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## Research article

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# Five new species of the long-legged sac spider genus *Cheiracanthium* C.L. Koch, 1839 (Araneae: Cheiracanthiidae) from China

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**Abstract.** Five species of the cheiracanthiid spider genus *Cheiracanthium* C.L. Koch, 1839 collected from China are diagnosed and described as new to science based on morphological characters: *Cheiracanthium arcilongum* sp. nov. (♂♀) from Yunnan, *C. circumum* sp. nov. (♂♀) from Yunnan, *C. digitatum* sp. nov. (♂♀) from Anhui, *C. jiuquan* sp. nov. (♂♀) from Guangxi and *C. xinjiangense* sp. nov. (♂♀) from Xinjiang. In addition, the photos of the habitus, copulatory organs and distribution map are provided for all species. However, DNA barcodes information is only provided for four species.

**Keywords.** Description, DNA barcodes, morphology, taxonomy.

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## Introduction

The genus *Cheiracanthium* C.L. Koch, 1839, with 214 valid species mainly from the Old World, is the largest genus of the family Cheiracanthiidae (World Spider Catalog 2022). Members of *Cheiracanthium* are slim and pale-colored, with long and slender legs, and often build silk nests in the folds of foliage, thus also earning these spiders the common name long-legged sac spiders (Lotz 2007; Deeleman-Reinhold 2001).

Although several major taxonomic studies of *Cheiracanthium* have been conducted (Bonaldo & Brescovit 1992; Ramírez *et al.* 1997; Song *et al.* 1999; Deeleman-Reinhold 2001; Bayer 2014; Ramírez 2014; Zhang *et al.* 2020; Esyunin & Zamani 2020), the global diversity of this genus still remains to be discovered. Currently, 43 species of *Cheiracanthium* have been recorded from China (mostly from southern regions), but the diversity of it is still poorly understood. For example, 14 species were

described from a single female (9) or male (5) (Li & Lin 2016; Li & Zhang 2019; World Spider Catalog 2022). Affirming correct sex matching is one of the challenges for taxonomic studies on *Cheiracanthium*. Some species are mismatched or conspecific male and females have been described as separate species (Bonaldo & Brescovit 1992; Dankittipakul & Beccaloni 2012; Marusik *et al.* 2020). Therefore, the application of the molecular tools such as DNA barcoding is valuable for correct sex matching.

Hebert *et al.* (2003) proposed the use of cytochrome c oxidase subunit I (COI) sequences on the mitochondrial gene in DNA barcoding techniques, which enable species identification in most animal phyla. DNA barcoding of spiders has been commonly used in the identification of species or delimitation of similar species, association of separate sexes and specimens collected at different localities (Zhang & Li 2014; He *et al.* 2016; Coddington *et al.* 2016; Tyagi *et al.* 2019; Zhang *et al.* 2020; Wang *et al.* 2021). Lo *et al.* (2021) applied DNA barcoding information to correct sex matching of *Cheiracanthium insigne* O. Pickard-Cambridge, 1874, the results showing that the significance of integrated morphological and the standard barcode sequence can be used as an effective tool for the identification of species and correctly matching sexes in species of *Cheiracanthium*.

In the current study, five new species of *Cheiracanthium* are recognized. The intraspecific and interspecific genetic distances based on the DNA barcode gene, cytochrome c oxidase subunit I (COI) are studied to match male and female of new species except *C. xinjiangense* sp. nov., which was failed to extract genomic DNA.

## Material and methods

All measurements are given in millimeters. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus). Eye diameters as AME, ALE, PME, PLE and interdistances as AME–AME, AME–ALE, PME–PME, PME–PLE. The leg spination pattern follow the model of Lotz (2015) and maintains the femur, tibia, metatarsus order, and each segment are divided equally into basal, middle and distal parts. First, the prolateral spines are counted, then the retrolateral ones, the dorsals and, lastly, the ventral spines. Epigynes were removed and cleared in a pancreatin solution and then transferred to 75% ethanol for images captured. Photographs were taken using the Leica M205A. All specimens examined were deposited in Museum of Hebei University, Baoding, China (MHBU).

We extracted total genomic DNA from spider legs using the QIAGEN DNeasy Blood & Tissue Kit (Qiagen Inc., Valencia, CA) following the manufacturer's protocols. We used the primer pair LCO1490/HCO2198 (Folmer *et al.* 1994) to amplify COI sequences under the following PCR reaction protocol: initial denaturation at 94°C for 5 min; 35 cycles of denaturation at 94°C for 30 s, annealing at 45°C for 40 s, and elongation at 72°C for 1 min; and final extension at 72°C for 7 min. The 25 µl PCR reactions included 12.5 µl of 2×Taq MasterMix (KangWei Biotech, Beijing, China), 0.8 µl of each forward and reverse 10 µM primer, 4 µl of genomic DNA, and 6.9 µl of double-distilled H<sub>2</sub>O. The PCR products were visualized by agarose gel electrophoresis (1% agarose). All PCR products were purified and sequenced at GENEWIZ Inc. (Suzhou, China).

Sequence alignments were carried out using Mafft ver. 7.313 (Katoh & Standley 2013) with the L-INS-I strategy. Ambiguously aligned positions were culled using trimAl ver. 1.2 (Capella-Gutierrez *et al.* 2009) with default parameters. The pairwise genetic distances (Kimura two-parameter [K2P]) were calculated using MEGA ver. 11 (Tamura *et al.* 2021) to assess the genetic differences.

## Abbreviations for morphological terms

A = atrium  
ALE = anterior lateral eyes

ALS	=	anterior lateral spinnerets
AME	=	anterior median eyes
AME–ALE	=	distance between AME and ALE
AME–AME	=	distance between AMEs
C	=	conductor
CD	=	copulatory duct
CF	=	cymbial fold
CO	=	copulatory opening
CS	=	cymbial spur
d	=	dorsal
DTA	=	dorsal tibial apophysis
E	=	embolus
FD	=	fertilisation duct
MA	=	median apophysis
MOA	=	median ocular area
p	=	prolateral
PLE	=	posterior lateral eyes
PLS	=	posterior lateral spinnerets
PME	=	posterior median eyes
PMS	=	posterior median spinnerets
PME–PLE	=	distance between PME and PLE
PME–PME	=	distance between PMEs
r	=	retrolateral
RTA	=	retrolateral tibial apophysis
SP	=	spermatheca
v	=	ventral

## Results

### DNA barcodes

All sequences were deposited in GenBank. The accession numbers of the generated DNA barcodes are provided in Table 1. The K2P genetic distance of intraspecific and interspecific nucleotide divergences of four *Cheiracanthium* are shown in Table 2.

The male (ZYL130) and female (ZYL122) were collected at different localities, but they have a relatively lower genetic distance (1.2%), which was much lower than the interspecific genetic distance within other species (7.4%–11.9%) (Table 2) in our dataset. Consequently, we consider the male (ZYL130) and female (ZYL122) conspecific.

The intraspecific genetic distance ranged from 0 to 1.2%, and the interspecific genetic distance ranged from 7.4% to 11.9%. All maximum intraspecific distances were much lower than minimum interspecific distances for all species. The results of Kimura two-parameter genetic distances confirm the correct matching of male and female in our dataset.

**Table 1.** Voucher specimen information.

species	voucher code	sex	GenBank accession number	collection localities
<i>C. arcilongum</i> sp. nov.	ZYL108	♂	OQ866248	China, Yunnan,
	ZYL109	♀	OQ866249	China, Yunnan
<i>C. circumum</i> sp. nov.	ZYL122	♀	OQ866243	China, Yunnan
	ZYL130	♂	OQ866250	China, Yunnan
<i>C. digitatum</i> sp. nov.	ZYL088	♂	OQ866247	China, Anhui
	ZYL107	♀	OQ866246	China, Anhui
<i>C. jiuquan</i> sp. nov.	ZYL090	♂	OQ866244	China, Guangxi
	ZYL091	♀	OQ866242	China, Guangxi
	ZYL092	♀	OQ866245	China, Guangxi

**Table 2.** Intraspecific and interspecific nucleotide divergences for four species of *Cheiracanthium*, using Kimura two-parameter model.

species	ZYL090	ZYL092	ZYL091	ZYL107	ZYL088	ZYL108	ZYL109	ZYL122	ZYL130
<i>C. jiuquan</i> _ZYL090									
<i>C. jiuquan</i> _ZYL092	0.006								
<i>C. jiuquan</i> _ZYL091	0.005	0.001							
<i>C. digitatum</i> _ZYL107	0.077	0.074	0.075						
<i>C. digitatum</i> _ZYL088	0.077	0.074	0.075	0.000					
<i>C. arcilongum</i> _ZYL108	0.089	0.086	0.087	0.096	0.096				
<i>C. arcilongum</i> _ZYL109	0.088	0.085	0.087	0.096	0.095	0.000			
<i>C. circumum</i> _ZYL122	0.113	0.110	0.112	0.100	0.099	0.119	0.118		
<i>C. circumum</i> _ZYL130	0.107	0.104	0.106	0.096	0.095	0.116	0.116	0.012	

## Taxonomy

Class Arachnida Cuvier, 1812  
 Order Araneae Clerck, 1757  
 Family Cheiracanthiidae Wagner, 1887

Genus *Cheiracanthium* C.L. Koch, 1839

*Cheiracanthium* C.L. Koch, 1839: 9.

*Cheiracanthium* – Ramírez *et al.* 1997: 45. — Ono 2009: 465. — Ono & Ogata 2018: 611. — Esyunin & Zamani 2020: 1296.

## Type species

*Aranea punctoria* Villers, 1789, by subsequent designation.

## Diagnosis

See Deeleman-Reinhold (2001) and Zhang *et al.* (2022).

*Cheiracanthium arcilongum* sp. nov.

urn:lsid:zoobank.org:act:E6D0EACE-ACDC-436B-A1CD-55C592555AD2

Figs 1–2, 11, Table 1

**Diagnosis**

The new species can be easily distinguished from all the other species of *Cheiracanthium* by the long (ca equal to tibia+patella length), curved and filiform cymbial spur with distal end tapering, the long median apophysis with a broad base and hook-shaped apex (Fig. 1C–F), the large (ca 2.5 × as long as wide), spindle shaped spermathecae, and the wide copulatory ducts (almost as wide as spermathecae) (Fig. 2C–D).

**Etymology**

The specific epithet is a composite adjective combining ‘*arcus*’ (= ‘bow’) and ‘*longus*’ (= ‘long’), referring to the long, curved, bow-shaped male palpal cymbial spur; noun in adjective.

**Type material**

**Holotype**

CHINA • ♂; Yunnan Province, Tengchong City, Laifeng Mountain National Forest Park; 25°08' N; 98°29' E; alt. 1796 m; 16 Jul. 2014; P.L. Wu leg.; voucher code: ZYL108, GenBank: OQ866248; MHBUS-ARA-1001.

**Paratypes**

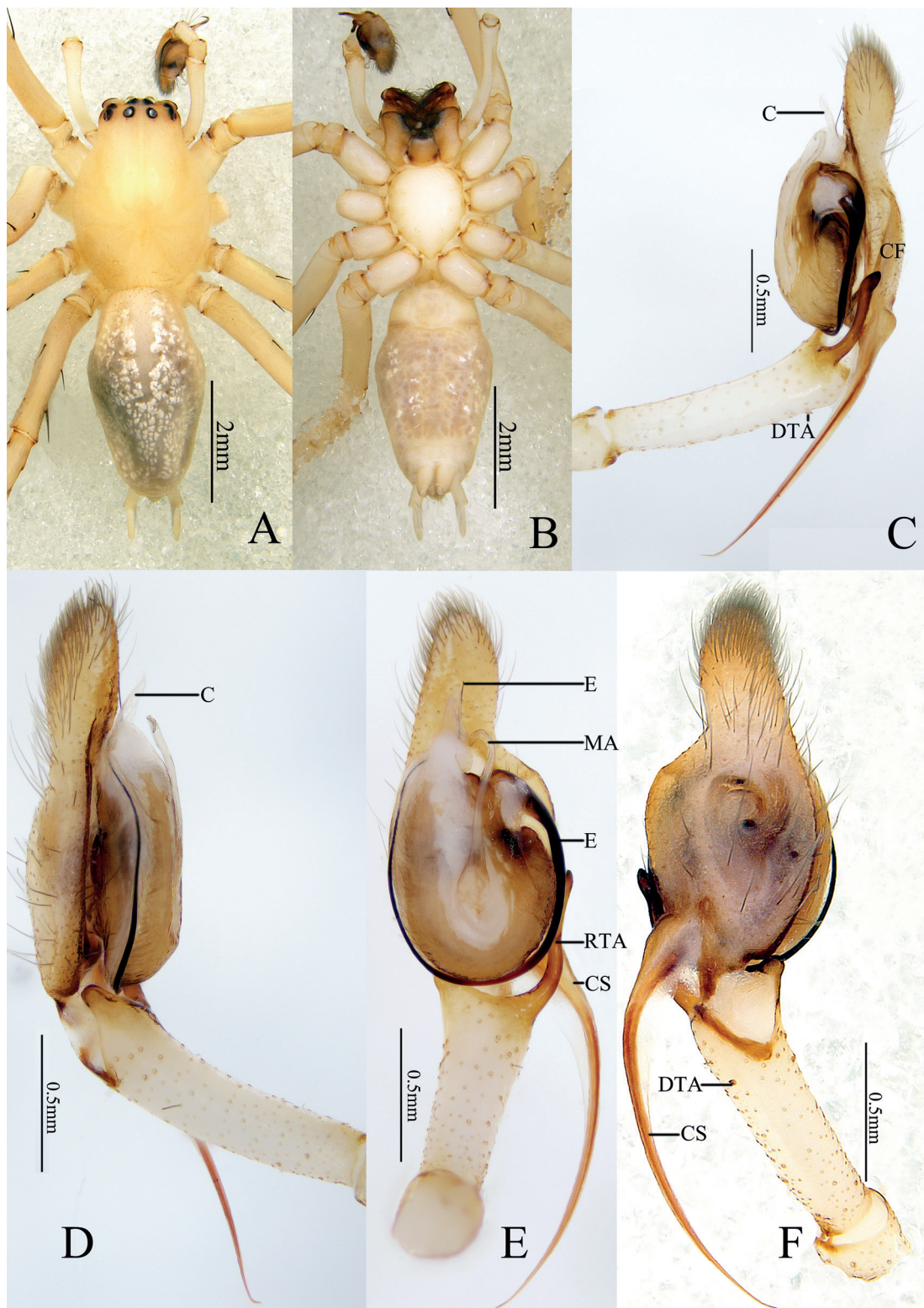
CHINA • 1 ♂, 5 ♀♀; same collection data as for holotype; MHBUS-ARA-1002 • 1 ♀; Tengchong City, Jietou Township; 25°25' N; 98°38' E; alt. 1602 m; 15 Jul. 2014; P.L. Wu leg.; voucher code: ZYL109, Genbank: OQ866249; MHBUS-ARA-1003 • 1 ♂; Tengchong City, Jietou Township, Shunhe Village; 25°24' N; 98°38' E; alt. 1552 m; 16 Jul. 2014; P.L. Wu leg.; MHBUS-ARA-1004.

**Description**

**Male (holotype)**

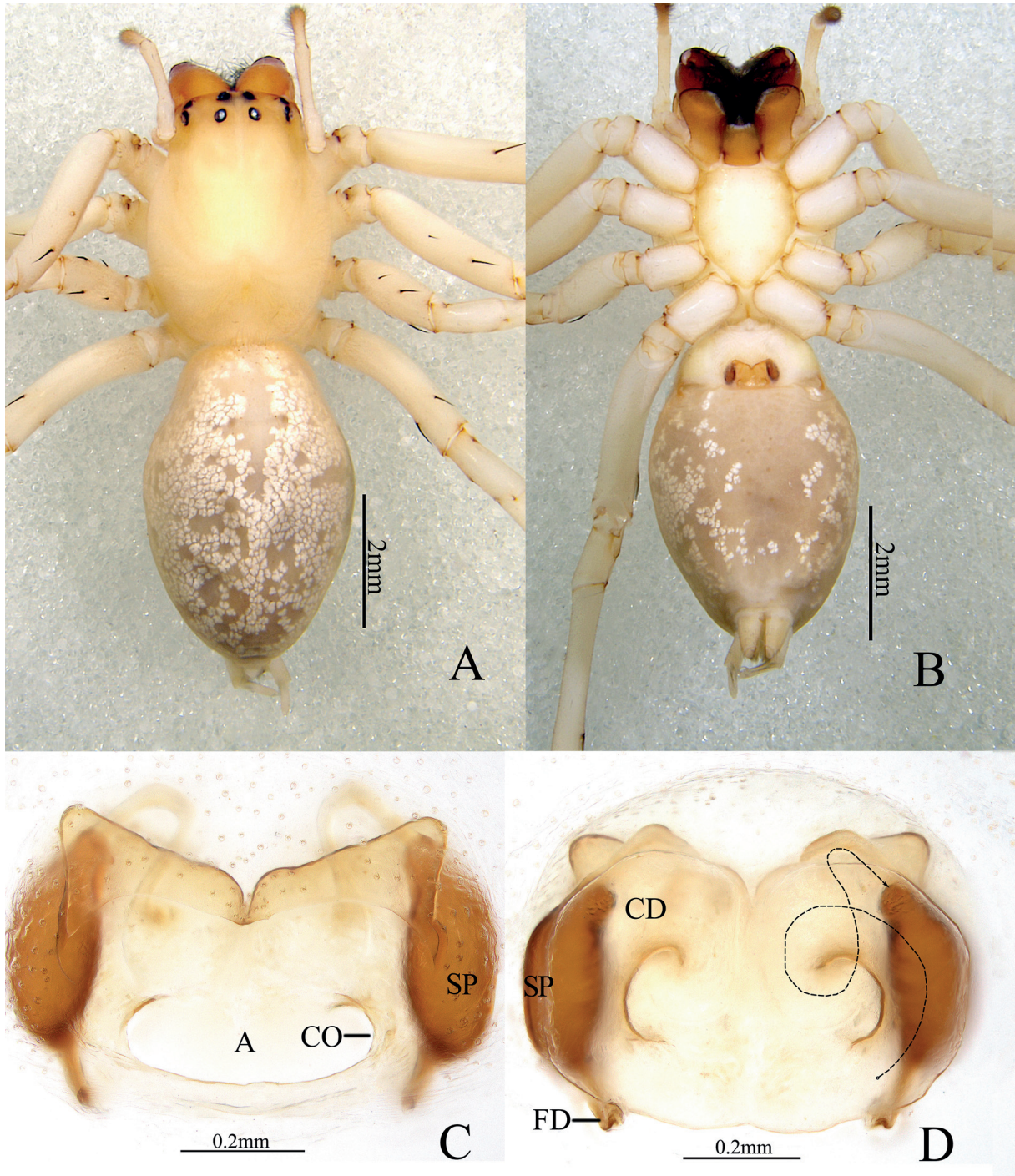
MEASUREMENTS. Total length 6.59. Carapace 2.89 long, 2.17 wide; abdomen 3.70 long, 1.88 wide. Eye sizes and interdistances: AME 0.15, ALE 0.14, PME 0.16, PLE 0.15; AME–AME 0.19, AME–ALE 0.21, PME–PME 0.27, PME–PLE 0.25. MOA 0.44 long, anterior width 0.46, posterior width 0.54. Clypeus height 0.11. Sternum 1.50 long, 1.22 wide. Leg measurements: I 19.20 (4.35, 0.91, 5.82, 6.00, 2.12), II 14.86 (4.13, 1.28, 4.10, 4.13, 1.22), III 9.34 (2.53, 0.95, 2.65, 2.39, 0.82), IV 14.95 (4.08, 1.17, 3.85, 4.58, 1.27).

BODY (Fig. 1A–B). Prosoma yellowish, without distinct colour pattern; cervical groove and radial striae indistinct. All eyes with black rings, AER slightly recurved in frontal view; PER slightly wider than AER, almost straight in dorsal view. Chelicerae reddish brown, both margins with 3 teeth. Sternum white, posterior margin extending between coxae IV. Labium wider than long, anteriorly truncated with several macrosetae distally. Endites yellowish brown, constricted at middle on lateral margin. Legs yellowish, without distinct colour markings. Leg spines: I 1p1r-1p-0, 0-1p1r-2v, 1v-1v-1p1v; II 1p1r-1p1r-0, 1p-1p2v-1r1v, 1v-1p2v-1p2v; III 1p1r-1p1r-0, 1p1r-1r-1d, 1p1r1v-1p1r2v-2p1r1v; IV 1p1r-1p1r-0, 1p1r-1p1r-1v, 1p2r1d1v-1p1r1d1v-2p1r1v. Opisthosoma lanceolate, dorsum grey, with many scattered light spots, and narrow longitudinal band in middle, enclosed by light spots, two pairs of muscular impressions; venter grey, lateral sides with scattered light spots. Spinnerets coniform, ALS larger and closed each other; PMS smallest; and PLS with two segments, length of basal segment shorter than distal segment.



**Fig. 1.** *Cheiracanthium arcilongum* sp. nov., ♂, holotype (MHBU-ARA-1001). **A.** Habitus, dorsal view. **B.** Same, ventral view. **C.** Left palp, retrolateral view. **D.** Same, prolateral view. **E.** Same, ventral view. **F.** Same, dorsal view. Abbreviations: see Material and methods.

PALP (Fig. 1C–F). Tibia long, about same length as cymbium; RTA long, about  $\frac{1}{2}$  of tibia's length, thumb-shaped; DTA short and thin, with sharp apex; cymbial fold long (ca  $\frac{1}{2}$  of cymbium's length), deep, cymbial spur extremely long, slightly curved, about same as tibia+patella length, tapering and forming filiform apex; median apophysis long, extending upwards, about  $\frac{2}{3}$  of tegulum's length, broad



**Fig. 2.** *Cheiracanthium arcilongum* sp. nov., ♀, paratype (MHBU-ARA-1003). **A.** Habitus, dorsal view. **B.** Same, ventral view. **C.** Epigyne, ventral view. **D.** Vulva, dorsal view. Abbreviations: see Material and methods.

at base and hook-shaped at apex; conductor large, membranous, distally curled; embolus arising at approximately 1 o'clock position and extending clockwise along tegular margin and ending at conductor apex.

#### Female (paratype)

MEASUREMENTS. Total length 8.37. Carapace 3.58 long, 2.78 wide; abdomen 4.79 long, 3.11 wide. Eye sizes and interdistances: AME 0.15, ALE 0.14, PME 0.16, PLE 0.15; AME–AME 0.25, AME–ALE 0.38, PME–PME 0.36, PME–PLE 0.41. MOA 0.54 long, anterior width 0.55, posterior width 0.68. Clypeus height 0.10. Sternum 1.87 long, 1.47 wide. Leg measurements: I 15.71 (3.84, 1.12, 4.97, 4.14, 1.64), II 10.38 (2.61, 0.82, 3.19, 2.77, 0.99), III 6.99 (0.89, 0.81, 1.94, 2.49, 0.86), IV 11.18 (1.46, 0.83, 3.51, 4.11, 1.27).

BODY (FIG. 2A–B). Prosoma pale yellow except reddish ocular area, without distinct colour pattern. Legs yellowish white. Leg spines: I 1p-1p-0, 0-1p1v-1v, 1v-1v -1p1v; II 1p-1p-0, 1p-1v-1v, 1v-1p1v-1p2v; III 2p-2p-0, 2p-2p-1v, 1p2d2v-1p1r1d1v-1p1r2v; IV 1p1r-1p-0, 1p1r-1r-1v, 1p1r2d1v-2d1v-1p1r2v. Opisthosoma elongate-oval, dorsum grey, with many scattered light spots.

EPIGYNE (FIG. 2C–D). Epigynal plate wider than long, atrium large, ca 4 × as broad as long, with posterior and lateral margins more developed than anterior margin; copulatory openings located close to lateral atrial margins; spermathecae large, ca 2.5 × as long as wide, spindle shaped; copulatory ducts membranous, wide, almost as wide as spermatheca, forming a 450° loop.

#### Variation

The total length in male specimens examined ranges from 6.04 to 7.26 (n = 3), in female specimens from 5.01 to 9.07 (n = 6).

#### Distribution

China, Yunnan (localities in Fig. 11).

#### *Cheiracanthium circulum* sp. nov.

urn:lsid:zoobank.org:act:337E422F-6B3F-459F-BD13-A85167F0F4E7

Figs 3–4, 11, Table 1

#### Diagnosis

The male of this new species (Fig. 4C–E) is similar to *C. uncinatum* Paik, 1985 (Zhang & Zhu 1993: 77, figs 3–6) in having a beak-shaped cymbial spur and a semicircular embolus, but can be distinguished by: (1) the shorter DTA; (2) the thinner median apophysis; (3) the circular tegulum (vs. longitudinally oval in *C. uncinatum*). The female can be easily distinguished from all other species of *Cheiracanthium* by the dumbbell-shaped spermathecae and arch-shaped anterior margin (Fig. 4A–B).

#### Etymology

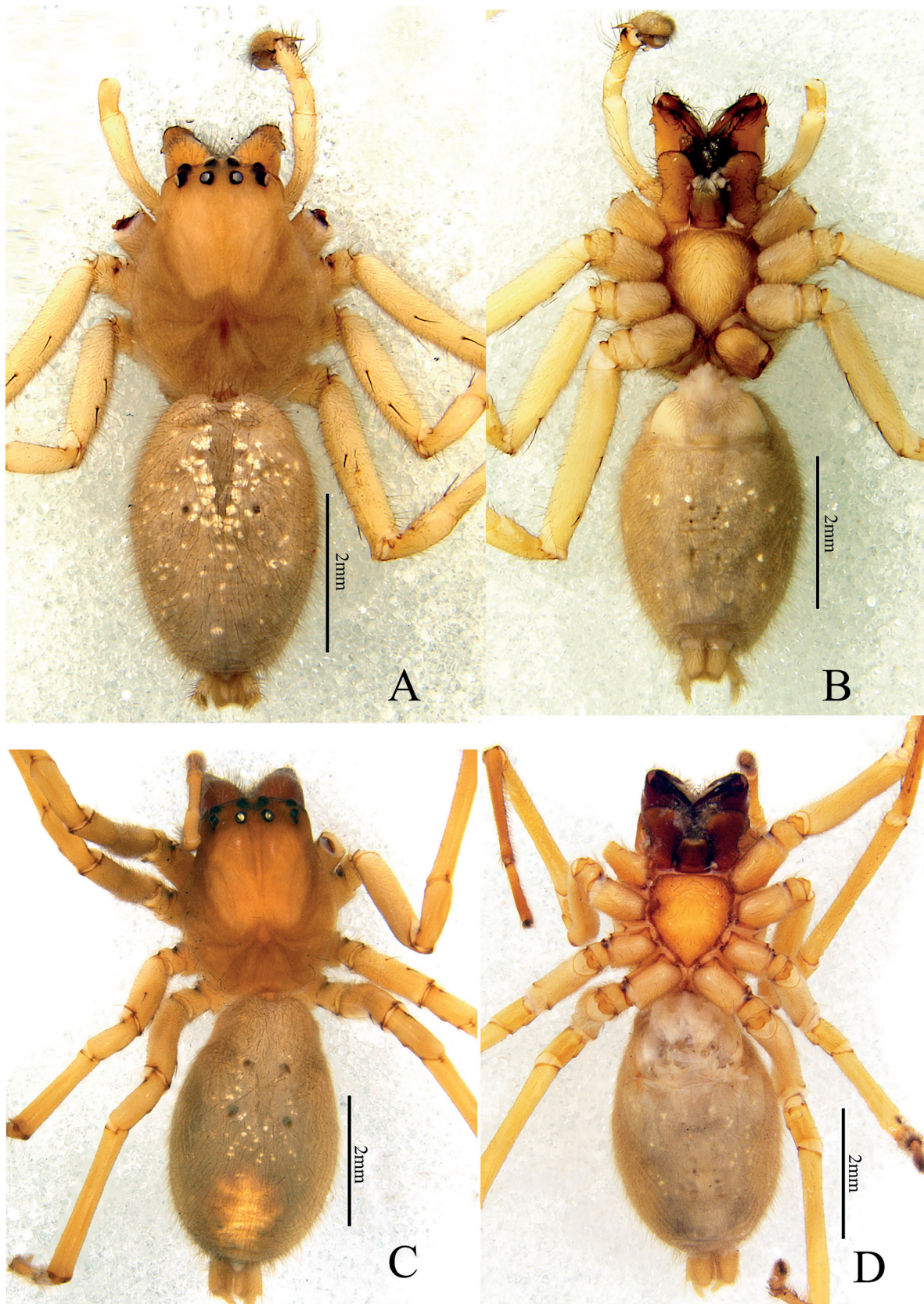
The specific epithet is an adjective from the Latin '*circulus*', referring to the circular tegulum in ventral view.

#### Type material

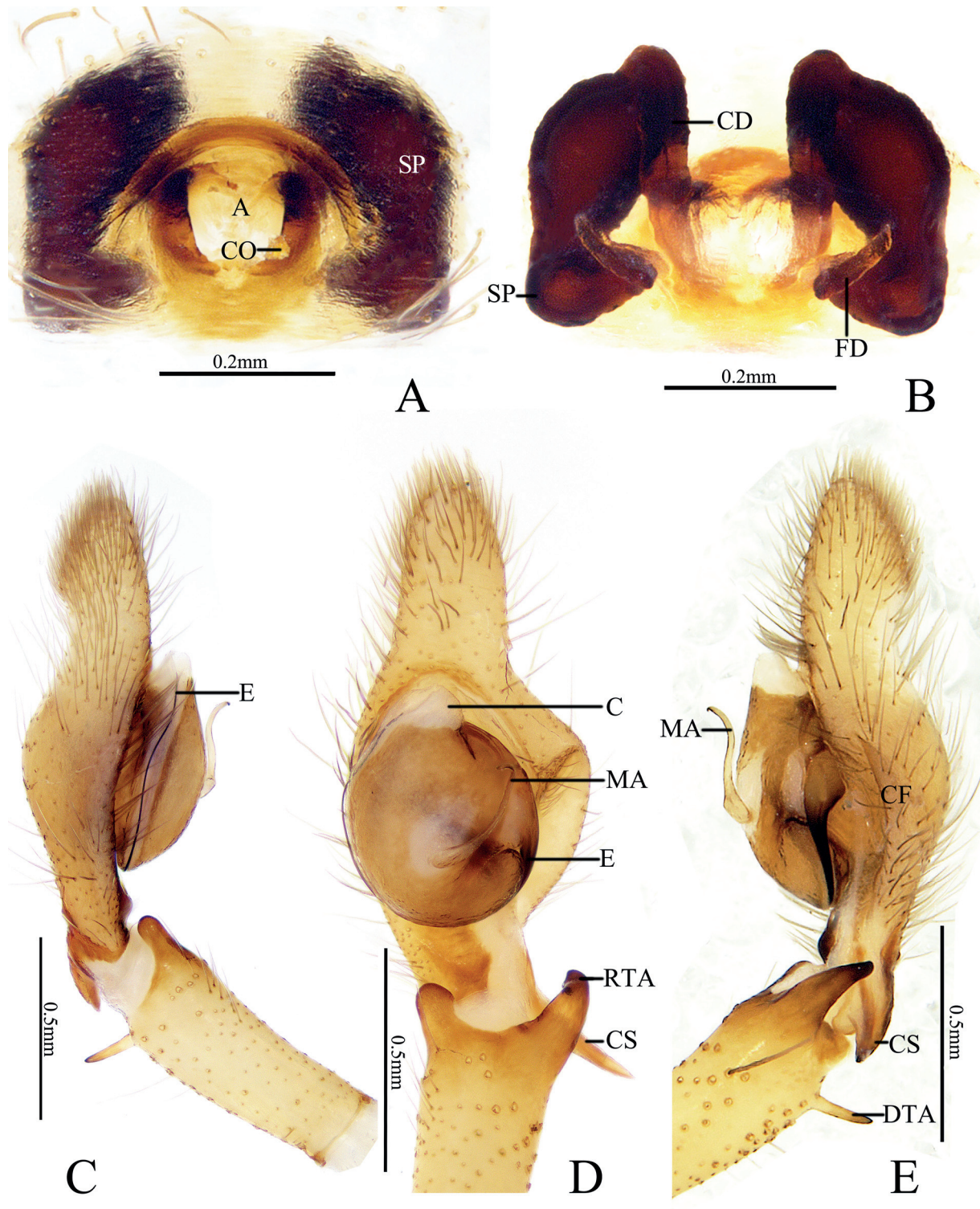
##### Holotype

CHINA • ♂; Yunnan Province, Baoshan City, Longling County, Longxin Town, Xiaoheishan Nature Reserve; 16 Feb. 2011; L.Y. Wang leg.; voucher code: ZYL130, Genbank: OQ866250; MHBU-ARA-1005.





**Fig. 3.** *Cheiracanthium circulum* sp. nov. A–B. ♂, holotype (MHBU-ARA-1005). C–D. ♀, paratype (MHBU-ARA-1006). A, C. Habitus, dorsal view. B, D. Habitus, ventral view.



**Fig. 4.** *Cheiracanthium circulum* sp. nov. **A–B.** ♀, paratype (MHBU-ARA-1006). **C–E.** ♂, holotype (MHBU-ARA-1005). **A.** Epigyne, ventral view. **B.** Vulva, dorsal view. **C.** Left palp, prolateral view. **D.** Same, ventral view. **E.** Same, retrolateral view. Abbreviations: see Material and methods.

**Paratype**

CHINA • 1 ♀; Yunnan Province, Lushui City, Pianma Town; 9 May. 2004; Z.Z. Yang leg.; voucher code: ZYL122, Genbank: OQ866243; MHBV-ARA-1006.

**Description**

**Male (holotype)**

MEASUREMENTS. Total length 6.63. Carapace 3.01 long, 2.31 wide; abdomen 3.62 long, 2.35 wide. Eye sizes and interdistances: AME 0.12, ALE 0.12, PME 0.13, PLE 0.13; AME–AME 0.18, AME–ALE 0.19, PME–PME 0.22, PME–PLE 0.25. MOA 0.47 long, front width 0.43, back width 0.55. Clypeus height 0.07. Sternum 1.45 long, 1.18 wide. Leg measurements: I missing, II 11.09 (2.94, 0.77, 2.96, 3.28, 1.14), III 8.70 (2.22, 0.62, 2.23, 2.65, 0.98), IV 11.29 (2.75, 0.87, 2.88, 3.54, 1.25).

BODY (Fig. 3A–B). Prosoma with distinct radial striae, cephalic region yellow, thoracic region yellowish brown. All eyes with black rings, AER slightly recurved in frontal view; PER slightly wider than AER, almost straight in dorsal view. Chelicerae yellowish brown, with 3 promarginal and 4 retromarginal teeth. Sternum yellowish brown. Labium and endites colored as sternum. Legs pale yellow, without distinct markings. Leg spines: I missing; II 1p1r-1p1r-0, 1p-1p2v-1r1v, 1v-1p2v-1p2v; III 1p1r-1p1r-0, 1p1r-1r-1d, 1p1r1v-1p1r2v-2p1r1v; IV 1p1r-1p1r-0, 1p1r-1p1r-1v, 1p2r1d1v-1p1r1d1v-2p1r1v. Opisthosoma elongate-oval, dorsally grey, with scattered white small patches and numerous black hairs, narrow longitudinal band in middle, enclosed by light spots, two pairs of muscular impressions; venter greyish, with sparse white spots. Spinneret coniform, ALS larger and closed each other; PMS smallest; and PLS with two segments, length of distal segment nearly length of base segment.

PALP (Fig. 4C–E). Tibia long, ca  $\frac{2}{3}$  of cymbium's length; RTA short, ca  $\frac{1}{4}$  of tibia's length, with wider base and hook-shaped tip, and pointed dorsally from ventral view; DTA slightly shorter than RTA, thin and rodlike; cymbium almost 2 × as long as wide; tip of cymbium long, ca  $\frac{1}{3}$  of cymbium's length; cymbium retrolateral margin with shallow dent, cymbial furrow short and shallow; cymbial spur slightly longer than RTA; tegulum circular; median apophysis long, ca  $\frac{1}{2}$  of tegulum's length, with wider base and hook-shaped apex in ventral view; embolus originating on retrolateral flank, at about 3 o'clock position, extending clockwise along tegular margin, tip covered by conductor; conductor membranous, with broad apex; sperm duct indistinct.

**Female (paratype)**

MEASUREMENTS. Total length 6.96. Carapace 2.98 long, 2.35 wide; abdomen 3.98 long, 2.60 wide. Eye sizes and interdistances: AME 0.15, ALE 0.16, PME 0.14, PLE 0.15; AME–AME 0.23, AME–ALE 0.28, PME–PME 0.32, PME–PLE 0.36. MOA 0.47 long, front width 0.49, back width 0.60. Clypeus height 0.04. Sternum 1.47 long, 1.33 wide. Leg measurements: I 13.03 (3.54, 1.14, 3.49, 3.66, 1.20), II 9.91 (2.76, 0.93, 2.40, 2.75, 1.07), III 7.44 (2.21, 0.64, 1.49, 2.13, 0.97), IV 10.55 (2.96, 0.89, 2.64, 3.00, 1.06).

BODY (Fig. 3C–D). Prosoma reddish brown, thoracic region darker than other parts except the eye area. Chelicerae with 3 promarginal and 5 retromarginal teeth. Sternum, labium and endites colored as carapace. Legs pale yellow. Leg spines: I 0-0-0, 0-0-0, 1v-0-2v; II 1p1r-1p-0, 1p-1v-1v, 1v-2v-2v; III 1p1r-1p-0, 1r-1r-1d, 1p1r2v-1v-2v; IV 1r-1p-0, 1r-1p-1v, 1p1r2v-2v-1v. Opisthosoma greyish brown, with scattered white spots and two pairs of muscular impressions.

EPIGYNE (Fig. 4A–B). Atrium heavily sclerotized, located at posterior portion of epigynal plate, with arch-shaped anterior margin and crescent-shaped lateral margins; two copulatory openings located at postero-lateral margins of atrium; part of dark copulatory duct and spermathecae visible through

tegument of epigynal plate in ventral view; spermathecae dumbbell-shaped, connected with simple copulatory duct, copulatory ducts ascend, then fold backwards and lastly descend to spermathecae.

### Distribution

China, Yunnan (localities in Fig. 11).

### *Cheiracanthium digitatum* sp. nov.

urn:lsid:zoobank.org:act:2AD7B3F8-7752-4952-B7D3-E1EEA35DC51C

Figs 5–6, 11, Table 1

### Diagnosis

The male of this new species (Fig. 6C–E) can be distinguished from other species of *Cheiracanthium* by having a short, robust cymbial spur, a needle-shaped median apophysis, and an inflated tegulum with indistinct markings. Among the congeners, the male of this new species resembles *C. antungense* Chen & Huang, 2012 (Chen & Huang 2012: fig. 1a–c) and *C. inflatum* Wang & Zhang, 2013 (Wang & Zhang 2013: figs 4–6) in having an inflated tegulum, but can be distinguished by: (1) the long needle-shaped median apophysis (vs. short thorn-shaped in *C. inflatum*; absent in *C. antungense*); (2) embolus originating at the 3 o'clock position (vs. 5 o'clock position in the other two species). (3) the long RTA, extending beyond the tegular base in retrolateral view (vs. extending only to the tegular base in the other two species). The female (Fig. 6A–B) is similar to *C. solidum* Zhang, Zhu & Hu, 1993 (Zhang *et al.* 1993: figs 5–6) in having a broad epigynal atrium and spherical spermathecae, but can be distinguished by: (1) the copulatory ducts curved for two circles, while curved only one circle in *C. solidum*; (2) the anterior margin of atrium with an inward median process, while with an arch-shaped margin in *C. solidum*.

### Etymology

The specific epithet is an adjective from the Latin '*digitatus*', referring to the finger-shaped retrolateral tibial apophysis in ventral view.

### Type material

#### Holotype

CHINA • ♂; Anhui Province, Jixi County, Fuling Town, Yonglai Village; 30°08' N; 118°43' E; 12 Jul. 2014; S.J. Zha leg.; voucher code: ZYL088, Genbank: OQ866247; MHBU-ARA-1007.

#### Paratypes

CHINA • 2 ♂♂, 1 ♀; same collection data as for holotype; voucher code: ZYL107, Genbank: OQ866246; MHBU-ARA-1008.

### Description

#### Male (holotype)

MEASUREMENTS. Total length 7.75. Carapace 3.63 long, 2.77 wide; abdomen 4.12 long, 2.10 wide. Eye sizes and interdistances: AME 0.15, ALE 0.16, PME 0.16, PLE 0.16; AME–AME 0.18, AME–ALE 0.23, PME–PME 0.26, PME–PLE 0.30. MOA 0.47 long, anterior width 0.48, posterior width 0.59. Clypeus height 0.11. Sternum 1.67 long, 1.40 wide. Leg measurements: I 21.10 (5.33, 1.00, 5.99, 6.69, 2.09), II 14.40 (3.68, 0.83, 3.99, 4.33, 1.31), III 10.96 (2.81, 0.99, 2.56, 3.45, 1.15), IV 16.63 (4.86, 1.12, 3.92, 5.39, 1.34).

BODY (Fig. 5A). Prosoma yellowish brown, without distinct colour pattern; cervical groove and radial striae indistinct. AER almost straight in frontal view; PER slightly wider than AER, slightly procurved

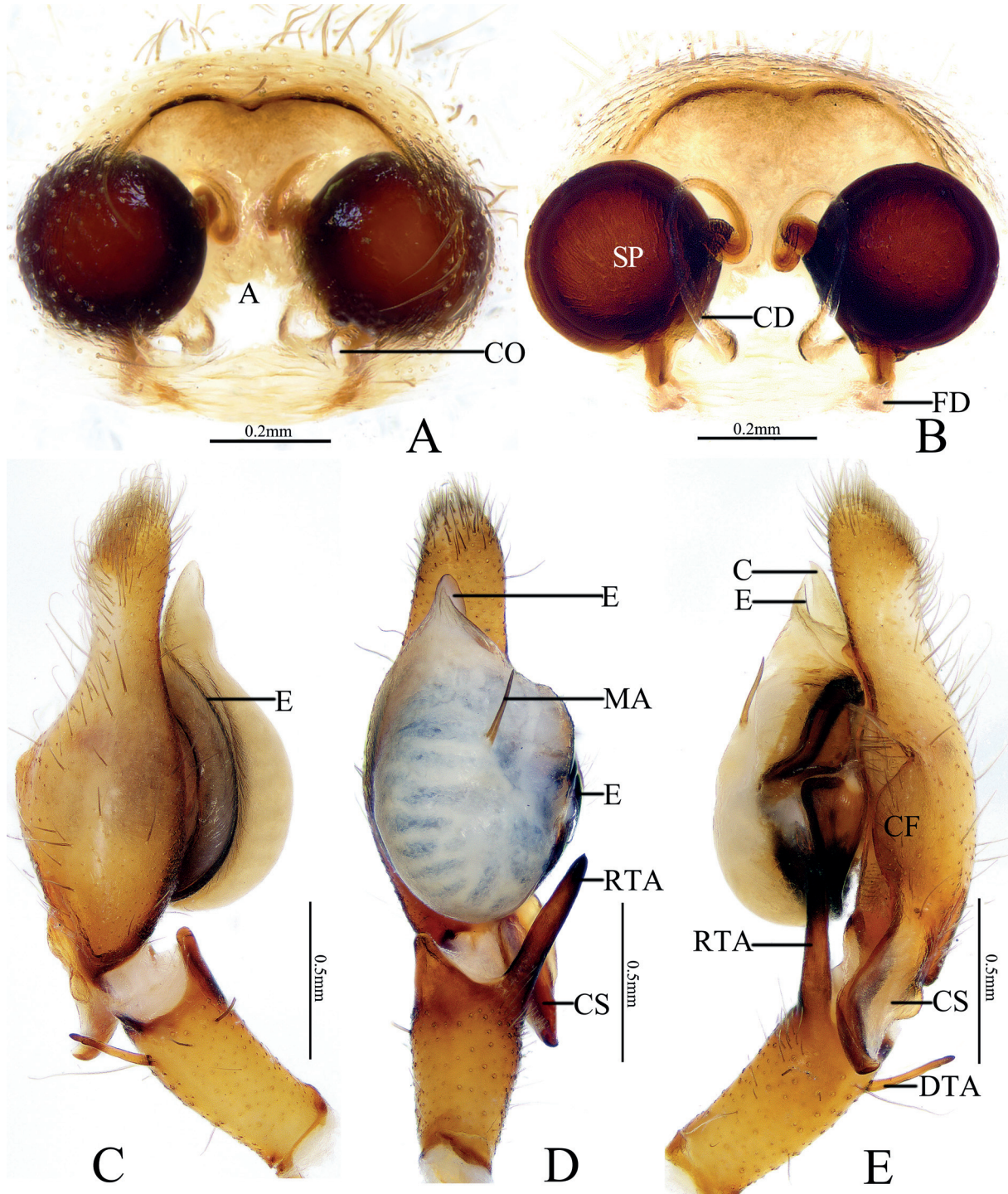
in dorsal view. Chelicerae yellowish brown, promargin with one large and one small teeth, retromargin with three teeth. Sternum dark brown. Labium, wider than long, anteriorly truncated and with several macrosetae distally. Endites brown, constricted at middle on lateral margin. Legs mostly yellow with darker tarsi and metatarsi. Leg spines: I 1p1r-1p1r-0, 2p2v-2p2r2v-2p1r1v, 1v-1p1r-2v; II 2p2r-2p2r-0, 1p1v-1p1r1v-1p1v, 1v-2p1r-1d1v; III 1p1r-1p1r-0, 1p1r-1r-1p1r1v, 1p1r2v-1p1r1v-1p1r2v; IV 1p1r-1p1r-0, 1p1r-1r1v-1p1v, 1p1r2v-1p1r1v-1p1r1v. Opisthosoma lanceolate, twice as long as wide, dorsum grey and with two pairs of obvious muscle impressions. Spinneret coniform, ALS larger and closed each other; PMS smallest; and PLS with two segments, length of distal segment nearly length of base segment.

PALP (Fig. 6C–E). Tibia short, ca  $\frac{1}{2}$  of cymbium's length; RTA long and finger-shaped, slightly shorter than tibia; DTA long and thin, rodlike, ca  $\frac{2}{3}$  of RTA's length; cymbial furrow short and shallow; cymbial spur short and robust; bulb oval, inflated, with indistinct markings and needle-like median apophysis;



**Fig. 5.** *Cheiracanthium digitatum* sp. nov. A. ♂, holotype (MHBU-ARA-1007), habitus, dorsal view. B. ♀, paratype (MHBU-ARA-1008), habitus, dorsal view.

embolus originating on retrolateral flank, at about 3 o'clock position, extending clockwise along tegular margin, tip covered by conductor; conductor membranous, with blunt apex; sperm duct indistinct.



**Fig. 6.** *Cheiracanthium digitatum* sp. nov. A–B. ♀, paratype (MHBU-ARA-1008). C–E. ♂, holotype (MHBU-ARA-1007). A. Epigyne, ventral view. B. Vulva, dorsal view. C. Left palp, prolateral view. D. Same, ventral view. E. Same, retrolateral view. Abbreviations: see Material and methods.

**Female** (paratype)

MEASUREMENTS. Total length 7.82. Carapace 3.52 long, 2.53 wide; abdomen 4.30 long, 2.83 wide. Eye sizes and interdistances: AME 0.16, ALE 0.17, PME 0.16, PLE 0.14; AME–AME 0.23, AME–ALE 0.26, PME–PME 0.28, PME–PLE 0.34. MOA 0.47 long, front width 0.48, back width 0.64. Clypeus height 0.09, Sternum 1.68 long, 1.28 wide. Leg measurements: I 18.30 (4.61, 1.48, 4.85, 5.48, 1.88), II 11.19 (3.04, 1.17, 2.79, 3.21, 0.98), III 7.66 (2.19, 0.81, 1.62, 2.23, 0.81), IV 11.81 (3.38, 1.24, 3.00, 3.59, 0.60).

BODY (Fig. 5B). Prosoma yellowish brown, with indistinct radial stripes. Legs yellow. Leg spines: I 1p-1p-0, 1p-1p1r-1p1r2v, 1v-1p1v-2v; II 1p-1p-0, 1p-1p2v-1p, 1v-1p2v-1p1v; III 1p1r-1p1r-0, 1p1r-1r-1p1v, 1p1r2d2v-1p1r1v-1p1r1v; IV 1p1r-1p1r-0, 1r-1v-1d1v, 1p1r2v-1r1v-1p1r1v. Opisthosoma elongate-oval, dorsum grey and with scattered white spots.

EPIGYNE (Fig. 6A–B). Epigynal plate wider than long, atrium large, with an arch-shaped anterior margin and slightly depressed in middle, posterior and lateral margins inconspicuous; two copulatory openings located at posterior portion of epigynal plate; part of dark copulatory duct and spermathecae visible through tegument of epigynal plate in ventral view; spermathecae large and globular, spaced by about 0.6 diameters; copulatory ducts long, ascending and descending portions curved for two circles, then connected with spermathecae.

**Variation**

The total length in male specimens examined ranges from 6.96 to 8.28 (n = 3).

**Distribution**

China, Anhui (localities in Fig. 11).

*Cheiracanthium jiuquan* sp. nov.

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Figs 7–8, 11, Table 1

**Diagnosis**

The male of this new species (Fig. 8C–D) is similar to *Cheiracanthium daofeng* Yu & Li, 2020 (Zhang *et al.* 2020: 56, figs 1a–c, 2a–d) by having the conductor and embolar tip extending to the apex of the cymbium, but can be distinguished by the longer cymbial furrow and the 12 o'clock embolus's origination (vs. 1 o'clock position in *C. daofeng*). The female (Fig. 8A–B) is similar to *C. exquestitum* Zhang & Zhu 1993 (Zhang & Zhu 1993: 5, figs 1–2), *C. taiwanicum* Chen, Huang, Chen & Wang, 2006 (Zhang *et al.* 2018: 41, fig. 3a–b) and *C. falcatum* Chen, Huang, Chen & Wang, 2006 (Chen *et al.* 2006: 12, fig. 2a–e) in having globular spermathecae and coiled copulatory ducts, but can be distinguished by the presence of 9 spiral coils of copulatory ducts (vs. 3 in *C. falcatum*, 4 in *C. exquestitum*, and about 5 coils in *C. taiwanicum*).

**Etymology**

The specific epithet is derived from the Chinese pinyin 'jiǔ quān', which means 'nine loops', and refers to the coiled copulatory ducts, forming nine entwined coils; noun in apposition.

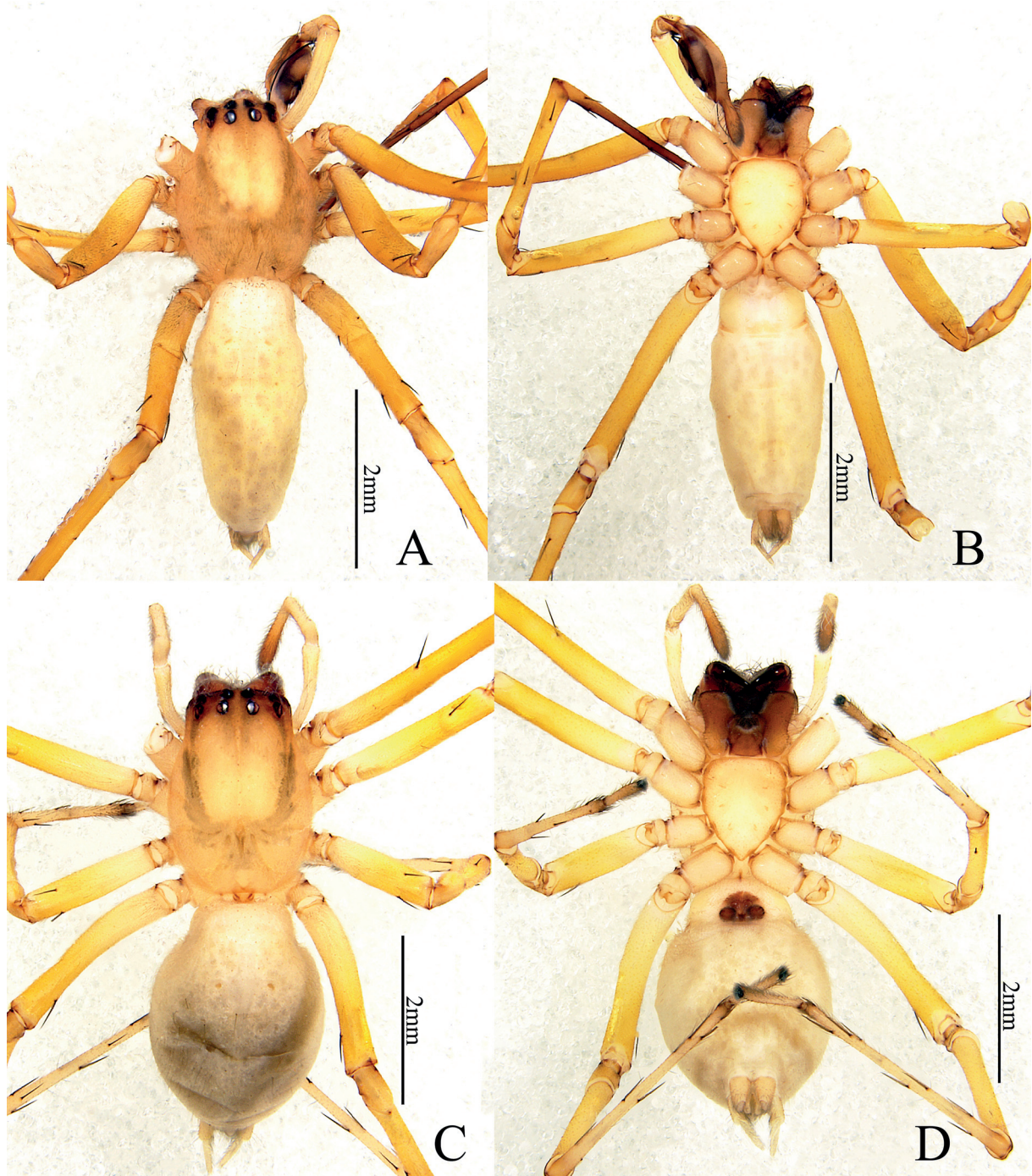
**Type material**

**Holotype**

CHINA • ♂; Guangxi Province, Qinzhou City, Guitai Town, Bazhaigou; 22°04' N; 108°15' E; alt. 330 m; 16 Aug. 2018; Z.Y. Li leg.; voucher code: ZYL090, Genbank: OQ866244; MHBU-ARA-1009.

**Paratypes**

CHINA • 1 ♀; same collection data as for holotype; voucher code: ZYL091, Genbank: OQ866242; MHBU-ARA-1010 • 3 ♂♂, 1 ♀; Bazhaigou; 22°11' N; 108°15' E; alt. 65 m; 15 Aug. 2018; Z.Y. Li leg.; voucher code: ZYL092, Genbank: OQ866245; MHBU-ARA-1011 • 1 ♂, 1 ♀; Nanning City, Luobo Town, Ban'ou Village; 23°28' N; 108°23' E; alt. 266 m; 10 Aug. 2018; Y. Chen leg.; MHBU-ARA-1012.



**Fig. 7.** *Cheiracanthium jiuquan* sp. nov. **A–B.** ♂, holotype (MHBU-ARA-1009). **C–D.** ♀, paratype (MHBU-ARA-1010). **A, C.** Habitus, dorsal view. **B, D.** Habitus, ventral view.



## Description

### Male (holotype)

MEASUREMENTS. Total length 4.95. Carapace 2.03 long, 1.55 wide; abdomen 2.92 long, 1.22 wide. Eye sizes and interdistances: AME 0.11, ALE 0.10, PME 0.14, PLE 0.12; AME–AME 0.11, AME–ALE 0.12, PME–PME 0.17, PME–PLE 0.16. MOA 0.35 long, front width 0.36, back width 0.42. Clypeus height 0.08. Sternum 1.05 long, 0.84 wide. Leg measurements: I 20.51 (4.93, 0.83, 5.83, 6.67, 2.25), II 9.06 (2.00, 0.68, 2.62, 2.88, 0.88), III 7.02 (2.03, 0.25, 1.69, 2.28, 0.77), IV 9.36 (2.14, 0.52, 3.08, 2.68, 0.94).

BODY (Fig. 7A–B). Prosoma with distinct radial striae, cephalic region yellow, thoracic region yellowish brown. All eyes with black rings, AER slightly recurved in frontal view; PER slightly wider than AER, almost straight in dorsal view. Chelicerae with 2 promarginal and 3 retromarginal teeth. Sternum yellow. Labium and endites yellowish brown. Legs yellow, without distinct markings. Leg spines: I 0-1p-0, 1p1v-1p-1p, 1v-1p1v-1p2v; II 1p1r-1p-0, 1p1v-1p1v-1p, 1p1r1v-1p1r1d1v-1p1r1v; III 1p1r-1p1r-0, 1p1r-0-1p1r1v, 2p2r1d-2p1d-1p2r1v; IV 1p1r-1p1r-0, 1p1r-0-1r1v, 2p1r1v-1p2r-1p1r. Opisthosoma lanceolate, dorsally yellow, with two pairs of muscular impression and numerous indistinct markings; venter greyish. Spinneret coniform, ALS larger and closed each other; PMS smallest; and PLS with two segments, length of basal segment shorter than distal segment.

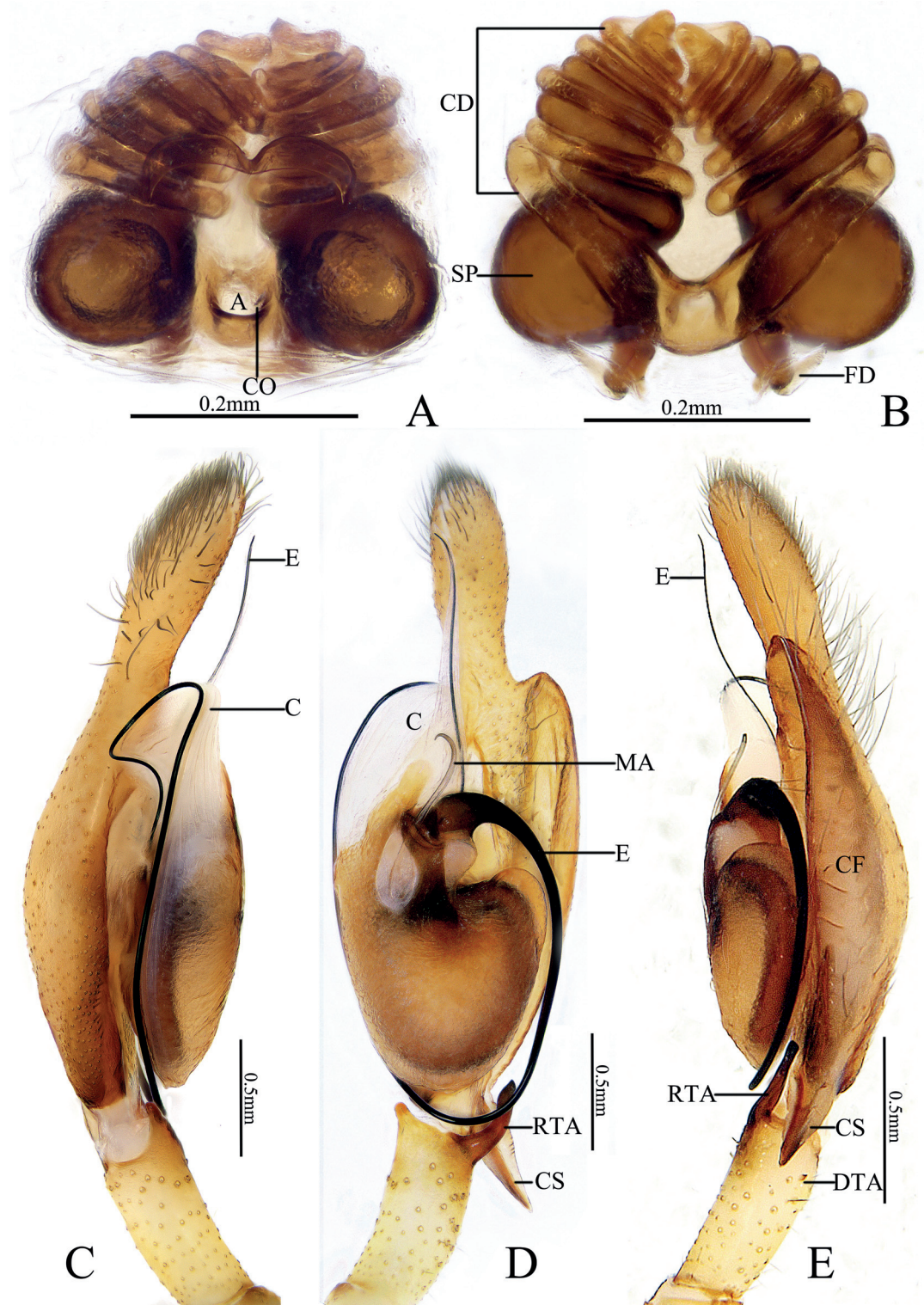
PALP (Fig. 8C–E). Tibia short, ca  $\frac{1}{3}$  of cymbium's length; RTA long, ca  $\frac{1}{2}$  of tibia's length, thorn-shaped; DTA tiny, with sharp apex; cymbium almost 2–2 longer than wide; distal cymbium long, ca  $\frac{1}{3}$  of cymbium's length; cymbial furrow strongly developed in ventral and retrolateral views, about  $\frac{2}{3}$  of cymbium's length; cymbial spur as long as RTA; tegulum oval, ca  $1.5 \times$  as long as wide; median apophysis long, membranous, more than  $\frac{1}{2}$  of tegulum's length, hook-shaped distally in ventral view; embolus arising on distal tegular, at about 12 o'clock position, extending clockwise along tegular margin to distal conductor and cymbium; conductor large, membranous, base wide, gradually tapering toward apex; sperm duct semicircular.

### Female (paratype)

MEASUREMENTS. Total length 5.28. Carapace 2.40 long, 1.76 wide; abdomen 2.88 long, 2.07 wide. Eye sizes and interdistances: AME 0.13, ALE 0.08, PME 0.14, PLE 0.09; AME–AME 0.16, AME–ALE 0.18, PME–PME 0.25, PME–PLE 0.23. MOA 0.41 long, front width 0.41, back width 0.50. Clypeus height 0.05. Sternum 1.28 long, 0.98 wide. Leg measurements: I 14.73 (3.60, 0.68, 3.60, 4.89, 1.96), II 7.90 (2.17, 0.65, 1.95, 2.31, 0.82), III 5.17 (1.57, 0.35, 0.87, 1.68, 0.70), IV 8.68 (2.61, 0.51, 1.91, 2.77, 0.88).

BODY (Fig. 7C–D). Prosoma pale reddish brown, with a pair of brown lateral bands extending from behind PLE, extending almost to posterior half of carapace and then merging and forming a U-shaped patch. Legs yellow. Leg spines: I 0-2p-0, 1p-1p1r-1p, 1v-1p1r-1p; II 1p-1p-0, 1p-1v-1p, 1v-1p2v-2v; III 1p1r-1p-0, 1r-0-1p, 2p2r1v-1d-1p1v; IV 1r-1p-0, 1r-0-1r, 2p1r1d2v-1p1r-1p1r. Opisthosoma oval, dorsally grey, with sparse black hairs.

EPIGYNE (Fig. 8A–B). Atrium large, slightly wider than long, anterior margin eyebrow-shaped and heavily sclerotized; two copulatory openings conjoined, located at posterior epigynal plate; copulatory duct and spermathecae partial visible in ventral view; spermathecae large, globular, separated by almost their diameters; copulatory ducts extend to 9 entwined loops (including 5 ascending and 4 descending coils).



**Fig. 8.** *Cheiracanthium jiuquan* sp. nov. **A–B.** ♀, paratype (MHBU-ARA-1010). **C–E.** ♂, holotype (MHBU-ARA-1009). **A.** Epigyne, ventral view. **B.** Vulva, dorsal view. **C.** Left palp, prolateral view. **D.** Same, ventral view. **E.** Same, retrolateral view. Abbreviations: see Material and methods.

### Variation

The total length in male specimens examined ranges from 4.01 to 7.74 (n = 5), in female specimens from 4.56 to 7.02 (n = 3).

### Distribution

China, Guangxi (localities in Fig. 11).

### *Cheiracanthium xinjiangense* sp. nov.

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Figs 9–10, 11

### Diagnosis

The male of this new species (Fig. 10C–E) is similar to *C. pennyi* O. Pickard-Cambridge, 1873 (Zhang *et al.* 2022: 180, fig. 133e–g) and *C. punctorium* (Villers, 1789) (Almquist 2006: 356, fig. 309b–c) in having a biforked RTA, a circular-shaped embolus, a similar conductor and cymbial furrow, but can be distinguished by: (1) the longer cymbial spur and median apophysis; (2) the prolateral apex of RTA shorter than the retrolateral one (vs. nearly equal in other two species). The female (Fig. 10A–B) is similar to *C. punctorium* (Villers, 1789) (Almquist 2006: 356, fig. 309d–e) and *C. brevispinum* Song, Feng & Shang, 1982 (Zhang *et al.* 2022: 180, fig. 132c–d) in having similar shaped spermathecae, but can be distinguished by: (1) the broader anterior atrial margin; (2) the thinner copulatory ducts.

### Etymology

The species epithet is an adjective derived from the type locality.

### Type material

#### Holotype

CHINA • ♂; Xinjiang Uygur Autonomous Region, Shihezi City; 12 Apr. 1982; MHBUS-ARA-1013.

#### Paratype

CHINA • 1 ♀; same collection data as for holotype; MHBUS-ARA-1014.

### Description

#### Male (holotype)

MEASUREMENTS. Total length 6.01. Carapace 2.57 long, 1.98 wide; abdomen 3.44 long, 1.82 wide. Eye sizes and interdistances: AME 0.11, ALE 0.12, PME 0.10, PLE 0.12; AME–AME 0.17, AME–ALE 0.18, PME–PME 0.24, PME–PLE 0.27. MOA 0.38 long, front width 0.34, back width 0.40. Clypeus height 0.06. Sternum 1.37 long, 1.17 wide. Leg measurements: I 14.14 (4.06, 0.91, 4.18, 3.13, 1.86), II 10.05 (2.91, 0.87, 2.71, 2.55, 1.01), III 7.52 (2.16, 0.86, 1.65, 2.11, 0.74), IV 12.32 (3.62, 0.91, 3.10, 3.63, 1.06).

BODY (Fig. 9A). Prosoma yellowish brown, with indistinct radial striae. AER slightly recurved in frontal view; PER slightly procurved, and wider than AER in dorsal view. Chelicerae reddish brown, with 1 promarginal and 3 retromarginal teeth. Sternum yellow. Labium and endites same as carapace in color. Legs pale yellow, without distinct markings. Leg spines: I 1p-0-0, 0-1p1r-1v, 1v-0-1p; II 1p-0-0, 1p-2v-2v, 1v-1p-2v; III 1p1r-0-0, 1p1r-0-1p1r, 1p1r1v-1p-1p1r; IV 1p1r-0-0, 1p1r1v-1p1v-1d1v, 1p1r2v-2v-1p2r1v. Opisthosoma elongate-oval, dorsum with two pairs of muscular impressions and numerous white freckles, narrow longitudinal band in middle, enclosed by light spots; venter brown, with scattered white spots. Spinnerets coniform, ALS larger, PMS smallest, and PLS with two segments, distal segment very short.

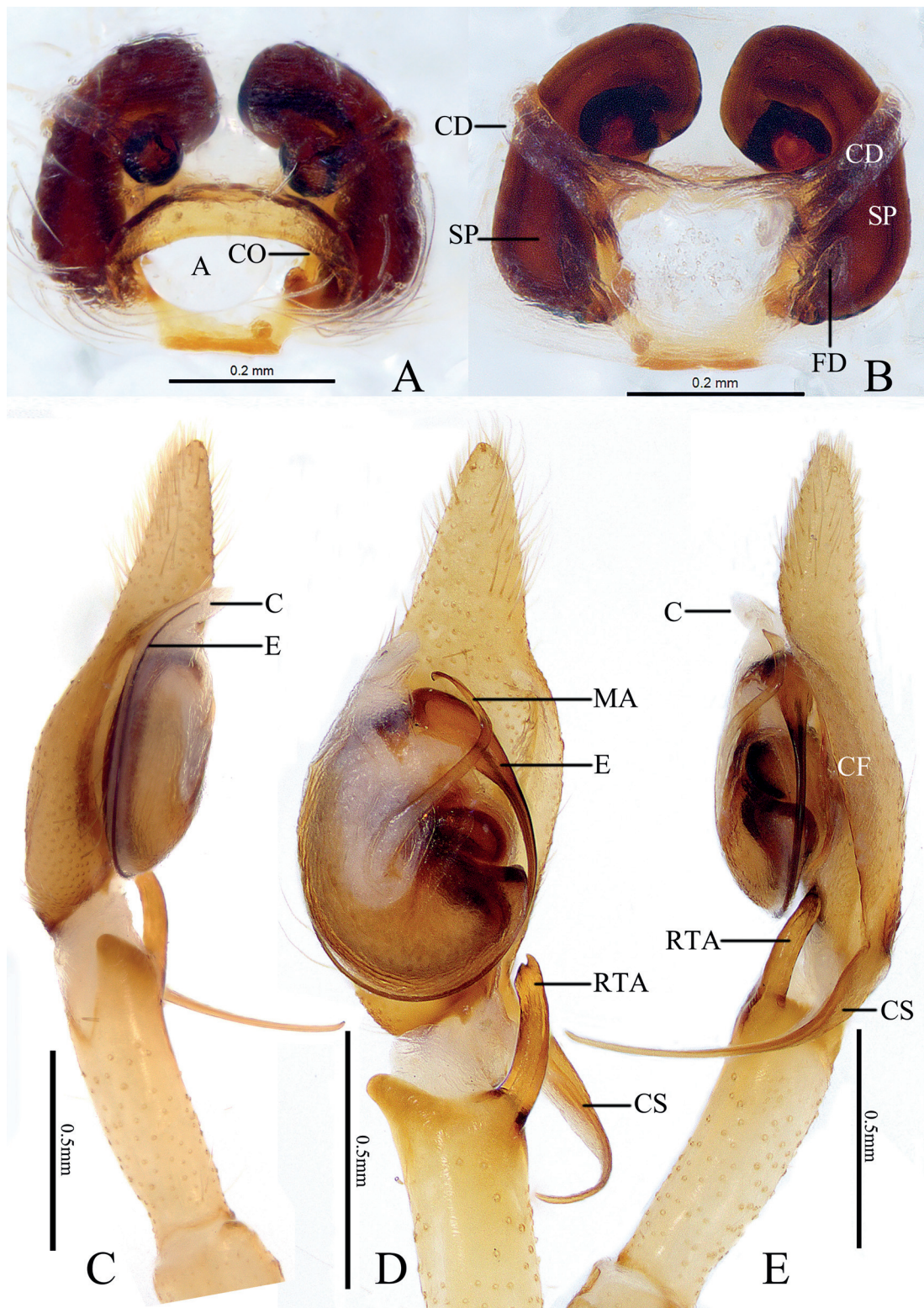
PALP (Fig. 10C–E). Tibia long, ca  $\frac{3}{4}$  of cymbium's length; RTA long, ca  $\frac{1}{2}$  of tibia's length, thorn-shaped, distally bifurcated, with prolateral apophysis blunt distally, slightly shorter than distally sharp retrolateral one; cymbium almost  $2 \times$  as long as wide; distal cymbium long, ca  $\frac{1}{3}$  of cymbium's length; cymbial furrow strongly developed, about  $\frac{2}{3}$  of cymbium's length; cymbial spur filiform, slightly shorter than tibia; tegulum oval, ca  $1.2 \times$  as long as wide; median apophysis long, more than  $\frac{1}{2}$  of tegulum's length, sickle-shaped in ventral view; embolus located on distal side of tegulum, at about 11–12 o'clock position, extending clockwise along tegular margin, curving to distal conductor; conductor large, membranous, gradually tapering toward apex, lying at tegular tip; sperm duct semicircular.

**Female (paratype)**

MEASUREMENTS. Total length 6.19. Carapace 2.83 long, 2.20 wide; abdomen 3.36 long, 2.68 wide. Eye sizes and interdistances: AME 0.11, ALE 0.10, PME 0.11, PLE 0.11; AME–AME 0.20, AME–ALE 0.26, PME–PME 0.30, PME–PLE 0.32. MOA 0.32 long, front width 0.45, back width 0.53. Clypeus height 0.08. Sternum 1.45 long, 1.18 wide. Leg measurements: I 12.97 (3.42, 1.22, 3.18, 3.38, 1.77), II 8.01 (2.31, 0.92, 1.81, 2.10, 0.87), III 6.03 (1.79, 0.70, 1.19, 1.77, 0.63), IV 9.70 (2.93, 1.10, 2.34, 2.61, 0.72).



**Fig. 9.** *Cheiracanthium xinjiangense* sp. nov. A. ♂, holotype (MHBU-ARA-1013), habitus, dorsal view. B. ♀, paratype (MHBU-ARA-1014), habitus, dorsal view.



**Fig. 10.** *Cheiracanthium xinjiangense* sp. nov. **A–B.** ♀, paratype (MHBU-ARA-1014). **C–E.** ♂, holotype (MHBU-ARA-1013). **A.** Epigyne, ventral view. **B.** Vulva, dorsal view. **C.** Left palp, prolateral view. **D.** Same, ventral view. **E.** Same, retrolateral view. Abbreviations: see Material and methods.

**BODY** (Fig. 9B). Prosoma orange, without distinct markings. Legs pale yellow. Leg spines: I 1p-0-0, 0-1p1r-1p1r, 2v-0-1r1v; II 1p-0-0, 1p-1v-1v, 2v-1p-2v; III 1p1r-0-0, 1p1r-0-1p, 1p1r2v-1p1r-1v; IV 1p-0-0, 1p1r-1p1r-d, 1p1r2v-2p1r-1p2v. Opisthosoma oval, with numerous pale white spots.

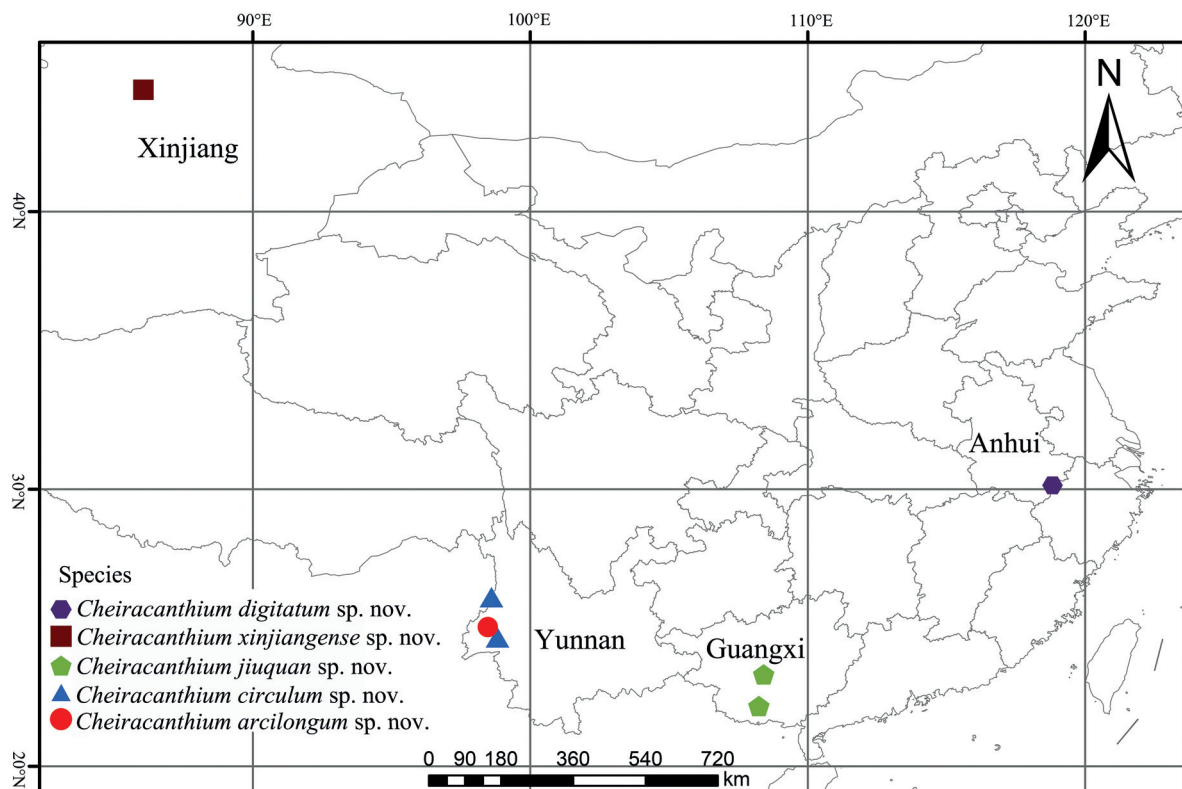
**EPIGYNE** (Fig. 10A–B). Atrium ca 2 × as wide as long, atrial anterior margin arch-shaped and heavily sclerotized, posterior and lateral margins inconspicuous; two copulatory openings located at postero-lateral margins of epigynal plate; part of dark copulatory duct and spermathecae visible through tegument of epigynal plate in ventral view; spermathecae elongated, ca 3 × longer than wide; copulatory ducts short, forming one entwined loop, then upward folding and ascending into spermathecae.

### Distribution

China, Xinjiang (localities in Fig. 11).

### Discussion

The genus *Cheiracanthium* is the most diverse among cheiracanthiids, with 214 extant species and represent 59% of the total number of species of Cheiracanthiidae (World Spider Catalog 2022). Due to cryptic habitat and almost half of the species are known from a single sex or juveniles, the identification of species in *Cheiracanthium* is often challenging (Zhang *et al.* 2020; Lo *et al.* 2021). All interspecific divergences were well above the largest intraspecific values (minimum interspecific 7.4% vs 1.2%). These results mirror those found in the closely related study of *Cheiracanthium* from Taiwan, whose mean intraspecific and interspecific COI genetic distances range are 0.33–1.95% and 3.32–14.67%,



**Fig. 11.** Distribution records of the five new species of *Cheiracanthium* in China.

respectively (Lo *et al.* 2021). Therefore, the combination of DNA barcodes with locality information may ease the identification of species of *Cheiracanthium*.

## Acknowledgements

We are grateful to Dr Xin-ping Wang (University of Florida) for reviewing the English of this manuscript and Yang Chen, Pan-Long Wu, Zi-Zhong Yang, Shan-Jie Zha and Lu-Yu Wang for their assistance during the field work and collection. We also thank Dr Rudy Jocqué (section editor) and two anonymous reviewers for their comments and suggestions that improved our manuscript. This work was supported by the Post-graduate's Innovation Fund Project of Hebei Province (CXZZBS2023004), the National Natural Science Foundation of China (No. 32170468) and the Science and Technology Fundamental Resources Investigation Program (No. 2022FY202100).

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