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Description of developmental stages of *Phyllognathus dionysius* Fabricius, 1792 (Insecta: Coleoptera: Scarabaeidae) with notes on biology from central India

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1 Description of developmental stages of *Phyllognathus dionysius* fabricius, 1792 (Insecta:
2 Coleoptera: Scarabaeidae) with notes on biology from central India

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13

14 Abstract – Detailed description of IIIrd Instar larva and pupa of *Phyllognathus dionysius* is
15 described along with notes on biology and distribution. Beetles belonging to the family
16 scarabaeidae are economically important as crop pests. Grubs of *P. dionysius* are polyphagous
17 and known to feed on roots of Jowar, Bajra, Maize, Turmeric, Sugarcane and Paddy while
18 adults are nocturnal in habit and feed on foliage of *Ficus* sp. For the study, grubs of *P. dionysius*
19 were collected from dung pads from the Bor forest of Maharashtra, central India. Collected
20 grubs were reared in rearing pots in the laboratory under optimum temperature and humidity.
21 Our knowledge of developmental stages of scarabs lags behind our knowledge of the adults
22 especially in the fields of morphology and taxonomy. In this study, we provide diagnostic
23 characters for identification of the immature stages in brief. Biology of the species is described
24 on the basis of its coprophagous behaviour. Life cycle of *P. dionysius* completed in 145-163
25 days with prepupal period of 24-36 hours and pupal period of 9-11 days.

26 Keywords – Developmental stages, scarabs, dung beetle, coprophagy, dynastinae

27 Introduction -

28 *Phyllognathus dionysius* belong to subfamily Dynastinae of family Scarabaeidae. Dynastines
29 are famous for their remarkably large size amongst scarabs. Burmeister (1847) and Endrodi
30 (1985) gave the earliest records of the Dynastinae of the world. Arrow (1910) described
31 Dynastinae of Indian subcontinent where 30 species from 14 genera were recorded. After
32 Arrow, various authors contributed to the Dynastinae fauna of India from different states of
33 India, Orissa (Biswas and Chatterjee 1991), from Madhya Pradesh (Chandra 2000), Sikkim
34 (Chatterjee and Biswas 2003), Tamil Nadu Chandra 2009), Uttarakhand Chatterjee 2010). *P.*
35 *dionysius* is an oriental species predominantly found in India: (Andhra Pradesh, Bihar,
36 Chhattisgarh, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Odisha, Uttar Pradesh,
37 West Bengal, Maharashtra, Sri Lanka, Myanmar), Vietnam and in Palaearctic region (Nepal,
38 Pakistan).

39 This species is commonly found in central Indian province. It is recorded from Melghat Tiger
40 Reserve, Maharashtra (Thakare et al. 2012), Madhya Pradesh (Chandra and Gupta 2013),
41 Achankamar Amarkantak Biosphere reserve, Veerangana Durgawati Wildlife Sanctuary
42 (Chandra and Gupta 2011, Chandra and Gupta 2012).

43 Grubs of *P. dionysius* are polyphagous and known to feed on roots of Jowar, Bajra, Maize,
44 Turmeric, Sugarcane and Paddy while adults are nocturnal in habit and feed on foliage of *Ficus*

45 sp. (AINPWB 2018). *P. dionysius* grubs are also recorded feeding on rice, maize, sugarcane
 46 (Bhawane et al. 2012) and garden palm trees (Bhatnagar 1971).

47 The immature stages, biology and lifecycle of *Phyllognathus dionysius* from Indian
 48 subcontinent is poorly known. Our knowledge of developmental stages of scarabs lags behind
 49 our knowledge of the adults especially in the fields of morphology and taxonomy (Hayes 1929).
 50 Arrow (1910) in his publication mentioned the immature stages of this species and Beeson
 51 (1941) gave short note on its biology but, the detailed description of immature stages is lacking
 52 since then. Hence an attempt has been made to describe IIIrd Instar larva and pupa of *P.*
 53 *dionysius* along with notes on its biology.

54 Methods -

55 Grubs of *P. dionysius* were collected from dung pads on open grounds of Zilpi village located
 56 at 21°06.58'N; 78°86.66'E situated around 35 Km from Nagpur district of Maharashtra, India.
 57 The collection site is adjacent to lush flora and fauna of Bor Tiger Reserve. Collected grubs
 58 were reared in rearing pots in the laboratory under optimum temperature and humidity (27°C
 59 ± 2 °C with RH 65 to 75 %). Rearing pots made up of glass were used for rearing. These were
 60 filled with soil and dung cakes. Potato tubers and wheat seedlings were grown in the rearing
 61 pots. Water was sprinkled on upper surface of rearing pots every alternate day to maintain the
 62 moisture content. Dung cakes were added in the rearing pots every 7 days to ensure adequate
 63 food supply. Temperature was maintained in the laboratory with the help of coolers and heaters.

64 For larval preservation methodology by Ritche (1967) is used. Larvae were dipped in near
 65 boiling water for about 3 minutes and preserved in 70 % alcohol or glycerol to prevent them
 66 from shrinking. 5 specimens of IIIrd instar grubs and 5 pupae were taken for taxonomic studies,
 67 photographed and documented. For description terminology of Ritche (1967) is used. For
 68 diagnosis of IIIrd instar larva, characters such as, head capsule, cranium, frons, clypeus,
 69 labrum, epipharynx, mandibles, antenna, thorax, legs, spiracles, number of setae on dorsum,
 70 raster pattern on last abdominal segment were found to be significant for species identification.
 71 The distinguishing character of Dynastinae pupae is the presence of 'gin traps'.

72 Studied material is submitted in the entomology section of Centre for Sericulture and
 73 Biological pest management and Research Laboratory (CSBR), RTM Nagpur University for
 74 future reference.

75

76 Results and Discussion -

77 Adults are active May onwards and lay eggs after mating. Larvae are active during June to
 78 September. The developing larvae were observed making individual, oval cells in the dung pats
 79 for feeding. Notes on biology of *P. dionysius* were given by Beeson (1941) from cold climates
 80 of North India and recently by Pathania (2014) from Himachal Pradesh.

81 Mating occurred mostly during the morning hours. Mating period is found to be of 6 to 8
 82 minutes and the same pair tried to mate multiple times a day. Similar mating period is recorded
 83 for scarab, *Protaetia aurichalcea* (Gujarathi and Pejaver 2014). Adult male tried to mate with
 84 other females in the captivity soon after the earlier mating was completed. After mating the
 85 female tried to bury herself in soil.

86 Life cycle of *P. dionysius* completed in 145-163 days with prepupal period of 24 hours and
 87 pupal period of 9-11 days.

88 Table 1: Duration of various developmental stages of *P. dionysius*

Sr No	Developmental stage	n	Range of duration (in days)
1	Egg	8	8–10
2	First Instar	7	11–16
3	Second Instar	7	23–27
4	Third Instar	35	92–98
5	Prepupal stage	31	24–36 hours
6	Pupa	27	9–11

89

90 Description of III instar larva and pupa of *Phyllognathus dionysius* is described herewith.

91 *Phyllognathus dionysius* Fabricius, 1792

92 A. III instar larva – Length 42 mm, width 10 mm.

93 Width of head capsule 6.46 mm, length of head capsule 7.22 mm, *Cranium* dark red brown,
 94 surface with deep, regular punctations. *Frons* with a pair of posterior frontal setae, 2
 95 anterior angle frontal setae on each side, anterior frontal setae absent. Remaining cranial
 96 surface with 2 long dorso epicranial setae on each side, 1 long epicranial seta on each side
 97 and 7 to 10 paracellar setae on each side. *Clypeus* somewhat rectangular, dark reddish
 98 brown in appearance, with irregular deep punctations with 2 pairs of long lateral setae on
 99 each side (Fig. E). *Labrum* Irregular in shape, dark reddish brown, with irregular deep
 100 punctations. 9 to 11 anterior setae, 5 to 7 posterior setae and 3 to 5 lateral setae on each
 101 side. *Epipharynx* Asymmetrical. Chaetoparia with 55 to 65 setae on each side (Fig. G).
 102 Maxillary stridulatory area is with a row of 8 wide, oval teeth (Fig. I). Apical uncus of
 103 Galea strong, wide at base and pointed towards end. Apex of Lacinia bears 3 unci fused at
 104 base (Fig. H). *Mandibles* Left mandible with 3 scissorial teeth anterior to scissorial notch
 105 and 1 scissorial tooth posterior to notch. Molar area with 2 lobes. Lateral edge is with 5
 106 setae (Fig. K). Right mandible with 3 scissorial teeth, third tooth smaller. Molar area with
 107 3 lobes. Lateral edge is with 7 setae (Fig. J). Stridulatory area of each mandible is well
 108 marked by 27 to 30 fine striae (Fig. L). *Antenna* Surface on last segment with 6 dorsal and
 109 6 ventral sensory spots (Fig. F). *Thorax* with thoracic spiracle ‘C’ shaped, 0.7 mm in width
 110 and 0.8 mm in length. Tarsal claws similar on all three pairs of legs bearing 1 basal thick
 111 and one lateral long seta (Fig. Q). Three thoracic segments with a single transverse row of
 112 8 – 10 setae. Ventrally each thoracic segment bears a single row of 25 to 30 setae arranged
 113 irregularly. *Abdomen* Abdominal spiracles I to IV similar in size while spiracles on
 114 segments V to VIII smaller progressively. Spiracles are surrounded by long setae (Fig. N).
 115 Dorsa of segments I to VI with long and short setae arranged irregularly. Dorsa of VIIth
 116 abdominal segment with 1 lower transverse row of 17 – 20 setae and 1 upper irregular row
 117 of 25 – 30 setae. Dorsa of VIII th abdominal segment with 2 transverse rows of 18 – 20
 118 setae. Dorsa of IXth segment with 2 transverse rows of 7 – 8 setae. Ventrally, segments I
 119 to VII with a single transverse row of 25 – 30 setae. Segment VIII – IX with 6 – 8 setae
 120 arranged transversely. Raster with lower and upper anal lobe with 55 – 60 setae
 121 respectively (Fig. O).

122

123 B. Prepupa – The prepupal stage lasts for 24 to 36 hours. The grub becomes inactive.

124 Transparent integument of III instar larva is replaced by dirty white appearance with
 125 shrunk body. Prepupal stage larva found to bury himself deep inside soil towards bottom
 126 of the rearing chamber compared to other mature III instar larva (Fig. S).

127

128 C. Pupa – Pupa exarate.

129

130 Male pupa, elongate, oval, 25 mm in length and 12 mm in width (Fig. T,V). *Frontoclypeus*
 131 with a dorsal, broad hornlike structure slightly bent upward. Antenna, mandibles, palpi are
 132 distinct. Fore, mid and hindlegs distinct. *Abdomen* 9 segmented (Fig. U). Spiracles on
 133 segment I are hidden, spiracles on segment II to IV elongate and sclerotised (Fig. Za).
 134 Tergal segments I to V with 5 pairs of dioneiform organs or “gin traps” (Fig. Y). Tergum
 135 VIII is with two ovate depressions laterally, one on each side. IX th tergal segment is with
 136 two triangular folds, tapering towards end (Fig. Z). Female pupa stout, oval, without horn,
 137 22 mm in length and 14 mm wide. Female pupa is shorter and wider than male pupa. Body,
 138 wooden brown in coloration, without horn, other characters similar to male pupa (Fig. T).
 139

140 *Phyllognathus dionysius* is a most common Dynastine in central India. Grubs of *P. dionysius*
 141 are polyphagous and known to feed on roots of Jowar, Bajra, Maize, Turmeric, Sugarcane,
 142 Paddy (AINPWG 2018, Bhawane et al. 2012), Potato (HP) garden palm trees (Bhatnagar
 143 1971), apple, pear and apricot (Kumar et al. 2005). However, host range of adult beetles has
 144 not been discovered in detail. Adult *P. dionysius* is known to feed on *Ficus* sp from Maharashtra
 145 (Bhawane et al. 2012).

146 During our study, life cycle of *P. dionysius* completed in 145-163 days with prepupal period
 147 of 24 hours and pupal period of 9-11 days. This period is shorter than the one recorded by
 148 Pathania (Pathania 2014) of 162.4 days from hilly region and colder temperatures of Himachal
 149 Pradesh. This suggest that weather conditions play an important role in duration of life cycle
 150 of this species. But furth *P. dionysius* completes its life cycle faster in warmer weather and
 151 plains of central India than in colder hills of Himachal Pradesh.

152 Considering the economic and ecological importance of white grubs, it is important to identify
 153 the larval and pupal stages of these beetles for better management strategies. Hence third instar
 154 larval characters are described along with description of pupa. With this study an attempt has
 155 been made to describe the developmental stages and biology of *P. dionysius* from central Indian
 156 province.

157 Some carabid adults were seen predated on *P. dionysius* larvae on field. This suggest that they
 158 may act in controlling the grub population. Further studies in this regard are needed.

159

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169

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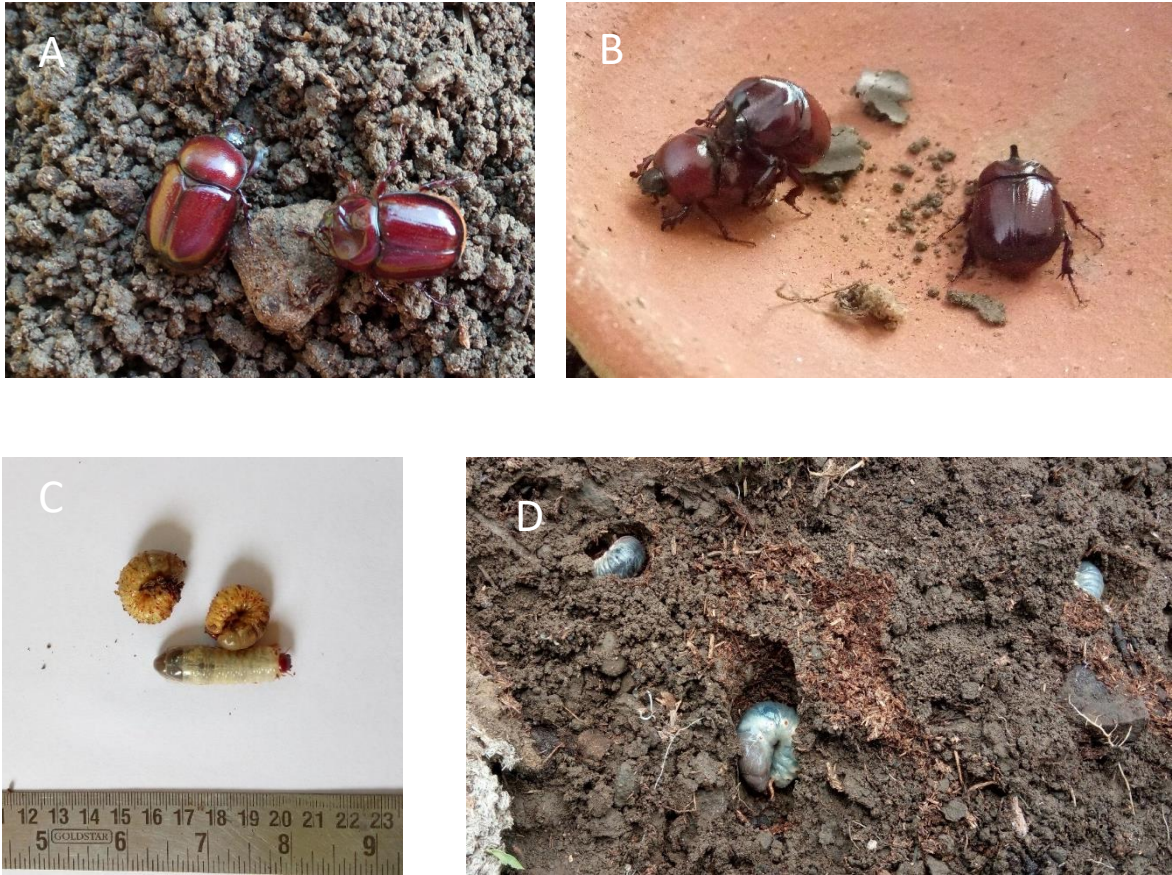


Fig A-D *Phyllognathus dionysius* adults and larva. A- Male and Female, B – Male and female during mating, C – Third instar larva, D - Habitat

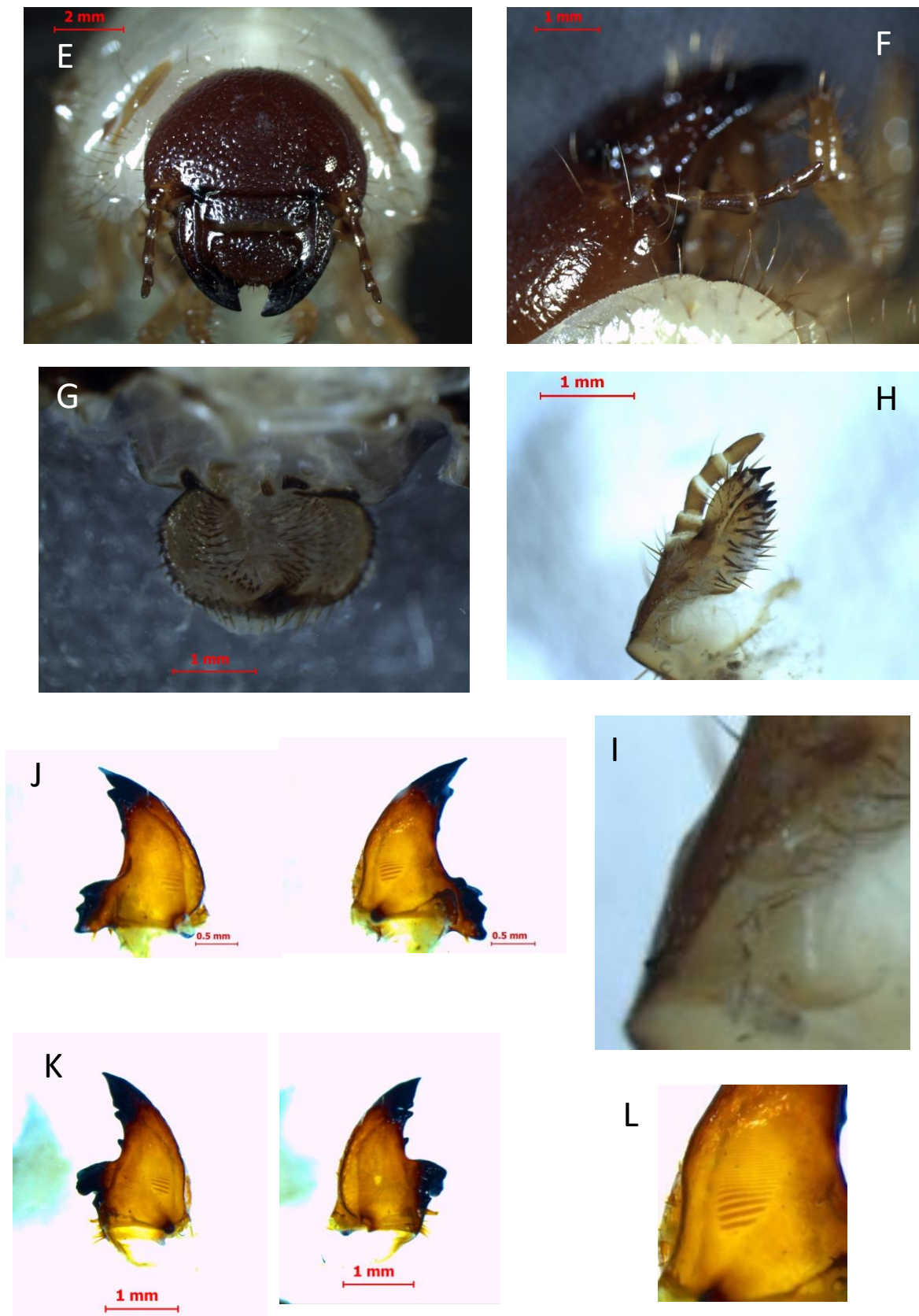


Fig E-L: Mouth parts of Third Instar larva of *Phyllognathus dionysius* E- Head, F – Antenna, G – Hypopharynx, H – Maxilla, I – Maxillary teeth, J – Right Mandible, K – Left Mandible, L – Mandibular striations

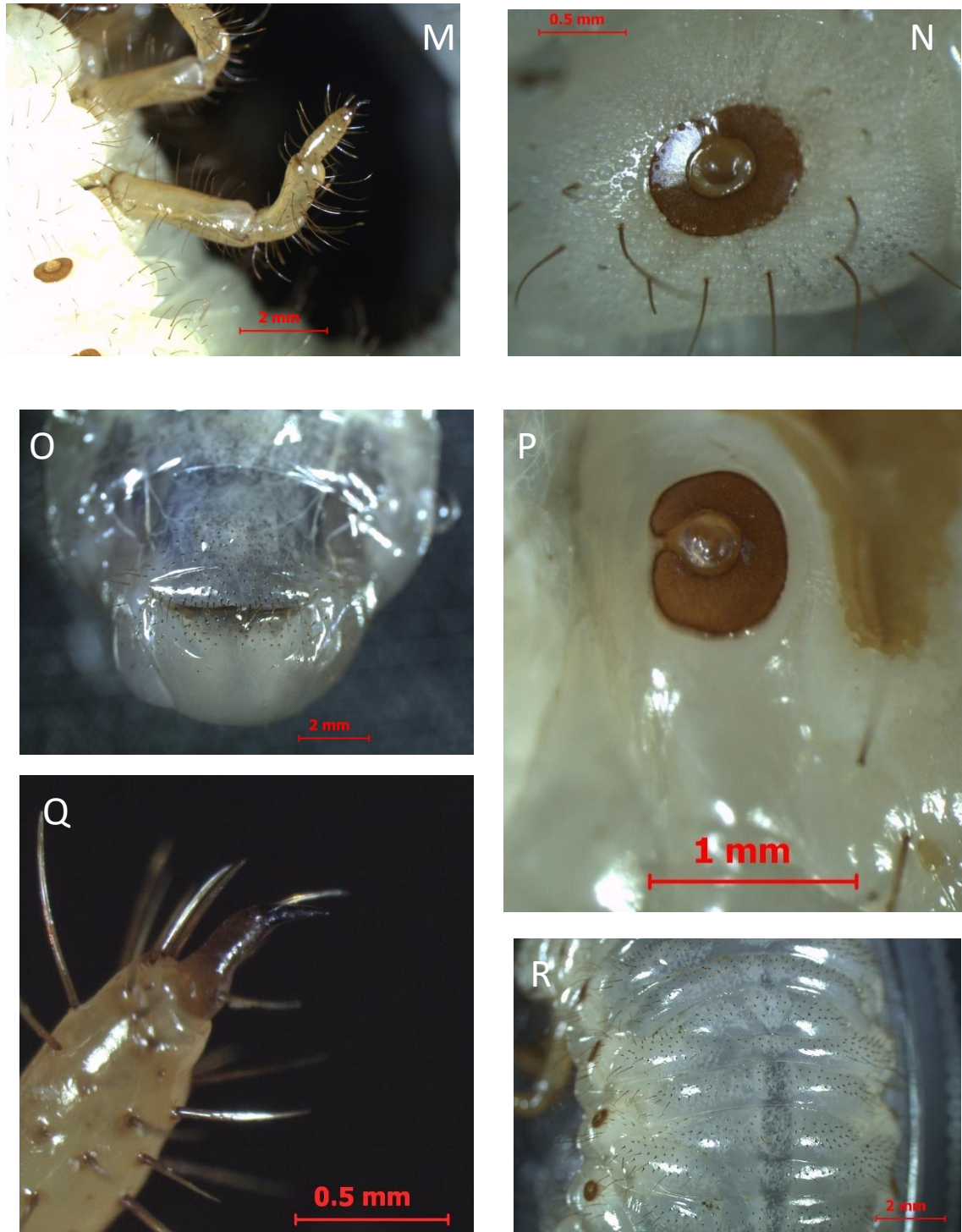


Fig E-L: Morphological characters of Third Instar larva of *Phyllognathus dionysius* M- Legs, N – Abdominal spiracle, O – Anal slit, P – Thoracic spiracle, Q – Tarsal claw, R – Abdominal segments



Fig S-W: Morphological characters of prepupa and pupa of *Phyllognathus dionysius* S- Prepupa, T – Male and female pupa, U – Pupa (Male) dorsal view, V – Pupa (Male) ventral view, W – Pupa (Male) lateral view

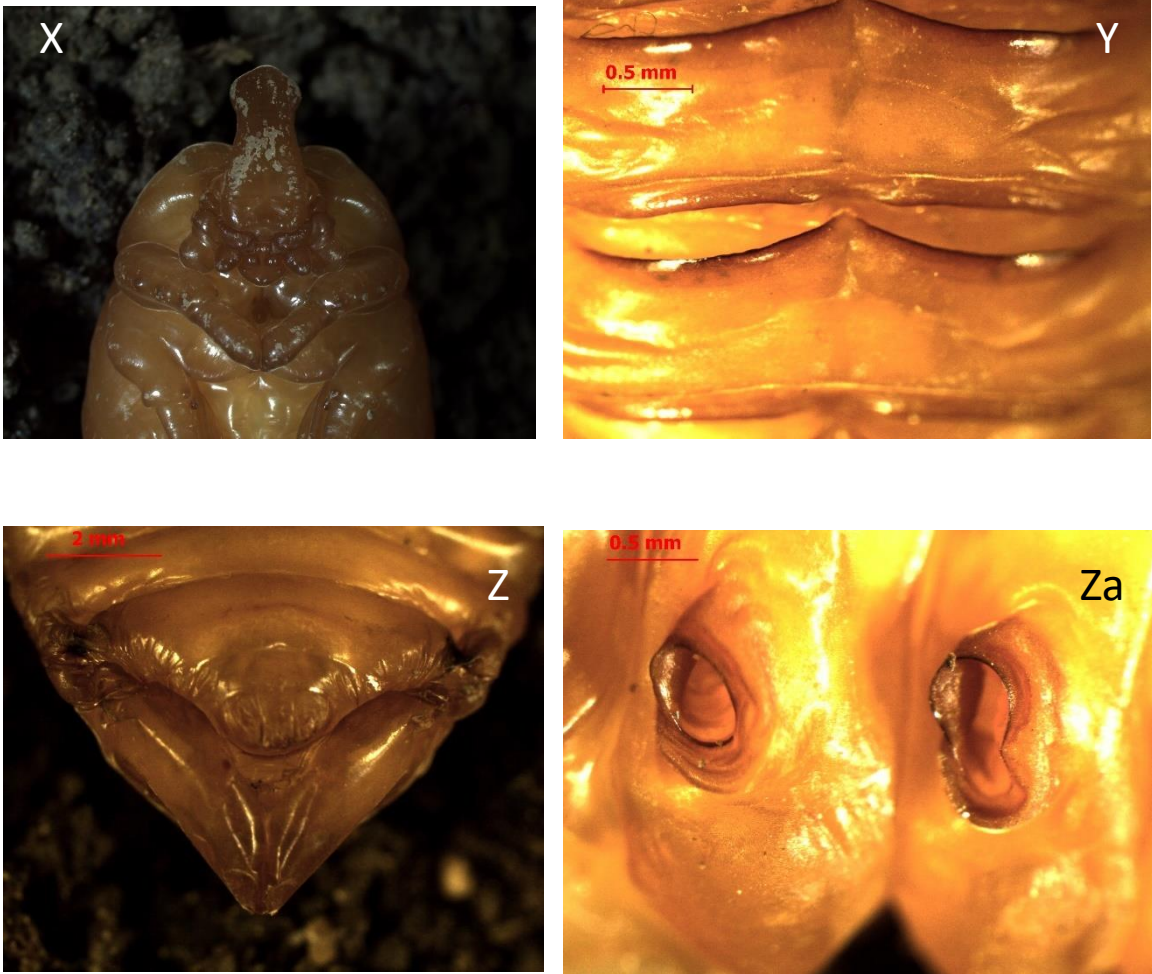


Fig X-Za: Morphological characters of pupa of *Phyllognathus dionysius* X- Male pupa head, Y – gin traps, Z – Pupa ventral segment, Za – Pupal spiracles