Dtsch. Entomol. Z. 66 (2) 2019, 179–202 | DOI 10.3897/dez.66.47447

Species composition and diagnoses of leaf- and fruit-scarring beetles (Coleoptera, Chrysomelidae) infesting bananas and plantains (Zingiberales, Musaceae) in the Indian subcontinent

Kaniyarikkal D. Prathapan[1], Janakiraman Poorani[2], S. Amritha Kumari[1], C. Anuradha[2], Balakrishnan Padmanaban[2], Ramalingam Thanigairaj[2]

1 *Department of Entomology, Kerala Agricultural University, Vellayani, Trivandrum 695522, Kerala, India*
2 *ICAR – National Research Centre for Banana, Thogamalai Road, Thayanur Post, Tiruchirappalli 620102, Tamil Nadu, India*

http://zoobank.org/85572917-1A87-4F97-8476-912B7B5CD580

Corresponding author: *J. Poorani* (pooranij@gmail.com)

Academic editor: *D. Zimmermann* ♦ **Received** 19 October 2019 ♦ **Accepted** 3 December 2019 ♦ **Published** 13 December 2019

Abstract

Leaf- and fruit-feeding chrysomelids (Coleoptera) on bananas and plantains (Musaceae, Zingiberales) cause major losses to banana growers in the northern and northeastern regions of India, Bangladesh, and other parts of Southeast Asia. The species composition of these beetles has not been studied so far in India and wrong names or wrong name combinations in the literature have caused confusion. Most particularly, the Central and South American species of *Colaspis hypochlora* Lefèvre (Chrysomelidae, Eumolpinae) has been erroneously reported as occurring in India and Bangladesh, and this name has been used for the Indian species. Based on extensive surveys for leaf- and fruit-feeding chrysomelids in the northern and northeastern regions of India from 2015 to 2019, three species of banana-feeding chrysomelids, namely, *Basilepta subcostata* (Jacoby) (Eumolpinae), *Bhamoina varipes* (Jacoby), and a new species, *Sphaeroderma cruenta* **sp. nov.** (Galerucinae, Alticini), are documented. Of these, the latter two are recorded as pests of banana in India for the first time. An illustrated diagnostic account of these three species is given to facilitate their identification by economic entomologists. COI sequences of populations of *B. subcostata* from Assam and Uttar Pradesh showed 98–100% homology, indicating that these populations are conspecific and that COI sequences can be used for rapid species determination. Brief notes on the biology and available management options for these pests are also given.

Key Words

COI sequences, leaf beetles, *Sphaeroderma cruenta* sp. nov., new records, South Asia, pest management

Introduction

India is one of the major centres of diversity for bananas and plantains (Zingiberales, Musaceae) and the largest producer of bananas in the world, with its annual production greater than what the rest of the world produces for export (Promusa 2019). The term “plantain” is often used specifically to refer to cooking bananas while “banana” is mainly used to refer to dessert bananas (Promusa 2019). Data from the Food and Agriculture Organization of the United Nations indicate the area under banana cultivation in India in 2017 was 860000 ha with a production of 30.48 million metric tonnes (FAOSTAT 2019). Rhizome weevil (*Cosmopolites sordidus* (Germar)) and pseudostem weevil (*Odoiporus longicollis* (Olivier)) (Coleoptera, Curculionidae) are considered as the most economically important insect pests of banana in this region. Besides these, leaf- and fruit-scarring beetles (Coleoptera, Chrysomelidae) are major seasonal pests of bananas and plantains in many states of northern, eastern, and northeastern India, Bangladesh, and parts of Southeast Asia.

At present, there is no systematic study on the species composition of leaf and fruit feeding chrysomelids from the Indian subcontinent. Ostmark’s (1974) review of the economic insect pests of banana was restricted to insect pests of mainly Central and South America and did not focus on the major South Asian pests of bananas, including the fruit-scarring beetles. The name "*Colaspis hypochlora* Lefèvre" (Coleoptera, Chrysomelidae) has been most extensively associated with bananas in the literature, but it is known to be a pest only in South and Central American countries (Ostmark 1975). Gowdey (1926) gave an overview of the biology of *C. hypochlora.* Ostmark (1975) gave an account of four species of *Colaspis* considered to be established pests of banana leaves and fruits in Central and South America. He also listed three more species of *Colaspis* collected in association with banana. He reported *C. hypochlora* as "common on plants near banana plantations" (Ostmark 1975: 2), but as only occasional or accidental feeders on banana. He recorded it as a frequent feeder on banana candelas in newly planted orchards in Panama and as an occasional pest of banana fruits. Hill (2008: 309) also referred to *C. hypochlora* as "a pest of some past importance in C. and S. American banana-growing areas". Hill (1983: 518) listed "*Colaspis* spp." as banana fruit scarring beetles in India, Central and South America with a note "larvae scar fruits". *Myochrous melancholicus* Jacoby is another potentially serious banana fruit-feeding chrysomelid reported from Mexico (Cruz-Zapata et al. 2018).

In South and Southeast Asia, three of the 24 chrysomelid genera on Musaceae are known to feed on banana (Jolivet and Hawkeswood 1995): *Basilepta*, *Bhamoina*, and *Sphaeroderma*. *Basilepta subcostata* (Jacoby) (Chrysomelidae, Eumolpinae) is rated as one of the major seasonal pests of regional importance in India, particularly in the northeastern region, which is host to a wide diversity of bananas. The extent of damage to banana bunches by this pest has been estimated at 30% (Ahmad et al. 2003) and 11.47–95.68% (Choudhary et al. 2010) in Bihar, north India, and is as high as 80% in Assam, northeastern India (unpublished observations) in the rainy and post-rainy seasons.

Despite its economic importance, the nomenclature has not been clarified and incorrect names have been used for this species in literature. Indian workers have erroneously applied the name "*Colaspis hypochlora*" to the Indian scarring beetles (e.g. Verghese and Kamala Jayanthi 2001), and Sah et al. (2018) used both "*Basilepta* sp." and "*Colaspis* sp." to refer to the leaf- and fruit-scarring beetle of banana occurring in Bihar. The names *Nodostoma* spp., *Nodostoma* (*Basilepta*) *subcostatum*, *Nodostoma subcostatum*, and *Nodostoma viridipenne* have been used for the common fruit-scarring beetle in the northeastern region even though *Nodostoma* is a junior synonym of *Basilepta* (Weise 1922; Kimoto and Gressitt 1982). Furthermore, taxonomic treatments of *B. subcostata* are sparse; Kimoto and Gressitt (1982) provided a key to *Basilepta* spp. of Thailand, Vietnam, and Laos which included *B. subcostata*, but a recent redescription of *B. subcostata* with illustrations of the genitalia is not available. Besides *B. subcostata*, the other chrysomelid species feeding on bananas were not identified.

The aim of this study is a) to determine the species composition of leaf- and fruit-scarring beetles infesting bananas and plantains in the Indian subcontinent, b) to describe or redescribe these species, and c) to provide a determination key facilitating their correct identification. In this way, we hope to provide a basis for a reliable identification of the banana-feeding chrysomelids, which is needed for species-specific, effective pest management strategies in future.

Materials and methods

Field collections

Surveys were carried out over a period of five years (2015–2019) for banana-feeding chrysomelids in seven states of India, namely, Uttar Pradesh, Bihar, Assam, Manipur, Meghalaya, West Bengal, and Odisha. Banana fruit-scarring beetles are major pests in the states surveyed (unpublished data from All India Co-ordinated Research Project on Fruits, operated by the Indian Council of Agricultural Research (ICAR), New Delhi).

Taxonomy

Morphological terminology follows Konstantinov (1998), Jolivet and Verma (2008), and Moseyko (2008). Males and females of *B. subcostata* were distinguished by the basitarsomeres having closely arranged capitate setae bordered by long, pointed setae on the ventral side in males, and only pointed setae in females. In the other two species, sexes were separated by the apical abdominal ventrites. Male and female genitalia of all species, including different colour morphs of *B. subcostata* from various Indian states, were dissected, photographed, and stored in glycerine in microvials pinned with the respective specimens.

The endophallus was everted using a KK-3 type C fine nozzle as follows. The endophallus was pushed towards the apical opening using the blunt end of a flexible fine needle through the basal opening and the tip of the fine nozzle, filled with K-Y gel, and affixed at the base of the aedeagus proper with a cyanoacrylate glue (Fevikwik). The assembly was allowed to dry for 5 min. and kept in water for 1 min. to relax the endophallic membrane. Then the aedeagus was immersed in K-Y gel on a glass slide and the endophallus was everted under controlled pressure of a syringe filled with K-Y gel.

Imaging

Photographs of whole specimens and their diagnostic characters were taken using a Leica M205A stereo microscope fitted with a Leica DMC 4500 digital camera. Image stacks were processed into composite, high resolution images using CombineZP software. Types of *Basilepta* spp. at the Natural History Museum, London, were studied and photographed with a Canon EOS 1500D DSLR camera fitted with a Canon MP-E 65 mm macrolens and processed with Helicon Focus Pro.

COI sequencing and analysis

Sequencing of a 660-base pair (bp) fragment of the mitochondrial cytochrome *c* oxidase subunit 1 (COI) was done for samples of *B. subcostata* from Assam and Uttar Pradesh. Morphologically identified specimens were used for extraction, amplification and sequencing of 5′ end of COI mtDNA. Genomic DNA was extracted using QiagenDNeasy kit, following the manufacturer's protocols using the following primers: forward primer (LCO 1490 5′-GGTCAACAAATCATAAAGA-TATTGG-3′), and reverse primer (HCO 2198 5′- TA-AACTTCAGGGTGACCAAAAAATCA-3′). Amplified products were sequenced using Sanger technology and the sequences were submitted to GenBank and accession numbers obtained.

Sequence identity matrix and alignment of COI sequences of *B. subcostata* from Assam and Uttar Pradesh were executed using the CLUSTAL W multiple alignment tool of BioEdit sequence alignment editor 7.0.5.3. Phylogenetic analysis was performed using the Maximum likelihood phylogenetic tree construct in MEGA X. Sequences of *Basilepta leechi* (MN343857), *B. variable* (MN344143), Eumolpinae sp. (KF946194), Chrysomelidae (MK083043), *Oryctes rhinoceros* (L.) (KP898260), and *Coccinella septempunctata* L. (MH976795) from GenBank were used for phylogenetic analysis with the last two forming outgroup taxa..

Specimen repositories

The specimens studied are deposited in the following collections:

BMNH	Natural History Museum, London, UK [formerly British Museum (Natural History)]
NPC	National Pusa Collection, Indian Agricultural Research Institute, New Delhi, India
ICAR-NBAIR	ICAR-National Bureau of Agricultural Insect Resources, Bangalore, India
KAU	Travancore Insect Collection, Kerala Agricultural University, Vellayani
UASB	University of Agricultural Sciences, Bangalore, India
USNM	National Museum of Natural History, Washington DC, USA
ICAR-NRCB	ICAR-National Research Centre for Banana, Tiruchirappalli, India

Results

About 1200 specimens of leaf and fruit feeding chrysomelids were collected on banana from seven states of India. The genera and species were identified by the keys given by Jacoby (1908), Kimoto and Gressitt (1982) (for Eumolpinae), Maulik (1926), and Scherer (1969) (for Alticini). One species, *Basilepta subcostata* (Eumolpinae), was collected from all seven states and was the most predominant and economically important leaf- and fruit-feeding chrysomelid in all locations. Two species, *Bhamoina varipes* (Jacoby) and a hitherto undescribed species of *Sphaeroderma* Stephens (Galerucinae, Alticini), were found to be restricted to the northeastern region. *Bhamoina varipes* was collected from the states of Assam and Meghalaya, and *Sphaeroderma* was collected only from the state of Meghalaya. These two species are recorded for the first time on banana in India.

Taxonomy

Chrysomelidae
Eumolpinae

Basilepta subcostata **(Jacoby, 1889)**

Figs 1–8

Nodostoma subcostatum Jacoby, 1889: Jacoby 1889: 164; Jacoby 1908: 334.
Nodostoma cyanipenne: Lefèvre 1893: 120; Kimoto and Gressitt 1982: 51 (synonymy).
Basilepta subcostatum: Kimoto 1967: 69; Medvedev 1990: 8–9; Chûjô 1964: 268–269.
Basilepta subcostata: Kimoto and Gressitt 1982: 51; Sprecher-Uebersax 1997: 144; Medvedev and Sprecher-Uebersax 1999: 288; Kimoto 2001: 27; Medvedev 2001: 608; Kimoto 2005: 31–32; Moseyko and Sprecher-Uebersax 2010: 639.

Material examined. ***Type material*****:** syntype female, "SYNTYPE (blue bordered circular label)/ Bhamò, Birmania, Fea, VII.1886/ Jacoby Coll. 1909-28a/ Nodostoma subcostatum Jac./ abdomen missing, S.L. Shute 1976/NHMUK014016383" (BMNH). ***Other material*****:** 64016/Birmah, Momeit/Doherty/Fry Coll. 1905-100, 1 ex.; Tharrawaddy, Burma/ Andrewes Bequest 1922-221/ Nodostoma subcostatum Jac., 1 male with genitalia glued to the same card; Assam, Sudiya/ Doherty/ Fry Coll. 1905-100, 1 male; Assam, Patkai Mts./ Doherty/ Fry Coll. 1905-100/ Jacoby det., 1 ex; Thailand, Lot 1830, Nakhonratchasima, June 15, 1912/24/To B.M. List 153.10/ C.I.E. Coll. A1720/ Pres. By Com. Inst. Ent. B.M.1967-2, 2ex. (BMNH); S.INDIA, Mysore, Vittal 1964, Arecanut Res. Stn., on banana/ C.I.E. Coll. No.19658, 2 ex; Deccan/ 67.56, 1 ex; NEPAL: Rampur, 14.vii.1981, Ex. Banana, 6 ex; NEPAL: Dhunibesi, 22.vi.65, Banana, Dept. Agric. C.I.E. A.573, Col.161/ Pres. By Com. Inst. Ent. B.M. 1966-22, 2 females and 2 unsexed; 61647/ Doherty/ Assam, Patkai Mts/ Fry Coll. 1905-100, 4 ex; Bacan, N. India/ 67.56, 3 ex.; Calcutta

/ Atkinson Coll. 92-3, 2 ex; Doherty/ Tenesserim, Mergui/ Fry Coll. 1905-100; W. Almora Divn., Kumaon, UP, Aug. 1917, HGC/ E8/ H.G. Champion Coll. B.M. 1953-156, 4 ex; Lansdowne Division, UP, India, F.W.C./ H.G. Champion Coll. B.M. 1953-156, 1 ex.; Ind./ Baly Coll., 1 ex.; Khasis/ Coll. Kraatz/ Pres. by Imp. Inst. Ent. BM 1938-351/ Nodostoma occipitale Jac., Det. G.E. Bryant, 1 ex. (BMNH). India: Assam: 7 ♂ and 5 ♀ Balipara 74 m msl/26°49'56"N, 92°46'41.1"E/17.v.2019/K D Prathapan Coll.; 3 ♂ Jorhat /19–22.xi.2007/ Prathapan K D Coll.; 4 ♂ and 10 ♀, Assam: Dergaon, 26°42'01.00"N, 093°54'01.26"E/2.x.2018, R. Thanigairaj; Assam: 2 ♂, 2 ♀ Nameri Nat. Park 85 m msl/ 26°55'27.4"N, 92°49'38.9"E/17.v.2019/ K D Prathapan Coll.; Assam: 17 ♂, 13 ♀ and 7 unsexed, Tezpur 72 m msl/ 26°37'33.4"N, 92°48'41.5"E/19.v.2019/ K D Prathapan Coll.;. 25 ♂ and 14 ♀, Assam: Kaziranga, Kohora 70 m msl/ 26°35'29.6"N, 93°23'56.1"E/18.v.2019/ K D Prathapan Coll./Ex Banana; 2 ♂ same data, except Host *Canna* sp.; Meghalaya: 11 ♂, 13 ♀, Barapani/25°41'17.6"N, 91°55'5.1"E/5.vi.2013 993 m/Prathapan K D Coll./Ex. Banana; 3 ♂, 1 ♀, Meghalaya: Nongpoh 587 m msl/25°50'34.4"N, 91°52'34.4"E/22.v.2019/ K D Prathapan Coll.; 1 ♂, 6 ♀ Meghalaya: Cherrapunjee 1426 m msl/ 25°17'11.0"N, 91°43'07.8"E/21.v.2019/ K D Prathapan Coll.; 3 ♂, 3 ♀ Meghalaya: Umroi/2.xii.2007/Prathapan K D Coll.; 4 ex, Meghalaya: Jorabat, 04.x.2018, 26°04'59.52"N, 091°52'36.59"E, R.Thanigairaj; Meghalaya: 2 ex, Umiam/19.vii.2019/D. M. Firake/Ex ginger; 3 ♂ and 10 ♀, West Bengal: Cooch Behar, x.2016, B. Padmanaban; Uttar Pradesh: 4 ♂, 9 ♀ Faizabad Dist, 27°37'06.96"N, 081°36'29.54"E, 12.xi.2018, J. Poorani; Bihar: 6 ♂ and 1 ♀ Bhagalpur, 6.iii.2016, B. Padmanaban; Bihar: Falka, 11–12.x.2017, B. Padmanaban; Odisha: 4 ex, Bhubaneshwar, 29.v.2015, Sangeetha.

Generic diagnosis. Body oblong; head mildly sulcate above eyes; antennae filiform or distal antennomeres widened; pronotum wider than long, widest posteriorly, lateral margins often angulate; anterior margin of proepisternum concave; legs long, all femora dilated, minutely dentate ventrally, tibia longitudinally sulcate with a sharp ridge along dorsal side; intermediate and posterior tibiae emarginated preapically; metatibia with a pair of short apical spines; prosternum broader than long. Claws appendiculate; bursa sclerites present in female genitalia.

Related species. *Basilepta makiharai* Kimoto, described from Nepal, is stated to "resemble *B. subcostata* in having the elytron with humeral ridge but differs by its shorter body length and in having the surface of vertex finely shagreened" (Kimoto 2001: 26). It is generally pitchy black to dark reddish brown with entirely yellowish-brown antenna. *Basilepta viridipennis* (Motschulsky), another species widely distributed in Southern Asia and erroneously reported as the banana fruit-scarring beetle from India and Bangladesh, is also externally similar to *B. subcostata*, but its antenna is almost fully blackish except for the first four antennomeres and the posterolateral callosity of pronotum does not project beyond lateral margin, and hence, the posterolateral corners of pronotum are obtuse and not angulate as in *B. subcostata.* Besides, the elytra are metallic green to violaceous and shinier and lack a distinct lateral costa.

Nodostoma obscurum Jacoby, 1908 and *Basilepta sakaii* Takizawa, 1987 were listed as synonyms of *B. subcostata* in the catalogue of Nepalese Chrysomelidae by Medvedev and Sprecher-Uebersax (1997: 288), but they did not mark it as a new synonymy. This appears to be incorrect because the type of *N. obscurum* is not even morphologically similar to *N. subcostatum*, whereas *B. sakaii* is a smaller insect according to the description (Alexey Moseyko, personal communication).

Description. *Length* 2.34–3.00 mm, width 1.36–1.86 mm, 1.6–1.7× longer than broad. Body (Fig. 1a–c) oblong ovate, shiny. Colour highly variable from red-brown to dark blue, black, or their mixtures without any spots, stripes or maculations; head entirely red-brown to tinted black except vertex red-brown, palpomeres light yellow to brown, some specimens with apex of last palpomere black; basal 4–6 antennomeres light brown and rest gradually turning piceous to black; colour of pronotum and elytra varies from red-brown or dark blue to shiny black, pronotum concolorous with elytra or not, general color of legs red-brown to dark brown or testaceous, tibia distally and tarsomeres darker.

Three major color morphs and their intermediates were commonly observed:

1. Head and pronotum red-brown; elytra blue, blue-black, dark green, or black; all ventrites dark (Fig. 1a). A syntype, images of which were made available by the Museum of Comparative Zoology (http://140.247.96.247/mcz/Species_record.php?id=9291), belongs to this category.
2. Entirely red-brown, except distal antennomeres, legs and palpi piceous to black (Fig. 1c);
3. Entirely dark blue, blue-black, dark green, or black (Figs 1b, 2), except head medially red-brown; metasternum and abdominal ventrites piceous to black; all entirely dark variants observed were females.

Head (Fig. 3a, b) distinctly punctured with impunctate areas on vertex and frons; punctures bold, slightly smaller than those on pronotum. Coronal suture weak but evident. Supraorbital pore adjacent to dorsal margin of eye, rounded, with a long seta. Orbital sulcus with deep, bold punctures. Frons hardly differentiated from vertex, supra frontal sulcus weak. Frons with a few bold punctures, impunctate medially. Antennal calli trapezoidal, raised; supracallinal sulcus well developed with a few bold punctures. Clypeus forms narrow transverse band with strongly concave anterior margin; frontoclypeal suture with a few small punctures. Labrum broader than long, with a pair of broadly placed setose punctures in middle and a pair of setae anterolaterally; anterior margin with thick short setae on either side of middle, apical margin emarginate medially. Antennae hardly extend up to middle of elytra; first antennomere thick, longer than second; second antennomere thinner than first, thicker than 3rd and 4th separately; 5th onwards antennomeres progressively thicker; basal four anten-

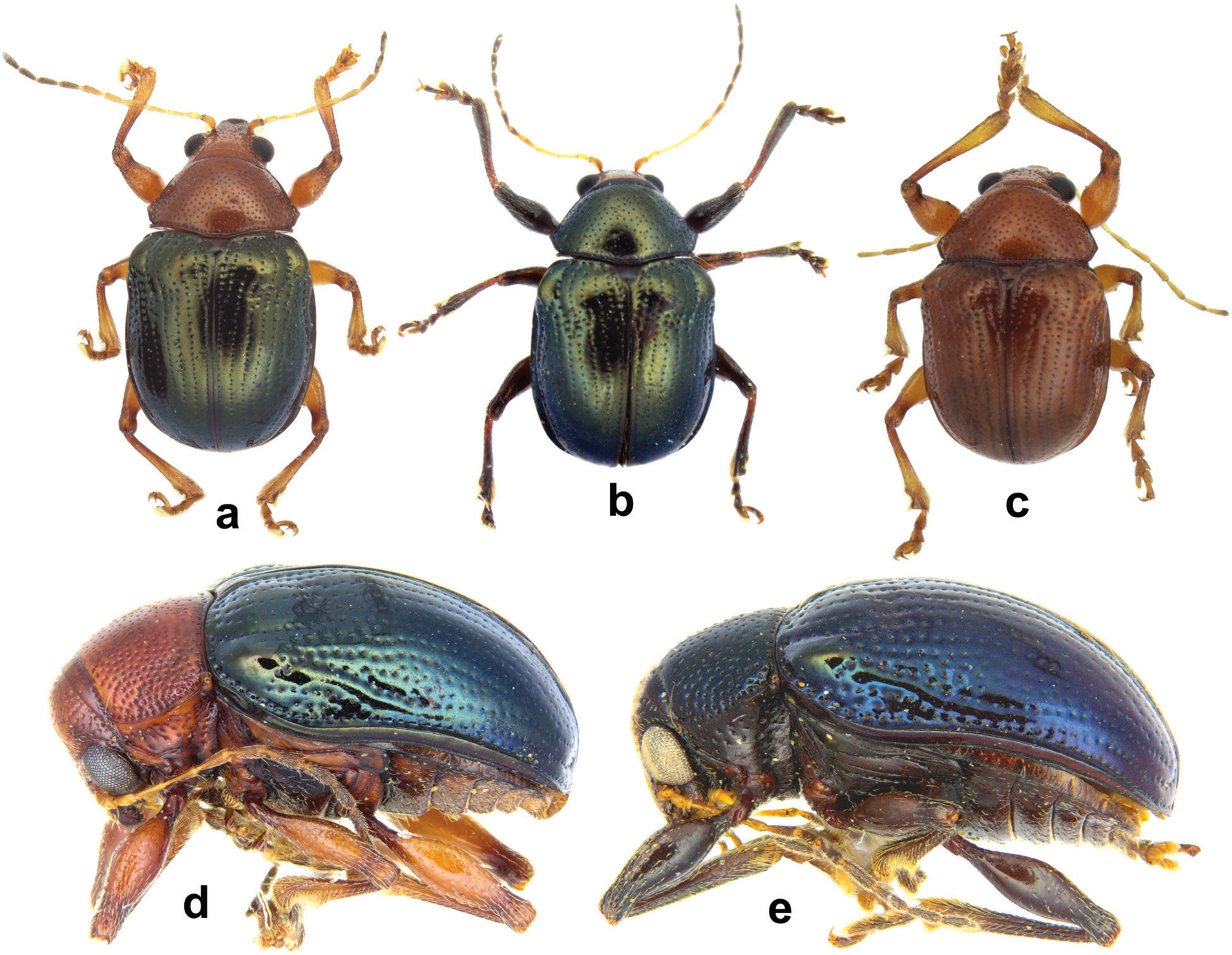

Figure 1. *Basilepta subcostata* (Jacoby). **a–c.** Habitus, dorsal: **a.** Nominate form, male; **b.** Female; **c.** Rufous form, male; **d.** Male, lateral view; **e.** Female, lateral view.

Figure 2. Syntype (female) of *Basilepta subcostata* (Jacoby) (BMNH). **a.** Dorsal view; **b.** Lateral view.

nomeres smooth, shiny, sparsely setose; distal seven thickly covered with short pointed setae, proportion of antennomeres as follows: 1 : 0.80 : 1.13 : 1.33 : 1.27 : 1.20 : 1.20 : 1.27 : 1.20: 1.13 : 1.33.

Compound eyes with inner margin feebly emarginate, transverse diameter about 1.4–1.5× vertical. Distance between eyes 1.8× distance between antennal sockets, shortest distance between compound eye to adjacent an-

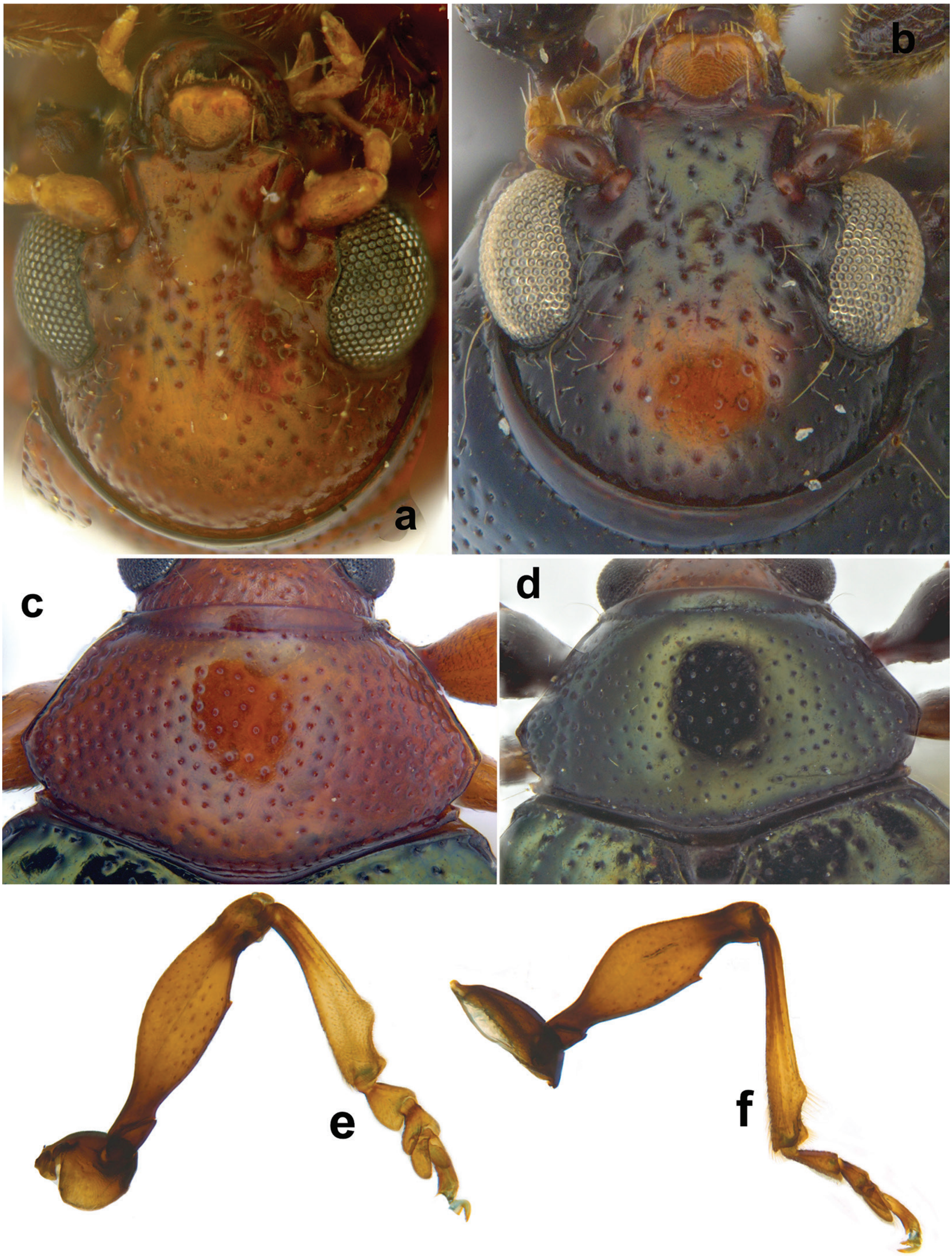

Figure 3. *Basilepta subcostata* (Jacoby). **a.** Head, dorsal view, male; **b.** Head, dorsal view, female; **c.** Pronotum, male; **d.** Pronotum, female; **e.** Middle leg; **f.** Hind leg.

tennal socket about 3.5× distance between antennal sockets. Mandibles with two large denticles; maxillary palpi three-segmented excluding palpifer; last palpomere longest, penultimate palpomere less than half length of last palpomere. Labial palpi with three palpomeres, excluding palpiger, first palpomere being shortest and last longest.

Pronotum (Fig. 3c, d) about 1.6× broader than long, posteriorly 1.6–1.7× wider than anteriorly, somewhat trapeziform in outline, narrowed anteriorly, with posterolateral callosity laterally projecting beyond lateral margin, hence posterolateral corners appear sharply angulate, lateral margins angulate at posterior one-third presenting octagonal appearance, densely punctate, punctures larger than those on head and smaller than those on elytra, posterior margin gently lobed in middle, anterior sulcus and posterior sulcus distinct with a row of punctures, posterior sulcus deeper than anterior. Scutellum wider than long, broadly rounded posteriorly, sparsely and minutely punctate. Elytra 1.2× longer than wide, punctate striate, punctation weaker towards apex, punctures regular post medially with 10 striae; partially confused and semiregular in anterior half of elytra due to incomplete or broken striae; distance between punctures in a row less than distance between adjacent rows; extreme lateral row of elytral punctures regular, complete, extending up to apex; second row merged with first row from anterior one-fourth to middle of elytra; third row arising from humerus extending up to apex of elytra; interstice between 2nd and 3rd lateral rows distinctly costate, extending as far as middle of elytra or beyond, costa variable in prominence, strongly convex and sinuate in the syntype female (Fig. 2b) (BMNH, examined), but only moderately prominent in most of the Indian material examined. Humeral calli well developed, post basal depression shallow but distinct; basal calli distinct, vary in prominence. Elytral apex narrowly convex. Epipleura outwardly oblique with sparse and fine punctures, narrowing beyond proximal one-third, hardly reaching elytral apex.

Prosternum broader than long, broader posteriorly than anteriorly, with bold punctures, posterior margin straight; mesosternum nearly twice as broad as long with a few punctures smaller than those on prosternum. Proepisternum depressed; hypomeron with bold punctures. Legs long; all femora dilated, minutely dentate ventrally beyond middle (Fig. 3e, f); tibia (Fig. 3f) with eight sharp carinae, variable in prominence: three each dorsally and ventrally, one each on either side laterally. Tarsomeres ventrally fringed with diverse forms of setae, basitarsomere with closely arranged capitate setae bordered by long pointed setae in males and only pointed setae in females, second tarsomere ventrally with pointed setae, bilobed third tarsomere with triangular or inverted arrowhead-shaped setae ventrally.

Ventrites sparsely punctate, pubescent; first ventrite medially longer than following two combined, ventrites 3 and 4 subequal, shorter than 2 and 5 separately which are subequal, last ventrite hardly sexually dimorphic, last tergite without longitudinal groove medially.

Male genitalia: aedeagus in lateral view (Fig. 4a, c, e, h, k, m, n, o) sharply bent almost at right angle near base of aedeagus proper, apical portion acutely narrowed and slightly recurved dorsally; in ventral view (Fig. 4b, d, f, g, i, j, l), depressed along ventral surface, apex narrowed forming obtuse denticle; apical opening wide, partially covered by a lamina with a pair of sclerotized stripes fused basally and joining dorsal surface. Tegmen (Fig. 4q) flat, membranous, lightly sclerotized, bilobed distally, proximally with a pair of arms which turn narrowed and encircle base of aedeagus proper. Spiculum gastrale (second spiculum of Jolivet and Verma 2008) Y-shaped, sclerotized. Tergite VIII semicircular with spindle-shaped sclerotization on either side, with short setae apically. Spiculum reclictum (sensu Slipinski and Escalona 2013) spoon-shaped, distally dilated (Fig. 4p).

Endophallus (Fig. 5a) long, membranous, tubular, about 3.7–3.9× longer than aedeagus proper; with three distinct regions: basal phallomere (BP), median phallomere (MP), and apical phallomere (AP); basal phallomere (Fig. 5b) very short with a lateral lobe on either side, followed by two inwardly curved central sclerites (CS) dorsally; median phallomere (Fig. 5c) longest, tubular, with setae or hair like spicules, a few circular spicules present near apical region; apical phallomere (Fig. 5d) much wider than other two regions, asymmetrical, with spicules varying in shape such as triangular, angular, oval; apical region proximally with three minute lobes facing median phallomere, apex with large lateral lobes and several smaller lobes medially.

Female genitalia (Fig. 6) with spermathecal capsule sickle-shaped (Fig. 6a, b), proximal portion very short, constricted medially, dumbbell-shaped where spermathecal duct and spermathecal gland join side by side, distal portion sickle-shaped, sharply curved, subacutely narrowed towards distal end; spermathecal gland long and tubular, length of spermathecal capsule 7.7× its maximum width. Bursa copulatrix (Fig. 6c) sac like, longer than wide, with a long bursa sclerite (BS) on either side, spermathecal duct joins bursa copulatrix between these sclerites, median oviduct attached on the other side of bursa copulatrix. Ovipositor (Fig. 6d) elongate, sclerotized distally, with almost 10–16 long setae, stylus absent; 8th sternite and 8th tergite fused laterally to form a membranous cylinder with mild sclerotizations laterally (Fig. 6f) ; 8th sternite with a long tignum *sensu* Konstantinov, 1998 (spiculum ventrale *sensu* Slipinski & Escalona, 2013) longer than ovipositor (Fig. 6e); collateral gland (CoG) present (Fig. 6g).

Distribution. India [Karnataka (new record); Delhi (Batra 1952); Uttarakhand; Uttar Pradesh; Bihar; Odisha; West Bengal; Sikkim; Assam; Manipur; Meghalaya]. Bangladesh. Myanmar, Thailand, Laos, Cambodia (Kimoto and Gressitt 1982; Vansilalom 2016); Nepal (Medvedev 1990; Sprecher-Uebersax 1997; Kimoto 2001). A distribution map is available at this link: https://www.google.com/maps/d/edit?hl=en&mid=1QgHVswL3eaPJ2soJ16_R5BTkIu8mRM6z&ll=23.692266951458954%2C78.67937627596257&z=6.

Host plants. *Musa* spp. (*Musa sapientum*, *M. acuminata*; Musaceae, Zingiberales) are principal hosts. Beetles were observed feeding on ginger (*Zingiber officinale* Roscoe; Zingiberaceae, Zingiberales) in Meghalaya (D.M. Firake, personal communication). In Assam, northeastern India, adult beetles were observed feeding on *Canna indica* L. (Cannaceae, Zingiberales) and tur-

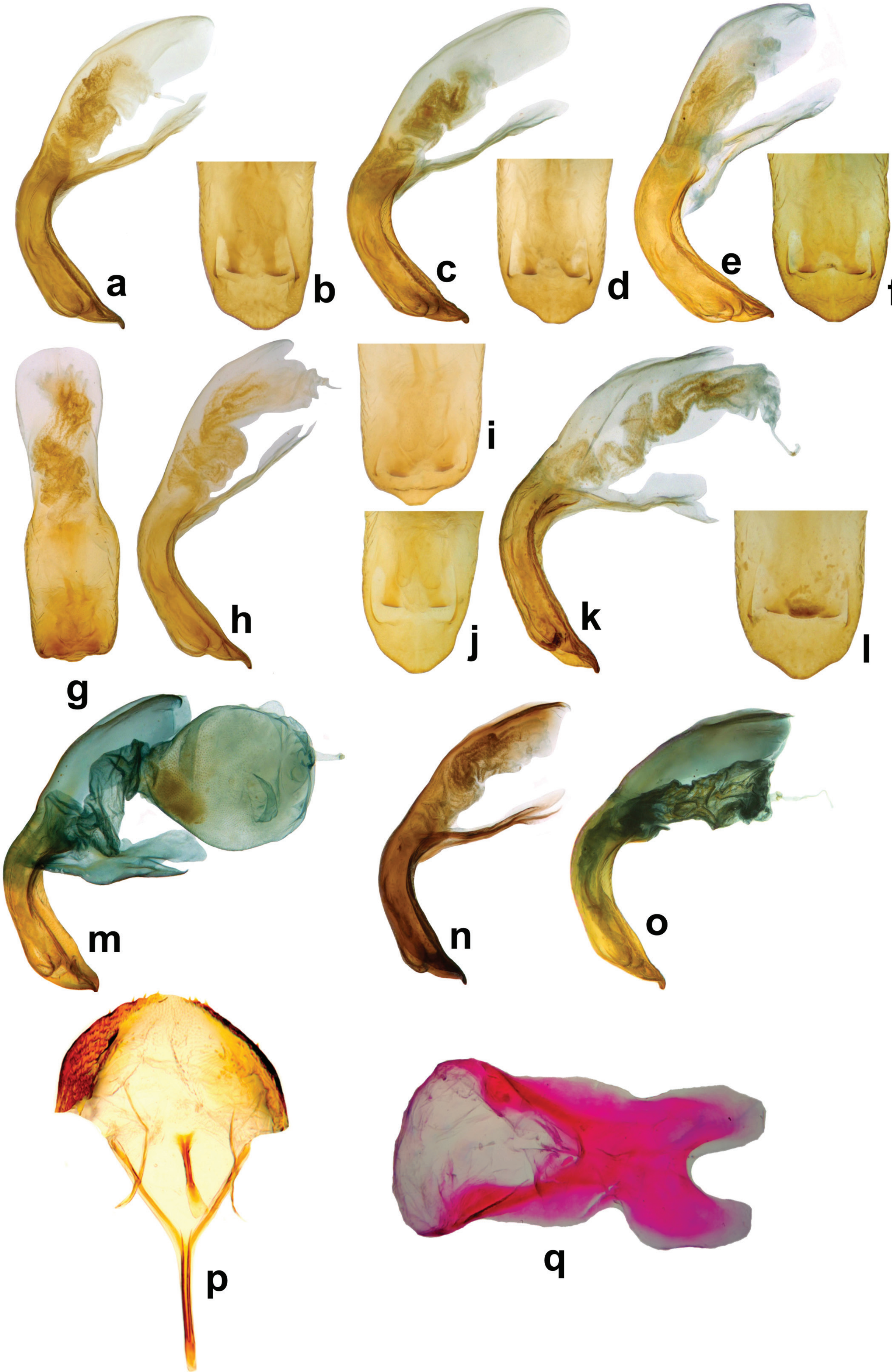

Figure 4. Male genitalia of different populations of *Basilepta subcostata* (Jacoby). **a, c, e, h, k, m–o.** Aedeagus, lateral view; **b, d, f, g, i, j, l.** Apex of aedeagus, ventral view; **p.** Male: tergite VIII, sternite VIII and IX; **q.** Male genitalia, tegmen.

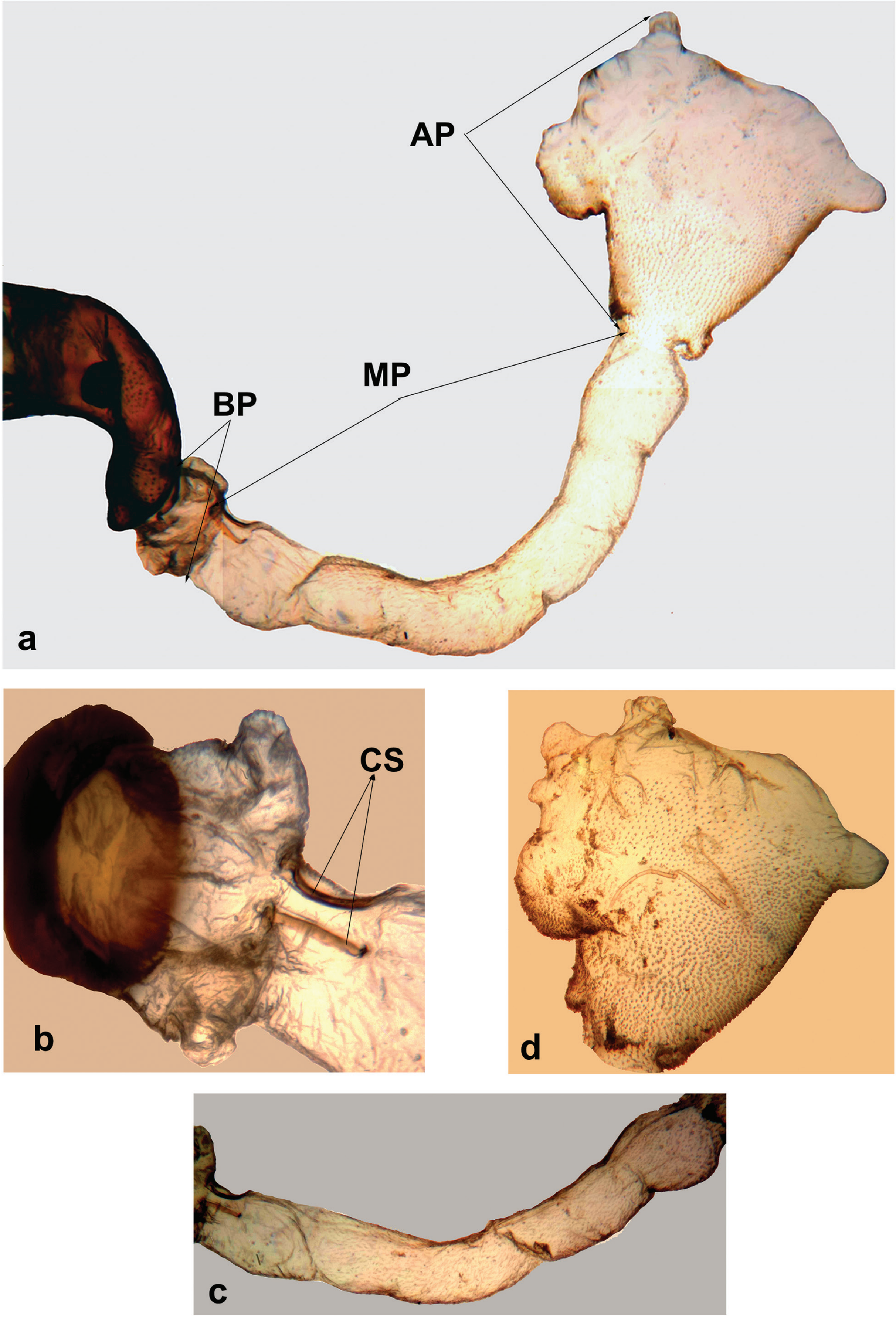

Figure 5. Endophallus of *Basilepta subcostata* (Jacoby). **a.** Endophallus completely everted, lateral view; **b.** Basal phallomere and central sclerite, dorsal view; **c.** Median phallomere, lateral view; **d.** Apical phallomere, dorsolateral view. Abbreviations: BP = Basal phallomere; MP = Median Phallomere; AP = Apical phallomere; CS = Central Sclerite.

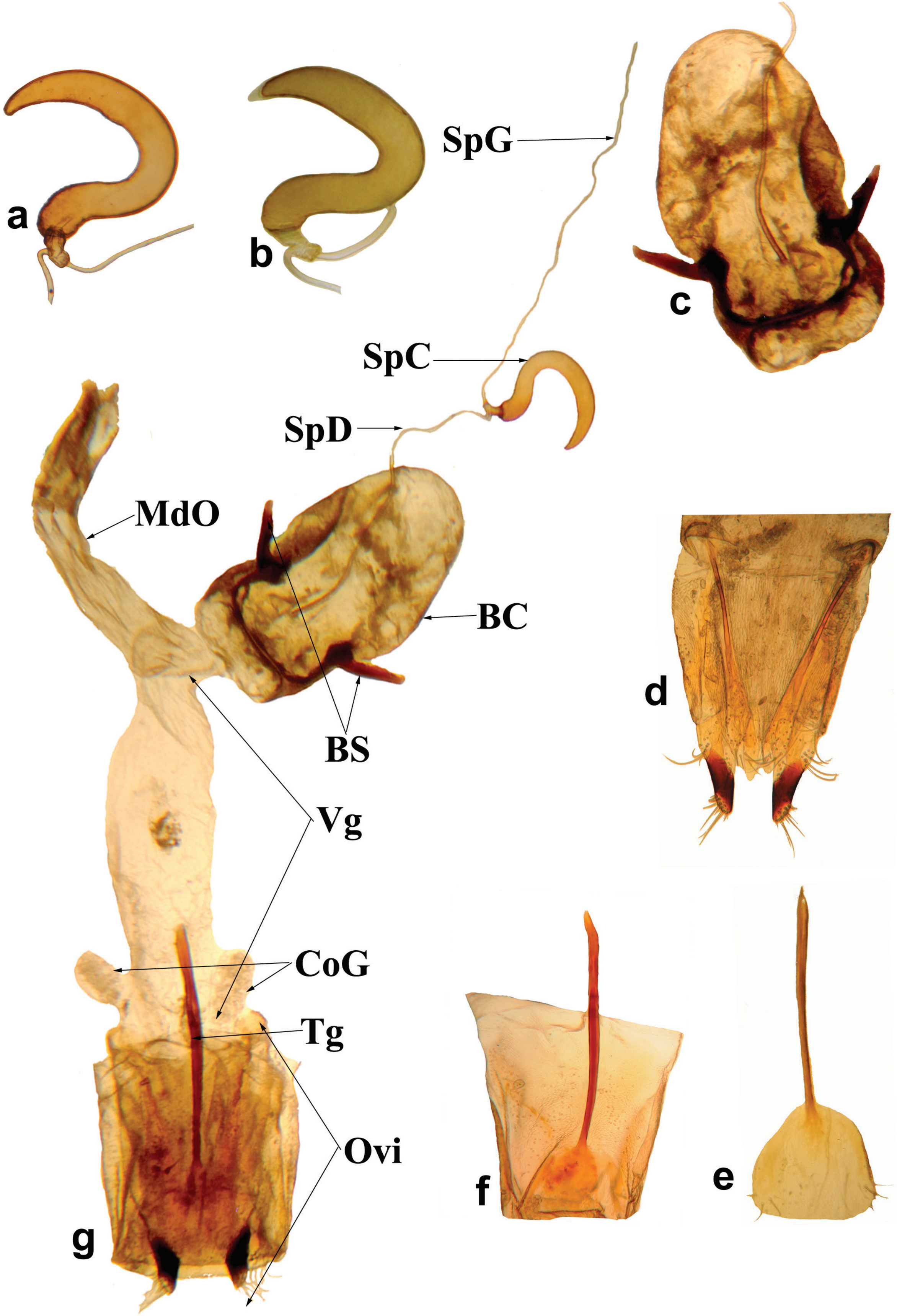

Figure 6. Female genitalia of *Basilepta subcostata* (Jacoby). **a, b.** Spermatheca; **c.** Bursa copulatrix; **d.** Ovipositor; **e.** Eighth sternite and tignum; **f.** Eighth sternite and 8th ventrite along with tignum; **g.** Female genitalia. Abbreviations: SpG = spermathecal gland; SpC = spermathecal capsule; SpD = spermathecal duct; MdO = median oviduct; BC = Bursa copulatrix; BS = bursa sclerite; Vg = vagina; CoG = collateral gland; Tg = tignum; ovi = ovipositor.

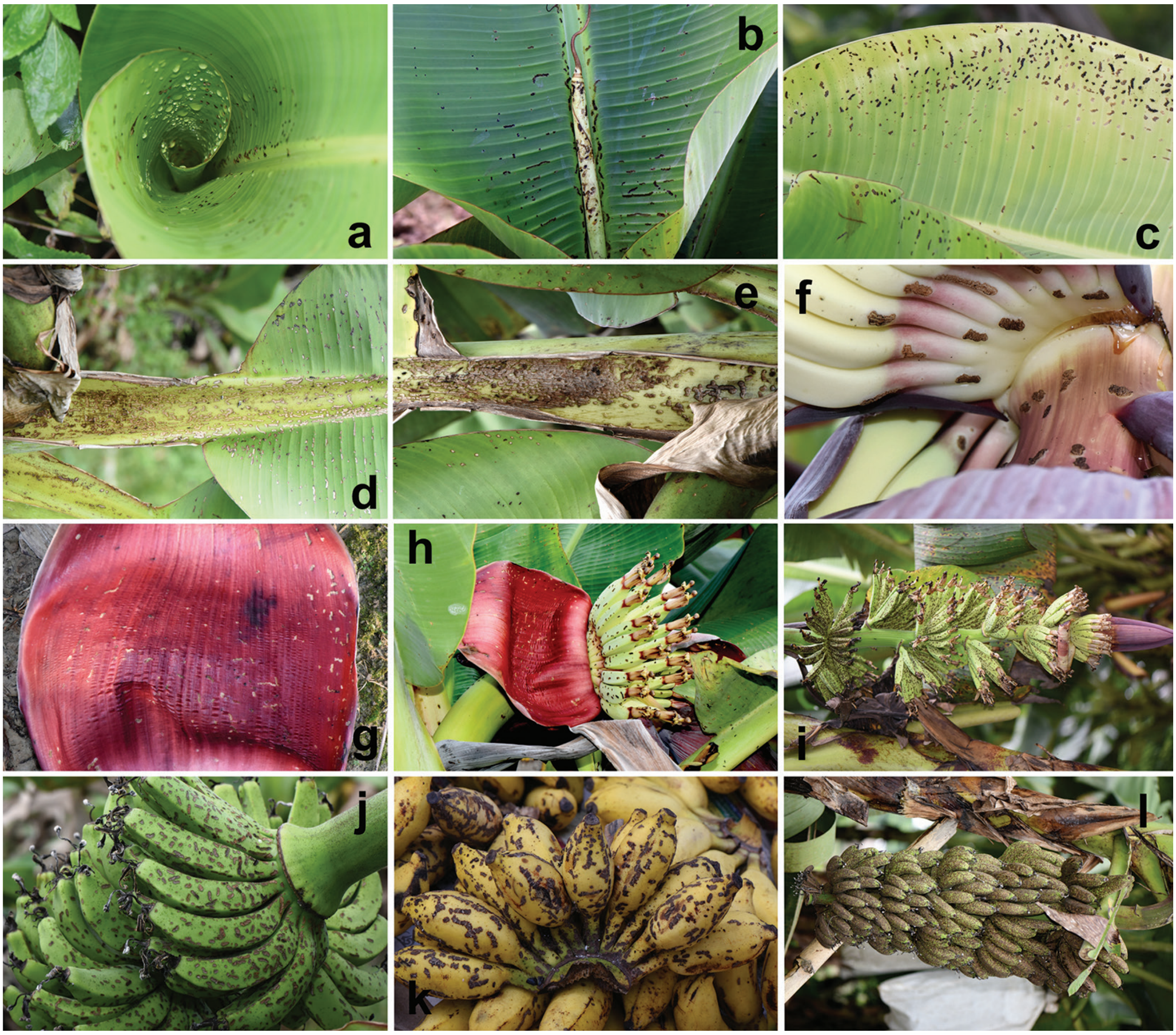

Figure 7. Damage caused by *B. subcostata* (Jacoby) on banana. **a.** Leaf whorl showing scarring damage; **b.** Scars on spindle leaf; **c.** Scars on leaf; **d, e.** Scarring on leaf petiole; **f.** Flower damage; **g.** Bract damage; **h–i.** Damage on young fruits and emerging bunch; **j–l.** Fruit damage.

meric (*Curcuma longa* L., Zingiberaceae) and characteristic feeding marks were observed on the latter. This is the first documentation of other hosts of *B. subcostata* besides banana. Adults were also found to be resting on taro (*Colocasia* sp., Araceae, Arales) (unpublished data).

Bioecology. The adult beetles are most active during the monsoon and post-monsoon seasons and summer. They are nocturnal and usually found hiding inside the leaf whorls and come out only when disturbed. They feed on the young unfurled leaves (Fig. 7a), leaf petioles (Fig. 7d, e), and stems of banana, and the emerging leaves (Fig. 7b, c) are badly scarred. Feeding damage was also observed on flowers (Fig. 7f) and bracts (Fig. 7g), as well as young, developing fruits (Fig. 7h, i). For more images of the damage symptoms on cultivated banana, see the website of ICAR-National Research Centre for Banana (2019). In severe cases, the developing bunches and fruits (Fig. 7j–l) are so badly scarred that they lose their market value.

Eggs are laid in the soil and the larvae feed on the roots of grasses and other weeds. Pupation takes place in the soil. Emerging adults feed on young leaves and fruits. Adults hibernate during winter. Seasonal incidence and population dynamics of fruit scarring beetles have been studied from some parts of India, including Assam (Mishra et al. 2015) and Bihar (Ahmad et al. 2010; Sah et al. 2018).

Pest status. Mukherjee et al. (2006) reported that meteorological factors accounted for about 85% of the beetle incidence in Bihar (India) and minimum temperature and maximum relative humidity had a positive and significant effect on scarring beetle populations. Though damage due to scarring beetles is believed to be mainly cosmetic, the fruit quality is also badly affected. Zahan et al. (2001) and Sah et al. (2018) reported that scarring beetle infestation significantly delayed fruit ripening, reduced the fruit weight, and adversely affected the skin colour and thickness of fruits and the

Figure 8. Naturally occurring epizootic of fungal pathogen, *Beauveria bassiana* on *Basilepta subcostata.*

taste and smell of the pulp. This damage considerably affects the consumption value.

Natural enemies. In Uttar Pradesh, North India, adults of the predatory beetle, *Paederus fuscipes* Curtis (Coleoptera, Staphylinidae), were found to be commonly associated with *B. subcostata.* Natural epizootics of entomofungal pathogens, such as *Beauveria bassiana*, are commonly observed on *B. subcostata* in the northeastern region of India (Fig. 8) and exert some control in the post-monsoon months.

Basilepta viridipennis (Motschulsky, 1860)

Fig. 9

Nodostoma viridipenne Motschulsky, 1860: Motschulsky 1860: 177; Jacoby 1908: 349; Kimoto 1967: 69.

Nodostoma frontale: Baly 1867: 253; Medvedev 2006: 412 (synonymy).

Nodostoma occipitale: Jacoby 1908: 335–336; Kimoto and Gressitt 1982: 36 (synonymy).

Nodostoma haroldi: Jacoby 1908: 331 (new name for *Nodostoma aeneipenne* Baly); Kimoto and Gressitt 1982: 36 (synonymy).

Nodostoma aeneipenne: Baly 1867: 235; Jacoby 1908: 331 (synonymy)

Nodostoma haroldi var. *apicipes*: Jacoby 1892: 87; Jacoby 1908: 331.

Basilepta viridipenne: Medvedev 2006: 412.

Basilepta viridipennis: Moseyko and Sprecher-Uebersax 2010: 639.

Basilepta occipitalis: Moseyko and Sprecher-Uebersax 2010: 639.

Material examined. ***Type material*** of *Nodostoma occipitale* Jacoby: 62590/ Type (red bordered circular label)/ Doherty/ Tenesserim, Mergui/ Fry Coll. 1905-100/ Nodostoma occipitale Jac., Type (blue label)" (BMNH). ***Other material*****:** Fea/ Birmah, Carin Cheba/ Fry Coll. 1905-100/ NHMUK0114016244, 1 ex; Doherty/ Tenesserim, Javoy/ Fry Coll. 1905-100/ NHMUK014016300, 1 ex (BMNH).

Remarks. *Basilepta viridipennis* (Fig. 9) has been erroneously reported in the literature as a pest of banana in the Indian Subcontinent (India and Bangladesh), and Waterhouse (1993) also listed it as a major pest of banana in Southeast Asia. All reports of its occurrence in northeastern India (Das and Baruah 2018), Bangladesh (Ahmed 1963; Zahan et al. 2001, 2003, 2004; Rahman et al. 2004), and Thailand (Wongsiri 1991) are most likely to refer to *B. subcostata.* The type of *N. occipitale* Jacoby (Fig. 9a, b) (BMNH, examined), a synonym of *B. viridipennis*, has only a superficial resemblance to *B. subcostata* and can be easily separated from the latter by the pronotum forming an obtuse angle posterolaterally (Fig. 9b) and its lateral margins abruptly converging an-

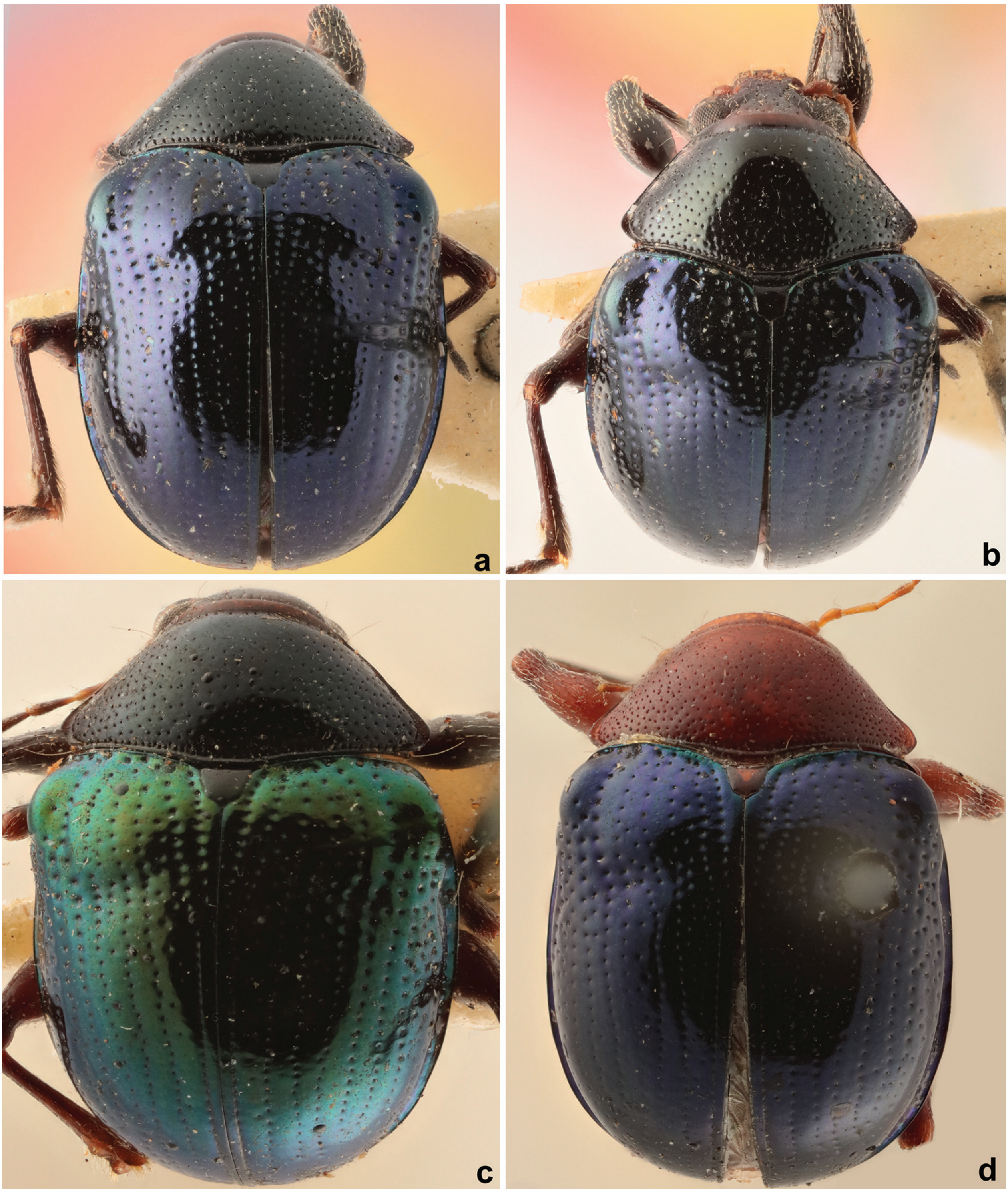

Figure 9. *Basilepta viridipennis* (Jacoby). **a, b.** Syntype of *Nodostoma occipitale* Jacoby, a synonym of *B. viridipennis* (BMNH); **c, d.** Colour forms of *B. viridipennis.*

teriorly in almost a straight line. Besides, pronotal punctures in *B. viridipennis* are smaller than average elytral punctures and finely and more closely impressed on lateral part and more sparsely and finely so on median and anterior parts. *Basilepta viridipennis* is of variable coloration and includes reddish, brownish, bluish, greenish, violaceous, and blackish forms. Medvedev (2006) designated a lectotype for *N. viridipenne* and synonymised *Basilepta frontalis* (Baly) with it, as he found the types of both species were identical.

Distribution. India, Nepal, Myanmar (= Burma), Thailand, Laos, Vietnam, Hainan, Malaya, Sumatra.

Chrysomelidae
Galerucinae
Alticini

Bhamoina varipes **(Jacoby, 1884)**

Figs 10–12

Eucycla varipes Jacoby, 1884: Jacoby 1884: 210 (Sumatra; Mus. Leiden); Duvivier 1885: 42 (Is. Bodjo).

Sphaeroderma varipes: Jacoby 1889: 193 (N Burma: Teinzo, Bhamo; Tenasserim: Meetan); Maulik 1926: 318, 328 (Burma: Karen Mts., Assam: Khasi Hills).

Bhamoina varipes: Bechyné 1958: 91; Scherer 1969: 202–203; Döberl 2010: 505.

Bhamonia [sic] *varipes*: Kimoto 2005: 80.

Sphaeroderma varipennis Jacoby 1892: 928 (Carin Cheba, Palon, Rangoon; Mus. Genova); Maulik 1926: 318, 325; Scherer 1969: 202 (synonymy).

Material examined. ***Type material*** of *Sphaeroderma varipennis* Jacoby: "Type (H.T.) (red bordered circular label)/ Carin Cheba, 900–1100 m, L. Fea, v.XII.88 / Jacoby Coll. 1909-28a / Sphaerod. varipennis Jac. (blue label)" (BMNH); Others: "Sumatra/ Jacoby Coll. 1909-28a/ variepennis Jac. In B.M. Coll. C.M.F. Von Hayek det. 1967/ Bhamoina varipennis (Jacoby), G. Scherer det. 1967" (BMNH). India: Assam: 5♂, 6♀♀, Balipara 74 m msl; 26°49'56.0"N, 92°46'41.1"E; 17.V.2019; K. D. Prathapan Coll. (KAU); Meghalaya: 3♂, 8♀ Barapani 993 m msl; 25°41'17.6"N, 91°55'5.1"E; 5.vi.2013; K. D. Prathapan Coll. Ex banana (KAU); Meghalaya: 11♂, 16♀, Ri Bhoi Dst., Saiden 540 m msl; 25°52'41.0"N, 91°53'1.4"E; 4.vi.2013; K. D. Prathapan Coll. Ex banana (KAU); Meghalaya: 5♂, 2♀, Nongpoh, 587 m msl; 25°50'34.4"N, 91°52'34.4"E; 22.v.2019; K. D. Prathapan Coll. (KAU).

Remarks. The genus *Bhamoina* closely resembles *Sphaeroderma* (see below for the generic diagnosis of *Sphaeroderma*). *Bhamoina acutangula* (Jacoby), the type species of the genus, was originally described in *Sphaeroderma*. *Bhamoina* can be easily separated from *Sphaeroderma* by the anteriorly produced anterolateral corners of pronotum (in *Sphaeroderma*, the anterolateral corners of pronotum are not produced forward, or only slightly produced). *Sphaeroderma varipennis* Jacoby, treated as a synonym of *B. varipes* by Scherer (1969), is bicolored (Fig. 11a) with the eltyra fully black and the head and pronotum reddish. It has a slightly more robust body form, and the anterolateral corners of pronotum (Fig. 11b, c) are less produced and somewhat obtusely rounded compared to those of *B. varipes.*

Scherer (1969) gave a key to the Oriental species of *Bhamoina. Sphaeroderma varipennis* has been known to be a pest of banana in Thailand, and adults defoliate banana (Hill 2008). Dean (1978) recorded "*Sphaeroderma veripennis*" on banana in Laos. Although *B. varipes* is distributed in India, there has been no previous records of its host plant association from India.

Description. Entirely red-brown (Fig. 10a, b), except eyes and distal portion of mandibles black. Elytra darker in a few examples. Proximal 5–7 antennomeres lighter than distal ones. Anterolateral corners of pronotum, palpi, fore- and midfemora, tarsomeres, and last abdominal ventrites often lighter than dorsum.

Length 2.71–3.41 mm, width 1.97–2.80 mm, 1.34× longer than broad. In lateral view vertex weakly convex, forming a concavity where it joins frons; frons strongly arched, joining clypeus at an obtuse angle. In frontal view vertex moderately flat, sparsely punctate with a mixture of small and minute punctures. Supraorbital pore circular, without shallow groove surrounding it, placed just above orbital sulcus, two or three smaller punctures anterior to supraorbital pore present. In frontal view (Fig. 10c), frontal ridge broad and raised between antennal sockets; narrowed dorsally entering between antennal calli; ventrally narrower than dorsally; frontolateral area anteriorly with a few setae; anterofrontal area flat, not forming ridge, with long and short setae. Antennal calli transverse-oblique, trapezoidal, slightly higher than vertex, narrowly separated dorsally; anteromesal ends acutely angulate, entering into interantennal space. Supracallinal sulcus deep, gently convex, oblique, narrower than orbital sulcus. Suprafrontal, supraorbital, supraantennal sulci well developed, all weaker than supracallinal sulcus. Distance between antennal sockets 1.57× diameter of a socket, antennal sockets separated from adjacent eye by a distance 0.38× transverse diameter of a socket. Labrum wider than long, dorsal surface convex anteriorly, anterior margin convex, with three pairs of labral setae arranged in a transverse row. First antennomere longer than second and third combined, second a little longer than third and fourth separately, sixth onwards antennomeres progressively thickened. Proportionate length of antennomeres I to XI: 1 : 0.48 : 0.41 : 0.52 : 0.56 : 0.44 : 0.59 : 0.52 : 0.52 : 0.52 : 0.8. Maxilla with penultimate palpomere thicker and longer than last and preceding palpomeres separately. Labium with penultimate palpomere thickened, subequal in length to thin, pointed last palpomere.

Pronotum (Fig. 10d) convex, distinctly narrowed anteriorly, 0.30× as long as wide, posteriorly 1.65–1.76× wider than anteriorly, profusely, uniformly covered with small punctures. Pronotal punctures as small as half of elytral punctures. Lateral margin weakly convex proximally, gently concave at anterolateral seta bearing pore; broader anteriorly than posteriorly. Anterior margin deeply concave, except gently convex in middle. Posterior margin bisinuate, forming a distinct lobe in middle. Anterolateral callosity (Fig. 10e) projecting forward on either side of head; seta bearing pore on dorsal posterior face of callosity. Posterolateral callosity not protruding laterally, with seta bearing pore on lateral face.

Scutellum triangular, acutely angulate posteriorly, shiny, flat on top, minutely punctate. Elytra as wide as pronotum at base, widened postbasally, lateral margin entirely visible in dorsal view. Elytral apex convex. Elytral punctures confused in mesal half, tend to form rows in

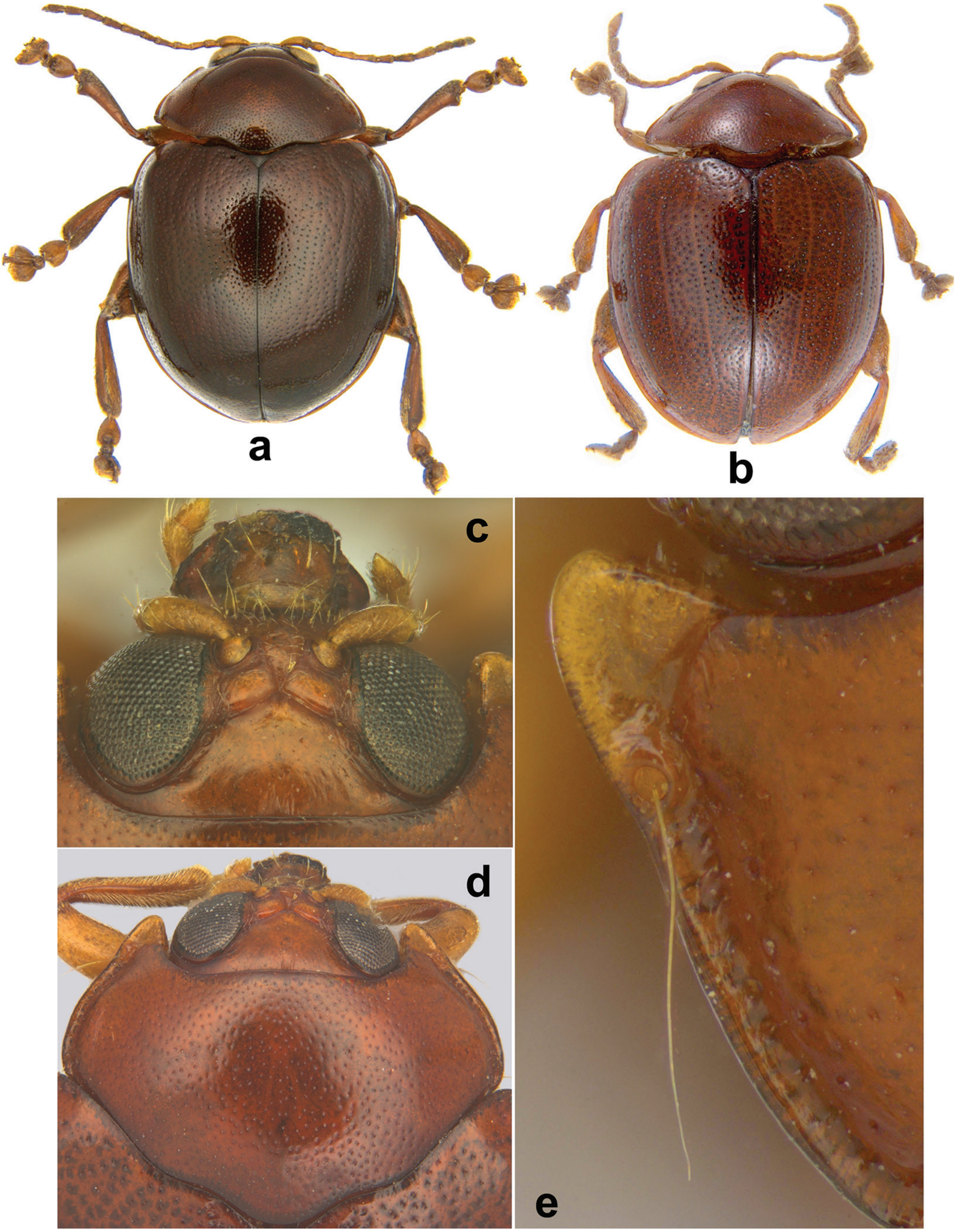

Figure 10. *Bhamoina varipes* (Jacoby). **a, b.** Dorsal view; **c.** Head, dorsal view; **d.** Pronotum, dorsal view; **e.** Lateral margin of pronotum.

lateral half, outermost punctures forming a regular row. Each elytral puncture surrounded by a dark halo, distance between adjacent punctures less than diameter of one puncture, including dark halo.

Maximum width of elytral epipleura subequal to that of midfemur. Epipleura subhorizontal, visible in lateral view, widest at proximal one-fourth, gradually narrowing till distal one-third and then abruptly narrowed, hardly

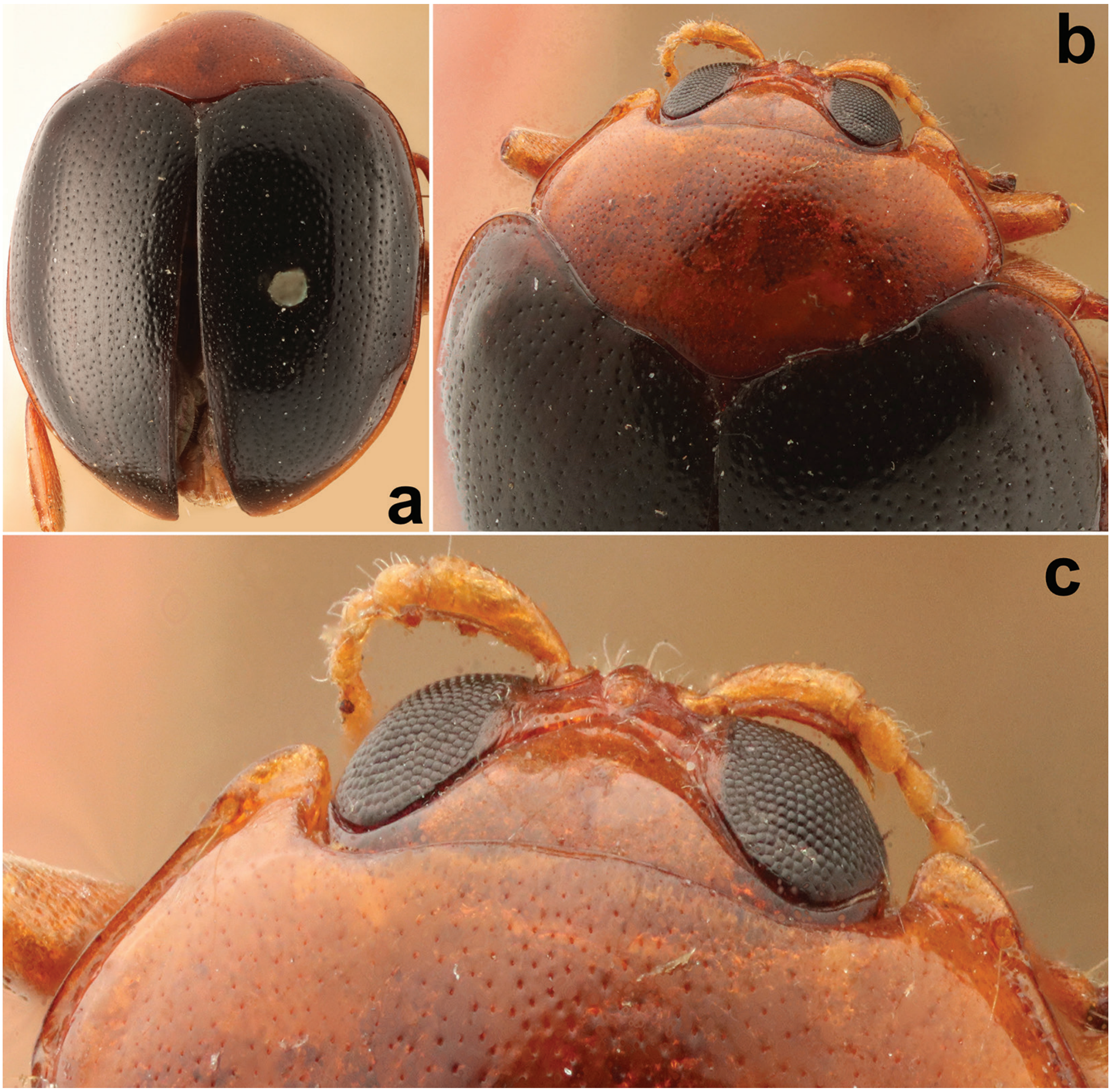

Figure 11. Type of *Sphaeroderma varipennis* Jacoby (=*B. varipes*) (female). **a.** Dorsal view; **b.** Pronotum of *S. varipennis*; **c.** Anterolateral corners of pronotum (magnified).

reaching apex. Prosternum gently depressed on top, setose, coarsely but shallowly punctate; minimum distance from anterior margin of prosternum to coxal cavity less than half of minimum width of prosternal intercoxal process; prosternal intercoxal process longer than wide, narrowed in middle, widened apically, posterior margin concave. Mesosternum transverse, nearly three times wider than long, with concave posterior margin; metasternum profusely setose medially, coarsely punctate. First abdominal ventrite profusely setose medially, coarsely punctate; in length, medially subequal to next three combined. Last ventrite a little longer than preceding two combined. Last visible tergite medially with a broad longitudinal groove not reaching apex.

Foretibia without apical spine. Mid- and hind tibiae with apical spine. First pro-, meso-, and metatarsomeres distinctly wider in male than in female; with capitate setae ventrally in male and pointed setae in female. Posterior margin of last ventrite entire in female; forms a lobe notched on either side, in middle in male. Last ventrite internally with a longitudinal apodeme along mid-line in male (Fig. 12a), externally visible as a dark line; apodeme absent in female (Fig. 12b).

Male genitalia with aedeagus in lateral view (Fig. 12f) curved, apex acutely pointed, recurved dorsally. In ventral view (Fig. 12g), aedeagus with a longitudinal depression along middle of ventral side, depression being stronger distally; aedeagus narrowed apically forming a triangular denticle. Dorsal opening (Fig. 12h) partially covered with three laminae.

Female genitalia with spermathecal receptacle (Fig. 12e) oblong, widest in middle, narrowed to-

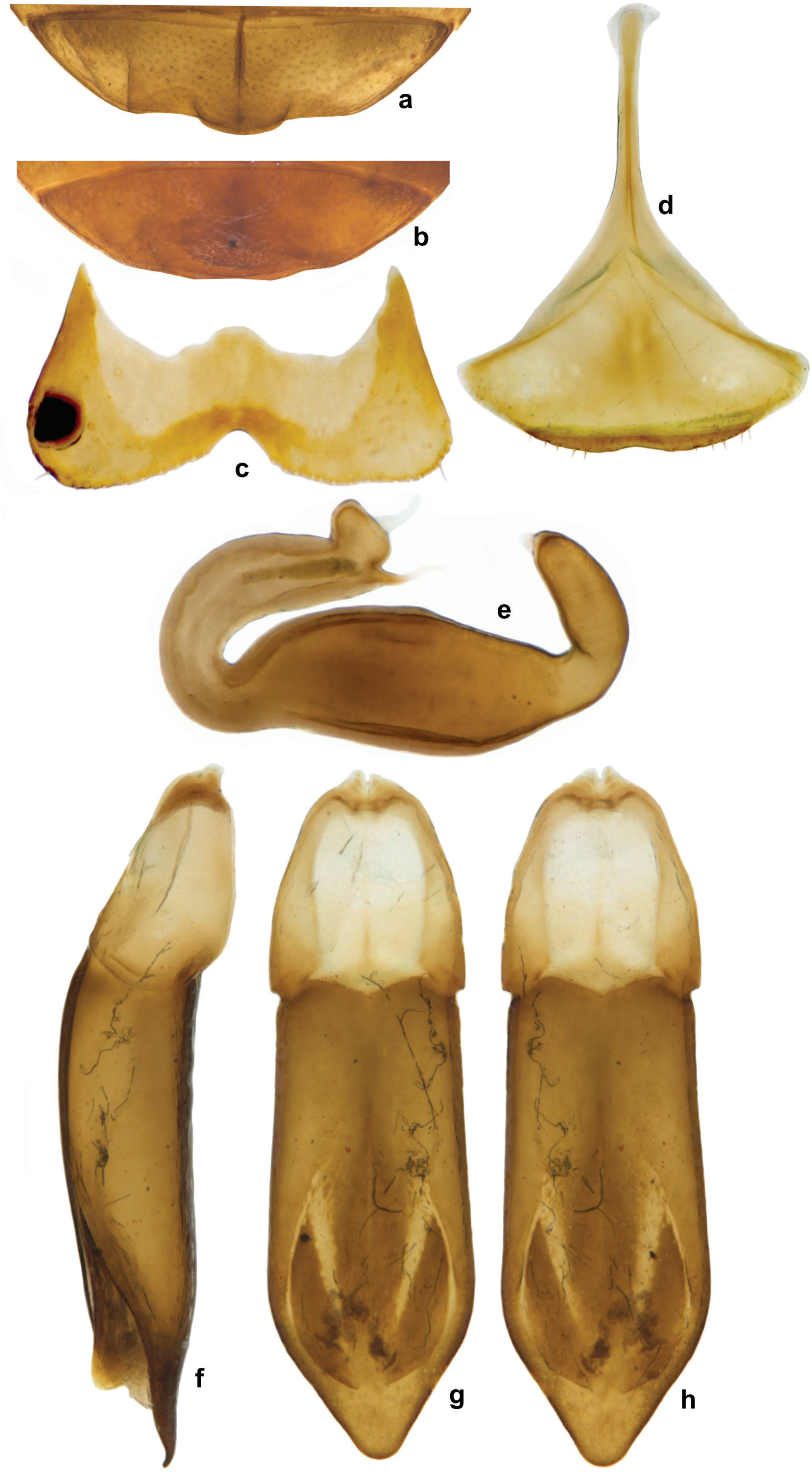

Figure 12. *Bhamoina varipes* (Jacoby). **a.** Abdominal apex, male; **b.** Abdominal apex, female; **c.** Vaginal palpi; **d.** Tignum; **e.** Spermatheca; **f–h.** Male genitalia: **f.** Aedeagus, lateral view; **g.** Aedeagus, ventral view; **h.** Aedeagus, dorsal view.

wards both ends, 2.2× longer than broad. Vaginal palpi (Fig. 12c) medially fused, both together 1.75× broader than long, posterior margin deeply emarginate with a seta on either side. Tignum (Fig. 12d) channeled along middle, posterior membranous area broadened greatly with posterior margin emarginate medially with a few short setae; tignum gently broadened anteriorly.

Nature of damage. Adults feed on the abaxial surface of the leaf lamina, making transverse, narrow linear scars. Feeding by *Basilepta subcostata* results in much shorter and broader feeding troughs, which is very different from that of *Bhamoina varipes*.

Distribution. India (Assam; Meghalaya; Uttarakhand (Dehra Dun)); Myanmar; Nepal (Medvedev 2000); Vietnam; China (Döberl 2010); Sumatra; Laos.

Sphaeroderma spp.

Notes. Unidentified species of *Sphaeroderma* Stephens have been reported from Laos as defoliators of banana (Dean 1978; Hill 2008; Vansilalom 2016). We collected a new species of *Sphaeroderma* feeding on banana from the state of Meghalaya, northeastern region of India, during our surveys, which is described and illustrated here.

Generic diagnosis. Small to medium sized flea beetles, convex and broadly oval. Red brown to black with or without spots or stripes on elytra. Head hypognathous, frontal ridge raised, forming T-shaped ridge with apical margin of head capsule. Antennal calli well delineated by sulci, supracallinal sulcus deep. Pronotum broader than long, without impressions or furrows. Posterior margin bisinuate with a lobe in middle. Procoxal cavity open behind. Anterolateral corners of pronotum not greatly produced forward. Metatibia dorsally flat or concave, with lateral and mesal margins forming ridge. Third tarsomere broad, its anterior margin entire, not bilobed. First metatarsomere short, not longer than next two combined. Intercoxal part of first abdominal ventrite truncate. Vaginal palpi broader than long.

Sphaeroderma cruenta Prathapan & Kumari, sp. nov.

http://zoobank.org3EC3F062-239F-4436-9647-EB5032384C7F

Figs 13, 14

Material examined. ***Holotype***: ♂: India: Meghalaya: Barapani, 25°41'17.6"N, 91°55'5.1"E; 5.vi.2013, 993 m; Prathapan K D Coll., Ex Banana (BMNH). ***Paratypes***: (17♂, 8♀): India: Meghalaya: Barapani, 25° 41'17.6"N, 91°55'5.1"E; 5.vi.2013, 993 m; Prathapan K D Coll., Ex Banana (2 BMNH; 2 USNM; 17 ICAR-NBAIR; 2 NPC; 2 UASB).

Diagnosis. This species closely resembles *S. mandarensis* Jacoby (Jacoby 1900: 123–124), from Mandar in

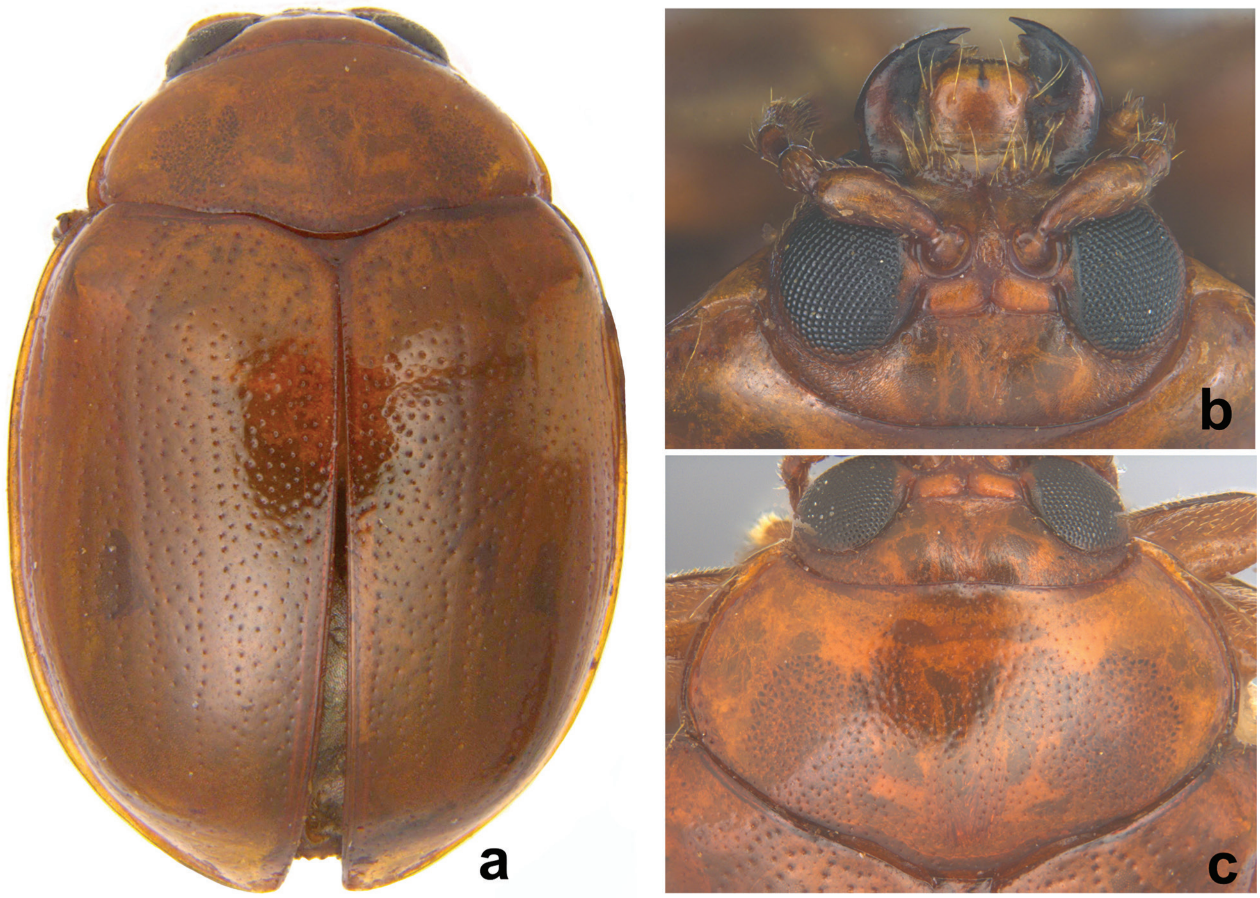

Figure 13. *Sphaeroderma cruenta* sp. nov. Paratype (female) **a.** Adult, dorsal view; **b.** Head, dorsal view; **c.** Pronotum, dorsal view.

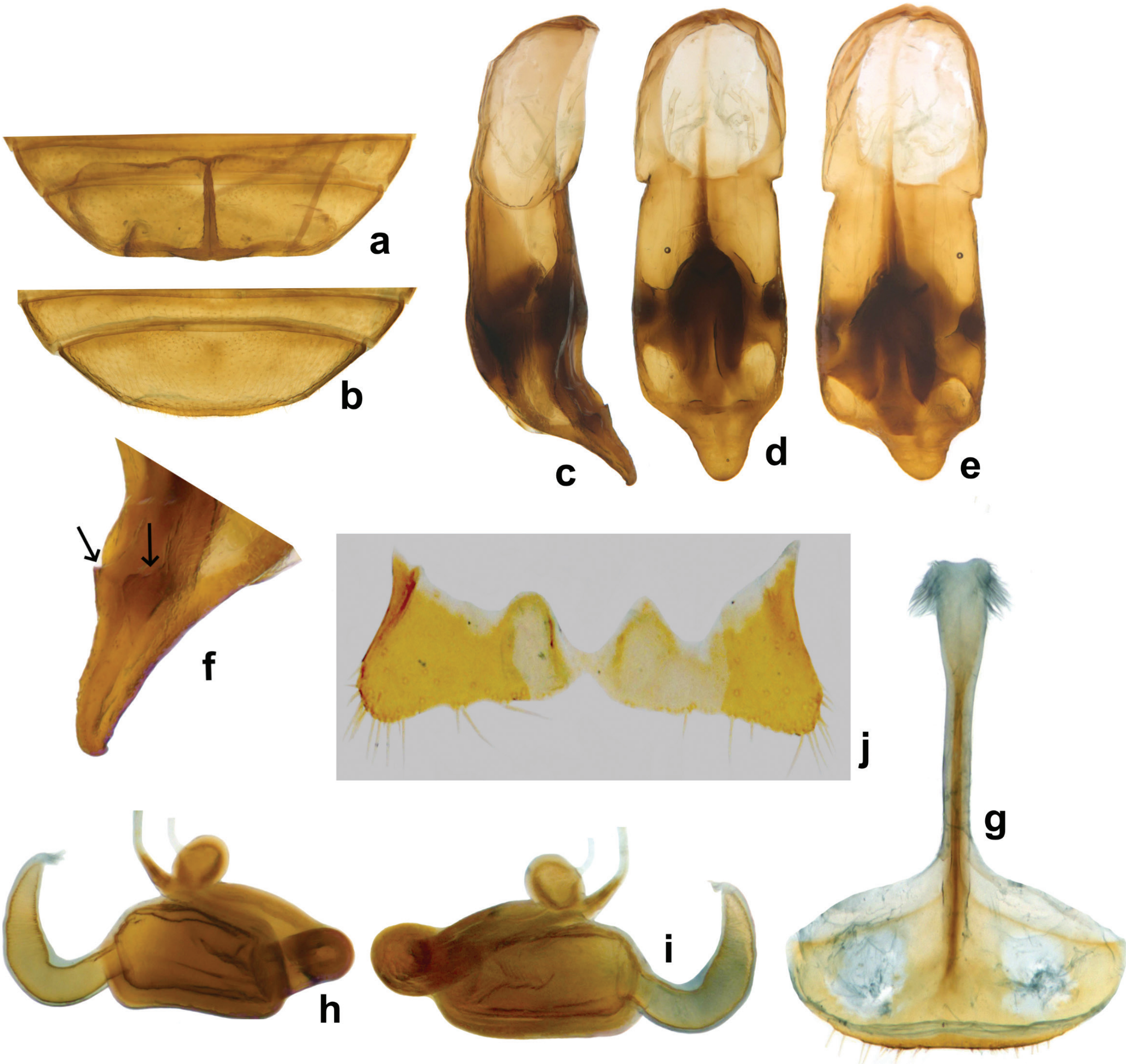

Figure 14. *Sphaeroderma cruenta* sp. nov. **a.** Abdominal apex, male; **b.** Abdominal apex, female; **c–f.** Male genitalia: **c.** Aedeagus, lateral view; **d.** Aedeagus, ventral view; **e.** Aedeagus, dorsal view; **f.** Aedeagus apex, lateral view; **g.** Tignum; **h, i.** Spermatheca; **j.** Vaginal palpi.

West Bengal, India, especially in size, coloration, structure of head and punctation. However, the pronotum is more narrowed anteriorly than in *S. mandarensis.* The male genitalia are diagnostic (Fig. 14c–f).

Description. Entirely red-brown (Fig. 13), except distal antennomeres darker. Length 2.97–3.33 mm, width 2.08–2.26 mm, ca 1.40× longer than broad. In lateral view, vertex and antennal calli form a gently curved line with an emargination at their meeting point; frontal ridge forms a strongly convex line that joins anterofrontal ridge at an obtuse angle. In frontal view (Fig. 13b), vertex gently convex on sides, flat in middle, with small punctures and indistinct rugosities. Antennal calli subhorizontal, laterally slightly narrower than medially, about twice wider than long, subquadrate. All sulci surrounding antennal calli well developed. Supracallinal sulcus gently convex. Supraorbital pore circular, with a long seta on a convex tubercle, not surrounded by shallow groove. Frontal ridge sharply raised, narrower ventrally than dorsally. Frontoclypeal suture with closely placed, irregularly arranged long setae. Anterior margin of clypeus straight. Frontolateral area concave, without long setae or bold punctures. Anterofrontal ridge poorly developed, not convexly raised. Distance between antennal sockets 0.84× diameter of a socket, antennal sockets separated from adjacent eye by a distance 0.36× transverse diameter of a socket. Labrum distinctly wider than long, anterior margin convex, with three pairs of transversely arranged setae.

Maxillary palpi with four palpomeres, penultimate palpomere being thicker and longer than last palpomere. First palpomere smallest, second subequal to last. Labial palpi three-segmented with the second palpomere thicker than last, subequal to last in length. Proportionate length of antennomeres I to XI: 1 : 0.61 : 0.57 : 0.61 : 0.74 : 0.70 : 0.74 : 0.70 : 0.70 : 0.70 : 1.09.

Pronotum (Fig. 13c) distinctly narrowed anteriorly, 0.38× times longer than wide, posterior margin 1.59× as wide as anterior margin, anterolateral corners only slightly produced forward, not reaching eye. Lateral margin gently and evenly curved, anteriorly as wide as posteriorly. Anterolateral callosity longer than wide, not forming denticle at pore, pore situated on posterior dorsal face of callosity. Posterolateral callosity not laterally protruding. Disc profusely covered with small punctures, much smaller than those on elytra.

Scutellum as broad as long, obtusely narrowed posteriorly, surface very minutely punctate. Elytra as broad as pronotum at basal margin, widening near humerus. Humerus convex, weakly depressed posteriorly. Elytra with a mixture of small and large punctures. Punctures confused, tend to form uncountable rows. Lateral most row regular, followed by one or two countable adjacent rows. Distance between adjacent punctures smaller than diameter of a puncture. Elytral apex convex. Maximum width of epipleura at anterior one-third; subequal to forefemur in width. Epipleura subhorizontal, narrowing posterior to anterior one-third, not reaching elytral apex.

Prosternum widened posteriorly, posterior margin concave medially, slightly depressed on top, setose with coarse shallow punctures. Mesosternum setose, transverse, with concave posterior margin. Metasternum with moderate sized, deep punctures, thickly setose on either side. First abdominal ventrite longest, 2–4 each shorter than fifth separately; fifth longer than preceding two combined, shorter than preceding three combined. Last visible tergite with a shallow groove along middle, not reaching apex. All tibiae with apical spine.

First pro-, meso-, and metatarsomeres slightly wider with capitate setae ventrally in male. In female, all first tarsomeres ventrally with pointed setae. Posterior margin of last ventrite entire in female, forms a lobe notched on either side in middle in male. Last ventrite internally with a longitudinal apodeme along mid-line in male (Fig. 14a), externally visible as a dark line; apodeme absent in female (Fig. 14b).

Male genitalia (Fig. 14c–f) with aedeagus in lateral view gently bent at middle (Fig.14c), apex acutely narrowed, recurved (Fig. 14f). In ventral view (Fig. 14d), ventral surface depressed preapically, narrowed to apex, forming a broad denticle. Dorsal side (Fig. 14e) of aedeagus convex, dorsal opening partially covered by a lamina; a characteristic, narrowly elongate, bifid sclerotization present preapically on dorsal side, it laterally extends forming an internal ring around aedeagus.

Female genitalia with spermathecal receptacle (Fig. 14h, i) 1.5× as long as broad, outer margin concave, inner margin convex; pump with unsclerotized denticle apically, horizontal part longer than vertical. Duct twisted proximally, curved over receptacle, reaching a little beyond middle of receptacle. Vaginal palpi (Fig. 14j) narrowly connected medially, both together 2.4× as wide as long. Tignum (Fig. 14g) straight, channeled along middle, gently broadened anteriorly, posterior membranous part broadened greatly with a few short setae along posterior margin, unsclerotized on either side of middle of posterior membranous part.

Etymology. The specific epithet is a Latin adjective in nominative case in reference to the reddish colour of this species.

Distribution. India (Meghalaya).

Biology. Adults feed on the foliage of banana (*Musa* spp.).

Key to chrysomelids feeding on bananas and plantains in the Indian Subcontinent

1 Form oblong-oval, metallic red and blue or entirely reddish, dark green, or blue (Fig. 1a–c). Antennal calli poorly developed, not delimited by deep sulci (Fig. 3a, b). Lateral margin of pronotum sharply angulate at distal-third (Fig. 3c, d). Elytra with a sharply raised costa/ridge running parallel with lateral margin to about middle (Fig. 2b). Forecoxal cavities closed behind. Legs with all femora dilated and ventrally with a small tooth, mid- and hind tibiae preapically emarginate (Fig. 3e, f) .... *Basilepta subcostata* (Jacoby)

– Form elongate-oval, entirely reddish to dark reddish brown, not metallic. Antennal calli well developed, delimited by deep sulci. Lateral margins of pronotum curved, not angulate. Elytra without a lateral ridge/costa. Forecoxal cavities open behind. Hind femora greatly enlarged compared to fore- and midfemora, tibiae preapically not emarginate, without a ventral tooth 2

2 Form broad oval, reddish to dark reddish brown (Fig. 10a, b). Anterolateral angles of pronotum distinctly produced forward (Fig. 10d, e); lateral margin of pronotum in dorsal view convex in proximal two-thirds, gently concave behind anterolateral callosity (Fig. 10e); male genitalia with apex of aedeagus gently recurved and slightly curved dorsad in lateral view (Fig. 12f); preapical, ring-like sclerotization absent on aedeagus (Fig. 12f–h); spermathecal duct not twisted promixally (Fig.12e) .... *Bhamoina varipes* (Jacoby)

– Form more elongate and less robust, entirely reddish (Fig. 13a). Anterolateral corners of pronotum rounded, not produced forward (Fig. 13c); lateral margin of pronotum in dorsal view evenly convex throughout; male genitalia with apex of aedeagus strongly bent ventrad in lateral view (Fig. 14c); a characteristic, narrowly elongate, bifid sclerotization present preapically on dorsal side of aedeagus (Fig. 14f), which laterally extends forming an internal ring around aedeagus; spermathecal duct twisted promixally (Fig. 14h, i) .... *Sphaeroderma cruenta* Prathapan & Kumari, sp. nov.

Molecular characterization of *B. subcostata*

In total 10 COI sequences of *B. subcostata* (six from Assam and four from Uttar Pradesh) were deposited in GenBank and accession numbers obtained (KY908365.1, MK414475.1, MK414474.1, MK414473.1, MK414472.1, K414470.1, MK414469.1, MK414468.1, MK414467.1 and MK414466.1). The pairwise nucleotide sequence identity of COI sequences of *B. subcostata* from Assam and Uttar Pradesh ranged from 98 to 100%, indicating that they were conspecific. The phylogenetic tree constructed by the maximum likelihood method based on COI gene sequence alignments revealed two clusters, with *B. subcostata* from Assam and UP forming one cluster (Group I), and the sequences from the outgroup taxa falling in another cluster (Group II) (Fig. 15).

Discussion

The chrysomelids recorded by us on banana here are also included in the host plants listed by Jolivet and Hawkeswood (1995). Of the three species of banana feeding chrysomelids studied by us, *B. subcostata* is the most predominant and widespread pest in northern and north-eastern regions of India and Bangladesh. The other two appear to be of minor importance as banana pests with a much more restricted distribution. *Bhamoina varipes* and *Sphaeroderma* are known from Thailand and Laos as defoliators of banana (Dean 1978; Hill 2008) but have not been reported from India until now. *Sphaeroderma cruenta* sp. nov. was collected from northeastern India; it still needs to be determined if the *Sphaeroderma* species reported from Laos (Dean 1978; Hill 2008; Vansilalom

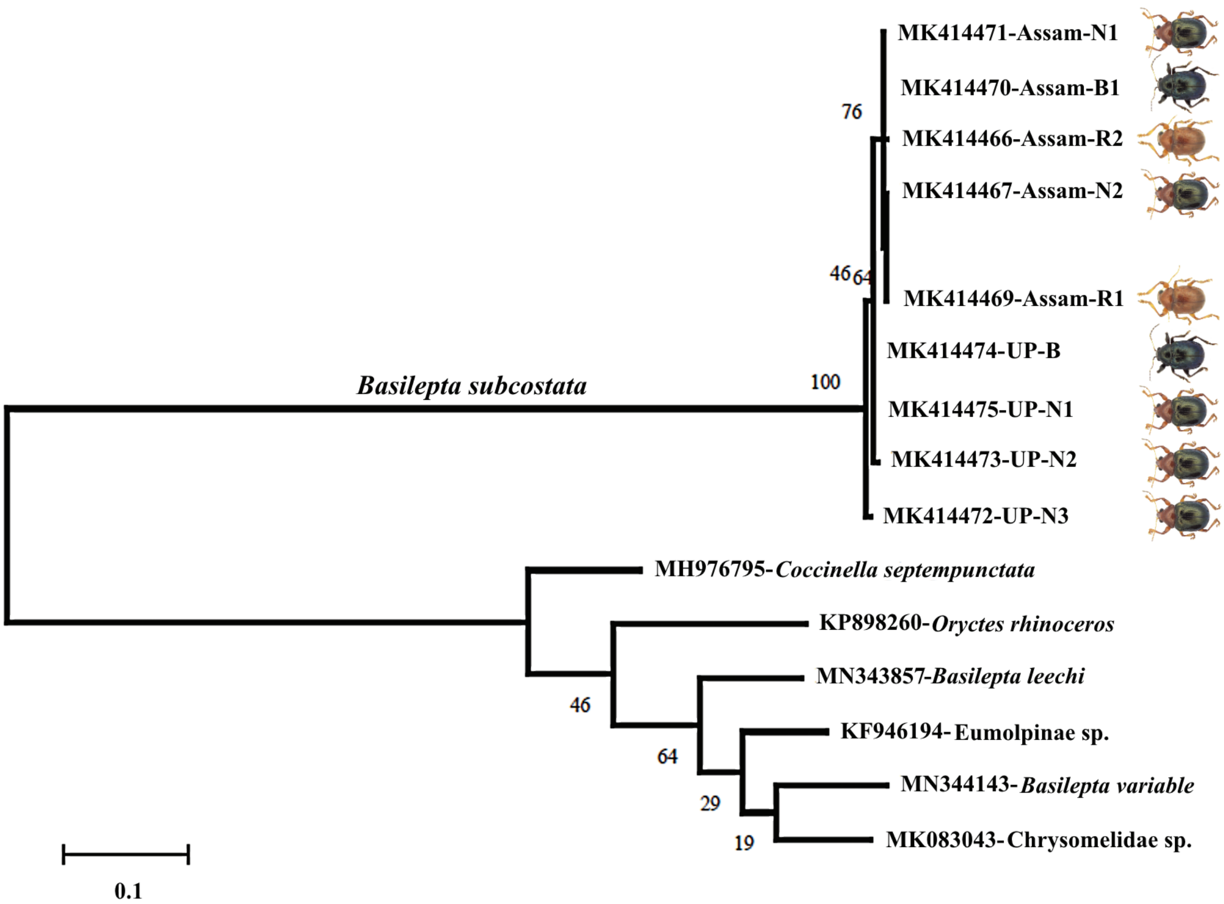

Figure 15. Maximum Likelihood phylogeny of *B. subcostata* populations from Assam and Uttar Pradesh, India. The evolutionary history was inferred by using the Maximum Likelihood method and Tamura-Nei model. The tree with the highest log likelihood (-3489.32) is shown. The percentage of trees in which the associated taxa clustered together is shown next to the branches. Initial tree(s) for the heuristic search were obtained automatically by applying Neighbor-Join and BioNJ algorithms to a matrix of pairwise distances estimated using the Maximum Composite Likelihood (MCL) approach, and then selecting the topology with superior log likelihood value. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. This analysis involved 16 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. There was a total of 660 positions in the final dataset. Evolutionary analyses were conducted in MEGA X.

2016) are conspecific with this new species or belong to a different species.

It is noteworthy that three species of chrysomelids belonging to two systematically distant subfamilies (Galerucinae and Eumolpinae) are feeding on the same host plant. More studies are needed to determine the nature and extent of damage to bananas caused by *B. varipes* and *S. cruenta* sp. nov. and to clarify their distribution in India, as they are not common pests. Taro (*Colacasia esculenta* L.) has been recorded as a host plant of *B. subcostata* [as "*Nodostoma subcostatum*"] in West Bengal (Bhattacharyya and Mandai 2006) and Manipur (Prasad and Singh 1987). We observed a few adults resting on taro, which is commonly grown with banana in homesteads and as an intercrop, but did not see any feeding damage. There is some doubt regarding the reliability of records of *B. subcostata* from Nepal (Medvedev 1990), as the specimens are not conspecific with *B. subcostata* and seem to belong to the genus *Pseudostonopa* Jacoby, 1903, which is closely related to *Basilepta* and probably can be included as a subgenus (Alexey Moseyko, personal communication). However, the specimens in the holdings of BMNH studied by JP seem to be conspecific with *B. subcostata.* The elytral costa characteristic of *B. subcostata* is highly variable in different populations and is distinctly convex and strongly sinuate in the female syntype (BMNH) and other specimens from Myanmar, but the Indian specimens have only a moderately convex and less sinuate costa. COI sequences of *B. subcostata* populations from Assam and Uttar Pradesh showed 98–100% similarity indicating they are conspecific and can be used as a rapid diagnostic tool by economic entomologists and plant protection workers. Morphological studies also did not show any major variations among different populations of *B. subcostata* and the genitalia of material from all locations surveyed were identical.

Although *Basilepta subcostata* is known to be a serious pest of bananas and plantains in the northeastern, eastern, and northern regions of India, there is no published record of its occurrence in any part of peninsular India. However, two specimens collected on banana from Vittal, Karnataka (South India), and one specimen from "Deccan" were examined by JP in the collections of the Natural History Museum, London. These specimens indicate that this pest is present in peninsular India albeit in very small numbers and highlights the importance of museum collections in determining the geographic range of economically important insect pests. Its occurrence in peninsular India is a major concern for banana growers, and it is essential to conduct more systematic surveys to acquire data on the extent of its presence there. Plant protection workers and applied entomologists in peninsular India need to be alerted about the presence of *B. subcostata*, as it is virtually unknown in peninsular India, although it has a huge potential to cause devastation. Management options for *B. subcostata* mainly involve removal of grassy weeds, application of insecticides, neem-based biopesticides, entomofungal pathogens like *Beauveria bassiana*, and covering fruit bunches with polythene sleeves (Das and Baruah 2018; Rituraj et al. 2018). Soil application of entomofungal pathogens and entomophilic nematodes targeting the larvae and pupae may be more effective in controlling this pest.

It is a matter of concern that systematic revisions of pests and related species important in agriculture and horticulture are lacking in biodiversity-rich countries like India, as well as the rest of Asia, and even for cash crops like banana. The International Plant Protection Convention (IPPC) stipulates that contracting parties should "conduct surveillance for pests and develop and maintain adequate information on pest status in order to support categorization of pests, and for the development of appropriate phytosanitary measures" (Cock 2011: 22) which can be done only if a country's pests, including newly introduced ones, can be identified and necessary facilities like reference collections and diagnostic capabilities are put in place (Cock 2011). The clarification of the nomenclature of leaf and fruit feeding chrysomelids of the Indian region provided in this paper is essential for future phytosanitary, quarantine and management purposes, as most of the available literature on *Basilepta* spp. as banana pests in Asia use wrong names, and we hope the illustrations provided here and the COI sequences will be useful for economic entomologists and non-taxonomists in identifying these insects. Future studies, including further field surveys and focused systematic studies, for identifying the chrysomelid species feeding on banana in other Asian countries are much needed.

Acknowledgements

We thank Dr S. Uma, Director, ICAR-National Research Centre for Banana, Trichy, for the facilities and support in carrying out this work. The second author gratefully acknowledges the Museum of Comparative Zoology, Harvard University, Massachusetts, for enabling her visit to Natural History Museum, London, funded by an Ernst Mayr travel grant and Dr Max Barclay, Dr Michael Geiser, and Dr Keita Matsumoto of the Natural History Museum, London, for facilitating the study and imaging of type material of Chrysomelidae. We thank the Museum für Naturkunde, Berlin, for waiving the fees for publishing this paper. We are grateful to Dr Elisabeth Geiser and an anonymous reviewer for their thorough and constructive reviews which greatly helped in improving the manuscript.

References

Ahmad MA, Singh PP, Singh B (2003) Efficacy of certain synthetic insecticides and plant products used as foliar and whorl application against the scarring beetle (*Nodostoma subcostatum* Jacoby) on banana. Journal of Entomological Research 27: 325–328.

Ahmad MA, Mandal SK, Mukherjee U (2010) Population dynamics of *Basilepta subcostatum* Jacoby on banana. Annals of Plant

Protection Sciences 18: 349–352. https://doi.org/10.5958/0974-8172.2015.00047.4

Ahmed A (1963) Notes on the Biology of Banana Leaf and Fruit Beetle, *Nodostoma viridipennis* Mots. A review of research, Division of Entomology. Published by Agricultural Information Service, Dhaka, 187–190.

Baly JS (1867) Phytophaga Malayana; a revision of the phytophagous beetles of the Malay Archipelago, with descriptions of the new species collected by Alfred R. Wallace. Transactions of the Entomological Society of London 4(3): 1–300. https://biodiversitylibrary.org/page/14694380

Batra HN (1952) Occurrence of three banana pests of Delhi. Indian Journal of Entomology 14: 1–60.

Bechyné J (1958) Contribution à l'etude des Chrysomeloidea des lies Mascareignes. II. Alticidae. The Mauritius Institute Bulletin 5(3): 83–93.

Bhattacharyya A, Mandai SK (2006) Pests infesting tare (*Colocasia esculenta* L.) in West Bengal. Indian Agriculturist 50: 153–156.

Choudhary SK, Mukherjee U, Ahmed MDA (2010) Efficacy of biopesticides against banana scarring beetle, *Basilepta subcostatum* Jacoby. Pest Management in Horticultural Ecosystems 16(2): 120–123. http://www.aapmhe.in/index.php/pmhe/article/view/106

Chûjô M (1964) Coleoptera from Southeast Asia. 32. Chrysomelidae. Nature & Life SE Asia 3: 252–315.

Cock MJW (2011) Strategic entry points for funding taxonomic support to agriculture in developing countries. CABI Working Paper 3: 1–32. https://www.cabi.org/Uploads/CABI/expertise/CABI-WP3-TaxAg.pdf

Cruz-Zapata G de la, Moreno-Jiménez M, Osorio-Osorio R, Hernández-Hernández LU, Márquez-Quiroz C, Cruz-Lázaro E de la, Valdez-Carrasco JM (2018) Fruit-scarring beetle *Myochrous melancholicus* Jacoby as a potential new pest of banana. Southwestern Entomologist 43(1): 57–66. https://doi.org/10.3958/059.043.0124

Das D, Baruah K (2018) Management of banana leaf and fruit scarring beetle *Nodostoma viridipennis* Motsch. in Assam. Indian Journal of Entomology 80(3): 703–705. https://doi.org/10.5958/0974-8172.2018.00226.2

Dean GJ (1978) Insects found on economic plants other than rice in Laos. PANS 24(2): 129–142. https://doi.org/10.1080/09670877809411603

Döberl M (2010) Subfamily Alticinae Newman, 1835. In: Lobl I, Smetana A (Eds) Catalogue of Palaearctic Coleoptera (Vol. 6). Apollo Books, Stenstrup, 491–562.

Duvivier A (1885) Catalogue des chrysomelides, halticides et galerucides décrites. Mémoires de la Société Royale des Sciences de Liège 2 11(15): 1–64. https://biodiversitylibrary.org/page/27434462

FAOSTAT (2019) Food and Agriculture Data. http://www.fao.org/faostat/en/#home [Accessed on: 18-11-19]

Gowdey CC (1926) The banana fruit-scarring beetle (*Colaspis hyperchlora*, Lef.). Bulletin of Entomological Research 17: 1–137. https://doi.org/10.1017/S0007485300019167

Hill DS (1983) Agricultural Insect Pests of the Tropics and Their Control. Cambridge University Press, Cambridge, 758 pp.

Hill DS (2008) Pests of Crops in Warmer Climates and Their Control. Springer, Dordrecht, 679 pp. https://doi.org/10.1007/978-1-4020-6738-9

ICAR-National Research Center for Bananas (2019) Banana fruit and leaf scarring beetles, *Basilepta* spp. http://nrcb.res.in/album/Fruit%20and%20leaf%20scarring%20beetles/index.html

Jacoby M (1884) Description of new genera and species of phytophagous Coleoptera collected by Dr. B. Hagen at Serdang (East Sumatra). Notes from the Leyden Museum 6: 201–230. https://biodiversitylibrary.org/page/9635686

Jacoby M (1889) Viaggio di Leonardo Fea in Birmania e Regioni Vicine, 17. List of the Phytophagous Coleoptera obtained by Signor L. Fea at Burmah and Tenasserim, with descriptions of the new species. Annali del Museo Civico di Storia Naturale de Genova, ser. 2, 27: 147–237. https://biodiversitylibrary.org/page/35995817

Jacoby M (1892) Description of the new genera and species of the phytophagous Coleoptera obtained by Sign. L. Fea in Burma. Annali del Museo Civico di Storia Naturale di Genova 32: 869–999. https://biodiversitylibrary.org/page/30084319

Jacoby M (1900) New species of Indian Phytophaga principally from Mandar in Bengal. Mémoires de la Societe Entomologique de Belgique 7: 95–140. https://biodiversitylibrary.org/page/10981179

Jacoby M (1903) Descriptions of the new genera and species of phytophagous Coleoptera obtained by Mr H. L. Andrewes and Mr T. R. D. Bell at the Nilgiri Hills and Kanara. Annales de la Société Entomologique de Belgique 47: 80–128. https://biodiversitylibrary.org/page/12371882

Jacoby M (1908) The Fauna of British India Including Ceylon and Burma. Coleoptera. Chrysomelidae (Vol. 1). Taylor and Francis, London, 534 pp. https://biodiversitylibrary.org/page/50883892

Jolivet P, Hawkeswood TJ (1995) Host-Plants of Chrysomelidae of the World: an Essay About the Relationships Between the Leaf-Beetles and Their Food-Plants. Backhuys Publishers, Leiden, 281 pp.

Jolivet P, Verma KK (2008) Eumolpinae – a widely distributed and much diversified subfamily of leaf beetles (Coleoptera, Chrysomelidae). Terrestrial Arthropod Reviews 1: 3–37. https://doi.org/10.1163/187498308X345424

Kimoto S (1967) A list of the chrysomelid specimens from the Himalayas and Kashmir, preserved in the Zoological Museum, Berlin. Esakia 6: 65–75. https://catalog.lib.kyushu-u.ac.jp/opac_download_md/2356/65.pdf

Kimoto S (2001) The Chrysomelidae (Insecta: Coleoptera) collected by the Kyushu University Scientific Expedition to the Nepal Himalaya in 1971 and 1972. Bulletin of Kitakyushu Museum of Natural History 20: 17–80. http://www.kmnh.jp/wp-content/themes/kmnh_jp/images/pdf/20-17-E-Kimoto.pdf

Kimoto S (2005) Systematic Catalog of the Chrysomelidae (Coleoptera) from Nepal and Bhutan. Bulletin of the Kitakyushu Museum of Natural History and Human History, Series A 3: 13–114. http://www.kmnh.jp/wp-content/themes/kmnh_jp/images/pdf/A3-13-E-Kimoto.pdf

Kimoto S, Gressitt L (1982) Chrysomelidae (Coleoptera) of Thailand, Cambodia, Laos and Vietnam. III. Eumolpinae. Esakia 18: 1–141. https://catalog.lib.kyushu-u.ac.jp/opac_download_md/2421/1.pdf

Konstantinov AS (1998) Revision of the Palearctic Species of *Aphthona* Chevrolat and Cladistic Classification of the Aphthonini (Coleoptera: Chrysomelidae: Alticinae). Memoirs on Entomology International (Vol. 11). Associated Publishers, Gainesville, 429 pp.

Kumar S, Stecher G, Li M, Knyaz C, and Tamura K (2018) MEGA X: Molecular Evolutionary Genetics Analysis across computing platforms. Molecular Biology and Evolution 35: 1547–1549.

Lefèvre E (1893) Contribution à la faune indo-chinoise. 12c Memorie (1). Clytrides & eumolpides (2[e] mémorie). Annales de la Société

Entomologique de France 62: 111–134. https://biodiversitylibrary.org/page/8236945

Maulik S (1926) The Fauna of British India, Including Ceylon and Burma. Coleoptera. Chrysomelidae (Chrysomelinae and Halticinae). Taylor and Francis, London, 442 pp. https://biodiversitylibrary.org/page/43810441

Medvedev LN (1990) Chrysomelidae from the Nepal Himalayas, II (Insecta: Coleoptera). Stuttgarter Beiträge zur Naturkunde, Serie A (Biologie) 453: 1–46. https://biodiversitylibrary.org/page/33385513

Medvedev LN (2000) Chrysomelidae from the Nepal Himalayas, with revision of the genus *Haplosomoides* (Insecta: Coleoptera). Stuttgarter Beiträge zur Naturkunde, Serie A (Biologie) 616: 1–32. https://www.naturkundemuseum-bw.de/sites/default/files/publikationen/serie-a/A616.pdf

Medvedev LN (2001) Jacoby's types of Chrysomelidae (Coleoptera) from Burma in the Museo Civio di Storia Naturale "Giacomo Doria", Genova Part 2. Annali del Museo civico di Storia naturale di Genova 93: 607–616.

Medvedev LN (2006) To the knowledge of Chrysomelidae (Coleoptera) described by V. Motschulsky. Russian Entomological Journal 15: 409–417. http://zmmu.msu.ru/files/images/spec/Russ%20Ent%20J/REJ_15-4_409-417%20%28Medvedev%29.pdf

Medvedev LN, Sprecher-Uebersax E (1999) Katalog der Chrysomelidae von Nepal. Entomologica Basiliensia 21: 261–354.

Mishra H, Bora DK, Bhattacharyya B, Das D, Baruah K (2015) Population dynamics of banana leaf and fruit scarring beetle, *Nodostoma subcostatum* Jacoby in Assam. Indian Journal of Entomology 77: 226–229. https://doi.org/10.5958/0974-8172.2015.00047.4

Moseyko AG (2008) The Reproductive Apparatus of Female Leaf Beetles (Coleoptera, Chrysomelidae) and its Importance for the Systematics of the Group. Unpublished PhD dissertation, Russian Acadamy of Sciences, Zoological Institute, St. Petersburg, 148 pp.

Moseyko A, Sprecher-Uebersax E (2010) Subfamily Eumolpinae Hope, 1840, In: Lobl I, Smetana A (Eds) Catalogue of Palaearctic Coleoptera (Vol. 6). Apollo Books, Stenstrup, 619–643.

Motschulsky V (1860) Dr. L. von Schrenk's Reisen und Forschungen im Amur-lande, II, 2, Coléoptères de la Sibérie Orientale et en Particulier des Rives de l'Amour. St. Petersburg, 77–258. https://biodiversitylibrary.org/page/33519815

Mukherjee U, Bharati RC, Arun K, Ranjan R (2006) Influence of weather factors on the incidence of scarring beetle, *Basilepta subcostatum* Jacoby (Coleoptera: Chrysomelidae) on banana in Bihar. Pest Management in Horticultural Ecosystems 12: 98–102. http://www.aapmhe.in/index.php/pmhe/article/view/614/569

Ostmark HE (1974) Economic insect pests of banana. Annual Review of Entomology 19: 161–176. https://doi.org/10.1146/annurev.en.19.010174.001113

Ostmark HE (1975) Banana pests in the genus *Colaspis*, including description of a new species (Coleoptera: Chrysomelidae). Florida Entomologist 58: 1–8. https://doi.org/10.2307/3493857

Prasad B, Singh OL (1987) Insect pests of banana and their incidence in Manipur. Indian Journal of Hill Farming 1: 71–73.

Promusa (2019) Promusa. http://www.promusa.org/Musapedia [Accessed on: 18-11-19]

Rahman MA, Hossain M, Islam KS (2004) Effectiveness of weeding and bunch covering in controlling banana leaf and fruit beetle, *Nodostoma viridipennis* Mots. Journal of Bangladesh Agricultural University 2(2): 237–243. https://ageconsearch.umn.edu/record/276357/?ln=en

Rituraj S, Bora DK, Baruah K, Mishra H (2018) Ecofriendly management of banana leaf and fruit scarring beetle *Basilepta subcostatum* Jacoby in Assam. Indian Journal of Entomology 80(3): 794–797. https://doi.org/10.5958/0974-8172.2018.00108.6

Sah SB, Prakash S, Parasnath, Kumar R (2018) Occurrence of leaf and fruit scarring Beetle, (*Basilepta* sp., *Colaspis* sp.) on banana in Koshi region of Bihar, India. International Journal of Current Microbiology and Applied Sciences, Special Issue 7: 2778–2784. https://www.ijcmas.com/special/7/Shyam%20Babu%20Sah,%20et%20al.pdf

Scherer G (1969) Die Alticinae des indischen Subkontinentes. Pacific Insects Monograph 22: 1–251. http://hbs.bishopmuseum.org/pim/pdf/pim22.pdf

Slipinski A, Escalona HE (2013) Australian Longhorn Beetles (Coleoptera: Cerambycidae) (Vol. 1). CSIRO Publishing, Melbourne, 504 pp. https://doi.org/10.1071/9781486300044

Sprecher-Uebersax E (1997) Blattkäfer aus Nepal in den Sammlungen des Naturkunde-museum Erfurt (Insecta: Chrysomelidae). Veroffentlichungen Naturkunde-museum Erfurt 453: 138–171.

Takizawa H (1987) Notes on chrysomelid beetles (Coleoptera: Chrysomelidae) of India and its neighboring areas. Part V. Proceedings, Japanese Society of Systematic Zoology 35: 40–58.

Vansilalom V (2016) Bananas, Laos and economic development: farming practice and farmers' perceptions. Ph.D. Thesis, James Cook University, Townsville. https://researchonline.jcu.edu.au/46825/

Verghese A, Kamala Jayanthi PD (2001) Integrated pest management (IPM) in major fruit crops. In: Reddy PP, Verghese A, Krishna Kumar NK (Eds) Integrated Pest Management in Horticultural Ecosystems. Capital Publishing Company, New Delhi, 23 pp.

Waterhouse DF (1993) The Major Arthropod Pests and Weeds of Agriculture in Southeast Asia: Distribution, Importance and Origin. Monograph No. 21, ACIAR, Canberra, 141 pp. https://www.aciar.gov.au/node/7856

Weise J (1922) Chrysomeliden der Indo-Malayischen Region. Tijdschrift voor Entomologie 65: 39–130. https://biodiversitylibrary.org/page/10857673

Wongsiri N (1991) List of Insect, Mite and Other Zoological Pests of Economic Plants in Thailand. Entomology and Zoology Division, Department of Agriculture, Bangkok.

Zahan ZMS, Ahad MA, Bari MS, Hossain MA, Islam MJ (2001) Estimation of yield and quality of banana fruit affected by banana leaf and fruit beetle, *Nodostoma viridipennis* (Coleoptera: Eumolpidae) in Bangladesh. Pakistan Journal of Biological Sciences 4: 1118–1119. https://doi.org/10.3923/pjbs.2001.1118.1119

Zahan ZMS, Ahad A, Bari S, Sardar MA (2003) Estimation of leaf damage of banana affected by banana leaf and fruit beetle, *Nodostoma viridipennis* Mots. (Coleoptera: Eumolpidae) in Bangladesh. Pakistan Journal of Scientific and Industrial Research 46(4): 261–264. http://agris.fao.org/agris-search/search.do?recordID=PK2004000101

Zahan ZMS, Ahad A, Bari S, Sardar MA (2004) Abundance and fruit damage estimation of banana leaf and fruit beetle, *Nodostoma viridipennis* (Coleoptera: Eumolpidae) on amrita sagar (*Musa* spp.) variety in Bangladesh. Journal of Science and Technology 2: 74–76.