

**Morphology of adult and immature stages,
and host plant use of *Doubledaya sinuata*
(Coleoptera: Erotylidae: Languriinae)**

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Abstract. Morphology of larvae, pupae, adult female and male genitalia of *Doubledaya sinuata* Zia, 1934 (Coleoptera: Erotylidae: Languriinae) are described. The adults were found to be sexually dimorphic in external morphology, particularly in the shape of the head and mandibles: females have a large asymmetric head and mandibles; males have a symmetrical head with slightly asymmetric mandibles. Adult females of *D. sinuata* excavate holes with their mandibles on intermediate-sized internodes of recently dead culms of the bamboo *Sinobambusa sat* (Balansa) C. S. Chao & Renvoize, in order to deposit eggs on their inner surface. Larvae of *D. sinuata* consume tissues of the bamboo and complete the development within the internode. Significance of the asymmetric head and mandibular morphologies, oviposition preference and feeding habits of *D. sinuata* are discussed.

Key words. Coleoptera, Erotylidae, Languriinae, Languriini, lizard beetle, larva, pupa, immature stages, morphology, host plant, *Sinobambusa sat*, bamboo, sexual dimorphism, asymmetry, Vietnam, Oriental Region

Introduction

The lizard beetle tribe Languriini Crotch, 1873 (Coleoptera: Erotylidae), the most diversified tribe in the subfamily Languriinae, is distributed worldwide and contains 56 genera and more than 750 species (LESCHEN et al. 2010). However, the immature morphology and biology have been poorly investigated. Thus far, larvae in only five genera (*Caenolanguria*

Gorham, 1887, *Doubledaya* White, 1850, *Languria* Latreille, 1802, *Microlanguria* Lewis, 1884, *Teretilanguria* Crotch, 1876) have been described (BÖVING & CRAIGHEAD 1931, GARDNER 1931, RYMER-ROBERTS 1939, PETERSON 1951, GENUNG et al. 1980, HAYASHI 1986). Larvae of the Languriini are generally considered phytophagous and plant stem borers (LAWRENCE 1991, LESCHEN & WĘGRZYNOWICZ 1998, LESCHEN 2003, LESCHEN & BUCKLEY 2007, LESCHEN et al. 2010).

The genus *Doubledaya* in the tribe Languriini is distributed mainly in the Oriental Region and contains 40 species (LESCHEN & WĘGRZYNOWICZ 1998). Most members of the genus show remarkable morphological characteristics: female adults have a large asymmetric head with an enlarged left mandible (VILLIERS 1945). The asymmetric head of female *D. bucculenta* Lewis, 1884 is likely to be an adaptive morphology for excavating holes in bamboos for oviposition (TOKI & TOGASHI 2011, 2013). However, the significance of the asymmetric head of the congeneric species is still unknown due to lack of biological information. Most larvae of the Languriini, including those of *Doubledaya*, are expected to be phytophagous. Interestingly, however, larvae of *D. bucculenta* farm and consume a yeast symbiont inside bamboo internodes (HAYASHI 1974; TOKI & TOGASHI 2011; TOKI et al. 2012, 2013). *Doubledaya sinuata* Zia, 1934 was described based on a single male collected in Tam Dao, Vinh Phuc Province, Vietnam, with no biological information (ZIA 1934).

In this study, we describe larval, pupal, female and male genital morphologies of *D. sinuata* collected in Tam Dao. The external morphology is compared between male and female adults. In addition, we report the host plant use of *D. sinuata*.

Material and methods

The study of the biology of the immature stages and adults was conducted in three patches of the bamboo *Sinobambusa sat* (Balansa) C. S. Chao & Renvoize (Poaceae) in Tam Dao, Vinh Phuc Province, Vietnam, between 19th and 26th April 2011.

Adults were obtained on recently dead culms of *S. sat*. Body and elytral lengths are defined as the distance between the apices of the mandibles and the elytral apices at midline, and the distance between the anterior margin of the elytra and the elytral apices at midline, respectively, and were measured using digital calipers. Mandibular length were determined using images taken under a stereo microscope with a digital camera, E-330 (Olympus, Tokyo, Japan) in the same manner as TOKI & TOGASHI (2011). When female adults were found boring oviposition holes, brief observations were made to determine the sequence of oviposition behaviors.

Larvae were obtained from recently dead internode cavities of *S. sat*. Some were reared in laboratory to obtain pupae and adults to confirm they were *D. sinuata*. Larval and pupal specimens were preserved in 70% ethanol. Body lengths for larvae are defined as the distance between the anterior margin of the epistome and the abdominal apices, and the distance between the anterior margin of head and the abdominal apices for pupae. Measurements were taken using digital calipers.

The specimens examined are deposited in the collections of Susumu Matsuo, Nagasaki, Japan (SMNJ), Wataru Toki, Shiga, Japan (WTSJ), or the following public collection: Ehime University Museum (EUM). Abbreviations in square brackets indicate the depositories of the specimens.

To examine the host plant use of *D. sinuata*, 13 recently dead culms of *S. sat*, some of which were artificially cut, were taken at random from the patches for measurement. The length, central diameter and wall thickness of internodes and the numbers of oviposition marks (OMs) were recorded for the internodes of each culm. OMs were divided into completed oviposition marks (COMs) and incomplete ones. The former is characterized by a hole reaching the internode cavity. The latter is a small depression, the bottom of which does not reach the cavity, indicating it was left behind due to cessation of the ovipositional behavior. The internodes were dissected to investigate the number of individuals and developmental stages of *D. sinuata* present. The cavity volume was calculated from the length (L) and diameter (D) of the cavity using an equation of $\pi LD^2/4$. To determine the spatial distribution patterns of OMs and COMs among *S. sat* internodes, Morisita's I_0 index (MORISITA 1959) was calculated. The I_0 values less than 1, equal to 1, and more than 1 represent uniform, random, and clumped distributions, respectively.

Results

Doubledaya sinuata Zia, 1934

(Figs 1–34)

Doubledaya sinuata Zia, 1934: 27, 29, Figs 63–64; VILLIERS (1945: 192, 193, Fig. 363).

Specimens examined. VIETNAM: VINH PHUC PROVINCE: 7 ♂♂ 10 ♀♀ (WTSJ), Mt. Tam Dao, ca. 1000 m altitude, 21°28'N, 105°38'E, 19. iv. 2011, Wataru Toki leg.; 1 ♀ 1 ♂ ex pupa (WTSJ), same locality and same collector, 21.iv.2011; 2 ♂♂ 2 ♀♀ (WTSJ), same locality and same collector, 24.iv.2011; 1 ♂ ex pupa, 4 mature larvae (1 dissected) (WTSJ), same locality, 21.iv.2011, Susumu Matsuo leg.; 1 ♀ (SMNJ), same locality and same collector, 24.iv.2011; 6 ♂♂ (WTSJ), Tam Dao Town, ca. 1000 m altitude, 21°27'N, 105°38'E, 20. iv. 2011, Wataru Toki leg.; 1 ♂ 1 ♀ (SMNJ), same locality and same date, Susumu Matsuo leg.; 5 ♂♂, 3 ♀♀, 1 ♂ ex pupa, 1 ♀ ex pupa (WTSJ), Tam Dao Town, ca 550 m altitude, 21°26'N, 105°37'E, 22. iv. 2011, Wataru Toki leg.; 3 ♂♂ 1 ♀ (WTSJ), same locality and same collector, 26.iv.2011; 2 ♂♂ 1 ♀ (WTSJ), same locality, 22. iv. 2011, Hoang Long leg.; 1 ♂ (SMNJ), same locality, 22. iv. 2011, Susumu Matsuo leg.; 1 ♂ 1 ♀ (EUM), Tam Dao Town, ca. 750 m altitude, 21°26'N, 105°38'E, 23.iv.2011, Wataru Toki leg.; 16 ♂♂ 9 ♀♀ (WTSJ), same locality, same date and same collector; 2 ♂♂ 2 ♀♀ (WTSJ), same locality, 26.iv.2011, Hoang Long leg.; 1 ♀ (SMNJ), same locality and same date, Susumu Matsuo leg.

Redescription of adult. Female. Body length = 8.60–13.66 mm (n = 33). Elytral length = 5.92–9.60 mm (n = 33).

Body (Fig. 1) elongate, subparallel-sided, lustrous. Coloration almost reddish orange to reddish brown though rather dark in specimens; apices of mandibles, antennae excepting the bases, apical part of elytra, legs excepting coxae black.

Head (Fig. 2) very large, convex, transverse, strongly asymmetric, dilated on left side, densely and finely punctate. Clypeus triangular, strongly asymmetric, dilated on right side of anterior margin, delimited by a transverse impressed line. Eyes large, prominent, finely faceted. Frons with a deep longitudinal ocular stria. Mandibles strongly asymmetric (mean length \pm SD = 1.48 \pm 0.15 mm, range = 1.26 to 1.69 mm, n = 5 for left; 1.14 \pm 0.13 mm, range = 0.94 to 1.19 mm, n = 5 for right); outer edges straight excepting for apices. Antennae (Fig. 3) not reaching basal margin of pronotum, with 5 segmented clubs; segment II > III = IV = V = VI; segment VII dilated terminally, but longer than wide; segment VIII as long as wide or slightly wider than long, distinctly wider than VII, much narrower than IX; segments

IX and X strongly transverse in each; segment XI rotundate-ovate, a little narrower than X.

Pronotum (Fig. 4) wider than long, the widest at middle of lateral sides, convex, densely and finely punctate, with a pair of long foveae divergent anteriorly at basal area; anterior margin almost straight; lateral side distinctly marginate, arcuate, slightly sinuate just before posterior angles; basal margin distinctly marginate, distinctly arched posteriorly at median part, gently arched forwardly at each lateral part; anterior angles not projected, rounded; posterior angles projected, pointed. Prosternal process (Fig. 5) short, subparallel-sided, with distinctly sinuated lateral margins.

Scutellar shield pentagonal (Fig. 6), short. Elytra (Figs 6, 7) strongly elongated, mostly subparallel-sided, narrowed apically at posterior part, marginate at basal and lateral border, each with eight punctual striae which are disappeared at posterior area, the intervals impunctate and smooth; basal area strongly depressed; apices slightly divergent at suture, distinctly arched posteriorly at the median part and gently arched forward at each lateral part, each with a very fine and inconspicuous inner tooth and short outer one.

Legs (Fig. 1) rather long and robust; femora smooth; tibiae smooth, a little curved inward; protarsi much wide; mesotarsi wide.

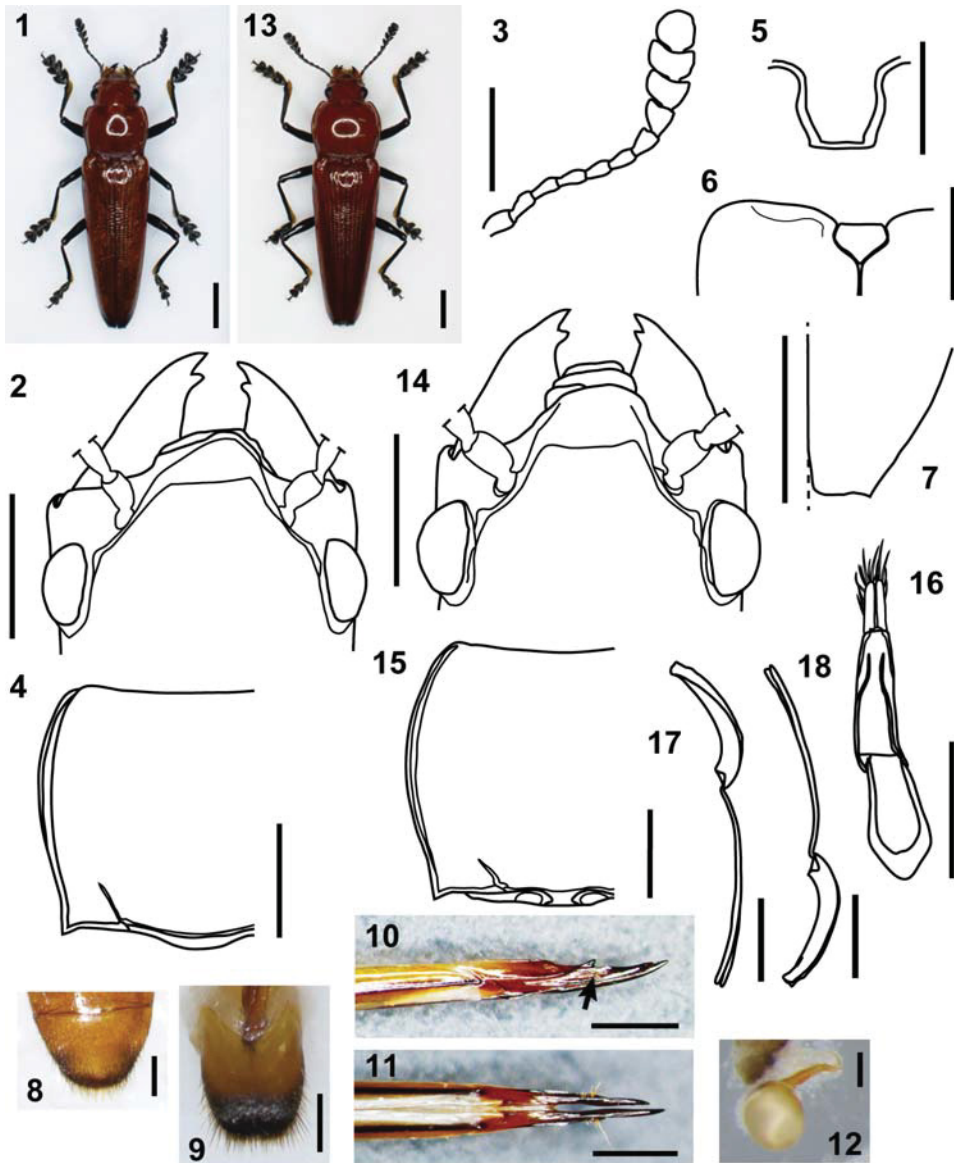
Caudal margin of sternite VII (Fig. 8) arcuate, very closely pubescent and punctate, but medio-basal area impunctate and smooth. Abdominal segment VIII (Fig. 9) parallel-sided, narrowed apically at the posterior part where very closely pubescent and punctate; basal margin strongly V-shaped. Ovipositor (Figs 10, 11) straight, long, narrow, slightly curved dorsally at apical part. Gonocoxite acute, with a pair of short triangular processes projecting dorso-apically on dorsal side near apex; right gonocoxite rather longer than left one; setae present near stylus. Stylus very short, with long setae, located subapically (Fig. 10). Spermatheca (Fig. 12) curved and elongate, with apex spherically-expanded.

Male. Body length = 8.58–14.09 mm ($n = 46$). Elytral length = 5.98–9.56 mm ($n = 46$) (Fig. 13). Male is similar to female in general appearance except for the following characters:

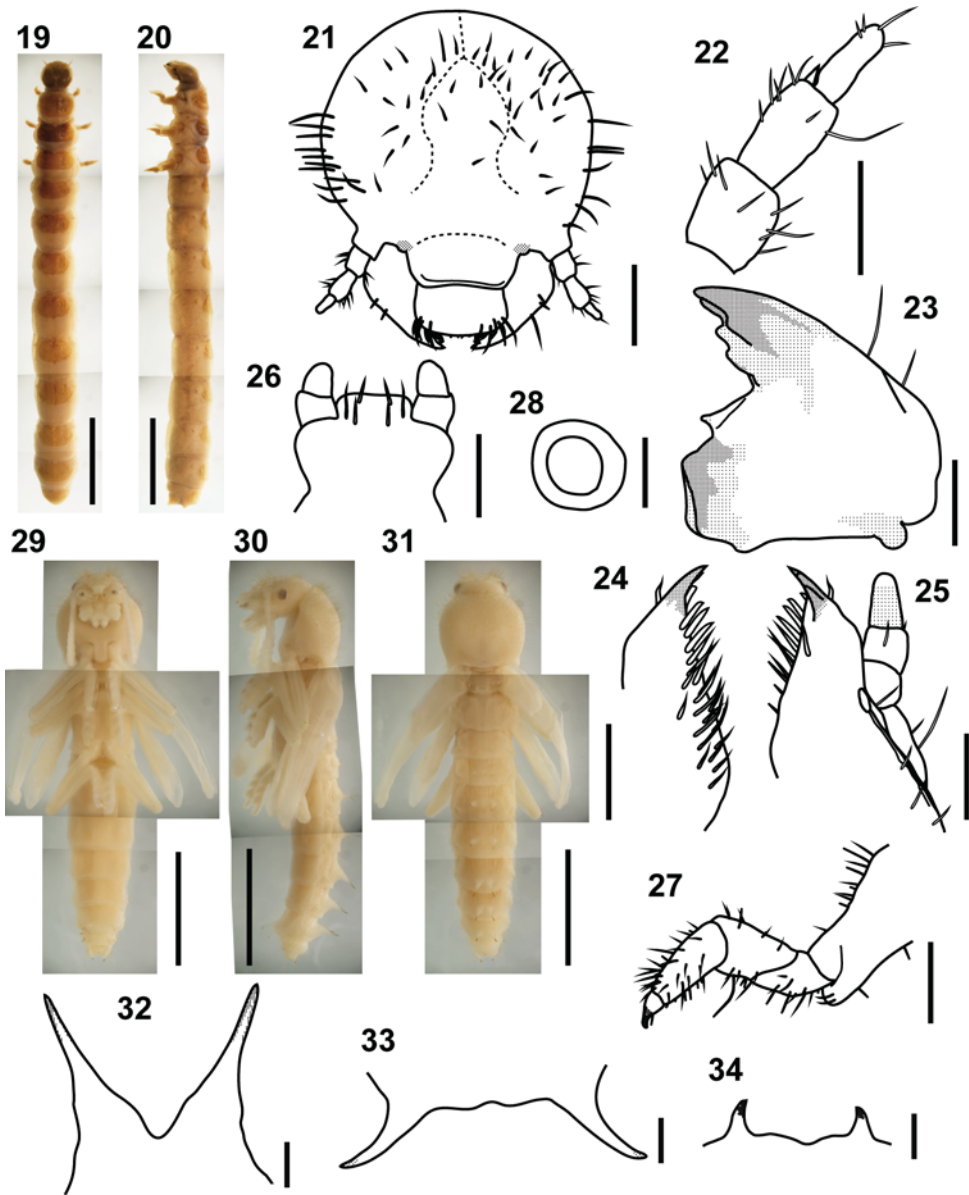
Head (Fig. 14) small, symmetric. Clypeus trapezoid-like. Eyes larger than in female, strongly prominent. Mandibles slightly asymmetric (mean length \pm SD = 1.17 ± 0.14 mm, range = 1.00 to 1.35 mm, $n = 5$ for left; 1.03 ± 0.13 mm, range = 0.86 to 1.09 mm, $n = 5$ for right); outer edges curved outward. Pronotum (Fig. 15) large, strongly convex; lateral side strongly arcuate; basal margin protruded outwardly at the median part. Legs (Fig. 13) longer than female; front femora finely serrate along the inner edge; front tibiae finely serrated along the inner edge; pro- and meso- tarsi moderately wide.

Male genitalia. Abdominal segment VIII parallel-sided, narrowed apically at the posterior part where very closely pubescent and punctate; basal margin strongly V-shaped. Tegmen (Fig. 16) ventrally with a pair of sclerotized ridges in middle, slightly twisted, enclosing median lobe; each lateral lobe flattened, stout, with long setae at apical part. Median lobe (Figs 17, 18) long, flat, curved laterally; apex weakly arcuate; penile struts approximately 1.5 times as long as the length of median lobe excluding penile struts.

Differential diagnosis. Although *D. sinuata* is very close to *D. mouhoti* Crotch, 1876 (VILLIERS 1945), it can be distinguished from *D. mouhoti* in both sexes by the following characteristics: apices of elytra (Fig. 7) sinuate (truncate in *D. mouhoti*); abdominal ventrites reddish orange



Figs 1–18. *Doubledaya sinuata* Zia, 1934, adult female (1–12) and male (13–18). 2, 14 – head, dorsal view; 3 – right antenna, dorsal view; 4, 15 – pronotum; 5 – prosternal process; 6 – anterior part of elytron with scutellum; 7 – apices of elytron; 8 – abdominal segment VII, ventral view; 9 – abdominal segment VIII, dorsal view; 10 – apex of ovipositor, left lateral view; 11 – apex of ovipositor, ventral view; 12 – spermatheca; 16 – tegmen, ventral view; 17–18 – median lobe, dorsal (17) and ventral (18) views. An arrow indicates gonostylus. Scale bars = 2.0 mm (1, 13), 1.0 mm (2–7, 14–18) 0.5 mm (8–11), 0.1 mm (12).



Figs 19–34. *Doubledaya sinuata* Zia, 1934, larva (19–28) and pupa (29–34). 19–20 – larva, dorsal (19) and left lateral (20) views; 21 – head; 22 – right antenna, dorsal view; 23 – left mandible, ventral view; 24–25 – left maxilla, dorsal (24) and ventral (25) views; 26 – labium, ventral view; 27 – right front leg, anterior view; 28 – spiracle of abdominal segment I; 29–31 – pupa, ventral (29), left lateral (30) and dorsal (31) views; 32 – spines on abdominal tergite VII, posterior view; 33 – spines on abdominal sternite VII, posterior view; 34 – urogomphi, dorsal view. Scale bars = 5.0 mm (19–20, 29–31), 0.5 mm (21, 27), 0.2 mm (22–26, 32–34), 0.1 mm (28).

to reddish brown (black in *D. mouhoti*). Those two species are distinguishable from most other *Doubledaya* species by the following characteristics: outer apex of elytra acute (round in others), coloration of elytra light (dark in others).

Description of mature larva. Body length: 22.86–26.24 mm (n = 3).

Body (Figs 19, 20) pale yellow though rather dark in specimens, elongate, subcylindrical, suffused with fine setae; thoracic segments I–III and abdominal segments I–IX pigmented dorsally.

Head (Fig. 21) globular, slightly depressed dorsally; lateral sides evenly rounded; epicranial stem and frontal arnes obscure, the latter being lyriform; endocarina absent; frons and clypeus confluent. Ocelli absent. Antennae (Fig. 22) 3-segmented; segment I slightly longer than broad; segments II and III longitudinal. Labrum nearly twice as wide as long, slightly constricted basally; cephalic margin with a number of setae. Mandibles (Fig. 23) symmetric, wedge-shaped, with two large apical and two small subapical teeth; apical teeth stout, finely curved inward; molar part moderately developed, projecting inward; prosthema broadened basally and pointed apically. Maxillae (Figs 24, 25) rather stout; palpus 3-segmented; segment I as long as II and shorter than III; segment III pigmented; palpifer large and located outside stipes; mala tridentate apically, bearing setae along inner margin of dorsum; stipes elongate. Labium (Fig. 26) with prementum transverse; palpi 2-segmented, far separated from each other; ligula developed and reaching the level of apical margin of segment II.

Thoracic segments transverse, with a pair of slight impressions on each tergite. Legs (Fig. 27) medium-sized. Abdominal segments I–IX transverse; segment IX tapered backward; urogomphi absent. Spiracles of thoracic and abdominal segments (Fig. 28) oval.

Remarks. The mature larva of *D. sinuata* can be distinguished from that of *D. bucculenta* based on the following characteristics: mandibles with two large apical and two small subapical teeth (three apical teeth present in *D. bucculenta*); apical teeth stout, finely curved inward (thin and curved inwardly in *D. bucculenta*); inside of molar part projecting interiorly (distinctly projecting in *D. bucculenta*).

Description of pupa. Body length: 13.9–17.0 mm (n = 3) in male; 11.6 mm (n = 1) in female.

Body (Figs 29–31) pale yellow, slender, lightly sclerotized; setae soft, densely distributed over head, pronotum and caudal parts of abdomen.

Head not completely covered with pronotum in dorsal view. Antennae club-shaped with small spines. Pronotum nearly as long as wide; lateral sides slightly projecting outward. Metathoracic tergum with a longitudinal groove on cephalomedian portion. Abdomen elongate, markedly ridged laterally; segments II and VIII bearing a pair of small spines dorsally; segments III–VI bearing a pair of large spines dorsally; segment VII bearing a pair of large outward-directed spines dorsally (Fig. 32) and ventrally (Fig. 33); apex (Fig. 34) bearing a pair of small spines inward.

Remarks. The pupa of *D. sinuata* can be distinguished from that of *D. bucculenta* based on the following characteristics: abdominal tergites bearing a pair of spines (bearing a pair of tubercles with a number of spines in *D. bucculenta*); abdominal sternite VII with a pair of spines (without spines in *D. bucculenta*); apex of abdomen with a pair of spines (absent in *D. bucculenta*).

Biology. Adults of *D. sinuata* were found on recently dead culms of *S. sat* bamboo. At night, they were walking, mating (Fig. 35), excavating oviposition holes using their mandibles (Fig. 36), or inserting the ovipositor into the hole for oviposition (Fig. 37). Oviposition behavior was observed briefly, for about 90 min. A female fixed the tip of one of the two mandibles in one of the two tiny depressions on either side of the oviposition hole (Fig. 38), while using the other mandible to cut bamboo tissue (Fig. 36). After a while, she alternated the mandibles for cutting the opposite side of the hole. Then she went forward and across the hole, turned 180°, went forward again and cut the bamboo fibers in the aforementioned manner. Holing behavior was repeated. In the late part of holing, she proceeded always touching the surface of the internode with the apex of her abdomen and tried inserting the ovipositor into the hole (Fig. 37). When the hole did not open into the internode cavity, she turned 180° and resumed holing. Although oviposition itself was not observed due to time limitation of the field survey, an egg deposited on the inner surface of a cavity of the bamboo internode near the hole was found on the following day.

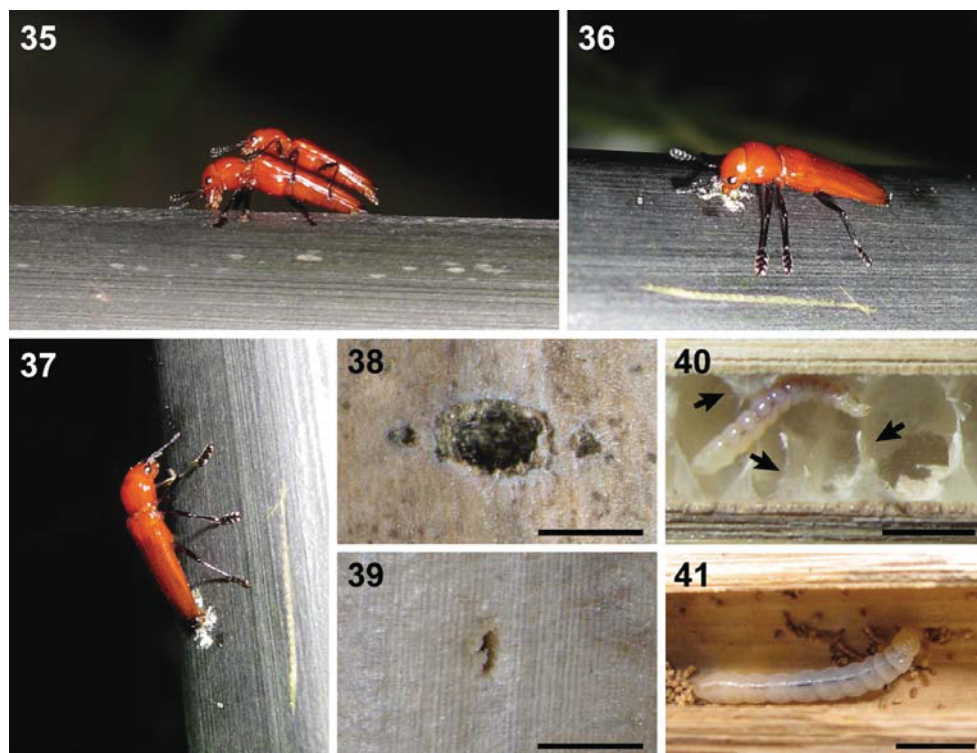
Thirteen dead culms of *S. sat* with *D. sinuata* OMs had one to 15 internodes when collected on 19–26 April 2011. A relatively small number of internodes on a culm were due to artificial cutting. Internodes larger in diameter were likely to have larger lengths, wall thickness, outer surface area and cavity volume (Table 1).

Observations on a total of 42 COMs made by *D. sinuata*, revealed that the hole had a tiny depression on each side (Fig. 38). The external opening was rectangle-shaped (mean \pm SD = 1.12 \pm 0.08 \times 0.76 \pm 0.11 mm, n = 5) (Fig. 38) and the internal opening was oval (0.48 \pm 0.13 mm for major axis, 0.20 \pm 0.09 mm for minor axis, n = 5) (Fig. 39). Cross sections showed that the hole was cone-shaped and was not plugged completely.

Table 1. Relationships of diameter class of internodes to internode traits, number of oviposition marks (OMs), completed oviposition marks (COMs), immatures and emergence holes of *Doubledaya sinuata* Zia, 1934 in 13 recently dead culms of *Sinobambusa sat.* All values are the mean \pm SD.

Diameter class of internodes (in mm)	No. of culms	No. of inter-nodes	Internode				Cavity volume (cm ³)	No. of internodes with 1 to 2 OMs (COMs)		No. of living eggs	No. of living larvae	No. of exit holes
			Length (cm)	Central diameter (mm)	Outer surface area (cm ²)	Wall thickness (mm)		1	2			
6–9	1	3	20.33 \pm 2.08	7.66 \pm 0.97	49.30 \pm 10.93	1.42 \pm 0.14 ^a	3.84 \pm 1.53 ^a	0(0)	0(0)	0	0	0
9–12	10	15	26.00 \pm 4.08	10.96 \pm 0.79	90.06 \pm 18.41	1.97 \pm 0.24 ^b	10.25 \pm 3.43 ^b	11(10)	1(0)	1	5	0
12–15	13	23	29.83 \pm 3.77	13.37 \pm 0.90	125.67 \pm 20.65	2.48 \pm 0.37 ^c	17.56 \pm 4.30 ^c	20(19)	0(0)	5	9	3
15–18	8	21	30.86 \pm 6.52	16.50 \pm 0.92	160.23 \pm 35.88	2.96 \pm 0.54 ^d	27.98 \pm 10.10 ^d	9(7)	0(0)	0	5	0
18–21	7	12	34.88 \pm 8.11	19.50 \pm 0.74	213.34 \pm 49.14	3.16 \pm 0.42 ^e	49.25 \pm 13.35 ^e	6(6)	1(0)	1	1	0
21–24	5	10	31.75 \pm 7.51	22.19 \pm 0.60	221.44 \pm 52.89	3.73 \pm 0.66 ^f	56.08 \pm 19.72 ^f	1(0)	0(0)	0	0	0
24–27	2	3	34.83 \pm 2.31	25.51 \pm 1.44	278.55 \pm 9.27	3.42 \pm 0.94 ^g	95.90 \pm 25.75 ^g	0(0)	0(0)	0	0	0

^{a, b, c, d, e, f, g} Numbers of internodes examined were 3, 12, 18, 19, 11 and 9, respectively.



Figs 35–41. *Doubledaya sinuata* Zia, 1934, adult male and female (35), adult female (36–37) and oviposition hole (38–39) on recently dead *Sinobambusa sat* bamboo culm and larva inside *S. sat* internode cavity (40–41). 35 – mating; 36 – making an oviposition hole; 37 – inserting the ovipositor into an oviposition hole; 38 – outer opening; 39 – inner opening; 40 – young instar larva; 41 – mature larva. Arrows indicate pith tissue. Scale bars = 1.0 mm (38–39), 5.0 mm (40–41).

The OMs of *D. sinuata* showed a random distribution among 13 randomly-sampled, dead culms containing OMs (mean density \pm SD = 3.92 ± 1.75 , $I_{\delta} = 0.95$, $P > 0.05$). This was the case for COMs (mean density \pm SD = 3.23 ± 1.36 , $I_{\delta} = 0.88$, $P > 0.05$). When internodes were divided into seven classes according to the diameters, mean numbers of OMs and COMs peaked at internode with 12.0 to 15.0 mm diameter class (Table 1). By contrast, the OMs showed a uniform distribution among 87 internodes (mean density \pm SD = 0.59 ± 0.54 , $I_{\delta} = 0.14$, $P < 0.01$). This was also the case for COMs (mean density \pm SD = 0.48 ± 0.50 , $I_{\delta} = 0.00$, $P < 0.01$). Excluding OM-free internodes and COM-free internodes, respectively, mean numbers \pm SD of OMs and COMs per internode were 1.04 ± 0.20 ($n = 49$) and 1.00 ± 0.00 ($n = 42$), respectively.

Dissection of 42 COM-containing, dead internodes between 19 and 26 April 2011 revealed that 27 internodes harbored the following forms of *D. sinuata*: seven living eggs and 20 living larvae. Three internodes had exit holes, presumably from *D. sinuata*, with no other insects

found inside. When living *D. sinuata* developmental stages were located within an internode cavity, they were found singly, and there were no holes in the division walls separating adjoining cavities, indicating that the beetle did not travel across the internodes. The internodes contained a large amount of white pith tissue when *D. sinuata* eggs or early-instar larvae were present (Fig. 40), whereas the pith tissue was not retained when *D. sinuata* mature larvae were present (Fig. 41). The remaining 15 internodes were empty.

Discussion

The heads of *D. sinuata* adults showed distinct sexual dimorphism. Females of *D. sinuata* exhibited large asymmetric head morphology, including mandibular length. By contrast, males showed a symmetric head and slightly asymmetric mandibles in length. A markedly asymmetric head, including mandibles, in languriine females is suggested to be an adaptation for excavating holes in hard materials in oviposition (TOKI & TOGASHI 2011, 2013). *Doubledaya bucculenta* females, which show a markedly large asymmetric head including mandibles (TOKI & TOGASHI 2011), utilize bamboo internodes as oviposition sites (TOKI 2009, TOKI & HOSOYA 2011, TOKI & TOGASHI 2013). The females excavate a small hole in a recently-dead culm of host bamboo, using their mandibles, and insert the ovipositor through the excavated hole into the internode cavity. They then deposit an egg on the inner surface of the cavity of the bamboo internode. The sequence of oviposition behavior of *D. bucculenta* is similar to that of *D. sinuata* (W. T., unpublished data). By contrast, females of 11 languriine species so far reported to oviposit in herbaceous plants, have 'symmetric' or slightly asymmetric mandibles (NAKAYAMA & TABASHI 1933, HIROSE 1935, FUKUDA 1957, KUROSAWA 1968, PIPER 1978, GENUNG et al. 1980, ELLSBURY & BAKER 1989, LESCHEN & BUCKLEY 2007, WARD et al. 2007, SASAOKA 2009, MATSUI & YOSHITOMI 2010, TOKI & TOGASHI 2013). Considering that *D. sinuata* utilizes bamboo internodes for oviposition sites (the second example of bamboo users in the subfamily Languriinae), the asymmetric head of *D. sinuata* females may be an adaptive trait for boring holes in hard materials in oviposition.

Spatial distributions of the OMs and COMs of *D. sinuata* among host culms and internodes indicated that adult females selected intermediate-sized internodes of dead *S. sat* culms as oviposition sites. Interestingly, however, *D. bucculenta* selects large basal internodes of host bamboo internodes in the field (TOKI & TOGASHI 2013). Moreover, females of *D. bucculenta* show oviposition preference for diameter of bamboo internodes depending on their body size in laboratory tests (TOKI & TOGASHI 2011). The range of body size of *D. bucculenta* females (7.38 to 17.01 mm in elytral length; TOKI & TOGASHI 2011) is larger than that of *D. sinuata* females (5.92 to 9.60 mm in elytral length), suggesting that the narrow range of body size in *D. sinuata* may be related to the narrow range of internode size selected as oviposition sites.

The larva of *D. sinuata* shares the following morphological traits with that of *D. bucculenta* (the only other *Doubledaya* for which the larva has been described (HAYASHI 1986)): ocelli and urogomphi absent. In contrast, ocelli are present and vary in number among the other genera in the tribe Languriini, and urogomphi are present (RYMER-ROBERTS 1939), suggesting that number of ocelli and presence/absence and shape of urogomphi could be characters with taxonomic significance.

Interestingly, number of larval ocelli is fewer in typical Languriini (0 to 2 on each side) than the genus *Microlanguria* Lewis, 1884 (formerly in Cladoxenini) (6 on each side), whose larval biology is unknown, in Languriini and Hapalipini (5 on each side) in the subfamily Languriinae, and in the subfamily Pharaxonothinae (5 on each side) and Erotylinae (5 to 6 on each side) (RYMER-ROBERTS 1939, 1958; LAWRENCE 1991; LESCHEN et al. 2010). It has been suggested that the decrease in number of ocelli, or their total reduction, may be related to the fact that the larvae of typical Languriini are borers of plant stems, while those of Hapalipini, Pharaxonothinae and Erotylinae are not (RYMER-ROBERTS 1939). Our findings support this hypothesis.

Larvae of *D. sinuata* fed on the internode tissue of newly dead *S. sat* and completed development within a single internode, suggesting a positive correlation between adult size and internode size. Their stout mandibles may work effectively for intake of fibrous plant tissues. Interestingly, in the case of *D. bucculenta*, the larvae feed on symbiotic yeast, using the maxillae not the mandibles, within a single internode of host bamboo (TOKI & TOGASHI 2011, TOKI et al. 2012). The larvae use their sharpened mandibles like scissors to attack enemies (W. T., personal observation). Thus, although detailed investigation about the feeding habits of *D. sinuata* is required, our findings suggest that bamboo users in Languriinae show various feeding habits such as phytophagy and mycophagy with morphological adaptations of mouthparts.

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