



Description of a new species of *Liocheles* Sundevall, 1833 (Hormuridae) from India

ZEESHAN A. MIRZA

National Centre for Biological Sciences, Tata Institute for Fundamental Research, Bangalore, Karnataka 560065, India.

E-mail: snakeszeeshan@gmail.com

Abstract

Scorpions of the genus *Liocheles* Sundevall, 1833 are widespread in forests of the Indo-Pacific region; however, its species diversity is poorly resolved. A new species of the genus *Liocheles* is herein described from northeast India after examination of freshly collected specimens and available museum material. The new species, *Liocheles schalleri* **sp. nov.**, occurs in the Indo-Burma biodiversity hotspot, a region that has been poorly explored for its arachnid diversity.

Key words: Scorpion, taxonomy, Arachnida, invertebrate, northeast India, biodiversity hotspot

Introduction

Scorpions are an interesting and ancient lineage of arachnids and are infamous for their medical importance. About eighteen families have been accepted, but higher level systematics of scorpions in a state of flux (Fet *et al.* 2000; Prendini *et al.* 2003; Rein 2017; Soleglad & Fet 2003). The family Hormuridae Laurie, 1896 has had a complex taxonomic history with regards to its higher level systematics, most of which was resolved recently by Monod & Prendini (2014). Members of this family are poorly represented in most museums, and this may be due to the narrow niche occupancy by these scorpions making them difficult to detect in regular biodiversity surveys (Mirza *et al.* 2015). Furthermore, a recent phylogenomic analysis of scorpion families of the world with two exemplar species of Hormuridae renders the family paraphyletic (Sharma *et al.* 2015). Currently the family is represented by 82 species in eleven genera distributed across the Neotropical, Afrotropical, Madagascan, Oriental, Sino-Japanese, and Australian zoogeographic realms (Fet *et al.* 2000). Three genera have been recorded from India: *Chiromachetes* Pocock, 1899; *Iomachus* Pocock, 1893; *Liocheles* Sundevall, 1833. Of the ten species recorded from India, nine are endemic (Mirza *et al.* 2015; Monod & Prendini 2014).

Scorpions in the genus *Liocheles* are widespread in forests of Indo-Pacific region; however, its species diversity is poorly documented (Mirza *et al.* 2015; Monod & Prendini 2014). Presently the genus contains only three species: *Liocheles australasiae* Fabricius, 1775; *Liocheles longimanus* Werner, 1939; and *Liocheles nigripes* Pocock, 1897. Of these species, *L. nigripes* is reported from mainland India and *L. australasiae* from the Andaman and Nicobar Islands (Fig. 1, Pocock 1900; Tikader & Bastawade 1983).

In the course of a biodiversity exploration of Tripura state, northeast India, I collected specimens of a hormurid scorpion that were later identified to be species on the genus *Liocheles* following Monod & Prendini (2014). The specimens differed from known species of the genus in several aspects following available keys and available data in literature (Monod 2011; Monod *et al.* 2011; Monod & Volschenk 2004; Pocock 1900; Tikader & Bastawade 1983). In this contribution, I describe this new species as *Liocheles schalleri* **sp. nov.** with notes on the genus and its distribution in India.

Methods

Field work and Morphological data: Specimens in field were located with the aid of a hand held ultra violet

flashlight. Individual burrows were dug and specimens were collected with forceps. Locality coordinates were recorded with a Garmin™ eTrex 10 set to WGS84 datum. Most of the specimens were photographed with a Canon 70D and were subsequently fixed and preserved in 70% ethanol. Several specimens were also preserved in 100% molecular grade ethanol for molecular work. The specimens have been deposited at the collections facility at the National Centre for Biological Sciences, Bangalore (NCBS). Measurements were taken with the help of a digital caliper with an error of 0.1mm. Specimens were examined under a Leica™ S8APO stereo-binocular microscope. To highlight characters for identification, specimens were illuminated with an ultraviolet flashlight and images were clicked with Leica™ S8APO stereo-binocular microscope which were converted to monochrome. Descriptive terms and terminologies follow Monod & Volschenk (2004). Hemispermatophore were dissected, cleaned manually using micro forceps and were imaged after immersion in clove oil. Institutional acronyms used in the manuscript are as follows: BNHS- Bombay Natural History Society, Mumbai; NHM- Natural History Museum, London.

Multivariate analysis: Multivariate Principal Component Analysis (PCA) was performed on morphometric values listed in Table 1, excluding number of pectines for the new species and *L. nigripes*. These analyses were performed using PAST v.3.x. (<http://folk.uio.no/ohammer/past/>) and the resulting loadings and scores are presented in Appendix I–II.

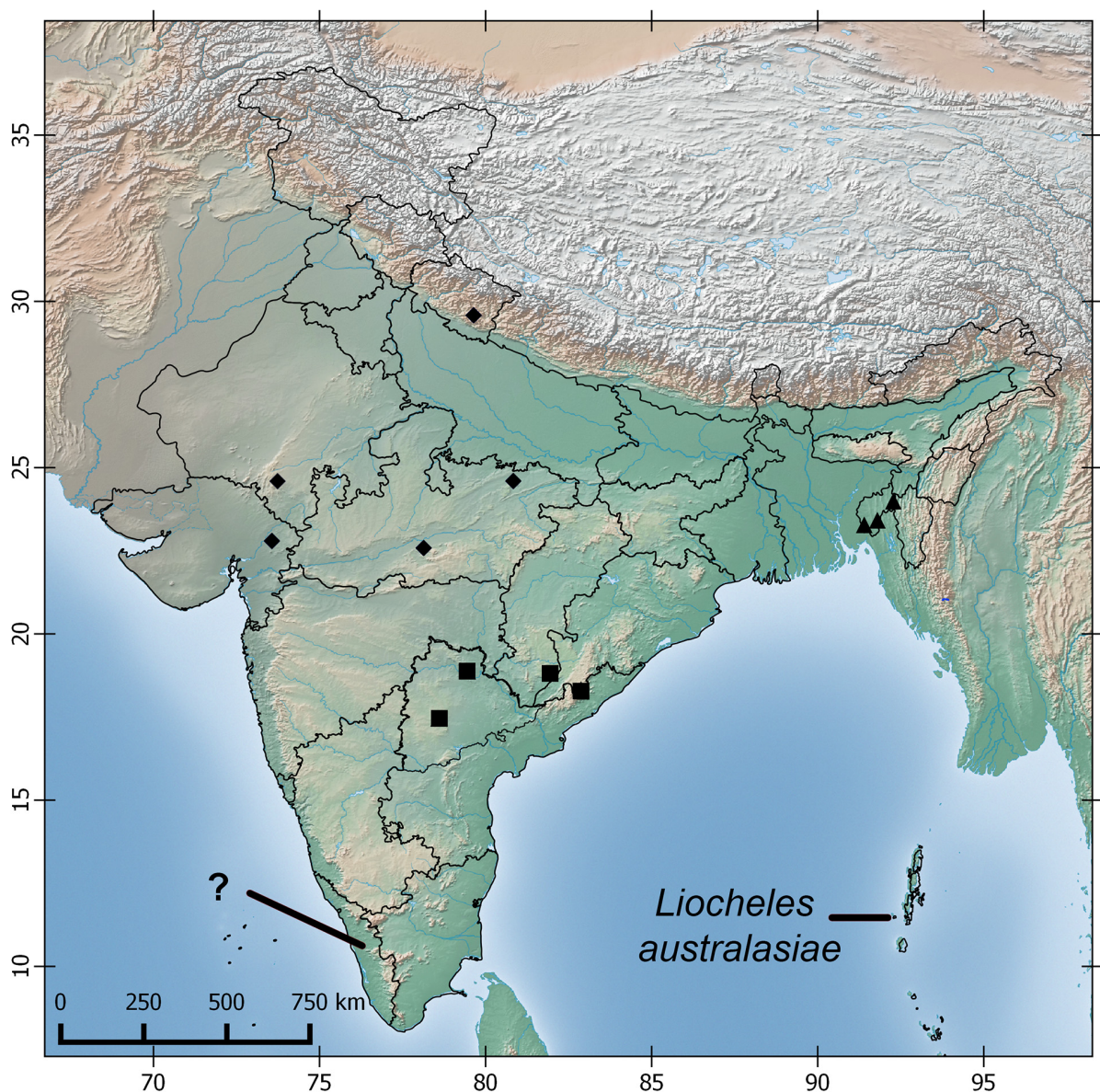


FIGURE 1. Distribution map of the genus *Liocheles* in India. Small black polygon- *Liocheles nigripes*, black triangles- *Liocheles schalleri* sp. nov., large black squares—unidentified *Liocheles* sp.

Systematics

Order SCORPIONES C. I. Koch 1837

Family HORMURIDAE Laurie, 1896

Genus *Liocheles* Sundevall, 1833

Liocheles nigripes (Pocock, 1897)

(Fig. 2–3)

Hormurus nigripes Pocock 1897: 117

Holotype: NHM 1896.9.26.84, female from Panch Mahals, Gujarat, India (examined).

Other material: four females AG810, AG812, AG814 & AG815 from Forsyth's Lodge, Sohagpur, Hoshangabad district, Madhya Pradesh, India (22.585467° N, 78.133361° E, elevation 367m), collected on 15th May 2014 by Rajesh Sanap, David Raju and Zeeshan Mirza.



FIGURE 2. *Liocheles nigripes* female NCBS AG814 from central India in life.

Diagnosis: A large species relative to other members of the genus reaching a total length of 38–41mm. Overall coloration deep blackish brown (Fig. 2) slightly faded to brown in preservative. Second lateral ocellus adjacent to the first ocellus, separated from the third ocellus. Patella prolateral process absent. Chela internomedian carinae present, composed of large sparsely placed granules. Metasomal segment V with three pairs of spiniform granules on ventrolateral carinae. Metasomal segment I with a large pronounced posterior granules on ventrosubmedian and ventrolateral carinae. Metasomal segment II with medial, sub-posterior and posterior granules on ventrolateral and ventrosubmedian carinae more pronounced than the preceding segment, granules on ventrosubmedian larger than those on ventrolateral carinae. Segment II, dorso-submedian carinae lacking posterior spiniform granules. Anal arch anterior carinae composed of large, subconical teeth (Fig. 3).

Natural history and distribution: Four specimens of this species were collected from slit-like deep burrows on mud escarpments along a dry stream near Forsyth's Lodge, Sohagpur, Hoshangabad district, Madhya Pradesh. Known from Panchmahal, Satna, Sohagpur, and Udaipur (Fig. 1). Records of the species listed in literature from Udaipur in Rajasthan, Almore in Uttarakhand, Gonda, Uttar Pradesh need confirmation.

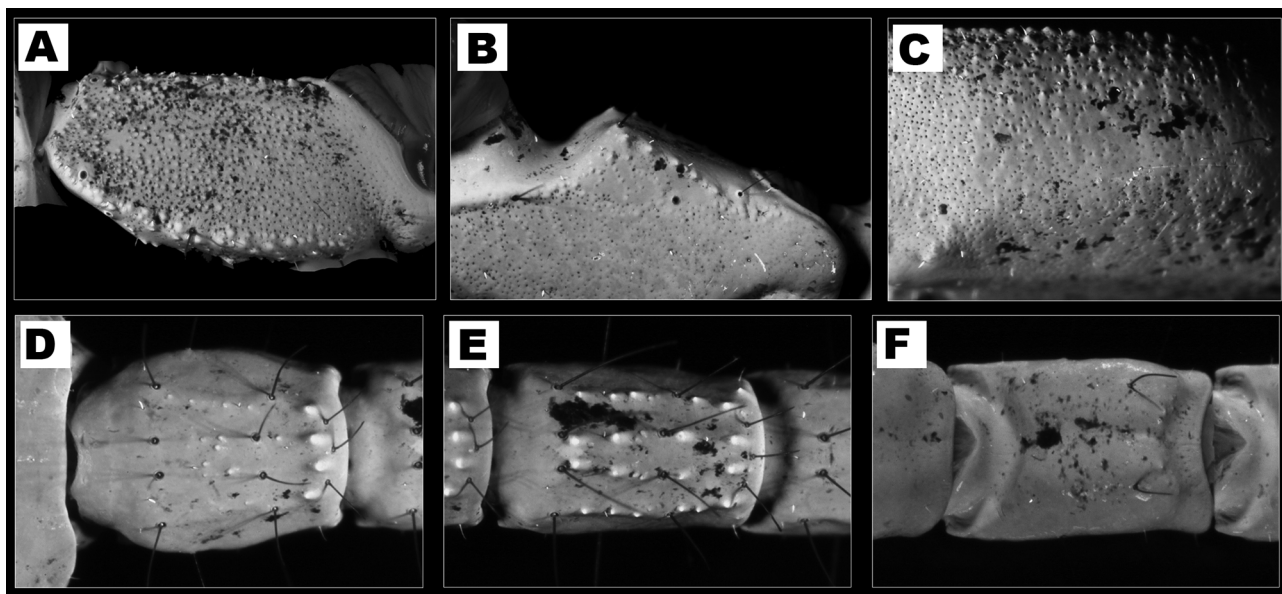


FIGURE 3. *Liocheles nigripes* female NCBS AG814, (A) femur dorsal, (B) patella prolateral process, (C) manus internal view, (D) ventral view of metasomal segment I, (E) ventral view of metasomal segment II, (F) dorsal view of metasomal segment II.

***Liocheles schalleri* sp. nov.**

(Figs. 4–8, Table 1)

Holotype: NCBS AG817, male from Trishna WLS, South Tripura district, Tripura, India, 23.281126° N, 91.401004° E (WGS84), elevation 30m, collected on 2nd October 2014 by Rajesh Sanap and Zeeshan A. Mirza.

Paratypes: 2 females NCBS AG818–AG819, 2 males NCBS AG820, NCBS AG809, same data as holotype; 1 female NCBS AG829 from a Sal plantation near Garjee forest rest house, 8km south of Udaipur, Tripura 23.44166° N, 91.48956° E (WGS84), elevation 56m on 9th October 2014.

Referred material: NCBS AG821, female from Trishna WLS, same data as holotype, NCBS AW215, female from Bidyabil, Tulashikhar Tehsil, Tripura (24.145910° N, 91.699040° E (WGS84), elevation 65m collected on 20th July 2016 by Akshay Khandekar.

Diagnosis: A fairly large species in relation to members of the genus reaching a total length of 33–40.5mm. Overall coloration in a shade of blackish brown to light brown. Second lateral ocellus adjacent to the first ocellus, separated from the third ocellus. Patella prolateral process strongly developed forming a single median spine. Chela internomedian carinae present, composed of large sparsely placed granules. Metasoma: segment I, lacking pronounced granules on its ventral aspect; segment II, with posterior granules on ventrolateral and ventrosubmedian carinae, and dorso-submedian carinae lacking posterior spiniform granules; V, with three pairs of spiniform granules on ventrolateral carinae. Anal arch anterior carinae composed of large, subconical teeth.

Liocheles schalleri differs from *L. nigripes* in bearing a strong spinoid prolateral process on patella (vs. absent in *L. nigripes*); differs from *L. longimanus* in having a short and stout pedipalps (vs. long and slender pedipalps in *L. longimanus*). The new species is most similar to *L. australasiae* with which it shares a similar spinoid prolateral process on patella. *Liocheles schalleri* differs from *L. australasiae* by the medial granules on the ventrolateral carinae metasomal segment II with medial granules on ventrolateral carinae which are less pronounced than the preceding segment in *L. schalleri* but large in *L. australasiae*.

Etymology: The specific epithet is a patronym honoring Wildlife Biologist Dr. George Beals Schaller of the Wildlife Conservation Society and Panthera, for his contribution to conservation of wildlife.



FIGURE 4. *Liocheles schalleri* sp. nov. showing coloration in life (A) holotype male NCBS AG817, (B) paratype female NCBS AG818. Photo by Rajesh Sanap.

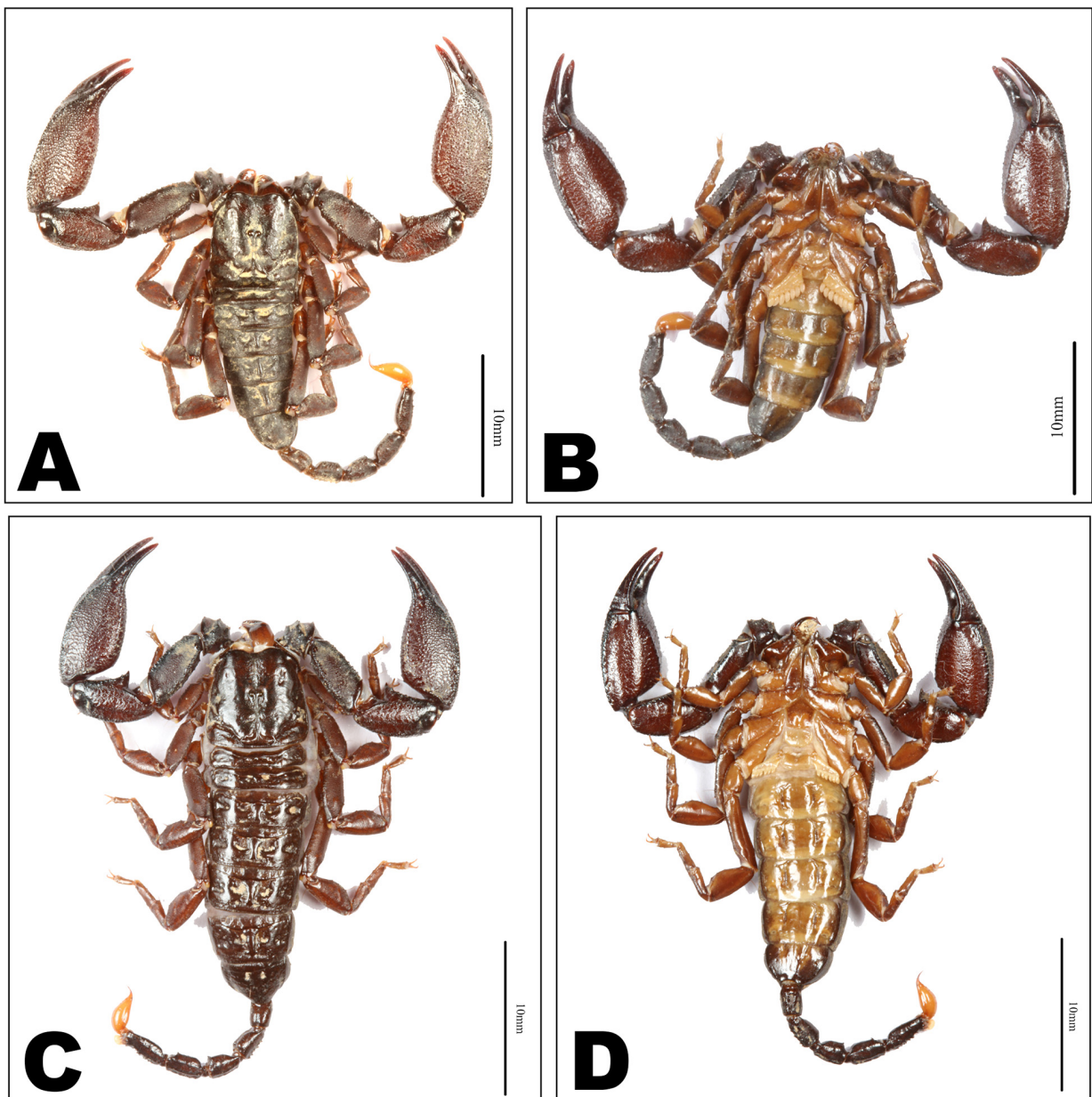


FIGURE 5. *Liocheles schalleri* sp. nov. (A) male dorsal NCBS AG817, (B) male ventral NCBS AG817, (C) female dorsal, (D) female ventral.

Description of holotype male NCBS-AG817: Coloration: ‘In life’ (Figs. 4–5): Overall in a shade of glossy black, extremities of legs with a brownish tinge. Color faded after preservation, the black coloration on the carapace, mesosoma and metasoma is retained; however, on the legs and pedipalps the color has faded to dark brown. Chelicerae yellowish brown with dark brown extremities of fingers and reticulate markings on cheliceral tibia. Telson pale yellow. Sternum anteriorly brownish grey gradually becoming tan in its posterior half. Pectines and pectinal plate pale yellow. Sternites brownish grey for more than half their length anteriorly excluding the stigmata and posterior half which are yellowish brown.

Carapace (Fig. 6A): Overall brown, borders and area surrounding the eye black. Surface of the carapace punctuate throughout except for two smooth, glossy patches between lateral and median oculi. Anterior margin with a subtle indentation scarcely forming a shallow cavity, with nearly a horizontal orientation. Posterior median furrow anterior to the posterior border of carapace deep, posterior lateral furrow on each side of the median furrow shallow (Fig. 6A). Median ocelli lacking a raised ocular tubercle. Median ocelli situated anteriorly in the ration of 1:2.2. Second lateral ocellus adjacent to the first ocellus, separated from the third ocellus. Chelicerae immovable finger with fused basal and middle tooth into a bicusps, basal tooth much smaller than median tooth. Movable finger with four teeth, basal and sub-basal touching their bases; distal and sub-distal adjacent separated from the basal group by a very short diastema. Ratio of cheliceral movable finger length to chelicerae tibia length is 1:1.5.

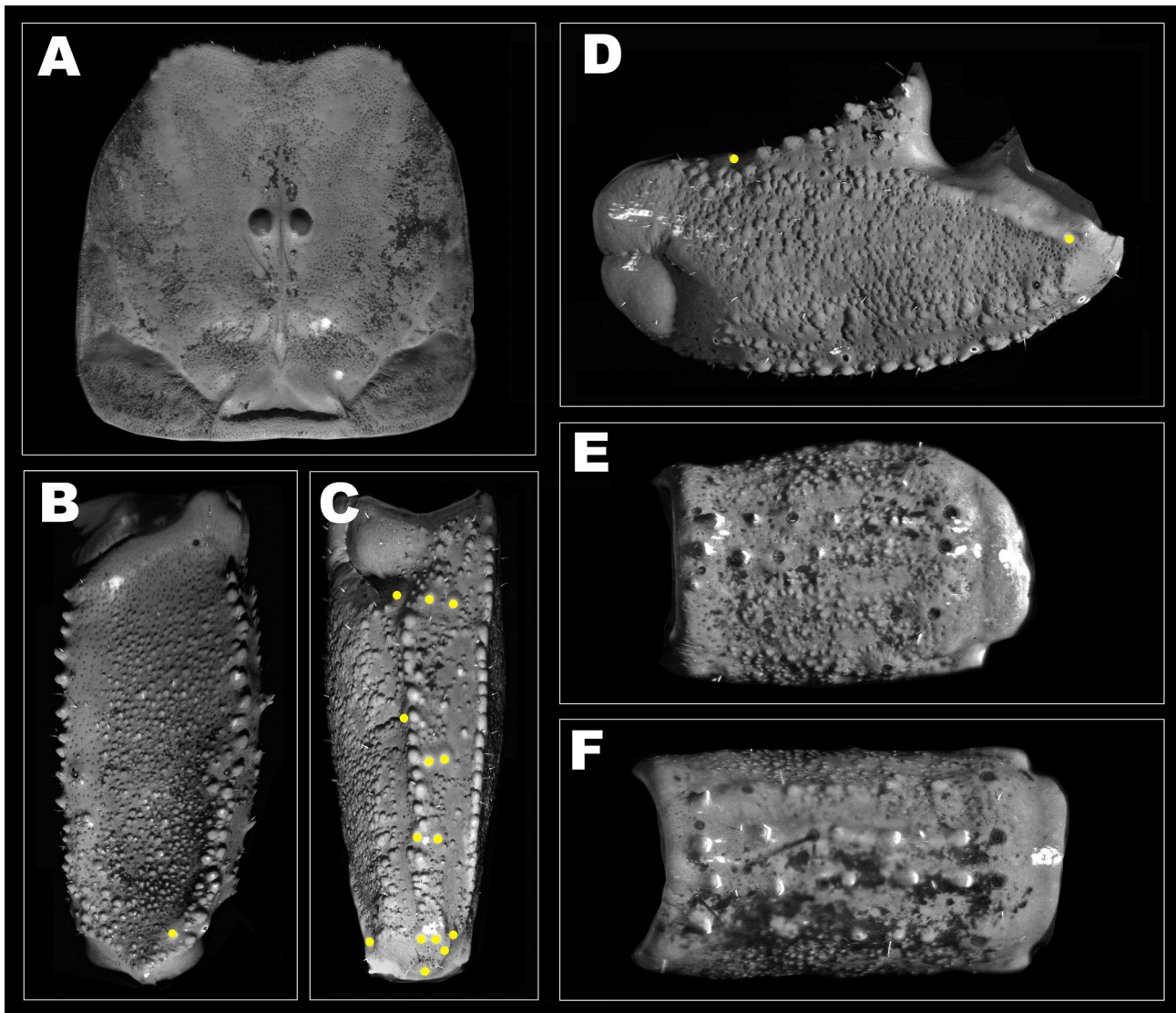


FIGURE 6. *Liocheles schalleri* sp. nov. holotype male NCBS AG817 (A) carapace, (B) femur dorsal, (C) patella external, (D) patella dorsal, (E) ventral view of metasomal segment I, (F) ventral view of metasomal segment II.

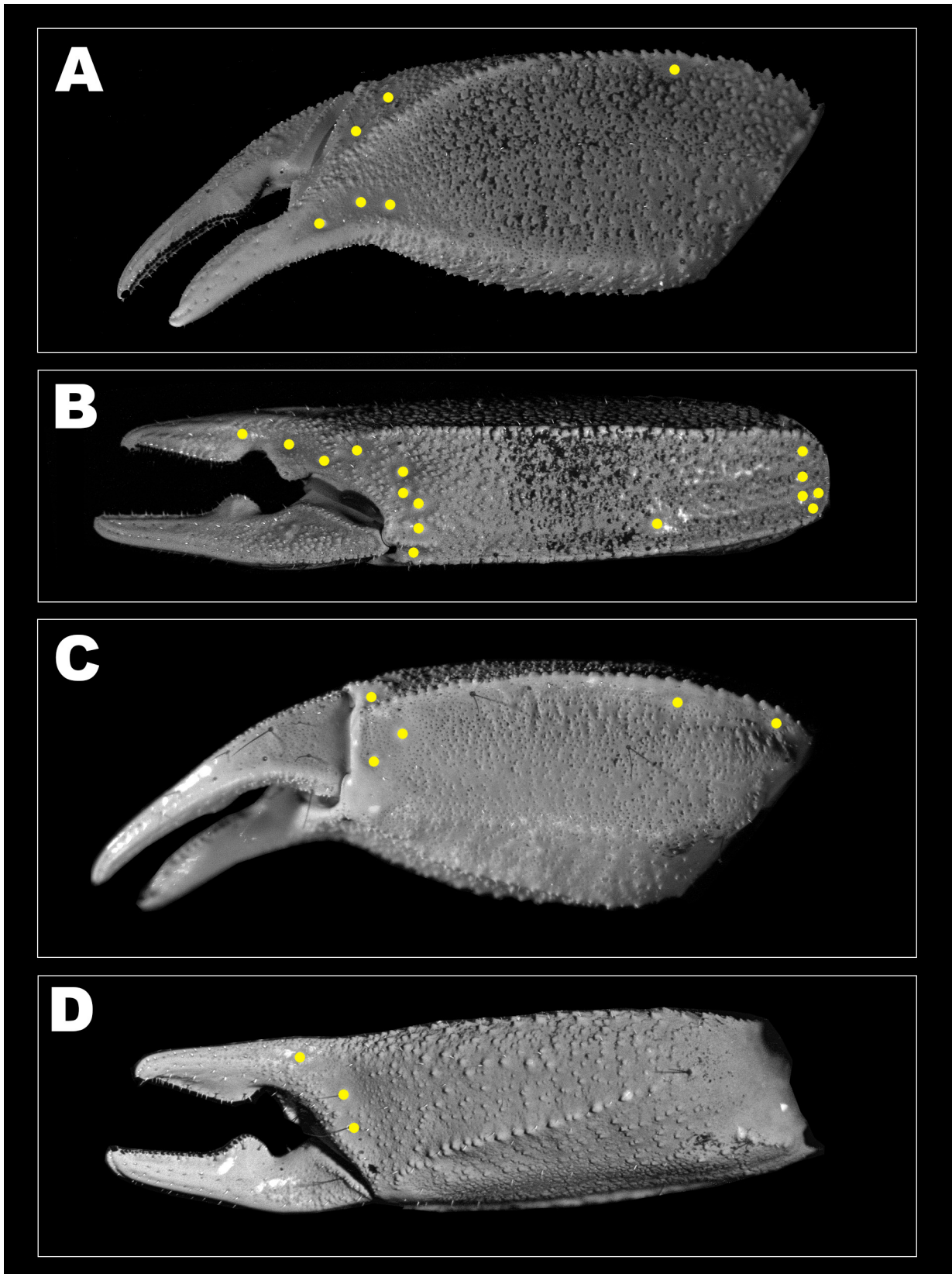


FIGURE 7. *Liocheles schalleri* sp. nov. holotype male pedipalp chela showing trichobothrial pattern (A) dorsal, (B) external, (C) ventral, (D) internal.

Mesosoma: All mesosomal tergites in a shade of blackish brown. Sternites tan yellow with darker posterior and lateral borders. Sternite VII dark brown to grey in color with slight tan yellow coloration in the anterior median portion of the segment. Sternites smooth glossy throughout, except for sternite VII which is granular throughout.

Tergites I–VII: with coarse granulation throughout; median carinae smooth and well developed. Sternum pentagonal, as wide as long. Genital operculum oval shaped, divided into two halves and with two genital papillae protruding from its posterior border. Pectine teeth well developed, seven each side. Pectinal plate with a median furrow anteriorly.

Metasoma (Fig. 6E & 6F): Metasomal segment I dark brown, segment II–V blackish brown. Telson tan yellow in color. Dorsal median furrow almost indistinct. Granular throughout excluding posterior half of segment V. Ventromedian and ventro-submedian carinae poorly developed, moderately developed on segment II–IV with scattered granules. Segment I lacking pronounced granules on its ventral surface (Fig. 6E). Segment II with posterior granules on ventrolateral and ventrosubmedian carinae (Fig. 6F). Segment II, dorso-submedian carinae lacking posterior spiniform granules. Segment V with three pairs of spiniform granules on ventrolateral carinae. Anal arch anterior carinae composed of large, subconical granules.



FIGURE 8. *Liocheles schalleri* sp. nov. holotype male NCBS AG817 hemispermatophore, (A) dorsal view, (B) close-up of capsule.

Pedipalp (Figs. 6B, 6C, 6D, 7): Pedipalp femur, patella and chela reddish brown dorsally, slightly paler on the venter. Fingers of pedipalp chela darker with the tip of the fingers with a reddish tinge. Coloration darker on carinae. Chela width to length ration 1:2.9. Pedipalp chela with 26 trichobothria; *db*, *eb*₃, *esb* aligned in a straight vertical line (Fig. 7B); *dt* on internal aspect of fixed finger with *it* & *ib* (Fig. 7D); *Esb*, *Eb1–3* in a group in basal region. Pedipalp chela manus granular, immovable and movable finger smooth. Dentate margin of pedipalp chela finger with a distinct sculpture (Fig. 7B). Patella prolateral view with a median spine like protrusion (Fig. 6D). Patella retro-lateral basally with a shallow concavity. Chela internomedian carinae present, composed of large sparsely placed granules (Fig. 7D).

Legs: Dorsally in a shade of dark brown and lighter ventrally. Dorsal surfaces of trochanter, femur & patella granular, basitarsus and tarsus smooth and glossy. Tarsi lacking median row of ventromedian spinules. Two rows of ventral macrosetae. Tarsal claws of equal length.

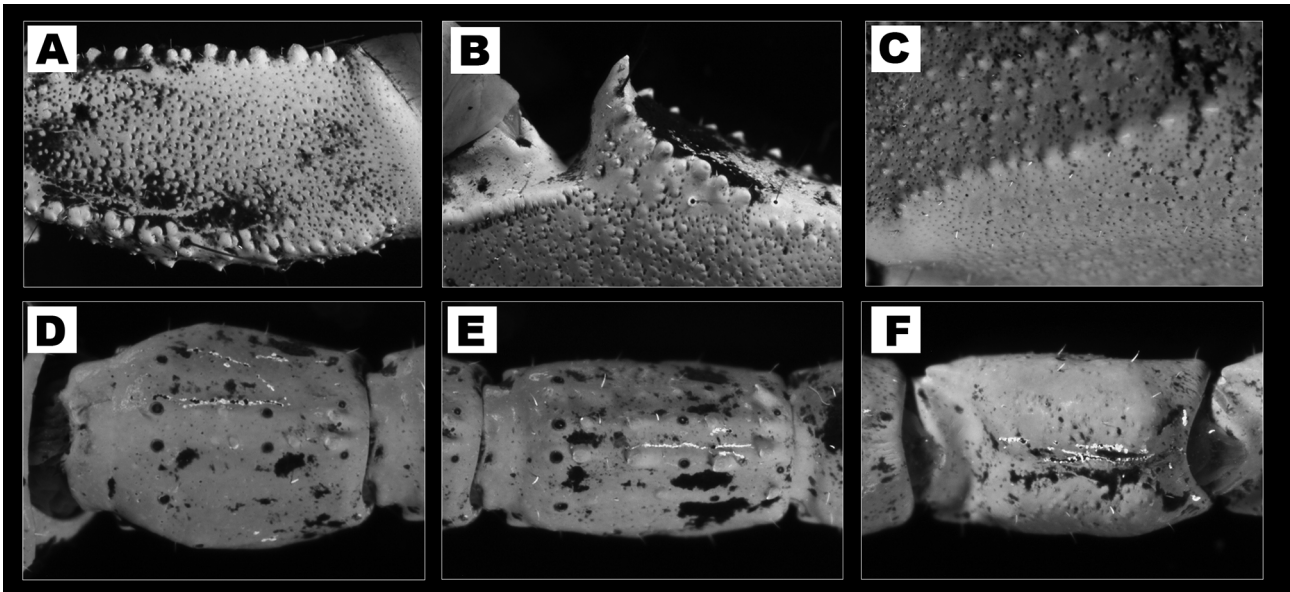


FIGURE 9. *Liocheles schalleri* sp. nov. female NCBS AG818, (A) femur dorsal, (B) patella prolateral process, (C) manus internal view, (D) ventral view of metasomal segment I, (E) ventral view of metasomal segment II, (F) dorsal view of metasomal segment II.

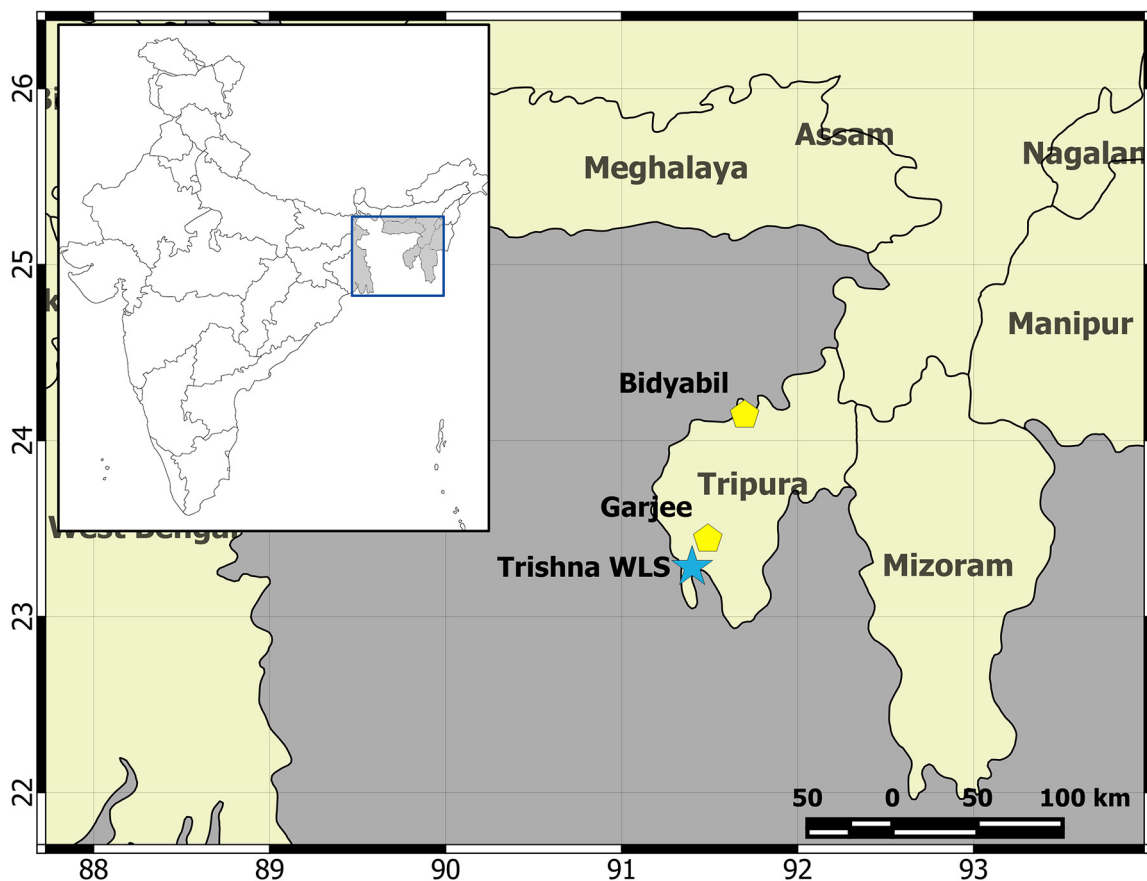


FIGURE 10. Map of eastern northeastern India showing known localities for *Liocheles schalleri* sp. nov.

Hemispermatochore (Fig. 8): Lamelliform with a complex capsule; distal lamellum stout, with a rounded tip and a slight protrusion at the apex (Fig. 8A). Flagellum length equal to that of the capsule region and trunk. A single lamellar hook arising from the transverse ridge, hook short, curved and pointing upwards. Lamellae arising from the posterior lobe is clearly apart from the lamellar hook, vertical in orientation with a slight angular tilt.

Variations: Morphometric variation is presented in Table 1, which highlight notable sexual dimorphism especially with regards to the robustness of the pedipalp chela in the males and can also be seen in the graphic output from PCA (Fig. 11). The males of this species are paler in coloration in comparison with the females. Ventral spiniform granules on metasomal segment I & II more pronounced in males, in females these are more depressed and less demarcated (Fig. 9D–E). Dentate margin of pedipalp chela finger with a distinct sculpture in males, absent in females. Carinae on patella of males composed of large tubercles in basal half and smooth in the distal half (Fig. 6D) whereas the carinae in females is smooth in its basal half and tuberculate in its distal half (Fig. 9B)

Natural history: Specimens of this species were found in slit like burrows ~30cm deep on mud escarpments near ponds, streams and in crevices on tree trunks, among boulders. Some burrows were vertical in their orientation and others horizontal depending on presence of obstacles like roots or boulders. Most burrows were observed in mud and a few in the root system of a tree. This is a low elevation species and is found bellow 50 MSL. Burrows of this species are concentrated at a single site and completely absent from areas where suitable mud escarpments are absent. The species is recorded from Trishna Wildlife Sanctuary, Bison National Park, Garjee reserve forest and Bidyabil (Fig. 10), however; is likely widespread across parts of Tripura and likely adjoining Bangladesh as the neighboring areas of Bangladesh share similar habitat and the country boarded is less than 3km from the type locality.

TABLE 1. Morphometry of type specimens of *Liocheles schalleri* sp. nov.

Characters	Holotype	Paratypes					Mean (n=6)	± SD
	AG817	AG818	AG819	AG820	AG829	AG809		
Sex	male	female	female	male	female	Male	-	-
Total L	35.45	38.62	36.6	34.19	38.79	33.32	36.16	2.26
Carapace L	6.47	6.64	6.51	6.19	6.62	6.01	6.41	0.25
Carapace anterior W	3.88	3.66	3.56	3.26	3.9	3.35	3.60	0.27
Carapace posterior W	5.63	6.23	5.45	4.92	6.13	5.25	5.60	0.51
Mesosomal L	12.13	16.57	14.84	12.59	16.77	11.6	14.08	2.29
Metasoma total L	16.85	15.41	15.25	15.41	15.4	15.71	15.67	0.60
Metasomal seg I L	2.3	2.11	2.42	2.09	1.9	2.05	2.15	0.19
Metasomal seg I W	1.41	1.47	1.49	1.54	1.52	1.52	1.49	0.05
Metasomal seg II L	2.5	2.28	2.23	2.42	2.15	2.33	2.32	0.13
Metasomal seg II W	1.24	1.26	1.2	1.27	1.32	1.31	1.27	0.04
Metasomal seg III L	2.35	2.35	2.46	2.19	2.18	2.37	2.32	0.11
Metasomal seg III W	0.99	1.09	1.43	1.08	1.22	1.3	1.19	0.16
Metasomal seg IV L	3.1	2.8	2.45	2.74	2.69	2.45	2.71	0.24
Metasomal seg IV W	0.87	0.92	1.26	0.93	1.08	1.19	1.04	0.16
Metasomal seg V L	3.5	3.02	2.9	2.87	3.02	3.08	3.07	0.23
Metasomal seg V W	0.94	1.12	1.08	0.96	1.17	1.15	1.07	0.10
Telson L	3.1	2.85	2.79	3.1	3.46	3.43	3.12	0.28
Femur L	6.37	5.44	5.22	5.4	5.35	5.6	5.56	0.41
Femur W	2.68	2.31	2.22	2.47	2.5	2.59	2.46	0.17
Patella L	6.32	5.47	5.7	5.58	5.41	5.58	5.68	0.33
Patella W	3.5	3.55	3.22	3.37	3.87	3.61	3.52	0.22
Chela L	12.88	11.4	11.19	12.39	12.17	11.58	11.94	0.65
Chela W	4.36	3.87	4.12	4.08	4.42	4.15	4.17	0.20
Movable finger L	5.42	5.59	5.09	4.62	5.96	5.15	5.31	0.46
Pectines Lf	7	6	6	7	6	8	6.67	0.82
Pectines Rt	7	6	6	7	7	7	6.67	0.52

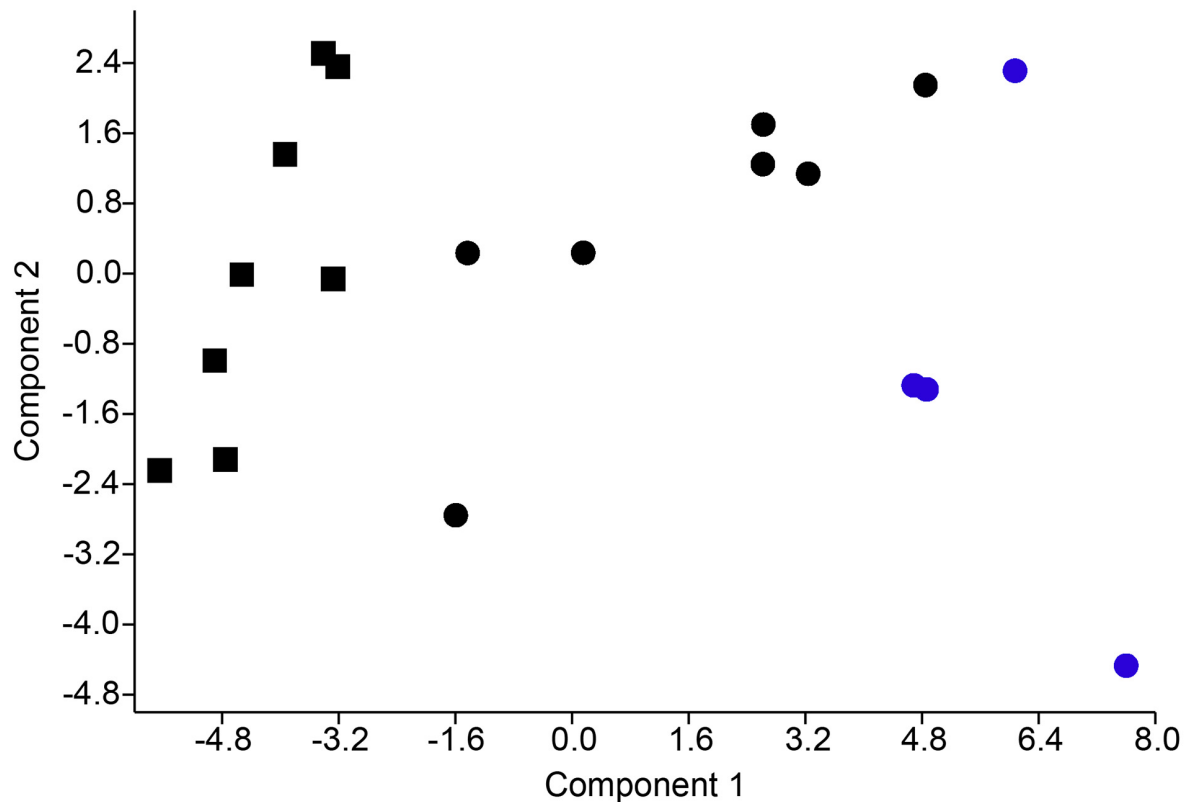


FIGURE 11. Multivariate PCA plot. Blue- *L. nigripes*, black- *Liocheles schalleri* sp. nov., male indicated by solid square and females by solid circles.

Discussion

The genus *Liocheles* appears to be widespread across India but is patchily distributed which may be attributed to lack of sampling (personal observation). Most records from the country of this genus are attributed to be conspecific with *L. nigripes* which is likely restricted to the Satpura and Vindya hills in central India. Other records from across the country likely represent *L. schalleri* or represents yet another undescribed species or a putative synonyms of *L. australasiae*. Records of *L. nigripes* from Andhra Pradesh, Chhattisgarh and Kerala (Javed *et al.* 2010; Sureshan *et al.* 2007; Zambre & Patil 2011) as well as record from Indonesia and Malaysia (Kovařík 2000) are considered incorrect identifications. A re-examination of specimens from Andhra Pradesh and Chhattisgarh, and close scrutiny of figure 14 of Kovařík (Kovařík 2000) reveal presence of a strong spinoid prolateral process on patella as seen in *Liocheles australasiae* and the new species. In the absence of multiple specimens of both sexes and, or molecular data from all relevant populations, it is difficult to assign populations to any species at present and work is underway to identify populations from peninsular India. The new species, *L. schalleri* is distinct morphologically as diagnosed. Multivariate PCA show two distinct cluster, one each of *L. nigripes* and *L. schalleri* and the cumulative variance explained by the first two components is 89.1% (Fig. 11, Appendix I–II).

Description of two new species of scorpions from the Indo-Burma biodiversity hotspot (Mirza *et al.* 2016) and discovered new genus of mygalomorph spider (Mirza *et al.* 2017) during the survey highlight the poor nature of biodiversity documentation in this region. Dedicated surveys across the Indo-Burma and the adjoining Himalayan region will certainly yield more interesting arachnid species.

Acknowledgments

Thanks are due to Atul Kumar Gupta (PCCF & CWLW, Member Secretary, Tripura Biodiversity Board) and Ajith Kumar (NCBS) for initiating the Tripura biodiversity surveys. This work was a collaboration with the Tripura

Biodiversity Board, which facilitated and funded this project. Survey and collection permits [No.F.8.(163)/For-WL-2012/Part/38802-08] were granted by the Principal Chief Conservator of Forests, Dept. of Forest, Govt. of Tripura. I thank Janet Beccaloni for necessary permissions and hosting us at the Natural History Museum, London. Krushnamegh Kunte for hosting me in his lab to carry out the present study. Special thanks to Rajesh Sanap for help during fieldwork, preparation of the manuscript and usage of his images. Akshay Khandekar permitted use of specimens collected by him from Tripura. Varad Giri (NCBS collection facility in-charge) facilitated access to the museum. Part of the work was carried out with funds from the Rufford Small Grant and Tulika Kedia through the Singinawa Conservation Foundation and equipment support from Idea Wild. Fieldwork conducted for the present work would not have been possible without David Raju, Gaurang Gowande, Surya Ramachandran, Harshal Bhosale, Aravind Sridharan and Aritra Kshetry. S. M. M. Javed and Amod Zambre provided valuable inputs during my discussion on Indian *Liocheles*. Lionel Monod, Lorenzo Prendini and two anonymous reviewers provided comment from which the manuscript greatly benefitted.

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APPENDIX I. Character loadings for Principal component 1 & 2

	PC 1	PC 2
Total L	0.65073	0.50272
Carapace L	0.016324	0.062623
Carapace anterior W	0.001905	-0.01331
Carapace posterior W	0.031911	0.074017
Mesosomal L	0.7079	-0.22635
Metasoma total L	-0.08569	0.67509
Metasomal seg I L	0.002268	0.034291
Metasomal seg I W	-0.00127	0.004801
Metasomal seg II L	-0.00412	0.039806
Metasomal seg II W	-0.01153	0.008336
Metasomal seg III L	-0.00931	0.049717
Metasomal seg III W	0.005749	-0.01644
Metasomal seg IV L	-0.00862	0.090136
Metasomal seg IV W	0.002238	-0.00259
Metasomal seg V L	-0.00215	0.096482
Metasomal seg V W	-0.00944	0.017898
Telson L	-0.07792	0.24671
Femur L	-0.10572	0.19337
Femur W	-0.05076	0.064525
Patella L	-0.08583	0.088221
Patella W	-0.06651	0.1108
Chela L	-0.16861	0.23153
Chela W	-0.05913	0.097883
Movable finger L	-0.05295	0.14728

APPENDIX II. Eigenvalues and variance explained by each principal component

PC	Eigenvalue	% variance
*1	18.8844	73.725
*2	3.94182	15.389
3	1.7318	6.7609
4	0.353207	1.3789
5	0.258451	1.009
6	0.101978	0.39812
7	0.088358	0.34495
8	0.065747	0.25668
9	0.057547	0.22466
10	0.031849	0.12434
11	0.030739	0.12001
12	0.021605	0.084348
13	0.018981	0.074101
14	0.010078	0.039345
15	0.008084	0.031561
16	0.004712	0.018397
17	0.002813	0.010981
18	0.002562	0.010001