



## Ride on female for “*prima nocta*” or close attachment in the araneid spider *Caerostris sumatrana* Strand, 1915 (Araneae: Araneidae)

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### Abstract

A unique type of mate guarding behavior is discovered in the araneid spider *Caerostris sumatrana* Strand, 1915: the male waits for the female’s maturity while staying tied to the dorsal surface of her abdomen. The species is redescribed in detail. General appearance of the male and its fine structures are illustrated by scanning electron microscopy for the first time. Genital emasculation in the male of this species is reported for the first time.

**Key words:** Araneae, Laos, Southeast Asia, mating behavior, secure paternity, female guarding

### Introduction

*Caerostris* Thorell, 1868 is a relatively large genus of orb-weaving spiders (Araneidae) with 18 nominal species (WSC, 2023) distributed mainly in the Afrotropical Realm, with only two species occurring in Southeast Asia. The taxonomy of the genus remains poorly studied. Ten of the 18 species are known from females only (WSC, 2023). There are already 31 synonyms in the genus and three species are considered as *nomina dubia* (WSC 2023).

This genus has attracted the attention of arachnologists during the last decades due to the huge webs made by females with frame lines up to 25 m (Kuntner & Agnarsson, 2010), pronounced sexual size dimorphism (Grasshoff, 1984), exhibiting a kind of an oral sex, and mate guarding (i.e., adult male staying close to subadult female) (Gregorič *et al.* 2016). In addition, members of this genus have spectacular morphology and unique characters that are unknown in other members of the family such as: modified spatulate setae on legs I–II, strongly flattened tibiae and metatarsi, absence of a paracymbium, strongly developed conductor hiding all bulbal structures, and male palpal tibia longer than wide (vs. wider than long in all subfamilies except for Phonognathinae).

During field work in Laos, a female of *C. sumatrana* Strand, 1915 was found and collected from its web. To our surprise, while taking pictures of the captured specimen, it was noticed that a male is attached to the subadult (epigynum is not developed, body size is large) female’s dorsum (Figs 24–27). It is a unique form of pre-copulatory mate guarding that has never been reported in *Caerostris*. Since the male of this species was found only recently (Jäger, 2007) and has not been described and measured in detail, here we redescribe and diagnose the male, and comment on interesting details of sexual biology of the species.

### Material and methods

Specimens in alcohol were photographed in dishes of different sizes with paraffin or soft white paper at the bottom (different size holes in the paraffin were made at the bottom to keep specimens in the right position), using an

Olympus Camedia C-5050 camera attached to an Olympus SZX12 stereomicroscope at the Zoological Museum of University of Turku, and a Nikon DS-Ri2 camera attached to a Nikon SMZ25 stereomicroscope at the Laboratory of Ecology and Evolutionary Biology of Aquatic Organisms at the Far Eastern Federal University. The images were montaged using “CombineZP” (<http://www.hadleyweb.pwp.blueyonder.co.uk/>) and “Zerene Stacker” (<http://www.zerene.com/cms/stacker>) image stacking software packages.

Photos *in situ* were taken with a Nikon D800 camera equipped with a Tamron SP 90mm f/2.8 Di Macro 1:1 VC USD lens. Lengths of leg segments were measured on the retrolateral side. All measurements are given in millimeters. Distribution data are given according to WSC (2023). Distribution map was produced using SimpleMappr web application (Shorthouse, 2010).

### Depository:

FEFU = Far Eastern State University (Vladivostok).

Terminology and abbreviations used in the text and figures follow Gregorič *et al.* (2015), with some modifications and additions.

Abbreviations used in the text and figure plates. Eyes: AME—anterior median eye, ALE—anterior lateral eye, PME—posterior median eye, PLE—posterior lateral eye. Legs: Fe—femora, Mt—metatarsus, Pa—patella, Ta—tarsus, Ti—tibia. Copulatory organs: C—conductor, Cb—base of conductor, Ct—tip of conductor, Da—dorsal tibial apophysis, E—embolus, Eb—base of embolus, Ec—crack of embolus, Ep—emasculated palp, Lb—lamellar bristles, So—outgrowth of subtegulum, St—subtegulum, T—tegulum. Others: Ch—carapace humps, Th—attaching threads.

### Taxonomy

#### Araneidae Clerck, 1757

#### *Caerostris* Thorell, 1868

*Caerostris* Thorell, 1868: 3.

*Caerostris*: Simon, 1895: 834.

*Caerostris*: Grasshoff, 1984: 727.

*Caerostris*: Gregorič *et al.*, 2015: 298.

Type species. *Epeira mitralis* Vinson, 1863, from Madagascar.

#### *Caerostris sumatrana* Strand, 1915

(Figs 1–28)

*C. sumatrana*: Grasshoff, 1984: 758, figs 5, 40, 48 (m#).

*C. sumatrana*: Song, Zhu & Chen, 1999: 262, fig. 154C–E (f#).

*C. sumatrana*: Jäger, 2007: 37, figs 10–17 (m#f#).

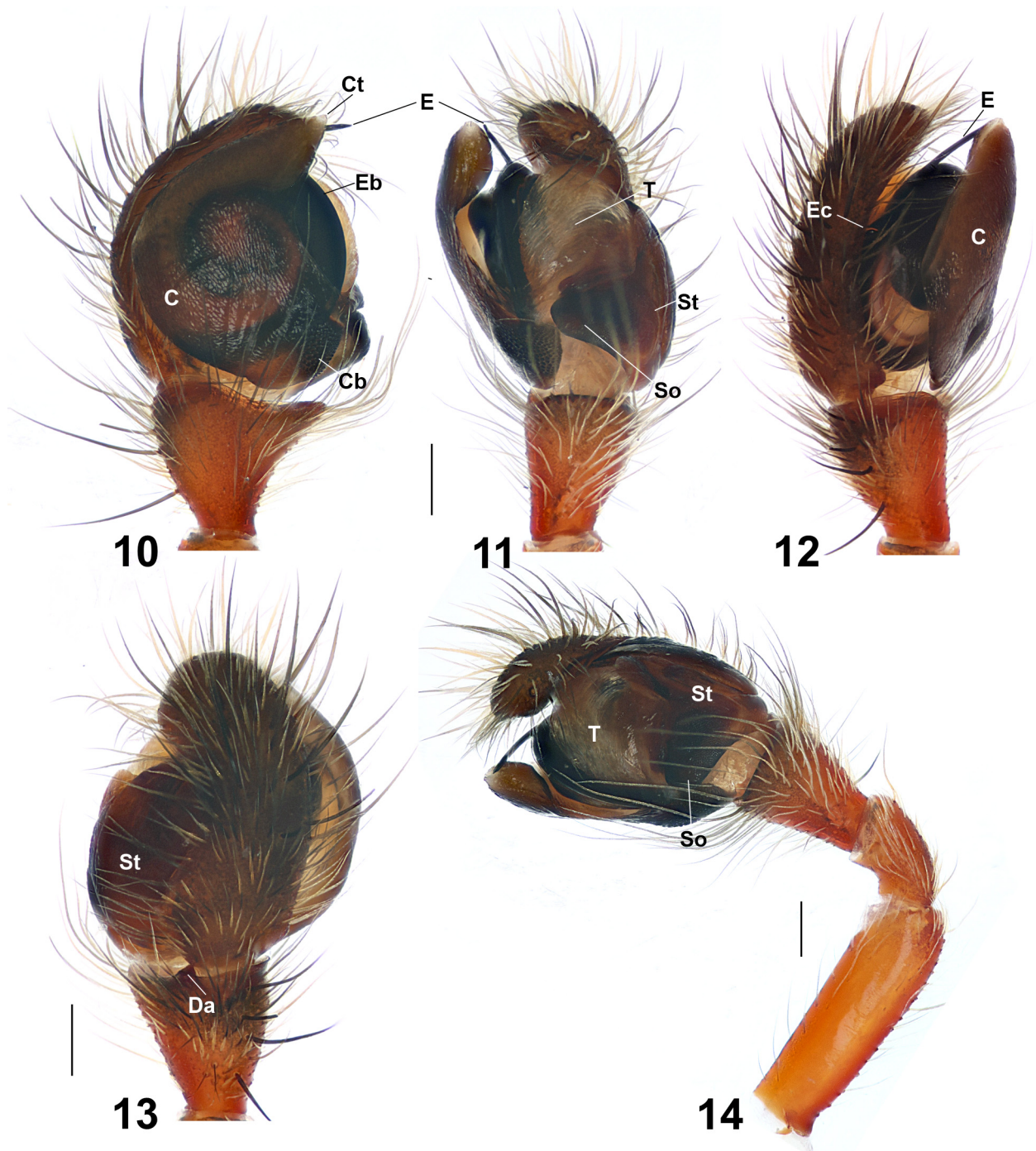
For the complete list of taxonomic references see WSC (2022).

**Material examined.** male, subadult female (FEFU), LAOS, Vientiane Prov., env. of Nam-Lik Eco-Village, 18°36'53.18"N 102°24'31.87"E, on web, coll. M.M. Omelko-senior, 28 June 2017.

**Diagnosis.** The male of *C. sumatrana* can be easily differentiated from all its congeners by the large, flat conductor covering most of the bulb ventrally (vs. small conductor covering bulb partially). The female of *C. sumatrana* can be distinguished by the large dorsal carapace humps (vs. small), epigynal hooks overhanging copulatory openings (vs. not overhanging) and wide lamellar bristles on femur IV (vs. narrow).



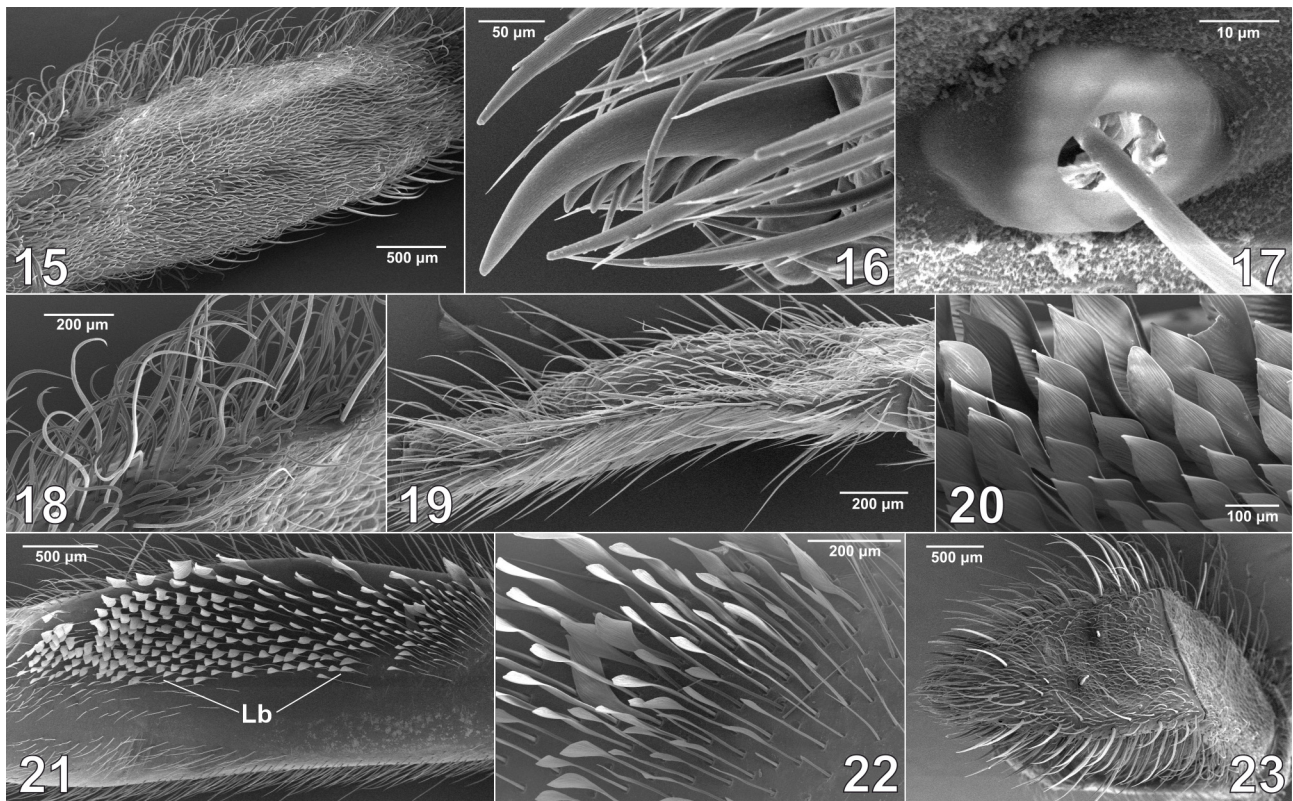
**FIGURES 1–9.** *Caerostris sumatrana*, female (1–4) and male (5–9). 1, 5, Habitus, dorsal. 6, Same, ventral. 2, 7, Same, anterior. 8, Same, lateral. 3, Femur, lateral. 4, 9, Metatarsus IV, lateral and dorsal. Scale bars, 1 mm. Abbreviations: Ch—carapace humps, Ep—emasculated palp, Lb—lamellar bristles.



**FIGURES 10–14.** Palp of *Caerostris sumatrana*. 10, Ventral. 11, 14, Retrolateral. 12, Prolateral. 13, Dorsal. Scale bars, 0.2 mm.

Abbreviations: C—conductor, Cb—base of conductor, Ct—tip of conductor, Da—dorsal tibial apophysis, E—embolus, Eb—base of embolus, Ec—crack of embolus, So—outgrowth of subtegulum, St—subtegulum, T—tegulum.

**Redescription.** Male (Figs 5–9). Total length 4.73. Carapace 2.73 long, 2.70 wide. Carapace reddish brown anteriorly, dark brown posteriorly. Clypeus dark brown. Chelicerae dark brown anteriorly, reddish brown laterally. Labium and endites dark brown. Sternum brown, 1.26 long, 1.34 wide, widest between second and third coxae, dark brown without pattern. Eye diameters and interdistances: AME 0.26, PME 0.16, ALE 0.10, PLE 0.08. AME–AME 0.30, PME–PME 0.67, PME–PLE 1.04, ALE–PLE 0.05, AME–PME 0.18. Clypeus 0.66 high. Lengths of leg segments as in Table 1.



**FIGURES 15–23.** SEM images of the somatic features of male (15–18) and female (19–23) *Caerostris sumatrana*. 15, Metatarsus IV. 16, Palpal claw. 17, Trichobothria at metatarsus IV. 18, Setae at metatarsus IV. 19, Metatarsus IV. 20, Lamellar bristles at metatarsus IV. 21, Femur IV, ventral. 22, Lamellar bristles. 23, Palpal tarsus.

Abbreviations: Lb—lamellar bristles.

**TABLE 1.** Lengths of leg segments of the male of *Caerostris sumatrana*.

	Fe	Pa	Ti	Mt	Ta	Total
<b>I</b>	2.56	1.43	2.15	2.34	0.92	9.4
<b>II</b>	2.36	1.33	2.06	2.15	0.93	8.83
<b>III</b>	1.78	0.81	0.99	1.13	0.70	5.41
<b>IV</b>	2.11	1.10	1.43	1.54	0.64	6.82

Palp brown except for cymbium (dark brown). Leg segments light brown without annulation, covered with white setae. Femur distally dark brown. Metatarsus IV strongly flattened dorsoventrally (Fig. 9).

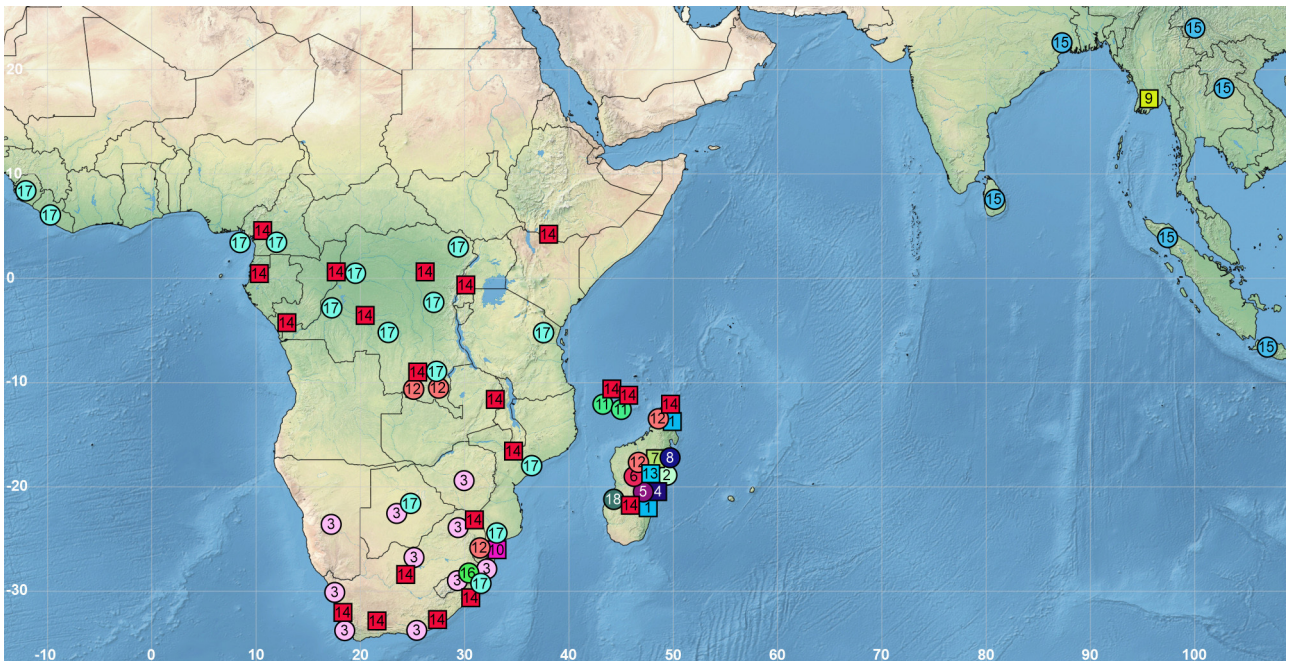
Opisthosoma 2.74 long, 3.78 wide; dorsally flat, without humps, covered with short whitish setae; dorsally dark brown with yellow anterior edge, ventrally grayish.

Palp as in Figs 10–14. Femur/cymbium length ratio 0.92; patella slightly shorter than tibia; tibia/cymbium length ratio 0.42. Cymbium narrow, curved. Tibia trapezoid with small, triangular dorsal apophysis (Da). Conductor (C) large, covering whole bulbus dorsally with pointed tip (Ct) and granulation at its base (Cb). Embolus (E) long, coiled with wide base (Eb) and crack (Ec) indicating location of breaking during copulation (unique character of *C. sumatrana*, not known in its congeners Jäger (2007)). Tegulum (T) large membranous. Subtegulum (St) large with long extension (So) prolaterally.

Female (subadult). Total length 12.59. Carapace 7.07 long, 6.92 wide. Carapace dark brown with short white setae and large humps (Ch) dorsally and laterally. Clypeus dark brown. Chelicerae uniformly dark brown, covered with white setae. Labium and endites dark brown. Sternum brown, slightly darker in middle part, 2.80 long, 3.10 wide, widest between second leg, without setae. AME diameter 0.29, PME diameter 0.27, ALE diameter 0/17, PLE diameter 0.16. AME–AME distance 0.58, PME–PME distance 1.23, PME–PLE distance 2.92, ALE–PLE distance 0.10, AME–PME distance 0.35. Clypeus height 1.33. Lengths of leg segments as in Table 1.



**FIGURES 24–27.** Male and female of *Caerostris sumatrana* in situ.  
Abbreviations: Th—attachment threads.



**FIGURE 28.** Distribution records of *Caerostris* spp.: *C. almae* (1), *C. bojani* (2), *C. corticosa* (3), *C. cowani* (4), *C. darwini* (5), *C. ecclesiigera* (6), *C. extrusa* (7), *C. hirsuta* (8), *C. indica* (9), *C. linnaeus* (10), *C. mayottensis* (11), *C. mitralis* (12), *C. pero* (13), *C. sexcuspidata* (14), *C. sumatrana* (15), *C. tinamaze* (16), *C. vicina* (17), *C. wallacei* (18).

**TABLE 2.** Length of leg segments for the female (subadult) of *Caerostris sumatrana*.

	Fe	Pa	Ti	Mt	Ta	Total
I	4.76	2.99	4.19	4.63	1.76	18.33
II	4.70	3.13	4.22	4.25	1.67	17.97
III	3.86	1.85	2.11	2.17	1.38	11.37
IV	4.89	2.46	3.50	4.08	1.32	16.25

Palp brown with short setae and long white hairs at prolateral. Leg segments dark brown without annulation, covered with white setae. All segments, except for femora, strongly flattened dorsoventrally (Figs 1, 2, 4). Femur IV with wide, semi-transparent lamellar bristles (Lb, Fig. 3).

Opisthosoma 9.72 long, 10.98 wide; dorsally yellowish, with a number of humps, covered with short whitish setae; ventrally grayish. Epigynum was well illustrated by Jäger (2007: figs 13–14).

**Notes.** Despite the fact that *Caerostris sumatrana* was described a long time ago, its male had not been discovered until recently (Jäger, 2007). However, Jäger (2007) provided only two black-and-white drawings of the male palp and one of its prosoma in frontal view. Also, the description of the male did not include any measurements and the body coloration was not discussed. It is worth mentioning that no details about sexual biology of this species have been known prior to our study.

**Distribution.** India, China (Yunnan), Indonesia (Java, Sumatra), Laos, Malaysia (Fig. 28).

## Discussion

Orb-weaving spiders (Araneidae) with a sexual size dimorphism have evolved interesting and numerous adaptations in regard to their sexual behavior, such as sexual cannibalism, opportunistic mating, mate-binding, mate-guarding, genital mutilation, plugging, mating with teneral (freshly moulted) females, remote copulation, emasculation, etc. (Fairbairn *et al.*, 2007; Gregorič *et al.*, 2016; Kuntner *et al.*, 2015; Wilder *et al.*, 2009). *Caerostris* is a typical example of such sexual dimorphism: females are several times larger than males (both in size and weight). Up to date, the sexual behavior in this genus have been studied in detail only for one species, so called the Darwin's bark spider, *C. darwini* Kuntner & Agnarsson, 2010 (Gregorič *et al.*, 2016; Kuntner & Agnarsson, 2010), known from Madagascar. This species is characterized by features of sexual behavior such as cannibalism, genital mutilation, male preference for teneral females and genital emasculation. Moreover, the unique behavior of oral sexual encounters has recently been discovered for this species (Gregorič *et al.*, 2016), in the form of injections of orally secreted fluids of the male into the copulatory openings of the female. The exact purpose of this behavior is still unclear, but, presumably, it may signal the quality of the male to the female or provide advantage to the donor's over its rival's sperm (Gregorič *et al.*, 2016).

For *C. sumatrana*, the subject of this paper, sexual behavior has not been studied yet. However, the presence of a small crack at the embolus (Fig. 12), which is assumed (Jäger, 2007) to be the point of predetermined breaking, suggests that this species uses plugging as many of its congeners. In addition, the male we collected did not have the bulb of the right palp (Figs 6, 7), which suggests the presence of self-emasculation for the species, a behavior in which the male chews off the bulb after the embolus breaks off during copulation.

During field work in Laos, a female of *C. sumatrana* was found and collected from its web. While taking pictures of the captured specimen, we noticed a male individual sitting on the dorsal surface of the female's abdomen (Figs 24–27). To hold itself on the female's body, the male used not only his legs and apparently chelicerae, but also weaved a special web of distinctive attachment threads (Fig. 25). In our opinion, this behavior is a special form of mate-guarding, a phenomenon known for other species of orb-weaving spiders, e.g., *C. darwini*. However, in the latter species, males guard females by staying on their webs (Kuntner & Agnarsson, 2010), not on the females themselves. The female we collected was subadult, which suggests that the male was expecting her to become mature in order to copulate with a freshly moulted (teneral) female.

Thus, *C. sumatrana* has complex forms of sexual behavior similar to those in *C. darwini* from Madagascar. Some of them were previously known from its congeners, while a special form of mate-guarding (i.e., the male sitting on the back of the female) was not previously reported. It is likely that other species of the genus, both in the Afrotropical region and in Southeast Asia, have complex forms of sexual behavior as well.

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