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***Cepheonodes sanshaensis* sp. nov. (Lepidoptera, Sphingidae) from Xisha islands, Hainan Province, China**

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Abstract

A new species, *Cepheonodes sanshaensis* Deng & Huang, **sp. nov.** is described from Xisha islands near Sansha City, China. Photographs of the adults and their genitalia are provided. The new species is similar to *C. hylas* (Linnaeus, 1771) and *C. picus* (Cramer, 1777), but it can be easily distinguished by characters in the male genitalia: the right lobe of the uncus is hook-shaped with distinctly acute apex, the left valva is long and narrow with a truncate apex, and the right valva is broad and knife-shaped. Molecular analysis based on COI barcode sequences is used to infer the phylogenetic position of the new species within the genus *Cepheonodes*. An updated key and checklist to the worldwide species of the genus *Cepheonodes* are also provided.

Keywords

Cepheonodes, molecular identification, new species, taxonomy

Introduction

Cepheonodes, which was established by Hübner with *Sphinx hylas* Linnaeus, [1771] as its type species in 1819, belongs to the tribe Hemarini of the subfamily Macrogossinae in the family

Sphingidae. From the 19th to the mid-20th centuries, more than ten new *Cephonodes* species were described but no additional species were found during the next 50 years, until 2002 when a new species, *C. santome* Pierre, 2002, was described from São Tomé Island. At present, 20 *Cephonodes* species are known worldwide, mainly distributed in the Ethiopian, Oriental, and Australian regions (Younus and Kamaluddin 2014; Kitching et al. 2018; Maxwell et al. 2020). Until now, only one species, *C. hylas*, a widespread Asian species, has been recorded in China, known for its important role as economic pest of coffee (Okelana and Odebiyi 2007). In addition, most larvae of *Cephonodes* species feed on Rubiaceae plants, including *Coffea* spp., *Canthium* spp., *Gardenia* spp., *Morinda* spp., *Antirhea* spp., and some other plant families such as Fabaceae, Moracea, Oleaceae, and Sapindaceae (Bell and Scott 1937; Dupont and Roepke 1941; Barnett et al. 1999; Martiré and Rochat, 2008; Ghorpadé et al. 2013; Atherton et al. 2014; Moulds et al. 2020).

In the present paper, we describe and illustrate another species, *Cephonodes sanshaensis* sp. nov. from Xisha islands, Hainan Province, China. We provide the adult morphological structures and discuss its phylogenetic position based on COI barcode sequences.

Materials and methods

All the specimens were collected on 26 June 2021 from Jinjin Island, Xisha islands, Sansha City, Hainan Province. The habitat photographs were taken with a Nikon D610 camera. The photographs of adults were taken with a Nikon D610 camera with a Nikon AF-S VR Micro-Nikkor 105mm f/2.8G IF-ED. Genitalia were dissected and examined following the methods of Liao et al. (2020). All studied materials were deposited in Hunan Agricultural University, China (**HUNAU**).

The DNA was extracted from legs of dry adult specimens following the methods of Liao et al. (2019), and the sequences of the cytochrome c oxidase I gene (COI) barcoding fragment (658 bp) was amplified via PCR (Hebert et al. 2004). The PCR products were recovered and cloned, and the positive plasmids were sequenced by Qingke Biotech Co. Ltd (Changsha, China). The COI fragment sequence was uploaded to GenBank with the accession number MZ734621.

For inferring the phylogenetic relationships of the new *Cephonodes* species, the recorded COI barcode sequences were downloaded from BOLD (Ratnasingham and Hebert 2007) and

GenBank (www.ncbi.nlm.nih.gov/Genbank), and one sequence was selected when the sequences from the different individuals at one locality were completely consistent. Forty sequences of 12 *Cephalodes* species/subspecies as ingroups, and two sequences of the family Lasiocampidae, *Phyllodesma americana* and *Eriogaster lanestris*, selected as outgroups (Wang et al. 2019) were used to construct the data set. In total, 42 sequences (Table 1) were used in phylogenetic analyses by MEGA X (Kumar et al. 2018) based on the Maximum Likelihood method (Kimura 1980) with General Time Reversible model (GTR) and Gamma distribution. Bootstrap analyses (Felsenstein 1985) were carried out with the same heuristic search setting for 1000 pseudoreplicates. Uncorrected pairwise p-distances amongst the COI sequences between *Cephalodes* species are provided.

Results

Taxonomy

Cephalodes sanshaensis sp. nov.

Figures 1–3

Material examined. **Holotype:** male, CHINA, Hainan Province, Xisha, Jinjin Is., alt. 10 m, 26.VII.2021, Min Deng leg. (HUNAU).

Paratypes: same data as holotype (10 males and 8 females, HUNAU).

Diagnosis. This species is similar to other *Cephalodes* species especially *C. picus* (Cramer, 1777), but can be distinguished by the following characters: i) the right lobe of the uncus hook-shaped with distinctly acute apex, while in *C. picus* it is slender and rod-like; ii) the left valva is long and narrow with a truncate apex, whereas in *C. picus* it is broad and somewhat dilated apically; iii) the costa of the right valva is straight, but in *C. picus* it is slightly concave.

Description. Male (Fig. 1A). Wing expanse 48–50 mm. Head covered with green hairs; compound eyes brown, with white hairs around the eyes; antennae clubbed, brown, apically hooked. Face white, proboscis brown. Thoracic tergites green. Foretibia with an apical claw. Forewing upperside with marginal band 2–2.5 mm broad at Rs_4 , inner edge even between the veins. Upper side of abdomen green with a black and dark red belt; tergite VI with a black median patch, usually mixed with some red scales; the above color pattern forms a funnel-shaped stripe. Underside of abdomen white, an oblique black and dark red band on each side

of sternites I–IV extended to the end and connected in the center. Upper side of anal tuft yellow-green with black hairs laterally, but underside black with white hairs centrally.

Male genitalia (Fig. 2A). Uncus quite asymmetrical, slightly tapering to apex, divided into two lobes by a medial groove, the left lobe a little longer than the right; left lobe rectangular, paralleled on each side, apex with two small spines; right lobe strongly developed, forming a long, acute pointed hook; gnathos without processes, represented by a low ridge; valvae asymmetrical, left valva long and narrow, almost paralleled on each side, with a truncate apex; right valva broad knife-shaped, costa straight with an arcuate ventral margin, cucullus blunt; juxta conical. Aedeagus slender, caudal 2/3 well sclerotized and tapering.

Female (Fig. 1B). Similar to the male, but slightly larger. Wing expanse 53–58 mm.

Female genitalia (Fig. 2B). Papillae anales small, suborbicular besets with scattered scales, apophyses posteriores large, rod-like with rounded apex much longer than apophyses anteriores, later somewhat club-shaped apex, ductus bursae large, gradually broadening, corpus bursae small, bag-like, without cornuti.

Biological notes. The holotype was collected on a leaf of *Terminalia* sp. on the coast (Fig. 3), and the larvae were found feeding on *Guettarda speciosa* L. (Rubiaceae).

Etymology. The new species is named after Xisha islands, Sansha City, the type locality.

Distribution. China (Hainan, Sansha).

Molecular identification

The nucleotide frequencies of the DNA barcode region (649 bp) in *Cephalodes sanshaensis* are A = 30.1%, C = 15.7%, G = 14.9%, and T = 39.4%, which show an A+T-rich pattern. The new species is closest to SOWC442-06|*C. xanthus* with 97.6% of COI barcode sequence identity and then SPHJT090-10|*C. picus* (96.6%), SPUEB206-07|*C. picus* (96.4%) and ANICC074-08|*C. janus* (96.4%). The interspecific minimum genetic distance within the genus *Cephalodes* is 0.019 between SOWC442-06|*C. xanthus* and SPHJT090-10|*C. picus* (Table S1). The ML tree shows the monophyly of the genus *Cephalodes* is well supported with bootstrap values of 98%. The relationships between *C. rufescens*, *C. sanshaensis*, *C. picus*, and *C. xanthus* are still vague, and the new species is presently an independent clade compared to the other *Cephalodes* species (Fig. 4). *Cephalodes sanshaensis* is closest to *C. xanthus*, with the genetic distance = 0.024.

KEY**Key to the *Cephonodes* species based on external characters**

- 1 Abdominal segments V and VI with a funnel-shaped stripe..... 2
- Abdomen without funnel-shaped stripe..... 12
- 2 Forewing upperside with marginal band > 4 mm..... 3
- Forewing upperside with marginal band < 2.5 mm..... 5
- 3 Foretibia with an apical claw..... 4
- Foretibia lacking an apical claw..... *C. kingii* (Macleay)
- 4 Forewing distal border 4 mm at Rs₄..... *C. lifuensis* Rothschild
- Forewing distal border only 2.5 mm at Rs₄..... *C. novebudensis* Clark
- 5 Transverse band on abdomen segment V interrupted medially..... *C. leucogaster* Rothschild & Jordan
- Transverse band on abdomen segment V completely..... 6
- 6 Foretibia with an apical claw..... 7
- Foretibia lacking an apical claw..... 9
- 7 Costa of right valva straight..... *C. sanshaensis* Deng & Huang sp. nov.
- Costa of right valva concave..... 8
- 8 Apex of right valva evenly rounded *C. cunninghami* (Walker)
- Apex of right valva sharply truncate..... *C. picus* (Cramer)
- 9 Distal margin of left valva extremely concave..... 10
- Left valva truncate without concave..... *C. woodfordii* Butler
- 10 Distal margin of right valva irregularly sinuate..... *C. santome* Pierre
- Distal margin of right valva without sinuate..... 11
- 11 Right lobe of the uncus twisted, foot-shaped..... *C. hylas* (Linnaeus)
- Right lobe of the uncus hook-shaped..... *C. australis* Kiching & Cadiou
- 12 Abdominal segment V to end red, distinctly divided into the upper and lower halves..... 13
- Abdomen uniformly colored without zones..... 14
- 13 Abdomen with a prominent transverse white line preceding the red band..... *C. banksi* Clark
- Abdomen without white line preceding the red band..... *C. apus* (Boisduval)
- 14 Head, thorax, and abdomen ground color green..... 15

- Head, thorax, and abdomen not green, ground color uniformly dark.....20
- 15 Marginal band of forewing upperside with wavey inner edge.....16
- Marginal band of forewing upperside with even inner edge.....18
- 16 Inner face of right valva with a longitudinal groove.....***C. trochilus* (Guérin-Méneville)**
- Inner face of right valva without longitudinal groove.....17
- 17 Apex of left valva dilated.....***C. xanthus* Rothschild & Jordan**
- Apex of left valva not dilated.....***C. tamsi* Griveaud**
- 18 Apex of left valva gradually narrowed.....19
- Apex of left valva evenly rounded.....***C. rothschildi* Rebel**
- 19 Apex of right valva evenly rounded.....***C. janus* Miskin**
- Apex of right valva sharply truncate.....***C. armatus* Rothschild & Jordan**
- 20 Marginal band of forewing upperside with wavey inner edge.....***C. rufescens* Griveaud**
- Marginal band of forewing upperside with even inner edge.....***C. titan* Rothschild**

Checklist of the *Cephalodes* species

***Cephalodes* Hübner, [1819]**

Cephalodes Hübner, [1819]; Verz. bek. Schmett. (9): 131; TS: *Sphinx hylas* Linnaeus

***Cephalodes apus* (Boisduval, 1833)**

Macroglossa apus Boisduval, 1833; Faune Madag. Bourb. 79.; TL: Bourbon (= Mauritius)

Distribution: Réunion and Mauritius islands.

Host plants: *Antirhea borbonica*.

***Cephalodes armatus* Rothschild & Jordan, 1903**

Cephalodes armatus Rothschild & Jordan, 1903; Rev. Sphing. 470; TL: Mariana Islands

Distribution: Fiji and the northern of Mariana Islands.

Host plants: *Gardenia jasminoides*, *Guettarda speciosa*, *Morinda citrifolia*.

***Cephalodes australis* Kiching & Cadiou, 2000**

Cephalodes australis Kiching & Cadiou, 2000; Haw. world. 206; TL: Millmerran, Queensland.

Distribution: Kimberley region, Northern Territory, Queensland, New South Wales, Coen, and Gosford, Australia.

Host plants: *Gardenia jasminoides*, *Guettarda speciosa*, *Larsenaikia ochreata*, *Pavetta australiensis*, *P. brownie*, *P. grantica*, *Psychotria* sp., *Psydrax odorata*, *Tabernaemontana orientalis*.

***Cephalodes banksi* Clark, 1923**

Cephalodes banksi Clark, 1923; Proc. New Engl. ZoClub. 7:75; TL: Philippines

Distribution: Philippines and Sulawesi, Indonesia.

Host plants: Unknown.

***Cephalodes cunninghami* (Walker, 1856)**

Sesia cunninghami Walker, 1856; List Spec. Lep. Col. Birt. Mus. 85; TL: Australia.

Distribution: Christmas Island and Cocos-Keeling Islands in Indian Ocean; Northern Territory, Queensland, Torres Strait, and Brisbane, Australia.

Host plants: *Aidia racemose*, *Atractocarpus fitzalani*; *Gardenia jasminoides*, *Gardenia megasperma*, *Guettarda speciosa*, *Nauclea orientalis*, *Pavetta australiensis*, *Psydrax odorata*, *Tarenna dallachiana*.

***Cephalodes hylas* (Linnaeus, 1771)**

Sphinx hylas Linnaeus, 1771; Mant. Plant. 2: 539; TL: China.

Distribution: Near East, Middle East, Africa, India, Sri Lanka, Japan, and Southeast Asia.

Host plants: *Gardenia jasminoides*, *Coffea* spp., *Catunaregam spinosa*, *Tarenna attenuate*, *Cinchona calisaya*, *Diplospora dubia*, *Ficus subpisocarpa*, *Ixora philippinensis*, *Mussaenda pubescens*, *Wendlandia formosana*, *Wendlandia uvariifolia*, *Burchellia* spp., *Gardenia* spp., *Kraussia* spp., *Pavetta* spp., *Vangueria* spp.

***Cephalodes janus* Miskin, 1891**

Cephalodes janus Miskin, 1891; Proc. Roy. Soc. Queensl. 8: 6; TL: Australia.

Distribution: Queensland, Australia; Flores, Indonesia; and New Caledonia.

Host plants: Unknown.

***Cephalodes kingii* (Macleay, W.S., [1826])**

Macroglossum kingii Macleay, [1826]; in King, Surv. Austr. 2: 465; TL: Australian.

Distribution: Northern two thirds of Australia.

Host plants: *Gardenia jasminoides*, *Canthium attenuatum*, *Canthium coprosmoides*, *Canthium odoratum*, *Canthium oleifolium*, *Gardenia ovularis*, *Gardenia ochreata*, *Pavetta australiensis*, *Medicago sativa*, *Citrus limon*.

***Cephalodes leucogaster* Rothschild & Jordan, 1903**

Cephalodes leucogaster Rothschild & Jordan, 1903; Rev. Sphing. 469; TL: Madagascar.

Distribution: Madagascar.

Host plants: Unknown.

***Cephalodes lifuensis* Rothschild, 1894**

Cephalodes lifuensis Rothschild, 1894; Novit. Zool. 1 (1): 66; TL: New Caledonia.

Distribution: New Caledonia.

Host plants: Unknown.

***Cephalodes novebudensis* Clark, 1927**

Cephalodes novebudensis Clark, 1927; Proc. New Engl. Zool. Club. 9:106; TL: Vanuatu.

Distribution: Vanuatu.

Host plants: Unknown.

***Cephalodes picus* (Cramer, 1777)**

Sphinx picus Cramer, [1777]; Pap. Exot. 2: 38; TL: India.

Distribution: India, Cocos-Keeling Islands, the Maldives, Papua New Guinea, Philippines, Torres Strait Islands, Brunei, and the Chagos archipelago.

Host plants: *Jasminum* spp., *Adina* spp., *Coffea* spp., *Gardenia* spp., *Guettarda* spp., *Morinda* spp., *Pavetta* spp., *Randia* spp., *Nephelium* spp.

***Cephalodes rothschildi* Rebel, 1907**

Cephalodes rothschildi Rebel, 1907; Verh. Zool.-bot. Ges. Wien. 57; TL: Papua New Guinea.

Distribution: Papua New Guinea.

Host plants: Unknown.

***Cephalodes rufescens* Griveaud, 1960**

Cephalodes rufescens Griveaud, 1960; Bull. Soc. ent. France. 65:40-47; TL: Madagascar.

Distribution: Madagascar.

Host plants: Unknown.

***Cephalodes sanshaensis* Deng & Huang sp. nov.**

Cephalodes sanshaensis Deng & Huang; TL: Xisha islands, China.

Distribution: Xisha islands, China.

Host plants: *Guettarda speciosa*.

***Cephalodes santome* Pierre, 2002**

Cephalodes santome Pierre, 2002; Rev. fr. Ent. 24:18; TL: São Tomé Island.

Distribution: São Tomé Island, Chad, Central Africa, Tanzania, Yemen, Malawi, Ghana, South Africa, Madagascar, Tanzania, Gabon, Kenya.

Host plants: Unknown.

***Cephalodes tamsi* Griveaud, 1960**

Cephalodes tamsi Griveaud, 1960; Bull. Soc. Ent. France. 65: 44; TL: Seychelles.

Distribution: Seychelles.

Host plants: *Canthium bibracteatum*.

***Cephalodes titan* Rothschild, 1899**

Cephalodes titan Rothschild, 1899; Novit. Zool. 6 (1): 69; TL: Indonesia.

Distribution: Ambon, Indonesia.

Host plants: Unknown.

***Cephalodes trochilus* (Guérin-Méneville, 1843)**

Macroglossum trochilus (Guérin-Méneville, 1843); Voy. Ind. Or. 81; TL: Mauritius.

Distribution: Mauritius.

Host plants: *Rubia* spp. and *Galium* spp.

***Cephalodes woodfordii* Butler, 1889**

Cephalodes woodfordii Butler, 1889; Trans. Ent. Soc. London. 289; TL: Salomon Islands.

Distribution: Papua New Guinea, the Louisiade Archipelago, and the Solomon Islands.

Host plants: Unknown.

***Cephalodes xanthus* Rothschild & Jordan, 1903**

Cephalodes xanthus Rothschild & Jordan, 1903; Rev. Sphing. 465; TL: Okinawa.

Distribution: Shikoku, Kyushu, Tanegashima, Tokara Island, and the Ryukyu Archipelago of Japan.

Host plants: Unknown.

Discussion

The genus *Cephalodes* is well known for its transparent wings and stout body, similar to a bumble bee. Because of this, *Cephalodes* species are very similar to each other, with the incorrect identifications based only on the external morphology. Some distinguishing external features are the color of the abdomen and the marginal band on the upper part of the forewing. The important characters of the uncus, valva, and juxta should be used for identifying the closely related species.

The minimum genetic distance between the new species and other *Cephalodes* species is 0.024 (Table S1), which is larger than 0.019 that is the minimum genetic distance among *Cephalodes* species. In addition, the new species is currently only known in the Xisha islands, a relatively fragmented habitat, which is similar to the isolated distribution of some endemic species, such as *C. rothschildi* (Papua New Guinea), *C. rufescens* (Madagascar), *C. tamsi* (Seychelles), and *C. titan* (Ambon). This long-term isolation results in species differentiation of geographical populations and endemic species (Worsham et al. 2017; Tóth et al. 2019). A new species is discovered in present study, increasing to 21 the number of *Cephalodes* species listed. A key to the *Cephalodes* species from worldwide is also provided.

It is interesting that the widespread species, *Cephalodes hylas*, may present a complex species group consisting of subspecies or species; Kitching and Cadiou (2000) considered that *C. hylas* includes four subspecies, *C. h. hylas* found from Sri Lanka to China and Japan,

C. h. australis from Australia, *C. h. melanogaster* from Indonesia, and *C. h. virescens* from the Ethiopian Region. Currently, the subspecies *C. h. australis* was upgraded to species level by Maxwell et al. (2020) based on the male genitalia and barcode differences. From the phylogenetic analyses, we consider that *C. h. melanogaster* may also be upgraded to species level in the further study. Additionally, the subspecies *C. h. virescens* may be considered as a synonym of *C. santome* if further study with more evidence of morphology and molecular data can provide evidence.

Supplementary Files

Supplement table 1. Uncorrected pairwise p-distances amongst the COI sequences of Cephalodes species and outgroup.

Conflict of Interest

The authors have no conflicts of interests to declare.

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Figure 1. *Cephalodes sanshaensis* sp. nov. **A.** Male, holotype; **B.** Female, paratype. Scale bars: 10 mm

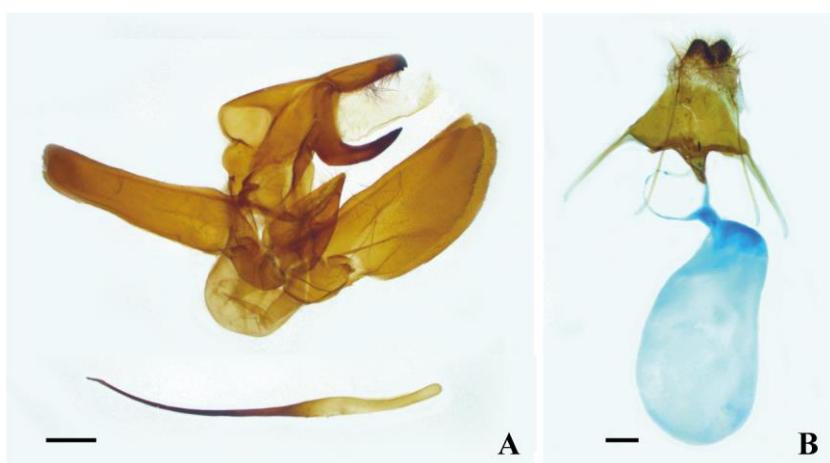


Figure 2. *Cephalodes sanshaensis* sp. nov. **A.** Male genitalia; **B.** Female genitalia. Scale bars: 1 mm.



Figure 3. Habitat of *Cephonodes sanshaensis* sp. nov. **A.** Adults; **B.** Mating adults; **C.** Habitat.

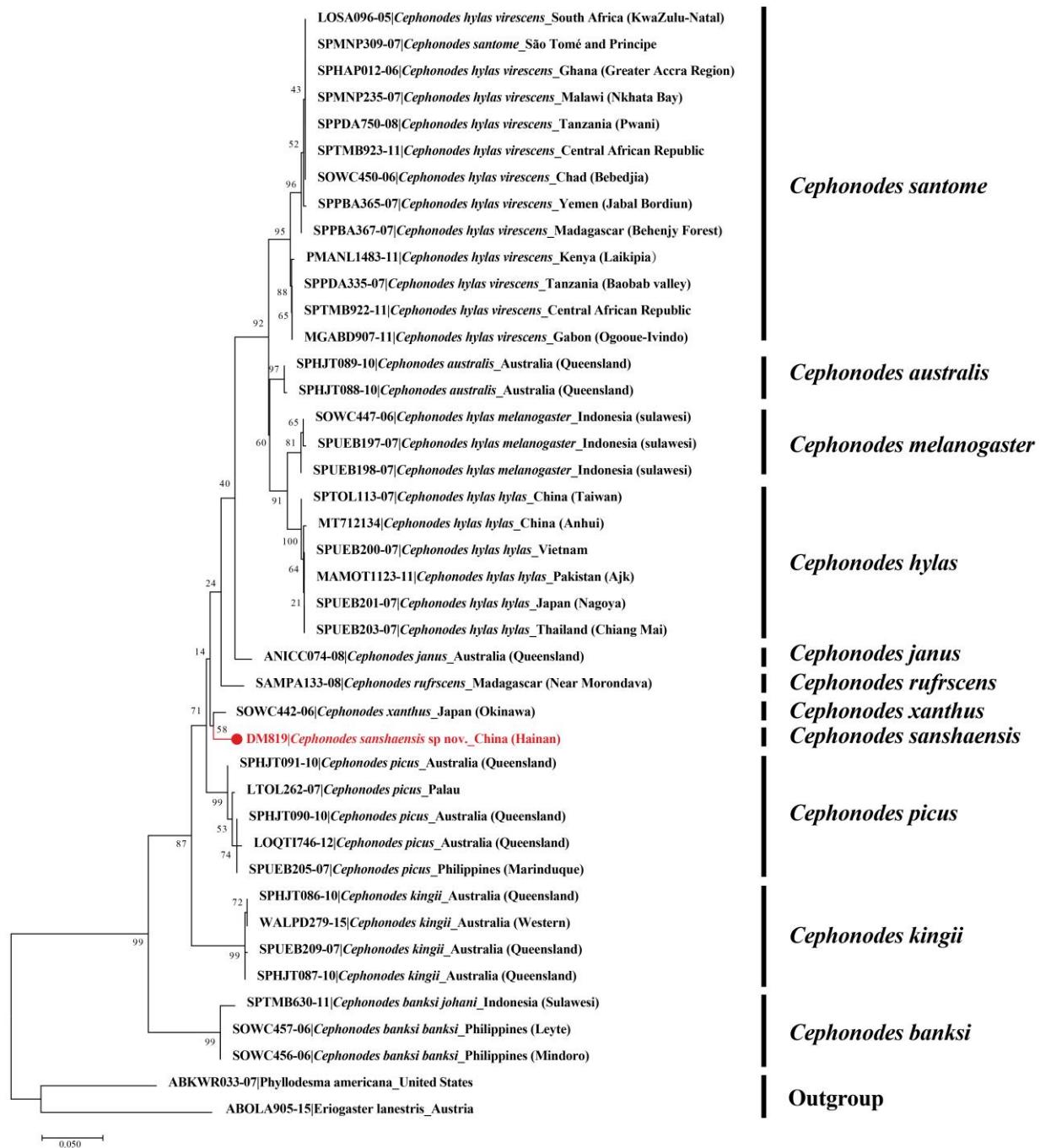


Figure 4. Maximum likelihood tree of the genus *Cephalodes* based on the CO1 sequences (658 bp) based on General Time Reversible (GTR) and Gamma distribution (+G) with a full heuristic search of 1,000 pseudo-replicates.

Table 1. Sequence information used in the phylogenetic analysis in this study.

No.	Species	Accession no./ BIN ID	Reference
1	SPTMB630-11 <i>Cephonodes banksi johani</i> _Indonesia (Sulawesi)	JN281147	Unpublished
2	SOWC457-06 <i>Cephonodes banksi banksi</i> _Philippines (Leyte)	JN677804	Wilson et al., 2011
3	SOWC456-06 <i>Cephonodes banksi banksi</i> _Philippines(Mindoro)	AAE9754	Unpublished
4	SAMPA133-08 <i>Cephonodes rufrscens</i> _Madagascar (Near Morondava)	JN677809	Wilson et al., 2011
5	LTOL262-07 <i>Cephonodes picus</i> _Palau	KJ168490	Unpublished
6	SPHJT091-10 <i>Cephonodes picus</i> _Australia (Queensland)	HQ975012	Rougerie et al., 2014
7	SPHJT090-10 <i>Cephonodes picus</i> _Australia (Queensland)	HQ975011	Rougerie et al., 2014
8	LOQTI746-12 <i>Cephonodes picus</i> _Australia (Queensland)	KJ169166	Rougerie et al., 2014
9	SPUEB205-07 <i>Cephonodes picus</i> _Philippines (Marinduque)	KJ168424	Unpublished
10	SOWC442-06 <i>Cephonodes xanthus</i> _Japan (Okinawa)	JN677810	Wilson et al., 2011
11	DM819 <i>Cephonodes sanshaensis</i> _China (Hainan)	MZ734621	This study
12	SPHJT086-10 <i>Cephonodes kingii</i> _Australia (Queensland)	HQ975007	Rougerie et al., 2014
13	WALPD279-15 <i>Cephonodes kingii</i> _Australia (Western)	AAE9759	Unpublished
14	SPUEB209-07 <i>Cephonodes kingii</i> _Australia (Queensland)	JN677807	Rougerie et al., 2014; Wilson et al., 2011
15	SPHJT087-10 <i>Cephonodes kingii</i> _Australia (Queensland)	HQ975008	Rougerie et al., 2014
16	ANICC074-08 <i>Cephonodes janus</i> _Australia (Queensland)	JN677806	Rougerie et al., 2014; Wilson et al., 2011
17	SOWC447-06 <i>Cephonodes hylas melanogaster</i> _Indonesia (sulawesi)	ACE5109	Unpublished
18	SPUEB197-07 <i>Cephonodes hylas melanogaster</i> _Indonesia (sulawesi)	KJ168307	Unpublished
19	SPUEB198-07 <i>Cephonodes hylas melanogaster</i> _Indonesia (sulawesi)	KJ168531	Unpublished
20	SPTOL113-07 <i>Cephonodes hylas hylas</i> _China (Taiwan)	KJ168407	Unpublished
21	MT712134 <i>Cephonodes hylas hylas</i> _China (Anhui)	MT712134	Wang et al., 2021
22	SPUEB200-07 <i>Cephonodes hylas hylas</i> _Vietnam	JN677805	Unpublished
23	MAMOT1123-11 <i>Cephonodes hylas hylas</i> _Pakistan (Ajk)	KC182190	Ashfaq et al., 2017
24	SPUEB201-07 <i>Cephonodes hylas hylas</i> _Japan (Nagoya)	KJ168398	Unpublished

No.	Species	Accession no./ BIN ID	Reference
25	SPUEB203-07 <i>Cephalodes hylas hylas</i> _Thailand (Chiang Mai)	KJ168419	Unpublished
26	SPHJT089-10 <i>Cephalodes australis</i> _Australia (Queensland)	HQ975010	Rougerie et al., 2014
27	SPHJT088-10 <i>Cephalodes australis</i> _Australia (Queensland)	HQ975009	Rougerie et al., 2014
28	SOWC450-06 <i>Cephalodes hylas virescens</i> _Chad (Bebedjia)	KJ168267	Unpublished
29	SPTMB923-11 <i>Cephalodes hylas virescens</i> _Central African Republic	KJ168267	Unpublished
30	SPPDA750-08 <i>Cephalodes hylas virescens</i> _Tanzania (Pwani)	AAB6177	Unpublished
31	SPPBA365-07 <i>Cephalodes hylas virescens</i> _Yemen (Jabal Bordiun)	AAB6177	Unpublished
32	SPMNP235-07 <i>Cephalodes hylas virescens</i> _Malawi(Nkhata Bay)	AAB6177	Unpublished
33	SPHAP012-06 <i>Cephalodes hylas virescens</i> _Ghana(Greater Accra Region)	AAB6177	Unpublished
34	LOSA096-05 <i>Cephalodes hylas virescens</i> _South Africa (KwaZulu-Natal)	AAB6177	Unpublished
35	SPMNP309-07 <i>Cephalodes sanctome</i> _São Tomé and Príncipe	AAB6177	Unpublished
36	SPPBA367-07 <i>Cephalodes hylas virescens</i> _Madagascar (Behenjy Forest)	AAB6177	Unpublished
37	SPPDA335-07 <i>Cephalodes hylas virescens</i> _Tanzania (Baobab valley)	AAB6177	Unpublished
38	SPTMB922-11 <i>Cephalodes hylas virescens</i> _Central African Republic	JN281270	Unpublished
39	MGABD907-11 <i>Cephalodes hylas virescens</i> _Gabon (Ogooué-Ivindo)	KJ168201	Delabye et al., 2018
40	PMANL1483-11 <i>Cephalodes hylas virescens</i> _Kenya (Laikipia)	KJ168563	Unpublished
41	ABKWR033-07 <i>Phyllodesma americana</i> _United States	ACF1193	Unpublished
42	ABOLA905-15 <i>Eriogaster lanestris</i> _Austria	AAE2337	(Huemer et al., 2016)

Supplementary Table 1. Uncorrected pairwise p-distances amongst the COI sequences of *Cephalonodes* species and outgroup

No. Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41			
32 SPMNP235-07 <i>Cephalodesmus virescens</i> _Malawi (Nkhata Bay)	0.082	0.074	0.074	0.043	0.048	0.043	0.045	0.048	0.045	0.051	0.055	0.058	0.058	0.058	0.057	0.046	0.033	0.034	0.034	0.039	0.043	0.041	0.041	0.041	0.041	0.031	0.033	0.000	0.000	0.000	0.000	0.002												
33 SPHAP012-06 <i>Cephalodesmus virescens</i> _Ghana (Greater Accra Region)	0.082	0.074	0.074	0.043	0.048	0.043	0.045	0.048	0.045	0.051	0.055	0.058	0.058	0.058	0.057	0.046	0.033	0.034	0.034	0.039	0.043	0.041	0.041	0.041	0.041	0.031	0.033	0.000	0.000	0.000	0.000	0.002	0.000											
34 LOSA096-05 <i>Cephalodesmus virescens</i> _South Africa (KwaZulu-Natal)	0.082	0.074	0.074	0.043	0.048	0.043	0.045	0.048	0.045	0.051	0.055	0.058	0.058	0.058	0.057	0.046	0.033	0.034	0.034	0.039	0.043	0.041	0.041	0.041	0.041	0.031	0.033	0.000	0.000	0.000	0.000	0.002	0.000	0.000										
35 SPMNP309-07 <i>Cephalodesmus sanctomei</i> _São Tomé and Príncipe	0.082	0.074	0.074	0.043	0.048	0.043	0.045	0.048	0.045	0.051	0.055	0.058	0.058	0.058	0.057	0.046	0.033	0.034	0.034	0.039	0.043	0.041	0.041	0.041	0.041	0.031	0.033	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000								
36 SPPBA367-07 <i>Cephalodesmus virescens</i> _Madagascar (Behenjy Forest)	0.080	0.072	0.072	0.041	0.046	0.041	0.043	0.046	0.043	0.050	0.053	0.057	0.057	0.057	0.055	0.045	0.031	0.033	0.033	0.038	0.041	0.039	0.039	0.039	0.029	0.031	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002								
37 SPPDA335-07 <i>Cephalodesmus virescens</i> _Tanzania (Baobab valley)	0.082	0.074	0.074	0.043	0.045	0.039	0.041	0.045	0.041	0.048	0.051	0.058	0.058	0.058	0.057	0.043	0.029	0.031	0.031	0.033	0.036	0.034	0.034	0.034	0.024	0.026	0.010	0.010	0.010	0.009	0.010	0.010	0.010	0.010	0.010	0.009								
38 SPTMB922-11 <i>Cephalodesmus virescens</i> _Central African Republic	0.082	0.074	0.074	0.043	0.045	0.039	0.041	0.045	0.041	0.048	0.051	0.058	0.058	0.058	0.057	0.043	0.029	0.031	0.031	0.033	0.036	0.034	0.034	0.034	0.024	0.026	0.010	0.010	0.010	0.009	0.010	0.010	0.010	0.010	0.009	0.000								
39 MGABD907-11 <i>Cephalodesmus virescens</i> _Gabon (Ogooué-Ivindo)	0.082	0.074	0.074	0.043	0.045	0.039	0.041	0.045	0.041	0.048	0.051	0.058	0.058	0.058	0.057	0.043	0.029	0.031	0.031	0.033	0.036	0.034	0.034	0.034	0.024	0.026	0.010	0.010	0.010	0.009	0.010	0.010	0.010	0.010	0.009	0.000	0.000							
40 PMANL1483-11 <i>Cephalodesmus virescens</i> _Kenya (Laikipia)	0.080	0.072	0.072	0.045	0.043	0.041	0.039	0.043	0.039	0.050	0.053	0.060	0.060	0.060	0.058	0.045	0.031	0.033	0.034	0.038	0.036	0.036	0.036	0.036	0.026	0.027	0.012	0.012	0.012	0.010	0.012	0.012	0.012	0.012	0.012	0.010	0.002	0.002	0.002					
41 ABKWR033-07 <i>Phyllodesma americana</i> _United States	0.120	0.111	0.111	0.104	0.108	0.106	0.104	0.104	0.104	0.108	0.106	0.122	0.122	0.122	0.120	0.113	0.128	0.130	0.128	0.127	0.130	0.128	0.128	0.128	0.128	0.122	0.123	0.120	0.120	0.122	0.120	0.120	0.120	0.118	0.116	0.116	0.116	0.118						
42 ABOLA905-15 <i>Eriogaster lanestris</i> _Austria	0.113	0.106	0.106	0.135	0.139	0.140	0.137	0.140	0.137	0.139	0.135	0.130	0.130	0.130	0.128	0.140	0.142	0.144	0.142	0.142	0.146	0.144	0.144	0.144	0.147	0.149	0.130	0.130	0.132	0.130	0.130	0.130	0.128	0.128	0.128	0.128	0.127	0.103						

Note: The values in bold are lower than the threshold (0.12) to distinguish separate species in the BOLD system.

