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The genus *Taira*, with notes on tibial apophyses and descriptions of three new species (Araneae: Amaurobiidae)

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Abstract. Homologies of the tibial apophyses of *Taira* with those of other members of the subfamily Amaurobiinae are evaluated. The monophyly of the genus *Taira* and the phylogenetic relationships of its species are analyzed using parsimony. The genus *Taira* is supported by two putative synapomorphies: the presence of broad epigynal teeth and the distally originating tegular sclerite apophysis. A diagnosis and description of *Taira* and a key to its species are provided. Three new species are described from China: *Taira qiuae* new species (♂♀), *T. sichuanensis* new species (♂♀), and *T. zhui* new species (♂♀).

Keywords: Identification key, taxonomy, homology, phylogenetic relationships, China

Lehtinen (1967) created the new genus *Taira* for the species *Amaurobius flavidorsalis* Yaginuma 1964, described from Japan, compared it with other genera of Amaurobiidae, and placed *Taira* with the genus *Tamgrinia* Lehtinen 1967 in the tribe *Tairini* within the Holarctic subfamily Amaurobiinae Thorell 1870. Only four papers have been published on *Taira* since its establishment in 1967. Wang (2000) questioned the sister group relationship between *Taira* and *Tamgrinia* by comparing spinnerets, tracheae, and trichobothria of the family Amaurobiidae. Zhu et al. (2004) and Wang & Ran (2004) described two new species based on specimens from two closely situated localities in Libo County, Guizhou, China. A study by Zhang et al. (2008) concluded that *T. lunaris* Wang & Ran 2004 is a junior synonym of *T. liboensis* Zhu, Chen & Zhang 2004. In recent years, field work by Zhang et al. (2008) in southern China has yielded five more new species: *T. cangshan* Zhang, Zhu & Song 2008, *T. latilabiata* Zhang, Zhu & Song 2008, *T. obtusa* Zhang, Zhu & Song 2008, *T. concava* Zhang, Zhu & Song 2008, and *T. sulciformis* Zhang, Zhu & Song 2008, and a new combination, *T. decorata* (Yin & Bao 2001). As a result, a total of eleven species from Japan and southern China are included in *Taira*, including the three new species described here. In all previous studies, the diagnosis of the genus *Taira*, and therefore the distinction between *Taira* and other amaurobiids, was only vaguely defined. Zhang et al. (2008) provided a diagnosis for *Taira* that we argue was based on a misinterpretation of non-homologous features (i.e., tibial apophyses, see below). This study is focused on diagnosing and describing the genus *Taira*, discussing its monophyly, estimating the species relationships, and providing a key to the *Taira* species described so far. The three new species described here belong to a distinct group, which differs from other *Taira* by the widely separated, elongated spermathecae in females and the long RTA (except *T. sichuanensis*), presence of an intermediate apophysis between the RTA and dorsal tibial apophysis, and the uniquely modified conductor in males.

METHODS

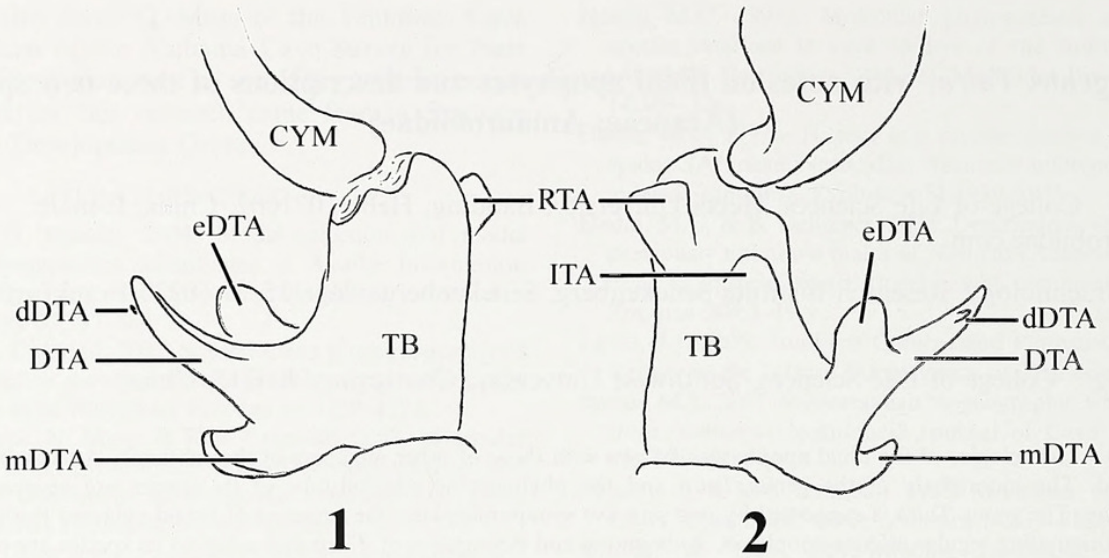
All measurements are in mm. Scale lines are 0.2 mm long except where indicated otherwise. Eye diameters are taken at the widest point. The length of body, prosoma, and opisthosoma do not include the length of the chelicerae or spinnerets. The distribution map was generated using GIS ArcView software, and the text files of the studied species are downloadable from Wang (2009). More type specimen photos of the species included in this paper can be viewed in Li & Wang (2009).

Anatomical abbreviations used in the text and figures: *Eyes*: AME–anterior median eyes; ALE–anterior lateral eyes; PLE–posterior lateral eyes; PME–posterior median eyes. *Female Genitalia*: CD–copulatory duct; EL–epigynal median lobe; ET–epigynal tooth; FD–fertilization duct; S–spermatheca. *Male palp*: C–conductor hyaline apophysis; C1–conductor apophysis I (from which hyaline apophysis arises); C2–conductor apophysis II, which is an extension of the conductor apophysis I; C3–conductor apophysis III; CYM–cymbium; dDTA–distal/subdistal tooth of DTA; DTA–dorsal tibial apophysis; E–embolus; eDTA–ectal branch of DTA; ITA–Intermediate tibial apophysis; MA–median apophysis; mDTA–mesal branch of DTA; RTA–retrolateral tibial apophysis; ST–subtegulum; T–tegulum; TB– tibia; TS–tegular sclerite; TSA–tegular sclerite apophysis.

Specimens studied in the current paper are deposited in the California Academy of Sciences, San Francisco (CAS); Hunan Normal University, Changsha, Hunan (HNU); Institute of Zoology, Chinese Academy of Sciences, Beijing (IZCAS); Museum of Hebei University, Baoding, Hebei (MHBU); Southwest University, Chongqing (SWUC); and Senckenberg Museum, Frankfurt (SMF).

AMAUROBIINAE TIBIAL APOPHYSES

Tibial apophyses of the subfamily Amaurobiinae are important characters in species identification, generic limitation, and, therefore, valuable tools for phylogenetic analyses. In previous publications, however, different arachnologists



Figures 1, 2.—Schematic drawings of *Taira* tibia (TB), showing the retrolateral tibial apophysis (RTA), dorsal tibial apophysis (DTA), intermediate tibial apophysis (ITA), external branch (eDTA) and mesal branch (mDTA) of DTA, and teeth (dDTA) on DTA. CYM = cymbium. 1. Prolateral view. 2. Retrolateral view.

have perceived and defined those apophyses in different ways and given them different names. In this study, we have conducted initial homology assessments of Amaurobiinae tibial apophyses based on similarities in their position and morphology. There are at least three apophyses on amaurobiine tibiae: a retrolateral tibial apophysis (RTA), a dorsal tibial apophysis (DTA) and an intermediate tibial apophysis (ITA), which originates between the RTA and DTA in most Amaurobiinae. The *Taira* DTA usually has branches on its external and mesal side, or teeth on its distal half; here we differentiate the external branch of the DTA (eDTA), mesal branch of the DTA (mDTA), and distal teeth of the DTA (dDTA) (Figs. 1, 2).

Retrolateral tibial apophysis (RTA)

The presence of the RTA, plus the presence of tarsal trichobothria and three or more metatarsal trichobothria, supports the monophyly of RTA-clade spiders (Coddington & Levi 1991; Griswold et al. 2005). The morphology of the RTA varies among amaurobiids. Rather than originating proximally or medially on tibia, extending along the tibial length, protruding distally as in coelotines (Wang 2002: figs. 44–46; Wang 2003; Wang & Jäger 2007; Xu & Li 2008), the RTA of most amaurobiines originates distally or medially on the tibia, and does not extend along the tibial length (Leech 1972; Yaginuma 1987; Thaler & Knoflach 1993). In *Taira*, the RTA varies from absent, as in *T. liboensis* (Zhang et al. 2008: figs. 31–33), long, sharply pointed, originating on the distal half of the tibia, as in *T. qiuae* new species (Figs. 19–21) and *T. zhui* new species (Figs. 33–35), to a small lobe, as in *T. sichuanensis* new species (Figs. 26–28) and five other remaining *Taira* species (i.e., *T. cangshan*, *T. concava*, *T. decorata*, *T. flavidorsalis*, and *T. sulciformis*) (Zhang et al. 2008: figs. 11, 16, 21, 26, 40). We follow Zhang et al. (2008) and treat this small apophysis as the RTA. Among those with a small RTA, *T. cangshan* has a RTA originating on the proximal half of the tibia; in the remaining species, it originates either medially or distally on the tibia. Except for *T. convava* and *T. sulciformis*, which have an RTA situated close to the DTA, other species have an RTA distinctly separated from the DTA. The RTA was labeled as the ectal process by Leech (1972: fig. 10) and Yaginuma (1987: figs. C, D, G, H).

Dorsal tibial apophysis (DTA)

The presence of a DTA, in combination with a hyaline conductor, is synapomorphic for the family Amaurobiidae (Griswold et al. 2005). The DTA is usually long with a slender distal end in *Amaurobius* and *Callobius* (Leech 1972: figs. 10, 11). In *Taira* the DTA is broad, modified with grooves, an external branch (eDTA) and mesal branch (mDTA), or with one or more distal teeth (dDTA) (Figs. 1, 2). eDTA is a branch protruding externally on the DTA toward the lateral side of the body, while mDTA is a branch protruding mesally on the DTA toward the middle of the body in natural condition (dorsal view of palp). The DTA was termed a "mesal process" by Leech (1972: fig. 10) and Yaginuma (1987. figs. G, H), an "innere apophyse" by Thaler (1990: figs. 7–10), a "prolateral-dorsal apophysis" by Thaler & Knoflach (1993: figs. 7–12), and a "prolateral apophysis" by Thaler & Knoflach (1991: figs. 3, 4). Zhang et al. (2008) treated the DTA as having two branches, iDTA (interior branch of DTA) and eDTA (exterior branch of DTA). The iDTA of Zhang et al. is in fact the DTA (rather than a branch on DTA), and the eDTA of Zhang et al. is the mDTA, which protrudes mesally toward the middle of the body (rather than on the external side of DTA). All *Taira* species have a long, deeply grooved DTA and a broad mDTA except *T. liboensis*, which has a less deeply grooved DTA and a broad eDTA, but no mDTA (Zhang et al. 2008: figs. 31–33). DTA of *T. cangshan* is less grooved and slightly larger than mDTA (Zhang et al. 2008: figs. 14–16).

Intermediate tibial apophysis (ITA)

The ITA is small, lobe-shaped, and present in most amaurobiines between the RTA and DTA. The ITA was referred to as a "dorsal process" by Leech (1972: fig. 10) and Yaginuma (1987: figs. G, H), as a "mittlere apophyse" by Thaler (1990: figs. 7–10), and as an "intermediate apophysis"

by Thaler & Knoflach (1993: figs. 7–12). The lateral tibial apophysis found in coelotines (Wang 2002: figs. 89, 107) also arises from the dorsal side of the RTA and its possible homology to the Amaurobiinae ITA needs further investigation. Most *Taira* species lack an ITA except for the three new species described in this study: *T. qiuae*, *T. sichuanensis*, and *T. zhui* (Figs. 20, 28, 35). We followed Zhang et al. (2008) and treated the small tibial apophysis of previous described *Taira* species as RTA, rather than ITA.

RELATIONSHIPS

Taxa

Representatives of other Amaurobiinae and Coelotinae are included as outgroup taxa to test the monophyly of *Taira* and to help root the tree: *Tamgrinia laticeps* (Schenkel 1936), *Coelotes atropos* (Walckenaer 1830), *Draconarius wudangensis* (Chen & Zhao 1997), *Callobius bennetti* (Blackwall 1846) and *Amaurobius fenestralis* (Ström 1768). We chose one *Tamgrinia* species to root the tree because it is cribellate and was treated as a member of the tribe *Tairini* together with *Taira* by Lehtinen (1967). *Tamgrinia* could be more closely related to Ageleninae and Coelotinae than to Amaurobiinae (Wang 2000; Wang & Zhu 2008; Wu et al. 2002). Two coelotine species were also chosen as outgroup taxa because they were previously placed in the same family with Amaurobiinae, they are well studied relative to other amaurobiids, and their relationship with Amaurobiinae has been explored in other studies (Spagna & Gillespie 2008; Wu et al. 2002). To reconstruct the relationships among the species, we compiled a data matrix that includes nine *Taira* species with both male and female described.

Characters

Twenty characters, mostly from genitalic structures, are used in the matrix. The female genitalia contributed nine characters, the male palp contributed nine, and the last two characters signify whether or not they are the cribellate spiders and whether the small hood of trichobothria is ridged:

Character 0: Epigynal teeth (0 = absent; 1 = present).

Character 1: Epigynal teeth, shape (0 = slender, longer than wide; 1 = broad, wider than long or with subequal length and width).

Character 2: Epigynal teeth, position (0 = situated anteriorly on anterior part of epigynum, with bases distinctly separated from epigastric furrow; 1 = situated posteriorly on posterior part of epigynum, with bases close to epigastric furrow). *Taira* species share the synapomorphy of having broad epigynal teeth. Similar to other amaurobiines, the epigynal teeth of *Taira* originate posteriorly near the epigastric furrow.

Character 3: Epigynal lobe (0 = absent; 1 = present).

Character 4: Epigynal lobe, shape (0 = epigynum with a small median lobe and two large lateral lobes; 1 = epigynum with a single, large, medially situated lobe).

Character 5: The single, large, medially situated epigynal lobe (0 = extending longitudinally, longer than wide; 1 = extending transversely, wider than long). An epigynal lobe is present in all *Taira* species, as well as in other Amaurobiinae. In *Callobius*, there are two broad lateral lobes and a small, anteriorly originated median lobe, but in *Amaurobius* and *Taira*, there is only one large lobe, which varies in size and shape. The size and shape of epigynal lobe could be species-specific and important in species diagnosis. The slightly elongated epigynal lobe is shared by *T. flavidorsalis* and *T. sulciformis*.

Character 6: Spermathecae, length (0 = long, with distinct heads arising distally; 1 = short, without heads). Another feature shared by *Taira* and other Amaurobiinae is the presence of short spermathecae, compared to the long ducts in most Coelotinae.

Character 7: Short spermathecae, separation (0 = separated by their width or less; 1 = separated by at least twice their width). Widely separated spermathecae apparently evolved in parallel in three species of the clade D and *T. cangshan* (Fig. 3).

Character 8: Short spermathecae, shape (0 = round; 1 = elongated, with the length twice the width). The short spermathecae in *Taira* are usually round or slightly elongated, but in three species of clade D (Fig. 3), (i.e., *T. qiuae*, *T. sichuanensis*, and *T. zhui*) they are elongated with the length at least twice the width.

Character 9: RTA (0 = extending along tibial length, protruding distally; 1 = not extending along tibial length). In Amaurobiinae, the RTA arises medially or distally on the tibia, rather than extending along the tibial length as in Coelotinae. The RTA is absent in *T. liboensis*, more or less long, with a sharply pointed distal end in *T. qiuae* and *T. zhui*, but small in other *Taira* species.

Character 10: DTA (0 = absent; 1 = present).

Character 11: ITA (0 = absent; 1 = present). The ITA arises between the RTA and DTA in Amaurobiinae, but only the three new species of the clade D (Fig. 3) have this apophysis in *Taira*.

Character 12: DTA, the broad, mesally protruding branch (mDTA) (0 = absent; 1 = present). Most *Taira* species have a broad, mesally protruding branch on the DTA. One species *T. liboensis* has a broad, externally protruding branch (eDTA) but lacks a mDTA. The three new species of clade D have small teeth on the DTA, but has neither an eDTA nor a mDTA.

	0 1 2 3 4 5 6 7 8 9	1 1 1 1 1 1 1 1 1 1 0 1 2 3 4 5 6 7 8 9
Tamgrinia laticeps	0 - - 0 - - 0 - - 0 1	? - - 1 0 - 0 1 0
Coelotes atropos	1 0 0 0 - - 0 - - 0 0	? - - 0 - - 0 0 0
Draconarius wudangensis	1 0 0 0 - - 0 - - 0 0	? - - 0 - - 0 0 0
Callobius bennetti	0 - - 1 0 - 1 0 0 1	1 1 0 0 1 0 - 0 1 1
Amaurobius fenestralis	1 0 1 1 1 1 1 0 0 1	1 1 0 0 1 0 - 0 1 1
Taira qiuae sp. nov.	1 1 1 1 1 1 1 1 1 1	1 1 0 1 1 1 1 1 1 1
T. flavidorsalis	1 1 1 1 1 0 1 0 0 1	1 0 1 0 1 1 0 0 1 1
T. cangshan	1 1 1 1 1 1 1 1 0 1	1 0 1 0 1 1 0 0 1 1
T. concava	1 1 1 1 1 1 1 0 0 1	1 0 1 0 1 1 0 0 1 1
T. decorata	1 1 1 1 1 1 1 0 0 -	1 0 1 0 1 1 0 0 1 1
T. liboensis	1 1 1 1 1 1 1 0 0 1	1 0 0 0 1 1 0 0 1 1
T. sulciformis	1 1 1 1 1 0 1 0 0 1	1 0 1 0 1 1 0 0 1 1
T. zhui sp. nov.	1 1 1 1 1 1 1 1 1 1	1 1 0 1 1 1 1 1 1 1
T. sichuanensis sp. nov.	1 1 1 1 1 1 1 1 1 2	1 1 0 1 1 1 1 1 1 1

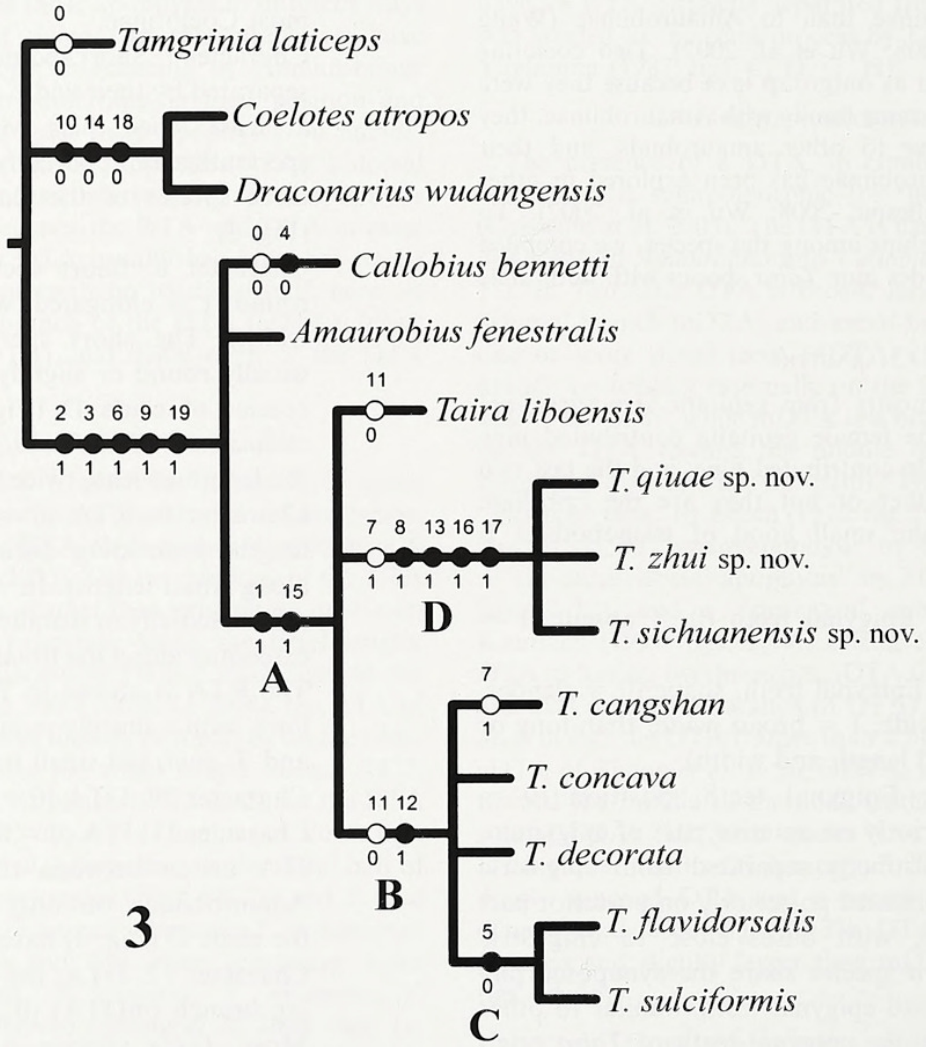


Figure 3.—The preferred cladogram of hypothesized *Taira* species relationships (L = 23, Ci = 90, Ri = 93); see text for discussion.

Character 13: DTA, distal teeth (0 = absent; 1 = present). DTA distal teeth are present in the three closely related new species of clade D.

Character 14: Tegular sclerite apophysis (0 = absent; 1 = present).

Character 15: Tegular sclerite apophysis, position (0 = proximal; 1 = distal).

Character 16: Distally originating tegular sclerite apophysis (0 = normal; 1 = strongly expanded anteriorly and covering most part of embolus). The presence of a tegular sclerite apophysis is another synapomorphy of Amaurobiinae, although in *Taira* it arises more distally and as a result is distinctly separated from the median apophysis by about the length of median apophysis. In three closely related D-clade *Taira* species, the tegular sclerite apophysis is strongly expanded anteriorly and leaves only the apex of the embolus visible in ventral view.

Character 17: Conductor modification (0 = absent; 1 = present). Unique to the three new *Taira* species at node D, the conductor is modified to have 2–3 strongly sclerotized apophyses (Figs 19–21: C1, C2, C3).

Character 18: Cribellum (0 = absent; 1 = present).

Character 19: Trichobothria, small hood (0 = smooth; 1 = ridged).

Results

We generated a data matrix and optimized characters using WinClada version 1.00.08 (Nixon, 1999) (Fig. 3). To perform the parsimony analyses, we used Hennig86 version 1.5 (Farris, 1988), with all characters treated as non-additive. The exact search algorithm (ie*;) was used, resulting in the eight most parsimonious trees. In the analysis, we arbitrarily used slow (Deltran) optimization, which favors parallelism over reversal. The preferred tree is shown in Fig. 3 (L = 23, Ci = 90, Ri = 93). Four of the eight resulting trees were excluded because they indicate the sister group relationship between *T. cangshan* and clade D, based on the widely separated spermathecae. The round-shaped spermathecae in *T. changshan*, which are similar to other *Taira*, differ from the elongated spermathecae of clade D taxa. We excluded two more trees because they show a sister group relationship between *T. liboensis* and clade B, supported by the absence of an ITA. Although having similar spermathecae and lacking an ITA, *T. liboensis* differs from others by the absence of an RTA, the absence of an mDTA, and the presence of an eDTA. Another tree shows the same *Taira* species relationship as the preferred tree but was excluded because it supports sister group relationship between *Amaurobius* and *Taira*. Our study focuses on *Taira* species relationships, so the characters indicating generic-level relationships are understudied.

The species of the genus *Taira* are united at node A by the presence of broad epigynal teeth (character 1, state 1) and the distally originating tegular sclerite apophysis (character 15, state 1). Three distinct species groups are found, and their relationships remain unresolved: *T. liboensis*, clade B species, and clade D species. Clade B includes five species: *T. cangshan*, *T. concava*, *T. decorata*, *T. flavidorsalis*, and *T. sulciformis*, based on the absence of an ITA (character 11, state 0, which is parallel in *T. liboensis*) and the presence of a broad, mesally protruding branch on the DTA (mDTA) (Character 12, state 1). The elongated epigynal median lobe (character 5, state 0) supports a sister group relationship between *T. flavidorsalis* and *T. sulciformis* at node C. Three new species (*T. qiuae*, *T. sichuanensis*, and *T. zhui*) are united at node D by the widely separated spermathecal bases (character 7, state 1), the long spermathecae, which can be twice as long as wide (character 8, state 1), the presence of teeth on distal and subdistal DTA (character 13, state 1), the anteriorly expanded tegular sclerite apophysis that hides most of the embolus (character 16, state 1), and the presence of 2–3 broad, strongly sclerotized conductor apophyses (character 17, state 1).

SYSTEMATICS

Family Amaurobiidae Thorell 1870
Subfamily Amaurobiinae Thorell 1870
Taira Lehtinen 1967

Taira Lehtinen 1967:266.
Type species: *Amaurobius flavidorsalis* Yaginuma 1964

Diagnosis.—The genus *Taira* can be distinguished from *Amaurobius* and related genera by two putative synapomorphies: the presence of broad epigynal teeth in females (Figs. 22, 29, 36) and the distally originating tegular sclerite apophysis in males (Figs. 19, 27, 34). An additional diagnostic character includes the branched or toothed dorsal tibial apophysis (Figs. 21, 26, 33).

Description.—Small to medium-sized cribellate spiders (Figs. 13, 14, 18, 24, 25, 31, 32, 38, 39), total length 4.18–6.43 (males) and 5.30–10.7 (females). Carapace elongate, dark brown, with distinct wide, light-colored, longitudinal median band and two wide, dark-colored, longitudinal lateral bands; cephalic area slightly narrowed, with cover of gray setae and sparsely distributed black setae; fovea longitudinal, deep. Anterior eye row straight or slightly recurved, posterior eye row strongly recurved, with anterior margin of PME distinctly posterior to posterior margin of PLE (Fig. 16); AME smallest, PME subequal to or slightly larger than AME, ALE largest, PLE subequal to or slightly smaller than ALE; AME separated from each other by less than their diameter, separated from ALE by 1–1.5 times AME diameter, PME separated from each other by 1.5–2 times PME diameter, widely separated from PLE by at least 2 times PME diameter; eyes with median ocular quadrangle wider in back than in front, longer than wide (Fig. 16). Clypeus high, approximately two times AME diameter, curved downward. Sternum longer than wide (width/length = 0.75–0.80), sparsely covered with black setae, anterior margin straight, lateral margins without extensions between coxae, posterior margin pointed, slightly separating coxae IV (Fig. 17). Chilum undivided, hairless. Chelicerae with 4 promarginal and 3 retromarginal teeth. Labium subequal or slightly longer than wide. Endites rectangular, anteriorly slightly pointed, laterally slightly depressed, with promarginal scopula, without serrula

(Fig. 15). Tibiae with two rows of trichobothria; metatarsi and tarsi with one row of trichobothria; trichobothria with large hood transversely striated, small hood longitudinally ridged (Fig. 5), tarsal organ with simple opening. Tarsi with three claws, paired superior claws with 8–10 teeth on each; scopulae absent; leg spination often varying among individuals, typical leg spination pattern (only surfaces bearing the spines listed, each leg segment was divided into four surfaces, dorsal, prolateral, ventral, retrolateral, then indicating the number of spines in the proximal, middle, and distal one-thirds of each segment): femur: I p0–0–2; II p0–0–2, r0–0–1; III p0–0–1, r0–0–1; IV p0–0–1; tibia: I p1–1–1, v2–2–2, r0-1-1; II p0–1–1, v0–2–2, r0-1-1; III p1–1–0, v1–1–2, r1-1-0; IV p0–0–1; v1–0–2; metatarsus: I p0-1-0, v2–2–2, r0-1-1; II p0-1-1, v2–2–2, r0-1-1; III p1–1–1, v2–2–2, r1–1–1; IV v0–0–2. Tracheal tubes simple, limited to opisthosoma, spiracle situated close to spinnerets and connected to atrium, from which two lateral and two median tubes arise (Fig. 4). Cribellum divided (Figs. 6, 7). ALS short, conical, two-segmented, apex of ALS with 2 major ampullate gland spigots and approximately 28–55 piriform gland spigots (Fig. 8); PMS short, one-segmented, with 1 minor ampullate gland spigot, 1 aciniform gland spigot, 1 cylindrical gland spigot, about 5–8 paracribellar spigots (Fig. 9); PLS with approximately 8–22 aciniform gland spigots, 2–3 cylindrical gland spigots, 1 "amaurobiid PLS spigot" on distal end, 2 paracribellar spigots beside "amaurobiid PLS spigot" (Fig. 10).

Female epigynum simple; atrium small or indistinct, with openings on anterior margin of epigynal median lobe; epigynal median lobe distinct; epigynal teeth short, broad, situated lateral of median lobe, close to but slightly separated from epigastric furrow; copulatory ducts small, originating medially, or indistinct in some species; spermathecae small, widely separated, round in most species (elongated only in *T. qiuae*, *T. sichuanensis* and *T. zhui*); fertilization ducts long, can be as long as spermathecae.

Male palp without patellar apophysis; retrolateral tibial apophysis (RTA) small, situated distally or medially, widely separated or close to dorsal tibial apophysis (DTA) (but long and bent dorsally in *T. qiuae* and *T. zhui*, and absent in *T. liboensis*); dorsal tibial apophysis large, with distinct groove, branched on its external and mesal surfaces, with mesal branch usually broad and large; intermediate tibial apophysis only observed in three clade D species; cymbium short, with distal end extending slightly beyond bulb, without distinct spines; proximal cymbium strongly constricted and concave to narrow base; conductor broad, arising from distal bulb, hyaline with sclerotized base (in *T. qiuae*, *T. sichuanensis*, and *T. zhui*, the conductor is modified to small, less sclerotized apophysis and broad, highly sclerotized, branched, beak-shaped apophyses); median apophysis long, with slender apex and broad base, arising from less sclerotized tegulum area; tegulum with distally originating tegular sclerite apophysis, which is widely separated from base of median apophysis; embolus broad, short, arising distally on prolateral tegulum.

Natural history.—Species of *Taira* build small cribellate webs (Figs. 40, 41), which are similar to *Amaurobius* webs. The spiders can be found on buildings, cliffs, trees, in caves, and on other substrates and favor shady, humid conditions. Individuals usually live together in high density, particularly in the late spring and early summer during which the adults are active. Although the adult female can also be found from July to August (personal observation), we collected specimens of *T. liboensis* from caves where adults are active in the summer (Wang & Ran 2004; Zhu et al. 2004).

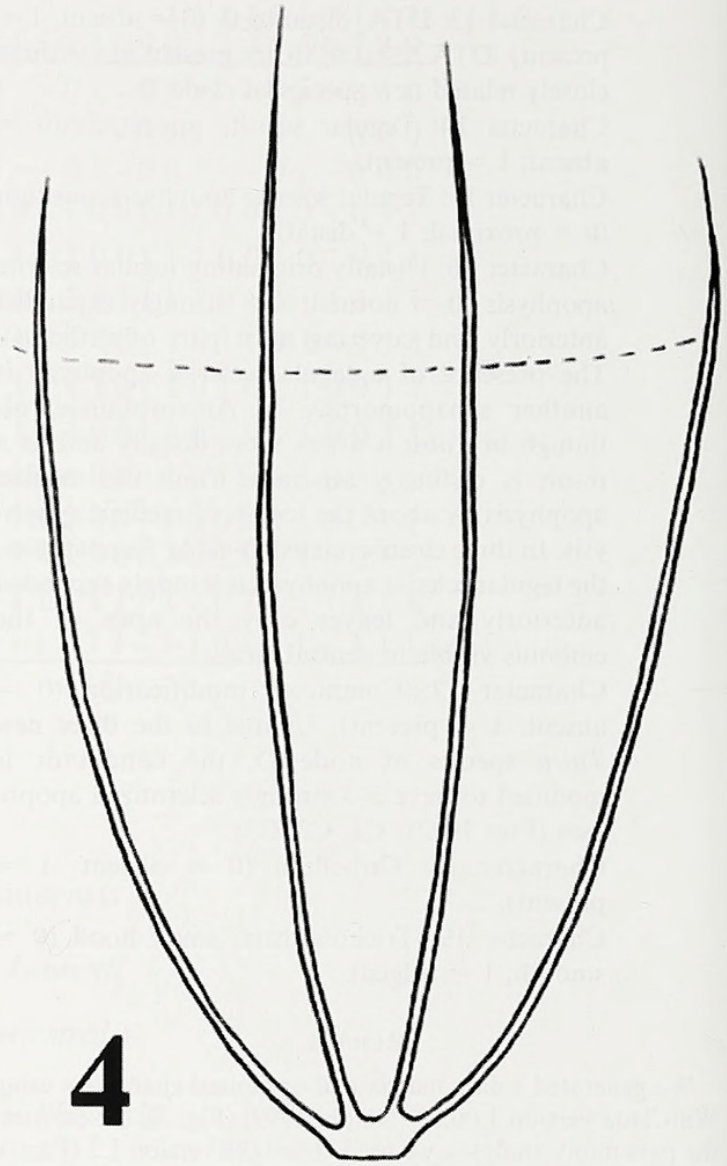
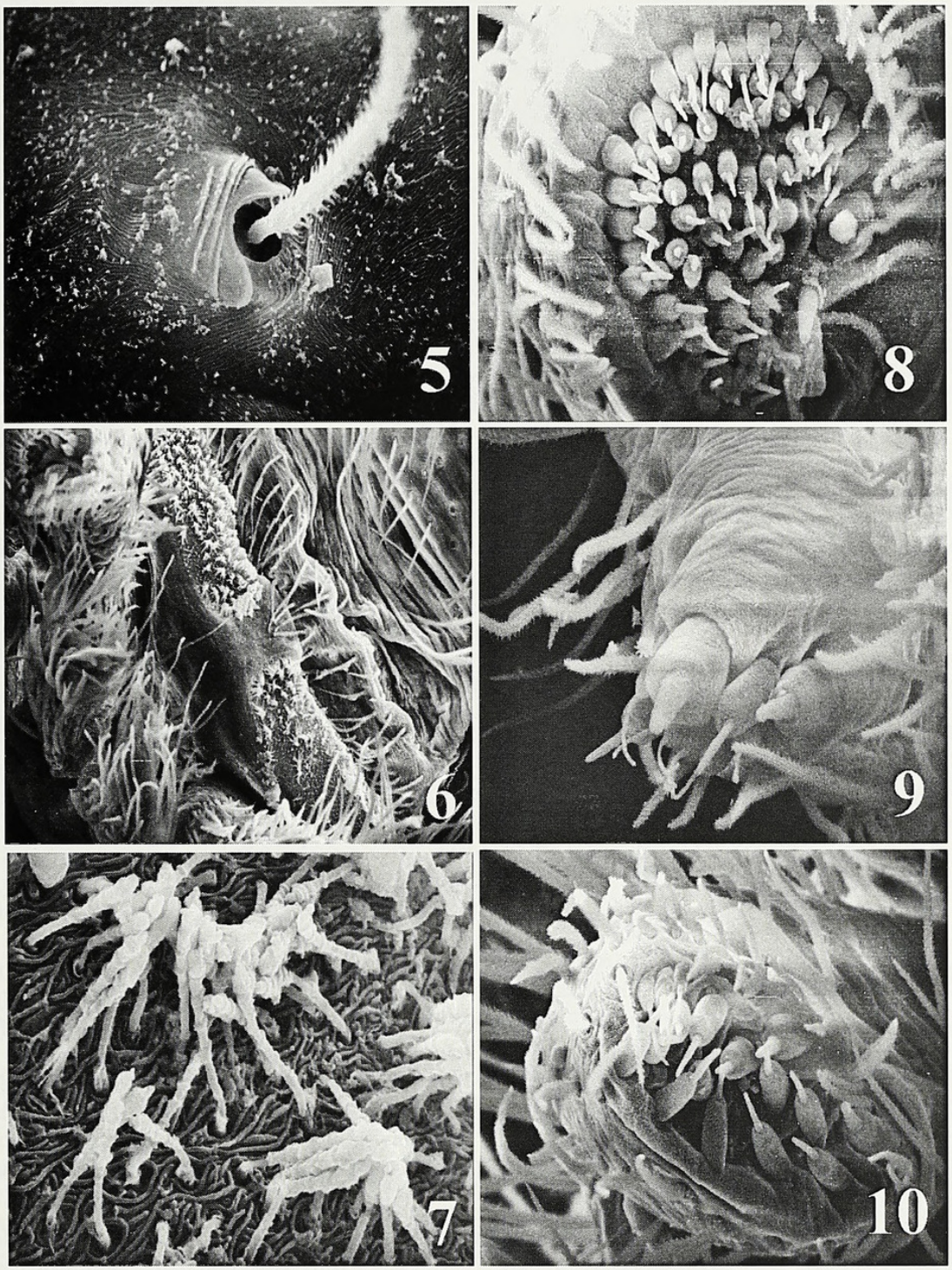


Figure 4.—*Taira decorata* (Yin & Bao 2001), female from Wuyi Mt., Fujian, China, trachea (dashed line refers to the position of epigastric furrow).

Composition.—Eleven species: *T. cangshan* Zhang, Zhu & Song 2008, *T. concava* Zhang, Zhu & Song 2008, *T. decorata* (Yin & Bao 2001), *T. flavidorsalis* (Yaginuma 1964), *T. latilabiata* Zhang, Zhu & Song 2008, *T. liboensis* Zhu, Chen & Zhang 2004, *T. obtusa* Zhang, Zhu & Song 2008, *T. qiuae* new species, *T. sichuanensis* new species, and *T. sulciformis* Zhang, Zhu & Song 2008, and *T. zhui* new species

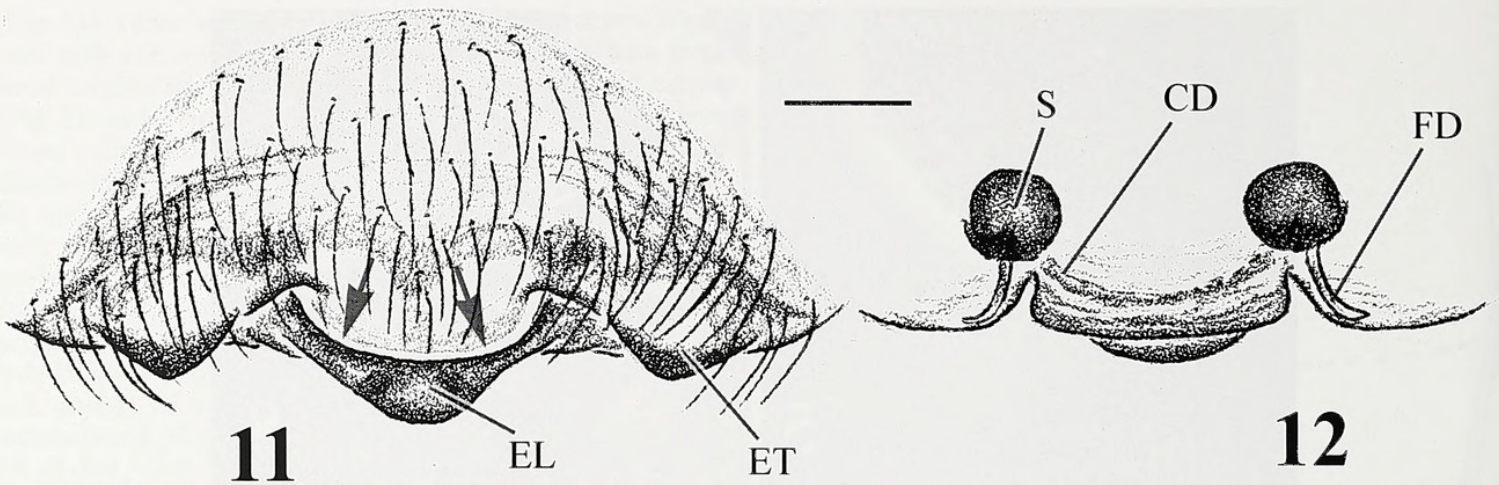
Distribution.—China, Japan (Fig. 42).



Figures 5–10.—*Taira decorata* (Yin & Bao 2001), female from Wuyi Mt., Fujian, China, SEM pictures. 5. Trichobothria. 6. Cribellum. 7. Cribellum, enlarged, showing the spigots. 8. ALS. 9. PMS. 10. PLS.

KEY TO SPECIES OF *TAIRA*

1. Male (those of *T. obtusa*, *T. latilabiata* unknown) 2
   Female 10
2. Conductor with additional, highly sclerotized apophyses (C1, C2 and C3 in Figs. 19–21); tegular sclerite apophysis (TSA) broad, anteriorly expanding, covering most of embolus from ventral view (Figs. 19–21, 26–28, 33–35) 3
   Conductor with single broad, hyaline apophysis; tegular sclerite apophysis small, embolus visible from ventral view (Zhang et al. 2008: figs. 9–11) 5
3. RTA long, bent distally, with a sharp distal end (Figs. 20, 35) 4
   RTA short, exhibiting only a small lobe (Figs. 27, 28) . . . . . *sichuanensis*
4. Median apophysis with sharp, long basal process (Fig. 34) . . . . . *zhui*
   Median apophysis with blunt, short basal process (Fig. 19) . . . . . *qiuae*



Figures 11, 12.—*Taira cangshan* Zhang, Zhu & Song 2008, female (CASENT9021382) from Lushui, Yunnan, China, epigynum (ventral and dorsal view).

5. RTA present; DTA with distinct branch on its mesal side; prolateral tegular lobe absent or indistinct (Zhang et al. 2008: fig. 10) . . . 6
   RTA absent; DTA with distinct branch on its ectal side; tegulum with distinct prolateral lobe (Zhang et al. 2008: figs. 32, 33) . . . *liboensis*
6. DTA distinctly longer than its mesal branch; RTA arising from distal half of tibia (Zhang et al. 2008: figs. 9–11) . . . 7
   DTA and its mesal branch about the same length; RTA arising from proximal half of tibia (Zhang et al. 2008: figs. 14–16) *cangshan*
7. RTA distinctly separated from DTA (Zhang et al. 2008: figs. 16, 26) . . . 8
   RTA close to DTA (Zhang et al. 2008: figs. 21, 40) . . . 9
8. Distal embolus abruptly narrowed; tegular sclerite apophysis with slightly notched apex (Zhang et al. 2008: figs. 9, 10) *flavidorsalis*
   Distal embolus as broad as its base; tegular sclerite apophysis with rounded apex (Zhang et al. 2008: fig. 25) . . . *decorata*
9. DTA slender; tegular sclerite apophysis round (Zhang et al. 2008: fig. 20) . . . *concava*
   DTA broad; tegular sclerite apophysis blunt (Zhang et al. 2008: fig. 39) . . . *sulciformis*
10. Epigynal lobe with length and width subequal, or longer than wide (Zhang et al. 2008: figs. 7, 36) . . . 11
    Epigynal lobe wider than long (Figs. 11, 22) . . . 12
11. Epigynal lobe widest anteriorly (Zhang et al. 2008: fig. 7) . . . *flavidorsalis*
    Epigynal lobe widest medially (Zhang et al. 2008: fig. 36) . . . *sulciformis*
12. Spermathecal bases widely separated by at least two times their width (Figs. 12, 23, 37) . . . 13
    Spermathecal bases slightly separated by less then their width (Zhang et al. 2008: figs. 18, 30) . . . 17
13. Spermathecae elongated, with length at least two times their width (Figs. 23, 37) . . . 14
    Spermathecae round (Fig. 12) . . . 16
14. Spermathecae strongly converging anteriorly, with distal ends separated by only ¼ of proximal separation (Fig. 30) *sichuanensis*
    Spermathecae slightly converging anteriorly, with distal ends separated by more than ½ of proximal separation (Figs. 23, 37) 15
15. Spermathecal bases distinctly folded (Fig. 37) . . . *zhui*
    Spermathecal bases smooth, not folded (Fig. 23) . . . *qiuae*
16. Epigynal lobe distinctly curved; spermathecae separated by about 2 times their width (Fig. 12) . . . *cangshan*
    Epigynal lobe not curved; spermathecae separated by about 3 times their width (Zhang et al. 2008: fig. 27) . . . *latilabiata*
17. Epigynal teeth and lateral margins of epigynal lobe widely separated by the width of epigynal teeth (Zhang et al. 2008: fig. 17) . . . *concava*
    Epigynal teeth and lateral margins of epigynal lobe close together (Zhang et al. 2008: figs. 22, 29) . . . 18
18. Spermathecae separated by less than half of their width (Zhang et al. 2008: fig. 23) . . . *decorata*
    Spermathecae separated by more than half of their width (Zhang et al. 2008: figs. 30, 35) . . . 19
19. Spermathecae with distinct, anterior extensions (Zhang et al. 2008: fig. 35) . . . *obtusa*
    Spermathecae round, without anterior extensions (Zhang et al. 2008: fig. 30) . . . *liboensis*

Taira decorata (Yin & Bao 2001)
Figs. 4–10, 42

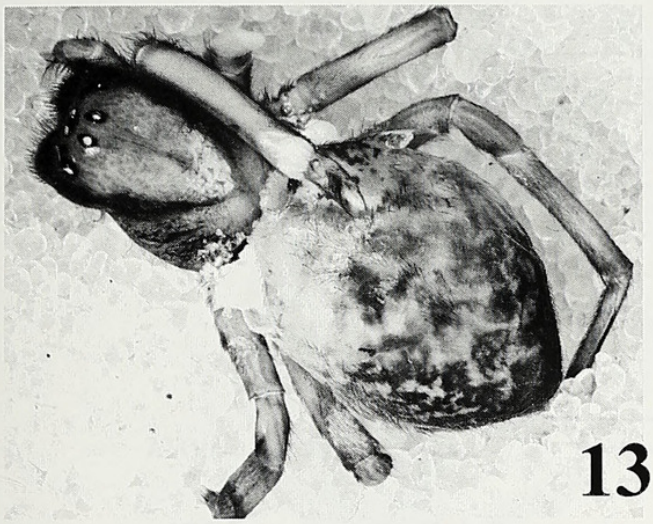
Titanoeca decorata Yin & Bao 2001:60, figs. 2a–e.
Taira decorata Zhang, Zhu & Song 2008:507, figs. 22–26.

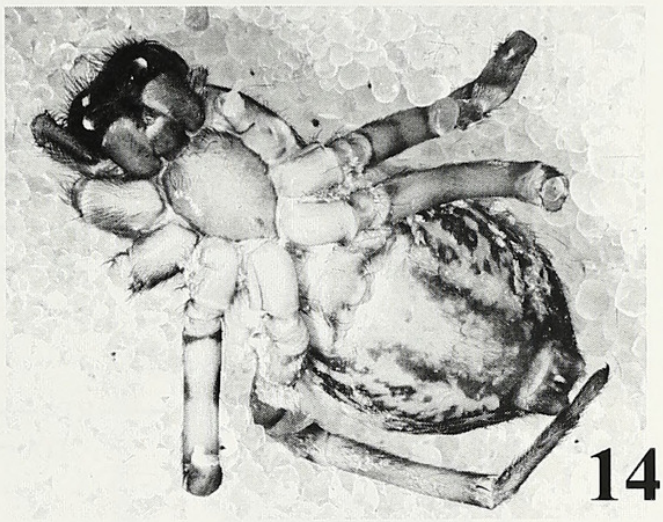
Remarks.—In addition to the genitalic illustrations by Zhang et al. (2008), in this study we also examined its tracheae (Fig. 4), trichobothria (Fig. 5), and spinnerets (Figs. 6–10), which are similar to *T. liboensis* of Wang (2000: figs. 16–18, 35).

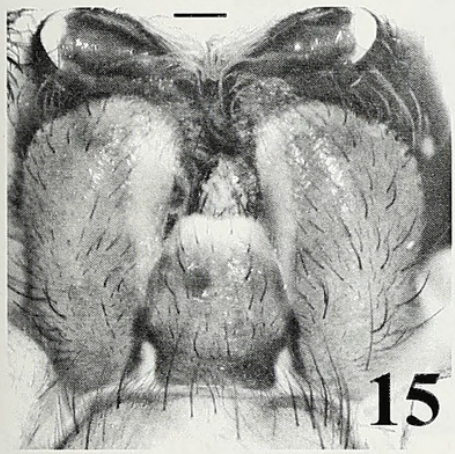
Taira cangshan Zhang, Zhu & Song 2008
Figs. 11–17, 42

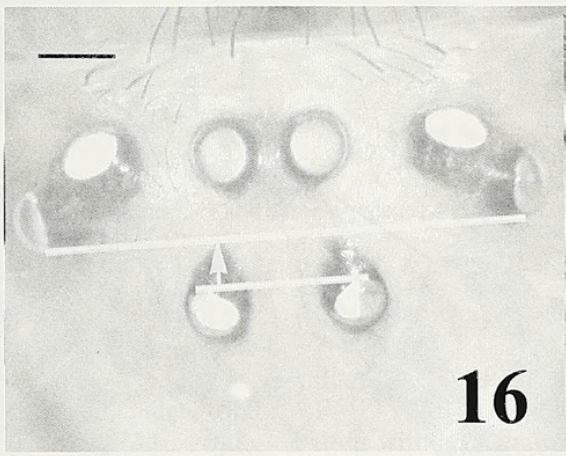
Taira cangshan Zhang et al. 2008:505, figs. 12–16.

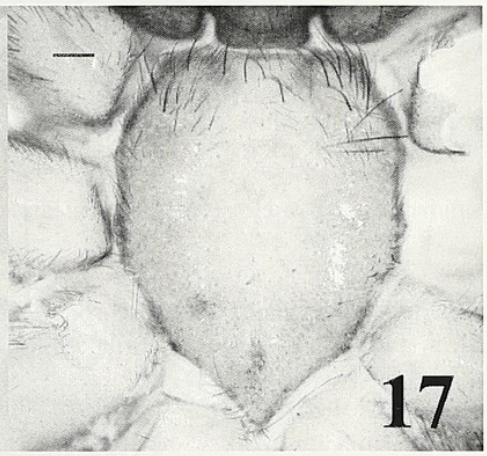
Remarks.—In addition to the material examined by Zhang et al. (2008), more specimens were collected from other parts of Yunnan, China (1♀, Lushui County, Yaojiaping He at Pianma Road, 44.7 km, elev. 2516 m, 25.97479°N, 098.71027°E, disturbed forest, night collecting in forest and











Figures 13–17.—*Taira cangshan* Zhang, Zhu & Song 2008, female (CASENT9021382) from Lushui, Yunnan, China. 13. Habitus, dorsal view. 14. Habitus, ventral view. 15. Labium and endites. 16. Eyes, view between dorsal and front. 17. Sternum.

along roadcuts, 20 May 2005, C. Griswold & D. Kavanaugh, CAS, CASENT9021382; 1♀, same data, CAS, ENT9022279); 1♀, same data, HNU, ENT9022278; 1♀, same data, HNU, ENT9022357).

In this study, we have re-illustrated the epigynum and vulva. Our illustration of the epigynum shows a much narrower lobe than that of Zhang et al. (2008) because it is viewed from a slightly different angle (Figs. 11, 12). We also took photos of habitus, eyes, sternum, labium, and endites to display the general somatic structures of *Taira* (Figs. 13–17).

Taira liboensis Zhu, Chen & Zhang 2004
Figs. 18, 42

Taira liboensis Zhu et al. 2004:61, figs. 1A–F (female holotype and male paratype, in MHBU, examined). Zhang et al., 2008:509, figs. 29–33.

Taira lunaris Wang & Ran 2004:31, figs. 1–4 (female holotype and paratype, in IZCAS, examined). First synonymized by Zhang et al. 2008.

Remarks.—In addition to the material examined by Zhang et al. (2008) and Wang & Ran (2004), we collected more specimens from Guizhou, China (4♀, Guiyang City, Qianlin Park, 8 August 2007, Z.S. Zhang, SWUC; 1♀, Guiding County, Yanxia Town, Jingangdong Cave, 10 August 2007, Z.S. Zhang, SWUC; 1♂2♀, Guiding County, Yanxia Town, Dayandong Cave, 9 August 2007, Z.S. Zhang, SWUC).

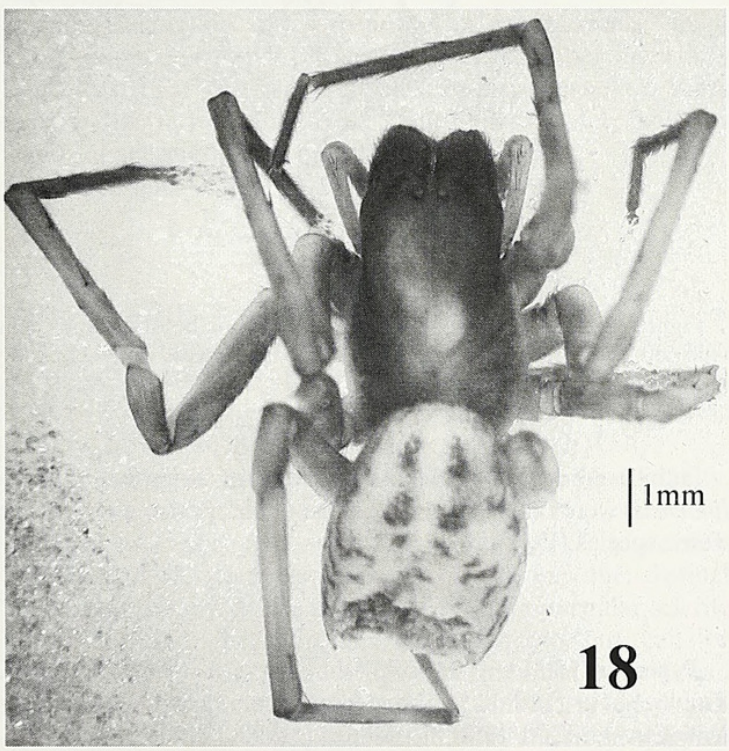
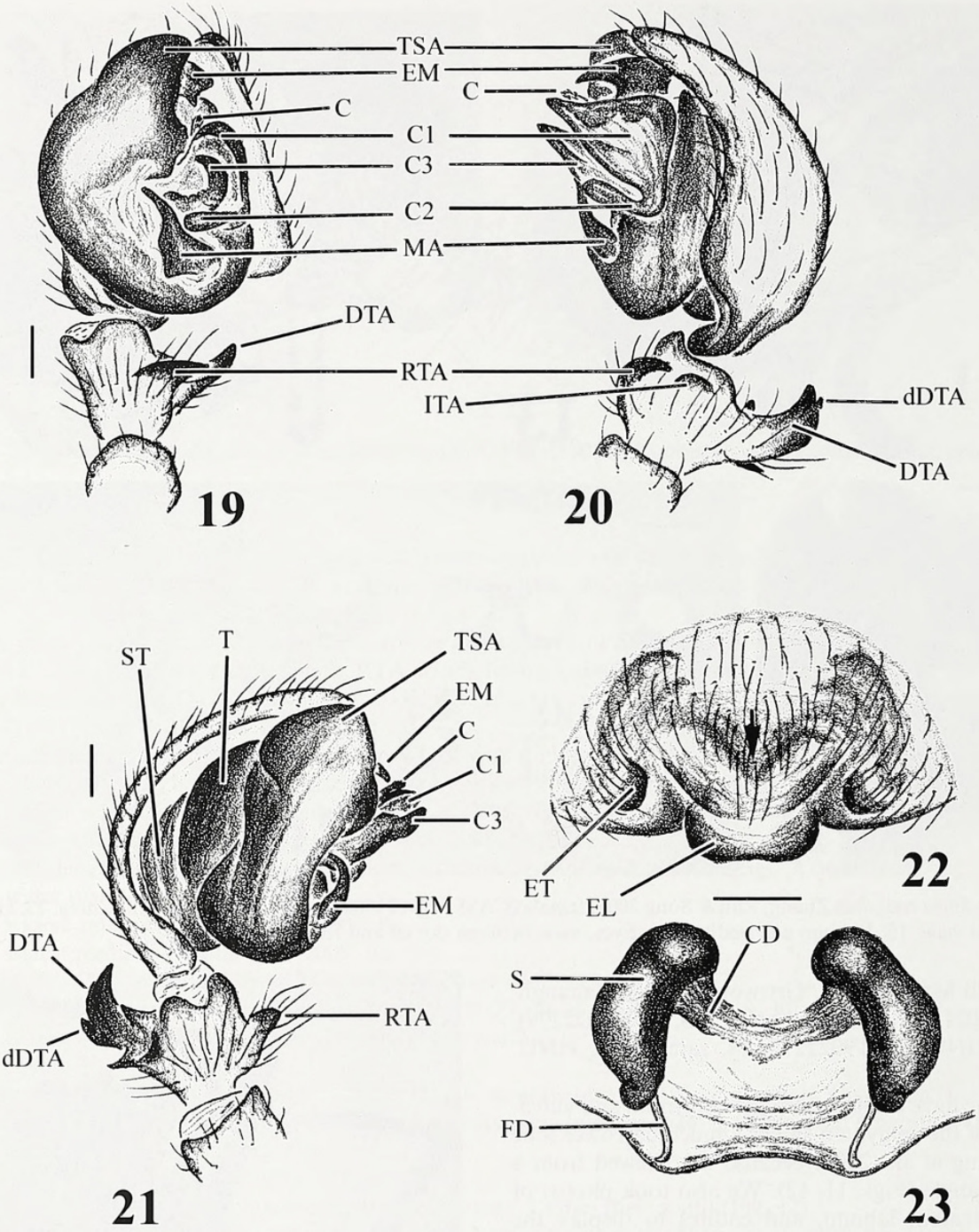


Figure 18.—*Taira liboensis* Zhu, Chen & Zhang 2004, female holotype of *T. lunaris* Wang & Ran, 2004 from Libo, Guizhou, China, habitus, dorsal view.



Figures 19–23.—*Taira qiuae* new species, male holotype and female paratype from Taibaishan, Shaanxi, China, drawings. 19. Palp, ventral view. 20. Palp, retrolateral view. 21. Palp, prolateral view. 22. Epigynum, ventral view (arrow points to copulatory opening). 23. Epigynum, dorsal view.

Habitus photos of the female holotype of *Taira lunaris* (=*T. liboensis*) were taken for the purpose of comparison with other *Taira* species (Fig. 18).

Taira qiuae new species
Figs. 19–25, 42

Types.—CHINA: *Shaanxi*, ♂ holotype, 4♀ paratypes from Taibai Shan, S. flanks, above Houzhenzi, secondary broad-leaf forest, 1300–1700 m, 8 June 1997, P. Jäger and B. Martens, deposited in SMF; 1♂ paratype from Taibai Shan, S. flanks, above Houzhenzi, secondary broad-leaf forest, 33°52′32.42″N, 107°48′34.73″E, 1700 m, sieving leaf litter, 7 June 1997, P. Jäger and B. Martens, deposited in SMF; 30♂32♀ paratypes from Taibai Shan, above Houzhenzi, 1250–1800 m, 23–25 May 2009, Z.S. Zhang, deposited in SWUC.

Etymology.—The specific name is in honor and memory of Professor Qiong-Hua Qiu (deceased), who advised and supported Xin-Ping Wang's work; noun (name) in genitive case.

Diagnosis.—This new species is similar to *T. zhui* new species in having a free standing, long RTA and the long, more or less anteriorly converging spermathecae but can be distinguished by the longer spermathecae, the smooth spermathecal bases (not folded) in females, the less extending

Figures 24, 25.—*Taira qiuae* new species, male holotype (24) and female paratype (25) from Taibaishan, Shaanxi, China, photos, habitus, dorsal view.

base of the median apophysis and the different shapes of the conductor apophyses (much larger C1 and strongly prolaterally curved C3) in male (Figs. 19–23).

Description.—*Male (holotype):* Medium-sized spider, total length 5.40 (Fig. 24). Carapace 3.00 long, 2.16 wide; opisthosoma 2.40 long, 1.65 wide. AME smallest, ALE largest, PME and PLE subequal in size (AME 0.07, ALE 0.14, PME 0.11, PLE 0.12); AME separated from each other by less than their diameter, widely separated from ALE by about 1.5 times AME diameter; PME separated from each other by slightly more than their diameter, from PLE by almost 2 times PME diameter; AME and PME widely separated by about 2 times AME diameter (AME–AME 0.05, AME–ALE 0.10, ALE–PLE 0.05, PME–PME 0.13, PME–PLE 0.18, AME–PME 0.15). Palpal RTA long, bent dorsally, with sharply pointed distal end (Fig. 20); dorsal tibial apophysis (DTA) large, toothed proximally and distally (Fig. 21); intermediate tibial apophysis (ITA) small, arising between the RTA and DTA (Fig. 20); conductor reduced to a slender, hyaline apophysis, which arises and hides behind the well-developed, strongly branched, beak-shaped conductor apophyses (C1, C2, C3 in Figs. 19–21); median apophysis long, with broad base and slender apex (Figs. 19, 20); tegular sclerite extending anteriorly and forming a broad apophysis on distal bulb, the latter covering most of embolus (Fig. 19); embolus broad, only the distal end visible from ventral view (Fig. 19).

Female (paratype): Medium-sized spider, total length 6.62 (Fig. 25). Carapace 2.77 long, 1.87 wide; opisthosoma 3.85 long, 2.82 wide. AME smallest, ALE largest, PME and PLE subequal (AME 0.07, ALE 0.13, PME 0.10, PLE 0.10); AME close together, separated from each other by less than their diameter, widely separated from ALE by about 1.5 times AME diameter; PME separated from each other by 1.5 times their diameter, from PLE by almost 2 times PME diameter; AME and PME widely separated by about 2 times AME diameter (AME–AME 0.05, AME–ALE 0.11, ALE–PLE 0.04, PME–PME 0.16, PME–PLE 0.18, AME–PME 0.15). Epigynum with a triangular plate anterior of median lobe; median lobe two times wider than long; epigynal teeth broad, separated from median lobe by approximately their width; copulatory ducts small but distinct, arising medially and extending laterally to spermathecae; spermathecae long, kidney-shaped, widely separated from each other anteriorly by at least their width and posteriorly by at least two times their width; fertilization ducts long, approximately half the length of spermathecae (Figs. 22, 23).

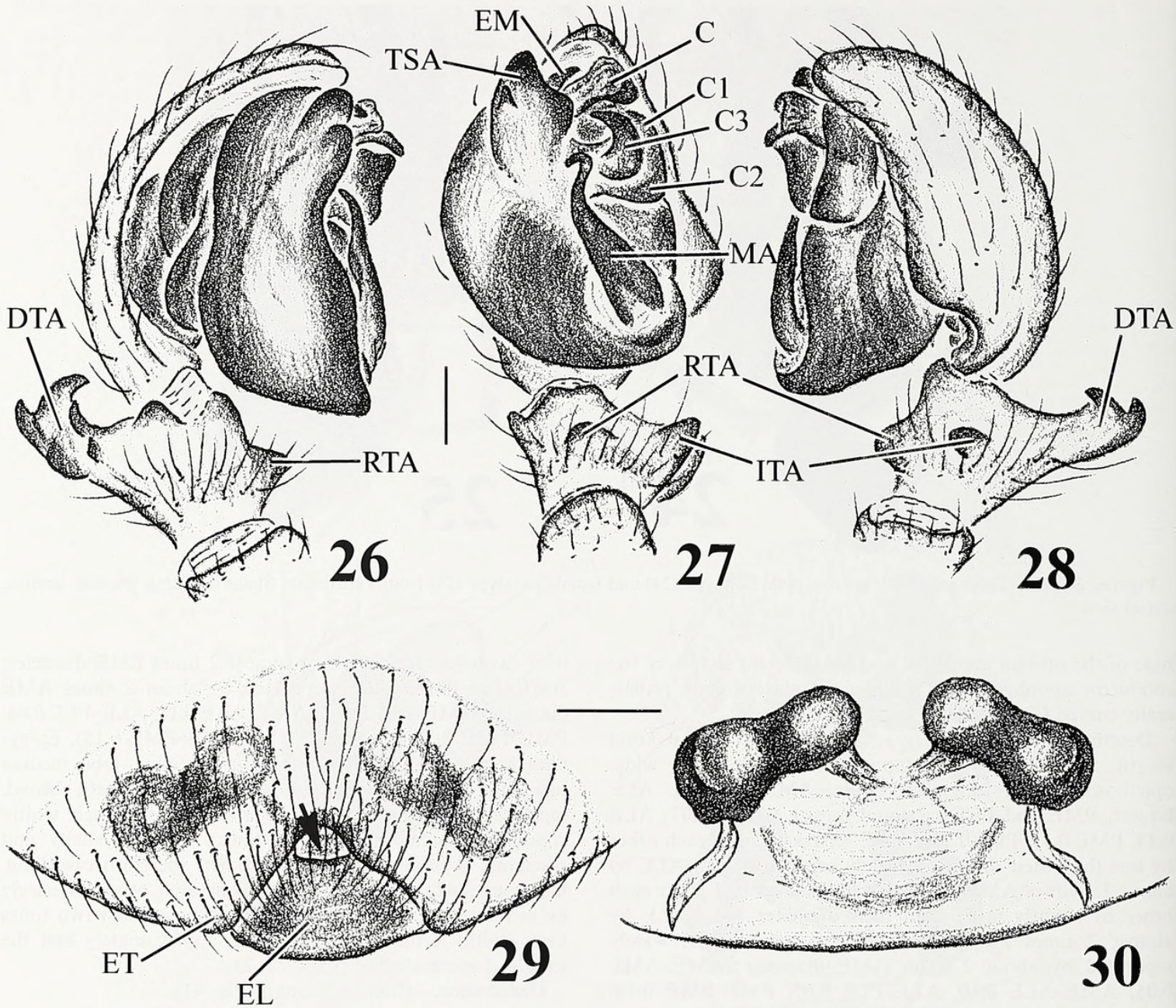
Distribution.—China (Shaanxi) (Fig. 42).

Taira sichuanensis new species
Figs. 26–32, 42

Types.—CHINA: *Sichuan*, ♂ holotype, 6♂12♀ paratypes from Changning County, Meidong Town, Gaojian Village, 28°18′5.0″N, 104°58′56.8″E, 700 m, 1 May, 2008, Z.S. Zhang & R.Y. Zuo, deposited in SWUC; 7♀ paratypes from the same locality, 5 June 2008, Z.S. Zhang, deposited in SWUC.

Etymology.—The specific name refers to the type locality, Sichuan Province, China; adjective.

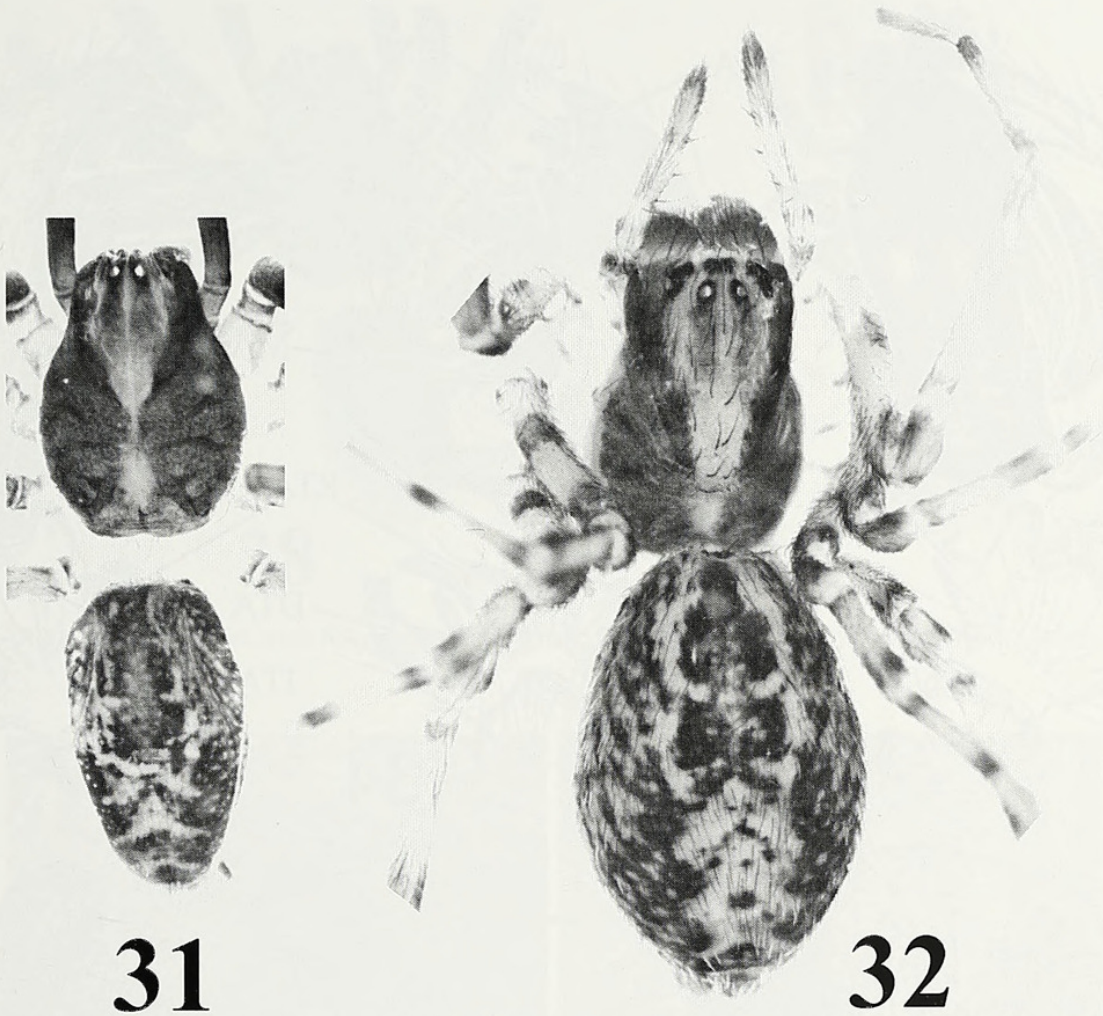
Diagnosis.—This new species is similar to *T. qiuae* new species and *T. zhui* new species in having the distinct conductor apophyses, the anteriorly expanding tegular sclerite apophysis, and the elongated spermathecae but can be distinguished by the small RTA, the presence of a broad conductor, and the different shapes of conductor apophyses (much smaller C1 and C2) in males, and by the small epigynal teeth, the presence of a distinct atrial opening, and the relatively transversely extending spermathecae in females (Figs. 26–30).



Figures 26–30.—*Taira sichuanensis* new species, male holotype and female paratype from Changning, Sichuan, China. 26. Palp, prolateral view. 27. Palp, ventral view. 28. Palp, retrolateral view. 29. Epigynum, ventral view (arrow points to copulatory opening). 30. Epigynum, dorsal view.

Description.—*Male (holotype):* Medium-sized spider, total length 4.90 (Fig. 31). Carapace 2.10 long, 1.50 wide; opisthosoma 2.80 long, 1.60 wide. Median eyes subequal in size, ALE largest, PLE slightly smaller than ALE (AME 0.08, ALE 0.13, PME 0.08, PLE 0.10); AME separated from each other by less than their diameter, from ALE by about AME diameter; PME separated from each other by slightly more than 1.5 times their diameter, from PLE by almost 2 times PME diameter (AME–AME 0.05, AME–ALE 0.08, PME–PME 0.13, PME–PLE 0.15, ALE–PLE 0.05). Palpal RTA short, forming a small lobe; dorsal tibial apophysis (DTA) large, toothed distally; intermediate tibial apophysis (ITA) arising between the RTA and DTA; conductor broad, distally hyaline; conductor apophyses broad, strongly branched; median apophysis long, with broad base and slender apex; tegular sclerite extending anteriorly and forming a broad apophysis on distal bulb, the latter covering most of embolus; embolus broad, only the distal end visible from ventral view (Figs. 26–28).

Female (paratype): Medium-sized spider, total length 3.80 (Fig. 32). Carapace 1.50 long, 1.00 wide; opisthosoma 2.30 long, 1.50 wide. AME smallest, ALE largest, posterior eyes subequal in size (AME 0.05, ALE 0.10, PME 0.08, PLE 0.08); AME separated from each other by about their diameter, from ALE by about 1.5 times AME diameter; PME separated from each other by slightly more than their diameter, from PLE by almost 2 times PME diameter (AME–AME 0.05, AME–ALE 0.08, PME–PME 0.10, PME–PLE 0.15, ALE–PLE 0.05). Epigynum with a small median lobe; epigynal teeth small, originating on posterior margin of epigynum and close to median lobe; copulatory ducts small, arising medially between



Figures 31, 32.—*Taira sichuanensis* new species, male holotype (31) and female paratype (32) from Changning, Sichuan, China, photos, habitus, dorsal view.

spermathecae; spermathecae long, more or less extending transversely, separated from each other anteriorly by approximately their width and posteriorly by at least three times their width; fertilization ducts long, at least half the length of spermathecae (Figs. 29, 30).

Distribution.—China (Sichuan) (Fig. 42).

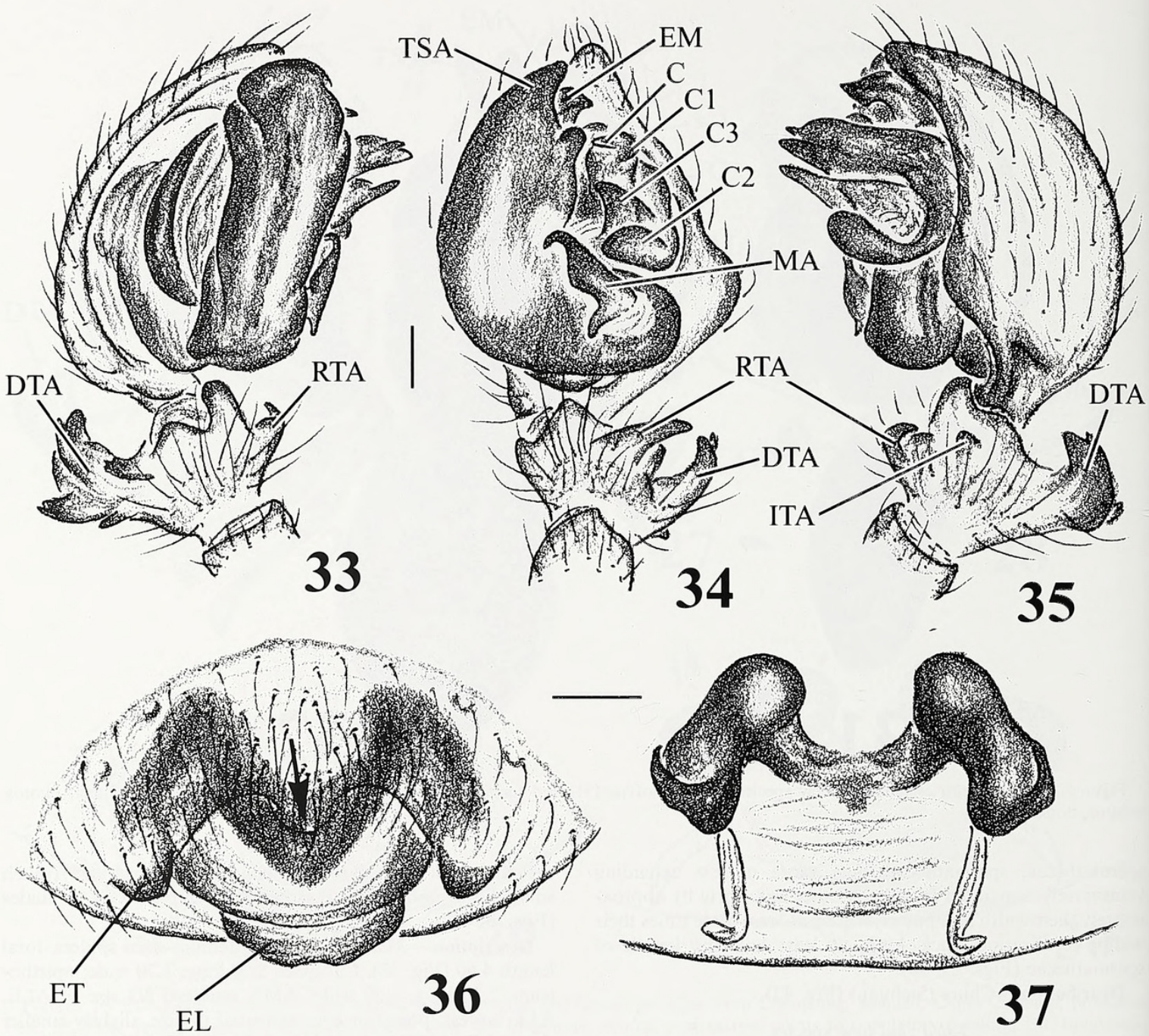
Taira zhui new species
Figs. 33–39, 42

Types.—CHINA: *Chongqing*, ♂ holotype, 2♂28♀ paratypes from Jinyunshan Natural Nature Reserve, 29°41′08″–29°52′03″N, 106°17′43″–106°24′50″E, 350–951 m, Beipei May 2008, R.Y. Zue & Z.H. Liu, deposited in SWUC; 1♂ paratype from same locality as above, 26 April 2008, Z. S. Zhang, deposited in SWUC. 6♂10♀ paratypes from same locality as above, 17 May 2009, Z.S. Zhang, deposited in SWUC.

Etymology.—The specific name is in honor of Professor Ming-Sheng Zhu, who advised and supported Zhi-Zheng Zhang's work; noun (name) in genitive case.

Diagnosis.—This new species is similar to *T. qiuae* new species in having a long RTA and long, anteriorly converging spermathecae but can be distinguished by the distinctly folded spermathecal bases in females, the distinctly extending base of the median apophysis and the different shapes of the conductor apophyses (much smaller C1 and slightly prolaterally curved C3) in males (Figs. 33–37).

Description.—*Male (holotype):* Medium-sized spiders, total length 4.60 (Fig. 38). Carapace 2.50 long, 1.70 wide; opisthosoma 2.30 long, 1.50 wide. AME smallest, 2/3 size of ALE, ALE largest; posterior eyes subequal in size, slightly smaller than ALE (AME 0.10, ALE 0.15, PME 0.13, PLE 0.13); AME close together, slightly separated from each other by 1/3 of their diameter, from ALE by slightly less than AME diameter; PME separated from each other by about their diameter, from PLE by almost 1.5 times PME diameter (AME–AME 0.03, AME–ALE 0.08, PME–PME 0.13, PME–PLE 0.18). Palpal RTA long, bent dorsally, with sharply pointed distal end; dorsal tibial apophysis (DTA) large, toothed proximally and distally; intermediate tibial apophysis (ITA) small, arising between the RTA and DTA; conductor reduced to a slender, hyaline apophysis, the latter arising from the distal end of the well-developed, strongly branched, beak-shaped conductor apophyses (C1, C2, C3); median apophysis long, with slender apex and broad base, the latter with a long, slender apophysis; tegular sclerite extending anteriorly and forming a broad apophysis on distal bulb, the latter covering most of embolus; embolus broad, only distal end visible from ventral view (Figs. 33–35).



Figures 33–37.—*Taira zhui* new species, male holotype and female paratype from Jinyunshan, Beipei, Chongqing, China, drawings. 33. Palp, prolateral view. 34. Palp, ventral view. 35. Palp, retrolateral view. 36. Epigynum, ventral view (arrow points to copulatory opening). 37. Epigynum, dorsal view.

Female (paratype): Medium-sized spider, total length 6.50 (Fig. 39). Carapace 2.60 long, 1.80 wide; opisthosoma 4.00 long, 3.00 wide. AME smallest, 2/3 size of ALE, ALE largest; posterior eyes subequal in size (AME 0.10, ALE 0.15, PME 0.13, PLE 0.13); AME close together, slightly separated from each other by 1/3 of their diameter, from ALE by slightly more than AME diameter; PME separated from each other by more than their diameter, from PLE by almost 2 times PME diameter (AME–AME 0.03, AME–ALE 0.13, PME–PME 0.18, PME–PLE 0.23, AME–PME 0.15. Epigynum with a triangular plate anterior of median lobe; median lobe two times wider than long; epigynal teeth broad, separated from median lobe by approximately their width; copulatory ducts small but distinct, arising medially and extending laterally to spermathecae; spermathecae long, kidney-shaped, widely separated from each other anteriorly by at least their width and posteriorly by at least two times their width; spermathecal bases with distinct folders looping around; fertilization ducts long, slightly longer than half the length of spermathecae (Figs. 36, 37).

Distribution.—China (Sichuan) (Fig. 42).

ACKNOWLEDGMENTS

The first author thanks Charles E. Griswold (CAS, San Francisco) and Norman I. Platnick (American Museum of Natural History, New York) for their advice and comments

Figures 38, 39.—*Taira zhui* new species, male holotype (38) and female paratype (39) from Jinyunshan, Beipei, Chongqing, China, photos, habitus, dorsal view.

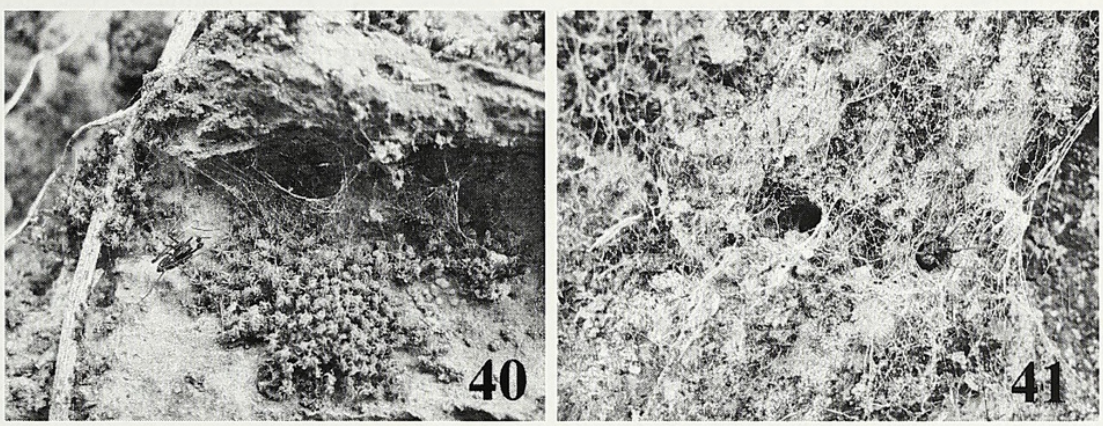


Figure 40, 41.—Habitat and web of *Taira*. 40. Male *T. sichuanensis* new species from Changning, Sichuan, China on the female web. 41. Female *T. obtusa* Zhang, Zhu & Song 2008 from Shennongjia, Hubei, China on the entrance of the web hole.

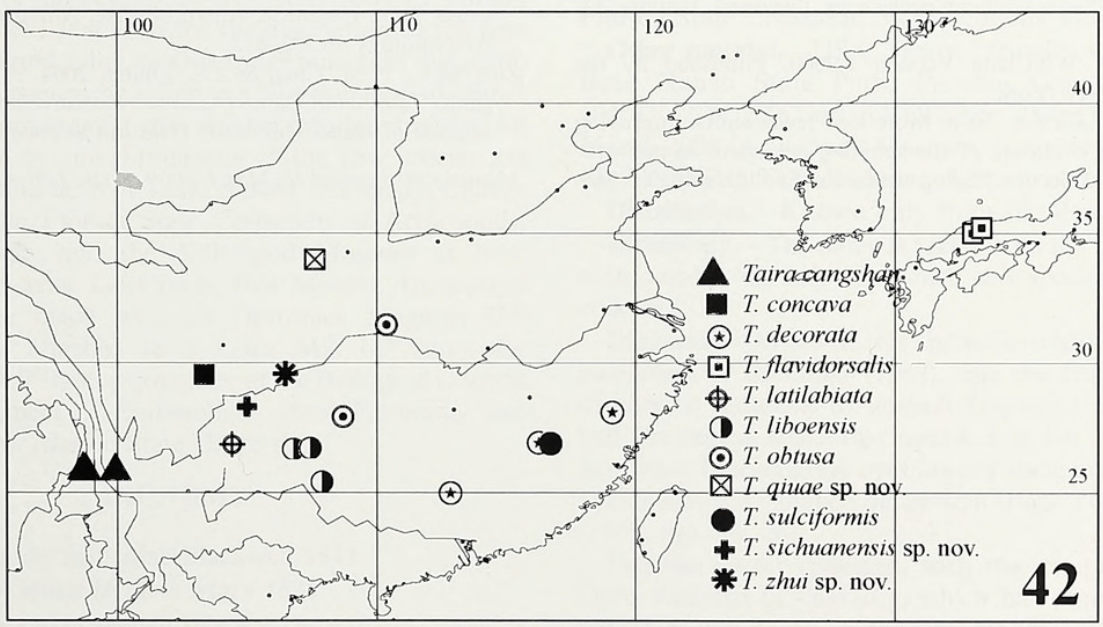


Figure 42.—Records of *Taira* species in China and Japan.

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