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SHORT COMMUNICATION

FIRST DEFINITIVE RECORD OF A WHIP SCORPION *LABOCHIRUS TAURICORNIS* (POCOCK, 1900) FROM GOA, INDIA: WITH NOTES ON ITS MORPHOMETRY AND PEDIPALP MICRO-MORPHOLOGY

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FIRST DEFINITIVE RECORD OF A WHIP SCORPION *LABOCHIRUS TAURICORNIS* (POCOCK, 1900) FROM GOA, INDIA: WITH NOTES ON ITS MORPHOMETRY AND PEDIPALP MICRO-MORPHOLOGY

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Abstract: Bastawade & Borkar in 2008 made a passing reference to the presence of a single uropygid species in Goa, though without much primary diagnostic data on the collected specimen of four females. The present study puts in place a definitive record of the uropygid, *Labochirus tauricornis* Pocock, (1900) in the state of Goa, and addresses an important gap in our understanding of its occurrence, morphology, and ecology. Besides documenting the species of this cryptozoic, nocturnal arachnid predator commonly known as ‘Vinegaroon’ on account of their vinegary allomone spray; the present study also describes the gross morphology, morphometry and micro-morphology of non-ambulatory sub-raptorial pedipalps which are of taxonomic-diagnostic value, elucidated using scanning electron microscopy, in addition to routine stereomicroscopy. The paper also examines in detail, sexual dimorphism and morphometry of this uropygid species.

Keywords: Scanning electron microscopy, sexual dimorphism, taxonomy, uropygid, whip scorpion.

As for whip scorpion diversity, 103 species under 16 genera have been reported worldwide (Harvey 2002, 2003). Currently 83 species of whip scorpions have been brought on record from the Asian continent, making it the most diverse region of the world for uropygid diversity (Harvey 2003). The Indian subcontinent is home to 19

species in six genera (Pocock 1900). As of now only six species of whip scorpions under four genera have been described from India (Bastawade 1988). Among the Indian states, the uropygids have been so far reported from Assam, Karnataka, Meghalaya, Tamil Nadu, West Bengal (Pocock 1900), Maharashtra (Bastawade 1988), Goa (Bastawade & Borkar 2008), Andhra Pradesh (Javed et al. 2009), and Chattisgarh (Sharma & Chandra 2012).

The extant records of number and distribution of whip scorpion species clearly suggest gaps in our understanding of the global and Indian uropygid diversity, and underpins the need to have more exploratory surveys for compiling a comprehensive inventory. Such a view that impetus be provided for arachnid taxonomic research, particularly in tropical and southern temperate regions before habitat modification and loss takes a toll on many species, is corroborated by Harvey (2002).

The Asian whipscorpion diversity has been a contentious premise for arachnologists; firstly due to inadequate understanding of uropygid taxonomy but mostly due to little agreement on species-specific

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morphological clues across affiliates of the order Telyphonida. With advancing imaging tools and techniques, finer morphological details of great value in taxonomy have been emerging, that can augment revisionary work (Harvey 2002).

Various researchers have attempted to define the telyphonid genera based on certain morphological attributes such as ommatoids, pedipalps, and integument sculpture, inviting criticism about over-emphasis of these morphological clues in uropygid taxonomy and phylogeny (Haupt 2009). Notwithstanding the above criticism, molecular methods are now central to determining phylogeny and nomenclature; taxonomists have relied on morphological features that present species specificity, and this approach is relatively inexpensive.

The arachnid diversity of the Indian state of Goa is poorly documented except for the inventory prepared by Bastawade & Borkar (2008), bringing species affiliates of five orders from the state on record. Further, much of the focus in their inventory is on Araneae; continuing the arachnid tradition of long neglect of other micro-diverse orders despite their incredible characters. In the present investigation, whip scorpion morphology has been further augmented by using the scanning electron microscope to elucidate the fine morphology that often escapes attention in conventional stereomicroscopy.

METHODS

Diurnal surveys were carried out on the basis of previously documented uropygid habitat compatibility areas of the Sanguem and Dharbandora talukas of the state of Goa during the monsoons of 2014–2017. The present active collection was made from the riparian forest patch of Tamdi Village outside the Bhagwan Mahaveer protected area limits, about one kilometer from the famous Tamdi Surla Temple (see Image 1). The forest floor was carefully scanned by slowly separating the leaf litter and upturning the stones to locate these cryptozoic arachnids.

Once located, utmost care was exercised not to disturb the species, as any slight mechanical stimulus triggers a reflex spray of a strong vinegary, pungent smelling secretion. Also, once disturbed these arachnids bury themselves in the crevices or the soft muddy substratum and get well camouflaged amidst the decaying leaf litter, making it difficult to locate them.

A few individuals of the species were collected and transferred in a container with a bedding of wet leaf litter and moderately sized stones for hiding. Animals were separated on the basis of their sexual dimorphism and

maintained individually in plastic terrariums at the School of Archnology in Biodiversity Research Cell of Carmel College for Women, Goa, under captive conditions, ensuring the desired hygro-thermal profile and natural photoperiod. Enclosure design and husbandry protocols were followed as per McMonegle (2013). Captive enclosures were provided with necessary substratum of leaf litter of approximately 2.5cm thickness and coconut shell hideouts. Regular cleaning of leftover dead prey helped in avoiding moulds. The captive individuals were supplied with freshly collected insect prey once a week. No separate provision for water was made in the containers, however, a piece of wet sponge was added to the terrarium.

Gross and micro-morphological studies and measurements necessitated killing the specimen by freezing and preservation in 70% ethanol for further



Image 1. The location of the habitat of *Labochirus tauricornis*, Pocock; locality Tamdi Village of Dharbandora Taluka in Goa, India. (A- Google image of the landscape; B- Riparian microhabitat at Tamdi Village.)

examinations. Routine stereomicroscopy (Model: Meiji Techno, Japan) was used for gross morphology whereas micro-morphology was elucidated by scanning electronic microscopy (SEM) at the National Centre for Antarctic and Ocean Research (NCAOR), Bogda Goa (Model: JSM-6360LV).

The present investigation is based on the examination of collected specimen of both sexes (BRC-GOA/Arachno/maleUro-339/2016 & BRC-GOA/Arachno/femaleUro-351/2016) and goes well beyond studying conventional gross morphological parameters, to include micro-morphology. Stereomicroscopy and SEM have been combined to elucidate fine structures of taxonomical value. Also, detailed meristic data has been generated for the whole body as well as individual ambulatory and non-ambulatory appendages. This is also the first attempt to understand an Indian uropygid with SEM as a tool of investigation. This paper takes a look at functional morphology of pedipalp, an important non-ambulatory structure. Also traditionally, pedipalps have been a focus of investigation in revisionary taxonomy of thelyphonid species (Haupt & Song 1996).

RESULTS

Habitat and habit

Most species of whip scorpions are encountered in moist or seasonally moist forested habitats in tropical or subtropical environments, burrowing in the deeper soil strata outside the wet season. In Goa, their appearance in their habitat coincides with the southwest monsoons, and by late July and early August their sightings are frequent. The present sighting was recorded and specimens collected from the riparian forest patch of Tamdi Village (15.4390°N & 74.2526°E), in the vicinity of Bhagwan Mahaveer Wildlife protected area in Dharbandora Taluka of southern Goa. Across

their geographic range the whip scorpions find habitable space under logs, leaf litter, rotting wood, rocks, and other natural dark places (Kern & Mitchell 2011).

In Goa, the habitat of the specimens recorded and examined in this study, is typically a riparian forest in and around the perennial and ephemeral forest streams; the predominant terrestrial flora here being *Gnetum ula*, *Wagatea spicata*, *Lagerstroemia dalbergioides*, *Pandanus odoratissimus*, *Garcinia indica*, and *Entada scandens*. The general landscape here conforms to moist deciduous (3B/C2) and semi evergreen (2A/C2) forest types (Champion & Seth 1968) Some of the common tree species encountered are *Mangifera indica*, *Syzygium cumini*, *Schleichera oleosa*, *Pongamia pinnata*, *Tetrameles nudiflora*, *Bridelia retusa*, *Calophyllum inophyllum*, *Mallotus philippensis*, *Caryota urens*, and *Carissa carandas*.

The flora of the uropygid habitat assumes significance as these trees are the source of leaf litter and decomposing dead wood that create the microhabitat of the whip scorpion. Woodlands best indicate the importance of habitat heterogeneity for various animals. Leaf litter, branches and rotting logs at ground level in woodlands are known to influence soil arthropod diversity and species richness, and particularly increase species richness and changes in spider guild composition (Uetz 1979).

Gross Morphology & Morphometry

In situ specimens of both sexes present shades of bluish-grey on the dorsal tergal plates and dark reddish-brown on the underside sternal surface (see Images 2A,B). Sexes were separated on the basis of established differences in the shape of genital sterna, shape as well as size of opisthosoma and pedipalpal character (Gravely 1912, 1916; Weygoldt 1971, 1972, 1978; Yoshikura 1973).



Image 2. A - male & B - female *Labochirus tauricornis* (Pocock, 1899) in the forest litter of southern Goa, India

The genital sternum of the male was characteristically bulged and with hexagonal profile, where as that of the female was tapering posteriorly presenting a pentagonal margin. Similar sexual dimorphism is also reported in *Thelyphonus indicus*, Stoliczka (Rajashekhar & Bali 1982).

In mature individuals the pleural folds are prominently ridged and appear creamish-white. The paired pedipalps in these specimen are robust imposing articulate appendages with prey crushing interface, that operate within a horizontal plane, aid in prey capture, courtship ritual and spermatophore insertion in the genital operculum of the female (Harvey 2003). Pedipalps are also implicated in fights with same sex conspecifics, that are perceived as territorial trespassers or mate competitors.

In this investigation, much emphasis has been laid on understanding the functional morphology of the pedipalps and the associated structures. Comparative meristic data for both sexes has been tabulated (Tables 1, 2 & 3). The males are slender bodied with longer pedipalps, as compared to the stouter profile of the females and short yet stocky pedipalps.

The modified first pair of non-ambulatory legs are longer in the males. The opisthosoma in both sexes terminate into a pygidium from which arises a whip like flagellum (Images 3E,F). There is a single pair of laterally placed ommatoids on the pygidium, which appear as pale opaque spots. Usually the caudal flagellum is segmented, folded and aligns flat over the body in resting individuals, but at the slightest perception of disturbance, this caudal appendage is raised and strategically manoeuvred to spray the defence secretion ejected from the base of the pygidium which is narrow, tubular and stub like.

Arising from the antero-lateral aspect of the prosoma, pedipalps show discrete sexual dimorphism. In males the pedipalps are leaner yet longer, with their femur and tibia being almost double the length of its female counterparts.

In the genus *Labochirus*, the pedipalps show sexual dimorphism, in shape and measurement. The pedipalps of the male are longer than those of the female, which are short and stout (Images 3A,B). In males, the femur is clearly longer and the terminal pincer comprising of the patella, tibia and tarsus is characteristically angular (Image 4C). The 'thumb like' patellar apophysis of the male is much enlarged and elaborated and is of much taxonomic value. In the examined specimen of a male, patellar apophysial spines are irregular in placement, with only the apical spine being distinctly longer (Image 4C). In the female pedipalp, the articulation between

Table 1. Meristic characters of *Labochirus tauricornis*, Pocock (male)

Parts of appendages	Pedipalps (mm)	1 st leg (mm)	2 nd leg (mm)	3 rd leg (mm)	4 th leg (mm)
Coxa	5.3	3.6	4.1	4.1	4
Trochanter	4.1	2	3	3.1	3.5
Femur	11.1	9	5.7	7.1	7.9
Patella	7.9	11.4	4.2	4	4
Tibia	6.7	12.1	6.8	5.4	8.8
Pre-tarsus	-	-	1.5	1.5	2.1
Tarsus	4.6	7	3	3.5	4
Total length	39.7	45.1	28.3	28.7	34.3

Table 2. Meristic characters of *Labochirus tauricornis*, Pocock (female)

Parts of Appendages	Pedipalps (mm)	1 st leg (mm)	2 nd leg (mm)	3 rd leg (mm)	4 th leg (mm)
Coxa	4.7	3.1	3.7	3.7	4.8
Trochanter	4.8	2	3	3.3	4
Femur	4.9	8	5.8	5.9	7.3
Patella	4.5	10.4	4	3.5	4
Tibia	3	9.6	5	5	7
Pre-tarsus	-	-	1.4	1.7	2
Tarsus	3	5.3	3	4.7	3.5
Total length	24.9	38.4	25.9	27.8	32.6

Table 3. Comparative meristics of male & female *Labochirus tauricornis*, Pocock from Tamdi, Goa

Cumulative dimensions (in mm)	Male	Female
Prosoma total length	12.8	11.6
Total breadth	6.1	6.3
Opisthosoma total length	16.2	16.7
Total breadth	7.3	9
Flagellum length	26	22
Patellar spine length	2.6	3.1
Maxillary process length	6	3.4

the tibia and patella present a smooth convex profile of the terminal segments (Image 5C).

In the males, patellar apophysis is larger and points upwards, its terminal spine intersecting the base of the tibial finger (Image 4C). The tibia is longer and flat rather than with a curved dorsal profile as in females. The basitarsus is articulated with the tibia at almost a right



Image. 3. Stereomicrographs of various body parts of male and female *Labochirus tauricornis* Pocock collected from the locality of Tamdi, Goa

Note the longer and slender pedipalps of the male (Image 3A) as compared to the stout and shorter ones of the female *L. tauricornis* (Image 3B). The genital sternum (curved yellow arrow) is bulged in male and presents a hexagonal profile (Image 3C), whereas that of the female tapers posteriorly (Image 3D). Greater apposition manoeuvrability is apparent in the pedipalps of the male. Note the flagellum (red arrow) arising from the pygidium (black arrow) in both the sexes (Images 3E & 3F). In both the sexes, the flagellar articles show presence of stiff spine whorls at the articulating joints (Images 3G & 3H).

angle and the distitarsus is bent inwards. The overall size, profile and articulation of terminal segments, grant higher degree of manoeuvrability to the pedipalps in the males. Also, the somewhat worn out apex of patellar apophysial spine suggest its abrasion with apposing surfaces (Image 4D). Comparatively the chelate construct of male pedipalps allow better apposition between the patellar apophysis and tibia- tarsal complex for efficient grasping. That the pedipalps are used by males in mate acquisition, spermatophore transfer, besides defence purpose; further explains their different design and worn out spines, as compared to that of the

females.

Wherein the pedipalpal surface in females is relatively smooth and shows sparse pits (Image 5), that of males has prominent tuberculation (Image 4). The distitarsal segment in both sexes is devoid of serrations or teeth and has a relatively smooth surface and margins. In the females, the proximal tarsal portion is characterised by conspicuous denticulate knobs bordering the inner margin (Image 5D). These 'tarsal teeth' are arranged closely and form an opposing surface with the fixed tibial finger and a pincer with the patellar apophysis (Image 5C). The inner margin of the tibial finger has a row of

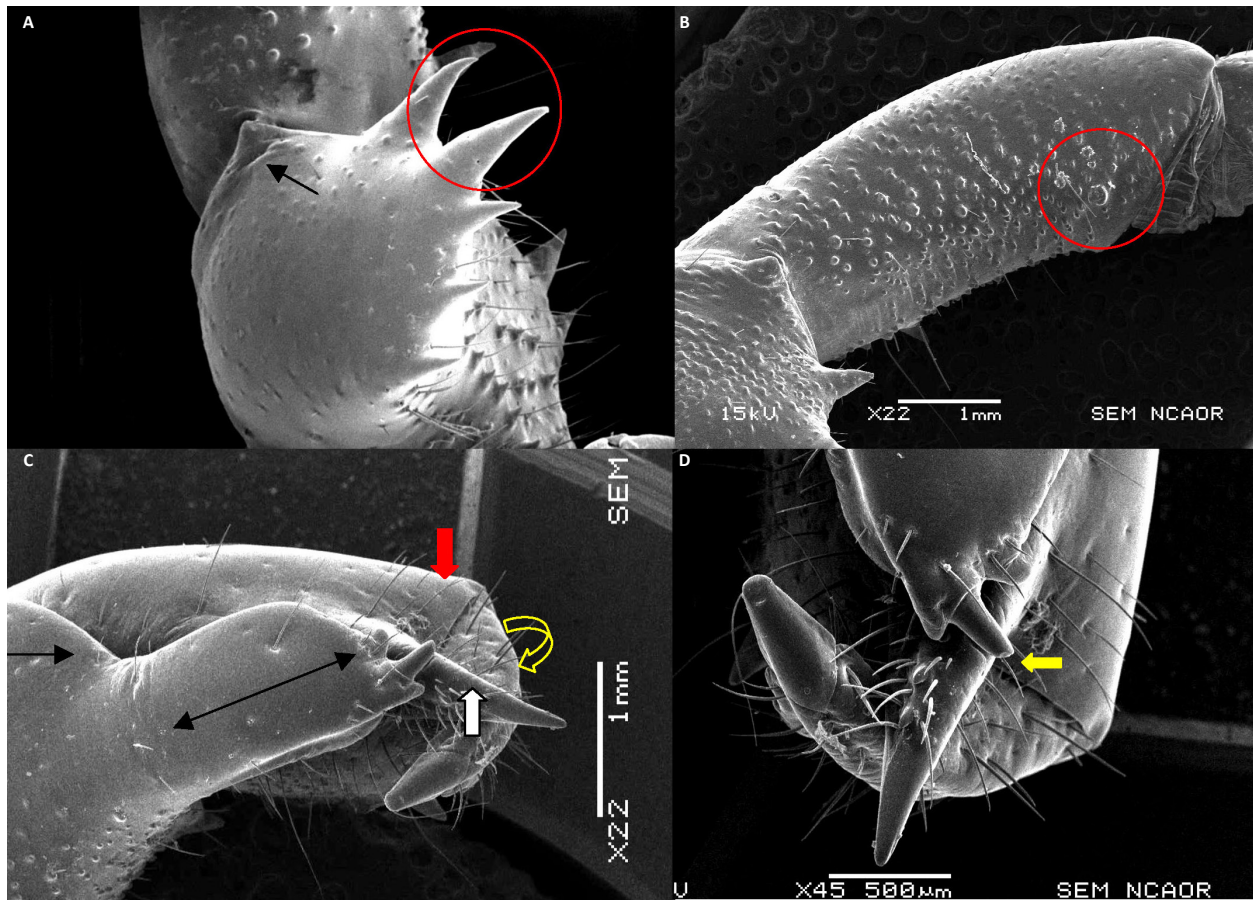


Image 4. Scanning electron micrographs of the pedipalpal articles of male *Labochirus tauricornis*

A - Trochanter is more bulged than flat, the spines being slightly curved than straight. The two proximal spines are almost equilength (circled). The trochanter surface shows tuberculate sculpting. The base of the triangular notch has a furrow lined by a ridge (single thin arrow head); B - Slender and longer femur with profuse closely arranged raised tuberculate sculping, a distinctly raised spinous knob on the inner surface (circled); C - Apposition of the patella (single thin arrow) with tibia (solid red arrow) and tarsus to form chelate terminus of the pedipalp. Note the extent of the apophysis (double sided thin arrow) almost reaching the articulation between tibia and tarsus (curved yellow arrow). Tarsal angle with tibia is acute and tibial finger (solid white arrow) extends beyond the edge of the tarsus giving a characteristic 'elephant head' like silhouette; D - Magnified view of strategic alignment of patellar apophysis, tibial finger and the tarsal claw of the pedipalp. Note the worn out and presumably broken end of the apophysial spine (solid yellow arrow).

spinous stubs extending from the base of the tibia to half the length of the tibial finger (Image 5C). Of these, the proximal ones are slightly longer and pointed. They are widely spaced as compared to the tarsal knobs.

DISCUSSION

Thus far, 103 species under 16 genera have been reported under the family Thelyphonidae from across the world (Harvey 2003). In India Bastawade (1988) reported *Labochirus tauricornis* under the subfamily Hypoctoninae (Pocock) and family Thelyphonidae (Lucas) from Kanara, Karnataka. Bastawade & Borkar (2008) reported this species for the first time in their preliminary arachnid inventory of the Zoological Survey of India State Fauna Series for Goa, based on specimens collected by Borkar; however, the material examined

were four females only and the approach was restricted to gross morphology alone. This is the first definitive record of occurrence of *Labochirus tauricornis* Pocock from Goa, with collection and detailed examination of individuals of both sexes; unlike the earlier report (Bastawade & Borkar 2008). The location of the present collection is a small hamlet called Tamdi in the Dharbandora Taluka of southern Goa, characterised by riparian patches of moist deciduous and semi evergreen flora. The present habitat is contiguous with the Bhagwan Mahaveer Wildlife Sanctuary of Goa. From the available distributional records in India, it seems that *L. tauricornis* has a restricted presence in a small stretch of Western Ghats in Karnataka and Goa.

Other species of Indian whip scorpion to have been recorded from several Indian states are: *Uropoctus*

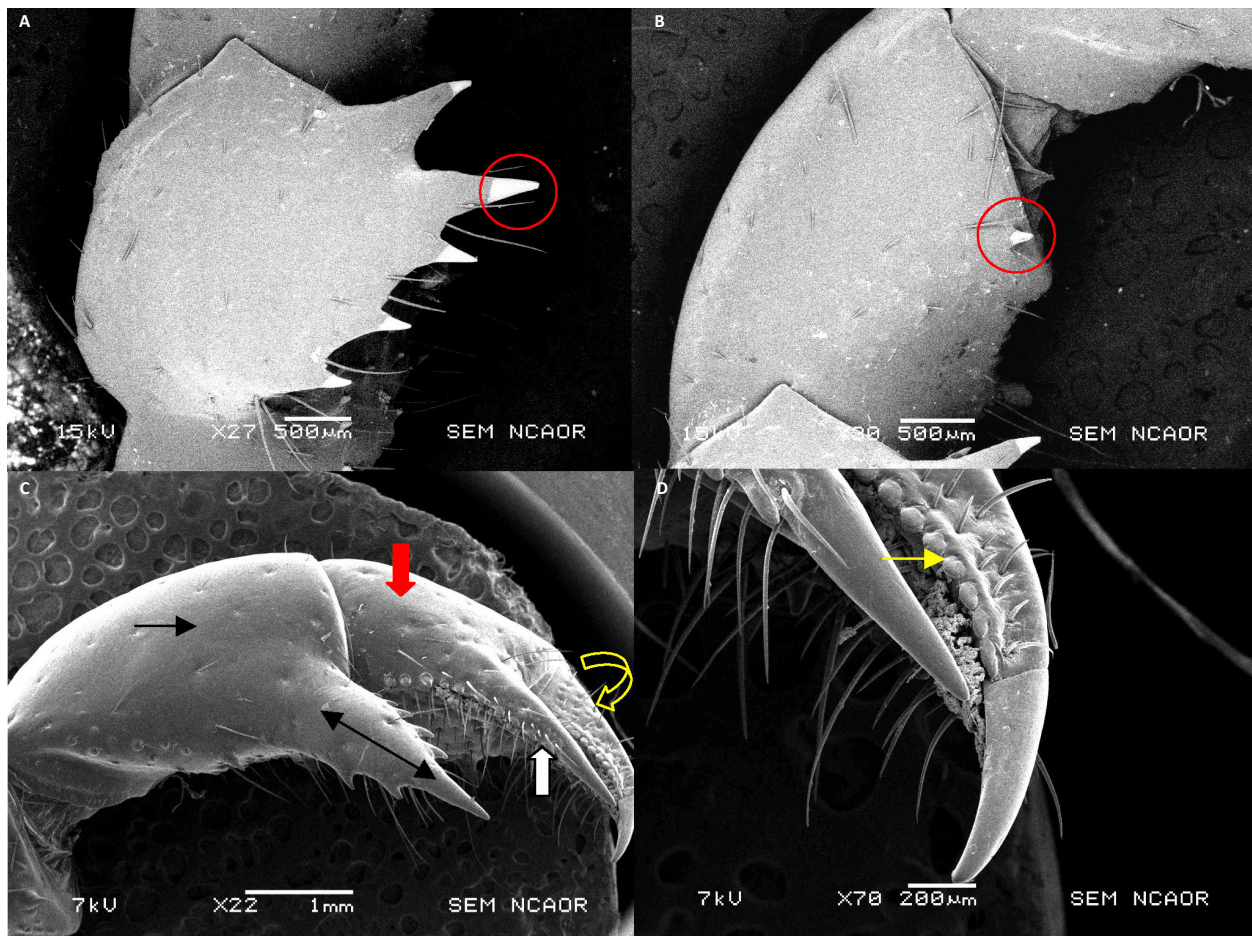


Image 5. Scanning electron micrographs of the pedipalpal articles of female *Labochirus tauricornis*

A - Dorsal surface of the Trochanter is relatively smooth and devoid of sculpting, its highest point being a sharp triangular notch pointing more inwards on the femur. Note the fringe of 5 solid pointed teeth on the internal border, the second being the longest (circled); B - Dorsal surface of the Femur shows a single conspicuous slender tooth on the inner margin (circled). Flexible cuticular membrane is seen at the articulation joint; C - Dorsal view of the patella (single thin arrow head) and patellar apophysis (double sided thin arrow). The patellar apophysis projects along the inner border with two teeth before apex. The low power electron-micrograph also shows discrete Tibia (solid red arrow) with a single immovable 'tibial finger' (solid white arrow) and tarsus with a movable 'tarsal finger' (curved yellow arrow); D - Inner margin of the tarsus shows a row of dentate knobs (thin yellow arrow) with a somewhat pointed apex and an inner row of 5-6 minute yet stiff and an outer row of 4 moderately longer spines. Also seen is a single typically socketed setum (trichobothrium) on the base of the pointed immovable tibial digit.

assamensis from Arunachal Pradesh (Bastawade 2006), and Jalda Village in Bilaspur Chattisgarh in central India (Sharma & Chandra 2012).

The elucidation of pedipalpal micro-morphology in the present study addresses the need to examine the particularly enlarged and elaborated patellar apophysis of the male of genus *Labochirus*, as being a valuable character for distinguishing species in uropygid systematics (Rowland & Cooke 1973). The data generated for morphometry and morphology of both sexes, besides the pedipalpal character of the examined specimen is in conformity with the description for *Labochirus tauricornis* by Pocock 1900. The SEM can be a particularly valuable tool in taxonomic investigation of smaller arachnid orders like Uropygi.

Since the first report of whip scorpion from Goa (Bastawade & Borkar 2008), no new species have been added to the uropygid list from this state. This could either suggest the presence of a mono-specific uropygid population in this state, or inadequate exploratory surveys dedicated to microdiverse arachnid orders. *Thelyphonus sepiaris* is the only uropygid that has been evaluated for its conservation status in the country under the aegis of Conservation Assessment and Management Plan workshop on selected soil invertebrates of southern India (Daniel et al. 1998). Perhaps this is because it has a wider distribution in India. The species is assessed as Near Threatened (NT) nationally, largely due to habitat loss; and as Data Deficient (DD) Globally. Intriguingly, no such data is available for the remaining thelyphonids

of India, including *Labochirus tauricornis*. But from the current status of known whip scorpion habitats in Goa, their existence in the precincts and proximity to protected areas of Bhagwan Mahaveer Wildlife Sanctuary keeps them inviolate.

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