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Taxonomic redescription of the coconut bark weevil (*Diocalandra frumenti*)

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Abstract

The taxonomic study was ultimately narrowed down to the 27 specimens of *Diocalandra frumenti* collected from four agroecological region of Kerala. All collected specimens were segregated into two different groups owing to their morphological variations. The present study includes detailed description of all the taxonomic characters like head, rostrum, (dorsal and lateral), antennae, pronotum, elytron, femur, tibia, tarsus, venter and genitalia and presented with 35 illustrations and 22 line diagrams. Taxonomic description of the species are supplemented with standard taxonomic terminology along with genital characters and loaded with the morphometric ratios. The taxonomic study revealed that, morphological variations present among the groups may be due to environmental conditions, availability of food, and life stage of the plant on which they are feeding on. All the variations within the species were depicted with the differential distinguishing characters along with line diagrams.

Keywords: Taxonomy, redescription, *Diocalandra frumenti*, Rhynchophorinae, weevil, coconut

Introduction

Coconut (*Cocos nucifera* L.) is grown in more than 90 countries in world with a total annual production of 55 trillion nuts (Jose *et al.*, 2008) [8]. Where 73% of nuts are produced by India, Philippines and Taiwan. Various insect pest attack the crop of which *Rhynchophorus ferrugineus* and *Diocalandra frumenti* are considered as the key pest of coconut (Jose *et al.*, 2008) [8]. Larvae of *Diocalandra frumenti* can bore galleries in any part of the palm: roots, petioles, inflorescences, fronds, leaf sheaths, fruits and to all heights of the trunk, thus causing indirect damage by inviting microbial infection besides debilitating the plants (Nunez *et al.*, 2002 [13]; Hill, 1983) [6].

Zimmerman (1993) [19] raised the Rhynchophoridae to family status within the super family Curculionoidea and proposed a new tribe, the Diocalandrini to include the genus *Diocalandra* with Arecaceae as hosts but excludes the seed and grain feeding genus *Sitophilus*. Zimmerman in his series of Australian Weevils III (1993) [19], suggested that spiculum gastrale (9th sternite) is deficient in both genera, *Diocalandra* and *Rhynchophorus*. Fabricius (1801) [3] described the bark weevil, *Calandra frumenti*; while the species was transferred to *Sitophilus* by Schoenherr in 1838. Later, Faust (1894) [4] erected new genus *Diocalandra* and included the species *frumenti* in it. In between 1950 to 2000 only 2 new species had been described under the genus *Diocalandra*.

A review work done on the taxonomy of this genera indicates that there are inadequacies which need to be addressed for streamlining the salient aspects. The available taxonomic information on is limited and lacking in essential diagnostic characters especially on genitalia, taxonomic terminology and require redefinition. Even in those where detailed descriptions are available, are lacking in morphometric ratios and need for more material and information. The genitalia diagrams available are incomplete, descriptions and diagrams are unsatisfactory. Keeping these in view, the present study is proposed to bridge glaring lacuna of taxonomic knowledge for important species *Diocalandra frumenti*. These weevils were collected from four different agroecological zones of Kerala and specimens were segregated into two different groups owing to their morphological variations and named in the alphabetical order as Group A and Group B.

Methodology

Live insects were collected from different agroecological zones of Kerala which later pinned, dried and stored for further studies. Collected specimens were run through the keys (Morimoto, 1978) [10] and specimens were identified. Further the identified specimens apparently resembling were pooled together according to morphological variations, and thus morphologically different groups were identified within the species. An accession number was

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allotted to every population (group).

The general morphological characters and genitalia were studied with the help of Leica M80 stereo zoom microscope. Photographs of habitus and genitalia were captured, using software Leica Application Suite (LAS) V4.4. Photographs of habitus of *Rhynchophorus ferrugineus* taken by Nikon L310 digital camera. The total length given in the description is excluding the rostrum, and standard length from anterior margin of pronotum to the end of pygidium. The illustrations were made by using tube fitted with a camera lucida and the scale of magnification are provided in the illustrations. For male and female genitalia study, terminologies of Zimmerman (1968) [18], Supare *et al.*, (1990) [16] and Thompson (1992) [17] were followed. Genitalic studies were carried out by the standard method of Supare *et al.*, (1990) [16].

Results

Diocalandra frumenti (Fabricius) (Plates 1, 2)

Synonyms: *Calandra frumenti* Fabricius, 1801: 438; Schoenherr, 1838: 982 (*Sitophilus*); Faust, 1894: 353

Sitophilus subfasciata Boheman in Schoenherr, 1938: 971; Csiki, 1936: 76

Sitophilus stigmaticollis Gyllenhal in Schoenherr, 1838: 972; Kolbe, 1910: 46 (*Calandra*); Hustache, 1925: 519

Sitophilus subsignata Boheman in Schoenherr, 1838: 973; Csiki, 1936: 77

Calandra punctigera Pascoe, 1885: 305; Csiki, 1936: 77

Diocalandra crucigera Motschulsky, 1858: 69; Csiki, 1936: 77

Diocalandra sechellarum Kolbe, 1910: 46; Csiki, 1936: 77

Digonistic characters

Elongated body, Last segment of club (tomentose) 0.2×–0.33× as long as club; head with fovea; head and rostrum not on same plane; head separated from rostrum by weak transverse depression at interocular region; third tarsal segment deeply bilobed. Rostrum apically more arcuate in case of female.

Description

General colour yellow to ferrugineous, with black markings on pronotum and elytron (Plate 2, A, B, C). *Head* dull black, coarsely punctate, with deep median sulcus; row of yellow, erect setae on either side; 3.8× as broad as long, dorsum partially covered with eyes, 0.1× as long as and 1.7× as broad as rostrum; frons separated from rostrum by weak transverse depression at interocular region. *Eyes* lateroventral, moderately flat, posteriorly approximating, 2.57× as long as broad. *Rostrum* black to ferrugineous, rounded transversely, more or less cylindrical, with deep depression between eyes; 0.78× as long as head and pronotum combined, 5.76× as long as broad basally; base 1.78× as broad as apex, moderately expanded in dorsal view, broadest at antennal insertion, 1.92× as broad as apex; dorsally and laterally dense deep punctures near base; dorsal punctures arranged in two rows on either side, lined parallel to central shiny region, extending upto apex, punctures finer and shallower towards apex; row of punctures extending backward, meets at interocular region forming transverse depression; in lateral view one row of punctures arranged on each side. *Scrobes* lateroventral, 3.93× as long as broad, dorsally enclosed, laterally concave (Plate 1, A, B, C, D). *Antennae* inserted 0.11× length from base of rostrum; scape clavate, strongly curved, shiny, impunctate, with small setae, 0.61× as long as funicle and club combined, 3.9× as long as broad; funicle with six antennomeres; all

antennomeres nearly conical, with sharp anterior edges, II antennomere 1.94× as long as I, III, IV and V, 1.6× as long as VI; antennomere V and VI subequally broad; V antennomere 1.67× as broad as I, II, III and IV; 0.60× club glabrous basally, 1.42× as long as broad, with circlet of setae, densely arranged on pubescent part (Plate 1, E).

Pronotum ferrugineous with triangular black spot, covering major area; coarsely punctate, with semi-rounded edges, basal part almost parallel-sided, narrowing down to a deep subapical constriction; dorsally flattened, 1.38× as long as broad, base 1.81× as broad as apex, uniformly punctate dorsally and ventrally, shallow punctures more broad at middle than lateral (Plate 1, F). *Scutellum*, subtriangular, 1.0× as long as broad.

Elytra punctatostriate, ferrugineous with edges black in colour, additional two spots at apical end and middle of elytron, rough in profile, nearly rectangular, gradually narrowing towards apex, clearly exposing pygidium; 3.7× as long as broad basally; base 1.11× and 1.76× as broad as middle and apex respectively; striae and intervals with broad quadrate punctures; alternate intervals more raised, bears shallow punctures with sparse row of erect clavate setae (Plate 1, G).

Sternum flattened. Pro, meso and metasternum with broad pits, metasternum centrally bears 0.37× long sulcus starts from posterior margin, fades away in middle; prosternum 2.46× and 1.73× as long as meso and metasternum respectively.

Legs densely punctate; procoxae raised; pro and mesocoxae cylindrical, metacoxae oval; pro, meso and metacoxae separated by 0.50×, 0.67× and 0.97× of breadth respectively; all femur laterally compressed, curved on outer side, distal end widened, bilobed apically, with groove, coarsely punctured, apically more dense in arrangement, clavate setae arising from puncture; meta femur 1.10× and 1.51× as long as pro and mesofemur respectively (Plate 1, H, I, J). *Tibia* moderately straight; uncinata, with sharp uncus arising from inner apical margin, apically curved downwards; along with uncus premucro arising from outer apical margin; punctures aligned into striae, arranged in four to five rows; meta tibia 1.07× and 1.16× as long as pro and mesotibia respectively, (Plate 1, K, L, M). *Tarsi* four segmented; tarsal segment III bilobed, matted with fine setae ventrally, extending to base; sclerotised extensions of IV tarsal segment distinctly separating bases of claws; tarsi of all three legs subequal, III tarsal segment 1.70× as broad as I and II, 2.30× as broad as IV; IV tarsal segment 1.92×, 3.60× and 1.71× as long as I, II, and III respectively; 0.7× and 0.58× as broad as II and III respectively (Plate 1, N, O, P).

Venter dull reddish brown with black patches, arcuate in profile, sternites uniformly punctate, setae arising from punctations, sulcus dividing sternite I and II not prominent, first sternite 1.52×, 3.96×, 4.73×, and 1.06× as long as II, III, IV and V, respectively (Plate 10, E). *Pygidium* ferrugineous to black, coarsely punctate, erect setae arranged in middle, extending in one row each laterally and two rows centrally; pygidium 0.94× as long as broad (Plate 1, Z).

Female genitalia (Plate 11): Spermatheca 'C' shaped having proximal arm 1.5× as broad and 0.75× as long as distal arm, subcylindrical; angle between proximal and distal arms acute; ramus well differentiated from nodulus, cornu pointed. Spiculum ventrale long-rectangular or more cylindrical, truncated posteriorly; arm 0.81× as long as basal plate and 1.5× as broad as spiculum ventrale basally, with setae at base; basal plate slender, spatulate with pointed apically, bifurcated, flattened, base fixed with sternite VIII (Plate 1, R, S, T, U).

Male genitalia (Plate 12): Spiculum gastrale abandoned. Aedeagus arcuate medially, base 0.85× as broad as median lobe apically, slightly arcuate at base, length: breadth ratio 3.67:1; apophyses 1.04× as long as median lobe, spatulate, apically globous; median lobe short, sturdy, sclerotized, with slight ventral curve. Tegmen with dorsal piece as broad as basal piece; parameres short, slender, apically pointed; manubrium elongate, slender, 0.95× as long as median lobe, 0.86× as long as apophyses, uniformly thick, with broadened, subconical apex (Plate 1, V, W, X, Y).

Total length: 2.11–2.45±0.18 mm; **Standard length:** 2.01–2.31±0.2 mm; **Breadth:** 0.62–0.75±0.09 mm.

Specimen examined: 3♀, 2♂, INDIA: Kerala: Kasargod: Padannakad, N 12° 15.423' E 075° 07.018', 13 m, 26.ii.2016, Coll. Arun Singh, Host: *Cocus nucifera* L.; 5♀, 3♂, Kasargod: RARS Pillicode, N 12°12.09420' E 075°09.78282', 25 m, 11.ii.2016, Coll. K. M. Sreekumar, Host: *Cocus nucifera* L.; 6♀, 8♂, Kottayam: RARS Kumarakom, N 09°37.650' E 076°25.871', 18.ix.2015, 3 m, Coll. Arun Singh, *Cocus nucifera* L.; 2♀, 1♂, Trivandrum: RARS Vellayani, N 8° 26.44' E 076° 59.33' 28m, 24.v.2016, Coll. Arun Singh, Feeding *Cocus nucifera* L.

Distribution: Australia, Bangladesh, Ecuador, Guam, India, Indonesia, Japan, Madagascar, Malaysia, Mauritius, Myanmar, Palau, Papua New Guinea, Philippines, Samoa, Seychelles, Singapore, Solomon Islands, Somalia, Sri Lanka, Taiwan, Tanzania (including Zanzibar) and Thailand. India:

Remarks: Body elongate subcylindrical. Black spots on pronotum and elytron vary in size and shape. Pronotum with small black spot to totally black. Elytron with laterally black margins, additionally apical end black in colour, with another black spot centrally. Elytron gives a vitae appearance due to alternate raised striae. Female have longer rostrum, 1.16× longer than male. All collected specimens were segregated into two different groups owing to their morphological variations. Groups were named in the alphabatcal order as Group A and Group B. Above description is based on individuals of Group A. In total 20 specimens studied under Group A. Differential distinguishing characters of three groups are compared in Table 1. Variations among these two groups can be discussed as follows;

Variation I (Group B)

Remarks: In total 9 specimens studied under this group. The characters of this group are similar with the Group A in many extents, the variations among the groups are as follows;

General colour dull black to ferrugineous (ferrugineous, with black patches in Group A), ovate, coarsely punctate (Plate 2, D, E, F). **Pronotum** black in colour, with traces of ferrugineous patch at apical end (ferrugineous, with triangular black patches at basal region in Group A).

Genitalia: There are no variations in genitalia observed.

Total length: 2.11–2.32±0.16 mm; **Standard length:** 1.98–2.23±0.18 mm; **Breadth:** 0.59–0.71±0.08 mm.

Specimens examined: 2♀, 1♂, INDIA: Kerala: Kasargod: Padannakad, N 12° 15.423' E 075° 07.018', 13 m, 26.ii.2016, Coll. Arun Singh, Host: *Cocus nucifera* L.; 2♀, 1♂, Kasargod: RARS Pillicode, N 12°12.09420' E 075°09.78282', 25 m, 11.ii.2016, Coll. K. M. Sreekumar, Host: *Cocus nucifera* L.; 1♀, Kottayam: RARS Kumarakom, N 09°37.650' E

076°25.871', 18.ix.2015, 3 m, Coll. Arun Singh, *Cocus nucifera* L.; 1♀, 1♂, Trivandrum: RARS Vellayani, N 8° 26.44' E 076° 59.33' 28m, 24.v.2016, Coll. Arun Singh, Feeding *Cocus nucifera* L.

Sexual dimorphism

Sexes can easily be separated on the basis of the rostral and pygidium characters. Rostrum in case of female is more slender shiny and apically arcuate; whereas in case of male, rostrum 1.10× broader than female, rough in texture with more prominent rugose punctures and apically not curved (Plate 1, A, B, C, D). Pygidium in case of female apically more pointed and bears dense row of setae apically, while male have very few setae at apical margin of pygidium.

Table 1: Comparison between differential distinguishing characters of two Groups of *Diocalandra frumenti* (Fabricius)

Characters	Group A	Group B
<i>Pronotum marking and colouration</i>	Triangular cum semi-rounded black spot basally, extending upto 0.6× length of pronotum from base	Dull black pronotum along with few small yellow to ferrugineous spots apically

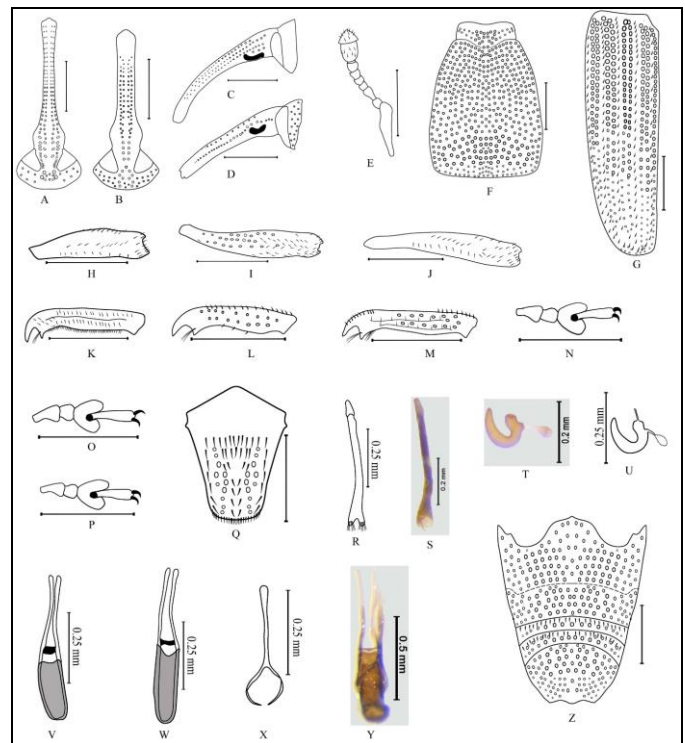


Plate 1. *Diocalandra frumenti*: (A)- (B) Rostrum, dorsal view; (A) ♀; (B) ♂; (C)-(D) Rostrum, lateral view; (C) ♀; (D) ♂; (E) Antenna; (F) Pronotum, dorsal view; (G) Elytron, dorsal view; (H) Profemur; (I) Mesofemur; (J) Metafemur; (K) Protibia; (L) Mesotibia; (M) Metafemur; (N) Protarsus; (O) Mesotarsus; (P) Metatarsus; (Q) Pygidium; (R)-(U) female genitalia, (R)-(S) Spiculum ventrale; (T)-(U) Spermatheca; (V)-(Y) male genitalia, (V) Aedeagus, dorsal view; (W) Aedeagus, ventral view; (X) Tegmen; (Y) Aedeagus and tegmen; (Z) Venter. Scale= 0.5mm.

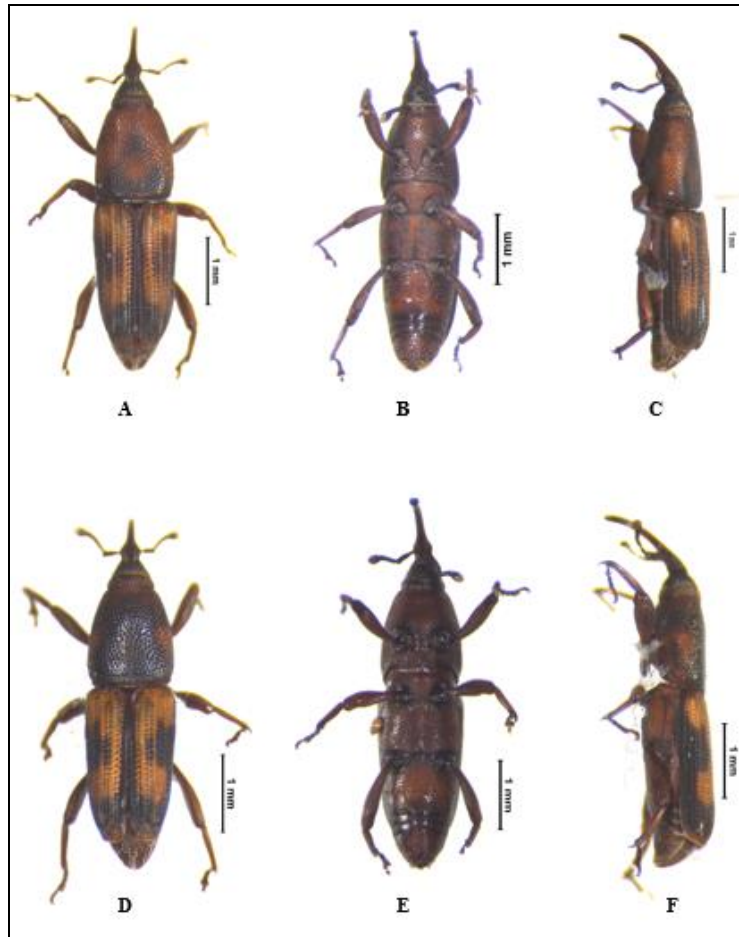


Plate 2: *Diocalandra frumenti*: Habitus; dorsal, ventral and lateral view; (A)-(C) Group A; (D)-(F) Group B.

Conclusion

Zimmerman (1993) [19] discussed about the characters of *D. frumenti* but the description lacks the detailed illustrations and morphometric observations. The species were lack of detailed taxonomic and genitalia illustrations. The present study corroborate the views of Fabricius (1801) [3], Faust (1894) [4] and Zimmerman (1993) [19] while rectifying the ambiguities and by covering descriptions, correcting line diagrams, in addition by giving genitalia characters, illustrations with detailed morphometric observations and photographs. The Present study includes the detailed morphometric observations along with the genitalia description using the standard taxonomic terms.

Colour morph was available in species but among the group, no difference was observed in genitalia characters. These particular coloured morphological variations may be recorded due to differential feeding or available food material (host plants). Variations may be due to the environmental variations in different zones of collection and the microclimatic conditions. The variations found among the different groups are compared in Table 1.

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