

**Research Article** 

# Description of three new species and new distributional data for three species of *Homalotylus* (Hymenoptera, Encyrtidae) from China

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#### Abstract

Homalotylus tianjinensis Zu, **sp. nov.**, *H. bicolor* Zu, **sp. nov.** and *H. guangxiensis* Zu, **sp. nov.** are described as new to science; *H. agarwali* Anis & Hayat, 1998, *H. hemipterinus* (De Stefani, 1898) and *H. varicolorus* Krishnachaitanya & Manickavasagam, 2016 are newly recorded from China. A key to Chinese species based on females is also presented.

**Key words:** Chalcidoidea, Echthroplexiellini, Encyrtinae, identification key, new species, taxonomy



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# Introduction

*Homalotylus* is a well-known genus of Encyrtidae, which was established by Mayr (1876) based on the type species *Encyrtus flaminius* Dalman. Depending on the classification, this genus is placed either in the tribe Homalotylini, subtribe Homalotylina (Trjapitzin 1989) or the tribe Echthroplexiellini, subtribe Homalotylina (Noyes 2010). The species in this genus are solitary or gregarious larval parasitoids, emerging from the prepupal stage of coccinellids (Coleoptera: Coccinellidae) and feeding on sternorrhyncha hemipterans (Hemiptera: Aphidoidea, Coccoidea, Psylloidea). Records of scale insects as hosts are incorrect and those of other hosts, e.g. Chrysomelidae, Bruchidae or Gelechiidae are also probably erroneous (Noyes 2010). The genus contains 66 valid species (Noyes 2019) and nine species from China (Xu and He 1997; Tan and Zhao 1997).

Contributions to the taxonomy of this genus have been made by several authors, such as Trjapitzin (1989) from the Palaearctic, Anis and Hayat (1998) and Krishnachaitanya et al. (2016) from India, Trjapitzin and Ruíz Cancino (1998) from the New World and Xu and He (1997) from China. In this paper,

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we describe three new species and three new Chinese records of *Homalotylus* from Tianjin and Guangxi, China, and provide a key to the females of the Chinese species.

# Materials and methods

All the specimens in the present study were collected from the campuses of Tianjin Agricultural University and Beibu Gulf University by malaise traps, then dissected and mounted in Canada Balsam on slides following the method described by Noyes (1982). Morphological terminology and abbreviations follow those of Noyes (2010) with some modifications. Photographs were taken with a digital CCD camera attached to an Olympus BX51 compound microscope. Body lengths were measured using a Leica M205A stereomicroscope; other measurements are relative and taken from micrometer divisions using the eye piece of a stereozoom microscope for carded specimens and the eye piece of a compound microscope for slide-mounted parts, and then transformed into absolute lengths. The holotype of the new species is deposited in the insect collections of Tianjin Agricultural University, China.

The following abbreviations are used in the text:

- F1-6 funicle segments 1-6 AOL minimum distance between a posterior ocellus and anterior ocellus EL maximum diameter of eye FV minimum width of the frontovertex HH length of head in facial view, excluding mouth parts HW head width measured in facial view malar space or minimum distance between eye and mouth margin MS OCL minimum distance between a posterior ocellus and occipital margin OD longest diameter of an ocellus OOL minimum distance between a posterior ocellus and eye margin POL minimum distance between posterior ocelli FWL maximum length of fore wing excluding marginal fringe FWW maximum width of fore wing excluding marginal fringe MV marginal vein **PMV** postmarginal vein SMV submarginal vein SV stigmal vein HWL length of hind wing excluding marginal fringe HWW width of hind wing, measured at widest point, excluding marginal fringe MT length of mid tibia GL length of gonostylus LTL last tergite length LTW last tergite width OL length of ovipositor EDAU Entomology Department, Annamalai University, Chidambaram, India HACO Hayat Collection, Aligarh, India USNM National Museum of Natural History, Washington, D.C., USA
- **ZAMU** Zoological Museum, Aligarh Muslim University, Uttar Pradesh, India.

# Results

# Key to Chinese species of Homalotylus (females)

1	Ovipositor distinctly exserted, the exserted part at least 0.2× as long as gaster
_	Ovipositor not or slightly exserted11
2	Funicle completely dark brown, sometimes F6 mixed with white
_	Funicle at least always with F6 completely white5
3	F6 completely dark brown H. zhaoi
-	F6 brown mixed with white4
4	Frontovetex 0.25× as wide as head width; fore wing 3.30× as long as width
-	Frontovetex 0.17× as wide as head width; fore wing 2.78× as long as widt
-	H. tranjinensis sp. nov.
5	F4-F5 always completely write
_	F4-F5 at least partially white
0	F3 white
- 7	F3 dark brown
/	Axillae dark brown agutallum maatly dark brown but vallowiab brown ani
_	cally H trigubalbus
8	EA dark brown E5 at least nartially white
_	F4 dark brown with anical half white E5 white
9	Frontovetex 0.19x as wide as head width: mid tibia spur as long as mid
2	hasitarsus H. Iongicaudus
_	Frontovetex 0.25× as wide as head width; mid tibia spur longer than mid
	basitarsus
10	Scape 6× as long as wide; clava unsegmented white
_	Scape 8.42× as long as wide; clava 3-segmented
11	F4 white; mid tarsus 1–4 white, with basal half of mid basitarsus brown
-	F4 dark brown or brown; mid tarsus 1–4 white12
12	F5 and F6 white H. yunnanensis
-	F5 dark brown, F6 dark brown or partially white, rarely completely white 13
13	Mid tibia spur longer than mid basitarsus H. sinensis
-	Mid tibia spur shorter than or equal to mid basitarsus14
14	Mid tibia spur about $8-10 \times$ as long as broad; hind tarsus dark brown
	H. flaminius
-	Mid tibia spur only about 7× as long as broad; hind tarsus mostly white

#### Homalotylus bicolor Zu, sp. nov.

https://zoobank.org/80414BF3-89A7-4C8B-A62A-319E45842713 Figs 1–12

**Type materials.** *Holotype*. ♀ [on slide], CHINA, Guangxi Province, Qinzhou City, Beibu Gulf University, 21°53′53″N, 108°36′56″E, c. 24 m, 06−26.X.2019, Wen-Quan Zhen, Malaise trapping. *Paratypes*. ♀♂ [on slides], CHINA, Guangxi

Province, Qinzhou City, Beibu Gulf University, 21°53'53"N, 108°36'56"E, c. 24 m, 06–13.X.2019, Wen-Quan Zhen, Malaise trapping.

**Description. Female.** Holotype. Length, 2.20 mm (excluding ovipositor). Head generally orange yellow, with genae, frontovertex and occiput dark brown. Antennae dark brown, F4 mostly white with lower margin brown, F5, F6 and clava white. Mesosoma dark brown with shallow metallic green sheen, scutellum mostly orange yellow, only with a brown area at base; legs dark brown, except for apical 3/5 of mid tibia, mid tibial spur, mid and hind tarsus 1–4 white. Metasoma dark brown.

Head (Fig. 1) with numerous conspicuous setae on frontovertex, each about as long as diameter of posterior ocellus. Head in front view 1.16× higher than wide. Frontovertex 0.22× head width. Ocelli forming an angle of 33°, posterior ocelli close to eye margin, distance to occipital margin 1.50× the diameter of anterior ocellus. Malar space 0.18× eye height. Antennal torulus with its dorsal margin slightly below lower eye margin and very close to oral margin, and the distance of antennal torulus by 1.95× its own height. Antennal (Fig. 2) scape slender, 8.42× as long as wide; pedicel 2.5× as long as wide, 1.5× as long as F1; all funicle segments longer than wide, F1 1.57× as long as wide, F6 1.11× as long as wide; funicle with linear sensilla on all segments; clava 3-segmented, 3.40× as long as wide, and as long as F4−F6 combined, apex strongly obliquely truncate, truncate part approach to the base of the clava. Measurements ( $\mu$ m): HH, 580; HW, 500; FV, 108; EL, 490; MS, 88; OD, 38; POL, 38; OCL, 58; AOL, 78; length and (width)−radicle, 105; scape, 400 (48); pedicel, 125 (50); F1, 83 (53); F2, 70 (55); F3, 75 (58); F4, 73 (60); F5, 70 (63); F6, 70 (63); clava, 213 (63).

Mesosoma (Fig. 3) with sculpture on dorsum similar to that on frontovertex but that on mesoscutum a little shallower; notaular lines conspicuous but not quite meeting at middle of posterior margin of mesoscutum. Mesoscutum  $0.72 \times$  as long as wide; scutellum  $0.94 \times$  as long as wide. Fore wing (Fig. 4)  $2.65 \times$ as long as wide; linea calva interrupted by 4 lines of setae and closed by 5 lines of setae posteriorly; marginal vein  $0.44 \times$  as long as stigmal vein, and about half the length of postmarginal vein. Hind wing (Fig. 5)  $3.73 \times$  as long as wide. Length of mid tibial spur (Fig. 6)  $0.48 \times$  of mid tibia and longer than mid basitarsus. Measurements (µm): FWL, 1325; FWW, 500; SMV, 600; MV, 50; PMV, 100; SV, 113; HWL, 970; HWW, 260; MT, 810; mid tibial spur, 390; mid basitarsus, 360.

Ovipositor (Fig. 3) 1.26× as long as mid tibia, distinctly exserted. Measurements ( $\mu$ m): OL, 1020.

**Male.** Length, 1.67 mm. Color is similar to female, except for F4 completely brown.

Head (Fig. 7) in front view 1.11× higher than wide. Frontovertex 0.23× head width, ocelli forming an angle of about 35°. Malar space 0.17× eye height. Antennal torulus with its dorsal margin slightly below lower eye margin and very close to oral margin. Antennal (Fig. 8) scape slender, about 5.9× as long as wide; pedicel 2.18× as long as wide, 1.40× as long as F1; all funicle segments longer than wide; clava unsegmented, 3.72× as long as wide.

Mesoscutum (Fig. 9) 0.58× as long as width; scutellum 0.9× as long as width. Fore wing (Fig. 10) 2.65× as long as width. Hind wing (Fig. 11) 3.86× as long as width. Length of mid tibial spur (Fig. 12) about 0.44× of mid tibia and longer than mid basitarsus.

Aedeagus (Fig. 9) about 1.34× as long as mid tibia. **Host.** Unknown.



Figures 1–6. *Homalotylus bicolor* Zu, sp. nov., holotype female 1 head 2 antenna 3 mesosoma and metasoma 4 fore wing 5 hind wing 6 legs. Scale bars: 100 µm.

**Etymology.** The specific name refers to its coloration of mesosoma. **Diagnosis.** The new species may be distinguished from *H. scutellaris* Tan & Zhao, 1997 and *H. mundus* Gahan, 1920, by the following characters: scape



Figures 7–12. *Homalotylus bicolor* Zu, sp. nov., paratype male 7 head 8 antenna 9 mesosoma and metasoma 10 fore wing 11 hind wing 12 legs. Scale bars: 100 µm.

8.42× as long as wide (6× in *H. scutellaris*), clava 3-segmented (unsegmented in *H. scutellaris*), metanotum and propodeum dark brown (yellow brown in *H. scutellaris*); F4 mostly white, mixed with brown on lower margin (completely white in *H. mundus*), axillae brown (pale orange yellow in *H. mundus*), pedicel 2.5× as long as wide (nearly 3× in *H. mundus*).

#### Homalotylus guangxiensis Zu, sp. nov.

# https://zoobank.org/7E6B1AC5-27FA-4C9A-93C5-366FF6480BE0 Figs 13-18

**Type materials.** *Holotype.* ♀ [on slide], CHINA, Guangxi Province, Qinzhou City, Beibu Gulf University, 21°53'53"N, 108°36'56"E, c. 24 m, 2–11.V.2019, Wen-Quan Zhen, Malaise trapping. *Paratypes.* 3♀ [on slides], CHINA, Guangxi Province, Qinzhou City, Beibu Gulf University, 21°53'53"N, 108°36'56"E, c. 24 m, 14–31. XII.2019, 1–13.I.2020, Wen-Quan Zhen, Malaise trapping.

**Description. Female.** Holotype. Length, 2.11 mm (excluding ovipositor). Head black, with metallic green luster; antennae dark brown, F3 paler apically, F4, F6 and clava white. Mesosoma dark brown with metallic sheen; basal half of tegula white, apical half dark brown; wings mostly hyaline but fore wing weakly infuscate at base and with a distinct, broad brown fascia across wing extending from parastigma, marginal and stigmal veins, setae distad of this uniform in color; legs dark brown, except for apical 1/2 of mid basitarsus and mid tarsus 2–4 white. Metasoma black brown.

Head (Fig. 13) with sparse setae on frontovertex, each about as long as diameter of posterior ocellus. Head in front view 1.13× higher than wide. Frontovertex 0.2× head width, with distinctly reticulate sculpture. Ocelli forming an angle of about 40°; posterior ocelli very close to eye margin, to occipital margin about 2× as long as the diameter of anterior ocellus. Malar space 0.23× eye height. Antennal torulus with its dorsal margins slightly below lower eye margins, and the distance of antennal torulus by about 1.69× its own height. Antennal (Fig. 14) scape slender, 7.11× as long as wide; pedicel 2.05× as long as wide, 1.63× as long as F1; F1 1.33× as long as wide; F6 slightly wider than long; funicle with linear sensilla on all segments; clava 3-segmented, 2.60× as long as wide, and longer than F4–F6 combined, apex strongly obliquely truncate, truncate part nearly two thirds of the clava. Measurements ( $\mu$ m): HH, 600; HW, 530; FV, 108; EL, 480; MS, 108; OD, 35; POL, 40; OCL, 58; AOL, 88; length and (width)-radicle, 83; scape, 320 (45); pedicel, 98 (48); F1, 60 (45); F2, 58 (50); F3, 53 (50); F4, 53 (50); F5, 53 (55); F6, 50 (60); clava, 163 (63).

Sculpture (Fig. 15) on mesoscutum and scutellum similar to that on head; notaular lines conspicuous and meeting at middle of posterior margin of mesoscutum. Mesoscutum  $0.65 \times$  as long as wide; scutellum  $0.84 \times$  as long as wide. Fore wing (Fig. 16)  $2.52 \times$  as long as wide; linea calva interrupted by 2 lines of setae and closed posteriorly by 3 lines of setae; postmarginal vein about as long as stigmal vein. Hind wing (Fig. 17)  $3.68 \times$  as long as wide. Length of mid tibial spur (Fig. 18)  $0.39 \times$  of mid tibia and shorter than mid basitarsus. Measurements (µm): FWL, 1325; FWW, 525; SMV, 560; MV, 53; PMV, 90; SV, 88; HWL, 920; HWW, 250; MT, 740; mid tibial spur, 290; mid basitarsus, 310.

Ovipositor (Fig. 15) 0.76× as long as mid tibia, slightly exserted. Measurements ( $\mu$ m): OL, 560.

Male. Unknown.

Host. Unknown.

Etymology. The specific name refers to its collecting location.

**Diagnosis.** The new species may be distinguished from *H. albitarsus* Gahan, 1910 and *H. agarwali* Anis & Hayat, 1998, by the following characters: F4 completely white (basal brown and apical white in *H. albitarsus*), hind tarsus brown



**Figures 13–18**. *Homalotylus guangxiensis* Zu, sp. nov., holotype female **13** head **14** antenna **15** mesosoma and metasoma **16** fore wing **17** hind wing **18** legs. Scale bars: 100 μm.

(1–4 white in *H. albitarsus*), mid tibial spur shorter than mid basitarsus (longer in *H. albitarsus*), pedicel 2.05× as long as wide (about 3× in *H. albitarsus*); ovipositor 0.76× as long as mid tibia (1.03× in *H. agarwali*), F3 dark brown, mixed with white apically (white in *H. agarwali*).

#### Homalotylus tianjinensis Zu, sp. nov.

https://zoobank.org/91147952-886C-449A-B0BB-2BFC2C7B889F Figs 19-25

**Type materials.** *Holotype*. ♀ [on slide], CHINA, Tianjin City, Xiqing District, Tianjin Agricultural University, 39°5'21"N, 117°5'38"E, c. 13 m, 18.VI–3.VII.2019, Guo-Hao Zu, Ze-Ning Yang, Malaise trapping. *Paratypes*. ♀ [on slide], CHINA, Tianjin City, Xiqing District, Tianjin Agricultural University, 39°5'21"N, 117°5'38"E, c. 13 m, 30.V–14.VI.2020, Ze-Ning Yang, Chen Zhang, Malaise trapping.

**Description. Female.** Holotype. Length, excluding ovipositor, 2.20 mm. Face yellowish brown, frontovertex dark brown, genae dark brown. Antennae dark brown, F6 from brown to white, clava white. Mesosoma black brown, but axilla yellowish brown, scutellum yellowish with a diamond-shaped brown area at the base; tegula white; wings largely hyaline but fore wing infuscate at base and with a distinct, broad more or less parallel-sided brown fascia across immediately distad of this, otherwise apical setae normal and dark; legs dark brown, except for apical 1/5 of mid tibia, all tibial spurs, mid and hind tarsus 1–4 white. Metasoma black, the protruding part of the ovipositor black brown, with only the base yellowish white.

Head (Fig. 19) with numerous conspicuous setae on frontovertex, each about as long as diameter of posterior ocellus; piliferous punctures shallow. Head in front view about 1.13× higher than wide. Frontovertex about 1/6 head width, and narrowest about midway between posterior ocelli and occipital margin, eye margins conspicuously diverging anteriorly. Ocelli forming an angle of about 40°. Malar space 0.17× eye height. Antennal torulus with its dorsal margin below lower eye margin and very close to oral margin. Clypeal margin slightly convex. Antennal (Fig. 20) scape slender, almost 7.60× as long as wide; pedicel 2.5× as long as wide, 1.49× as long as F1; all funicle segments longer than wide, F1 1.74× as long as wide, F6 1.26× as long as wide; funicle with linear sensilla on all segments; clava 3-segmented, about as long as F4-F6 combined, apex strongly obliquely truncate, truncate part approach to the middle of the first clava segment. Measurements (µm): HH, 590; HW, 530; FV, 90; EL, 500; MS, 87; OD, 38; POL, 38; OCL, 76; AOL, 66; length and (width)-radicle, 125; scape, 380 (50); pedicel, 130 (52); F1, 87 (50); F2, 85 (57); F3, 80 (60); F4, 82 (62); F5, 80 (62); F6, 82 (65); clava, 232 (65).

Mesosoma (Fig. 21) with sculpture on mesoscutum of similar mesh size to that on frontovertex, but much shallower; sculpture on scutellum similar to that on frontovertex, but slightly deeper and coarser; notaular lines conspicuous but not quite meeting at middle of posterior margin of mesoscutum. Scutellum about as long as wide and about as long as mesoscutum. Fore wing (Fig. 22)  $2.78 \times$  as long as width; venation and setation as in Fig. 23; costal cell narrow; linea calva interrupted by 3 lines of setae and closed posteriorly by 5 lines of setae; marginal vein about  $1.5 \times$  as long as wide; postmarginal vein slightly shorter than stigmal vein, angle between them about  $30^\circ$ . Hind wing (Fig. 23)  $3.81 \times$  as long as width. Length of mid tibial spur (Fig. 25) about  $0.45 \times$  of mid tibia and longer than mid basitarsus. Measurements (µm): FWL, 1420; FWW, 510; SMV, 645; MV, 62; PMV, 145; SV, 151; HWL, 1030; HWW, 270; MT, 860; mid tibial spur, 390; mid basitarsus, 350.

Ovipositor (Fig. 24) distinctly exserted,  $1.14 \times$  as long as mid tibia and the exserted part nearly equal to mid tibial spur. Measurements (µm): OL, 980.



Figures 19–25. *Homalotylus tianjinensis* Zu, sp. nov., holotype, female **19** head **20** antenna **21** mesosoma **22** fore wing **23** hind wing **24** metasoma **25** legs. Scale bars: 100 μm.

Male. Unknown.Host. Unknown.Etymology. The specific name refers to its collecting location.

**Diagnosis.** The new species may be distinguished from *H. albiclavatus* (Agarwal, 1970) and *H. vicinus* Silvestri, 1915, by the following characters: scape completely dark brown, 7.60× as long as wide (with a long light-colored strip medially, 8.55× in *H. albiclavatus*), F6 from brown to white (completely white in *H. albiclavatus*), scutellum yellowish with a diamond-shaped brown area at the base (yellow in *H. albiclavatus*); F6 from brown to white (dark in *H. vicinus*), hind femur dark brown (ventrally pale yellow apically in *H. vicinus*), hind tarsus 1–4 white (2–4 white in *H. vicinus*).

# Homalotylus agarwali Anis & Hayat, 1998

Figs 26-31

*Homalotylus agarwali* Anis & Hayat, 1998: 203–204. Holotype ♀, India, HACO, not examined.

### Host. Unknown.

Distribution. China (Guangxi), India.

**Material examined.** 2 $\bigcirc$ , CHINA, Guangxi Province, Qinzhou City, Beibu Culf University, 21°53′53″N, 108°36′56″E, c. 24 m, 6–17.XI.2019, Wen-quan Zhen, Malaise trapping.

**Diagnosis.** This is the first record from China.

# Homalotylus hemipterinus (De Stefani, 1898)

Figs 32-37

Phaenodiscus hemipterinus De Stefani, 1898: 250. Holotype? ♀, Italy, ? lost. Homalotvlus orci Girault, 1917a: 3. Syntypes, Indonesia (Java), USNM, examined. Homalorylus flavimesopleurum Girault, 1917b: 5. Lectotype ♀, Japan, USNM, examined.

- *Neoaenasioidea nigritus* Agarwal, 1970: 27. Holotype ♀, India, ZAMU, not examined.
- *Echthroplexis tumkurensis* Shafee & Fatma, 1985: 375. Holotype ♀, India, ZAMU, not examined.

*Homalotvlus evtelweinii* (Ratzeburg); Hayat 2006, Trjapitzin and Ruiz Cancino 2003, misidentification.

**Host.** Coleoptera (Coccinellidae): *Chilocorus bipustulatus, Chilocorus bijugus, Chilocorus nigritus, Chilocorus sp., Coccinella septempunctata, Cycloneda sanguinea, Menochilus sexmaculatus.* 

**Distribution.** China (Guangxi), Japan, Thailand, India, Myanmar, Malaysia, Indonesia, Iran, Austria, Brazil, Czech Republic, France, Germany, Israel, Italy, Kenya, Congo, Democratic Republic of Congo, Malawi, South Afica, Chad, Sudan, Togo, Cosat Rica, Bahamas, Paraguay, Colombia, Fiji.

**Material examined.** 15♀, CHINA, Guangxi Province, Qinzhou City, Beibu Gulf University, 21°53′53″N, 108°36′56″E, c. 24 m, 26.III–29.XII.2019, Wen-quan Zhen, Malaise trapping.

**Diagnosis.** This is the first record from China.



**Figures 26–31**. *Homalotylus agarwali* Anis & Hayat, 1998, female **26** head **27** antenna **28** mesosoma and metasoma **29** fore wing **30** hind wing **31** legs. Scale bars: 100 μm.



**Figures 32–37**. *Homalotylus hemipterinus* (De Stefani, 1898), female **32** head **33** antenna **34** mesosoma and metasoma **35** fore wing **36** hind wing **37** legs. Scale bars: 100 μm.

*Homalotylus varicolorus* Krishnachaitanya & Manickavasagam, 2016 Figs 38–49

Homalotylus varicolorus Krishnachaitanya, Manickavasagam & Abhinav, 2016: 2373, 2380–2382. Holotype ♀, India, EDAU, not examined.

Host. Unknown.



**Figures 38–43**. *Homalotylus varicolorus* Krishnachaitanya & Manickavasagam, 2016, female **38** head **39** antenna **40** mesosoma and metasoma **41** fore wing **42** hind wing **43** legs. Scale bars: 100 µm.



**Figures 44–49**. *Homalotylus varicolorus* Krishnachaitanya & Manickavasagam, 2016, male **44** head **45** antenna **46** mesosoma and metasoma **47** fore wing **48** hind wing **49** legs. Scale bars: 100 µm.

### Distribution. China (Guangxi), India.

**Material examined.** 17 $\bigcirc$ , 16 $\bigcirc$ , CHINA, Guangxi Province, Qinzhou City, Beibu Gulf University, 21°53'53"N, 108°36'56"E, c. 24 m, 21.IV.2019–19.IV.2020, Wenquan Zhen, Malaise trapping.

**Diagnosis.** This is the first record from China. The specimens agree very well with the description of *H. varicolorus*, but a minor difference should be noted. In our specimens ovipositor 1.57× as long as mid tibia, whilst in the original description of *H. varicolorus* ovipositor 2.19× as long as mid tibia.

# **Additional information**

### **Conflict of interest**

The authors have declared that no competing interests exist.

#### **Ethical statement**

No ethical statement was reported.

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# Author contributions

Dawei Huang and Guohao Zu designed the experiments; Wenquan Zhen participated in the collection specimens; Hao Xue and Haiyang Wang identification of specimens. Guohao Zu, Hao Xue and Haiyang Wang wrote the original draft of the manuscript.

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### Data availability

All of the data that support the findings of this study are available in the main text.

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