



# New records of Chrysochroinae Laporte de Castelnau, 1835 (Coleoptera, Buprestidae) from China

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Academic editor: Vinicius S. Ferreira

Received: 10 Nov 2023 | Accepted: 04 Mar 2024 | Published: 11 Mar 2024

Citation: Ai H-M, Qi Z-H, Su R-X, Liao Z-Y, Song H-T (2024) New records of Chrysochroinae Laporte de Castelnau, 1835 (Coleoptera, Buprestidae) from China. Biodiversity Data Journal 12: e115599.

<https://doi.org/10.3897/BDJ.12.e115599>

## Abstract

## Background

Chrysochroinae Laporte de Castelnau, 1835 is the very colourful subfamily of Buprestidae. There are 127 species and subspecies of the subfamily which have been recorded in China.

## New information

In this paper, we reported three genera, two subgenera and five species of the subfamily Chrysochroinae Laporte de Castelnau, 1835 (Coleoptera, Buprestidae) which are all newly recorded from China. These reported taxa belong to two tribes and four genera: *Chrysochroa* (*Chroodema*) *corbetti* (Kerremans, 1893), *Chrysochroa* (*Pyanthe*) *fulgens ephippigera* White, 1843, *Demochroa* (*Demoxantha*) *gratiosa indica* Csiki, 1900, *Xanthocata bonvouloirii* (Deyrolle, 1861) (all the above four being Chrysochroini) and

*Cardiaspis mouhotii* E. Saunders, 1866 (Dicercini). The five newly-recorded species are briefly described, illustrated and supplemented with relevant biological information.

## Keywords

jewel beetle, *Cardiaspis*, *Chrysochroa*, *Demochroa*, *Xanthocata*, new record, south China

## Introduction

Chrysochroinae Laporte de Castelnau, 1835 is the very colourful subfamily of Buprestidae, with many large ornamental species living in tropical rainforests. Before this study, 127 species and subspecies of the subfamily have been recorded in China, belonging to five tribes and 17 genera (Bellamy 2008a, Bellamy 2008b, Kubáň 2016, Ong and Hattori 2019, Frank and Sekerka 2020, Peng et al. 2021, Frank 2022, Peng and Song 2022, Qi et al. 2022, Hołyński 2023, Ong et al. 2023).

Five newly-recorded species of the subfamily Chrysochroinae from China are presented herein: *Chrysochroa* (*Chroodema*) *corbetti* (Kerremans, 1893) found in Hainan Province, *Chrysochroa* (*Pyranthe*) *fulgens ephippigera* White, 1843, *Demochroa* (*Demoxantha*) *gratiosa indica* Csiki, 1900, *Xanthocata bonvouloirii* (Deyrolle, 1861) and *Cardiaspis mouhotii* E. Saunders, 1866 found in Yunnan Province. The five species are briefly described, illustrated and supplemented with relevant biological information.

## Materials and methods

Habitus photographs were taken using a Canon 5D mark IV digital camera with a Canon EF 100 mm USM macrolens. A Canon MT-26EX twin flash was used as the light source. Fig. 1A was taken using a Canon 5D mark IV digital camera with a Canon EF 70-200 mm f/2.8L IS III USM lens. Photographs of smaller characters were photographed using a Keyence VHX-5000 digital microscope with a Keyence VH-Z20R zoom lens (20-200×). The photograph in Fig. 4 was taken using a Canon EOS 50D by Lu Qiu, while that in Fig. 7 was taken using an iPhone 14 smartphone by Yi-Wei Wang. The images were processed and combined into figures using Adobe Photoshop CC 2019. All photographs were taken by the authors, except those with captions.

Abbreviations for collections in this study are:

- **CHTS** Collection of Hai-Tian Song, Fuzhou, China.
- **KIZ** Kunming Institute of Zoology, Chinese Academy of Sciences, Kunming, China.

## Taxon treatments

### Family Buprestidae Leach, 1815

### Subfamily Chrysochroinae Laporte de Castelnau, 1835

### Tribe Chrysochroini Laporte de Castelnau, 1835

### Genus *Chrysochroa* Dejean, 1833

### Subgenus *Chroodema* Hołyński, 2009

Notes: New record of China.

### *Chrysochroa (Chroodema) corbetti* (Kerremans, 1893)

#### Nomenclature:

*Demochroa corbetti* Kerremans, 1893: 326. Kerremans 1893

#### Materials

- a. country: China; stateProvince: Hainan; verbatimElevation: 350 m; locationRemarks: label: Hainan, Sanya City, Mt. Lizhiling, 28.06.2020, Jia-Sheng Lu Leg.; verbatimCoordinates: 18°21'N 109°27'E; samplingProtocol: sweep net; habitat: Rain Forest; individualCount: 1; sex: male; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2020; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: B2DA381F-62CC-5534-8554-9813F326C55E
- b. country: China; stateProvince: Hainan; verbatimElevation: 390 m; locationRemarks: label: Hainan, Sanya City, Mt. Lizhiling, 15.06.2021, Jia-Sheng Lu Leg.; verbatimCoordinates: 18°21'N 109°27'E; samplingProtocol: sweep net; habitat: Rain Forest; individualCount: 1; sex: male; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2021; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: 9B6935EC-B048-5FC0-A52E-02E8BB48EB79
- c. country: China; stateProvince: Hainan; verbatimElevation: 390 m; locationRemarks: label: Hainan, Sanya City, Mt. Lizhiling, 19.06.2021, Hai-Tian Song & Zhi-Hao Qi Leg.; verbatimCoordinates: 18°21'N 109°27'E; samplingProtocol: high sweep net; habitat: Rain Forest; individualCount: 2; sex: 2 males; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2021; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: 45F3671A-6C00-5AD6-93CB-EEB86190EA3D
- d. country: China; stateProvince: Hainan; verbatimElevation: 390 m; locationRemarks: label: Hainan, Sanya City, Mt. Lizhiling, 06.2023, Jia-Sheng Lu Leg.; verbatimCoordinates: 18°21'N 109°27'E; samplingProtocol: sweep net; habitat: Rain Forest; individualCount: 1; sex: male; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2023; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: A1130627-711B-5D53-83E7-3C5504167273

- e. country: China; stateProvince: Hainan; locationRemarks: label: Hainan, Ledong County, Jianfengling National Forest Park, Tianchi, 02.05.2022, local collector Leg.; habitat: Rain Forest; individualCount: 1; sex: unknown; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2022; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: 01D43CAA-C80D-561D-807B-BFF69BF348D9

**Host of:** *Pterospermum acerifolium* (quote from Ek-Amnuay (2008)), *P. heterophyllum* (Fig. 1, new host plant found in Hainan).



Figure 1. [doi](#)

Male living individuals of *Chrysochroa* (*Chroodema*) *corbetti* (Kerremans, 1893) from Sanya, Hainan: **a** an individual flying around the host plant *Pterospermum acerifolium*; **b** dorsal view; **c** lateral view of feeding *P. acerifolium* leaves.

**Distribution:** China (Hainan) (new country record); Myanmar; Vietnam; Thailand (Akiyama and Ohmomo 2000, Bellamy 2008a, Ek-Amnuay 2008).

**Notes:** The adult has been found in Sanya, Hainan Province with *Catoxantha brunnea hainana* (Kurosawa, 1991) feeding together on *Pterospermum heterophyllum* leaves.

### Description:

**Male** (Fig. 2): Body (n = 4) length: 33.3–36.8 mm, width: 12.1–13.5 mm, length/width ratio: 2.60–2.94. Body polychromatic; head, pronotum and base of elytra densely punctate. Head bicoloured, frons and both sides of posterior margin metallic purple, other areas metallic blue; antenna black with 11 antennomeres, antennomeres V–XI expanded. Pronotum tricoloured, metallic purple-red at sides, with a broad metallic green or blue stripe at median, more than half of pronotum; narrow in front and broader behind, widest at basal third. Scutellum absent. Elytra four-coloured, bearing two large blue to black bands at the front half and behind half of each elytron, their borders

reaching the suture and the lateral margins, with metallic yellow-orange bands and metallic-greenish suffusion at base and apex and a broad creamy-yellow band at middle; lateral margins of elytra smooth, non-serrated, with one small spine at the apex of each elytron, widest at nearly half of elytra. All tibiae and femora metallic blue to purple-red; outer margin at apex of protibia with nearly triangular protrusion. Abdominal sternum and ventrites metallic blue to purple, ventrite V triangularly excavated at tip. The characters of the male genitalia are shown in Fig. 2.

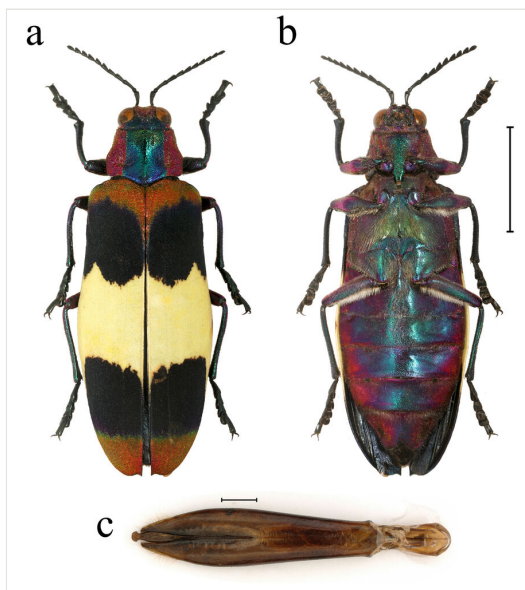


Figure 2. [doi](#)

*Chrysochroa (Chroodema) corbetti* (Kerremans, 1893), male, from Sanya, Hainan Province: **a** dorsal view of habitus; **b** ventral view of habitus; **c** dorsal view of aedeagus. Scale bars: a, b = 10.0 mm; c = 1.0 mm.

**Female:** not examined.

## Subgenus *Pyranthé* Gistel, 1834

### *Chrysochroa (Pyranthé) fulgens* subsp. *ephippigera* White, 1843

#### Nomenclature:

*Chrysochroa ocellata* var. *ephippigera* White, 1843: 343. White 1843

#### Materials

- a. country: China; stateProvince: Yunnan; verbatimElevation: 1006 m; locationRemarks: label: Yunnan, Dehong Dai and Jingpo Autonomous Prefecture, Yingjiang County, Nabang Town, Rongshuwang, 06.2020, local collector Leg.; verbatimCoordinates:

- 24°39'N 97°36'E; habitat: Forest; individualCount: 1; sex: male; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2020; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: 6DC302D9-D8C1-5126-BE64-784C1F5E6CFE
- b. country: China; stateProvince: Yunnan; locationRemarks: label: Yunnan, Dehong Dai and Jingpo Autonomous Prefecture, Yingjiang County, Xima Town, 12.2020, local collector Leg.; habitat: Forest; individualCount: 1; sex: unknown; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2021; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: E0D1BB9C-6D12-540D-AEC9-E7E325BB27BA
- c. country: China; stateProvince: Yunnan; locationRemarks: label: Yunnan, Dehong Dai and Jingpo Autonomous Prefecture, Yingjiang County, Xima Town, 08.2021, local collector Leg.; habitat: Forest; individualCount: 1; sex: female; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2021; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: 3C25E79A-CC5A-59DD-99C1-EA6B9E103530
- d. country: China; stateProvince: Yunnan; locationRemarks: label: Yunnan, Dehong Dai and Jingpo Autonomous Prefecture, Yingjiang County, Xima Town, 10.12022, local collector Leg.; habitat: Forest; individualCount: 2; sex: 2 females; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2023; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: 7D7B7DB4-972A-5BB3-AB41-8901AA1C7782

**Host of:** *Cratoxylon* sp. (quote from Ek-Amnuay (2008)).

**Distribution:** China (Yunnan) (new country record); Myanmar; Laos; Vietnam; India; Thailand (Akiyama and Ohmomo 2000, Ek-Amnuay 2008, Holyński 2009).

**Notes:** All individuals found in China with tibiae and femora metallic purple-red.

### Description:

**Male** (Fig. 3): Body (n = 1) length: 37.4 mm, width: 13.0 mm, length/width ratio: 2.88. Body polychromatic and shiny; head, pronotum and elytra densely punctate. Head tricoloured, metallic green or blue, tinted with coppery-red at middle of frons. Pronotum five-coloured, metallic purple-red at sides with a broad longitudinal dark blue stripe at median, with transition areas of metallic blue, green and orange between the two colours; narrow in front and broader behind, widest at base. Scutellum absent. Elytra five-coloured, the basal and apical parts tinted with two large metallic purple-red spots on each elytron, with a narrow metallic orange ring around each spot on the periphery, followed by a wide metallic light blue ring around; a broad creamy-yellow patch across the middle, with two narrow dark blue bands in front and behind the creamy-yellow patch; lateral margins of elytra smooth, non-serrated, with one small spine at apex of each elytron, widest at nearly half of elytra. All tibiae and femora metallic purple-red; outer margin at apex of protibia with nearly triangular protrusion. Abdominal sternum and ventrites metallic yellow-orange to purple, with dense setae, ventrite V triangularly excavated at tip.

**Female** (Fig. 3): Body (n = 3) length: 39.4–41.6 mm, width: 13.2–14.0 mm, length/width ratio: 2.85–3.08. The female specimen differs from the male in the colour spots. Setae on the ventral side of body more sparse. Ventrite V without triangular excavation at tip. Other morphological descriptions refer to male specimens.

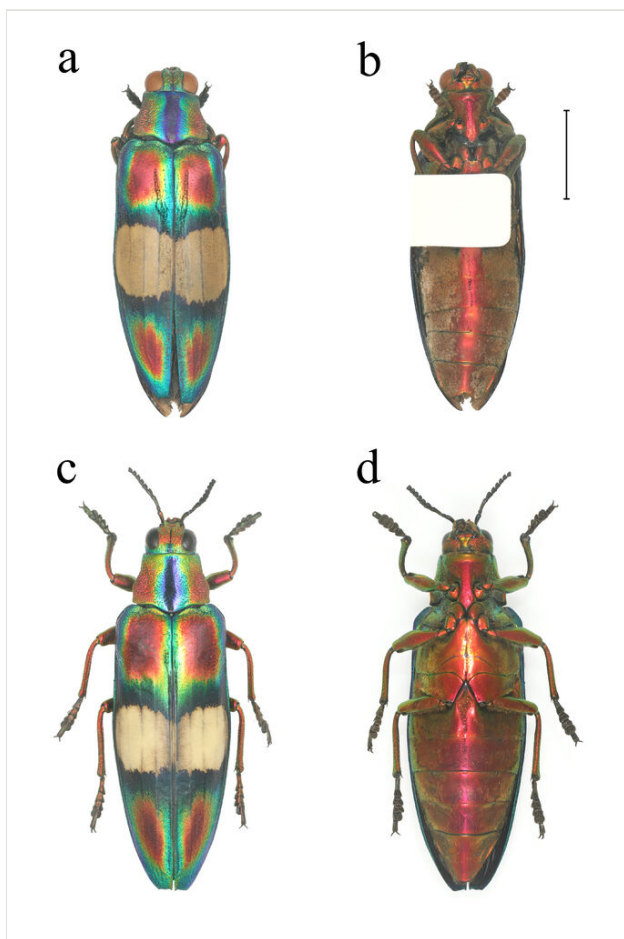


Figure 3. [doi](#)

*Chrysochroa (Pyranthe) ehippigera* (White, 1843) from Yingjiang, Yunnan: **a** male dorsal view; **b** male ventral view; **c** female dorsal view; **d** female ventral view. Scale bar = 10.0 mm.

## Genus *Demochroa* White, 1859

Notes: New record of China.

## Subgenus *Demoxantha* Hołyński, 2009

Notes: New record of China.

## *Demochroa (Demoxantha) gratiosa* subsp. *indica* Csiki, 1900

Nomenclature:

*Demochroa indica* Csiki, 1900: 402. Csiki 1900



= *Demochroa bowringii* Waterhouse, 1904: 265. Waterhouse 1904

= *Demochroa meldolana* Waterhouse, 1904: 265. Waterhouse 1904

### Material

- a. country: China; stateProvince: Yunnan; verbatimElevation: 200-400 m; locationRemarks: label: Yunnan, Dehong Dai and Jingpo Autonomous Prefecture, Yingjiang County, Nabang Town, 03.06.2018, photo by Lu Qiu.; habitat: Forest; individualCount: 1; sex: unknown; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2018; basisOfRecord: HumanObservation; occurrenceID: BEDA431B-B565-5F03-806A-5BA1582EC861

**Distribution:** China (Yunnan) (new country record); Bangladesh; India; Laos; Thailand (Akiyama and Ohmomo 2000, Ek-Amnuay 2008, Holyński 2009, Kubáň 2016).

**Notes:** The purple part is replaced by light green in most specimens of the species. Since the first individual found in China was incomplete, we provisionally classified it as the subspecies *indica* based on the subspecies distribution map of Holyński (2009).

### Description:

Sex unknown (Fig. 4): Body trichromatic and shiny. Pronotum transverse, bicoloured, dark green with two purple longitudinal stripes on lateral margins; anterior margin nearly straight; lateral margins concave at half of the base; posterior margin bisinuate. Scutellum not distinct. Elytra tricoloured, dark green with two large, transverse, white stripes behind the middle, terminal areas purple; widest behind half of the elytra, each elytron with four convex costae; apical half of lateral margins serrated, apices of elytra nearly truncate with one spine at apex of each elytron. All tibiae metallic green.



Figure 4. [doi](#)

A crushed individual of *Demochroa* (*Demoxantha*) *gratiosa* Deyrolle, 1864 from Yingjiang, Yunnan Province; the photo taken by Lu Qiu in Nabang Town on 3 June 2018.



## Genus *Xanthocata* Kubáň, 2016

Notes: New record of China.

### *Xanthocata bonvouloirii* (Deyrolle, 1861)

#### Nomenclature:

*Catoxantha bonvouloirii* Deyrolle, 1861: 395. Deyrolle 1861

= *Catoxantha regina* Schaufuss, 1863: 168. Schaufuss 1863

#### Materials

- a. country: China; stateProvince: Yunnan; verbatimElevation: 1000 m; locationRemarks: label: Yunnan, Dehong Dai and Jingpo Autonomous Prefecture, Yingjiang County, Xima Town, 10.2020, local collector Leg.; habitat: Forest; individualCount: 1; sex: female; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2022; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: 731ECCD6-862C-5689-BA43-A680BF1C8741
- b. country: China; stateProvince: Yunnan; verbatimElevation: 760 m; locationRemarks: label: Yunnan, Dehong Dai and Jingpo Autonomous Prefecture, Yingjiang County, Nongzhang Town, 08.04.2023, local collector Leg.; habitat: Forest; individualCount: 3; sex: 1 male, 2 females; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2023; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: 2DF2B98C-7C36-56D0-AF8A-1E5847989F71

**Distribution:** China (Yunnan) (new country record); India; Bhutan; Myanmar; Thailand; Laos; Vietnam; Indonesia (Akiyama and Ohmomo 2000, Bellamy 2008a, Kubáň 2016).

**Notes:** The living individual is shown in Fig. 5.

#### Description:

**Male** (Fig. 6): Body (n = 1) length: 51.1–51.5 mm, width: 18.2–19.1 mm, length/width ratio: 2.67–2.83. Body trichromatic and moderately shiny; head, pronotum and elytra densely punctate. Head tricoloured, metallic green to violet, frons with an obviously longitudinal depression along the middle. Pronotum transverse, subtrapezoidal; bicoloured, metallic orange-red with two dark purple longitudinal stripes on both sides of middle line; lateral margins protruding strongly at half of the base, widest behind the middle. Scutellum absent. Elytra bicoloured, dark violet to black with two large, transverse, white stripes behind the middle; widest at nearly half of elytra, each elytron with eight convex costae; lateral margins of elytra smooth, non-serrated, apices of elytra nearly truncate with two small spines at apex of each elytron. All tibiae and femora metallic green to dark purple; outer margin at apex of protibia with nearly triangular protrusion, inner margin at apex densely setose. Ventrites yellow, non-metallic lustre, each ventrite with two large black spots at both sides of the base, ventrite V triangularly excavated at tip. The characters of the male genitalia are shown in Fig. 6.

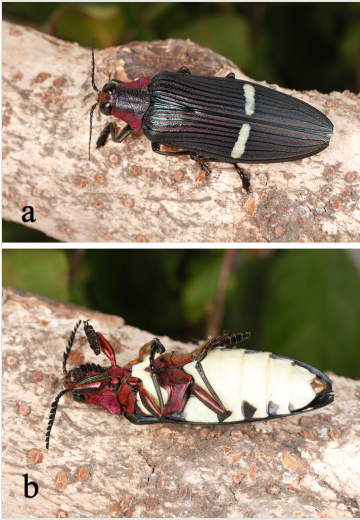


Figure 5. [doi](#)

A male living individual of *Xanthocata bonvouloirii* (Deyrolle, 1861) from Yingjiang, Yunnan Province: **a** dorsal view; **b** ventral view.

**Female** (Fig. 6): Body ( $n = 1$ ) length: 51.6 mm, width: 19.1 mm, length/width ratio: 2.70. Ventrite V without triangular excavation at tip. Other morphological descriptions refer to male specimens.

## Tribe Dicercini Gistel, 1848

### Genus *Cardiaspis* E. Saunders, 1866

**Notes:** New record of China.

### *Cardiaspis mouhotii* E. Saunders, 1866

#### Nomenclature:

*Cardiaspis mouhotii* E. Saunders, 1866: 307. Saunders 1866

#### Materials

- a. country: China; stateProvince: Yunnan; locationRemarks: label: Yunnan, Xishuangbanna Dai Autonomous Prefecture, Jinghong City, Mengyang Town, 01.09.2020, Zhong-Xiong Fu Leg.; habitat: Rain Forest; individualCount: 1; sex: female; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2020; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: E260F3C5-F7F6-535D-9943-9AE276D4B0CF
- b. country: China; stateProvince: Yunnan; verbatimElevation: 800 m; locationRemarks: label: Yunnan, Xishuangbanna Dai Autonomous Prefecture, Mengla County, Wangtianshu Scenic Region, 12.07.2022, Pei-Lin Xue Leg.; habitat: Rain Forest; sex: female; lifeStage: adult; identifiedBy: Zhi-Hao Qi; dateIdentified: 2022; institutionCode: CHTS;

- basisOfRecord: PreservedSpecimen; occurrenceID: 6AE549FC-CB79-5AE7-9C7B-ABD423870CA9
- c. country: China; stateProvince: Yunnan; verbatimElevation: 1456 m; locationRemarks: label: Yunnan, Xishuangbanna Dai Autonomous Prefecture, Jinghong City, Jinuoshan, 24.07.2022 Hai-Tian Song Leg.; verbatimCoordinates: 22°03'N, 100°40'E; samplingProtocol: flight intercept trap; habitat: Rain Forest; individualCount: 1; sex: female; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2022; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: 84639BEB-AE46-5BC9-A462-22E2F2CD692F
- d. country: China; stateProvince: Yunnan; verbatimElevation: 1024 m; locationRemarks: label: Yunnan, Xishuangbanna Dai Autonomous Prefecture, Jinghong City, Jinuoshan, 14.09.2022, Hai-Tian Song Leg.; verbatimCoordinates: 22°05'N, 101°00'E; samplingProtocol: flight intercept trap; habitat: Rain Forest; individualCount: 1; sex: female; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2022; institutionCode: CHTS; basisOfRecord: PreservedSpecimen; occurrenceID: 0EB2C03C-5533-5D45-B6AA-C81FAF3DAB0F
- e. country: China; stateProvince: Yunnan; locationRemarks: label: Yunnan, Xishuangbanna Dai Autonomous Prefecture, Jinghong City, Xiaomengyang, 30.05.1981, Da-Zhi Dong Leg.; habitat: Rain Forest; individualCount: 1; sex: unknown; lifeStage: adult; identifiedBy: Hai-Tian Song; dateIdentified: 2021; institutionCode: KIZ; basisOfRecord: PreservedSpecimen; occurrenceID: 7488BAAD-FD1D-5382-B9F1-413451F67C2B

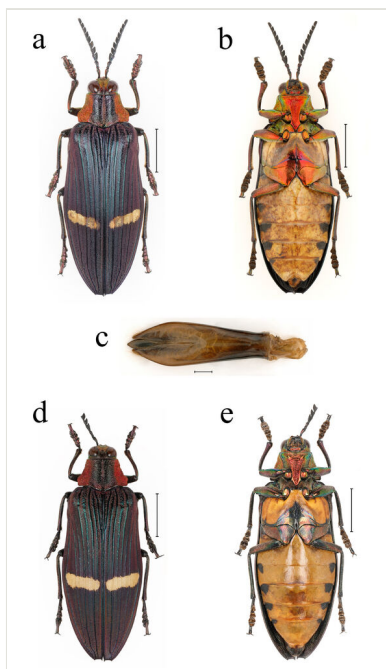


Figure 6. [doi](#)

*Xanthocata bonvouloirii* (Deyrolle, 1861) from Yingjiang, Yunnan Province: **a** male dorsal view; **b** male ventral view; **c** dorsal view of aedeagus; **d** female dorsal view; **e** female ventral view. Scale bars: a, b, d, e = 10.0 mm; c = 1.0 mm.

**Distribution:** China (Yunnan) (new country record); Bhutan; India; Laos; Malaysia; Vietnam; Thailand (Akiyama and Ohmomo 2000, Bellamy 2008a, Ek-Amnuay 2008, Kubáň 2016).

**Notes:** The body surface of the living adult with a yellow wax layer formed by powdery substance (Fig. 7).



Figure 7. [doi](#)

A living individual of *Cardiaspis mouhotii* E. Saunders, 1866 from Mengla, Yunnan Province; the photo taken by Yi-Wei Wang in Xishuangbanna Tropical Botanical Garden of Chinese Academy of Sciences on 13 August 2023.

### Description:

Female (Fig. 8): Body (n = 4) length: 23.9–29.8 mm, width: 8.9–11.4 mm, length/width ratio: 2.60–2.68. Body monochromatic metallic green with some metallic yellow, shiny; head and pronotum, densely and larger punctate, elytra very small punctate. Head small, frons with two longitudinal carinae along the eyes. Pronotum transverse, subtrapezoidal with lateral depressions moderate; anterior margin almost straight, lateral margins protruding outwards widely, posterior margin bisinuate, widest at base. Scutellum heart-shaped. Each elytron with eleven convex costae; lateral margins of elytra smooth, non-serrated, apices of elytra enlarged with three obvious spines at apex of each elytron. Protibia short, slightly incurved, outer margin with weak serrations, apex without distinct protrusion, inner margin at apex densely setose. Anterior margin of ventrite V protrusion at middle.

**Male:** not examined.

### Discussion

Due to a lack of understanding of their habits, most species of Chrysochroinae from China are often difficult to collect in the wild. It is considered that, especially in south China, there

may be more potential species waiting to be discovered. It is hoped that more biological information, such as host plants, distribution and occurrence of the species can be recorded in future studies to provide reference for us to understand the habits of these species.

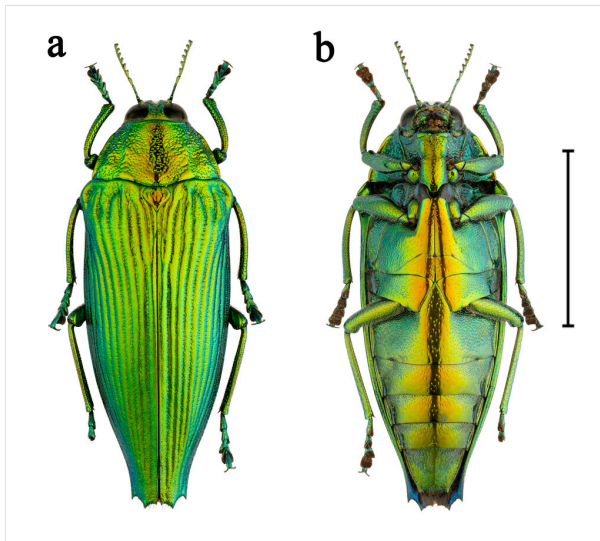


Figure 8. [doi](#)

*Cardiaspis mouhotii* E. Saunders, 1866, female, from Mengla, Yunnan: **a** dorsal view; **b** ventral view. Scale bar = 10.0 mm.

## Acknowledgements

We are grateful to Prof. Ling-Zeng Meng (Honghe University, Yunnan, China), Mr. Yi-Feng Zhang (Honghe University, Yunnan, China) and Mr. Zhong-Xiong Fu (Jinghong, Yunnan, China) for their help in setting traps, collecting and sorting buprestid specimens in Yunnan; to Mr. Jia-Sheng Lu (Sanya, Hainan, China) and Mr. Shi-Jie Lu (Guiping, Guangxi, China) for providing some specimens from Hainan for this study and guiding the authors in the wild; to Dr. Lu Qiu (Mianyang Normal University, Sichuan, China) for the valuable specimen photo for used in this article; to Dr. Kai-Qin Li (KIZ) for helping us study the specimen from Yunnan. We also express our gratitude to Dr. Xin-Hua Li (Nanjing Agricultural University, Jiangsu, China) for the identification of the host plant from Sanya, Hainan; to Mr. Pei-Lin Xue (Ya'an, Sichuan, China) for providing us with a specimen from Yunnan for our study; to Mr. Yi-Wei Wang (Hangzhou, China) for the living habitus photograph used in this study; to Mr. Bing Wang (Fuzhou, Fujian, China) for lending us a telephoto lens for field shooting; to Mr. David Frank (Prague, Czech Republic) and Dr. Vinicius S. Ferreira (Montana State University, Bozeman, USA) for their valuable comments on the manuscript. This research was supported by the National Natural Science Foundation of China (grant no. 31900354), the Science and Technology Plan Project of Fujian Province (grant no. 2022N5010), the

Key Laboratory of State Forestry and Grassland Administration on Timber Forest Breeding and Cultivation for Mountainous Areas in Southern China, the Fujian Key Laboratory of Forest Cultivation and Forest Products Processing and Utilization and the Fujian Science and Technology Museum, the Museum of Forest Pests of Fujian Academy of Forestry.

## References

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