RESEARCH ARTICLE



Revision of the pseudo-orbweavers of the genus Fecenia Simon, 1887 (Araneae, Psechridae), with emphasis on their pre-epigyne

Steffen Bayer

Senckenberg Research Institute, Senckenberganlage 25, 60325 Frankfurt am Main, Germany

Corresponding author: Steffen Bayer (bayer@senckenberg.de)

Academic editor: D. Logunov | Received 16 September 2011 | Accepted 1 November 2011 | Published 9 December 2011

Citation: Bayer S (2011) Revision of the pseudo-orbweavers of the genus *Fecenia Simon*, 1887 (Araneae, Psechridae), with emphasis on their pre-epigyne. ZooKeys 153: 1–56. doi: 10.3897/zooKeys.153.2110

Abstract

The present paper provides a taxonomic revision of the genus *Fecenia* with emphasis on the characteristics of the pre-epigynes which are integrated for the first time into an identification key. As a result, one species is revalidated, *F. protensa* Thorell, 1891, **stat. n.**, and two new junior synonyms for *F. protensa* are recognised: *F. sumatrana* Kulczyński, 1908, **syn. n.** and *F. nicobarensis* (Tikader, 1977), **syn. n**. New records are reported: *F. ochracea* (Doleschall, 1859) from Malaysian Borneo, *F. macilenta* (Simon, 1885) from Sumatra, Indonesia, *F. protensa* from Thailand and Malaysia, *F. travancoria* Pocock, 1899 from Sri Lanka and Thailand, and *F. cylindrata* Thorell, 1895 from Thailand and Laos. Additional information on the biology of *Fecenia* is provided and the validity of characters for identifying *Fecenia* species is discussed.

Keywords

Taxonomy, copulatory organs, spination, distribution, South-East Asia, pseudo-orbweb, enrolled leaf, predatory behaviour, mating behaviour, moult, identification key

Introduction

Representatives of the spider genus *Fecenia* are distributed from southern India to the Solomon Islands. They are not known beyond the latitudes of 25°N and 15°S. To date (Platnick 2011) this genus comprises five valid species. *Fecenia* species possess relatively long and prograde legs. The first two pairs are directed anteriorly whereas the third and

Copyright Steffen Bayer. This is an open access article distributed under the terms of the Creative Commons Attribution License 3.0 (CC-BY), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

fourth leg pairs are directed posteriorly. *Fecenia* species have a flat carapace and a slender body shape (Thorell 1881). Their chelicerae are short and strong and bear a distinct condyle latero-proximally (Levi 1982). Adults build a vertical web, which is similar to the typical orbwebs of (most) Araneidae and related families like Tetragnathidae, respectively. Thus representatives of *Fecenia* are here called 'pseudo-orbweavers'. Simon (1892) described their web as more irregular than the webs of Araneidae. Furthermore he stated that it contains an enrolled leaf as a retreat in the centre. Despite this somewhat similar web style, Fecenia is not closely related to the Araneidae and does not belong to the Orbiculariae either (Coddington 1990). Together with Psechrus Thorell, 1878, this genus belongs to the Psechridae Simon, 1890 (Simon 1892; Lehtinen 1967; Levi 1982; Griswold 1993; Griswold et al. 2005; Platnick 2011). Previously the pseudo-orbweavers were revised twice. Levi (1982) provided a worldwide revision and Wang and Yin (2001) covered Chinese representatives. In the study of Lehtinen (1967) several Fecenia species were synonymised. Levi (1982) matched a female of a different species with the male of F. macilenta (Simon, 1885). Murphy (1986) recognised this mistake and described the female of *F. macilenta* for the first time. At present, further taxonomic ambiguities still persist. Some of these were caused by descriptions of new species using subadult females (which only possess pre-epigynes) as type specimens.

Pre-epigynes do not occur in all entelegyne spiders, but seem to be common within the families supposed to be related to Psechridae (Griswold 1993; Griswold et al. 1999, 2005), e.g. Pisauridae, Lycosidae, Stiphidiidae, Zoropsidae and Ctenidae. Up to now pre-epigynes were mostly disregarded in arachnological studies. There are some first descriptions where pre-epigynes had been erroneously regarded as epigynes (e.g. Psechrus mimus Chamberlin, 1924, Heteropoda shillongensis Sethi and Tikader, 1988, Psechrus ghecuanus Thorell, 1897). A study on Agelena labyrinthica (Clerck, 1757) noted the presence of a primordial copulatory organ in females (Strand 1906). Jäger and Ono (2000), Jäger (2008) as well as Jäger and Bayer (2009) illustrated pre-epigynes of a few particular species of Olios Walckenaer, 1837 and Heteropoda Latreille, 1804 respectively. Several differently developed primordial copulatory organs in different stages of immature females of Cupiennius salei (Keyserling, 1877) were documented in Lachmuth et al. (1985). In Psechridae pre-epigynes were illustrated for the first time by Levi (1982). However, he studied only a few species in this regard. Moreover, in the case of Psechrus himalayanus Simon, 1906, he regarded a pre-epigyne as an adult epigyne. This led to misunderstandings in species determination and characterisation. As an ongoing revision shows (Bayer unpubl. data), Griswold (1993) examined a subadult female of P. marsyandi Levi, 1982, identified as P. himalayanus, as the female representative of the genus Psechrus in his study on the phylogeny of Lycosoidea. Wang and Yin (2001) showed the pre-epigyne of one species, Psechrus rani Wang and Yin, 2001, and compared it with features of the conspecific adult female. A fairly complete investigation on the pisaurid genus Thalassius Simon, 1885 was carried out by Sierwald (1987) where most species concerned were characterised by their pre-epigyne II (penultimate instars) and some even by their pre-epigyne I (antepenultimate instars). An even more detailed study on American Pisauridae described changes in the development of preepigynes of different stages via very detailed illustrations (Sierwald 1989). Nevertheless, no study to date has examined variation within pre-epigynes of penultimate instar females within a species, nor has there been any attempt to integrate the pre-epigyne and pre-vulva- features into an identification key. In this context, the intention of this paper is to provide a thorough taxonomic revision of *Fecenia* including some remarks on their biology and above all the character states of pre-epigynes.

Material and methods

Part of the spider material was collected by hand during an expedition in Thailand and Laos from October-December 2009. Further material was obtained from colleagues, who collected specimens in different regions of SE Asia. Most of the material examined in the present study was borrowed from several natural history museums, which are listed below. Examinations and illustrations were made using a Leica MZ 165 C stereomicroscope with a drawing mirror. Photos of living spiders were taken with a Canon EOS 500D (equipped with a Sigma 105 macro lens and a Canon ringlite). Photos of preserved spiders and copulatory organs were taken with a Sony DSC W70 compact camera via the ocular of the stereomicroscope. The material was preserved in 70% denatured ethanol. Female copulatory organs were cleared from surrounding hairs and dissected. The opaque tissue surrounding the vulva was removed. Vulvae were cleared in 96% DL-lactic acid ($C_3H_6O_3$). As the cuticle surrounding the epigyne may curl and structures may get shifted in the course of applying lactic acid, this method could not be applied to every specimen. In males, hairs along the margin of the cymbium were removed to give a clear view of the bulb structures.

All measurements are in millimetres (mm). Leg formula (from longest to shortest leg) and leg spination pattern follow those in Bayer and Jäger (2010). In leg/palp spination the femur, patella, tibia and metatarsus (tarsus in palp) are listed in exactly this sequence. First, all spines on the prolateral surface of the respective limb article are counted and listed, then the ones on the dorsal, then retrolateral and finally the ventral surface. Thus the resulting number is generally one of 4-digits. Some limb articles, e.g. the femur and patella, always lack ventral spines, so here the number is of 3-digits. If a spination pattern from a certain limb article differs between the left and right sides, the pattern for the right article is listed in parenthesis behind, without a blank. Palp and leg lengths are listed as: total (femur, patella, tibia, metatarsus, tarsus).

Abbreviations used in the text: ALE – Anterior lateral eye. AME – Anterior median eye. AML – Anterior margin of lateral lobe. AS – Anterior part of median septum. bEA – Basal embolus apophysis. BL – Borderline between SSI and TSI. C – Conductor. CA – Cymbium alveolus. CO – Copulatory opening. DRTA – Dorso–retrolateral tibial apophysis. E – Embolus. EF – Epigynal field. EM – Epigynal muscle sigilla. FD – Fertilisation duct. juv. – Juvenile (convention in the present work: juveniles are immature specimens of instars where no sex determination is possible, otherwise called juvenile male or juvenile female). LL – Lateral lobe. MA – Median apophysis. MP – Membranous process of tegulum. PLE – Posterior lateral eye. PME – Posterior median eye. PS – Posterior part of median septum. p.s.a. – Pre-subadult. RPA – Retrolateral patellar apophysis. RTA – Retrolateral tibial apophysis. s.a. – Subadult. SB – Serial individual numbers of Psechridae examined by the author. SH – Spermathecal head. SO – Slit sense organ. SSI – Strongly sclerotised section of internal duct system. T – Tegulum. TR – Transverse edge/ridge of median septum. TSI – Transparent section of internal duct system. VPA – Ventral patellar apophysis.

Terminology of structures belonging to the copulatory organs is given as follows:

The female epigyne consists of two slits, which separate the lateral lobes (LL) from the median septum. The latter is folded transversely, resulting in a transverse edge or ridge (TR) (Fig. 79). Consequently, an anterior part of the septum (AS) and a posterior part (PS) can be distinguished (Fig. 79). Anteriorly, each of the LL exhibits a more or less sclerotised margin (anterior margin of lateral lobe, AML). The entire epigyne is surrounded by an epigynal field (EF), which is a sclerotised area. It is not as intensively sclerotised as the median septum or the LL and is distinguished from the adjacent areas of the ventral opisthosoma by a darker colour. The following structures certainly do not belong to the epigyne, but they may be of additional taxonomic information, so they are illustrated and described here, too. Namely the two muscle sigilla (epigynal muscle sigilla, EM) in front of EF (sometimes they are integrated into the epigynal field) and the slit sense organs (SO) near the epigyne (Fig. 79). The vulva consists of an internal duct system (more precisely a folded slit system, cf. Sierwald 1987). It is divided into an initial, rather transparent section (TSI), a strongly sclerotised section (SSI) and the fertilisation duct (FD) (Fig. 83). The border line (BL) between TSI and SSI is clearly visible (Fig. 83). The initial section of SSI features a wide area with pores leading to associated glands. As this area is presumably homologous to the spermathecal head in Psechrus (for location of the spermathecal head see Wang and Yin 2001 or Bayer and Jäger 2010) the term spermathecal head (SH) is used here for *Fecenia* too, despite its different shape (Fig. 83). Griswold (1993: p. 21) even denominated the entire SSI as "head of spermatheca", which is not followed here. In Fecenia it is very difficult to locate the receptaculum. It is not clear where the functional copulatory duct actually ends. Moreover, nobody has ever observed how far a Fecenia embolus penetrates within the internal duct system or where the sperm are finally stored.

Apart from structures of a male palp that are well known in arachnology, e.g. conductor, sperm duct or RTA, the *Fecenia* palp shows a retrolateral patellar apophysis (RPA), a ventral patellar apophysis (VPA) and a membranous process (MP) close to the embolus base (Fig. 8). In one species, *F. macilenta*, an additional large apophysis arises dorso-retrolaterally from the tibia (dorso-retrolateral tibial apophysis, DRTA, Fig. 53). Presently it cannot be clarified whether this apophysis is just the dorsal branch of an extended RTA or an additional apophysis. In either case, the DRTA can be regarded as an autapomorphy of this species.

Symbols/styles used in the illustrations: Regular solid lines indicate edges/margins/ rims of structures as recognised in the respective view; Weak solid lines indicate edges of fine structures, e.g. membranous structures, or wrinkles in the area of the epigyne; Dashed lines indicate inner walls of ducts and/or slits; Dotted lines (wide) indicate structures shining through the cuticule (e.g. parts of vulva shining through epigynal cuticula). Dotted lines (fine) indicate clear colour differences (e.g. border of epigynal field). In schematic illustrations showing the course of the internal duct system the spermathecal head area is marked with several "T" marks, the copulatory opening with a circle and the end of the fertilisation duct in the direction of the uterus externus with an arrow (see e.g. Fig. 3). When a copulatory opening comprises an elongated slit/area, the circle is put at the central position of that slit/area. Arising points and/or directions of tegular appendages in males are described as clock-positions of the left palp in ventral view. This refers also to directions of some structures of the female vulva. As a convention in this latter case: In every species only the right vulva half is considered.

Museum collections (with curators): AMS - Australian Museum, Sydney (G. Milledge). CAS - California Academy of Sciences, San Francisco (C. E. Griswold, A. Carmichael). HBI - Hunan Biological Research Institute, Hunan Normal University, Changsha (X. J. Peng, L. Ping). IRSN - Institut Royal des Sciences Naturelles de Belgique, Brussels (L. Baert, B. Goddeeris). MCSN - Museo Civico di Storia Naturale, Genoa (M. Tavano). MCZ - Harvard University, Museum of Comparative Zoology, Cambridge, Massachusetts (G. Giribet, L. Leibensperger). MHNG - Muséum d'histoire naturelle, Geneva, Switzerland (P. Schwendinger). MIZ - Museum and Institute of Zoology, Warszawa (D. Mierzwa). MNHN – Muséum National de Histoire Naturelle, Paris (C. Rollard, E. Leguin). NHM - Natural History Museum, London (J. Beccaloni). NHMW - Naturhistorisches Museum Wien, Vienna (J. Gruber, C. Hörweg). NRS – Naturhistoriska Riksmuseet, Stockholm (G. Lindberg). NZSI – Zoological Survey of India, National Zoological Collection, Calcutta. RMNH – Nationaal Natuurhistorisch Museum Naturalis, Leiden, Netherlands (J. Miller, I. J. Smit). SJPC - Sunil Jose Private Collection, Kottayam, India (S. Jose). SMF - Senckenberg Museum, Frankfurt am Main, Germany (P. Jäger, J. Altmann). USNM – National Museum of Natural History, Washington D.C. (J. Coddington). ZMA - Zoologisch Museum Amsterdam (B. Brugge). ZMB – Museum für Naturkunde, Berlin (J. Dunlop, B. Nitsche). ZMH - Zoologisches Institut und Zoologisches Museum, Hamburg (H. Dastych). ZMUC – Zoological Museum of the University of Copenhagen (N. Scharff).

In the species descriptions the spider material is listed as follows: localities are listed from North to South, then from West to East; countries, provinces and towns/villages are listed as far as possible by their presently valid names.

Results

Characteristics of pre-epigynes

Distinction of pre-epigyne from adult epigyne. Pre-epigynes are considerably smaller than epigynes. If there is no adult female available to compare the size of the epigyne with that of the pre-epigyne of a subadult female the slit sense organs (SO) and epigynal muscle sigillae (EM) in front of the pre-epigyne can help. The distance between

the SO from left to right side is about twice as long as the width of a pre-epigyne, but only slightly longer than the width of an adult epigyne. Furthermore, the pre-epigyne is only slightly longer than one EM. The adult epigyne, in contrast, is at least twice as long as EM. Moreover, the pre-epigyne exhibits either no epigynal field or the latter does not reach SO and/or EM.

Ontogeny of the epigyne. Pre-epigynes from four pseudo-orbweaver species were examined and found to exhibit apparently species-specific characteristics. Basic structures of adult epigynes can be recognised as primordial structures in the pre-epigynes. The following general ontogenetic process apparently leads from the primordial to the adult female copulatory organ: The anterior part of median septum (AS) and the anterior margins of lateral lobes (AML) extend strongly anterio-laterally.

In the subadult female of *F. protensa* Thorell, 1891 the transverse ridge/edge of the median septum (TR) is clearly recognisable as a broad "W"-shaped edge (Fig. 69). In addition to the changes that happen from the subadult to adult stage described above, the median section of TR becomes strongly notched, together with a distinct median folding of AS. The result is the characteristic adult epigyne (Figs 55, 64, 108).

In *F. cylindrata* Thorell, 1895, AML run at more or less a right angle anteriorly and face each other. This can be recognised overall in pre-subadult, subadult and adult females (Figs 79–82). A clearly developed TR is only present in subadult females and adults. In pre-subadult females the TR is at best only slightly indicated (dotted line in Fig. 82).

In *F. ochracea* (Doleschall, 1859), it is easy to identify corresponding structures of subadult females and adults, because the pre-epigyne (Figs 20–21) already strongly resembles the adult one (Fig. 19). TR is present in subadult females. As on both sides TR is strongly curved anteriorly the characteristic broad-"nose-like" AS, like in adults (Fig. 19), is already recognisable. By contrast, in pre-subadult females TR is at best very weakly developed (Fig. 22).

In *F. travancoria* Pocock, 1899, the situation is very similar to that in *F. protensa*, although its pre-epigyne (Fig. 74) slightly differs from that of *F. protensa* (Figs 58, 69) (see respective species descriptions).

Different developmental stages of pre-epigynes. Epigynes of adult females within the same species are similarly shaped (this is the reason why they can serve as an identification tool). In general this applies to the pre-epigynes, too. Yet, in one out of fifteen subadult females of *F. cylindrata* the pre-epigyne was larger and somewhat differently shaped (Fig. 80) than generally (Figs 81, 94). It gives the impression that it may be further developed than the others. This phenomenon of a differing character state of the pre-epigyne does not mean that identification via the pre-epigyne is not possible. Because if the respective pre-epigyne is interpreted accurately, it is noticeable that it tends to fall along a developmental continuum together with the "regularly" shaped pre-epigynes, the pre-pre-epigynes of p.s.a. QQ and the adult epigynes (Figs 79–82). The s.a. Q of *F. cylindrata* illustrated in Fig. 80 is already more similar to the adult (Fig. 79). Its pre-vulva already exhibits a clear division into a

transparent section of internal duct system (TSI) and a strongly sclerotised one (SSI) (Fig. 86). Hence, it is clearly recognised as *F. cylindrata*.

In summary, pre-epigynes are easily distinguished from adult epigynes and apparently exhibit species-specific characters (note that one species pair *F. protensal F. travancoria* is difficult to distinguish, but this is not surprising as it applies to the adults too; see respective species descriptions). In rare cases, in *F. cylindrata* pre-epigynes of particular subadult females may differ from the general type. But by the means of an accurate interpretation of those pre-epigynes the respective subadult females can be recognised as *F. cylindrata*, anyway. So, in *Fecenia* the pre-epigynes can be used as an identification tool. Here they are integrated in an identification key for the first time.

Taxonomy

Psechridae Simon, 1890

In combination, the following characters are diagnostic for Psechridae: cribellum and calamistrum present; claw tufts distally on the 3-clawed tarsi; rectangular calamistrum comprising at least 3 rows of setae; indirect eyes with grate shaped tapetum (Simon 1892; Homann 1950; Lehtinen 1967; Levi 1982; Griswold et al. 2005).

Key to genera

Fecenia Simon, 1887

http://species-id.net/wiki/Fecenia

Mezentia Thorell 1881: 203 (Type species: Mezentia angustata Thorell, 1881); Simon 1885: 451.

Fecenia Simon 1887: 194 (homonym recognised, Mezentia Stål, 1878 [Orthoptera], replacement name established); Simon 1890: 80; Simon 1892: 226; Lehtinen 1967: 234, 383 (syn. of type species F. angustata with F. ochracea); Levi 1982: 131; Coddington 1990: 7; Murphy and Murphy 2000: 264; Griswold et al. 2005: 38. **Diagnosis.** *Fecenia* species differ from *Psechrus* in the following characters: AME larger than all other eyes (in *Psechrus*, AME smaller or at most as large as other eyes); ventral side of opisthosoma centrally with pair of two white or beige patches, never with light median line like in *Psechrus*; clypeus flatter than in *Psechrus*, not or just slightly higher than diameter of AME, hence cephalic part of carapace rather flat; leg IV always shorter than leg II (in *Psechrus*, leg IV slightly longer or as long as leg II); in contrast to *Psechrus*, males with RTA, RPA, VPA and MA; females with clearly divided median septum of epigyne, vulva always lacking spherical spermathecal heads (in *Psechrus* females, median septum simple and spherical spermathecal heads generally present).

Description. Medium sized to large Psechridae, body length in males: 7.2-13.2 mm; females: 7.7–20.2 mm. Cephalic part of carapace not distinctly narrower than broadest (thoracic) section. Anterior eye row recurved, posterior row straight (or at least almost straight). Chelicerae strong, shorter than in Psechrus, basal article at most 2.5 times longer than broad. Cheliceral furrow with three promarginal and four retromarginal teeth. Basal article of chelicerae ventrally with long field of short, transverse striae. Ventral surface of former distally with semicircular lobe with long, curved hairs (Fig. 6). Labium slightly longer than broad (Fig. 5). Gnathocoxae ca. twice as long as broad, distal section slightly broader than basal one (Fig. 5). Serrula with ca. 130-170 (size-dependant) very small, dark, apically blunt teeth, very densely arranged. Sternum slightly longer than broad, with pointed posterior ending and broad-angled (160°) anterior ending (Fig. 4). Pedipalp in females with single claw (Fig. 51) containing 8-12 teeth. Legs extremely long in males (metatarsus I ca. three times longer than carapace (Fig. 117), relatively long in females (metatarsus I ca. 1.5-2 times longer than carapace, Fig. 119). Leg formula 1243. Coxae of legs I, II broader than III, IV. Calamistrum dorso-retrolaterally on metatarsus IV consisting of 3-4 rows of setae (inner rows irregular). Spination of palp and legs: Highly variable within each species. Therefore, no species-specific and no common genus-specific spination pattern could be found. Consequently the spination will only be listed for the primary type specimen in the species descriptions. At the following positions spines are always absent: All patellae, dorsal surface of all tibiae and all metatarsi. Palpal femur spination varies from 000, 010, 110, 120, 130, which are the most common ones, to 141. Palpal patella, tibia and tarsus mostly without spines, if present, then very small, the most common patterns in this case are: patella 110, tibia 0100, tarsus 1004. Femora of legs I and II with even more variable spination, e.g. 100, 110, 210, 300, 310, 312, 320, 401, 412, 501, or 613. The most common one is 310. The same for those of legs III and IV, but here the number of spines is lower on average, most common is 010. The tibial spination pattern in Fecenia includes a characteristic aspect: Legs I and II: retrolateral spines absent; legs III and IV: prolateral ones absent. At each opposite side the number of spines varies from 0 to 4, with legs I and II mostly having one to two spines more than III and IV. Ventrally at tibiae I and II there are mostly 6, at tibiae III and IV mostly 4 spines (paired spines at all tibiae). The spination of metatarsi is more conservative: I-II 2015, III 1025 or 1015, IV 1015 (ventrally the four proximal

spines are paired). But there are exceptions, too. Colouration: Chelicerae, carapace and sternum vellowish brown to dark brown. In rare cases specimens exhibiting a darker carapace margin and a median longitudinal band. Sternum unicoloured. Legs from yellowish brown or light brown to brown, may be annulated. Tibiae I and II in some cases darker than other limbs/legs. Femora at distal third often with dark, annulated patches. Opisthosoma dorsally greyish-brown with yellowish patches. Heart region with darker lanceolate patch with light centre (Fig. 119). Distal half of opisthosoma dorsally with two converging rows of dark brown spots. Lateral surface of opisthosoma is covered with 3-4 larger yellowish patches running diagonally. Opisthosoma ventrally dark brown to black, centrally with a pair of white to beige patches (Figs 116, 118), which differ intraspecifically in size and shape. In some cases those patches are fused, in extremely rare cases absent. Additionally, with white to beige transverse patch in front of spinnerets/cribellum (Fig. 116). The whole body is covered with grey hairs (Fig. 116). Spinnerets are relatively short and conical, except for median ones, which are distinctly smaller, slender and cylindrical. Bipartite character clearly visible in posterior spinnerets. Copulatory organs: Male palp with almost round tegulum (T). Embolus (E) filiform, arising in prolateral half of tegulum (T) and at least twice as long as conductor (C). The latter membranous, mostly arising centrally on upper half of T (Fig. 8) and mostly shorter than median apophysis (MA). T next to E-base (Fig. 8) with membranous process (MP). MA relatively large with general retrolateral direction (e.g. Fig. 89). Cymbium distinctly broader than palpal tibia and patella (e.g. Fig. 62). RTA differently shaped among the particular species, DRTA only present in F. macilenta (Simon, 1885) (Figs 53-54). VPA often slightly bent anteriorly (e.g. Fig. 87). RPA mostly small and inconspicuous. Palpal femur modifications, e.g. ventral bulge as present in some Psechrus species, absent in all Fecenia species. Scopula dorsally on cymbium present in the same form in all Fecenia species (Figs 99-101), but less distinct than in most Psechrus species. Female epigyne generally broader than long, with folded median septum (e.g. Fig. 55). Anterior part of median septum (AS) larger than posterior part (PS). Anterior margins of lateral lobes (AML) iin some species strongly sclerotised (Fig. 108). Vulva simple, with internal duct system divided in three sections: Transversal section (TSI), strongly sclerotised section (SSI) and fertilisation duct (FD) (Fig. 83). Borderline (BL) between TSI and SSI clearly recognisable and often of taxonomic importance.

Biological notes. The pseudo-orbweavers are found in shrubs and trees, and also in the canopy (Deeleman, pers. comm.). *Fecenia* suspends its vertical pseudo-orbweb (Fig. 120) in the vegetation, mostly between twigs. The web possesses an enrolled leaf at the hub serving as a retreat. This is true for adults and later instar juveniles of all *Fecenia* species. Earlier instars build an elongate cone-shaped tube as a retreat, which is disguised with small prey remains and soil- and leaf-particles. The very early instars do not even build a pseudo-orbweb, but a rather conical or dome-shaped web with the retreat at the top of the cone. This web can be found in the herb layer too (Robinson and Lubin 1979). The pseudo-orbweb (Fig. 120) is more irregular than the webs of araneids and related families building orb-webs. In *Fecenia* there is no regular spiral of capturing thread(s) as in araneids etc. In *Fecenia*, one cannot speak of a real spiral as the distance between the threads and their orientation differs. The irregularity applies to the radii too. In many cases they are not continuous.

Predatory behaviour was observed in the lab using several *F. cylindrata* and *F.* protensa specimens. In each case the spider was transferred to a large cylindrical glass (30 cm high, diameter 20 cm) with a leaf, already partly enrolled, placed at the bottom. The next day the leaf was suspended by threads in the middle of the glass, a day later it was already fixed at the top. The pseudo-orbweb was completed another day later. After placing a house fly into the lower area of the web it took a few seconds until the spider stretched its two forelegs out of the retreat, and after ca. 1 minute it came out. The fly was grabbed with the chelicerae and immediately dragged into the retreat. A few centimetres before the leaf entrance the spider turned and crawled backwards into the retreat. In the case of larger prey items like crickets, the spider was extremely shy and careful. It took two or three attempts of coming out of the leaf and escaping back into it, sometimes interrupted by 5-15 minutes within the retreat. During the last attempt the cricket was bitten for about 7 minutes at the capturing site of the web before it was dragged to the retreat. Binding behaviour, as described in Robinson and Lubin (1979), was observed after providing an even larger cricket. But in addition to their observations I could recognise that Fecenia took threads out of the web, too, in order to bind its prey. An attack-wrapping behaviour like in Araneidae does not exist.

Robinson and Lubin (1979) observed the mating behaviour of a male F. ochracea (however in their publication identified as Fecenia sp.) approaching the female retreat, which I corroborate observing (raised) F. cylindrata from Champasak Province, Laos (males SB 509, 510 and females SB 486-487, 511, 514, see list in description of *F. cylindrata*, additional material examined). These were maintained in cylindrical glasses (see above) and fed on house flies and crickets. A few days after one male's final moult its web was reduced to a few frame threads. In two corners of that thread-framework sperm webs were found (Fig. 123). The bulb filling procedure was not observed. A female was transferred into a terrarium (30 cm high, diameter 20 cm) and offered a small "cone" of transparent film as retreat, which was accepted and later on integrated in the new web. In the respective trial the male was placed into the female's terrarium. After a while it approached the retreat from the top of the terrarium by roping down onto it. There it tapped and stroked the retreat carefully (Fig. 121). Later on it moved to the margin of the opening of the leaf retreat and repeated this behaviour. After some more repeats it stayed there motionless. Unfortunately, neither the moment of entering the retreat nor the copulation itself could be observed. The next day the male was sitting within the leaf retreat, together with the female (Fig. 122). In another trial a raised F protensa male from Flores (SB 196, see description of *F. protensa*, list of additional material examined) was transferred to a terrarium with an already adult conspecific female from Bali. The behaviour was the same as described above, but in this case the next day saw the

male half digested lying at the bottom underneath the retreat, which means it had been attacked and killed by the female. In one further trial a *F. protensa* male was put into the terrarium of a *F. cylindrata* female. The approaching behaviour upon the leaf was executed up to the point when the male reached the leaf opening. Here he turned and disappeared to an upper corner of the terrarium and stayed there motionless for more than one day.

Key to species:

1	Male (that of <i>F. travancoria</i> unknown)
_	Female (subadult one of <i>F. macilenta</i> unknown) 5
2	DRTA absent, MA prominent, in some species massive
_	Prominent DRTA (Figs 53-54) present, MA slender and rather inconspicu-
	ous (Fig. 53) macilenta
3	RTA short, at most $\frac{1}{2}$ the width of palpal tibia, MA shorter than width of T4
_	RTA at least as long as width of palpal tibia, MA large and massive, at least as
	long as width of T (Fig. 10)ochracea
4	RTA knobbed, almost as broad as long, E without bEA, VPA arising proxi-
	mally on patella (Figs 60–61)protensa
-	RTA rather slender, longer than broad, E with distinct, pointed bEA (Fig.
	89), VPA arising centrally (Figs 87-88) cylindrata
5	AML distinctly visible, AS with similar colour as surrounding parts of epi-
	gyne6
-	AML hardly visible, posterior half of AS distinctly darker than surrounding
	parts of epigyne (Figs 48, 114)macilenta
6	AML converging anteriorly and surrounding epigynal pit partly, pre-epigyne
	with TR running completely from left to right AML, in pre-vulva distance be-
	tween centres of pre-receptacula $> 3 \times diameter of one pre-receptaculum7$
-	AML diverging anteriorly (Fig. 1), in pre-epigyne gaps between TR and AML
	(Figs 20–21), in pre-vulva distance between centres of pre-receptacula $< 3 \text{ x}$
_	diameter of one pre-receptaculum (Figs 23–24)ochracea
7	AS with longitudinal folding, the latter mostly anteriorly pointed (e.g. Figs
	55, 76), TR with distinct notch, pre-epigyne with double curved TR, the
	latter broadly W-shaped (Fig. 69), in general appearance pre-epigyne looking
	crown-shaped, pre-receptaculum bulbous/spherical (Figs $6/-68$) 8
-	AS flat (at least anteriorly), without longitudinal folding (Fig. 79), 1 K with-
	out notch, pre-epigyne with continuous IR (Fig. 81), the latter slightly
0	curved, pre-receptaculum with lateral extension (Fig. 85) cylindrata
8	In vulva BL running almost longitudinal (Fig. //), lateral prongs of the
	crown in pre-epigyne narrow (Fig. /4) travancoria
_	In vulva DL running +/- transversal (Fig. 56), lateral prongs of the crown in $(\Gamma_{12}, 56, 60)$
	pre-epigyne not distinctly narrow (Figs 58, 69) protensa

Fecenia ochracea (Doleschall, 1859)

http://species-id.net/wiki/Fecenia_ochracea Figs 1–47, 96, 102–104, 118

- *Tegenaria ochracea* Doleschall, 1859: 50, pl. 8, fig. 8 (Description of \mathcal{Q}), [Holotype \mathcal{Q} (SB 94) from INDONESIA: Maluku Prov.: Ambon Isl.; C. L. Doleschall leg. 1855–1858; NHMW 12·389, examined]; Thorell 1878: 302 (sub *Tegenaria* [?]); Thorell 1881: 694 (sub *T*. [?]).
- *Mezentia angustata* Thorell, 1881: 204 (Description of ♀), [Holotype ♀ (SB 460) from INDONESIA: Maluku Utara Prov.: Ternate Isl. next to Halmahera; Prof. O. Beccari leg. 1872–1877; MCSN, examined]; Simon 1885: 451.
- Mezentia ochracea-Simon 1885: 451 (Transfer from Tegenaria).
- Fecenia ochracea—Simon 1887: 194 (Formal transfer from *Mezentia*, preoccupied by Stål, 1878 in Orthoptera, replacement name *Fecenia*); Simon 1892: 226; Simon 1906: 287, fig. 1B (Illustration of ♀); Kulczyński 1908: 570; Reimoser 1936: 407; Lehtinen 1967: 234; Levi 1982: 133, figs 68–79, 90 (Illustration of ♂ and ♀♀); Murphy 1986: 65; Griswold 1993: 7; Murphy and Murphy 2000: plate 21, fig. 5 (Photo of ♀); Song et al. 2002: 373 (listed as fauna element of Singapore; doubtful!, to date no records from Singapore).
- Fecenia angustata—Simon 1887: 194 (Formal transfer from Mezentia); Simon 1892: 226; Pocock 1900: 212; Kulczyński 1908: 570; Petrunkevitch 1928: 90; Reimoser 1936: 407; Chrysanthus 1967: 102, figs 55–57, 60–64 (Description of ♂, illustration of ♂ and ♀♀); Lehtinen 1967: 234 (Synonymy).
- Fecenia maforensis Simon, 1906: 287, fig. 1A (Description of ♀), [Holotype ♀ (SB 464) from INDONESIA: Irian Jaya Barat Prov.: Numfor Isl., formerly Mafor; A. Raffray leg.; MNHN AR185, examined]; Kulczyński 1908: 570; Strand 1915: 191 (Description of ♀); Reimoser 1936: 407; Chrysanthus 1967: 104, fig. 65 (Illustration of ♀); Lehtinen 1967: 234 (Synonymy).
- Fecenia montana Kulczyński, 1910: 389, pl. 17, fig. 1 (Description of ♀), [Holotype ♀ (SB 461) from PAPUA NEW GUINEA: East New Britain Prov.: Baining Mountains; K. Rechinger leg. 1906; NHMW 12.388, examined], Reimoser 1936: 407, Lehtinen 1967: 234 (Synonymy).
- Fecenia oblonga Rainbow, 1913: 7, fig. 5 (Description of ♀), [Holotype ♀ from SOL-OMON ISLANDS: Western Prov., Shortland Island Group, Island of Howla; W. W. Froggatt leg. ca. 1900; AMS, lost (Milledge, AMS, pers. comm.), thus not examined]; Reimoser 1936: 407; Lehtinen 1967: 234 (Synonymy).
- Fecenia cinerea Hogg, 1914: 56 (Description of Q), [Holotype Q (SB 404) from IN-DONESIA: Papua Prov.: Possibly near Mount Utakwa; A.F.R. Wollaston leg. 1912–1913 (Wollaston Expedition in Dutch New Guinea); NHM 1921·3·24·9, examined]; Hogg 1915: 437, fig. 23 (Illustration of Q); Reimoser 1936: 407; Lehtinen 1967: 234 (Synonymy).
- *Fecenia buruana* Reimoser, 1936: 406, fig. 1 (Description of $\mathcal{J} \, \mathcal{Q}$), [Lectotype \mathcal{Q} (SB 418), paralectotype \mathcal{J} (SB 417) by designation of Levi (1982: 134), both from

INDONESIA: Maluku Prov.: Buru Isl., station 1; L.J. Toxopeus leg. 1921; ZMA, examined]; Chrysanthus 1967: 104, figs 66–67 (Illustration of \Im and \Im); Lehtinen 1967: 234 (Synonymy).

Note on the holotype of *Tegenaria ochracea.* The first description of Doleschall (1859) lacks any remarks concerning deposition of the type specimen. Generally, material recorded by naturalists of the "Natuurkundige Vereeniging in Nederlandsch Indie" has been deposited either in RMNH or in ZMA. Lehtinen (1967) stated that the type deposition was unknown (to him). Levi (1982) mentioned a personal communication from Van der Hammen, the curator of the arachnid collection in RMNH at that time, who stated that the type was lost. At present, the colleagues of the arachnid collection of RMNH still cannot find any type material of *Tegenaria ochracea* there (K. van Dorp and J. Miller, RMNH, pers. comm.). In the arachnid collection of ZMA there is also



Figures 1–6. *Fecenia ochracea*, ♀ holotype (SB 94) from Ambon, Indonesia I Epigyne, ventral view 2 Vulva, dorsal view 3 Schematic course of internal duct system, dorsal view 4 Sternum, ventral view 5 Labium and gnathocoxae, ventral view. 6 Right chelicere, ventral view.

no type specimen of *Tegenaria ochracea* (B. Brugge, pers. comm.). During a stay at the natural history museum in Vienna in April 2009 I recognised a syntype specimen of Psechrus argentatus (Doleschall, 1857). Both Lehtinen (1967) and Levi (1982) believed that the syntypes of this species had been lost. However, for this latter species found on Ambon, too, and recorded and described by the same author just two years before, it is evident that at least a part of the original syntype series was once deposited in RMNH (Van Hasselt 1877). After consulting Jürgen Gruber and Verena Stagl (both NHMW) I learned that Doleschall sent only a part of his spider- and insect material collected on Ambon to the museum in Leiden; a large part of the material was sent to the museum in Vienna (Stagl 1999). In the spider collection of NHMW I found a Fecenia female (SB 94), which was labelled "Fecenia - Insel Ambon" (oldest label). According to Gruber (pers. comm.) the handwriting is that of E. Reimoser, the curator of NHMW from 1923-1940. It is well known that Reimoser often discarded old labels and substituted them with new ones (Gruber pers. comm.). It is most likely that in this case the same had happened. Assuming that the handwriting on the original label from Doleschall was unclear, it is likely that Reimoser discarded that label, determined the female as Fecenia and just added the locality on the new label. Anyway, it is evident that before 1950 nobody other than Doleschall sent spider material from the island Ambon to the natural history museum in Vienna (Gruber pers. comm.). Hence, the female SB 94 (see synonymy list above) can be considered the holotype of Tegenaria ochracea.

11 juvenile specimens). PHILIPPINES: Luzon: Laguna Prov.: Los Baños; Baker leg.; 1 ♀ (SB 153), MCZ 82529. MALAYSIA: Borneo: Sabah Prov.: Kinabalu N.P., Poring Hot Springs, 5°02'N, 116°42'E, 600–700 m, primary forest; A. Floren leg. 03.III.1996 by canopy fogging "ridge"; 1 \bigcirc (SB 518), Deeleman Coll. in RMNH. **INDONESIA:** Sumatra: Nanggroe Aceh Darussalam Prov.: Ketambe, Gunung Leuser N.P., 3°51' N, 97°37' E, ca. 1300 m, primary forest, from leaves; S. Djojosudharmo leg. 03.V.1986; 1 Q (SB 127), Deeleman Coll. in RMNH. Halmahera: Maluku Utara Prov.: Jailolo Distr., Kampung Pasir Putih, 0°53'N, 127°41'E; A.C. Messer, P.M. Taylor leg. 1981; 1 🗟 (SB 187), USNM. Maluku Utara Prov.: Ternate Isl.; A. Raffray leg.; 1 s.a. 👌 (SB 465), MNHN. Maluku Prov.: Buru Isl., station 1; L. J. Toxopeus leg. 1921; 1 Q (SB 419), ZMA. Ceram Isl.; 6 9 9 (SB 470-473, 475-476), 1 s.a. (SB 467), 1 s.a. 9 (SB 469), 1 juv. (SB 468), MNHN AR193. Ambon Isl.; 1 ♀ (SB 474), MNHN AR193. Aru Isls; 1 s.a. \mathcal{Q} (SB 80), Roewer Coll. 1819 in SMF. Irian Java Barat Prov.: Manokwari, Dorey; A. Raffray leg.; 1 Q (SB 466), MNHN. Papua Prov.: Sentani; leg. IV. 1903; 1 Q (SB 661), MIZ. Mindiptana; B. Monulf leg. 1958-1965; 3 QQ (SB 96-98) Coll.-No. 8474, 1 ♂ (SB 95), 1 ♀ (SB 442) Coll.-No. 8476, all RMNH. Merauke; B. Monulf leg. 1956-1957; 16 ♀♀ (SB 426-441) Coll.-No. 8475, 8 ♀♀ (SB 443-447, 450, 452-453), 1 s.a. \mathcal{A} (SB 444) Coll.-No. 8477, 4 $\mathcal{Q}\mathcal{Q}$ (SB 99-102) Coll.-No. 8478, all RMNH. Java: Jawa Barat Prov.: Gunung Gedeh N.P., Cibodas Nature Reserve, 6°44'S, 107°00'E, 1450 m; S. Djojosudharmo leg. 06.XII.1986; 1 🖑 (SB 120), Deeleman Coll. in RMNH. **PAPUA NEW GUINEA: West Sepik Prov.:** Aitape, Seleo; $1 \ \bigcirc$ (SB 662), MIZ. Morobe Prov.: Wau, 7°20'S, 146°43'E; M. Robinson leg. 10–15.IV.1977, 5 99



Figures 7–10. *Fecenia ochracea*, left ♂ palp, ventral view 7 SB 120 from Java, Indonesia 8 Paralectotype of *F. buruana* (SB 417) from Buru, Indonesia 9 SB 95 from Mindiptana, Indonesia 10 SB 180 from Wau, Papua New Guinea. Remark on Fig. 8 Embolus slipped behind conductor. C = Conductor; CA = Cymbium alveolus; E = Embolus; MA = Median apophysis; MP = Membranous process of tegulum; RPA = Retrolateral patellar apophysis; RTA = Retrolateral tibial apophysis; T = Tegulum; VPA = Ventral patellar apophysis.

(SB 163–166, 484), 2 juvs (SB 482–483); H. Levi, Y. Lubin, M. Robinson leg. 07.–12. III.1979, MCZ 82521, 5 ♀♀ (SB 156–157, 162, 479–480), 1 s.a. ♀ (SB158), MCZ 82533, J.E. Carico leg. 22.–29.VI.1982, 2 $\Im \Im$ (SB 154–155), 1 p.s.a. \Im (SB 478), 1 juv. (SB 477), MCZ 82531. Wau; 7°20'S, 146°43'E; J.E. Carico leg. 05.–06.VII.1982; 1 ♂ (SB 180), USNM. Wau, Ecology Center; E.I. Schlinger leg. 17.II.1978; ♀ (SB 947), CAS 9032225. East New Britain Prov.: "Putie Bucht", South coast; Dr G. Ducker leg. 05.-19.II.1909, Hamburg Südsee Exp., No. 300; 1 s.a. ♀ (SB 896), ZMH. Jacquinot Bay, ca. 5°34'S, 151°26'E; Dr G. Duncker leg. 19.-20.XII.1908, Hamburg Südsee Exp., No. 261; 2 ♀♀ (SB 892-893), ZMH. Keravat, 4°21'S, 152°07'E, 300 m, lowland tropical rain forest; I. Agnarsson leg. 03.-07.IV.2009; 1 s.a. ♀ (SB 540), 1 juv. (SB 541), SMF. Keravat, Laes; Y.D. Lubin leg. 01.VII.1980; 1 Q (SB 167), MCZ 82525. Kokopo, Ralum, ca. 4°20'S, 152°15'E, ca. 50 m; F. Dahl leg. 12.X.1896; 1 Q (SB 801), 1 s.a. ♀ (SB 794), 4 juvs (SB 795–800), ZMB 15472, 19244–19248. "Dörper Spitze, S.O. Bucht": Dr G. Duncker leg. 14.V.1909, Hamburg Südsee Exp., No. 534; 2 QQ (SB 894-895), ZMH. New Ireland Prov.: New Ireland, Lemkamin; Nocna Dan Exp. 1961-1962; 1 ♀ (SB 887), ZMUC 5728. Feni Isls, Ambitle Isl. (Anir); E. Wolf leg. 04.V.1909; $1 \$ (SB 86), SMF 2769/1. Papua New Guinea [no other locality data]: L. Biro leg.; 1 \bigcirc (SB 668), 1 p.s.a. \bigcirc (SB 669), 2 juvs (SB 670-671), MIZ 46/51U. **SOLOMON ISLANDS:** New Georgia Group; J.F. P. leg. 1965; 1 s.a. ♀ (SB 392), NHM. Auki; W.M. Mann leg. 1916; 3 ♀♀ (SB 159–161), MCZ 82524.

Diagnosis. Distinguished from other *Fecenia* species by the epigyne with diverging anterior margins of lateral lobes (AML) (Fig. 1). Males differ from all other *Fecenia* species by RTA at least as long as width of palpal tibia, MA large and massive, at least as long as width of tegulum (T) (Fig. 8).

Description. MALE: Body and eye measurements. Carapace length 4.2–4.7, carapace width 2.8–3.4, anterior width of carapace 1.7–2.1, opisthosoma length 4.8–7.1, opisthosoma width 2.0-3.3. Eyes: AME 0.28-0.33, ALE 0.20-0.23, PME 0.20-0.23, PLE 0.20-0.22, AME-AME 0.17-0.28, AME-ALE 0.06-0.13, PME-PME 0.22-0.28, PME-PLE 0.28-0.42, AME-PME 0.14-0.17, ALE-PLE 0.11-0.17, clypeus height at AME 0.28-0.42, at ALE 0.21-0.34. Measurements of palp and legs. Palp 5.2–6.1 [2.0–2.4, 0.8–1.1, 0.7–0.8, 1.3–1.8], I 46.6–55.9 [12.6–15.6, 1.9–2.2, 12.3– 15.5, 13.4–16.9, 5.2–5.7], II 21.7–26.8 [5.8–6.7, 1.5–1.8, 6.0–7.6, 6.0–7.0, 2.4– 3.0], III 12.1-14.2 [3.4-4.1, 1.1-1.4, 3.0-3.6, 3.1, 1.4-1.7], IV 20.6-24.0 [5.4-6.8, 1.4, 5.4–6.5, 6.2–6.5, 2.2–2.6]. Leg formula: 1243. Copulatory organ: Ventral patellar apophysis (VPA) arising in basal third of palpal patella (Figs 11–18), retrolateral patellar apophysis (RPA) mostly inconspicuous (Figs 9, 17). RTA distally not or just slightly broader than basally (Fig. 10). MA ventrally in basal third with distinct bulge (Figs 8–9, 96). Distal part of MA bent prolaterally. General direction of MA 1:00 or 1:30-o'clock. Embolus (E) arising in ca. 9-o'clock-position on T, at most as long as width of T (Figs 7–10, 96). T with corner-like lobe ventrally in prolateral half, T slightly longer than broad. MP with differing lengths (Figs 7–10, 96). Conductor (C) small, arising centrally in upper third of T.



Figures 11–14. *Fecenia ochracea*, left \circ palp, prolateral view **11** SB 120 from Java, Indonesia **12** Paralectotype of *F. buruana* (SB 417) from Buru, Indonesia **13** SB 95 from Mindiptana, Indonesia **14** SB 180 from Wau, Papua New Guinea.

FEMALE (Measurements of holotype (SB 94) first, those of other specimens given as ranges in parentheses; Holotype misses both legs I as well as all limbs of legs IV from tibia on): Body and eye measurements. Carapace length 6.4 (3.2-6.9), carapace width 4.2 (2.2-4.3), anterior width of carapace 3.0 (1.7-3.1), opisthosoma length 9.1 (4.5–9.3), opisthosoma width 4.8 (2.2–5.2). Eyes: AME 0.33 (0.20–0.33), ALE 0.23 (0.15-0.23), PME 0.23 (0.15-0.23), PLE 0.25 (0.15-0.25), AME-AME 0.29 (0.22-0.29), AME-ALE 0.17 (0.09-0.17), PME-PME 0.36 (0.24-0.36), PME-PLE 0.48 (0.33-0.48), AME-PME 0.30 (0.15-0.30), ALE-PLE 0.24 (0.14-0.24), clypeus height at AME 0.44 (0.27-0.44), at ALE 0.42 (0.20-0.42). Measurements of palp and legs. Palp 6.3 (3.5-6.7) [2.2 (1.3-2.4), 1.1 (0.5-1.1), 1.2 (0.7-1.3), 1.8 (1.0-2.0)], I 17.2-40.7 [4.6-10.8, 1.3-2.9, 4.7.7-11.3, 4.5-11.4, 2.1-4.3], II 23.5 (10.8-24.5) [6.4 (3.0-6.6), 2.2 (1.1-2.2), 6.4 (2.9-6.8), 5.9 (2.50-6.2), 2.6 (1.3–2.7)], III 13.6 (6.6–14.6) [4.0 (1.9–4.3), 1.6 (0.8–1.7), 3.3 (1.5–3.5), 3.2 (1.5– 3.4), 1.5 (0.9–1.7)], IV 10.0–21.4 [5.7 (2.7–5.8), 2.0 (1.0–2.1), 2.6–5.8, 2.5–5.3, 1.2-2.4]. Leg formula: 1243. Palpal claw with 10 (8-11) teeth. Spination (holotype from Ambon [except for leg I as well as tibia and metatarsus of leg IV, which are lost in holotype: spination of SB 474 from Ambon is listed instead]). Palp: 110, 000, 0000, 0000; legs: femur I 533(423), II 313, III 213, IV 111; patella I-IV 000; tibia I 3008, II 3006, III 0025, IV 2024; metatarsus I 2025, II 2025, III 1025, IV 1026. Copulatory organ: Anterior part of median septum (AS) of epigyne broad-"nose-like", slightly broader than its posterior part (PS). Lateral lobes massive (Fig. 1, 102). Epigynal muscle sigillae (EM) mostly integrated in epigynal field (EF). Slit sense organs (SO) mostly outside EF. Vulva with relatively short and narrow transparent section of internal duct system (TSI). Strongly sclerotised section (SSI) compact, duct with two curves (Figs 2–3), apex of first one directed posterio-medially, of second anterio-laterally. Primordial copulatory organs: Pre-epigyne: Already strongly resembling the adult epigyne (Figs 20–21, 104). All major structures present in adult epigyne are recognizable in the pre-epigyne, too (of course much smaller). Epigynal field not or only poorly developed, EM far outside epigynal field (Fig. 21). Pre-pre-epigyne (antepenultimate instar): AML far shorter than in pre-epigyne and transversal ridge/ edge of median septum (TR) hardly recognisable (Fig. 22, fine dotted line). Pre-vulva: Pre-receptacula bulbous/spherical and relatively close to each other. Distance between centres of pre-receptacula less than 3 times of diameter of one pre-receptaculum (Figs 23–24). Colouration: Male and female: As described for *Fecenia* in general, but white to beige patch in front of spinnerets may be rather unclear (Fig. 118), smaller or even absent. In one (SB 98, from Mindiptana, Eastern Papua Province, Indonesia) out of 103 specimens the light patches ventrally on opisthosoma are absent. Variation of copulatory organs: Among male specimens examined, cymbium differing at most slightly in length (Figs 11-18). In some specimens MA may be more massive (Fig. 10) or T slightly broader (Figs 9–10) than in others. Shape of prolatero-ventral lobe variable (Figs 7–10, 96). One specimen differing slightly more from the paralectotype of F. buruana (Figs 8, 12, 16) from Buru island (which is the closest male record to the type locality, Ambon) than the others. This is SB 95 from Mindiptana, Eastern



Figures 15–18. *Fecenia ochracea*, left ♂ palp, retrolateral view **15** SB 120 from Java, Indonesia **16** Paralectotype of *F. buruana* (SB 417) from Buru, Indonesia. **17** SB 95 from Mindiptana, Indonesia **18** SB 180 from Wau, Papua New Guinea.

Papua Province of Indonesia: MA directed to 2:30-o'clock position (Fig. 9), embolus (E) slightly longer than in the other males examined, RTA broadest distally (Fig. 9). Additionally, T protruding a bit more out of cymbium (Fig. 13) than in the other specimens. In females intraspecific variation is higher. The shape of AS (Figs 1, 19, 27–33, 102) as well as the course of AML are highly variable. Number of SO varying among specimens without geographical dependence. Vulvae of the specimens examined show less variation than epigynes. The initial part of SSI may be slightly more prominent (Fig. 38). Further on, the position of SSI seems slightly shifted in some specimens (Figs 25, 34). Pre-epigynes also differing in shape of AS and in course of AML (Figs 20–21). Based on almost 80 females examined, all the variation described so far is neither geographically fixed, nor are there distinct forms of variants which recur here and there. In some cases females from exactly the same recording site show clear differences. And on the other hand females which are recorded in different localities, partly hundreds of km away from each other, look strikingly similar. Anyway, the following 'form of females' has to be discussed separately (see remark below).

Remarks. The vulvae of the holotype of *F. cinerea* (SB 404) (Fig. 40) and the specimens recorded from Mindiptana, Eastern Papua Province of Indonesia (SB 96-98, 442) (SB 98 illustrated in Fig. 44) differ from all other females examined. The duct of SSI is somewhat longer, especially the second curve (Figs 40, 44). Consequently, the course of the internal duct system of these specimens (Figs 41, 45) differs from the remaining F. ochracea females (Figs 3, 35, 37, 39, 43, 47). However, the vulvae of the holotype of F. cinerea (SB 404) and female SB 98 do not correspond completely. In SB 404 the second curve of SSI protrudes more strongly in a lateral direction. In one specimen (SB 97, not illustrated) from Mindiptana the second curve of SSI is a bit shorter than in the others from this locality. The epigynes of SB 96-98, 404 and 442 differ in shape (SB 404: Fig. 28; SB 98: Fig. 32; others not illustrated). According to the differences in the shape of the vulvae (see above) it may be justified to revalidate *F cinerea* Hogg, 1914. However, the difference is little (second curve of SSI slightly longer than in *F. ochracea*) and thus does not provide evidence for a clear species delimitation; especially considering that in one specimen from Mindiptana the second curve is again slightly shorter. In addition, if the females from Mindiptana should be regarded as *F. cinerea*, then the male (SB 95, Figs 9, 13, 17), which was recorded from exactly the same locality, should be placed here, too. However, as discussed above, the palp structures of this male only slightly differ from the ones of other F. ochracea males (though these differences are worth mentioning as intraspecific variation). Moreover, no males have been recorded from the type locality of *F. cinerea* so far. Consequently, I refrain from changing the taxonomic status of F. cinerea. More material from the type locality of *F. cinerea*, especially males may enlighten this "problematic case".

Disribution. Philippines, Malaysia [Borneo], Indonesia [Sumatra, Borneo, Moluccas, West Papua, Java], Papua New Guinea, Solomon Islands, Australia [Northern Queensland].



Figures 19–26. *Fecenia ochracea*, \bigcirc copulatory organ/primordial copulatory organ **19,25–26** Holotype \bigcirc of *F. montana* (SB 461) from East New Britain **20, 23** s.a. \bigcirc SB 540 from East New Britain **21, 24** s.a. \bigcirc SB 158 from Wau, Papua New Guinea **22** p.s.a. \bigcirc SB 669 from New Guinea **19** Epigyne, ventral view **20–21** Pre-epigyne, ventral view **22** Pre-pre-epigyne, ventral view **23–24** Pre-vulva, dorsal view **25** Vulva, dorsal view **26** Course of internal duct system.



Figures 27–28. *Fecenia ochracea*, \mathcal{Q} epigyne, ventral view **27** Holotype of *F. maforensis* (SB 464) from Northwestern Irian Jaya, Indonesia **28** Holotype of *F. cinerea* (SB 404) from Southern Papua Prov., Indonesia.



Figures 29-30. *Fecenia* ochracea, \bigcirc epigyne, ventral view **29** Holotype of *F. angustata* (SB 460) from Ternate, Indonesia **30** Lectotype of *F. buruana* (SB 418) from Buru, Indonesia.



Figures 31–33. *Fecenia ochracea*, ♀ epigyne, ventral view **31** SB 430 from Southeastern Papua Prov., Indonesia **32** SB 98 from Mindiptana, Southeastern Papua Prov., Indonesia **33** SB 127 from Northern Sumatra, Indonesia.



Figures 34–41. *Fecenia ochracea*, ♀ vulva, dorsal view **(34, 36, 38, 40)** with course of internal duct system **(35, 37, 39, 41). 34–35** Holotype of *F. angustata* (SB 460) from Ternate, Indonesia. **36–37** Lectotype of *F. buruana* (SB 418) from Buru, Indonesia. **38–39** Holotype of *F. maforensis* (SB 464) from Northwestern Irian Jaya, Indonesia. **40–41** Holotype of *F. cinerea* (SB 404) from Southern Papua Prov., Indonesia.



Figures 42–47. *Fecenia ochracea*, ♀ vulva, dorsal view **(42, 44, 46)** with course of internal duct system **(43, 45, 47). 42–43** SB 430 from Southeastern Papua Prov., Indonesia. **44–45** SB 98 from Mindiptana, Southeastern Papua Prov., Indonesia. **46–47** SB 127 from Northern Sumatra, Indonesia.

Fecenia macilenta (Simon, 1885)

http://species-id.net/wiki/Fecenia_macilenta Figs 48–54, 95, 101, 114–115

Mezentia macilenta Simon, 1885: 451, pl. 10, fig. 17 (Description and illustration of ∂), [Holotype ∂ (SB 395) from MALAYSIA: Perak Prov. (Malacca): Region of Ipoh, Kinta river valley; M.J. de Morgan leg. 1884; MNHN AR5164, examined]. *Fecenia macilenta*—Simon 1887: 194 (Formal transfer from *Mezentia*, preoccupied by Stål, 1878 in Orthoptera, replacement name *Fecenia*); Simon 1892: 223, figs 171–172 (Illustration of ∂); Kulczyński 1908: 570; Reimoser 1936: 406; Lehtinen 1967: 234; Levi 1982: 136, figs 83–87, ad part, figs 84–85 (Illustration of ∂), figs 83, 86–87 misidentified; Murphy 1986: 65, figs 1–2 (Description and illustration of ♀); Coddington 1990: 10, fig. 18 (Illustration of ∂); Murphy and Murphy 2000: plate 21, fig. 6 (photo of ♀).

Additional material examined. $(1 \ 3, 2 \ 9 \ 9)$. MALAYSIA: Selangor Prov.: Banting; W. Corley leg. VIII. 1981; $1 \ 3 \ (SB389)$, $1 \ 9 \ (SB 390)$, NHM. INDONESIA: Sumatra: Sumatera Barat Prov.: Panti (Road to Lubuk Sikaping & Bukittinggi), Rimba Panti Nature Reserve, primary rainforest; C. Deeleman leg.; $1 \ 9 \ (SB 124)$, Deeleman Coll. in RMNH.

Diagnosis. Males differ from other species by prominent dorso-retrolateral tibial apophysis (DRTA) (Figs 53–54, 95, 101) and slender and rather inconspicuous median apophysis (MA) (Fig. 53). Furthermore, ventral patellar apophysis (VPA) larger and retrolateral patellar apophysis (RPA) extending more clearly than in all other *Fecenia* species (Fig. 53–54, 95). Females distinguished from other species by epigyne with anterior margins of lateral lobes (AML) hardly visible and by posterior half of anterior part of median septum (AS) being distinctly darker than surrounding parts of epigyne (Fig. 114). Moreover, AS with permanent semicircular posterior half (Figs 48, 114).

Description. MALE (Holotype (SB 395) is the largest of the males examined; consequently its measurements appear as maximum in each range. Eye measurements differ only insignificantly, so only those of the Holotype are listed): Body and eye measurements. Carapace length 5.4–5.8, carapace width 3.5–4.1, anterior width of carapace 2.3–2.7, opisthosoma length 5.4–7.4, opisthosoma width 2.8–3.2. Eyes: AME 0.47, ALE 0.34, PME 0.31, PLE 0.29, AME–AME 0.27, AME–ALE 0.08, PME–PME 0.35, PME–PLE 0.40, AME–PME 0.15, ALE–PLE 0.19, clypeus height at AME 0.67, at ALE 0.54. Measurements of palp and legs. Palp 7.3–8.5 [2.8–3.3, 1.2–1.4, 1.1–1.3, 2.2–2.5], I 53.5–67.4 [14.7–18.8, 2.3, 15.3–19.2, 16.7–19.9, 4.5–7.2], II 27.9–35.0 [7.5–9.4, 1.9–2.2, 7.7–9.7, 7.7–9.9, 3.1–3.8], III 15.9–19.4 [4.6–5.6, 1.5–1.7, 3.8–4.8, 4.1–4.9, 1.9–2.4], IV 25.1–30.9 [6.8–8.3, 1.7–2.0, 6.4–8.2, 7.4–8.9, 2.8–3.5]. Leg formula: 1243. Male chelicerae differing from general appearance of *Fecenia*: Basal limb ca. 4 times longer than broad. Spination (holotype from Kinta river, Malaysia). Palp: without any spines; legs: femur I 410(300), II 100, III 010, IV 001; patella I–IV 000; tibia I–II 2004, III 0000(0001), IV 0013; meta-



Figures 48–54. *Fecenia macilenta.* **48–51** \bigcirc (SB 390) from Selangor Prov., Malaysia. **52–54** Holotype \bigcirc (SB 395) from Perak Prov., Malaysia. **48** Epigyne, ventral view. **49** Vulva, dorsal view. **50** Course of internal duct system. **51** Left palpal claw, retrolateral view. **52–54** left palp, prolateral (**52**), ventral (**53**) and retrolateral (**54**) view. DRTA = Dorso-retrolateral tibial apophysis; RPA = Retrolateral patellar apophysis; RTA = Retrolateral tibial apophysis.

tarsus I 3014(1014), II 1015, III 1015(1014), IV 1015. Copulatory organ: Ventral patellar apophysis (VPA) arising centrally on palpal patella (Figs 52, 54), RTA small, less than 1/3 of the length of the massive DRTA. Median apophysis (MA) distally slightly bent. General direction of MA is 12:30 or 1:00-o'clock. Embolus (E) arising in ca. 6:30-o'clock-position on tegulum (T), broader than in all other *Fecenia* species and almost twice as long as width of T. The latter slightly longer than broad. Membranous process (MP) of tegulum directed proximally (Figs 53, 95). Conductor (C) longer than MA, arising centrally in upper third of T.

FEMALE (The two females examined differ not or only marginally in almost all measurements, so only those of SB 390 are listed, except for opisthosoma measurements [ranges, SB 390 from Banting, Malaysia first]): Body and eye measurements. Carapace length 5.3, carapace width 3.7, anterior width of carapace 3.0, opisthosoma length 7.6-8.3, opisthosoma width 4.5-4.9. Eyes: AME 0.34, ALE 0.27, PME 0.27, PLE 0.22, AME-AME 0.26, AME-ALE 0.12, PME-PME 0.34, PME-PLE 0.46, AME-PME 0.22, ALE-PLE 0.24, clypeus height at AME 0.44, at ALE 0.41. Measurements of palp and legs. Palp 5.9 [2.0, 1.0, 1.0, 1.9], I 30.2 [8.1, 2.3, 8.5, 7.9, 3.4], II 19.7 [5.4, 1.9, 5.3, 4.7, 2.4], III 12.4 [3.6, 1.5, 2.9, 2.8, 1.6], IV 17.7 [4.9, 1.7, 4.6, 4.4, 2.1]. Leg formula: 1243. Palpal claw with 12 teeth (Fig. 51). Copulatory organ: Anterior part of median septum (AS) of epigyne "nose-like", broader than posterior part (PS) (Fig. 48). Lateral lobes voluminous (Figs 48, 114). Epigynal muscle sigilla (EM) integrated in epigynal field. Slit sense organs (SO) outside epigynal field. Vulva with voluminous sclerotised section of internal duct system (SSI) (Fig. 49) and short and narrow transparent section (TSI), which is in dorsal view partly covered by SSI. The latter almost in contact with each other. Duct of SSI with three curves (Fig. 50). Fertilisation duct (FD) narrow. Colouration: Male and female: As described for Fecenia in general, but white to beige patch in front of spinnerets in one female rather unclear and smaller. Variation of copulatory organs: Males varying only insignificantly. Females: In female from Banting, Malaysia (SB 390) dark section of AS reaching further anteriorly (dotted line within AS in Fig. 48) than in SB 124 (Fig. 114). Number of SO among specimens varies from two to four. Distance between SSI slightly longer in SB 124 (Fig. 115).

Disribution. Malaysia, Indonesia [Sumatra].

Fecenia protensa Thorell, 1891, stat. n.

http://species-id.net/wiki/Fecenia_protensa Figs 55–70, 98–99, 108–110, 119

Fecenia protensa Thorell, 1891: 31 (Description of immature ♀), [Holotype s.a. ♀ (SB 620) from INDIA: Nicobar Islands: Nancowry; Bille, Kjellerup, Behn and Reinhardt leg. 1845–1847, Galathea Expedition; ZMUC 13091, examined]; Kulczyński 1908: 570; Reimoser 1936: 406; Lehtinen 1967: 234; Levi 1982: 136 (Synonymy with *F. macilenta*, rejected); Murphy 1986: 65 (Statement concerning synonymy with *F. macilenta*).



Figures 55–59. *Fecenia protensa*, \bigcirc copulatory organ/primordial copulatory organ **55–57** Holotype \bigcirc of *F. sumatrana* (SB 357) from Southern Sumatra, Indonesia **58–59** Holotype s.a. \bigcirc (SB 620) of *F. protensa* from Nicobar Islands, India **55** Epigyne, ventral view **56** Vulva, dorsal view **57** Course of internal duct system **58** Pre-epigyne, ventral view **59** Pre-vulva, dorsal view. TR = Transversal edge/ridge of median septum (**55** in epigyne, **58** corresponding structure in pre-epigyne).

Fecenia sumatrana Kulczyński, 1908: 568, pl. 23, fig. 20 (Description of \bigcirc), [Holotype \bigcirc (SB 357) from INDONESIA: Sumatra: Lampung Prov.: Palembang; Dr S. Libelt leg.; MIZ 212.322, examined]; Reimoser 1929: 132 (Listing of first record from Mentawai islands); Reimoser 1936: 407; Lehtinen 1967: 234 (Synonymy with *F. macilenta*, rejected by subsequent author); Murphy 1986: 65 (Synonymy with *F. travancoria*, rejected). Syn. n.

- Psechrus nicobarensis Tikader, 1977: 208, fig. 27A–E (Description and illustration of ♂ and ♀), [Holotype ♀ as well as 8 ♀♀ paratypes and 2 ♂♂ paratypes from INDIA: West Bengal Province: Nicobar Islands, Car-Nicobar Isl., Kakana village; B.K. Tikader leg. 9.III.1970; NZSI, not available on request, thus not examined]; Jose and Sebastian 2001: 304 (genus name misapplied). Syn. n.
- Fecenia nicobarensis-Levi 1982: 138 (Transfer from Psechrus).
- *Fecenia macilenta*—Levi 1982: 136, figs 83–87, ad part, figs 83, 86–87 misidentified (figs 83 and 87: Illustration of s.a. \bigcirc and \bigcirc); Koh 1989: 76, fig. embedded in text, misidentified (Illustration of \bigcirc).
- Psechrus alticeps—Jose and Sebastian 2001: 304, fig. 1, misidentified. Note: Jose and Sebastian (2001) copied the illustrations of fig. 27 in Tikader (1977), pasted them in their fig. 1 and partly modified them. In their fig. 1a they changed the eye arrangement and colour pattern of the carapace as well as the colour pattern of the opisthosoma "Psechrus"-like. Their figs 1b and 1g show the female and male copulatory organs of F. protensa after Tikader (1977, there sub Psechrus nicobarensis). Their fig. 1f is a misinterpretation and definitely shows neither the vulva of F. protensa nor the one of Psechrus alticeps Pocock, 1899, which is a junior synonym of P. torvus (O. Pickard-Cambridge, 1869) (Levi 1982).

Additional material. (6 \bigcirc \bigcirc , 38 \bigcirc \bigcirc , 2 s.a. \bigcirc \bigcirc , 5 s.a. \bigcirc \bigcirc , 10 juvenile specimens). THAILAND: Nakhon Nayok Prov.: Khao Yai N.P. located ca. 120 km North-East of Bangkok, evergreen tropical rainforest, ca. 150 m; P. Hillyard leg. 12.III.1984; 1 \bigcirc (SB 393), NHM. Khao Yai N.P., forests surrounding Park Headquarters, 800-900 m; P. Dankittipakul leg. 15.XI.2006; 1 3 (SB 218), MHNG. Nakhon Ratchasima Prov.: Khao Yai N.P., rainforest; C.L. and P.R. Deeleman leg. 28.XII.1988; 1 ♂ (SB 128, died directly after adult moult), Deeleman Coll. in RMNH. Chantaburi Prov.: Chantaburi Distr.: Nam Tok Phliu N.P., 50 m; P. Schwendinger leg. 11.IX.1993; 1 🖒 (SB 136), MHNG. Trat Prov.: Koh Chang Isl.: Khlong Chao Luam, 12°06'30"N, 102°17'49"E, 30-150 m, secondary forest along stream, in shrubs; P. Jäger and S. Bayer leg. 3.XI.2009; 1 ♂ (SB 512), 1 ♀ (SB 458), 2 juvs (SB 328, 350), SMF. Surat Thani Prov.: Khao Nan N.P.; P. Dankittipakul leg. 17.VIII.2006; 1 Q (SB 202), MHNG; P. Dankittipakul leg. 27.X.2006; 1 ♀ (SB 206), SMF. Krabi Prov.: Krabi Distr.: Thab Khaek, Hang Nak Hill Nature Trail, 8°05'43"N, 98°45'11"E, 300 m, semi-evergreen rainforest; P. Schwendinger leg. 6.VI.2009; 1 ♀ (SB 195), SMF. Phuket Prov.: Phuket, Ton Sai Waterfall, 8°01'N, 98°25'E, 150–200 m; M. Andersen, O. Martin and N. Scharff leg. 12.X.1991; 3 ♀♀ (SB 888–890), 1 s.a. ♂ (SB 891), ZMUC 4536. Song Khla Prov.: Khao Khor Hong, a small mountainous area behind Prince of Song Khla University campus; B. Phongsee leg. 15.IX.2005; 1 Q (SB 215), 1 s.a. ♀ (SB 216), 3 juvs (SB 782–784), MHNG. MALAYSIA: Pahang Prov.: Cameron Highlands at Tanah Rata, 4°28'N, 101°23'E; V. and B. Roth leg. 14.-20.IV.1990; 1 ♀ (SB 184), 1 s.a. ♀ (SB 185), USNM, 1 ♀ (SB 949), CAS ENT9032226. Selangor **Prov.:** Gombak, field station, forest; C.L. Deeleman leg. 6.VII.1992; $1 \text{ } \subseteq \text{ } (\text{SB } 117);$ C.L. Deeleman and J.C. van Kempen leg. 2.VII.1992, by night; $1 \stackrel{\bigcirc}{\downarrow}$ (SB 112), both



Figures 60–63. *Fecenia protensa*, \eth palp **60–62** SB 218 from Nakhon Ratchasima Prov., Thailand **63** SB 137 from Bali, Indonesia **60** Prolateral view. **61** Retrolateral view **62–63** Ventral view.

Deeleman Coll. in RMNH. Borneo: Sarawak Prov.: Northern Sarawak; P. Nabawi leg.; [ex Coll. Wunderlich]; 1 Q (SB 1142), SMF. Gunong Mulu N.P., Environs Camp I, 1150 m, shrubs; F. Wanless leg. by net sweeping, R.G.S. Mulu Exped. 1977-78; $1 \ Q$ (SB 391), NHM. Gunong Mulu N.P., rain forest; C.L. and P.R. Deeleman leg. 4.X.2003; 1 \bigcirc (SB 131), s.a. \bigcirc (SB 897), 1 juv. (SB 898), Deeleman Coll. in RMNH. Kuching: Matang Reserve, primary forest, big old tree in clearing; C.L. and P.R. Deele-Deeleman Coll. in RMNH. Sabah Prov.: Kinabalu N.P., Poring Hot Springs, 5°02'N, 116°42'E, 600-700 m, primary forest; A. Floren leg. 3.III.1996 by canopy fogging "Ridge"; 1 \bigcirc (SB 519), Deeleman Coll. in RMNH. **SINGAPORE:** Singapore (no further details); H.N. Ridley leg.; $7 \ 9 \ 9$ (SB 408–414), 1 s.a. 9 (SB 407), NHM. Singapore: Sime Road: secondary forest; J. Koh leg. 1998; 1 ♀ (SB 186), USNM. INDONESIA: Sumatra: Nanggroe Aceh Darussalam Prov.: Simeulue Isl.; E. Jacobson leg.; 1 s.a. \mathcal{Q} (SB 462), NHMW 12387. Sumatera Barat Prov.: Lubuk Sikaping, Panti Reserve; C.L. and P.R. Deeleman leg. 14.VIII.1982; 1 Q (SB 125), Deeleman Coll. in RMNH. Borneo: Kalimantan Timur Prov.: 40 km NNW of Balikpapan, Sepaku, isolated stand of rainforest; C.L. and P.R. Deeleman leg. 5.VIII.1980; 1 \bigcirc (SB 126), Deeleman Coll. in RMNH. Bali Prov.: Air Terjung Waterfall, c/o Munduk, 8°15'27.8"S, 115°04'14.1"E, ca. 1000 m; S. Huber leg. 11.IV.2011; 5 ♀♀ (SB 1013– 1017), SMF. Ubud, 8°29'51''S, 115°15'18.4''E, ca. 330 m; S. Huber leg. 30.III.2011; 1 ♀ (SB 1028), SMF. Candi Dasa, creek forest, 8°30'13''S, 115°33'47''E; S. Huber leg. 16.–20.III.2009; 1 ♂ (SB 137), 2 ♀♀ (SB 196, 256), 1 juv. (SB 906), SMF. Nusa Tenggara Barat Prov.: Flores Isl., East of Labuan Bajo, rainforest, 8°33'60''S, 120°00'02''E; S. Huber leg. 24.III.2009; 1 👌 (SB 196, only left palp and a few body parts remained), SMF.

Diagnosis. Females distinguished from other *Fecenia* species except *F. travancoria* by having anterior margins of lateral lobes (AML) anteriorly more or less converging and surrounding epigynal pit partly and the anterior part of median septum (AS) comprising a longitudinal, anteriorly pointed folding (Fig. 55); moreover, by having a notched transversal edge (TR) of median septum. Distinguished from *F. travancoria* by borderline (BL) between strongly sclerotised section of internal duct system (SSI) and transparent section (TSI) running almost transversal (Fig. 56). In males RTA short, at most ½ the width of palpal tibia, and knobbed, almost as broad as long (Figs 62–63, 98). Median apophysis (MA) almost semicircular and shorter than width of tegulum (T) (Fig. 62, 98). In contrast to the similar male of *F. cylindrata* embolus (E) without basal apophysis (bEA) and ventral patellar apophysis (VPA) arising proximally on patella (Figs 60–61, 99).

Description. MALE: Body and eye measurements. Carapace length 3.1–4.4, carapace width 2.1–3.0, anterior width of carapace 1.4–1.9, opisthosoma length 4.1–6.4, opisthosoma width 1.6–2.6. Eyes: AME 0.25–0.27, ALE 0.17–0.18, PME 0.18–0.19, PLE 0.17–0.19, AME–AME 0.14–0.22, AME–ALE 0.07–0.19, PME–PME 0.18–0.25, PME–PLE 0.25–0.34, AME–PME 0.13–0.19, ALE–PLE 0.10–0.18, cl-



Figures 64–70. *Fecenia protensa*, \bigcirc copulatory organ/primordial copulatory organ **64–65** \bigcirc SB 410 from Singapore **66–67** s.a. \bigcirc SB 185 from Pahang Prov., Malaysia **68–69** s.a. \bigcirc SB 216 from Songkhla Prov., Thailand **70** p.s.a. \bigcirc SB 897 from Sarawak Prov., Malaysia **64** Epigyne, ventral view **65** Vulva, dorsal view **66, 69** Pre-epigyne, ventral view **67–68** Pre-vulva, dorsal view **70** Pre-pre-epigyne, ventral view. TR = Transverse edge/ridge of (in this case primordial) median septum.

ypeus height at AME 0.29–0.35, at ALE 0.21–0.26. Measurements of palp and legs. Palp 4.0–5.2 [1.5–2.1, 0.7–0.9, 0.5–0.7, 1.3–1.6], I 34.7–52.5 [9.1–14.2, 1.4–2.1, 9.5–14.6, 10.6–16.2, 4.1–5.4], II 16.3–25.1 [4.3–6.7, 1.2–1.6, 4.5–7.0, 4.3–7.0, 2.0–2.8], III 9.2–14.0 [2.6–4.0, 0.9–1.3, 2.2–3.6, 2.3–3.4, 1.2–1.7], IV 15.5–23.1 [4.1–6.3, 1.1–1.6, 4.1–6.2, 4.4–6.5, 1.8–2.5]. Leg formula: 1243. Copulatory organ. Retrolateral patellar apophysis (RPA) rather inconspicuous (Figs 61–63, 98–99). Median apophysis (MA) with tip in ca. 1:00-o'clock-position (Fig. 62) and in retrolateral view almost straight (Figs 61, 99). Embolus (E) arising in ca. 7:30-o'clock-position on tegulum (T), distally thicker than in *F. cylindrata* and at most as long as width of T. The latter almost round. Membranous process of tegulum (MP) reaches far up, mostly 10:00–10:30-o'clock-position. Conductor (C) small, size and shape similar like in *F. ochracea*, arises medially in upper third of T.

FEMALE: Body and eye measurements. Carapace length 3.3-4.7, carapace width 1.9-3.1, anterior width of carapace 1.6-2.3, opisthosoma length 5.5-8.1, opisthosoma width 2.4-4.2. Eyes: AME 0.22-0.28, ALE 0.15-0.21, PME 0.17-0.22, PLE 0.16-0.19, AME-AME 0.19-0.26, AME-ALE 0.10-0.14, PME-PME 0.23-0.29, PME-PLE 0.29-0.40, AME-PME 0.23-0.24, ALE-PLE 0.16-0.19, clypeus height at AME 0.33-0.41, at ALE 0.29-0.38. Measurements of palp and legs. Palp 3.5-5.1 [1.2-1.7, 0.6-0.9, 0.6-1.0, 1.1-1.5], I 19.2-26.8 [4.8-7.0, 1.5-2.0, 5.4-7.8, 5.1-7.2, 2.4–2.8], II 11.3–16.5 [3.0–4.3, 1.1–1.6, 3.1–4.7, 2.7–4.0, 1.4–1.9], III 7.1– 10.6 [2.1-3.1, 0.8-1.3, 1.8-2.6, 1.5-2.3, 0.9-1.3], IV 10.7-16.0 [2.8-4.4, 1.1-1.7, 3.1–4.6, 2.5–3.6, 1.2–1.7]. Leg formula: 1243. Palpal claw with 8–11 teeth. Spination (immature holotype of *F. protensa* from Nicobar Islands in poor condition! spination of holotype of *E sumatrana* from Palembang, Sumatra listed instead). Palp: 110, 110, 0100, 1004 (spines on patella, tibia and tarsus with only half the size as those of femur!); legs: femur I 310, II 320, III 011, IV 020; patella I-IV 000; tibia I-II 3006, III 0023, IV 0024; metatarsus I 2025, II-III 2015, IV 1015. Copulatory organ: Epigyne in general appearance characteristically rounded-"W"-shaped (Figs 55, 64, 108). AML mostly strongly sclerotised, converging anteriorly and surrounding epigynal pit partly. AS clearly broader than PS. Epigynal muscle sigilla (EM) integrated in epigynal field or at least located very close by, same for slit sense organs (SO) (Figs 55, 64). Vulva with medium sized (longer than in *F. ochracea*, *F. macilenta* and *F. travancoria*, shorter than in F. cylindrata) and broad TSI (56, 65, 109). SSI more slender than in all other Fecenia species, duct with 2-3 curves (Fig. 57). Primordial copulatory organ: Pre-epigyne: "Crown"-like (Figs 58, 66, 69, 110). Primordium of AS already recognisable, broad "W"-like. Epigynal field not or only poorly developed, EM far outside epigynal field (Fig. 69). Pre-pre-epigyne: Prongs of the "crown" small (Fig. 70). Prevulva: Pre-receptacula bulbous/spherical (Figs 59, 67–68). Distance between centres of pre-receptacula more than three times diameter of one pre-receptaculum. Variation of copulatory organs: Cymbium length of male palp differing slightly among specimens examined (Figs 60-63, 98-99), MA may be extending further beyond retrolateral cymbium margin (Figs 63, 98). T in some specimens slightly broader (Fig. 98) than in others. RPA may be slightly larger (Fig. 63) than in general. In females the shape of AS may vary, e.g. the posterior notch is larger and the anteriorly pointed longitudinal folding is as such hardly recognisable (Fig. 64). Number of SO among specimens varying without geographical dependence. TSI varying in length (Fig. 56, 65). In dorsal view BL direction of vulva varies from 8:30 (Fig. 65) to almost 9:30-o'clock-position (Fig. 56). Pre-epigynes differing in shape of TR (Figs 58, 66). The most frequent shape seems to be the one of SB 216 (Fig. 69) and holotype SB 620 (Figs 58, 110). Number of SO varying strongly.

Pre-vulva may be slightly more structured (Fig. 67).

Remarks. The reasons for revalidation of *F. protensa* and the synonymy of *F. su-matrana* with the former are as follows: In Thailand, Malaysia, Singapore and on Bali at several localities subadult *Fecenia* females were collected together with adult females respectively, which showed the characteristic rounded-"W"-shaped epigyne. The pre-epigyne of the subadult female holotype of *F. protensa* (SB 620) matches the ones of the subadult female holotype of *F. protensa* (SB 620) matches the ones of the subadult female holotype of this species exhibits the characteristic rounded-"W"-shaped epigyne. The (adult) female holotype of this species exhibits the characteristic rounded-"W"-shaped epigyne. The adult females mentioned above match the holotype of *F. sumatrana*. *F. protensa* is the oldest name available and hence the valid name for this taxonomical species. It is distinguished from *F. travancoria* by the BL of the vulva running almost transversal. Consequently, *F. sumatrana* is not a junior synonym of *F. travancoria* as postulated in Murphy (1986), but a junior synonym of *F. protensa*. Both, *F. protensa* and *F. travancoria* are regarded as valid species (see also remarks sub species description of *F. travancoria*).

Reason for synonymy of *F. nicobarensis* with *F. protensa*: Although the types of *Psechrus nicobarensis* were not available on request it became obvious that Tikader (1977) dealt with *F. protensa*. The drawing of the female epigyne in Tikader (1977: 208, fig. 27B) is not very informative, however, the rounded-"W"-shaped character of the epigyne is very clear. His fig. 27E of the right male palp is more detailed. However, the proportions probably do not reflect the real situation. Additionally, this illustration does not represent an exact ventral view of the palp. If the left palps of the males examined herein (SB 128, 136, 137, 218, 219, 512) were arranged in the same way/ position, they would match the (mirrored) drawing in Tikader (1977).

Disribution. India [Nicobar Islands], Thailand, Malaysia, Singapore, Indonesia [Sumatra, Borneo, Bali].

Fecenia travancoria Pocock, 1899

http://species-id.net/wiki/Fecenia_travancoria Figs 71–78, 111–113

- Fecenia travancoria Pocock, 1899: 750 (Description of ♀), [Holotype ♀ (SB 403) from INDIA: Kerala Prov.: Madatory; H. Ferguson leg. III.1896; NHM 99·1·17·36, examined]; Kulczyński 1908: 570; Reimoser 1936: 406; Lehtinen 1967: 234 (Synonymy with *F. macilenta*); Murphy 1986: 65 (Removed from synonymy with *F. macilenta*); Jose and Sebastian 2001: 304; Sebastian and Peter 2009: 277 (Description of ♀).
- Fecenia macilenta—Levi 1982: 136, figs 83–87, ad part, figs 83, 86–87 misidentified (fig. 86: Illustration of ♀).


Figures 71–78. *Fecenia travancoria*, ♀ copulatory organ/primordial copulatory organ **71–73** ♀ SB 118 **74–75** s.a. ♀ SB 119, both from Erawan, Kanchanaburi Prov., Thailand **76–78** Holotype ♀ (SB 403) from Kerala Prov., India **71,76** Epigyne, ventral view **72,77** Vulva, dorsal view **73,78** Course of internal duct system **74** Pre-epigyne, ventral view. **75** Pre-vulva, dorsal view.

Additional material examined. $(3 \ Q \ Q, 2 \ s.a. \ Q \ Q, 2 \ juvenile specimens)$. INDIA: Kerala Prov.: Ernakulam; K. S. Jose leg. 23.III.2001; 1 Q (SB 863, checked via photo of entire specimen, ventral view, kindly provided by K. S. Jose), SJPC. SRI LANKA: Sabaragamuwa Prov.: Ratnapura, peak wilderness area; W. Sedgwick leg. 11.VIII.1979; 1 juv. (SB 481), MCZ 82528. Pitadeniya, Sinharaja Nature Reserve, 6°21'40.2''N, 80°29'03.6''E, ca. 300 m, primary forest, in palm, 1.5 m above ground; V. Hartmann leg. 16.I.2011 as immature, raised in laboratory, adult 05.IV.2011; 1 Q (SB 982, from this specimen the exuviae of the subadult instar, thus its pre-epigyne, was kept and preserved), SMF. THAILAND: Kanchanaburi Prov.: Erawan Waterfall in Erawan N.P., evergreen rainforest; C.L. & P.R. Deeleman leg. 15.III.1986; 1 Q (SB 118), 1 s.a. Q (SB 119), 2 juvs (SB 903–904), Deeleman Coll. in RMNH.

Diagnosis. Females distinguished from other *Fecenia* species except *F. protensa* by having anterior margins of lateral lobes (AML) anteriorly more or less converging and surrounding epigynal pit partly and the anterior part of median septum (AS) comprising a longitudinal, anteriorly pointed folding (Fig. 76); moreover, by having a notched transversal edge (TR) of median septum. Females are distinguished from *F. protensa* by the almost longitudinal borderline (BL) between strongly sclerotised section (SSI) and the transparent section of internal duct system (TSI) in vulva (Fig. 77).

Description. MALE: unknown.

FEMALE (measurements of holotype first, those of other females in parentheses): Body and eve measurements. Carapace length 5.9 (4.4-5.2), carapace width 4.0 (3.0-3.3), anterior width of carapace 2.9 (2.2-2.5), opisthosoma length 7.8 (7.2-12.3), opisthosoma width 4.3 (4.0-5.4). Eyes: AME 0.36 (0.23-0.28), ALE 0.20 (0.12-0.18), PME 0.24 (0.14-0.21), PLE 0.23 (0.14-0.20), AME-AME 0.37 (0.22-0.31), AME-ALE 0.15 (0.09-0.13), PME-PME 0.47 (0.26-0.39), PME-PLE 0.48 (0.39-0.43), AME-PME 0.37 (0.22-0.30), ALE-PLE 0.26 (0.21-0.24), clypeus height at AME 0.43 (0.36–0.40), at ALE 0.39 (0.32–0.34). Measurements of palp and legs. Palp 6.2 (4.5– 5.7) [2.1 (1.5–1.9), 1.1 (0.8–1.0), 1.1 (0.8–1.0), 1.9 (1.4–1.8)], I 33.3 (24.4–29.7) [8.8 (6.4–7.9), 2.4 (1.9–2.1), 9.0 (7.1–8.0), 9.2 (6.2–8.1), 3.9 (2.8–3.6)], II 21.3 (15.0–18.9) [5.9 (4.0–5.1), 2.0 (1.5–1.9), 5.7 (4.1–5.0), 5.2 (3.5–4.6), 2.5 (1.9–2.3)], III 13.1 (9.8– 11.8) [3.9 (2.8–3.4), 1.6 (1.3–1.5), 3.1 (2.4–2.8), 2.9 (2.1–2.7), 1.6 (1.2–1.4)], IV 19.8 (14.5–17.9) [5.5 (4.0–4.9), 2.0 (1.5–1.7), 5.2 (4.1–4.8), 4.8 (3.3–4.5), 2.3 (1.6–2.0)]. Leg formula: 1243. Palpal claw with 9 (9–10) teeth. Spination (holotype from Madatory, India). Palp: 110, 000, 0000, 0000; legs: femur I 412, II 312, III 113, IV 011; patella I-IV 000; tibia I 2006, II 3004, III 0013, IV 0013; metatarsus I-II 2015, III 1015, IV 1014. Colouration: As described for the genus Fecenia. Sebastian and Peter (2009, plate 94) show a photo of female habitus. Copulatory organ: In epigyne AS clearly broader than PS (Figs 76, 111). AML strongly sclerotised. Epigynal muscle sigilla (EM) integrated in epigynal field. Female holotype with four slit sense organs (SO) on each side outside the epigynal field (EF) (Fig. 76), \bigcirc SB 982 from Sri Lanka with three SO on each side, all in EF and \bigcirc SB 118 from Thailand with one on each side outside EF (Fig. 71). In contrast to *F. protensa*, folding of AS may be extending further anteriorly than AML (Figs 76, 111), but not always. Vulva with short (shorter than in all Fecenia species but F. macilenta) and broad TSI (Fig. 77). SSI may be darker than in *F. protensa* and with ca. 2 curves (Figs 78, 112). Primordial copulatory organ: Pre-epigyne: Very similar to *F. protensa*, but lateral prongs of the "crown" narrower (Fig. 74, in Fig. 113 hard to recognise). Pre-vulva: Very similar to *F. protensa* in having bulbous/spherical pre-receptacula (Figs 59, 67–68, 75), with centres of the latter being rather far away (more than three times the diameter of one pre-receptaculum). *F. travancoria* is hard to distinguish from *F. protensa* by the characters of the pre-vulva. In *F. travancoria* the receptacula are rather oval in shape (Fig. 75), in *F. protensa* round. Variation of copulatory organs: In \Im SB 118 (Fig. 71) from Erawan, Thailand the distance between AS and AML is shorter than in holotype. In \Im SB 118 (Fig. 71) and in \Im SB 982 from Sri Lanka the folding of AS extending not as far anteriorly than in holotype (Fig. 76). The vulvae of the $\Im \Im$ examined as well as the primordial copulatory organs of the s.a. $\Im \Im$ showed no significant variation.

Remarks. This species is very similar to *F. protensa*. There are only fine differences in characters of the vulva (see diagnosis). Up to now, no intermediate forms concerning the shape of vulva have been found. Though it cannot be fully excluded, it seems rather unlikely that *F. travancoria* is a junior synonym of *F. protensa*. Generally, in *Fecenia* species the vulva shows less intraspecific variation than the epigyne. By now I consider *F. travancoria* as valid species. But with more material from the southern Provinces of India, especially males, it may be possible to clarify this 'difficult taxonomic case'.

Disribution. India [Kerala Prov.], Sri Lanka, Thailand.

Fecenia cylindrata Thorell, 1895

http://species-id.net/wiki/Fecenia_cylindrata Figs 79–94, 97, 100, 105–107, 116–117, 120–123

- *Fecenia cylindrata* Thorell, 1895: 64 (Description of juveniles), [2 syntypes: juvenile syntype (SB 281, neither penultimate nor antepenultimate instar, thus sex unknown) from MYANMAR: Bago Prov.: Delta near Tharrawaddy (ca. 100 km NW of Yangon); 1884–1887, ded. E.W. Oates; NRS Thorell-Coll.-No. 70a., examined; other juvenile syntype from MYANMAR: Tanintharyi Prov.: Dawei, "on an island in Tavoy river"; 1884–1887, ded. E.W. Oates; type deposition unknown, maybe lost, thus not examined]; Thorell 1897: 263 (Description of \Im and \Im); Pocock 1900: 212 (Description of \Im); Kulczyński 1908: 570; Reimoser 1936: 406; Lehtinen 1967: 234, figs 472–473 (Illustration of carapace, illustration of \Im); Levi 1982: 136, figs 80–82 (Illustration of \Im and \Im); Murphy 1986: 65; Yang and Wang 1993: 29, figs 1–4 (Illustration of \Im and \Im); Song et al. 1999: 397, figs 2310–Q (Illustration of \Im and \Im); Wang and Yin 2001: 332, figs 1–4 (Illustration of \Im).
- Fecenia hainanensis Wang, 1990: 257, figs 1–3 (Description of ♀), [Holotype ♀ from CHINA: Hainan Province: Tongqian city, 18°30' N, 109°45' E; Liu leg. 01.VII.1984; HBI, not available on request, thus not examined, examined by Wang and Yin (2001)]; Wang and Yin 2001: 332 (Synonymy).



Figures 79–82. *Fecenia cylindrata*, \bigcirc epigyne/primordial epigyne, ventral view **79** \bigcirc SB 919 **81** s.a. \bigcirc SB 911, both from Bago Prov., Myanmar **80** s.a. \bigcirc SB535 from Champasak Prov., Laos **82** p.s.a. \bigcirc SB 937 from Luang Prabang Prov., Laos **79** Epigyne **80–81** Pre-epigyne **82** Pre-pre-epigyne. AML = Anterior margin of lateral lobe; AS = Anterior part of median septum; CO = Copulatory opening; EF = Epigynal field; EM = Epigynal muscle sigilla; LL = Lateral lobe; PS = Posterior part of median septum; SO = Slit sense organ; TR = Transversal edge/ridge of median septum.



Figures 83–86. *Fecenia cylindrata*, ♀ vulva/pre-vulva, dorsal view **83–84** ♀ SB 919 **85** s.a. ♀ SB 911, both from Bago Prov., Myanmar **86** s.a. ♀ SB535 from Champasak Prov., Laos **83** Vulva **84** Course of internal duct system **85–86** Pre-vulva. BL = Borderline between SSI and TSI; FD = Fertilisation duct; SH = Spermathecal head; SSI = Strongly sclerotised section of internal duct system; TSI = Transparent section of internal duct system.

Additional material examined. (10 33, 35 99, 5 s.a. 33, 15 s.a. 99, 1 p.s.a. 9, 12juvenile specimens). CHINA: Hainan Prov.: Mount Jainfeng; 20.IV.1990, ded. D.X. Song; 1 ♂ (SB 111), 1 ♀ (SB 110), Deeleman Coll. in RMNH. MYANMAR: Sagaing Prov.: Chattin Wildlife Sanctuary, Takontaing camp, 22°37'20''N, 95°31'52''E; USNM. Bago Prov.: Palon; L. Fea leg. 1885-1889, "Viaggio in Birmania"; T. Thorell det. 20.X.1896; 2 \bigcirc (SB 289–290), 5 \bigcirc (SB 282–286), 1 s.a. \bigcirc (SB 287), 1 s.a. \bigcirc (SB 288), NRS Thorell-Coll.-No. 70b; 5 ♀♀ (SB 915–919), 3 s.a. ♀♀ (SB 910–912), 2 s.a. ♂♂ (SB 913–914), ZMH; 1 ♂ (SB 928), 4 ♀♀ (SB 929–932), 8 s.a. ♀♀ (SB 920–927), 2 s.a. ♂♂ (SB 933–934), 1 juv. (SB 935), ZMUC 5772. The following material has the same dates as above, but was checked via photos of copulatory organs kindly provided by P. Dankittipakul: 2 $\bigcirc \bigcirc$ (SB 827–828), 5 $\bigcirc \bigcirc$ (SB 822–826), MCSN. **THAILAND: Chiang Mai Prov.:** Doi Suthep N.P.; P. Dankittipakul leg.; 1 Q (SB 205), MHNG. Lamphun Prov.: Mae Tha Distr.: Doi Khuntan N.P., 800 m; P. Schwendinger leg. 22.IX.1994; 1 Q (SB 135), MHNG. Loei Prov.: Na-Haeo, field research station; J. Constant, K. Smets & P. Frootaart leg.15.-19.V.2003; 1 Q (SB 11), IRSN. Chaiyaphoom Prov.: Phu Kradung N.P., 1200-1300 m, flat plateau with mixed deciduous + pine + evergreen forest; P. Dankittipakul leg. 15.VIII.2006; 1 $\stackrel{\circ}{\triangleleft}$ (SB 204), MHNG. LAOS: Luang Prabang Prov.: near Luang Prabang: Tham Sieng Mang, 19°54'09"N, 102°08'32"E, 270 m, sunny + dry area, low shrubs; P. Jäger & S. Bayer leg. 15.XI.2009; 1 Q (SB 485), SMF. Luang Prabang: Phou Si, 19°53'23'' N, 102°08'04'' E, 300 m, dry



Figures 87–90. *Fecenia cylindrata*, ♂ palp **87–89** SB 928 from Bago Prov., Myanmar **90** SB 111 from Hainan, China **87** Prolateral view **88** Retrolateral view **89–90** Ventral view. Remark on Fig. 90: Details omitted, embolus slipped behind conductor. bEA = Basal embolus apophysis.



Figures 91–94. *Fecenia cylindrata*, \bigcirc copulatory organ/primordial copulatory organ **91–92** \bigcirc SB 110 from Hainan, China **93–94** s.a. \bigcirc SB 921 from Bago Prov., Myanmar **91** Epigyne, ventral view **92** Vulva, dorsal view **93** Pre-vulva, dorsal view. **94** Pre-epigyne, ventral view. Remark on Figs **91–92**: Details omitted. Asterisk indicates the folding, which divides the anterior from the posterior part of AS.

secondary forest in town, in shrubs; P. Jäger & V. Vedel leg. 12.XI.2004; 3 juvs (SB 938–940); P. Jäger leg. 25.III.2007; 1 s.a. ♀ (SB 62), 1 p.s.a. ♀ (SB 937); P. Jäger & S. Bayer leg. 14.XI.2009; 1 🖧 (SB 488, deformed, died during adult moult), all SMF. SE of Luang Prabang: Nam Khan, Xieng Ngeun Distr., Ban Keng Koung, 19°40'963"N, 102°18'442''E, ca. 370 m, along river bank; P. Jäger leg. 24.II.2008; 1 juv. (SB 936), SMF. Champasak Prov.: Muang Bachieng: That Paxuam, 15°10'35"N, 105°55'21"E, 200 m, secondary forest; P. Jäger & S. Bayer leg. 25.XI.2009; 1 ♀ (SB 318), 2 juvs (SB 40-401), SMF. Ban Lak 38, That Fane, 15°11'03"N, 106°07'37"E, 950 m, coffee plantation; P. Jäger leg. 11.–16.III.2010; 1 Q (SB 528), 1 s.a. Q (SB 535), 3 juvs (SB 527, 532-533), SMF. Near Pakse: Ban Ke, 15°07'57"N, 105°48'54"E, 100 m, dry shrubs; P. Jäger & S. Bayer leg. 27.XI.2009, by night; 1 juv. (SB 351), SMF. Muang Pathoumphone: Vat Phou Salao, 15°05'39"N, 105°48'35"E, 150 m, dry bed of stream, dry shrubs; P. Jäger & S. Bayer leg. 24.XI.2009, by night; 3 99 (SB 48-487, 514), 3 juvs (SB 349, 398, 526), SMF. Ban Nog Hoy, N slope of Phou Malong, 15°03'14"N, 105°49'07''E, 115 m, dry bed of stream, dry shrubs; P. Jäger leg. 23.XI.2009; 2 승경 (SB 50-510), 1 \bigcirc (SB 511), 1 s.a. \bigcirc (SB 420), 2 juvs (SB 39-397), SMF. Ban Tha Hou, 14°46'10"N, 105°59'35"E, 130 m, dry forest, near summit of a prominent hill; P. Jäger & S. Bayer leg. 22.XI.2009; 2 ♀♀ (SB 513, 525), SMF.

Diagnosis. Females distinguished from other *Fecenia* species except *F. protensa* and *F. travancoria* by having anteriorly converging anterior margins of lateral lobes (AML)



Figures 95–101. *Fecenia* spp., male palp 95, 101 *F. macilenta* 96 *F. ochracea* 97, 100 *F. cylindrata* 98–99 *F. protensa* 95, 101 SB 389 from Selangor Prov., Malaysia 96 SB 187 from Halmahera, Indonesia 97 SB 510 from Champasak Prov., Laos 100 SB 204 from Chaiyaphoom Prov., Thailand 98–99 SB 512 from Koh Chang, Thailand 95–98 ventral view 99–101 retrolateral view.

partly surrounding epigynal pit; distinguished from *F. protensa* and *F. travancoria* by the even and unfolded anterior part of median septum (AS) and by transverse edge of median septum (TR) lacking distinct notch (Figs 79, 105). In vulva transparent section of internal duct system (TSI) larger than strongly sclerotised section (SSI) (Figs 83, 92, 106). Males distinguished from other *Fecenia* species except *F. protensa* by having short (at most half as long as width of palpal tibia) RTA; distinguished from *F. protensa* in having RTA, which is longer than broad, and ventral patellar apophysis (VPA) arising centrally on patella (Fig. 88). Median apophysis (MA) running almost in transversal plane (Figs 87–88, 100). Embolus (E) with pointed basal apophysis (bEA) (Fig. 89).



Figures 102–115. *Fecenia* spp., female copulatory organs/primordial copulatory organs **102–104** *F. ochracea* **105–107** *F. cylindrata* **108–110** *F. protensa* **111–113** *F. travancoria* **114–115** *F. macilenta* **102–103** \bigcirc SB 668 from New Guinea **104** s.a. \bigcirc SB 540 from New Britain, Papua New Guinea **105–106** \bigcirc from Loei Prov., Thailand **107** s.a. \bigcirc from Palon, Bago Prov., Myanmar **108–109** \bigcirc SB 215 from Song-khla Prov., Thailand **110** s.a. \bigcirc holotype of *F. protensa* (SB 620) from Nicobar Islands. **111** \bigcirc holotype of *F. travancoria* (SB 403) from Kerala Prov., India **112–113** \bigcirc SB 982 from Sri Lanka (remark on 113: photo of exuviae of subadult instar of same specimen as in 112) **114–115** \bigcirc SB 124 from Sumatera Barat Prov., Indonesia **102, 105, 108, 111, 114** \bigcirc epigyne, ventral view **103, 106, 109, 112, 115** \bigcirc vulva, dorsal view **104, 107, 110, 113** pre-epigyne of s.a. \bigcirc .



Figures 116–120. *Fecenia* spp., habitus, web **116–117, 120** *F. cylindrata*, \bigcirc SB 486 (**116**), \bigcirc SB 509 (**117**) from Champasak Prov., Laos, web (**120**) from Xishuangbanna, China **118** *F. ochracea*, \bigcirc SB 161 from Auki, Solomon Islands **119** *F. protensa*, \bigcirc SB 256 from Bali, Indonesia **116, 118** Habitus, ventral view **117** Habitus, dorso-lateral view **119** Habitus, dorsal view **116–117, 119** Photos by Peter Jäger **120** Photo by Jeremy Miller.



Figures 121–123. *Fecenia cylindrata*, \mathcal{J} (SB 510) and \mathcal{Q} (SB 487) from Champasak Prov., Laos, mating behaviour, sperm web **121** \mathcal{J} stroking behaviour upon the retreat of the female **122** \mathcal{J} and \mathcal{Q} together in the retreat **123** \mathcal{J} sperm webs (SB 510) **123** Photo by Peter Jäger.

Description. MALE: Body and eye measurements. Carapace length 3.6–4.4, carapace width 2.2–2.8, anterior width of carapace 1.6–1.9, opisthosoma length 4.8–6.5, opisthosoma width 1.9–2.5. Eyes: AME 0.23–0.29, ALE 0.17–0.22, PME 0.17–0.22, PLE 0.18–0.21, AME–AME 0.16–0.23, AME–ALE 0.09–0.14, PME–PME 0.17–0.25, PME–PLE 0.28–0.35, AME–PME 0.12–0.16, ALE–PLE 0.10–0.15, clypeus height at AME 0.30–0.41, at ALE 0.24–0.35. Measurements of palp and legs. Palp 4.0–5.0 [1.6–2.0, 0.6–0.7, 0.4–0.5, 1.4–1.8], I 35.1–48.3 [9.5–12.9, 1.5–2.1, 9.3–13.6, 10.5–14.9, 4.3–4.8], II 16.6–22.0 [4.3–5.9, 1.3–1.6, 4.6–6.4, 4.3–5.6, 2.1–2.5], III 8.7–11.8 [2.5–3.4, 1.0–1.2, 2.0–2.9, 2.1–2.8, 1.1–1.5], IV 15.0–20.2 [4.2–5.4, 1.2–1.6, 3.8–5.6, 4.0–5.4, 1.8–2.2]. Leg formula: 1243. Copulatory organ: Retrolateral patellar apophysis (RPA) mostly more clearly visible (Fig. 89) than in *F. protensa* and *F. ochracea*. Tip of MA in ca. 2:30–3:00-o'clock-position, MA shorter than width of tegulum (T) (Figs 89–90, 97) and in pro- and retrolateral view curved distally (Figs 87–88, 100). E very slim, especially distally, arising in ca. 7:30-o'clock-position on T and clearly longer than width of T (Figs 89–90, 97). The latter almost round. Membra-

nous process of tegulum (MP) reaches at most to 8:30-o'clock-position (Figs 89–90, 97). Conductor (C) longer than in *F. ochracea* and *F. protensa*, shorter than in *F. macilenta*, arises medially (or slightly shifted retrolaterally) in upper third of T (Figs 89–90). Cymbium in relation a bit longer than in all other *Fecenia* species (Figs 87–88, 97, 100). Scopula dorsally on cymbium slightly less developed than in other *Fecenia* species.

FEMALE: Body and eye measurements. Carapace length 3.7-7.2, carapace width 2.2-4.2, anterior width of carapace 1.7-3.2, opisthosoma length 7.3-13.0, opisthosoma width 3.5-6.0. Eyes: AME 0.20-0.27, ALE 0.15-0.24, PME 0.16-0.22, PLE 0.16-0.22, AME-AME 0.18-0.34, AME-ALE 0.07-0.18, PME-PME 0.20-0.29, PME-PLE 0.33-0.54, AME-PME 0.14-0.27, ALE-PLE 0.12-0.27, clypeus height at AME 0.27-0.54, at ALE 0.25-0.48. Measurements of palp and legs. Palp 3.8-6.5 [1.3-2.3, 0.6-1.1, 0.7-1.1, 1.2-2.0], I 22.7-39.3 [6.0-10.8, 1.6-2.9, 6.3-10.8, 6.1-10.7, 2.7-4.1], II 13.1–23.7 [3.3–6.4, 0.9–2.3, 3.7–6.8, 3.1–5.7, 1.6–2.5], III 7.5–14.1 [2.2–4.1, 0.9–1.9, 1.8–3.4, 1.6–3.1, 1.0–1.6], IV 12.3–21.4 [3.3–5.9, 1.2–2.3, 3.5–6.2, 2.9–4.9, 1.4–2.1]. Leg formula: 1243. Palpal claw with 8–11 teeth. Spination (remaining immature syntype from Tharrawaddy in poor condition! Spination of female SB 285 from Palon, Birma (Myanmar) listed instead). Palp: 110, 000, 0100, 2004 (spines on tibia and tarsus with only half the size as those of femur!); legs: femur I 300(200), II 210, III 221(111), IV 010; patella I–IV 000; tibia I 0006(1005), II 2004(3005), III–IV 0024; metatarsus I 2015(2016), II-III 2015, IV 1018. Copulatory organ: Anterior part of AS divided from posterior part of AS by a differently developed folding (asterisk in Fig. 91). AS broader than PS (Fig. 79). Epigynal muscle sigilla (EM) clearly outside epigynal field (Figs 79, 91). Slit sense organs (SO) outside epigynal field. Vulva with large and broad TSI (Fig. 83), mostly larger than SSI. The latter with longer duct than in *F. protensa*, *F. travancoria* and *F. ochracea*, with 3–4 curves (Fig. 84). Border line (BL) between TSI and SSI of vulva in ca. 7:00-8:00 o' clock position (Figs 83, 92, 106). Primordial copulatory organs: Preepigyne: TR continuous (Fig. 81, 107), slightly recurved. AML anteriorly bent sharply, running medially and (almost) meeting each other (Figs 81, 94, 107). Epigynal field not or only poorly developed, EM far outside epigynal field. Pre-pre-epigyne: AML similar to pre-epigyne, TR hardly recognisable (Fig. 82). Pre-vulva: Pre-receptacula with lateral extension (Figs 85, 93). Distance between centres of pre-receptacula more than three times the diameter of one pre-receptaculum (Figs 85, 93). Variation of copulatory organs: In males position of VPA may shift retrolaterally (Fig. 90). Direction of MA (Figs 89-90, 97) may vary. Anterio-medial section of C differs among specimens examined (Figs 89– 90, 97). RTA in some specimens basally broader (Fig. 90). In females the folding which divides (or partly divides) the anterior from the posterior part of AS differently developed (Figs 79, 91). TR rarely with a very small, flat and indistinct notch (Fig. 91). AS and PS in some specimens less broad than in others. Number of SO among specimens varying without geographical dependence. Anterio-lateral section of SSI may differ in shape (Figs 83, 92). Pre-epigynes differing in length and direction of AML (Figs 81, 94), further in shape of TR (Figs 81, 94). The most frequent pre-epigyne type is the one of SB 911 (Fig. 81). Number of SO varying strongly. SB 535 from Champasak Province, Laos (Fig. 80) is an exception, which is discussed explicitly (see discussion below).

The pre-vulvae differ only slightly (Figs 85, 93). SB 535 (Fig. 86) is an exception, which is discussed explicitly (see discussion below).

Remarks. Thorell (1895) described this species based on juvenile types. Two years later Thorell himself redescribed this species based on $\Im \Im$ and $\Im \Im$ recorded just ca. 70 km away from type locality Tharrawaddy (Thorell 1897). This material is deposited in NRS, ZMH and MCSN and was examined (see material list above). Moreover, to date no other *Fecenia* species than the one described above had been found in Myanmar. For that reason there are no doubts about the identity of *Fecenia cylindrata*.

Fecenia hainanensis Wang, 1990 was synonymised with *F. cylindrata* by Wang and Yin (2001). The female holotype from Tonqian, Hainan Province, China was not available on request. According to the illustrations in Wang (1990), which are not very detailed, it is more likely that his *F. hainanensis* was in fact conspecific with *F. cylindrata*. The specimens from Hainan checked in the present study are considered belonging to *F. cylindrata*, though there are slight differences (see variation of copulatory organs in the description of *F. cylindrata*). More material from Hainan and also from regions of South East China and Northern Vietnam is necessary to assess the consistency of those slight differences among the different specimens. At the moment *F. hainanensis* is regarded as junior synonym of *F. cylindrata*.

Distribution. China, Myanmar, Laos, Thailand.

Discussion

Characteristics of the pre-epigyne

The pre-pre-epigyne (antepenultimate instar), although hardly useful for species determination, may bear important information. In some Fecenia species both presubadult and subadult females were available for examination. A continuous developmental trend from pre-pre-epigyne (p.s.a. QQ) to the epigyne of adults can be traced (e.g. Figs 19–22 for *F. ochracea*, Figs 79–82 for *F. cylindrata*). Sierwald (1989) showed that in most of the American Pisauridae even more primordial epigyne stages exist. In Pisaurina mira (Walckenaer, 1837) up to five stages with differently developed primordial copulatory organs (which Sierwald denominated as "anlagen") occur. Gradually from earlier to later stages the anlagen resemble more and more the adult. The changes from penultimate instar to adult constitute the largest developmental step as the shapes of pre-epigynes and adult epigynes differ the most. The number of primordial stages in *Pisaurina mira* varies between three and five (Sierwald 1989). Interestingly, in specimens with only three primordial stages, the anlagen of the antepenultimate and penultimate instars were less developed and differentiated. Anyway, these specimens moult following their third anlage to "normal" mature females (Sierwald 1989). The total number of juvenile stages varies in Pisauridae. For example in *Dolomedes triton* (Walckenaer, 1837) the number ranges from 10 to 15 in males and 9 to 15 in females (Zimmermann and Spence 1998).

The present study reveals the occurrence of a different developmental stage of the pre-epigyne (penultimate instar) in the pseudo-orbweaver *F. cylindrata* (Fig. 80). The following preliminary considerations may explain this phenomenon:

In insects a juvenile hormone (JH) regulates the development of the larva throughout the several moults up to the imago. Following Wigglesworth (1952), a controlled hormone balance between JH and prothoracotrope hormone is essential for regular development of the bug *Rhodnius prolixus* Stål, 1859. From 1st to 4th stage larva the concentration of JH decreases more or less continuously, but from the 4th to 5th stage the decrease is much stronger and from 5th stage to imago JH is completely absent (Wigglesworth 1952). It is likely that JH exists in spiders, too (Webber 2005). Prothoracotrope hormone does not exist in spiders, but instead of this it is possible, that another, equivalent hormone exists.

On the other hand it is known from spiders that the number of moults, and thus the number of instars, to reach maturity may differ, for example in Pisauridae (see above). In Latrodectus mactans (Fabricius, 1775) the number of instars varies from 7 to 9 depending on food supply (Deevey 1949). From particular species of Stegodyphus Simon, 1873 it is also known that maturity is reached after different numbers of moults in different specimens examined, irrespective of their sex (Kullmann et al. 1972, Kraus and Kraus 1988). Furthermore, Kraus and Kraus (1988) state that the enormous size variation in species of Stegodyphus seems to be caused mainly by this flexibility. At least in the species F. ochracea and F. cylindrata, the size variation is high. This becomes obvious by their carapace-length size ranges (see respective descriptions). It is possible that in *Fecenia* the number of moults required to reach maturity differs intraspecifically, too. Considering that the number of stages of immature females with differently developed primordial copulatory organs varies in Pisauridae (see above), a family also belonging to the Lycosoidea (Griswold et al. 2005), it is not unlikely that this applies to the pseudo-orbweavers too. A preepigyne of a s.a. \bigcirc of the 6th instar would then most likely differ from the one of an 8th instar.

In *Fecenia* it seems to be rare, that the pre-epigyne of a particular subadult female differs from the ones of the others belonging to the same species. But, anyway, as the example of the subadult female of *F. cylindrata* (Fig. 80) shows, this phenomenon may appear. In such a case additional consideration concerning the identification of subadults is necessary. Does the respective subadult female fit into a conceivable developmental continuum for the species in question? This is, of course, much easier if several "regularly" developed s.a. QQ and/or p.s.a. QQ are available. As the pre-epigyne of a "further developed" s.a. Q most likely resembles more an adult epigyne than a "regularly developed" one does, it should not be too difficult to identify it. Thus, in *Fecenia* the pre-epigynal characters apparently are species-specific (pre-epigynes, take notice; this must not inevitably mean that this applies also to the pre-pre-epigynes or other primordial epigynes of instars below subadult females!). Following the studies of Sierwald (1987, 1989) the pre-epigynes of the Pisauridae species examined seem to be specific, too. Hence, it is justified to use the pre-epigyne as a tool for identification.

Validity of characters in Fecenia.

Somatic characters are not useful for species determination in *Fecenia*. Colouration and spination, for example, are highly variable intraspecifically. Figures 69 and 82 in Levi (1982) suggest that species discrimination between *F. ochracea* and *F. cylindrata* via colouration of the ventral surface of the opisthosoma is possible. According to the present study, this cannot be confirmed. Species identification is only possible by checking the copulatory organs.

Remarks on spination

In the description of the genus *Fecenia* above a characteristic aspect of the spination pattern on the tibiae is mentioned. This may be explained by the life style of the pseudo-orbweavers. Fecenia is the only spider genus in which all representatives spend at least 95% of their lifetime in a very narrow enrolled-leaf retreat or cone retreat in early juveniles. In Araneidae there are several genera including species, that have similar lifestyles, e.g. Acusilas, Cyclosa, Neoscona, Araneus, Cyrtophora, also in Theridiidae, e.g. Parasteatoda simulans (Thorell, 1875). In any case, there is no genus in which all representatives use enrolled leaves as a retreat. Furthermore, in representatives of the families mentioned above the leaf-retreat is never as narrow (in relation to body size) as in Fecenia. A pseudo-orbweaver enters its retreat always with its opisthosoma first. The patellae and tibiae have the most intensive contact with the inner walls of the leaf retreat. As the legs are prograde with leg pairs I-II held anteriorly and III-IV posteriorly it becomes obvious that in the first two leg pairs the retrolateral and in the last two leg pairs the prolateral spines on the tibiae would be an impediment while moving inside the retreat. Perhaps in the course of the evolution of this genus, specimens with shorter spines or even no more spines at these respective positions were preferred? Like in *Psechrus* the patellae completely lack spines (Lehtinen 1967). This characteristic aspect of the tibial spination pattern in Fecenia may be an adaptation to this special life style. It would be interesting to check if the tibial spination pattern of species from the Araneidae and Theridiidae genera listed above using enrolled leaves, differ from the ones with different lifestyles. But in contrast to Psechridae in Araneidae and Theridiidae the spines are in any case not so prominent in comparison to leg diameter.

Acknowledgements

Many thanks to Peter Jäger (SMF, Frankfurt), who collected and provided numerous spider material important for this study, provided photos, gave fruitful advice, helpful comments on this manuscript, and provided a workplace at Senckenberg Research Institute as scientific mentor for my Ph.D.-thesis. Michael Türkay (SMF & University, Frankfurt) supported my Ph.D.-study as the scientific supervisor. The following colleagues provided freshly collected spider material, which was important for this study and/or for the study on Psechridae in general, and are thanked very much: Christa Deeleman (Ossendrecht), Siegfried Huber (Oberuhldingen), Peter Schwendinger (Geneva), Pakawin Dankittipakul (provided also photos of copulatory organs) (Auckland), Volker Hartmann (Koblenz), Ingi Agnarsson (Puerto Rico), Nikolaj Scharff (Copenhagen), Hirotsugu Ono (Tokyo), Cor Vink (Christchurch), Brian Mike Fitzgerald (Wellington), Robert Raven (Brisbane), Mark Harvey (Perth), I-Min Tso & Ren-Chun Cheng (Tunghai), Joachim Haupt (Berlin), Helmut Steiner (Hanau), Booppa Ponksee (Thailand) and Xiang Xu (Changsha). The following curators loaned (type) material of Fecenia: Jeremy Miller (is also thanked for providing photos), Karen van Dorp & I. Jaques Smit (RMNH, Leiden), Leon Baert & B. Goddeeris (IRSN, Brussels), Maria Tavano (MCSN, Genoa), Gonzalo Giribet & Laura Leibensperger (MCZ, Cambridge), Peter Schwendinger (MHNG, Geneva), Dominika Mierzwa (MIZ, Warsaw), Christine Rollard & Elise-Anne Leguin (MNHN, Paris), Janet Beccaloni (NHM, London), Jürgen Gruber & Christoph Hörweg (NHMW, Vienna), Gunvi Lindberg (NRS, Stockholm), Peter Jäger & Julia Altmann (SMF, Frankfurt am Main), Jonathan Coddington (USNM, Washington), Ben Brugge (ZMA, Amsterdam, kindly translated dutch labels, too), Jason Dunlop, Anja Friederichs & Benjamin Nitsche (ZMB, Berlin), Hieronymus Dastych (ZMH, Hamburg), Nicolaj Scharff (ZMUC, Copenhagen), Charles Griswold & Anthea Carmichael (CAS, San Francisco). G. Milledge (AMS, Sydney) and Liu Ping (HBI, Changsha) gave information on spider material deposited in their museums. Charles Griswold (San Francisco) and Shuqiang Li (Beijing) provided arachnological literature. Sunil Jose (Kottayam) provided photos of a Fecenia specimen from his private collection. Jürgen Gruber & Verena Stagel (Vienna) gave important information concerning the type specimen of Tegenaria ochracea. Julia Altmann (Frankfurt) helped in assigning old (colonial) locality terms to recent localities and in deciphering handwriting on old labels. Three research stays at natural history museums in Europe were financially supported via SYNTHESYS project "Worldwide revision of the spider family Psechridae (Arachnida: Araneae) with an emphasis on SE-Asian Representatives", granted to the author by the European Community Research Infrastructure Action under the FP6 "Structuring the European Research Area" Programme. The German Academic Exchange Service (DAAD) financially supported a research stay at an arachnological congress and a visit of a natural history museum in Poland. The Senckenberg Research Institute and Natural History Museum, Frankfurt am Main financially supported a research travel to/field excursion in Thailand and Laos. Many thanks to Jason Dunlop (ZMB, Berlin) for the English proofreading. Many thanks to Norman Platnick (New York), Martin Ramirez (Buenos Aires), Yuri Marusik (Magadan), Dimitri Logunov (Manchester), Jeremy Miller (Leiden) and an anonymous referee for fruitful comments on this manuscript.

References

- Bayer S, Jäger P (2010) Expected species richness in the genus *Psechrus* in Laos (Araneae: Psechridae). Revue suisse de Zoologie 117(1): 57–75.
- Chamberlin RV (1924) Descriptions of new American and Chinese spiders, with notes on other Chinese species. Proceedings of the United States National Museum 63(13): 1–38. doi: 10.5479/si.00963801.63-2481.1
- Chrysanthus OFM (1967) Spiders from South New Guinea IX. Tijdschrift voor Entomologie 110(afl. 1): 89–105.
- Coddington JA (1990) Ontogeny and homology in the male palpus of orb-weaving spiders and their relatives, with comments on phylogeny (Araneoclada: Araneoidea, Deinopoidea). Smithsonian Contributions to zoology 496: 1–52. doi: 10.5479/si.00810282.496
- Deevey GB (1949) The developmental history of *Latrodectus mactans* at different rates of feeding. The American Midland Naturalist 42: 189–219. doi: 10.2307/2421795
- Doleschall CL (1859) Tweede Bijdrage tot de Kennis der Arachniden van den Indischen Archipel. Verhandelingen der Natuurkundige Vereeniging in Nederlandsch Indie 5: 1–60.
- Griswold CE (1993) Investigations into the phylogeny of the Lycosid spiders and their kin (Arachnida: Araneae: Lycosoidea). Smithsonian contributions to zoology 539: 1–39. doi: 10.5479/si.00810282.539
- Griswold CE, Coddington JA, Platnick NI (1999) Towards a phylogeny of entelegyne spiders (Araneae, Araneomorphae, Entelegynae). The Journal of Arachnology 27: 53–63.
- Griswold CE, Ramírez MJ, Coddington JA, Platnick NI (2005) Atlas of phylogenetic data for entelegyne spiders (Araneae: Araneomorphae: Entelegynae) with comments on their phylogeny. Proceedings of the California Academy of Sciences 56(Suppl. II): 1–324.
- Hasselt van AWM (1877) Araneae exoticae, quas quondam in India Orientali (praesertim insula Amboina) collegit Cel. Dr. C. L. Doleschall, AC, pro Museo Lugdunensi. Tijdschrift voor Entomologie 20(1): 51–56.
- Hogg HR (1914) Spiders collected by the Wollaston and British Ornithological Union Expeditions in Dutch New Guinea. Proceedings of the Zoological Society of London (Series C Abstracts) 137: 56–58.
- Hogg HR (1915) Report on the spiders collected by the British Ornithologists' Union Expedition and the Wollaston Expedition in Dutch New Guinea. Transactions of the Zoological Society of London 20(14): 425–484.
- Homann H (1950) Die Nebenaugen der Araneen. Zoologische Jahrbücher, Abteilung für Anatomie und Ontogenie der Tiere 71: 56–144.
- Jäger P (2008) Revision of the huntsman spider genus *Heteropoda* Latreille 1804: species with exceptional male palpal conformations from Southeast Asia and Australia (Arachnida, Araneae, Sparassidae, Heteropodinae). Senckenbergiana biologica 88(2): 239–310.
- Jäger P, Bayer S (2009) The male of *Heteropoda ocyalina* (Simon, 1887) (Araneae: Sparassidae: Heteropodinae). Bulletin of the British Arachnological Society 14(9): 368–370.
- Jäger P, Ono H (2000) Sparassidae of Japan. I. New Species of *Olios, Heteropoda*, and *Sinopoda*, with Notes on Some Known Species (Araneae: Sparassidae: Sparassinae and Heteropodinae). Acta Arachnologica 49(1): 41–60. doi: 10.2476/asjaa.49.41

- Jose KS, Sebastian PA (2001) Occurrence of *Psechrus alticeps* Pocock (Araneae: Psechridae) in Western Ghats, Kerala with a redescription and notes on its habit and habitat. Journal, Bombay Natural History Society 98: 304–306.
- Koh JKH (1989) A guide to common Singapore spiders. Singapore Science Centre. Singapore, 160 pp.
- Kraus O, Kraus M (1988) The genus Stegodyphus (Arachnida, Araneae). Sibling species, species groups, and parallel origin of social living. Verhandlungen des Naturwissenschaftlichen Vereins in Hamburg 30: 151–254.
- Kulczyński W (1908) Symbola ad faunam Aranearum Javae et Sumatrae cognoscendam. I. Mygalomorphae et Cribellatae. Bulletin de l'academie des sciences de Cracovie 6 (1908): 527–581.
- Kulczyński W (1910) Botanische und zoologische Ergebnisse einer wissenschaftlichen Forschungreise nach den Samoainseln, dem Neuguinea-Archipel und den Salomonsinseln von März bis Dezember 1905 von Dr Karl Rechinger. IV. Araneae et Arachnoidea Arthrogastra. Denkschriften der mathematisch-naturwissenschaftlichen Klasse der kaiserlichen Akademie der Wissenschaften, Wien 85: 389–411.
- Kullmann E, Nawabi S, Zimmermann W (1972) Neue Ergebnisse zur Brutbiologie cribellater Spinnen aus Afghanistan und der Serengeti (Araneae, Eresidae). Zeitschrift des Kölner Zoos 14(3): 87–108.
- Lachmuth U, Grasshoff M., Barth FG (1985) Taxonomische Revision der Gattung *Cupiennius* SIMON 1891 (Arachnida: Araneae: Ctenidae). Senckenbergiana biologica 65(3/6): 329–372.
- Lehtinen PT (1967) Classification of the Cribellate Spiders and some allied families, with notes on the evolution of the suborder Araneomorpha. Annales Zoologici Fennici 4: 199–468.
- Levi HW (1982) The spider genera *Psechrus* and *Fecenia* (Araneae: Psechridae). Pacific Insects 24(2): 114–138.
- Murphy F, Murphy J (2000) An introduction to the Spiders of South East Asia with notes on all the genera. Malaysian Nature Society, Kuala Lumpur, Malaysia, 625 pp.
- Murphy J (1986) Additional information concerning the spider family Psechridae. Bulletin of the British Arachnological Society 7(2): 65–68.
- Platnick NI (2011) The world spider catalog, version 11.5. American Museum of Natural History. Available from: http://research.amnh.org/entomology/spiders/catalog/ (accessed: 01 March 2011)
- Petrunkevitch A (1928) Systema Aranearum. Transactions of the Connecticut Academy of Arts and Sciences 29: 1–270.
- Pocock RI (1899) Diagnoses of some new Indian Arachnida. Journal of the Bombay Natural History Society 12: 744–753.
- Pocock RI (1900) The fauna of British India, including Ceylon and Burma. Taylor and Francis, London, 279 pp.
- Rainbow WJ (1913) Arachnida from the Solomon Islands. Records of the Australian Museum 10(1): 1–16. doi: 10.3853/j.0067-1975.10.1913.893

- Reimoser E (1929) Spolia Mentawiensia. Araneae. Bulletin of the Raffles Museum Singapore 2: 125–133.
- Reimoser E (1936) Fauna Buruana. Arachnoidea. Treubia 7(Suppl.): 405-413.
- Robinson H, Lubin YD (1979) Specialists and generalists: The ecology and behaviour of some web-building spiders from Papua New Guinea. II. *Psechrus argentatus* and *Fecenia sp.* (Araneae: Psechridae). Pacific Insects 21: 133–164.
- Sebastian PA, Peter KV (2009) Spiders of India. Universities Press, Hyderabad, 614 pp.
- Sethi VD, Tikader BK (1988) Studies on some giant crab spiders of the family Heteropodidae from India. Records of the Zoological Survey of India. Miscellaneous publication occasional paper 93: 1–94.
- Sierwald P (1987) Revision der Gattung *Thalassius* (Arachnida, Araneae, Pisauridae). Verhandlungen des Naturwissenschaftlichen Vereins in Hamburg 29: 51–142.
- Sierwald P (1989) Morphology and ontogeny of female copulatory organs in American Pisauridae, with special reference to homologous features (Arachnida: Araneae). Smithsonian Contributions to Zoology 484: 1–24. doi: 10.5479/si.00810282.484
- Simon E (1885) Matériaux pour servir à la faune arachnologique de l'Asie méridionale. III. Arachnides recueillis en 1884 dans la presqu'ile de Malacca par M. J. de Morgan. Bulletin de la Societe zoologique de France 10: 1–39.
- Simon E (1887) Observation sur divers arachnides: synonymies et descriptions. Annales de la Societe Entomologique de France (6)7(Bull.): 193–195.
- Simon E (1892) Histoire naturelle des araignées. Librairie Encyclopédique de Roret, Paris, 1: 1–256.
- Simon E (1906) Etude sur les araignées de la section des cribellates. Extrait des Annales de la Societe Entomologique de Belgique 50: 284–308.
- Song DX, Zhu MS, Chen, J. (1999) The Spiders of China. Hebei Science and Technology Publishing House, Shijiazhuang, 640 pp.
- Song DX, Zhang JX, Li D (2002) A checklist of spiders from Singapore (Arachnida: Araneae). The Raffles Bulletin of Zoology 50(2): 359–388.
- Stagl V (1999) Carl Ludwig Doleschall Arzt, Forscher und Sammler. Quadrifina 2: 195–203.
- Strand E (1906) Studien über Bau und Entwicklung der Spinnen. I-III. Zeitschrift für wissenschaftliche Zoologie 80(4): 515–543.
- Strand E (1915) Wissenschaftliche Ergebnisse der Hanseatischen Südsee-Expedition 1909. III. Indoaustralische, papuanische und polynesische Spinnen des Senckenbergischen Museums, gesammelt von Dr E. Wolf, Dr J. Elbert u. a. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 36(2): 179–274.
- Thorell T (1878) Studi sui ragni Malesi e Papuani. II. Ragni di Amboina raccolti dal Prof. O. Beccari. Annali del Museo Civico di Storia Naturale Giacomo Doria, Genova 13: 1–317.
- Thorell T (1881) Studi sui Ragni Malesi e Papuani. III. Ragni dell'Austro Malesia e del Capo York, conservati nel Museo civico di storia naturale di Genova. Annali del Museo Civico di Storia Naturale di Genova 17: 1–727.
- Thorell T (1891) Spindlar från Nikobarerna och andra delar af södra Asien. Kongl. Svenska Vetenskaps-Academiens Handlingar 24(2): 1–149.

- Thorell T (1895) Descriptive catalogue of the spiders of Burma. Longmans & Co., British Museum of Natural History, and others, London, 406 pp.
- Thorell T (1897) Viaggio di Leonardo Fea in Birmania e regioni vicine (LXXIII). Secondo saggio sui Ragni birmani. I. Parallelodontes. Tubitelariae. Annali del Museo Civico di Storia Naturale Giacomo Doria, Genova (2) 17[=37]: 161–267.
- Tikader BK (1977) Studies on spider fauna of Andaman and Nicobar islands, Indian Ocean. Records of the Zoological Survey of India 72: 153–212.
- Wang JF (1990) A new species of psechrid spider from China (Araneae: Psechridae). Acta Scientiarum Naturalium Universitatis Normalis Hunanensis 13: 257–258.
- Wang XP, Yin CM (2001) A review of the Chinese Psechridae (Araneae). The Journal of Arachnology 29: 330–344. doi: 10.1636/0161-8202(2001)029[0330:AROTCP]2.0.CO;2
- Webber RP (2005) The role of juvenile hormone (JH) and its analogs (JHA) in *Nephila clavipes* development. Biology 198, Senior Research Project, Burlington, Vermont, USA: The University of Vermont. http://www.webberdigital.com/web/uploads/seniorresearch.pdf
- Wigglesworth VB (1952) Hormone balance and the control of metamorphosis in *Rhodnius prolixus* (Hemiptera). Journal of Experimental Biology 29: 620–631.
- Yang ZL, Wang XZ (1993) A newly recorded of the spider genus *Fecenia* (Araneae: Psechridae) from China. Acta arachnologica sinica 2: 29–30.
- Zimmermann M, Spence JR (1998) Phenology and life-cycle regulation of the fishing spider *Dolomedes triton* Walckenaer (Araneae, Pisauridae) in central Alberta. Canadian Journal of Zoology 76(2): 295-309.

RESEARCH ARTICLE



Glenea coomani Pic, 1926 and its related species of South China with description of a new species

Meiying Lin[†], Xingke Yang[‡]

Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, Beichen West Road, Chaoyang Dist., Beijing, 100101, China

† urn:lsid:zoobank.org:author:4725CAC1-80E0-442D-BAFD-D5723AE41B6B‡ urn:lsid:zoobank.org:author:A2537A31-1150-4780-9724-4C8EAFA7A04C

Corresponding author: Meiying Lin (linmeiying@ioz.ac.cn), Xingke Yang (yangxk@ioz.ac.cn)

Academic editor: S. Lingafelter Received 16 September 2011 Accepted 8 November 2011 Published 9 December 201
urn:lsid:zoobank.org:pub:8EE69422-1957-4D53-A13C-90FF4AA6D4BD

Citation: Lin M-Y, Yang X-K (2011) *Glenea coomani* Pic, 1926 and its related species of South China with description of a new species. ZooKeys 153: 57–71. doi: 10.3897/zooKeys.153.2106

Abstract

Glenea coomani Pic, 1926 distributed in Vietnam, Laos and China is redescribed, and its sibling species, *G. neohumerosa* **sp. n.** is described from China (Guangxi, Hainan and Fujian) and North Vietnam. They are separated from each other by differences in genitalia, and apical teeth and maculae of elytra. Another four related species and one subspecies are illustrated with short notes and new localities, and the lecto-type and paralectotype of *Glenea tonkinea* Aurivillius, 1925 are designated. A key to the related species is presented.

Keywords

Glenea, new species, taxonomy, distribution, Oriental region

Introduction

Glenea coomani Pic, 1926 was originally described from North Vietnam, and *G. humerosa* Gressitt, 1940, described from Hainan Island, China had been synonymized with it by Breuning (1956). In the course of our study of saperdine beetles from South China, we confirmed their conspecific status based on the study of the type material. However, we sur-

prisingly found another species, which had been identified as *G. coomani* or *G. humerosa* by predecessors. This new species is distinguishable from *G. coomani* by having different elytral maculae, longer elytral apical teeth, and differing structure of male genitalia. Therefore, we describe *G. neohumerosa* sp. n., and compare it with *G. coomani* which is redescribed. We show the habitus of similar species which are compared with short notes and new localities. The following species are mentioned and keyed: *G. coomani* Pic, 1926, *G. neohumerosa* sp. n., *G. lacteomaculata* Schwarzer, 1925, *G. lacteomaculata quadriguttata* Pic, 1926, *G. laodice* Thomson, 1879, *G. subalcyone* Breuning, 1964, *G. tonkinea* Aurivillius, 1925.

Materials and methods

Types and other material studied are deposited in the following institutions or private collections:

BM	Bishop Museum, Honolulu, USA
CAS	California Academy of Sciences, San Francisco, USA
CAU	China Agricultural University, Beijing, China
CBWX	Collection of Wenxuan Bi, Shanghai, China
CCCC	Collection of Chang-chin Chen, Tianjin, China
СЈМ	Collection of Ming Jin, Shanghai, China
CWD	Collection of Dong Wen, Qingdao, Shandong, China
IZAS	Institute of Zoology, Chinese Academy of Sciences, Beijing, China
MNHN	Muséum National d'Histoire Naturelle, Paris, France
MHNL	Muséum d'Histoire Naturelle, Lyon, France
NHRS	Swedish Museum of Natural History, Stockholm, Sweden (= Naturhistor-
	iska Riksmuseet Stockholm)
NMB	Naturhistorisches Museum, Basel, Switzerland (including ex Museum G.
	Frey, Tutzing)
SHEM	Shanghai Entomology Museum, Shanghai, China
SYSU	Sun-Yatsen University, Guangzhou, China

Results

Glenea coomani Pic

http://species-id.net/wiki/Glenea_coomani Figs 1–11

Glenea coomani Pic, 1926: 21(Tonkin). [MNHN] *Glenea humerosa* Gressitt, 1940: 206, pl. 6, fig. 4 (Hainan). [CAS, syn. by Breuning 1956] *Glenea* (s. str.) *coomani*; Rondon and Breuning 1971: 537 (Laos). *Glenea coomani*; Breuning 1956: 744; Hua 2002: 210. **Redescription.** Male (Figs 2–6): length: 11.5–14.2 mm, humeral width: 3.5–4.5 mm. Female (Fig. 1): length: 14.0–16.2 mm, humeral width: 4.5–5.4 mm. Body black, in part provided with white to pale yellow pubescent maculae. Head with white to pale yellow maculae on genae, borders of eyes, temple and two parallel stripes between upper eye lobes; antennae black, with thin, whitish pubescence on inner sides of first three segments and base of fourth segment, and scattered with short, black bristles on undersides of first seven segments. Prothorax with a medial white to pale yellow stripe, and each side white to pale yellow near base; each disc with 5 white to pale yellow maculae: a large oval spot close to suture at the end of basal 1/4; a smallest spot near the middle, far from suture; the third one large, oval, close to suture just behind the middle; the fourth medium in size, round, far from suture; an oblique transverse band just before apex. Ventral surface covered with dense white to pale yellow pubescence, thinly so along middle. Legs black, thinly pubescent. Pronotum and elytral bases with sparse, erect, black bristles.

Head hardly broader than prothorax, deeply, and in part densely punctured, feebly concave at vertex. Eyes deeply emarginate, inferior eye lobes subequal to (female), or 2 times as high as (male) genae below it, width much less than half of front. Antennae longer than body; scape slightly thickened apical without cicatrix nor a ridge; antennomere ratio (male): 12 : 3 : 21 : 16 : 16 : 15 : 14 : 13 : 13 : 12 : 13; (female): 15 : 4 : 24 : 17 : 17 : 16 : 15 : 14 : 14 : 13 : 13. Prothorax almost as broad as long (male) or broader than long (female), swollen laterally before middle; disc convex and somewhat deeply and closely punctured. Elytra prominently angulate at humeri, slightly narrowed apically; each with 2 humeral longitudinal ridges beginning after humeri and reaching near the apex, truncated apically, with short and small teeth at the suture and the outer angle, surface with coarse and irregular punctures. Legs stout, middle tibiae grooved, hind femur reaching fourth abdominal segment, first hind tarsal segment longer than (male), or nearly as long as (female) following two segments combined. Male claws: the anterior claws of the fore and mid tarsi are toothed at the base, but the tooth in the fore tarsus is very small (Fig. 5), the tooth in the mid tarsus is long (Fig. 6, almost same size of the normal claw). Female claws simple.

Male genitalia (Figs 7–11): Tegmen length about 3.0 mm; lateral lobes stout, each about 0.6 mm long and 0.3 mm wide, with fine haired ridge at the base (in ventral view), apex nearly truncated and with fine setae which are shorter than lateral lobes; ringed part elbowed in the widest portion, converging; basal piece bifurcated distally (Fig. 9); median lobe plus median struts moderately curved, a little longer than tegmen (6:5); the median struts about one half of the whole length of median lobe; dorsal plate shorter than ventral plate; apex of ventral plate narrowly pointed, with sharp apex which is always curved to right side (in ventral view; Fig. 10); median foramen elongated triangular, with a small projection in lateral view; internal sac about 3 times as long as median lobe plus median struts, with 4 pieces of basal armature, 2 bands of supporting armature and 3 rods; the two longer rods each about 1.6 mm, shorter than tegmen, the short middle rod about 1.1 mm long.



Figures 1–6. Habitus, *G. coomani* Pic. 1 holotype, female, from Tonkin, Vietnam 1a showing lateral pubescent stripe on prothorax 2 holotype of *G. humerosa* Gressitt, male, from Hainan, China (picture from Carolus Holzschuh) 3 male, from Yunnan, China 4 male, from Hainan, China. Scale 2 mm. 1a, 5–6 not to scale 5 showing claw of front tarsus 6 showing claw of mid tarsus.

Ejaculatory duct single. Tergite VIII (Fig. 8c) broader than long, apex truncated with middle slightly projected, setae near lateral corner dense and long, and sparse and short around middle.

Diagnosis. Differs from *G. lacteomaculata* Schwarzer, 1925 (Fig. 24), *G. lacteomaculata quadriguttata* Pic, 1926 (Figs 25–26) and *G. tonkinea* Aurivillius, 1925 (Figs 30–33) in elytron having only one big oval macula at basal fourth, instead of two small spots, the second macula smallest instead of the first one. Differs from *G. laodice* Thomson, 1879 (Fig. 27) and *G. subalcyone* Breuning, 1964 (Figs 28–29) in elytron without long and sharp tooth at the outer angle, having only one big oval macula at basal fourth, instead of two spots.

Remarks. Based on the study on the types and material from type localities, we agreed with Breuning (1956) that *G. humerosa* Gressitt, 1940 is conspecific with *G. coomani* Pic, 1926. Though the holotype of *G. humerosa* Gressitt (Fig. 2) has the middle oval pubescent spot reaching suture and seems to be different from the type of *G. coomani* Pic (Fig. 1), the male (Fig. 4) also from Hainan Island looks no different from those from Tonkin. Nevertheless, such pubescent markings are quite variable in shape and size within same species.

Distribution. China: Hainan, Yunnan (new province record); Vietnam, Laos.

Type specimen examined. Holotype of *G. coomani* Pic, female, Tonkin (MNHN). Holotype of *G. humerosa* Gressitt, male, Ta-hian, foot of Five Finger Moutains, south-central Hainan, 1935.VI.18, leg. Gressitt (CAS) [by original description and pictures].



Figures 7–11. Terminalia of *G. coomani* Pic **7** male genitalia **8** tergite VIII and sternite VIII & IX **a** ventral view **b** lateral view **c** dorsal view **9** tegmen, showing the basal piece. Scale 1 mm. **10–11** not to scale **10** showing ridges in base of lateral lobes and apex of ventral plate of median lobe **11** showing three rods of endophallus.

Other specimens examined. China: Yunnan: 1 male, Cheli to Damenglong, alt. 600 m, 1957.IV.22, leg. Dahua Liu (IZAS). **Hainan:** 1 male, Ledong, 1984.VIII.26, leg. Zhiqing Chen (IZAS). **Vietnam:** 1 male, Tonkin, Hoa-Binh (MNHN); 1 female, same data but (NMB, ex Coll. Frey); 1 male, Tonkin, Hoa-Binh, leg. A. de Cooman (IZAS); 1 female, same data but (NMB, ex Coll. Frey). **Laos:** 2 males, Ban Van Heue, 20 km E. of Phou-kow kuei, 1965.V.1–15, leg. J. A. Rondon (BM); 18 males 18 females, Phontiou, 1965.V.15 (MNHN, ex Coll. J. Rondon, 1967).

Glenea neohumerosa sp. n.

urn:lsid:zoobank.org:act:9C4BC446-D2E5-4E4E-9BDD-F66245CC93C5 http://species-id.net/wiki/Glenea_neohumerosa Figs 12–23

Description. Male (Figs 14, 14h, 16–18): length: 8.4–10.8 mm, humeral width: 2.3–3.0 mm. Female (Figs 12–13, 15, 15h): length:10.5–13.0 mm, humeral width: 3.2-3.9 mm. Body black, in part provided with thick, white (dry and old specimens, Figs 14-15) to yellow (alive or fresh specimens, Figs 12-13) pubescent maculae. Head black, frons with two white or yellow stripes (almost fused in male, Fig. 14h) from inner side of antennae insertions along eyes and genae to clypeus (Fig. 15h), temple white or yellow (Fig. 12a), vertex with two parallel stripes (usually fused) between upper eye lobes; antennae black, scattered with short, black bristles on undersides of first seven segments. Prothorax with a medial white or yellow stripe, each side white or yellow except a transverse black vitta (Fig. 12a). Scutellum white or yellow. Elytra without surural stripes, each disc with 5 white or yellow maculae: two spots at basal 1/4, the one near suture much bigger than the one near margin; a moderate sized oval spot at middle, near suture; the fourth one smaller than middle one, closer to lateral margin than to suture, at the centre of apical half; an oblique transverse band just before apex. Ventral surface covered with dense white or yellow pubescence, thinly so along middle. Legs black, thinly pubescent. Pronotum and elytral bases with sparse, erect, black bristles.

Head hardly broader than prothorax, deeply, and in part closely punctured, feebly concave at vertex. Eyes deeply emarginate, inferior eye lobes subequal to (female) or 2 times as high as (male) genae below it, width much less than half of frons. Antennae longer than body, male longer than female; scape thicknened apical without cicatrix not a ridge; antennomere ratio (male): 12:3:18:15:14:13 : 13 : 12 : 12 : 11 : 12; (female): 13 : 3 : 21 : 17 : 16 : 15 : 14 : 14 : 13 : 12 : 13. Prothorax almost as broad as long (male) or broader than long (female), swollen laterally before middle, disc convex and somewhat deeply and closely punctured. Elytra rounded at humeri, slightly narrowed apically, each with 2 humeral longitudinal ridges beginning after humeri and reaching close to apex, truncated apically, with short and small teeth at the suture, long and sharp spine at the outer angle, surface with coarse and irregular punctures. Legs stout, middle tibiae grooved, hind femur reaching middle to apex of third abdominal segment, first hind tarsal segment longer than (male), or nearly as long as (female) following two segments combined. Male claws: the anterior claws of the mid tarsi with a short (half of the normal claw) tooth (Figs 17-18), fore and hind tarsi with simple claws (Fig. 16). Female claws simple.

Male genitalia (Figs 19–21): Tegmen length about 1.9 mm; lateral lobes slender, each about 0.6 mm long and 0.2 mm wide, with finely haired ridge at the base (in ventral view, Fig. 20), apex obliquely rounded and with fine setae which are shorter than lateral lobes; ringed part elbowed in the widest portion, converging; basal piece



Figures 12–18. Habitus, *G. neohumerosa* sp. n. **12–13** paratype, female, from Hainan, China, showing yellow coloration of fresh material (not to scale) (taken by Wenxuan Bi in June, 2011) **14** holotype, male, from Guangxi, China **14h** head of male, frontal view **15** female, from Hainan, China **15h** head of female, frontal view. Scale 2 mm **16** simple claw, showing claw of front tarsus of male. **17–18** showing claw of mid tarsus of male (not to scale).

bifurcated distally; median lobe plus median struts moderately curved, subequal to tegmen in length; the median struts about one half of the whole length of median lobe; dorsal plate shorter than ventral plate; apex of ventral plage (Fig. 20) pointed, apex not so sharp and not curved to right side; median foramen elongated with a projection in lateral view (Fig. 19b); internal sac about 3 times as long as median lobe plus median struts, with 4 pieces of basal armature, 2 bands of supporting armature and 3 rods; the two longer rods each about 1.2 mm, shorter than tegmen, the short middle rod about 0.7 mm long. Ejaculatory duct single. Tergite VIII (Fig. 21c) longer than broad, apex rounded, setae near lateral corner dense and long, and sparse and short around middle.

Female genitalia (Figs 22–23): spermathecal gland located at the base of spermathecal capsule. Spermathecal capsule with a curved basal stalk and a rounded apical orb, stalk more than twice the length of capsule.



Figures 19–23. Terminalia of *G. neohumerosa* sp. n. **19** male genitalia. **20** showing ridges in base of lateral lobes and apex of ventral plate of median lobe (not to scale) **21** tergite VIII and sternite VIII & IX **a** ventral view **b** lateral view **c** dorsal view **22–23** female genitalia **22** spermathecal capsule distorted (not to scale). Scale 1 mm.

Diagnosis. Differs from long spine elytron (Fig. 35) species *G. laodice* Thomson, 1879 (Fig. 27) and *G. subalcyone* Breuning, 1964 (Figs 28–29) in elytron having five white or yellow maculae instead of six, and their positions different. Differs from *G. coomani* and other short tooth elytron (Fig. 34) species in elytral apex having a long and sharp spine at the outer angle. Differs from *G. coomani* also in male terminalia: tergite VIII with apex rounded instead of truncated; lateral lobes of tegmen slender, the length ratio of lateral lobes to tegmen much bigger; apex of ventral plate not so sharp and not curved to right side.

Etymology. Named derived on similarity to and misidentification as *G. humerosa* by Gressitt and Hua (based on material deposited in SYSU and IZAS).

Remarks. The yellow color of the pubescence turns into white when the specimens are dried.

Distribution. China: Guangxi, Hainan, Fujian; Vietnam (Tonkin).

Type material. Holotype: male (10.2 mm long), Guangxi, Jinxiu, Shengtangshan, alt. 900 m, 1999.V.17, leg. Xingke Yang (IZAS, IOZ(E)1859448). Paratypes: **China: Guangxi:** 2 males, Jinxiu, Luoxiang, alt. 400 m, 1999.V.14, 15, leg. Decheng Yuan (IZAS, IOZ(E)1859449, 1859447); 1 male, Guangxi, Nanning, Wuming county, Mt. Damingshan [23°24'N, 108°28'E], alt. 1200 m, 2011.VII.11, coll. Yanquan Lu (CWD). **Hainan:** 1 female, Hainan Exp. 1934.IV.18 (IZAS, IOZ(E)1859445); 1 male, Hainan Exp. 1934.III.26 (IZAS, IOZ(E)1859446); 1 male 1 female, Hainan, Lingshui county, Diaoluoshan, alt. 1000 m, 2010.IV.23, leg. Ziwei Yin (SHEM); 1 female, Hainan, Ledong, Jiangfengling, Mingfenggu, 2011.V.25, alt. 1000 m, leg. Wenxuan Bi (CBWX); 1 female, Hainan, Ledong, 1962.IX.17, leg. Yaoquan Li (SYSU, En-366148). **Fujian:** 1 female, Wuyishan Nature Reserve, 2009.VII.10–17, leg. Ming Jin (CJM). **Vietnam:** 1 female, Tonkin, Backan, 1907, leg. Lemee (IZAS, ex MNHN, ex Coll. R. Oberthür, 1952, IOZ(E)1859450).

Glenea lacteomaculata quadriguttata Pic

http://species-id.net/wiki/Glenea_lacteomaculata_quadriguttata Figs 25–26

Glenea 4-guttata Pic, 1926: 22. *Glenea (Glenea) lacteomaculata* sbsp. *quadriguttata*; Breuning, 1956: 743.

Remarks. Due to lack of material from Taiwan, the differences between *G. lacteomaculata* Schwarzer, 1925 and *G. lacteomaculata quadriguttata* Pic, 1926 are doubtful for the authors. The specimens from Guangxi and Yunnan provinces are conspecific to *G. lacteomaculata quadriguttata* and herein the new localities are reported.

Distribution. China (new country record): Guangxi, Yunnan; Vietnam (Tonkin).

Type specimen examined. Syntype (Fig. 25), 1 female, Vietnam, Tonkin, Djang (MNHN, ex Collection M. Pic).

Other specimens examined. China: Guangxi: 1 male (Fig. 26), Longzhou, Nonggang, alt. 240m, 1982.V.19, leg. Jikun Yang (CAU); 1 female, Guangxi Baohuqu, 1983.V, leg. Xiangtian Kong (IZAS); 2 females, Longrui, 1980.VI.1 (SYSU, En. 366147). Yunnan: 2 males, Hekou, Nanxi, Huayudong, alt. 150 m, 2010.IV.28, leg. Xiaodong Yang (CCCC). Vietnam: 5 males 4 females, Tonkin occ. Env. de Hoa-Binh, 1919, leg. R.P.A. de Cooman (MNHN, ex Coll. R. Oberthür, 1952); 1 male 1 female, Tonkin Env. De Hoa-Binh (MNHN, ex Coll. R. Oberthür, 1952); 2 females, Tonkin, HoaBinh, 1939.VII, leg. A. de Cooman (SYSU, Ce-002361–002362).



Figures 24–26. Habitus, *G. lacteomaculata* Schwarzer and *G. lacteomaculata quadriguttata* Pic. **24** paratype of *G. lacteomaculata*, female, from Taiwan, China. **25–26** *G. lacteomaculata quadriguttata* **25** syntype, female, from Tonkin, Vietnam **26** male, from Guangxi, China.

Glenea subalcyone Breuning

http://species-id.net/wiki/Glenea_subalcyone Figs 28–29

Glenea (s. s) subalcyone Breuning, 1964: 20, fig. page 21. *Glenea* (s. str.) subalcyone; Rondon and Breuning 1971: 535.

Remarks. This species is very similar to *G. laodice* Thomson, 1879 (Fig. 27), but can be distinguished by having legs black instead of testaceous. It is recorded from Chinese fauna for the first time.

Distribution. China (new country record): Yunnan; Laos.

Type specimen examined. Holotype (Fig. 28), female, Laos, région de Thakhek (Phontiou in label), 1963.VI, leg. J. A. Rondon (BM).

Other specimens examined. China: Yunnan: 1 female (Fig. 29), Yiwubanna, Menglun, alt. 650 m, 1959.VIII.27, leg. Facai Zhang (IZAS).



Figures 27–29. Habitus, *G. laodice* Thomson and *G. subalcyone* Breuning 27 holotype of *G. laodice*, female, from Laos. 28–29 *G. subalcyone* 28 holotype, female, from Laos. 29 female, from Yunnan, China.

Glenea tonkinea Aurivillius

http://species-id.net/wiki/Glenea_tonkinea Figs 30–33

Glenea tonkinea Aurivillius, 1925: 521, fig. 160 (Tonkin). [MNHN] *Glenea (Glenea) tonkinea* m. *basirufofemorata* Breuning, 1956: 743 (Tonkin). [MHNL] *Glenea (Glenea) tonkinea* m. *apicetruncata* Breuning, 1956: 743 (Tonkin). [NMB]

Diagnosis. Differs from *G. pici* Aurivillius in having pubescent maculae white; in having different male claws. Differs from *G. lacteomaculata* Schwarzer in having spot at middle of elytron transverse, anterior claw in mid tarsus of male with long tooth (Fig. 31).

Lectotype designation. According to Aurivillius' original description, there were multiple type specimens, deposited in "Reichsmuseum in Stockholm und Collectio Pic". In order to fix the species concept and ensure universal and consistent interpretation of this species, we designate the male specimen in MNHN as the lectotype (Figs 30–31, 8.5 mm long, 2.4 mm wide) and the female in NHRS as the paralectotype (Fig. 33) of *G. tonkinea* Aurivillius.



Figures 30–32. Habitus, *G. tonkinea* Aurivillius. **30** lectotype, male, from Tonkin, Vietnam **31** claw of mid tarsus in male (not to scale) **32** cotype of *G. tonkinea* m. *apicetruncata* Breuning, 1956, male, from Tonkin, Vietnam.

Remarks. The record from Taiwan is doubtful. It might be based on *Glenea diversenotata* Schwarzer, whose taxonomic position was not clear yet.

Distribution. China (Taiwan?, Hainan, Guangxi); Vietnam (Tonkin), Myanmar (new country record).

Type specimens examined. Lectotype, male, Tonkin, Hoo Binh (=Hoa Binh) (MNHN, ex Coll. M. Pic). Paralectotype, female, Tonkin, Ho Bing (=Hoa Binh) (NHRS-JLKB000020243). Holotype of *G. (Glenea) tonkinea* m. *apicetruncata* Breuning, male, Tonkin Mts. Mauson, alt. 2000–3000 feet, IV–V, leg. H. Fruhstorfer (NMB, ex Coll. Frey). Type of *G. (Glenea) tonkinea* m. *basirufofemorata* Breuning, male, Tonkin, Hoa Binh (MHNL, ex Coll. Lepesme); paratype, female, same data.

Other specimens examined. China: Guangxi: 1 male, Longzhou, Nonggang, alt. 330 m, 2000.VI.5, leg. Wenzhu Li (IZAS); 1 male, Longzhou, Shida, 1980.V.24 (SYSU, En-366136); 1 female, Guangxi, Xiashi, 1963.V.7, leg. Jikun Yang (CAU). Vietnam: 1 female, Tonkin, Hoa-Binh (IRSNB); 3 males 3 females, same data but (MNHN, ex Coll. M. Pic); 1 male 1 female, Tonkin occ. Env. de Hoa-Binh, 1919, leg. A. de Cooman (MNHN, ex Coll. R. Oberthür, 1952); 1 female, Tonkin (MNHN, ex Coll. M. Pic); 1 male, Tonkin N. env. D'ha-Giang, 1914, leg. Lieut (MNHN); 1 female, Tonkin Reg. de Hao-Binh, 1927, leg. A. de Cooman (MNHN); 1 female, Tonkin, Baokan, 1907.VIII, leg. P. Lemee (MNHN, ex Coll. R. Oberthür, 1952); 1 female, Tonkin centr. Region de Chiem-Hoa et de Tuyen-Quam, 1901, leg. A. Weiss

(MNHN). **Myanmar:** 1 female, Birmanie (Hte.) Mines des Rubis, alt. 1200–2300 m, 1890, leg. Doherty (MNHN).

Discussion

The above species are grouped as *G. coomani* group by the following characters (not meant to be presumed synapomorphies, but rather only for identification of species having similar makings): pronotum largely black, generally with a white or yellow median stripe; body covered with pubescence instead of metallic squama (such as the metallic green maculae of *G. pici* Aurivillius, 1925); elytron black with an apical spot and 4 or 5 unequal sized spots. They differ from *G. relicta* group by elytral spots (not include the band just before apex) with unequal size and located in different position.

Key to species of Glenea coomani group

1	Elytral apex only having a short tooth at the outer angle (subequal to that at
	the inner angle, Fig. 34)2
_	Elytral apex having a long and sharp spine at the outer angle (much longer
	than that at the inner angle, Fig. 35)
2	Elytron having only one big oval macula at basal fourth; the second macula
	located behind the basal one smallest (Figs 1-4) G. coomani
_	Elytron having two small spots at basal fourth, the first spot is the smallest
	one
3	Elytral apex truncate or slightly emarginate, the middle spot on elytron al-
	most rounded (Figs 25–26) or somewhat transverse (still far from suture, Fig.
	24); male with apex of tergite VIII truncate
_	Elytral apex obliquely truncate, the middle spot on elytron transverse and
	oblique (almost touching sutural stripe, Figs 30-33); male with apex of ter-
	gite VIII doubly emarginate (with a middle projection)
4	Elytron having 5 white or yellow maculae; legs black (Figs 12–15)
_	Elytron having 6 white or yellowbrown maculae
5	Legs testaceous; elytral apical spot smaller, not touching suture; vertex with
	two yellowbrown spots between upper eye lobes(Fig. 27) G. laodice
_	Legs black; elytral apical spot bigger and touching suture; vertex with one
	yellowbrown spot between upper eye lobes (Figs 28-29) G. subalcyone



Figures 33–35. 33 Habitus, *G. tonkinea* Aurivillius, paralectotype, female, from Tonkin, Vietnam. a dorsal view b lateral view. L labels. **34–35** elytral apex of left elytron (not to scale) **34** showing short teeth, tooth length at the outer angle subequal to that at the inner angle **35** showing long spine at the outer angle, much longer than that at the inner angle.

Acknowledgements

We are grateful to Olivier Montreuil and Thierry Deuve (MNHN), Alain Drumont and Patrick Grootaert (IRSNB), Chang-chin Chen (CCCC), Hong Pang, Lizhong Hua, Fenglong Jia and Binglan Zhang (SYSU), Isabelle Zürcher-Pfander, Eva Sprecher and Michel Brancucci (NMB), Xinli Wang and Siliang Liu (CAU), Yanquan Lu and Dong Wen (CWD), Wenxuan Bi (CBWX), Shepherd Myers (BM), Johannes Bergsten (NHRS) and Virgile Marengo (MHNL), for giving access to the collections and the loans of specimens. We wish to express our sincere thanks to Laurence Livermore (The Natural History Museum, London, UK), Nobuo Ohbayashi (Miura City, Japan), Steven W. Lingafelter (National Museum of Natural History, Washington, USA) and Carolus Holzschuh (Villach, Austria) for improving this manuscript. This research was supported by NSFC program 31000967, the National Basic Research Program of China (973 Program) (No. 2011CB302102) and the Knowledge Innovation Program of Chinese Academy of Sciences (Nos. KSCX2-EW-G-4).

References

- Aurivillius C (1925) Neue oder wenig bekannte Coleoptera Longicornia. 21. Arkiv för Zoologi, Uppsala 18A (9): 503–524, 23 figs.
- Breuning S (1956) Revision der Gattung *Glenea* Newm. (1. Fortsetzung). Entomologischen Arbeiten aus dem Museum G. Frey, Tutzing bei München 7 (2): 671–893.

- Breuning S (1964) Contribution à la connaissance des Lamiens du Laos (Coll. Céramb.) Neuvième Partie. Bulletin de la Société Royale des Sciences Naturelles du Laos 10: 15–24, 12 figs.
- Gressitt JL (1940) The Longicorn Beetles of Hainan Island, Coleptera: Cerambycidæ. The Philippine Journal of Science 72 (1–2): 1–239, pls 1–8.
- Hua LZ (2002) List of Chinese Insects. Zhongshan (Sun Yat-sen) University Press, Guangzhou. List of Chinese Insects 2: 1–612.

Pic M (1926) Nouveautés diverses. Mélanges Exotico-Entomologiques 47: 1-32.

Schwarzer B (1925) Sauters Formosa-Ausbeute (Cerambycidae. Col.). (Subfamilie Lamiinae.). Entomologische Blätter 21 (4): 145–154.
RESEARCH ARTICLE



Two new species of *Tovlinius* Zaitzev, from China, with a key to the genera of Bombyliinae from China and a second key to the world species (Diptera, Bombyliidae, Bombyliinae, Bombyliini)

Gang Yao^{1,2,†}, Ding Yang^{1,‡}, Neal L. Evenhuis^{3,§}

I Department of Entomology, China Agricultural University, Beijing 100193, China 2 Zhejiang Forestry Academy, 399 Liuhe Street, Hangzhou, Zhejiang 310020, China 3 Department of Natural Science, Bishop Museum, 1525 Bernice Street, Honolulu, Hawaii 96817-2704, USA

t urn:lsid:zoobank.org:author:D11911F2-3EB5-4E3C-B93D-72F5850E3BE2

turn:lsid:zoobank.org:author:FD9077E0-D8D5-4A3A-80FD-2862726AA066

§ urn:lsid:zoobank.org:author:14ABAF50-BB8C-42D5-BED8-96875E82F9E7

Corresponding author: Ding Yang (dyangcau@126.com)

Academic editor: M. Hauser | Received 8 August 2011 | Accepted 22 November 2011 | Published 9 December 2011 urn:lsid:zoobank.org:pub:8D4CBF53-FDDF-4472-A6BD-6A14F9337477

Citation: Yao G, Yang D, Evenhuis NL (2011) Two new species of *Tovlinius* Zaitzev, from China, with a key to the genera of Bombyliinae from China and a second key to the world species (Diptera, Bombyliidae, Bombyliinae, Bombyliini). ZooKeys 153: 73–80. doi: 10.3897/zookeys.153.2031

Abstract

The genus *Tovlinius* Zaitzev is a Palaearctic genus with just one previously described species, *T. albissimus* Zaitzev. *Tovlinius* is here recorded from China for the first time, and two new species *T. pyramidatus* **sp. n.** and *T. turriformis* **sp. n.** are described and illustrated. A key to the genera of Bombyliinae from China and a second key to the World species of *Tovlinius* are also presented herein.

Keywords

Diptera, Bombyliidae, Tovlinius, new species, China, Palaearctic, taxonomy

Introduction

The genus *Tovlinius* Zaitzev, 1979 belongs to the tribe Bombyliini of Bombyliinae (Evenhuis and Greathead 1999). Species of this genus are easily identified by the

following characters: Proboscis 3.5 times longer than head; eyes of males not converging in the front of ocellar triangle; scape not swollen, tip of first flagellomere with clear terminal stylus; mid-tibial spur absent; vein R_1 - R_{2+3} absent (2 submarginal cells); wing with basicostal infuscation tending to be more intense along margins of veins; wing distinctly swollen close to tip, cell r_5 closed and with long stalk; abdomen broad; body sometimes with pale markings (Greathead and Evenhuis 1997; Zaitzev 1979). *Tovlinius* previously included just one known species (*T. albissimus* Zaitzev) which is known only from Kazakhstan (Evenhuis and Greathead 1999). In the present paper, two new species, *T. pyramidatus* sp. n. and *T. turriformis* sp. n., are added, both from Sichuan Province in western China. A key to the genera of the Bombyliinae from China and a key to World species of the genus *Tovlinius* are presented.

Material and methods

Specimens were studied and illustrated with a ZEISS Stemi 2000-c stereomicroscope. Genitalic preparations were made by macerating the apical portion of the abdomen in cold 10% NaOH for 12–15 hours. After examination they were transferred to fresh glycerin and stored in a microvial pinned below the specimen. Photographs of the wing and adult abdomen were taken with a digital camera (Canon 450D) and modified with Adobe Photoshop. Voucher specimens examined are deposited in the Nankai University, Tianjin (NKU) and the Shanghai Entomological Museum, Chinese Academy of Sciences, Shanghai (SEMCAS). The following abbreviations are used: ad – anterodorsal, av – anteroventral, pd – posterodorsal, pv – posteroventral, dm – discal cell.

Key to genera of Bombyliinae from China

1	Wing with discal cell broadest towards apex, vein M-M meeting M-CuA at
	an obtuse angle; radial sector broad with costa tending to bulge forwards near
	apex of wing, wing broadest towards apex2
_	Wing with discal cell broadest near middle, vein M-M meeting M-CuA at
	not much more than a right angle; radial sector not enlarged with costa more
	or less straight along fore margin of wing, wing not broader toward apex3
2	Antennal scape greatly swollen; mid-tibial spur present; vein R ₁ -R ₂₊₃ present
	in some species (2 or 3 submarginal cells); abdomen elongate ovate; body
	hairs long Conophorus Becker
_	Antennal scape at most only moderately swollen; mid-tibial spur absent; vein
	R ₁ -R _{2,3} absent (2 submarginal cells); abdomen elongate ovate or short and
	broad; body hairs short

3 Head usually as broad as thorax; hind margin of eyes indented; wings often small, narrowed at base with at least alula reduced; body usually more elongate, even narrow conical or cylindrical...... Anastoechus Osten Sacken Head usually distinctly narrower than thorax; eyes not indented on hind margin; wing usually large, broad at base with anal lobe, alula and squama well 4 Wing with cell br as long as cell bm; vein R-M shorter than vein M-M, occasionally almost equal in length; vestiture fine and silky with a clipped appearance at least on occiput and thorax, hairs white to straw-yellow or brown shading to paler on underside Systoechus Loew Wing with cell br longer than cell bm; vein R-M as long as vein M-M; vestiture various, often with black hairs and scale patches; wing pattern various, sometimes with a clear-cut dark infuscation and with isolated dark spots....5 Body length usually less than10 mm, wing entirely infuscated 5 Euchariomyia Bigot Body length usually longer than 10 mm, wing at least with hyaline spots ... 6 6 Antennal scape about twice length of pedicel; upper facets of eyes of males not enlarged; face short and with short sparse hairs only; wing base black, remainder hyaline or tinged yellowish; body hair short and with a clipped appearance, usually with abundant black elements contrasting with areas of white, orange or grey Bombomyia Greathead Antennal scape more than twice length of pedicel; upper facets of eyes of males enlarged; face long, prominent and with long hairs; wing pattern, if present, confined to basicostal area, often diffuse and sometimes with isolated spots, wing rarely completely infuscated; body hair usually long, sometimes tufted and rarely with a clipped appearance, usually predominantly white to yellow or brown with a few black elements, if predominantly black then

Key to world species of Tovlinius

1	Antennal scape covered with long dense black and white hairs; legs mostly
	covered with yellow hairs and bristles2
_	Antennal scape covered with long white hairs; legs mostly covered with white
	scales and black bristles
2	Antenna black, first flagellomere bare; legs black except tibiae yellow; haltere
	dark brown; epandrium slightly narrowing toward tip in dorsal view
_	Antenna black except joints brown, first flagellomere with sparse white scales;
	Legs yellow except femora black; haltere black; epandrium almost parallel-
	sided in dorsal view Tovlinius turriformis sp. n.

Tovlinius pyramidatus sp. n.

urn:lsid:zoobank.org:act:2E882E27-F45A-4C55-BE2E-0FE0310BB51E http://species-id.net/wiki/Tovlinius_pyramidatus Figs 1–7

Diagnosis. Antenna black, first flagellomere elongate, bare. Scutellum with long dense white hairs. Wing uniformly weak brown except base brown; vein C with brush-like long black bristles, white hairs, and yellowish scales. Dorsum of abdomen with long dense white erect hairs and black bristles laterally becoming denser apically; legs black except tibiae yellow; haltere dark brown. Epandrium trapezoidal in lateral view, slightly narrowing toward tip in dorsal view; epiphallus pyramid-shaped.

Description. Male. Body length 10 mm, wing length 9 mm.

Head black. Hairs on head black and white; frons narrowing distally, with long dense black erect hairs; face with long dense white erect hairs; occiput with dense white erect hairs and long sparse black hairs. Antenna black; scape elongate with long dense black and white hairs; first flagellomere elongate, bare, with stylus at tip. Proboscis broken.

Thorax black. Hairs on thorax mostly white; postpronotal lobe with long dense white hairs, mesonotum with long dense white hairs; thorax with sparse white hairs on an an episternum, and with long dense white hairs on katepisternum. Scutellum black with long dense white hairs. Legs black except tibiae yellow. Hairs on legs mostly yellow, bristles yellow. Femora with dense white hairs and scales; tibiae and tarsi with short yellow hairs and white scales. Hind femur with three *av*. Fore tibia with seven *ad*, eight *pd*, six *pv*; mid tibia with seven *ad*, eight *pd*, eight *av*, seven *pv*; hind tibia with eight *ad*, seven *pd*, six *av*, six *pv*. Wing (Fig. 1) uniformly weak brown except base brown. Vein r-m close to tip of cell dm, cell r_5 closed. Base of vein C with brush-like long black bristles, white hairs, and yellowish scales. Haltere dark brown.

Abdomen black. Hairs on abdomen mostly white; with long dense white erect hairs and sparse yellowish hairs dorsally, and with black bristles laterally that become denser apically. Sternites black except posterior edge and middle brown, sternites with long dense white erect and recumbent hairs.

Male genitalia (Figs 2–7). Epandrium trapezoidal in lateral view, distinctly higher than long, distinctly wider than long in dorsal view; cercus well exposed in lateral view; gonocoxite distinctly narrowing apically in ventral view; gonostylus oval with apex pointed (seen laterally); epiphallus pyramid-shaped with apex very narrow, epiphallus with narrow, long, and curved tip in lateral view.

Female. Unknown.

Type material. Holotype male, CHINA: Sichuan, Hongyuanxian, Shuajingsi (32°00'52"N, 102°36'59"E), 5.VIII.1983, Leyi Zheng (NKU).

Distribution. China (Sichuan).

Etymology. The species is named after the pyramid-form of the epiphallus.

Remarks. *Tovlinius pyramidatus* is similar to *T. albissimus* Zaitzev, but it can be differentiated from the latter by the following points: Scape covered with long dense



Figures 1–7. *Tovlinius pyramidatus* sp. n. wing and male genitalia 1 wing, dorsal view 2 epandrium and cercus, dorsal view 3 epandrium and cercus, lateral view 4 gonocoxite and gonostylus, lateral view 5 phallus, dorsal view 6 phallus, lateral view 7 gonocoxite and gonostyli, ventral view.

black and white hairs; legs black except tibiae yellow, mostly covered with yellow hairs and bristles; haltere dark brown; epandrium slightly narrowing toward tip in dorsal view. In *T. albissimus*, the scape is covered with the long white hairs; the legs are yellow and covered with the white scales; the haltere is pale yellow; the epandrium is distinctly narrowing toward the tip in dorsal view (Zaitzev 1979).

Tovlinius turriformis sp. n.

urn:lsid:zoobank.org:act:EEDE376A-9368-4247-9403-38A795B35FEB http://species-id.net/wiki/Tovlinius_turriformis Figs 8–14

Diagnosis. Antenna black except joints brown, first flagellomere elongate with sparse white scales. Scutellum with long white hairs, posterior edge with white bristles. Wing uniformly weak brown; base of vein C with brush-like long black bristles, white hairs, and white scales. Dorsum of abdomen with long dense white erect hairs and white bristles laterally, hairs and bristles becoming denser apically; legs yellow except femora black; haltere black. Epandrium trapezoidal in lateral view, almost parallel-sided in dorsal view; epiphallus turriform in dorsal view.

Description. Male. Body length 10 mm, wing length 9 mm.

Head black. Hairs on head black and white; frons narrowing distally, with long dense black and white erect hairs; face with long dense white erect hairs; occiput with long dense white erect hairs and long sparse black hairs. Antenna black except joints brown; scape elongate with long dense black and white scales; first flagellomere elongate with sparse white scales, and tip with a stylus. Proboscis black, nearly five times longer than head.

Thorax black with brown pollen. Hairs on thorax mostly white; postpronotal lobe with long dense white hairs, mesonotum with sparse long white hairs; anepisternum and katepisternum with long dense white hairs. Scutellum black with long white hairs, posterior edge with white bristles. Legs yellow except femora black. Hairs on legs mostly yellow, bristles yellow, scales white. Femora with dense white hairs and scales; tibiae and tarsi with short yellow hairs and white scales. Hind femur with three *ad*, three *av*, and three *pv*. Fore tibia with seven *ad*, eight *pd*, five *av*, and six *pv*; mid tibia with seven *ad*, seven *pd*, eight *av*, and six *pv*; hind tibia with eight *ad*, seven *pd*, seven *av*, and six *pv*. Wing (Fig. 8) uniformly weak brown. Vein r-m close to tip of cell dm, cell r_5 closed. Base of vein C with brush-like long black bristles, white hairs, and white scales. Haltere black.

Abdomen black. Hairs on abdomen mostly white; dorsum with long dense white erect hairs and lateral surface with white bristles that become denser apically, tergites 4-7 with some black bristles laterally. Sternites with long dense white hairs.

Male genitalia (Figs 9–14). Epandrium trapezoidal, distinctly higher than long, slightly wider than long in dorsal view; cercus well exposed in lateral view; gonocoxite distinctly narrowing apically in ventral view; gonostylus oval, its tip acute in lateral view; epiphallus turriform, obtuse at tip in dorsal view, epiphallus with a narrow, long, and curved tip in lateral view.

Female. Unknown.

Type material. Holotype male, CHINA: Sichuan, Maerkang (31°54'21"N, 102°12'23"E), 30.VII.1986, Tianqi Wang (SEMCAS).



Figures 8–14. *Tovlinius turriformis* sp. n. wing and male genitalia 8 wing, dorsal view 9 epandrium and cercus, dorsal view 10 epandrium and cercus, lateral view 11 gonocoxite and gonostylus, lateral view 12 phallus, dorsal view 13 phallus, lateral view 14 gonocoxite and gonostyli, ventral view.

Distribution. China (Sichuan).

Etymology. The species epithet derives from the Latin "*turri* [=tower, turret] + *formis*" [= form]; referring to the tower-like shape of the epiphallus.

Remarks. *Tovlinius turriformis* is similar to *T. albissimus* Zaitzev, but it can be separated from the latter by the following points: Antenna black except joints brown; legs yellow except femora black, mostly covered with yellow hairs and bristles, and white scales; haltere black; epandrium almost parallel-sided in dorsal view. In *T. albissimus*, the basal two antennal segments are yellow; the legs are yellow and covered with the white scales; the halteres are pale yellow; the epandrium is distinctly narrowing toward the tip in dorsal view (Zaitzev 1979).

Acknowledgements

We are very grateful to Prof. Leyi Zheng (Tianjin) and Mr. Tianqi Wang (Shanghai) for collecting the specimens. We also thanks Mr. Xianwei Liu and Mrs. Weinian Zhang (Shanghai) for they enormous help on the research. This research is funded by Special Fund for Agro-scientific Research in the Public Interest (No. 200903021).

References

- Evenhuis NL, Greathead DJ (1999) World catalog of bee flies (Diptera: Bombyliidae). Backhuys Publishers, Leiden, 756 pp.
- Greathead DJ, Evenhuis NL (1997) Family Bombyliidae. In: Papp L, Darvas B (Ed) Contribution to a manual of Palaearctic Diptera (with special reference to flies of economic importance). Vol 2, Science Herald Press, Budapest, 487–512.
- Zaitzev VF (1979) [A new genus of bee flies (Diptera, Bombyliidae) from the Palaearctic]. Trudy Zoologicheskogo Instituta 88: 116–119.

RESEARCH ARTICLE



A new species of *Chilicola* from Bahia, Brazil (Hymenoptera, Colletidae), with a key to the species of the *megalostigma* group

Favízia Freitas de Oliveira^{1,†}, Thiago Mahlmann^{1,‡}, Michael S. Engel^{2,§}

I Laboratório de Bionomia, Biogeografia e Sistemática de Insetos (BIOSIS), Departamento de Zoologia, Instituto de Biologia, Universidade Federal da Bahia, Rua Barão de Jeremoabo, s/n, Campus Universitário de Ondina, Salvador, CEP 40170-115, Bahia, Brazil 2 Division of Entomology, Natural History Museum, and Department of Ecology & Evolutionary Biology, 1501 Crestline Drive − Suite 140, University of Kansas, Lawrence, Kansas 66045, USA

turn:lsid:zoobank.org:author:6960CB08-30C5-4A9A-8374-9D30D460D79D
 turn:lsid:zoobank.org:author:89C58412-B525-4183-8155-7DEA375FD0C2
 urn:lsid:zoobank.org:author:3714A7FF-E19E-495A-AAF9-98D2F597B757

Corresponding author: Favízia Freitas de Oliveira (favosgyrl@gmail.com)

Academic editor: M. Ohl	Received 2 October 2011 Accepted 28 November 2011 Published 9 December 2011
	urn:lsid:zoobank.org:pub:E5D1C44A-1252-4959-A9A3-E930ACE23514

Citation: de Oliveira FF, Mahlmann T, Engel MS (2011) A new species of *Chilicola* from Bahia, Brazil (Hymenoptera, Colletidae), with a key to the species of the *megalostigma* group. ZooKeys 153: 81–90. doi: 10.3897/zookeys.153.2188

Abstract

The bee genus *Chilicola* Spinola (Xeromelissinae) is recorded from the State of Bahia, Brazil for the first time, based on a new species of the *megalostigma* group of the subgenus *Hylaeosoma* Ashmead. *Chilicola* (*Hylaeosoma*) *kevani* **sp. n.** is described and figured from males collected in Wesceslau Guimarães, Bahia. The species can be distinguished on the basis of coloration, size, integumental sculpturing, and structure of the hidden metasomal sterna and genitalia. A revised key to the species of the *megalostigma* group is provided.

Keywords

Apoidea, Anthophila, Colletidae, Xeromelissinae, taxonomy, new species, Chilicola, Hylaeosoma, Brazil

Introduction

The Neotropical genus *Chilicola* Spinola (Xeromelissinae) comprises small (ca. 3–8 mm in length), slender bees. The body is typically very long and usually black, without

dense pubescence, and superficially resembling bees of the genus *Hylaeus* Fabricius (Hylaeinae). The genus occurs from Mexico to Chile, with its greatest diversity in Chile (Michener 1992, 1995, 2002, 2007; Packer and Genaro 2007). There are nearly 100 described species assigned to *Chilicola* and these are segregated into 15 subgenera (Packer 2008). While these subgenera appear to be good monophyletic units, the relationships among them are not entirely stable (Packer 2008).

The subgenus *Hylaeosoma* Ashmead has been thoroughly characterized by Michener (1992, 1995, 2002, 2007) and, unlike other subgenera, is not found in the temperate regions of South America, but occurs widely from Peru to northern Mexico (e.g., Michener 2002, 2007). Hitherto the subgenus has included 16 living and two fossil species (Table 1: Moure and Urban 2008). Michener (1992) divided the subgenus into two distinct groups of species, with those of the *megalostigma* group consisting of bees with polished and very shiny integument, elongate heads, and a flared and prominent preoccipital carina. Five species have been included in the group: *Chilicola (Hylaeosoma) megalostigma* (Ducke), *C. (H.) polita* Michener, *C. (H.) stenocephala* Brooks and Michener, *C. (H.) yanezae* Hinojosa-Díaz and Michener, and *C. (H.) muruimuinane* Smith-Pardo and Gonzalez. Four of the five species occur from Colombia to Mexico (Table 1), while *C. megalostigma* is known from Peru, Bolivia, and Brazil (Moure and Urban 2008).

Taxon	Sex known	Distribution			
Subgenus <i>Hylaeosoma</i> Ashmead					
megalostigma species group (= Group B, Michener 1992)					
C. megalostigma (Ducke, 1908)	₽ <i>3</i>	Bolivia, Brazil, Peru			
C. polita Michener, 1992 [1994]	Q3	Mexico to Costa Rica			
C. stenocephala Brooks & Michener, 1999	₽ <i>3</i>	Colombia: Amazonas			
C. yanezae Hinojosa-Díaz & Michener, 2005	₽ <i>3</i>	Mexico: Morelos			
C. muruimuinane Smith-Pardo & Gonzalez, 2007	₽ <i>3</i>	Colombia: Caquetá, Putumayo			
C. kevani sp. n.	8	Brazil: Bahia			
longiceps species group (= Group A, Michener 1992)					
C. longiceps (Ashmead, 1900)	2 <i>3</i>	Mexico: Jalisco; St. Vincent			
<i>C. huberi</i> (Ducke, 1908)	Ŷ	Brazil: Ceará			
C. aequatoriensis Benoist, 1942	₽ <i>3</i>	Colombia, Ecuador, Peru, Venezuela			
C. mexicana Toro & Michener, 1975	₽ <i>3</i>	Mexico: México, Hidalgo, Morelos			
C. griswoldi Michener, 1992 [1994]	₽ <i>3</i>	Mexico: México, Michoacán			
C. gracilis Michener & Poinar, 1996	8	Dominican amber (Miocene)			
C. electrodominica Engel, 1999	Ŷ	Dominican amber (Miocene)			
C. belli Michener, 2002	23	Colombia, Venezuela			
C. canei Michener, 2002	2 <i>3</i>	Colombia: Antioquia			
C. involuta Michener, 2002	<u></u> \$3	Ecuador: Azuay			
C. smithpardoi Michener, 2002	₽ <i>ð</i>	Colombia: Antioquia			
C. umbonata Michener, 2002	8	Colombia: Valle; Ecuador: Loja			
C. bochica Gonzalez in Gonzalez and Giraldo 2009	£3	Colombia: Boyacá			

 Table 1. Species of Chilicola subgenus Hylaeosoma.

The present paper describes a sixth species of the *megalostigma* group, which also represents the first record of the genus *Chilicola* for the State of Bahia in Brazil. In addition, we provide an expanded and updated identification key to species for the *megalostigma* group.

Material and methods

Morphological terminology used herein is adapted from Engel (2001) and Michener (2007), while the format for the description is taken from those of Hinojosa-Díaz and Michener (2005) and Smith-Pardo and Gonzalez (2007). Abbreviations used for common morphological terms are: S, metasomal sternum; T, metasomal tergum; F, flagellomere; DS, diameter of the antennal scape; and OD, ocellar diameter (based on the median ocellus). Measurements and proportions are adapted from Moure and Sakagami (1962): body length, head length and width, upper and lower ocular distances, and ocellocipital distance. Photomicrographs were prepared using a Nikon D1x digital camera attached to an Infinity K-2 long-distance microscope lens.

Systematics

Genus *Chilicola* Spinola Subgenus *Hylaeosoma* Ashmead

Chilicola (*Hylaeosoma*) *kevani* Oliveira, Mahlmann & Engel, sp. n. urn:lsid:zoobank.org:act:E90007EC-B88D-40D2-ABDD-CD5E5BB34D30 http://species-id.net/wiki/Chilicola_kevani Figs 1–8

Holotype. (3), Brazil, Bahia (Wesceslau Guimarães, Estação Ecológica, 18.I.2011 [18] January 2011], Rede Entomológica, P. Ferreira *Leg.* // Colletidae: *Chilicola* (*Hylaeo-soma*) sp. n. ?, Det. Oliveira & Mahlmann, 2011 // Coletada na flor: Cyperaceae: *Scleria arundinacea* Kunth. The specimen is in excellent condition and is deposited in the Entomological Collection of the Zoological Museum of the Federal University of Bahia (MZUFBA), in Salvador, Bahia, Brazil.

Paratype. *C*, with same label data as holotype. Paratype deposited in the Division of Entomology (Snow Entomological Collections), University of Kansas Natural History Museum (SEMC), Lawrence, Kansas, USA.

Diagnosis. This species is quite similar to other species of its group but differs from them in the markedly larger body size (ca. 7.6 mm), the largely honey yellow integument (Figs. 1, 3) (except dark brown on head, flagellum, disc and sides of pronotum, mesoscutum, mesoscutellum, metanotal disc, basal dorsal surface of propodeum, most of the mesepisternum, and large portions of T4–T7 and S5–S6:



Figures 1–2. Photomicrographs of paratype (SEMC) male of *Chilicola (Hylaeosoma) kevani* Oliveira, Mahlmann, and Engel sp. n. I Lateral habitus 2 Facial aspect.

refer to Description, *infra*), and the form of the hidden sterna (Figs. 4, 5) and genital capsule (Figs. 6–8).

Description. \mathcal{T} : *Structure*: Total body length 7.60 mm; forewing length 4.70 mm. Head elongate (Fig. 2), length 2.12 mm, width 1.05 mm; compound eyes converging below (Fig. 2), upper ocular distance 0.65 mm, lower ocular distance 0.25 mm; paraocular depressed area well developed for reception of scape, terminating at level of upper tangent of compound eyes; area adjacent area to inner edge of depression above antennal alveoli with prominent gray oval spot, with diameter about 1OD and 2.5×longer than wide; F1 slightly longer than pedicel and about 2× longer than wide; F2 and F3 as long as broad; F11 approximately 3× longer than wide; malar area about 2× wider than long; occeloccipital distance about 2.5OD as measured from apex of preoccipital carina; preoccipital carina markedly laminate (Figs. 1, 2); metasomal T1 longer than wide, length 0.90 mm, width 0.80 mm; T2 and T3 weakly constricted in basal half in profile; apex of T7 slightly truncate; distal margin of S6 terminating in two lateral lamellate projections from which arise a tuft of relatively long and thick bristles; S7, S8, and genitalia as in figures 4-8: S7 with two lateral projections between basal apodemes and more apical ventral and dorsal lobes, each lateral projection about 2× longer than wide (Fig. 4); apex of inferior lobe of S7 strongly narrowed and curved inward apically, outer edge with a comb of very long bristles (Fig. 4); superior lobe of



Figures 3–8. Photomicrographs of male paratype (SEMC) of *Chilicola (Hylaeosoma) kevani* Oliveira, Mahlmann, and Engel sp. n. 3 Dorsal habitus 4 Seventh metasomal sternum 5 Eighth metasomal sternum 6 Genital capsule, dorsal view 7 Genital capsule, lateral view 8 Genital capsule, ventral view.

S7 broad (Fig. 4); S8 basad of apodemes strongly narrowed, not forming a broad triangular area (Fig. 5); apical bifurcation of S8 nearly orthogonal to central axis of sternum, bearing small bilobed process between diverging processes, each lobe with prominent setae (Fig. 5); genital capsule as in figures 6–8, with gonostylus broadly rounded apically and curved ventrally near apex.

Sculpturing: Integument strongly polished and shining (as in other species of the *megalostigma* group), generally smooth or with very faint imbricate microsculpture,

with scattered shallow punctures, most punctures separated by more than $2-3 \times a$ puncture width; two small, half-moon-shaped foveae on each side of head near concavity of compound eyes; dorsal base of propodeum with approximately 18 longitudinal carinae set in slight depression and radiating from basal margin.

Coloration: Integument predominantly honey yellow or amber colored (Figs. 1, 3); head dark brown except labiomaxillary complex, labrum, apical margin of clypeus, scape, and pedicel honey yellow; F1 and F2 lighter brown than remainder of flagellum; pronotum largely brown with anterior margin and pronotal lobe honey yellow to amber colored; mesoscutum and mesoscutellum brown; metanotum and dorsal base of propodeum light brown; tegula translucent, honey yellow; axillary sclerites and base of C+Sc honey yellow, otherwise wing venation brown, pterostigma prominent and slightly darker brown than other veins; wing membrane hyaline, slightly and faintly infumate apically; majority of preëpisternum and mesepisternum brown; lower portion of metepisternum light brown; outer surface of metatibia slightly brownish, particularly in apical half; outer surface of metabasitarsus slightly brownish; distal margin of T3 with brown band interrupted medially (absent in paratype); T4–T7 brown except some honey yellow present at lateral extremities of T4; S5–S6 brown, with slightly brownish area apically on S4.

Pubescence: Mostly consisting of golden setae (Figs. 1-3); head with scattered, largely simple setae, those on supraclypeal area, above compound eyes, vertex, gena, and postgena longer; setae dorso-apically on scape longer, ca. 1DS, remainder much shorter; a few short, branched setae on face near concavity of compound eyes. Mesosomal setae generally simple except more plumose around pronotal lobe; posterior margin of pronotum and lateral margins of mesoscutum with numerous, minute, pale, branched setae, becoming more whitish around pronotal lobe; discs of mesoscutum and mesoscutellum with relatively short and sparse setae; posterior margin of metanotum with minute whitish plumose setae interspersed with longer, gold setae, laterally with long setae, about 1.5DS, such setae apically curved; meso- and metapleura and lateral surface of propodeum generally with long, largely simple setae scattered over surface, although setae more numerous than on mesosomal dorsum, setae of preëpisternum slightly shorter and distinctly branched; pro- and metacoxae, protrochanter, and ventral surface of profemur with dense, long branched setae, such setae about 0.5× length of scape, density of setae on posterior of metacoxa about one-half that of procoxa; setae longer on inner surfaces of metatibia and metabasitarsus. Metasoma generally with sparsely scattered, long setae, mostly apically on terga and sterna, setae becoming progressively longer on more apical segments; lateral areas of S5 with very long, thick setae, extending to apex of metasoma (Fig. 1), such setae typically curved apically; S6 with lateral setae about one-third shorter, apically curved; setae distribution on S7–S8 and genitalia as in figures 4–8.

♀: Unknown.

Etymology. The specific epithet is a patronym honoring Dr. Peter G. Kevan, University of Guelph, who has encouraged the study and highlighted the importance of pollinators in Brazil, particularly through field courses on pollination biology and ecology.

87

Key to species of the megalostigma species group

Modified and updated from keys provided by Brooks and Michener (1999) and Smith-Pardo and Gonzalez (2007).

1	Body size small (4.5–6 mm); integument predominantly dark brown to
	black; male S/ with inferior apical processes broad, without prominent comb
	ing anisulum with out constriction at base of elements eniced extension, eniced
	hig spiculum, without construction at base of clongate apical extension, apical
	bifurcating processes with acute angle between them, without small bilobed
	area between diverging processes
-	Body size relatively large (ca. 7.60 mm); integument predominantly honey
	yellow (Figs. 1, 3); male S7 with inferior apical processes tapering rapidly
	to thin, elongate processes bearing prominent comb of strong bristles along
	margin (Fig. 4); male S8 basally narrowed around spiculum, strongly con-
	stricted at base of apical process, with diverging apical processes nearly or-
	thogonal to longitudinal axis of sternum, with small bilobed area between
	diverging processes (Fig. 5) (Brazil: Bahia) C. kevani sp. n.
2(1)	Minimum distance between compound eyes about that of width of com-
	pound eye; malar area short, almost one-half or less than its maximum width;
	female basal metatarsomeres with apical process variable, ranging from al-
	most straight to curved; male S8 more typical for subgenus and megalostigma
	group, elongate extension bifurcate apically, with thin diverging processes
	separated by an acute angle
_	Minimum distance between compound eyes about three-fourths width of
	compound eye; malar area long, more than one-half of its maximum width;
	female basal metatarsomeres with apical process distinctly curved; male S8
	unique for subgenus, not bifurcate apically, apical extension spatulate, with
	broad apical area bearing prominent setae (Colombia: Amazonas)
3(2)	Frontal line without depression; female basal metatarsomeres with apical pro-
	cess variable, with or without long thicker setae
_	Frontal line with conspicuous depression about 1OD in size just above level
	of antennal toruli, with antennal toruli forming a triangle of equal sides
	(isosceles); female basal metatarsomeres with apical process almost straight,
	terminating in a prominent setae thicker than other tarsal setae (Bolivia,
	Brazil, Peru)
4(3)	Total length ca. 4.5-5.2 mm; pronotal coloration variable; male S7 with
	more elongate processes relatively broad
_	Total length ca. 5.5 mm; pronotum dark brown; female basal metatarsomeres
	with apical process almost straight, terminating in setae similar to other tarsal
	setae; male S7 with more elongate processes narrower, particularly in basal
	half (Mexico to Costa Rica)

Discussion

Among the species of the megalostigma group perhaps one of the most unusual is C. stenocephala. In this species the form of the terminalia differs dramatically from other members of the group and, indeed, from other Hylaeosoma as well. While species of the group tend to have S8 bifid apically, with the bifurcation comprising thin, diverging processing at the apex of a narrow elongate extension of the disc (e.g., Fig. 5), C. stenocephala instead has a broad apical expansion bearing prominent setae [refer to figures in Brooks and Michener (1999)]. The gonostyli are also considerably different in this species in which they are narrowed apically, elongate, and curved mesally (Brooks and Michener 1999) in contrast to the otherwise broad and weakly or not curved mesally (typically curved ventrally) in the others species [e.g., Figs. 6-8; and figures in Michener (1992, 2002), Hinojosa-Díaz and Michener (2005), Smith-Pardo and Gonzalez (2007)]. The remaining species have terminalia that are more or less of a similar structure. The S8 of C. megalostigma, C. polita, C. yanezae, and C. muruimuinane are the most similar in that each have a broadly triangular base encompassing the basal spiculum and extending to the lateral apodemes, while in C. kevani this is greatly narrowed and the lateral apodemes are more prominent (e.g., Fig. 5). Chilicola muruimuinane perhaps comes closest in form to that of C. kevani in that the sides of this triangular base are distinctly concave (Smith-Pardo and Gonzalez 2007), albeit not nearly as strongly so as in C. kevani. In addition, while the aforementioned species have the discal process tapering rapidly to a narrow and elongate extension becoming bifid apically (a general structure somewhat characteristic of the megalostigma group), in C. kevani there is a prominent constriction between the extreme base of the disc and the remainder of the apical portion of the sternum. Immediately apicad of the constriction the sternum flares outward, curves apicad and tapers rapidly to the narrow neck of the extension (Fig. 5). Apically the extension bifurcates with the thin processes diverging more strongly such that they are nearly orthogonal with the longitudinal axis of the sternum (Fig. 5). Between the processes is a small, apically bilobed structure which bears prominent setae at the apex of each lobe (Fig. 5), a unique autapomorphy among the subgenus. It is too

early to comment on the possible interrelationships of these species as most features are autapomorphic and there are undoubtedly additional species to be discovered in the vast areas of suitable habitat throughout South America and southern Central America. Continued collecting in Bahia should be undertaken in order to discover the female of *C. kevani*, to better document the distributions of the diversity of bee species in the region, and to document any new species that may come to light.

Acknowledgements

The authors are grateful to Patrícia Alves Ferreira (doctoral student of UFBA) and her advisors for providing the specimens referred herein. The material was collected as part of Patricia's PhD project entitled "Influence of habitat loss on the networks interactions between plants and pollinators in fragmented landscapes in Bahia" and under the guidance of Prof. Dr. Blandina Felipe Viana (UFBA) and co-led by Dr. Danilo Boscolo (UNIFESP). Their project was supported by the Foundation for Research of the State of Bahia - FAPESB and as part of "Effect of reduced vegetation cover and biogeographic history of extinction thresholds", itself a subset of the principal project "Integrating Levels of Organization in Ecological Predictive Models: Contributions of Epistemology, Modeling and Empirical Research" supported by the Support Program for Centers of Excellence PRONEX/FAPESB/CNPg and coordinated by Prof. Charbel El-Hani (UFBA). We are indebted to the institutions supporting these interdisciplinary projects which made possible the collections in which the new species of *Chilicola* was discovered. We are additionally grateful to two anonymous reviewers and Dr. Michael Ohl, the last as editor, for comments and assistance with the manuscript. This is also a contribution of the Division of Entomology, University of Kansas Natural History Museum and partially supported by US NSF DBI-1057366 (to MSE).

References

- Ashmead WH (1900) Report upon the aculeate Hymenoptera of the islands of St. Vincent and Grenada, with additions to the parasitic Hymenoptera and a list of the described Hymenoptera of the West Indies. Transactions of the Entomological Society of London 48(2): 207–367. doi: 10.1111/j.1365-2311.1900.tb02379.x
- Benoist R (1942) Les Hyménoptères qui habitent les tiges de ronce aux environs de Quito (Equateur). Annales de la Société Entomologique de France 111: 75–90.
- Brooks RW, Michener CD (1999) The *Chilicola megalostigma* species group and notes on two lost types of *Chilicola* (Hymenoptera: Colletidae, Xeromelissinae). Journal of Hymenoptera Research 8(2): 132–138.
- Ducke A (1908) Contribution à la connaissance de la faune hyménoptérologique du Nord-Est du Brésil. Revue d'Entomologie 27: 57–87.

- Engel MS (1999) A new xeromelissine bee in Tertiary amber of the Dominican Republic (Hymenoptera: Colletidae). Entomologica Scandinavica 30(4): 453–458. doi: 10.1163/187631200X00561
- Engel MS (2001) A monograph of the Baltic amber bees and evolution of the Apoidea (Hymenoptera). Bulletin of the American Museum of Natural History 259: 1–192. doi: 10.1206/0003-0090(2001)259<0001:AMOTBA>2.0.CO;2
- Gonzalez VH, Giraldo C (2009) New Andean bee species of *Chilicola* Spinola (Hymenoptera: Colletidae, Xeromelissinae) with notes on their biology. Caldasia 31(1): 145–154.
- Hinojosa-Díaz IA, Michener CD (2005) A new bee of the genus *Chilicola* Spinola (Hymenoptera: Colletidae: Xeromelissinae) from central Mexico. Proceedings of the Entomological Society of Washington 107(1): 1–6.
- Michener CD (1992 [1994]) Mexican and Central American species of *Chilicola* (Hymenoptera: Colletidae). Folia Entomológica Mexicana 85: 77–93.
- Michener CD (1995) A classification of the bees of the subfamily Xeromelissinae (Hymenoptera: Colletidae). Journal of the Kansas Entomological Society 68(3): 332–345.
- Michener CD (2002) The bee genus *Chilicola* in the tropical Andes, with observations on nesting biology and a phylogenetic analysis of the subgenera (Hymenoptera: Colletidae, Xeromelissinae). Scientific Papers, Natural History Museum, University of Kansas 26: 1–47.
- Michener CD (2007) The Bees of the World [2nd Edition]. Johns Hopkins University Press, Baltimore, xvi+[i]+953 pp., +20 pls.
- Michener CD, Poinar G, Jr (1996) The known bee fauna of the Dominican amber. Journal of the Kansas Entomological Society, Supplement 69(4): 353–361.
- Moure JS, Sakagami SF (1962) As mamangabas sociais do Brasil (*Bombus* Latreille) (Hymenoptera, Apoidea). Studia Entomologica 5(1–4): 65–194.
- Moure JS, Urban D (2008) Xeromelissini Cockerell, 1926. In: Moure JS, Urban D, Melo GAR (Eds) Catalogue of Bees (Hymenoptera, Apoidea) in the Neotropical Region, 743–756. Available and updated online at http://www.moure.cria.org.br/catalogue [accessed 1 October 2011].
- Packer L (2008) Phylogeny and classification of the Xeromelissinae (Hymenoptera: Apoidea, Colletidae) with special emphasis on the genus *Chilicola*. Systematic Entomology 33(1): 72–96.
- Packer L, Genaro JA (2007) Fifteen new species of *Chilicola* (Hymenoptera: Apoidea; Colletidae). Zootaxa 1468: 1–55.
- Smith-Pardo AH, Gonzalez VH (2007) Abejas Chilicola (Hylaeosoma) Ashmead (Colletidae: Xeromelissinae) del grupo megalostigma: Una especie nueva de Colombia y clave para las especies. Neotropical Entomology 36(6): 910–913. doi: 10.1590/S1519-566X2007000600012
- Toro H, Michener CD (1975) The subfamily Xeromelissinae and its occurrence in Mexico (Hymenoptera: Colletidae). Journal of the Kansas Entomological Society 48(3): 351–357.