source of the St. Peter's River, Lake of the Woods 1823, under the command of Major Long*. Geo B. Whittaker, London, pp. 3-104.

Schellenberg, J. R. (1803) *Genres des Mouches Dipteres, representes en XLII Planches projettees et dessinees par Mr. J. R. Schellenberg et expliquees par deux amateurs de l'Entomologie*. Zürich: Orell.

Speiser, P. (1906) Über die systematische Stellung der Dipterenfamilie Termitomastidae. *Zoologische Anzeiger, 30*, 716-718.

Speiser, P. (1910) 10. Diptera. Orthorapha. *In:* Y. Sjöstedt (Ed), *Wissenschaftliche ergebnisse der Schwedischen zoologischen expedition nach dem Kilimandjaro, dem Meru und den umgebenden Massaisteppen Deutsch-Ostafrikas 1905-1906*. Kungliga Svenska vetenskapsakademien, Stockholm, pp. 31-112.

Stuckenberg, B. R. (1962) The South African species of *Nemopalpus* (Diptera: Psychodidae). *Annals of the Natal Museum, 15*, 201-218.

Stuckenberg, B. R. (1978) Two new species of *Nemopalpus* (Diptera, Psychodidae) found in rock hyrax abodes in South West Africa. *Annals of the Natal Museum, 23*, 367-374.

Tokunaga, M. (1957) Moth-Flies from Formosa (Psychodidae, Diptera). *Scientific Reports of the Saikyo University. Agriculture, 9*, 53-77.

Tokunaga, M. (1958) Japanese Psychodidae, IV. Descriptions and revision of Psychoda species. *Philippine Journal of Science, 86*, 359-403.

Tonnoir, A. L. (1920) Notes sur queques Psychodidae Africains. *Revue de zoologie Africaine, 8*, 127-147.

Tonnoir, A. L. (1922a) Contribution á l'étude des Psychodidae d'Afrique (Dipt.). *Bulletin de la Société Entomologique D'Égypte, 6*, 80-112.

Tonnoir, A. L. (1922b) Notes sur le genre *Nemopalpus* (Dipt. Psychodidae) et description d'une espèce nouvelle. *Annales de la Société Entomologique de Belgique, 62*, 125-136.

Tonnoir, A. L. (1922c) Synopsis des espèces Européennes du genre Psychoda (Diptères). *Annales de la Société Entomologique de Belgique, 62*, 49-88.

Tonnoir, A. L. (1929) Psychodidae. *Diptera of Patagonia and South Chile, 2 (1)*, 1-32.

Tonnoir, A. L. (1939a) New *Psychoda* from Kenya Colony (Chyulu Hills). *Journal of the East African and Uganda Natural History Society, 14*, 11-14.

Tonnoir, A. L. (1939b) Psychodidae. *In: British Museum (Natural History): Ruwenzori Expedition 1934-5, 1 (4)*, 35-80.

Tonnoir, A. L. (1940) A synopsis of the British Psychodidae (Dipt.) with descriptions of new species. *Transactions of the Society for British Entomology, 7*, 21-64.

Vaillant, F. (1963a) An African psychodid larva with ventral suckers (Diptera, Psychodidae). *Bulletin de la Société Entomologique de France, 68*, 71-91.

Vaillant, F. (1963b) Diptères Psychodidae recueillis par M. le Dr. K. Lindberg en Afghanistan. *Opuscula Entomologica, 28*, 211-214.

Vaillant, F. (1971) Psychodidae - Psychodinae. *In:* E. Lindner (Ed), *Die Fliegen der Palaearktischen Region. Lief. 287*. E. Schweizerbart'scheVerlagsbuchhandlung, Stuttgart, pp. 1-48.

Vaillant, F. (1972) Psychodidae - Psychodinae. *In:* E. Lindner (Ed), *Die Fliegen der Palaearktischen Region. Lief. 291*. E. Schweizerbart'scheVerlagsbuchhandlung, Stuttgart, pp. 49-78.

Vaillant, F. (1975) Psychodidae - Psychodinae. *In:* E. Lindner (Ed), *Die Fliegen der Palaearktischen Region. Lief. 310*. E. Schweizerbart'scheVerlagsbuchhandlung, Stuttgart, pp. 143-182.

Vaillant, F. (1982a) Les tribus de la sous-familie de Psychodidae Psychodinae (Diptera). *Nouvelle Revue d'Entomologie, 12*, 189-194.

Vaillant, F. (1982b) Quelques considérations sur la classification des Psychodidae Psychodinae. *Bulletin de la Société Entomologique de France, 87*, 292-301.

Vaillant, F. (1990) Propositions pour une révision de la classification des Diptères Psychodidae Psychodinae. *Bulletin de la Société Vaudoise des Sciences Naturelles, 80*, 141-163.

Vaillant, F. (1991) Sur la position générique et tribale de deux espéces de Diptères. Psychodidae Psychodinae. Classification de 2 espèces de Diptères. *Bulletin de'l Institut Royal des Sciences Naturelles de Belgique, Entomologie, 61*, 207-209.

Vaillant, F. & Mobayed, Z. (1987) Cinq espèces nouvelles de Diptères Psychodidae Psychodinae du Liban. *Annales de Limnologie, 23*, 121-127.

Vargas, L. & Diaz-Najera, A. (1953) *Trichomyia fairchildi* n.sp. y *Eubonetia* n.gen. (Diptera: Psychodidae). *Revista del Instituto de Salubridad y Enfermedades Tropicales, 13*, 153-158.

Wagner, R. (1979) Moth-flies from a central African mountain stream (Diptera, Psychodidae). *Aquatic Insects, 1*, 55-63.

Wagner, R. (1983) On some Psychodidae (Diptera: Nematocera) from Senegambia. *Entomologica Scandinavica, 14*, 98-100.

Wagner, R. (1988) Psychodiden (Diptera) der Kanarischen Inseln. *Stuttgarter Beiträge zur Naturkunde Serie A (Biologie), 425*, 1-14.

Wagner, R. (1989) Neue und wenig bekannte Psychodidae, Psychodinae von Südafrika (Diptera, Nematocera). *Spixiana, 12*, 183-191.

Wagner, R. (1990) Family Psychodidae. *In:* Ã. Soós & L. Papp (Eds), *Catalogue of Palaearctic Diptera. 2. Psychodidae-Chironomidae*. Akadémiai Kiadó, Budapest, pp. 11-65.

Wagner, R. (2001) Contribution to the knowledge of Spanish Psychodidae (Diptera) with description of two new species. *Zoologica Baetica, 12*, 83-90.

Wagner, R. & Andersen, T. (2007) Psychodidae (Diptera: Nematocera) from the West Usambara Mountains, Tanzania. *In:* T. Andersen (Ed), *Contributions to the Systematics and Ecology of Aquatic Diptera – A tribute to Ole A. Sæther*. The Caddis Press, Columbus, pp. 287-307.

Withers, P. (1986) Recent records of moth flies in Norfolk including a species new to science and five species new to Britain. *Transactions of the Norfolk and Norwich Naturalists' Society, 27*, 227-231.

Zetterstedt, J. W. (1850) Diptera Scandinaviae disposita et descripta (Psychodidae). *Lundie, 9*, 3367-3710

Chapter 3

Diversity of Psychodidae (Diptera) in relation to vegetation types in Budongo Forest, Uganda

INTRODUCTION

The most serious threat to biodiversity in the 21st century is changes in land use (Pimm *et al.*, 1995, Sala *et al.*, 2000). Both the conversion of natural landscapes for human use and changes in the way humans manage and use cultural landscapes have negative consequences for biodiversity (and as a consequence for long-term human well-being) on a global scale (Foley *et al.*, 2005). The serious effects of land use change on biodiversity are likely to be most pronounced in the most diverse terrestrial biome of them all, the tropical rain forest (Sala *et al.*, 2000).

Studying how tropical biodiversity responds to land use changes is no easy task. A major challenge for many biological disciplines is the taxonomic impediment: the lack of adequate identification tools, and in many cases also of active taxonomic specialists, hinders or delays the identification of the species that make up the diversity under study (Gotelli, 2004). This has lead to a majority of conservation studies considering the responses only of a few select groups that are relatively popular and comparably easy to identify, e.g. birds, mammals, butterflies and vascular plants (Clark & May, 2002).

Data from large-scale studies comparing a range of different organism groups have, however, found that community responses often are very idiosyncratic between different taxa (e.g. Lawton *et al.*, 1998; Wolters, Bengtsson & Zaitsev, 2006; Kessler *et al.*, 2011). This suggests that future conservation studies should either 1) attempt to simultaneously analyse multiple groups of organisms, or 2) survey previously unstudied groups for an area to see whether the responses of these groups conform to previously observed patterns.

The present study is of the latter sort and investigates the influence of vegetation type on species assemblages of non-biting moth flies (Diptera: Psychodidae). Moth flies are a diverse group both ecologically and taxonomically and are easily collected using standard trapping techniques. Another advantage is their abundance in many tropical systems, especially in streams (Böttger, 1975; Wolf, Matthias & Roldan, 1988; Wagner & Masteller, 1993; Freitag, 2004) but also in

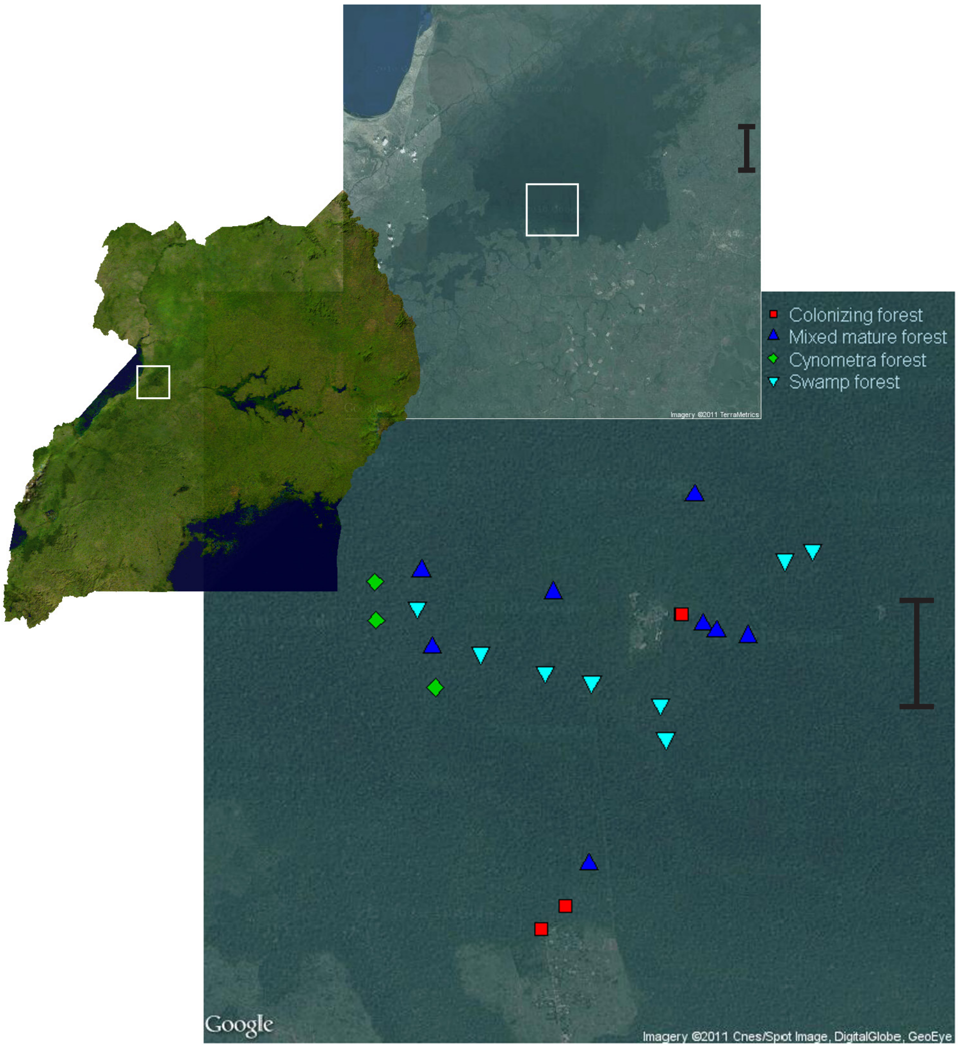

Fig. 3.1. Map of Uganda (left), Budongo forest (top, scale = 5 km) and the study area (scale = 1 km) with sampling sites. Satellite photos from http://maps.google.com, obtained using the R package *Rgooglemaps* version 1.1.9.6 (Loecher and Sense Networks, 2011), and from http://www.maplibrary.org (accessed Aug.25. 2011)

more general forest assemblages (Brown, 2005; Kitching *et al.*, 2004). Furthermore, their high morphological variability makes them comparatively easier to identify than some more commonly used indicator groups such as the Chironomidae (Wagner, 1979b). Disadvantages include a very imperfectly explored taxonomy and poorly known ecological requirements of the different species. However, these challenges are not unique to the moth flies.

Study site

Budongo Forest (Figure 3.1) is a moist semi-deciduous, medium altitude tropical forest in the Albertine Rift Valley, Western Uganda. This forest is among the most well-known tropical forests in the world in terms of vegetation ecology and land use history (Paterson, 1991; Plumptre, 1996). Because of good historical floristic records and the well documented land use history of the forest reserve, the area is particularly well suited for ecological studies.

Eggeling (1947) classified Budongo Forest into four distinct vegetation types: Colonizing forest, mixed forest, monodominant *Cynometra alexandrei* forest and swamp forest. Following selective logging of mahoganies and arboricide treatments of *C. alexandrei* in the 1950s and the 1960s, the dominant vegetation type is currently the mature mixed forest (Plumptre, 1996).

Some, but not all of the vegetation types can be attributed to a successional gradient; the colonizing forest precedes the mixed forest, but it is not clear whether the *Cynometra* forest really represents a climax community. Data from satellite photo analyses indicate that undisturbed mixed forest gradually transform into *Cynometra* forest (Plumptre, 1996). On the other hand, vegetation analyses by Sheil *et al.* (2000) did not find that plant communities changed in the fashion predicted by a successional model: with time, stem recruitment did not decrease in undisturbed forest. Sheil & Salim (2004) suggested that the most important factor in *Cynometra* forest formation was natural disturbance from elephant damage, and as the elephants of Budongo Forest went extinct in the 1970s it is likely that the forest's current successional cycle is not the same as it was at the time Eggeling (1947) performed his study.

In the present study, the four vegetation types defined by Eggeling (1947) form the basis for a community-level analysis of Budongo's non-phlebotomine Psychodidae. Some other insect groups sampled during this project will be treated elsewhere in collaboration with specialists in the respective groups.

MATERIAL AND METHODS

Fieldwork

Fieldwork was carried out in July and August 2010 in the area around Budongo Conservation Field Station (Figure 3.1). A total of 25 sites were sampled using light-weight Malaise traps (for design, see Townes, 1972). The traps were placed on the ground in areas far from trees with ripe fruit to avoid disturbance from chimpanzees. Vegetation types were identified in collaboration with Afeku Alfred of Budongo Conservation Field Station based on vegetation structure and plant species composition. Each trap was operated for a total of five days.

Data on temperature and air humidity was logged for the duration of each trapping event using a Hobo Pro v2 data logger (Onset Computer Corporation, USA) hung in a tree between 100 and 150 cm above the ground.

Additional specimens were collected by sweep-netting, in water traps and on light. These were, however, not subject to statistical analysis and are omitted from the data tables.

Identification

The Malaise trap collections were examined with a 10-20x hand lens and moth flies were sorted out. Prior to identification, the animals were microdissected and each specimen was mounted on an individual slide. Only males were considered, as many psychodid females are impossible to identify even to genus (Wagner, 1997). All material is housed in the entomological collections at Bergen Museum, University of Bergen.

Specimens were dissected using a micropin and a pair of fine forceps. The head, both wings and the abdomen were separated from the thorax. Wings were washed in 96% alcohol and mounted directly onto the slide in Euparal. The thorax with legs was preserved in alcohol. The head and abdomen were transferred to small vials with 10% KOH, where they were macerated for a few days at room temperature. Following the KOH maceration, each specimen was rinsed in subsequent baths of 90-100% acetic acid and 75% and 96-100% ethanol. The abdomens and heads were then mounted on the slide in a manner similar to that of Withers (1989, Figure 180). In some specimens, the 9th tergite with cercopods were separated from the gonopods and aedeagus to facilitate examination from both sides (cf. Duckhouse, 1987). To avoid compression and/or distortion of morphological features, the coverslips were supported on small platforms made from broken pieces of coverslip.

Identification of tropical arthropods remains notoriously difficult. As of today, no single work is sufficient for accurate identifications of Afrotropical moth flies even to genus level. The only comprehensive identification key for Psychodidae covering this region is the key in Satchell (1955), which today is too outdated and incomplete to be of much use for this study. Genera were mostly identified through comparisons with genus diagnoses in the taxonomic literature, but also using comparisons with material in the collections at the entomological collections, Bergen Museum and the Natural History Museum of London. Morphospecies were identified according to morphological differences in genitalia, antenna, mouthparts, wing, eyebridge and facial chaetotaxy (see chapter 1 for a brief overview of Psychodid morphology, and appendix 1 for a key to genera of Psychodidae known from the Budongo Forest).

The nomenclature of taxa is according to chapter 2 in this thesis.

Statistical analysis

Statistical analyses were performed in R version 2.12.0 (R Development Core Team, 2010). The different vegetation types were compared in terms of environmental variables using a one-way ANOVA with single-step Tukey contrasts as implemented in the *multcomp* package (Hothorn, Bretz & Westfall, 2008). Specimen counts and species diversities were compared between vegetation types using generalized linear models (GLMs) assuming a Poisson distribution of the response variable. To avoid problems with over- or underdispersion, a quasi-likelihood model was preferred when the Poisson distributed model's residual deviance strongly exceeded the residual degrees of freedom. Species compositions of different vegetation types were compared using a Bray-Curtis distance matrix as implemented in the *vegdist* function in the *vegan* libary version 1.17.4 (Oksanen *et al.*, 2010). Sex ratios were compared between vegetation types using a chi-square test.

The species diversity of the sites was studied using the exponent of Chao & Shen's (2003) bias-corrected Shannon-Wiener index; which was preferred over the original Shannon-Wiener index as it accounts for undetected species. Rarefaction curves were also used. Full species pools were estimated using the Chao 1 estimator (Chao, 1984; Colwell & Coddington, 1994). The standard error of Chao 1 is implemented in R, but as the Chao 1 estimator itself only is to be considered a lower bound (Colwell & Coddington, 1994) I have not included confidence intervals in figures 3.6-3.7. Rarefaction was performed both on the basis of specimens per site and specimens per vegetation type. Biodiversity statistics were performed using functions from the R packages *entropy* version 1.1.6 (Hausser & Strimmer, 2011) and *vegan* version 1.17.4 (Oksanen *et al.*, 2010).

The code used for the statistical procedures can be found in appendix 2

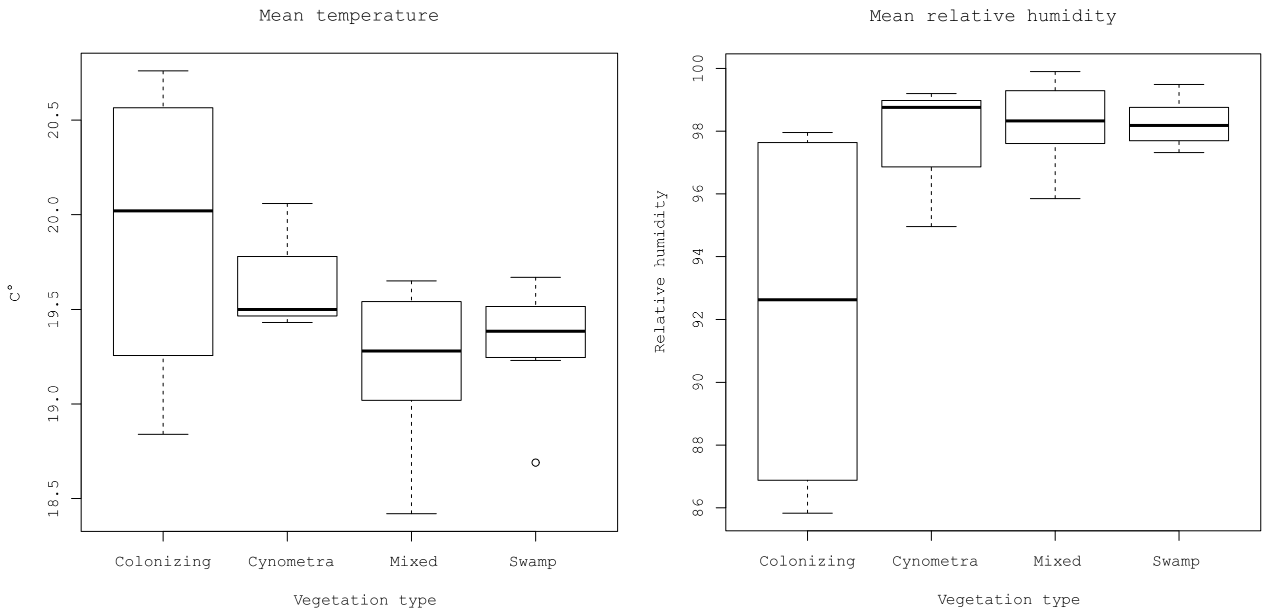

Fig. 3.2-3.3. Boxplots of environmental variables for each site in the different vegetation types. (3.2) Mean temperature at time of sampling. (3.3) Mean relative air humidity

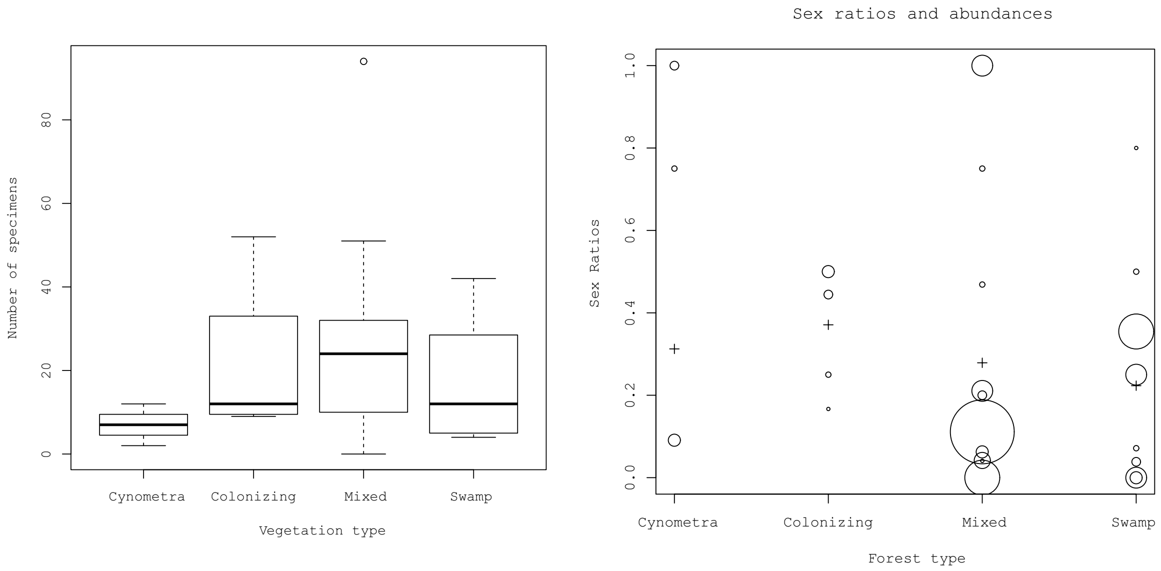

Fig. 3.4-3.5. Abundance and sex ratios. (3.4) Boxplot of total number of specimens per site. (3.5) Circle plot of sex ratios given as males:females; abundance per site given as circle diameters. Mean values for each vegetation type are given as crosses.

RESULTS

Environmental variables

Different vegetation types differed significantly in mean relative humidity (ANOVA, $p = 0.005$; Figure 3.2), while the difference in mean temperature was nearly significant (ANOVA, $p = 0.08$, Figure 3.3). The significant differences were mainly the relative dryness of the early colonizing forest – these sites differed significantly from mixed ($p = 0.005$) and swamp forest sites ($p = 0.007$, both single-step Tukey contrasts). The difference in humidity between colonizing and climax forests were only nearly significant ($p = 0.06$, single-step Tukey contrasts).

Diversity and habitat ecology

The Malaise trap sampling yielded a total of 546 specimens of the subfamilies Psychodinae, Trichomyiinae and Phlebotominae. All localities but one yielded specimens, but the differences in

Forest type	Species number	Unique species	Chao1 estimate
Colonizing	19	9 (47.4%)	47,13
Mixed	21	9 (42.9%)	53
Cynometra	3	2 (66.7%)	N/A
Swamp	10	4 (40%)	42
Total	38	-	86

Table 3.1. Observed and estimated species numbers per vegetation type

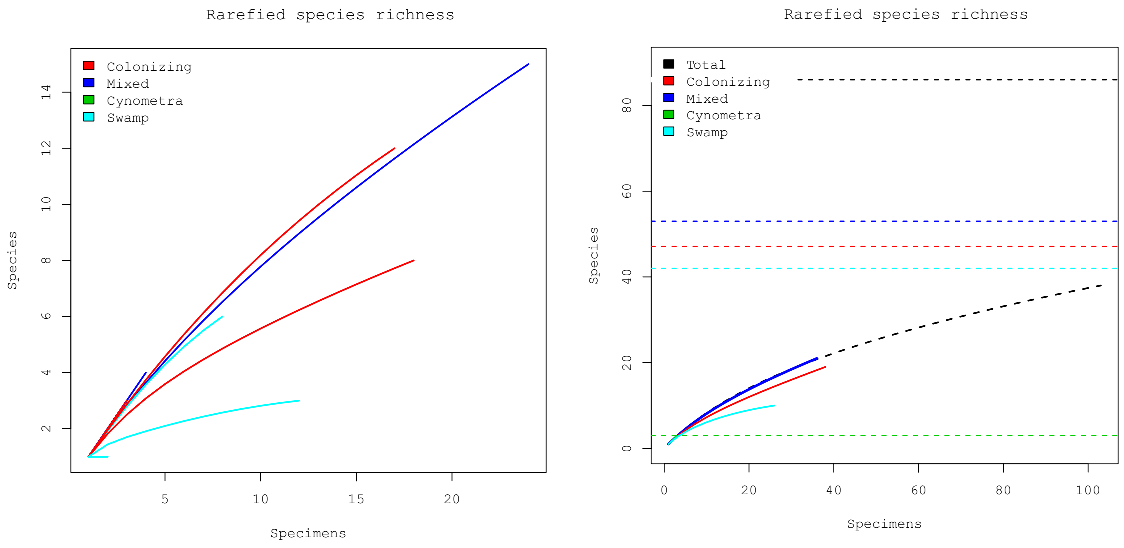

Fig. 3.6-3.7. Rarefaction curves. (3.6) Rarefied species number per individual site, (3.7) Rarefied species number per vegetation type, with Chao 1 estimate of total species number given as horizontal lines.

specimen count were not significant between the vegetation types (ANOVA on a GLM, $p = 0.30$; Figures 3.4 and 3.5). The sex ratio was significantly skewed in all vegetation types (Pearson's chi-square test; $p << 0.001$) with females outnumbering males in all but two localities. The relationship between sex ratio and vegetation type was not significant (ANOVA on a GLM, $p = 0.45$; Figure 3.5).

None of the rarefaction curves produced in this study reached any definite plateaus (Figures 3.6 and 3.7). Some of the curves produced for individual sites seemed to be flattening out (e.g. site 25), but no single site had enough specimens identified for such estimates to be considered statistically robust. The Chao species pools, i.e. the Chao estimates of total species numbers in the forest and in the different vegetation types, were markedly higher than the observed species numbers except for in the *Cynometra* forest (Table 3.1).

Vegetation types had no significant effect on overall species diversity that could be detected (ANOVA on a GLM of the bias-corrected Shannon index, $p = 0.11$; Figure 3.8). The species numbers did, however,

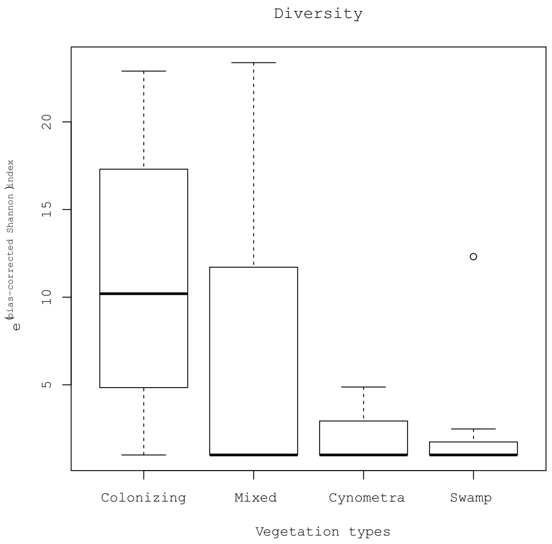

Fig. 3.8. Diversity as measured by the bias-corrected Shannon index (see text). To make the numbers more intuitively interpretable, the numbers are displayed as exponents.

	Colonizing	Mixed	*Cynometra*
Mixed	0.65		
Cynometra	0.95	0.95	
Swamp	0.91	0.81	1

Table 3.2. Bray-Curtis distance matrix of vegetation types

differ considerably between habitats (Table 3.1). The lack of statistical significance is probably only an artifact of the low number of identified specimens. According to the Bray-Curtis distance matrix, the colonizing and mixed forest types had the most similar species assemblages. The Bray-Curtis values are, however, all rather high; meaning that there are not many shared species between the vegetation types (Table 3.2).

Species composition

Of a total of 120 males in the collection, 103 could be reliably identified. A total of 38 (morpho-) species in 8 genera were identified, belonging to the subfamilies Psychodinae and Trichomyiinae (Table 3.3). Except for *Psychoda, Telmatoscopus* and *Clogmia,* none of the genera have previously been recorded from Uganda.

More than half of the species, and about two thirds of the identified specimens, belonged to the genus *Psychoda*. This is a very diverse and heterogeneous genus inhabiting many different terrestrial to semiaquatic habitats. The species vary from extreme generalists to specialists on e.g. dung, fungal fruit bodies or decaying vegetable matter (Satchell, 1947; Withers, 1988; Svensson, 2009).

Four species of *Trichomyia* were represented by males and are treated further in chapter 4. The larvae of this genus apparently develop in dead wood, although the biology is unknown for most species (Duckhouse, 1978b).

Hemimormia is here used as a name for the species placed by Duckhouse (1987) in *Mormia (Afromormia)* (see chapter 2). No specific biological information is available for this genus, although other known genera in the subtribe Mormiina develop in moist soils and mud (Vaillant, 1974). Another Mormiini male could not be placed in any described genus, but until the systematic relationships within this taxon are better understood I will refrain from naming it.

Tonnoiriella is thought to be very specific in its larval requirements. The single species for which the larva is known lives in water films on the underside of stones and leaves at the edges of unpolluted springs and streams (Satchell, 1949). *Tonnoiriella drepanopenis* (Duckhouse, 1975) has been recorded as emerging from a tropical forest stream in Kalengo, the Democratic Republic of Congo (Wagner, 1979a). *Threticus* larvae are found in similar habitats (Vaillant, 1972; Curler & Moulton, 2010).

Neotelmatoscopus is not previously recorded from Africa. The described species of the genus are found in tropical Asia. Its larvae live in water films and in the splash zones of fast-flowing streams (Curler & Courtney, 2009).

Clogmia, as interpreted here, is a large and heterogenous genus mostly inhabiting water-filled tree-holes (Duckhouse, 1978a). As evident from its palmate ascoids, the recorded specimen is a member of the subgenus *Cryptotelmatoscopus.* This subgenus has a wide distribution in the old world tropics, however in the Afrotropical region it has previously only been recorded from the Cape Verde Islands (Ježek & van Harten, 1996; see also chapter 2)**.**

The genus *Telmatoscopus, sensu stricto,* is properly used for a small group of treehole-dwelling species in the Holarctic region. This name is, however, also extensively used for many species not presently assigned to any valid genus. It is not clear to the author whether the specimens recorded here under the name *Telmatoscopus* belong to any described telmatoscopoid genus, as the taxonomy of the morphological group traditionally associated with that name is complex and poorly resolved. As the systematics are so unclear, no biological information can be inferred about species in the *Telmatoscopus* group of genera.

The larvae of the genus *Philosepedon* are generally thought to be cocchlobionts, that is that they develop in dead snails (Vaillant, 1974). It is not known whether this also is true for tropical species: Beaver (1987) recorded no representatives of the genus in his study of Diptera bred from snail carrion in the Malay Peninsula. However, as no Psychodid specialists were involved in his study specimens may have been misidentified.

DISCUSSION

Diversity

The non-asymptotic rarefaction curves of the different habitats suggest that the sampling was incomplete and that more species remain undiscovered. The pattern can be seen both at the level of vegetation type and at some individual sites. The sites with the highest numbers of individuals identified also had the highest species counts and also showed some of the steepest rarefaction curves (Figure 3.4). The curves for the total within the forest and within each vegetation type are more uniform, but all rather steep. This is supported by the Chao1 estimates, which suggest that there are at least 86 species of Psychodidae in Budongo Forest.

The climax forest exhibited the lowest numbers both of specimens caught and identified; too few specimens to calculate a meaningful Chao1 estimate. Only three specimens belonging to three

Taxon	**Site**																								
	Colonizing				Mixed										*Cynometra*			Swamp							
	11	12	17	23	1	2	7	8	9	10	18	19	20	24	3	5	13	4	6	14	15	16	21	22	25
TRICHOMYIINAE Tonnoir, 1922																									
***Trichomyia* Haliday *in* Curtis, 1839**																									
sp. 1	1																								
sp. 2																	1								
sp. 3			1								4														
sp. 4											1														
PHLEBOTOMINAE Rondani, 1840 (not treated in species-level analyses)																									
indet. males		2		1		1									1										
indet. females		4	2	3	2		1	12	3	1				1				1	1		1		2		
PSYCHODINAE Newman, 1834																									
Maruinini Enderlein, 1937																									
***Tonnoiriella* Vaillant, 1971**																									
sp. near *drepanopennis* (Duckhouse, 1975)							1																		
Mormiini Enderlein, 1937																									
***Hemimormia* Krek, 1971**																									
sp. 1				2																					
sp. 2			1																						
sp. 3							1																		
New genus 1																									
sp. 1			1																						
Paramormiini Enderlein, 1937																									
***Neotelmatoscopus* Tonnoir, 1933**																									
sp. 1	1								1																
***Clogmia* Enderlein, 1937**																									
sp. 1 (subg. *Cryptotelmatoscopus* Vaillant, 1983)																1									
***Telmatoscopus* Eaton, 1904 (*sensu lato*)**																									
sp. 1																									9
Psychodini Enderlein, 1935																									
***Philosepedon* Eaton, 1904**																									
sp 1 (cf. *africanum* Wagner, 1979)											1										1	2			
***Threticus* Eaton, 1904**																									
sp. 1									1																
***Psychoda* Latreille, 1796**																									
sp. 1			3		1				4		7														
sp. 2						1			1	1															2
sp. 3			2						1		2														
sp. 4																					1				
sp. 5			1						1	1									1		2				1
sp. 6 (cf. subg. *Psychodula* Jezek, 1984)									1												1				

	Colonizing							Mixed							*Cynometra*			Swamp							
	11	12	17	23	1	2	7	8	9	10	18	19	20	24	3	5	13	4	6	14	15	16	21	22	25
sp. 7 (subg. *Tinearia* Schellenberg, 1803)									5	1	1														
sp. 8 (near *scuticopenis* Satchell, 1955)			1																						
sp. 9			1																						
sp. 10								1																	
sp. 11									2																
sp. 12			2						2				1												
sp. 13			1							1															
sp. 14									1												1				
sp. 15 (cf. subg. *Psychodula* Jezek, 1984)			2						1		1					1									
sp. 16									1																
sp. 17											1									1					
sp. 18																					2				
sp. 19			1																						
sp. 20														1											
sp. 21							1																		
sp. 22	1																								
sp. 23									1																
sp. 24									1																

Table 3.3. Abundance of Psychodidae species in Budongo forest, Uganda

different species could be identified. Two of these species, however, were wood-associated species not found in any other localities; *Clogmia (Cryptotelmatoscopus)* sp. 1 and *Trichomyia* sp. 2. The third species found here, *Psychoda* sp. 15, belongs to the subgenus *Psychodula* and is probably a generalist as other members of this taxon have been bred from many different media including dung, fungi and rotting vegetation (Ježek & van Harten, 2005; Svensson, 2009). *Psychoda* sp. 15 is also found in both mixed and colonizing forest sites.

The high numbers of both recorded (21) and estimated (53) species in the mixed forest may have to do with the heterogeneity of the habitat – whereas the other three forest types were relatively easy to categorize, the mixed forest included sites in valley bottoms, close to rivers, close to temporal ponds etc. The most species-rich single site in the entire study was a mixed forest site on an island in the Sonso river (figure 3.9). Its diversity might be explained by the trap being located between an area of rapids and a more lentic pool, suggesting a high diversity of aquatic microhabitats in the close vicinity. This site had 24 identified specimens of 15 species; far more than any other mixed forest locality - the second most diverse site had 4 identified specimens of 4 species only.

The two second-most species rich single sites were both in the colonizing forest and had

Fig. 3.9. The malaise trap at site 9

12 and 8 species, respectively. Although this vegetation type in general was drier than the other habitats, the fauna sampled at these sites included some taxa generally considered aquatic, such as *Neotelmatoscopus*. Due to the more even distribution of specimens per colonizing forest site, the total rarefaction curve for the vegetation type does not resemble any of its constituent locality curves more than the others.

Whereas the colonizing forest sites had an unexpectedly high species richness, the swamp forests were surprisingly species-poor – only 10 species were recorded. It also exhibits the rarefaction curve with the least steep slope. This may, however be a statistical artifact of the most specimen-rich swamp site (12 identified specimens) having only 3 different species. Nevertheless, the Chao1 estimator suggests that the real number of species to be found in the swamp forests is much higher, giving a total of 42 species.

Taxonomic composition and biogeography

According to Satchell (1955), the most abundant genus of Psychodinae in the Afrotropical region is *Psychoda*. The present study provides further support to this claim, especially so as the Budongo species of *Philosepedon* and *Threticus* would have been included in Satchell's concept of the genus. On the other hand, Duckhouse (1987) further suggested that Afrotropical communities in addition to *Psychoda* was dominated by the genera *Clytocerus, Neoarisemus* and *Setomima.* This was not found in the Budongo samples as none of these genera even were present in the Malaise trap catches. The incongruence between the present findings and Duckhouse's claim may be due to regional differences within the Afrotropical region as Duckhouse's experience was primarily with South African collections.

The recorded *Trichomyia* species are described in chapter 4. Further species are planned to be described and named later.

Habitat ecology and succession in tropical Psychodidae

The low species richness in the *Cynometra* forest is consistent with observations from other tropical forests with monodominant trees (Torti, Coley & Kursar, 2001). The impoverished Psychodidae fauna is probably due to a lack of suitable media for larval development. Because of the powdery soil and the sparse undergrowth, the forest floor in *Cynometra* forests can become very dry, especially during the dry season (Eggeling, 1947). Furthermore, vertebrate faeces are likely to be less abundant in the *Cynometra* forest because the habitat type is avoided by many vertebrate groups, notably frugivorous birds (Owiunji & Plumptre, 1998) and primates (Plumptre & Reynolds, 1994; Tweheyo, Lye & Weladji, 2004).

Based on the present data set, the most consistently species rich terrestrial habitats in Budongo Forest are the colonizing and mixed forests. The present study superficially contrasts the only comparable study in terms of research questions, namely Alexander, Freitas & Quate's (2001) comparisons of the Psychodidae fauna in a 31 year old colonizing forest patch with that of a site of pristine old-growth rainforest. Based on samples collected with CDC light traps and Malaise traps, they concluded that the old-growth rainforest site harboured a far higher diversity than the regenerating forest site. Because of differences in sampling effort, the two patches in Alexander *et al.*'s (2001) study were not directly comparable; I have therefore produced rarefaction curves for the two sites (Figure 3.10). Contrary to Alexander *et al.*'s (2001) own conclusions, the species richness in their study seems to be higher in the colonizing forest patch than in the pristine one. This is similar to the results in the present study, and may suggest that the early successional communities of tropical Psychodidae are generally more diverse than those of undisturbed forests. Due to the low sample sizes in both studies, however, these inferences must be treated with caution.

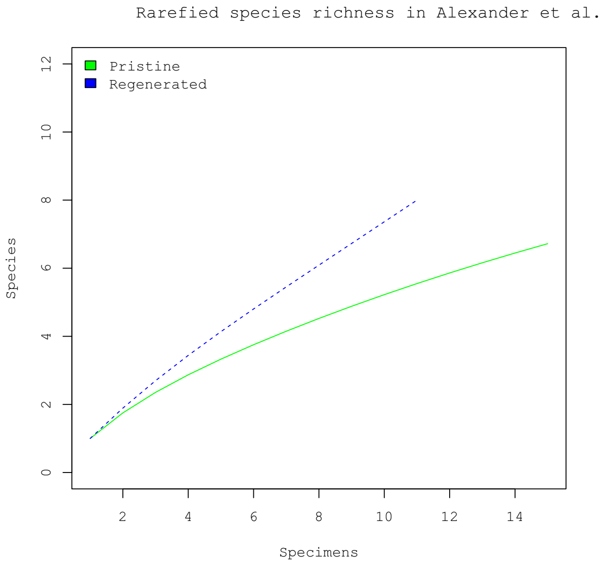

Fig. 3.10. Rarefaction curves for the two forests sampled by Alexander *et al.* (2001)

Sex ratios

The female-biased sex ratio observed in the Budongo collection was a consistent pattern that did not differ significantly between vegetation types. Biased sex ratios are typical for many insect groups; in the Psychodidae these are commonly observed both in the tropics and at higher latitudes (Wagner, 1979b, 1980; Wolf *et al.*, 1988; Svensson, 2009). The bias is also seen across sampling techniques, e.g. in emergence traps (Wagner, 1979, 1980, Wolf *et al.*, 1988), Malaise traps (Svensson, 2009) and light traps (Louis Boumans, *unpubl.*). Several explanations for such biased sex ratios have been proposed. Wagner (1980) suggested that the trapping methods themselves produced biased samples. This is, however, unlikely as a general explanation given that the phenomenon is observed across so many different sampling techniques. Life history traits of the species in question have also been considered; including facultative parthenogenesis in some species and shorter life spans of males relative to females (Wagner, 1980).

Biased sex ratios may often arise in inbreeding mating systems where gene flow is low between populations (Hamilton, 1967). At least for *Psychoda* this is an unlikely general explanation due to the high dispersal capability of this genus (see e.g. Duckhouse, 1971). Evidence that male *Psychoda* disperse far for females comes from field experiments with bolas spiders (*Mastophora spp.*): Juvenile bolas spiders use highly efficient species-specific chemical cues to attract males of certain *Psychoda* species, with each *Mastophora* species specializing on a different species of *Psychoda* (Yeargan & Quate, 1996).

Lastly, many insect groups are subject to infections with *Wolbachia* bacteria, which are known to induce parthenogenesis and/or surpress male development in many host species (Werren, 1997). This pathogen is apparently not known from non-phlebotomine moth flies, although it is found in many species of Phlebotominae (Ono *et al.*, 2001; Matsumoto *et al.*, 2008).

Limitations of the current study

The main limitation for the current study is the incomplete taxonomy of female Psychodidae. For many genera, reliable taxonomic characters are not known in the females; meaning that large proportions of the samples are excluded from species- or genus-level analysis. In *Trichomyia* and *Psychoda*; genera for which females possess both good genus- and in some cases species-level characters, insecure association of sexes prevents a proper treatment. In the Chironomidae, it has been shown that species diversity profiles change significantly when females are identified reliably through DNA barcoding and included in analyses (Ekrem, Stur & Hebert, 2010). There is nothing to suggest that the Psychodidae are any different in this respect.

The field work in the present study was done during the dry season in the summer of 2010 and thus seasonality poses a possible source of bias. Emergence trap catches from tropical streams have shown that the emergence of Psychodidae can vary greatly throughout the year (Böttger, 1975; Wolf *et al.*, 1988; Wagner & Masteller, 1993). Even though very few of the species encountered in this study are likely to be strictly aquatic, it is not unlikely that the annual variation in abundance applies to terrestrial or semiaquatic Psychodidae as well.

Lastly some potentially species-rich habitats in Budongo Forest still remain unsampled, notably the canopy fauna. In Kitching *et al.*'s (2004) survey of some Old World Dipteran faunas, Psychodidae were found to be most abundant at ground level, but the specimen counts obtained from canopy fogging were also considerable. It has yet to be studied whether there exists a specialized canopy fauna within the Psychodidae.

CONCLUSIONS

Budongo Forest has a rich and varied fauna of Psychodidae, with the genus *Psychoda* as the most dominant genus both in number of individuals and in number of species. Low sample sizes prevent a robust characterization of the fauna's communities; however the data preliminarily suggest that there are marked differences in species composition between vegetation types. The most diverse assemblages are found in colonizing and mature mixed forests, whereas the monodominant *Cynometra* forest on the other hand proved to be very species poor.

Despite the higher diversities of the colonizing and the mixed forest, it is deemed premature to ascribe conservation priorities to any of the vegetation types for Psychodidae species diversity. Too little is still known of the Afrotropical moth fly species distributions to determine whether any of the observed species assemblages are unique to Budongo.

REFERENCES

ALEXANDER, B., FREITAS, J. M. & QUATE, L. W. (2001) Some Psychodidae (Diptera) from Atlantic Forest in South-Eastern Brazil, with descriptions of *Trichomyia dolichopogon* sp.nov. and *Trichomyia riodocensis* sp.nov. *Brazilian Journal of Biology,* **61,** 467-474.

BEAVER, R. A. (1987) Biological studies of non-muscoid flies (Diptera) bred from mollusc carrion in Southeast Asia. *Japanese Journal of Sanitary Zoology,* **38,** 187-195.

BROWN, B. V. (2005) Malaise Trap Catches and the Crisis in Neotropical Dipterology *American Entomologist,* **51,** 180-183.

BÖTTGER, K. (1975) Produktionsbiologische Studien an dem zentralafrikanischen Bergbach Kalengo. *Archiv für Hydrobiologie,* **75,** 1-31.

CHAO, A. (1984) Non-parametric estimation of the number of classes in a population. *Scandinavian Journal of Statistics,* **11,** 265-270

CHAO, A. & SHEN, T. J. (2003) Nonparametric estimation of Shannon's index of diversity when there are unseen species in sample. *Environmental and Ecological Statistics,* **10,** 429-443.

CLARK, J. A. & MAY, R. M. (2002) Taxonomic bias in conservation research. *Science,* **297,** 191-192.

COLWELL, R. K. & CODDINGTON, J. A. (1994) Estimating terrestrial biodiversity through extrapolation. *Philosophical Transactions of the Royal Society of London (B),* **345,** 101-118.

CURLER, G. R. & MOULTON, J. K. (2010) Descriptions of three new species of Psychodidae (Diptera) from the southeastern United States. *Zootaxa,* **2524,** 51-62.

DUCKHOUSE, D. A. (1971) Entomology of the Aucklands and other islands south of New Zealand: Diptera: Psychodidae. *Pacific Insects Monograph,* **27,** 317-325.

DUCKHOUSE, D. A. (1978a) Non-phlebotomine Psychodidae (Diptera, Nematocera) of southern Africa. II. Subfamily Psychodinae: *Neoarisemus* and the brunettoid and telmatoscopoid genera. *Annals of the Natal Museum,* **23 (2),** 305-359.

DUCKHOUSE, D. A. (1978b) Taxonomy, phylogeny and distribution of the genus *Trichomyia* (Diptera, Psychodidae) in Australia and New Guinea. *Systematic Entomology,* **3,** 197-243.

DUCKHOUSE, D. A. (1987) A revision of Afrotropical *Setomima*, elucidation of their genealogical relationships and descriptions of other Afrotropical Psychodinae (Diptera: Psychodidae). *Annals of the Natal Museum,* **28,** 231-282.

EGGELING, W. J. (1947) Observations on the Ecology of the Budongo Rain Forest, Uganda. *Journal of Ecology,* **34,** 20-87.

EKREM, T., STUR, E. & HEBERT, P. D. (2010) Females do count: Documenting Chironomidae (Diptera) species diversity using DNA barcoding. *Organisms, Diversity and Evolution,* **10,** 397-408.

FOLEY, J. A., DEFRIES, R., ASNER, G. P., BARFORD, C., BONAN, G., CARPENTER, S. R., CHAPIN, F. S., COE, M. T., DAILY, G. C., GIBBS, H. K., HELKOWSKI, J. H., HOLLOWAY, T., HOWARD, E. A., KUCHARIK, C. J., MONFREDA, C., PATZ, J. A., PRENTICE, I. C., RAMANKUTTY, N. & SNYDER, P. K. (2005) Global consequences of land use. *Science,* **309,** 570-574.

FREITAG, H. (2004) Composition and longitudinal patterns of aquatic insect emergence in small rivers of Palawan Island, the Philippines. *International Review of Hydrobiology,* **89,** 375-391.

GOTELLI, N. J. (2004) A taxonomic wish-list for community ecology. *Philosophical Transactions of the Royal Society of London (B),* **359,** 585-597.

HAMILTON, W. D. (1967) Extraordinary Sex Ratios. *Science,* **156,** 477-488.

HAUSSER, J. & STRIMMER, K. (2011) entropy: Entropy and Mutual Information Estimation. *R package version 1.1.6.***,** Available from http://CRAN.R-project.org/package=entropy.

HOTHORN, T., BRETZ, F. & WESTFALL, P. (2008) Simultaneous Inference in General Parametric Models. *Biometric Journal,* **50,** 346-363.

JEŽEK, J. & VAN HARTEN, A. (1996) Psychodidae (Diptera) of the Cape Verde Islands, captured with a Johnson-Taylor suction trap. *Boletim do Museu Municipal do Funchal, História Natural, 48*, 63-86.

JEŽEK, J. & VAN HARTEN, A. (2005) Further new taxa and little-known species of non-biting moth flies (Diptera, Psychodidae) from Yemen. *Acta Entomologica Musei Nationalis Pragae,* **45,** 199-220.

KESSLER, M., ABRAHAMCZYK, S., BOS, M., BUCHORI, D., PUTRA, D. D., GRADSTEIN, S. R., HOHN, P., KLUGE, J., OREND, F., PITOPANG, R., SALEH, S., SCHULZE, C. H., SPORN, S. G., STEFFAN-DEWENTER, I., TJITROSOEDIRDJO, S. S. & TSCHARNTKE, T. (2011) Cost-effectiveness of plant and animal biodiversity indicators in tropical forest and agroforest habitats. *Journal of Applied Ecology,* **48,** 330-339.

KITCHING, R. L., BICKEL, D., CREAGH, A. C., HURLEY, K. & SYMONDS, C. (2004) The biodiversity of Diptera in Old World rain forest surveys: a comparative faunistic analysis. *Journal of Biogeography,* **31,** 1185-1200.

LAWTON, J. H., BIGNELL, D. E., BOLTON, B., BLOEMERS, G. F., EGGLETON, P., HAMMOND, P. M., HODDA, M., HOLT, R. D., LARSEN, T. B., MAWDSLEY, N. A., STORK, N. E., SRIVASTAVA, D. S. & WATT, A. D. (1998) Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. *Nature,* **391,** 72-76.

MATSUMOTO, K., IZRI, A., DUMON, H., RAOULT, D. & PAROLA, P. (2008) First detection of Wolbachia spp., including a new genotype, in sand flies collected in Marseille, France. *Journal of Medical Entomology,* **45,** 466-469.

OKSANEN, J., BLANCHET, F. G., KINDT, R., LEGRENDE, P., O'HARA, R. B., SIMPSON, G. L., SOLYMOS, P., STEVENS, M. H. H. & WAGNER, H. (2010) vegan: Community Ecology Package. R package version 1.17-4. *Available from http://CRAN.R-project.org/package=vegan*.

ONO, M., BRAIG, H. R., MUNSTERMANN, L. E., FERRO, C. & O'NEILL, S. L. (2001) Wolbachia infections of phlebotomine sand flies (Diptera : Psychodidae). *Journal of Medical Entomology,* **38,** 237-241.

OWIUNJI, I. & PLUMPTRE, A. J. (1998) Bird communities in logged and unlogged compartments in Budongo Forest, Uganda. *Forest Ecology and Management,* **108,** 115-126.

PATERSON, J. D. (1991) The Ecology and History of Uganda's Budongo Forest. *Forest & Conservation History,* **35,** 179-187.

PIMM, S. L., RUSSELL, G. J., GITTLEMAN, J. L. & BROOKS, T. M. (1995) The Future of Biodiversity. *Science,* **269,** 347-350.

PLUMPTRE, A. J. (1996) Changes following 60 years of selective timber harvesting in the Budongo Forest reserve, Uganda. *Forest Ecology and Management,* **89,** 101-113.

PLUMPTRE, A. J. & REYNOLDS, V. (1994) The effect of selective logging on the primate populations in the Budongo Forest Reserve, Uganda. *Journal of Applied Ecology,* **31,** 631-641.

R DEVELOPMENT CORE TEAM (2010) R: A language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna.

SALA, O. E., CHAPIN, F. S., ARMESTO, J. J., BERLOW, E., BLOOMFIELD, J., DIRZO, R., HUBER-SANWALD, E., HUENNEKE, L. F., JACKSON, R. B., KINZIG, A., LEEMANS, R., LODGE, D. M., MOONEY, H. A., OESTERHELD, M., POFF, N. L., SYKES, M. T., WALKER, B. H., WALKER, M. & WALL, D. H. (2000) Global biodiversity scenarios for the year 2100. *Science,* **287,** 1770-1774.

SATCHELL, G. H. (1947) The Larvae of the British Species of Psychoda (Diptera, Psychodidae). *Parasitology,* **38,** 51-69.

SATCHELL, G. H. (1949) The early stages of the British species of *Pericoma* Walker. (Diptera: Psychodidae). *Transactions of the Royal Entomological Society of London,* **100**.

SATCHELL, G. H. (1955) New species of East and Central African Psychodidae. Part 1. *Revue de zoologie et de botanique africaines,* **51,** 339-372.

SHEIL, D. & SALIM, A. (2004) Forest tree persistence, elephants, and stem scars. *Biotropica,* **36,** 505-521.

SVENSSON, B. W. (2009) Fjärilsmyggfaunan i ett hagmarksområde och en ladugård i östra Blekinges skogsland. Med en översikt av familjen Psychodidae:s morfologi, systematik och utforskande, samt särskilt de svenska *Psychoda* s.l. -arternas biologi. *Entomologisk Tidskrift,* **130,** 185-206.

TORTI, S. D., COLEY, P. D. & KURSAR, T. A. (2001) Causes and consequences of monodominance in tropical lowland forests. *American Naturalist,* **157,** 141-153.

TOWNES, H. K. (1972) A light-weight Malaise trap. *Entomological News,* **83,** 239-247.

TWEHEYO, M., LYE, K. A. & WELADJI, R. B. (2004) Chimpanzee diet and habitat selection in the Budongo Forest Reserve, Uganda. *Forest Ecol Manag,* **188,** 267-278.

VAILLANT, F. (1972) Psychodidae - Psychodinae. In: *Die Fliegen der Palaearktischen Region. Lief. 292* (Ed. E. LINDNER). E. Schweizerbart'scheVerlagsbuchhandlung, Stuttgart.

VAILLANT, F. (1974) Psychodidae - Psychodinae. In: *Die Fliegen der Palaearktischen Region.*

Lief. 305 (Ed. E. LINDNER). E. Schweizerbart'scheVerlagsbuchhandlung, Stuttgart.

WAGNER, R. (1979a) Moth-flies from a central African mountain stream (Diptera, Psychodidae). *Aquatic Insects,* **1,** 55-63.

WAGNER, R. (1979b) Psychodidenstudien im Schlitzerland. - Schlitzer produktionsbiologische Studien (26). *Archiv für Hydrobiologie Supplement,* **57,** 38-88.

WAGNER, R. (1980) Lunzer Psychodiden (Diptera, Nematocera). Schlitzer produktionsbiologische Studien (21). *Limnologica (Berlin),* **12,** 109-119.

WAGNER, R. (1997) Family Psychodidae. In: *Contributions towards a Manual of Palearctic Diptera. Volume 2* (Eds. L. PAPP & B. DARVAS). Science Herald, Budapest.

WAGNER, R. & MASTELLER, E. C. (1993) Composition and temporal abundance of mothflies (Diptera, Psychodidae) from a tropical rainforest stream at El Verde, Puerto Rico. *Journal of the Kansas Entomological Society,* **66,** 181-186.

WERREN, J. H. (1997) Biology of *Wolbachia*. *Annual Review of Entomology,* **42,** 587-609.

WITHERS, P. (1988) Revisionary notes on British species of *Psychoda* Latreille (Diptera, Psychodidae) including new synonyms and a species new to science. *British Journal of Entomology and Natural History,* **1,** 69-76.

WITHERS, P. (1989) Moth Flies Diptera: Psychodidae. *Dipterists Digest,* **4,** 1-83.

WOLF, M., MATTHIAS, U. & ROLDAN, P. (1988) Estudio del desarrollo de los insectos acuaticos, su emergencia y ecologia en tres ecosistemas diferentes en el departamento de Antioquia. *Actualidades Biologicas (Medellin),* **17,** 2-27.

WOLTERS, V., BENGTSSON, J. & ZAITSEV, A. S. (2006) Relationship among the species richness of different taxa. *Ecology,* **87,** 1886-1895.

YEARGAN, K. V. & QUATE, L. W. (1996) Juvenile Bolas spiders attract Psychodid flies. *Oecologia,* **106 (2),** 266-271.

Chapter 4

A review of Afrotropical *Trichomyia* Haliday *in* Curtis, 1839, with the description of five new species

INTRODUCTION

Trichomyia Haliday *in* Curtis, 1839 is a heterogeneous genus of Psychodidae consisting of about 100 described species from all biogeographical regions except Antarctica. It was long considered a rather rare genus, but due to more systematic surveys in tropical countries and improved collection methods during the last decades it has been proved both widespread and diverse (Duckhouse 1978, 1980; Quate 1963). However, due to its inconspicuous habits and often low abundances it is easily overlooked by general collectors. As a result its taxonomy is still incomplete and new species are frequently described from all over the world (e.g. Withers 2003; Ibañez-Bernal 2004; Bejarano *et al.* 2009, 2010; Beran *et al.* 2010; Curler & Moulton 2010; Pérez-Doria *et al.* 2010).

The first Afrotropical species of *Trichomyia* were described from the Democratic Republic of Congo and Madagascar by Freeman (1949), Satchell (1956) and Quate (1957). Duckhouse (1980) later described two species from South Africa. However, the bulk of the Afrotropical fauna most probably remain undiscovered. The present review of the Afrotropical members of the genus *Trichomyia* includes descriptions of five new species of *Trichomyia* from Uganda and Ghana, brief redescriptions of Freeman (1949) and Satchell's (1956) African species and some preliminary considerations on the fauna's phylogenetic and biogeographic affinities. A key to the males of known Afrotropical species of the genus is also included.

MATERIAL AND METHODS

Specimens were collected, dissected and mounted as described in chapter 3. All drawings were made with the aid of a camera lucida.

Wing length is based on slide-mounted specimens and measured from the end of the costal node to the apex of R_{4+5}. Antennal length is given as the sum of the length of the individual segments, when available. Measurements are given as ranges, followed by the mean when four or more specimens are available. The number of specimens the measurement is based on follows in parantheses when this is not specified elsewhere.

Morphological terminology is in agreement with chapter 1. Terminology specific to *Trichomyia* is in accordance with Duckhouse (1978).

All type material is temporarily deposited in ZMBN, except when stated otherwise. Some of the material from Uganda will be transferred to the MZUM when the facilities and capacities of the latter institution improve.

The following abbreviations for museum collections are used in the text:

BMNH – The Natural History Museum, London, United Kingdom.
MRAC – Musée Royal de l'Afrique Centrale, Tervuren, Belgium.
MZUM – Makerere University, Zoology Museum, Kampala, Uganda.
NMSA – KwaZulu-Natal Museum, Pietermaritzburg, South Africa.
ZMBN – The Entomological collection, Bergen Museum, University of Bergen, Norway.

THE SPECIES

Trichomyia Haliday *in* Curtis

Trichomyia Haliday *in* Curtis, 1839: 745

For complete synonymy, see chapter 2.

Type species: *Trichomyia urbica* Haliday *in* Curtis, 1839, by monotypy.

Trichomyia Haliday *in* Curtis, 1839 is an ancient and diverse genus comprising about 100 described species from all zoogeographical regions except Antarctica. It is the only extant member of the Trichomyiinae, a subfamily which most easily can be recognized on the combination of a 4-branched R vein (only one vein between the two wing forks, see Fig. 4.6) and a long CuA_2. All other Psychodid genera either have two veins between the two wing forks (Fig. 1.4), a very short CuA_2 (Sycoracinae, Fig. 1.6) or no veins at all between the wing forks (*Horaiella* Tonnoir, 1933, see Curler *et al.* (2006), fig. 4). For a general discussion of Trichomyiine monophyly, see chapter 1.

Duckhouse (1965) noted that most of the species of *Trichomyia* could be placed in one of two distinct groups he referred to as «group A» and «group B». Due to uncertainty about character polarity and monophyly he did not name either of these groups formally. The genus has later been partially split into several subgenera (Duckhouse 1978, 1980, 1985; Bravo 1999, 2001). However, many species still remain unplaced.

«Group A»

According to Duckhouse (1965), group A can generally be characterized by the following combination of characters: Relatively large and often dark species; palp with four segments; inner side of second palpomere with sensillae; first flagellomere distinctly longer than second; ascoids variable but usually diminutive; flagellomeres 15 and 16 always separated; genitalia comparatively simple; gonostylus setose and articulated with distal end of gonocoxite. Some of the species ascribed to group A below do not conform to all of these characters, see the discussion for details.

Subgenus *Gondwanotrichomyia* Duckhouse

Gondwanotrichomyia Duckhouse, 1980; *nomen nudum.*
Gondwanotrichomyia Duckhouse, 1985: 355.

Type species: *Trichomyia nodosa* Duckhouse, 1980, by designation of Duckhouse (1985).

Diagnostic characters based on Duckhouse (1980): Epandrium with a long sharp hook on its upper side; cercopods connected by a basal flap and with single posterior row of sensory setae.

Trichomyia brochata Quate

Trichomyia brochata Quate, 1957: 252.

Type material (not examined): Holotype male. MADAGASCAR: «forêt de l'Ankarafantsika, Tsaramandroso», i.1956, Stuckenberg leg. Coll. unknown (originally deposited in «l'Institut de Recherche scientifique de Madagascar, Tsimbazaza-Tananarive»).

Diagnostic characters: Genitalia similar in structure to *T. nodosa* and *T. dlinzae*; presumably the species is similar in other characters too. Gonostylus with blunt apex (Fig. 4.1). Details of the aedeagal apparatus difficult to see based on the figures; apparently aedeagus very broad, distally U-shaped; gonapophyses basally convergent to gonopods, less than half the length of aedeagus (Fig. 4.1).

Notes: The location of the type material of *T. brochata* is not known to the author. The collections of the Madagascar Institute of Scientific Research, Tsimbazara-Tananarive is now in the Bibikely Biodiversity Institute/Madagascar Biodiversity center. Most of their type material, however, is now housed in the Natural History Museum in Paris.

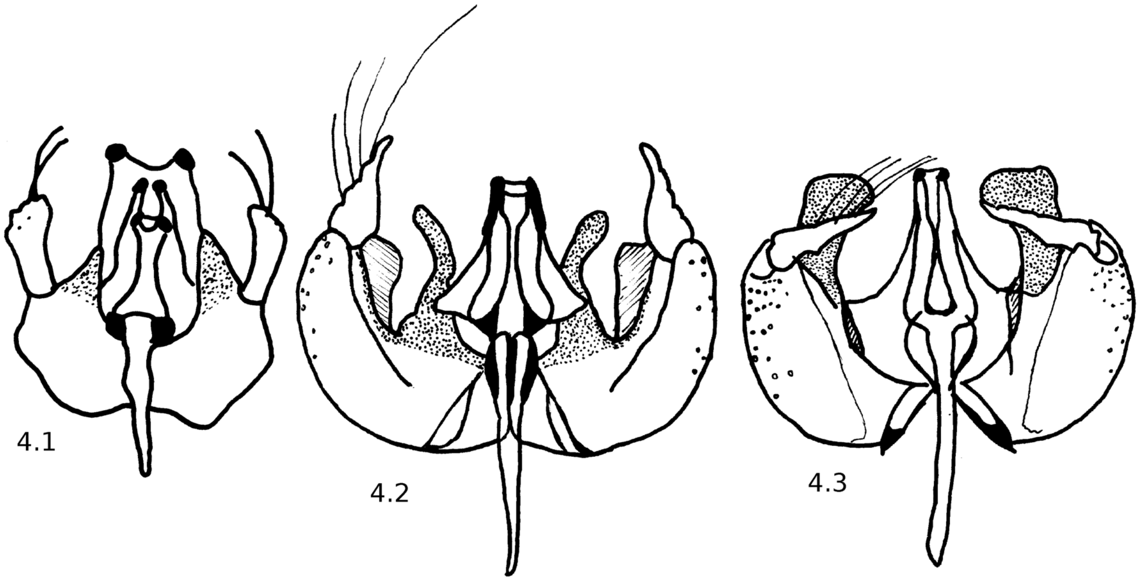

Fig. 4.1-4.3. Terminalia of Afrotropical *Trichomyia.* (4.1). *Trichomyia brochata* Quate, 1957. (4.2) *Trichomyia dlinzae* Duckhouse, 1980. (4.3) *Trichomyia nodosa* Duckhouse, 1980. Redrawn from Duckhouse (1980) and Quate (1957)

Trichomyia dlinzae Duckhouse

Trichomyia (Gondwanotrichomyia) dlinzae Duckhouse, 1980: 187.

Type material (not examined): Holotype male. South Africa: Natal, Eshowe district, Dlinza forest, 450 m from herbage, 20.ix.1978, Stuckenberg leg. Paratypes: 1 male, same data; 1 male, same data except 21.xi.1978, Malaise trap, Londt leg.; 1 male, South Africa: Natal, Howick district, Karkloof, Benvie Farm, *Podocarpus* forest, 6.xii.1978, Stuckenberg & Londt leg. All in coll. NMSA.

Diagnostic characters: Flagellomeres nodiform with multiple insertions of branched ascoids (Duckhouse 1980, fig. 4). Palp with four segments, second segment with rows of sensillae on its inner side (Duckhouse 1980, fig. 6). Male genitalia with single pair of ventral gonapophyses which are basally divergent, distally convergent to the gonopods, not expanded at apex, narrower and shorter than aedeagus (Fig. 4.2).

Notes: No material was examined. However, the figures and description in Duckhous (1980) are sufficient for identification.

Trichomyia nodosa Duckhouse

Trichomyia (Gondwanotrichomyia) nodosa Duckhouse, 1980: 184.

Type material (not examined): Holotype male: South Africa: Transkei, Port St. Johns district, coastal forest, 16.-17.x.1959, Stuckenberg & Stuckenberg leg. Paratypes:1 male and 3 females, South Africa: Natal, Pietermaritzburg, Town Bush, 28.xi.1978, sweep net, Stuckenberg & Londt leg.; 1 male, same locality, xi.1976, Malaise trap, Miller leg. All in coll. NMSA.

Diagnostic characters: Antennal and palpal characters as in *T. dlinzae*. Ventral gonapophyses parallel to the gonopods, expanded at apex, broader and about as long as aedeagus (Fig. 4.3).

Notes: No material was examined. However the figures and description in Duckhouse (1980) are sufficient for identification.

«Group A» species not assigned to any subgenus:

Trichomyia anderseni n. sp.

Type material: Holotype male: Ghana: Central Region, Kakum forest reserve, 8.-18.xi.1994, Malaise trap, NUFU project leg., coll. ZMBN.

Diagnostic characters: *Trichomyia anderseni* can be separated from all other *Trichomyia* species by the following combination of characters: Flagellomeres pyriform with elongate ascoids; gonocoxite with elongate outer apodeme; basiphallus widened anteriorly; distiphalli recurved 180º.

Description male (n = 1):

Head (Fig. 4.4): Broader than long. Frontal scar patch undivided, laterally convex, vertex narrow. Clypeus narrowly protruding from level of eyes. Palp (Fig. 4.5) with four segments, first two palpomeres broadly joined. Inner lateral surface of palpomere 2 with scattered hyaline sensillae. Length of palpomeres (in μm): ?, 48, 44, 72. Labellae bulbous. Attachment points of antennae broadly joined medially. Antennae (basal part Fig. 4.7, apex Fig. 4.9) 2,1 mm long, with 14 flagellomeres. Scape cylindrical, about as long as broad. Pedicel subglobular. Flagellomeres 1-13 slender, elongate, pyriform, slightly asymmetrical, carrying one pair of very long digitiform ascoids. Flagellomere 14 strongly reduced, ovoid, without ascoids but carrying three stout setae. Ascoids digitiform, paired, about 2-3 times as long as their respective flagellomere. Lengths of

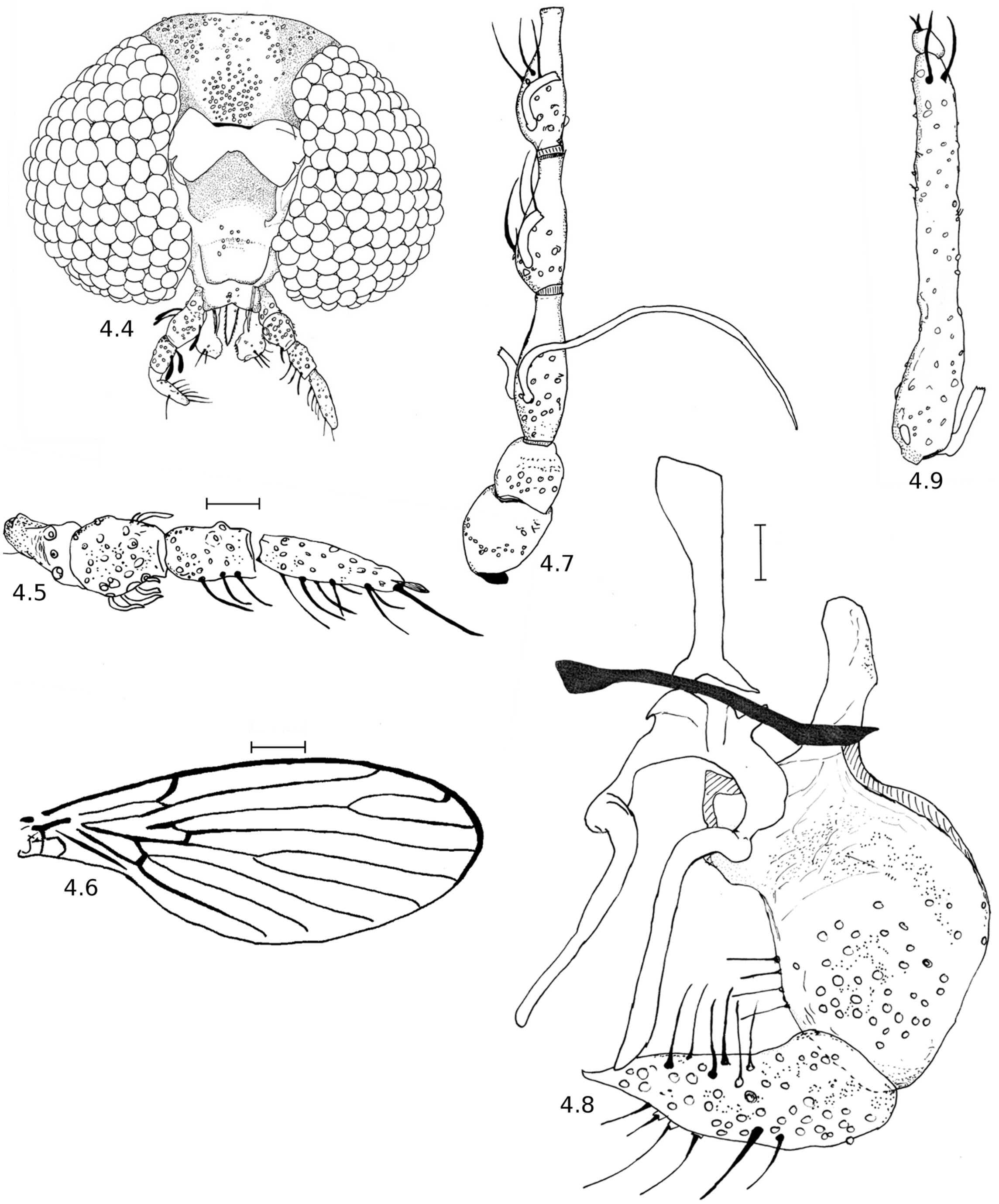

Fig. 4.4-4.9. *Trichomyia anderseni* **n.sp.** (4.4). Head. (4.5). Palp. (Scale=25 µm) (4.6). Wing. (Scale=250 µm) (4.7). Base of antenna. (4.8). Gonopods and aedeagus (Scale=40 µm). (4.9). Antennal tip.

antennal segments (in µm): 88, 84, 140, 120, 128, 132, 136, 144, 140, 144, 156, 168, 168, 168, 168, 12.

Wing (Fig. 4.6): Length 1.5 mm. Sc bifurcate, lower branch ending in R_1 basal to upper branch ending in C. Both basal cells closed. R, M and CuA veins more weakly sclerotized distally. M-fork basal to CuA_2 and R-fork. Apices of R_1, R_2 and CuA_2, and to a lesser degree M_3 and CuA_1

abruptly curved at apex.

Genitalia (Fig. 4.8): Gonocoxite broad with long, narrow outer apodeme. Gonocoxal inner posterior apodemes meeting medially. Gonostylus broad with numerous long setae, conical, tapering towards apex. Aedeagus symmetrical; basiphallus broad; distiphalli recurved 180º. Hypandrium of equal width for its whole length, slightly curved. Cerci triangular.

Biology: The specimen was taken in a Malaise trap in the Kakum forest reserve (now Kakum National Park), a lowland rainforest in southern Ghana.

Distribution: Only known from the type locality in Ghana.

Etymology: Named after Trond Andersen, Bergen Museum, University of Bergen, who collected the type material and has offered much good advice throughout the present project.

Notes: *Trichomyia anderseni* **n. sp.** is morphologically similar to *T. piricornis* Freeman, 1949 and *T. budongoensis* **n. sp.** These Central African species probably form a monophyletic group, differing from other species in having particularly long ascoids and a simple trifid aedeagus with two distiphalli.

Trichomyia budongoensis n. sp.

Type material: Holotype male: UGANDA: Western Region, Masindi District, Budongo forest, 1,7243°N, 31,5477°E, 9.-14.viii.2010, Malaise trap, G. Kvifte leg. Paratypes: 4 males, UGANDA: Western Region, Masindi District, Budongo forest, 1,7243°N 31,5478°E, 16.-21.vii.2010, Malaise trap, G. Kvifte leg., coll. ZMBN.

Diagnostic characters: *Trichomyia budongoensis* has pyriform flagellomeres with elongate ascoids; straight hypandrium; trifid aedeagus with narrow basiphallus; distiphalli bent in an acute angle; and distiphalli weakly sclerotized and expanded distally. The very similar *Trichomyia piricornis* Freeman on the other hand has an arched hypandrium and distiphalli sickle-shaped, of even width and sclerotization.

Description male (n = 5, if not otherwise stated):

Head (Fig. 4.10). Broader than long. Frons narrow between antennae; antennal attachment points narrowly separated. Vertex approximately one facet diameter wide. Palp (Fig. 4.11) with four segments; first and second segment broadly fused. Second palpomere with short, hyaline sensillae scattered on its inner surface. Lengths of palpomeres (in µm): 45-70, 64; 55-63, 59; 48-55, 51; 60-83, 72. Base of antennae as in Fig. 4.14. Scape subcylindrical, occasionally bulbous in distal half;

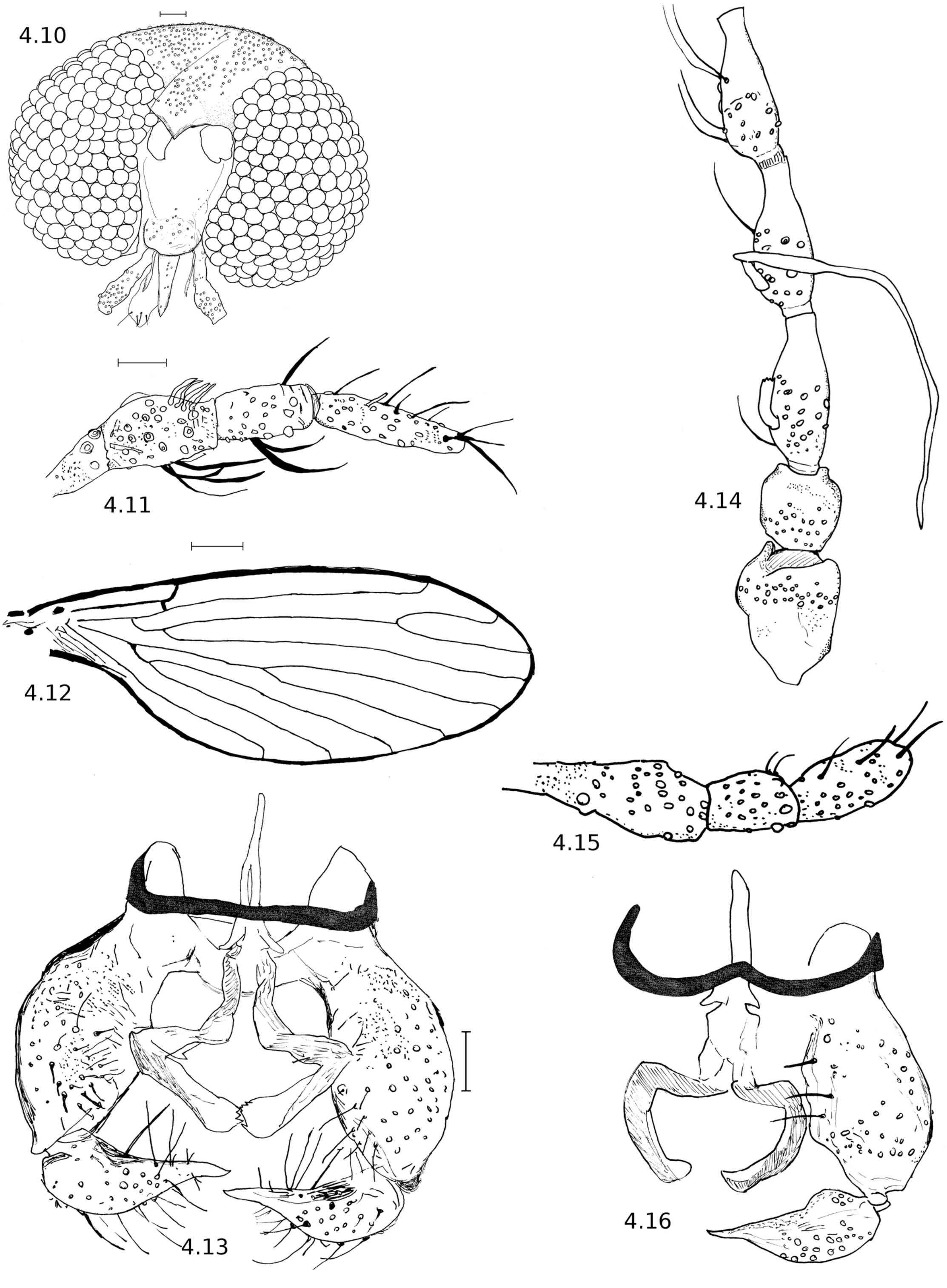

Fig. 4.10-4.14 *Trichomyia budongoensis* n.sp., 4.15-4.16 *Trichomyia piricornis* Freeman, 1949. (4.10). Head (Scale= 40 μm) (4.11). Palp (Scale= 25 μm). (4.12). Wing (Scale=250 μm). (4.13). Gonopods and aedeagus, dorsal (Scale=40 μm). (4.14). Base of antenna. (4.15). Palp. (4.16). Gonopods and aedeagus, dorsal.

pedicel globular. Flagellomeres pyriform, each carrying single pair of ascoids about 3 times as long as the flagellomere. Lengths of antennal segments (in µm): 78-112, 91; 65-68, 66; 118-133, 127; 108-124, 114; 118-128, 121; 115-136, 125; 120-138, 130 (n = 4); 120-143, 135 (n = 4); 130-144 (n = 3); 150-152 (n = 2); 156-164 (n = 2); 170-180 (n = 2); 140-168 (n = 2); 150 (n = 1).

Wing: (Fig. 4.12) Length 2.28-2.51, 2.37 mm. Sc bifurcate, lower branch ending in R_1 basal to and less than half as long as upper branch ending in C. Second basal cell and upper part of first basal cell closed. Apices of R_1 and R_2 abruptly curving upwards at apex. Tips of M_1, M_2, M_3, CuA_1 and CuA_2 abruptly curving downwards. CuA_2 about at level with M-fork, R-fork distal to both. Veins R_1, R_2, R_{4+5}, M_1, M_2, M_3, CuA_1 and CuA_2 weakening at apex.

Genitalia (Fig. 4.13): Gonocoxites oblong elipsoid with rounded to slightly pointed outer apodeme; inner posterior apodemes meeting medially; gonocoxite about twice as long as gonostylus. Gonostylus pubescent, bulbous at base, tapering in distal half. Inner surface of basal part flat or slightly concave. Hypandrium straight or weakly arched, slightly narrowed medially at level of aedeagus. Aedeagus symmetrical; distiphalli sickle-shaped with spatuliform apices, weakly sclerotized at apex. Cerci fleshy. Tergite 10 convex laterally.

Biology: The species is treated as *Trichomyia* sp. 3 in chapter 3. Specimens were collected in Malaise traps in two different patches of relatively young pioneer forest.
Distribution: Only known from its type locality in Uganda
Etymology: Named after the type locality, Budongo forest, Uganda.

Trichomyia piricornis Freeman

Trichomyia piricornis Freeman, 1949: 239.

Material examined: Holotype male mounted in euparal (remounted from Berlese fluid). «Congo Belge: Luna, 1945. B.M. 1949-211». [Democratic Republic of Congo: Luna, near Lake Mai-Ndombe (ca. 2,67°S, 18,87°E)], Crosara leg., coll. BMNH. Other type material (not examined): 3 males, 1 female, same data as holotype; 1 female, [Democratic Republic of Congo]: Bongolokoro, near Lake Mai-Ndombe, vii.1945, Crosara leg. All in coll. BMNH.

Diagnostic characters: *Trichomyia piricornis* has pyriform flagellomeres with elongate ascoids; hypandrium consisting of two symmetrical arches meeting medially above aedeagus; aedeagus trifid with sickle-shaped distiphalli; distiphalli strongly sclerotized at least on their lateral side. The similar *Trichomyia budongoensis* has straight hypandrium and distiphalli weakly sclerotized, expanding distally, bent in an acute angle.

Redescription male (n = 1):

Head: Palp (Fig. 4.15) with 4 segments, palpomere 1 fused with palpomere 2. Inner side of palpomere 2 with scattered sensillae (not figured). Relative length of palpomeres 1+2, 3 and 4 as 19 : 10 : 12. Antennae broken basally; both antenna only with scape, pedicel and a weakly pyriform first flagellomere.

Wing. Ovoid, apex between R_3 and R_{4+5}. Sc bifurcate, lower branch ending in R_1 basal to upper branch ending in C. Veins R_2, M_1, M_2, M_3, CuA_1 and CuA_2 abruptly weakened at apex.

Genitalia (Fig. 4.16): Gonocoxites elipsoid, about twice as long as gonostyli, with rounded outer apodeme. Gonostyli basally bulbous, tapering abruptly in distal two thirds; inner surface of basal part convex. Hypandrium consisting of two symmetrical arches, meeting over aedeagus. Aedeagus symmetrical; basiphallus narrow, distiphalli sickle-shaped with spatuliform apices, sclerotized over their full length. Cerci fleshy. Tergite 10 convex laterally.

Female: Briefly described in Freeman (1949); not examined.

Biology: Unknown.

Distribution: Known from two localities in the Democratic Republic of Congo only (Freeman, 1949). One of these records is based on a single female and should be considered doubtful.

Notes: No material of *T. piricornis* was available for absolute measurements or detailed drawings. The description and figures are based on sketches and notes made during a visit to the Natural History Museum, London, by the author in February 2011.

«Group B»

According to Duckhouse (1965), «group B» is characterized by the following characters: Comparatively small and pale species; palps with three segments, first palpomere with sensillae set in a shallow circular pit on the inner side; flagellomeres 1 and 2 subequal in size; ascoids paired, digitiform; flagellomere 14 occasionally fused with flagellomere 13; genitalia generally complex; gonostylus usually bare, articulated with gonocoxite ventrally.

Subgenus *Dactylotrichomyia* Duckhouse

Dactylotrichomyia Duckhouse, 1978: 213.

Type species: *Trichomyia tanypenis* Duckhouse, 1978, by original designation.

Diagnostic characters: Gonocoxite with single setose, digitiform, laterodistal process. Gonostylus usually with ventral lobe; lobe sometimes developed into a second gonostylus, occasionally reduced. Ventral gonapophyses usually present, occasionally reduced.

Notes: A further character of *Dactylotrichomyia* given by Duckhouse is the fusion of the hypandrium with the gonocoxite. The hypandrium is, however, clearly separated from the gonocoxite in *T. telfordi* **n. sp.**

Trichomyia congoensis Satchell

Trichomyia congoensis Satchell, 1956: 154.

Material examined: Holotype male, mounted on strips: [Democratic Republic of Congo]: N. Kivu, Kibati, xi-xii.1933, coll. MRAC.

Diagnostic characters: *Trichomyia congoensis* can be recognized on the following combination of characters: Gonostylus and gonocoxal process comparatively straight, dorsal gonapophyses with comb of 10 elongate, dark teeth projecting orally. *Trichomyia telfordi,* on the other hand, has gonostylus and gonocoxal process curved and dorsal gonapophyses with a comb of 10 short and stout dark teeth projecting caudally.

Redescription male (n = 1):

Head. Broader than long. Frons slightly bulbous, with lobes medially above antennal bases. Frontal scar patch triangular. Vertex narrow. Palp (Fig. 4.19) with three segments, first palpomere with circular pit with of hyaline sensillae. Length of palpomeres (in µm): 84, 60, 60. Labellae broad. Attachment points of antennae narrowly joined medially. Antennae with 16 segments (base Fig. 4.22). Scape cylindrical, about as long as broad. Pedicel globular. Flagellomeres elongate pyriform, with digitiform paired ascoids about twice as long as the flagellomere. Flagellomere 16 separated from flagellomere 15. Length of antennal segments (in µm): 80, 74, 144, 140, 146, 148, 152, 152, 148, 136, 140, 128, 132, 120, 146, 23.

Wing: (Fig. 4.18) Length 1.9 mm. Sc bifurcate, lower branch ending in R_1 distal to upper branch ending in C. Basal cells apparently open, but difficult to observe. M-fork slightly basal to CuA_2, R-fork clearly distal to both.

Genitalia: In poor condition, but gonostylus, gonocoxal process and gonapophyses clearly visible (Figs 4.19, 4.21). Gonapophyses broad with posterior inner comb of 10 long teeth, separated from the rest of gonapophysis by distinct neck (Fig. 4.19). Gonocoxal process elongate, slender, setose (Fig. 4.21). Gonostylus elongate, slender (Fig. 4.21). Aedeagus not well preserved, but clearly unlobed at base. Cercopods (Fig. 4.20) subtriangular to ovoid in

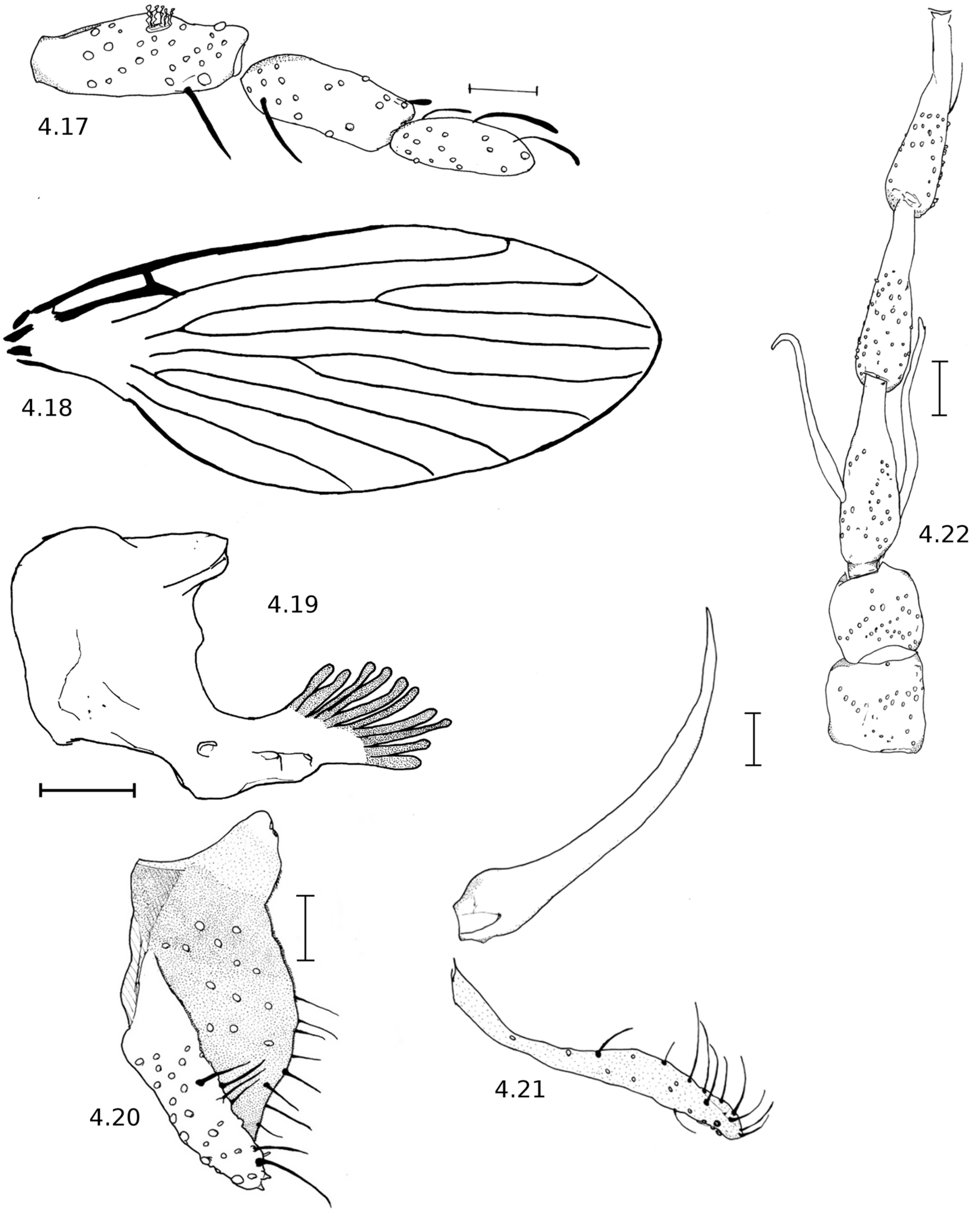

Fig. 4.17-4.22 *Trichomyia congoensis* Satchell, 1956. (4.17). Palp (Scale=25 µm). (4.18). Wing. (4.19). Dorsal gonapophysis (Scale=25 µm). (4.20). Cercus, dorsal (Scale=25 µm). (4.21) Gonostylus and lateral process of gonocoxite (Scale=25 µm). (4.22). Base of antenna (Scale=40 µm).

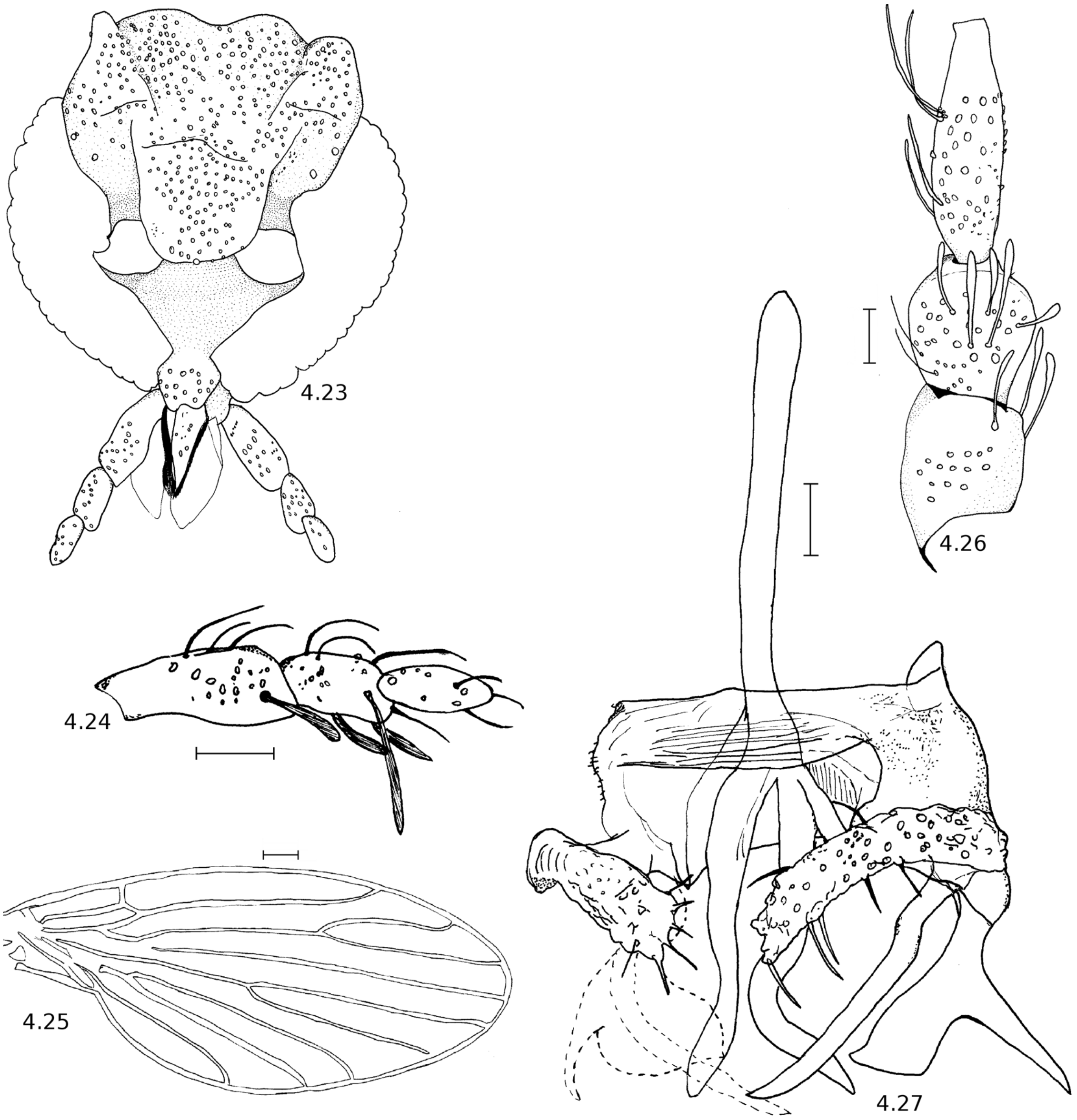

Fig. 4.23-4.27. *Trichomyia cornifera* n.sp. (4.23). Head. (4.24). Palp (Scale=25 µm). (4.25). Wing (Scale=100 µm). (4.26) Base of antenna (Scale=25 µm). (4.27). Gonopods and aedeagus, dorsal (Scale=40 µm).

dorsal view, lateral side thickened, rod-like, inner side broad and flattened.

Biology: Unknown.

Distribution: Only known from the type locality in the Democratic Republic of Congo.

Trichomyia cornifera n. sp.

Type material: Holotype male. Uganda: Western Region, Masindi District, Budongo forest, 1,7243°N, 31,5478°E, 16.-21.viii.2010, Malaise trap, G. Kvifte leg., coll ZMBN.

Diagnostic characters: *Trichomyia cornifera* can be recognized on the following combination of characters: Vertex with two lateral lobes and median notch; gonocoxal inner apodemes fused; ventral gonostylus broad and bifurcate with lateral branch half as wide as mesal branch; dorsal gonostylus slender and longer than ventral gonostylus.

Description male (n = 1):

Head (Fig. 4.23). Slightly broader than long. Frons broad with laterally convex scar patch. Vertex with two lateromedial protuberances at about eye level. Clypeus round, small, notched apically. Labellae laterally convex, broad. Palp (Fig. 4.24) with three segments, pit of hyaline sensillae on first palopmere not clear. Length of palpomeres (in µm): 65, 43, 40. Antennae (Fig. 4.26) with 10 intact flagellomeres, tip presumably broken. Scape inverted conical; pedicel globular. First flagellomere subcylindrical; other flagellomeres pyriform, slender, with weak basal apophyses. Ascoids not observed. Length of scape, pedicel and 10 first flagellomeres (in µm): 70, 63, 110, 103, 103, 103, 105, 103, 103, 100, 100, 88.

Wing (Fig. 4.25). Ovoid, 1,5 mm long. Sc bifurcate, lower branch ending in R_1 distal to upper branch ending in C. R_1 and R_2 curving more or less abruptly upwards at apex. CuA_2 about at level with M-fork, both basal to R-fork. M_1 weakly converging towards R_{4+5} distally. M_2, CuA_1 and CuA_2 curving downwards at apices.

Genitalia (Fig. 4.27): Basiphallus parallel-sided, comparatively broad, with narrow lobes anteriorly. Distiphalli long, reaching to level of apices of cercopod and gonostyle, slightly expanded subapically; flanked by two parameres reaching to level of origin of gonocoxal process. Dorsal gonapophyses triangular with tooth-like posterior apex. Gonocoxites connected dorsally through fused inner apodemes, fused to hypandrium. Hypandrium membranous, transversely striped. Gonocoxal process setose, bent in a slightly obtuse angle, broadened at apex, carrying 5 apical setae. Dorsal gonostylus smooth, slender, slightly S-shaped. Ventral gonostylus broad, flattened, bifurcate, with slender outer branch and broad inner branch. Epandrium with laterodorsal anterior apodeme slightly S-shaped. Cercopods fleshy, elongate, weakly tapering.

Biology: The species is treated as *Trichomyia* sp. 4 in chapter 3. It was taken in a Malaise trap in a patch of moist pioneer forest.

Distribution: Only known from the type locality in Uganda.

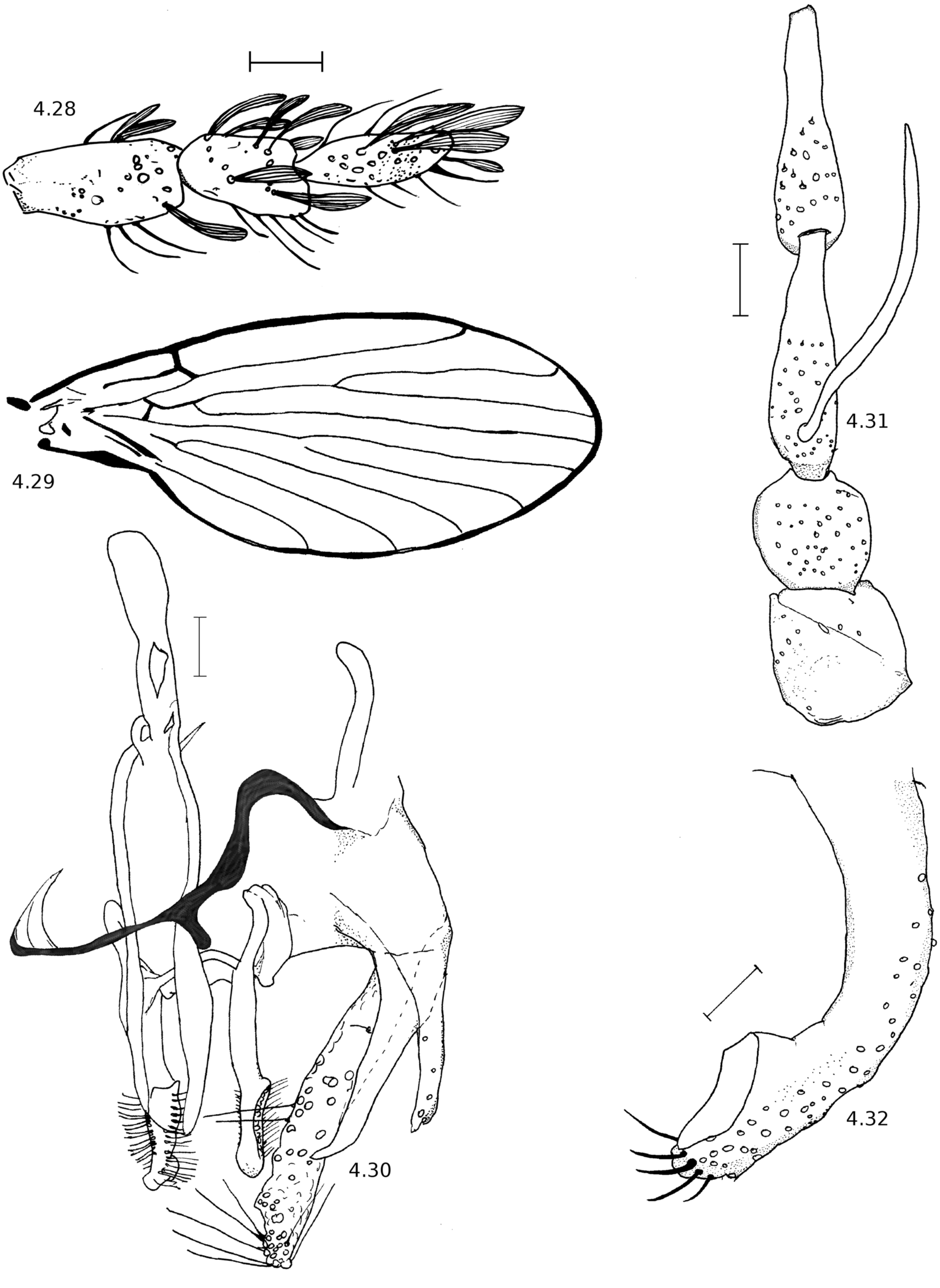

Fig. 4.28-4.32. *Trichomyia cynometrae* n.sp. (4.28). Palp. (Scale=25 µm) (4.29). Wing. (4.30). Male genitalia, dorsal (Scale=25 µm). (4.31) Base of antenna (Scale=25 µm). (4.32). Cercus, laterodorsal (Scale=25 µm).

Etymology: From Latin *cornifera,* carrying horns, referring to the protuberances of the vertex.

Trichomyia cynometrae n. sp.

Type material. Holotype male: UGANDA: Western Region, Masindi District, Budongo forest, 1,719°N, 31,5298°E, 8.-13.viii.2010, Malaise trap, G. Kvifte leg., coll ZMBN.

Diagnostic characters: *Trichomyia cynometrae* can be recognized on the following combination of characters: Aedeagus with basiphallus spatuliform; distiphalli fused; parameres longer than distiphalli with setose rectangular disk at apex; ventral gonostylus sparsely setose, similar in size to dorsal gonostylus; cercopod elongate, curved, with dorsal smooth area subapically and apical row of stout setae.

Description male (n = 1):

Head. Broader than long. Frons narrow, with triangular scar patch. Vertex narrow. Clypeus evenly tapering, narrow. Labellae bulbous, expanded mediolaterally. Palp (Fig. 4.28) with three segments. First palpomere with circular patch of hyaline sensillae. Length of palpomeres (in µm): 70, 48, 55. Antennae with 8 intact flagellomeres, broken at apex (Base in fig. 4.31). Scape cylindrical, about as long as broad; pedicel globular. Flagellomeres elongate pyriform, carrying paired digitiform ascoids which are slightly longer than their respective flagellomere. Length of scape, pedicel and 8 first flagellomeres (in µm): 80, 64, 140, 140, 142, 136, 132, 140, 140, 136.

Wing (Fig. 4.29) Ovoid, 1,74 mm long. Sc bifurcate, branch ending in R_1 distal to branch ending in C. Veins R_1 and R_2 abruptly curved upwards, veins M_2, M_3, CuA_1 and CuA_2 abruptly curved downwards. Base of M_2 incomplete.

Genitalia (Fig. 4.30). Basiphallus broad, short. Distiphalli nearly straight, fused with subgenital plate, reaching almost to level of apex of gonostylus. Seminal ducts thick, inconspicuous, connected to branching point of aedeagus. Parameres longer than phallomeres, curved at base, distally with setose, subrectangular disk. Ventral gonapophyses present as long rectangular, weakly sclerotized appendages, reaching to mid-level of parameral disk (not figured). Dorsal gonostylus smooth, tapering, slightly hooked apically. Ventral gonostylus narrow, digitiform, setose. Gonocoxal process massive, long, extensively setose especially at apex. Cercopod (Fig. 4.32) long, curved, setose except for smooth dorsal patch subapically; cercopod with a row of stout setae apically.

Biology: The species is treated as *Trichomyia* sp. 2 in chapter 3. It was taken in a Malaise trap in a mature unlogged *Cynometra alexandrei* forest.

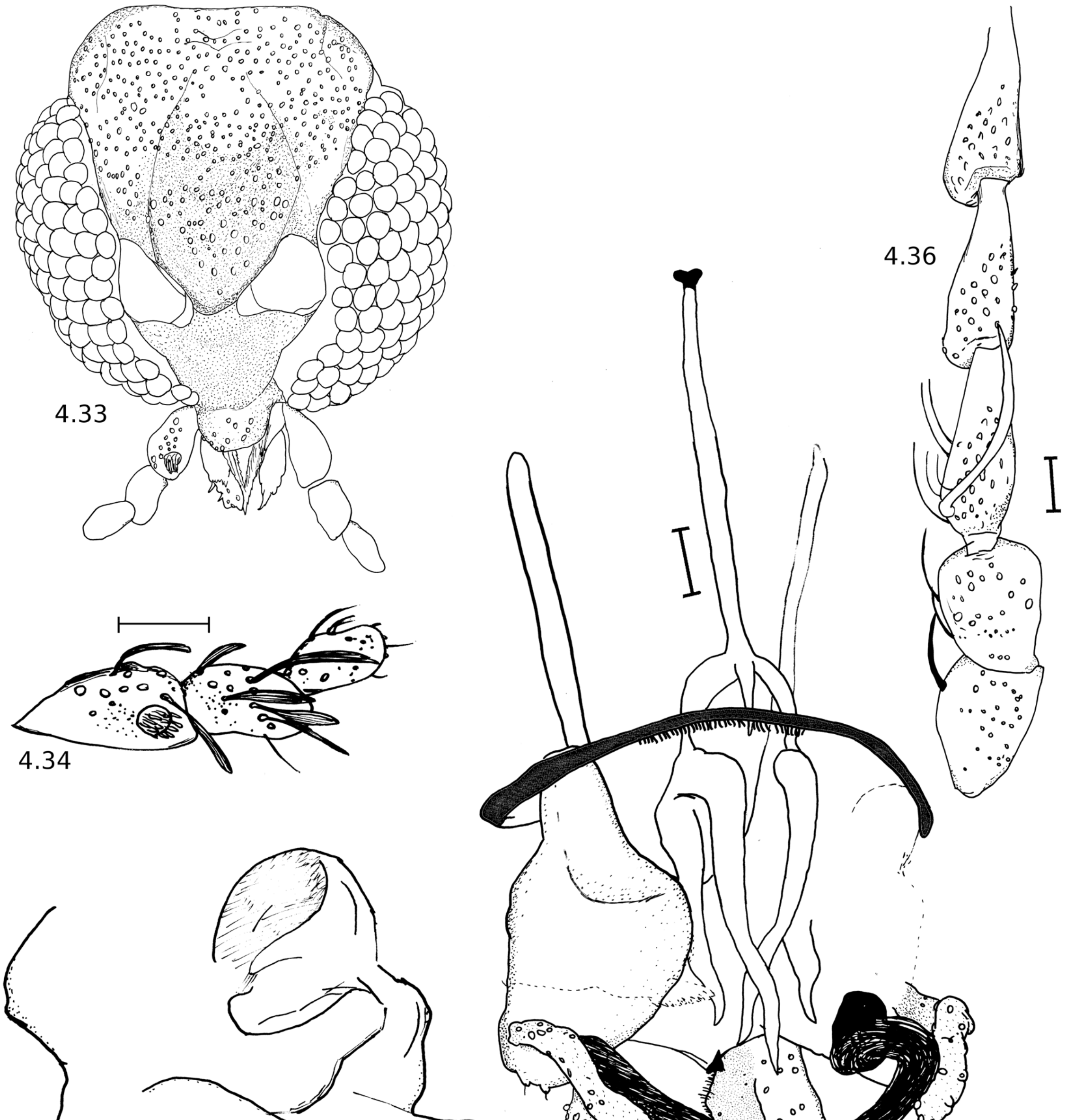

Fig. 4.33-4.37. *Trichomyia telfordi* n.sp. (4.33). Head. (4.34). Palp (Scale=25 µm). (4.35). Dorsal gonapophysis (Scale=25 µm). (4.36). Base of antenna (Scale=25 µm). (4.37). Male genitalia, dorsal (Scale=25 µm).

Distribution: Only known from the type locality in Uganda
Etymology: Named after *Cynometra alexandrei,* the predominant tree species at the type locality.

***Trichomyia telfordi* n. sp.**

Type material. Holotype male. UGANDA: Western Region, Masindi District, Budongo forest, 1,7014°N, 31,5375°E, 5.-9.vii.2010, Malaise trap, G. Kvifte leg., coll ZMBN.

Diagnostic characters: *Trichomyia telfordi* has frons bulbous; hypandrium without connection to gonocoxites; dorsal gonapophyses with posterior row of ten short, stout teeth, directed caudally; gonostylus and gonocoxal process strongly curved and epandrium with strongly elongated anterior projections. It is similar to *Trichomyia congoensis* in the structure of the gonapophyses and gonopods. However, in the latter species has frons not markedly bulbous; dorsal gonapophyses with posterior row of ten elongate teeth, directed orally; and gonostylus and gonocoxal process comparatively straight.

Description male (n = 1):

Head (Fig. 4.33): Longer than broad. Frons bulbous, protruding over antennal bases, with triangular scar patch. Vertex narrow. Clypeus with single semicircular dorsal lobe protruding in front of the eyes to about the basal 1/3 of first palpomere. Palp (Fig. 4.34) with three segments, first palpomere with circular pit of hyaline sensillae. Length of palpomeres (in µm): 50, 35, 35. Labellae bulbous, pointed, weakly sclerotized. Attachment points of antennae separated medially. Antennae (basal part in fig. 4.36) with 7 intact flagellomeres, tip broken. Scape subovoid to cylindrical, longer than broad; pedicel cylindrical, slightly longer than broad. Flagellomeres slender, elongate pyriform, slightly asymmetrical, from second flagellomere and outwards with short proximal apophyses. Ascoids about as long as flagellomeres, paired. Lengths of scape, pedicel and first 7 flagellomeres (in µm): 75, 63, 90, 95, 90, 90, 90, 88, 90.

Wing: Lost.

Genitalia (Fig. 4.37): Basiphallus bilobed anteriorly; distiphallus branching into three parts slightly anterior to level of hypandrium. Median branch very short, other branches forming two pointed phallomeres twisted inwards, reaching level of apex of gonocoxite. Pointed ventral parameres present on both sides of aedeagus, connected both to phallomeres and to gonocoxite, slightly shorter than phallomeres. Seminal ducts (not figured) long, annulated, conspicuous, linked to aedeagus at branching point. Hypandrium narrow, medially setose. Dorsal gonapophyses broad with posterior inner comb of 10 short, stout teeth, separated from rest of gonapophysis by short neck. Gonocoxites subtrapezoid in dorsal view, carrying two long ventral setae along posterior margin.

Gonocoxal process comparatively slender, elongate, with sparse, very long setae. Gonostylus strongly sclerotized, slender. Both gonocoxal process and gonostylus strongly curved. Epandrium with long rod-shaped dorsal outer apodemes. Cercopods rather narrow, laterally thickened, rod-like; inner side narrow, flattened.

Biology: The species is treated in chapter 3 as *Trichomyia* sp. 1. It was collected in a Malaise trap in a patch of young pioneer forest.

Distribution: Known from the type locality in Uganda only.

Etymology: Named after Dr. Richard Telford, Department of Biology, University of Bergen, in recognition of his help in organizing the fieldwork.

Notes: The missing fusion of the hypandrium and the gonocoxites in *Trichomyia telfordi* is seemingly unique in *Dactylotrichomyia.* This species shows similarities with *Trichomyia congoensis* Satchell in the structure of the genitalia. However, it is not known whether *T. congoensis* has a separated hypandrium or not. The two species do not appear to have any close affinities with any other species group of *Dactylotrichomyia*.

KEY TO THE MALES OF AFROTROPICAL *TRICHOMYIA*

1. Gonocoxite simple (e.g. Fig. 4.3, 4.16). Palp with 4 segments, of which the first two are often broadly joined or fused; second palpomere with hyaline sensillae not confined to a circular pit (e.g. Fig. 4.5)..2.

– Gonocoxite with setose laterodistal, digitiform process (e.g. figs. 4.30, 4.37). Palp always with three segments; first palpomere usually with hyaline sensillae in circular pit (Fig. 4.17)......7.

2 (1). Ascoids branched, filiform. First and second palpomere not fused. Cercopods rounded with single posterior row of spines. Epandrium usually with median hook projecting ventrally between the cercopods. (subgenus *Gondwanotrichomyia* Duckhouse, 1985).........................3.

– Ascoids unbranched, digitiform (Fig. 4.7). First and second palpomere fused (Fig. 4.11). Epandrium without median hook...5.

3 (2). Gonostylus blunt. (Fig. 4.1) CuA_2 basal to M-fork. (Madagascar) ....*Trichomyia brochata* Quate

– Gonostylus pointed. CuA_2 distal to M-fork...4.

4 (3). Gonapophyses as long as aedeagus, broad, parallel with and closer to gonocoxites than to aedeagus (Fig. 4.3). (South Africa) ....*Trichomyia nodosa* Duckhouse

– Gonapophyses shorter than aedeagus, narrow, closer to aedeagus than to gonocoxites; basally divergent, distally convergent to gonocoxites (Fig. 4.2) (South Africa) ....

....*Trichomyia dlinzae* Duckhouse

5 (2). Gonocoxite with long, narrow outer apodeme (Fig. 4.9). Distiphalli of aedeagus recurved 180º. (Ghana)..*Trichomyia anderseni* **n. sp.**

– Gonocoxite with comparatively short, broad outer apodeme (Figs 4.13, 4.16). Distiphalli of aedeagus bent in acute angle or sickle-shaped...6.

6 (5). Last palpomere less than 2.5 times as long as broad. (Fig. 4.15). Hypandrium arched (Fig. 4.16). Distal phallomeres strongly sclerotized, uniformly wide (Fig. 4.16). (Democratic Republic of Congo)...*Trichomyia piricornis* Freeman

– Last palpomere 3 times as long as broad. (Fig. 4.11). Hypandrium straight or weakly arched (Fig. 4.13) Distal phallomeres weakly sclerotized, expanded apically (Fig. 4.13). (Uganda) ....*Trichomyia budongoensis* **n. sp.**

7 (1). Gonopods with single gonostylus (Fig. 4.37). Gonapophyses present as broad plates with inner posterior row of 10 teeth (Fig. 4.19, 4.35)..8.

– Gonopods with two gonostyli; dorsal one smooth and pointed (Fig 4.27, 4.30). Gonapophyses without inner posterior row of teeth..9.

8. Gonapophyses with long, slender teeth on a comparatively long neck (Fig. 4.19). Base of basiphallus not bilobate (Satchell 1956, Fig. 7E). (Democratic Republic of Congo)..*Trichomyia congoensis* Satchell

– Gonapophyses with short, stout teeth on a short neck (Fig. 4.35). Base of basiphallus bilobate (Fig. 4.37). (Uganda)...*Trichomyia telfordi* **n. sp.**

9. Ventral gonostylus digitiform, setose, as long as dorsal gonostylus (Fig. 4.30). Parameres long, distally with setose subrectangular expansion (Fig. 4.30). Vertex smooth, without protuberances. (Uganda)..*Trichomyia cynometrae* **n. sp.**

– Ventral gonostylus bifurcate, flat and smooth, shorter than dorsal gonostylus (Fig. 4.27). Parameres short, tapering, without setae (Fig. 4.27). Vertex with mediolateral protuberances reminiscent of horns and medial notch (Fig. 4.23). (Uganda)........*Trichomyia cornifera* **n. sp.**

DISCUSSION

Including the present work, the number of *Trichomyia* known from the Afrotropical Region has increased to 10 species. The «group A» species fall into two distinct groups. The South African and Malagasy species described by Duckhouse and Quate belong to the subgenus *Gondwanotrichomyia* Duckhouse, 1985, whereas the Central and East African species belong to a species group which apparently does not have any close affinities to species in other regions.

Bravo (2000) suggested that the «group A» species *Trichomyia urbica* Haliday *in* Curtis, 1839, *T. biloba* Quate, 1999 and *T. saga* Bravo, 2000 form a monophyletic group together with «group B». He proposed 4 synapomorphies for this clade: Complete reduction of tergite 8 in the male, sternite 8 reduced to a narrow band in the female, flagellomeres pyriform to nodiform rather than fusiform, and first and second palpomeres fused or partially fused. *Trichomyia piricornis, T. anderseni* and *T. budongoensis* seem to belong to this clade as well, as all of Bravo's proposed male synapomorphies for the group are present in at least *T. budongoensis*. Some possible additional synapomorphies for this group include second flagellomere approximately equal in length to the first, and the reduction in number of ascoids in the males. In most «group A» species, each flagellomere carries numerous ascoids, whereas «group B» and the «group A» species *T. urbica, T. biloba, T. saga, T. piricornis, T. anderseni* and *T. budongoensis* have one pair of ascoids on each flagellomere (Duckhouse 1978, Bravo 2000).

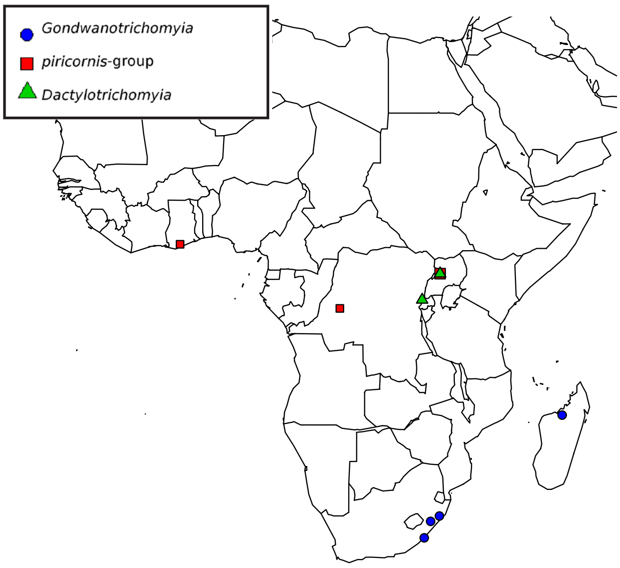

Fig. 4.38. Distribution of the African species groups of *Trichomyia.*

The African «group B» species all seem to be members of the subgenus *Dactylotrichomyia* Duckhouse, 1978, as evidenced from the long, setose apicolateral process of the gonocoxite. In *T. cynometrae* and *T. cornifera,* the elongate ventral lobes of the gonostylus form an additional gonostylus; a character they share with the *Dactylotrichomyia* species *T. trifida* Quate, 1965 from the Philippines and the two New Guinea species *T. furtiva* Quate & Quate, 1967 and *T. parafalcata* Duckhouse, 1978 (the *parafalcata* group of Duckhouse (1978)). *Trichomyia cynometrae* and *T. cornifera* are apparently not, however, closely related to these species as they both have separated gonapophyses – in the *parafalcata* group the gonapophyses are meeting medially (Duckhouse 1978).

Trichomyia telfordi and *T. congoensis* resemble one another in the general construction of the genitalia; they both have a strongly sclerotized gonostylus, a rather thin apicolateral gonocoxal process and large dorsal gonapophyses with a posterior inner comb of teeth. The enlarged gonapophyses are similar to those found in *Apotrichomyia* Duckhouse, 1978. However, in this taxon the gonapophyses are placed ventrally. The apicolateral gonocoxal processes suggest that *T. congoensis* and *T. telfordi* form a species group within the subgenus *Dactylotrichomyia*.

Afrotropical *Trichomyia* are still severely under collected and little can thus be said about their biogeographic patterns. A presumably Gondwanan group consisting of *T. brochata, T. dlinzae* and *T. nodosa* exists in South Africa and Madagascar and shows affinities to species in South America and Australia (Duckhouse 1980). In Central and East Africa, the known species belong either to «group B», subgenus *Dactylotrichomyia* Duckhouse (viz. *T. congoensis, T. cynometrae, T. telfordi* and *T. cornifera*) or to a «group A» species group forming a clade with *T. urbica, T. biloba* and «Group B» (*T. anderseni, T. budongoensis, T. piricornis*) (Fig. 4.38).

REFERENCES

Bejarano, E. E., Pérez-Doria, A. & Sierra, D. 2009. *Trichomyia quimbaya*, a new species of Trichomyiinae (Diptera: Psychodidae) from the Cordillera Central of Colombia. *Biota Neotropica,* 9, 98-100.

Bejarano, E. E., Pérez-Doria, A. & Sierra, D. 2010. *Trichomyia andina* sp. nov., a new non-hematophagous psychodid fly (Diptera: Psychodidae: Trichomyiinae) of Colombia *Biota Neotropica,* 10, 75-78.

Beran, B., Doczkal, D., Pfister, K. & Wagner, R. 2010. Two new species of Psychodidae (subfamilies Trichomyiinae and Psychodinae) from Germany associated with decaying wood. *Zootaxa,* 2386, 59-64.

Bravo, F. 1999. *Septemtrichomyia*, Subgênero Novo de Trichomyiinae Neotropical (Diptera, Psychodidae). *Revista Brasileira de Entomologia,* 43, 1-7.

Bravo, F. 2000. Descrição de uma espécie nova de *Trichomyia* (Diptera, Psychodidae) do sudeste Brasileiro, com comentários sobre a genealogia do gênero. *Acta Biologica Leopoldensia,* 22, 185-192.

Bravo, F. 2001. *Opisthotrichomyia*, Subgênero novo de Trichomyiinae (Diptera, Psychodidae) e descrição de três novas espécies do Brasil. *Sitientibus Série Ciências Biológicas,* 1, 50-55.

Curler, G. R., Phasuk, J., Chanpaisaeng, J. & Courtney, G. W. (2006) A new species of *Horaiella* Tonnoir (Diptera: Psychodidae) from Thailand. *Proceedings of the Entomological Society of Washington,* 108, 519-524.

Curler, G. R. & Moulton, J. K. 2010. Descriptions of three new species of Psychodidae (Diptera) from the southeastern United States. *Zootaxa,* 2524, 51-62.

Curtis, J. (1839) *British entomology: being illustrations and descriptions of the genera of insects found in Great Britain and Ireland: containing coloured figures from nature of the most rare and beautiful species, and in many instances of the plants upon which they are found.*

Volume 16. Printed by the author, London.

Duckhouse, D. A. 1965. Psychodidae (Diptera, Nematocera) of Southern Australia, subfamilies Bruchomyiinae and Trichomyiinae. *Transactions of the Royal Entomological Society of London,* 117, 329-343.

Duckhouse, D. A. 1978. Taxonomy, phylogeny and distribution of the genus *Trichomyia* (Diptera, Psychodidae) in Australia and New Guinea. *Systematic Entomology,* 3, 197-243.

Duckhouse, D. A. 1980. *Trichomyia* species (Diptera, Psychodidae) from southern Africa and New Zealand, with a discussion of their affinities and the concept of monophyly in Southern Hemisphere biogeography. *Annals of the Natal Museum,* 24, 177-191.

Duckhouse, D. A. 1985. Type-species designation for *Trichomyia* subgenus *Gondwanotrichomyia* Duckhouse (Diptera: Psychodidae). *Annals of the Natal Museum,* 24, 177-191.

Freeman, P. 1949. Two new Ethiopian species of Psychodidae (Diptera). *Proceedings of the Royal Entomological Society of London (B),* 18, 238-240.

Ibañez-Bernal, S. 2004. Notes on the known species of *Trichomyia* Haliday of Mexico, with the establishment of a synonymy and the description of a new species (Diptera: Psychodidae). *Zootaxa,* 523, 1-14.

Pérez-Doria, A., Hernández, E. & Bejarano, E. E. 2010. Una nueva especie de *Trichomyia* Haliday (Diptera, Psychodidae) de Los Montes de María, Colombia. *Revista Brasileira de Entomologia,* 54, 38-41.

Quate, L. W. 1957. Premier etude des Psychodidae de Madagascar. *Le Naturaliste Malgache,* 9 (2), 251-261.

Quate, L. W. 1963. Fossil Psychodidae in Mexican Amber, Part 2. Diptera: Insecta. *Journal of Paleontology,* 37 (1), 110-118.

Satchell, G. H. 1956. On the genus *Trichomyia* Haliday (Diptera: Psychodidae) with descriptions of four new species. *Proceedings of the Royal Entomological Society of London (B),* 24, 147-156.

Withers, P. 2003. The British *Trichomyia* Haliday in Curtis (Diptera, Psychodidae), with the description of a new species. *Dipterists Digest,* 10, 107-110.

Appendix 1

Key to the genera of Psychodidae in Budongo forest

1. Wing with R 4-branched - one vein only between wing forks. Palp usually with 3 segments, sometimes four.......Subfamily Trichomyiinae. One genus: *Trichomyia* Haliday *in* Curtis, 1839

– Wing with R 5-branched - two veins between wing forks. Palp with 4 or 5 segments...................2.

2 (1). Palp with 5 segments. Eyes without eyebridge. Dorsal appendages of male genitalia with sensory spines. Wings and body narrow............Subfamily Phlebotominae (not treated further)

– Palp with 4 segments. Eyes usually with eyebridge. Ventral appendages of male genitalia with sensory rods. Body humpbacked, compact...................................Subfamily Psychodinae – 3.

3 (2). Antennal segments barrell-shaped...4.

– Antennal segments distal of 2nd segment differentiated into one broad and one narrow part (except occasionally the 3rd and the distalmost three segments)..5.

4 (3). Eyebridge present. Male genitalia asymmetrical and with only one pair of dorsal appendages...*Tonnoiriella* Vaillant, 1971

– Eyebridge absent. Male genitalia symmetrical with three pairs of dorsal appendages...*Notiocharis* Eaton, 1913

5 (3). Outer lobes of labium flat with a row of microscopic teeth at their apex. Genitalia often asymmetrical...6.

– Outer lobes of labium round, usually hairy, without microscopic teeth at their apex. Genitalia never asymmetrical..7.

6 (5). Ventral appendages of male genitalia with three sensory rods. Sensory filaments of antennae with two branches..*Threticus* Eaton, 1904

– Ventral appendages of male genitalia with one sensory rod only. Sensory filaments of antennae with three or four branches...*Psychoda* Latreille, 1796

7 (5). Sensory filaments of antennae with three branches, Y-shaped. Ventral appendages of male genitalia with two sensory rods...*Philosepedon* Eaton, 1904

– Sensory filaments of antennae not Y-shaped. Ventral appendages of male genitalia with more than two sensory rods...8.

8 (7). Sensory filaments of antennae digitiform - one branch only..........*Telmatoscopus* Eaton, 1904

-. Sensory filaments of antennae with multiple branches..9.

9 (8). R2+3 without connection to R4 or connected to R4 basal to origin of R5. Eyebridge with four rows of facets ....10.

– R2+3 with connection to R4 distal to origin of R5. Eyebridges with three rows of facets........11.

10 (9). Each antennal segment with six pairs of sensory filaments ....
....*Neotelmatoscopus* Tonnoir, 1933

– Each antennal segment with one pair only of sensory filaments..........*Clogmia* Enderlein, 1935

11 (9). Sensory rods of ventral male genital appendages with pinhead-like tips. 3rd antennal segment barrell-shaped...N. gen. 1

– Sensory rods of ventral male genital appendages spatula-shaped. 3rd antennal segment with both a broad and a narrow part...*Hemimormia* Krek, 1971

Appendix 2

R code used in the statistical analyses in chapter 3

```
#CHAPTER 3. MAPS
library(maps)
library(mapdata)
library(rimage)
library(maptools)
library(RgoogleMaps)
env.df <- read.csv(”C:\\Documents and Settings\\Gunnar\\Mine dokumenter\\Fjas.csv”, sep=”;”, dec=”,”, header=T)
lonlat <- read.csv(”C:\\Documents and Settings\\Gunnar\\Mine dokumenter\\Masteroppgåve\\Ymse data\\Lonlat.csv”, dec=”,”, sep=”;”)
long <- lonlat$Lat
lati <- lonlat$Lon
centlon <- mean(long)
centlat <- mean(lati)
plot.new()
roykebein <- 1+(as.numeric(env.df$Type))
MyMap2 <- GetMap(center=c(centlat, centlon), zoom=14, sensor=”false”, maptype=”satellite”, destfile=”C:\\Documents and Settings\\Gunnar\\Mine dokumenter\\Masteroppgåve\\Ymse data\\Kart\\MyMap3.jpg”, format=”jpg”)
tmp <- PlotOnStaticMap(MyMap2, lon=long, lat=lati, cex=1.7, pch=roykebein+20, bg=roykebein)
habitats <- c(”Colonizing forest”, ”Mixed mature forest”, ”Cynometra forest”, ”Swamp forest”)
legend(”topright”, pch=c(22,24,23,25), bty=”n”, text.col=”lightblue”, pt.bg=c(2,4,3,5), habitats)
#THIS IS A MAP OF THE SAMPLING SITES IN BUDONGO
plot.new()
MyMap1 <- GetMap(center=c(centlat, centlon), zoom=11, sensor=”false”, maptype=”satellite”, destfile=”C:\\Documents and Settings\\Gunnar\\Mine dokumenter\\Masteroppgåve\\Ymse data\\Kart\\MyMap4.jpg”, format=”jpg”)
lowlife <- c(1.692931, 1.747838, 1.747838, 1.692931)
umpire <- c(31.51291, 31.51291, 31.56784, 31.56784)
```

```
ump <- PlotOnStaticMap(MyMap1, lon=umpire, lat=lowlife, FUN=polygon, border=”lightblue”)
#THIS IS A MAP OF BUDONGO, WITH THE SAMPLED AREA OUTLINED

#CHAPTER 3. ENVIRONMENTAL DATA
Meantemp.lm <- lm(Mean.temp~Type, data=env.df)
anova(Meantemp.lm)   #Temperature not significantly affected by vegetation type
summary(Meantemp.lm)
Meanhum.lm <- lm(Mean.RH~Type, data=env.df)
anova(Meanhum.lm) #Relative Humidity significantly affected by vegetation type!
plot(env.df$Type, env.df$Mean.temp, xlab=”Vegetation type”, ylab=”C°”, main=”Mean temperature”, names=c(”Colonizing”, ”Cynometra”, ”Mixed”, ”Swamp”))
plot(env.df$Type, env.df$Mean.RH, xlab=”Vegetation type”, ylab=”Relative humidity”, main=”Mean relative humidity”, names=c(”Colonizing”, ”Cynometra”, ”Mixed”, ”Swamp”))
library(multcomp)
Tukey <- glht(Meanhum.lm, linfct=(mcp(Type = ”Tukey”)))
summary(Tukey) #Relative humidity is significantly lower in the colonising forest than in the other vegetation types, save for Cynometra forest.
Tukey2 <- glht(Meantemp.lm, linfct=(mcp(Type = ”Tukey”)))
summary(Tukey2)
#CHAPTER 3 DIVERSITY STATISTICS 1

Tabdf <- read.csv(”C:\\Documents and Settings\\Gunnar\\Mine dokumenter\\Masteroppgåve\\Budongotab4.csv”, sep=”,”, header=T)
library(entropy)
Tabdf[is.na(Tabdf)]<-0
Tab.df <- data.matrix(Tabdf)
BCI <- Tab.df
Sex.df <- read.csv(”C:\\Documents and Settings\\Gunnar\\Mine dokumenter\\Masteroppgåve\\Ymse data\\Sexes.csv”, header=T, sep=”;”, dec=”,”)
Tot <- Sex.df$Males+Sex.df$Females
Tot.glm <- glm(Tot~Sex.df$Type, family=”poisson”)
Tot2.glm <- glm(Tot~Sex.df$Type, family=”quasipoisson”)
anova(Tot.glm, test=”Chi”)      #PROBLEMS WITH OVERDISPERSION -> CHOOSE QUASI-LIKELIHOOD
```

```
MODEL
anova(Tot2.glm, test=”F”)

plot(Sex.df$Type, Tot, xlab=”Vegetation type”, ylab=”Number of specimens”, names=c(”Cynometra”, ”Colonizing”, ”Mixed”, ”Swamp”))

#CHAPTER 3 - SEX RATIOS

Sex2.df <- data.frame(Sex.df$Males, Sex.df$Females)
names(Sex2.df) <- c(”M”, ”F”)
colsex <- subset(Sex2.df, Sex.df$Type==”colonizing”)
mixsex <- subset(Sex2.df, Sex.df$Type==”mixed”)
cynsex <- subset(Sex2.df, Sex.df$Type==”climax”)
swasex <- subset(Sex2.df, Sex.df$Type==”swamp”)
sum(colsex$M)/sum(colsex$F)
sum(mixsex$M)/sum(mixsex$F)
sum(cynsex$M)/sum(cynsex$F)
sum(swasex$M)/sum(swasex$F)
SEX <- cbind(c(colsex, mixsex, cynsex, swasex))
malesums <- c(sum(colsex$M), sum(mixsex$M), sum(cynsex$M), sum(swasex$M))
femalesums <- c(sum(colsex$F), sum(mixsex$F), sum(cynsex$F), sum(swasex$F))
chisq.test(c(sum(malesums), sum(femalesums)))
(sum(malesums)/sum(femalesums))

VegType<-factor(Sex.df$Type)
levels(VegType)<-c(”Cynometra”, ”Colonizing”, ”Mixed”, ”Swamp”)#replace with real names
SexyRat <- Sex2.df$M/Sex2.df$F
SexyRat[is.na(SexyRat)]<-0
stripchart(SexyRat~VegType, vertical=T, pch=1, cex=Tot/10+.1, ylab=”Sex Ratios”, xlab=”Forest type”, main=”Sex ratios and abundances”)
mn<-tapply(1:length(VegType),VegType, function(n) sum(Sex2.df$M[n])/sum(Sex2.df$F[n]))
points(1:4,mn,pch=3)
```

```
#RAREFACTION CURVES
library(vegan)
x<-sapply(1:max(rowSums(BCI)),function(n){ifelse(rowSums(BCI)>=n,rarefy(BCI, n),NA)})
matplot(1:max(rowSums(BCI)), t(x), type=”l”, lty=1, xlab=”Specimens”, ylab=”Species”, main=”Rarefied species richness”, col=roykebein, lwd=2)
legend(”topleft”, fill=c(2,4,3,5), c(”Colonizing”, ”Mixed”, ”Cynometra”, ”Swamp”), bty=”n”)
tab.mix <- subset(Tab.df, env.df$Type==”Mixed”)
tab.col  <- subset(Tab.df, env.df$Type==”Colonising”)
tab.cyn <- subset(Tab.df, env.df$Type==”Ironwood”)
tab.swa  <- subset(Tab.df, env.df$Type==”Swamp”)

mixtot <- colSums(tab.mix)
coltot <- colSums(tab.col)
cyntot <- colSums(tab.cyn)
swatot  <- colSums(tab.swa)
tutot <- colSums(Tab.df)
Tut <- rbind(tutot,mixtot, coltot, cyntot, swatot)
y<-sapply(1:max(rowSums(Tut)),function(n){ifelse(rowSums(Tut)>=n,rarefy(Tut, n),NA)})
matplot(1:max(rowSums(Tut)), t(y), type=”l”, ylim=c(0,90), lty=c(2,1,1,1,1), xlab=”Specimens”, ylab=”Species”, main=”Rarefied species richness”, col=c(1,4,2,3,5), lwd=c(2,3,2,2,2))

#CHAO ESTIMATOR
Tab.sp <- specpool(Tab.df)
mix.sp <- specpool(tab.mix)
col.sp <- specpool(tab.col)
cyn.sp <- specpool(tab.cyn)
swa.sp <- specpool(tab.swa)
abline(h=Tab.sp$chao, lty=2, lwd=1.5)
lines(x=c(-5,30), y=c(Tab.sp$chao, Tab.sp$chao), lty=1, lwd=6, col=”white”)
abline(h=mix.sp$chao, lty=2, lwd=1.5, col=4)
abline(h=col.sp$chao, lty=2, lwd=1.5, col=2)
abline(h=cyn.sp$chao, lty=2, lwd=1.5, col=3)
```

```
abline(h=swa.sp$chao, lty=2, lwd=1.5, col=5)
legend(”topleft”, fill=c(1,2,4,3,5), c(”Total”, ”Colonizing”, ”Mixed”, ”Cynometra”, ”Swamp”), bty=”n”, bg=”white”)
sppul <- rbind(Tab.sp,mix.sp,col.sp,cyn.sp,swa.sp)
row.names(sppul) <- c(”Total”, ”Mixed”, ”Colonizing”, ”Climax”, ”Swamp”)
Chaos <- c(Tab.sp$chao, mix.sp$chao, col.sp$chao, cyn.sp$chao, swa.sp$chao)
sum(Chaos)-Tab.sp$chao
Chaose <- c(Tab.sp$chao.se, mix.sp$chao.se, col.sp$chao.se, cyn.sp$chao.se, swa.sp$chao.se)
1.96*Chaose
Spptot <- c(Tab.sp$Species, mix.sp$Species, col.sp$Species, cyn.sp$Species, swa.sp$Species)
chisq.test(sppul$chao, sppul$Species)

#CHAPTER 3 - CHAO & SHEN’S BIAS-CORRECTED SHANNON INDEX


z<-sapply(1:25,function(n){entropy.ChaoShen(Tab.df[row(Tab.df)==n])})
mixshan <- exp(z[env.df$Type==”Mixed”])
colshan <- exp(z[env.df$Type==”Colonising”])
cynshan <- exp(z[env.df$Type==”Ironwood”])
swashan <- exp(z[env.df$Type==”Swamp”])
Shan <- data.frame(cbind(z, env.df$Type))
boxplot(colshan, mixshan, cynshan, swashan, main=”Diversity”, ylab=expression(paste(e^(”bias-corrected Shannon index”))), xlab=”Vegetation types”, names=c(”Colonizing”, ”Mixed”, ”Cynometra”, ”Swamp”))

# MODEL OF CHAO-SHANNON
rawnumb3rs <- glm(Shan$z~Tot, family=quasipoisson)
anova(rawnumb3rs, test=”F”)
divtype3 <- glm(Shan$z~V2fact, family=quasipoisson)
anova(divtype3, test=”F”) #Resid.Dev. / Resid.Df < 2, overdispersion is probably not too much of a problem. It is insignificant anyway.
#Species diversity is significantly related to total specimens collected, but not to vegetation type. Hardly worth reporting.

# BRAY-CURTIS
Mixpool <- colSums(tab.mix)
```

```
Colpool <- colSums(tab.col)
Cynpool <- colSums(tab.cyn)
Swampool <- colSums(tab.swa)
Totpool <- rbind(Mixpool, Colpool, Cynpool, Swampool)
Braydist <- vegdist(Totpool, method=”bray”)
Braydist
Brayclust <- hclust(Braydist)
plot(Brayclust)
plot(Brayclust, labels=c(”Mixed”, ”Colonizing”, ”Cynometra”, ”Swamp”))

# COMPARISON WITH ALEXANDER ET AL 2001
Alex <- read.csv(”C:\\Documents and Settings\\Gunnar\\Mine dokumenter\\Masteroppgåve\\alexanderetal.csv”, sep=”,”)
MN <- subset(Alex, X ==”MN”)
FN <- subset(Alex, X ==”FN”)
North <- MN[2:16] + FN[2:16]
MS <- subset(Alex, X ==”MS”)
FS <- subset(Alex, X ==”FS”)
South <- MS[2:16] + FS[2:16]
exp(entropy.ChaoShen(North))
exp(entropy.ChaoShen(South))
rarefy(North, 11)
rarefy(South, 11)
afq <- rbind(North, South)
row.names(afq)=c(”North”, ”South”)
rarefy(afq, max(afq))
afqmalaise <- data.frame(c(afq[1:7], afq[12:15]))
q<-sapply(1:max(afq),function(n){ifelse(rowSums(afq)>=n,rarefy(afq, n),NA)})
matplot(1:max(afq), t(q), type=”l”, ylim=c(0,12), xlab=”Specimens”, ylab=”Species”, main=”Rarefied species richness in Alexander et al.”, col=c(”green”, ”blue”))
legend(”topleft”, fill=c(”green”, ”blue”), c(”Pristine”,”Regenerated”), bty=”n”)
```