

Discovery of a New World ladybird beetle *Nephaspis indus* Gordon, 1996 (Coleoptera: Coccinellidae: Scymnini) on the Island of Taiwan

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Abstract

Background

Nephaspis indus Gordon, 1996 was imported into Taiwan from Hawaii in 1990 as a biological control agent for the spiralling whitefly, *Aleurodicus dispersus* Russell, 1965 (Hemiptera: Aleyrodidae). However, its establishment was not known prior to this study.

New information

Nephaspis indus Gordon, 1996, a natural enemy of *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae) native to the Neotropical region, is recorded as established in Taiwan for the first time. The present paper provides a detailed further description and illustrations of the adult. Diagnostic characters for the genus and species are given and the nomenclature of this species is also discussed.

Keywords

Coccinelloidea, taxonomy, morphology, spiralling whitefly predator, biological control

Introduction

Nephaspis Casey, 1899 (Coleoptera: Coccinellidae: Scymnini) is a New World genus and currently includes 43 species distributed from southern United States to Argentina (

Gordon 1996). This genus was initially described by Casey (1899) based on two species, *N. gorhami* and *N. brunnea* from Central America. Later, he placed *N. brunnea* as a synonym of *N. gorhami* (Casey 1905). Wingo (1952) described another species, *N. amnicola* from North America. However Gordon (1985) synonymised this species with *N. oculatus* (Blatchley) which was transferred from *Scymnus* to *Nephaspis*, based on the examination of their holotype. *Nephaspis* was first revised by Gordon (1972) who described an additional species *N. cocois* from Brazil and also recognised that the Guyana species *Clitostethus dispar* Sicard, 1929 (Sicard 1929) is congeneric. Subsequently, Gordon (1978, 1982, 1990) described five species from Trinidad, Colombia, Argentina and Puerto Rico and Duverger (1986) described one more species from Nicaragua. In his comprehensive revision of the genus *Nephaspis*, Gordon (1996) recognised and described 32 more species to this genus from South America, transferred *Scymnus convexus* Nunenmacher, 1937 to *Nephaspis* and provided a detailed description of this species.

Members of the genus *Nephaspis* are predators of whiteflies (Hemiptera: Aleyrodidae) (Gordon 1996). In 1988, the spiralling whitefly, *Aleurodicus dispersus* Russell, 1965 which is native to the Central America and Caribbean regions, was discovered in southern Taiwan and soon became a serious pest for fruit trees, vegetables, food crops, shade trees and landscape ornamentals (Chien et al. 2002). Due to the wide range and scattered distribution of its host plant and the difficulty with insecticide spraying on tall trees, biological agents were sought to control this invasive pest. Therefore, *Nephaspis indus* Gordon was imported into Taiwan from Hawaii in 1990 with a view to controlling the spiralling whitefly, *Aleurodicus dispersus* (Wen 1995). However, it is uncertain whether it was established at that time (Chien et al. 2002, Yu 2011).

In this paper, *Nephaspis indus* Gordon, 1996 is recorded as being established in Taiwan for the first time. The detailed further description and illustrations of the adult are provided. Diagnostic characters for the genus and species are given and the nomenclature of this species is also discussed.

Materials and methods

Specimens examined were collected from the Island of Taiwan and deposited in the Department of Entomology, South China Agricultural University, Guangzhou, China (SCAU). The morphological terms follow Ślipiński (2007) and Ślipiński and Tomaszewska (2010).

Measurements were taken using a micrometer attached to a SteREO Discovery V20 dissecting stereoscope and are defined as follows: (TW) total width, across both elytra at widest part; (TH) total height, at highest part of elytra in lateral view; (TL) total length, from apical margin of clypeus to apex of elytra; (PL) pronotal length, from the middle of anterior margin to the base of pronotum; (PW) pronotal width at widest part; (EW) elytral width, equal to TW; (EL) elytral length, along suture from base to apex including scutellum; (HW) head width, at widest part including eyes.

Male and female genitalia were dissected, cleared in a 10% solution of NaOH by boiling for several minutes and placed on slides for further study. Photographs of the whole beetles and their genitalia were taken using digital cameras (AxioCamHRc and Coolsnap-Procf& CRI Micro*Color) attached to the microscope. The final plates were laid out with Adobe Photoshop CS 8.0.

Taxon treatments

Nephaspis Casey, 1899

Nomenclature

Nephaspis Casey, 1899: 168. Type species: *Nephaspis gorhami* Casey, 1899, by subsequent designation of Gordon 1972: 148.

Nephasis: Korschefsky 1931: 168; Blackwelder 1945: 445 (misspelling).

Type species

Nephaspis gorhami Casey, 1899 - Gordon 1972.

Description

Body elongate oval, moderately convex, with dense pubescence, widest around middle of elytra.

Head with mouthparts directed posteroventrally in repose (Fig. 1a), concealing prosternum; frons wide (Fig. 1a), clypeus extended beyond eye, truncate anteriorly with large, apically rounded flange. Eyes large, finely faceted, inner ocular margin slightly arcuate. Antennae composed of 11 antennomeres (Fig. 1d); 1st antennomere strongly enlarged, curved and distinctly rounded on inner side; 2nd shorter and narrower than the 1st; 3rd obviously smaller than the 2nd; 4th to 6th as wide as 3rd; 7th to 11th forming a fusiform club (Fig. 1d). Labrum exposed, transverse, feebly emarginate anteriorly (Fig. 1a). Mandible with single apical tooth (Fig. 1c). Terminal maxillary palpomere stout, moderately securiform, apical margin strongly obliquely truncate (Fig. 1e). Labial palps with 3 palpomeres, terminal palpomere blunt, subcylindrical (Fig. 1f).

Pronotum convex, hind margin wider than anterior one (Fig. 2b, Fig. 2e). Pronotal hypomeron broad without delimited foveae (Fig. 1b). Prosternum short, straplike, slightly longer than anterior coxa, prosternal process very short, transversely oval (Fig. 1b); prosternal carinae narrowly separated, distinctly convergent anteriorly. Scutellum triangular (Fig. 2a). Elytra slightly wider than pronotum at base, surface finely punctate. Elytral epipleuron narrow and nearly horizontal, inner carina apically incomplete, reaching up to 1st abdominal ventrite. Mesoventrite short, tumid medially, anterior margin truncate, intercoxal area with hind margin deeply emarginate.

Metaventrite strongly tumid, anterior margin distinctly ridged, median area strongly prominent forward. Abdomen with six ventrites (Fig. 2g). Abdominal postcoxal lines incomplete (Fig. 1j, Fig. 2g). Front leg slender (Fig. 1h), femora of hind leg distinctly enlarged (Fig. 1g); tibiae without apical spur; tarsi with 4 tarsomeres, claws simple without basal teeth (Fig. 1i).

Diagnosis

Nephaspis Casey is similar to the Old World genus *Clitostethus* Weise, 1885 in general appearance and shares the following characters with the latter: body small, length less than 2 mm; antennae composed of 11 antennomeres (Fig. 1d); prosternum straplike, prosternal process short, transversely oval (Fig. 1b); abdominal postcoxal line incomplete (Fig. 1j, Fig. 2g); abdomen with six ventrites (Fig. 2g). *Nephaspis* is separated from *Clitostethus* mainly by the tarsi with 4 tarsomeres (Fig. 1i) and the stout basal antennomere (Fig. 1d). However, *Clitostethus* has the tarsi with 3 tarsomeres and the slender basal antennomere.

Distribution

This genus is apparently endemic to Neotropical region with a natural geographic range extending from southern United States (Florida, Louisiana and Texas) and Mexico to Argentina (Gordon 1996). In addition, several species of this genus are specialist predators of the spiralling whitefly, *Aleurodicus dispersus*. As important biological control agents against the spiralling whitefly, these members of *Nephaspis* have been introduced into different parts of the world, such as Hawaii, Guam, Fiji, Taiwan and Thailand (Waterhouse and Norris 1989, Chien et al. 2002, Napompeth 2004).

Nephaspis indus Gordon, 1996

Nomenclature

Nephaspis indus Gordon, 1996: 43; Yu 2011: 88.

Nephaspis amnicola: Yoshida and Mau 1985 (nec. Wingo 1952)

Materials

- a. scientificName: *Nephaspis indus*; island: Taiwan; locality: Zhiben, Taidong county; verbatimElevation: 140 m; locationRemarks: label transliteration: "Taiwan, Taidong, Zhiben, 2012.08.20, Ren Shunxiang"; [台湾台东知本 140 m, 22°41.63'N 120°59.94'E, 2012.08.20, sweeping, 任顺祥]; verbatimCoordinates: 22°41.63'N 120°59.94'E; decimalLatitude: 22.6938; decimalLongitude: 120.999; georeferenceProtocol: label; samplingProtocol: sweeping; eventDate: 2012-8-20; individualCount: 8; sex: male; lifeStage: adult; catalogNumber: SCAU (E) 11661; recordedBy: Ren Shun-Xiang; identifiedBy: Xiaosheng Chen; dateIdentified: 2016; modified: 2016-05-13T10:24:32Z;

language: en; collectionCode: Insects; basisOfRecord: PreservedSpecimen; occurrenceID: D8DD0B01-6872-5AF4-BE9E-925CB9F2AC67

- b. scientificName: *Nephaspis indus*; island: Taiwan; locality: Zhiben, Taidong county; verbatimElevation: 140 m; locationRemarks: label transliteration: "Taiwan, Taidong, Zhiben, 2012.08.20, Ren Shunxiang"; [台湾台东知本 140 m, 22°41.63'N 120°59.94'E, 2012.08.21, sweeping, 任顺祥]; verbatimCoordinates: 22°41.63'N 120°59.94'E; decimalLatitude: 22.6938; decimalLongitude: 120.999; georeferenceProtocol: label; samplingProtocol: sweeping; eventDate: 2012-8-20; individualCount: 7; sex: female; lifeStage: adult; catalogNumber: SCAU (E) 11670; recordedBy: Ren Shun-Xiang; identifiedBy: Xiaosheng Chen; dateIdentified: 2016; modified: 2016-05-13T10:24:32Z; language: en; collectionCode: Insects; basisOfRecord: PreservedSpecimen; occurrenceID: 83AF23FC-CD60-5A8B-B24F-FC76640C1E43

Description

TL: 1.23–1.32 mm, TW: 0.87–0.92mm, TH: 0.67–0.69mm, TL/TW: 1.41–1.43, PL/PW: 0.52–0.53, EL/EW: 1.05–1.07, HW/PW: 0.61–0.62, PW/EW: 0.84–0.85.

Body rounded oval, moderately convex, dorsum covered with white pubescence (Fig. 2a–f). Head, antennae and mouthparts yellow in male (Fig. 2a–c). Pronotum yellow with dark brown at central base. Scutellum black. Elytra black with apical 1/15 yellow. Prothoracic hypomeron and prosternum yellow. Mesoventrite and metaventrite reddish brown to black. Elytral epipleuron black. Legs yellow.

Head with fine frontal punctures, as large as eye facets, 0.5 diameter apart. Eyes densely faceted, interocular distance 0.44 times head width. Pronotal punctures smaller than those on frons, 1.0–1.5 diameters apart. Surface of elytra with punctures larger than those on pronotum, separated by 1.0–2.0 diameters. Prosternal process very short, transversely oval (Fig. 1b). Abdominal postcoxal lines strongly recurved and distinctly incomplete laterally (Fig. 2g), nearly reaching posterior margin of abdominal ventrite 1, area enclosed by lines coarsely punctate, broadly smooth along line. Abdominal ventrite 5 with apex truncate in both sexes.

Male genitalia. Penis long, strongly curved at basal 1/2 length (Fig. 2h); penis capsule with long inner arm and short outer arm; apex of penis with membranous appendage (Fig. 2i). Tegmen stout (Fig. 2j–k) with penis guide widest at base, tapering gradually to pointed apex in ventral view (Fig. 2j) and its base with prominent dorsal keel in lateral view (Fig. 2k). Parameres tapering toward apex, as long as 2/3 length of penis guide, covered with several long setae at apices (Fig. 2k).

Female externally similar to male but with black pronotum (Fig. 2d) except anterolateral angles yellow (Fig. 2e–f); head yellow with vertex dark brown (Fig. 2e).

Diagnosis

This species is similar to *Nephaspis bicolor* Gordon, 1982 in general appearance, but can be distinguished from the latter by details of male genitalia, particularly the stout penis guide with a dorsal keel at basal 1/3 length in lateral view (Fig. 2k) and the

black pronotum with yellow anterolateral angles in female (Fig. 2e). In *N. bicolor*, the penis guide with a high dorsal keel at basal half in lateral view and the yellow pronotum with median 1/3 dark brown in female (Gordon 1996).

Distribution

Taiwan, Hawaii, Trinidad, Honduras.

Notes

There was some confusion about the taxonomy and nomenclature of *N. indus*. This species was introduced from Honduras, Trinidad and the West Indies into Hawaii as *N. amnicola* in 1979–1980 where it became effective in biological control of the spiralling whitefly (Kumashiro et al. 1983). A few years later, Gordon (1996) described a new species, *N. indus*, based on the specimens from Hawaii. Actually, this is a Trinidadian species, although the type series were all from Hawaii. He also pointed out that the male genitalia figured in Gordon (1982) for *N. bicolor* are those of *N. indus*, because a male of the latter species was mixed in with the type series of *N. bicolor* and that was the specimen selected for illustration (Gordon 1996).

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Author contributions

X. Chen conceived the study and wrote the manuscript. X. Xie and X. Wang performed the laboratory work. S. Ren collected the specimens.

References

- Blackwelder RE (1945) Checklist of the coleopterous insects of Mexico, Central America, the West Indies, and South America. Part 3. United States National Museum Bulletin 185: 343-550. [In English]. <https://doi.org/10.5479/si.03629236.185.3>
- Casey TL (1899) A revision of the American Coccinellidae. Journal of the New York Entomological Society 7 (2): 71-169. [In English].
- Casey TL (1905) A new *Carabus* and *Cychrus*, with miscellaneous notes on Coleoptera. The Canadian Entomologist 37: 160-164. [In English]. <https://doi.org/10.4039/ent37160-5>

- Chien CC, Chou LY, Chang SC (2002) Occurrence and biological control of *Aleurodicus dispersus*. Formosan Entomologist (Special Publication) 3: 93-109. [In Chinese with English summary].
- Duverger C (1986) *Nephaspis maesi* nouvelle espèce de Scymnini du Nicaragua (Coleoptera, Coccinellidae). Revue Française d'Entomologie (Nouvelle Serie) 8 (4): 167-169. [In French].
- Gordon RD (1972) A review of the genus *Nephaspis* Casey and a comparison with the genus *Clitostethus* Weise (Coleoptera: Coccinellidae). Revista de Agricultura Piracicaba 47: 145-154. [In English].
- Gordon RD (1978) West Indian Coccinellidae (Coleoptera): some scale predators with keys to genera and species. The Coleopterists Bulletin 32 (3): 205-218. [In English].
- Gordon RD (1982) Two new species of *Nephaspis* Casey (Coleoptera: Coccinellidae) from Trinidad and Colombia. Proceedings of the Entomological Society of Washington 84 (2): 332-336. [In English].
- Gordon RD (1985) The Coccinellidae (Coleoptera) of America north of Mexico. Journal of the New York Entomological Society 93 (1): 1-912. [In English].
- Gordon RD (1990) Additions to the genus *Nephaspis* Casey (Coleoptera: Coccinellidae). Acta Zoologica Lilloana 39 (2): 23-26. [In English].
- Gordon RD (1996) South American Coccinellidae (Coleoptera). Part V: A taxonomic revision of the genus *Nephaspis* Casey. Frustula Entomologica 19: 1-50. [In English].
- Korschefsky R (1931) Coleopterorum Catalogus. Pars 118. Coccinellidae. I. W. Junk, Berlin, 224 pp.
- Kumashiro BR, Lai PY, Funasaki GY, Teramoto KK (1983) Efficacy of *Nephaspis amnicola* and *Encarsia ?haitiensis* in controlling *Aleurodicus dispersus* in Hawaii. Proceedings of the Hawaiian Entomological Society 24: 261-269. [In English].
- Napompeth B (2004) Management of invasive alien species in Thailand. http://www.agnet.org/htmlarea_file/library/20110718163847/eb544.pdf. Accessed on: 2016-7-25.
- Sicard A (1929) LVIII.— Description d'espèces nouvelles de Coccinellidæ. Journal of Natural History Series 10 4 (23): 515-524. <https://doi.org/10.1080/00222932908673088>
- Ślipiński A (2007) Australian ladybird beetles (Coleoptera:Coccinellidae): their biology and classification. ABRS, Canberra, 286 pp. [In English].
- Ślipiński A, Tomaszewska W (2010) Coccinellidae Latreille, 1802. In: Leschen RAB, Beutel RG, Lawrence JF (Eds) Handbook of Zoology, Vol. 2, Coleoptera. Walter de Gruyter GmbH & Co. KG, Berlin/New York, 454–472 pp. [In English].
- Waterhouse DF, Norris KR (1989) Biological control: Pacific prospects—Supplement 1. Australian Centre for International Agricultural Research 12: 11-12. [In English].
- Wen HC (1995) Bionomics and control of spiralling whitefly (*Aleurodicus dispersus* Russell) in Taiwan. Doctoral dissertation of the Graduate Institute of Plant Pathology and Entomology. National Taiwan University, 194 pp.
- Wingo CW (1952) The Coccinellidae (Coleoptera) of the upper Mississippi basin. Iowa State College Journal of Science 27: 15-53. [In English].
- Yoshida HA, Mau RFL (1985) Life history and feeding behaviour of *Nephaspis amnicola* Wingo. Proceedings of the Hawaiian Entomological Society 25: 155-160. [In English].
- Yu GY (2011) Spiralling whitefly and its natural insect enemies. Science Press, Beijing, 211 pp. [In Chinese with English summary].

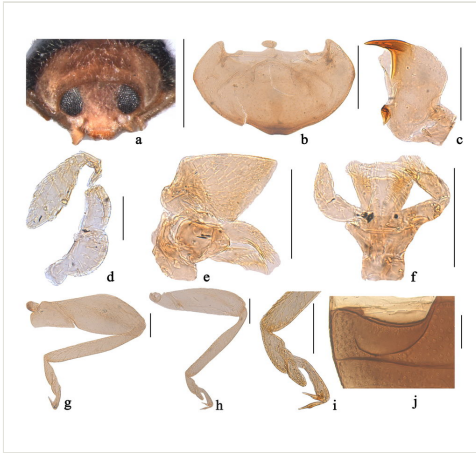


Figure 1.

Figure 1. Main characters of the genus *Nephaspis* Casey: (a) head; (b) prothorax, ventral; (c) mandible; (d) antenna; (e) maxilla; (f) labium; (g) hind leg; (h) front leg; (i) tarsi; (j) part of abdominal ventrite 1 and 2. Scale bars: a = 0.5 mm, b = 0.2 mm, c-j = 0.1 mm.



Figure 2.

Figure 2. *Nephaspis indus* Gordon, 1996: (a–c) male; (d–f) female; (a, d) dorsal view; (b, e) frontal view; (c, f) lateral view; (g) abdomen; (h) penis; (i) apex of penis; (j) tegmen, ventral view; (k) tegmen, lateral view. Scale bars: a–f = 0.5 mm, g–h = 0.2 mm, i–k = 0.1 mm.