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**DESCRIPTION OF THE FEMALE IMAGO AND IMMATURE STAGES OF
ALLUAUDOMYIA FORMOSANA OKADA (DIPTERA:
CERATOPOGONIDAE)**

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Summary. Detailed description of the female imago, larva and pupa of *Alluaudomyia formosana* Okada, 1942 is given. The species is recorded from India for the first time. Specimens were associated with algal mats near the margin of water body located within the Burdwan University campus (West Bengal).

Key words: biting midges, morphology, adult, larva, pupa, fauna, new record, India.

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Резюме. Даны описания самки, личинок и куколок мокреца *Alluaudomyia formosana* Okada, 1942. Этот вид впервые приводится для Индии, где обитает в скоплениях водорослей в прудах в окрестностях кампуса университета Бердуэн (Западная Бенгалия).

INTRODUCTION

The predaceous midges of the genus *Alluaudomyia* Kieffer are small, ubiquitous with marked wing prevalent in all biogeographical regions of the world except Antarctica (Sinha *et al.*, 2005). The Oriental species of *Alluaudomyia* was revised by Wirth & Delfinado (1964), followed by Debenham (1971). Prior to this study, 24 species of *Alluaudomyia* were recorded based on the adult from India (Chaudhuri *et al.*, 1972, Chaudhuri & Ghosh, 1980, Sinha *et al.*, 2005).

Information of immature taxonomy of this genus is restricted to the only few species. Borkent (2016) listed 206 species worldwide, with 23 of these known as immature: *A. appendiculata* Debenham, *A. bella* (Coquillett), *A. bicornis* Debenham, *A. biestori* Spinelli, *A. caribbeana* Spinelli & Wirth, *A. claudia* de Meillon, *A. distispinulosa* Spinelli & Wirth, *A. footei* Wirth, *A. fragmentum* Debenham, *A. fumosipennis* Debenham, *A. latipennis* (Skuse), *A. maculithorax* (Carter, Ingram et Macfie), *A. megaparamera* Williams, *A. natalensis* de Meillon, *A. needhami* Thomsen, *A. paraspina* Wirth, *A. parva* Wirth, *A. quadripunctata* (Goetghebuer), *A. reyei* Debenham, *A. schnacki* Spinelli, *A. splendida* (Winnerttz), *A. unguistyla* Debenham, and *A. variegata* Glick & Mullen. The detailed description of larva and pupa of *A. amazonica* Spinelli & Wirth, 1984 and the redescription of *A. schnacki* Spinelli, 1983 are given recently (Diaz *et al.*, 2015).

This article provides diagnosis of the species with detail description of immature stages based on SEM studies following recent terminologies and usages.

MATERIAL AND METHODS

The larvae and pupae of *Alluaudomyia formosana* were found associated with the entangled mass of algae, in a pond margin at the Burdwan University campus (23°16'N, 87°54'E). The immatures attached with algal material were transported in plastic bags containing water from the natural habitat. The larvae, pupae were segregated carefully placed in separate clean glass vials and were observed daily for emergence. The larvae, pupae and emerged adults were mounted on microscope slides following Wirth & Marston (1968). Detail study of the immature stages was made by Scanning Electron Microscope [SEM, S5 30] at the University Science Instrumentation Centre, University of Burdwan. For larval morphology and terminologies, Murphree & Mullen (1991), and for pupa, Borkent (2012, 2014) were followed. All photomicrographs were obtained with Leica DM200 and Magnüs MLX-TR compound microscope fitted with Instavision CCD MVV3000 (MIPS) digital camera. The morphological measurements of the immatures and adults are in millimeter (mm) except the SEM figures which are expressed in micrometer (µm). The values are given as ranges with “n” in parentheses indicating the number of specimens observed and followed by mean. Presently the slides are retained in the Entomology Research Unit, Department of Zoology, The University of Burdwan and subsequently deposited to the National Zoological Collections (NZCI), Kolkata.

The larval abbreviations in the text and figures are as follows: Antennae (AN); collar (CO); dorsal comb (DC); epicranial suture (ES); epipharyngeal comb (EC); epipharynx (EP); frontoclypeus (FC); galeolacinia (GL); hypopharynx (HP); hypostoma (HY); labrum (LB); lacinial sclerite 1 (LC1); lacinial sclerite 2 (LC2); mandible (MD); maxillary palpus (MP); messors (MS); palatum (PL); scopae (SC); sensilla campaniformia (SCa); sensilla styloconica (ss); sensilla trichoidea (st); ventral comb (VC). Head capsule chaetotaxy are indicated by single alphabets: posterolateral pits (m); parahypostomal seta (o); postfrontal seta (q); anterior perifrontal seta (s); prefrontal seta (t); posterolateral seta (v); anterolateral seta (w); ventral seta (y). Caudal segment chaetotaxy are indicated by single alphabets: dorsal seta ('d'); inner seta ('i'); first lateral seta ('l₁'); second lateral seta ('l₂'); outer seta ('o').

The pupal abbreviations in the text and figures are as follows: Pedicel (P); respiratory organ (RO); terminal process (TP); Anterolateral sensilla (AL-1-T, AL-2-T, AL-3-T); anteromedial sensilla (AM-1-T, AM-2-T); dorsal apotome sensilla (DA-1-H and DA-2-H); dorsal sensilla (D-1-T, D-2-T, D-3-T, D-4-T, D-5-T); dorsal sensilla of abdominal segment 1 (D-2-I, D-3-I, D-4-I, D-5-I, D-8-I, D-9-I); dorsal sensilla of abdominal segment 4 (D-2-IV, D-3-IV, D-4-IV, D-5-IV, D-8-IV, D-9-IV); terminal process seta (D-5-IX); lateral sensilla of abdominal segment 4 (L-1-IV, L-2-IV, L-3-IV, L-4-IV); ocular sensilla (O-1-H, O-2-H, O-3-H, O-4-H); ventral sensilla of abdominal segment 4 (V-5-IV, V-6-IV, V-7-IV).

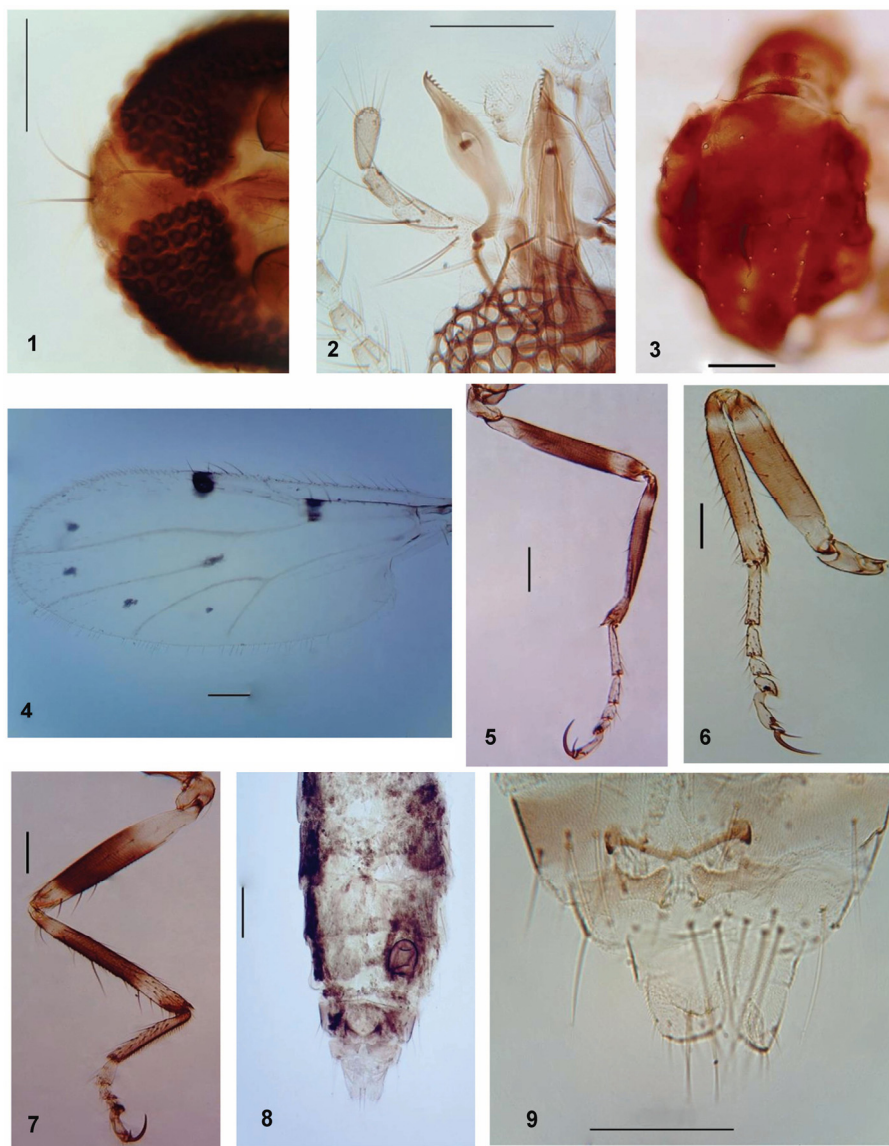
DESCRIPTIONS

Alluaudomyia formosana Okada, 1942

Figs 1–30

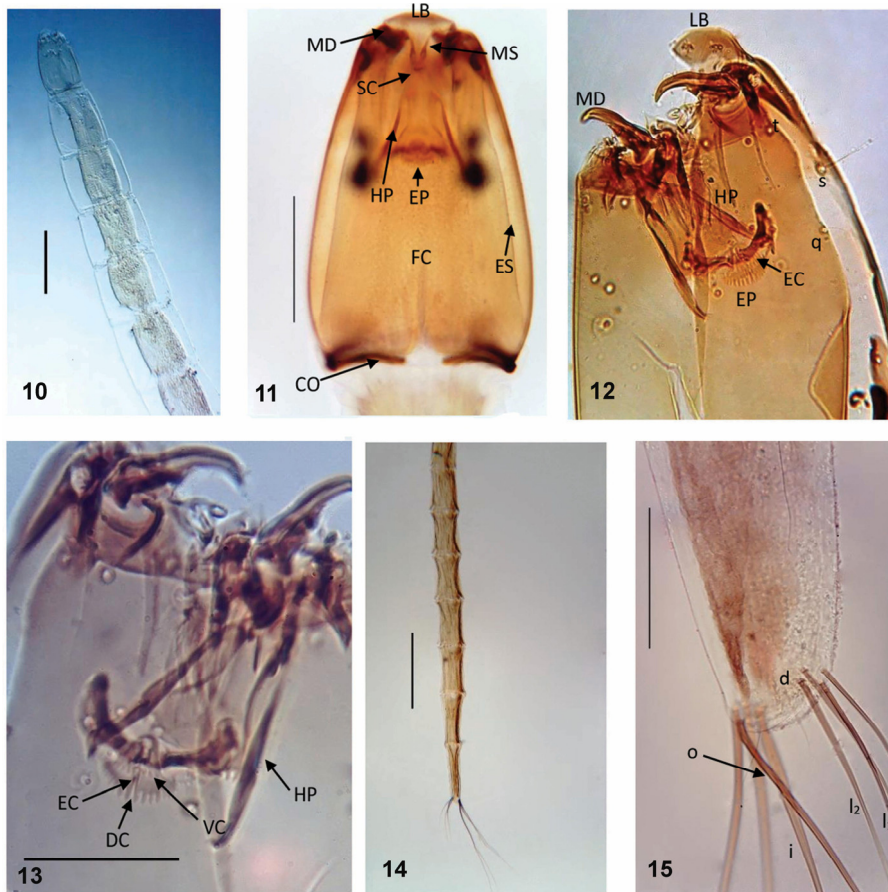
Alluaudomyia maculipennis var. *formosana* Okada, 1942: 32: 317, figs. 5–8 (♀; Taiwan).

SPECIMENS EXAMINED. **India:** West Bengal, Burdwan, (23°16'N, 87°54'E), 04 III 2014, coll. S. Sarkar, 6 ♀ (4 pupal exuviae), 3 pupal exuviae, 3 larval exuviae, 11 larvae. Specimens were also examined under SEM India, the same data, 3 larvae and 3 pupa.



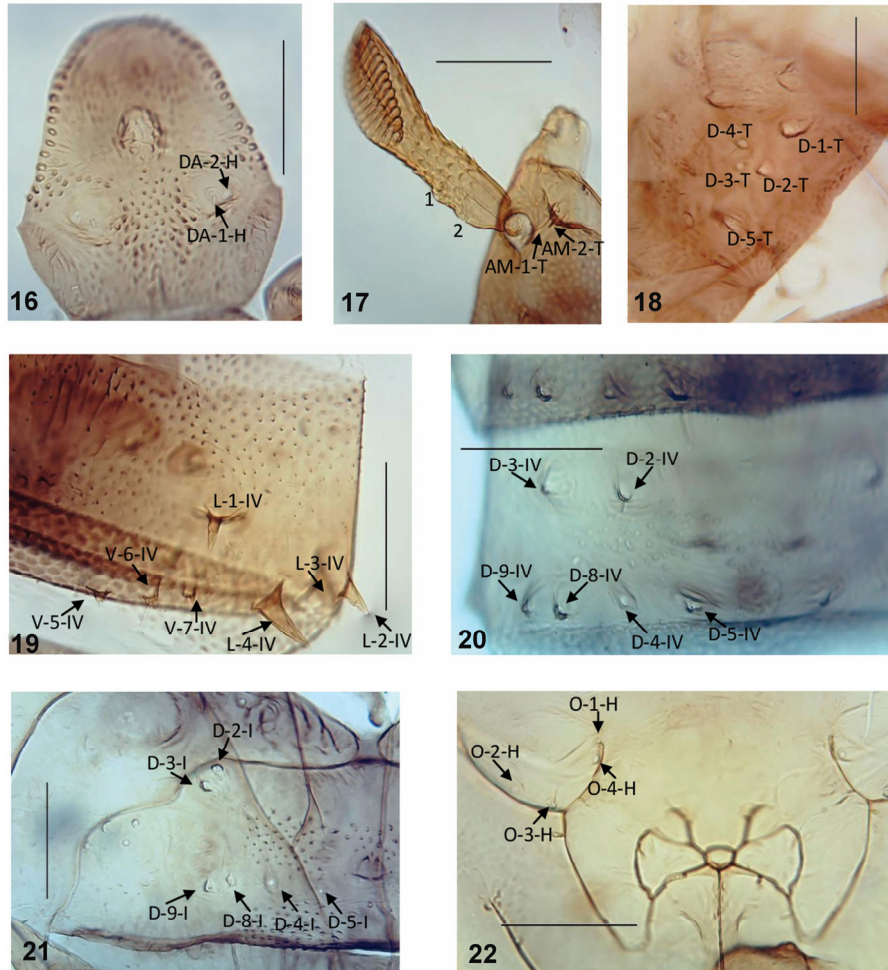
Figs. 1–9. *Alluaudomyia formosana*, adult female. 1 – frontovortex; 2 – mouthparts; 3 – thorax; 4 – wing; 5 – fore leg; 6 – mid leg; 7 – hind leg; 8 – abdomen; 9 – genitalia (scale bar 0.1 mm).

DIAGNOSIS OF FEMALE ADULT (Figs 1–9). Eyes bare, nearly contiguous; frontovertex (Fig 1) with 8 sensilla chaetica. Mandible with 14–15 teeth of which 7–8 are smaller (Fig. 2). Third palpal segment short with minute sensory pit bearing 3–4 stalked capitate sensilla (Fig. 2). Scutum with 2 lateral longitudinal brown bands with irregular yellow areas; scutellum with 4 large setae (Fig. 3). Wing (Fig. 4) pale brown with yellowish veins, wing length 0.89–0.96 (0.92, n=6); 2 conspicuous large dark spots, one proximal to r-m cross vein and other at end of costa and 5 small irregular black spots, one near base of M_2 , the others near apices of r_5 , m_1 , m_2 and cu_1 . Hind tibial comb with 7 spines (n=6). Colour pattern of legs in Fig 5–7. Sermatheca well sclerotized, subspherical (Fig. 8) with short, narrow, tapering neck, measuring 0.078–0.084 (0.08, n=6) \times 0.058–0.063 (0.061, n=6). Cerci brown, sinuose (Fig. 9).



Figs. 10–15 *Alluaudomyia formosana*, larva. 10 – larva and thoracic pigmentation; 11 – head capsule (ventral view); 12 – head capsule (ventrolateral view); 13 – detail of head capsule; 14 – caudal setae; 15 – detail caudal setae (scale bar for all figs 0.1mm except fig 13, scale bar 0.05 mm).

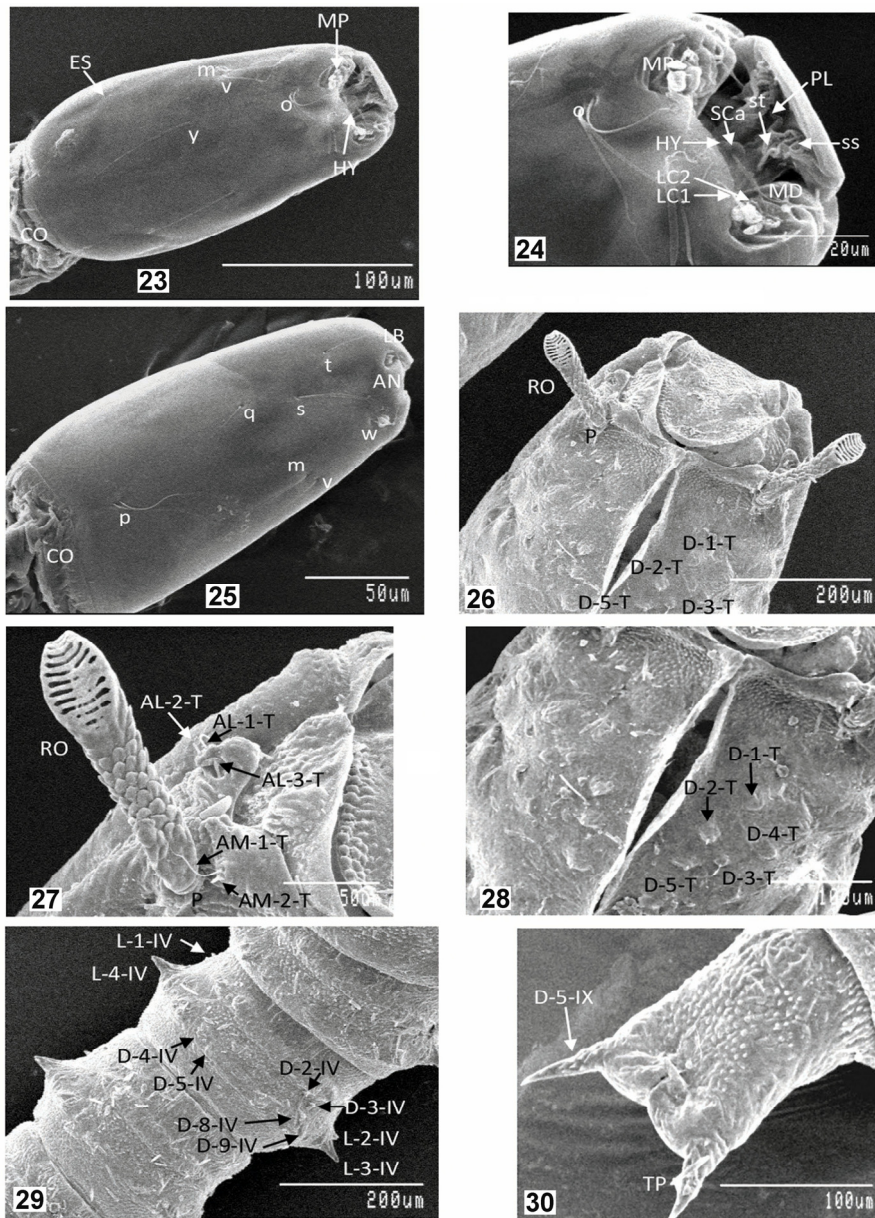
DESCRIPTION OF FOURTH INSTAR LARVA (Figs 10–15, 23–25). Body length 2.79–3.20 (3.01, n=5). Exuviae yellow. Head capsule (Figs 11, 12, 23–25) yellow to brown, oval, with well developed frontal suture; head capsule length (HL) 0.204–0.244 (0.224, n=8), head capsule width (HW) 0.144–0.163 (0.151, n=8); head capsule ratio (HR) 1.42–1.56 (1.49, n=8); eyes with 2 separated spots; head setae simple, short to elongate but ‘s’, ‘u’, ‘x’ and ‘o’ setae bifurcated and branched, chaetotaxy shown in Figs. 12, 23–25. AN (Fig 25) small, antennal length (AL) 0.013 (n=6). CO (Figs 11, 23) and subgenal band dark; subgenal width (SGW) 0.081–0.098 (0.088, n=8); subgenal ratio (SGR) 1.67–1.79 (1.71, n=8).



Figs. 16–22 *Alluaudomyia formosana*, female pupa. 16 – dorsal apotome; 17 – respiratory organ (1 and 2 indicates two lateral pores); 18 – dorsal sensilla; 19 – fourth abdominal segment (ventral view); 20 – fourth abdominal segment (dorsal view); 21 – first abdominal segment; 22 – ocular sensilla (scale bar 0.1 mm).

Labrum 0.8 times longer than wide; palatum (Figs 11, 23, 24) with three pairs of anterior ss, two pair of posterior st and one pair of SCa; MS (Fig. 11) well developed, elongated, club shaped; SC (Fig. 11) well developed with six stout, lanceolate teeth; HY (Figs 23, 24) round, sclerotized and smooth. MD (Figs 11–13, 24) base broadened, minute seta on the basal portion near hypocondyle, apical tooth gently curved, pointed, sub median tooth small, blunt. Length of mandible (MDL) 0.037–0.046 (0.040, n=8), width (MDW) 0.012 (n=8). EP (Figs 11–13) with three combs: DC sclerites relatively wide with 14 moderate size, sub-equal, lanceolate teeth directed posteriorly, 7 on each half, a large median tooth; comb 2 with a large tooth-like process, comb 3 absent, comb 4 or VC with 10 stout, short teeth; each lateral arm with a fringe with 5–6 minute teeth like projection; lateral arm width (LAW) 0.042–0.053 (0.049, n=8), dorsal comb width (DCW) 0.017–0.029 (0.023, n=8). HP (Figs. 11–13) slender, heavily sclerotised, posterior end of each arm irregular without fringe. Thoracic pigmentation brown (Fig. 10). Caudal segment (Figs. 14, 15) slender, chaetotaxy as in Figs. 14 and 15; caudal segment length (CSL) 0.319–0.390 (0.341, n=8), caudal segment width (CSW) 0.065–0.081 (0.073, n=8); caudal segment ratio (CSR) 4.42–4.75 (4.53, n=8).

DESCRIPTION OF FEMALE PUPA (Figs 16–22, 26–30). Total length 1.88–2.04 (1.97, n=7). Exuvium light brown, cephalothorax brown, length 0.83 (0.80–0.84, n=7) and width 0.56–0.60 (0.58, n=7). RO light brown, short (Figs 17, 26–27), length 0.154–0.162 (0.158, n=7) and width 0.046 (n=7); apex expanded, brown, arranged in double rows of 14–15 pairs pores; 2 lateral pores near the base; outer surface covered with spicules. P short (Figs 17, 26, 27), length 0.025 (n=7), yellowish, smooth, base membranous with several folds; tracheal tube prominent, slightly curved; P/RO 0.154–0.162 (0.158, n=7). Dorsal apotome (Figs. 16, 26) yellowish brown, disc slightly wider than length, anterior end rounded, central region with pair of sub lateral, more or less circular raised areas. Surface with small knob like projections around a median portion and arranged in a single row of larger projections lying behind lateral angles. Surface of posterior margin with numerous spicules and a few tubercles between the raised areas; posterior margin slightly concave. Dorsal apotome length (DAL) 0.129–0.133 (0.131, n=7), dorsal apotome width (DAW) 0.154–0.158 (0.155, n=7), DAW/DAL 1.157–1.224 (1.19, n=7). Two dorsal apotomal sensilla (Fig. 16): DA-1-H short, stout located on rounded small tubercle, DA-2-H campaniform sensillum, located at the base of tubercle; clypeal/labral absent; four ocular sensilla (Fig. 22): O-1-H thin, short, at the base of palpus, O-3-H thin, long, seta, with 2 campaniform sensilla (O-2-H, O-4-H); dorsolateral cephalic sclerite sensilla with one stout small seta (DL-1-H) from well developed base and one campaniform sensillum (DL-2-H). Five dorsal setae clearly distinguished (Figs 18, 26, 28): D-1-T, D-2-T and D-5-T with small, stout seta; D-4-T with long, thin seta, D-3-T campaniform sensillum; one supra alar (SA-2-T) campaniform sensillum; anteromedials (Figs 17, 27) two setae: one short, stout (AM-2-T) and other long, thin (AM-1-T); anterolaterals (Fig. 27) three setae: one short and blunt (AL-3-T), one medium sized (AL-2-T) and one long, thin (AL-1-T). Metathorax (Fig. 21) completely divided with rounded ends, metathoracic-1 seta (M-1-T), and 2 campaniform sensilla (M-2-T, M-3-T). Abdominal tubercles short, with single, pointed or rounded apex; abdominal segment 1 (Fig. 21) with 8 setae including 3 lateral setae, 1 campaniform sensillum, D-2-I, D-3-I closely associated, D-7-I absent, D-4-I campaniform sensillum. Segment 4 (Figs. 19, 20, 29): D-2-IV short seta on small, stout and simple tubercle, D-3-IV long, thin bifurcated seta on stout, small tubercle; D-4-IV campaniform sensillum, D-5-IV short, stout seta on small tubercle, D-7-IV sensillum absent, D-8-IV medium sized, stout seta, D-9-IV long and thin seta; L-1-IV short seta on pointed tubercle; L-2-IV, L-3-IV and L-4-IV short setae on pointed tubercles; V-5-IV short, stout seta, V-6-IV long, thin seta and V-7-IV short, thin seta, all on small tubercles. Segment 9 (Fig. 30) broad, posteriorly directed spinules covering 2–3 rows anterodorsally, spinules scattered over dorsal surface, tapering to pointed apex. Caudal segment length (CSL) 0.141–0.145 (0.142, n=7),



Figs. 23–30 SEM photomicrographs of *Alluaudomyia formosana*, larva (23–25), pupa (26–30). 23 – head capsule chaetotaxy (ventral view); 24 – head capsule (frontal view); 25 – head capsule chaetotaxy (lateral view); 26 – Dorsal apotome & cephalothorax; 27 – Cephalothoracic chaetotaxy; 28 – Dorsal sensilla; 29 – Chaetotaxy of abdominal segment 4; 30 – Segment 9.

caudal segment width (CSW) 0.116–0.121 (0.118, n=7), TP 0.054–0.062 (0.057, n=7) short, with several spinules and sharp end with D-5-IX campaniform sensillum on base.

DISTRIBUTION. Taiwan, Malaysia, Thailand, and India (new record).

BIONOMICS. Larvae were collected from floating algae by scoop sampler and also from algal substances associated with rotten logs, stems from a margin of permanent pond coexisting with *Dasyhelea ornaticornis* Kieffer and *Alluaudomyia xanthocoma* Kieffer. The physiochemical characteristics of pond water at the time of collection were as follows: water temperature 32.8°C, pH 8.47, TDS 182 ppm, salinity 139 ppm and conductivity 257 µS/m. Due to minute size and rapid movement the larvae it was difficult to separate from algal mat. Possession of larvae with 4 pairs of long setae at caudal segment indicates that they are good swimmer and heavy pigmentation of thoracic region helps in better camouflaging and are adapted to avoid and escape from predator (Elson-Harris & Kettle, 1985). The larva performs very fast serpentine movement on the surface film, a unique habit observed by Thomsen (1937) and Grogan & Messersmith (1976) for some Nearctic species and Elson-Harris & Kettle (1985) for some Australian species.

DISCUSSION

Worldwide 23 species of *Alluaudomyia* are known as pupae and 12 species as larvae (Borkent, 2014). Several descriptions of the immature stages are incomplete and lack of SEM study or micro-photographs except in case of *A. amazonica* and *A. schnacki* (Diaz *et al.*, 2015), thus comparison with other species or construct a world key remains inconclusive.

Possession of bifurcated 's' setae in larva of *A. formosana* resemble with that of *A. splendida* and presence of three epipharyngeal combs in *A. fumosipennis*, *A. quadripunctata*, and *A. splendida* but differs in number of teeth in epipharyngeal combs. The caudal segment of *A. formosana* contains 4 pairs of long setae, of which 2 pairs exceeds the length of the segment which contradicts the generic limit of Elson-Harris & Kettle (1985). The pupa of *A. formosana* differs from *A. bella*, *A. footei*, *A. fumosipennis*, *A. megaparamera*, *A. needhami*, *A. paraspina*, and *A. unguistyla* by the follow combination of characters: respiratory organ with 2 lateral pores and 14–15 pairs of apical pores; dorsal apotome consists DA-2-H with distinct bare rounded region located medially; metathorax deeply indented, divided completely. Borkent (2014) published a pupal diagnosis of this genus based on the specimens belonging to the Nearctic, Central America (Costa Rica) and Australian regions. Reexamination of all available specimens by Borkent (2014) revealed sensillum D-7-IV located between the D-8-IV and D-9-IV sensilla which is absent in *A. formosana*. The character i.e. absence of D-7-IV sensillum in the species is shared with family Chironomidae (Borkent, 2012) which probably indicates synapomorphy. A correlation between the relative length of the scutellar setae of the pharate adult and the relative length of the posteromedial projection of the mesonotum was pointed by Borkent (2014). In several species of *Forcipomyia*, the scutellar setae present in pharate are long but in this species the seta are relatively small despite the posterior mesonotum completely divides the metathorax medially.

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REFERENCES

- Borkent, A. 2012. The pupae of Culicomorpha – Morphology and a new phylogenetic tree. *Zootaxa*, 3396: 1–98.

- Borkent, A. 2014. The Pupae of the Biting Midges of the World (Diptera: Ceratopogonidae), With a Generic Key and analysis of the Phylogenetic Relationship Between Genera. *Zootaxa*, 3879(1): 1–327.
- Borkent, A. 2016. World species of biting midges (Diptera: Ceratopogonidae). <http://www.inhs.uiuc.edu/research/FLYTREE/Borkent.html>
- Chaudhuri, P.K., Das Gupta, S.K. & Chaudhuri, D.K. 1972. Biting midges of the genus *Alluaudomyia* Kieffer (Diptera: Ceratopogonidae) from India. *Oriental Insects*, 6(1): 83–110.
- Chaudhuri, P.K. & Ghosh, M. 1980. Addition to the studies of genus *Alluaudomyia* Kieffer (Ceratopogonidae: Diptera) of India. *Oriental Insects*, 14(4): 421–424.
- Chaudhuri, P.K., Das Gupta, S.K. & Chatterjee, A.K. 1981. *Alluaudomyia fuscitarsis* n. sp. and *Stilobezzia ensistyla* n. sp. from India (Diptera: Ceratopogonidae). *Entomologica Scandinavica*, 12: 147–150.
- Debenham, L.M. 1971. Australasian Ceratopogonidae (Diptera: Nematocera) Part XV. The genus *Alluaudomyia* Kieffer in Australia and New Guinea. *Proceedings of the Linnean Society of New South Wales*, 96(3): 128–174.
- Diaz, F., Marino, P.I., Ronderos, M.M. & Spinelli, G.R. 2015. Detailed description of larvae and pupae of two Neotropical species of *Alluaudomyia* Kieffer (Culicomorpha: Ceratopogonidae). *Zoologischer Anzeiger*, 257: 87–95.
- Elson-Harris, M.M. & Kettle, D.S. 1985. The immature stages of some Australian *Alluaudomyia* Kieffer (Diptera: Ceratopogonidae). *Journal of the Australian Entomological Society*, 24: 287–299.
- Grogan, W.L. & Messersmith, D.H. 1976. The immature stages of *Alluaudomyia paraspina* (Diptera: Ceratopogonidae) Wirth with notes on its biology. *Annals of the Entomological Society of America*, 69(4): 687–690.
- Murphree, C.S. & Mullen, G.R. 1991. Comparative larvae morphology of the genus *Culicoides* Latreille (Diptera: Ceratopogonidae) in North America with a key to species. *Bulletin of the Society of Vector Biology*, 16: 269–399.
- Okada, T. 1942. *Alluaudomyia* (Diptera, Heleidae) from Formosa with a revised key. *Transactions of the Natural History Society of Formosa*, 32: 315–320.
- Sinha, S., Mazumdar, A. & Chaudhuri, P.K. 2005. New species of predaceous midges of the genus *Alluaudomyia* Kieffer, 1913 (Insecta, Diptera, Ceratopogonidae) from the coastal region of the West Bengal, India. *Zoosystema*, 27(1): 115–122.
- Thomsen, L.C. 1937. Aquatic Diptera. Part V. Ceratopogonidae. *Memoirs of the Cornell University Agricultural Experimental Station*, 210: 57–80.
- Wirth, W.W. & Delfinado, M.D. 1964. Revision of the Oriental species of *Alluaudomyia* Kieffer (Diptera, Ceratopogonidae). *Pacific Insects*, 6(4): 599–648.
- Wirth, W.W. & Marston, N. 1968. A method for mounting small insects on microscope slides in Canada balsam. *Annals of the Entomological Society of America*, 61: 783–784.

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