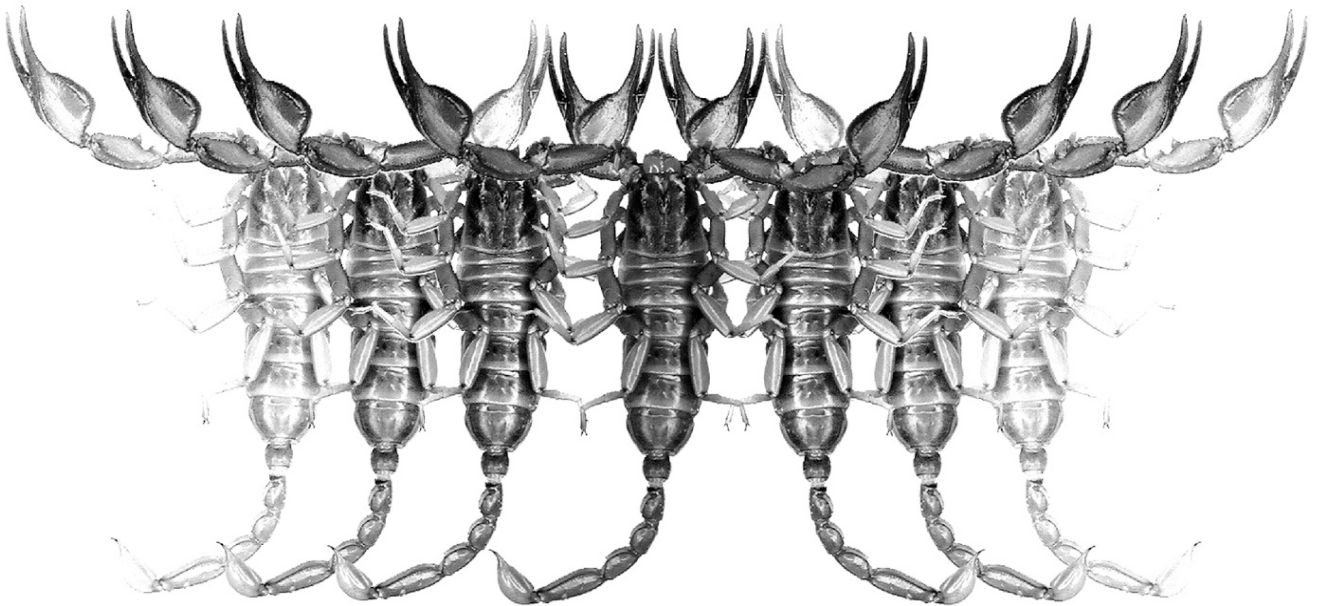


Euscorpium

Occasional Publications in Scorpiology



**Four new lithophilic species of
Scorpiops Peters, 1861 (Scorpiones:
Scorpiopidae) from peninsular India**

**Shauri Sulakhe, Shubhankar Deshpande, Nikhil Dandekar,
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Occasional Publications in Scorpiology

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Four new lithophilic species of *Scorpiops* Peters, 1861 (Scorpiones: Scorpionidae) from peninsular India

Shauri Sulakhe¹, Shubhankar Deshpande¹, Nikhil Dandekar¹,
Anand Padhye^{1,2} & Deshabhushan Bastawade¹

¹Institute of Natural History Education and Research (INHER), C26/9, Ketan Heights, Kothrud, Pune, Maharashtra – 411038, India.

²Department of Zoology, MES Abasaheb Garware College, Karve Road, Pune, Maharashtra – 411004, India. Email (Corresponding author): shaurisulakhe@gmail.com

<http://zoobank.org/urn:lsid:zoobank.org:pub:71DBBF82-F6C2-4010-B79A-E0EA6A04B772>

Summary

Four new lithophilic species of *Scorpiops* Peters, 1861 (Scorpionidae) have been described from peninsular India using an integrated taxonomic approach. Three species *Scorpiops vrushchik* sp. n., *S. nagphani* sp. n. and *S. neera* sp. n. have been described from northern Western Ghats and *S. lioneli* sp. n. is described from Deccan Plateau. *S. vrushchik* sp. n. is closely related to *S. tenuicauda* and *S. telbaila* and differs by a raw genetic divergence of 9.6–9.8% from *S. tenuicauda* and 11% from *S. telbaila*. *S. nagphani* sp. n. is closely related to *S. lioneli* sp. n. and *S. maharashtraensis* and differs by a raw genetic divergence of 6.7% from *S. lioneli* sp. n. and 9.6% from *S. maharashtraensis*. *S. neera* sp. n. is closely related to *S. deccanensis*, *S. satarensis* and *S. phaltanensis* and differs by a raw genetic divergence of 6.1–7.1% from *S. deccanensis*, 7.3% from *S. satarensis* and 9.6–9.8% from *S. phaltanensis*. *S. lioneli* sp. n. is closely related to *S. nagphani* sp. n. and *S. maharashtraensis* and differs by a raw genetic divergence of 6.7% from *S. nagphani* sp. n. and 11% from *S. maharashtraensis*. Hemispermatophore morphology of all the new species is described with photographs. A taxonomic key to all species of *Scorpiops* from peninsular India is provided. This study elevates the number of species of *Scorpiops* found in India to 27, out of which 11 are found in peninsular India.

Introduction

Recently the family Scorpionidae Kraepelin, 1905, underwent major taxonomic revision based on a detailed study of morphological characters, variation in trichobothriotaxy, karyotype and DNA analysis (Kovářík et al., 2020; Štáhlavský et al., 2020). In this study, genera *Neoscorpions* Vachon, 1980, *Alloscorpions* Vachon, 1980, *Dasyscorpions* Vachon, 1974, *Euscorpions* Vachon, 1980, *Plethoscorpions* Lourenço, 2017, and *Vietscorpions* Lourenço & Pham, 2015, and subgenus *Alloscorpions* (*Laoscorpions*) Lourenço, 2013, were all synonymized under *Scorpiops* Peters, 1861. After the revision this family now includes two genera (*Parascorpions* Banks, 1928; *Scorpiops* Peters, 1861) and 96 species.

Genus *Scorpiops* with type species *Scorpiops hardwickii* Gervais, 1843 (type locality Himalayas, India), consists of 95 species distributed widespread in Asia. Out of these, 23 species are found in India; only seven are found in peninsular India and all the remaining species, in the Himalayas. Except *Scorpiops pachmarhicus* Bastawade, 1992, described from Pachmarhi, Hoshangabad District, Madhya Pradesh, India, the remaining six species were described from the state of Maharashtra, including the recent description of *Scorpiops telbaila* Sulakhe et al., 2020 from Saltar Khind (pass), near

Ambawne Village, Pune District, Maharashtra. Other species of *Scorpiops* from peninsular India include *S. deccanensis* Tikader and Bastawade, 1977 (type locality: Sinhagad Fort, Pune District), *S. tenuicauda* Pocock, 1894 (Matheran, Raigad District), *S. satarensis* Pocock, 1900 (Mahabaleshwar, Satara District), *S. maharashtraensis* Mirza et al., 2014 (Shidi Ghat near Wadali Village, Aurangabad District) and *S. phaltanensis* Sulakhe et al., 2020 (Asraidevi Temple, Phaltan, Satara District).

During the arachnological surveys of peninsular India, we encountered a few populations of *Scorpiops*, which were morphologically and genetically different from their congeners. In this study we describe four new species using integrated taxonomic approach.

Methods, Materials & Abbreviations

Material sampling, processing, imaging, and repository. Sampling was carried out in peninsular India, Maharashtra in Ahmednagar District, Khireswar Village, near Harishchandragad Fort (19°22'54"N 73°48'25"E, 719 m a. s. l.), Pune District, Nigdale Village, near Bhimashankar Wildlife Sanctuary (19°04'40"N 73°33'32"E, 963 m a. s. l.) and Pune District, Varandha Ghat (18°05'52"N 73°39'14"E,



Figure 1. *Scorpiops vrushchik* sp. n., male, holotype *in vivo* habitus.

693 m a. s. l.) from northern Western Ghats, India and Nashik District, Pardhadi Village (20°16'47"N 74°49'39"E, 559 m a. s. l.) from the Deccan Plateau. Specimens were located with the help of ultraviolet light (AmiciVision 18w 100 LED UV Torch) and collected. All photographs of holotypes and paratypes presented in this study were taken using Nikon D500, 105 mm F2.8 micro lens and R1C1 flash kit. Specimens were euthanized and preserved in absolute ethanol, and later transferred to 70% ethyl alcohol in collection jars for long term preservation. Examination and morphological measurements were done using LEICA EZ4HD microscope with LEICA application suite. Morphometry was performed following Stahnke (1971); trichobothrial terminology follows Vachon (1974); metasoma carination follows Francke (1977); pedipalp carination follows González-Santillán & Prendini (2013); leg terminology follows Tikader & Bastawade (1983); morphological terminology follows Hjelle (1990); pedipalp chela dentition follows Kovařík et al. (2020); lateral ocelli terminology follows Loria & Prendini (2014); pectine terminology follows Kovařík et al. (2020). Terminology for tubercles on internal aspect of pedipalp patella follows Sulakhe et al. (2020a). Measurements were taken (in mm) for 42 morphological characters (Tables 1–3). The trichobothrial

terminology follows Vachon (1974).

Paraxial organs were dissected out of mature male specimens using scalpel, pointed needles and forceps under a stereo microscope without damaging the organ. All the paraxial organs containing hemispermatophores were digested with a treatment of 50% concentrated proteinase K from *Tritirachium album* (Type B). The organs were then kept in an oven at 40°C in a sealed glass tube. The paraxial organs were checked every 10 minutes until they had become soft enough to remove their muscle manually without damaging the hemispermatophore. At the end of the process the specimens were immersed with several water baths to wash off the proteinase K. The specimens were then mounted on cavity slides and photographed. Finally, the specimens were transferred to clove oil for long term preservation. Hemispermatophore terminologies follow Lamoral (1979) and Monod et al. (2017). Hemispermatophore morphometry was performed following Kovařík et al. (2020).

Specimens collected and studied are deposited in the museum collection of the Bombay Natural History Society (BNHS), Mumbai and Institute of Natural History Education and Research (INHER), Research Laboratory, Pune, Maharashtra, India.

Microscopy. Field emission scanning electron microscopy (FESEM) was performed on dorsal aspect of movable fingers of chelae. Movable fingers of chelae of specimens preserved in 70% ethanol were removed from the animals and treated with 2% KOH to remove the fungal growth. Specimens were then water washed several times to remove the KOH and cleaned manually with soft brush before being dehydrated and air dried. Specimens were then coated with gold/palladium in a Quorum Q150T ES sputter coater for 40 seconds. FESEM images were acquired using FEI Nova NanoSEM 450 with resolution of 1.0 nm at 15 kV, 1.4 nm at 1 kV and 1.8 nm at 3 kV and 30 Pa. Digital images were taken at 100x magnification and multiple images were stacked in Adobe Photoshop CC 2014.

Additional material examined. Data used for comparison, diagnosis and statistical analysis of *S. tenuicauda*, *S. deccanensis*, *S. satarensis*, *S. maharashtraensis*, *S. phaltanensis* and *S. telbaila* were from Kovařík (2000), Sulakhe et al. (2020a, 2020b).

Statistical analysis.

Statistical analysis of the morphometric data was performed on size adjusted measurements by taking all measurements as percent of carapace median length (CML) to remove the bias due to body size variation. Multivariate normality of the data was checked using Doornik & Hansen (2008) omnibus. Principal Component Analysis (PCA) and Discriminant Function Analysis (DFA) were performed to specifically assess the degree of morphological differentiation among the members of the *Scorpiops* found in Northern Western Ghats. PCA was performed using 19 morphometric parameters taken from adult males. Factor scores of the first two Principal Components (PC) were observed on a scatter plot. Furthermore, sets of 19 predictor variables were generated from the PCA and all the factor scores were used as input variables for performing a DFA, in order to also determine the classification success of the studied samples. PCA and DFA were performed using the statistical software PAST 4.03 (Hammer et al., 2001).

Following characters were used for statistical analysis: Carapace (W), Mesosoma VII (L), Metasomal Segment I, II, III, IV and V (L), Femur and Patella (L/W), Pedipalp Chela (L), Pedipalp Manus (W), Telson Vesicle (W/D), Pectine, and Genital Operculum (L/W). L (Length), W (Width), D (Depth),

Molecular analysis.

DNA extraction, amplification and sequencing. Protocol as per Sulakhe et al. (2020c) was followed. Genomic DNA was isolated from preserved (ethanol 99.9%) muscle tissue (leg fragment) of *Scorpiops* species (voucher numbers and GenBank accession numbers of specimens used for DNA analysis, generated in this study are mentioned in Table 7, Figs. 156, 157,) with the help of MACHEREY-NAGEL NucleoSpin® DNA Insect kit as per manufacturer's protocols. Other sequences are sourced from Sulakhe et al. (2020a, 2020b). A 550–600 base pair (bp) fragment of the cytochrome

c oxidase subunit I (*COI*) mitochondrial gene was amplified by polymerase chain reaction (PCR) using the primers as per Table 1. A 25 µl PCR reaction (TaKaRa Taq™ DNA Polymerase) was prepared containing 1 unit of Taq DNA polymerase (0.2µL), 2.5 µL of 10x buffer, 2 µl of dNTPs (2.5mM each), 2 µl (5mM) of each primer, 2 µl template DNA, and 14.3 µl of water, and reactions were carried out with an Miniamp Thermal Cycler. Thermal cycler profiles used for amplification were as follows: 95° C for 3 min (denaturation temperature 95° C for 30 seconds, annealing temperature 50° C for 30 seconds, elongation temperature 72° C for 1 minute) x 35 cycles, 72° C for 7 minutes, hold at 4° C. PCR products were cleaned through column purification with Qiagen PCR Cleanup Kit and sequenced with a 3730 DNA Analyzer. The sequencing primers were the same as those used in PCRs. All sequences were deposited in the GenBank® nucleotide sequence database (<http://www.ncbi.nlm.nih.gov>) under accession numbers (Table 2).

The sequences were also checked in BLAST (Altschul et al., 1990) tool to find the closest available sequences in the GenBank® and related ones were downloaded for analysis.

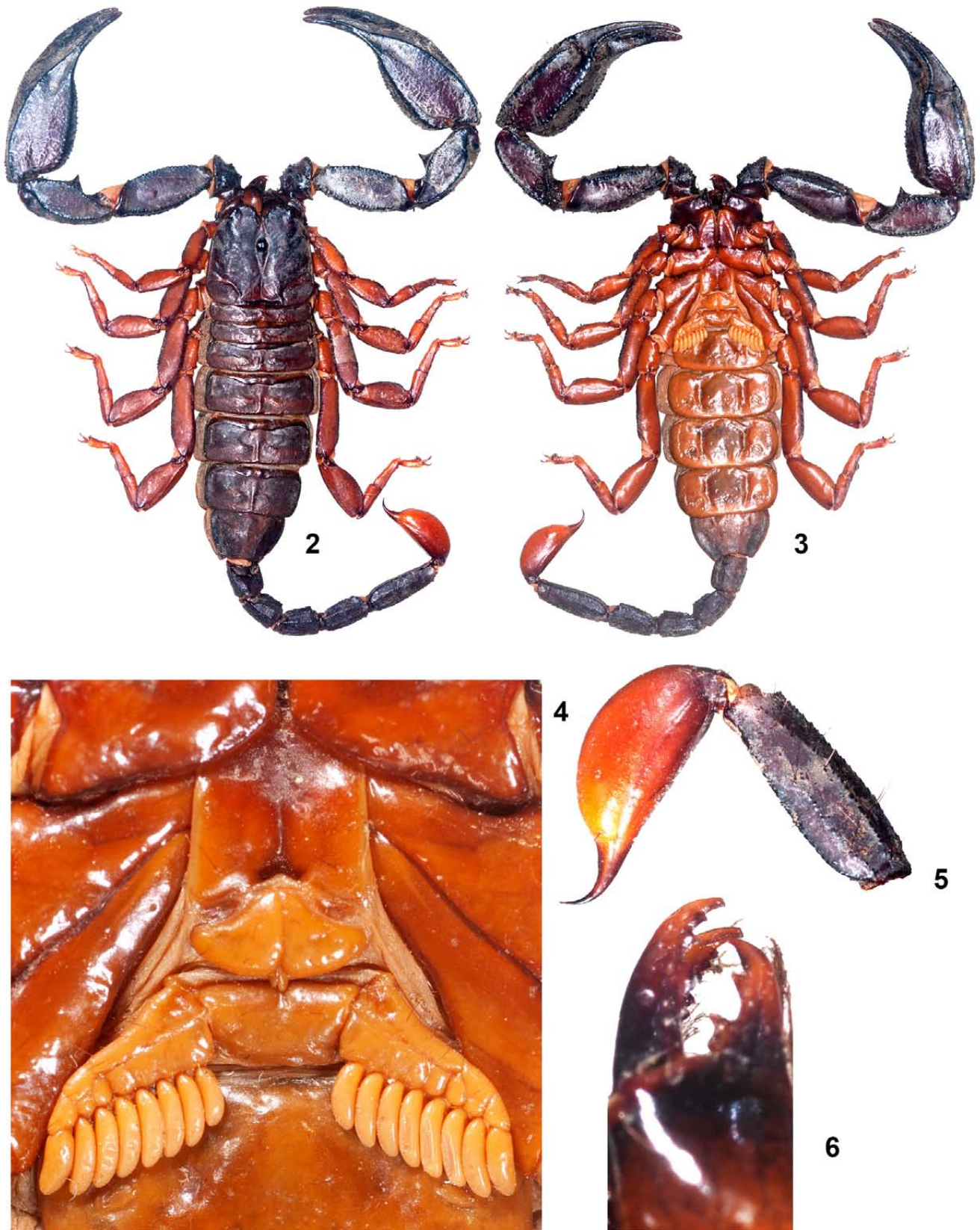
Sequence alignment. Generated sequences were cleaned manually in MEGA7 (Kumar et al., 2016) using chromatograms visualised in Chromas V.2.6.5 (Technelysium PTY. Ltd.). Cleaned and downloaded sequences were aligned using MUSCLE (Edgar 2004) implemented in MEGA 7 (Kumar et al., 2016) with default parameters. The final alignment contained 26 sequences each 509 bp in length, including two sequences of *Scorpiops tibetanus* Hirst, 1911 (Table 7) used as outgroup to root the phylogenetic tree. This alignment was used in molecular phylogenetic analyses.

Molecular phylogenetic analysis. Maximum Likelihood (ML) and Bayesian Inference (BI) methods of phylogenetic analysis were implemented. The *COI* region was partitioned per codon position and the best substitution model for BI phylogenetic analysis was determined using PartitionFinder V.1.1.1 (Lanfear et al., 2012). Model search was performed with a greedy search algorithm (Schwarz, 1978) and models were selected using the Akaike Information Criterion (AIC). Maximum Likelihood analysis was performed in IQ-tree (Nguyen et al., 2015) under the (HKY+F+R2: part1, HKY+F+I: part2, F81+F+I: part3) models of sequence evolution, determined using ModelFinder (Kalyaanamoorthy et al., 2017) on IQ tree web platform and branch support was tested using 1000 non-parametric rapid bootstrap pseudo-replicates (Minh et al., 2020). Bayesian trees were generated using MrBayes v .3.2.6 (Ronquist et al., 2012). The models of sequence evolution were as follows: HKY+G for codon position 1, HKY+I for codon position 2, and HKY+I for codon position 3. For BI analysis, two simultaneous, independent analyses were run starting from different random trees. Three heated and one cold chain was used in the analysis. Markov chains were sampled every 500 generations for 20 million generations. At the end of the run we ensured convergence of the two MCMC runs by ensuring that the standard deviation of split frequencies was less than

		<i>Scorpiops vrushchik</i> sp. n.			
Dimensions (mm)		♂ holotype BNHS SC 250	♂ paratype INHER 238	♂ paratype INHER 239	♂ paratype BNHS SC 251
Carapace	L / W	7.98 / 8.67	7.82 / 8.31	7.58 / 7.76	7.7 / 8.0
Mesosoma	L	22.56	22.16	20.02	20.72
Tergite VII	L / W	4.72 / 6.38	4.59 / 6.19	4.17 / 6.09	4.17 / 6.16
Metasoma + telson	L	25.47	24.77	23.15	24.88
Segment I	L / W / D	2.59 / 2.96 / 2.33	2.45 / 2.89 / 2.23	2.38 / 2.60 / 2.03	2.60 / 2.63 / 1.95
Segment II	L / W / D	2.67 / 2.76 / 1.98	2.64 / 2.55 / 2.44	2.18 / 2.41 / 2.12	2.90 / 2.53 / 1.90
Segment III	L / W / D	3.28 / 2.49 / 2.44	3.13 / 2.33 / 2.34	2.86 / 2.08 / 2.09	3.01 / 2.24 / 2.07
Segment IV	L / W / D	3.52 / 2.16 / 2.22	3.4 / 2.16 / 2.08	3.32 / 2.09 / 2.09	3.12 / 2.14 / 2.07
Segment V	L / W / D	5.36 / 2.15 / 2.18	5.49 / 2.11 / 2.20	5.06 / 1.84 / 2.06	5.56 / 2.10 / 2.01
Telson	L / W / D	8.05 / 2.46 / 2.87	7.35 / 2.24 / 2.66	7.35 / 2.31 / 2.34	7.69 / 2.33 / 2.75
Pedipalp	L	35.29	32.38	30.58	32.30
Femur	L / W	9.17 / 3.73	8.5 / 3.62	7.93 / 3.48	8.36 / 3.4
Patella	L / W	8.35 / 3.67	7.52 / 3.45	6.96 / 3.28	7.49 / 3.49
Chela	L	17.77	16.36	15.67	16.45
Manus	L / W / D	8.89 / 6.09 / 4.02	9.47 / 5.74 / 4.25	8.5 / 5.23 / 3.66	9.38 / 5.72 / 3.73
Movable finger	L	8.93	8.19	8.22	8.17
Pectine	L / W	4.12 / 2.57	3.96 / 2.54	3.97 / 2.34	3.98 / 2.62
Genital Operculum	L / W	1.86 / 2.94	1.78 / 2.4	1.78 / 2.4	2.00 / 2.98
Total	L	56.00	54.80	50.8	53.30
Pectinal teeth count	PTC	8 / 8	7 / 7	8 / 8	7 / 7
Trichobothria count	TPV	14 / 14	13 / 14	15 / 13	14 / 14
Trichobothria count	TPE	22 / 23	23 / 22	23 / 22	22 / 23

		<i>Scorpiops vrushchik</i> sp. n.		
Dimensions (mm)		♀ paratype BNHS SC 253	♀ paratype INHER 231	♂ paratype BNHS SC 252
Carapace	L / W	8.46 / 8.64	8.84 / 8.85	7.29 / 7.84
Mesosoma	L	23.14	23.62	19.63
Tergite VII	L / W	4.30 / 7.02	4.55 / 7.10	4.28 / 5.88
Metasoma + telson	L	18.29	24.49	22.67
Segment I	L / W / D	2.28 / 2.84 / 2.20	2.66 / 2.94 / 2.24	2.25 / 2.72 / 2.23
Segment II	L / W / D	2.52 / 2.57 / 2.24	2.32 / 2.69 / 2.15	2.57 / 2.44 / 2.25
Segment III	L / W / D	2.85 / 2.43 / 2.26	3.08 / 2.14 / 1.88	2.81 / 2.33 / 2.26
Segment IV	L / W / D	3.13 / 1.98 / 2.24	3.26 / 2.18 / 2.28	2.96 / 2.13 / 2.11
Segment V	L / W / D	5.32 / 2.02 / 2.07	5.69 / 2.06 / 1.94	5.05 / 2.20 / 2.11
Telson	L / W / D	7.39 / 2.11 / 2.19	7.39 / 2.08 / 2.29	7.03 / 2.24 / 2.52
Pedipalp	L	33.43	33.34	30.59
Femur	L / W	8.49 / 3.58	8.06 / 3.81	8.08 / 3.51
Patella	L / W	8.11 / 3.83	7.97 / 3.75	7.29 / 3.36
Chela	L	16.83	17.31	15.22
Manus	L / W / D	9.41 / 5.75 / 3.91	9.36 / 5.58 / 4.06	8.8 / 5.34 / 4.21
Movable finger	L	8.77	8.71	7.53
Pectine	L / W	3.75 / 1.60	3.58 / 1.74	3.73 / 2.53
Genital Operculum	L / W	1.46 / 3.31	1.36 / 3.77	1.82 / 3.02
Total	L	55.10	56.90	49.60
Pectinal teeth count	PTC	7 / 7	6 / 7	7 / 7
Trichobothria count	TPV	14 / 14	14 / 15	14 / 14
Trichobothria count	TPE	24 / 22	23 / 23	22 / 21

Table 1. Morphometric data for *Scorpiops vrushchik* sp. n. Abbreviations: length (L), width (W, in carapace it corresponds to median width), depth (D).



Figures 2–6. *Scorpiops vrushchik* sp. n., male, holotype, dorsal (2) and ventral (3) views, sternopectinal area (4), metasomal segment V and telson in lateral view (5) and chelicera in dorsal view (6).



Figures 7–8. *Scorpiops vrushchik* sp. n., male, holotype dorsal (7) and ventral (8) views under UV light.

0.002 and by checking the trace plots using Tracer v. 1.7 (Rambaut et al., 2018). We also ensured that the Effective Sample Size (ESS) values for all the parameters were above 200. A total of 25% trees were discarded as burn-in. The tree representing the best evolutionary hypothesis was selected using a 50% majority consensus rule.

Species delimitation analysis. Bayesian tree was used as input for delimitation analyses. Sequence-based methods to delimit species are central to DNA taxonomy. A coalescent based species delimiting approach was used to estimate the number of putative species. For this we used the Bayesian Poisson Tree Processes (bPTP) model, which considers an evolutionary placement algorithm to estimate the number of Operational Taxonomic Units (OTU) from a phylogenetic BI tree as input (Zhang et al., 2013). This model delimits species in terms of number of substitutions based on an input of a rooted phylogenetic tree. As bPTP is an updated version of the original maximum likelihood PTP, the maximum likelihood PTP search result is part of the bPTP results. The online server for bPTP was used to run 500000 MCMC iterations with thinning parameter of 100 and burn-in of 0.1 to obtain convergence (<http://species.h-its.org/ptp/>).

Apart from bPTP, we also used another molecular species delimitation approach, the generalized mixed Yule-coalescent (GMYC) method (Fujisawa et al., 2013). GMYC models speciation (among-species branching events) via a pure birth process and within-species branching events as neutral

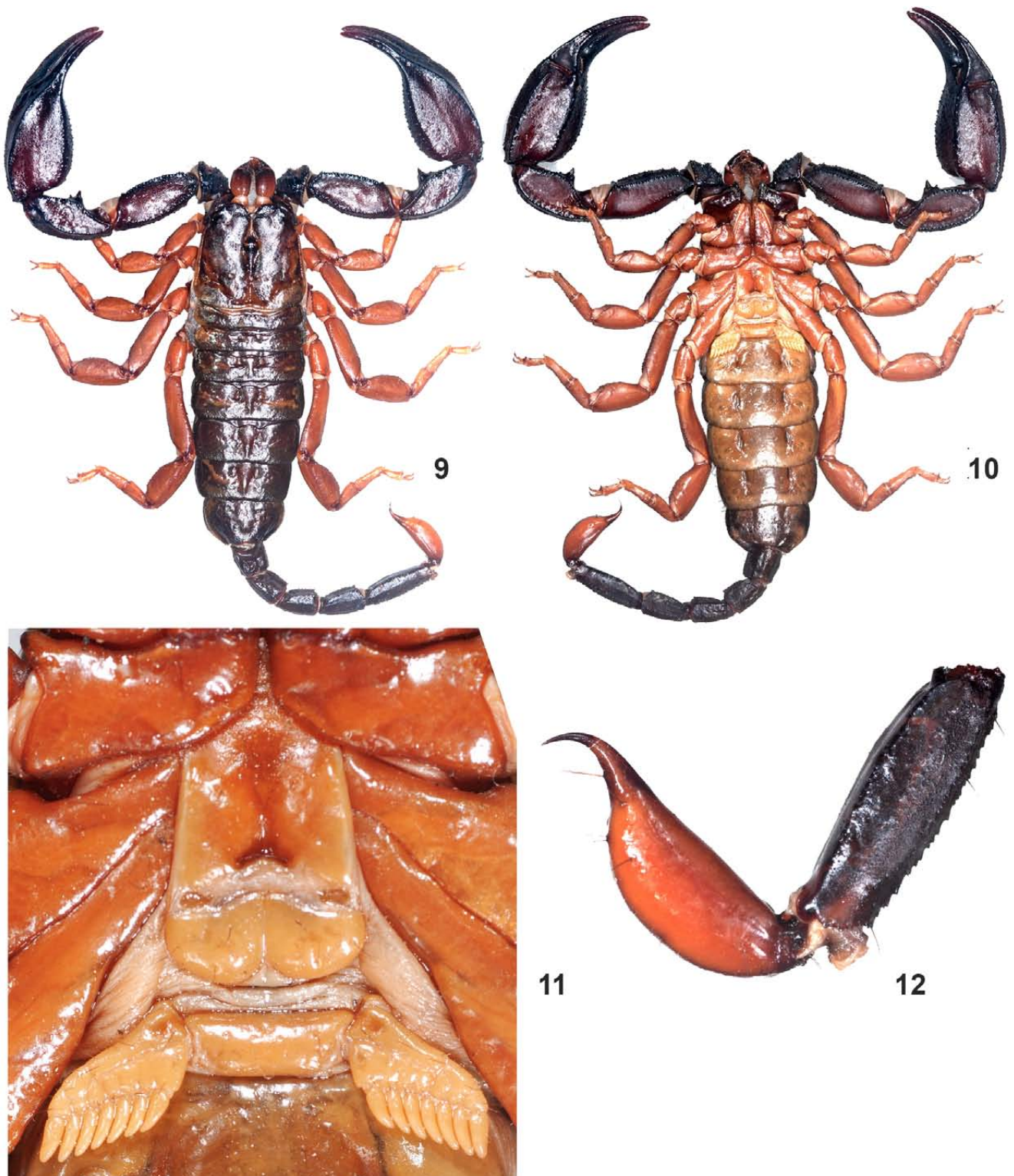
coalescent processes. GMYC identifies the transition points between inter- and intra-species branching rates on a time-calibrated ultra-metric tree by maximizing the likelihood score of the model. It assumes that all lineages leading from the root to the transition points are different species (Esselstyn et al., 2012). An online implementation of GMYC (<https://species.h-its.org/gmyc/>) was used in single threshold mode with the ultra-metric tree as input. The BI output was converted to ultra-metric tree using the packages APE (Paradis & Schliep, 2019), PHANGORN (Schlip, 2011), PHYLOGRAM (Wilkinson & Davy, 2018) in R v. 3.6.1 (R Core team, 2013).

Numerous tests show bPTP outperforms GMYC on simulation data, and bPTP results are comparable to GMYC on real data sets (Zhang et al., 2013).

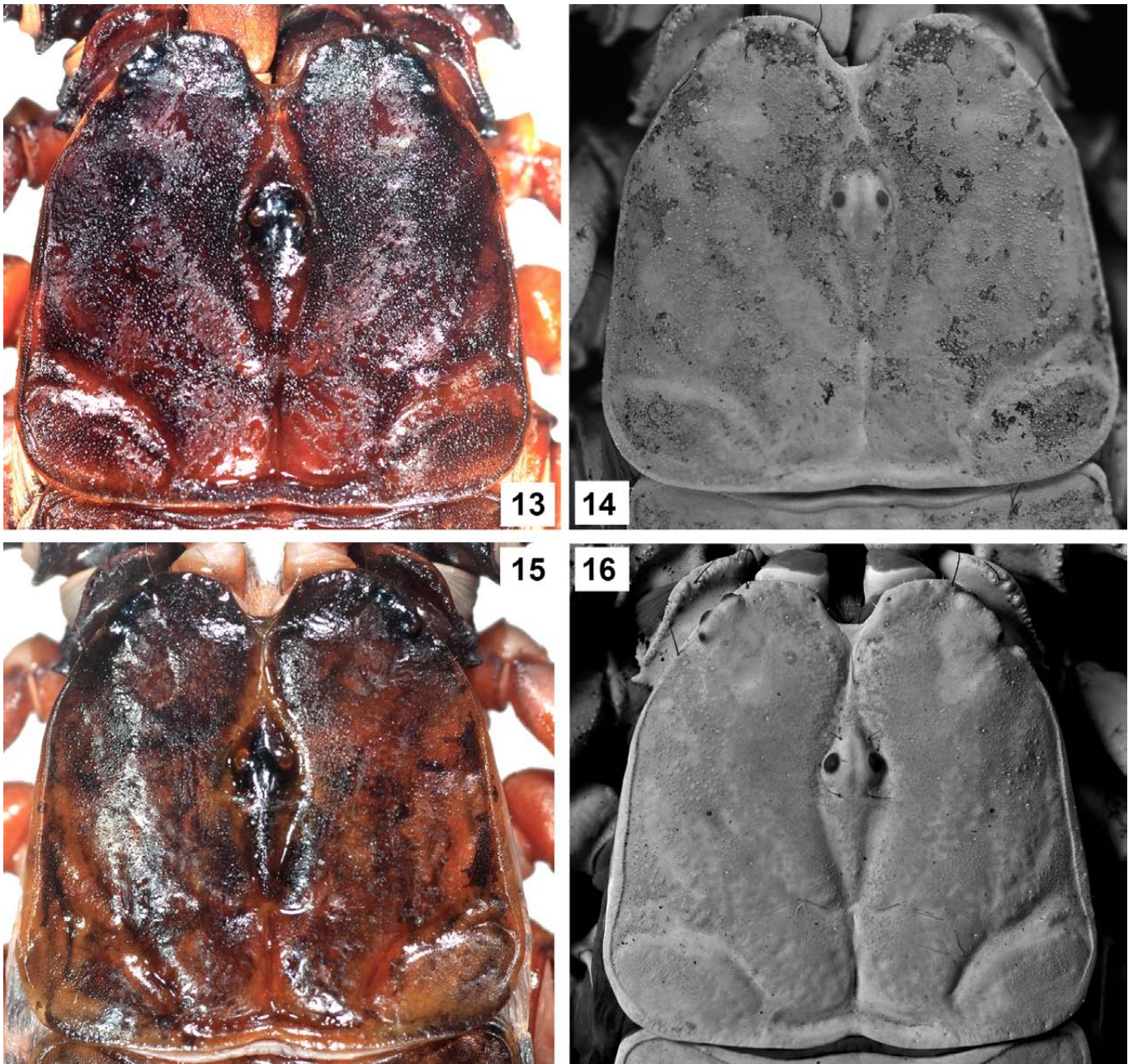
Genetic delimitation of species was also performed using barcode gap analysis in AUTOMATIC BARCODE GAP DISCOVERY (ABGD) software (Puillandre et al., 2012) using simple distances and transition of 2.0.

We also calculated the genetic p -distance for the mitochondrial loci (*COI*) in MEGA 7.

We considered putative species that showed strong separation on a minimum of three axes identified by PTP, bPTP, GMYC, ABGD and p -distance; however we have considered morphological separation as a compulsory axis to identify new species. In this study we have considered the species as valid only where we have encountered morphological separation along with other supporting evidences.



Figures 9–12. *Scorpiops vrushchik* sp. n., female, paratype, BNHS SC 253, dorsal (9) and ventral (10) views, sternopectinal area (11) and metasomal segment V and telson in lateral view (12).



Figures 13–16. *Scorpiops vrushchik* sp. n. **Figures 13–14.** Male, holotype, carapace under white light (13) and UV fluorescence (14). **Figures 15–16.** Female, paratype, BHNS SC 253, carapace under white light (15) and UV fluorescence (16).

Systematics

Family **Scorpiopidae** Kraepelin, 1905

Scorpiops Peters, 1861

(Figures 1–157, Tables 1–7)

<http://zoobank.org/urn:lsid:zoobank.org:act:45E3D60F-43C5-4655-9675-E8C72D771112>

TYPE SPECIES. *Scorpiops hardwickii* Gervais, 1843

Scorpiops vrushchik sp. n.

(Figures 1–32, 127, 131, 135, 139, 149, 153–157, Tables 2, 5–7)

<http://zoobank.org/urn:lsid:zoobank.org:act:E88A7E34-E5B3-497B-810D-85C41F0417A4>

TYPE LOCALITY AND AND TYPE REPOSITORY. **India**, Maharashtra State, Ahmednagar District, Khireswar Village, near Harishchandragad Fort, 19°22'54"N 73°48'25"E; BNHS.

TYPE MATERIAL. **India**, Maharashtra State, Ahmednagar District, Khireswar village, near Harishchandragad Fort, 19°22'54"N 73°48'25"E, 719 m a. s. l., 1♂ (holotype, BNHS SC 250), 4♂ (paratypes, INHER-238, 239, BNHS SC 251, 252), 2♀ (paratype, INHER-231, BNHS SC 253), 29 June 2020, leg. S. Sulakhe, S. Deshpande, M. Ketkar & A. Marathe.

ETYMOLOGY. The specific epithet is derived from a Sanskrit word *vrushchik*, meaning scorpion.



Figures 17–22. *Scorpiops vrushchik* sp. n., male, holotype. **Figures 17–22.** Pedipalp chela dorsal (17), ventral (18) and dorsoexternal (19), patella external (20), dorsal (21) and ventral (22) views under UV fluorescence. Trichobothrial pattern indicated by yellow circles.

DIAGNOSIS (♂♀). Total length 49–57 mm. Base color uniformly dark brownish to blackish. Pectinal teeth number 6–8 in both sexes, fulcra reduced to absent. Pectine morphology of type P4. Anterior margin of carapace between lateral ocelli and U shaped anterior median notch curved. Patella of pedipalp with 21–24 (5 *eb*, 2 *esb*, 2 *em*, 7–9 *est*, 5–6 *et*) external and 13–15 ventral trichobothria. Chela of pedipalp with 4 ventral trichobothria located on ventral surface. Chelal trichobothrium *Eb*₃ is located in proximal half of manus between trichobothria *Dt* and *Db*. Fingers of pedipalps strongly undulate in male and margins undulate in female. Chela length to width ratio 2.9–3.0 in males. Pedipalp movable finger with ca 50–55 IAD, which form second row, parallel with MD (ca 60–65 in number); there are also 4–5 ID and 11–12 OD present. Tarsomere II of legs with 4–6 stout median ventral spinules. Metasoma I with ten, metasoma II–IV with eight and metasoma V with 7 carinae. Dorsal lateral carina on II–IV metasomal segments ending posteriorly into a short spine. Telson elongate and smooth, length to depth ratio 2.8–3.1; annular ring absent.

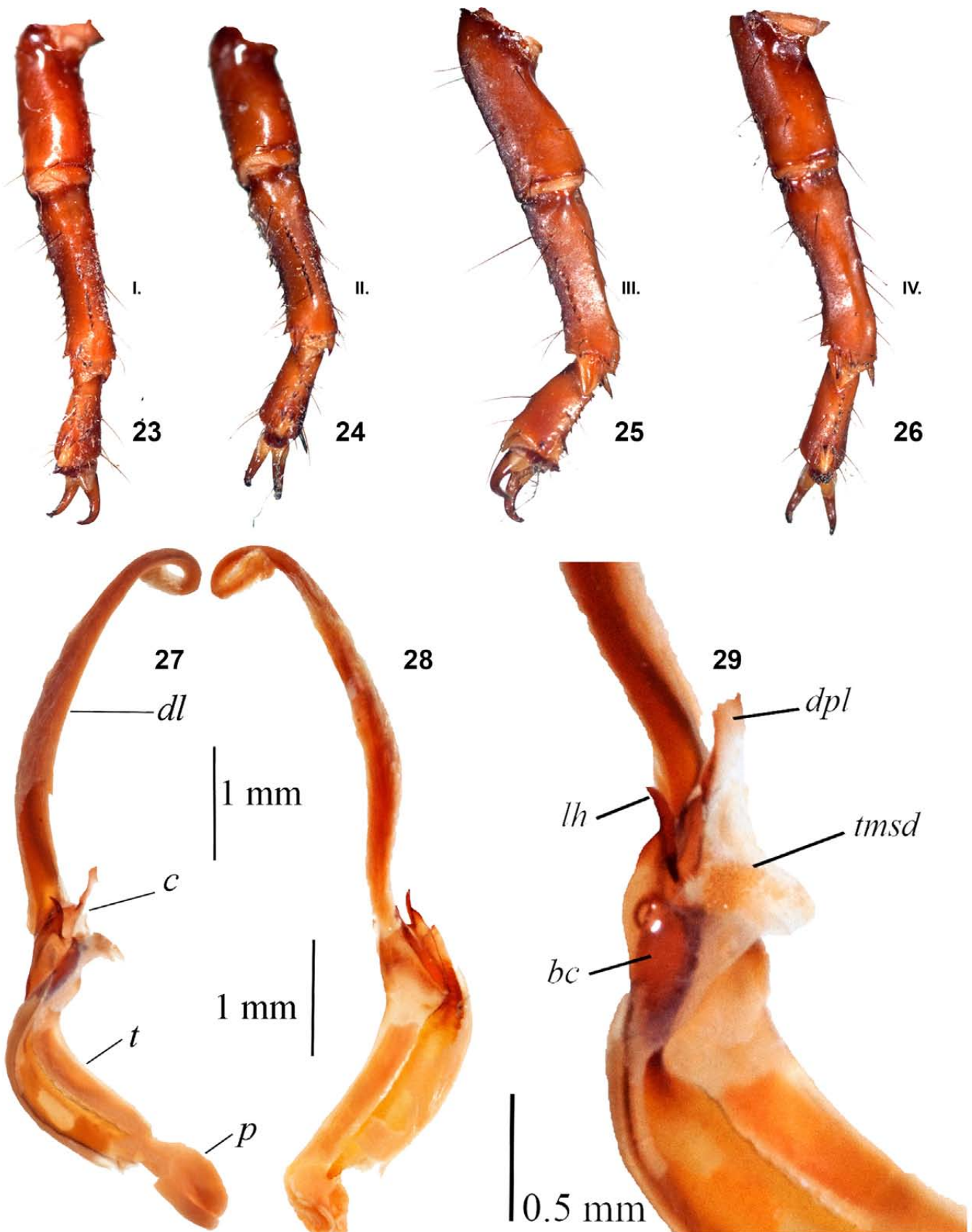
DESCRIPTION. (♂ holotype, measurements in Table 1)

Coloration (in preservation) (Figs. 1–3, 9, 10). Overall body

color dark brownish to blackish. Legs uniformly brownish. Telson orangish brown on vesicle and dark brown on aculeus. Ventral portion of body yellowish brown. Carapace and fingers of manus blackish. Pedipalps dark brown, darker on carinae. Chelicera basal segment blackish brown. Fingers of chelicera dark brown.

Carapace (Figs. 13–16). Anterior margin of carapace almost smooth with deep U shaped anterior median notch. Anterior sub margin finely granular. Anterior margin of carapace between lateral eyes and U shaped anterior median notch curved. Entire surface of carapace with fine granules. Anterior-lateral ocular tubercles granular provided with type 3A lateral ocelli. Two pairs of large major ocelli and one pair of minor ocelli. Median ocular tubercle smooth on dorsal portion with a pair of median ocelli situated in the ratio of 1:2.1 (ratio of median ocelli to anterior margin and median ocelli to posterior margin).

Chelicerae (Fig. 6). Proximal portion with reticulated mosaic design. Fixed finger of chelicera with 3 large triangular teeth on inner margin. Ventral fang of movable finger with a row of 6 minute teeth on inner margin. Dorsal fang of movable finger with 4 teeth on inner margin.



Figures 23–29. *Scorpions vrushchik* sp. n. **Figures 23–26.** Male, holotype, left legs I–IV, retrolateral aspect. **Figures 27–29.** Male, paratype, INHER-238, hemispermatophore internal (27), external (28) views and capsular region in internal view (29). Abbreviations: distal lamina (*dl*), capsule (*c*), trunk (*t*), pedicel (*p*), distal posterior lobe (*dpl*), lateral hook (*lh*), terminal membrane of the sperm duct (*tmsd*) and basal carina (*bc*).



Figures 30–32. Type locality of *Scorpiops vrushchik* sp. n., view of mountains surrounding Harishchandragad fort very close to type locality (30, 31) and view of Ganesh caves on top of Harishchandragad fort where population of the new species was observed (32).

Pedipalp (Figs. 17–22, 127, 135, 149). Femur and patella dorsoventrally flattened. Femur with 6 carinae (dorsal retrolateral, dorsal prolateral, retrolateral dorsosubmedian, prolateral ventrosubmedian, ventral retrolateral and ventral prolateral). Ventral prolateral carina present only on 1/3rd proximal portion. Intercarinal space finely and almost evenly granular. Patella with 5 carinae (dorsal retrolateral, dorsal

prolateral, retrolateral dorsosubmedian, ventral retrolateral and ventral prolateral). Internal surface of patella with one large postero-ventral tubercle and with one small, thick adjacent bulge, one adjacent small postero-dorsal tubercle and one very small, antero-ventral tubercle (Fig. 135). Manus stout with 5 carinae (dorsal retrolateral, retrolateral median, ventral retrolateral, dorsal prolateral and ventral prolateral). Dorsal

retrolateral and dorsal prolateral carinae running anteriorly up to the tip of fixed finger. Intercarinal space coarsely granular on inner and outer surface. Both fingers scalloped deeply at the base. Trichobothrial pattern neobothriotaxic.

Legs (Figs. 2, 3, 7–10, 23–26). Femur and patella carinated, intercarinal space almost smooth. Tarsomere I provided with three to four rows of spinules and tarsomere II with single ventral row of spinules.

Sternum, genital operculum and pectines (Figs. 4, 11). Sternum broad, pentagonal and finely granular only on anterior middle portion. Genital operculum with a pair of strongly protruding genital papillae. Basal piece with slight depression on anterior middle portion. Pectine morphology of type P4 with 8/8 pectinal teeth.

Mesosoma (Figs. 2, 3, 7–10). All tergites finely granular, with median carina absent on segment I. Tergite VII additionally with two pairs of lateral granular carinae present only on half posterior portion. Sternites III–VI entirely smooth. Sternite VII finely granular with a pair of weak granular lateral carinae.

Metasoma (Figs. 2, 3, 7–10, 131, 139). Metasomal segments I with 5 pairs of carinae (dorsal lateral, lateral suprmedian, lateral inframedian, ventral lateral and ventral submedian), metasomal segments II–IV with 4 pairs of carinae (dorsal lateral, lateral suprmedian, ventral lateral and ventral submedian) and segment V with 3 pairs (dorsal lateral, lateral inframedian and ventral lateral) and 1 single ventral median carinae. Lateral inframedian present only on anterior portion of segment V. Intercarinal space finely granular. Dorsal lateral carination on segments II–IV ending posteriorly into a short spine. Anal rim of segment V evenly crenulated. A pair of dorsolateral granules of anal rim weakly tuberculate.

Telson (Figs. 5, 12). Elongated and almost entirely smooth. A depression present in between vesicle and at the base of aculeus. A pair of dorsal lateral carinae present on the vesicle.

Hemispermatothore ♂ paratype, INHER-238 (Figs. 27–29). Lamelliform; distal basal carina (*bc*) with a plate like structure present, sclerotized, crown-like structure (*cls*) with distal margin smooth without denticles whose internal surface is attached to terminal membrane of the sperm duct (*tmsd*) on the inner concave side of the capsule with numerous spicules; pointed lateral hook (*lh*); a long, inwardly twisted distal posterior lobe (*dpl*) close to the distal lamina, with finely denticulate margin; short and stout trunk; long and slender distal lamina (*dl*) narrow at the base and sharply bent and tapered apex. Total length 8.5 mm; pedicel 1.15 mm long; trunk 1.78 mm long; capsule 1.15 mm long; *dpl* length 0.40 mm; *dl* length 4.42 mm long.

SEXUAL DIMORPHISM. Male genital operculum with pair of genital papillae. In females, the genital operculum medially sutured. Pedipalp manus slender in males and stouter in females (Figs. 2–5, 7–16).

AFFINITIES. *Scorpiops vrushchik* sp. n. is closely related to *S. tenuicauda* and *S. telbaila*. The new species is separated by a raw genetic divergence of 9.6–9.8% from *S. tenuicauda* and

11% from *S. telbaila*. It also differs from its close congeners based on following set of morphological characters: Dorsal lateral carina on II–IV metasomal segments ending posteriorly into a short spine as opposed to ending into a larger tuberculate spine in *S. tenuicauda* and *S. telbaila*; anterior margin of carapace almost smooth as opposed to strongly tuberculate in *S. telbaila*.

It differs from all the remaining species of *Scorpiops* from northern Western Ghats and northern Maharashtra (India) by a raw genetic divergence of 12.4–13.4 % (Table 5). It is also distinguished from all the species of *Scorpiops* from peninsular India based on the key of morphological characters (See below).

DISTRIBUTION, HABITAT AND ECOLOGY. Presently *Scorpiops vrushchik* sp. n. is known from its type locality, Khireswar Village, near Harishchandragad Fort, Ahmednagar District, Maharashtra, India and surrounding area on the Harishchandragad Fort. The type series is collected from private land surrounding Khireswar Village, however specimens were observed commonly throughout the trek route till the top of the fort. Specimens were also observed inside the Ganesh caves on top of the fort. The species is found in the crevices of basaltic boulders in the semi-evergreen forest patches and on rocky cliffs. Individuals were found to be active at night sitting at the openings of rock crevices and occasionally in the open. The ecology and morphology of the new species is congruent with the lithophilic scorpions (Figs. 30–32, 153).

Scorpiops nagphani sp. n.

(Figures 33–64, 128, 132, 136, 140, 150, 153–157, Tables 2, 3, 5–7)

<http://zoobank.org/urn:lsid:zoobank.org:act:9D96DC3C-E77E-43B7-8C3A-D9515CE3CCED>

TYPE LOCALITY AND TYPE REPOSITORY. India, Maharashtra State, Pune District, Nigdale Village, near Bhimashankar Wildlife Sanctuary, 19°04'40"N 73°33'32"E; BNHS.

TYPE MATERIAL. India, Maharashtra State, Pune District, Nigdale Village, near Bhimashankar Wildlife Sanctuary, 19°04'40"N 73°33'32"E, 963 m a. s. l., 1♂ (holotype, BNHS SC 254), 4♂ (paratypes, INHER-257, 259, 263, BNHS SC 255), 2♀ (paratype, INHER- 260, BNHS SC 257), 21 July 2020, 2♀ (paratype, INHER- 338, BNHS SC 256), 02 July 2020. All specimens collected by S. Sulakhe, S. Deshpande, M. Ketkar, A. Marathe & G. Gowande.

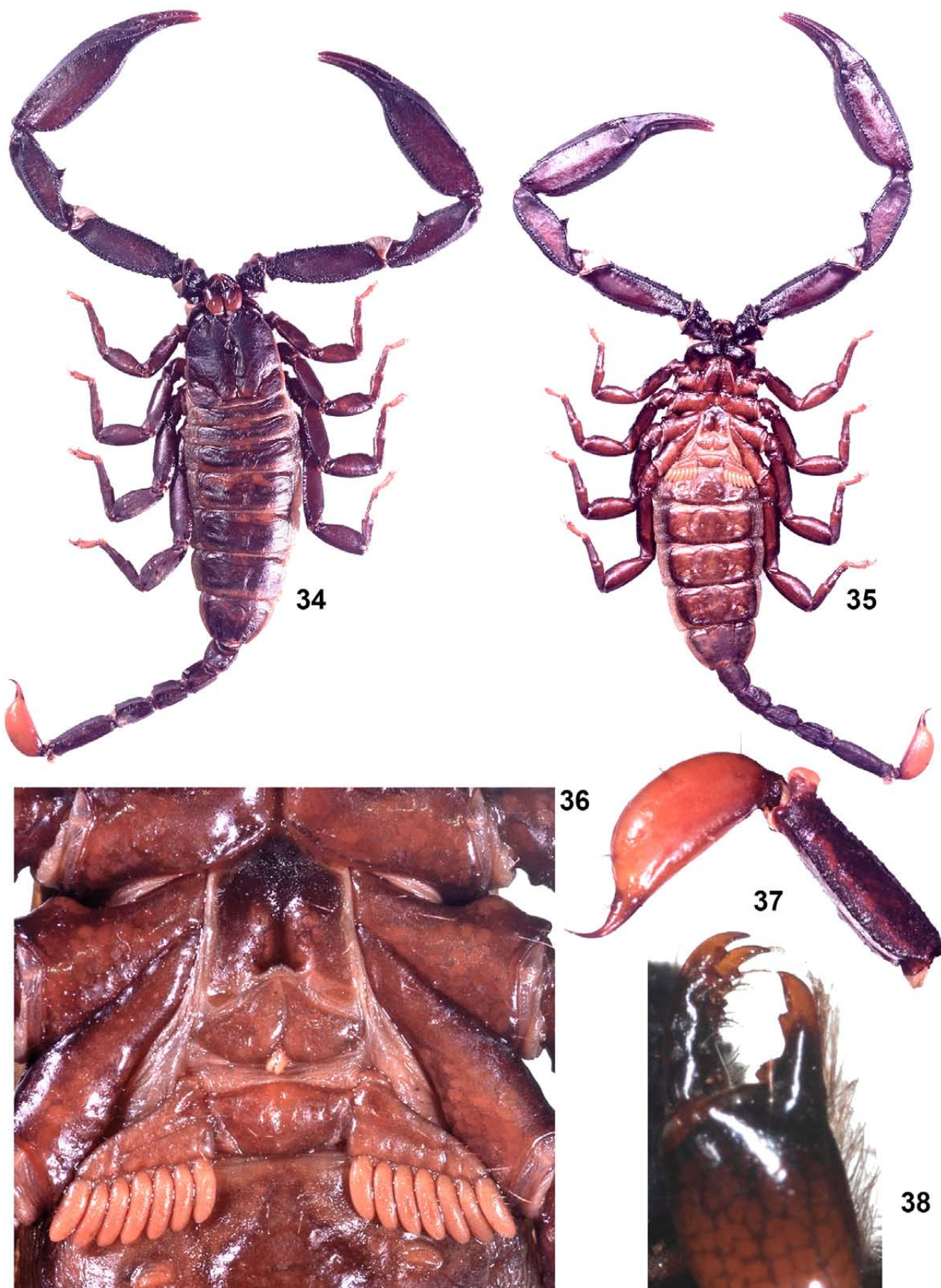
ETYMOLOGY. The specific epithet is noun in opposition, named after a steep hill top with a rocky cliff inside Bhimashankar Wildlife Sanctuary, which is popularly known as “Nagphani” in Marathi language, meaning Cobra (nag) hood (phani), which is very close to the type locality. The hiking route to Nagphani passes through thick semi-evergreen forest with basaltic boulders where abundance of the new species was observed.



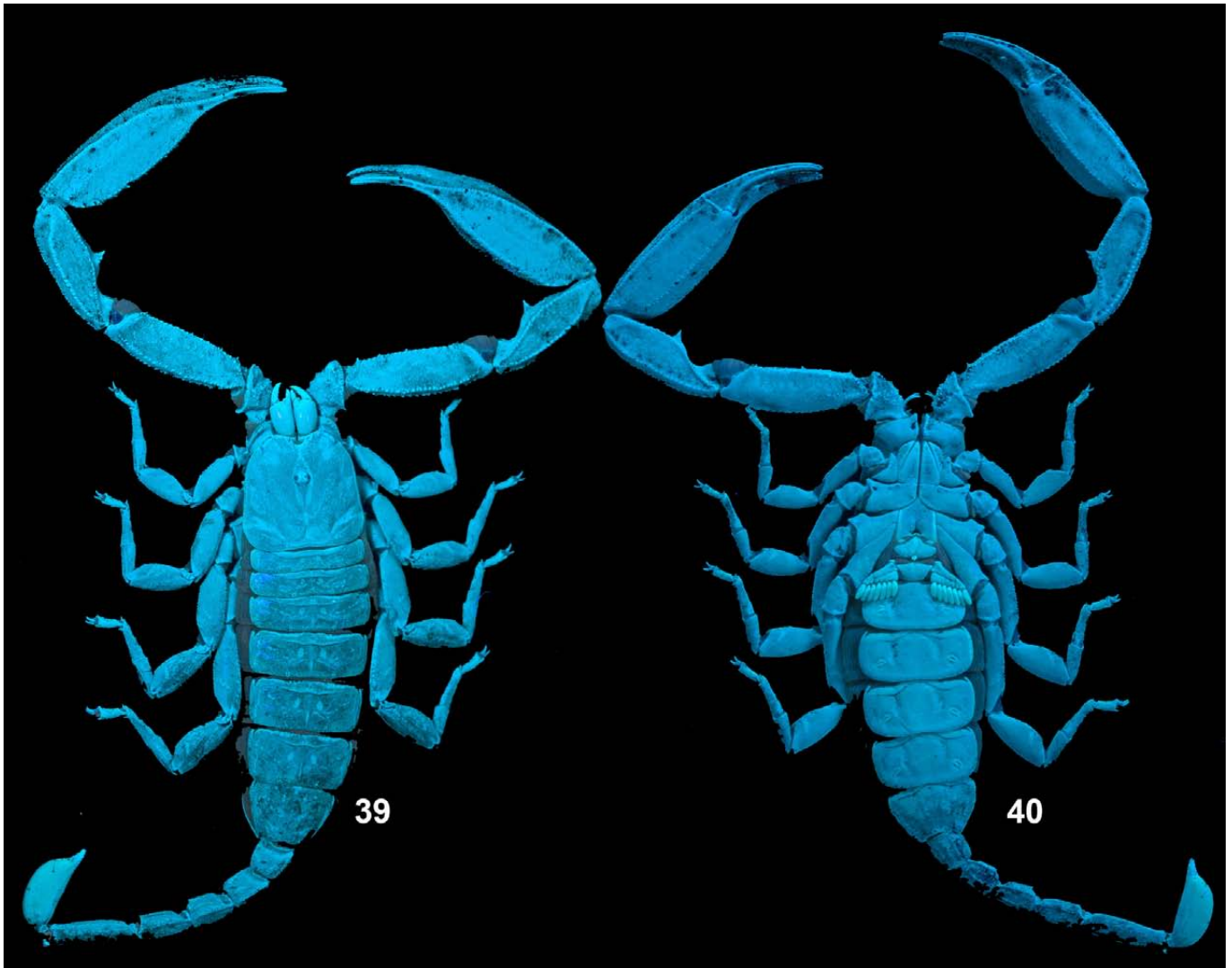
Figure 33. *Scorpiops nagphani* sp. n., female, paratype BNHS SC 256 in vivo habitus.

DIAGNOSIS (♂♀). Total length 38–42 mm. Base color uniformly blackish. Pectinal teeth number 6–7 in both sexes, fulcra reduced to absent. Pectine morphology of type P3. Patella of pedipalp with 18–23 (5 *eb*, 2 *esb*, 2 *em*, 4–8 *est*, 5–6 *et*) external and 12–14 ventral trichobothria. Chela of pedipalp with 4 ventral trichobothria located on ventral

surface. Chelal trichobothrium *Eb*₃ is located in proximal half of manus between trichobothria *Dt* and *Db*. Fingers of pedipalps strongly undulate in male and margins undulate in female. Chela length to width ratio 3.7–4.0 in males. Pedipalp movable finger with ca 45–50 IAD, which form second row, parallel with MD (ca 60–65 in number); there are also 3–4 ID



Figures 34–38. *Scorpiops nagphani* sp. n., male, holotype, dorsal (34) and ventral (35) views, sternopectinal area (36), metasomal segment V and telson in lateral view (37) and chelicera in dorsal view (38).



Figures 39–40. *Scorpiops nagphani* sp. n., male, holotype in dorsal (39) and ventral (40) views under UV light.

and 10–11 OD present. Total pedipalp length to mesosomal tergite length in males 1.6–1.9. Tarsomere II of legs with 4–6 stout median ventral spinules. Metasoma I, II and III with ten, metasoma IV with eight and metasoma V with 7 carinae. Dorsal lateral carina on II–IV metasomal segments ending posteriorly into a short spine. Telson elongate and smooth, length to depth ratio 2.5–2.9; annular ring absent.

DESCRIPTION (♂ holotype, measurements in Tables 2–3).

Coloration (in preservation) (Figs. 33–35, 41, 42). Overall body color blackish. Legs blackish brown. Telson orangish brown on vesicle and dark brown on aculeus. Ventral portion of body dark brown. Carapace and fingers of manus blackish. Pedipalps blackish brown, darker on carinae. Chelicera basal segment blackish brown. Fingers of chelicera brownish black. **Carapace** (Figs. 45–48). Anterior margin of carapace strongly granular with deep U shaped anterior median notch. Anterior sub margin coarsely granular. Anterior margin of carapace between lateral eyes and U shaped anterior median notch slightly curved. Entire surface of carapace with fine granules. Anterio-lateral ocular tubercles granular provided with type

3A lateral ocelli. Two pairs of large major ocelli and one pair of minor ocelli. Median ocular tubercle granular on dorsal portion with a pair of median ocelli situated in the ratio of 1:2.1 (ratio of median ocelli to anterior margin and median ocelli to posterior margin).

Chelicerae (Fig. 38). Proximal portion with reticulated mosaic design. Fixed finger of chelicera with 3 large triangular teeth on inner margin. Ventral fang of movable finger with a row of 5 minute teeth on inner margin. Dorsal fang of movable finger with 4 teeth on inner margin.

Pedipalp (Figs. 49–54, 128, 136, 150). Femur and patella dorsoventrally flattened. Femur with 6 carinae (dorsal retrolateral, dorsal prolateral, retrolateral dorsosubmedian, prolateral ventrosobmedian, ventral retrolateral and ventral prolateral). Ventral prolateral carina weak and present only on 1/3rd proximal portion. Intercarinal space finely and almost evenly granular. Patella with 5 carinae (dorsal retrolateral, dorsal prolateral, retrolateral dorsosubmedian, ventral retrolateral and ventral prolateral). Internal surface of patella with one large postero-ventral tubercle with one small, thick adjacent bulge and one adjacent small postero-dorsal tubercle



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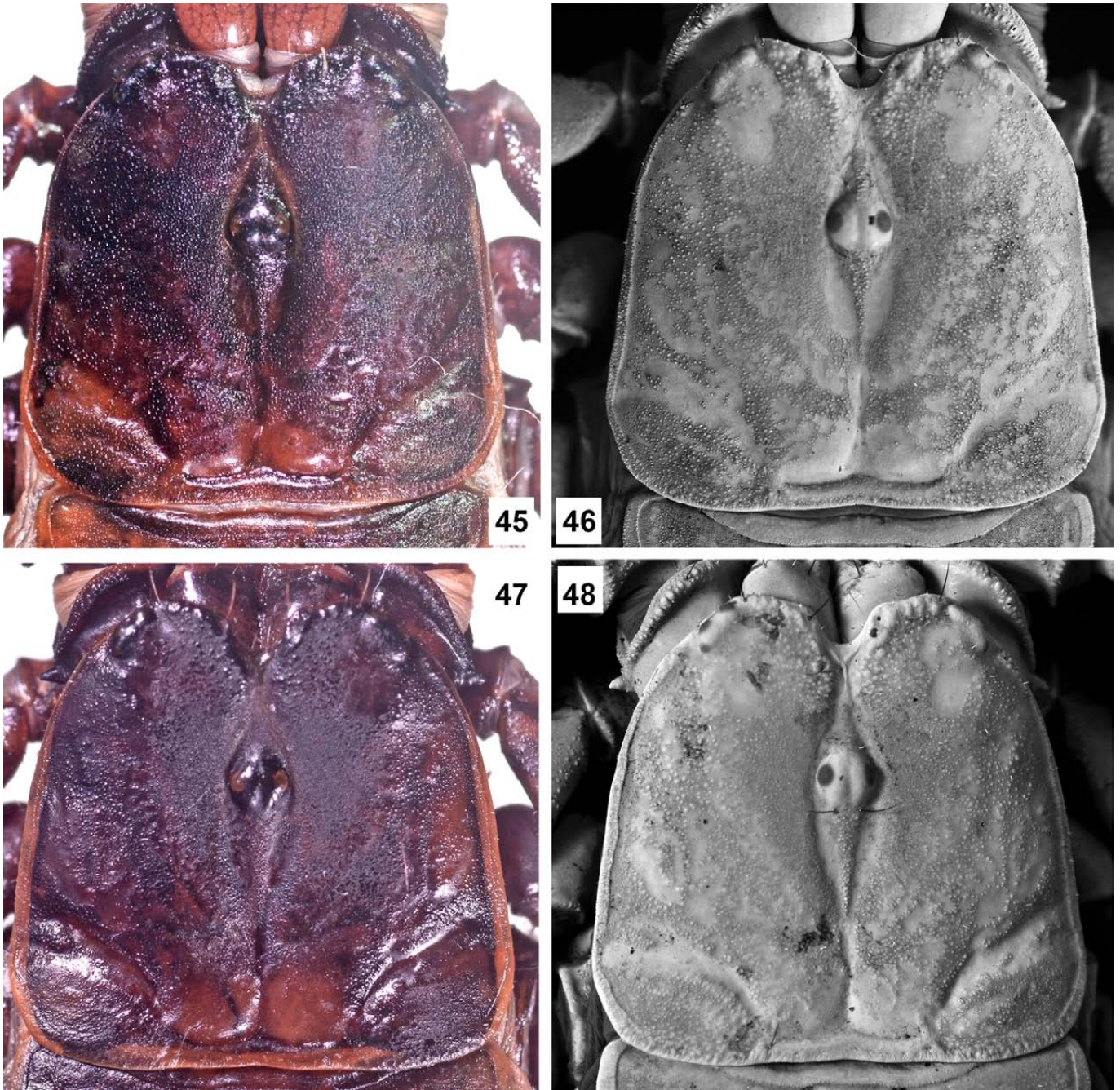


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Figures 41–44. *Scorpiops nagphani* sp. n., female, paratype, BNHS SC 256, in dorsal (41) ventral (42) views, sternopectinal area (43) and metasomal segment V and telson in lateral view (44).



Figures 45–48: *Scorpiops nagphani* sp. n. **Figures 45–46.** Male, holotype, carapace under white light (45) and UV fluorescence (46). **Figures 47–48.** Female, paratype, BHNS SC 256, carapace under white light (47) and UV fluorescence (48).

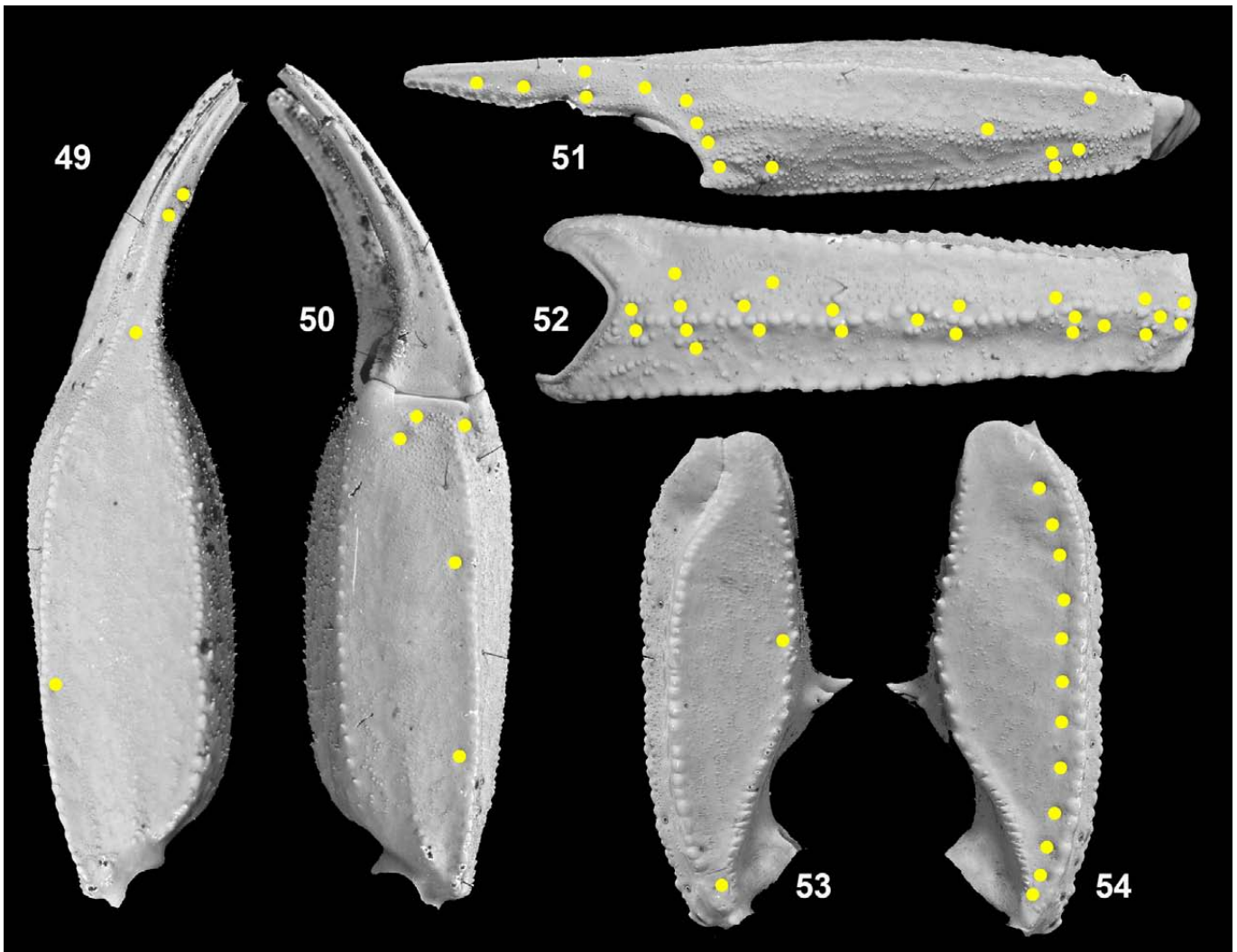
and antero-ventral tubercle absent (Fig. 136). Manus elongated with 5 carinae (dorsal retrolateral, retrolateral median, ventral retrolateral, dorsal prolateral and ventral prolateral). Dorsal retrolateral and dorsal prolateral carinae running anteriorly up to the tip of fixed finger. Intercarinal space finely granular on inner and outer surface. Both fingers scalloped deeply at the base. Trichobothrial pattern neobothriotaxic.

Legs (Figs. 34, 35, 39–42, 55–58). Femur and patella carinated, intercarinal space densely granular on femur and sparsely granular on patella. Tarsomere I provided with two to four rows of spinules and tarsomere II with single ventral row of spinules.

Sternum, genital operculum and pectines (Figs. 36, 43). Broad, pentagonal and finely granular only on anterior middle portion. Genital operculum with a pair of strongly protruding genital papillae. Basal piece with slight depression on middle portion. Pectine morphology of type P3 with 7/7 pectinal teeth.

Mesosoma (Figs. 34, 35, 39–42). All tergites finely granular, with median carina absent on segment I. Tergite VII additionally with two pairs of lateral granular carinae present only on half posterior portion. Sternites III–VI entirely smooth. Sternite VII finely granular.

Metasoma (Figs. 34, 35, 39–42, 132, 140). Metasomal segments I, II and III with 5 pairs of carinae (dorsal lateral,



Figures 49–54. *Scorpiops nagphani* sp. n., male, holotype. **Figures 49–54.** Pedipalp chela dorsal (49), ventral (50) and dorsoexternal (51), patella external (52), dorsal (53) and ventral (54) views under UV fluorescence. Trichobothrial pattern indicated by yellow circles.

lateral suprmedian, lateral infrmedian, ventral lateral and ventral submedian), segment II and III with lateral infrmedian carina present only on posterior portion, metasomal segments IV with 4 pairs of carinae (dorsal lateral, lateral suprmedian, ventral lateral and ventral submedian), and segment V with 3 pairs (dorsal lateral, lateral infrmedian and ventral lateral) and 1 single ventral median carinae. Intercarinal space with mixed granules (fine and coarse). Dorsal lateral carination on segments III and IV ending posteriorly into a short spine. Anal rim of segment V evenly crenulated. A pair of dorsolateral granules of anal rim strongly tuberculate.

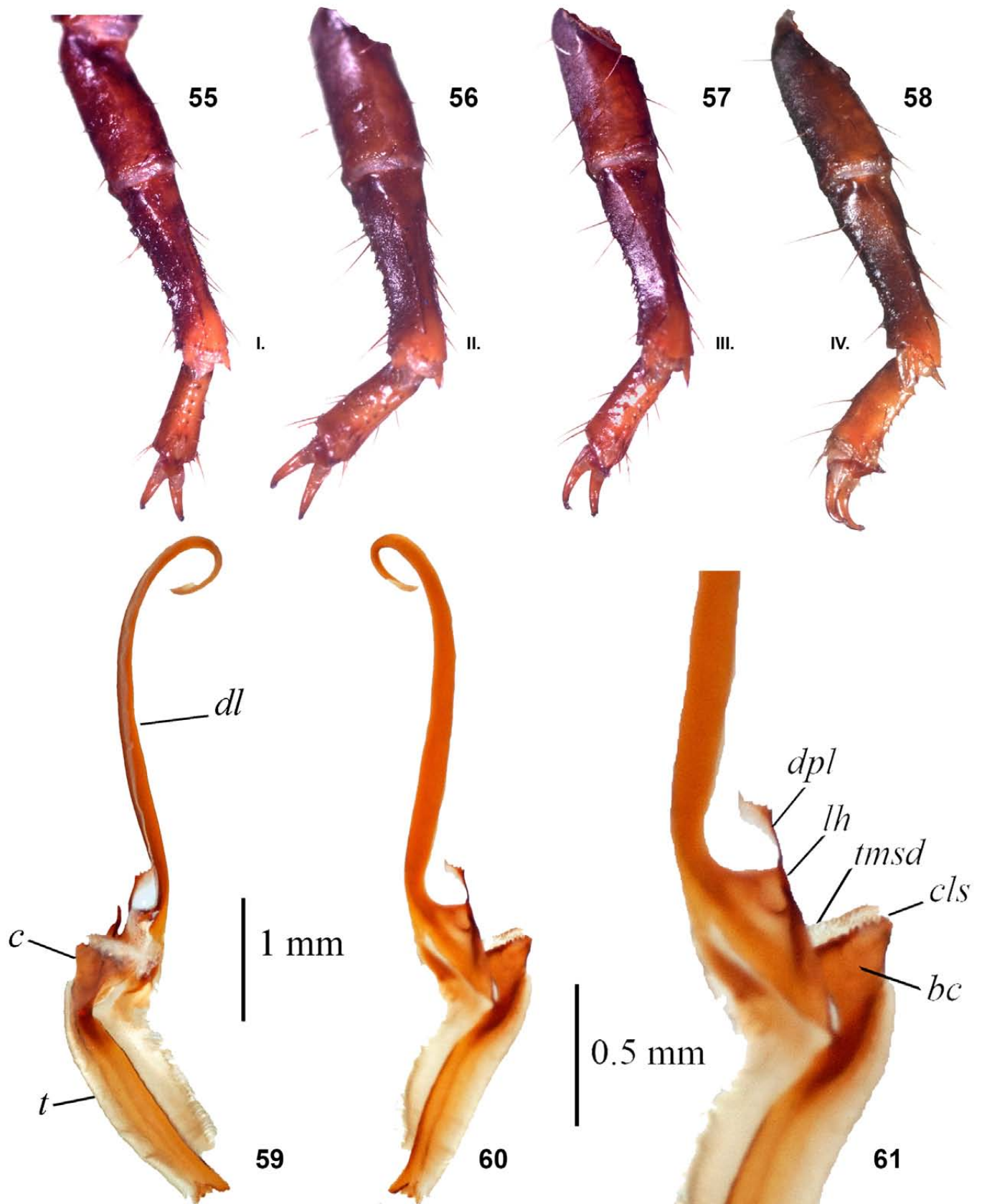
Telson (Figs. 37, 44). Elongated and almost entirely smooth. A weak depression present in between vesicle and at the base of aculeus.

Hemispermatothore ♂ paratype, INHER-259 (Figs. 59–61). Lamelliform; distal *basal carina* (*bc*) with a plate like structure present, sclerotized, crown-like structure (*cls*) with distal margin with 5–6 denticles whose internal surface is attached to terminal membrane of the sperm duct (*tmsd*) on the inner concave side of the capsule with numerous

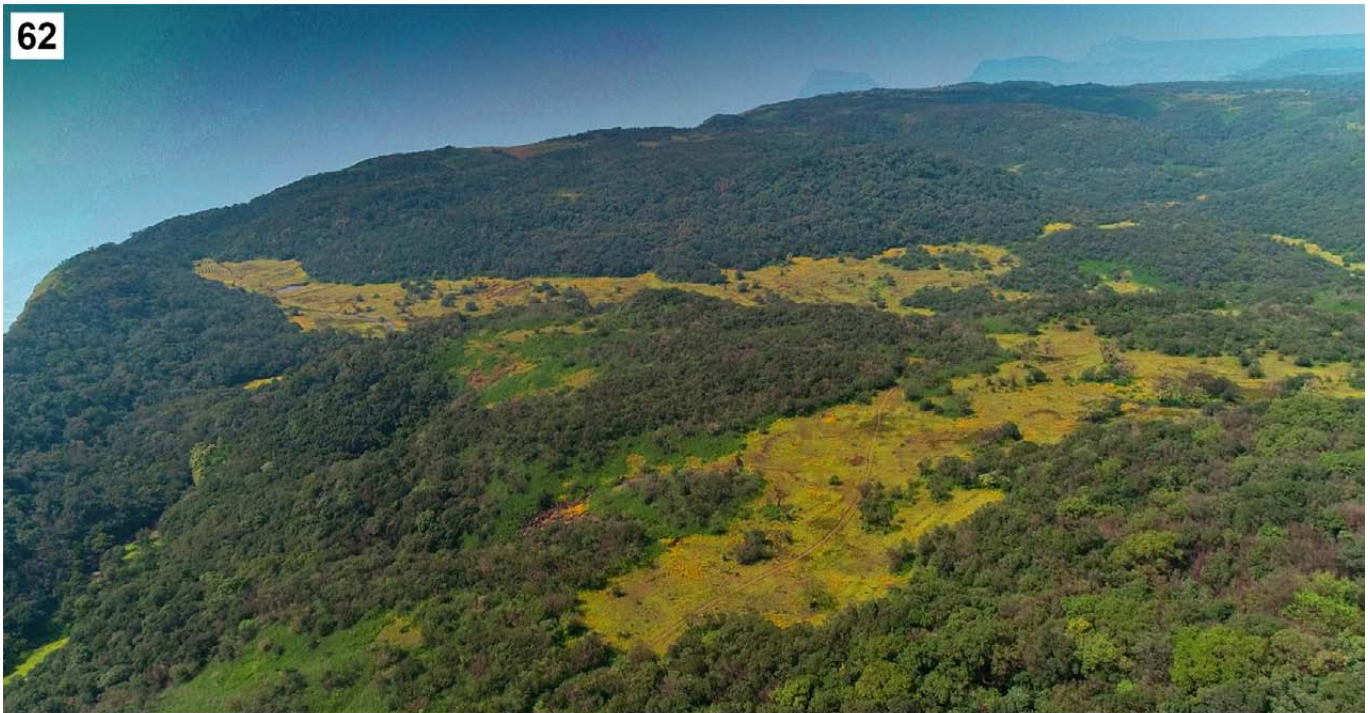
spicules; pointed lateral hook (*lh*); a long, inwardly twisted distal posterior lobe (*dpl*) close to the distal lamina, with denticulate margin; short and stout trunk; long and slender distal lamina (*dl*) narrow at the base and sharply bent and tapered apex. Total length 8.1 mm; pedicel 1.18 mm long; trunk 1.83 mm long; capsule 1.11 mm long; *dpl* length 0.31 mm; *dl* length 3.98 mm long.

SEXUAL DIMORPHISM. Male genital operculum with pair of genital papillae. In females, the genital operculum medially sutured. Pedipalp manus slender in males and stouter in females (Figs. 34–37, 39–48).

AFFINITIES. *Scorpiops nagphani* sp. n. is closely related to a species from Pardhadi Village, Nashik District, Maharashtra (INDIA) and *S. maharashtraensis*. It is separated by a raw genetic divergence of 6.7% from a species from Pardhadi Village, Nashik District, Maharashtra (INDIA) and 9.6% from *S. maharashtraensis*. The new species also differs from its close congeners based on following set of morphological characters.



Figures 55–61. *Scorpiops nagphani* sp. n. **Figures 55–58.** *Scorpiops nagphani* sp. n., male, holotype, left legs I-IV, retrolateral aspect. **Figures 59–61.** *Scorpiops nagphani* sp. n., male, paratype, INHER-259, hemispermatophore internal (59), external (60) views and capsular region in internal view (61). Abbreviations: distal lamina (*dl*), capsule (*c*), trunk (*t*), pedicel (*p*), distal posterior lobe (*dpl*), lateral hook (*lh*), terminal membrane of the sperm duct (*tmsd*) and basal carina (*bc*).



Figures 62–64. Type locality of *Scorpions nagphani* sp. n., aerial view of semi-evergreen forest inside Bhimashankar wildlife sanctuary (BWLS), very close to the type locality (62), view of Kolvan waterfalls inside BWLS where the new species was observed (63) and *Scorpions nagphani* sp. n., female (specimen not collected) in vivo habitus with juveniles (64).

Trichobothria on patella ventral 12–14 as opposed to 15–18 in the species from Pardhadi Village, Nashik District, Maharashtra (INDIA) and 15–17 in *S. maharashtraensis*; chela length to width ratio in males 3.7–4.1 as opposed to 4.4 in a species from Pardhadi Village, Nashik District, Maharashtra (INDIA) and 4.3–4.4 in *S. maharashtraensis*; body coloration blackish brown as opposed to yellowish brown in a species from Pardhadi Village, Nashik District, Maharashtra (INDIA) and *S. maharashtraensis*.

It differs from all the remaining species of *Scorpions* from the northern Western Ghats and northern Maharashtra (INDIA) by a raw genetic divergence of 10.2–13.2 % (Table 5). It is also distinguished from all the species of *Scorpions* from peninsular India based on the key of morphological characters (See below).

DISTRIBUTION, HABITAT AND ECOLOGY. Presently *Scorpions nagphani* sp. n. is known from its type locality, Nigdale

Village, near Bhimashankar Wildlife Sanctuary, Pune District, Maharashtra, India and surrounding areas inside Bhimashankar Wildlife Sanctuary. The type series is collected from private land around Nigdale Village. Scarce population of this species was observed around the exact type locality however dense population was observed inside the sanctuary on the hiking route to Nagphani and Sambarshingi. The species was seen in the crevices of basaltic boulders in the semi-evergreen forest patches. Dense population was observed in the boulders adjacent to the streams on the hike route to Nagphani cliff and around the route leading to the forest guest house. Interestingly specimens were also seen below the small rocks placed along the hike route to Sambarshingi. Individuals were found to be active at night sitting at the openings of rock crevices and occasionally in the open. The ecology and morphology of the new species is congruent with the lithophilic scorpions (Figs. 63, 64, 153).

Dimensions (mm)		<i>Scorpiops nagphani</i> sp. n.			
		♂ holotype BNHS SC 254	♂ paratype INHER 257	♂ paratype INHER 259	♂ paratype INHER 263
Carapace	L / W	6.05 / 6.51	5.26 / 6.59	5.28 / 5.99	6.39 / 6.99
Mesosoma	L	17.1	16.53	16.05	18.36
Tergite VII	L / W	3.22 / 5.01	3.35 / 3.97	3.08 / 4.11	3.88 / 4.91
Metasoma + telson	L	18.37	18.37	18.04	19.98
Segment I	L / W / D	1.80 / 2.38 / 1.79	1.66 / 2.25 / 1.84	1.77 / 2.04 / 1.73	1.98 / 2.58 / 1.86
Segment II	L / W / D	1.98 / 2.16 / 1.79	2.06 / 2.08 / 1.81	1.95 / 1.76 / 1.57	2.07 / 2.3 / 1.93
Segment III	L / W / D	2.09 / 2.01 / 1.73	2.06 / 1.98 / 1.80	2.15 / 1.57 / 1.57	2.17 / 2.13 / 1.89
Segment IV	L / W / D	2.23 / 1.74 / 1.62	2.46 / 1.91 / 1.72	2.43 / 1.51 / 1.52	2.57 / 1.92 / 1.88
Segment V	L / W / D	4.64 / 1.64 / 1.42	4.35 / 1.72 / 1.73	3.98 / 1.48 / 1.48	4.8 / 1.85 / 1.80
Telson	L / W / D	5.63 / 1.67 / 2.25	5.78 / 1.84 / 2.14	5.76 / 1.70 / 2.01	6.39 / 1.97 / 2.27
Pedipalp	L	31.84	30.29	27.21	33.01
Femur	L / W	8.54 / 2.82	8.42 / 2.73	7.18 / 2.50	9.0 / 3.11
Patella	L / W	7.94 / 2.83	7.48 / 2.76	6.81 / 2.53	8.17 / 3.19
Chela	L	15.36	14.39	13.22	15.84
Manus	L / W / D	8.75 / 3.85 / 3.32	8.36 / 3.80 / 2.83	7.93 / 3.53 / 2.73	9.88 / 3.91 / 3.00
Movable finger	L	7.21	6.43	6.09	6.98
Pectine	L / W	3.00 / 2.15	3.24 / 2.00	2.92 / 1.81	3.27 / 2.22
Genital Operculum	L / W	1.16 / 2.38	1.22 / 2.48	1.05 / 2.22	1.52 / 2.78
Total	L	41.52	40.16	39.37	44.73
Pectinal teeth count	PTC	7 / 7	7 / 7	7 / 6	7 / 7
Trichobothria count	TPV	12 / 12	13 / 12	13 / 13	12 / 13
Trichobothria count	TPE	23 / 20	21 / 22	18 / 21	21 / 22

Dimensions (mm)		<i>Scorpiops nagphani</i> sp. n.			
		♀ paratype INHER 260	♀ paratype INHER 338	♀ paratype BNHS SC 256	♀ paratype BNHS SC 257
Carapace	L / W	6.48 / 7.08	6.04 / 6.19	5.43 / 7.10	6.29 / 7.08
Mesosoma	L	20.22	16.19	19.22	19.13
Tergite VII	L / W	3.85 / 5.97	3.07 / 5.17	3.69 / 5.85	3.53 / 5.24
Metasoma + telson	L	18.87	14.23	18.47	17.46
Segment I	L / W / D	1.86 / 2.38 / 1.91	1.04 / 1.72 / 1.90	1.94 / 2.36 / 1.95	1.50 / 2.45 / 1.97
Segment II	L / W / D	2.01 / 2.10 / 1.93	1.40 / 1.52 / 1.88	1.84 / 1.93 / 1.90	1.76 / 2.14 / 1.92
Segment III	L / W / D	2.36 / 1.91 / 1.80	1.52 / 1.33 / 1.68	2.29 / 1.89 / 1.86	2.11 / 1.91 / 1.84
Segment IV	L / W / D	2.35 / 1.80 / 1.76	1.90 / 1.15 / 1.63	2.45 / 2.16 / 1.66	2.41 / 1.76 / 1.74
Segment V	L / W / D	4.49 / 1.44 / 1.54	3.77 / 1.11 / 1.52	4.50 / 1.72 / 1.57	4.1 / 1.62 / 1.64
Telson	L / W / D	5.80 / 1.56 / 1.96	4.60 / 1.18 / 1.15	5.45 / 1.37 / 1.85	5.58 / 1.53 / 1.90
Pedipalp	L	26.94	26.87	25.95	27.48
Femur	L / W	6.58 / 2.96	6.73 / 2.37	5.27 / 2.97	7.07 / 2.79
Patella	L / W	6.58 / 3.05	6.51 / 2.55	6.78 / 3.06	6.87 / 3.12
Chela	L	13.78	13.63	13.90	13.54
Manus	L / W / D	7.82 / 4.58 / 3.17	7.72 / 4.11 / 2.24	7.39 / 4.50 / 3.17	7.49 / 4.68 / 3.11
Movable finger	L	6.88	6.54	6.75	7.53
Pectine	L / W	2.31 / 1.79	1.82 / 1.10	2.52 / 1.81	2.69 / 1.81
Genital Operculum	L / W	1.17 / 2.83	0.62 / 2.21	1.27 / 2.87	1.33 / 3.05
Total	L	45.57	36.46	43.12	42.88
Pectinal teeth count	PTC	7 / 6	6 / 6	6 / 6	6 / 6
Trichobothria count	TPV	13 / 13	13 / 13	12 / 13	13 / 13
Trichobothria count	TPE	20 / 22	19 / 18	21 / 21	19 / 18

Table 2. Morphometric data for *Scorpiops nagphani* sp. n. Abbreviations: length (L), width (W, in carapace it corresponds to median width), depth (D).

		<i>Scorpiops neera</i> sp. n.			
Dimensions (mm)		♂ holotype BNHS SC 258	♂ paratype INHER 251	♂ paratype BNHS SC 260	♀ paratype INHER 255
Carapace	L / W	6.95 / 7.22	6.32 / 6.88	6.16 / 6.36	6.74 / 7.44
Mesosoma	L	20.43	18.66	18.23	21.07
Tergite VII	L / W	4.20 / 6.11	3.48 / 5.26	3.73 / 4.93	3.98 / 6.28
Metasoma + telson	L	22.01	18.88	18.77	19.73
Segment I	L / W / D	2.07 / 2.74 / 1.76	1.62 / 2.29 / 1.98	1.87 / 2.22 / 1.87	1.90 / 2.62 / 1.81
Segment II	L / W / D	2.33 / 2.21 / 1.92	1.85 / 2.16 / 1.87	1.96 / 2.04 / 1.77	2.21 / 2.20 / 1.87
Segment III	L / W / D	2.38 / 2.18 / 1.85	2.16 / 1.90 / 1.87	2.15 / 1.93 / 1.80	2.43 / 2.07 / 1.88
Segment IV	L / W / D	3.10 / 2.11 / 1.98	2.32 / 1.80 / 1.78	2.36 / 1.74 / 1.80	2.72 / 1.87 / 1.89
Segment V	L / W / D	4.96 / 2.02 / 1.95	4.53 / 1.77 / 1.80	4.59 / 1.65 / 1.73	4.80 / 1.68 / 1.84
Telson	L / W / D	7.17 / 2.22 / 2.27	6.40 / 2.04 / 2.23	5.84 / 1.86 / 2.00	5.67 / 1.63 / 1.84
Pedipalp	L	32.58	27.89	27.31	29.88
Femur	L / W	8.40 / 3.66	7.10 / 3.11	6.80 / 3.13	7.67 / 3.18
Patella	L / W	7.93 / 3.68	6.84 / 2.95	6.81 / 3.03	7.15 / 3.37
Chela	L	16.25	13.95	13.70	15.06
Manus	L / W / D	9.51 / 5.31 / 3.28	8.39 / 4.50 / 2.82	7.86 / 4.40 / 2.67	8.55 / 5.50 / 3.35
Movable finger	L	7.59	6.38	6.88	7.75
Pectine	L / W	3.99 / 2.59	3.25 / 1.95	3.30 / 1.82	2.76 / 2.00
Genital Operculum	L / W	1.78 / 2.96	1.17 / 2.70	1.26 / 2.44	1.41 / 3.06
Total	L	49.39	43.86	43.16	46.53
Pectinal teeth count	PTC	8 / -	7 / 7	7 / 7	6 / 6
Trichobothria count	TPV	14 / 14	15 / 14	15 / 15	14 / 14
Trichobothria count	TPE	21 / 22	21 / 21	21 / 21	22 / 23

		<i>Scorpiops neera</i> sp. n.		<i>S. nagphani</i> sp. n.
Dimensions (mm)		♀ paratype BNHS SC 259	♀ paratype BNHS SC 261	♂ paratype BNHS SC 255
Carapace	L / W	6.49 / 7.26	6.60 / 7.41	5.52 / 6.02
Mesosoma	L	20.75	20.55	16.47
Tergite VII	L / W	4.00 / 5.96	3.66 / 5.02	3.07 / 4.68
Metasoma + telson	L	18.91	18.66	16.88
Segment I	L / W / D	1.89 / 2.29 / 1.77	1.08 / 2.14 / 1.99	1.51 / 2.06 / 1.72
Segment II	L / W / D	1.91 / 1.99 / 1.73	2.00 / 1.90 / 1.97	1.62 / 1.82 / 1.63
Segment III	L / W / D	2.30 / 1.94 / 1.81	2.25 / 1.71 / 1.91	1.92 / 1.73 / 1.53
Segment IV	L / W / D	2.27 / 1.72 / 1.78	2.96 / 1.76 / 1.82	2.20 / 1.64 / 1.52
Segment V	L / W / D	4.63 / 1.75 / 1.62	4.46 / 1.79 / 1.64	3.89 / 1.47 / 1.56
Telson	L / W / D	5.91 / 1.74 / 2.05	5.91 / 1.87 / 1.78	5.74 / 1.83 / 2.06
Pedipalp	L	27.05	29.46	26.57
Femur	L / W	6.56 / 2.96	7.39 / 3.11	7.14 / 2.56
Patella	L / W	6.70 / 3.13	7.16 / 3.34	6.47 / 2.6
Chela	L	13.79	14.91	12.96
Manus	L / W / D	7.81 / 4.54 / 2.99	9.04 / 4.84 / 3.09	7.87 / 3.55 / 2.64
Movable finger	L	7.71	7.46	5.76
Pectine	L / W	2.85 / 2.03	3.06 / 2.01	2.73 / 2.15
Genital Operculum	L / W	1.04 / 2.71	1.39 / 2.80	1.45 / 2.19
Total	L	46.15	45.81	38.87
Pectinal teeth count	PTC	6 / 6	6 / 7	7 / 7
Trichobothria count	TPV	14 / 14	14 / 15	12 / 13
Trichobothria count	TPE	21 / 22	22 / 21	21 / 22

Table 3. Morphometric data for *Scorpiops neera* sp. n. and a male paratype of *S. nagphani* sp. n. Abbreviations: length (L), width (W, in carapace it corresponds to median width), depth (D).



Figure 65. *Scorpiops neera* sp. n., male, holotype in vivo habitus.

***Scorpiops neera* sp. n.**

(Figures 65–95, 129, 133, 137, 141, 151, 153–157,
Tables 3, 5–7)

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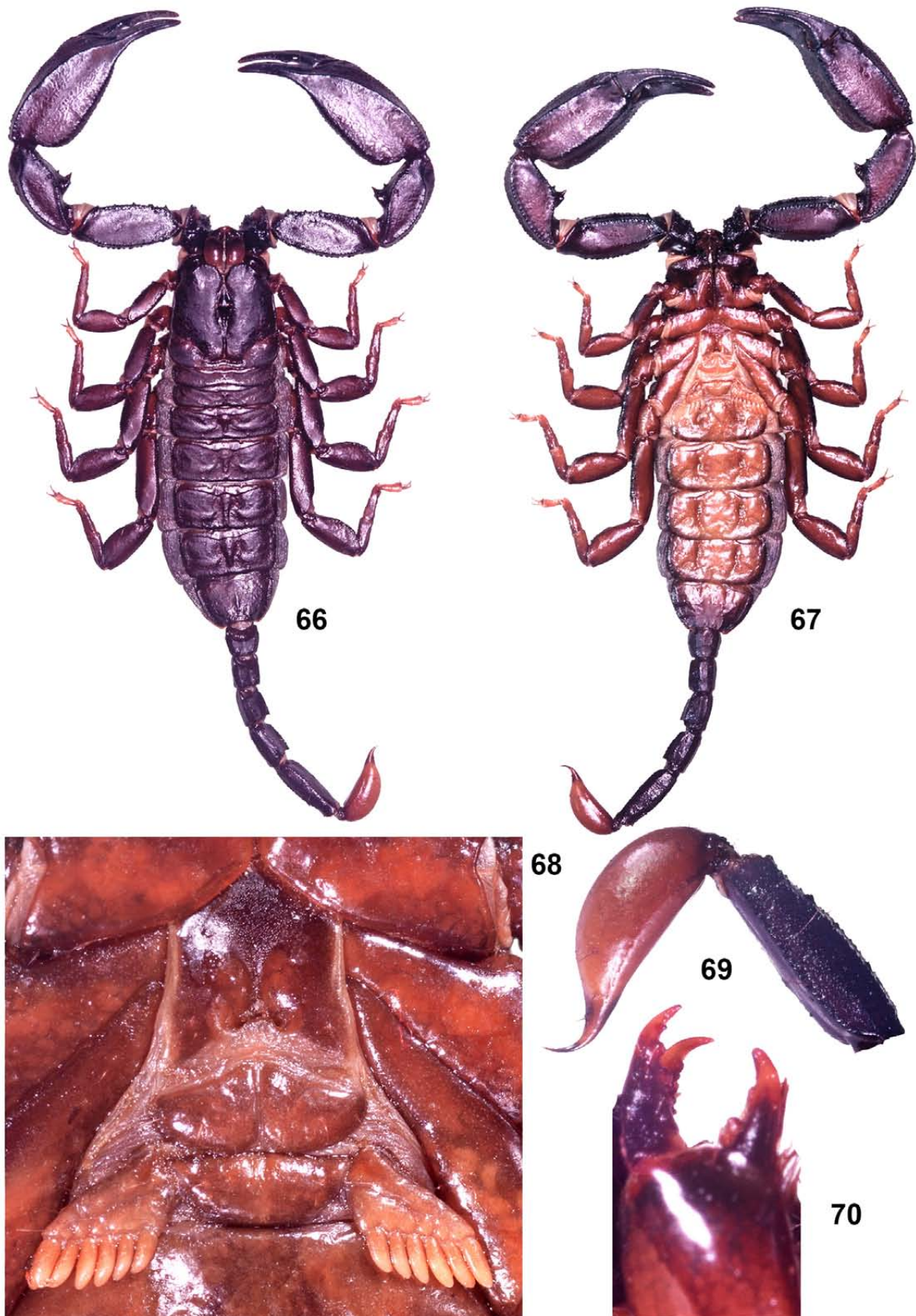
TYPE LOCALITY AND AND TYPE REPOSITORY. **India**, Maharashtra State, Pune District, Varandha Ghat, 18°05'52"N 73°39'14"E, 693 m a. s. l. BNHS.

TYPE MATERIAL. **India**, Maharashtra State, Pune District, Varandha Ghat, 18°05'52"N 73°39'14"E, 693 m a. s. l., 1♂ (holotype, BNHS SC 258), 13 November 2020, leg. N. Dandekar, S. Deshpande, S. Bhavé & A. Marathe, 1♂ (paratype, INHER-251), 9 July 2020, leg. S. Sulakhe, S. Deshpande, M. Ketkar & A. Marathe, 1♂ (paratype, BNHS SC 260), 2 March 2021, leg. S. Deshpande & A. Date, 2♀ (paratypes, INHER-255, BNHS SC 261), 11 July 2020, leg. S. Deshpande, M. Ketkar, A. Marathe & O. Oak, 1♀ (paratype, BNHS SC 259), 13 November 2020, leg. N. Dandekar, S. Deshpande, S. Bhavé & A. Marathe.

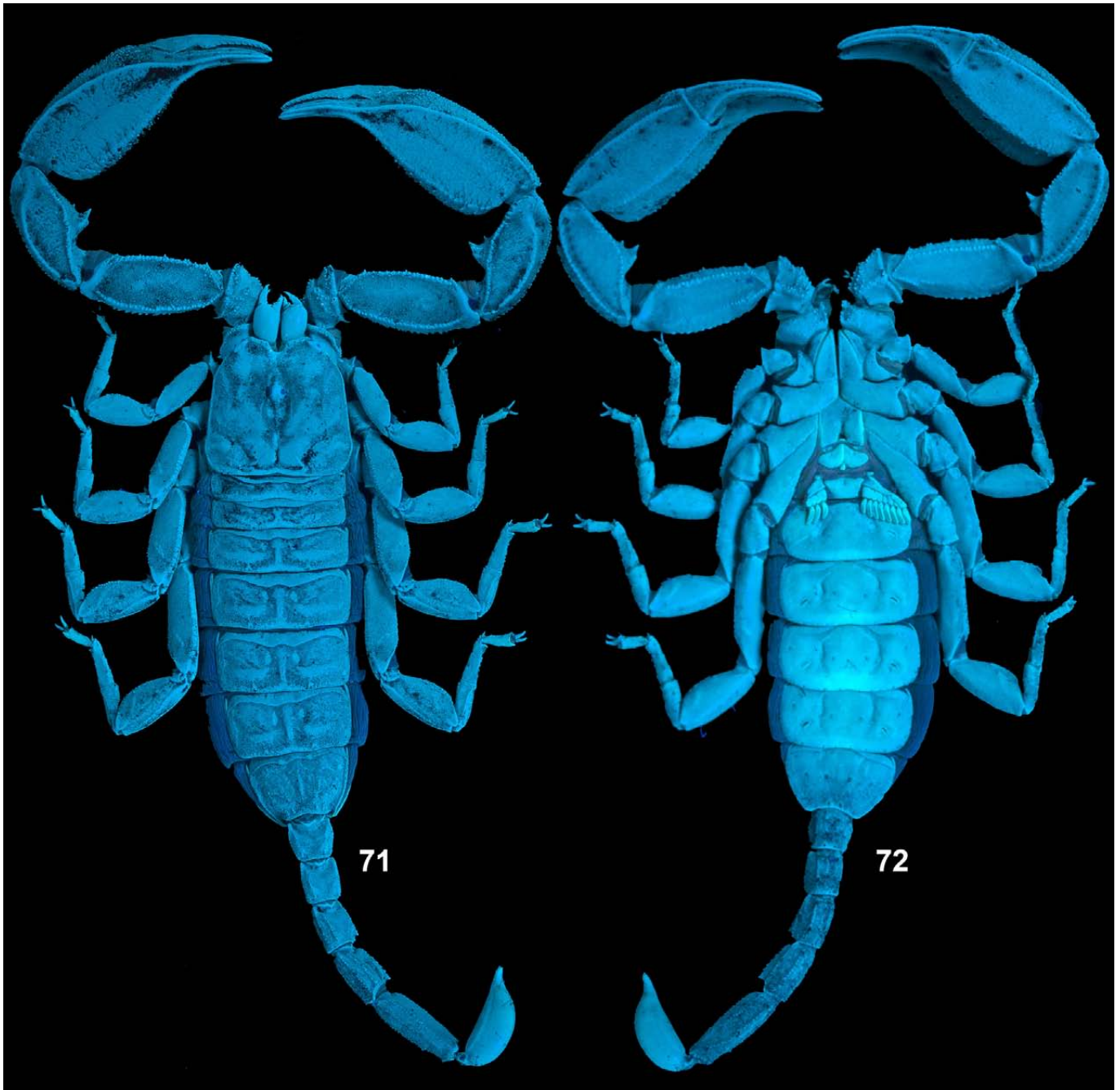
ETYMOLOGY. The specific epithet is a noun in opposition, named after the famous river Neera, which flows very close to

the type locality. Neera River originates in the Western Ghats in Pune district and flows through the Satara and Solapur Districts to finally meet the Bhima River. The type series of the new species was collected from the rock walls and huge boulders along the road which leads from the Bhor town to Varandha Ghat.

DIAGNOSIS (♂♀). Total length 43–50 mm. Base color uniformly blackish brown. Pectinal teeth number 6–7 in both sexes, fulcra reduced to absent. Pectine morphology of type P4. Anterior margin of carapace between lateral ocelli and U shaped anterior median notch straight. Patella of pedipalp with 21–23 (5 *eb*, 2 *esb*, 2 *em*, 7–8 *est*, 5–6 *et*) external and 14–15 ventral trichobothria. Chela of pedipalp with 4 ventral trichobothria located on ventral surface. Chelal trichobothrium *Eb*₃ is located in proximal half of manus between trichobothria Dt and Db. Fingers of pedipalps strongly undulate in male and margins undulate in female. Chela length to width ratio 3.1 in males. Pedipalp movable finger with ca 50–55 IAD, which form second row, parallel with MD (ca 65–70 in number); there are also 2–3 ID and 11–12 OD present. Tarsomere II of legs with 4–6 stout median ventral spinules. Metasoma I with ten, metasoma II–IV with eight and metasoma V with 7 carinae. Dorsal lateral carina on II–IV metasomal segments



Figures 66–70. *Scorpions neera* sp. n., male, holotype, dorsal (66) and ventral (67) views, sternoplectinal area (68), metasomal segment V and telson in lateral view (69) and chelicera in dorsal view (70).



Figures 71–72. *Scorpiops neera* sp. n., male, holotype in dorsal (71) and ventral (72) views under UV light.

ending posteriorly into a short spine. Telson elongate and smooth, length to depth ratio 2.9–3.2; annular ring absent.

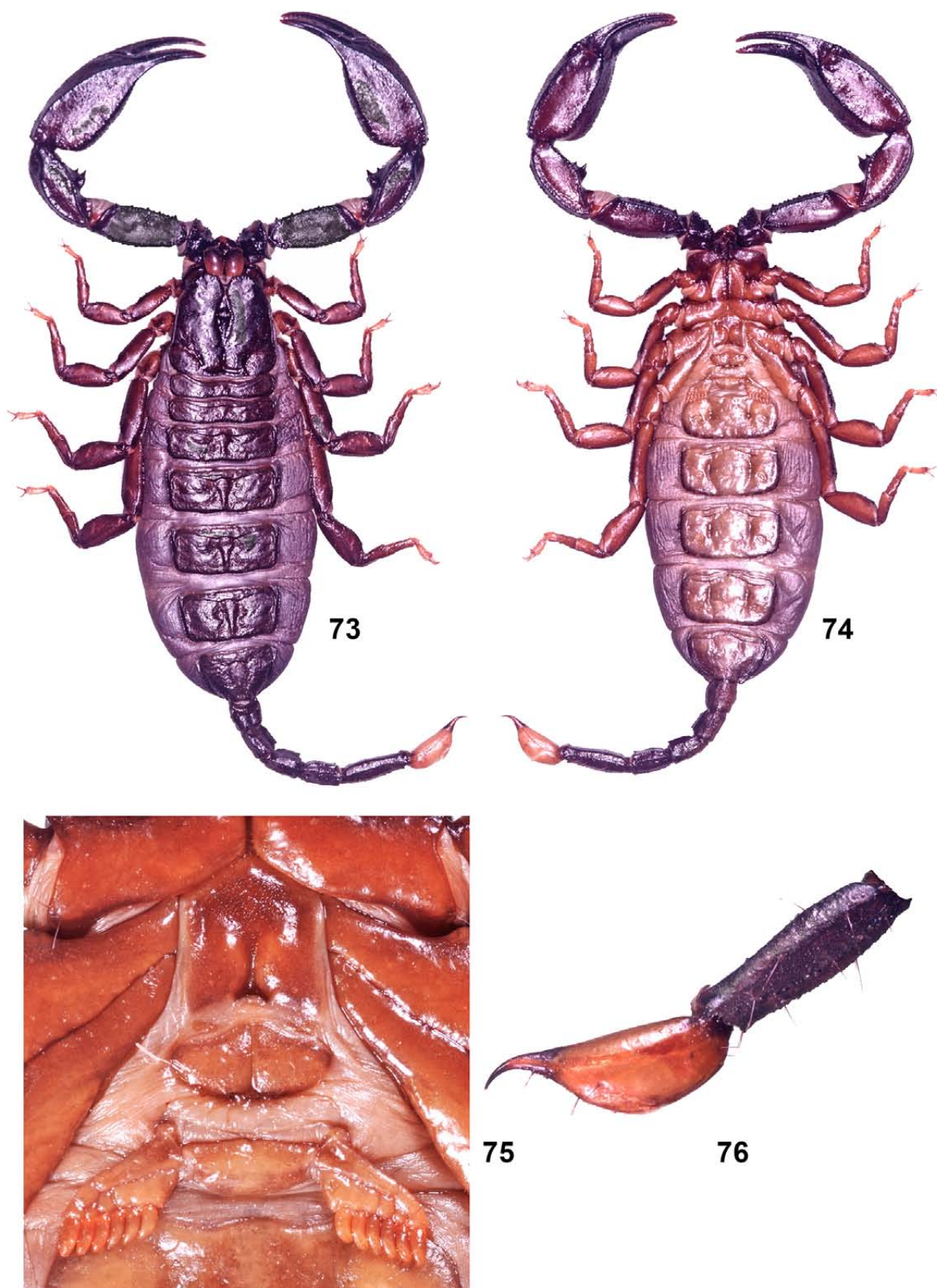
DESCRIPTION (♂ holotype, measurements in Table 3).

Coloration (in preservation) (Figs. 65–67, 73, 74). Overall body color blackish brown. Legs blackish brown. Telson orangish brown on vesicle and dark brown on aculeus. Ventral portion of body dark brown. Carapace and fingers of manus blackish. Pedipalps blackish brown, darker on carinae. Chelicera basal segment blackish brown. Fingers of chelicera blackish brown.

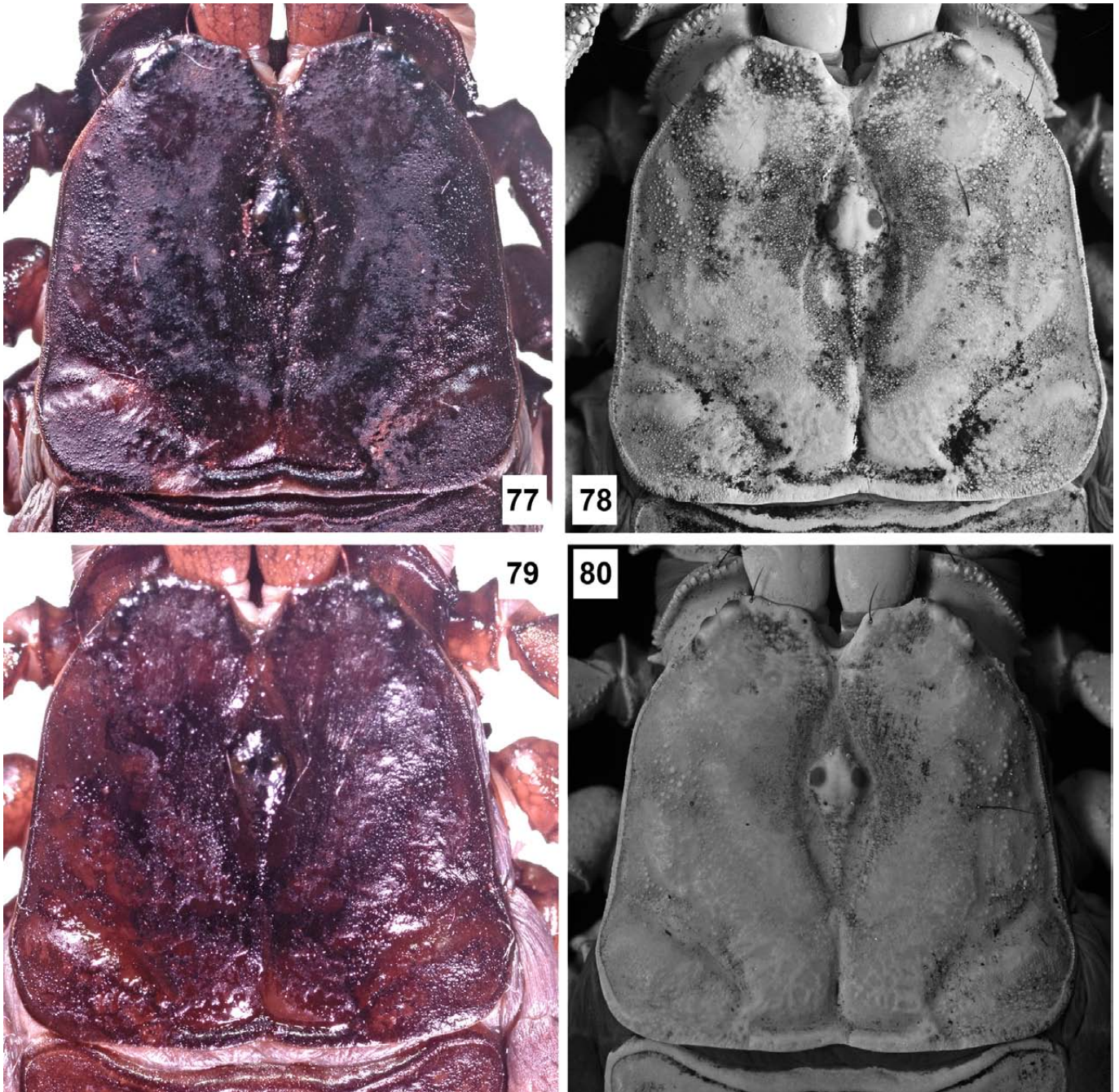
Carapace (Figs. 77–80). Anterior margin of carapace moderately granular with deep U shaped anterior median notch. Anterior sub

margin coarsely granular. Anterior margin of carapace between lateral eyes and U shaped anterior median notch straight. Entire surface of carapace with fine granules. Anterio-lateral ocular tubercles granular provided with type 3A lateral ocelli. Two pairs of large major ocelli and one pair of minor ocelli. Median ocular tubercle smooth on dorsal portion with a pair of median ocelli situated in the ratio of 1:2.1 (ratio of median ocelli to anterior margin and median ocelli to posterior margin).

Chelicerae (Fig. 70). Proximal portion with reticulated mosaic design. Fixed finger of chelicera with 3 large triangular teeth on inner margin. Ventral fang of movable finger with a row of 6 minute teeth on inner margin. Dorsal fang of movable finger with 4 teeth on inner margin.



Figures 73–76. *Scorpiops neera* sp. n., female, paratype, BNHS SC 259, in dorsal (73) ventral (74) views, sternopectinal area (75) and metasomal segment V and telson in lateral view (76).



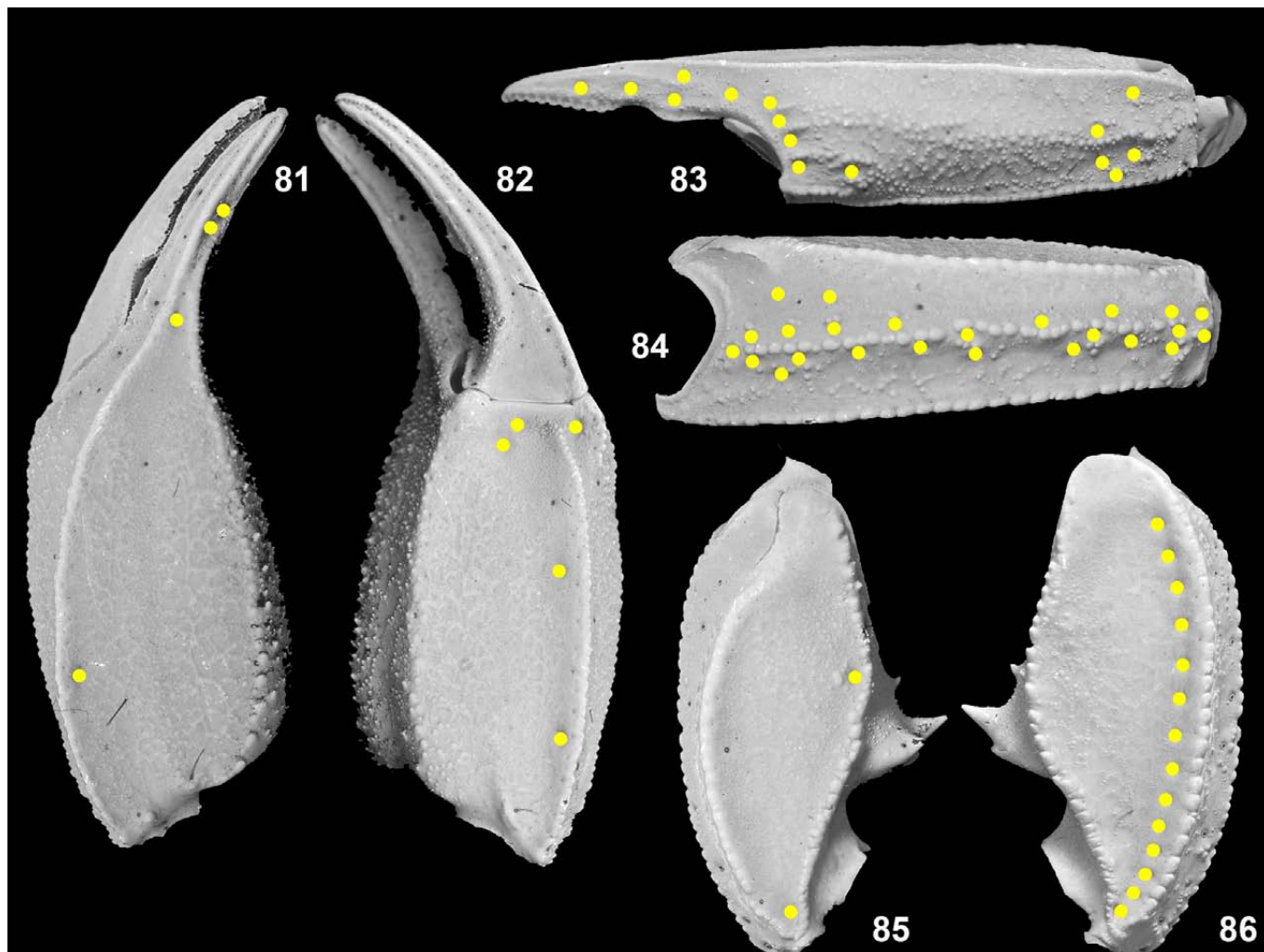
Figures 77–80: *Scorpiops neera* sp. n. **Figures 77–78.** Male, holotype, carapace under white light (77) and UV fluorescence (78). **Figures 79–80.** Female, paratype, BHNS SC 259, carapace under white light (79) and UV fluorescence (80).

Pedipalp (Figs. 81–86, 129, 137, 151). Femur and patella dorsoventrally flattened. Femur with 6 carinae (dorsal retrolateral, dorsal prolateral, retrolateral dorsosubmedian, prolateral ventrosubmedian, ventral retrolateral and ventral prolateral). Ventral prolateral carina strong and present only on 1/3rd proximal portion. Intercarinal space with coarse and fine granules. Patella with 5 carinae (dorsal retrolateral, dorsal prolateral, retrolateral dorsosubmedian, ventral retrolateral and ventral prolateral). Internal surface of patella with one large postero-ventral tubercle with one small, thick adjacent bulge and one adjacent small postero-dorsal tubercle and small antero-ventral tubercle (Fig. 137). Manus stout with

5 carinae (dorsal retrolateral, retrolateral median, ventral retrolateral, dorsal prolateral and ventral prolateral). Dorsal retrolateral and dorsal prolateral carinae running anteriorly up to the tip of fixed finger. Intercarinal space coarsely granular on inner and outer surface. Both fingers scalloped deeply at the base. Trichobothrial pattern neobothriotaxic.

Legs (Figs. 66, 67, 71–74, 87–90). Femur and patella carinated, intercarinal space with coarse and fine granules. Tarsomere I provided with three to four rows of spinules and tarsomere II with single ventral row of spinules.

Sternum, genital operculum and pectines (Figs. 68, 75). Broad, pentagonal and finely granular only on anterior middle



Figures 81–86. *Scorpions neera* sp. n., male, holotype. **Figures 81–86.** Pedipalp chela dorsal (81), ventral (82) and dorsoexternal (83), patella external (84), dorsal (85) and ventral (86) views under UV fluorescence. Trichobothrial pattern indicated by yellow circles.

portion. Genital operculum with a pair of strongly protruding genital papillae. Basal piece with slight depression on middle portion. Pectine morphology of type P4 with $-/7$ pectinal teeth.

Mesosoma (Figs. 66, 67, 71–74). All tergites finely granular. Median carina present on all tergites. Tergite VII additionally with two pairs of lateral granular carinae present only on half posterior portion. Sternites III–VI entirely smooth. Sternite VII finely granular.

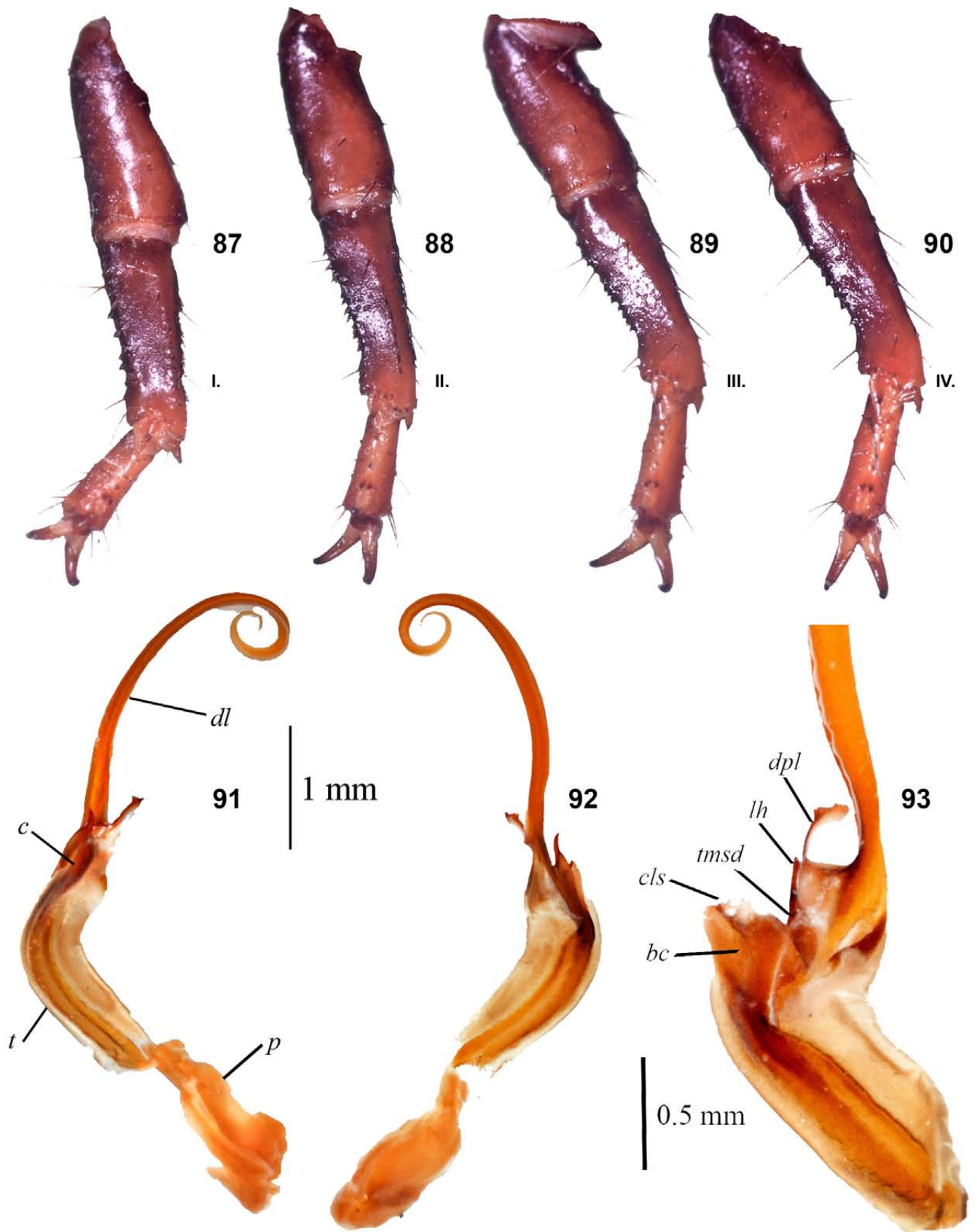
Metasoma (Figs. 66, 67, 71–74, 133, 141). Metasomal segments I with 5 pairs of carinae (dorsal lateral, lateral supramedian, lateral inframedian, ventral lateral and ventral submedian), metasomal segments II & IV with 4 pairs of carinae (dorsal lateral, lateral supramedian, ventral lateral and ventral submedian) and segment V with 3 pairs (dorsal lateral, lateral inframedian and ventral lateral) and 1 single ventral median carinae. Intercarinal space with coarse granules. Dorsal lateral carination on segments III and IV ending posteriorly into a short spine. Anal rim of segment V evenly crenulated. A pair of dorsolateral granules of anal rim strongly tuberculate.

Telson (Figs. 69, 76). Elongated and finely granular.

Hemispermatothore ♂ paratype, BNHS SC 260 (Figs. 91–93). Lamelliform; distal *basal carina* (*bc*) with a plate like structure present, sclerotized, crown-like structure (*cls*) with distal margin smooth whose internal surface is attached to terminal membrane of the sperm duct (*tmsd*) on the inner concave side of the capsule with numerous spicules; pointed lateral hook (*lh*); a long, inwardly twisted distal posterior lobe (*dpl*) close to the distal lamina, with denticulate margin; short and stout trunk; long and slender distal lamina (*dl*) narrow at the base and sharply bent and tapered apex. Total length 8.0 mm; pedicel 1.44 mm long; trunk 1.47 mm long; capsule 1.19 mm long; *dpl* length 0.30 mm; *dl* length 3.89 mm long.

SEXUAL DIMORPHISM. Male genital operculum with pair of genital papillae. In females, the genital operculum medially sutured. Pedipalp manus slender in males and stouter in females (Figs. 66–69, 71–80).

AFFINITIES. *Scorpions neera* sp. n. is closely related to *S. deccanensis*, *S. satarensis* and *S. phaltanensis*. It is separated by a raw genetic divergence of 6.1–7.1% from *S. deccanensis*, 7.3% from *S. satarensis* and 9.6–9.8% from *S. phaltanensis*.



Figures 87–93. *Scorpiops neera* sp. n. **Figures 87–90.** Male, holotype, left legs I–IV, retrolateral aspect. **Figures 91–93.** Male, paratype, BNHS SC 260, hemispermatophore internal (91), external (92) views and capsular region in internal view (93). Abbreviations: distal lamina (*dl*), capsule (*c*), trunk (*t*), pedicel (*p*), distal posterior lobe (*dpl*), lateral hook (*lh*), terminal membrane of the sperm duct (*tmsd*) and basal carina (*bc*).



Figures 94–95. Type locality of *Scorpiops neera* sp. n., view of Neera river backwaters very close to the type locality (94) and basaltic rock wall at the type locality from where the type series is collected (95).

Dimensions (mm)		<i>Scorpiops lioneli</i> sp. n.			
		♂ holotype BNHS SC 262	♂ paratype INHER 177	♂ paratype BNHS SC 263	♀ paratype INHER 323
Carapace	L / W	6.14 / 6.08	6.13 / 6.60	6.28 / 6.47	6.77 / 6.80
Mesosoma	L	15.76	14.63	17.04	19.84
Tergite VII	L / W	3.18 / 4.40	3.10 / 4.60	3.38 / 4.55	4.24 / 5.57
Metasoma + telson	L	19.68	20.91	19.11	19.06
Segment I	L / W / D	1.83 / 2.11 / 1.75	1.83 / 2.11 / 1.83	1.86 / 2.27 / 1.64	1.81 / 2.26 / 2.35
Segment II	L / W / D	2.11 / 1.89 / 1.83	2.24 / 1.99 / 1.78	2.09 / 2.07 / 1.86	2.19 / 2.08 / 1.90
Segment III	L / W / D	2.30 / 1.71 / 1.63	2.42 / 1.70 / 1.88	2.33 / 1.79 / 1.44	1.95 / 1.99 / 1.97
Segment IV	L / W / D	2.73 / 1.60 / 1.81	2.64 / 1.68 / 1.76	2.56 / 1.68 / 1.83	2.47 / 1.49 / 1.85
Segment V	L / W / D	4.56 / 1.48 / 1.66	5.01 / 1.45 / 1.86	3.96 / 1.57 / 1.89	4.58 / 1.60 / 1.79
Telson	L / W / D	6.15 / 1.89 / 2.19	6.77 / 2.01 / 2.29	6.31 / 1.97 / 2.04	6.06 / 1.94 / 2.07
Pedipalp	L	32.17	35.30	33.60	30.11
Femur	L / W	9.57 / 2.70	9.92 / 2.70	9.32 / 2.76	7.59 / 3.02
Patella	L / W	8.04 / 3.34	8.50 / 3.33	8.18 / 2.81	7.28 / 3.22
Chela	L	15.10	16.88	16.10	15.24
Manus	L / W / D	9.10 / 3.42 / 2.41	9.85 / 3.86 / 2.12	9.92 / 3.66 / 2.73	8.77 / 4.39 / 3.03
Movable finger	L	6.76	7.50	7.01	7.17
Pectine	L / W	2.40 / 1.18	2.44 / 2.40	3.31 / 2.28	2.82 / 1.95
Genital Operculum	L / W	1.13 / 2.38	1.43 / 2.65	1.58 / 2.32	1.05 / 2.56
Total	L	41.58	41.67	42.43	45.37
Pectinal teeth count	PTC	8 / 7	8 / 8	7 / 7	7 / 7
Trichobothria count	TPV	17 / 18	16 / 17	17 / 18	17 / 18
Trichobothria count	TPE	25 / 24	26 / 27	27 / 27	26 / 25

Dimensions (mm)		<i>Scorpiops lioneli</i> sp. n.	
		♀ paratype BNHS SC 264	♀ paratype BNHS SC 265
Carapace	L / W	7.30 / 8.26	7.03 / 7.37
Mesosoma	L	20.99	20.71
Tergite VII	L / W	4.32 / 6.60	4.13 / 5.88
Metasoma + telson	L	19.95	20.31
Segment I	L / W / D	1.84 / 2.53 / 2.35	2.36 / 1.87 / 1.93
Segment II	L / W / D	1.91 / 2.13 / 2.02	1.93 / 2.27 / 1.65
Segment III	L / W / D	2.43 / 2.08 / 1.67	2.30 / 1.85 / 1.79
Segment IV	L / W / D	2.31 / 1.85 / 1.96	2.57 / 1.61 / 1.82
Segment V	L / W / D	4.81 / 1.74 / 1.84	4.91 / 1.76 / 1.84
Telson	L / W / D	6.65 / 1.96 / 2.06	6.84 / 2.00 / 1.94
Pedipalp	L	32.53	31.92
Femur	L / W	8.32 / 3.22	8.54 / 3.01
Patella	L / W	8.01 / 3.25	7.86 / 3.10
Chela	L	16.20	15.52
Manus	L / W / D	9.25 / 4.62 / 3.26	8.55 / 4.74 / 2.90
Movable finger	L	7.94	7.87
Pectine	L / W	3.21 / 2.22	2.50 / 2.03
Genital Operculum	L / W	1.07 / 2.87	1.09 / 2.58
Total	L	48.24	48.05
Pectinal teeth count	PTC	7 / 7	8 / 8
Trichobothria count	TPV	17 / 17	16 / 15
Trichobothria count	TPE	27 / 25	23 / 25

Table 4. Morphometric data for *Scorpiops lioneli* sp. n. Abbreviations: length (L), width (W, in carapace it corresponds to median width), depth (D).



Figure 96. *Scorpiops lioneli* sp. n., male, paratype BHNS SC 263 in vivo habitus.

The new species also differs from its close congeners based on following set of morphological characters:-

Telson total length to telson vesicle depth ratio in males 2.9–3.2 as opposed to 3.3 in *S. deccanensis*; total pedipalp length to mesosomal tergite length in males 1.5–1.6 as opposed to 2.2 in *S. satarensis* and 1.7–2.0 in *S. phaltanensis*; internal surface of patella with antero-ventral tubercle small as opposed to medium to almost equal in *S. phaltanensis*; dorsal lateral carina on II–IV metasomal segments ending posteriorly into a short spine as opposed to large tuberculate spine in *S. satarensis*.

The new species also differs from all the remaining species of *Scorpiops* from the northern Western Ghats and northern Maharashtra (INDIA) by a raw genetic divergence of 10.2–13.8 % (Table 5). It is also distinguished from all the species of *Scorpiops* from peninsular India based on the key of morphological characters (See below).

DISTRIBUTION, HABITAT AND ECOLOGY. Presently *Scorpiops neera* sp. n. is known only from its type locality, Varandha Ghat, Pune District, Maharashtra, India. The type series was collected from rock wall on hill side of the road leading to Varandha Ghat from Bhor town. The type locality is surrounded by mix of degraded and semi-evergreen forest.

Any further road widening work may be a direct threat to the species. Our surveys around the type locality on the hill slopes and surrounding regions did not yield any success. Scarce population of the new species was observed at the type locality. Interestingly the habitat from the crest line of Western Ghats down the Varandha Ghat road leading towards Raigad district boundary is densely occupied by *Chiromachetes ramdasswamii*. The new species is not sympatric with *Chiromachetes ramdasswamii*. Individuals were found to be active at night sitting at the openings of rock crevices and occasionally in the open. The ecology and morphology of the new species is congruent with the lithophilic scorpions (Figs. 94, 95, 153).

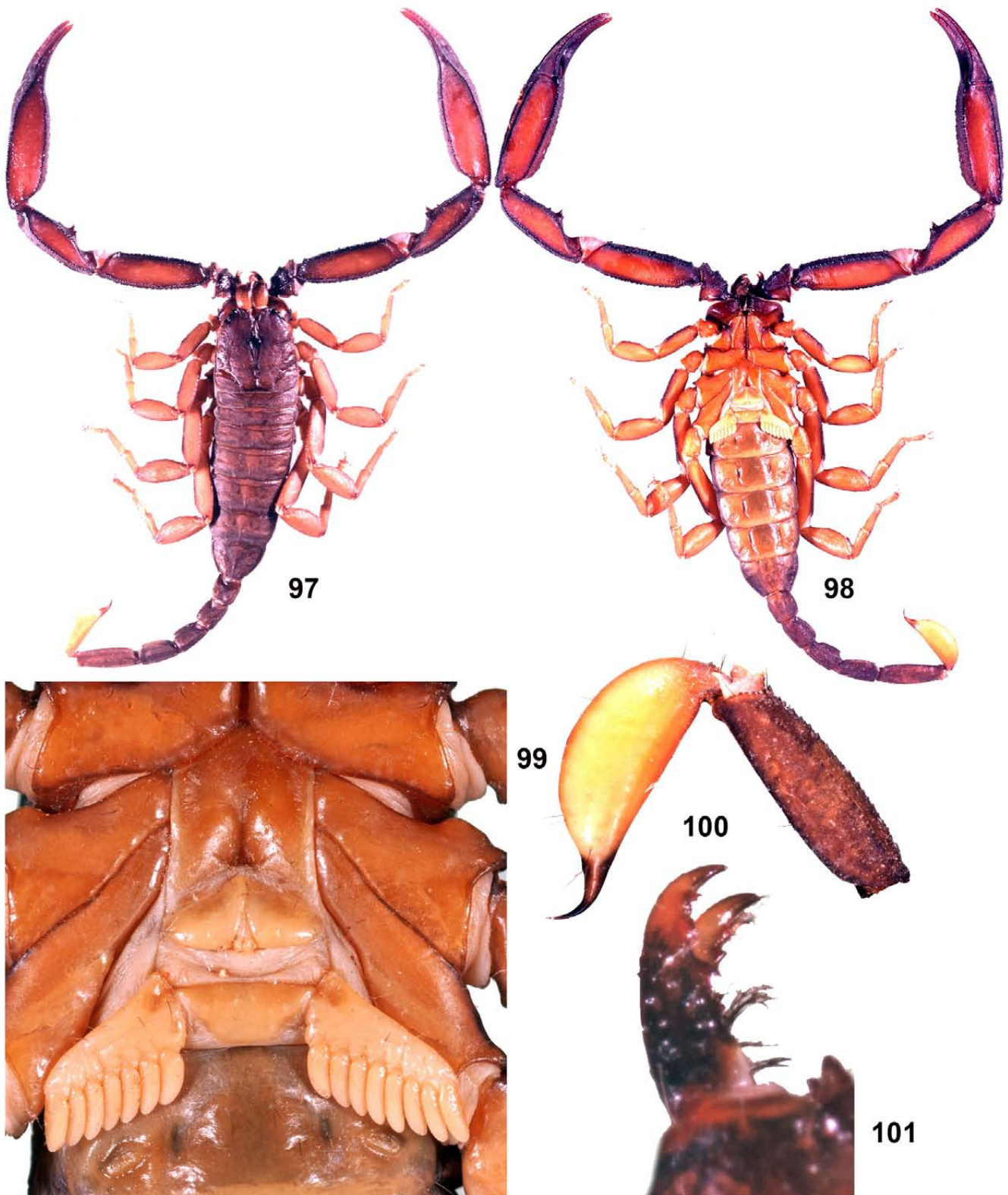
***Scorpiops lioneli* sp. n.**

(Figures 96–126, 130, 134, 138, 142, 152–157, Tables 4, 5–7)

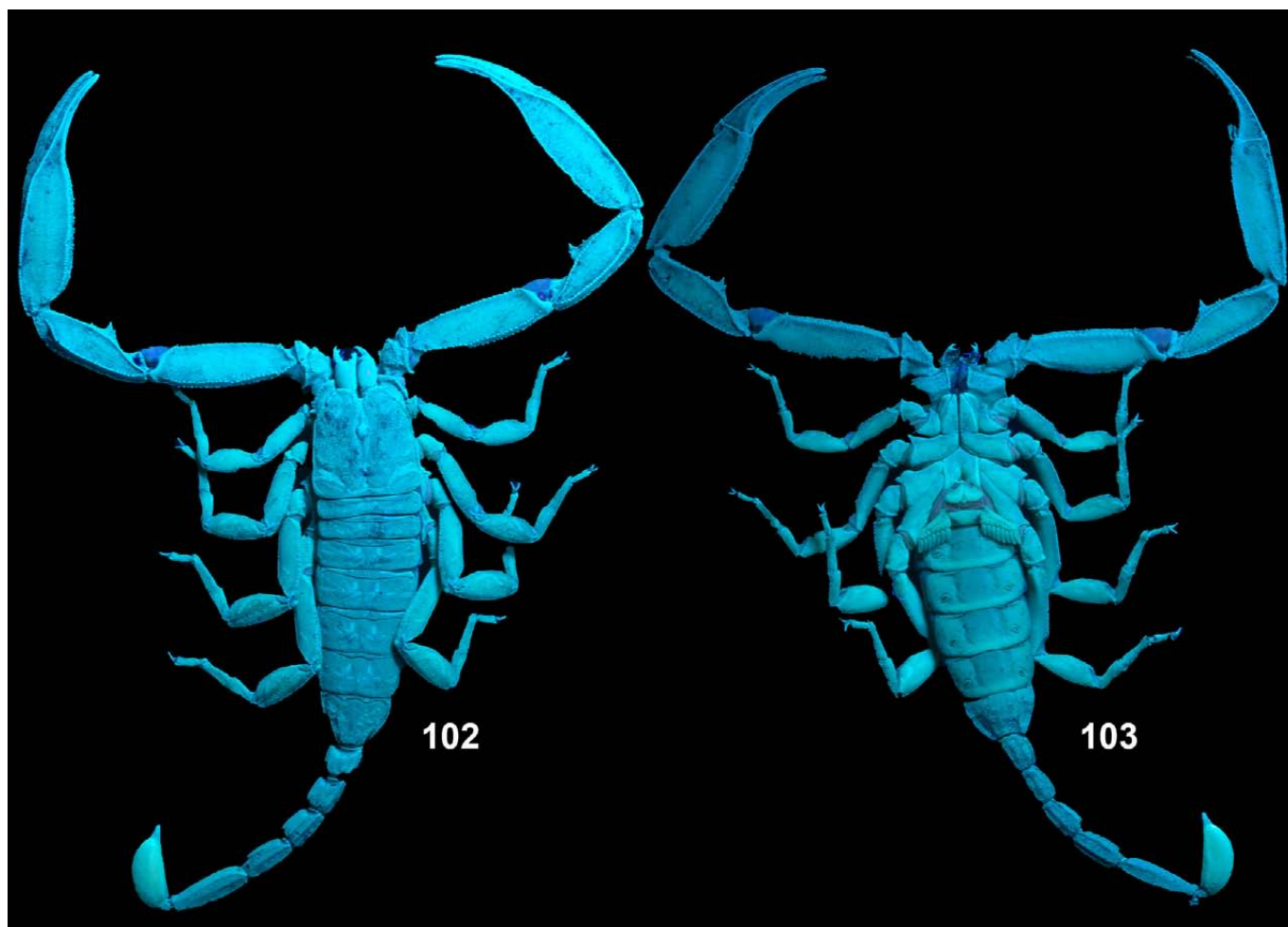
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TYPE LOCALITY AND AND TYPE REPOSITORY. India, Maharashtra State, Nashik District, Pardhadi Village, 20°16'47"N 74°49'39"E, 559 m a. s. l.; BNHS.

TYPE MATERIAL. India, Maharashtra State, Nashik District,



Figures 97–101. *Scorpiops lioneli* sp. n., male, holotype, dorsal (97) and ventral (98) views, sternopectinal area (99), metasomal segment V and telson in lateral view (100) and chelicera in dorsal view (101).



Figures 102–103. *Scorpiops lioneli* sp. n., male, holotype in dorsal (102) and ventral (103) views under UV light.

Pardhadi Village, 20°16'47"N 74°49'39"E, 559 m a. s. l., 1♂ (holotype, BNHS SC 262), 1♂ (paratype, INHER-177), 15 September 2019, leg. S. Sulakhe, C. Risbud & M. Ketkar, 1♂ (paratype, BNHS SC 263), 3♀ (paratypes, INHER- 323, BNHS SC 264, 265), 16 March 2021, leg. S. Sulakhe, S. Deshpande, A. Date & D. Pangarkar.

ETYMOLOGY. The specific epithet is a patronym honouring Lionel Monod for his remarkable contribution to the world of scorpiology.

DIAGNOSIS (♂♀). Total length 41–49 mm. Base color yellowish brown. Pectinal teeth number 7–8 in both sexes, fulcra reduced to absent. Pectine morphology of type P4. Patella of pedipalp with 23–27 (5 *eb*, 2 *esb*, 2 *em*, 8–11 *est*, 6–7 *et*) external and 15–18 ventral trichobothria. Chela of pedipalp with 4 ventral trichobothria located on ventral surface. Chelal trichobothrium *Eb*₃ is located in proximal half of manus between trichobothria *Dt* and *Db*. Fingers of pedipalps strongly undulate in male and margins undulate in female. Chela length to width ratio 4.4 in males. Pedipalp movable finger with ca 65–70 IAD, which form second row, parallel with MD (ca 75–80 in number); there are also 3–4 ID and 11–12 OD present. Internal surface of patella with small antero-ventral tubercle. Carapace with deep U

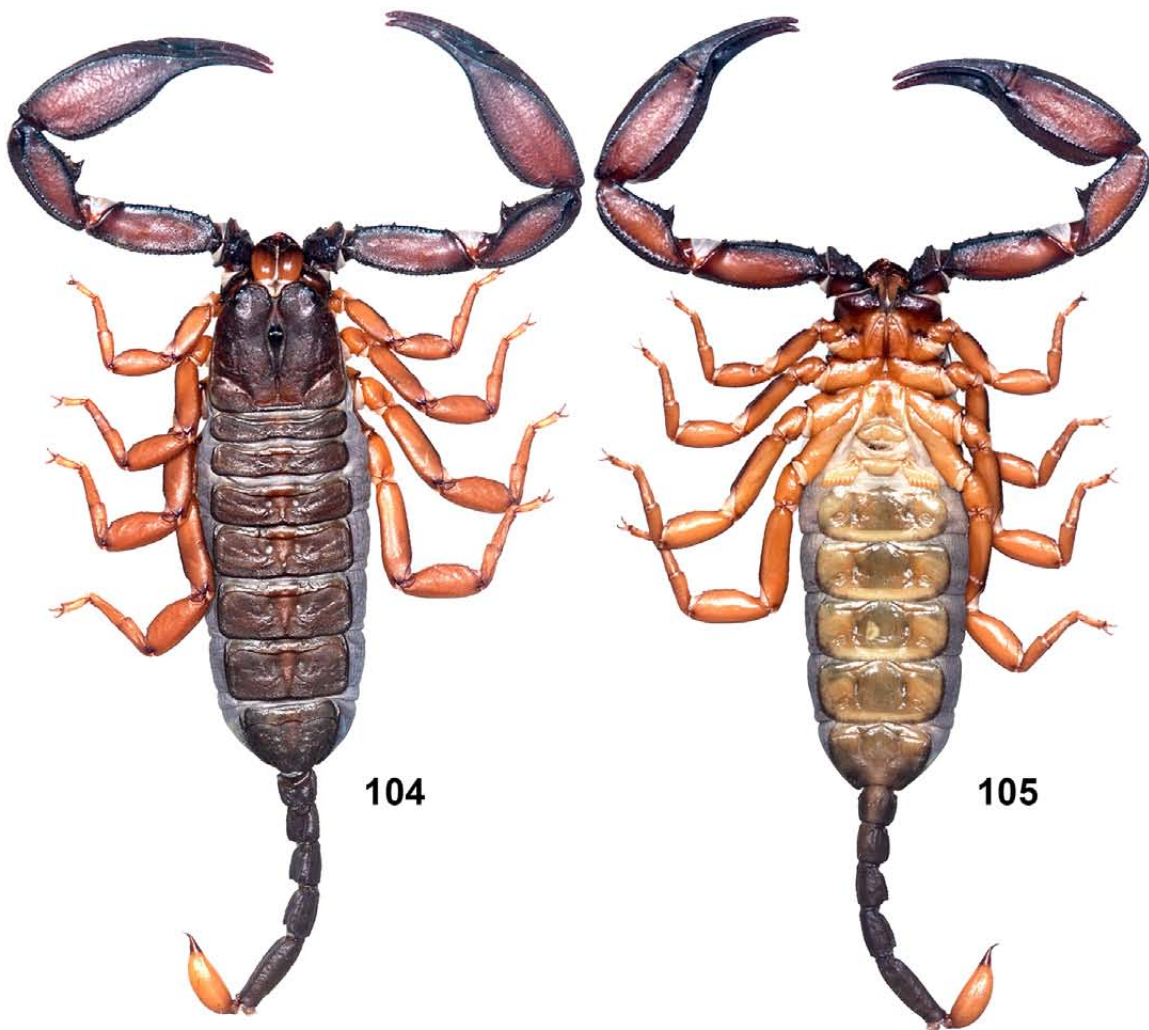
shaped anterior median notch. Tarsomere II of legs with 4–6 stout median ventral spinules. Metasoma I–III with ten, metasoma IV with 8 and metasoma V with 7 carinae. Telson elongate and smooth, length to depth ratio 2.8–3.5; annular ring absent.

Description (♂ holotype, measurements in Table 1).

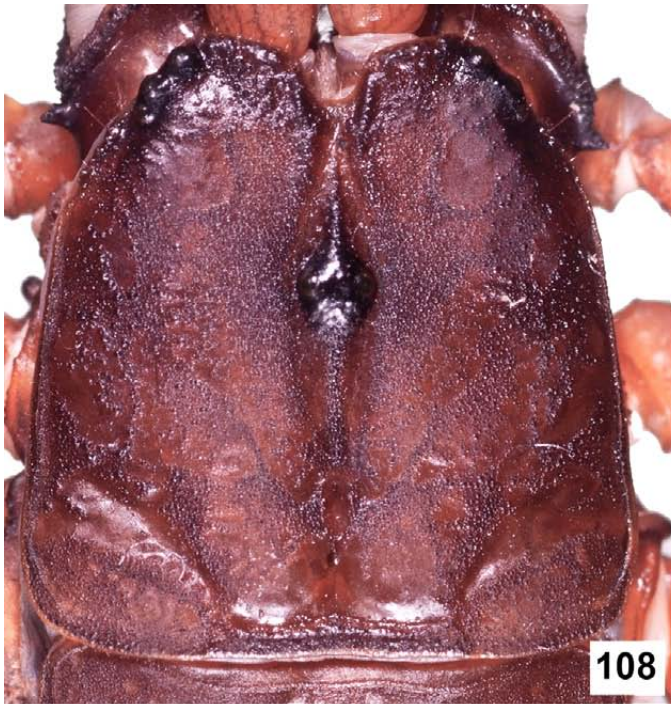
Coloration (in preservation) (Figs. 96–98, 104, 105). Overall body color yellowish brown. Legs yellowish brown. Telson brownish yellow on vesicle and dark brown on aculeus. Ventral portion of body yellowish brown. Carapace and fingers of manus dark brown. Pedipalps yellowish brown, darker on carinae. Chelicera basal segment dark brown. Fingers of chelicera brownish black.

Carapace (Figs. 108–111). Anterior margin of carapace strongly granular with deep U shaped anterior median notch. Anterior sub margin coarsely granular. Anterior margin of carapace between lateral eyes and U shaped anterior median notch curved. Entire surface of carapace with coarse and fine granules. Anterio-lateral ocular tubercles granular provided with type 3A lateral ocelli. Two pairs of large major ocelli and one pair of minor ocelli. Median ocular tubercle smooth on dorsal portion with a pair of median ocelli situated in the ratio of 1:2 (ratio of median ocelli to anterior margin and median ocelli to posterior margin).

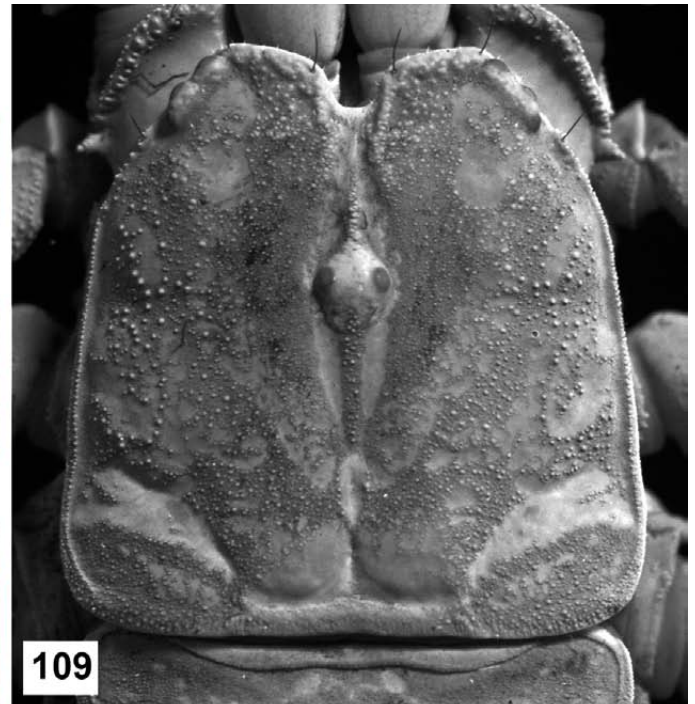
Chelicerae (Fig. 101). Proximal portion with reticulated



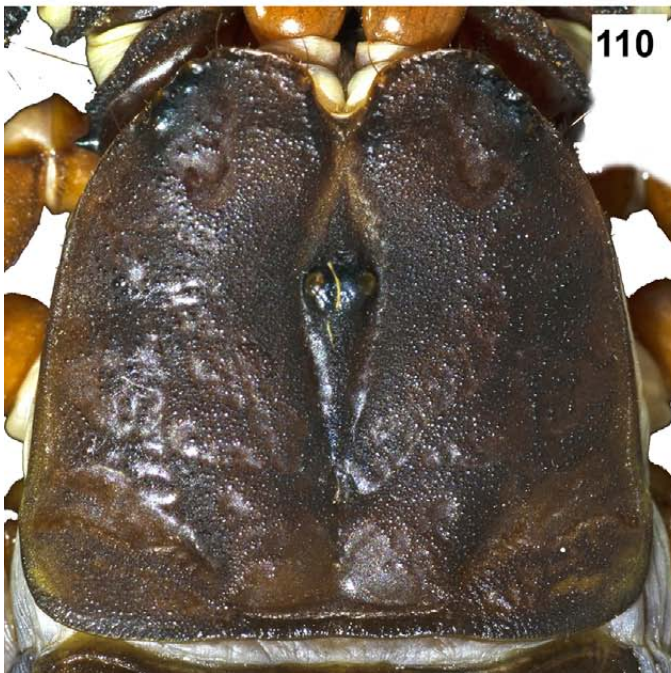
Figures 104–107. *Scorpiops lioneli* sp. n., female, paratype, BNHS SC 264, in dorsal (104) ventral (105) views, sternopectinal area (106) and metasomal segment V and telson in lateral view (107).



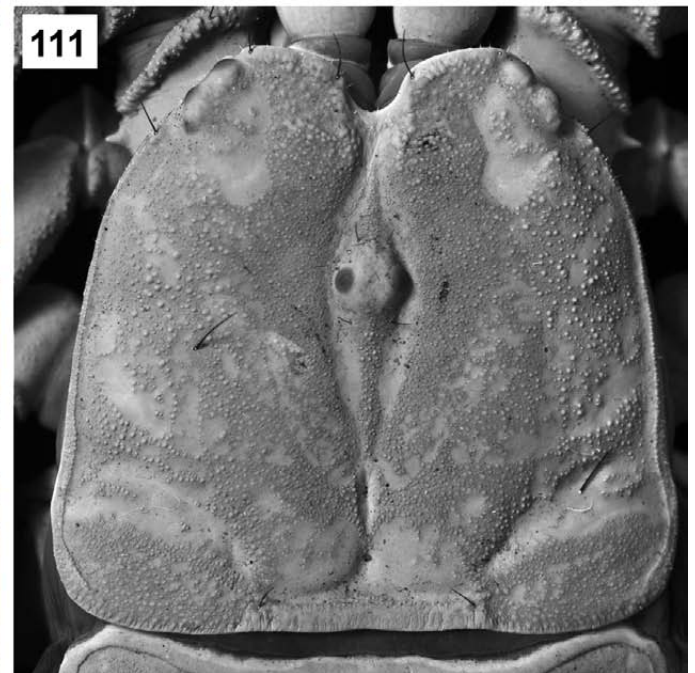
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110



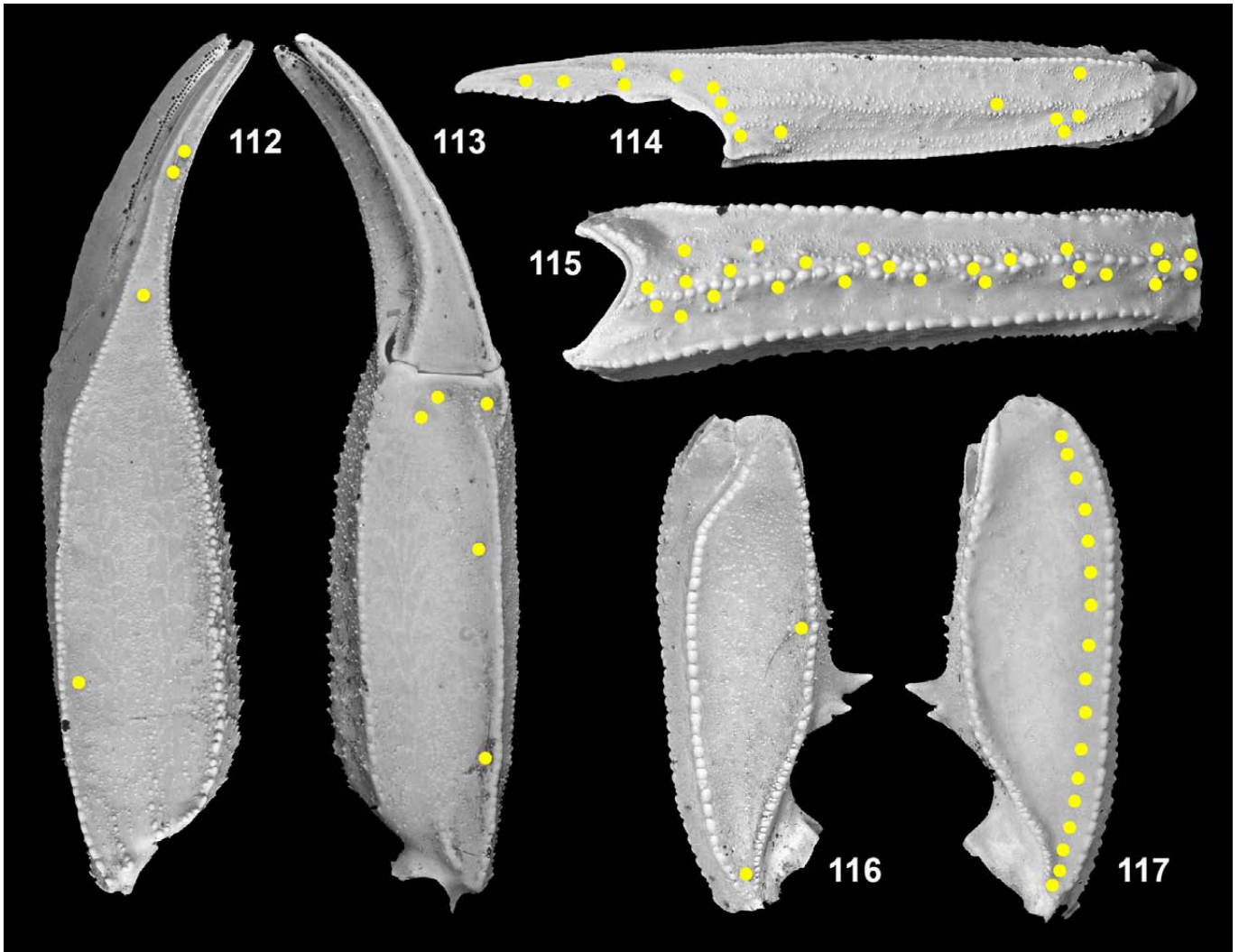
111

Figures 108–111: *Scorpiops lioneli* sp. n. **Figures 108–109.** Male, holotype, carapace under white light (108) and UV fluorescence (109). **Figures 110–111.** Female, paratype, BHNS SC 264, carapace under white light (110) and UV fluorescence (111).

mosaic design. Fixed finger of chelicera with 3 large triangular teeth on inner margin. Ventral fang of movable finger with a row of 7 minute teeth on inner margin. Dorsal fang of movable finger with 4 teeth on inner margin.

Pedipalp (Figs. 112–117, 130, 138, 152). Femur and patella dorsoventrally flattened. Femur with 6 carinae (dorsal retrolateral, dorsal prolateral, retrolateral dorsosubmedian, prolateral ventrosobmedian, ventral retrolateral and ventral prolateral). Ventral prolateral carina weak and present only on 1/3rd proximal portion. Intercarinal space with fine granules. Patella with 5 (dorsal retrolateral, dorsal prolateral,

retrolateral dorsosubmedian, ventral retrolateral and ventral prolateral). Internal surface of patella with one large postero-ventral tubercle with one small, thick adjacent bulge and one adjacent small postero-dorsal tubercle and small antero-ventral tubercle (Fig. 138). Manus elongated with 5 carinae (dorsal dorsal retrolateral, retrolateral median, ventral retrolateral, dorsal prolateral and ventral prolateral). Dorsal retrolateral and dorsal prolateral carinae running anteriorly up to the tip of fixed finger. Intercarinal space finely granular on inner and outer surface. Both fingers scalloped deeply at the base. Trichobothrial pattern neobothriotaxic.



Figures 112–117. *Scorpiops lioneli* sp. n., male, holotype. **Figures 112–117.** Pedipalp chela dorsal (112), ventral (113) and dorsoexternal (114), patella external (115), dorsal (116) and ventral (117) views under UV fluorescence. Trichobothrial pattern indicated by yellow circles.

Legs (Figs. 97, 98, 102–105, 118–121). Femur and patella carinated, intercarinal space with coarse and fine granules. Tarsomere I provided with three to four rows of spinules and tarsomere II with single ventral row of spinules.

Sternum, genital operculum and pectines (Figs. 99, 106). Broad, pentagonal and finely granular only on anterior middle portion. Genital operculum with a pair of strongly protruding genital papillae. Basal piece without depression on middle portion. Pectine morphology of type P4 with 8/7 pectinal teeth.

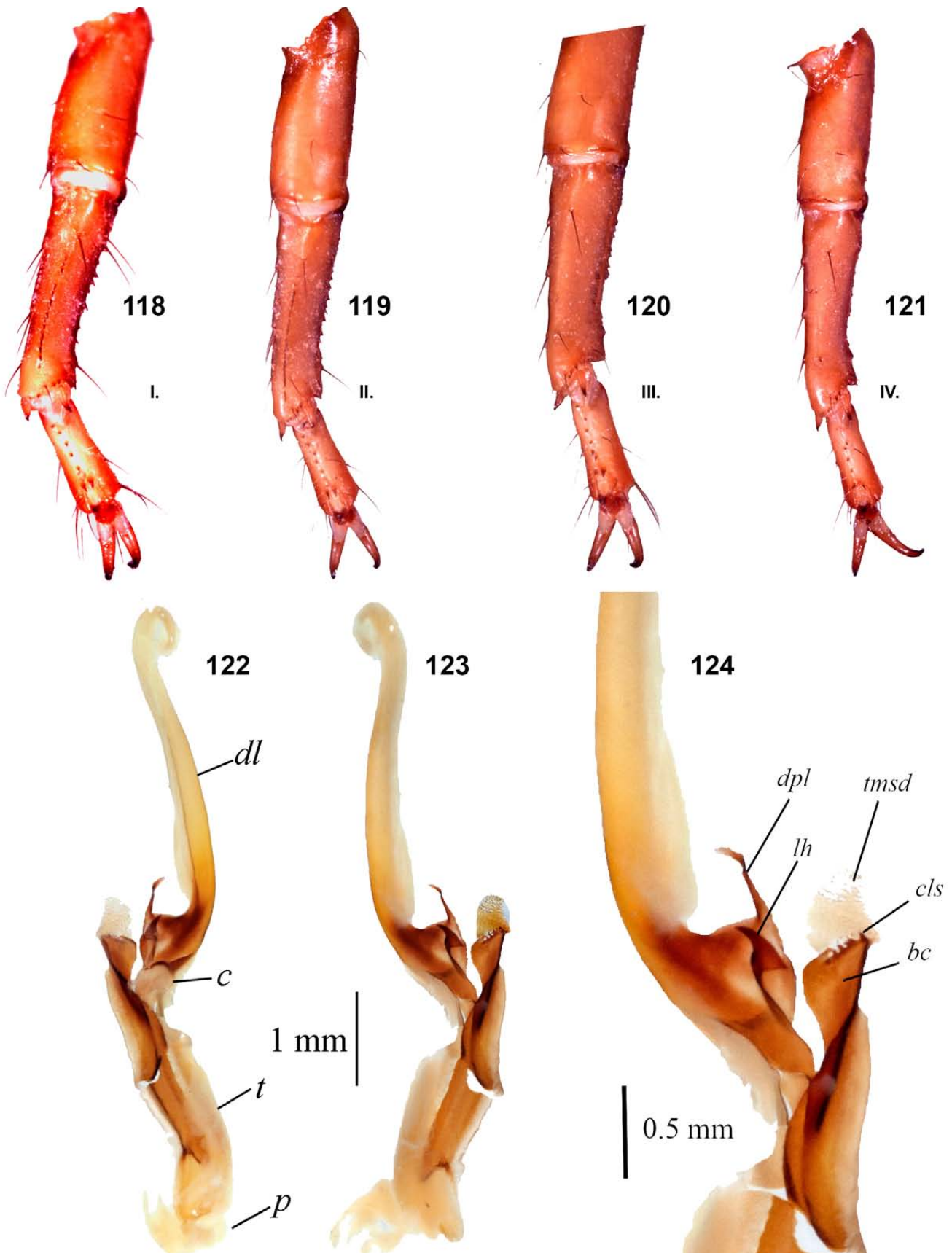
Mesosoma (Figs. 97, 98, 102–105).). All tergites finely granular, with median carina absent on segment I. Tergite VII additionally with two pairs of lateral granular carinae present only on half posterior portion. Sternites III–VI entirely smooth. Sternite VII finely granular.

Metasoma (Figs. 97, 98, 102–105, 134, 142). Metasomal segments I with 5 pairs of carinae (dorsal lateral, lateral suprmedian, lateral inframedian, ventral lateral and ventral submedian), metasomal segments II, III and IV with 4 pairs of carinae (dorsal lateral, lateral suprmedian, ventral lateral and ventral submedian), segment II and III with additional lateral inframedian carina present only on posterior portion and

segment V with 3 pairs (dorsal lateral, lateral inframedian and ventral lateral) and 1 single ventral median carinae. Intercarinal space with fine granules. Dorsal lateral carination on segments III and IV ending posteriorly into a short spine. Anal rim of segment V evenly crenulated. A pair of dorsolateral granules of anal rim weakly tuberculate.

Telson (Figs. 100, 107). Elongated and almost entirely smooth. **Hemispermaphore** ♂ paratype, BNHS SC 263 (Figs. 122–124). Lamelliform; distal *basal carina* (*bc*) with a plate like structure present, sclerotized, crown-like structure (*cls*) with distal margin with 5–6 denticles whose internal surface is attached to terminal membrane of the sperm duct (*tmsd*) on the inner concave side of the capsule with numerous spicules; pointed lateral hook (*lh*); a long, inwardly twisted distal posterior lobe (*dpl*) close to the distal lamina, with denticulate margin; short and stout trunk; long and slender distal lamina (*dl*) narrow at the base and sharply bent and tapered apex. Total length 8.0 mm; pedicel 1.14 mm long; trunk 1.66 mm long; capsule 1.12 mm long; *dpl* length 0.43 mm; *dl* length 4.08 mm long.

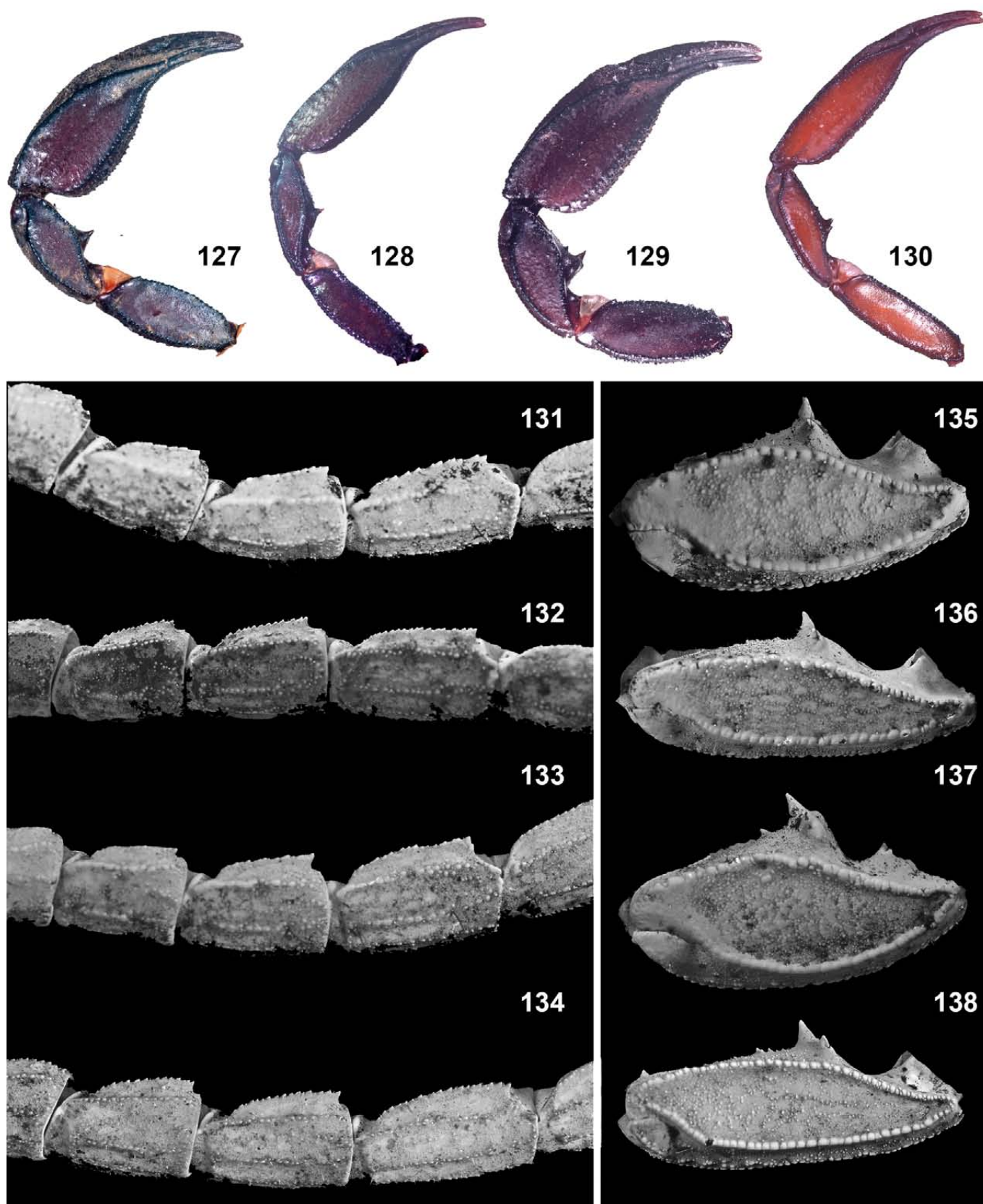
SEXUAL DIMORPHISM. Male genital operculum with pair of



Figures 118–124. *Scorpiops lioneli* sp. n. **Figures 118–121.** *Scorpiops lioneli* sp. n., male, holotype, left legs I–IV, retrolateral aspect. **Figures 122–124.** Male, paratype, BNHS SC 263, hemispermatophore internal (122), external (123) views and capsular region in internal view (124). Abbreviations: distal lamina (*dl*), capsule (*c*), trunk (*t*), pedicel (*p*), distal posterior lobe (*dpl*), lateral hook (*lh*), terminal membrane of the sperm duct (*tmsd*) and basal carina (*bc*).



Figures 125–126. Type locality of *Scorpiops lioneli* sp. n., view of mountains with semi-arid habitat and rocky out-crops at the type locality (125, 126).



Figures 127–138: **Figures 127–130:** Comparison of left pedipalps. **Figures 131–134:** Comparison of metasomal segments II-IV in lateral view. **Figures 135–138:** Comparison of pedipalp patella dorsal view with internal aspect tubercles. **Figures 127, 131, 135.** *Scorpiops vrushchik* sp. n., male, holotype. **Figures 128, 132, 136.** *Scorpiops nagphani* sp. n., male, holotype. **Figures 129, 133, 137.** *Scorpiops neera* sp. n., male, holotype. **Figures 130, 134, 138.** *Scorpiops lioneli* sp. n., male, holotype.

genital papillae. In females, the genital operculum medially sutured. Pedipalp manus slender in males and stouter in females (Figs. 97–100, 102–111).

AFFINITIES. *Scorpiops lioneli* sp. n. is closely related to *S. nagphani* sp. n. and *S. maharashtraensis*. It is separated by a raw genetic divergence of 6.7% from *S. nagphani* sp. n. and 11% from *S. maharashtraensis*. The new species also differs from its close congeners based on following set of morphological characters: Trichobothria on patella ventral 15–18 as opposed to 12–14 in *S. nagphani* sp. n.; chela length to width ratio in males 4.4 as opposed to 3.7–4.1 in *S. nagphani* sp. n.; body coloration yellowish brown as opposed to blackish brown in *S. nagphani* sp. n.; carapace with deep U shaped anterior median notch as opposed to moderate U shaped anterior median notch in *S. maharashtraensis*.

It differs from all the remaining species of *Scorpiops* from the northern Western Ghats and northern Maharashtra (INDIA) by a raw genetic divergence of 9.4–12.4 % (Table 5). It is also distinguished from all the species of *Scorpiops* from peninsular India based on the key of morphological characters (See below).

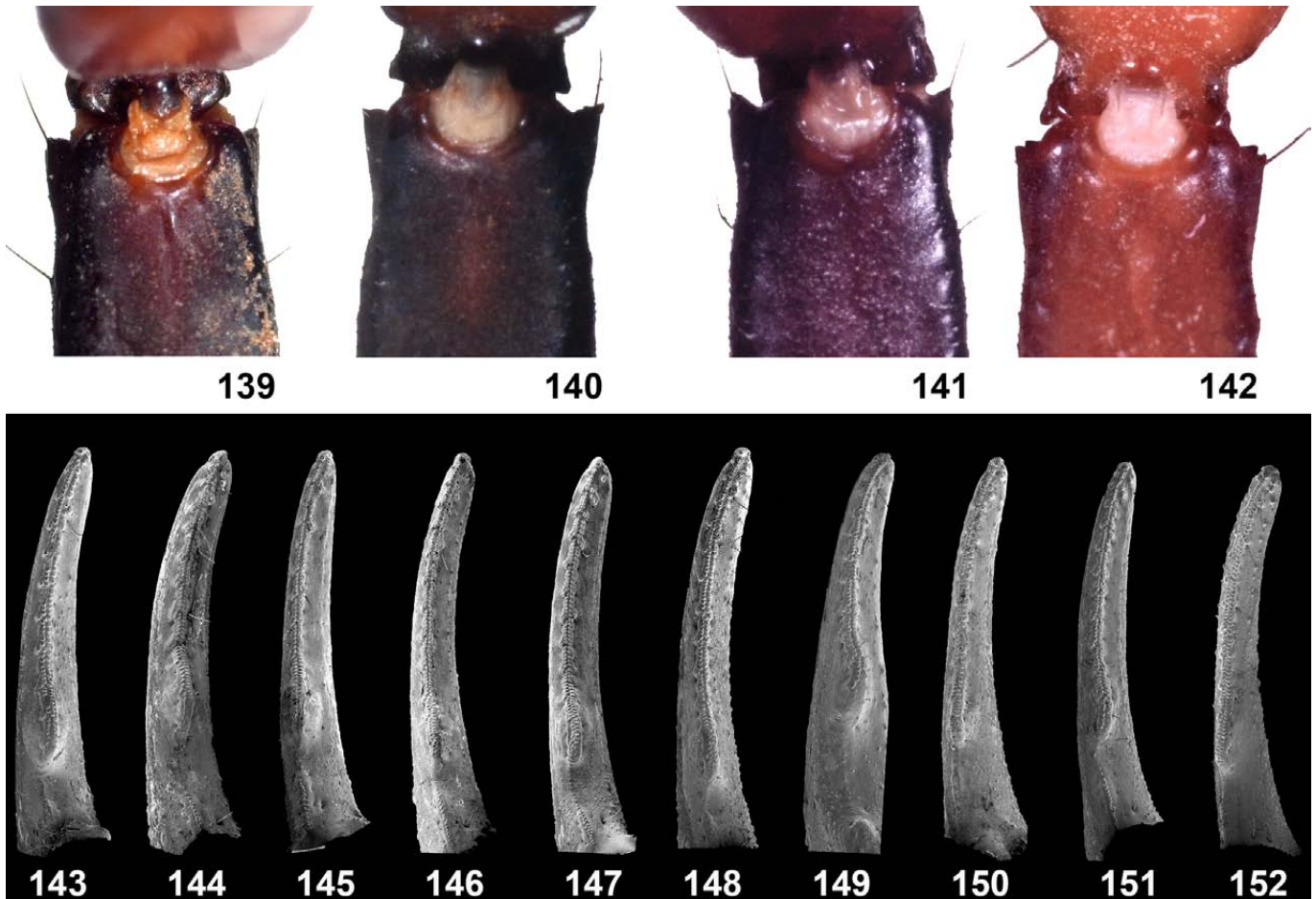
COMMENTS. *S. maharashtraensis*, holotype, ♂ (BNHS SC-62) is described from the type locality “Shidi Ghat” near Wadali Village, Tehsil-Sillod, Aurangabad District, Maharashtra, India (20.5321808, 75.879628, elevation 586 m). Paratypes 2♀ (BNHS SC-63, 64) are also collected from the type locality. 1♂ (BNHS SC-65) and 1♀ (BNHS SC-66) are collected from Chalisgaon Taluka, near Ghodegaon, Jalgaon District, Maharashtra (20.3127998, 74.8622418, elevation 460 m). Type locality of *Scorpiops lioneli* sp. n. India, Maharashtra State, Nashik District, Pardhadi Village, 20° 16' 47" N 74° 49' 39" E, 559 m a. s. l. (locality data is same for all type material) is ca 10 kms from the locality of *S. maharashtraensis* from where the paratypes BNHS SC-65 and BNHS SC-66 are collected. Our surveys did not yield any success from this locality. Type specimens of *S. maharashtraensis* are deposited at BNHS without accession numbers assigned to individual specimens and preserved in single preservation jar with more specimens apart from the type series. Sulakhe et al. (2020a) were able to identify only the holotype, BNHS SC-62 and 1 paratype, BNHS SC-63 collected from the type locality based on the photographs published by Mirza et al. (2014). The deteriorating condition of the preserved specimens, ambiguity in assigning accession numbers to individual specimens (type material is collected from one more locality apart from the type locality) and inability of extracting DNA due to preservation in 70% ethanol, the status of paratypes BNHS SC-65 and 66 could not be tested. Considering the geographical proximity these specimens could be *S. lioneli* sp. n., however this needs to be confirmed with more sampling and genetic data from this locality.

DISTRIBUTION, HABITAT AND ECOLOGY. Presently *Scorpiops lioneli* sp. n. is known only from its type locality, Pardhadi Village, Nashik District, Maharashtra, India. The type series was collected from rock boulders on a hill side of the

road leading from Pardhadi Village to Dheku Village. The type locality is surrounded by scrub forest in deep valleys interspersed with semi-arid grasslands. Any further road widening work may be a direct threat to the species. Locations around the type locality in the deep valleys may have more populations of this species and need to be confirmed with dedicated surveys (Figs. 125–126, 153).

Key to *Scorpiops* species from Peninsular India

1. Trichobothria on patella ventral 10; Chela length to width ratio in males 2.6 (*vide* Mirza & Gowande, 2016).
..... *S. pachmarhicus* Bastawade, 1992
– Trichobothria on patella ventral 12–19; Chela length to width ratio in males > 2.7. 2
2. Trichobothria on patella ventral 15–19. 3
– Trichobothria on patella ventral 12–16. 6
3. Trichobothria on patella ventral 17–19; antero-ventral tubercle on internal surface of patella medium to almost equal compared to postero-ventral tubercle.
..... *S. phaltanensis* (Sulakhe et al., 2020)
– Trichobothria on patella ventral 15–18; antero-ventral tubercle on internal surface of patella small compared to postero-ventral tubercle. 4
4. Chela length to width ratio in males 3.1–3.4; color of body blackish brown
..... *S. deccanensis* Tikader & Bastawade, 1977
– Chela length to width ratio in males 4.3–4.4; color of body yellowish brown. 5
5. Carapace with moderate U shaped anterior median notch.
..... *S. maharashtraensis* (Mirza et al., 2013)
– Carapace with deep U shaped anterior median notch.
..... *S. lioneli* sp. n.
6. Trichobothria on patella ventral 12–14. 7
– Trichobothria on patella ventral 13–16. 8
7. Total pedipalp length to mesosomal tergite length in males 2.2; dorsal lateral carina on metasoma II-IV ending posteriorly into a large tuberculate spine.
..... *S. satarensis* Pocock, 1900
– Total pedipalp length to mesosomal tergite length in males 1.6–1.9; dorsal lateral carina on metasoma II-IV ending posteriorly into a short spine. *S. nagphani* sp. n.
8. Chela length to width ratio in males 2.9–3.1; dorsal lateral carina on metasoma II-IV ending posteriorly into a short spine. 9
– Chela length to width ratio in males 3.2–4.0; dorsal lateral carina on metasoma II-IV ending posteriorly into a large tuberculate spine. 10



Figures 139–152: **Figures 139–142:** Comparison of dorsolateral granules on anal rim of metasomal segment V in dorsal view. **Figures 143–152:** Comparison of dentition on movable finger of chela with field emission scanning electron microscopy (FESEM) images in dorsal view. **Figures 139, 149.** *Scorpiops vrushchik* sp. n., male, holotype. **Figures 140, 150.** *Scorpiops nagphani* sp. n., male, holotype. **Figures 141, 151.** *Scorpiops neera* sp. n., male, holotype. **Figures 142, 152.** *Scorpiops lioneli* sp. n., male, holotype. **Figure 143.** *S. tenuicauda*, male, INHER-214. **Figure 144.** *S. satarensis*, male, INHER-213. **Figure 145.** *S. deccanensis*, male, INHER-86. **Figure 146.** *S. maharashtraensis*, male, INHER-179. **Figure 147.** *S. phaltanensis*, male, paratype, INHER-64. **Figure 148.** *S. telbaila*, male, paratype, INHER-123.

9. Chela length to width ratio in males 2.9–3.0; anterior margin of carapace between lateral ocelli and U shaped anterior median notch curved. *S. vrushchik* sp. n.
 – Chela length to width ratio in males 3.1; anterior margin of carapace between lateral ocelli and U shaped anterior median notch straight. *S. neera* sp. n.
10. Anterior margin of carapace with strong tuberculate granulation; telson with annular ring at juncture between vesicle and aculeus. *S. telbaila* (Sulakhe et al., 2020)
 – Anterior margin of carapace with moderate granulation; telson with annular ring at juncture between vesicle and aculeus absent. *S. tenuicauda* Pocock, 1894

Statistical analysis

Size corrected morphometric data was not significantly different from multivariate normal (Doornik and Hansen omnibus, within group $Ep = 62.81$, $P < 0.05$). All the newly described species formed distinct clusters from the already described species when projected on the first two PCA factor planes

that had eigenvalues > 1.0 and explained 81.89% of variation among the species (Fig. 154). PCA Factor 1 loaded heavily on two morphometric parameters, chela length (CL) and pedipalp femur length (PFL), while PCA Factor 2 loaded heavily on two morphometric parameters, pectine length (PL) and pectine width (PW). Furthermore, our DFA resulted in 100% classification success with all the individual samples being classified into their respective species. First four discriminant function roots showed eigenvalues > 1.0 and explained 97.4% of the variations among these species. *Scorpiops satarensis* was excluded from the analysis due to availability of single male specimen. Overall, the PCA and DFA results showed morphological differentiation among the analysed species and were considered reliable for recognition of new species based on the morphometric data. (Statistical data available with the authors) (Figs. 154, 155).

Molecular analysis

Molecular Phylogenetics (Figs. 156, 157). All known species of the genus *Scorpiops* found in northern Western Ghats and northern Maharashtra were included in our phylogenetic

Species	STI	SM	SV	STB	ST	SN
<i>S. tibetanus</i> (STI)	(0)					
<i>S. montanus</i> (SM)	13.6–13.8	(0–0.4)				
<i>S. vrushchik</i> sp. n. (SV)	15.7	12.4–12.6	(0)			
<i>S. telbaila</i> (STB)	14.3	14.1–14.3	11	(0)		
<i>S. tenuicauda</i> (ST)	14.1–14.3	13.6–13.9	9.6–9.8	5.5–5.7	(0–0.2)	
<i>S. nagphani</i> sp. n. (SN)	14.3	13.0–13.2	12.4	10.8	10.4–10.6	(0)
<i>S. lioneli</i> sp. n. (SL)	12.4	12.0–12.2	124	11.0	11.0–11.2	6.7
<i>S. maharashtraensis</i> (SMH)	12.6	12.2–12.4	13.4	11.4	12.0–12.2	9.6
<i>S. neera</i> sp. n. (SNE)	15.7	13.6–13.8	13.4	10.8	10.8–11.0	10.2
<i>S. deccanensis</i> (SD)	13.2–14.1	13.8–14.3	12.4–13.0	10.8–11.2	11.0–11.8	10.8–12.6
<i>S. satarensis</i> (SS)	13.8	12.4–12.6	13.2	11.0	11.8–12.0	11.0
<i>S. phaltanensis</i> (SP)	12.8–13.0	13.8–14.1	12.8–13.0	11.0–11.2	11.6–12.0	12.6–12.8

Species	SL	SMH	SNE	SD	SS	SP
<i>S. lioneli</i> sp. n. (SL)	(0)					
<i>S. maharashtraensis</i> (SMH)	11.0	(0)				
<i>S. neera</i> sp. n. (SNE)	9.4	11.8	(0)			
<i>S. deccanensis</i> (SD)	9.6–10.0	11.4–12.2	6.1–7.1	(0–3.7)		
<i>S. satarensis</i> (SS)	9.4	13.0	7.3	6.7–7.7	(0)	
<i>S. phaltanensis</i> (SP)	10.8–11.0	12.4–12.6	9.6–9.8	8.6–9.2	6.5–6.7	(0–0.2)

Table 5. Pairwise uncorrected raw distances (%) expressed as minimum–maximum based on COI gene sequence for *Scorpiops* species from Maharashtra, India. Values in brackets are intra-clade distances.

Primers- Cytochrome c Oxydase I	5' –3' Primer Sequence	Source
HCO2198	TAAACTTCAGGGTGACCAAAAAATCA	Folmer et al. (1994)
HCOoutout	GTAAATATATGRTGDGCTC	Prendini et al. (2003)
LCO1490	GGTCAACAAATCATAAAGATATTGG	Folmer et al. (1994)
Nancy	CCCGGTAAAATTTAAAATATAAACTTC	Simon et al. (1994)
Chelicerate F1	TACTCTACTAATCATAAAGACATTGG	Barrett & Hebert (2005)
Chelicerate R1	CCTCCTCCTGAAGGGTCAAAAAATGA	Barrett & Hebert (2005)
Chelicerate R2	GGATGGCCAAAAATCAAAATAAATG	Barrett & Hebert (2005)

Table 6: Primers used for PCR amplification and sequencing of (COI) mitochondrial gene.

Species	Voucher	GeneBank Accession Number
<i>Scorpiops vrushchik</i> sp. n.	*INHER 230	MZ093587
<i>Scorpiops vrushchik</i> sp. n.	*INHER 236	MZ093586
<i>Scorpiops nagphani</i> sp. n.	BNHS SC 256	MZ093589
<i>Scorpiops nagphani</i> sp. n.	*INHER 339	MZ093590
<i>Scorpiops neera</i> sp. n.	INHER 251	MZ093585
<i>Scorpiops neera</i> sp. n.	*INHER 252	MZ093584
<i>Scorpiops lioneli</i> sp. n.	BNHS SC 262	MZ093594
<i>Scorpiops lioneli</i> sp. n.	INHER 177	MZ093593
<i>S. deccanensis</i> (Kadve Ghat)	*INHER 304	MZ093592

Table 7: Voucher numbers and GenBank accession numbers for the sequence data used for the phylogenetic analysis.

* Specimens with voucher numbers INHER 230, 236, 339, 252, 304 are additional specimens which are not a part of type material.

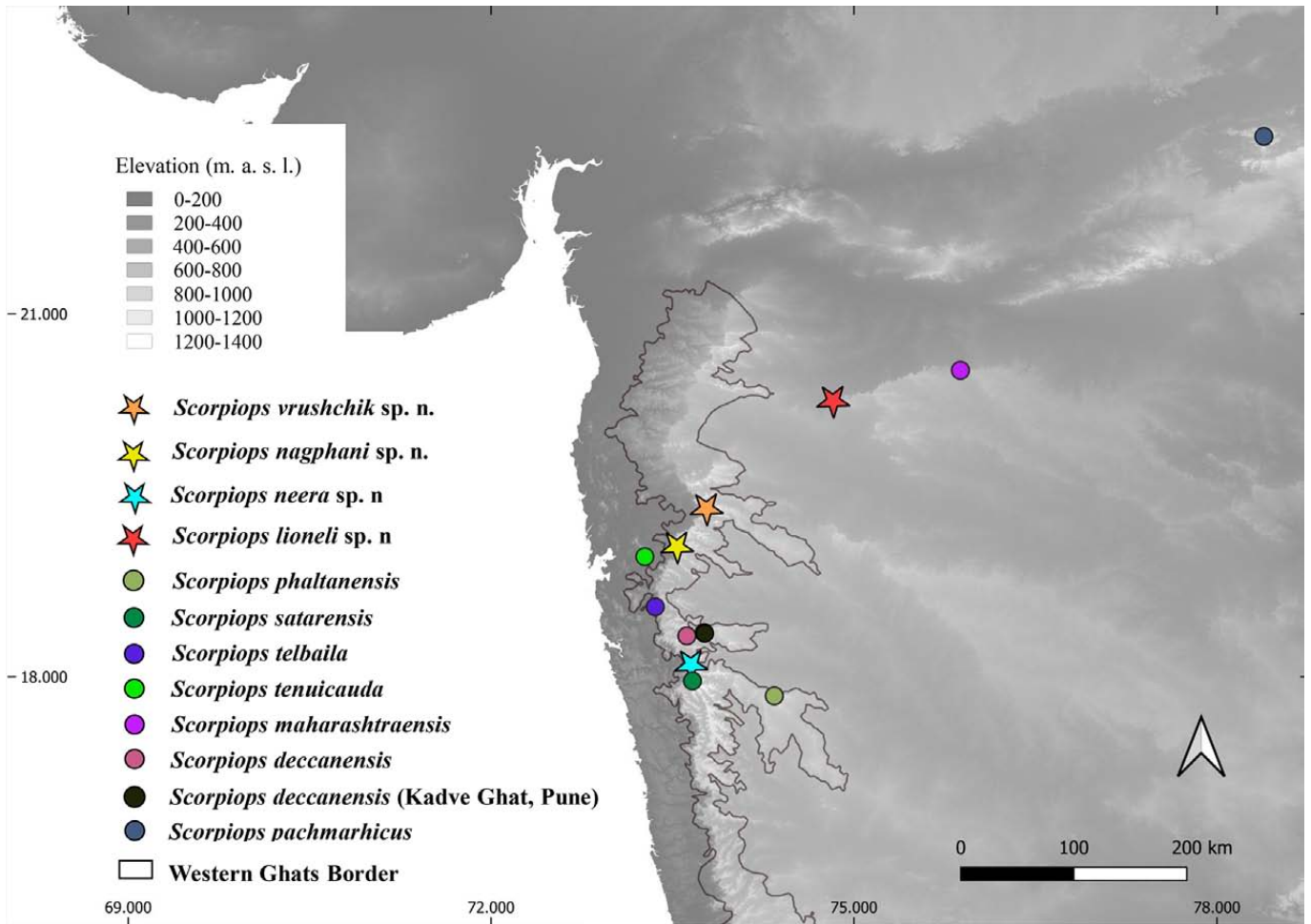


Figure 153. Distribution of *Scorpiops* species from Peninsular India. Localities with a star indicate new species described in this study.

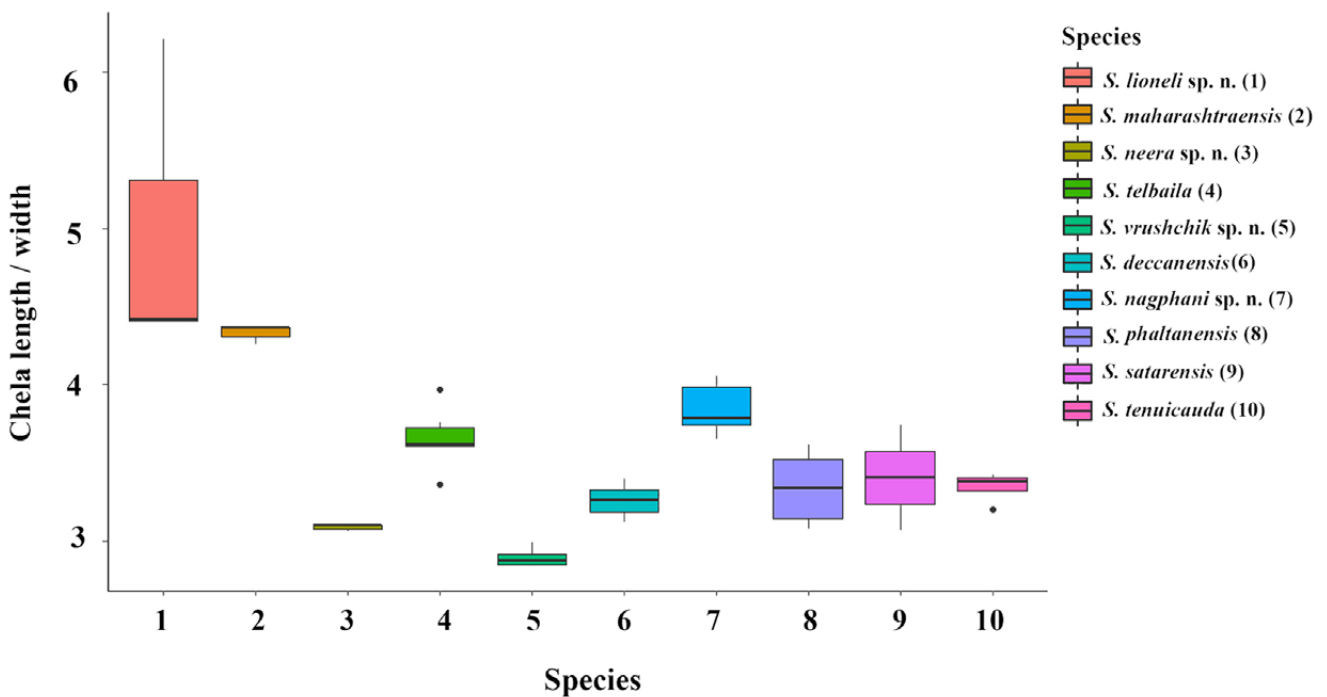


Figure 154. Boxplots showing variations in ratios of pedipalp chela length to width in males for all *Scorpiops* species from Peninsular India (except *S. pachmarhicus* due to unavailability of sufficient males).

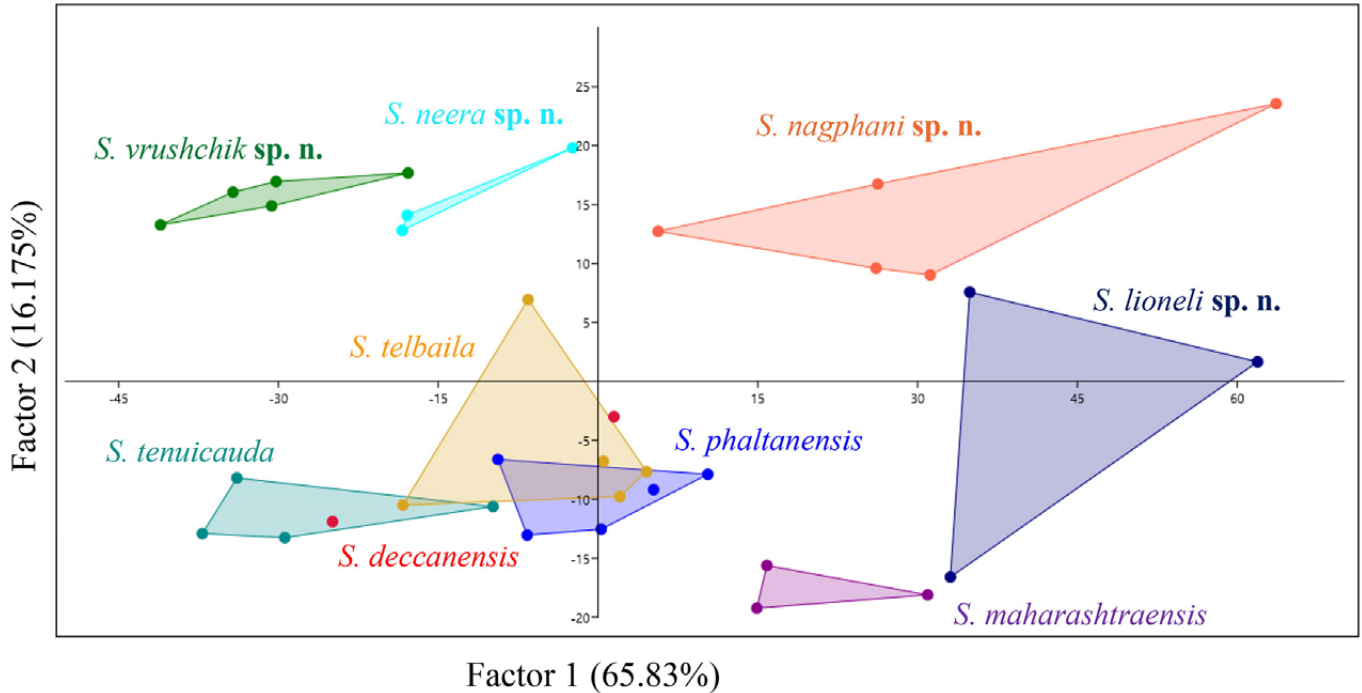


Figure 155. Projection of first two Principal Component factors explaining 81.89% variation among the nine species of the genus *Scorpiops* from Peninsular India (except *S. pachmarhicus* and *S. satarensis* due to unavailability of sufficient males).

analysis of a 509 bp fragment of the COI mitochondrial gene. ML and BI analyses generated trees with different topologies, however all new species of *Scorpiops* described in this study were each recovered as monophyletic with moderate to high bootstrap support in ML analysis (>85) and high posterior probability values in the BI analysis (posterior probability = 1). All sequences of *S. vrushchik sp. n.* were recovered as sister to a clade comprising *S. telbaila* and *S. tenuicauda* in both ML and BI analyses. All sequences of *S. neera sp. n.* were recovered as sister to a clade comprising *S. deccanensis*, *S. satarensis* and *S. phaltanensis* in both ML and BI analyses. All sequences of *S. nagphani sp. n.* were recovered as sister to *S. lioneli sp. n.* in both ML and BI analyses. This clade comprising these two species was recovered as sister to *S. maharashtraensis* in ML analysis however all sequences of *S. maharashtraensis* were basally aligned and recovered as sister to clades comprising *S. nagphani sp. n.*, *S. lioneli sp. n.*, *S. phaltanensis*, *S. satarensis*, *S. deccanensis*, *S. neera sp. n.*, *S. tenuicauda*, *S. telbaila* and *S. vrushchik sp. n.*

Genetic divergence (p-distance). All species of *Scorpiops* showed moderate to high genetic divergence based on the 509 bp fragment of the COI mitochondrial gene. *S. vrushchik sp. n.* recovered as nearest to *S. tenuicauda* and separated with a minimum genetic divergence of 9.6%, but showed 11–13.4% divergence from all other congeners. *S. neera sp. n.* recovered as nearest to *S. deccanensis* and separated with a minimum genetic divergence of 6.1%, but showed 7.3–13.8% divergence from all other congeners. *S. nagphani sp. n.* recovered as nearest to *S. lioneli sp. n.* with a minimum genetic divergence of 6.7%, but showed 9.6–13.2% divergence from all other congeners. *S. lioneli sp. n.* recovered as nearest to *S. nagphani sp. n.* with a minimum genetic divergence of 6.7%,

but showed 9.4–12.4% divergence from all other congeners. **Species delimitation** (Fig. 157). PTP and bPTP species delimitation analyses each identified 15 distinct species groups. All the new species described in this study were supported with high support values. GMYC species delimitation analysis identified 11 species. All the new described species in this study were identified as independent species entities in this analysis, however this analysis result identified *S. deccanensis*, *S. satarensis* and *S. phaltanensis* as a single species cluster. ABGD species delimitation analysis identified 14 species groups on all 8 partitions and identified all the new described species in this study as independent species groups. All these analyses strongly support the presence of four new species described in this study. However, considering the differential results in the delimitation analyses in this study, these results should be considered as supporting evidence for new species diagnosis. Morphological separation has thus been considered as a mandatory factor for description of new species in this study as the molecular dataset is limited, based on 509 bp fragment of the COI mitochondrial gene.

Discussion

This study elevates the total number of species of the genus *Scorpiops* to 99, out of which 27 are found in India and 11 are found in peninsular India. This study clearly indicates the rich species diversity in Western Ghats and peninsular India. All the new species described in this study are point endemic with aerial distance ranging from minimum 43 kms to maximum 271 kms. More sampling from predictable locations with more genetic data will help in understanding the evolutionary relationships within *Scorpiops*.

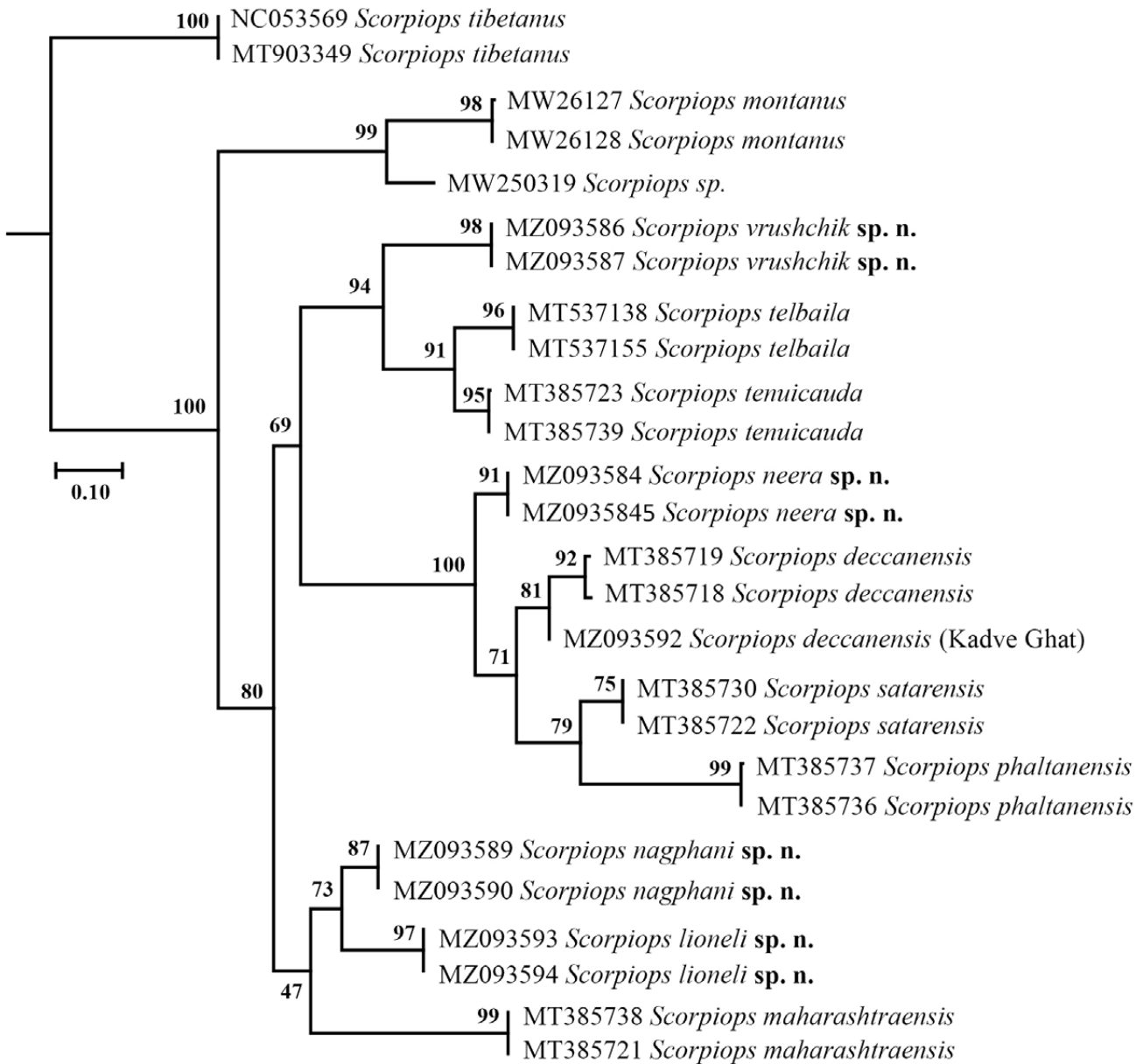


Figure 156. Maximum Likelihood phylogenetic tree (ML) for *Scorpiops*. Values along the nodes are bootstraps for 1000 iterations.

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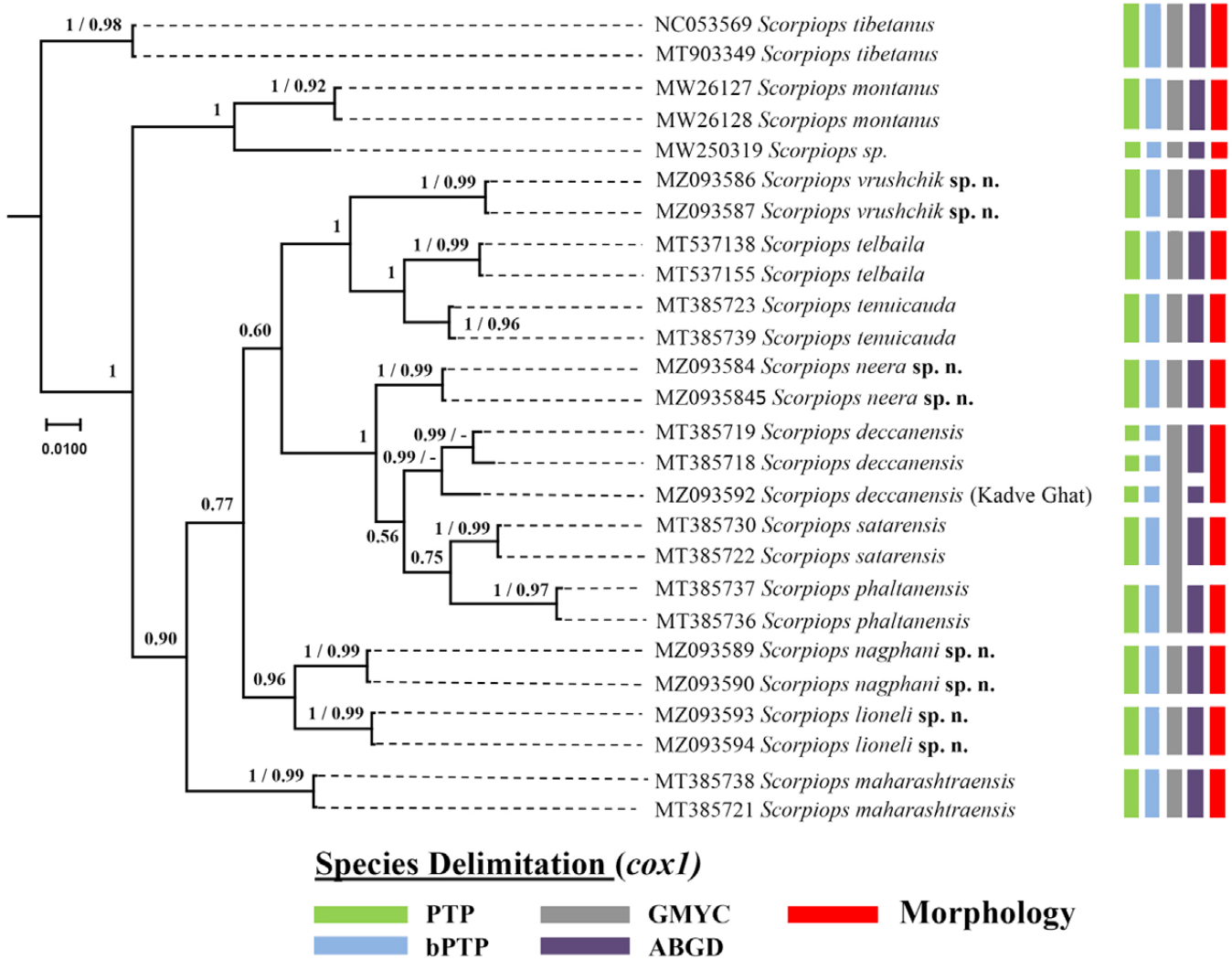


Figure 157. Bayesian phylogenetic tree for *Scorpiops*. Values along the nodes are Bayesian posterior probabilities for Bayesian Inference and Bayesian Poisson Tree Process (bPTP) respectively. Vertical bars represent delimitation analyses results.

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