

Biosystematics of the Genus *Nathanella* Demoulin (Ephemeroptera: Leptophlebiidae: Atalophlebiinae) from South India

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lophlebiinae) from South India.

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The genus *Nathanella* and the species *N. indica* Demoulin are redescribed. The female imago and the nymph of *N. indica* are described for the first time. A new species *N. saras-wathiae* is described from male and female imagines and nymph. Illustrated keys for the nymphs and imagines are provided for the species.

Keywords: Ephemeroptera, Leptophlebiidae, Atalophlebiinae, *Nathanella*, India.

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INTRODUCTION

Preliminary investigations on the role of the Ephemeroptera-Plecoptera-Trichoptera complexes as sensitive bioindicators of water quality in peninsular India necessitated extensive exploration of the pristine hill streams of the Western Ghats. This region is characterized by distinctive habitats called the "sholas," areas of undisturbed forest polyculture canopy through which first and second order streams cascade during the monsoon season; streams are intermittent during other seasons.

As a result of these endeavors, we discovered new taxa of mayflies forming a vital trophic spectrum to efficiently harbor and recycle the solar energy locked up in decaying debris. Since inventorying and monitoring are primary prerequisites for efficient conservation of endangered aquatic entomofauna and their habitat, we began to work on the biosystematics of biogeographically significant mayfly taxa, including *Nathanella*.

Demoulin (1955) established the genus *Nathanella* for a distinctive species, *N. indica* Demoulin, known only from male imagines collected in Kodaikanal, Palani Hills and Cinchona, Anamalai Hills, South India. The presumed nymph of *Nathanella* described by Peters and Edmunds (1970) was later shown to be that of *Notophlebia jobi* by Sivaramakrishnan and Peters (1984). Sivaramakrishnan

and Venkataraman (1987) described the eggs of *N. indica* from one female imago collected in the Palani Hills. The nymph of *Nathanella* remained unknown until our research on the hill streams of Western Ghats.

The description of *N. indica* by Demoulin (1955) was based on six pinned male imagines; Peters and Edmunds also used a pinned male in their 1970 revision. We now have series of imagines, some pinned and some collected in alcohol, and are able to expand the description of the male imago. We also describe the female imago and nymph of *N. indica* and male and female imagines and nymph of *N. saraswathiae*, new species. Terminology and procedures used in the description follow those of Sivaramakrishnan and Peters (1984).

Genus *Nathanella* Demoulin (Figs. 1-32)

Nathanella Demoulin, 1955:1; Peters and Edmunds, 1970:212; Hubbard and Peters, 1978:25; Sivaramakrishnan and Peters, 1984:115; Sivaramakrishnan and Venkataraman, 1987:643; Hubbard, 1990:64.

Type Species: *Nathanella indica* Demoulin, by original designation.

Species included: *N. indica* Demoulin, *N. saraswathiae* new species.

Distribution. Southern India.

Imago. Length: male body 7.0-9.5 mm, fore wings 7.5-9.5 mm; female body 7.0-10.2 mm, fore wings 7.5-10.2 mm. Male eyes separated on meson of head by a distance $1/5$ to $4/5$ width of lateral ocellus, upper portion subcircular dorsally, lower portion $3/5$ length of upper portion, upper portion on short stalk (Figs. 6-7); female eyes separated on meson of head by a length 3 times width of an eye. Wings (Fig. 1): maximum width of fore wings $1/3$ maximum length of fore wings; vein Rs of fore wings forked about $1/4$ of distance from base to margin; vein MA forked slightly more than $1/2$ of distance from base to margin, fork symmetrical to slightly asymmetrical; vein MP_2 attached at base to vein MP_1 and CuA by a cross vein, attachment of vein MP_2 to MP_1 $>1/4$ to $<1/3$ distance from base to margin (Fig. 1); cubital area with 2 intercalaries as in Fig. 1, cross veins few; anal area reduced posteriorly. Hind wings absent. Legs: ratios of segments in male fore legs, 0.67-0.80: 1.00 (3.20-3.60 mm): 0.03-0.05: 0.29-0.33: 0.18-0.19: 0.10-0.12: 0.10-0.12. Claws of a pair alike, both apically hooked each with an opposing hook (Fig. 5). Male genitalia (Figs. 2-4): segment 2 of forceps a little shorter than segment 3 and $1/10$ length of segment 1, apex of segment 3 rounded, base of forceps broad, its inner margin forming a smooth bend near middle of forceps (Figs. 2-3); maximum length of styliger plate along median line a little less to a little more than $1/2$ maximum width, dorsal margin broadly convex or convex with a median depression as in Figs. 2-3; penes divided, straight, tubular, apex expanded dorsally (Figs. 2-4). Female with well developed egg guide on posteromedian margin of sternum 7 extending to middle of

sternum 8 (Figs. 11, 14). Female 9th sternum cleft apically (Fig. 11). Terminal filament a little longer than cerci.

Mature nymph. Head prognathous, margins of head capsule broadly expanded (Fig. 15). Antennae 1-1/2 times maximum length of head. Mouthparts (Figs. 16-24): length of labrum approximately 1/4 times maximum width, labrum expanded and angled laterally, dorsal hair on labrum as in Fig. 22: submedian to anterior and lateral areas of hair ventrally, anteromedian margin of labrum without emargination and with 5 broad-based denticles as in Fig. 23. Clypeus as in Fig. 22. Outer margin of mandibles smoothly curved basally and straight apically with a row of hair along distal half (Fig. 17). Lingua of hypopharynx with well developed lateral processes and internal dorsal hair patches (Fig. 24), superlinguae as in Fig. 24 with a row of hair along anterior margin, lateral margins rounded. Galea-lacinia of maxillae slightly broader apically, with a row of about 25 subapical pectinate setae; segment 2 of maxillary palpi slightly longer to 1-1/3 times length of segment 1, segment 3 of palpi 1/2 length of segment 2, triangular; a V-shaped ridge near the ventral, inner anterolateral margin of maxillae; hair on maxillae as in Fig. 16. Labium as in Fig. 21; segment 2 of palpi equal in length to segment 1, segment 3 of palpi 1/2 length of segment 2, triangular (Figs. 19-20); paraglossae ventral to glossae; lateral margins of submentum without setae or spines (Fig. 21). Legs (Figs. 25-30): femora broad, inner margin deeply indented so tibiae can draw partially into femora (Figs. 25-26); maximum width of tibiae approximately 2 times maximum width of tarsi; tibiae oval in cross section (Fig. 27), tarsi circular in cross section; tibiae with heavy spines apically (Figs. 28-30), these most pronounced on hind legs (Figs. 29-30); apex of claws hooked and narrow, a row of approximately 10-12 denticles, denticles progressively larger apically (Fig. 28). Abdomen: posterolateral spines on segments 2-9, spines progressively larger posteriorly. Gills (Figs. 31-32): gills on abdominal segments 1-7, dorsal and ventral portions of lamellae leaf-like, both portions apically terminated in 3 projections, with median projection longer than laterals, tracheae branched. Terminal filament longer than cerci.

Discussion. The above redescription of *Nathanella* is based on *N. indica* and *N. saraswathiae* sp. n. In most specimens, the penes are straight (Fig. 2), but in some the penes are strongly divergent (Fig. 3). Possibly this represents the condition before and after mating. Another such variation in condition of the penes was illustrated for *Sulawesi haema* Peters and Edmunds (1990). *Nathanella* can be distinguished from all genera of the Leptophlebiidae by the following combination of characters. In the imagines: (1) hind wings are absent; (2) vein MP_2 of fore wings is attached at base to vein MP_1 and CuA by a cross vein, and attachment of vein MP_2 to MP_1 is greater than 1/4 to 1/3 distance from base to margin (Fig. 1); (3) penes are divided, straight, with apex expanded dorsally (Figs. 2-4); and (4) claws of a pair are similar (Fig. 5). In the nymph: (1) abdominal gills are present on segments 1-7, and dorsal and ventral portions of lamellae are leaf-like

and apically terminated in 3 projections, median longer than laterals (Figs. 31-32); (2) outer margin of mandibles is smoothly curved basally and straight apically with a row of hair in the apical half (Fig. 17); (3) anteromedian margin of labrum is straight with 5 broad-based denticles (Fig. 23); and (4) lateral margins of the head capsule are broadly expanded (Fig. 15).

Nathanella appears to be most closely related to *Petersula* Sivaramakrishnan from Southern India and *Kimminsula* Peters and Edmunds and yet to be established genera from Sri Lanka (Hubbard and Peters 1984). It can be distinguished from all these genera by the absence of hind wings in the imago and by the broadly expanded margins of the head capsule in the nymph. *Nathanella* can be distinguished from all genera of Eastern Hemisphere Leptophlebiidae which lack hind wings by the similar claws in the male imago and by the broadly expanded margins of the head capsule in the nymph.

Key to Species of *Nathanella*

Imagines

1. Membrane of fore wing golden brown, cross veins in cells C and Sc narrowly clouded with brown; abdominal terga 3-7 of ♂ brown except irregularly pale apically (Fig. 12); dorsal margin of styliger plate of ♂ broadly convex *N. indica* Demoulin
- Membrane of fore wing hyaline with weak brown tint, veins in fore wing broadly clouded with dark brown (Fig. 1); maculae on ♂ abdominal terga 3-7 as in Figs. 8-10; dorsal margin of styliger plate of ♂ convex with a median shallow depression (Figs. 2-3) *N. saraswathiae* sp. n.

Mature Nymphs

1. Median projection of abdominal gills broad and approximately twice length of laterals (Fig. 32); tracheation in gills uniformly distributed (Fig. 32); distal, irregular light brown maculae on femora of legs (Fig. 26) *N. indica* Demoulin
- Median projection of abdominal gills narrow and approximately 1-1/2 times length of laterals (Fig. 31); main trunk of tracheae of gills forked near distal half of lamellae (Fig. 31); medial and distal, irregular black maculae on femora of legs (Fig. 25) *N. saraswathiae* sp. n.

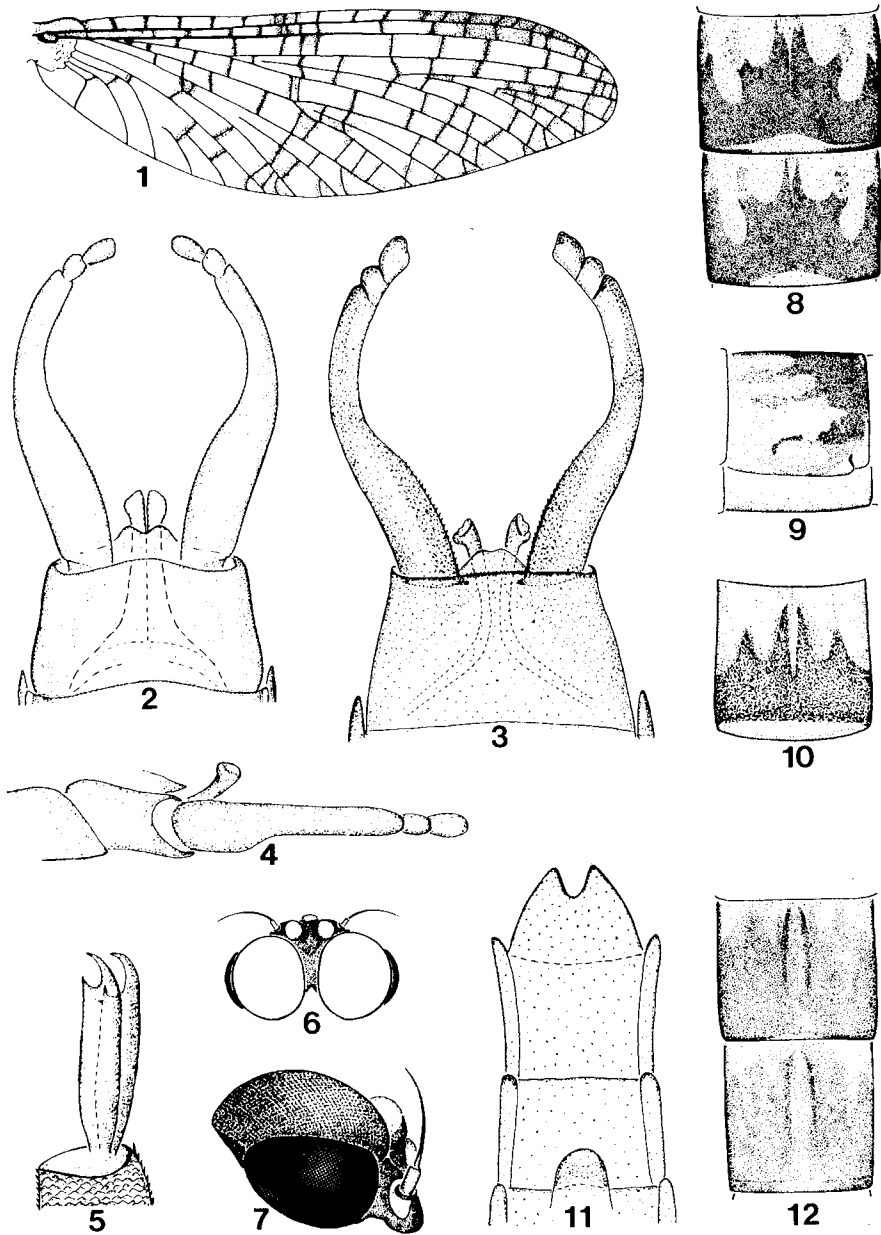
Nathanella indica Demoulin (Figs. 11-12, 15-24, 26, 32)

Nathanella indica Demoulin, 1955:2 (♂); Peters and Edmunds, 1970:212 (partim, ♂); Hubbard and Peters, 1978:25; Sivaramakrishnan and Venkataraman, 1987:643 (egg).

Type locality. Kodaikanal, Palney [SIC] Hills, South India. Type deposited in Royal Institute of Natural Science, Belgium.

Distribution. Palani and Anamalai Hills, south India.

Material. India, Tamil Nadu, Palani Hills, Gandhi Nagar, 1600 m, 20.XII.1986, K. G. Sivaramakrishnan and K. Venkataraman, 9 ♂ imagines, 1 ♀ imago and 11 nymphs; Kerala, Munnar, 3,500 ft, 15.XII.1961, F. Schmid, 1 ♂ imago.



Figs. 1-12. Imagines of *Nathanelle*: 1-10, *N. saraswathiae*; 11-12, *N. indica*. 1, fore wing. 2-4, genitalia of ♂ (2-3, ventral; 4, lateral). 5, fore claw. 6-7, eyes of ♂ (6, dorsal; 7, lateral). 8-10, 12, abdominal segments of ♂ (8, 12, terga 5-6; 10, tergum 5; 9, segment 6, lateral); 11, ventral view of sterna 7-9 of ♀.

Male imago as described by Demoulin 1955, except: Length: body 7.0-8.5 mm, fore wings 7.5-9.5 mm. Wings: membrane hyaline golden brown; longitudinal and cross veins yellowish-brown, cross veins in cells C and Sc narrowly clouded with brown. Legs: dorsum of legs yellowish-brown except coxae and distal edge of metafemora distinctly washed with reddish-brown, venter yellowish-brown. Caudal filaments yellowish-brown with brown annulations at articulations.

Female imago (in alcohol). Length: body 7.0-8.0 mm, fore wings 7.2-10.5 mm. Color and marks as in ♂ imago, generally dark brown.

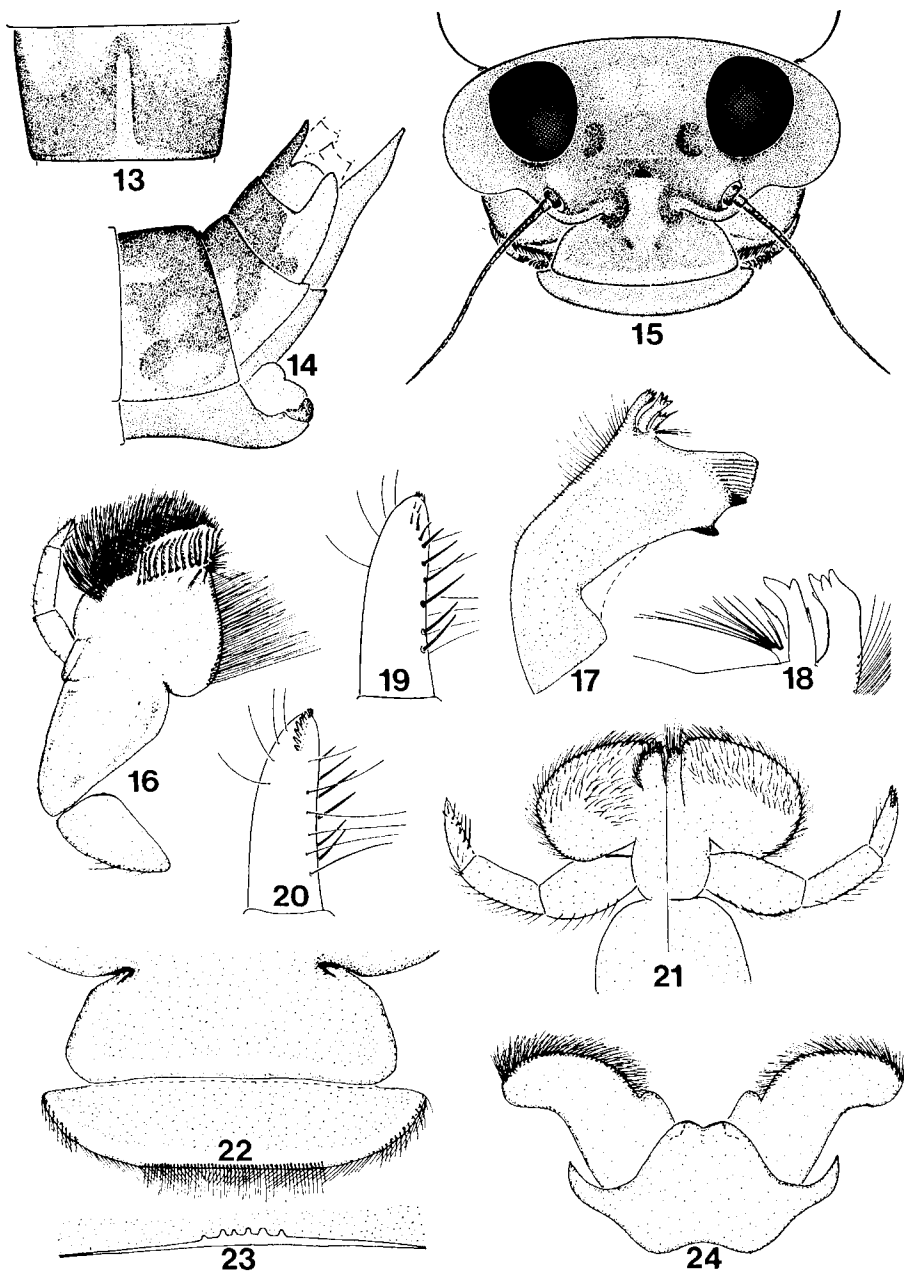
Male and female subimagines. Unknown.

Mature nymph (in alcohol). Body length 9.0-10.0 mm. Dorsum of head yellowish-brown washed with dark brown, venter paler. Antennae pale tan. Thoracic nota brown with scattered dark brown markings along margins; sterna yellowish-brown. Legs yellowish-brown except coxae dark brown; distal irregular light brown maculae on femora of legs (Fig. 26); claws with 9-12 denticles. Abdomen: terga yellowish-brown, sterna paler brown. Gills: median projection of gills broad and approximately twice length of lateral projections (Fig. 32), tracheation in gills uniformly distributed (Fig. 32). Caudal filaments yellowish-brown.

Discussion. Male imagines and nymphs of *Nathanella indica* can be distinguished from *N. saraswathiae* by characters given in the keys. Demoulin (1955) described the wing membrane as hyaline. In fresh material and in material preserved in alcohol, the hyaline membrane is golden brown. The color is also present, but less intense, in one specimen that had been pinned and later placed in alcohol.

Biology. *Nathanella indica* is found in small streams which flow through relatively undisturbed sholas. Nymphs were found on small rocks to pebbles in streams at an altitude of 1200 m from September to January (monsoon season); from March to May, very little water was present and nymphs were absent. Water temperatures ranged from 17-22°C. Emergence occurred from 10.00 h to 14.00 h (when the morning mist lifted and full sun appeared) whenever we visited the study site between September and January, indicating that emergence was generally asynchronous. Longevity of subimagines was 4-12 hours and that of imagines 12-36 hours (air temperatures 17-24°C). The nymphs were primarily detritivores: gut contents were dominated by detritus (68%), algae (30%) and other plant materials (2%). Mean number of eggs per female mature nymph (average of 10 nymphs) was 282±19.

Diversity of aquatic insects in sholas with *N. indica* is high. However, because of the restricted distribution of remaining sholas and erosion of this habitat



Figs. 13-24. Female imago of *N. saraswathiae*: 13, abdominal tergum 6; 14, lateral view of abdominal segments 7-10. Figs. 15-24. Nymph of *N. indica*: 15, head capsule; 16, ventral view of right maxilla; 17, left mandible; 18, detail of incisors of right mandible; 19-21, labium (19-20, dorsal and ventral detail of third palpal segment; 21, labium with dorsum on left, venter on right); 22-23, clypeus and labrum (23, detail of anterior margin); 24, hypopharynx.

from anthropogenic impacts, *N. indica* should be considered as a threatened or endangered species.

Nathanella saraswathiae sp. n. (Figs. 1-10, 13-25, 28-31)

Male imago (in alcohol). Length: body 7.5-9.5 mm, fore wings 8.0-9.5 mm. Head brown, area between ocelli and vertex of head washed with blackish-brown. Antennae: scape brown, pedicel yellowish-brown, flagellum yellow, lighter towards apex. Upper portion of eyes reddish-brown, lower portion black. Thorax: nota blackish-brown, pleura and sterna yellowish-brown, except lateral lobes of furcasternum brown. Wings: membrane hyaline with weak brown tint; longitudinal and cross veins reddish-brown, all cross veins broadly clouded with dark brown (Fig. 1). Legs: yellowish-brown, except coxae and apex of femora dark brown. Abdomen: tergum 1 dark brown, tergum 2 brown with anterolateral pale brown area, brown maculae on terga 3-7 as in Figs. 8-10, similar maculae on tergum 8 less distinct, tergum 9 brown, tergum 10 lighter; sterna yellowish-brown, sterna 1-7 translucent, sterna 8-9 opaque. Genitalia: forceps yellowish-brown washed with reddish-brown. Caudal filaments yellow with brown annulations at articulations.

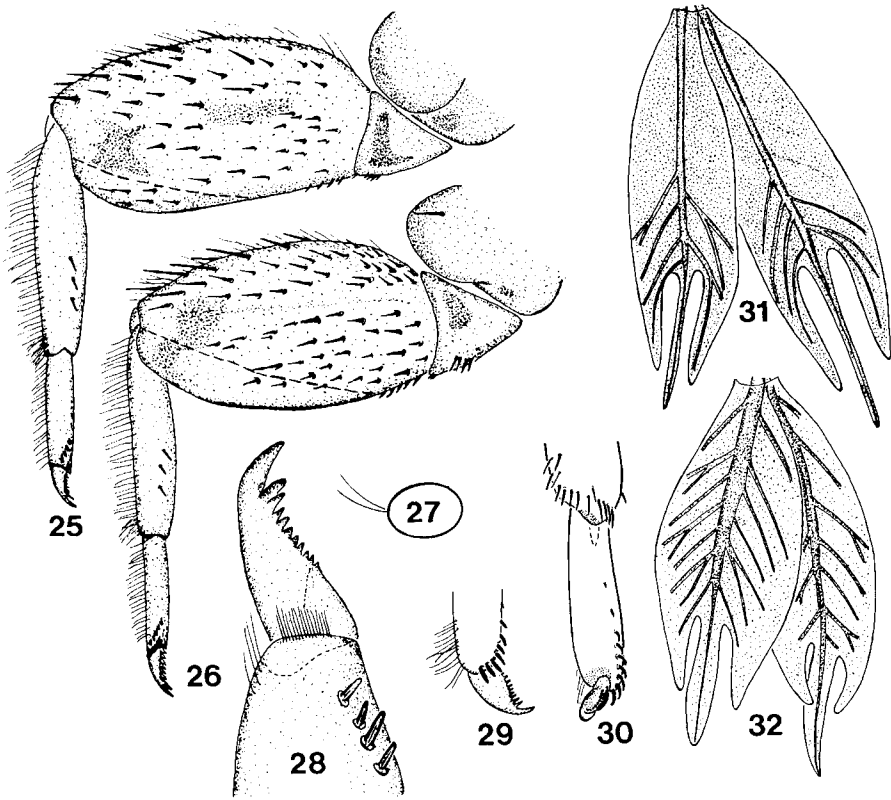
Female imago (in alcohol). Length: body 7.0-8.0 mm, fore wings 7.5-10.5 mm. Head dark brown, carinae darker. Antennae brownish-yellow, flagellum paler. Color and marks of thorax, wings, and legs as in ♂ imago. Abdomen: terga yellowish-brown, posterior margins brown, dark brown maculae on terga 3-7 as in Fig. 13; sterna light brown. Caudal filaments yellowish-brown with brown annulations at articulations.

Male and female subimagines. Unknown.

Mature nymph (in alcohol). Body length 10.0-12.0 mm. Dorsum of head yellowish-brown washed with reddish-brown, venter paler. Antennae pale tan. Thoracic nota brown with scattered dark brown markings along margins; sterna yellowish-brown. Legs yellowish-brown except coxae dark brown; median and distal, irregular black maculae on femora of legs (Fig. 25); claws with 10-12 denticles. Abdomen: terga brownish-yellow with dark brown maculae, sterna yellowish-brown. Gills: median projection of gills narrow and approximately 1-1/2 times length of lateral projections (Fig. 31); main trunk of tracheae forked near distal half of gills (Fig. 31). Caudal filaments yellowish-brown.

Etymology. Species is named for senior author's wife, S. Saraswathi, for her many years of support of research on mayflies.

Material. Holotype male imago, INDIA: Kerala border near Bodimettu, Cardamom Hills, 1460 m, 13.VIII.1994, K. G. Sivaramakrishnan, K. Venkataraman and C. Balasubramanian; allotype fe-



Figs. 25-32. Nymphs of *Nathanella*: 25, 27-31, *N. saraswathiae*; 26, 32, *N. indica*. 25-26, fore leg. 27, cross section of fore tibia. 28, fore claw. 29-30, hind leg detail (29, apex of tarsus; 30, ventral apex of tibia with tarsus turned). 31-32, left gill 4.

male imago, same data as for holotype; paratypes: 9 ♂ imagines and 15 nymphs, same data as for holotype, types in alcohol; same locality as holotype (Bodi Mettu), 24.I.1962, F. Schmid, 5 ♂ imagines (4 pinned, 1 in alcohol). Association of nymph and imagines is by rearing. Holotype, allotype, 4 ♂ imagines and 6 nymphs (paratypes) are deposited in collections of Zoological Survey of India, Calcutta, India; 10 ♂ imagines and 6 nymphs (paratypes) are deposited in the collections of Florida A&M University, Tallahassee, U.S.A.

Discussion. Imagines and nymphs of *Nathanella saraswathiae* can be distinguished from *N. indica* by characters given in the keys. The figures of the abdominal color pattern of the ♂ imago were drawn from a typical dark specimen (Figs. 8-9). In lighter specimens, the color on terga 3-7 is less extensive (Fig. 10) and the light median line may be broader.

Biology. *Nathanella saraswathiae* was found above 1400 m in very small, well-shaded, intermittent streams. All mature nymphs were found clinging onto

seepage areas of surface rocks where water was trickling, but younger nymphs were found on rocks in the stream. Apparently the row of stout spines on the apex of nymphal tarsi are efficient holdfast structures to cling to abruptly sloping rocks. The nymphs were found from August to January (monsoon season); water temperatures ranged from 18-25°C. Diel emergence occurred from 08.45 h to 14.00 h, and emergence was generally asynchronous throughout the season. Longevity of subimagines was 4-12 hours and that of imagines 12-36 hours (19-27°C). The nymphs were primarily detritivores. Mean number of eggs per female mature nymph (average of 10 nymphs) was 235 ± 24 . *N. saraswathiae* has only been collected from the type locality.

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