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ORIGINAL ARTICLE

Two new spider families from Late Cretaceous Kachin amber (Arachnida: Araneae)

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Abstract Two new spider families from Late Cretaceous Kachin amber (Myanmar), †Pilosarachnidae Jiang & Li, **fam. nov.** and †Gigarachnidae Jiang & Li, **fam. nov.**, are described: *Pilosarachne ju* Jiang & Li, **gen.** & **sp. nov.** and *Gigarachne bian* Jiang & Li, **gen.** & **sp. nov.** Type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS). Both families bear three tarsal claws and are most likely entelegyne. Diagnostic characters of extinct families in Kachin amber with uncertain relationships with extant fauna are listed and discussed.

Key words Lagerstätte, Myanmar, new species, new genus.

1 Introduction

The Cretaceous is a crucial geological period in the evolution of the terrestrial ecosystem (Lloyd *et al.*, 2008), as well as a crucial stage of spider evolution. Kachin amber from Myanmar is a famous Lagerstätte with a huge number of extremely well-preserved invertebrates from Late Cretaceous, including highly diverse spider fauna. Excluding the brilliant but controversial long-tailed arachnid *Chimerarachne yingae* (Huang *et al.*, 2018; Wang *et al.*, 2018), with uncertain placement in Araneae or Uraraneida, 250 species of spiders have been recorded in Kachin amber up to date, belonging to 26 extinct families and 18 extant families (Dunlop *et al.*, 2020; Wunderlich & Müller, 2020; Guo *et al.*, 2020). Most are three-clawed spiders that presumably spin foraging webs. Among the 26 extinct families, 9 are araneomorph spiders that cannot be assigned to any extant major araneoid clades (Mesothele, Mygalomorphae, Synspermiata, Hypochilidae + Filistatidae, Leptonetidae, Austrochilioidea, Palpimanoidea, Eresidae, Nicodamoidea, Araneoidea, Uloboridae, Hersiliidae + Oecobiidae, Deinopidae or RTA clade; see Wheeler *et al.*, 2017 and Fernández *et al.*, 2018).

Here, we describe two further new species from Kachin amber with uncertain relationships to modern clades and erect new families based on them: *Pilosarachne ju* Jiang & Li, **gen.** & **sp. nov.**, type species of †Pilosarachnidae Jiang & Li, **fam. nov.**, and *Gigarachne bian* Jiang & Li, **gen.** & **sp. nov.**, type species of †Gigarachnidae Jiang & Li, **fam. nov.**

2 Materials and methods

All materials described here are deposited in the Institute of Zoology, Chinese Academy of Sciences (IZCAS). Kachin ambers were excavated in Kachin State, Myanmar. U–Pb dating indicates a maximum age of 98.79 ± 0.62 Ma (earliest

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Cenomanian, Late Cretaceous) for amber from Hukawng Valley of Kachin State, northern Myanmar (Shi *et al.*, 2012), but the actual age might be slightly older (Mao *et al.*, 2018).

All specimens were examined and measured with a Leica M205C stereomicroscope. Photos of amber pieces and spider bodies were either taken with a Canon EOS 60D digital camera with Canon EF 100 mm f/2.8L IS USM Macro lens or with an Olympus C7070 digital camera mounted on an Olympus SZX12 dissecting microscope. Details of specimens were taken with an Olympus C7070 camera mounted on an Olympus BX51 compound light microscope. Photos were stacked using Helicon Focus® 6.7.1 and processed using Adobe Photoshop CC® 2014 and Adobe Photoshop Lightroom® 5.2. The interpretive drawing was done using Procreate®.

All measurements are in millimeters (mm). Measurements of appendages of both sides are given as follows: for legs: total length (femur, patella, tibia, metatarsus, tarsus); for palps: total length (femur, patella, tibia, cymbium). Spination follows Davies (1994). Terminology of morphological characters follows Griswold *et al.* (2005), Ramírez (2014) and Polotow *et al.* (2015). Arising points of tegular appendices are given as clock positions on the left palp in ventral view. If the left palp is strongly deformed or not observable in particular views, the images of the right palp will be taken instead but horizontally flipped for the sake of comparison.

Abbreviations used in the text and figures are listed below:

ALE—anterior lateral eyes;
AME—anterior median eyes;
C—conductor;
CH—clypeal height;
Cy—cymbium;
E—embolus;
En—endite;
Fe—femur;
ITC—inferior tarsal claw;
Lb—labium;
MA—median apophysis;
Pa—patella;
PLE—posterior lateral eyes;
PME—posterior median eyes;
PP—pars pendula;
RTA—retrolateral tibial apophysis;
SACS—serrate accessory claw setae;
Sp—spine;
Sr—serrula;
STC—superior tarsal claw;
T—tegulum;
Ti—tibia;
VCR—vestigial cribellar region.

3 Systematic palaeontology

Order Araneae Clerck, 1757
Infraorder Araneomorphae Smith, 1902

Family †Pilosarachnidae Jiang & Li, fam. nov.

Type genus. *Pilosarachne* Jiang & Li, **gen. nov.**

Diagnosis. Pilosarachnidae Jiang & Li, **fam. nov.** can be distinguished from Synspermiata by the presence of AME and the morphology of bulb which is not piriform; from Araneoidea and Palpimanoidea by the presence of cribellum; from Dionycha of RTA clade by the presence of ITC. The new family resembles modern cribellate RTA clade spiders (*e.g.*, members of marronoid clade such as Dictynidae O. Pickard-Cambridge, 1871, Desidae Pocock, 1895, *etc.*) by the shape of cymbium, attaching angle of bulb relative to cymbium and the arrangement of tegular apophyses (Figs 3A–D), but can be

easily distinguished by the absence of an RTA and the presence of serrate accessory claw setae. Pilosarachnidae Jiang & Li, **fam. nov.** resembles Hersiliidae Thorell, 1870 by the presence of feathery scales (in the sense of Griswold *et al.*, 2005), discoid tegulum, presence of median apophysis and filiform embolus, but can be distinguished from the latter by the short clypeus, eye domain in an anterior-most position rather than in the center of the carapace, posterior lateral spinnerets not elongated and the presence of cribellum. The family also resembles Deinopidae C. L. Koch, 1850 and Uloboridae Thorell, 1869 by the presence of abundant feathery scales, a cribellum, and serrate accessory claw setae, but can be distinguished from both families by the absence of tarsal spines and contiguous lateral eyes; and additionally, from Deinopidae by the absence of enlarged PME and coiled embolus; and from Uloboridae by the absence of femoral trichobothria.

As for the extinct cribellate families at the same time and locality (*i.e.*, Kachin amber), Pilosarachnidae Jiang &Li, **fam. nov.** can generally be distinguished from most cribellate families by the presence of rich feathery scales on carapace, abdomen and all appendages, such as †Alteruloboridae Wunderlich, 2018, †Fraterulobordae Wunderlich, 2018, †Praearaneidae Wunderlich, 2017 and †Protoaraneoididae Wunderlich, 2018 (Wunderlich, 2017; Wunderlich & Müller, 2018). Pilosarachnidae Jiang & Li, **fam. nov.** resembles †Mongolarachnidae Selden *et al.*, 2013 (occurs in Jurassic Daohugou bed and Kachin amber; Selden *et al.*, 2011, 2013; Wunderlich, 2015, 2017) by the presence of serrate accessory claw setae, and with the presence of femoral spines and apical spines on male palpal tibia, but can be distinguished by the following combination of characters: 1. the absence of extremely long femur of male palp (palpal femur of almost identical length to femur III and shorter than carapace length), while male palpal femur in two subfamilies of Mongolarachnidae (Longissipalpinae and Pedipalparaneinae) is longer than femur III and the length of carapace; 2. the contiguous lateral eyes; 3. the spoon-like membranous conductor (Figs 3A–B, D), while in Mongolarachnidae the conductor is absent (see Selden *et al.*, 2013: 1175, fig. 2f) or a filiform tegular apophysis (*e.g.*, Wunderlich, 2015: 383–384, figs 186–190) or a fork-like sclerotized apophysis (see Wunderlich, 2015: 384, fig. 197) is present instead. Wunderlich (2015) provided a set of characters for Mongolarachnidae with description of two new genera from this family, *i.e.*, *Longissipalpus* Wunderlich, 2015 and *Pedipalparaneus* Wunderlich, 2015, in which he concluded that feathery hairs (equivalent to feathery scales in Griswold *et al.*, 2005) are absent in this family. However, after examining our own specimens, we found that feathery scales are actually present in both *Longissipalpus* and *Pedipalparaneus*. Thus, we do not distinguish Pilosarachnidae Jiang & Li, **fam. nov.** and Mongolarachnidae base on the existence of feathery scales.

Additionally, Pilosarachnidae Jiang & Li, **fam. nov.** has a remarkable autapomorphy, the serrate structure on the prolateral-proximal margin of the tegulum, near the base of embolus (Figs 3B, D). This character is unique in comparison to other known spiders from Kachin amber. However, the detailed structures on male palp are highly variable at species-level and shouldn't be considered for higher-level classification (Ramírez, 2014), so we do not exclude the possibility that undiscovered species from the same family will lack such a structure.

Description. Medium-sized cribellate spider from Kachin amber. Three tarsal claws (Figs 2B–C), serrate accessory claw setae present; eight eyes, ALE and PLE contiguous (Fig. 2E); fovea distinct, longitudinal; body and appendages covered by dense feathery scales; spines numerous on legs but absent on tarsi, spines forming a ring at apex of each metatarsi (Fig. 2A); paracymbium absent; tibia of male palp without apophyses, embolus with pars pendula (a membranous structure that accompanies embolus), conductor and median apophysis present, and with a serrate structure on tegulum, present near base of embolus (Figs 3A–D).

Distribution. Late Cretaceous Kachin amber, Myanmar.

Genus *Pilosarachne* Jiang & Li, gen. nov.

Type species. *Pilosarachne ju* Jiang & Li, **sp. nov.**

Etymology. The generic name is derived from Greek word *pilos* meaning "hair or wool wrought into felt", referring to dense feathery scales on the spider's body and appendages; and Greek word *arachne* meaning "spider". The generic name is feminine.

Diagnosis. *Pilosarachne* Jiang & Li, **gen. nov.** can be distinguished by the characters of the family, as given above.

Distribution. Late Cretaceous Kachin amber, Myanmar.

Pilosarachne ju Jiang & Li, sp. nov. (Figs 1–3)

Holotype ♂ (IZCAS-Ar41629Fo), Late Cretaceous amber from Myanmar, Kachin State, Hukawng Valley. No biotic syninclusions.

Etymology. The specific name is derived from the Chinese pinyin word for "saw" (jù), referring to the saw-like serrate structure near embolus, and is a noun in apposition.

Figure 1. Piece of amber IZCAS-Ar41629Fo with inclusion of *Pilosarachne ju* Jiang & Li, **gen.** & **sp. nov.**, holotype male. A. Lateral view. B. Dorsal view. Scale bars = 10.0 mm.

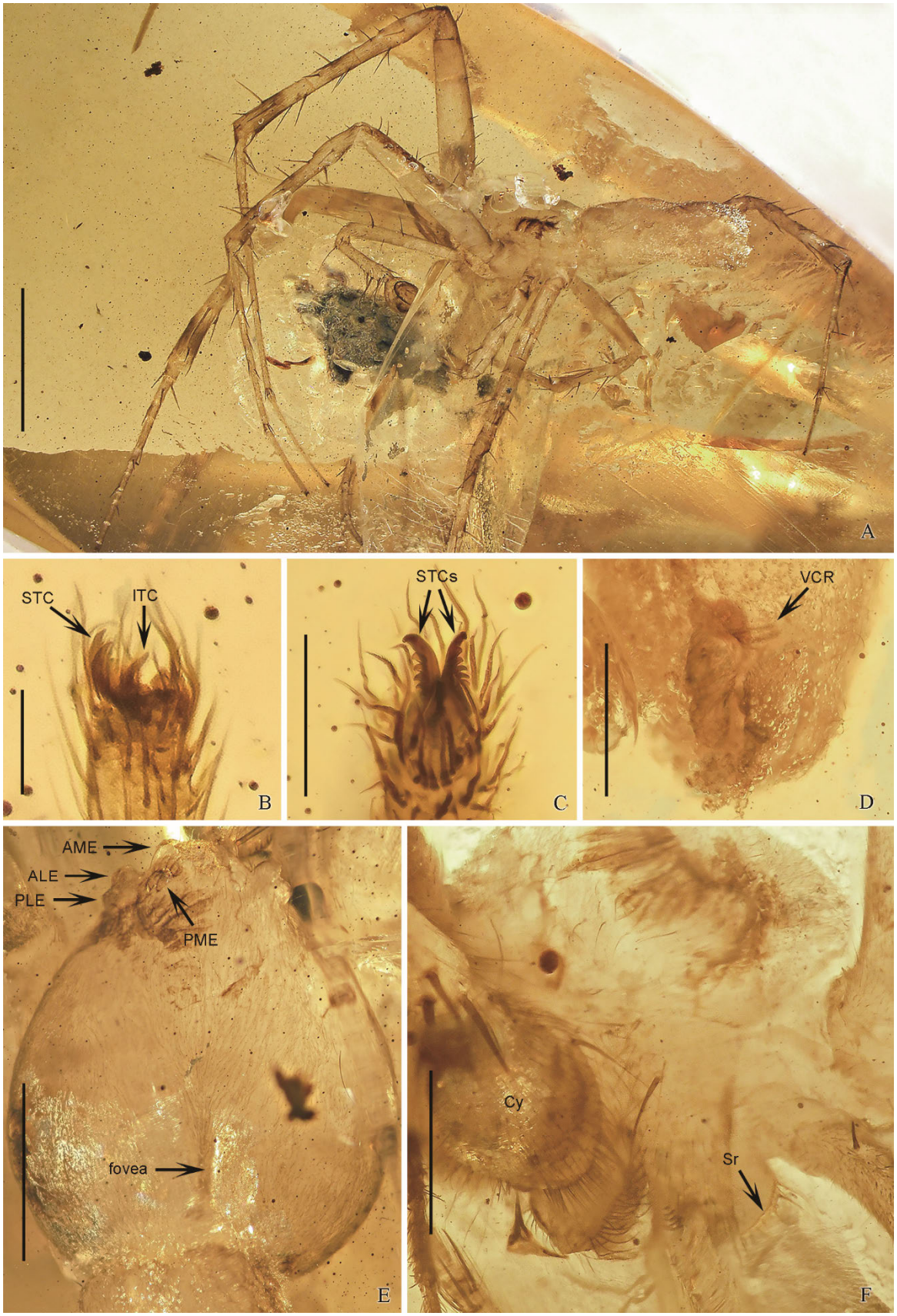

Figure 2. *Pilosarachne ju* Jiang & Li, **gen. & sp. nov.**, holotype male. A. Habitus, lateral view. B. Tarsal claws of left leg II, lateral view. C. Tarsal claws of right leg II, ventral-apical view. D. Spinnerets, ventral view. E. Carapace, dorsal view. F. Chelicerae, anterior view. Scale bars: A = 2.0 mm; B–C, E = 1.0 mm; D, F = 0.5 mm.

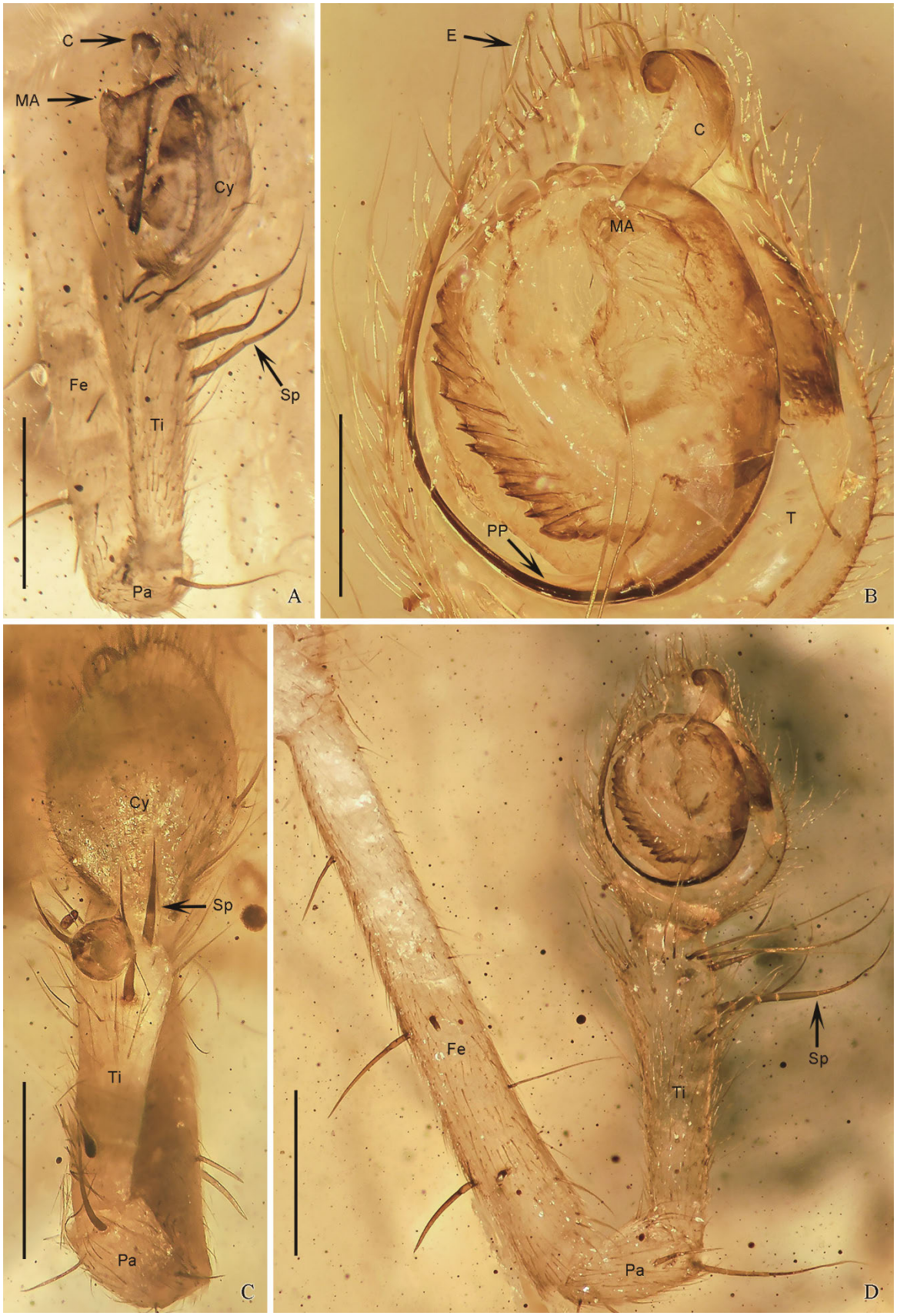

Figure 3. *Pilosarachne ju* Jiang & Li, **gen. & sp. nov.**, holotype male. A. Left palp, retrolateral view. B. Bulb of left palp, ventral view. C. Right palp, dorsal view, horizontally flipped for the sake of comparison. D. Left palp, ventral view. Scale bars: A, C–D = 0.5 mm; B = 0.2 mm.

Diagnosis. The new species can be distinguished by the characters of the family, as given above.

Description. Male (holotype). Body length 5.12, carapace 2.50 long, 2.20 wide, abdomen 2.62 long, 1.25 wide. Eyes: AME 0.20, ALE 0.13, PME 0.15, PLE 0.14, AME-AME 0.39, AME-ALE 0.31, PME-PME 0.44, PME-PLE 0.26, AME-PME 0.19, ALE-PLE 0.03, CH AME 0.17, CH ALE 0.21. Spination: palp: 1320, 1210, 1314; legs: femur I 424, II 324, III 2(3)22(3), IV 2(3)33; patella I 2122, II 2013, III 2100, IV 21(2)20; tibia I 3223, II 1022 (incomplete), III 2123, IV 2226; metatarsus I 2(4)332(3), II 3(4)43(4)3(4), III 2234 (incomplete), IV 3222; tarsus without spines. Measurements of palp and legs: left side: palp 3.71 (1.75, 0.31, 0.88, 0.77), leg I 12.71 (3.38, 0.98, 2.65, 4.02, 1.68), leg II 8.98 (2.63, 0.66, 1.71, 2.84, 1.14), leg III - (1.6, -, -, 1.36, -), leg IV - (2.28, 0.49, 1.71, -, -); right side: palp - (-, 0.40, 0.93, 0.80), leg I - (3.56, 1.03, 2.78, -, -), leg II - (2.68, 0.65, -, -, 1.15), leg III 4.9 (1.73, 0.30, 0.88, 1.40, 0.59), leg IV 7.79 (2.30, 0.45, 1.56, 2.50, 0.98).

Carapace piriform, covered by dense feathery scales; pars cephalica not elevated; fovea distinct, longitudinal (Fig. 2E). Eight eyes; ALE and PLE contiguous, arising from a common tubercle; anterior eye row slightly recurved in anterior view, posterior eye row recurved in dorsal view (Fig. 2E). Clypeus short, clypeus height at AME shorter than diameter of AME. Cheliceral teeth covered by setae at promargin and thus unknown; fangs long; chilum absent (Fig. 2F). Endite not converging, widened distally, probably longer than width; serrula in a single row (Fig. 2F); labium not observable; sternum extending between coxae IV. Legs annulated, leg formula 1243, covered by dense feathery scales; tactile hairs plumose (Fig. 2C); spines numerous (Fig. 2A; see above), but absent from all tarsi; spines at apex of metatarsi forming a ring (or "garland"); metatarsal preening combs absent; vestigial calamistrum in male absent (in contrast to some extinct families, e.g., †Burmadictynidae Wunderlich, 2017, †Fraterulobordidae Wunderlich, 2018, which have a distinct vestigial calamistrum even in adult males); femoral trichobothria absent; ITC present, slightly smaller than STC (Fig. 2B); STC teeth uniseriate, four or five (Fig. 2C); serrate accessory claw setae present. Abdomen elongated, length more than two times width, unsclerotized, covered by feathery scales; pedical, booklungs and spiracle not well observable; three pairs of spinnerets, a small vestigial cribellar region is most likely present but was not able to be observed explicitly (Fig. 2D).

Male palp (Figs 3A–D). Femur shorter than length of carapace, without apophysis (Fig. 3D). Tibia without apophysis, but apically with curved tapering spines on retrolateral and dorsal sides (Figs 3A, C–D). Cymbium spoon-shaped, with two prolateral spines (Figs 3B–D). Tegulum discoid. A serrate structure is present at prolateral margin of tegulum, near base of embolus, bearing more than 10 teeth (Figs 3B, D). A dubious median apophysis is present, arising near center of tegulum, wrinkled and blunt, covering base of conductor in ventral view. Conductor most likely membranous, arising from tegulum at 1 o'clock, curved, its end directed proximally (Figs 3A–B, D). Embolus arising from tegulum at 5 o'clock position, accompanied by membranous pars pendula nearly its whole length, running counterclockwise, embolic tip ending near apex of cymbium (Figs 3B, D).

Female. Unknown.

Family †Gigarachnidae Jiang & Li, fam. nov.

Type genus. *Gigarachne* Jiang & Li, **gen. nov.**

Diagnosis. Gigarachnidae Jiang & Li, **fam. nov.** can be distinguished from most extant Araneoidea by the absence of paracymbium; from Palpimanoidea by the absence of peg teeth; from Synspermiata by the presence of AME and non-piriform bulb (Figs 5D, 6A–C); from RTA clade by the absence of an RTA and the relative position of cymbium and bulb (Figs 6A–C); from Hypochilidae and Austrochilidae by the presence of only one pair of booklungs.

The cribellar area of Gigarachnidae Jiang & Li, **fam. nov.** is covered by impurity and was thus not observable, but it can be distinguished from many extinct families from Kachin amber by the combination of gigantic size (the largest known araneomorph spider in Kachin amber), absence of any apophyses on the male palpal podomeres (Fig. 6C) and the complex tegular apophyses (Figs 6A–C). Some members of the family †Pholcochyroceridae Wunderlich, 2008 have large-sized body (*i.e.*, *Autotomiana* Wunderlich, 2015) or complex tegular apophyses (*i.e.*, *Pholcochyrocer* Wunderlich, 2008 and *Spinicreber* Wunderlich, 2015; see Wunderlich, 2012: 226–227, figs 33–37; Wunderlich, 2015: 382, figs 177–178; Wunderlich & Müller, 2020: 155, figs 147–149) and also have serrate accessory claw setae (Wunderlich, 2015). However, Gigarachnidae Jiang & Li, **fam. nov.** can still be well distinguished from †Pholcochyroceridae by the presence of feathery scales and modified eye domain (Fig. 5D). Gigarachnidae Jiang & Li, **fam. nov.** resembles the other new family, †Pilosarachnidae Jiang & Li, **fam. nov.**, by the presence of feathery scales, distinct longitudinal fovea and the absence of apophyses on all male palpal podomeres, but can be distinguished by the relative position of cymbium and bulb (Figs 6A–C) and the presence of AME-PME protruding tubercle (Fig. 5D).

The flat body, long hairs bore at the end of abdomen (Figs 5A–B) and PME-AME tubercle (Fig. 5D) of Gigarachnidae Jiang & Li, **fam. nov.** are unique characters in Kachin amber.

Description. Gigantic araneomorph spider from Kachin amber. Three tarsal claws, serrate accessory claw setae present

(Fig. 5C); eight eyes, AME and PME on a common protruding tubercle, ALE and PLE on lateral tubercles (Fig. 5D); fovea distinct, longitudinal; feathery scales present on legs, carapace and abdomen; spines numerous on walking legs but absent on tarsi, spines forming a ring at apex of each metatarsi; paracymbium absent, tegular apophyses many and complex.

Distribution. Late Cretaceous Kachin amber, Myanmar.

Comments. The lack of cribellar information hampered further discussion on the taxonomic placement of such a remarkable family. A new conspecific specimen will definitely help, but regarding its rareness, it seems rather difficult to obtain one. Spiders of large size may be difficult to find in amber because they have a greater chance of struggling out instead of being caught, as mentioned in Wunderlich (2017). Indeed, the traces of struggle near the legs of the spider can be easily seen in the type specimen (Figs 5A–B).

Genus *Gigarachne* Jiang & Li, gen. nov.

Type species. *Gigarachne bian* Jiang & Li, **sp. nov.**

Etymology. The generic name is derived from Greek word *gígas* meaning “giant”, referring to the large size of the spider; and Greek word *arachne* meaning “spider”. The generic name is feminine.

Diagnosis. *Gigarachne* Jiang & Li, **gen. nov.** can be distinguished by the characters of the family, as given above.

Distribution. Late Cretaceous Kachin amber, Myanmar.

Gigarachne bian Jiang & Li, sp. nov. (Figs 4–6)

Holotype ♂ (IZCAS-Ar41630Fo), Late Cretaceous amber from Myanmar, Kachin State, Hukawng Valley. Syninclusions include a Neuropteran near the spider’s mouthpart, which is a potential prey of the spider, but not wrapped with silk. In addition, two dipterans and three hymenopterans also occur in the same piece of amber.

Etymology. The specific name is derived from the Chinese pinyin word for “flat” (biǎn), referring to the flattened prosoma and abdomen of the species, and is a noun in apposition.

Figure 4. Piece of amber IZCAS-Ar41630Fo with inclusion of *Gigarachne bian* Jiang & Li, **gen.** & **sp. nov.**, holotype male. A. Dorsal view. B. Ventral view. Scale bars = 10.0 mm.

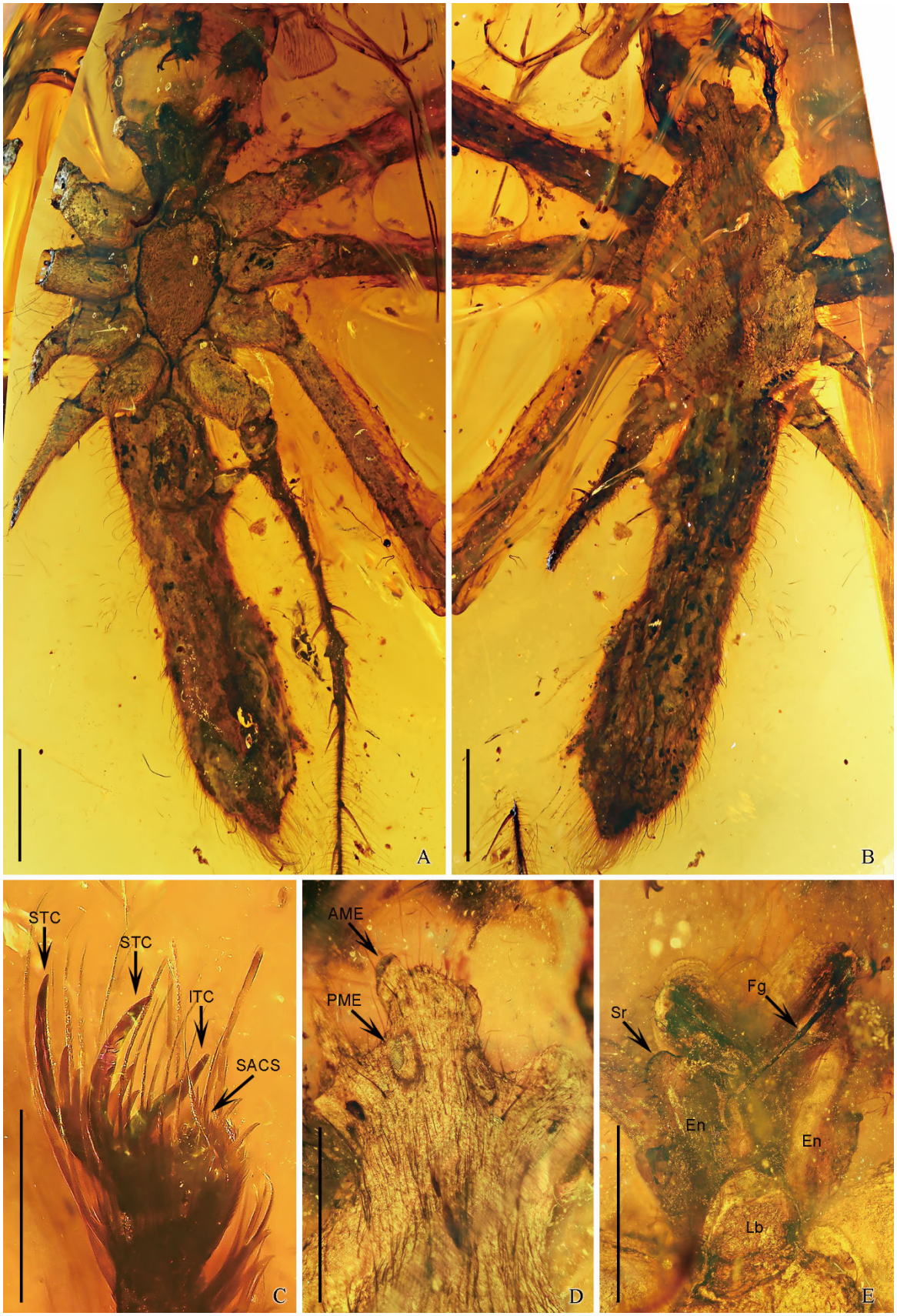

Figure 5. *Gigarachne bian* Jiang & Li, **gen.** & **sp. nov.**, holotype male. A. Habitus, ventral view. B. Habitus, dorsal view. C. Tarsal claws of left leg II. D. Eye domain, dorsal view. E. Mouthparts, ventral view. Scale bars: A–B = 2.0 mm; C = 0.2 mm; D–E = 1.0 mm.

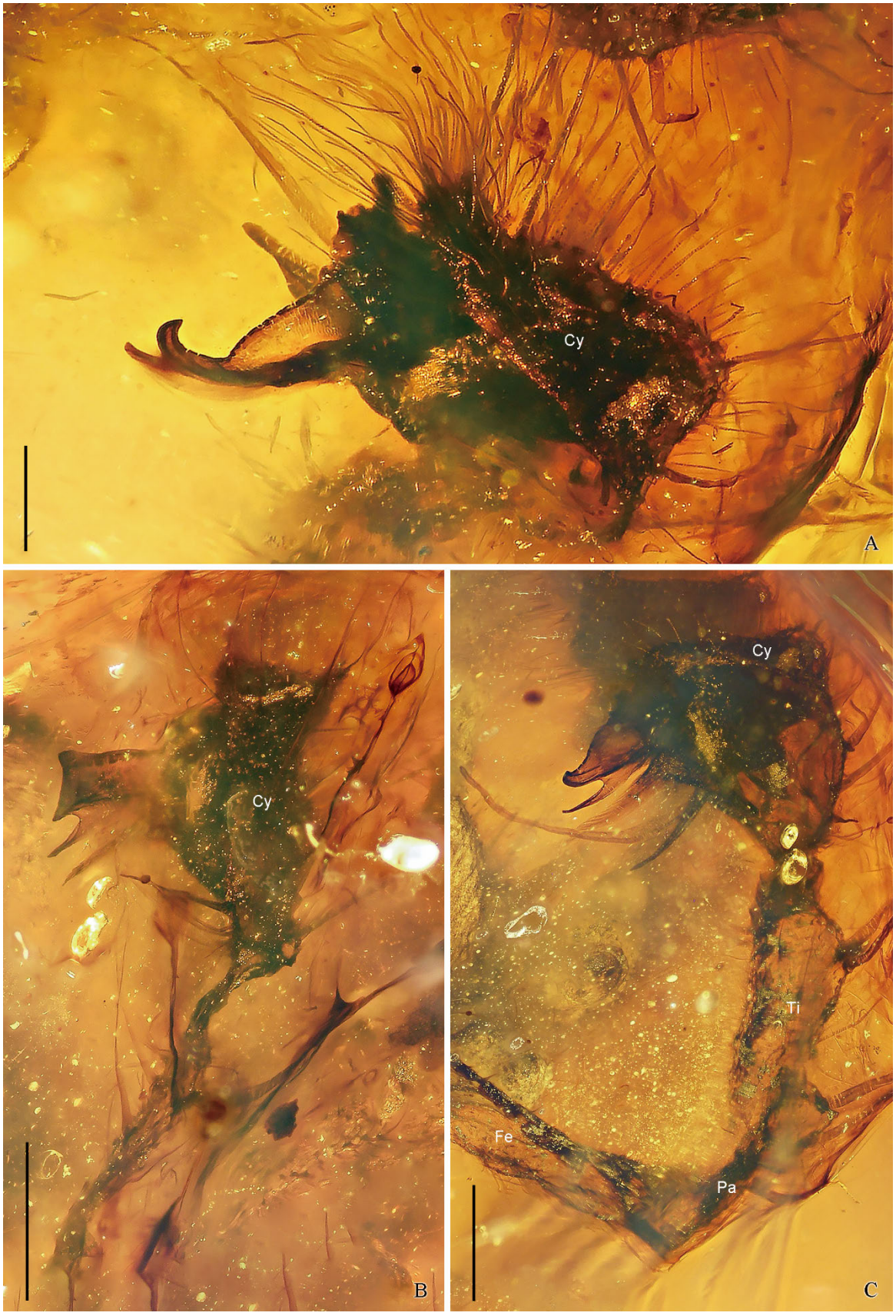

Figure 6. *Gigarachne bian* Jiang & Li, **gen. & sp. nov.**, holotype male, right male palp. A. Apical view. B. Retrolateral view. C. Ventral view. Images horizontally flipped for the sake of comparison. Scale bars: A = 0.2 mm; B–C = 0.5 mm.

Diagnosis. *Gigarachne bian* Jiang & Li, **sp. nov.** can be distinguished by the characters of the family, as given above.

Description. Male (holotype). Body length 14.42, carapace 5.77 long, 3.24 wide, prosoma 0.97 high, abdomen 8.65 long, 2.03 wide, 0.51 high. Eyes (severely deformed by preservation and thus asymmetric in measurements): left AME 0.23, right AME 0.30, left ALE 0.225, right ALE -, left PME 0.23, right PME 0.30, left PLE -, right PLE -, AME-AME 0.28, AME-ALE 0.24, PME-PME 0.29, PME-PLE -, AME-PME 0.30, ALE-PLE -, CH AME -, CH ALE -. Spination: palp: 1100, 1210, 2111; legs: femur I 144, II 350, III -, IV 012 (incomplete); patella I -, II 2010, III -, IV 1211; tibia I -, II 1012, III -, IV 1211 (incomplete); metatarsus I 1112, II 4442, III 3234, IV 3332; tarsus without spines. Measurements of palp and legs: left side: palp 5.08 (2.00, 0.67, 1.25, 1.16), leg I - (11.09, -, -, -, 5.77), leg II 32.18 (10.83, 1.87, 7.75, 8.11, 3.62), leg III - (6.41, -, -, -, -), leg IV 23.71 (6.53, 1.85, 6.45, 6.75, 2.13); right side: palp - (-, 0.72, -, 1.23), leg I - (-, -, -, -, -), leg II - (-, -, -, -, -), leg III 17.63 (6.44, 1.63, 3.80, 4.04, 1.72), leg IV 23.50 (6.60, 1.88, 6.06, 6.64, 2.32).

Carapace ampullate; prosoma extremely flat (height/length ratio 0.168), covered by hairs and few feathery scales; pars cephalica slightly elevated; fovea distinct, deep and longitudinal (Fig. 5B). Eight eyes, all severely deformed; eye domain strongly protruding, AME and PME on a tubercle with AME situated on apex; ALE and PLE separate, but on common lateral tubercles; both anterior and posterior eye row recurved in dorsal view (Fig. 5D). Chelicerae covered by setae at promargin (Fig. 5E); few true teeth present on promargin and retromargin; fangs long. Endite not converging, tapering, longer than width; serrula in a single row; labium longer than wide, not fused to sternum (Fig. 5E); sternum shield-shaped, longer than wide, extending between coxae IV (Fig. 5B). Legs elongated, leg formula 1243, covered by hair, feathery scales present but not dense; tactile hairs plumose; spines numerous (see above), but absent in all tarsi; spines at apex of metatarsi forming a ring; metatarsal preening combs absent; vestigial calamistrum in male absent; femoral trichobothria absent; ITC present, slightly smaller than STC; STC teeth uniseriate, three or four; serrate accessory claw setae present (Fig. 5C). Abdomen elongated and extremely flattened (height/length ratio 0.059), severely wrinkled by preservation, with scattered black spots and patches, length more than four times width, unsclerotized, covered by many hairs and few feathery scales; one pair of booklungs; clusters of plumose setae present on distal half of dorsal abdomen in one pair; spiracle and spinnerets covered by dark grey cloudy matter and thus not observable; end of abdomen most likely extending beyond invisible spinnerets and anal tubercle, bearing long hairs (Figs 5A–B).

Male palp (Figs 6A–C). Both palps severely deformed, rendering asymmetrical morphology of podomeres and bulbs. Femur longest, bearing spines, without apophysis. Tibia with dorsal spines, without apophysis. Cymbium spoon-shaped, densely covered by long hairs, dorsal spines present, paracymbium absent. Tegulum bearing five apophyses, homology difficult to infer.

Female. Unknown.

4 Discussion

There are 28 extinct spider families that can be found in the Cretaceous period (†Chimerarachnidae Wunderlich, 2019 is excluded; Dunlop *et al.*, 2020; Wunderlich & Müller, 2020). Most of them are restricted to Kachin amber, with a few exceptions. Among extinct families that occur in the Cretaceous, four families belong to Mesothele (†Burmathelidae Wunderlich, 2017; †Cretaceothelidae Wunderlich, 2018; †Eomesothelidae Wunderlich, 2019 and †Parvithelidae Wunderlich, 2019); one family belongs to Mygalomorphae (†Fossilcalcaridae Wunderlich, 2015); six families belong to Synspermiata (†Aliendiguetidae Wunderlich, 2020; †Burmorsolidae Wunderlich, 2008; †Eopsilodercidae Wunderlich, 2008; †Parvosegestriidae Wunderlich, 2020; †Plumorsolidae Wunderlich, 2008 and †Praepholcidae Wunderlich, 2017); four families belong to Palpimanoidea (†Micropalpimanidae Wunderlich, 2008; †Lagonomegopidae Eskov & Wunderlich, 1995; †Spatiatoridae Petrunkevitch, 1942 and †Vetiatoridae Wunderlich, 2017); and three families belong to Araneoidea (†Cretamysmenidae Wunderlich, 2018; †Leviunguidae Wunderlich, 2018 and †Zarqaraneidae Wunderlich, 2008). Like the remaining ten families, †Pilosarachnidae Jiang & Li, **fam. nov.** and †Gigarachnidae Jiang & Li, **fam. nov.** cannot be assigned to any of the clades mentioned above. Hence, the diagnostic characters of known families with no certain affinity are provided (mainly as in Dunlop *et al.*, 2020 and Magalhaes *et al.*, 2020) for the sake of comparison, with comments about their monophyly, taxonomic placement and their resemblance to †Pilosarachnidae Jiang & Li, **fam. nov.** and †Gigarachnidae Jiang & Li, **fam. nov.**

4.1 Family †Alteruloboridae Wunderlich, 2018

Occurrence. Cretaceous Kachin amber.

Diagnostic characters (Wunderlich & Müller, 2018). Lateral eyes close together, prosoma with AMEs distinctly projecting, leg I long and quite hairy, metatarsus I almost twice as long as tibia I, femoral trichobothria, feathery hairs and pectunculus absent. Male pedipalpus: Medial position of the cymbium, femur strongly thickened and bearing at least two dorsal apophyses.

Further characters (Wunderlich & Müller, 2018). Cribellate, patellae with a single dorsal-apical spine. Male pedipalpus: Patella and tibia spiny, apical cymbial setae and paracymbium absent.

Genus included (1). *Alteruloborus* Wunderlich, 2018.

Comments. Only one species. Easily distinguished from both Pilosarachnidae Jiang & Li, **fam. nov.** and Gigarachnidae Jiang & Li, **fam. nov.** by the absence of feathery scales and the presence of apophyses on male palpal femur.

4.2 Family †Burmadictynidae Wunderlich, 2017

Occurrence. Cretaceous Kachin amber and Lebanese amber.

Diagnostic characters (Wunderlich, 2017). Cribellum and calamistrum well developed in both sexes, legs spiny, order I/II/IV/III, three tarsal claws, femoral and tarsal trichobothria absent, leg bristles usually existing on femora to metatarsi, ventral tarsal III-IV bristles frequently existing, metatarsus IV not depressed laterally, straight or slightly to fairly bent, eyes in two wide rows, posterior row recurved, lateral eyes usually close together, AME not enlarged, fovea apparently absent, opisthosoma usually soft but scutate in *Burmadictyna postcopula*, anal tubercle quite large. Male pedipalpus: Tibia dorsally-apically modified in the type genus, embolus building a spiral which is quite long and cylindrical in the type genus.

Genera included (3). *Burmadictyna* Wunderlich, 2008 (Kachin amber); *Eodeinopis* Wunderlich, 2017 (Kachin amber); *Palaeomicromenneus* Penney, 2003 (Lebanese amber).

Comments. Easily distinguished from both new families by the absence of feathery scales, distinct vestigial calamistrum in males and circular embolus describing at least three loops.

4.3 Family †Burmascutidae Wunderlich, 2008

Occurrence. Cretaceous Kachin amber.

Diagnostic and important characters (Wunderlich & Müller, 2018). 8 large eyes in two rows of a very wide field with PMEs widely spaced and AMEs not reduced, eye region not elevated, chelicerae free, anterior margin of the cheliceral furrow with *ca.* 5 long and slender teeth, legs stout, feathery hairs absent, leg bristles completely absent, all legs unmodified, tarsi distinctly shorter than metatarsi, paired tarsal claws apparently smooth, abdomen strongly armored, 3 pairs of spinnerets in an anterior position, pedipalpus of the probably conspecific female of *Burmascutum aenigma* not reduced. Body length *ca.* 0.85–1.3 mm. Male pedipalpus: Articles slender without modifications, cymbium large and without modifications, paracymbial hook existing, bulbus large and protruding, tegulum bearing several apophyses including a long, slender and bent probasal apophysis, embolus unknown.

Genus included (1). *Burmascutum* Wunderlich, 2008.

Comments. Magalhaes *et al.* (2020) suspected that this is a family within Araneoidea because of the presence of paracymbium on the male palp, at least in *Burmascutum brevis* Wunderlich, 2018. This family is easily distinguished from both new families by the absence of leg macrosetae, teeth on STC and feathery scales.

4.4 Family †Frateruloboridae Wunderlich, 2018

Occurrence. Cretaceous Kachin amber.

Diagnostic characters (Wunderlich & Müller, 2018). Cribellate, 8 eyes in a very wide field with the lateral eyes contiguous, clypeus very long and vertical, leg bristles quite few, existing only ventrally on tarsi and metatarsi, femoral trichobothria apparently existing, metatarsus IV straight, abdomen hardened, leathery or even scutate. Male pedipalpus: Cymbium long and not modified, bulbus very large and quite simple, embolus fairly long.

Further characters (Wunderlich & Müller, 2018). Entelegyne, cribellum entire, tarsal trichobothria as well as feathery hairs absent, prosoma and legs covered with very long hairs, eyes small, quite anterior position of the AMEs which are difficult to observe in dorsal view, unpaired tarsal claw existing, paired claws with very long teeth, 3 pairs of spinnerets with the ALS basally widely spaced, anal tubercle small. Male pedipalpus: Articles stout but not distinctly thickened, not spiny.

Genus included (1). *Fraterulobor*us Wunderlich, 2018.

Comments. Only one species. Easily distinguished from both new families by the absence of feathery scales, the presence of tarsal macrosetae and femoral trichobothria.

4.5 Family †Mongolarachnidae Selden, Shi & Ren, 2013

Occurrence. Jurassic Daohugou bed; Cretaceous Kachin amber.

Provisional diagnostic characters (Wunderlich, 2015). Male pedipalpus: Podomeres extremely long and slender, leg-shaped (similar to the relatively short leg III), usually spiny, cymbium and bulbus quite/relatively small, bulbus with a thin embolus and probably two tegular apophyses.

Further characters (Wunderlich, 2015). Cribellum existing, undivided, 8 eyes (number unknown in *Mongolarachne*), most probably a single pair of lungs, long legs (at least I very long), order of the legs I/II/IV/III (in contrast to the Uloboridae in which IV is usually longer than II), numerous leg bristles, usually existence of ventral tarsal IV bristles (except in the *Longissipalpus*), metatarsus IV straight in the three treated subfamilies, feathery hairs absent.

Genera included (3). *Mongolarache* Selden *et al.*, 2013 (Daohugou); *Longissipalpus* Wunderlich, 2015 (Kachin amber); *Pedipalparaneus* Wunderlich, 2015 (Kachin amer).

Comments. Magalhaes *et al.* (2020) questioned the monophyly of the family after the inclusion of species in Kachin amber. The resemblance and differences between this family and Pilosarachnidae Jiang & Li, **fam. nov.** are already discussed (see diagnosis for Pilosarachnidae Jiang & Li, **fam. nov.**). Mongolarachnidae can be distinguished from Gigarachnidae Jiang & Li, **fam. nov.** by the absence of protruding AME-PME tubercle.

4.6 Family †Pholcochyroceridae Wunderlich, 2008

Occurrence. Cretaceous Kachin amber.

Characterization (Wunderlich & Müller, 2018). Cribellum entire, lateral eyes distinctly widely spaced, ventral tarsal bristles like in related taxa. Male pedipalpal articles usually spiny and usually at least two large slender and pointed tegular apophyses, one is apparently connected with the embolus.

Further characters (Wunderlich, 2015). Eight eyes in a wide field, a pair of booklungs, basal cheliceral articles not fused, probably basically a long unpaired tarsal claw and existence of "auxiliary hairs" of tarsus IV, bulbus attached ventrally on the cymbium.

Genera included (5). *Autotomiana* Wunderlich, 2015; *Parvibulbus* Wunderlich, 2018; *Pholcochyrocer* Wunderlich, 2008; *Spinicreber* Wunderlich, 2015; *Spinipalpus* Wunderlich, 2015.

Comments. As Magalhaes *et al.* (2020) has pointed out, there is no evidence of monophyly of this family. The resemblance and differences between this family and Gigarachnidae Jiang & Li, **fam. nov.** are already discussed (see diagnosis for Gigarachnidae Jiang & Li, **fam. nov.**). Pholcochyroceridae can be distinguished from Pilosarachnidae Jiang & Li, **fam. nov.** by the absence of feathery scales.

4.7 Family †Praearaneidae Wunderlich, 2017

Occurrence. Cretaceous Kachin amber.

Diagnostic characters (Wunderlich, 2017). Cribellum existing, undivided, calamistrum of the probably congeneric adult female long, metatarsus IV not depressed laterally, distinctly concave dorsally, feathery hairs absent, 8 eyes in two rows of a wide field with the lateral eyes close together and the posterior row straight, clypeus short and not protruding, ventral tarsal bristles existing. Male pedipalpus: Patella and tibia short, tibia with a retrolateral outgrowth, cymbium wide and short, paracymbium absent, median apophysis large and divided, further apophyses unknown, embolus coiled in 2–3 wide loops near the cymbial margin.

Further characters (Wunderlich, 2017). Unpaired tarsal claw existing, prosoma low, basal cheliceral articles relatively large, metatarsal preening combs, leg scopulae, claw tufts as well as femoral and tarsal trichobothria absent, position of the metatarsal trichobothrium in the juvenile *Praearaneus* sp. indet. in *ca.* 0.8, 3 pairs of spinnerets, anal tubercle only fairly large and unmodified; larger spiders, body length 3.5– 6.5 mm. No distinct sexual size dimorphism.

Genus included (1). *Praearaneus* Wunderlich, 2017.

Comments. A cribellate family erroneously assigned to Araneoidea by Dunlop *et al.* (2020). Distinguished from both new families by the presence of tarsal spines and apophysis on short male palpal tibia.

4.8 Family †Praeterleptonetidae Wunderlich, 2008

Occurrence. Cretaceous Kachin amber.

Diagnostic characters for males (Wunderlich & Müller, 2018). Ecribellate, 8 eyes, position of the metatarsal

trichobothrium in *ca.* 0.9 – 0.95. Male pedipalpal articles long, slender and spiny, retrolatertal "paracymbial spine" well developed.

Genera included (3). *Biapophyses* Wunderlich, 2015; *Palaeohygropoda* Penney, 2004; *Praeterleptoneta* Wunderlich, 2008.

Comments. *Biapophyses beate* Wunderlich, 2015 was regarded as a plesion in Wunderlich & Müller (2018), a "distinctive named taxon which does not fit well in a higher taxon", which means it may not belong to this family. There is no evidence of monophyly of this family (Magalhaes *et al*., 2020). *Biapophyses* can be distinguished from both new families by the smooth STC and the presence of tibial apophyses on male palp. *Palaeohygropoda* and *Praeterleptoneta* can be distinguished from both new families by the presence of strong paracymbial spine.

4.9 Family †Protoaraneoididae Wunderlich, 2018

Occurrence. Cretaceous Kachin amber.

Diagnostic characters (Wunderlich & Müller, 2018). Cribellate, cribellum divided, unpaired tarsal claws more or less reduced. Male pedipalpus: Cymbium long and slender, paracymbium large, pointed, usually in a more retrolateral (not retrobasal) position, divided or entire.

Further characters (Wunderlich & Müller, 2018). Eight eyes in two rows, PME widely spaced, prosomal cuticula smooth or very finely corniculate, endites converging, metatarsal trichobothria in a subapical position, tibial I-II bristles straight and frequently only fairly long, medial cheliceral lamella, ventral tarsal bristles and feathery hairs absent, metatarsus IV straight, the calamistrum may be difficult to recognize or reduced in males but well developed in females, abdomen oval, coxa-trochanter (not patella-tibial) autotomy existing, legs probably not annulated.

Genera included (4). *Praeteraraneoides* Wunderlich, 2018; *Proaraneoides* Wunderlich, 2018; *Protoaraneoides* Wunderlich, 2018; *Spinipalpitibia* Wunderlich, 2015.

Comments. Easily distinguished from both new families by the presence of paracymbium.

4.10 Family †Salticoididae Wunderlich, 2008

Occurrence. Cretaceous Jordanian amber.

Diagnostic characters (Wunderlich, 2008). AME very large and directed anteriorly, 8 eyes in two rows, feathery leg hairs present. Most likely dwellers of capture webs. Male pedipalpus: Patella with a dorsal-apical outgrowth, tibial apophysis and paracymbium absent, cymbium large, embolus probably describing few circular loops, conductor unknown, "median apophysis" large and standing out from the bulbus.

Further characters (Wunderlich, 2008). Cribellum/calamistrum apparently absent, the legs bear numerous bristles, ventral tarsal bristles are most probably absent, unpaired tarsal claws are apparently present.

Genus included (1). *Salticoidus* Wunderlich, 2008.

Comments. This family was first described by Wunderlich (2008) based on the type genus *Salticoidus* Wunderlich, 2008 from Jordanian amber. *Palaeomicromenneus* Penney, 2003 (formerly Deinopidae) and *Burmadicyna* Wunderlich, 2008 (formerly Dictynidae) were transferred to this family (Wunderlich, 2015), but excluded later (Wunderlich, 2017). Hence, the diagnosis here was based on *Salticoidus*. Easily distinguished from both new families by the presence of enlarged AME and patellar apophysis on male palp.Since most extinct families from Kachin amber have never been included in a phylogenetic analysis, we don't want to make conclusions about the taxonomic or phylogenetic placements and possible sister taxa of Pilosarachnidae Jiang & Li, **fam. nov.** and Gigarachnidae Jiang & Li, **fam. nov.** A more extensive scoring of morphological characters should be provided in future publications.

Supplementary Data Supplementary data (3D and drawing figures) to this article can be found online.

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