

A new record of *Heptagenia* (H.) *quadripunctata* Kluge, 1989 (Heptageniinae: Heptageniidae: Ephemeroptera) from the Western Himalaya, India

M. Vasanth¹, T. Kubendran^{2*}, K. A. Subramanian¹, Nisar Ahmad Paray³, and Soumen Roy²

¹Zoological Survey of India, Southern Regional Centre, Santhome High Road, Chennai - 600028, Tamil Nadu, India; E-mail: vasan071994@gmail.com, subbuka.zsi@gmail.com

²Miscellaneous Insect Order Section, Zoological Survey of India, Prani Vigyan Bhawan, M-Block, New Alipore, Kolkata - 700053, West Bengal, India; E-mail: roypapai91@gmail.com

³Department of Zoology, University of Kashmir, Hazratbal, Srinagar - 190006, Jammu and Kashmir, India; E-mail: nisarparay143@gmail.com, tkbaetis@gmail.com

Abstract

As part of continued efforts to explore the Ephemeroptera fauna of the streams or rivers of Indian Himalaya, *Heptagenia* (H.) *quadripunctata* Kluge, 1989 is newly recorded based on the fresh materials collected from the North Western Himalaya, India. The redescription of this species with morphological characters of larvae based on freshly collected specimens and earlier descriptions is appended. The distribution map of the species localities is also provided.

Keywords: Cold desert, *Heptagenia* s.s., *Heptagenia* (H.) *quadripunctata*, India, new record

Introduction

The flat-headed mayfly of the tribe Heptageniini Lameere, 1917 (Heptageniidae: Heptageninae), which comprises more than fifty species distributed in the Palearctic, North America and Oriental regions. The genus *Heptagenia* Walsh, 1863 belongs to three subgenera viz., *Heptagenia* s.s., *Kageronia* Matsumura, 1931 and *Dacnogenia* Kluge, 1988. The characters of the subfamily Heptageniini of larva and imago stages of this genus are updated by Kluge (2004) and the cladistic study worldwide by Wang and McCafferty (2004) and Webb and McCafferty (2008), considering the earlier publications by Bauernfeind and Soldán (2012). In India, the new record of the subgenus *Heptagenia* s.s. Kluge, 1987 comprises three species, which were distributed in the Indian Himalayas and northeast Indian states viz., *Heptagenia nubile* Kimmins, 1937 described by imagoes from the Assam; *H. solangensis* Dubey, 1971 described by imagoes from the North Western Himalaya; and *H. (H.) traversae* Braasch, 1986 described by larvae and subimagoes from Ladakh

(Union Territory). In the last two decades, the genus *Heptagenia* has not been studied, and no new species have been described worldwide. While examining our recent collection from Ladakh, we have identified the larvae of the species *H. quadripunctata* Kluge, 1989 as a new record from India. The diagnostic characters and descriptions are upgraded from freshly collected larvae and based on the previous original description, which was in the Russian language and translated into the English language. The total number of species in the genus *Heptagenia* of India is thereby increased to four species in the hotspot of Indian Himalaya (Figure 41). Further more extensive surveys in under and unexplored regions to explore the biodiversity of mayflies.

Materials and Methods

Larval materials were collected from streams and rivers of Ladakh (Union Territory of India), during the expedition of the Zoological Survey of India. The specimens were collected by hand picking using a fine brush and kick net

* Author for correspondence

sampling. All the materials were stored in 85% alcohol in the field, preserved at absolute alcohol brought back to the laboratory for further processing. In permanent mounts were made in Hoyer's medium and sealed with Canada Balsam to enable detailed microscopic observations. Photographs were taken by using microscopes of Leica SAPO and Leica DM3000. The new record of the specimens was deposited in the Southern Regional Centre (SRC), Zoological Survey of India (ZSI), Chennai, India.

Systematic Accounts

Morphological characters of the genus *Heptagenia* Walsh, 1863

Type species: Palingenia flavescens Walsh, 1862

The description of the genus *Heptagenia* Walsh, 1863 in subgenus *Heptagenia* s.s. here are understood in the context of Kluge (2004), Wang and McCafferty (2004), Webb and McCafferty (2008) and Bauernfeind and Soldán (2012). The larva is commonly dorsoventrally flattened, head broad. Abdominal segments are usually without conspicuous markings. Maximum size 9-12 mm in large specimen, length of forewings 7-17 mm. Larvae with three caudal filaments, in case of winged stages the terminal filament missing.

Larvae: Head quadrangular and broad, lateral sides of pronotum extended slightly and laterally rounded margins. 1. Labrum variable, much shorter than wide, anterior margin without distinct medioventral cleft and a transverse row of robust pointed setae on ventrally. 2. Incisors of mandible long and stout, apex of outer incisors and inner incisors similar in both left and right mandible and molar with strong setae. 3. Galeolacinia of maxilla with a row of long setae submarginally along the inner margin; distal margin with 10-12 comb-shaped setae. 4. Superlinguae are usually not bent on the apex. 5. Labium of glossae slightly narrow, and blunt (some species distinctly bent inwards). 6. Legs of all femora broad, claws usually with or without teeth. 7. Seven pairs of gills are present on the lateral side, gills I-VI consisting of a plate and a bunch of filaments. **Imagoes:** 1. Compound eyes of male imagoes separated by a gap equal to the diameter of the middle ocellus. 2. Abdominal segments without a distinct colour. 3. In genitalia, penis distally extended into broad and folded lobes, without distinct sclerites,

dorsal fold of lobe with a visible internal and external spine laterally, medially with a pair of slender, spine-like titillators located and forceps with four joints, without lateral teeth.

Results

***Heptagenia* (*Heptagenia*) *quadripunctata* Kluge, 1989** (Figures 1-41)

1989. *Heptagenia* (*Heptagenia*) *quadripunctata*, Bulletin of Leningrad University, 3(4): 4.

2022. *Heptagenia* (*Heptagenia*) *quadripunctata* Kluge, 159(2): 151-186.

Materials examined: 03 larvae, India, Union Territory of Ladakh, Leh, Shey village (15 km far from Leh towards Hemis), Indus River, Indus Valley, 34.06915°N, 77.63618°E, 3446 m, 16. viii.2019. Coll. T. Kubendran. 03 larvae, India, Union Territory of Ladakh, Leh, Hemis, (40 km far from Leh) Indus River, Indus Valley, 33.91421°N, 77.71136°E, 3589 m, 15. viii.2019. Coll. T. Kubendran. 01 larva, India, Union Territory of Ladakh, Leh, Phey village, (21 km far from Leh) Indus River, Indus Valley, 34.13350°N, 77.46266°E, 3209 m, 18. viii.2019. Coll. T. Kubendran.

Description: Body brownish yellow, with indistinct pattern. Dorsally with long and thin setae; Length of mature larva, antennae 1.5-2.0 mm; body 9.5-10 mm; caudal filaments 9-10 mm.

Head: The head is quadrangular, brownish with irregular pale-yellow markings, sometimes expanding anteriorly, with a narrow posterior margin (Figures 1, 2) and slight width in the middle of the thorax (Figure 2); the front of head semi-dark for most part and the medial ocellus departs as a light spot ahead (Figures 1, 2); anterior margin of head with small hair-like setae; width and length of the head 2.7-2.9 mm and 2.2-2.3 mm respectively; antennae brownish, scape broad and pedicel with thin hair-like setae (Figure 10). The ventral surface is pale yellow and whitish in the thoracic part (Figure 3). Labrum: length shorter than wide, anterior margin slightly shallow medially and curved laterally, dorsal and ventral side with a transverse row of robust, dense, long hair-like setae (Figures 11, 12). Hypopharynx: superlinguae slightly longer than lingua and bulged laterally with long hair-like setae; and dorsal surface with small hair-like setae, lingua anteriorly with a V-shaped cleft with thin hair-like setae (Figures 13, 14).

Mandibles: anterolateral margin without smooth and broad, mixed with long hair-like setae; incisors long and stout; outer incisors similar in both mandibles, apex with serrated; inner incisors well developed in left mandible, in case of right mandible poorly developed; prostheca with hair-like setae, a molar with strong setae (Figures 15-18). **Labium:** the outer edge of glossae convex, bent inwards, paraglossae slightly rounded with dense hair-like setae; palps three-segmented, Segment I broad, surface with a bunch of small setae outward, and Segment III broad, outward with mixed hair-like setae (Figures 19-21). **Maxilla:** Galeolacinia with a row of long setae submarginally along with inner margin, distal margin with 11-12 comb-shaped setae, surface with a bunch of long, stout setae and 2-3 dentisetae on anterior margin; palps three-segmented; Segment I smaller, Segment II slightly broad with long hair-like setae on inner and outside, Segment III longer, apically sharp, outward with long hair-like setae and apically stout setae, inside with small setae (Figures 22-24).

Thorax: Thorax with indistinct brown and yellowish-brown markings, ventrally pale white (Figures 2, 3). Pronotum anteriorly with a pair of dark brown spots. Laterally, slightly wider than the head and the posterior margin is shallowly cleft medially (Figure 4). Mesonotum without spines, laterally with a pair of distinct spine-like projections, dark-tinted flat protrusions sticking out to the sides and somewhat bent dorsally and under the form of distinct blunted spine of supracoxal protrusions of mid femur (Figure 2). Fore and hind femur supracoxal protrusions of thorax not developed. Wing pad is well developed. **Legs:** Femur brown with pale yellowish, proximal and distal parts narrow and medially wider with two prominent dark bands; dorsally with small, stout, spatulate spine-like and hair-like setae, anterior margin with slight, long, stout, spatulate spine-like and long hair-like setae; apex with blunt apical projection (Figures 25-27). Tibia with dense hair-like setae, in-between with small and large sharp spine-like setae on the dorsal side (Figure 28). Middle and hind femora well developed; tibiae with dense, long, hair-like setae on the outer margin and smaller setae on the dorsal edge (Figures 29-30). Claw with a single prominent denticle (Figure 31).

Abdomen: Terga brownish yellow with distinct pair of oblique markings; terga I-X without posterolateral spines and medial tubercles, sternites pale (Figures 1-3); terga

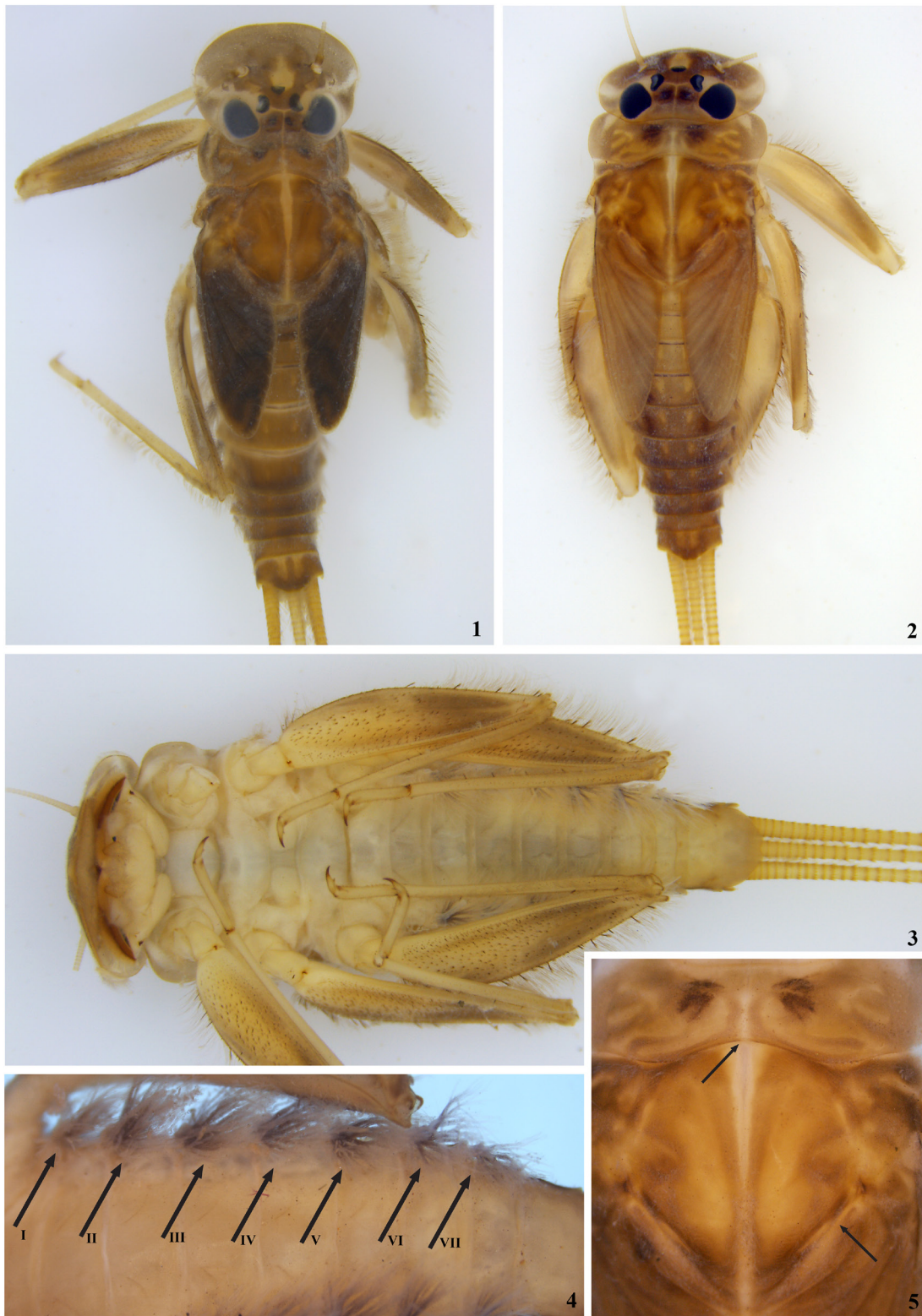
I-X with a punch of hair-like setae on each side (Figure 8); each posterior margin with small distinct spines (Figure 7). Gills present on terga I-VII with two lamellae, upper lamellae lobes, each with rudimentary, narrow, without rigid ribs and lower lamellae with large, dense filamentous (Figures 4, 32-38). Caudal filaments are yellowish-brown, each segment covered with stout setae (Figures 2, 3, 9).

Distribution: Palearctic and Oriental regions (India). Details of the Palearctic type locality for the species *H. (H.) quadripunctata*, Kluge (1989). This species is first recorded from the high-altitude region of Ladakh. It is a narrow-restricted species and is currently reported in cold deserts.

Diagnosis: Larva: *H. (H.) quadripunctata* can be differentiated from its congeners in having the following unique combination of characters: 1. superlinguae of hypopharynx slightly longer than lingua and bulged laterally (Figures 13, 14); 2. anterior margin of labrum slightly shallow medially and curved laterally (Figures 11, 12) 4. apex of femora with dorsal process projected (Figures 25, 29, 30); 5. gills I-VII, dorsal lamellae lobe and ventral lamellae filamentous (32-38); 6. Claw with a single prominent denticle (Figure 31).

Discussion

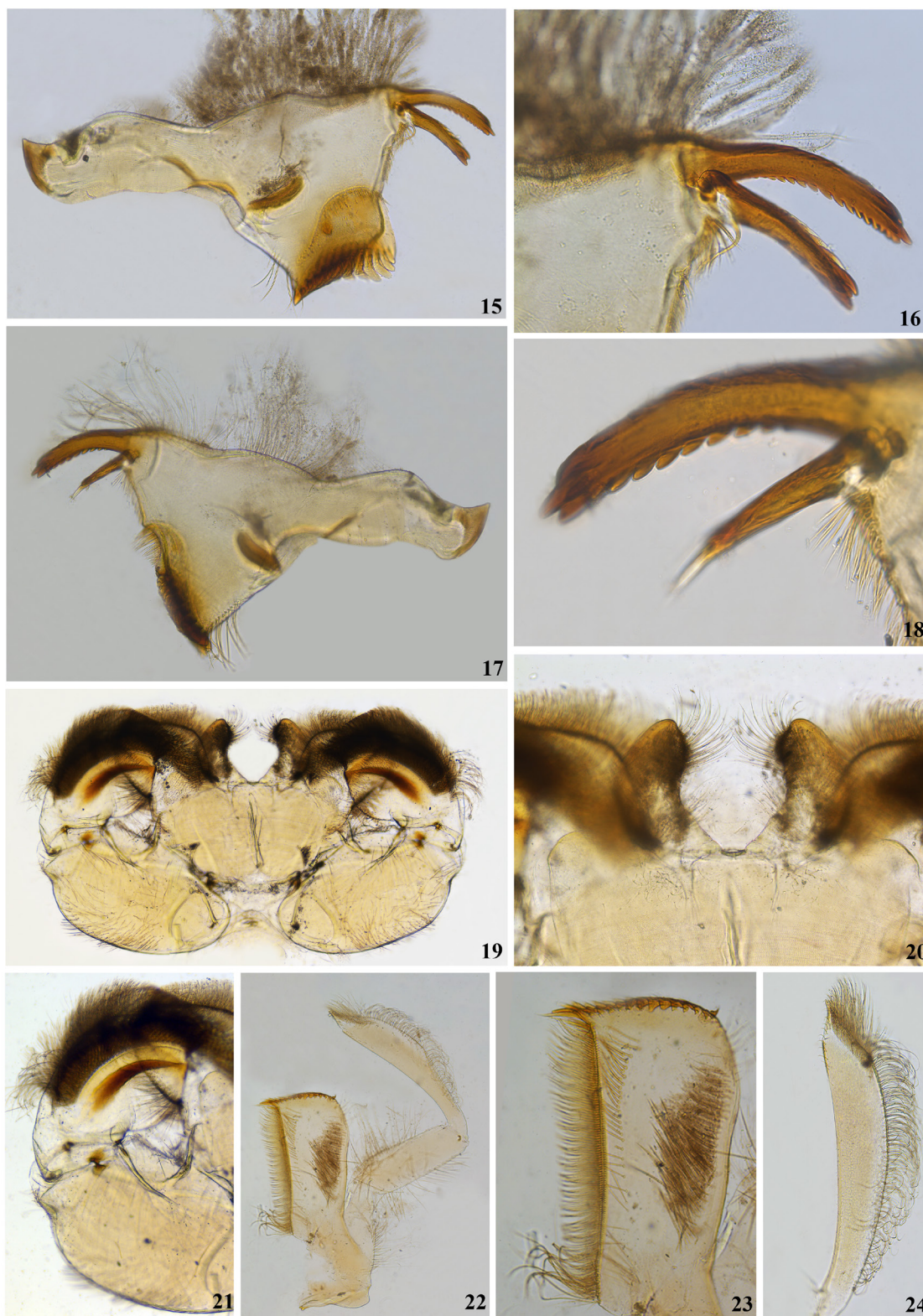
Heptagenia (H.) quadripunctata was originally described by Kluge (1989) based on the larvae and imagoes from Russia. The present study reveals that the taxonomy and morphology of *H. (H.) quadripunctata* updated herewith the recently collected larval materials. Only three species are described so far from India with inadequate description and diagnostic characteristics. The original descriptions of this species were illustrated by accurate drawings and without photographs. The description and diagnostic characters of the species were provided in Russian language. The new record of this species is confirmed by Dr. N. J. Kluge (personal communication). The Oriental *Heptagenia* Walsh, 1863 is one of the poorly studied genera of the order Ephemeroptera (mayflies). The diversity and distribution of *Heptagenia* in India are poorly known due to a lack of exploration in high-altitude regions in India especially Trans Himalaya and lack of studies on the association of life stages by rearing in the field and species delimitations not supplemented by molecular studies (Vasanth *et al.*, 2021). The detailed description of the species is quite helpful to the budding



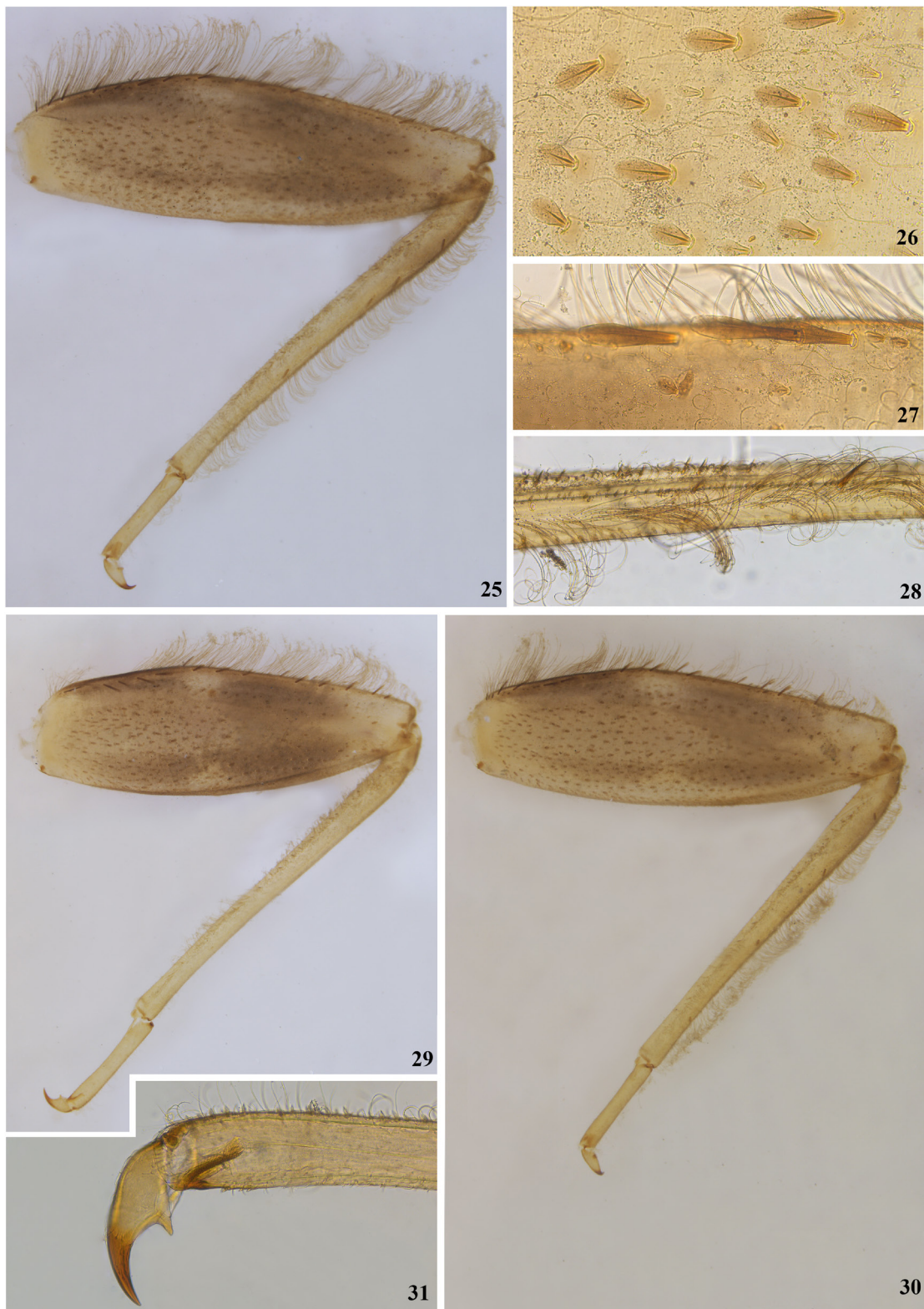
Figures 1-5. Larva of *H. (H.) quadripunctata* 1. Dorsal view (ultimolarva); 2. Dorsal view; 3. Ventral view; 4. Ventral view of abdomen showing gills; 5. Dorsal view of thorax.



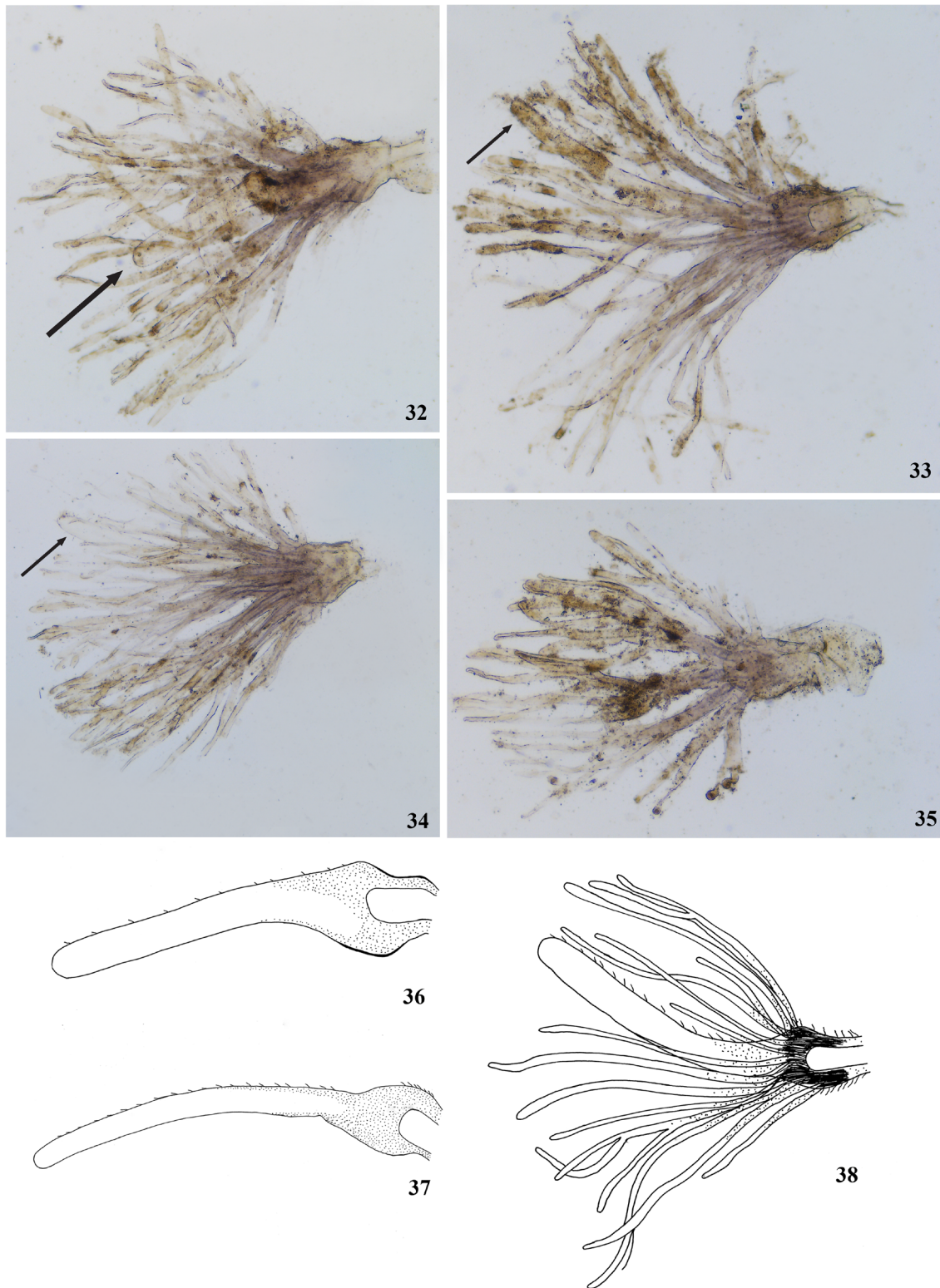
Figures 6-14. Larva of *H. (H.) quadripunctata* **6.** Lateral view of thorax; **7.** Abdominal terga IV-V; **8.** Abdominal terga VI-VIII with lateral setae; **9.** Cerci; **10.** Antennae; **11.** Labrum; **12.** Labrum closer view; **13.** Hypopharynx; **14.** Hypopharynx closer view.



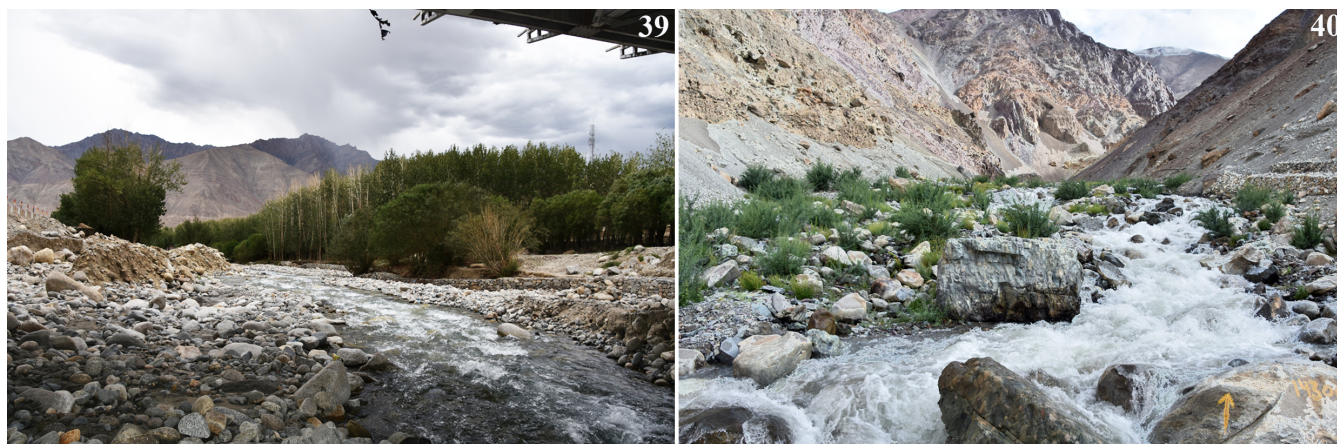
Figures 15-24. Larva of *H. (H.) quadripunctata* 15. Left mandible; 16. Left mandible closer view; 17. Right mandible; 18. Right mandible closer view; 19. Labium; 20. Labium closer view of glossae; 21. Closer view of labial palp; 22. Maxilla; 23. Galealacinia of maxilla; 24. Maxillary palp.



Figures 25-31. Larva of *H. (H.) quadripunctata* 25. Foreleg; 26. Dorsal surface; 27. Anterior margin; 28. Tibia; 29. Midleg; 30. Hindleg; 31. claw.



Figures 32-38. Larva of *H. (H.) quadripunctata* 32. Gill I; 33. Gill II; 34. Gill III; 35. Gill IV; 36. Gill V (lobe); 37. Gill VI (lobe); 38. Gill VII



Figures 39-40. Sampling sites of *H. (H.) quadripunctata* 39. Shey village, Leh, Indus River, Indus Valley, 40. Phey village, Leh, Indus River, Indus Valley.

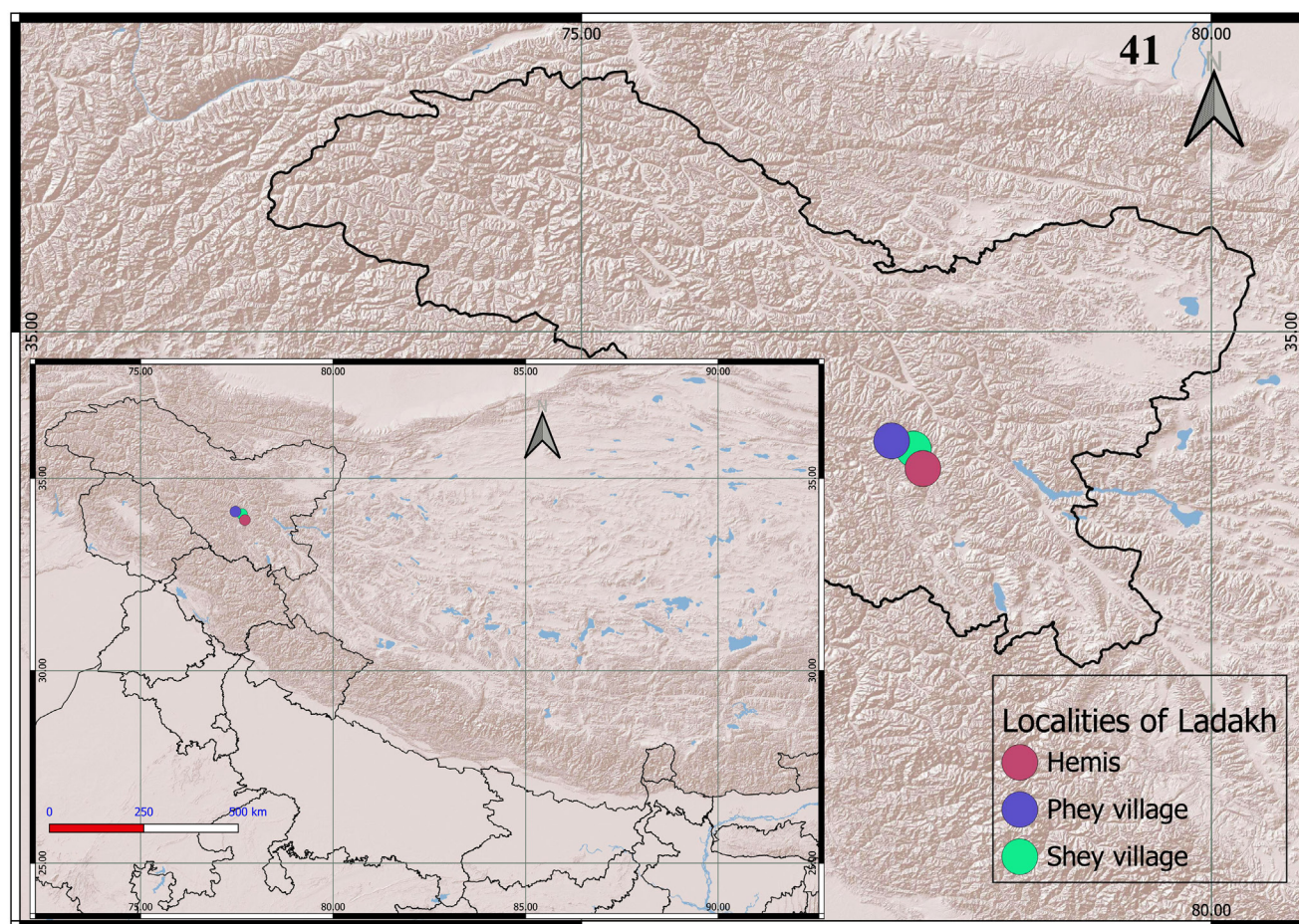


Figure 41. Distribution map of *H. (H.) quadripunctata* of India

mayfly research. Hopefully, future investigations employing integrative taxonomic and phylogenetic approaches of all biogeographic zones of Indian Himalaya viz, Western Himalaya, Northern Himalaya, Eastern Himalaya and Trans Himalaya may contribute to this genus. *Heptagenia (H). quadripunctata* was the only species collected from the Trans Himalayan or cold desert tributary of the Indus River with an altitude range from 3209-3589 m asl (Figures 39-41).

Acknowledgements

The authors are grateful to Dr. Dhriti Banerjee, Director, Zoological Survey of India, Kolkata, for providing facilities

to carry out the research work. K. A. Subramanian and M. Vasanth thank Long-Term Ecological Observatories (LTEO) Project, Ministry of Environment, Forest and Climate Change, Government of India for carrying out this research. T. Kubendran thanks to the Science and Engineering Research Board (SERB), Govt. of India, New Delhi for financial support under the Empowerment and Equity Opportunities for Excellence in Science (F.N. EEQ/2018/000481) carrying out this research. Nisar Ahmad Paray thanks to Ph. D supervisor Dr. Altaf Hussain Mir, Sr. Asst. Professor and also thank HOD, Department of Zoology, University of Kashmir, Srinagar for their constant encouragement for the mayfly studies.

References

- Bauernfeind, E. and Soldán, T. 2012. *The mayflies of Europe (Ephemeroptera)*. Apollo Books, Ollerup, 781 pp.
- Kluge, N.J. 2004. *The phylogenetic system of Ephemeroptera*. Kluwer Academic Publishers: 456 pp. <https://doi.org/10.1007/978-94-007-0872-3>
- Kluge, N.J. 1989. Revision of genera of the family Heptageniidae (Ephemeroptera). I. Diagnoses of tribes, genera and subgenera of the subfamily Heptageniinae. *Entomological Review*, **68**: 1-24.
- Vasanth, M., Selvakumar, C., Subramanian, K.A., Sivaramakrishnan, K.G. and Sinha, B. 2021. Contribution to the study of *Epeorus* Eaton, 1881 (Ephemeroptera: Heptageniidae) from India. *Zootaxa*, **4991**(3): 499-522. <https://doi.org/10.11646/zootaxa.4991.3.4> PMID:34186833
- Walsh, B. D. 1863. Observations on certain Neuroptera with notes and descriptions of about twenty new species of Pseudoneuroptera. *Proceedings of the Entomological Society of Philadelphia*, 2: 167-272.
- Wang, T.Q. and McCafferty, W.P. 2004. Heptageniidae (Ephemeroptera) of the world. Part I: Phylogenetic higher classification. *Transactions of the American Entomological Society*, **130**(1): 11-45.
- Webb, J.M. and McCafferty, W.P. 2008. Heptageniidae of the World. Part II: Key to the Genera. *Canadian Journal of Arthropoda Identification*, **7**: 1-55.