TAXONOMIC STUDIES ON THE SCORPIONS (ARACHNIDA: SCORPIONES) OF KERALA WITH OBSERVATIONS ON THEIR ECOLOGY

Thesis
submitted to the University of Calicut in partial fulfillment of
the requirements for the award of the degree of

DOCTOR OF PHILOSOPHY IN ZOOLOGY
(Faculty of Science)

by

ASWATHI K.

Under the guidance of

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Mrs. Aswathi K has successfully qualified the Preliminary Qualifying Examination held on July, 2015 by the University of Calicut.

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DECLARATION

I do hereby declare that the thesis entitled **"Taxonomic studies on the scorpions (Arachnida: Scorpiones) of Kerala with observations on their ecology"** submitted by me to the University of Calicut in partial fulfillment for the award of the **Degree of Doctor of Philosophy in Zoology** included the data generated by the original research carried out by me under the supervision and guidance of Dr P. M. Sureshan, Scientist-D, **Zoological Survey of India, Western Ghat Regional Centre, Kozhikode.** The work has not been submitted to any University or Institution for the award of any degree. I further declare that the findings of this research contribute in general to the advancement of knowledge in Science and in particular to scorpions of Kerala state, India.

Kozhikode **Aswathi K**

12. 03. 2018

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Aswathi K

Dedicated to My Family

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CHAPTER 1
INTRODUCTION

1.1. Biodiversity: Taxonomy

A variety of life on earth includes the variations at all levels of biological organization. Biodiversity includes a number of components of genetic, organism and ecological diversity (Gatson and Spicer, 2004). The main reasons for the depletion of biodiversity include climate change, habitat destruction, human overpopulation, over exploitation of natural resources and pollutions. Convention on Biological Diversity (2010) made huge funds to promote the biodiversity studies. Taxonomy is an essential science of classification and description of organisms, in biology (Lincoln et al. 1998; Wagele, 2005; Sureshan, 2012). Obviously, taxonomy plays an important role, about 1.7 million species have been named since Linnaeus and it is estimated only around 5-10% of the world's biota has been described so far (Wilson, 2000; Disney, 2000). Devoid of taxonomy, no one would be sure on the identity of organisms they were interested in, and without taxonomy, we could not understand biodiversity and related issue on its conservation (Nature, 2002). The projects are mostly aimed at providing services to taxonomy through technology or to develop the approaches to taxonomy via modern molecular studies. Recently the attitude towards traditional taxonomy was overly neglected and has been, worldwide it is facing a serious distress. The traditional and novel ways are essential to know the biodiversity and due to the result of an unwise policy in the era of biodiversity leads to the demise of traditional taxonomy (Boero, 2010)

Researchers in other areas like ecology, conservation, pest management and naturalists would have to pay sufficient attention to taxonomy in order to identify animals and plants (Godfray, 2002). The

impediment inhabits the ability to analyse community-level phenomena by ecologists working in the tropics felt lack of taxonomic knowledge (Brosnan, 1992), taxonomy do facilitate, not obstruct, ecological and biodiversity studies (Wheeler et al. 2004). In fact, one of the main reasons for the "bad image of taxonomists are the taxonomists themselves; they have not been able to sell their product" properly (Guerra-Garcia et al. 2008). The fundamental query of biology is that how many species inhabit on earth, even if the discovery of many organisms is progressing at the same time many are vanishing. This is mainly due to the issues facing ourselves- 1) invasive species, 2) climate change, 3) loss of biodiversity as a result of over-exploitation and habitat destruction, 4) the need for authoritative taxonomic information is higher than ever.

The basic taxonomic data on any organisms are very important to every user of biodiversity information. The users include not only other taxonomists but also all others are important to achieve a greater impact on taxonomy (Zhi, 2011). Nowadays the attitude towards traditional taxonomy is fortunately changing and is given some light by the advances in molecular techniques/phylogeny statistics development, an initiative in new taxonomic funding and global projects. However, the overriding of modern techniques on traditional taxonomy should be avoided and both should be brought under same umbrella.

1.2. Arthropoda: Arachnida: Scorpiones

Arthropoda, the largest and the most diverse phylum represented 1, 242, 040 species or about 80% of the total (Zhi, 2011). They are very sensitive in nature and are not able to withstand if the environment is disturbed. Around 85% of the soil fauna is represented by arthropods in terms of their species richness (Thomas, 2013). Some arthropods are considered as soil 'litter transformers' or 'ecosystem engineers'. The former humidify the

ingested plant debris, thereby improves the soil quality and the latter which physically modify the habitat (Jones et al. 1994).

The class Arachnida, one of the major classes of phylum Arthropoda, represented 112, 201 species (Zhi, 2011). The order Scorpiones of class Arachnida includes all scorpions of the world. Scorpions are macro arthropods, females are usually larger than males and can be separated by the shape of genital operculum and pedipalp. The body of the scorpion is divided mainly into two parts namely, trunk and tail or cauda. The trunk comprises the cephalothorax (prosoma) and the pre-abdomen (mesosoma). The cauda consists of five post-abdominal segments and the sting bearing telson (Ametasoma) (pre and post-abdomen plus telson=opisthosoma). Prosoma is composed of unsegmented carapace with a pair of median eyes, and three to five pairs of lateral eyes, frontal area or anteocular triangular is the area between the eye-groups. Anterior margin of the carapace notched medially or straight. Chelicerae present in front of the carapace with movable and immovable fingers. Pedipalp is mainly divisible into coxa, femur, patella and chela (manus plus movable and immovable fingers). Mesosoma dorsally consists of seven tergites and ventrally with sternites, sternum, genital operculum and pectines. Four pairs of legs present on mesosoma, each is divided into coxa, femur, patella, tibia, tarsomere I and tarsomere II. Metasoma comprises five segments plus telson. Telson comprises vesicle and aculeus (Stahnke, 1970).

1.3. Scorpions: the focal group for taxonomic study

Scorpions are terrestrial, venomous arthropods belonging to the order Scorpiones of class Arachnida. They represent one of the oldest arthropods since their continued success over the past 450 million years. Scorpions are known for their notorious nature due to their poisonous sting, though the venom of only a few species of scorpions is lethal to man. They are

ubiquitous except in Antartica and are common in tropical and subtropical regions. Scientists interested in scorpions are captivated by their great antiquity and the excellent suite of physiological, biochemical, behavioural, and ecological adaptations since dates back to their appearance in the middle Silurian that is about 425-450 million years ago. Scorpions are strictly nocturnal in habits usually seen under medium to large stones, barks, thin crevices, burrows and occasionally in dark corners of houses. They are strictly carnivores in nature and feed mainly on soft-bodied insects, spiders, small lizards. In the terrestrial ecosystem, scorpions play an important link in the food chains and also act as bioindicators of the health of the ecosystem too. Scorpions inhabit specific microhabitats in the terrestrial ecosystem and potentially are an important group of an organism for ecological studies because their diversity appears to correlate with habitat characteristics and are sensitive to environmental changes. They are of ecologically and medical importance, which is not quite, appreciated owing to their fearsome appearance, venomous nature and painful bite (Polis, 1990).

Globally, there are 2338 species of 198 genera belonging to 17 families known to occur (http://www.ntnu.no/ub/scorpion-files/intro.php). Members of 6 families under 25 genera and 117 species are known to occur in India. Six families in India includes Bothriuridae (1 species), Buthidae (60 species), Chaerilidae (6 species), Euscorpiidae (18 species), Liochelidae (8 species) and Scorpionidae (24 species) (http://www.scorpiones.PL). According to the present study, of the six families in India include only three families viz. Buthidae, Liochelidae and Scorpionidae are known to occur in Kerala. Despite having a rich fauna, systematic studies on the scorpions is still in an infantile stage in India especially in south India when compared to the north-east states of the country and the world studies (Tikader and Bastawade, 1983).

The important and major taxonomic characters for the identification of scorpions include the cheliceral dentition. Vachon (1956, 1963) recognized that dentition as rather consistent within the families and genera. According to the morphology of cheliceral dentition in scorpion, families are arranged into four types. The families Buthidae, Chaerilidae and Luridae each have unique dentition, and the remaining families have the fourth basic type (Sissom, 1990). Trichobothria, fine hairs present on the segments of pedipalp, the numbers and patterns are the most useful external character used in scorpion systematics. Actually, the nomenclature system proposed by Vachon (1973) is quite simple. Three types of trichobothrial patterns occur among scorpions viz. Type 'A, B and C'. Type 'A' pattern could be seen only in the family Buthidae with two different configurations, α and β present on the femur of pedipalp (Vachon, 1975). Type 'B' is present only in the Chaerilidae and the remaining families have Type 'C' pattern. The shape of the sternum is another taxonomic character used for the identification of scorpions namely subpentagonal, subtriangular and broadly slit like (Petrunkevitch, 1953). Leg spination includes the presence and absence of tibial and pedal spurs, have taxonomic value at the generic and species levels especially in the families Bothriuridae and Buthidae (Sissom, 1990). Telson the last segment or part of metasoma often bears a raised protuberance underneath the curvature of the aculeus. The protuberances are of different structure (Lourenço, 1983). The male genitalia have great importance in scorpion taxonomy, which was recognized by Pavlovsky (1924). Pectinal tooth count, carinal structure, granulation and dentition on pedipalp chela, shape of book lung spiracles, and structure of tarsi are also used as major characters in the scorpion systematics.

1.4. Scorpions: biological roles

1.4.1. Habits and habitats

All scorpions are active during night and are strictly nocturnal in habit. Every species of scorpions are specific in the selection of their habitat. In case of scorpions, their habitats are known as ‘microhabitats'. Microhabitats include stones, barks, thin crevices, burrows, fallen logs, soil litters and human inhabits (Tikader and Bastawade, 1983).

The ecological studies on scorpions in India are at an early embryological stage. According to the habitats, the scorpions are divided into three as burrowing (Psammophilous and Pelophilous), rock-dwelling (Lithophilous) and arboreal. Many genera of the family Buthidae are almost exclusively bark scorpions (Kjellesvig-Waering, 1966) and these bark scorpion, may also be associated with fallen logs, soil litters, and human dwelling (Stahnke, 1966). Arboreal scorpions sometimes live at great heights, for example, *Liocheles australasiae* lives on branches of pine at heights of up to 40 m (Koch, 1977). Psammophilous scorpions are unable to dig or burrow in harder soil, but they are adapted to loose sand. Generally, such scorpions burrow to a depth of 0.3-1 m below the surface (Polis et al. 1986)

Some scorpion species live in burrows during daytime and climb onto shrubs and herbs at night (Polis, 1979). Ground-dwelling scorpions build burrows and also live in rock crevices, under rocks, logs, and soil litters. Sometimes scorpions live in burrows made by other animals (Polis, 1990). Several species of scorpions live in caves, but the species *Alacran tartarus*, is found at depths of more than 800 m (Francke, 1982). The species of the genus *Heterometrus* usually burrowing in habit and the burrows are protected by boulders and are not more than 6” to 9” deep. Buthid species burrows are very difficult to locate as they are small in diameter. Some buthids could be seen in

colonies and all the members of a colony live in the same burrow or hole. Some scorpions live among plants near the seashore and are able to remain under tidal water for a short time, but most of the scorpions avoid water. Cave dwelling scorpions lack both eyes and pigments (Tikader and Bastawade, 1983).

1.4.2. Feeding activities and foraging behaviour

Scorpions are strictly carnivorous in habit. The food of scorpions ranges from small soft-bodied insects to small mammals like rodents. Prey capturing in scorpions is quite interesting, if the prey moving within 15 cm from the scorpion are located and sensed by tarsal sense organs and captured in a single motion; prey more than 30 cm away from the scorpion is located by a series of orientation responses; scorpions trichobothria, the long and very fine, thin sensory hairs scattered on the segments of pedipalp are used to detect the prey if they betray their position by producing air movements. Trichobothria are also used to orient accurately towards insects flying within 10 cm of the scorpion and then captured the prey in midair with a very rapid grab by the pedipalps (Le Berre, 1979). Depending on the ratio of prey size to scorpion pedipalp size, they may or may not sting. Generally, large scorpions avoid sting on small prey, especially if the prey is secured in the pedipalps. Usually smaller species of scorpions would necessarily sting their prey (Casper, 1985). Some scorpions remain motionless within a meter of the burrow opening; insects and other prey are detected by the waiting scorpion as they pass close. Most of the scorpions eat their prey outside the burrow, usually from the area where they are caught (Hardley and Williams, 1968).

Some of the arboreal scorpions foraging at night by moving around the branches of young *Acacia* trees and during daytime they are retreated under the bark of older and dead trees (Newlands, 1978). Scorpion species feed within shallow burrows just under logs, small pieces of wood and cow dung.

The difficulties of observing within the burrow obstruct the study of many aspects of scorpion ecology (Mac Cormick and Polis, 1990).

Scorpions use their chelicera to initiate digestion by tearing the prey into small pieces. Digestion of the food may take from one to several hours (Eastwood, 1978; Mac Cormick and Polis, 1990). Actually, the digestion begins outside the mouth, used by the digestive juices from the gut. Scorpions usually have a low metabolic rate, but the metabolic rate increased markedly with temperature (John et al. 2001). Some scorpion species may survive for 6 to 12 months or more without food (Stahnke, 1945, 1966). Cannibalism is very rarely found in these animals, sometimes the males are eaten by females after mating (Polis and Sissom, 1990).

1.4.3. Venom of scorpions

Scorpion envenomation plays drastic effect on farmers, farm labours, villagers, hunters and migrating populations. The family Buthidae occupies all the venomous scorpion species, except for the species *Hemiscorpius lepturus*. The notorious genera found in the family are, *Hottentotta*, *Parabuthus*, *Buthus*, *Tityus*, *Leiurus*, *Androctonus*, *Centruroides* and *Mesobuthus*. Since scorpion sting is not listed as a notifiable disease, most of the victims prefer to consult traditional healers. Thus the morbidity and mortality are scarce. According to the scorpion species, the lethality of venom varies. The species under the family Scorpionidae evokes severe pain which radiates along with corresponding dermatomes, whereas the sting by buthids can result in a life-threatening effect. The LD50 of some scorpion neurotoxins are ten folds more potent than cyanide. Most lethal scorpions include the yellow scorpion *Leiurus quinquestriatus* and *Mesobuthus tumulus* (Bawaskar and Bawaskar, 2012).

In children, the scorpion sting envenomation is an acute life - threatening emergency, and the therapy with Prazosin may be life -saving (Ramesh et al. 2011). Certain aspects of scorpion venomology and toxicology, continue to provide the scientists with unique tools for investigations such as studies on the Na^+ channel of excitable membranes, the phylogeny of proteins, and structural function relations of proteins (Simard and Watt, 1990).

1.4.4. Reproduction in scorpions

Scorpions have ritualized and complex courtship with fertilization by means of the spermatophore. They are viviparous in nature, which lasts from several months to almost two years. Maternal care is well noticed social behaviour and post-embryonic development might be extraordinarily long and lasting from 7 to 85 months. The courtship and mating are very interesting in scorpions. The sperm transfer in scorpions is a complex process involving several aspects of behaviour. Reproduction process can be summarized by the classical 'Promenade à deux' or mating dance, in which the male approaches the female and grasp the chelae fingers. Then the male leads to to and fro movements until he has been found a suitable substratum to deposit his spermatophore, this process may last for several minutes. In the next step, the male brings the female to position her genital operculum over the deposited spermatophore, and the female takes up the sperm. After the completion of sperm transfer by the female, normally they separate. Males are able to mate more than once. Considerable evidence is there that the newly mated males can produce new spermatophores and within a short period of time they can mate again (Lourenço, 2000 a). Cannibalism by the female of the male among scorpions is exaggerated and this only happens in certain species (Polis and Sissom, 1990).

In most of the scorpion species, the process of parturition is almost same, but the duration of the process may vary. Several hours before birth, female scorpions maintain a stilting posture. A 'birth basket' is prepared underneath the mesosoma, in the proximity of genital opercula by flexing of pedipalps and the first two pairs of legs. The young emerge one by one through the opened genital opercula into the 'birth basket'. After a short period of time, they become active and climb up the female's legs or pedipalps until they reach her back. The litter size is variable according to the species of scorpions, ranging from 3-4 to 105-110 young per brood. The young stay with the mother until their first moult. The lifespan of scorpions may vary, ranging from 4 to 25 years (Lourenço, 2000 a). Parthenogenesis in scorpions was discovered by Matthiesen (1962) in Brazilian species *Tityus serrulatus* Lutz and Mello.

1.4.5. Fluorescence in scorpions

A well-known phenomenon in scorpions is the fluorescence in ultraviolet light, which was discovered more than 60 years ago. The epigean species of the family Chaerilidae, living in rainforests and mountain forests, and both soil-dwelling and cave species have a negative reaction to the ultraviolet light. This excludes the possibility of any ecological adaptation. However, in other families like buthids, fluorescence is observed among species inhabiting all types of ecological environment (Lourenço, 2012 a). Fluorescence that act as a protection against ultraviolet light, and also considers this as a relict function given the usual nocturnal habits of scorpions (Lourenço and Cloudsley Thompson, 1996; Frost et al. 2001). Scorpion fluorescence act as a prey attractant revealed that the aerial insects are more likely to avoid fluorescing scorpions than being attracted to them (Kloock, 2005). In the studies of zoologists and ecologists, the presence of fluorescence under ultraviolet light is an important and useful tool, but the function of

fluorescence remains an enigmatic question to be answered by eco-physiologists (Lourenço, 2012 a).

1.5. Objectives of the study

- To make a systematic revision of the scorpions (Arachnida: Scorpiones) of Kerala which includes the habitats of southern Western Ghats by undertaking extensive field surveys and collection of specimens from different ecosystems.
- To describe new taxa and redescribe known taxa of scorpions of Kerala based on the material to be collected through field surveys and studies on collections deposited in Zoological Survey of India (ZSI), Western Ghat Regional Centre, Kozhikode.
- To prepare identification keys to genera and species of scorpions occurring in Kerala for stabilizing the systematic status of species.
- To provide basic knowledge about the ecology of scorpions of Kerala such as microhabitat preferences, and the distributional patterns of them in relation to the various ecological and physio-geographic parameters.

1.6. Scope of the study

- Scorpions are ancient, medically important, ecologically, morphologically and taxonomically diverse group of animals and distributed in most terrestrial habitats. They form a rewarding group of arthropods for various aspects of scientific studies such as systematics, biology, ethology, ecology, etc.
- Systematic studies on the scorpions have so far been restricted to the North and North-Eastern states of India and selected parts of Deccan

plateau. Since no serious studies have been undertaken on the scorpions of Kerala, it is imperative to undertake a detailed systematic study on the scorpion fauna occurring in Kerala and habitats of Southern Western Ghats in order to fill the gaps in the systematic knowledge about the group.

- The ecological role played by scorpions in the terrestrial ecosystem is a totally unrevealed area of research, hence a preliminary approach is proposed.

- Detailed observations on the patterns of distribution of scorpions in relation to various ecological and physio-geographic parameters will be useful to understand their ecological role and the bio-geographic affinities of the fauna occurring in the area.

CHAPTER 2
REVIEW OF LITERATURE

2.1 Major historical review on worldwide studies of order Scorpiones

The taxonomic studies on scorpions were initiated by Linnaeus (1758) who had described five species of scorpions belonging to the single genus *Scorpio* of the family Scorpionidae viz. *S. maurus*, *S. australis*, *S. afer*, *S. europaeus* and *S. americus* among "Insecta Aptera" in the 10th edition of '*Systema Naturae'*. Later the diagnosis provided by him was misunderstood by many other workers due to brevity.

Herbst (1800) included many scorpion species descriptions in the "Natural system of the winged Insects". The family *Scorpionidae* was erected by Latreille (1802). Leach (1815) discovered the genus *Buthus*. The genus *Isometrus* was defined by Hemprich and Ehrenberg (1828) and they divided the genus *Buthus* into a subgenus *Heterometrus*. Koch (1836) presented several original descriptions of the scorpion species. Later Peters (1861) elevated the subgenus *Heterometrus* into genus rank. In the same year, Peters erected the first family Diplocentridae. Simon (1872) studied the scorpions and revised the genus, *Heterometrus* Ehrenberg. Thorell (1876 a) dealt with the classification of scorpions of the world. He also distinguished the Indian and African species and placed the Indian forms into the genus *Heterometrus* and African forms into the genus *Palamnaeus*. Along with this, Thorell in the same year discovered the scorpion families Vaejovidae and Iuridae. The largest family Buthidae was erected by Simon (1879). Simon (1880) proposed the family Bothriuridae. Pocock (1893 a) established the family Chactidae, most of the species were described recently and also proposed the family Chaerilidae and Hemiscorpiidae. The family Hemiscorpiidae was previously

known as Ischnuridae, Simon. Laurie (1896) discovered the families Euscorpiidae and Hormuridae. The family Hormuridae was previously placed as a subfamily in the family Hemiscorpiidae Pocock. Kraepelin (1899) studied the Scorpiones including six families viz. Buthidae, Scorpionidae, Chaerilidae, Chactidae, Vaejovidae and Bothriuridae.

The family Carboctonidae was defined by Kraepelin (1905), the family was established by Soleglad and Fet in their major revision of higher scorpion systematics. He also erected another family Heteroscorpionidae in the same year and the family is endemic to Madagascar. Birula (1910) published *Scorpio maurus* Linnaeus and its subspecies. The family Superstitioniidae was erected by Stahnke (1940), which was represented only by one genus and one species viz. *Superstitionia* and *S. donensis.*

Vachon (1952) studied the scorpions of Africa, which included the morphology, classification, biogeography and description of scorpions under three families viz. Buthidae, Scorpionidae and Chactidae. Matthiesen (1962) noted the parthenogenesis in scorpions. Stahnke (1970) presented the nomenclature and mensuration of scorpions. The family Typhlochactidae was erected by Mitchell (1971) and the family includes four genera and eleven species. Vachon (1973) provided a knowledge of the characteristics used to classify the genera and families of Scorpionida (= Scorpiones) and also studied the trichobothria among scorpions. Koch (1977) discussed the ecology, behaviour, taxonomy and zoogeography of Australo-Papuan scorpions.

Bruno (1979) published the scorpions of Namibia that includes the description of species, identification keys and locality details. The behaviour and ecology of mating in the cannibalistic scorpion species *Paruroctonus mesaensis* Stahnke were discussed by Polis and Farley (1979). Francke (1980) revised the genus *Nebo* Simon and described four new species viz. *Nebo*

grandis, Nebo henjamicus, Nebo omanensis, and *Nebo yemenensis,* Couzijn (1981) revised the genus *Heterometrus* Hemprich and Ehrenberg. Formerly the scorpions were classified under the order Scorpionida, which was later raised to the rank of class with three orders, Protoscorpiones, Palaeoscorpiones and Scorpiones (Stockwell 1989)

Hjelle (1990) studied the anatomy and morphology of scorpions. Polis (1990) dealt with the various aspects of scorpions in the book 'Biology of scorpions'. Pointer (1991) presented the family Scorpionidae and the genus *Heterometrus* Ehrenberg. Kovarik (1994) discussed the taxonomic position of the three *Isometrus* species with the description of a new species from Malaysia and Indonesia. Lourenço and Cloudsley (1996) studied the evolutionary significance of colour, colour patterns and fluorescence in scorpions.

Notes on the taxonomy of some scorpions of the families viz. Buthidae, Chactidae, Ischnuridae and Scorpionidae was proposed by Fet (1997). He discussed that no nomenclature problems inside the old world scorpion fauna created by many generations of scorpion taxonomists. Kovarik (1997) revised the genera *Lychas* Koch, and *Hemilychas* Hirst, with the description of six new species and a key to the genus *Lychas*, was also provided.

The family Pseudochactidae was proposed by Gromov (1998). Lourenço (1998) discovered the family Troglotayosicidae and it is a small family represented by two genera and six species. So far only three genera and six species were described under this family. The sexual population of one of the morphs *Tityus serrulatus* Lutz & Mello, within the complex *Tityus stigmurus* was discovered by Lourenço and Cloudsley (1999).

Fet et al. (2000) studied the entire scorpion species described until 1998. Revision of family Scorpiopidae, with descriptions of six new species, was proposed by Kovarik (2000 a). He also provided the checklist and a key to the genera and species of the family Scorpiopidae. Kovarik (2000 b) revised the family Chaerilidae, Pocock and the genus *Chaerilus*. Lourenço (2000 a) provided all aspects of scorpion reproduction and especially parthenogenesis in scorpions. Lourenço et al. (2000) described the stridulatory apparatus of some species of the genus *Rhopalurus* Thorell.

Fet and Bechly (2001) changed the name of the family Ischnuridae into Liochelidae. The reason for the change was the conflict between the subfamily name of dragonfly Ischnurinae and scorpion family Ischnuridae. Revision of the synonyms and subspecies of the genus *Opistophthalmus* Koch was done by Prendini (2001). Soleglad and Sissom (2001) proposed the revision of the family Euscorpiidae with the inclusion of the family Scorpiopidae and the chactid genus *Chaerilus*.

Fet et al. (2002) reanalyzed the scorpion species described by Linnaeus in 1758. Lourenço (2002) published the scorpions of Brazil, which includes the taxonomy, biology, ecology and biogeography.

Fet et al. (2003) proposed the first molecular phylogeny of the family Buthidae. A review of the genus *Isometrus* Ehrenberg with descriptions of four new species from Asia and Australia was published by Kovarik (2003). Soleglad and Fet (2003) attempted the phylogeny and higher level systematics of the extant scorpions. They provided the detailed classification, taxonomic history and diagnosis of all scorpion taxa above genus level and also discussed the phylogeny and biogeographical contributions.

Kovarik (2004 a) dealt with the taxonomic position and revision of one Asian genus *Orthochirus* Karsch, and six genera viz. *Afghanorthochirus*

Lourenço & Vachon, *Baloorthochirus* Kovařík, *Butheolus* Simon, *Nanobuthus* Pocock, *Orthochiroides* Kovařík, *Pakistanorthochirus* Lourenço, with descriptions of twelve new species. Kovarik (2004 b) revised the genus *Heterometrus* Ehrenberg, with the description of seven new species, four species from India, one species each from Nepal, Thailand and Vietnam and a key was provided to all species except *H. tristis*.

Fet and Soleglad (2005) approached on the recent changes in higher level taxonomy and the contributions to scorpion systematics. Fet et al. (2005) dealt a new trichobothrial character for the high-level systematics of Buthoidea. Description of two new species of *Tityus* Koch and discussion on scorpion diversity and endemism from Bazilian Amazonia was proposed by Lourenço (2005). Prendini and Wheeler (2005) presented the scorpion higher phylogeny, classification and taxonomic anarchy. Rolando & Montano (2005) revealed the presence of two families, Buthidae and Scorpionidae with the first record of three species including some ecological aspects and geographical distribution from Cuba. Rolando & Pérez Bote (2005) recorded the second finding of *Buthus ibericus* Lourenço & Vachon from Spain and Portugal including the morphological variability, ecology and geographical distribution.

Kovarik (2006) reviewed the Tunisian species of the genus *Buthus* and described two new species. He also discussed and revalidated the Ehrenberg's types. Lourenço (2006) outlined the relationships of several species of the genus *Buthacus* Birula distributed in northern Africa and the Middle East with the discovery of one new species and two subspecies from Algeria and Morocco. Lourenço et al. (2006) reviewed the distributional patterns of Malagasy scorpions belonging to the endemic genus *Neogrosphus* Lourenço from the southern and western parts of the Island. Rolando (2006 a) dealt with the updated key which covers all the taxa of the genus *Centruroides* Marx

including the description of two new species from Cuba. Rolando (2006 b) described two new species from Cuba with notes on the taxonomy and biogeography of the genus *Rhopalurus* Thorell**.** Revision of the "*Tityus crassimanus*" group, and a new species description from the Dominican Republic with a key to identify five endemic species from the Greater Antilles was presented by Rolando and Armas (2006).

Kovarik (2007) published the revision of the genus *Hottentotta* Birula, along with the description of four new species from different parts of the world and a key to species was also provided. A new family Akravidae was discovered by Levy (2007), from the Ayalon cave in Israel. He was not able to collect live or recently dead specimen. Rein (2007) updated the taxonomy of the family Bothriuridae based on the catalogue of the scorpions of the world (1758-1998) and Fet et al. 2000, Part I.

Lourenço (2008) discussed the history and new data of parthenogenesis in scorpions. Vignoli and Salomone (2008) proposed the review of the scorpion genus *Euscorpius* Thorell and every species is presented briefly with notes on taxonomy, distribution and ecology.

De Souza et al. (2009) revised the genus *Tityus* and included the *Tityus stigmurus* complex erected by Lourenço. Fet et al. (2009) reviewed the genus *Calchas* Birula of the family Luridae Thorell with the description of two new species. The genus *Scorpio* Linnaeus from sub-Saharan Africa was reanalyzed and described one new species from Cameroon by Lourenço (2009). Vignoli and Prendini (2009) published a systematic revision of the family Typhlochactidae Mitchell endemic to eastern Mexico.

In vitro physiological studies of envenomation, clinical and epidemiology of scorpion species *Hemiscorpius lepturus* from Iran was reviewed by Jalali et al. (2010). Kovarik et al. (2010) proposed the revision of

the *Iurus* Thorell and described two new species from Turkey. They presented the distribution map for the genus *Iurus* based on 198 localities.

Botero-Trujillo and Florez (2011) discussed the value of trichobothria and hemispermatophore for scorpion taxonomy and revised the Colombian *Ananteris* with the descriptions of two new species. Kovarik (2011) described two new species of the *Pandinus (Pandinus) ugandaensis* from Uganda and *Pandinus (Pandinus) mazuchi* from Ethiopia along with the review of the genus *Pandinus*, Thorell. They discussed the diagnosis, descriptions and provided distribution maps for the species. Monod (2011) discussed the taxonomic emendations of the genus *Liocheles* Sundevall. Ochoa et al. (2011) provided the systematic revision of the genus *Orobothiurus* Maury (Bothriuridae) and discussed the altitudinal records for scorpions. Warburg (2011) published a partial review of scorpion reproductive strategies including the allocation and potential.

The revision of the genus *Microtityus* Kjellesvig-Waering, with the discovery of five new species was presented by Armas and Teruel (2012). Kovarik (2012 a) published an identification key of the genus *Compsobuthus* Vachon and three species was described from different parts of the world. Kovarik (2012 b) performed a review of the subgenus *Pandinurus* Fet with the descriptions of three new species viz. *Pandinus (Pandinurus) awashensis* from Ethiopia, *Pandinus (Pandinurus) somalilandus* from Somaliland, and *Pandinus (Pandinurus) lowei* from Democratic Republic of Congo. Kovarik and Lowe (2012) reviewed the genus *Neobuthus* Hirst with a new species description from Africa and also presented the key characters distinguishing between the genera *Neobuthus* and *Butheolus* Simon. Navidpour (2012) presented the review of the genus *Hottentotta* Birula of Iran. Soleglad et al. (2012) published a further revision of *Iurus* Thorell with the description of a new genus *Protoiurus* and two new species.

Al-Asmari et al. (2013) provided a historical review of the scorpions of Saudi Arabia and the study revealed the presence of 28 species and subspecies under three families. Di et al. (2013) presented the historical review of the taxonomical studies on scorpions and highlighted the updated checklist, distribution, and key to the scorpions from China and the study revealed the occurrence of 53 species and subspecies of 12 genera belonging to five families, of the 53 species 33 species and 1 genus were endemic to the country. Gonzalez-Santillan & Prendini (2013) redefined and revised the genera of the Vaejovid subfamily Syntropinae Kraepelin with the descriptions of six new genera. The revision on the Neotropical scorpion genus *Chactopsis* Kraepelin was discussed by Ochoa et al. (2013). They provided the new diagnostic characters for already described species, trichobothria patterns were reillustrated and for the first time, hemispermatophore was described. Kovarik (2013 a) published an illustrated catalogue of scorpions, which includes two families Chaerilidae, Buthidae and five genera viz. *Compsobuthus*, *Hottentotta*, *Isometrus*, *Lychas* and *Sassanidotus*. He described eight new species of the family Buthidae and the catalogue contains 332 species including 143 synonyms of which 19 were new. Kovarik and Ahmed (2013) described two new species from Pakistan and India along with the review of *Androctonus finitimus* (Pocock, 1897). Ojanguren Affilastro (2013) reviewed the family Bothriuridae and key to identify up to generic level was provided. Santibanez-Lopez et al. (2013) studied the systematics of the *keyserlingii* group of *Diplocentrus* Peters. Turiel (2013) presented the review of the genus *Androctonus* Ehrenberg, which covers the taxonomy, species description, distributions and identification keys.

Lourenço (2014 a) approached the historical scorpion studies with special reference to 20^{th} and 21^{st} centuries. Lourenço (2014 b) reviewed the biogeography of the scorpions of Southeast Asia (and Wallacea). Lowe et al. (2014) discovered four new species of scorpions from the Arabian Peninsula

along with the review of the genus *Leiurus* Ehrenberg. A key to identify the species of the same genus, and distribution maps were also provided. Monod and Prendini (2014) presented the evidence for Eurogondwana which included the major revision including the status of many taxa, the revalidation of taxa and the role of dispersal, extinction, vicariance in the evolution and biogeography of Indo-Pacific Hormuridae.

Brito and Borges (2015) proposed a checklist on scorpions of Ecaudor with notes on the distribution and medical significance of some species. Gonzalez-Santillan and Prendini (2015) implied a systematic revision of the scorpions with subaculear tubercle of the North American Syntropine Veajovid. Kovarik and Mazuch (2015) reviewed the genus *Gint* Kovarik et al. (2013) of the family Buthidae with two new species described from Somaliland and Somalia. Lourenço et al. (2015) revised the geographical distribution patterns of the endemic genus *Neogrophus* Lourenço from Malagasy. Pham et al. (2015) updated the checklist of the all known scorpion species of Vietnam. Rossi (2015) provided the revision of the genus *Pandinurus* Fet and described seven new species and three new subgenera. He elevated the five historical subgenera of the genus *Pandinus* to genus level. Santibanez-Lopez et al. (2015) attempted a major review on the scorpions of Mexico which covers taxonomy, distribution, biology, venom and its medical importance. Tropea et al. (2015) revised the Anatolian-Caucasian subspecies of *Euscorpius mingrelicus* (Kessler).

Dupre (2016) studied the high altitude scorpion species by summing up all available literature and he included 227 species under 56 genera occupying heights of 2000 meters or above. Gonzalez-Santillan and Prendini (2016) discussed the systematic revision of the Vaejovid genera *Maaykuyak*, *Syntropis* and *Vizcaino* from North America that included the redescriptions of the known taxa, description of the adults of *Syntropis williamsi* Soleglad et

al. 2007, new locality records, key to identify the species of *Maaykuyak* and *Syntropis* and an updated distribution maps for all species presented.

Habibulla (2016) published a book on the "Secretive life of amazing living fossils" includes the physiology, neurochemistry and natural behaviour of scorpions. Kovarik et al. (2016 a) reviewed the genus *Buthacus* and described a new species *Buthacus stockmanni* from Morocco and Western Sahara. Kovarik et al. (2016 b) for the first time revised the scorpions of the genus *Parabuthus* collected from Eritrea, Ethiopia and Somaliland with the descriptions of two new species from Ethiopia and provided the detailed morphological characters and an identification key to the species of the region. Santos et al. (2016) attempted the systematic review on scorpion envenomations all over the world, especially the epidemiological and clinical aspects.

Esposito et al. (2017) revalidated *Heteroctenus* Pocock, 1893 and presented the systematic revision of Neotropical club-tailed scorpions of the genera *Physoctonus*, *Rhopalurus* and *Troglorhopalurus*. They also described two new genera and three new species. Sousa et al. (2017) presented an updated catalogue and revised the taxonomy of the genus *Buthus* Leach.

2.2 Historical review of studies on order Scorpiones of India

The studies on Indian scorpions are believed to begun with, Thorell (1876 a) who separated the genus *Heterometrus* into *Palamnaeus* for Indian forms and *Heterometrus* for African forms. Simon (1889) proposed the scorpion studies based on the collection from the Indian Museum by M. Oldham and Wood-Mason.

Pocock (1892) erected two genera of scorpions with notes on some species of the genus *Palamnaeus*. The small collection of scorpions from the Govt. Centre Museum, Madras was reported and studied by Pocock (1893 b).

Pocock (1894) provided a small contribution to the knowledge of Indian scorpions. Pocock (1896) distinguished between the two genera *Scorpio* and *Palamnaeus*. Some new species from India were described by Pocock (1897). The scorpion study was conducted by Simon (1897) based on the collections from Dehra Dun and Deccan by Smythies. Pocock (1899) discovered six new species of scorpions from India.

The scorpions of the genus *Heterometrus* was discussed by Pocock (1900 a). Pocock (1900 b) published the fauna of British India including Burma and Ceylon with 86 species belonging to 15 genera under 5 families.

Simon (1905) studied the scorpion fauna of South India based on the collection made by the travel conducted by M. Maurice Maindron. Gravely (1911) provided notes on the pedipalpi in the collection of the Indian Museum. An interesting scorpion in India *Charmus indicus* was described by Hirst (1915). Henderson (1919) added two new species to the scorpion fauna of south India. Rahimullah (1939) published a work on the systematics of scorpions and reported a preliminary study on scorpions of Hyderabad, Andhra Pradesh. The taxonomy and anatomy of the scorpion species *Buthus tumulus* (Fabricius) were studied by Tembe and Awati (1942). The nutrition in the advanced embryo of the scorpion species *Palamnaeus scaber* Thorell was discussed by Mathew (1948). Bahadur (1952) proposed the morphology of the Indian scorpion *Palamnaeus bengalensis*. Mani (1959) studied the high altitude scorpion and pseudo-scorpions of the North-western Himalaya. Sreenivasa Reddy (1959) contributed knowledge on the pectine function of scorpions.

Mathew (1960) published knowledge on the embryonic nutrition in *Lychas tricarinatus* (Simon). Vachon (1960) presented few remarks on the species *Hemibuthus crassimanus* Pocock from India. Deoras (1961) had undertaken studies on the scorpions of Bombay with an explanation on the

rearing and a method of venom extraction by means of electricity. A study about a scorpion species *Buthoscorpio laevicauda* Werner synonym of the species *Stenochirus politus* Pocock was conducted by Vachon (1961). Basu (1964) observed and studied two scorpion species of the genus *Lychas* from the western Himalaya, Hizaribagh and Bihar. Venkateswar (1967) proposed a study on the feeding apparatus of the species *Heterometrus fulvipes* (Pocock). The structure of pedipalp of scorpions and its function was explained by Dubale and Vyas (1968). Contributions on the knowledge on the Indian species *Charmus indicus* Hirst, *Iomachus punctulatus punctulatus* Pocock, *Iomachus nitidus* Pocock and the genus *Iomachus* Pocock was provided by Sreenivasa Reddy (1966, 1968 a, b, c) respectively.

Dubale and Vyas (1970) discussed on the endosternite and the associated muscles of the *Heterometrus* species. Raj Tilak (1970) published an interesting observation on the living habits of the species *Hormurus nigripes*. Sreenivasa Reddy (1970) discussed the systematic position of the genus *Charmus*. Dubale and Vyas (1973) proposed the myology of the feeding apparatus of the species *Heterometrus fulvipes* (Koch). Tikader (1973) published a list of scorpions from the Deccan area of India. Tikader and Bastawade (1977) published a new species *Scorpiops deccanensis* from Maharashtra state.

The taxonomic account of 99 species belonging to 18 genera under 5 families from India was updated by Tikader and Bastawade (1983) and also provided the knowledge on the origin, habits, habitats, feeding and reproductive behaviours. Bastawade (1985) studied the scorpion families Chaerilidae and Vaejovidae from Namdapha area, with a key to the families and discussed the diagnostic characters and distribution of three scorpion species. The first record of the family Ischnuridae (= Liochelidae) with the description of a new species *Iomachus surgani* from Maharashtra was

described by Bastawade (1986 a). A new species of the genus *Lychas* was described from the Nasik district of Maharashtra state by Bastawade (1986 b).

Ahmed (1992) presented the scorpion fauna of West Bengal, which revealed the occurrence of 14 species belonging to 8 genera under 5 families, of these, 8 species were recorded for the first time from the state. For the first time, Bastawade (1992) recorded the presence of genus *Scorpiops* Peters from Mahadeo hills, Madhya Pradesh and were described a new species *Scorpiops pachmarhicus*.

Morphological study of spermatophore of the species *Mesobuthus tumulus tumulus* (Fabricius) was conducted by Bastawade (1993). Yadav and Kamble (1993) published a note on the temperature preferences in the species *Mesobuthus tamulus tumulus* (Fabricius).

Bastawade (1994) described the scorpion hemispermatophores of three families viz. Vaejovidae, Chaerilidae and Ischunuridae. Biswas (1994) discussed the scorpion fauna in the fauna of Rajaji National Park with the presence of 5 species under 3 families viz. Buthidae, Scorpionidae and Vaejovidae. Shivashankar (1994) discussed the advanced subsocial behaviour in the scorpion *Heterometrus fulvipes* Brunner.

Arora and Arun Kumar (1995) reported 17 species of scorpions under 10 genera belonging to 4 families in the Fauna of western Himalaya. Biswas (1995) presented knowledge on the scorpion fauna of western Himalaya (Uttar Pradesh), which revealed the presence of 4 families 10 genera and 17 species, most of the families are reported under the family Vaejovidae.

Bastawade (1997) studied the distribution of the genus *Neoscorpiops* in Western Ghats of Maharashtra and Gujarat and discussed the trichobothria variations among isolated populations. Kovarik (1997) revised the genera

Lychas and *Hemilychas*, with descriptions of six new species. Of the six new species, two species *L. hillyardi* and *L. rackae* were described from India.

Kovarik (2000 a) revised the family Scorpiopidae with the descriptions of six new species including three Indian species namely *S. braunwalderi*, *S. dastychi* and *S. feti*. Lourenço (2000 b) proposed the considerations on the taxonomy and distribution of the genus *Charmus* Karsch and added a new species, *Charmus brignolii* from Pondicherry. Bastawade (2001) reported a new record of the rare scorpion species *Hemibuthus crassimanus* (Pocock) from Madhya Pradesh. The scorpion fauna of Nilgiri Biosphere Reserve was discussed by Indra (2001) and reported 13 species under 5 genera belonging to 3 families, with their localities, distribution, status and remarks. Bastawade (2002) studied the scorpion diversity and provided a checklist of the scorpion fauna regarding the biodiversity of the Western Ghats of Maharashtra. Two new species *Isometrus (Sreenivasaanus) problematicus* and *Isometrus (Sreenivasaanus) khammamensis* was described in the review of the genus *Isometrus* Ehrenberg by Kovarik (2003).

Bastawade (2004 a) dealt with scorpion studies based on the collection available from DNP area of Jaisalmer and Barmer districts of Rajasthan, and revealed the presence of 8 species of family Buthidae. The scorpion fauna of Pench National Park was studied by Bastawade (2004 b) and reported the presence of 6 species belonging to 2 families. Kovarik (2004 b) described four new *Heterometrus* species viz. *H. beccaloniae*, *H. mysorensis*, *H. rolciki* and *H. ubicki* from India along with the review of the same genus.

Bastawade (2005 a) conducted a study on the scorpion fauna of Melghat Tiger Reserve resulted in the presence of 8 species under 6 genera belonging to 3 families. Bastawade (2005 b) presented scorpion fauna from Tadoba-Andhari Tiger Reserve revealed the occurrence of 4 species, 3 genera and 2 families. Rao et al. (2005) discussed the scorpion fauna of Nallamalai

Region Eastern Ghats of Andhra Pradesh state and revealed the presence of 7 species under 5 genera belonging to two families viz. Buthidae and Scorpionidae.

Bastawade (2006 a) studied the scorpions of Sanjay Gandhi National Park and reported the occurrence of 5 species belonging to the genera viz. *Mesobuthus, Lychas, Neoscorpiops and Heterometrus* under 3 families. The scorpion fauna of Arunachal Pradesh was conducted and described two new species *Chaerilus dibangvalleycus* under the family Chaerilidae and *Euscorpiops kamengensis* under the family Scorpiopsidae by Bastawade (2006 b). Indra (2006) for the first time published the scorpions of Biligiri Rangaswamy Temple Wildlife Sanctuary and reported 4 species belonging to 3 families along with their diagnostic characters and distributions.

Indra (2007) revealed the scorpion fauna of Bannerghatta National Park based on the collections made during the year 2002-2004 and disclosed the occurrence of 3 species Viz. *Lychas tricarinatus, Stenochirus politus* and *Heterometrus kanarensis*, which were newly recorded from the National Park. Kovarik (2007) revised the genus *Hottentotta* Birula with the description of four new species. Of the four species, two species *Hottentotta jabalpurensis* and *Hottentotta stockwelli* were described from the states of India. In connection with the whole phylogeny of the superfamily Buthoidea Kovarik, et al. (2007) discussed the taxonomic placement of the group '*Charmus*' and described a new species *Thaicharmus lowei*.

Bastawade (2008 a) reported the presence of 2 scorpions belonging to 2 genera and 2 families from the Lonar Wildlife Sanctuary. The scorpion fauna of Pin Valley National Park was studied by Bastawade (2008 b) and reported the presence of 3 species belonging to 2 genera under 2 families along with their diagnostic characters, distribution, habits and habitats. Bastawade and Borkar (2008) published the scorpion fauna with 8 species

belonging to 5 genera under 2 families with the key to families and subfamilies and provided the diagnostic characters, distribution, habitat and habitats of the known species. Zambre (2008) proposed a preliminary report of Scorpion fauna of Eagle nest Wildlife Sanctuary, Arunachal Pradesh.

Bastawade (2009) presented the scorpion fauna of Bhimashankar Wildlife Sanctuary with the distribution, diagnostic characters, habits and habitats of 6 species. Of the 6 species, 3 species viz. *Mesobuthus rugiscutis* (Pocock), *M. pachyurus* (Pocock) (Family Buthidae) and *Neoscorpiops tenuicauda* (Pocock) (Family Euscorpiidae) were recorded for the first time from the sanctuary. The scorpion study in Tamil Nadu was conducted by Indra (2009) resulted in the occurrence of 25 species under 7 genera belonging to 3 families. Of the 25 species, 7 species were endemic and 5 species were known for the first time from the state. Mirza and Sanap (2009) presented the detailed reproductive biology of the species *Heterometrus phipsoni* Pocock and which included short notes on the gestation period, brood size and description of the post-insemination spermatophore. Mirza et al. (2009) provided a short description of the breeding behaviour of a female *Hottentotta pachyurus* Pocock. Zambre and Bastawade (2009) described the male of *Orthochirus krishnai* Tikader and Bastawade with the comments on its taxonomic status.

Two species of scorpion *Campsobuthus acute-carinatus rugosulus* (Pocock) and *Mesobuthus tamulus sindicus* (Pocock) were reported for the first time from Ranthambhore National Park, Rajasthan and key to the genera are also presented by Bastawade (2010). Chandra et al. (2010) published a checklist on scorpions of Narmada River basin, Madhya Pradesh includes 10 species under 4 families. Javed et al. (2010 a) prepared a checklist of the scorpions of the state Andhra Pradesh and recorded the species *Liocheles nigripes* Pocock for the first time from the state. A new species *Heterometrus*

telangaensis was erected from the Indian state Andhra Pradesh by Javed et al. (2010 b), which differed from the other species of the genus in having short metasoma. Javed et al. (2010 c) compared the new species described belonging to the genus *Buthoscorpio*, Werner from Andhra Pradesh with other two species of the genus *Buthoscorpio sarasinorum* (Karsch) and *Buthoscorpio politus* (Pocock). Lourenço (2010) attempted the genus *Chaerilus* in the Himalayas of India and described a new species. Mirza and Sanap, (2010) described a new species from Maharashtra under the genus *Lychas* C. L. Koch with notes on its natural history. The genus *Buthacus*, Birula was reported for the first time from India and a new species under the same genus was described based on the specimens collected from theThar Desert by Zambre and Lourenço (2010).

Lourenço et al. (2011) erected a new species *Chaerilus andamanensis* from the Andaman Islands and the new species showed affinities with *Chaerilus variegates* Simon, and *Chaerilus borneensis* Simon. Prasad et al. (2011) studied the various factors affecting the outcome of scorpion sting envenomation in children treated with Prazosin. Zambre et al. (2011) provided a key to the species of the genus *Orthochirus* Karsch, 1892 with the description of a new species *Orthochirus bastawadei* from Maharashtra, India.

Bastawade (2012) provided the systematic list of scorpion from Maharastra and revealed the occurrence of 34 species under 10 genera belonging to 4 families. Bastawade et al. (2012) proposed an updated checklist on scorpions of India with their distribution list. With observations and studies from other parts of the world, Bawaskar and Bawaskar (2012) published an updated review on scorpion venom, envenomation and treatment. Lourenço (2012 b) proposed the taxonomy and distribution of the genus *Buthoscorpio* Werner with the inclusion of the redescription of the

species *Buthoscorpio sarasinorum* (Karsch, 1891) and the description of *Buthoscorpio indicus* from north-central India. A new scorpion species of the genus *Heterometrus* Ehrenberg was erected by Mirza et al. (2012) from the southern Western Ghats of the state Tamil Nadu, India. Pande et al. (2012) dealt with the diversity of scorpions from western India and discussed the conservation implications of quantitative studies and reported eight species of scorpions from five genera and three families from 10 microhabitats.

Indra (2013) provided knowledge on the scorpions of Karnataka state with the distribution and status of 13 species belonging to 3 families and 6 genera. Kovarik (2013 b) reviewed the genus *Thaicharmus* Kovarik with the description of a new species *Thaicharmus indicus* from the state Goa, India and identification key was provided. Kovarik and Ahmed (2013) described two new species, *Androctonus robustus* and *A. cholistanus* from Pakistan and India and compared with the species *Androctonus finitimus* (Pocock).

Mirza et al. (2014) described a new species *Neoscorpiops maharashtraensis* from northern Maharashtra. A new high elevation species *Scorpiops spitiensis* was discovered by Zambre et al. (2014) from the Indian state Himachal Pradesh, which is the second high elevation scorpion species in Asia.

Lourenço (2015 a) proposed new considerations on the genus *Hottentotta* Birula, 1908 and described one new species from the state Tamil Nadu. A new species was erected under the enigmatic genus *Vachonus* Tikader and Bastawade viz. *Vachonus inexpectatus* from the state of Gujarat by Lourenço (2015 b). A key to the genus *Chiromachetes* Pocock was presented by Mirza et al. (2015) with the description of a new species *Chiromachetes sahyadriensis* from the Western Ghats of India. Nagaraj et al. (2015) were conducted a study to develop a convenient method to maintain scorpions and extracted their venom for toxicity studies.

Aswathi et al. (2016 a) revealed the new distributional records of the two buthid species *Buthoscorpio indicus*, Lourenço and *Lychas biharensis* Tikader and Bastawade and described the male *Buthoscorpio* species. Mirza and Gowande (2016) redescribed the species *Scorpiops pachmarhicus* Bastawade from Pachmarhi, Madhya Pradesh and the collected population was designated as neotype since the type was non traceable. Mirza et al. (2016) erected a new species *Thaicharmus guptai* from the northeast of Tripura state and the new species differs from the other species of the genus from a set of morphological characters.

Rodrigo and Gnanathasan (2017) published the systematic review on the scorpion envenomations and studied the effect of anti-venom against *Centruroides* sp. from USA/Mexico and *Mesobuthus tamulus* from India. Suranse et al. (2017) provided the first molecular phylogeny based on the mitochondrial cytochrome oxidase subunit I (COI) gene for the buthids from central western India and confirmed the placement of previous *Mesobuthus* in the genus *Hottentotta*, Birula.

2.3 Historical review of the studies of order Scorpiones of Kerala

Tikader and Bastawade (1983) described three new species for the first time from Kerala viz. *Isometrus (Closotrichus) sankariensis* (= *Isometrus (Isometrus) thurstoni*), *Heterometrus (H) keralaensis* (=*H. keralaensis*) and *Heterometrus (H) malapuramensis* (=*H. scaber*).

Bastawade et al. (2004) published an illustrated key for the identification of scorpion of Kerala which included 16 species under 7 genera belonging to 3 families and reported some species for the first time from the state. Bastawade et al. (2005) proposed a new subfamily, genus and species namely, *Rugodentinae, Rugodentus* and *R. keralaensis* respectively based on the collections made from the Malayatoor forests of Ernakulam district.

Sureshan et al. (2007 a) compiled the scorpion fauna of Parambikulam Wildlife Sanctuary which comprised 6 species belonging to 4 genera of 3 families and provided their diagnostic characters, distribution and remarks. Sureshan et al. (2007 b) published a taxonomic account on the scorpion fauna of Western Ghats of Kerala, and reported the presence of 21 species under 9 genera under 3 families from the region.

Aswathi et al. (2015) described a new species of the genus *Buthoscorpio* Werner, 1936 from Kerala. Aswathi and Sureshan (2016) provided an identification guide to the scorpions of Kerala along with the pictorial key to the families and genera. The publication discussed the diagnostic characters, distribution and remarks of 22 species under 9 genera. Aswathi et al. (2016 b) described a new species *Hottentotta keralaensis* from Chinnar Wildlife Sanctuary of Idukki district of Kerala state and which was the second species known under this genus.

Aswathi and Sureshan (2017 a) added two new species records *Heterometrus flavimanus* (Pocock) and *Lychas laevifrons* (Pocock) to the scorpion fauna of Kerala with a checklist and an illustrated key to the genera. This addition revealed the presence of 22 species belonging to 3 families and 9 genera from Kerala state. Aswathi and Sureshan (2017 b) published a systematic account of the scorpions of Chinnar Wildlife Sanctuary with keys to families and genera. Aswathi et al. (2017) published a systematic account of 6 species of scorpions and 7 species of centipedes from Chinnar Wildlife Sanctuary.

CHAPTER 3
MATERIALS AND METHODS

3.1 Selection of localities for taxonomic studies through random sampling methods

The sites from the study area, Kerala state (Map 1) was selected through random sampling. The study area was primarily divided into Northern Kerala, Central Kerala and Southern Kerala. From this broad division, each region was subdivided into districts and each place from the subdivision was again divided based on the diversity of habitat, ecosystem and geography.

The present work also includes the study of unidentified samples deposited in the faunal depository of Zoological Survey of India, Western Ghat Regional Centre, Kozhikode (ZSIK, WGRC) according to the area of samples collected.

3.2 Applications used for the selection of sites in Kerala

The random sampling method was used to conduct field surveys in Northern, Central and Southern Kerala. Applications such as DIVA-GIS 7.5, Google Earth, Geoplanner online and Geographic Positioning System (GPS) were used for plotting the distribution maps for the studied species (Map 2-9).

3.3 Selection of sites for ecological studies through sampling methods.

Only few studies have so far been undertaken on the ecological aspects of scorpions in India. In the present work, the ecological studies mainly focus on the relationship between species abundance and ecological parameters.

Especially in Kerala, such a study has not been conducted yet and very less information is available on scorpion's ecology. So, here I attempted to study the effect of seasonal fluctuation and ecosystem characteristics on species abundance of scorpions. Due to the difficulties in night sampling, all the above-mentioned studies were conducted during daytime (8 am to 12 pm) for 4 hours and the study period was extended from December 2015 to November 2016. Ecological study sampling was performed monthly through active collection during every last week of each month only from the selected sites.

Soil parameters such as temperature, electrical conductivity (EC), pH and organic carbon (OC) were analyzed during different seasons to study the effect and influence of such parameters on the species abundance of scorpions.

3.4 Collection methods

Scorpions inhabit in a wide variety of microhabitats **(Plate 2)**. Sampling was performed in different localities of 14 districts in Kerala from 2014-2017. Different collection methods were used for the collection of scorpions according to their microhabitats viz. litter sampling was done by sorting the litters using the stick, hand collections were performed under rocks, logs, and rock crevices.

3.5 Killing of scorpions

Killing and preservation techniques were as that of Sissom et al. (1990). Scorpions were collected with the help of forceps to avoid the stinging by telson and they were killed by heat shock, immersing the live scorpions in 90-99°C hot water for less than 5 seconds. Then the killed specimens were kept in flat trays for cleaning with distilled water.

3.6 Fixation and Storing

The cleaned specimens were fixed in 70% ethyl alcohol. According to the size of the scorpions, suitable containers were selected for storage. The above-mentioned killing method assured the flexibility of specimens, which avoided the damage of scorpions at the time of identification. The containers with preserved specimens were kept in almirah without glass to avoid bleaching of specimens under sunlight.

3.7 Labeling and Registering

At the time of collection, temporary labels were prepared with locality details and field collection number. Registration was done after identification under stereo zoom microscopes and permanent labels were provided with the Scientific name, Order, Family, Genus, Species, Locality, Name of the collector, Date of the collection, Collection number (provided at the time of collection), Registration number, Number of samples and the name of person who identified the specimens. Labels were written using Rotring pen with 0.2/0.3 microtip.

3.8 Identification of stored specimens

For the identification of scorpions, taxonomic keys provided by Kovarik (1997, 2003, 2004 b), Tikader and Bastawade (1983), Sureshan et al. (2007 a, b) were followed.

3.9 Microscopy and Illustrations

Imaging and illustrations were made with Leica DFC 500 and Leica M205 A & C, equipped with a drawing tube (Camera lucida) and an ocular micrometre.

3.10 Terminology

General taxonomical terminology was followed from Stanhke (1970).

3.11 Depository

All type specimens and other registered specimens were deposited in the faunal depository of Zoological Survey of India, Western Ghat Regional Centre, Kozhikode (ZSIK), Kerala, India **(Plate 3).**

3.12 Study area

Kerala state is geographically positioned between 8° 18' & 12° 48 ' North and 74° 52' & 77° 24 ' East. One side of the state is bounded with a narrow strip of Western Ghats and the other with Arabian Sea **(Plate 6, Fig. a).**The study area includes representative habitats of all the four physiographic divisions of Kerala [Highlands (elevation over 600 m), Midlands (elevation 300-600 m), Plains (elevation between 30-300 m) and Lowlands (elevation below 30 m)]

Besides, two different localities were selected for ecological observations. Observations on the ecology of scorpions of Kerala presented here were based on the studies from the two ecosystems. After a pilot study, a size of 50m x 50m was selected and five quadrates (10m x10m each) were laid for the random sampling. Monthly observations were made during Dec 2015 to November 2016 and the number of species and individuals were recorded from site 1 and site 2.

Site 1-Kakkavayal, Kozhikode (11.49306′N &75.9739’E, Elevation 55m)**:** A natural deciduous forest area located about 43.4 km from Kozhikode via Wayanad road. Scattered stones and rocks were abundant over the forest area. The vegetations of the study area were represented by a variety of plants and trees **(Plate 6, Fig. b)**.

Site 2- Cherukkad, Balussery, Kozhikode (11.52719’ N, 75.82993’ E, Elevation 116.2m)**:** A hilly rubber plantation located about 40 km from Kozhikode town. The area was fully covered with litter, some rocks and scorpions holes were also present. The study area was covered with a variety of plants and trees **(Plate 6, Fig. c)**.

CHAPTER 4
TAXONOMIC TREATMENT

4.1 ORDER SCORPIONES

1838. Scorpiones: C. L. Koch, *Die Arachniden*, 4 (1-5): 1-108.

4.2 Diagnosis: Body is divided into two, the cephalothorax (Prosoma) and the abdomen (Opisthosoma). Cephalothorax includes dorsally by the carapace, with median and lateral eyes. The number of lateral eyes varies according to the species. Median eyes are always two in number. Cephalothorax constitutes seven postoral somites (III-VIII). Somite III represents the chelicerae, which are three-segmented appendages used for feeding and grooming. Somite IV consists of pedipalps, which are six segmented from very proximal are the coxa, trochanter, femur, patella and chela [manus plus fixed finger (tibia) and movable finger (tarsus)], which are used for immobilization, sensation and defence. The surfaces of these segments and in many other areas of the body possess linear structures called keels or carinae, which may be plain or sometimes crenulated and the appendages may have crenulation according to the species. Somites V-VIII represents the four pairs of legs, each with segments coxa, trochanter, femur, patella, tibia, tarsomere I (basitarsus), tarsomere II (tarsus), lateral claws and median claws. Ventrally the coxae of first two pairs of legs extended to coxapophyses, which substitute for the sternum and serve to close the preoral cavity. The fused sterna of somites VII and VIII constitute the sternum, its shapes varied in species and it has been considered as the major taxonomic character.

The abdomen is again divisible into anterior Mesosoma (Pre abdomen) and tail like metasoma (Post abdomen). The Mesosoma consists of seven segments dorsally called tergites (I-VII) and ventrally with the sternum. Mesosomal segment I ventrally comprise the paired genital opercula, which covers the gonopore. Genital opercula usually fused in females and partially or completely separated in males. Two genital papillae present in males. Mesosomal segment II represents the basal piece and the pectines. Mesosomal segments III-VI each consists a pair of spiracles or stigmata. The apertures shapes may vary. Mesosomal segment VII consists of taxonomically important external structures, no appendages present.

The metasoma comprises five segments plus the Telson or sting. The size of the segment increases towards distally and bears taxonomically important keels (carinae), setae and bristles. Segment V bears the anal opening, which is bordered by anal arch. The Telson is divided into vesicle in which the venom is stored for defence and the aculeus to sting. Some species bear Subaculear tubercle present between vesicle and aculeus **(Plate 1, Fig. a & b)**.

Distribution

All around the world except Antartica; maximum diversity in arid and semi-arid regions.

Diversity

Approximately 2345 extant species under 166 genera belonging to 18 families worldwide.

4.3 Key to the families of order Scorpiones in Kerala (Plate 4)

[Modified from Aswathi et al. (2016)]

1. Pedipalp with slender segments and chelae comparatively narrow **(Fig. a)**. Pectines generally long and provided with numerous teeth (20-23). Cephalothoracic sternum generally triangular in shape except for two Genera [sub-pentagonal in *Charmus* and *Buthoscorpio*]. Conspicuous apical node present on sternum. Trichobothriotaxy type'A' .....

..... ***Family Buthidae***

− Pedipalp with segments not slender as above and chelae more wider **(Fig. b)**. Pectines not long and provided with 5-22 numbers of teeth. Cephalothoracic sternum pentagonal or sub-pentagonal. No conspicuous apical node present on sternum. Trichobothriotaxy type 'C'…..... **2**

2. Pedipalp manus flat **(Fig. d)**. Metasoma very narrow. Telson vesicle compressed or pyriform with short aculeus **(Fig. c)**. Body punctuated ……..……..…. ..... ***Family Liochelidae***

− Pedipalp manus not flat as above. Metasoma thick and strong, not narrow. Telson vesicle not compressed with long aculeus **(Fig. e)**. Body not punctuated..... .....*Family Scorpionidae*

4.4 Key to the genera of order Scorpiones in Kerala (Plate 5)

[Modified from Aswathi et al. (2016)]

1. Carapace without carinae. Cephalothoracic sternum sub-pentagonal **(Fig. c)**. Subaculear tooth absent. Trichobothria d_1, d_3 & d_4 on femur of pedipalp with α – configuration **(Fig. b)**.....**2**

− Carapace with carinae. Cephalothoracic sternum triangular **(Fig. a)**. Subaculear tooth present. Trichobothria d_1, d_3& d_4 on the femur of pedipalp with β – configuration **(Fig. d)** **3**

2. Entire body hirsute. Telson vesicle round with short aculeus. 4 contiguous pairs of lateral eyes. Total length10-16 mm……..……. ….....***Charmus*** Karsch

− Entire body not hirsute. Telson vesicle pyriform with short aculeus **(Fig. e)**. 5 contiguous pairs of lateral eyes. Total length 30-45 mm …… ……..….. ..... ***Buthoscorpio*** Werner

3. Subaculear tooth distinctly present. Telson vesicle pyriform with ventral granulation **(Fig. f)**. Total length 20-80 mm….....……..….....**4**

− Subaculear tooth present but not distinct as above **(Fig. g)**. Telson vesicle round with ventral granulation. Total length 30-130 mm….....….....…..…….….....…….....…… .....***Hottentotta*** Birula

4. Tarsomere II of legs smooth with a ventro-median row of fine spinules **(Fig. h)** …..... ..... .**5**

− Tarsomere II of legs smooth without a ventro-median row of fine spinules **(Fig. i)** .....***Liocheles*** Sundevall

5. Body dorso-ventrally flat **(Fig. j)**. Pyriform telson vesicle without subaculear tubercle…… .....……**6**

− Body not dorso-ventrally flat. Pyriform telson vesicle with subaculear tubercle…… **7**

6. Median eye situated anteriorly in the ratio 1:1.**5 (Fig. k)**. Total length 40-60 mm..... .***Iomachus*** Pocock

- Median eye situated anteriorly in the ratio 1:2 **(Fig. l)**. Total length 80-90 mm .....***Chiromachetes*** Pocock

7. Tibial spur present on legs III and IV **(Fig. m)**…….. ***Lychas*** C. L. Koch

- Tibial spur absent on all legs..... ..... **8**

8. Adults of small to moderate in size with thin metasoma. Fingers of chela of pedipalp with oblique rows of granules **(Fig. n)**……..……..…… ..... ***Isometrus*** Ehrenberg

- Adults of large size with thick metasoma. Fingers of chela of pedipalp without oblique rows of granules..... **9**

9. Pedipalp manus round or lobed and fingers of chela with pointed triangular teeth **(Fig. o)**..... ***Heterometrus*** Ehrenberg

- Pedipalp manus globular or lobed and chela fingers with rugously granular dentition in a band along the interior surface …..... .....***Rugodentus*** Bastawade, Sureshan & Radhakrishnan

4.5 Family Buthidae

Subfamily Buthinae

Diagnosis: Small sized scorpions with slender chelae of pedipalp. Sternum usually triangular and narrowed anteriorly with or without an apical button, sometimes pentagonal sternum can be observed. Legs III & IV generally bear tibial spur. Trichobothrial pattern Type A. Three or five pairs of lateral eyes. Four genera and eight species were reported from Kerala under this family.

Distribution: Almost distributed worldwide with more than 1113 species under 91 genera.

4.5.1 Key to the species of the family Buthidae in Kerala

1. Thick metasoma. Subaculear tubercle absent..... **2**

− Thin metasoma. Subaculear tubercle present……..... …**3**

2. Metasoma thickly hirsute. Movable fingers of chela with 9 oblique rows of granules ..... ***Charmus indicus*** Hirst

− Metasoma not much hirsute. Movable fingers with 11 oblique rows of granules.... ***Buthoscorpio chinnarensis*** Aswathi, Sureshan & Lourenço

3. Telson vesicle pyriform. Subaculear tubercle distinct **4**

− Telson vesicle globular. Subaculear tubercle weak **5**

4. Tibial spur present on legs III-IV……..... .**6**

− Tibial spur absent on legs III-IV……..... …**7**

5. Pectinal teeth number 23-29 in males, 19-26 in females. Movable fingers of chela of pedipalp with 12-14 oblique rows of granules ….....…….....…***Hottentotta rugiscutis*** Pocock

− Pectinal teeth number 27-29 in males, 23-25 in females. Movable fingers of chela of pedipalp with 13 oblique rows of granules .....***Hottentotta keralaensis*** Aswathi, Sureshan & Lourenço

6. Pedipalp chela manus with clear yellow ……..…....……. .... ***Lychas albimanus*** Henderson

− Pedipalp chela manus with same colour as femur and patella ……..…… **8**

7. Pedipalp chela finger trichobothria *db* is situated between *et* and *est* ....***Isometrus (Reddyanus) brachycentrus*** Pocock

− Pedipalp chela finger trichobothria *db* is situated between *dt* and *et*.....**9**

8. Pectinal teeth number 17-18. Tergites I-IV monocarinated .... ***Lychas hendersoni*** (Pocock)

− Pectinal teeth number 21-23. Tergites I-IV tricarinated **12**

9. Sexual dimorphism present. Manus of pedipalp very thin in males. Pectinal teeth number 14-19 ……..... **10**

− Sexual dimorphism absent. Manus of pedipalp with same width to length in both sexes. Pectinal teeth number 15-18.....**11**

10. Long metasomal segments in male. Pectinal tooth count 16-19 ..... ***Isometrus (Isometrus) maculatus*** (De Geer)

− Short metasomal segments in both sexes. Pectinal tooth count 14-16 ....***Isometrus (Isometrus) sureshani* sp. nov.**

11. Metasomal segments in both sexes long. Pectinal tooth count 16-17 ... . ***Isometrus (Isometrus) wayanadensis* sp. nov.**

− Metasomal segments in both sexes short. Pectinal tooth count 15-18..... ....***Isometrus (Isometrus) thurstoni*** Pocock

12. Pectinal teeth number 21-22. First to third metasomal segment with 10 keels ... .***Lychas laevifrons*** (Pocock)

− Pectinal teeth number 21-23. First to second metasomal segment with 10 keels .....***Lychas tricarinatus*** (Simon)

4.5.2 Genus *Buthoscorpio* Werner, 1938

1891. *Stenochirus* Karsch, *Berliner Entomologische Zeitschrift,* 36: 267–307.
1936. *Buthoscorpio* Werner, *Festschrift zum 60. Geburtstage von Professor Dr. Embrik Strand,* 2: 171–193.
1938. *Buthoscorpio* Werner, *Sitzungsberichte der Akademie der Wissenschaften, Wien*, 147 (5-10): 151-173.

Type species: *Buthoscorpio sarasinorum* (Karsch)

Diagnosis: Medium sized scorpions. Cheliceral fixed fingers with two ventral accessory denticles. Legs III & IV with a tibial spur.Metasomal segments thick.Telson without subaculear tubercle. Trichobothrium d3 on patella placed external to dorsomedial carinae. Trichobothrial pattern type A.

Distribution: India and Sri Lanka.

***Buthoscorpio chinnarensis* Aswathi, Sureshan & Lourenço, 2015**

(Plate 7, Fig a)

2015. *Buthoscorpio chinnarensis*, Aswathi, Sureshan & Lourenço, *Taprobanica* 7 (4): 213-218.

Type locality: India: Kerala.

Diagnosis: Carapace with scattered granulation on lateral portions **(Fig. b)**. Median eyes situated anteriorly in the ratio 1:2. Prominent tubercles present at the basal portion of the pedipalp femur **(Fig. c)**. Marginal lamellae of pectines composed of three pieces and middle lamellae comprise seven pieces of sclerites. Dorsal carinae present on metasomal segments III–V **(Fig. d)**. Metasomal segments I–IV wider than long, segment V longer than wide. Subaculear tubercle absent on telson. Pectinal teeth count 14/16 for male and female with 17/17 **(Fig. e)**.

Distribution: Kerala (Idukki).

Materials examined: 1♂ Holotype, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 22.v.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 3503; 2♀, Paratypes, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 22.v.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 3504; 1♂, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Koottar, 13.xii.2006, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 6988.

Habitat: All specimens were found under boulders and were collected from the thorny scrub jungle.

Remarks: Recently described new species from Chinnar Wildlife Sanctuary, Idukki. The genus *Buthoscorpio* Werner was reported for the first time from the state.

4.5.3 Genus *Charmus* Karsch, 1879

1879. *Charmus* Karsch, *Mitt. Munch. Ent. Ver.,*3: 104.

Type species: *Charmus laneus*, Karsch

Diagnosis: Hirsute body. Carinae absent on carapace. Monocarinated mesosomal tergites. Sternum small, pentagonal and which is wider than long. Metasomal segments weakly carinated and segments IV & V punctured ventrally. Vesicle of telson round and small. Trichobothria d1, d2 & d3 form α angle on the femur of pedipalp.

Distribution: India and Sri Lanka.

***Charmus indicus* Hirst, 1915**

1915. *Charmus indicus* Hirst, *Ann. Mag. Nat. Hist.*:224.
2000 b. *Charmus indicus* Lourenço, *Mem. Soc. entomol. ital.*: 296.

Type locality: India: Tamil Nadu, Coimbatore.

Diagnosis: Body colour dark black with variegated yellowish spots. Hirsute body. Carapace finely granular. Median ocular tubercles granular with a pair of median eyes, situated anteriorly in the ratio 1:1.9. Lateral ocular tubercle provided with four contiguous lateral eyes. Anterior margin of carapace straight. Pectinal tooth count 17/17.

Distribution: India: Andhra Pradesh, Kerala, Pondicherry and Tamil Nadu.

Materials examined: No material was examined during the study and the diagnosis provided here is based on the descriptions by Hirst (1915) and Lourenço (2000 b).

4.5.4 Genus *Hottentotta* Birula, 1908

1908. *Buthus (Hottentotta)* Birula, *Sitzungsberichte der Kaiserlich-Königlichen Akademie der Wissenschaften. Wien:* 141.
1935. *Hottentotta:* Werner, *In* H. G. Bronns *Klassen und Ordnungen des Tierreichs.:* 269

Type species: *Scorpio hottentotta* Fabricius, 1787

Diagnosis: Carapace with distinct carinae and dense granulation. Femur of pedipalp exhibit β-configuration dorsally. Tergite I-IV of mesosoma bears tricarinae. Third and fourth legs with tibial spurs. Vestigial subaculear tubercle present on telson.

Distribution: Tropical and subtropical regions of Asia, Africa and Arabia.

***Hottentotta rugiscutis* (Pocock, 1897)**

(Plate 8, Fig a)

1897. *Buthus rugiscutis* Pocock, *Journal of the Bombay Natural History Society,*102-117
1998. *Hottentotta (Hottentotta) rugiscutis*: Kovařík *Štíři* [*Scorpiones*]: 110.
1999. *Hottentotta rugiscutis:* Kovařík, *Acta Societatis Zoologicae Bohemicae*: 291 (in part).

Type locality: Tamil Nadu: Madras, Yercaud, Tanjore, Trichinapally.

Diagnosis: Body colour uniformly yellow to reddish brown; entire body sparsely hirsute; femur and patella of pedipalp granulated on dorsal surfaces; chela of pedipalp lacks carinae; movable fingers of pedipalp with 12-14 rows of granules and 5 terminal granules; pectinal tooth count 19-29.

Description of adult female

Colouration: Body yellow to yellowish brown. Prosoma: carapace yellowish brown, dark at the furrows, black colour behind lateral eyes and little on the median ocular tubercle. Mesosoma: tergites yellowish brown to dark brown on carinae; sternites yellow except the last segment which is yellowish brown. Metasoma: segments yellowish brown, dark brown dorso-medially of each segment, vesicle yellow with half brown and half yellow aculeus. Pectines yellow. Sternum yellow.Genital operculum yellow with some brown.Basal piece yellowish brown. Chelicera: yellow without any reticulation on the basal piece; fingers yellow with brown denticles. Pedipalp: yellowish brown throughout.

Carapace: Coarsely granular entirely; median and postero-median carinae present; anterior margin slightly concave medially. Shallow postero-lateral and deep postero-median furrows present. Well developed median ocular tubercle distinctly anterior to the centre of the carapace **(Fig. b)**; median eyes are almost equal in size and are separated by a distance slightly less than half

ocular diameter. Lateral eyes, numbering five; first eye smaller than second and third eyes; fourth and fifth almost equal in size and smallest among all; second and third larger than all eyes and almost equal in size; the fifth eye situated just behind the third eye.

Mesosoma: All tergites coarsely granular; posterior margin of all tergites crenulated. Monocarination present in all tergites except first with weak carination; lateral carinae on either side of the median monocarinae present on all segments; tergite I and II lateral carinae represent by one or two granules; tergite VII with single carina next to the lateral carina on both sides. Sternites smooth without any carina except the last sternites with four incomplete carinae and intercarinal space slightly granulated; shallow longitudinal depression present on either side of the median line of all sternites except the last. Stigmata moderate in size and rod-like in shape.

Metasoma: Segments I-III with ten carinae; segment IV with eight to ten carinae, but lateral carinae represent by only a few granules; segment V with five carinae; all intercarinal space except dorsal surface coarsely granular.

Telson: Vesicle strictly globular with curved and moderate-sized aculeus. Subaculear node very weak and which is guarded by a pair of setae; lined granules present ventrally and slightly extended to the lateral portion, dorsal surface smooth **(Fig. c)**.

Pectines: Long and well-developed sclerites, marginal lamellae composed of three pieces with different shapes and sizes; middle lamella comprises eight pieces of different shapes and sizes; fine setae present all over. Pectinal tooth count 23-24. The Basal piece composed of single sclerite with deep median depression **(Fig. d)**.

Genital operculum: Sclerites longitudinally separated and each sclerite is triangular like in shape.

Sternum: Triangular in shape with deep postero-median depression; anteriorly narrow and posteriorly widened; apical button present anteriorly.

Chelicerae: Smooth on the basal piece with tuberculated margin; ventrally clothed with thick, short, fine and silky hairs; dentition characterized as in the family **(Fig. e)**.

Pedipalp: Slender and stout; femur shorter than carapace and with crenulated carinae; femoral intercarinal spaces weakly granular except the ventral side smooth. Patella as long as the carapace, longer and broader than femur, carinated, internal tubercles present.Chela longer than carapace, carina and granulation absent; movable and immovable fingers each with ten oblique rows of denticles plus one denticle at the base with two accessory granules **(Fig. f)**.

Legs: Femur, patella and tibia carinated and all carinae crenulated; all intercarinal spaces with granulation. Tibial spur present on legs III and IV, moderately thick setae present on tarsomere I and II.

Trichobothrial pattern: Type 'A' as characterized as in the family **(Plate 9, Fig. a-e)**.

Distribution: India: Andhra Pradesh, Jharkhand, Karnataka, Kerala (Idukki), Madhya Pradesh, Maharashtra, Pondicherry, Tamil Nadu and West Bengal.

Materials examined: 1♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, 19.xi.1996, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 3250.

Habitat: The specimen collected was found under boulders fro thorny scrub jungle.

Remarks: Not a common species, restricted distribution in Kerala and it is only reported from Idukki district.

***Hottentotta tamulus* (Fabricius, 1798)**

(Plate 10, Fig. a)

1798. *Scorpio tamulus*: Fabricius, 294.
1983. *Mesobuthus tamulus gangeticus*: Tikader & Bastawade, Fauna of India, *Zool. Surv. India*: 208.
2007. *Hottentotta tamulus*: Kovarik, *Euscorpius*, 58: 110.

Type locality: India: (original type lost) neotype from Maharastra, Mumbai.

Diagnosis: Adult with 50-90 mm in total length. Movable finger of pedipalp with 13-15 rows of oblique rows of granules. Metasomal segments I-III with ten carinae and segment IV with eight carinae. Pectinal tooth count 27-39.

Description of subadult female

Colouration: Body orange yellow with appendages of the same colour. Prosoma: carapace orange yellow with some scattered brown colouration. Mesosoma: tergites medially brown and lateral portions orange-yellow. Sternites orange yellow with some pale brown; last sternite with dark brown carinae. Metasoma: orange yellow with ventral dark brown carinae, vesicle orange yellow with aculeus of the same colour. Pectines: orange yellow. Sternum: orange yellow with slight brown around the apical button. Genital operculum orange yellow with pale brown shade. Basal piece orange-yellow. Chelicera: yellow and brown reticulation with brown tubercles present at the anterior margin; fingers yellow with denticles bordered with brown colour. Pedipalp orange-yellow. Legs: femur, patella orange-yellow; tibia, tarsomere I and II orange-yellow to yellow.

Carapace: Entire surface coarsely granular but weak in middle portion; granular carinae present; single lateral carina on either sides of the median carina, which extending from just below the median ocular eye and the posterior margin; a pair of carinae present on either sides of the median ocular

tubercle; another pair of carinae extending from median ocular tubercle to the anterior margin and which is not continuous; anterior margin slightly concave; postero-lateral, median and postero-median shallow to moderately deep furrows present. Median ocular tubercle distinctly anterior to the centre of carapace; median eyes are almost equal in size and are separated by a distance slightly less than half ocular diameter **(Fig. b)**. Lateral eyes, numbering five, first four eyes arranged in a curve-like manner; first eye slightly smaller than second and third; second and third are almost equal in size; fourth and fifth are also almost equal in size; first three eyes are separated each other by equidistance; the fourth eye is slightly far from the third and fifth eye is situated just behind the third eye.

Mesosoma: All tergites coarsely granular; tergite I-VI with a median carina and two lateral carinae; tergite VII with median carina present anteriorly and two pairs of lateral carinae present on either side of the median carina. Sternites smooth without any granulation; a pair of shallow longitudinal depression present on all sternites except the last; last sternite with four keeled carinae. Stigmata present, which is short and oval-like in shape.

Metasoma: Segments are coarsely granular with crenulated carinae; segment I-III with ten carinae, but lateral carinae incomplete on segment III; segment IV with eight carinae and segment V with seven carinae; all segments very sparsely hirsute.

Telson: Vesicle globular with a weak Subaculear tubercle, ventrally guarded by two long setae. Vesicle ventrally moderately hirsute; two bands present ventrally. Dorsal surface of vesicle smooth and ventrally granular **(Fig. c)**.

Pectines: Well developed sclerites, marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae comprises nine pieces with irregular shapes; moderate to minute setae present all over the pectine;

pectinal tooth count 30-30. The Basal piece composed of single sclerite with antero-median ‘V' shaped depression **(Fig. d)**.

Genital operculum: Sclerites longitudinally separated and each sclerite somewhat semi-triangular in shape, but the pointed portion is not in the middle; anterior and posterior suture present.

Sternum: Sub-triangular in shape; anteriorly narrow posteriorly widened; apical button present anteriorly, deep depression present posteriorly; few setae present.

Chelicerae: Movable finger possess single basal (b), median (m), subdistal (sd) and external distal (ed) denticles. Immovable finger with basal, median, subdistal and distal (d) denticles; basal denticles of both fingers are not much developed; basal piece uniformly reticulated and the anterior margin tuberculated.

Pedipalp: Slender and small appendages; chela longer than carapace; both fingers are also longer than carapace. Patella longer and wider than femur; crenulated carinae present on the femur; all intercarinal spaces finely to coarsely granular. Patella wider than chela; internal carinae crenulated. Chela smooth without any carinae; movable and immovable fingers each with 13-13 oblique rows of denticles and 13-13 non-imbricate oblique rows **(Fig. e)**.

Legs: Femur coarsely granular and internal carinae serrated. Patella slightly granular with internal carinae serrated. Tibia carinated, smooth, legs III and IV provided with the tibial spur. Tarsomere I carinated and ventrally with two rows of moderately long bristles; tarsomere II ventrally with two rows of spinules.

Trichobothrial pattern: Type 'A' as characterized as in the family **(Plate 11, Fig. a-e)**.

Distribution: India: Gujarat, Maharashtra, Uttar Pradesh, Andhra Pradesh, Bihar, Jharkhand, Madhya Pradesh, Pondichery, Rajasthan, Tamil Nadu and West Bengal.

Materials examined: 4♀, India: Kerala: Kollam, Thenmala, Kazhuthuruthi, 9.viii.1997, coll. P. M. Sureshan, IR/INV/ZSI/WGRC/10200.

Habitat: All specimens were collected from high elevations of Thenmala, Kollam. These species were found under boulders.

Remarks: *Hottentotta tamulus* is one of the scorpion species venom fatal to the human. The present study reveals the first report of this species from Kollam district of Kerala.

***Hottentotta keralaensis* Aswathi, Sureshan & Lourenço, 2016**

(Plate 12, Fig. a)

2016. *Hottentotta keralaensis*, Aswathi, Sureshan & Lourenço, *Arachnida-Rivista Aracnologica Italiana*, X: 34-44.

Type locality: India: Kerala, Idukki, Champakkad.

Diagnosis: Scorpions of moderate size, with adult male and female reaching 51.4 mm and 63.8 mm respectively in total length. General colouration orange-yellow to golden-yellow, without spots or infuscations. Carinae and granulations moderately to strongly marked on the carapace **(Fig. b)**, tergites and metasomal segments; intermediate carinae complete on metasomal segments I to IV, represented by only a few granules on IV. Metasomal segment II and III longer than wide. Pectinal teeth count 28-29 **(Fig. c)**. Chela fixed and movable fingers with 13-13 rows of denticles **(Fig. d)**. Presence of scalloping at the proximal dentate margin of the male fixed finger **(Fig. e)**.

Distribution: India: Kerala.

Materials examined: ♂ holotype, India: Kerala: Idukki, Chinnar Wildlife Sanctuary, 3.VI.2015, coll. K. Aswathi, IR/INV/ZSI/WGRC/7666; ♂♂ paratypes, ♀♀ paratypes, India: Kerala: Idukki, Chinnar Wildlife Sanctuary, 3.VI.2015, coll. K. Aswathi, IR/INV/ZSI/WGRC/7667.

Habitat: All specimens were found under boulders with loose soil from the thorny scrub jungle.

Remarks: This species was recently described from the state and it differs from other species in having characters such as 1) 13-13 rows of denticles on movable and immovable fingers of chela of pedipalp 2) metasomal segment II and III longer than wide. Sexual dimorphism present, males with robust chela of pedipalp whereas chela slender in females.

4.5.5 Genus *Isometrus* Ehrenberg, 1829

1829. *Buthus* (*Isometrus*): Ehrenberg in Hemprich & Ehrenberg, *Verhandlungen der Gesellschaft Naturforschende Freunde in Berlin*: 351.
1876 a. *Isometrus*: Thorell, *Annals and Magazine of Natural History*: 8.

Type species: *Scorpio maculatus* De Geer, 1778.

Diagnosis: Carapace sometimes with only median carinae. Monocarinated mesosomal tergites. Sternum small, triangular. Metasomal segments slender and subaculear tubercle present on vesicle, at the base of the aculeus. Tibial spur absent on legs III & IV. Trichobothria d1, d3 & d4 on the femur of pedipalp form β angle.

Distribution: Asia, Java, Australia, Africa, South America.

***Isometrus (Isometrus) maculatus* (De Geer, 1778)**

(Plate 13, Fig. a)

1778. *Scorpio maculatus* DeGeer, *Mémoires pour servir à l'histoire desinsectes*: 346.
1876. *Isometrus maculatus*: Simon, *Bulletin de la Société Zoologique de France*: 219.
2003. *Isometrus* (*Isometrus*) *maculatus*: Kovařík, *Euscorpius*: 2.

Type locality: Suriname and Pennsylvania.

Diagnosis: Total length 50-60 mm; body colour yellowish to pale yellow with blackish-brown spots and bands; markedly long pedipalp in males than females; carapace granulation moderately developed and with 'V' shaped anterior margin; dentate margins of fixed and movable fingers of chela of pedipalp with 7 rows of granules; subaculear tubercle triangular and well developed with two ventral granules; pectinal tooth count 16-19.

Description of adult female

Colouration: Body yellow variegated with black bands and spots; Prosoma: carapace equally black and yellow; median and lateral ocular tubercle black. Mesosoma: tergites yellow variegated with black bands. Sternites yellow except the last with some black spots. Metasoma: segments yellow with black spots and stripes, vesicle yellow with black spots, more black on the subaculear tubercle. Pectines yellow. Sternum yellow with a brown apical button.Genital operculum yellow. Basal piece yellow. Chelicera: yellow with black reticulation with anterior margin yellow; fingers black with brown tip. Pedipalp: yellow with black stripes and spots more on femur and patella; chela fingers black with yellow tip and denticles black. Legs yellow striped with black.

Carapace: Coarsely granular entirely; carinae absent; anterior margin medially concave; shallow postero-lateral, median and postero-median

furrows present. Median ocular tubercle distinctly anterior to the centre of the carapace; median eyes are almost equal in size and are separated by a distance less than half ocular diameter **(Fig. b)**. Lateral eyes, numbering five; first eye smaller than second and third; the fourth eye is the smallest among all eyes; the fifth eye larger than fourth but smaller than first and is situated just behind the third eye; second and third almost equal in size and larger among other eyes.

Mesosoma: All tergites coarsely granular; median monocarination present in all tergites except the first with very weak monocarinae; tergite VII with pairs of carinae on either side of the monocarina. Sternites smooth except the lateral margins with granulation; last sternite with four carinae and intercarinal spaces weakly to finely granular; shallow longitudinal depression present on all sternites except the last. Stigmata very short and rod-like in shape.

Metasoma: Segment I with ten carinae; segment II-IV with eight carinae; segment V with five carinae; all intercarinal spaces coarsely granular and all carinae crenulated.

Telson: Vesicle pyriform with short to moderately sized aculeus; subaculear tubercle spinoid with a single pair of granules on dorsal surface; slightly granular on the ventral surface of the vesicle **(Fig. c)**.

Pectines: Well developed sclerites; marginal lamellae composed of three pieces with different shapes and sizes; middle lamella comprises seven pieces with irregular shapes and sizes; entire pectine covered with minute and moderately sized setae. Pectinal tooth count 20-21. The Basal piece composed of single sclerite with deep antero-median depression **(Fig. d)**.

Genital operculum: Sclerites longitudinally separated and each sclerite is semi-oval like in shape.

Sternum: Triangular in shape with deep postero-median depression; anteriorly narrow and posteriorly widened; apical button present anteriorly.

Chelicerae: Smooth on the basal piece and slight tuberculation on anterior margin; fingers ventrally clothed with moderately thick, fine, silky hairs; dentition characterized as in the family **(Fig. e)**.

Pedipalp: Slender and stout; femur as long as the carapace, crenular carination present and all intercarinal spaces granulated except the ventral surface smooth. Patella slightly longer than carapace, carinae crenulated and intercarinal spaces granulated except the ventral surface smooth, internal tubercle present. Chela longer than carapace, carinae absent, scattered granulation present; movable and immovable fingers each with six oblique rows of denticles plus one denticle at the base with two accessory granules **(Fig. f)**.

Trichobothrial pattern: Type 'A' as characterized as in the family **(Plate 14, Fig. a-e)**.

Legs: femur, patella, tibia and tarsomere I carinated and granulated; all carinae crenulated. Tibial spur absent on all legs, moderately thick setae present on the tibia, tarsomere I and II ventrally with thick two rows of setae.

Distribution: India: Kerala (Palakkad, Wayanad, Kozhikode), Andhra Pradesh, Madhya Pradesh, Karnataka, Maharashtra, Meghalaya and Tamil Nadu.

Materials examined: 1♂, India: Kerala, Wayanad, Manikunnumala, 20.ix.2015, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 4821; 3♀, India: Kerala, Trivandrum, Neyyar Wildlife Sanctuary, 9.xi.2016, coll. Bindu, Reg. No. ZSI/WGRC/IR/INV 7951; 1♂, India: Kerala, Wayanad, Meenmutty, Banasura Hill11.viii.2016, coll. B. H. C. K. Murthy, Reg. No.

ZSI/WGRC/IR/INV 7569; 1♀, India: Kerala, Kollam, Schendurney Wildlife Sanctuary, Eettakkad, 19.i.2014, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 6986; 2♀, India: Kerala, Palakkad, Silent valley N P, Poochippara, 21.ii.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 6740; 2♀, India: Kerala, Palakkad, Silent valley N P, Poochippara, 21.ii.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 6740; 1♀, India: Kerala, Pathanamthitta, Konni, Palayapara, 21.i.2014, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 8927; 1♂, India: Kerala, Kozhikode, Narikuni, 2.ix.2004, coll. Bimalnath, Reg. No. ZSI/WGRC/IR/INV 9384; 1♂, 1♀, India: Kerala, Kannur, Aralam Wildlife Sanctuary, Paripputhodu, 11.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9426; 2♀, India: Kerala, Palakkad, Nelliyampathy, 28.ii.2017, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9583.

Habitat: Generally found under tree barks and under boulders.

Remarks: An uncommonly distributed species found in forests tracts of the state. This species shows excellent sexual dimorphism with characters such as 1) males possess slender pedipalp whereas females with short and robust pedipalp 2) males with extremely long metasomal segments but in females the segments are short.

***Isometrus (Isometrus) thurstoni* Pocock, 1893**

(Plate 15, Fig. a)

1893 b. *Isometrus thurstoni* Pocock, *Journal of the Bombay Branch of the Royal Asiatic Society*: 297.
1972. *Isometrus* (*Isometrus*) *thurstoni*: Vachon, *Cahiers Pacifique*: 177.
1983. *Isometrus (Closotrichus) sankeriensis*: Tikader & Bastawade, *Fauna of India*, 2: 273.
2003. *Isometrus* (*Isometrus*) *thurstoni*: Kovařík, *Euscorpius*: 4.

Type locality: India: Sheveroy Hills.

Diagnosis: Body delicate white with variegated black to brown spots and bands; mesosomal tergites with three dark bands medially and two bands laterally; telson with pointed subaculear tubercle; chela fingers and cheliceral fingers brownish; pectinal tooth count 15-18.

Description of adult female

Colouration: Body delicate and white to yellow variegated with brown to black bands and spots. Prosoma: carapace mostly yellow with some brown to black spots; median ocular tubercle black. Mesosoma: Tergites yellow with two lateral bands and single band originated from the pretergite and bifurcated to the posterior margin from the middle. Sternite white to light yellow. Metasoma: segments yellow with dark spots throughout and more dark at the posterior portion of the last segment. Telson: vesicle yellow with black spots, more black at the dorsal base of aculeus and subaculear tubercle. Pectines pale yellow. Sternum yellow.Genital operculum yellow.Basal piece brownish yellow. Chelicera: yellow with black reticulation anteriorly on the basal piece with yellow anterior margin; fingers yellow with brown spot dorsally with yellow lined with brown denticle. Pedipalp: yellow with black spots more on the patella. Chela fingers brown to black and yellow at the tip with black denticles. Legs: yellow variegated with black spots dorsally.

Carapace: Coarsely granular entirely; carinae absent; anterior margin medially concave; yellow ‘T' shape present between the median ocular eye and anterior margin of the carapace; shallow postero-lateral, median and postero-median furrow present. Median ocular tubercle distinctly anterior to the centre of carapace; median eyes are almost equal in size and are separated by a distance less than half ocular diameter. Lateral eyes, numbering five; first, three eyes are almost equal in size; the fourth eye is slightly larger than fifth and smaller than first three eyes; the fifth eye is situated just behind the gap between second and third eyes.

Mesosoma: All tergites coarsely granular except the yellow spots on the posterior margin of each tergite; all tergites monocarinated except the tergite I without distinct carina; one pair of carinae present on either side of the median carina on tergite VII. Sternites smooth without any carinae except the last sternite with four carinae and intercarinal space slightly granulated; shallow longitudinal depression present on all sternites except the last. Stigmata short and oval-like in shape.

Metasoma: Segment I with ten carinae; segment II-IV with eight carinae; segment V with five carinae. All intercarinal spaces granular but not much distinct.

Telson: Vesicle somewhat globular with short aculeus; Subaculear tubercle spinoid with a single pair of granules on dorsal surface; vesicle ventrally and laterally granular. Few setae present more on subaculear tubercle **(Fig. b)**.

Pectines: Well developed sclerites; marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae comprise seven pieces with irregular shapes; fine setae present all over the pectine. Pectinal tooth count 15-16. Basal piece single sclerite with deep antero-median depression **(Fig. c)**.

Genital operculum: Sclerites longitudinally separated and sclerite is triangular like in shape.

Sternum: Subtriangular in shape with deep postero-median depression; anteriorly narrow and posteriorly widened. Apical button present anteriorly; few setae present.

Chelicerae: Smooth on the basal piece; ventrally clothed with thick, fine, silky hairs. Dentition on fingers as characterized in the family **(Fig. d)**.

Pedipalp: Slender and stout; femur longer to as long as carapace; carinated and all carinae crenulated; femoral intercarinal space slightly granulated. Patella as long as and broader than femur; carinated and internally tuberculated with triangular tubercles. Chela longer than carapace; carina absent but scattered granulation present; movable and immovable fingers each with six oblique rows of denticles plus single denticle at the base with two accessory granules **(Fig. e)**.

Trichobothrial pattern: Type 'A' as characterized as in the family **(Plate 16, Fig. a-e)**.

Legs: Femur, patella, tibia, tarsomere II carinated and all carinae crenulated; all intercarinal spaces with granulation. Tibial spur absent on all legs; thick moderately sized setae present ventrally on the tibia, tarsomere I and II.

Distribution: India: Kerala (Kannur, Kollam), Andhra Pradesh, Madhya Pradesh, Karnataka, Maharashtra, Tamil Nadu and West Bengal.

Materials examined: 1♂, India: Kerala, Kannur, Muzhupilangadi beach, 15.xii.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4096; 1♂, India: Kerala, Kollam, Schendurney Wildlife Sanctuary, Kazhuthurutty, 17.i.2014, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9584.

Habitat: The specimens were found under stones and under tree barks. This is for the first time these species were collected near the coastal region, the locality was only about 15 m away from the sea.

Remarks: Species commonly found in plains, near to human habitations and sea coast. Tikader and Bastawade (1983) described this species as *Isometrus (Closotrichus) sankeriensis* later this species was synonymised under *Isometrus (Isometrus) thurstoni* by Kovarik (2003).

***Isometrus (Isometrus) wayanadensis* sp. nov.**

(Plate 17, Fig. a)

Diagnosis: Adult of moderate size, male measuring 41.01 mm in total length. General colouration pale yellow to yellow in both sexes; variegated body with brown marks all over the body. Carinae and granulations moderate to weak. Anterior margin of carapace 'V' shaped. Pectines moderately long; Pectinal tooth count 16/17 in the male. Pedipalp short and robust in both sexes. Metasomal segments long in both sexes.

Description of holotype male

Colouration: Body yellow variegated with brown spots and stripes, appendages yellow with brown spots and stripes. Prosoma: carapace yellow with some brown patches medially and laterally. Mesosoma: tergites yellow variegated with brown bands and spots. Metasoma: segments yellow with brown markings mainly on carinae; reddish brown on the last segment, vesicle reddish brown, dark brown on subaculear tubercle and at the tip of the aculeus. Pectines pale yellow. Sternum yellow with slight brown lateral borders. Genital operculum yellow.Basal piece yellow.Chelicera yellow with brown reticulation and dark brown at the end of the reticulation; anterior margin yellow; fingers mix of yellow and brown, denticle brown to dark brown at the tip. Pedipalp yellow variegated with brown patches; fingers brown and yellow at the tip. Legs: yellow with brown stripes.

Carapace: Coarsely granular except some yellow coloured areas; carinae absent; anterior margin deeply concave medially; postero-lateral shallow furrow and postero-median moderately deep furrow present. Median ocular tubercle distinctly anterior to the centre of the carapace **(Fig. b)**; median eyes are almost equal in size and are separated by a distance less than half ocular diameter. Lateral eyes, numbering five, first four eyes are arranged in a curve-

like manner; second and third eyes are large and almost equal in size; first eye is smaller than second and third; the fourth eye is smaller than first three eyes but larger than fifth; the fifth eyes is smallest among all eyes and placed behind the third eye.

Mesosoma: All tergites are monocarinated medially; tergites I-VII coarsely granular except some areas; tergite VII with two pairs of lateral carinae on either side of the median carina. All sternites smooth and without any carinae except the last sternite with four crenulated carinae; lateral margins crenulated; a pair shallow longitudinal depression medially except the last sternite. Stigmata present, which is very short and rod-like in shape.

Metasoma: Elongated segments; segment I-IV with eight carinae but segment V with seven carinae; all carinae keeled and all intercarinal space very slightly granular except the dorsal; very few hairs present on all segments.

Telson: Vesicle pyriform with short aculeus; dorsal surface of the vesicle smooth, ventrally with slight granulation and single keeled carinae present, which is extending from Subaculear tubercle to the vesicle; Subaculear tubercle triangular with a pair of granules dorsally **(Fig. c)**.

Pectines: Well developed sclerites; marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae comprise eight pieces with irregular shapes; moderately long setae present all over the pectine. Pectinal teeth count 16-17. The Basal piece composed of single sclerite with shallow antero-median ‘V' shaped depression **(Fig. d)**.

Genital operculum: Sclerites separated longitudinally; each sclerite with bean-like in shape; posterior suture present.

Sternum: Sub-triangular in shape; anteriorly narrow and posteriorly widened; deep depression present posteromedially; few setae present on either side of the depression.

Chelicerae: Movable finger possesses two basal (b), median (m), subdistal (sd) and external distal (ed) denticles. Immovable finger with basal, median, subdistal and distal (d) denticles; among the basal denticles one is small but both are blunt; basal piece reticulated except the anterior margin **(Fig. e)**.

Pedipalp: Slender and moderately long appendages; chela longer than carapace; movable and immovable fingers are also longer than carapace. Patella as long as femur; both patellar and femoral internal carinae sharply crenulated and other carinae with blunt crenulation; dorsal intercarinal spaces of both patella and femur slightly granular. Chela smooth without any carinae and granulation; few setae present on all segments; movable and immovable fingers each with six oblique rows of denticles and an extra granule present on two fingers **(Fig. f)**.

Legs: Femur, patella, tibia, tarsomere I are carinated. Ventral carinae of femur and patella crenulated; dorsal surface of femur and patella coarsely granular; tibial spur absent on all segments; both tarsomere I and II ventrally clothed with thick long setae.

Trichobothrial pattern: Type 'A' as characterized as in the family **(Plate 18, Fig. a-e)**.

Distribution: India: Kerala (Wayanad, Idukki, Pathanamthitta).

Etymology: This species is named after the collection region of the holotype.

Materials examined: 1♂ Holotype, India: Kerala, Wayanad, Kumarapura, Aragaladha, 18.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9782; 2♂ Paratypes, India: Kerala, Wayanad, Kumarapura, 18.x.2011, coll. P.

M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9783; 1♀, India: Kerala, Idukki, Marayoor forest IB, 1.iv.2016, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9784; 1♂, India: Kerala, Pathanamthitta, Kukkara, Konni, 20.i.2014, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9785.

Habitat: All specimens collected were found under tree barks and under leaf litters.

Remarks: This new species exhibits resemblance with the species *Isometrus (Isometrus) thurstoni* Pocock, 1893 in appearance. But in the new species, both males and females possess long metasomal segments with short and robust pedipalp, which differ this species from the species *Isometrus (Isometrus) thurstoni.*

***Isometrus (Isometrus) sureshani* sp. nov.**

(Plate 19, Fig. a, b)

Diagnosis: Adult of moderate size, male measuring 34.93 mm in total length. General colouration yellow to pale brownish yellow in both sexes; variegated body with dark marking all over the body. Carinae and granulations moderately to weakly marked. Four pairs of lateral eyes. Anterior margin of carapace 'V' shaped. Pectines moderately long; Pectinal tooth count 14/13 in male and 15/16 in the female.Pedipalp very narrow and slender in male but moderately long and robust in the female.Metasomal segments short in both sexes.

Description of holotype male

Colouration: Generally yellow to pale brownish yellow. Prosoma: carapace yellow with black markings, more black on the anterior margin of the carapace. Median ocular and lateral tubercles black. Strips and spots same in both sexes. Mesosoma: tergites yellow with single black stripes starting from

anteriorly and from the middle the same trifurcated posteriorly in all tergites but the anterior trifurcation starts from tergite III to VI. Lateral stripes also present in all tergites. Metasomal segments yellow, with black spots and stripes, ventrally more black on segment V. Vesicle yellow with black subaculear tubercle, the tip of the aculeus reddish brown and yellow at the base. Venter pale yellow. Chelicerae yellow with black reticulation more anteriorly, fingers yellow with black spots and teeth reddish brown. Pedipalp ventrally clear yellow, dorsally with black stripes and spots on both sexes but more in the female.Chela finger brownish, rows of granules on dentate margins of fingers with dark reddish. Legs yellow with black stripes.

Carapace: Anterior margin of the carapace 'V' shaped. Carapace carinae weakly marked. Anterio-median, posterio-median and median furrows present; coarsely granulated. Median ocular tubercle present from anterior to the centre of the carapace; median eyes separated by less than half ocular diameter **(Fig. c)**; Lateral eyes, numbering four, first three eyes are arranged in a straight line; second and third eyes are large and almost equal in size; first eye is smaller than second and third; fourth eye is very smaller than first three eyes.

Mesosoma: Tergites I-VI with distinct median carinae, extending from middle to the posterior margin, intercarinal space weakly to moderately granular but more in the female; sternite III-VI smooth, VII with weak granulation (Moderate in female). Sternite VII with four carinae, interior pair extends from middle to the posterior margin, exterior pair weak & present only at the middle; spiracles moderately long.

Metasoma: Segment I with ten crenulated carinae, II to IV with eight crenulated carinae; segment V with five crenulated carinae; intercarinal space weakly smooth in male and weakly to moderately granular in the female; dorsal furrow weak in all segments.

Telson: Slightly globular in male and weakly elongated in the female with weakly scattered granulation present in both sexes; prominent ventral carinae in the female, weak in male; subaculear tubercle strong and spinoid with one pair of granules on the dorsal face of tubercle **(Fig. d)**.

Pectines: Moderately long and teeth count 14-15 in holotype male, 15-16 in paratype female **(Fig. e)**.

Genital operculum: Sclerites separated longitudinally; each sclerite with a bean like in shape; posterior and anterior suture present.

Sternum: Subtriangular in shape; anteriorly narrow and posteriorly widened; deep depression present postero-medially; triangular shaped apical node present; few setae present on either side of the depression.

Chelicerae: Movable finger possesses two basal (b), median (m), subdistal (sd) and external distal (ed) denticles. Immovable finger with basal, median, subdistal and distal (d) denticles; among the basal denticles on movable finger one is much reduced but both are blunt; basal piece reticulated except the anterior margin with few tubercles.

Pedipalp: Femur pentacarinated, all carinae crenulated; patella pentacarinated but interior carinae not continuous in male-only a few keels present **(Fig. f)**. True carinae absent on chela but scattered granules present which provide a carina like an appearance; intercarinal space on femur weakly granular in male but densely in female and same in patella but the dorsal surface slightly granular in the female. 6-6 rows of denticles plus one on the proximal part of both fingers with two accessory granules **(Fig. g)**.

Legs: Femur, patella, tibia, tarsomere I with crenulated carinated; dorsal surface of femur and patella coarsely granular; tibial spur absent on all segments; both tarsomere I and II ventrally clothed with thick long setae.

Trichobothrial pattern: Type 'A' as characterized as in the family **(Plate 20, Fig. a-e)**.

Distribution: India: Kerala (Wayanad, Kozhikode).

Etymology: This species is named after Dr P. M. Sureshan in honour of his significant contributions to the scorpion studies.

Materials examined: 1♂ Holotype, India: Kerala, Wayanad, Manikunnumala, 20.ix.2015, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 4821; 1♀, India: Kerala, Wayanad, Meenmutty, 10.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 6984; 1♀ Paratype, India: Kerala, Kozhikode, Kakkadampoyil, Cheenkannipari, 19.i.2017, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 9793; 1♀, India: Kerala, Kozhikode, Kakkadampoyil, Cheenkannipari, 13.i.2017, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9794; 1♀, India: Kerala, Wayanad, Meenmutty, 10.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 6984; 1♂, India: Kerala, Wayanad, Meenmutty, 10.viii.2016, coll. B. H. C. K. Murthy, Reg. No. ZSI/WGRC/IR/INV 7569; 1♂, India: Kerala, Kozhikode, Malabar Wildlife Sanctuary, Kakkayam, 19.xi.2014, coll. Aswathi. K, Reg. No.ZSI/WGRC/IR/INV 4932.

Habitat: The collected specimens were found under tree barks.

Remarks: This new species resembles the species *Isometrus (Isometrus) maculatus* (De Geer) in having characteristics such as 1) slender pedipalp in males and differ from characters such as 1) metasoma short in both sexes in new species, but males of *Isometrus (Isometrus) maculatus* have long metasomal segments 2) Pectinal tooth count 14-16 in new species **(Plate 19, Fig. c)** and 16-19 in *Isometrus (Isometrus) maculatus* **(Plate 13, Fig. d).**

***Isometrus (Reddyanus) brachycentrus* Pocock, 1899**

(Plate 21, Fig a)

1899. *Isometrus brachycentrus* Pocock, *Journal of the Bombay Natural History Society*: 263.
1972. *Isometrus* (*Reddyanus*) *brachycentrus*: Vachon, *Cahiers Pacifique*: 177.
2003. *Isometrus* (*Reddyanus*) *brachycentrus*: Kovařík, *Euscorpius*: 6.

Type locality: India: Tamil Nadu, Mangalore.

Diagnosis: Total length 42-43mm. Body colour dark brown, black on metasoma; entire body surface finely granular; weakly developed granular median monocarinae present on mesosomal tergites; telson with granular vesicle and triangular subaculear tubercle; pectinal tooth count 12-12.

Description of adult female

Colouration: Body reddish brown to black with yellowish brown appendages variegated with black spots and stripes. Prosoma: carapace black with some brown patches. Mesosoma: tergites black with two yellow spots at the posterior margin on either side of the median carinae. Sternites yellowish brown, more brown on the last sternite. Metasoma: segments reddish brown with some black on segments IV and V, vesicle golden brown to reddish brown with reddish brown aculeus. Pectines pale yellow. Sternum yellowish brown.Genital operculum yellowish brown.Basal piece yellowish brown. Chelicera: yellowish brown with black reticulation on the basal piece and with black anterior margin; fingers yellowish at the tip and the remaining black, with reddish brown denticles. Pedipalp: yellowish brown with scattered black spots; chela fingers yellow at the tip and remaining black with black denticles. Legs: femur and patella yellowish brown with black stripes throughout.

Carapace: Coarsely granular except the patches; carinae absent; anterior margin slightly concave medially; shallow postero-lateral and deep postero-median furrows present. Median ocular tubercle distinctly anterior to the centre of the carapace; median eyes are almost equal in size and are separated by a distance less than half ocular diameter **(Fig. b)**. Lateral eyes, numbering five, fifth eye is the smallest among others and placed just behind the third eye; first three eyes are almost equal in size; the fourth eye is smaller than first three eyes and larger than the fifth eye.

Mesosoma: All tergites coarsely granular and monocarinated medially except in tergite I; '><' marks present on either side of the monocarinae; one pair of carinae present on either side of the monocarinae of tergite VII. Sternite smooth without any carinae except the last sternite with four incomplete carinae; shallow longitudinal depression present on either side of the median line. Stigmata short and rod-like in shape **(Fig. c)**.

Metasoma: Segments coarsely granular all over; segment I with ten carinae; segment II-VI with eight carinae; segment V with five carinae but two dorsal carinae not much distinct.

Telson: Vesicle pyriform with short and curved aculeus; subaculear tubercle laterally flattened and triangular in shape with three pairs of granules on dorsal surface; single ventral band present **(Fig. d)**.

Pectines: Well developed sclerites; marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae comprises six pieces with irregular shapes; covered with short fine setae. Pectinal tooth count 12-13 in number. The Basal piece with a deep antero-median depression **(Fig. e)**.

Genital operculum: Longitudinally separated sclerites; each sclerite is triangular like in shape.

Sternum: Sub-triangular in shape; anteriorly narrow and posteriorly widened. Deep furrow present postero- medially; apical button present anteriorly and few setae present.

Chelicerae: Smooth on basal piece except for the anterior margin with slight tuberculation; ventral portion clothed with fine, thick, silky hairs; dentition characterized as in the family.

Pedipalp: Slender and stout; femur short or as long as the carapace, carinated and all carinae crenulated. All intercarinal space of femur granulated except the ventral surface. Patella as long as the carapace, carinated and all carinae crenulated. Chela manus longer than carapace and carinated; slight granulation present on intercarinal space of manus; movable and immovable fingers each with six oblique rows of denticles plus one denticle at the base with a single accessory granule **(Fig. f)**.

Legs: femur, patella, tibia and tarsomere I, granulation carinated and all carinae crenulated. Tibial spur absent on legs; moderately thickened setae present ventrally on tarsomere I and II.

Trichobothrial pattern: Type 'A' as characterized as in the family **(Plate 22, Fig. a-e)**.

Distribution: India: Kerala (Trivandrum, Kannur, Pathanamthitta, Kasargode, Ernakulam, Palakkad, Kollam, Kozhikode, Idukki), Karnataka, and Tamil Nadu.

Materials examined: 4♀, India: Kerala, Trivandrum, Neyyar Wildlife Sanctuary, Meenmutty, 10.xi.2016, coll. Bindu, Reg. No. ZSI/WGRC/IR/INV 7952; 2♀, India: Kerala, Trivandrum, Neyyar Wildlife Sanctuary, Kallippara, 9.xi.2016, coll. Bindu, Reg. No. ZSI/WGRC/IR/INV 7950; 2♀, India: Kerala, Kannur, Kottiyoor R F, 1.iii.2006, coll. K. Rajmohana, Reg. No.

ZSI/WGRC/IR/INV 6739; 2♀, India: Kerala, Trivandrum, Neyyar Wildlife Sanctuary, Meenmutty, 10.x.2012, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 6737; 2♀, India: Kerala, Kannur, Aralam Wildlife Sanctuary, 19.iii.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4405; 1♀, India: Kerala, Pathanamthitta, Pekkavu, Ranni, 23.i.2014, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 6736; 1♂, India: Kerala, Kasargode, Mandekol, 7.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 6742; 1♀, India: Kerala, Trivandrum, Peppara Wildlife Sanctuary, Agasthyamala, 12.xi.2016, coll. Bindu, Reg. No. ZSI/WGRC/IR/INV 7953; 1♀, India: Kerala, Kasargode, Kottenchery, 6.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 6985; 1♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Urulanthanni, 21.iv.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 8162; 1♀, India: Kerala, Trivandrum, Peppara Wildlife Sanctuary, Vyvanthol, 14.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 5311; 2♀, India: Kerala, Kannur, Aralam Wildlife Sanctuary, Paripputhodu, 13.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8590; 1♀, India: Kerala, Malappuram, Karuvarakundu, 28.ii.1992, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8567; 2♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Karienchola, 22.i.1997, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9035; 8♀, India: Kerala, Palakkad, Nelliyampathy, Thoothempara, 1.iii.2017, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 8602; 1♀, India: Kerala, Trivandrum, Chathankkode, Bonakkad, 25.ii.2017, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9409; 4♀, India: Kerala, Kollam, Schendurney Wildlife Sanctuary, Eetakkana, 19.i.2014, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9414; 1♀, India: Kerala, Kollam, Kallipara, 12.i.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9436; 1♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Urulanthanni, 17.vi.2016, coll. P. M. Sureshan,

Reg. No. ZSI/WGRC/IR/INV 9455; 1♀, India: Kerala, Kasargode, Bellipadi, 4.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9547; 1♀, India: Kerala, Kozhikode, Kakkayam, Malabar Wildlife Sanctuary, 16.xi.2011, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9578; 1♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 4.iv.2016, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9610.

Habitat: Generally observed under tree barks, under decaying logs and under boulders.

Remarks: This species shows narrow distribution only from the southern part of India. Found only in the forests tracts. Sexual dimorphism present, males with long segments of metasoma whereas metasoma short in females.

4.5.6 Genus *Lychas* Koch, 1845

1845. *Lychas* Koch, *Die Arachn*., 12: pp 166.

Type species: *Lychas scutilus* Koch, 1845.

Diagnosis: Carapace with weak posterior and lateral carinae. Two to three carinae present on mesosomal tergites. Sternum triangular and which is longer than wide. Metasomal segments thick & carinated with a subaculear tubercle present at the base of the aculeus of the telson. Tibial spur present on legs III & IV. Trichobothria d1, d3 & d4 on the femur of pedipalp form β angle.

Distribution: India, Burma, Malaya, Philippines, Thailand, China, Australia, East, West and South Africa.

***Lychas albimanus* Henderson, 1919**

(Plate 23, Fig. a)

1919. *Lychas albimanus* Henderson, *Rec. Indian Museum*: 379.
1997. *Lychas albimanus*: Kovařík, *Acta Soc. Zool. Bohem.*: pp 371.

Type locality: India: Kerala, Cochin.

Diagnosis: Total length 36-42 mm; body colour brownish variegated with yellow patches on mesosoma and carapace; femur, patella and fingers of chela brownish except manus with yellow; telson yellowish brown with pointed subaculear tubercle; pectinal tooth count 19-21.

Description of adult female

***Colouration*:** Body blackish-brown variegated with brown patches, yellow to brown appendages. Prosoma: carapace blackish-brown with some brown patches. Mesosoma: Tergites blackish variegated with '><' shaped brown patches on both sides of the median carinae; sternites with yellow shade except the last sternite, which is light brown. Metasoma: segments brown dorsally and ventrally, vesicle brown with aculeus reddish brown. Pectines pale yellow. Sternum yellow with some brown at the anterior tip. Genital operculum pale yellow. Basal piece yellow.Chelicera: brown with black reticulation on the basal piece and anterior margin black; fingers brown at the tip and the remaining is black. Pedipalp blackish-brown except for manus of chela which is clear yellow **(Fig. b)**. Legs: femur & patella brown, tibia, tarsomere I and II yellow.

Carapace: Lustrous only the space between anterior margin and median ocular tubercle; coarsely granulated except the patches and furrows; carinae absent; anterior margin of the carapace slight 'V' shape. Shallow postero-median, median and postero-lateral furrows present on either side of the

carapace. Median ocular tubercle moderate and situated anterior to the centre of the carapace; median eyes almost equal in size and are separated by a distance less than one ocular diameter **(Fig. c)**. Lateral eyes, numbering five, first eye smaller than two and three of equal size; fourth and fifth eyes almost equal in size and are very smaller than other three eyes; first four eyes continuous; fifth eyes is placed beyond the third eye.

Mesosoma: All tergites coarsely granulated except the patches; monocarinated except the last tergite with four carinae with one median projection; sternites smooth except the lateral margin and the last sternite granulated with four carinae. Stigmata present, which is short and oval-like in shape **(Fig. d)**.

Metasoma: Segments I-II with ten carinae and all intercarinal spaces very finely granulated; segments III and IV with eight carinae and all intercarinal spaces very finely granulated. Segment V pentacarinated but the dorsolateral carinae not much developed.

Telson: Vesicle pyriform; subaculear tubercle present which spinoid in shape with a single pair of granules on dorsal surface; tuberculated band present at the ventral side with a short and long seta; aculeus curved **(Fig. e)**.

Pectines: Well developed sclerite; marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae composed of eight pieces with different shapes and sizes fine small setae present all over the pectin. Pectinal tooth count 20-20. The Basal piece with an anterior median notch **(Fig. f)**.

Genital operculum: Two sclerites, both constitute an inverted anchor-like in shape.

Sternum: Subtriangular with a median furrow extended from anterior to posterior margin, anterior apical node present; anteriorly narrow and posteriorly widened; few setae present.

Chelicerae: Smooth on the basal piece without any granulation and punctuation; ventral portion clothed with fine, thick, silky hairs. Dentition as characterized as in family **(Fig. g)**.

Pedipalp: Slender and short; femur shorter than carapace; carinated, intercarinal spaces with very fine scattered granulation, except the ventral surface; patella as long as carapace and wider than the femur, carinated but not much developed, granulation not much noticeable. Chela longer than carapace; manus without granulation and carinae; few setae present. Chela finger dentition: movable and immovable fingers each with six oblique rows of denticles, two accessory granules present.

Legs: Dorsal granulation present on femur and patella; long tibial spur present on legs III and IV; ventrally tibia, tarsomere I and II clothed with thick moderate size setae.

Trichobothrial pattern: Type 'B' as characterized as in the family **(Plate 24, Fig. a-e)**.

Distribution: India: Kerala (Palakkad, Ernakulam, Kannur, Idukki, Thrissur, Trivandrum, Kollam), Himachal Pradesh, Odisha, Uttar Pradesh and Tamil Nadu.

Materials examined: 1♂, India: Kerala, Palakkad, Parambikulam Tiger Reserve, 24.iii.1997, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 7949; 1♂, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Knasserry, 29.x.2015, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 4934; 5♂, India: Kerala, Kannur, Aralam Wildlife Sanctuary, 13.x.2011, coll. P. M.

Sureshan, Reg. No. ZSI/WGRC/IR/INV 5532; 5♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Kanthalloor, 5.ix.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 6987; 1♂, India: Kerala, Thrissur, Chimmoney, 25.ii.1996, coll. C. Radhakrishnan, Reg. No. ZSI/WGRC/IR/INV 8391; 1♀, India: Kerala, Trivandrum, Kulathupuzha, 31.xii.1983, coll. G. U. Kurup, Reg. No. ZSI/WGRC/IR/INV 8576; 1♀, India: Kerala, Ernakulam, Perumthodu, 15.xi.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8582; 1♂, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Pezhakunnu, 27.ii.1997, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9011; 1♀, India: Kerala, Kollam, Kattilapara, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9027; 1♂, 1♀, India: Kerala, Trivandrum, Aruvikara, 3.i.1984, coll. G. U. Kurup, Reg. No. ZSI/WGRC/IR/INV 9416.

Habitat: Generally found under tree barks and occasionally found under boulders and decaying logs. Usually inhabits in dry and moist deciduous forests tracts.

Remarks: This species exhibits narrow distributions from Kerala and this species is named after its peculiar character 1) albinism of the manus of chela whereas other body parts dark **(Plate 23, Fig. a & b)**.

***Lychas hendersoni* (Pocock, 1897)**

1897. *Archisometrus hendersoni* Pocock, *J. Bombay nat. Hist. Soc.*: 111.
1900 b. *Lychas hendersoni*: Pocock, *Fauna Brit. India, Arachn*. : 40.

Type locality: India: Tamil Nadu, Yercaud.

Diagnosis: Total length 32.50 mm; body colour dark brownish black to black; entire surface of the body coarsely to finely granular on median portions of the carapace and posterior portion of each mesosomal tergites; tergites I-IV monocarinated medially; median eyes situated anteriorly in the ratio 1:2.75 mm.

Distribution: India: Kerala and Tamil Nadu.

Materials examined: No Materials examined.

Remarks: I have not been able to study the type or other specimens of this species. The diagnosis provided here is based on the available literatures.

***Lychas laevifrons* (Pocock 1897)**

(Plate 25, Fig. a)

1897. *Archisometrus laevifrons* Pocock, *J. Bombay nat. Hist. Soc.*: 113.
1900 b. *Lychas laevifrons*: Pocock, *Fauna Brit. India, Arachn.*: 41.
1997. *Lychas laevifrons*: Kovařík, *Acta Soc. Zool. Bohem.*: 356.

Type locality: India: West Bengal, Calcutta.

Diagnosis: Total length 31 mm; external and internal granules absent on the six cutting edge of movable fingers of pedipalp; metasomal segments I-III with 10 keels, but lateral keels may weakly developed in segment III; mesosomal segments II- VI with three carinae or one dorsal carinae; fingers and manus of pedipalp of the same colour, light and spotted legs variegated black and yellow; pectinal tooth count 22-25.

Description of adult male

Colouration: Body yellow variegated with black, same as in appendages. Prosoma: carapace black with yellow patches. Mesosoma: tergites black variegated with '><' shaped, and spots of yellow; sternites yellow with some black stripes and spots. Metasoma: segments yellow with black stripes and spots, segment V with black; vesicle of telson brown dorsally and blackish brown ventrally. Pectines pale yellow. Sternum yellow with light brown apical node.genital operculum pale yellow.Basal piece yellow. Chelicera: yellow with black reticulation, anterior margin black, and a clear yellow spot present anteriorly on the basal piece; fingers yellow at the tip and remaining

black, denticles reddish brown. Pedipalp: yellow variegated with black, more black on femur and patella, chela manus mostly yellow only some black stripes and spots; fingers light brownish yellow. Legs: yellow variegated with black, more black on femur and patella.

Carapace: Coarsely granular except the yellow patches and area between anterior margin of carapace and median ocular tubercle. Carinae absent; anterior margin of carapace slightly concave medially; shallow postero-lateral, deep median and postero-median furrows present on either side of the carapace. Median ocular tubercle distinct and eyes situated anterior to the centre of the carapace; median eyes almost equal in size and are separated by a distance less than one ocular diameter **(Fig. b)**. Lateral eyes, numbering five, first eye smaller than second and third eyes; the fifth eye is the smallest among five eyes, second and third large and almost equal in size fourth is larger than fifth and smaller than the first eye.

Mesosoma: All tergites coarsely granular except the patches; medially carinated except the first and last tergites others with two lateral carinae; lateral carinae weak on tergites II and III; tergite VII with a pair of lateral carinae on either side of median carinae. Sternites smooth except lateral margins and the last sternite. Four carinae present on the last sternite. Stigmata present, which is moderate in size and rod-like in shape.

Metasoma: Segments I-II with ten carinae, but the lateral carinae not much developed on segment II; segment III and IV with eight carinae; segment V pentacarinated; intercarinal spaces of all segments with fine and scattered granulation. Setae present on all segments.

Telson: Wheat-like shape vesicle somewhat flat ventrally. Subaculear tubercle spinoid with a pair of granules present dorsally. Few long setae

present throughout the vesicle; aculeus long and curved. Ventrally three bands present on vesicle and tuberculated **(Fig. c)**.

Pectines: Well developed sclerites; marginal lamellae composed of three pieces of different shapes and sizes; middle lamellae with seven pieces of irregular shapes: fine small setae present throughout. Pectinal tooth count 21-22. The Basal piece with a deep anteromedian 'V' shaped depression **(Fig. d)**.

Genital operculum: Two sclerites both constitute together to form an inverted anchor like in shape.

Sternum: Subtriangular sternum with a median furrow extended from anterior to posterior margin: anterior apical button present; anteriorly narrow and posteriorly widened; few setae present.

Chelicerae: Smooth on the basal piece without any granulation and punctuation. Ventral portion clothed with fine, thick, and silky hairs. Dentition as characterized as in the family **(Fig. e)**.

Pedipalp: Slender and stout; femur as long as the carapace, carinated and granulated except the ventral surface; patella slightly longer than carapace, carinated and granulated except the ventral surface. Chela longer than carapace, carinae absent but slight granulation present; internally of manus of chela few setae present. Chela finger dentition movable and immovable fingers each with six oblique rows of denticles plus one single denticle at the base with a single accessory granule **(Fig. f)**.

Legs: Dorsal granulation present on femur and patella; long tibial spur present on legs III and IV; tarsomere I and II thickly clothed with moderately sized setae: femur, patella and tibia with few scattered long setae.

Trichobothrial pattern: Type 'B' as characterized as in the family **(Plate 26, Fig. a-e)**.

Distribution: India: Kerala (Idukki, Kozhikode, Ernakulam, Palakkad, Kannur, Wayanad, Kasargode), Bihar, Gujarat, Madhya Pradesh, Maharashtra, Odisha and West Bengal.

Materials examined: 4♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 7.xi.1996, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 7782; 1♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kallippara, 22.ix.2016, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 7781; 4♀, 3♂, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Champakkad, 7.xi.1996, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 7281; 1♀, India: Kerala, Kozhikode, Narayamkulam, Balussery, 28.vii.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4649; 2♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 22.v.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 6534; 1♂, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Alempatty, 12.ix.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4816; 1♂, 2♀, India: Kerala, Palakkad, Seetharkundu, 10.x.2014, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4245; 1♀, India: Kerala, Idukki, Eravikulam N P, Vasyapara, 5.iv.2012, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4938; 2♀, India: Kerala, Kozhikode, Narayamkulam, Balussery, 24.xii.2014, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4246; 1♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 21.xi.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 8151; 1♂, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Champakkad, 12.ix.2015, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 4818; 1♀, India: Kerala, Kozhikode, Vanaparvam, Kakkavayal, 29.iii.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 6936; 1♂, India: Kerala, Kozhikode, Vanaparvam, Kakkavayal, 29.viii.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 8157; 1♂, 2♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, 4.vi.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4585; 1♂, India: Kerala, Kozhikode, Cherukkad,

Balussery, 6.ix.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 8160; 1♂, 5♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Alempatty, 12.ix.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4767; 1♀, India: Kerala, Kozhikode, Mankavu, Pattelthazham, 6.ix.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5308; 2♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 22.v.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 5016; 3♀, India: Kerala, Kannur, Aralam Wildlife Sanctuary, Paripputhodu, 13.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8589; 1♀ (damaged), India: Kerala, Kannur, Madaippara, 12.iii.1995, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9376; 1♂, 5♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Alempatty, 12.ix.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4767; 2♂, India: Kerala, Kasargode, Kottanchery, 6.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9449; 1♂, 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Venkoli, 10.ix.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9454; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Baghapallam, 11.ix.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9458; 1♂, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Pooppara, Muthuvans colony, 12.ix.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9459; 2♀, India: Kerala, Ernakulam, Mallana R F, Kodanad, 14.iii.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9460; 1♀, India: Kerala, Wayanad, Muthanga Wildlife Sanctuary, Maragadha, 17.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9456.

Habitat: The collected specimens were found mostly under boulders, but occasionally under decaying logs, leaf litters and coconut husks. Generally observed in forests tracts, laterite hills and sometimes in the residential area near to forest area.

Remarks: Aswathi et al. (2017) recorded this species for the first time from Kerala and the characters of this species are very close to the species *Lychas tricarinatus* (Simon). Sexual dimorphism present, males with long segments of metasoma whereas metasoma short in females.

***Lychas tricarinatus* (Simon, 1884)**

(Plate 27, Fig. a)

1884. *Isometrus tricarinatus* Simon: *Ann. Mus. Civ Stor. Natr Genova,*: 47.
1900 b. *Lychas tricarinatus*: Pocock, *Fauna Brit. India, Arachn*. : 40.
1997. *Lychas tricarinatus*: Kovařík, *Acta Soc. Zool. Bohem.*: 336.

Type locality: India: Pondicherry.

Diagnosis: Total length 44-54.7 mm; external and internal granules absent on the six cutting edge of movable fingers of pedipalp; three carinae present on mesosomal segments II-VI; metasomal segments I-II with 10 keels and III-IV with 8 keels, but sometimes the III segment may have 10 keels; pectinal tooth count 20-26.

Description of adult male

Colouration: Body and appendages yellow variegated with black. Prosoma: carapace black with yellow patches. Mesosoma: tergites black variegated with '><' shaped and spots of yellow. Stenites yellow with pale brown shade. Metasoma: segments yellow with pale brown stripes and spots except the last with well-marked black stripes ventrally, vesicle of telson golden brown. Pectine pale yellow. Sternum yellow. Genital operculum yellow. Basal piece yellow. Chelicerae yellow with reticulation, anterior margin black and clear yellow spot present anteriorly; movable finger yellow at the tip and remaining black, denticles brown. Pedipalp yellow variegated with black, more black on femur and patella; fingers yellow same as manus colour. Legs yellow variegated with black, more black on femur and patella.

Carapace: Coarsely granular except the yellow patches. Carinae absent. Anterior margin of carapace slightly concave medially, shallow postero-lateral, deep median and postero-median furrows present on either side of the carapace. Median ocular tubercle smooth and distinct, eyes situated anterior to the centre of carapace; median eyes almost equal in size and are separated by a distance less than one ocular diameter **(Fig. b)**. Lateral eyes, numbering five; the fifth eye is the smallest when compared to others; the fourth eye is larger than the fifth but smaller than others; first eye smaller than second and third.

Mesosoma: All tergites coarsely granular except the patches, medially carinated on all tergites; tergite I with carinae on either side of the median carina. Tergite II with weak carinae represented by large granules on either side of the median carina.Tergite III-VI with well-marked incomplete carinae on either side of the median carina; last tergite with a pair of lateral carinae on either side of the median carina. Sternites smooth except the last with granules and four carinae. Stigmata present, which is moderate in size and oval-like in shape **(Fig. c)**.

Metasoma: Segment I with ten carinae. Segment II, III and IV with eight carinae, lateral carinae on segment II only represented by few granules.Segment V pentacarinated; intercarinal spaces of all segments occupied with granules. Setae present on all segments.

Telson: Vesicle pyriform and flat. Subaculear tubercle spinoid with a pair of granules dorsally; long few setae present laterally and ventrally; aculeus shorter than vesicle and curved. Single median band tuberculated ventrally **(Fig. d)**.

Pectines: Well developed sclerites. Marginal lamellae composed of three pieces of different shapes and sizes; middle lamellae with seven pieces of

irregular shapes; fine and small numerous setae present throughout. Pectinal tooth count 22-23. The Basal piece with a moderate antero-median notch **(Fig. f).**

Genital operculum: Well developed sclerites, two sclerites together constitute to form an inverted anchor like in shape.

Sternum: Triangular sternum with a deep median furrow; anterior apical button present; anteriorly narrow and posteriorly widened; few setae present.

Chelicerae: Smooth on the basal piece without any granulation and punctuation; ventral portion clothed with fine, thick and silky hairs. Dentition characterized as in the family **(Fig. e)**.

Pedipalp: Slender and stout; femur shorter than carapace carinated and granulated throughout; patella slightly shorter than carapace but longer than the femur, carinated and granulated throughout, slightly on the ventral surface. Chela longer than carapace, carinae absent but fine scattered granulation present and short setae present; chela finger dentition on movable and immovable fingers each with six oblique rows of denticles; slightly scallope at the base of the movable finger with a single accessory granule **(Fig. g)**.

Legs: Dorsal granulation present on femur and patella. Long tibial spur present on legs III and IV. Tibia, tarsomere I and II ventrally clothed with thick setae.

Trichobothrial pattern: Type 'B' as characterized as in the family **(Plate 28, Fig. a-e)**.

Distribution: India: Kerala (Wayanad, Thrissur, Idukki, Palakkad, Kasargode, Kozhikode), Andhra Pradesh, Madhya Pradesh, Karnataka, Maharashtra, Tamil Nadu, Bihar and Goa.

Materials examined: 1♀, India: Kerala, Wayanad, Pookode, Vetirinary college campus, 31.vii.2015, coll. Nithin, Reg. No. ZSI/WGRC/IR/INV 4671; 1♂, India: Kerala, Wayanad, Pookode, Vetirinary college campus, 11.iv.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4403; 2♀, India: Kerala, Thrissur, Vazhachal, Poringalkuthu, 31.iii.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4404; 1♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 19.xi.1996, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 5018; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Pulickal, 1.xi.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8129; 1♂, 6♀, 9juveniles, India: Kerala, Kasargode, Muliyar R F, Irukanni, 13.x.1993, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 8397; 1♀, India: Kerala, Kasargode, Parappa, 24.ix.1993, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 8573; 1♂, 4♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Kamaltlachi, 30.x.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8600; 1♀, India: Kerala, Kozhikode, Malaparamba, 9.x.1982, coll. Joseph Abraham, Reg. No. ZSI/WGRC/IR/INV 8923; 1 (damaged), India: Kerala, Kozhikode, Sitantpuram temple, Badagara, 30.x.1981, coll. S. C. Nahar, Reg. No. ZSI/WGRC/IR/INV 8926; 1♂, India: Kerala, Kozhikode, Peruvannamuzhi, 10.ii.1983, coll. K. N. Nair, Reg. No. ZSI/WGRC/IR/INV 8931; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Thunakadavu, 2.xi.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9020; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Padippara, 28.x.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9021; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Peruvarapallam, 25.i.1997, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9033; 2♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Venkoli, 23.i.1995, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9038; 2♀, India: Kerala, Thrissur, Asurakundu, 8.x.1995, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9375; 2♀, India: Kerala, Kozhikode, Peruvannamuzhi, 4.ix.1983, coll. G. U. Kurup, Reg. No. ZSI/WGRC/IR/INV 9408; 1♀, India: Kerala, Idukki, Chinnar Wildlife

Sanctuary, 19.xi.1996, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9403; 1♀, India: Kerala, Thrissur, Asurakundu, 8.x.1995, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9424; 1♀, India: Kerala, Thrissur, Kalluchal, 10.x.1995, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9420; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Anapadi, 14.iii.1996, coll. C. Radhakrishnan, Reg. No. ZSI/WGRC/IR/INV 9421; 1♂, 1♀, India: Kerala, Palakkad, Muthikulam, Nilgiri Biosphere, 19.xi.1990, coll. Raghunath, Reg. No. ZSI/WGRC/IR/INV 9427; 3♀, India: Kerala, Thrissur, Olakara, 11.x.1995, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9430; 1♀, India: Kerala, Kozhikode, Badagara, 28.vii.1983, coll. K. N. Nair, Reg. No. ZSI/WGRC/IR/INV 9431; 2♀, India: Kerala, Kozhikode, Chamarchi Hills, Badagara, 21.x.1981, coll. S. C. Nahar, Reg. No. ZSI/WGRC/IR/INV 9432; 1♀, India: Kerala, Kozhikode, Narikuni, 23.vi.2007, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9434; 1♀, India: Kerala, Wayanad, Noolpuzha, 12.i.1991, coll. K. N. Nair, Reg. No. ZSI/WGRC/IR/INV 9435; 1♀, India: Kerala, Kozhikode, Peruvannmuzhi, 5.xi.2014, Reg. No. ZSI/WGRC/IR/INV 9440; 1♀, India: Kerala, Kozhikode, Belrod Hill, Badagara, 28.vii.1983, coll. K. N. Nair, Reg. No. ZSI/WGRC/IR/INV 9441; 4♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Muthalakkayam, 6.xi.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9470; 2♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Anchupoola, 3.xi.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9534.

Habitat: Generally found under boulders and decaying logs.

Remarks: This species is very close to *Lychas laevifrons* (Pocock). But this species is named after its character 1) tricarinae present on the tergites **(Plate 27, Fig c)**. Sexual dimorphism present, males with long segments of metasoma whereas metasomal segments short in females.

4.6 Family Liochelidae

Diagnosis: Medium sized scorpions with flat manus of pedipalp. Three pairs of lateral eyes and narrow metasoma.

Diversity: Inhabits in Southeastern Asia and Australia with 11 genera and 84 species.

4.6.1 Key to the species of the family Liochelidae in Kerala

1. Tarsomere II provided ventrally with spinules…… **2**

− Tarsomere II provided ventrally without spinules……..... ... .***Liocheles australasiae*** (Fabricius)

2. Tarsomere II ventrally with a row of spinules…..……**3**

− Tarsomere II ventrally with 2-3 spinules at the proximal end ….....**5**

3. Legs lighter than body colour…… ..... …***Iomachus laeviceps*** (Pocock)

− Legs same as body colour…..... .**4**

4. Trichobothriotaxy 'Type C' as characterized as in the family..... ....***Iomachus mathikettanensis*** **sp. nov.**

Trichobothriotaxy exhibit the combination of both 'Type C and B' ....***Iomachus Vazhachalensis*** **sp. nov.**

5. Sexual dimorphism present on chela of pedipalp……..... .... ***Chiromachetes manikandani*** **sp. nov.**

− Sexual dimorphism absent on chela of pedipalp…..…….**6**

6. Pectinal teeth number 5-6. Scallope at the base of the movable finger of chela weak ..... ***Chiromachetes bastawadei*** **sp. nov.**

− Pectinal teeth number 7-8. Scallope at the base of the movable finger of chela distinct .....***Chiromachetes fergusoni*** Poccok

4.6.2 *Genus Chiromachetes* Pocock, 1900

1900 c. *Chiromachetes* Pocock, *J. Bombay Nat. Hist. Soc*., 12: 744.
1900 b. *Chiromachetes*: Pocock, *Fauna Brit. India, Arachn*., 77.
1983. *Chiromachetes*: Tikader & Bastawade, *Fauna of India*: 511.

Type species: *Chiromachetes fergusoni* Pocock

Diagnosis: Body colour dark brown to reddish brown, smooth, punctuate. Mesosomal tergites with longitudinal projection medially. Median eyes situated in the ratio 1: 2. Dentition on fingers of pedipalp with two parallel rows of small granules.

Distribution: India: Kerala, Trivandrum.

***Chiromachetes fergusoni* Pocock, 1900**

(Plate 29, Fig. a)

1900 c. *Chiromachetes fergusoni* pocock, *J. Bombay Nat. Hist. Soc.,* 12: 744.
1900 b. *Chiromachetes fergusoni*: Pocock, *Fauna Brit. India, Arachn*., 78.
1983. *Chiromachetes fergusoni*: Tikader & Bastawade, *Fauna of India*: 511- 516.

Type locality: India: Kerala, Trivandrum.

Diagnosis: Total length 89.50mm; entire body smooth and punctuated; anterior margin of the carapace with a deep median notch; metasomal segments thin; median eyes situated anteriorly in the ratio 1:2; pectinal tooth count 7-11.

Description of adult female

Colouration: Body reddish-black with brown to reddish brown appendages. Prosoma: Carapace reddish- black with some reddish patches. Mesosoma: tergites reddish-brown with very few reddish patches; sternites yellowish-brown except the last with more brown on lateral portions. Metasoma: Blackish-brown; vesicle yellow with brown single bands laterally and

ventrally. Pectines pale brown. Sternum pale yellow with brown anteriorly. Genital operculum pale yellow. Basal piece pale yellow. Chelicerae yellowish brown with brown reticulation and at the anterior margin; fingers pale brown at the tip and black at the base, denticles reddish-black. Pedipalp reddish-brown. Legs: reddish brown overall except tarsomere II brown.

Carapace: Somewhat lustrous, smooth and punctuated; granulation and carinae absent; anterior margin with a deep median concavity; postero-lateral and postero-median shallow furrows present. Median ocular tubercle not much developed and situated distinctly anterior to the centre of carapace; median eyes almost equal in size and are separated by a distance less than one ocular diameter **(Fig. b)**. Lateral eyes, numbering three, situated on the margin of carapace and almost equal in size, third eye is slightly far from the second eye.

Mesosoma: All tergites lustrous with a median transverse elevation; granulation and carinae absent; punctuation present. Sternites lustrous without any granulation and carinae; a pair of longitudinal shallow depression present on all sternites and fine punctuation present. Stigmata present, which is long and rod-like in shape.

Metasoma: Segments lustrous, punctuation present; carinae absent except segment V with two vestigial carinae and the intercarinal space slightly granulated.

Telson: Vesicle pyriform with short aculeus; slight granulation and a bunch of long setae present at the base of the aculeus **(Fig. c)**.

Pectines: Well developed sclerites; marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae single piece but two uncleared partition present; long setae present on marginal lamellae, minute

hairs present on teeth; Pectinal teeth count 7-10. The Basal piece with a deep median anterior ‘V' shaped depression **(Fig. e)**.

Genital operculum: Single sclerite without longitudinal separation and heart-like in shape.

Sternum: Sub-pentagonal in shape; anteriorly widened and posteriorly narrow; shallow depression present postero-medially; few setae present.

Chelicerae: Smooth on the basal piece without any granulation and punctuation; ventral portion clothed with very fine yellow, thick and silky hairs. Dentition characterized as in the family **(Fig. d)**.

Pedipalp: Dorso-ventrally flattened large appendages. Chela longer than carapace; femur with keeled carinae; dorsal surface slightly granulated and highly punctuated; patella with keeled carinae, dorsal surface tuberculated and slightly granulated; chela carinated with dorsal tuberculation, punctuation and granulation; external and internal intercarinal spaces granulated. Fingers carinated and base of the movable finger highly scallope **(Fig. f)**.

Legs: Slight granulation present on the femur; all segments punctuated and smooth; long setae present. Femur of first three segments ventrally carinated, fourth leg carinae on femur vestigial. Single row of spinules absent on tarsomere II but two to three strong spinules present.

Trichobothrial pattern: Type ‘C’ as characterized as in the family **(Plate 30, Fig. a-e)**.

Materials examined: 1♀, 2Young ones, India: Kerala, Kollam, Thenmala R F, Kaduvapallam, 11.viii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 3249; 1♀, India: Kerala, Kollam, Thenmala R F, Kaduvapallam, 11.viii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9051; 4♀, 1♂Young one, India: Kerala, Kollam,

Thenmala R F, Kazhuthurutty, 9.viii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9305; 1♀, India: Kerala, Kollam, Thenmala R F, Palaruvi, 10.i.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9308; 1♀, 1♂, 1Young one, India: Kerala, Kollam, Rosemala, 18.x.2012, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9615;

Habitat: The collected specimens generally found under boulders.

Remarks: *Chiromachetes fergusoni* Pocock is endemic to the state. This species exhibits very restricted distribution in the state. No specimens were collected from the type locality.

***Chiromachetes bastawadei* sp. nov.**

(Plate 31, Fig. a)

Diagnosis: Total length 39.71 mm. Genital operculum single sclerite with a posterior point which is blunt. Movable finger with very slightly scallope at the base. Few granules present dorsally on the femur. Three moderately long spines present ventrally at the base on tarsomere II. Marginal lamellae of pectine composed of two pieces, middle lamellae comprise a single piece. Pectinal tooth count 5-6.

***Colouration*:** Body black with brown patches; appendages of dark brown to brown in colour. Prosoma: carapace black with scattered brown patches. Mesosoma: tergites black with some black patches. Sternites yellowish brown with black lateral margins except for the first sternite and more black on the last sternite. Metasoma: segments black with scattered brown patches, vesicle yellow with reddish brown at the tip of the aculeus. Pectines pale yellow. Sternum pale brown with pale yellow border. Genital operculum pale yellow with slight brown shade. Basal piece slightly brown. Chelicera pale brown with dark brown reticulation and with dark brown anterior margin; fingers

pale brown on movable fingers with reddish brown denticles. Pedipalp: femur dark brown, patella dark brown with pale brown patches. Chela pale brown patches all carinae and two dorsal bands dark brown; fingers dark brown to black with pale brown tip. Legs: femur, patella, tibia and tarsomere I dark brown to black with pale brown patches. Tarsomere II yellow to pale brown with a blackish shade.

***Carapace*:** Somewhat lustrous and smooth without any granulation but punctuation present throughout except patches; carinae absent; anterior margin with deep median concavity; antero-lateral, postero-median and postero-lateral shallow furrows present. Median ocular tubercle slightly anterior to the centre of carapace; median eyes are almost equal in size and are separated by a distance less than half ocular diameter **(Fig. b)**. Lateral eyes, numbering three, arranged in a straight line; first, two eyes are almost equal in size and separated by a small distance but the third eye is the smallest among three eyes and separated from the second eye with a distance slightly more than the distance between first two eyes.

***Mesosoma*:** All tergites slightly lustrous without any carinae but a transverse elevation medially on tergite II-VI; granulation absent on all tergites but punctuated; carinae and granulation absent on all sternites but punctuated; a pair of longitudinal depression present on all sternites. Stigmata present, which is short and rod-like in shape.

***Metasoma*:** Segments slightly lustrous without any granulation but punctuated and patched; dorsal carinae absent on all segments; ventral carinae present on the segment but are weak in nature; sparsely to moderately hirsute on all segments.

***Telson*:** Vesicle pyriform with short aculeus; thickly hirsute ventrally on vesicle; punctuation not much distinct; ventrally with a pair of bands extended from anterior to the base of the aculeus **(Fig. c)**.

***Pectines*:** Well developed sclerites; marginal lamellae composed of two pieces with different shapes and sizes; middle lamella comprises a single piece; moderately long setae present mainly on marginal and middle lamellae. Pectinal tooth count 5-6 distal teeth widened and somewhat triangular in shape. The Basal piece composed of single sclerite with antero-median shallow depression **(Fig. d)**.

***Genital operculum*:** Single sclerite not separated longitudinally; posteriorly pointed, which is blunt in nature; sclerite is heart-like in shape.

***Sternum*:** Sub pentagonal in shape; anteriorly widened and slightly narrow posteriorly when compared to the anterior wideness; shallow depression present posteriorly; few setae present.

***Chelicerae*:** Movable finger possess basal (b), median (m), subdistal (sd) and external distal (ed) denticles. Immovable finger with basal, median, subdistal and distal (d) denticles; basal denticle weak and median denticle is well developed on movable finger. Basal piece uniformly reticulated except the anterior margin **(Fig. e)**.

***Pedipalp*:** Small to moderate appendages. Chela longer than carapace; movable and immovable fingers are slightly longer to as long as the carapace. Patella slightly longer to as long as the femur. Femur without any granulation but punctuated; dorsal carinae crenulated. Patella punctuated with exterior crenulated incomplete carinae. Chela manus dorsally slightly tuberculated and punctuated with some blunt granules anteriorly; all carinae crenulated and slight granulation present exteriorly, ventrally smooth; movable and

immovable fingers with smooth carinae dorsally; movable finger slightly scallope at the base **(Fig. f)**.

***Legs*:** Few granules present dorsally on the femur, patella, tibia, tarsomere I and II without granulation but punctuated; all segments moderately hirsute; three moderately long spines present ventrally on tarsomere II **(Fig. g)**.

***Trichobothrial pattern*:** Type 'C' as characterized as in the family **(Plate 32, Fig. a-f)**.

Distribution: India: Kerala (Kollam).

Etymology: This species is named after Dr D. B. Bastawade in honour of his significant contributions to the scorpion studies.

Materials examined: 1 holotype ♀, India, Kerala, Kollam, Pandimotta,

17.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV/10016.

Habitat: The holotype was found under boulders from the forests tracts.

Remarks: *Chiromachetes* Pocock is a rare genus known only from India, with three species reported so far. *Chiromachetes fergusoni* Pocock is known from Kerala, the described new species *Chiromachetes bastawadei sp. nov.* can be distinguished from the characters including 1) movable finger of chela with weak scallope at the proximal end, 2) few granules present on the dorsal surface of the femur, 3) Pectinal tooth count 5-6.

***Chiromachetes manikandani* sp. nov.**

(Plate 33, Fig. a)

Diagnosis: Medium sized scorpions, the total length of holotype male reaching 39.2 mm. Flat carapace; three pairs of lateral eyes. Pedipalp chela slender and somewhat long when compared to other species of the genus **(Fig.**

b). Leg tarsi with 2-3 very small spinoid spinules at the base.Pectinal tooth count holotype male 10/11; paratype male 10/10; paratype female 8/9.

Description of holotype male

***Colouration*:** Basically brown to blackish in whole except the telson. Prosoma: carapace blackish with some scattered pale brown patches; posterior margin yellow. Mesosoma: tergites I-VI black with yellow posterior margin; sternites brown to black. Metasoma: segments black with scattered brown patches, vesicle yellow with brown at the tip of the aculeus. Pectines yellow. Sternum pale brown.Genital operculum yellow. Chelicera: proximally pale brown with black reticulation, distally blackish; fingers black with reddish brown denticles. Pedipalp reddish brown; chela fingers dark dorsally. Legs with scattered yellow patches, ventrally tarsomere II pale yellow.

***Carapace*:** Dark brown to black; overall punctuation scattered patches of pale brown with the exception of punctuation; lacks carinae; smooth, glossy without any granulation. Anterior margin with a 'U' shaped median indentation; a pair of shallow furrows present postero laterally and postero medially. Median ocular tubercle not much elevated with two eyes, which are almost equal in size and lateral ocular tubercle present at the anterior margin provided with three lateral eyes on each side; three eyes are almost equal in size, first and second separated by a small distance but the distance is more in between second and third eyes **(Fig. b)**.

***Mesosoma*:** Tergites black with scattered tan brown colouration. All tergites smooth, glossy, punctuated and lacks carinae; Sternites tan-brown overall except for the last sternite with black colouration. Each tergite medially with longitudinal projection **(Fig. c)**.

***Metasoma*:** Segments smooth throughout, lacks granulation and carinae but median depression present on segments III-V, others shallow; anal arch crenulated; ventrally all segments with dense bristles.

***Telson*:** Vesicle pyriform and bulbous with short aculeus; densely hirsute on vesicle with long hairs; punctuation distinct **(Fig. e)**.

***Pectines*:** Well developed sclerites; marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae comprise of two pieces; moderately long setae present mainly on marginal and middle lamellae. Pectinal tooth count 10-11 distal teeth widened. The Basal piece composed of single sclerite with antero-median deep depression **(Fig. f)**.

***Genital operculum*:** Well developed sclerite separated longitudinally; each sclerite is somewhat semi-triangle in shape.

***Sternum*:** Sub pentagonal in shape; anteriorly widened and slightly narrow posteriorly when compared to the anterior wideness; shallow depression present postero-medially; few setae present.

***Chelicerae*:** Movable finger possess basal (b), median (m), subdistal (sd) and external distal (ed) denticles. Immovable finger with basal, median, subdistal and distal (d) denticles; all denticles are blunt on the movable finger; all denticles are somewhat pointed on the immovable finger; the basal piece uniformly reticulated except the anterior margin **(Fig. g)**.

***Pedipalp*:** Moderate appendages. Chela longer than carapace; movable and immovable fingers are slightly longer or as long as carapace; femur dorsally granulated; manus of chela with four carinae, tuberculated and granules present internally and ventrally smooth. Patella with carinae not smooth, but tuberculated and punctuated. Movable and immovable fingers with smooth carinae dorsally; movable finger very slightly scallope at the base **(Fig. d)**.

***Legs*:** Few granules present dorsally on the femur; patella, tibia, tarsomere I and II without granulation but punctuated; all segments moderately hirsute; three moderately long spinules present ventrally at the base of tarsomere II **(Fig. h)**.

***Trichobothrial pattern*:** Type 'C' as characterized as in the family **(Plate 34, Fig. a-g)**.

Distribution: India: Kerala (Ernakulam).

Etymology: This species is named after Mr Manikanadan in honour of his contributions in the collection of scorpions in ZSI, WGRC, Kozhikode.

Materials examined: 1♂ holotype, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kolumba, 20.ix.2016, coll. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9786; 2♂, 1♀ paratypes, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kolumba, 20.ix.2016, coll. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9787; 2♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kolumba, 5.ii.2017, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9788.

Habitat: The specimens were collected from a rocky region with loose black soil and were found in rock crevices.

Remarks: The enigmatic genus *Chiromachetes* Pocock is rare among the family, represented only by three species from the world. The status of the species *Chiromachetes tirupati* Lourenço is still a controversy. The newly described species is different from other species in having 1) pedipalp chela manus very slender the species *Chromachetes fergusoni* Pocock, but slightly more than the species *Chiromachetes sahyadriensis* Mirza et al. 2015 2) pectinal tooth count ranges from 8-11, 3) scallope at the proximal end of the movable finger is not much distinct as in *Chiromachetes fergusoni* Pocock.

4.6.3 Genus *Iomachus* Pocock

1893 a. *Iomachus*: Pocock, *Ann. Mag. Nat. Hist.,* 6 (12): 320.
1983. *Iomachus*: Tikader & Bastawade, Zoological Survey of India: 479.

Type species: *Iomachus laeviceps* (Pocock,1890).

Diagnosis: Body smooth and punctuate. Median eyes situated anteriorly in the ratio 1:1.5. Tarsi with a ventro-median row of small spinules between the setae.

Distribution: India and Eastern Africa.

***Iomachus laeviceps* (Pocock, 1893)**

(Plate 35, Fig. a)

1893. *Iomachus laeviceps*: Pocock, *J. Bombay Branch of the Royal Asiatic Soc.*: 300.
1968 c. *Iomachus laeviceps*: Sreenivasa Reddy*, Bull. Mus. Natn. Hist. Nat., Paris, 2e ser*: 1066.
1983. *Iomachus laeviceps laeviceps*: Tikader & Bastawade, Zoological Survey of India: 490.

Type locality: India: Tamil Nadu, Yercaud.

Diagnosis: Entire body smooth and punctuate except metasomal segments V with weak granulation and carinae; body colour dark brown with scattered yellow patches; legs clear yellow; median eyes situated anteriorly in the ratio 1: 1.5; pectinal tooth count 5-6.

Description of an adult female.

Colouration: Body is blackish-brown to yellow appendages. Prosoma: carapace blackish-brown with some pale brown patches. Mesosoma: tergites blackish-brown with scattered pale brown patches; sternites yellowish-brown, except the last sternite with some blackish border. Metasoma: segments

blackish-brown, vesicle yellow with reddish-brown aculeus. Pectines: pale yellow. Sternum pale brown with some black at the anterior portion. Genital operculum pale yellow. Basal piece pale brown. Chelicerae: brown with black reticulation on the basal piece and more black on anterior margin; Fingers with pale brown at the tip and black at the base. Pedipalp: blackish-brown to reddish black; chela margins and fingers more black. Legs: yellow.

Carapace: Somewhat lustrous smooth and punctuated without any granulation; carinae absent; anterior margin 'V' shaped. Postero-lateral and postero-median shallow furrows present. Median ocular tubercle vestigial and situated anterior to the centre of carapace; median eyes almost equal in size and as separated by a distance less than one ocular diameter **(Fig. b)**. Lateral eyes, numbering three, arranged on the margin of carapace; three eyes almost equal in size and first two eyes separated by an equal distance.

Mesosoma: All tergites lustrous with a median transverse elevation including the pretergites; granulation and carinae absent; punctuation present. Sternites lustrous, smooth and very finely punctuated; a pair of longitudinal shallow depressions present on all sternites; long setae present on lateral margins. Stigmata present, which is moderate in size and rod-like in shape.

Metasoma: Segments lustrous without granulation; punctuation present throughout; dorsal keeled carinae present. Ventral and lateral carinae absent on segments I-IV; segment V with three keeled ventral carinae. Long setae present on all segments.

Telson: Vesicle pyriform with short aculeus, covered with long setae ventrally and laterally; no granulation and carinae absent **(Fig. c)**.

Pectines: Well developed sclerites; marginal lamellae composed of two pieces with different shapes and sizes; middle lamellae comprise a single piece; long setae present on marginal lamellae; minute setae present on teeth.

Pectinal teeth count 6-7. Basal piece a single sclerite with a shallow antero-median depression **(Fig. d)**.

Genital operculum: Single sclerite not separated longitudinally; posterior tip pointed and with a heart – like in shape.

Sternum: Sub pentagonal sternum in shape; anteriorly widened, posteriorly narrow. Shallow depression present at the posterior margin; few setae present.

Chelicerae: Smooth on the basal piece without any granulation and punctuation; ventral portion clothed with shiny, thick and silky hairs; punctuation present on the dorsal surface of fingers **(Fig. e)**.

Pedipalp: Dorso-ventrally flattened and moderate appendages. Chela longer than carapace; movable and immovable fingers shorter than carapace; femur and patella shorter than the chela. Femur as long as the carapace, carinated and punctuated, internal intercarinal space granulated. Patella carinated and punctuated. External and internal intercarinal space of chela granulated and punctuated; movable and immovable fingers carinated, movable finger slightly scallope at the base **(Fig. f)**.

Legs: Slight granulation present on first three legs dorsally, otherwise all segments smooth and punctuated; long setae present throughout; a pair of ventral carinae present on femur of legs I-III, same as in patella but not much developed as in femur; single row of spinules present on the ventral aspect of tarsomere II **(Fig. g)**.

Trichobothrial pattern: Type 'C' as characterized as in the family **(Plate 36, Fig. a-g)**.

Distribution: India: Kerala (Palakkad, Idukki, Kozhikode, Malappuram, Wayanad, Trivandrum, Thrissur, Kasargode, Kollam), Tamil Nadu.

Materials examined: 2♂, 2♀, India: Kerala, Palakkad, Seetharkundu, 10.x.2014, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4823; 3♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 21.x.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 3942; 2♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Champakkad, 12.ix.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4817; 2♀, 1 Subadult, India: Kerala, Idukki, Eravikulam N P, Vasyapara, 5.iv.2012, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8158; 1♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Alempatty, 12.ix.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4768; 4♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Champakkad, 21.ix.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 3941; 3♀, 1♂, 22juveniles, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 22.v.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 5017; 1♂, India: Kerala, Kozhikode, Malabar Wildlife Sanctuary, Urakuzhi, 22.xii.2015, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 5112; 1♀, India: Kerala, Wayanad, Periya R F, 19.xii.1985, coll. K. N. Nair, Reg. No. ZSI/WGRC/IR/INV 8170; 1♂, 1♀, India: Kerala, Malappuram, Manjeri, 25.i.1983, coll. S. C. Nahar, Reg. No. ZSI/WGRC/IR/INV 8394; 1♀, 2juveniles, India: Kerala, Malappuram, Karuvarakundu, Paragenkundu, 1.v.1993, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8396; 1♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, 21.ix.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 8924; 1♂, 5♀, 3Young ones, India: Kerala, Ernakulam, Panneli R F, 13.ii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9041; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Muthuvarachal, 5.xi.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9053; 2♂, 2♀, India: Kerala, Thrissur, Asurakundu, 8.x.1995, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9044; 1♂, 3♀, 22juveniles, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 22.v.2014, coll. P. M. Sureshan,

Reg. No. ZSI/WGRC/IR/INV 9045; 3♀, India: Kerala, Ernakulam, Perumthodu, 15.xi.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9306; 1♂, India: Kerala, Palakkad, Parambikulam Tiger Reserve, 24.iii.1997, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9309; 1♂, India: Kerala, Trivandrum, Kolathupuzha, 31.xii.1983, coll. G. U. Kurup, Reg. No. ZSI/WGRC/IR/INV 9413; 1♀, 3Young ones, India: Kerala, Thrissur, Asurakundu, 8.x.1995, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9429; 1♀, India: Kerala, Ernakulam, Perumthodu, 15.xi.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9433; 1♂, India: Kerala, Kasargode, Ranipuram, 8.xi.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9457; 4♂, 3♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Muthuvarachal, 28.i.1997, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9471; 1♀, 1Young ones, India: Kerala, Kozhikode, Malabar Wildlife Sanctuary, 1.ii.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9577; 1♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Alampatty, 14.xii.2006, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9579; 1♂, India: Kerala, Ernakulam, Mallana R F, Kodanad, 12.xi.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9614; 2♂, 3♀, India: Kerala, Trivandrum, Pandipath, 14.x.2012, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9618; 3♀, India: Kerala, Trivandrum, Ponmudi, 24.ii.2017, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9619; 2♀, 4Young ones, India: Kerala, Thrissur, Olakara, Peechi, 11.x.1995, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9620; 1♂, 1♀, India: Kerala, Kollam, Pandimotta, 17.x.2012, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9621; 2♀, India: Kerala, Kollam, Pandimotta, 19.xi.2016, coll. Bindu, Reg. No. ZSI/WGRC/IR/INV 9622; 1♀, India: Kerala, Palakkad, Silent valley N P, Poochippara, 21.ii.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9623; 3♂, 2♀, India: Kerala, Trivandrum, Pandipath, Bonakkad, 15.xii.2015, coll. K. Rajmohana, Reg. No.

ZSI/WGRC/IR/INV 9624; 1♂, 1♀, India: Kerala, Ernakulam, Ponganchuvadu, Idamalayar, 8.xii.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9625; 1♂, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 4.iv.2016, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9611.

Habitat: The collected specimens were found in rock crevices and under boulders. localities of all type materials examined included thorny scrub jungle, evergreen forest and deciduous forest.

Remarks: An uncommonly distributed species found only in the highlands and midlands of Kerala state. In the fauna of India: scorpions, Tikader and Bastawade (1983) included the species *Iomachus laeviceps laeviceps* Pocock and *Iomachus laeviceps malabarensis* Pocock, but both are synonymised under this species. Sreenivasa Reddy (1968 c) studied the genus *Iomachus*, which dealt with all species under the same genus. He described the species *Iomachus laeviceps* Pocock, but no description on *Iomachus laeviceps malabarensis* Pocock was provided. But later Bastawade et al. (2012) provided a checklist of Indian scorpions where only the species *Iomachus laeviceps* Pocock was listed. This revealed that both species provided by Tikader and Bastawade (1983) comes under *Iomachus laeviceps* Pocock.

***Iomachus mathikettanensis* sp. nov.**

(Plate 37, Fig. a)

Diagnosis: Total length 70.36 mm. Body reddish brown to black and legs with the same colour. Slight granulation present on the femur. Scallop absent on fingers of chela of pedipalp. Marginal and middle lamellae of pectine composed of a single piece. Pectinal tooth count 4-5.

Description of holotype male

***Colouration*:** Body reddish-brown to black with scattered brown markings all over the body. Prosoma: carapace brown with black scattered colouration present more on median and lateral ocular regions. Mesosoma: tergites blackish brown with pale brown patches on both the sides of the median projection; sternites brown with some yellow colouration except the last sternite black. Metasoma: black with scattered brown patches; telson yellowish-brown with reddish-brown aculeus. Pectines: pale yellow. Sternum: dark brown anteriorly and pale brown posteriorly. Genital operculum: yellow with little brown; Basal piece yellowish-brown. Chelicera: yellowish-brown with dark brown reticulation on the basal piece. Anterior portion of the basal piece with thick dark brown colouration extending to the base of the fixed finger and also present on movable finger. Pedipalp: reddish-brown to black. Legs: femur, patella, tibia and tarsomere I reddish brown to black with the exception of tarsomere II pale brown.

***Carapace*:** Smooth, lustrous and punctuated on black colouration without any granulation; carinae absent; anterior margin smooth with few setae and a shallow concavity medially. Furrow present posterior-medially and posterior-laterally; median ocular tubercle and lateral ocular tubercle slightly elevated; median eyes with moderate size, lateral eyes present on the margin of the carapace **(Fig. b)**. Three lateral eyes of different sizes, the first eye larger than the others; second and third eyes are of equal size; second and third eyes are somewhat close to each other but the first is little apart from the second.

***Mesosoma*:** All tergites smooth and lustrous with full of punctuation; granulation and carinae absent; median projection well developed in all tergites except tergite I and II less developed. Sternites smooth and punctuated with ‘M' shaped furrow present medially; stigmata present on sternites I-IV, which is short and oval-like in shape **(Fig. c)**.

***Metasoma*:** All segments are lustrous; few setae present; punctuation present on black colouration; smooth tricarinae present ventrally on all segments but granulated on segment V **(Fig. d)**.

***Telson*:** Smooth, lustrous and bulbous pyriform vesicle with short aculeus; reddish long setae present ventrally and laterally **(Fig. e)**.

***Pectines*:** Well-developed sclerites; marginal lamellae and middle lamellae composed of a single piece. Pectinal teeth count 5/4 **(Fig. f)**.

***Genital operculum*:** Two sclerites each with semi-oval shape constitute an oval-like shape.

***Sternum*:** Sub-pentagonal widened anteriorly with a posterior-median furrow; two setae present on either side of the furrow.

***Chelicerae*:** Basal piece with not much-developed reticulation, with few setae present at the anterior portion; movable finger possesses basal (b), median (m), subdistal (sd), external distal (ed) and internal distal (id) denticles. Subdistal denticle very poorly developed, median denticle well developed. Fixed finger with basal (b), median (m), subdistal (sd) and distal (d) denticles **(Fig. h)**.

***Pedipalp*:** Chela longer than carapace; femur as long as carapace; femur slightly granular dorsally and internally, smooth on ventral and external portions; four granular carinae present two externally and two internally; punctuation present. Patella: slightly tuberculate dorsally and ventrally, granular internally and externally. Four carinae and punctuation present. Chela: tuberculate dorsally, densely granular externally and slightly granular internally; ventrally smooth, punctuation present; four carinae two external carinae well developed and two internal carinae weakly developed. The inner

edge of the chela fingers with two longitudinal rows of teeth which are nearly parallel except the distal extremity **(Fig. g)**.

Legs: All segments smooth but punctuated; a row of spinules present ventrally on tarsomere II; moderately hirsute; internal carinae present on femur and patella **(Fig. i)**.

Trichobothrial pattern: Type 'C' as characterized as in the family **(Plate 38, Fig. a-d)**.

Distribution: India: Kerala (Idukki).

Etymology: This species is named after the collection region.

Materials examined: 1♀ holotype, India: Kerala, Idukki, Mathikettan shola, Shanthanpara, 17.ix.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9789; 1♀, 1♂ paratypes, India: Kerala, Idukki, Mathikettan shola, Shanthanpara, 17.ix.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9790; 5♀, 11 juveniles, India: Kerala, Idukki, Mathikettan shola, Shanthanpara, 25.ix.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9791; 2♀, 1juvenile, India: Kerala, Idukki, Mathikettan shola, Shanthanpara, 25.ix.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9792.

Habitat: This species was collected from a cardamom plantation and found under rock crevices and boulders.

Remarks: The only known species under the genus *Iomachus* Pocock, 1893 from Kerala is *Iomachus laeviceps* Pocock. The described new species *Iomachus mathikettanensis* sp. nov.can be differentiated from that by the following characters 1) movable finger of the chela of pedipalp without scallope at the proximal end, 2) marginal and middle lamellae of pectine with a single piece, 3) Pectinal tooth count 4-5.

***Iomachus vazhachalensis* sp. nov.**

(Plate 39, Fig. a)

Diagnosis: Medium sized scorpions, the total length of holotype male reaching 49.41 mm. Pectinal tooth count holotype male 5/6. Trichobothriotaxy exhibit the combination of type B and C.

Description of holotype male

Colouration: Body is blackish-brown with blackish-brown to brown appendages. Prosoma: Carapace brown with scattered black colouration more on anterior margin, median and lateral ocular regions and also on anterio-lateral portions. Mesosoma: tergites brown with some yellow patches on both sides of the median projection; sternites pale brown except the last sternite with black posteriorly. Metasoma: blackish with scattered reddish-brown patches dorsally and ventrally; vesicle yellowish brown with reddish-brown aculeus. Pectines: pale yellow with brown at the proximal tip of the marginal lamellae. Sternum: brown anteriorly and yellow posteriorly; genital operculum yellow; basal piece brownish-yellow. Chelicera: brown with dark brown reticulation on the basal piece and dark brown pigmentation at the anterior portion extending up to the median portion of the fixed finger; movable finger with dark brown extending to the median portion from the base. Pedipalp: reddish-brown with carinae and half of the fingers black. Legs: femur, patella, tibia and tarsomere I blackish-brown with brown patches, tarsomere II pale brown.

Carapace: Lustrous and smooth with scattered punctuation without any granulation; carinae absent; anterior margin smooth with few setae and medially with a shallow concavity; furrows present posterior-medially and posterior- laterally; median ocular tubercle flattened and situated slightly anterior to the centre of the carapace **(Fig. b)**. Median eyes with moderate

size, lateral eyes present on the margin of the carapace with a not much-developed tubercle. Three lateral eyes of equal size but first and two are close to each other, the third eye is little apart from the second.

Mesosoma: All tergites lustrous with a median projection but not much developed in tergite I and VII carinae and granulation absent with punctuation **(Fig. c)**. Sternites smooth, punctuated and lustrous with a pair of shallow furrows on either side of the median axis; stigmata present on sternites I-IV which are short and oval-like in shape.

Metasoma: All segments lustrous, smooth without any granulation; punctuation present only on black colouration; long scattered reddish setae present on all segments.

Telson: Pyriform vesicle with short aculeus vesicle smooth dorsally and laterally but a few granulations present ventrally at the base of the aculeus; long reddish setae present ventrally and laterally **(Fig. d)**.

Pectines: Well developed sclerites, marginal lamellae composed of two pieces; minute setae present all over the pectine. Pectinal teeth count 6/5, the distal teeth somewhat broader than the remaining; middle lamellae composed of a single piece. The basal piece, a single sclerite with anterio-median concavity **(Fig. e)**.

Genital operculum: Longitudinal cut made the sclerite into two; both sclerites constitute horizontally an oval-like shape.

Sternum: Sub-pentagonal in shape, anteriorly wider and posteriorly narrow; punctuated; furrow present posterior-medially, few setae present on either side of the furrow.

Chelicerae: Movable finger possess basal (b), median (m), subdistal (sd), external distal (ed) and internal distal (id) denticles; median denticle longer

than basal denticle and subdistal is shorter than external distal denticle. Fixed finger with basal (b), median (m), subdistal (sb) and distal denticles; the basal piece with not much- developed reticulation **(Fig. f)**.

Pedipalp: Chela two times longer than carapace; fingers of chela shorter than or as long as carapace; femur as long as patella. Femur: granulated dorsally, externally and internally, but ventrally smooth and punctuated; four granulated carinae present. Patella: granulated externally and internally with not much developed internal tubercle; two complete granulated carinae externally and two internal incomplete or weak carinae dorso-internally. Chela: manus tuberculate dorsally, granulated externally, internally and ventrally smooth except near the portion of ventro-internal margin; four granulated carinae present, external carinae well developed and internal carinae weak; the inner edge of the chela fingers with two longitudinal rows of teeth which are nearly parallel **(Fig. g)**.

Legs: Covered with long setae, tarsomere II with a row of spinules ventrally. Slight granulation present on femur and patella **(Fig. h)**.

Trichobothrial pattern: Orthobothriotaxy: it's a combination of type B and C; femur dorsally with internal (i), dorsal (d) and external (e) trichobothria; dorsally patella of pedipalp exhibit *eb*, *esb*, *est*, est_2, d_1, d_2 and *id*; ventrally patella possess eb_2, v_1, v_2 and v_3 **(Plate 40, Fig. a-g)**.

Distribution: India: Kerala (Thrissur).

Etymology: This species is named after the collection region.

Materials examined: holotype ♂, India, Kerala, Thrissur, Vazhachal, 31.iii.2015, coll. Aswathi. K, Reg. No.ZSI/WGRC/IR/INV/10201. ♂♀paratypes, India, Kerala, Thrissur, Vazhachal, 31.iii.2015, coll. Aswathi. K, Reg. No.ZSI/WGRC/IR/INV/10204.

Habitat: The collected specimens were found in rock crevices and under boulders.

Remarks: The new species *Iomachus vazhachalensis* sp. nov. can be distinguished by the important character 1) Trichobothriotaxy exhibit the combination of type B and C **(Plate, 40).**

4.6.4 Genus *Liocheles* Sundevall, 1833

1833. *Liocheles* Sundevall, *Londini Gothorum.*: 39.

Type species: *Liocheles australasiae* (Fabricius, 1775)

Diagnosis: Body smooth and punctuate. Mesosomal tergites carinated. Median eyes situated anteriorly in the ratio 1:1.5. Tarsi lack the ventro-median row of small spinules between the setae. In both sexes genital operculum with a median suture, not pointed posteriorly.

Distribution: India, Philippines, Indonesia, north-western Sumatra, New Caledonia.

Liocheles australasiae (Fabricius, 1775)

1775. *Scorpio australasiae* Fabricius: *Syst. Ent*., 399.

Type locality: India: Kerala.

Diagnosis: Small to medium size; colour dark brown; carapace and mesosoma punctuate; carinae present on metasomal segments I, II and V; carinae on manus and patella of pedipalp distinct and granular; strong internal tubercle present on patella of pedipalp; median eyes situated anteriorly in the ratio 1: 1.5; single inferior median and inferior lateral carinae regularly crenulated; pectinal tooth count 6-7.

Distribution: Kerala and Andaman & Nicobar Island.

Materials examined: No Materials examined.

Remarks: I have not been able to study the type or other specimens of this species. The diagnosis provided here is based on the available literatures.

4.7 Family Scorpionidae

Subfamily Scorpioninae

Diagnosis: Large sized scorpions with round or lobed manus of pedipalp. Deep median notch present medially on the anterior margin of the carapace. Granulation on the body may or may not be present. Three pairs of lateral eyes. Metasomal segments strong. Trichobothrial pattern type C.

Diversity: The family occupies about 311 species under 21 genera, and have representatives in Africa, Asia, North America, Central and South America, Australia.

4.7.1 Key to the species of the family Scorpionidae in Kerala.

1. Pedipalp chela manus round or lobed with triangular teeth on fingers…..... **2**

− Pedipalp chela manus globular with rugously arranged teeth on fingers ……..***Rugodentus keralaensis*** Bastawade, Sureshan & Radhakrishnan

2. Pedipalp manus with granules……..... **3**

− Pedipalp manus without granules…….....…...**4**

3. Pectinal teeth number 12-16…….....……..**5**

− Pectinal teeth number 19-22…….....……...**6**

4. Pedipalp chela manus flat dorsally. Pectinal teeth number 10-14 .....**10**

− Pedipalp chela manus not flat dorsally but convex. Pectinal teeth number 7-14 ..… .....……**7**

5. Pedipalp length to width ratio 2.5-3 in males and 2.2-2.5 in females ....***Heretometrus phipsoni*** (Pocock)

− Pedipalp length to width ratio between 2-2.2 mm ..……..... .... ***Heterometrus gravimanus*** (Pocock)

6. Pectinal teeth number 19-22. Chela of pedipalp length to width ratio 1.7 mm in both sexes. Legs lighter than body..... .....***Heterometrus flavimanus*** (Pocock)

− Pectinal teeth number 16-20. Chela pedipalp length to width ratio 1.6-1.8 mm in both sexes. Legs same as body colour..... ……. .....***Heterometrus swammerdami*** Simon

7. Sexual dimorphism in proportions of pedipalp chela present .....…..**8**

− Sexual dimorphism in proportions of pedipalp chela absent .....……**9**

8. Body entirely smooth except some granulation at the lateral side of carapace.....***Heterometrus keralaensis*** Tikader & Bastawade

− Body not smooth, some blunt granulation present on carapace, Mesosoma and metasoma .....***Heterometrus kanaraensis*** (Pocock)

9. Dense granulation present all over the body. Chela of pedipalp length to with ratio 1.7-2 mm in both sexes..... .....***Heterometrus scaber*** (Thorell)

− Dense granulation absent all over the body. Chela of pedipalp length to width ratio 2.2 mm.....…….....***Heterometrus barberi*** (Pocock)

10. Pedipalp segments very long. Pectinal tooth count 12-14 ....***Heterometrus thattekkadensis*** **sp. nov.**

− Pedipalp segments moderately long. Pectinal tooth count 10-11..... .....***Heterometrus lourencoi*** **sp. nov.**

4.7.2 Genus *Heterometrus* Ehrenberg, 1828

1828. *Heterometrus* Hemprinch & Ehrenberg, *Symb. Phys.,* 7: 1-2.
1981. *Heterometrus*: Couzijn, *Zool. Verln*., 184: 1-196.
1983. *Heterometrus*: Tikader and Bastawade, *Fauna of India*, 2: 518.
2004. *Heterometrus*: Kovařík, *Euscorpius*, 15: 1-60

Type species: *Buthus (Heterometrus) spinifer* Ehrenberg, 1828.

Diagnosis: Body colour reddish-brown to a green tint, smooth or granular without any complete carinae. Sternum sub-pentagonal, wider than long. Metasomal segments thick and carinated. Fingers of pedipalp with strong, triangular pointed teeth. Chela of pedipalp with 26 trichobothria.Pedipalp femur with 3 trichobothria, of them only one on the dorsal surface.Patella of pedipalp with 19 trichobothria, 3 on ventral 13 on the external surface.

Distribution: India, Sri Lanka, Burma, Borneo, Philippines, Africa.

Heterometrus swammerdami Simon, 1872

1872. *Heterometrus swammerdami* Simon, L. *Revue et Magasin de Zoologie Pure et Appliquée,*: 56.
1991. *Heterometrus swammerdammi*: Pointer, *Journal of British Tarantula Society*: 24.
1983. *Heterometrus (Gigantometrus) swammerdami*: Tikader and Bastawade, *Fauna of India*, 2: 562.
2004. *Heterometrus swammerdami*: Kovařík, *Euscorpius*: 42.

Type locality: East Indies.

Diagnosis: Adults 130-176 mm long; colour reddish brown to reddish black; manus of pedipalp covered with large, rounded granules; carapace smooth except margins and posterior portions granulated; legs thin, elongated, granular and carinated; median eyes situated anteriorly in the ratio 1: 1; pectinal tooth count 16-20.

Distribution: India: Kerala, Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Karnataka, Maharashtra, Odisha, Pondicherry, Uttarakhand, Uttar Pradesh , Tamil Nadu and West Bengal.

Materials examined: No Materials examined.

Remarks: I have not been able to study the type or other specimens of this species. The diagnosis provided here is based on the available literatures.

***Heterometrus scaber* (Thorell, 1876)**

(Plate 41, Fig. a)

1876 b. *Pandinus scabro* Thorell, *Atti della Societá Italiana di Scienze Naturali*: 202
1899. *Heterometrus scaber*: Kraepelin, *In* Dahl, F. (ed.), *Das Tierreich. Herausgegeben vonder Deutschen Zoologischen Gesellschaft*, 116
1983. *Heterometrus (Heterometrus) malapuramensis*: Tikader and Bastawade, *Fauna of India*, 2: 533.
2004. *Heterometrus scaber*: Kovařík, *Euscorpius*: 38.

Type locality: India: Bengal.

Diagnosis: Adult 100-130 mm long; colour uniformly reddish brown; entire body granulated; pedipalp manus reticulated; carapace granulated; femur of pedipalp shorter than carapace; metasomal segments I and II wider than long; median eyes situated anteriorly in the ratio 1: 1.1; pectinal teeth number 10-12.

Description of adult male.

Colouration: Body dark green with some reddish brown. Prosoma: carapace dark green with reddish brown anterior margin. Mesosoma: tergites dark green with reddish brown posterior margin. Sternites dark brown. Metasoma: segments reddish brown dorsally and dark brown ventrally. Telson vesicle dark brown with reddish brown aculeus.Pectines golden brown. Sternum dark brown.Genital operculum golden brown. Basal piece golden brown.

Chelicerae: brown with dark anterior margin, reticulation not much distinct on the basal piece. Pedipalp: reddish brown with little green tint. Legs: dorsally femur, patella, tibia greenish but ventrally reddish brown. Tarsomere I and II reddish brown.

Carapace: Granular entirely, shallow postero-median and deep posterior lateral furrows present. Carinae absent; anterior margin smooth with a deep median notch. Median ocular tubercle smooth, distinct and situated at the centre of the carapace **(Fig. b)**. Median eyes are equal in size. Lateral eyes, numbering three, first two eyes are almost equal in size, the third eye smaller than other two; first two eyes are separated by a small distance but the third eye distance is more from the second eye.

Mesosoma: All tergites without any carinae only slight elevation in the middle. Densely granular from median to the posterior margin. Sternites smooth without any longitudinal depression. Carinae absent on all sternites. Stigmata present, which is long and rod-like in shape.

Metasoma: Segments with granulation on dorsal and lateral portions, but ventrally smooth. Segment I wider than long with eight carinae. Segments II-V always longer than wide. Eight carinae present on segments II-IV; segment v with VII carinae, but lateral carinae incomplete.

Telson: Vesicle globular with long curved aculeus. Subaculear tubercle absent. Dorsally smooth and ventrally with four keeled carinae, lateral granulation present. Densely hirsute. Setae absent.

Pectines: Well developed sclerites, marginal lamellae composed of three pieces of different shapes and sizes. Middle lamellae comprise three pieces. Entire pectin covered with moderately sized setae. Pectinal tooth count 10/11. The basal piece composed of single sclerite with a deep antero-median notch **(Fig. c)**.

Genital operculum: Sclerites longitudinally separated and each sclerite with semi oval-like in shape. Posterior suture absent.

Sternum: Sub-pentagonal sternum deep longitudinal depression present and which extends from median to the posterior margin.

Chelicerae: Smooth on the basal piece and moderately sized setae present on the anterior margin. Fingers ventrally clothed with thick, fine, silky hairs; punctuation present dorsally on movable fingers. Dentition as characterized in the family **(Fig. d)**.

Pedipalp: Short and stout; femur shorter than carapace, keeled carinae present. Dorsal and internal intercarinal spaces granulated. Patella slightly longer than the femur, but shorter than carapace, carinated and all intercarinal spaces smooth except internal portion.Chela manus moderately convex; two carinae running from the proximal part of the manus to the immovable finger. Dorsal manus tuberculated; fingers short and curved with triangularly shaped dentition **(Fig. e)**.

Trichobothrial pattern: Type 'C' as characterized as in the family **(Plate 42, Fig. a-e)**.

Legs: Femur and patella slightly granulated dorsally otherwise smooth. Tibial spur absent. Setae present throughout. Tarsomere I furnished ventrally with a single row of spinules. Tarsomere II with two rows of spinules.

Distribution: India: Kerala (Thrissur, Kozhikode, Malappuram, Idukki, Kasargode, Pathanamthitta, Kollam, Ernakulam, Trivandrum, Wayanad, Kannur), Karnataka, Maharashtra, Puduchery and Tamil Nadu.

Materials examined: 1♂, India: Kerala, Thrissur, KFRI campus, 15.xi.2014, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4012; 1♂, India: Kerala, Kozhikode, Vellimadukunnu, 19.x.2014, coll. Amina, Reg. No.

ZSI/WGRC/IR/INV 3945; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 4.i.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5533; 1♂, 1♀ Subadult India: Kerala, Kozhikode, Pazhashiraja Museum, Easthill, 5.xi.2015, Reg. No. ZSI/WGRC/IR/INV 4940; 1♂, India: Kerala, Kozhikode, Panikarkkadavu, Malabar Wildlife Sanctuary, Kakkayam, 19.v. 2012, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 5183; 4♂, India: Kerala, Kozhikode, Kulathupuzha range, Kollam; 16.viii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 3489; 1 Subadult, India: Kerala, Kozhikode, Vanaparvam, Kakkavayal, 4.i.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5304; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 4.i.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5118; 1♀, India: Kerala, Kozhikode, Adivaram, 3.xi.2014, Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5534; 1♀, India: Kerala, Kozhikode, Vellimadukunnu, 27.vi.2016, Reg. No. ZSI/WGRC/IR/INV 7280; 1♂, 2♀, India: Kerala, Kozhikode, Kakkad, Kakkavayal, 28.ix.2010, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 7279; 1♂, India: Kerala, Kozhikode, Pantheerankavu, 16.viii.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 7282; 1♀, India: Kerala, Kozhikode, Pooladikunnu, 3.x.2016, coll. Vijayan, Reg. No. ZSI/WGRC/IR/INV 7780; 1♂, India: Kerala, Kozhikode, Narikuni, 21.ix.2015, coll. Aslam, Reg. No. ZSI/WGRC/IR/INV 4824;1♂, India: Kerala, Kottayam, Puthupally, Eravinalloor, 2.ii.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 10202; 1♂, India: Kerala, Kozhikode, Kannoor, Koyilandy, 23.vii.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 7570; 1♀, India: Kerala, Kozhikode, Kakkavayal, 28.viii.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 7572; 1♂, India: Kerala, Malappuram, Kozhikode University campus, 4.xii.2015, coll. Renjith, Reg. No. ZSI/WGRC/IR/INV 5306; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 28.vi.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 7278; 1♂, India: Kerala, Kozhikode, Malabar Wildlife Sanctuary, Kakkayam,

16.xi.2011, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 3278; 1♂, India: Kerala, Kozhikode, Nedumala, Koduvally, 16.iv.2016, coll. Aswathi. K, Reg. No.ZSI/WGRC/IR/INV 6535; 1♂, India: Kerala, Kozhikode, Venappara, Omassery, 30.v.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 6938; 1♂, India: Kerala, Kozhikode, Mudoor, 19.ix.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4825; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 28.vi.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 7278; 1♂, India: Kerala, Alapuzha, Arthungal, 15.iv.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 10203; ♂, ♀, India: Kerala, Idukki, Thekkady, Pachamala, 4.iv.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 3488; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 6.iv.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 6533; 1♂, India: Kerala, Kozhikode, Narayamkulam, Balussery, 25.vi.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4622; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 1.ii.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5288; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 3.xii.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5536; 1♂, India: Kerala, Kozhikode, Kakkodi, 4.vi.2014, coll. Santhosh, Reg. No. ZSI/WGRC/IR/INV 3487; 1♀, 2♂, India: Kerala, Kozhikode, Nellipoyil, 12.vii.2016, coll. Ulahannan, Reg. No. ZSI/WGRC/IR/INV 6939; 1♀, India: Kerala, Kozhikode, Peruvannamuzhi, 3.ii.2016, coll. Sheeja, Reg. No. ZSI/WGRC/IR/INV 5305; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 24.viii.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4822; 1♂, India: Kerala, Kozhikode, Narayamkulam, Balussery, 12.xi.2014, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4011; 1♀, India: Kerala, Kozhikode, Nedumala, Koduvally, 19.i.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5303; ♂ Subadult, India: Kerala, Kozhikode, Kakkavayal, 29.iii.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 6937; 3 Subadults, India: Kerala, Kasargode,

Kottenchery, 6.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 8135; 1♂, India: Kerala, Kozhikode, Narayamkulam, Balussery, 26.viii.2015; coll. Aswathi.K, Reg. No. ZSI/WGRC/IR/INV 4819; 2♂, India: Kerala, Kollam, Schendurney Wildlife Sanctuary,Rajakoop, 14.viii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8130; 1♂, India: Kerala, Trivandrum, Neyyar WLS, Kolumba, coll. Aswathi.K, Reg. No. ZSI/WGRC/IR/INV 8132; 6 Subadults, India: Kerala, Pathanamthitta, Mozhiyoor, 23.ii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8131; 2♂, India: Kerala, Kozhikode, Nanminda, 2.xii.2016, coll. Nikhil, Reg. No. ZSI/WGRC/IR/INV 8133; 1♂, India: Kerala, Kozhikode, Kadalundi, 23.xii.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 4097; 1♀, India: Kerala, Kozhikode, Thamarassery, 29.ix.2016, coll. Aswathi.K, Reg. No. ZSI/WGRC/IR/INV 7779; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 6.ix.2016, coll. Aswathi.K, Reg. No. ZSI/WGRC/IR/INV 8156; 3 Subadults, India: Kerala, Ernakulam, Perumthodu, 15.xi.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8153; 4 Subadults, India: Kerala, Kasargode, Mandekol, 7.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 8155; 1♀, India: Kerala, Kozhikode, Necholi, Chathamangalam, 2.iii.2016, coll. Aswathi.K, Reg. No. ZSI/WGRC/IR/INV 8159; 1♂, India: Kerala, Kollam, Thenmala, Kazhuthurutty, 9.iii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4214; 1♂, India: Kerala, Kasargode, Kottenchery, 6.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 4591; 1♂, India: Kerala, Trivandrum, Peppara Wildlife Sanctuary, Vyvanthol, 14.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 5114; 1♂, 2♀, India: Kerala, Trivandrum, Peppara Wildlife Sanctuary, 11.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 5115; 1♀, India: Kerala, Kozhikode, Kakkayam, Malabar Wildlife Sanctuary, 8.ii.1996, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 5189;1♂, India: Kerala, Kozhikode, Kakkavayal,

Vanaparvam, 29.x.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 5307; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 1.ii.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5288; 1♂, India: Kerala, Kozhikode, Cherukkad, Balussery, 27.iv.2014, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5288; 1 juvenile, India: Kerala, Kasargode, Maruthome, 7.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 8392; 1 Subadult, India: Kerala, Malappuram, Nilambur, 25.v.1992, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8574; 1♀, 1♂, 1 Subadult, India: Kerala, Kozhikode, NIT campus, 3.xii.2014, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 8584; 1♀, India: Kerala, Kozhikode, Kakkavayal, Vanaparvam, 21.vi.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 8585; 2♂, India: Kerala, Kozhikode, Koduvally, Nedumala, 5.vi.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 8586; 1♀, India: Kerala, Kozhikode, Malikadavu, 22.xi.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 8592; 1Subadult, India: Kerala, Kozhikode, Narayamkulam, 23.vi.2011, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 8593; 1Subadult, India: Kerala, Kozhikode, Ponoor Estate, 22.i.1983, coll. S. C. Nahar, Reg. No. ZSI/WGRC/IR/INV 8595; 1Subadult, India: Kerala, Kozhikode, Vadagara, Vengalam, 20.x.1981, coll. S. C. Nahar, Reg. No. ZSI/WGRC/IR/INV 8596; 1♂, India: Kerala, Kozhikode, Koottalida, 9.ii.2011, coll. B & D, Reg. No. ZSI/WGRC/IR/INV 8597; 1♂, India: Kerala, Kozhikode, Kadalundi, 12.i.2011, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 8599; 1Young one, India: Kerala, Kozhikode, Peruvannamuzhi, 13.x.1981, coll. K. N. Nair, Reg. No. ZSI/WGRC/IR/INV 8925; 1Subadult, India: Kerala, Thrissur, Vellanimala, 9.x.1995, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 8929; 1♀, India: Kerala, Kozhikode, Narikuni, 9.ii.2004, coll. Bimalnath, Reg. No. ZSI/WGRC/IR/INV 9010; 1♀, 1♂, India: Kerala, Kannur, Madaipara, 2.i.2004, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9012; 1Subadult, India: Kerala, Kannur, Madaipara,

22.vii.2004, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9013; 1♂, India: Kerala, Kozhikode, Kakkavayal, Vanaparvam, 13.iv.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 9017; 1♀, India: Kerala, Kozhikode, Kadalundi, 15.x.2009, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9018; 1♂, 1♀, 1Young one, India: Kerala, Pathanamthitta, Kummannur, 27.ii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9019; 1Young one, India: Kerala, Kozhikode, Easthill, Pazhashiraja Museum, 13.ix.2015, coll. Madhavan, Reg. No. ZSI/WGRC/IR/INV 9028; 1♂, 1♀, 2Young ones, India: Kerala, Kollam, Thenmala, Kaduvapallam, 11.viii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9054; 1♂, India: Kerala, Kozhikode, Karaparamba, 30.i.2005, coll. Sabhi, Reg. No. ZSI/WGRC/IR/INV 9055; 1♀, India: Kerala, Kozhikode, Cherukkad, Balussery, 29.xii.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 9056; 1♂, India: Kerala, Ernakulam, Pooyamkutty, 24.xi.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9372; 2Subadult, India: Kerala, Kannur, Aralam Wildlife Sanctuary, 11.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9377; 1♂, India: Kerala, Wayanad, Thirunelly, 18.viii.2016, coll. B. H. C. K. Murthy, Reg. No. ZSI/WGRC/IR/INV 9380; 1Subadult, India: Kerala, Wayanad, Kumarapura, Aragaladha, 18.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9381; 2Subadult, India: Kerala, Ernakulam, Malayatoor, 18.xii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9382; 2♀, 3♂subadults, India: Kerala, Trivandrum, Peppara Wildlife Sanctuary, Agasthyamala, 11.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9386; 1♀, 2Young ones, India: Kerala, Trivandrum, Peppara Wildlife Sanctuary, 15.xi.2016, coll. Bindu, Reg. No. ZSI/WGRC/IR/INV 9387; 9Young ones, India: Kerala, Trivandrum, Peppara Wildlife Sanctuary, 12.xi.2016, coll. Bindu, Reg. No. ZSI/WGRC/IR/INV 9388; 1 Young one, India: Kerala, Trivandrum, Peppara Wildlife Sanctuary, Vyvanthol, 14.xi.2016, coll. Bindu, Reg. No.

ZSI/WGRC/IR/INV 9389; 1♂, India: Kerala, Trivandrum, Peppara Wildlife Sanctuary, Vyvanthol, 14.xi.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9390; 1♀, India: Kerala, Trivandrum, Ponmudi, 12.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9392; 1♀ (damaged), India: Kerala, Kozhikode, Moolampalli, 28.i.1983, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9393; 5Young ones, India: Kerala, Trivandrum, Peppara dam site, 13.x.2012, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9395; 2Young ones, India: Kerala, Trivandrum, Meenmutty, 10.x.2012, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9396; 3Young ones, India: Kerala, Kollam, Kattilappara, 12.viii.1997, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9397; 1♂, 2 young ones, India: Kerala, Kollam, Schendurney Wildlife Sanctuary, Edapalayam, 18.i.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9399; 1Young one, India: Kerala, Kozhikode, Peruvannamuzhi, 4.ix.1983, coll. Kurup, Reg. No. ZSI/WGRC/IR/INV 9407; 1♂, India: Kerala, Kozhikode, Jail road, 18.viii.2012, coll. Manikandan, Reg. No. ZSI/WGRC/IR/INV 9411; 1Young one, India: Kerala, Kannur, Koothuparamba, 30.i.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9422; 1♂, India: Kerala, Thrissur, Peechi, Olakara, 11.x.1995, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9437; 1♀subadult, India: Kerala, Kannur, Kottiyoor, 2.ii.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9439; 1♀, India: Kerala, Kozhikode, Parambath, 19.i.2014, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 9448; 1♂, India: Kerala, Kannur, Aralam Wildlife Sanctuary, 19.iii.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 9451; 1♀, 1Young one, India: Kerala, Kannur, Kottiyoor, Pannimala, 13.iii.2016, coll. Nikhil. K, Reg. No. ZSI/WGRC/IR/INV 9452; 1♀, 3♂subadults, India: Kerala, Kannur, Kottiyoor, Pannimala, 14.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9453; 1♂, India: Kerala, Ernakulam, Pooyamkutty,

Narakathodu, 23.xi.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9472; 2♀, India: Kerala, Kannur, Aralam Wildlife Sanctuary, 12.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9533; 1♀, 1♂, 5Young ones, India: Kerala, Ernakulam, Idamalayar, Keerithodu, 20.xi.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9541; 1♀, India: Kerala, Kozhikode, Kathipara, 27.v.1989, coll. K. N. Nair, Reg. No. ZSI/WGRC/IR/INV 9542.

Habitat: The specimens were collected from moist deciduous, dry deciduous, evergreen forest tracts, laterite hills and residential areas. Usually found under stones, rocks, holes, under coconut husks and holes under rocks. The depth of holes measures about 5-9 cm from the surface of the soil.

Remarks: A common species found throughout Kerala state. Tikader and Bastawade 1983, in Indian Fauna of scorpions described this species as *Heterometrus (Heterometrus) malapuramensis.* The collected specimens exhibit the same characters as the description provided in the Fauna of India: scorpions by Tikader and Bastawade, 1983, but later in 2004 Kovarik synonymised these species under *Heterometrus scaber* (Thorell).

***Heterometrus phipsoni* (Pocock, 1893)**

1893 b. *Scorpio phipsoni* Pocock, *Journal of the Bombay Branch of the Royal Asiatic Society*,: 307
1899. *Heterometrus phipsoni*: Kraepelin, *In* Dahl, F. (ed.), *Das Tierreich. Herausgegeben vonder Deutschen Zoologischen Gesellschaft*: 114.
1983. *Heterometrus (Chersonesometrus) phipsoni*: Tikader and Bastawade, *Fauna of India*, 2: 646.
2004. *Heterometrus phipsoni*: Kovařík, *Euscorpius*: 34

Type locality: India: Tamil Nadu, Madras.

Diagnosis: Adults 85-130 mm long; colour reddish brown to black; pedipalp manus with rounded granules of uneven size; carapace smooth and glossy; margins with sparse granules; mesosoma tergites I-VI granular on lateral, posterior and latero-median portions, but smooth on median portion without

carinae; median eyes situated anteriorly in the ratio 1: 1.1; pectinal tooth count 10-16.

Distribution: Kerala, Andhra Pradesh, Madhya Pradesh, Maharashtra, Odisha, West Bengal and Tamil Nadu.

Materials examined: No Materials examined.

Remarks: I have not been able to study the type or other specimens of this species. The diagnosis provided here is based on the available literatures.

***Heterometrus gravimanus* (Pocock, 1894)**

1894. *Scorpio gravimanus* Pocock, *Annals and Magazine of Natural History,* 6 (13): 72-84.
1945. *Heterometrus gravimanus*: Takashima, *Acta Arachnologica*, 94.
1983. *Heterometrus (Srilankametrus) gravimanus*: Tikader and Bastawade, *Fauna of India*, 2: 550.
2004. *Heterometrus gravimanus*: Kovařík, *Euscorpius*, 15.

Type locality: Sri Lanka: Ceylon.

Diagnosis: Adults 80-110 mm long; colour uniformly reddish brown; entire manus of pedipalp granulated with round granules; carapace smooth and glossy; metasoma with aculeus slightly less than half the length of segment V, not much curved, stout, sharp and dark reddish; median eyes situated anteriorly in the ratio 1: 1.1; pectinal tooth count 12-15.

Distribution: India: Kerala and Tamil Nadu.

Materials examined: No materials examined.

Remarks: I have not been able to study the type or other specimens of this species. The diagnosis provided here is based on the available literatures.

***Heterometrus kanaraensis* (Pocock, 1900)**

(Plate 43, Fig. a)

1900 b. *Palamnaeus scaber kanarensis* Pocock, *Fauna Brit. India, Arachn*., 93.
1983. *Heterometrus (Chersonemetrus) kanarensis*: Tikader and Bastawade, *Fauna of India*, 2: 636.
2004. *Heterometrus kanaraensis*: Kovařík, *Euscorpius*, 20.

Type locality: India: Karnataka, Kanara.

Diagnosis: Adults 120-150 mm long; colour reddish brown to black with a green tint; pedipalp manus relatively smooth without any granules; carapace smooth and glossy with sparse marginal granules; legs granular on femur and patella; median eyes situated anteriorly in the ratio 1: 1.1; pectinal tooth count 13-14.

Description of adult male

Colouration: Body reddish brown with same colour appendages. Prosoma: Carapace reddish brown more dark on anterior portion. Mesosoma: tergites reddish brown to dark brown; sternites dark brown. Metasoma: segments reddish brown to dark brown. Telson vesicle golden brown to dark brown at the tip of the aculeus. Pectines yellow to brownish yellow. Sternum dark brown anteriorly but yellowish brown posteriorly and laterally. Genital operculum: yellowish brown. Basal piece yellowish brown to brown. Chelicerae: yellowish brown with brown reticulation on the basal piece with dark brown anterior margin. Fingers: reddish brown. Pedipalp reddish brown. Legs: femur, patella, tibia, tarsomere I and reddish brown tarsomere II brown.

Carapace: Smooth except for anterior and lateral granulations. Carinae absent; anterior margin with deep median concavity. Postero-lateral and postero-median furrows present. Median ocular tubercle not much distinct and at the centre of the carapace; median eyes are equal in size **(Fig. b)**. Lateral

eyes, numbering three, first and third eyes are almost equal in size, second eye smallest among three eyes. The distance between second and third eyes are large when compared to the first and second.

Mesosoma: All tergites without any carination but a button like slight elevation at the centre of every tergite. Densely granular on tergites except for first two tergites. A pair of longitudinal depression present on all sternites except the last. Stigmata present, which is moderately long and rod-like in shape.

Metasoma: Segments I and IV with eight carinae and additional two incomplete lateral carinae present. Segments I and II lateral and dorsal carinae keeled but ventral carinae smooth on segments I to IV. Segments V with seven carinae, but lateral carinae incomplete and all carinae keeled. Dorsal and lateral granulation present on intercarinal spaces of segments I to IV; intercarinal spaces of segment V granular.

Telson: Vesicle not globular with long downwardly facing aculeus. Subaculear tubercle absent. Dorsal and lateral portion smooth but ventrally with four keeled carinae. Sparsely hirsute; setae absent **(Fig. c)**.

Pectines: Well developed sclerites, marginal lamellae composed of three pieces, middle lamellae comprises only a single piece. Entire pectine covered with moderately sized setae. Pectinal tooth count 11/12. The basal piece without any notch but a shallow depression extending from anterior margin to the middle **(Fig.d)**.

Genital operculum: Well developed sclerites longitudinally separated and each sclerite with a triangle like in shape; posterior suture present.

Sternum: Sub-pentagonal in shape; deep furrow present from median to the posterior margin; few setae present on either side of the furrow.

Chelicerae: Smooth on the basal piece, thickly clothed with fine silky hairs on ventral portion. Punctuation present dorsally on the movable finger; finger dentition as characterized in the family **(Fig. e)**.

Pedipalp: Moderately long and flat. Femur shorter than or as long as carapace; keeled carinae present; all intercarinal spaces smooth except dorsal and internal, which are densely granular. Patella longer than the femur, smooth carinae present except the internal carinae, which is slightly keeled; all intercarinal spaces smooth. Chela manus convex, carinae not much distinct, immovable finger carinated; densely hirsute; fingers curved with triangularly shaped dentition.

Legs: Femur densely granulated dorsally; patella slightly granulated, carinae not much distinct tibial spur absent. Setae present throughout tarsomere I with a single row of spinules and tarsomere II with two rows of spinules.

Trichobothrial pattern: Type 'C' as characterized as in the family **(Plate 44, Fig. a-d)**.

Distribution: India: Kerala (Thrissur, Palakkad, Wayanad, Kasargode, Kannur), Maharashtra, Karnataka and Goa.

Materials examined: 1♀, India: Kerala, Thrissur, Vazhachal, Orukomban, 26.ii.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4213; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Venkoli, 27.x.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9022; 5 Young ones, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Kamaltlachi, 30.x.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9023; 1♂, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Pezhakunnu, 27.iii.1997, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9031; 3 Young ones, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Sarkarpadi, 29.x.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9039; 1♀,

India: Kerala, Palakkad, Parambikulam Tiger Reserve, Pulickal, 1.xi.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9040; 1♂, India: Kerala, Palakkad, Parambikulam Tiger Reserve, 24.iii.1997, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9042; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Kuriyarkutty, 9.xii.2007, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9374; 1♀, 3 Young ones, India: Kerala, Thrissur, Vazhachal, Orukomban, 9.ix.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9391; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Thellickal, 9.xii.2007, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9401; 1♀, 1♂, 1Young one, India: Kerala, Wayanad, Muthanga WLS, Maragadha, 17.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9402; 1♀, 1♂, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Anchupoola, 3.xi.1995, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9535; 1♂, 4Young ones, India: Kerala, Thrissur, Vazhachal, Malakkapara, 27.ii.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9536; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Venkoli, 10.ix.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9540; 1♀, 1Young one, India: Kerala, Kasargode, Bellipadi, 4.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9546; 2♀, India: Kerala, Idukki, Thekkady, Anjuruli, 9.iv.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9580; 10♀, 5♂, India: Kerala, Kannur, Aralam Wildlife Sanctuary, Paripputhodu, 13.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9581.

Habitat: All specimens collected were observed under boulders from dry deciduous forest tracts.

Remarks: Found only in narrow distributions from Kerala state, the present study revealed the presence of this species from north and middle of Kerala.

***Heterometrus barberi* (Pocock, 1900)**

(Plate 45, Fig. a)

1900 b. *Palamnaeus barberi* Pocock, *Fauna Brit. India, Arachn*., 95.
1945. *Heterometrus barberi*: Takashima, *Acta Arachnologica*, 94.
1983. *Heterometrus (Chersonesometrus) barberi*: Tikader and Bastawade, *Fauna of India*, 2: 614.
2004. *Heterometrus barberi*: Kovařík, *Euscorpius*, 4.

Type locality: India: Tamil Nadu, Thirunnelvelly.

Diagnosis: Adult holotype female 124 mm long; colour uniformly brownish with green tint except for telson and manus of pedipalp; manus of pedipalp rugate without carinae; carapace smooth except granulation at margins; median eyes situated anteriorly in the ratio 1: 1.2; pectinal tooth count 10-12.

Description of adult male

Colouration: Body dark greenish. Prosoma: carapace dark green with brown anterior margin. Mesosoma: tergites dark green; sternites greenish brown to yellowish brown except the last sternite dark brown with some pale patches. Metasoma: Segments dorsally dark green, but ventrally blackish- brown with some pale brown patches. Telson vesicle reddish brown with dark brown aculeus. Genital operculum yellowish brown. Basal piece yellowish brown; brownish with dark reticulation on the basal piece and with black anterior margin; fingers brown on denticles and immovable finger brown with dark brown at the tip; movable finger dark brown. Pedipalp dark green; chela green with slight reddish brown. Legs: femur, patella, tibia and tarsomere I dark green; tarsomere II brown.

Carapace: Almost granular except some anterio-median, postero-median portions and median ocular tubercle. Carinae absent. Anterior margin moderately concave medially. Deep posterior lateral and posterior median furrows present **(Fig. b)**. Median ocular tubercle distinctly at the centre of the

carapace; median eyes are equal in size. Lateral eyes, numbering three, three are almost equal in size but third eye slightly far from the second eye.

Mesosoma: All tergites without any carinae, but granulation present at the posterior margin and laterally. Sternites smooth with longitudinal shallow depression on all sternites except the last sternite. Carinae absent on all sternites. Stigmata present, which is moderately long and rod-like in shape.

Metasoma: Segment I wider than long, other segments always longer than wide. Segments I to IV with eight carinae, additional lateral incomplete carinae present on segments I and II. Dorsal granulation increasing from segments I to V. segment V with seven carinae. Two lateral carinae incomplete. Lateral and ventral intercarinal spaces smooth.

Telson: Vesicle globular, densely hirsute with moderately long downwardly facing aculeus. Subaculear tubercle absent. Dorsal portion smooth, lateral portion slightly granular and ventrally with four keeled carinae **(Fig. c)**.

Pectines: Well developed sclerites, marginal lamellae composed of three pieces of different shapes and sizes. Middle lamellae comprise three pieces of different shapes. Entire pectin covered with moderately sized setae. Pectinal tooth count 11/11. The basal piece with a shallow antero-median notch **(Fig. d)**.

Genital operculum: Sclerites longitudinally separated and each sclerite with semi-triangular in shape. Posterior suture present.

Sternum: Sub-pentagonal sternum with deep longitudinal depression present, which extending from median to the posterior margin.

Chelicerae: Smooth on the basal piece, small setae present on the anterior margin; fingers ventrally clothed with, thick, fine, silky hairs. Dentition as characterized in the family **(Fig. e)**.

Pedipalp: Short and stout; femur shorter than carapace; carinated with weak crenulation, and granular dorsally and internally. Patella longer than femur but shorter than carapace and weakly carinated. Internal tubercle not much pronounced. Chela manus deeply convex, carinae not much distinct but exterior and inner margin strong.Ventral surface irregularly granular. Chela fingers curved with broad triangular dentition **(Fig. f)**.

Legs: Femur dorsally with dense granulation. Patella slightly granular.Weakly carinated on femur and patella, but well carinated on the tibia. Slight granulation present on tarsomere I. Tarsomere II ventrally with two rows of spinules.

Trichbothrial pattern: Type 'C' as characterized as in the family **(Plate 46, Fig. a-d)**.

Distribution: India: Kerala (Ernakulam, Palakkad, Trivandrum, Thrissur, Idukki, Kollam, Kozhikode) and Tamil Nadu.

Materials examined: 1 Juvenile, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Pullasserykuthu, 29.x.2015, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 4937; 1♀, India: Kerala, Palakkad, Silent valley National Park, 9.xi.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4939; 1Subadult, India: Kerala, Ernakulam, Kodanad, Mallana R F, 12.iv.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8154; 1♂, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, 20.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8152; 1♂ Subadult, 2♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Koottickal, 30.x.2015, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 4935; 1♂ Juvenile, 2♀, 1♂ Subadult, 4♀ Subadults, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Koottampara, 28.x.2015, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 4933; 1♂, 1♀, India: Kerala, Ernakulam, Thattekkad

Bird Sanctuary, Knassery, 29.x.2015, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 4036; 1♂, 5♀, India: Kerala, Palakkad, Dhoni R F, 9.x.2014, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 3943; 1♀, 1♂, 2Young ones, India: Kerala, Ernakulam, Kodanad, Mallana R F, 14.iii.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8161; 1♀, India: Kerala, Ernakulam, Kodanad, Malayattoor R F, 14.iii.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 3277; 3♂, 2♀, India: Kerala, Idukki, 3.iv.2013, coll. K. Rajamohana, Reg. No. ZSI/WGRC/IR/INV 3492; 1♂, India: Kerala, Palakkad, Parambikulam Tiger Reserve, 10.ix.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4154; 4♀, 1♂, 4 Juveniles, India: Kerala, Trivandrum, Ananirathi, Amboori, 13.xii.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 5113; 3♂, 3♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Thoppimudi Foot hills, 23.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 7283; 2♀, India: Kerala, Kollam, Pandimotta, 17.x.2012, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 4590; 1♀, India: Kerala, Trivandrum, Ponmudi, 12.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 5116; 1♀, India: Kerala, Kollam, Rosemala, 18.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 5117; 1♂, 1♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Knasserry, 29.x.2015, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 4936; 1♂, 1♀, 1Young one, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Thoppimudi, 23.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8163; 6♂, 1♀subadult, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kallippara, 22.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8164; 1♀, India: Kerala, Ernakulam, Idamalayar, 21.xi.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8165; 1♀, India: Kerala, Thrissur, Chimmoni, 24.ii.1996, coll. C. Radhakrishnan, Reg. No. ZSI/WGRC/IR/INV 8167; 1♀, India: Kerala, Idukki, Vellaikamalai, 14.xii.1996, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8169; 1♀, 2Young ones, India:

Kerala, Ernakulam, Thattekkad Bird Sanctuary, Urulanthanni, 22.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8172; 1subadult, 9Young ones, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Koottickal, 24.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8173; 1♀, India: Kerala, Kollam, Rosemala, 18.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9014; 6subadults, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Thoppimudi, 23.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9015; 2subadults, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Thoppimudi, 23.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9016; 1♀, 9Young ones, India: Kerala, Trivandrum, Ananirathi, Amboori, 12.x.2012, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9024; 1♂, 1♀, 4Young ones, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Thoppimudi, 21.xi.2014, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9025; 1♀, 1Young one, India: Kerala, Kollam, Pandimotta, 17.x.2012, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9026; 6Young ones, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kolumba, 27.xi.2014, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9032; 1♂, 4♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Thoppimudi, 23.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9034; 1♂, 1♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Thoppimudi, 23.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9036; 1♀, 3Young ones, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Urulanthanni, 22.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9037; 1♀, 1Young one, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kolumba, 11.viii.2015, coll. B. H. C. K. Murthy, Reg. No. ZSI/WGRC/IR/INV 9046; 1♂, 2♀, 1Young one, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Urulanthanni, 25.xi.2015, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9047; 9 (damaged), India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kolumba, 20.vi.2016, coll. P.

M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9048; 2♂, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Koottickal, 20.vi.2016, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9049; 3subadults, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Koottampara, 19.vi.2016, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9378; 2♀, 2subadults, India: Kerala, Kollam, Rosemala, 18.x.2012, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9383; 2♂, 2♀, 2Young ones, India: Kerala, Trivandrum, Neyyar Wildlife Sanctuary, Kallippara, 9.xi.2016, coll. Bindu, Reg. No. ZSI/WGRC/IR/INV 9385; 1♂, 1♀, India: Kerala, Ernakulam, Kalady R F, Manjapara, 14.ii.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9394; 2♂subadults, India: Kerala, Kollam, Achankovil, Kallippara, 17.xi.2016, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9398; 1♀, India: Kerala, Kollam, Palaruvi, 16.xi.2016, coll. Bindu, Reg. No. ZSI/WGRC/IR/INV 9400; 1♀, India: Kerala, Palakkad, Parambikulam Tiger Reserve, Muthuvans colony, 12.ix.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9404; 1♀, India: Kerala, Thrissur, Pothundi, Peechi, 15.iii.1992, coll. K. C. Gopi, Reg. No. ZSI/WGRC/IR/INV 9405; 1subadult, India: Kerala, Trivandrum, Neyyar Wildlife Sanctuary, Meenmutty, 10.xi.2016, coll. Bindu, Reg. No. ZSI/WGRC/IR/INV 9406; 6subadults, India: Kerala, Kollam, Schendurney Wildlife Sanctuary, 18.xi.2016, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9410; 1♂, 3 young ones, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Urulanthanni, 17.vi.2016, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9450; 1♂ India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Urulanthanni, 3.xii.2006, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9538; 1♀, India: Kerala, Ernakulam, Pooyamkutty, 24.ii.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9539; 1♂, 4♀, India: Kerala, Ernakulam, Mallana R F, 14.iii.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9545; 1♀, India: Kerala, Kozhikode, Karimpupara, Kakkadampoyil,

30.xii.2016, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9582; 1♀, India: Kerala, Palakkad, Pakuthipalam, 2.iii.2017, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9612.

Habitat: Generally found in moist soil under boulders and decaying logs from deciduous and evergreen forests tracts.

Remarks: This species was found only in the forested tracts of Kerala and showed narrow distribution in the country. After Tikader and Bastawade (1983), the presence of this species was reported by Sureshan et al. (2007 b) from the state.

***Heterometrus flavimanus* (Pocock 1900)**

(Plate 47, Fig. a)

1900 b. *Palamnaeus swammerdami flavimanus* Pocock, *Fauna Brit. India, Arachn*., 87.
1983. *Heterometrus (Gigantometrus) flavimanus*: Tikader and Bastawade, *Fauna of India*, 2: 568.
2004. *Heterometrus flavimanus*: Kovařík, *Euscorpius*, 13.

Type locality: India: Tamil Nadu, Coimbatore.

Diagnosis: Adult 87-141mm long; body uniformly brown; legs clear yellow; manus of pedipalp yellow with blunt golden brown granules; carapace sparsely granulated; patella of pedipalp without internal tubercle; 5th segment of metasoma longer than femur; telson vesicle longer than aculeus; median eyes situated anteriorly in the ratio 1: 1; pectinal tooth count 16-22.

Description of an adult female.

Colouration: Body uniformly brown with yellow appendages. Prosoma: carapace brown with yellow in furrows. Mesosoma: tergites brown with yellow patches on either side of the median line; sternites yellow shaded with some brown around the stigmata and the last sternite more browner.

Metasoma: basically brown with yellow patches all over; vesicle clear yellow with brown aculeus much darker at the tip. Pectines pale yellow, basal piece yellow. Chelicera: basal piece clear yellow with slight brown reticulation, anterior margin brown; fingers dark brown. Pedipalp: femur, patella brownish with some yellow; fingers of chela dark brown with yellow manus spotted with golden brown blunt granules. Legs: clear yellow with brown claws on tarsomere II.

Carapace: Lustrous and mostly granular except the area above median eyes and around the eyes; carinae absent; anterior margin crenulated, long bristles present and medially concave; postero-lateral and postero-median deep furrows present **(Fig. b)**. Median ocular tubercle at the centre of the carapace; median eyes equal in size; lateral eyes, numbering three, size of the eyes are slightly increased from the first.

Mesosoma: All tergites lustrous without any carinae and with slight elevation medially; posterior margin granular on all tergites and anteriorly with very minute granulation. Sternites lustrous and smooth with single longitudinal depression on both sides of the median imaginary line; carinae absent on all sternites. Stigmata present on all sternites except the last, which are long and rod-like in shape.

Metasoma: All segments lustrous and granulation present. Dorsal surface slightly granular which contributed to two incomplete carinae like appearance from segments I- IV; segment V more granular dorsally when compared to others; ventral granulation absent; lateral portions are slightly granular. Carinae present in all segments; segments I- IV with eight carinae; segment V with five complete carinae and two lateral incomplete carinae.

Telson: Vesicle globular with long curved aculeus; tubercle absent; dorsal and ventral granulation absent but lateral granulation present; four carinae present ventrally and sparsely hirsute without setae **(Fig. c)**.

Pectines: Well developed sclerites; marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae with a single piece; fulcra triangular in shape; minute setae present all over more on fulcra; Pectinal teeth count 17-18. Basal piece a single sclerite with antero-median shallow furrow **(Fig. d)**.

Genital operculum: Single sclerite with a median longitudinal line; posterior median suture present.

Sternum: Sub-pentagonal in shape; deep depression extending from middle to the posterior margin; few short setae present on either side of the depression.

Chelicerae: Smooth on the basal piece; thickly clothed with silky hairs on ventral portion; punctuation present dorsally on fingers; fingers short and stout dentition as characterized in the family **(Fig. e)**.

Pedipalp: Short and stout; femur shorter than carapace, carinated and all intercarinal spaces granulated except the external aspect. Patella slightly short or as long as the femur, carinated and less granular. Manus of chela much larger with dorsal surface convex and fully covered with large blunt granules; carinae not much developed; fingers short, curved with triangularly shaped dentition **(Fig. f)**.

Legs: Smooth but slightly granulated, carinated on femur and patella. Tarsomere I furnished with a ventral row of spines; tarsomere II furnished ventrally with two rows of spines; a pair of claws stout and whole legs clothed with fine reddish setae.

Trichobothrial pattern: Type 'C' as characterized as in the family **(Plate 48, Fig. a-e)**.

Distribution: India: Kerala (Idukki, Palakkad,) and Tamil Nadu.

Materials examined: 1♂, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, 19.xi.1996, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4243; 1♂, India: Kerala, Palakkad, Chittoor college campus, 24.i.2015, coll. Gnanakumar, Reg. No. ZSI/WGRC/IR/INV 4186; 1♂, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Champakkad, 21.ix.2014, K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 3940; 1♀, India: Kerala, Palakkad, Sitharkundu, 10.ii.2011, coll. Bijoy. C, Reg. No. ZSI/WGRC/IR/INV 4242; 2♂, India: Kerala, Palakkad, Puthunagaram, 15.v.2015, coll. Gnanakumar, Reg. No. ZSI/WGRC/IR/INV 4823; 1♀, India: Kerala, Idukki, Chinnar Wildlife Sanctuary, Churulipatty, 22.v.2014, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4244.

Habitat: Few specimens collected were observed under boulders from dry thorny scrub jungle. Some were collected from residential areas.

Remarks: The type locality of this species is Coimbatore, Tamil Nadu and for the first time this species was reported from the state. It's noticeable that this species was reported from Idukki and Palakkad, both districts share the boundary with Tamil Nadu showed the narrow distribution of the species.

***Heterometrus keralaensis* Tikader & Bastawade, 1983**

(Plate 49, Fig. a)

1983. *Heterometrus* (*Heterometrus*) *keralaensis* Tikader & Bastawade, *Fauna of India*: 528.
2004. *Heterometrus keralaensis*: Kovařík, *Euscorpius*: 20.

Type locality: India: Kerala, Wayanad, Meenmutty.

Diagnosis: Body colour brownish with greenish tint except for reddish brown manus of pedipalp and telson vesicle; body smooth without granulation; pedipalp manus narrow in male and broader in the female; median eyes situated anteriorly in the ratio 1: 1.25; pectinal tooth count 11-13.

Description of an adult female.

Colouration: Body dark green with greenish-brown appendages. Prosoma: carapace dark green. Mesosoma: tergites dark green without any markings; sternites greenish yellow except the last sternite, which is dark green. Metasoma: segments dark green with brownish tint; vesicle reddish brown with aculeus of the same colour but much darker at the tip. Pectines pale brown with teeth ventrally dark brown. Sternum: dark green with a brownish tint. Genital operculum brown with some pale brown patches.Basal piece dark brown. Chelicerae: basal piece brown and much darker anteriorly with reticulation; fingers reddish brown. Pedipalp: dark green to brown; chela fingers with reddish brown denticles. Legs: femur, patella dark green; tibia, tarsomere I brown; tarsomere II pale brown.

Carapace: Lustrous and mostly smooth except the lateral portion with granulation; carinae absent; anterior margin of carapace crenulated with deep median concavity; postero-lateral and postero-median furrows present. Median ocular tubercle not much distinct and located at the centre of the carapace **(Fig. b)**. Median eyes almost equal in size and are separated by a distance of near to one ocular diameter. Lateral eyes, numbering three, they are almost equal in size and separated each other by an equal distance.

Mesosoma: All tergites lustrous without any carinae, only a very slight protrusion present. Granulation absent in all tergites except the last tergite with lateral granulation **(Fig. c)**. Sternites smooth and lustrous without any granulation and carinae; longitudinal shallow depressions present on either

side of the median line in all sternites except the last sternite; stigmata present, which are long and rod-like in shape.

Metasoma: Lustrous and granulation absent on the lateral sides; dorsolateral and lateral carinae keeled. Segments I-IV with eight carinae. Segments V with five carinae, which are keeled and an incomplete carina present on lateral sides. Fine reddish setae present on all segments more on segments III-V.

Telson: Vesicle globular with long and curved aculeus, which is as long as vesicle; tubercle and granulation absent. Lateral and ventral keeled carinae present. Vesicle clothed thickly with long setae **(Fig. d)**.

Pectines: Well developed, marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae comprise a single piece and which is fused with the second piece of marginal lamellae; moderately long setae present on marginal lamellae and fulcra with short setae. Pectinal teeth count 11-13 **(Fig. e)**.

Genital operculum: Two sclerites constitute heart like shape with a longitudinal median line and a posterior suture.

Sternum: Sub-pentagonal sternum in shape; anteriorly narrow and widened posteriorly. Deep depression present extending from middle to the posterior margin; few short setae present on either side of the depression.

Chelicerae: Smooth on the basal piece, yellow coloured thickly clothed fine silky hairs present on the ventral portion. Punctuation present on the dorsal surface of the movable finger; fingers short and stout, dentition as characterized in the family **(Fig. f)**.

Pedipalp: Short and stout; femur and patella shorter than carapace; dorsally femur carinated and granulated. Patella carinated, internal tuberculation present. Manus of chela flat and dorsally convex; single carinae present on the

dorsal surface; half tuberculation and half granulation present on dorsal surface; a pair of ventral carinae present with scattered granulation. Fingers short and curved with triangularly shaped dentition **(Fig. g)**.

Legs: Dorsal granulation present on femur and patella; tarsomere II furnished ventrally with a pair of rows of spinules.

Trichobothrial pattern: Type 'C' as characterized as in the family **(Plate 50, Fig. a-e)**.

Distribution: India: Kerala (Wayanad, Kozhikode, Malappuram, Kannur, Kasargode) and Maharashtra.

Materials examined: 2♂, India: Kerala, Wayanad, Manikunnumala, 11.viii.2016, coll. B. H. C. K. Murthy, Reg. No. ZSI/WGRC/IR/INV 7571; 1♂, India: Kerala, Kozhikode, Thusharagiri, 30.ix.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 7777; 1♀, India: Kerala, Wayanad, Manikunnumala, 11.viii.2016, coll. B. H. C. K. Murthy, Reg. No. ZSI/WGRC/IR/INV 7574; 2♂, India: Kerala, Wayanad, Sukanthagiri, 14.x.2016, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 7778; 1♂, India: Kerala, Wayanad, Manikunnumala, 11.viii.2016, coll. B. H. C. K. Murthy, Reg. No. ZSI/WGRC/IR/INV 7573; 1♀, India: Kerala, Kozhikode, Kakkayam, Malabar Wildlife Sanctuary, 19.xi.2014, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4010; 1♀, India: Kerala, Kozhikode, Kakkayam, Malabar Wildlife Sanctuary, 13.ii.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4931; 1♀, India: Kerala, Kozhikode, Kakkayam, Malabar Wildlife Sanctuary, 7.xii.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 4930; 1♀, India: Kerala, Wayanad, Pookode, Veterinary college campus, 31.vii.2015, coll. Nithin, Reg. No. ZSI/WGRC/IR/INV 4670; 7♂, India: Kerala, Kozhikode, Kakkayam, Ambalapady, Malabar Wildlife Sanctuary, 30.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV

5190; 1♂, India: Kerala, Kozhikode, Kakkayam, Panikkarkadavu, Malabar Wildlife Sanctuary, 25.xi.2011, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 5187; 2♂, India: Kerala, Kozhikode, Kakkayam, Panikkarkadavu, Malabar Wildlife Sanctuary, 19.iii.2012, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 5186; 1♂, India: Kerala, Kozhikode, Kakkayam, Ambalapara road, Malabar Wildlife Sanctuary, 29.xii.2015, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 5185; 1♂, 1♀, India: Kerala, Wayanad, Bhramagiri hills, Thirunelli, 15.ii.2016, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 5310; 5♂, 1♀, India: Kerala, Wayanad, Periya range, Chanthanathodu, 4.iv.2014, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 4153; 2♂, India: Kerala, Kozhikode, Kakkayam, Malabar Wildlife Sanctuary, 27.v.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 4820; 1♀, 1♂juvenile, India: Kerala, Kozhikode, Kakkayam, Malabar Wildlife Sanctuary, Urakuzhi, 22.xii.2015, coll. Md. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 5111; 1♂, India: Kerala, Kozhikode, Kakkayam, Malabar Wildlife Sanctuary, Urakuzhi, 3.iii.2015, coll. Aswathi. K, Reg. No. ZSI/WGRC/IR/INV 5184; 1♂, India: Kerala, Kozhikode, Kakkayam, Malabar Wildlife Sanctuary, Urakuzhi, 8.xii.2015, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 5188; 1♀, India: Kerala, Wayanad, Chembra foothills, 20.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8171; 1♂, 10 young ones, India: Kerala, Wayanad, Thirunelly, 12.viii.1994, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 8588; 1♂, 1young one, India: Kerala, Kasargode, Ranipuram, 8.xi.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9050; 1♂, India: Kerala, Kozhikode, Kakkayam, Malabar Wildlife Sanctuary, 1.ii.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9373; 3♂, India: Kerala, Wayanad, Thirunelly, 18.viii.2016, coll. B. H. C. K. Murthy, Reg. No. ZSI/WGRC/IR/INV 9379; 1♂, India: Kerala, Kannur, Aralam Wildlife Sanctuary, 12.x.2011, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV

9532; 3♂, 2 young ones, India: Kerala, Kannur, Kottiyoor, 9.i.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9544; 1♂subadult, India: Kerala, Malapuram, Puthukkode, 28.x.2014, coll. Aswathi. K, Reg. No.ZSI/WGRC/IR/INV 9029.

Habitat: These species were collected from evergreen forest tracts of high elevations. All specimens were found in moist soil under big boulders and sometimes in shallow holes under boulders about 5-6 cm from the surface.

Remarks: The species exhibit narrow distribution in Kerala and was described by Tikader and Bastawade, 1983 from the state itself. Sexual dimorphism present, males with narrow manus of chela of pedipalp whereas manus well lobed in females.

***Heterometrus lourencoi* sp. nov.**

(Plate 51, Fig. a)

Diagnosis: Total length 95.23 mm. Body smooth and lustrous except with slight granulation on lateral sides of the carapace. Movable fingers of chelicerae with flat denticles except (ed) and median denticle is the largest. Chela manus of pedipalp somewhat flat and with three longitudinal bands. Marginal lamellae of pectine composed of three pieces; middle lamellae with three pieces. Pectinal tooth count holotype male 10/11.

Description of holotype male.

Colouration: Body dark green with dark green to brown appendages. Prosoma: carapace dark green. Mesosoma: tergites dark green, sternites yellowish–brown, except the last segment which is dark brown to dark green. Metasoma: segments brown to dark green dorsally, dark green ventrally, vesicle coffee brown with blackish at the tip of the aculeus. Pectine yellowish to yellowish brown. Sternum: dark brown with yellow lateral borders. Genital

operculum: yellowish brown. Basal piece yellowish brown. Chelicera: brown with dark brown reticulation on the basal piece and black anterior margin; fingers black with reddish brown denticles. Pedipalp: dark green except chela, which is somewhat brown. Legs: femur, patella, tibia and tarsomere I dark brown, tarsomere II light brown.

Carapace: Somewhat lustrous and smooth except lateral granulations and granulations just above the median eyes; carinae absent; anterior margin with moderately deep median concavity. Postero-lateral and postero-median furrows present. Median ocular tubercle smooth and situated at the centre of carapace; median eyes almost equal in size and are separated by a distance less than one ocular diameter. Lateral eyes, numbering three, arranged in a curve like in shape; three eyes are an almost equal size and separated each other by an equal distance.

Mesosoma: All tergites are lustrous without any carinae; tergites III-VI with a median drop like elevation; tergite I-V with anterior half portions depressed and posterior half slightly elevated. Tergite I-VI smooth, except some oblique granules at lateral portions. Tergite VII smooth medially but laterally and postero-medially with pointed granules which constitute into few oblique rows **(Fig. b)**. Sternites lustrous and smooth with a pair of longitudinal depression, except the last sternite. Carinae absent on all sternites. Stigmata present, which are long and rod-like in shape.

Metasoma: Segments are lustrous dorsally. Dorsal keels present on segments I-IV, segment V smooth. Ventral carinae smooth on segments I-IV except the last with keeled carinae; intercarinal spaces smooth without any granulation except the lateral portions with some granules, which constitute into incomplete oblique rows; sparsely hirsute.

Telson: Vesicle globular to partially pyriform with long aculeus; dorsally smooth, ventrally with four keeled carinae and lateral portions slightly granular; moderately hirsute **(Fig. c)**.

Pectines: Well developed sclerites; marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae comprises three pieces with irregular shapes. Moderately long setae present on marginal lamellae whereas minute setae on middle lamellae, fulcra and teeth. Pectinal tooth count 10-11, moderately long tooth. The basal piece composed of single sclerite with antero-median shallow depression **(Fig. d)**.

Genital operculum: Sclerite longitudinally separated and each sclerite is semi-oval in shape. Anterior and posterior sutures present **(Fig. e)**.

Sternum: Sub-pentagonal in shape; deep depression present and which extended from centre to the posterior margin; few setae present on either side of the depression.

Chelicerae: Movable finger possess single basal (b), median (m), subdistal (sd) and external distal (ed) denticles; except (ed) others are flat and median denticle is the largest. Immovable finger with basal, median, subdistal and distal (d) denticles; median denticle is the largest. Basal piece reticulated; moderately long setae present at the anterior margin and fingers **(Fig. f)**.

Pedipalp: Moderately long, chela longer than carapace; movable and immovable fingers are long or as long as the carapace. Femur with dorsal keeled carinae and dorsally granular but other sides smooth. Patella longer than femur; smooth with blunt carinae; internal tubercle present. Chela flat, reticulated and moderately hirsute. Triangular shaped teeth present on both fingers.

Legs: Femur and patella granular, other segments smooth. Single carina present on the tibia. Tarsomere II with moderately long spinules present; moderately to long setae present throughout.

Trichobothrial pattern: Type 'C' as characterized as in the family **(Plate 52, Fig. a-e)**.

Distribution: India: Kerala (Idukki).

Etymology: This species is named after Dr Wilson R Lourenco in honour of his significant contributions to scorpion studies.

Materials examined: 1♂ Holotype, India: Kerala, Idukki, Alampatty, 4.vi.2015, coll. Aswathi. K, Reg. No.ZSI/WGRC/IR/INV 9795. 1♂ moulted, India: Kerala, Idukki, Alampatty, 4.vi.2015, coll. Aswathi. K, Reg. No.ZSI/WGRC/IR/INV 9796. 1♂ Paratype, India: Kerala, Idukki, Alampatty, 14.xii.2006, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9797. 4♂, India: Kerala, Idukki, Palapatty, Kanthaloor range, 5.ix.2013, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9798.

Habitat: The holotype was collected from a rocky area and found under big boulders with moist black soil. The locality included rocky areas and thick forest. The collection was carried out during a rainy day. The specimens were collected from high elevations.

Remarks: The genus *Heterometrus* Ehrenberg, 1828 is an interesting group that shows more diversity in Kerala. The new species differs from other species under this genus in having 1) movable fingers of chelicerae with flat denticles except (ed) and median denticle is the largest 2) overall body smooth with somewhat flat manus of chela instead of convex manus. It shares the character such as pectinal tooth count 10/11 with *Hereterometrus barberi* (Pocock).

***Heterometrus thattekkadensis* sp. nov.**

(Plate 53, Fig. a)

Diagnosis: Total length 112.7 mm. Body smooth and lustrous except with slight granulation on lateral sides of the carapace, posterior portion of the tergites and dorsal surface of the metasomal segments I-IV. Chela manus of pedipalp with a flat surface and with three longitudinal bands. Marginal lamellae of pectine composed of three pieces; middle lamellae with two pieces. Pectinal tooth count holotype male 12/12, paratype male 13/14.

Description of holotype male

Colouration: Body dark green with appendages of same colour dorsally. Prosoma: carapace dark green. Mesosoma: tergites dark green; sternites dark brown. Metasoma: segments dark green to brown, vesicle coffee brown to reddish brown with aculeus much darker to black at the tip. Pectines yellowish brown. Sternum dark brown to black with yellow lateral borders. Genital operculum yellowish brown. Basal piece yellowish brown. Chelicera brown with slight reticulation on the basal piece with black anterior margin; movable fingers black with brown tip; immovable fingers brown with black tip and reddish brown to black denticles. Pedipalp: dark green to brown; femur, patella dark green; chela brown. Legs: femur, patella, tibia, tarsomere I dark green dorsally, and tarsomere II brown.

Carapace: Lustrous and smooth medially otherwise granular; carinae absent; anterior margin with moderately concave medially; postero-lateral and postero-median furrows present. Median ocular tubercle smooth and distinctly at the centre of the carapace; median eyes are almost equal in size and are separated by a distance less than one ocular diameter. Lateral eyes, numbering three, arranged in a curve-like shape; first and third eyes are almost equal in size; the second eye is the largest among the three eyes; the first eye is

somewhat close to the second but the distance between second and third are slightly more than the distance between first and second.

Mesosoma: All tergites are lustrous without any carinae; tergite III to VI with a single circular to drop-like shape median elevation; anterior half of tergites I-VII except the lateral portion smooth; posterior half of all tergites granular; granules are blunt on all tergites except the last tergite with sharp granules. Sternites lustrous and smooth with a pair of longitudinal depression present; carinae absent on all sternites. Stigmata present which is long and rod-like in shape.

Metasoma: Segments moderately lustrous, with dorsal granulation present on segments I-IV; dorsal and dorso-lateral carinae keeled on segments I-III; segment IV with partially keeled carinae; all carinae keeled on segment V and dorsal carinae not absolute, which appears as scattered sharp granules; ventral intercarinal spaces smooth on segment I but other segments with slight granulation; lateral carinae incomplete on segment V. Setae sparse on segments I-IV. Segment V with more setae.

Telson: Vesicle globular to slightly pyriform with long curved aculeus; dorsal surface smooth, ventrally with four indistinct carinae; slight granulation present on lateral sides; densely hirsute **(Fig. b)**.

Pectines: Well developed sclerites, marginal lamellae composed of three pieces with different shapes and sizes; middle lamellae comprises two pieces with irregular shapes; moderately long setae present on marginal lamellae, other parts with minute setae. Pectinal tooth count of holotype male 12-12, paratype male 13-14. The basal piece composed of sclerite with antero-median ‘V' shaped depression **(Fig. c)**.

Genital operculum: Longitudinal separated sclerites; each sclerite with semi-triangular in shape; anterior and posterior suture present **(Fig. d)**.

Sternum: Sub-pentagonal in shape; deep depression present extending from median to the posterior margin; few short to moderately long setae present on either side of the depression.

Chelicerae: Movable finger possess single basal (b), median (m), subdistal (sd) and external distal (ed) denticles; basal denticle blunt. Immovable finger with basal, median, subdistal and distal (d) denticles. The basal piece with not much-developed reticulation **(Fig. e)**.

Pedipalp: Long appendages; chela longer than carapace; movable and immovable fingers longer than carapace; patella longer than the femur. Femur with all carinae keeled; granulation absent all over but few tubercles present dorsally. Patella smooth with smooth carinae and internal tubercle blunt. Chela flat and reticulated, carinae indistinct; three longitudinal bands present dorsally; movable and immovable fingers with sharp triangular denticles.

Legs: Dorsal granulation present on femur and patella; single, smooth carinae present on the tibia. Tarsomere II with two rows of spinules.

Trichobothrial pattern: Type 'C' as characterized as in the family **(Plate 54, Fig. a-e)**.

Distribution: India: Kerala (Ernakulam).

Etymology: This species is named after the collection region.

Materials examined: 1♂ holotype, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Knacherry, 21.ix.2016, coll. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9799; 1♀ paratype, 3 young ones, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Urulanthanni, 6.i.2015, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9803; 1♂, 6 young ones, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Knachery, 21.ix.2016, coll. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9800; 1♂, 2 young ones, India:

Kerala, Ernakulam, Thattekkad Bird Sanctuary, Koottickal, 23.ix.2016, coll. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9801; 1♂, 2 young ones, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Urulanthanni, 2.iv.2013, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9802; 6 young ones, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kallipara, 22.ix.2016, coll. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9804; 1♂, 1♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kallipara, 22.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9805; 1♂, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Thoppimudi foothills, 23.iv.2015, coll. P. M. Sureshan, Reg. No. ZSI/WGRC/IR/INV 9806; 2 young ones, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Urulanthanni, 4.ii.2017, coll. K. Rajmohana, Reg. No. ZSI/WGRC/IR/INV 9807; 3♀, 2Young ones, 2 juveniles, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Kolumba, 20.vii.2016, coll. Jafer Palot, Reg. No. ZSI/WGRC/IR/INV 9808; 1♂ subadult, 1♀, India: Kerala, Ernakulam, Thattekkad Bird Sanctuary, Knacherry, 29.x.2015, coll. K. G. Emiliyamma, Reg. No. ZSI/WGRC/IR/INV 9809.

Habitat: This new species was collected from an evergreen forest. The specimens were found under big boulders and the soil seen under the boulders were dry and moist. Sometimes these species were found in holes under boulders.

Remarks: *Heterometrus* is a very confusing genus among scorpions for species identification. Formerly the genus was designated for only African forms by Peters (1861). The newly described species *Heterometrus thattekkadensis* sp. nov. differs from others in having 1) extremely long segments of pedipalp in male, 2) Pectinal tooth count ranges from 12-14. Sexual dimorphism present, males with long segments of pedipalp whereas moderately long segments of pedipalp in females.

Subfamily Rugodentinae

4.7.3 Genus *Rugodentus* Bastawade, Sureshan & Radhakrishnan, 2005

2005. *Rugodentus* Bastawade, Sureshan & Radhakrishnan, *Rec. Zool. Surv. India.* 104(3-4): 77-82.

Type species: *Rugodentus keralaensis* Tikader and Bastawade, 1983.

Diagnosis: Body finely granular on lateral portions of the cephalothorax and mesosomal tergites I-VII. Sternum pentagonal. Metasomal segments short, robust & strongly carinated. Pedipalp manus of chela globular and robust with one smooth carina externally. A weak subaculear tubercle present at the base of the aculeus. Fingers of chela short with dentition rugously granular in a band. Trichobothrial type 'C'.

Distribution: India: Kerala.

Rugodentus keralaensis Bastawade, Sureshan & Radhakrishnan, 2005

(Plate 55, Fig. a)

2005. *Rugodentus keralaensis* Bastawade, Sureshan & Radhakrishnan, *Rec. Zool. Surv. India.* 104 (3-4): 77-82.

Type locality: India: Kerala, Ernakulam, Malayattoor R F, Mallana, Kodanad.

Diagnosis: Size medium; colour reddish brown. Cephalothoracic sternum pentagonal. Pedipalp comparatively stout but not much strong and manus of chela globular **(Fig. d)**. Rugously granular dentition on fingers of chela in two rows **(Fig. e)**. Femur of pedipalp shorter than carapace. Metasomal segments short, robust and strongly carinated. Telson globular, ventrally granular with a minute subaculear tubercle **(Fig. b)**. Legs granular on the femur. Pectinal tooth count 12/12 **(Fig. c)**.

Distribution: India: Kerala (Ernakulam).

Materials examined: 1♂ Holotype India: Kerala: Ernakulam, Kodanad, Mallana Reserve forest, 12.ii.1999, coll. P. M. Sureshan, Reg. No. ZSI/WGRC//IR/INV 8687.

Habitat: The holotype was collected from the deciduous forest. The specimen was found under the boulder.

Remarks: Very rare species known only from the type locality and the diagnosis described is based on the type material deposited in Zoological Survey of India, Western Ghat Regional Centre, Kozhikode. After the holotype, this species was not collected from the type locality and anywhere else. The species differs from the genus *Heterometrus* in having globular manus of chela with rugously arranged denticles on movable and immovable fingers.

CHAPTER 5
RESULTS AND DISCUSSION

5.1 Diversity

Apart from the preliminary studies conducted on scorpions of Kerala by Bastawade et al. 2004, 2005 and Sureshan et al. 2007a, 2007b, the present study contains the first detailed documentation and taxonomic treatment on scorpions of Kerala. Taxonomic treatment includes the details of 32 species under 10 genera belonging to 3 families. Ten species are described as new to science, of this two species were published. A checklist is prepared based on the taxonomic data.

Table 6.1 Checklist of scorpions from Kerala, India

Sl. no.	Species name	Status
1	*Buthoscorpio chinnarensis* Aswathi, Sureshan & Lourenço, 2015	**Published**
2	*Hottentotta keralaensis* Aswathi, Sureshan & Lourenço, 2016	
3	*Isometrus (Isometrus) wayanadensis* sp. nov.	**New species described**
4	*Isometrus (Isometrus) sureshani* sp. nov.	
5	*Chiromachetes bastawadei* sp. nov.	
6	*Chiromachetes manikandani* sp. nov.	
7	*Iomachus mathikettanensis* sp. nov.	
8	*Iomachus vazhachalensis* sp. nov.	
9	*Heterometrus lourencoi* sp. nov.	
10	*Heterometrus thattekkadensis* sp. nov.	
11	*Hottentotta tamulus* (Fabricius, 1798)	**New report from the state**
12	*Lychas laevifrons* (Pocock, 1897)	
13	*Heterometrus flavimanus* (Pocock, 1900)	

14	*Hottentotta rugiscutis* (Pocock, 1897)	**Redescription**
15	*Isometrus (Isometrus) thurstoni* Pocock, 1893	
16	*Isometrus (Isometrus) maculatus* (DeGeer, 1778)	
17	*Isometrus (Reddyanus) brachycentrus* Pocock, 1899	
18	*Lychas albimanus* Henderson, 1919	
19	*Lychas tricarinatus* (Simon, 1884)	
20	*Chiromachetes fergusoni* Pocock, 1899	
21	*Iomachus laeviceps* (Pocock, 1893)	
22	*Heterometrus scaber* (Thorell, 1876)	
23	*Heterometrus kanaraensis* (Pocock, 1900)	
24	*Heterometrus barberi* (Pocock, 1900)	
25	*Heterometrus keralaensis* Tikader & Bastawade, 1983	
26	*Charmus indicus* Hirst, 1915	**Kovarik (1997, 2003, 2004), Tikader and Bastawade (1983), Sureshan et al. (2007 a, b)**
27	*Lychas hendersoni* (Pocock, 1897)	
28	*Liocheles australasiae* (Fabricius, 1775)	
29	*Heterometrus swammerdami* Simon, 1872	
30	*Heterometrus phipsoni* (Pocock, 1893)	
31	*Heterometrus gravimanus* (Pocock, 1894)	
32	*Rugodentus keralaensis* Bastawade, Sureshan & Radhakrishnan, 2005	

The checklist is prepared in the order which includes scorpion species new to science, species reported for the first time from the state, known species and the species known from the state, which are not collected during the study. New species are described, newly reported and known species are redescribed and diagnosis is provided for the known but uncollected species. Dichotomous keys are prepared for the identification of scorpions up to species level. Taxonomic characters are presented in the form of images and genus-wise distribution maps are prepared based on the GPS data.

During the study, it was noted that the genus *Heterometrus* exhibit maximum diversity in species [31% (10 species)]. Least number of species was observed under the genera *Buthoscorpio*, *Charmus*, *Liocheles* and *Rugodentus* (Fig. 6.1). District wise distribution of scorpion species from Kerala is prepared (Table. 6.2).

Fig. 6.1 Diversity of genera from the study area

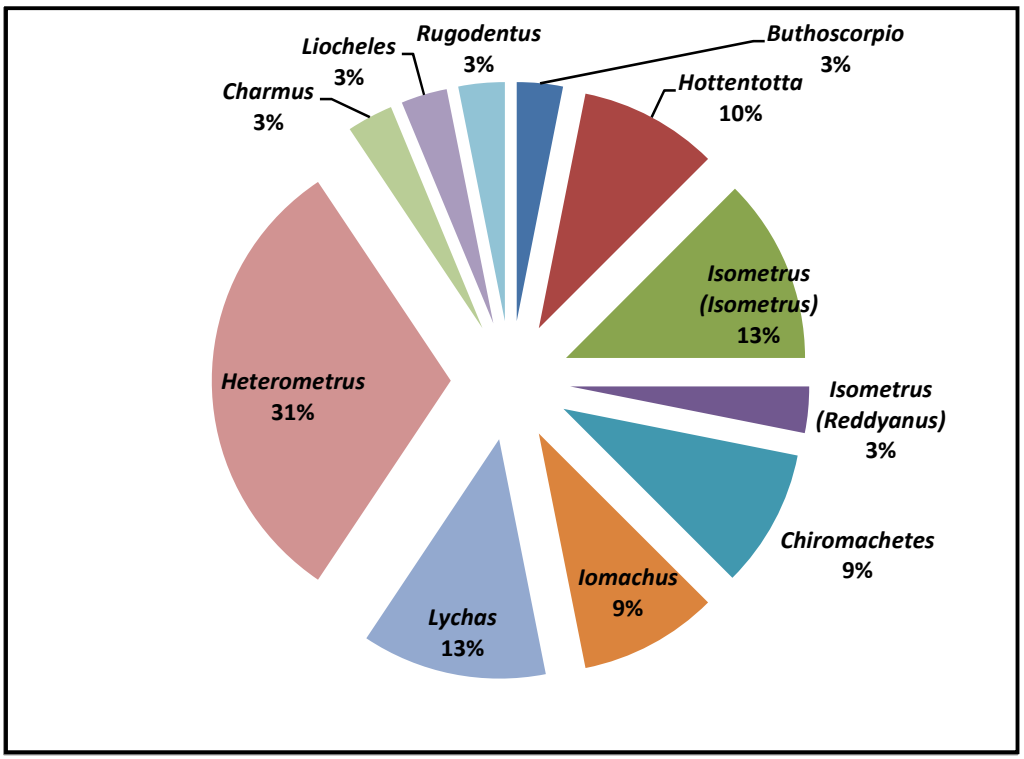


Table 6.2 District-wise distribution of scorpions in Kerala

Sl. No.	Species	Kasargode	Kannur	Kozhikode	Wayanad	Malappuram	Palakkad	Thrissur	Ernakulam	Idukki	Kottayam	Pathanamthitta	Alappuzha	Kollam	Trivandrum
1	*Buthoscorpio chinnarensis* Aswathi, Sureshan & Lourenço, 2015									+					
2	*Charmus indicus* Hirst, 1915*														
3	*Hottentotta rugiscutis* (Pocock, 1897)									+					
4	*Hottentotta tamulus* (Fabricius, 1798)													+	
5	*Hottentotta keralaensis* Aswathi, Sureshan & Lourenço, 2016									+					
6	*Isometrus (Isometrus) maculatus* (DeGeer, 1778)		+	+	+		+					+		+	+
7	*Isometrus (Isometrus) thurstoni* Pocock, 1893		+											+	
8	*Isometrus (Isometrus) wayanadensis* sp. nov.				+					+		+			
9	*Isometrus (Isometrus) sureshani* sp. nov.			+	+										
10	*Isometrus (Reddyanus) brachycentrus* Pocock, 1899	+	+	+		+	+		+	+		+		+	+
11	*Lychas albimanus* Henderson, 1919		+				+	+	+	+				+	+
12	*Lychas hendersoni* (Pocock, 1897)*														
13	*Lychas laevifrons* (Pocock, 1897)	+	+	+	+		+		+	+					
14	*Lychas tricarinatus* (Simon, 1884)	+		+	+		+	+		+					
15	*Chiromachetes fergusoni* Pocock, 1899													+	

Sl. No.	Species	Kasargode	Kannur	Kozhikode	Wayanad	Malappuram	Palakkad	Thrissur	Ernakulam	Idukki	Kottayam	Pathanamthitta	Alappuzha	Kollam	Trivandrum
16	*Chiromachetes bastawadei* sp. nov.													+	
17	*Chiromachetes manikandani* sp. nov.								+						
18	*Iomachus laeviceps* (Pocock, 1893)			+	+	+	+	+	+	+				+	+
19	*Iomachus mathikettanensis* sp. nov.									+					
20	*Iomachus vazhachalensis* sp. nov.							+							
21	*Liocheles australasiae* (Fabricius, 1775)*														
22	*Heterometrus swammerdami* Simon, 1872*														
23	*Heterometrus scaber* (Thorell, 1876)	+	+	+	+	+		+	+	+	+	+	+	+	+
24	*Heterometrus phipsoni* (Pocock, 1893)*														
25	*Heterometrus gravimanus* (Pocock, 1894)*														
26	*Heterometrus kanaraensis* (Pocock, 1900)	+	+		+		+	+		+					
27	*Heterometrus barberi* (Pocock, 1900)			+			+	+	+					+	+
28	*Heterometrus flavimanus* (Pocock, 1900)						+			+					
29	*Heterometrus keralaensis* Tikader & Bastawade, 1983	+	+	+	+										
30	*Heterometrus lourencoi* sp. nov.									+					
31	*Heterometrus thattekkadensis* sp. nov.								+						
32	*Rugodentus keralaensis* Bastawade, Sureshan & Radhakrishnan, 2005								+						

*** Scorpion species which are not collected from the state during the study.**

5.2 Ecology- Results and Discussion

Scorpion ecology is least known in India. Undertaking ecological studies in the field is very difficult in this organism since they loose their experimental marks during every moult (Polis, 1990). The present study is a preliminary attempt on the ecology of scorpions to the extent possible which comprise the observations on seasonal abundance of scorpions and soil properties between two selected ecosystems. Observations on associated fauna, microhabitat preferences, distribution across the altitudinal gradient, parental care, ecdysis, ectoparasitism, feeding behaviour and fluorescence in scorpions were also reported.

5.2.1 Comparison of seasonal abundance of scorpions within two ecosystems

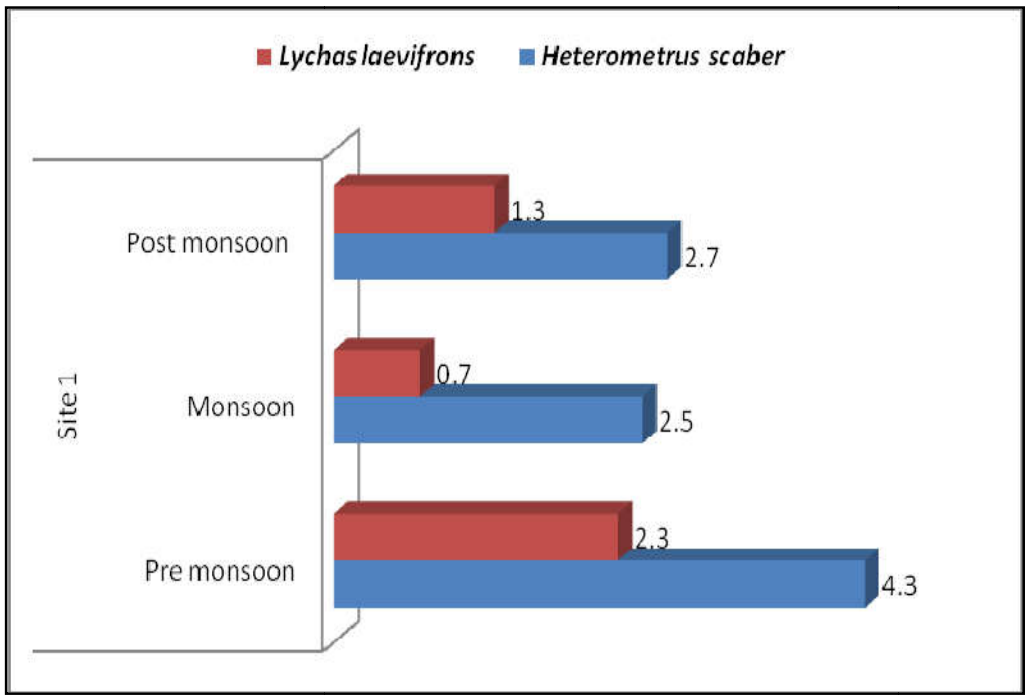
The values from the tables given below indicated the abundance of scorpion species from two sites, site 1 was a forest and site 2 was a rubber plantation. Both sites shared the common species, *Heterometrus scaber* and *Lychas laevifrons*.

Table 6.3 Seasonal abundance (mean) of scorpion species from site 1

	Abundance of *H. scaber* (Mean)	**Abundance of *L. laevifrons* (Mean)**
PrM	4.3	2.3
M	2.5	0.7
PsM	2.7	1.3

Site 1: Forest; PrM: Pre monsoon; M- monsoon; PsM- Post monsoon.

Fig. 6.2 Seasonal abundance (mean) of scorpion species from site 1



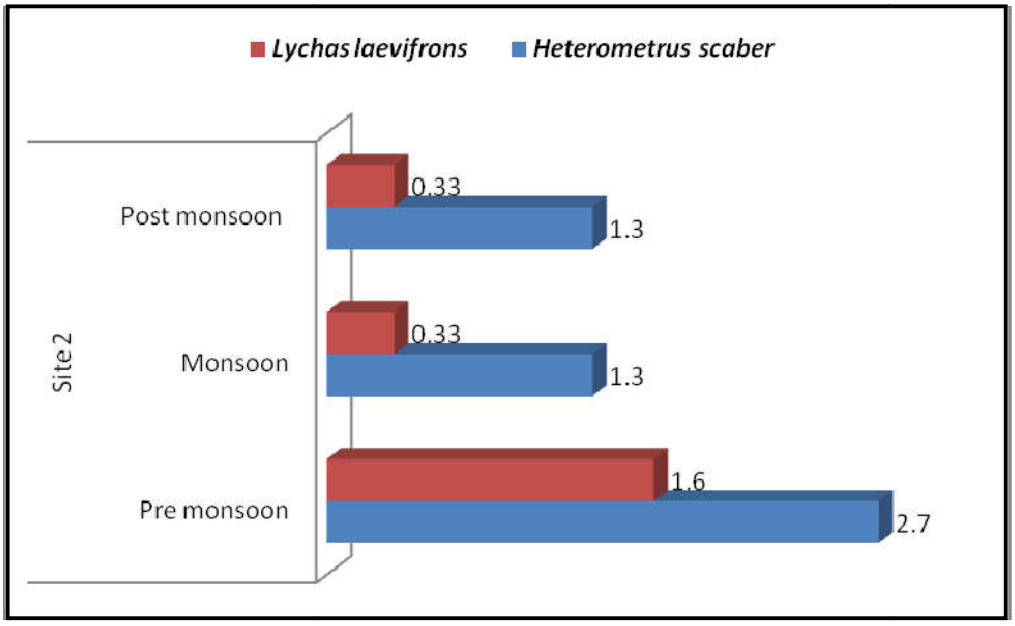
Site 1: Forest

Table 6.4 Seasonal abundance (mean) of scorpion species from site 2

	Abundance of *H. scaber* (Mean)	**Abundance of *L. laevifrons* (Mean)**
PrM	2.7	1.6
M	1.3	0.33
PsM	1.3	0.33

Site 2: Rubber Plantation; PrM: Pre monsoon; M- monsoon; PsM- Post monsoon.

Fig. 6.3 Seasonal abundance (mean) of scorpion species from site 2



Site 2: Rubber plantation

The highest values [4.3 (*H. scaber*, site 1), 2.3 (*L. laevifrons*, site 1) and 2.7 (*H. scaber*, site 2), 1.6 (*L. laevifrons*, site 2)] were recorded during Pre-monsoon (March-May) period for both species from site 1 and site 2. These results are supported by the study of Polis (1990) who pointed out that maximum activities of scorpions occur during warm months. Few individuals were collected from both sites during Monsoon (June-November) (30 individuals from site 1 and 16 individuals from site 2) and Post monsoon (December-February) (24 individuals from site 1 and 20 individuals from site 2). Overall abundance was higher in site 1, which is due to the occurrence of more number of individuals of *Heterometrus scaber* collected from the same site. Generally, low abundance was observed from site 2; since scorpions are determinants and indicators of soil quality, the reason for low abundance may be due to the disturbances caused by human activities and chemical application in plantation crop. When compared to the species *Heterometrus*

scaber, very little number of individuals of the species *Lychas laevifrons* were traced from both sites (Table 6.3 and Table 6.4).

5.2.2 Comparison of seasonal abundance (mean) and seasonal soil physico-chemical properties in the study areas

During the present study, soil physico-chemical properties such as soil temperature, soil pH, Electrical conductivity (EC) and organic carbon (OC) were analyzed.

Table 6.5 Seasonal abundance (mean) and seasonal soil physico-chemical properties in site 1

	Abundance of *H. scaber* (Mean)	**Abundance of *L. laevifrons* (Mean)**	**Soil Temperature**	**pH**	**EC (ds/m)**	**OC%**
PrM	4.3	2.3	30.1	5.9	0.8	3.52
M	2.5	0.7	22	4.2	0.06	2.42
PsM	2.7	1.3	25.5	5	0.02	1.77

Site 1: Forest; EC: Electrical conductivity; OC: Organic carbon PrM: Pre monsoon; M- monsoon; PsM- Post monsoon.

Table 6.6 Seasonal abundance (mean) and seasonal soil physico-chemical properties in site 2

	Abundance of *H. scaber* (Mean)	**Abundance of *L. laevifrons* (Mean)**	**Soil Temperature**	**pH**	**EC (ds/m)**	**OC%**
PrM	2.7	1.6	27	5.8	0.08	3.44
M	1.3	0.33	26.7	4	0.04	2.7
PsM	1.3	0.33	27.5	4.3	0.7	3

Site 2: Rubber Plantation; EC: Electrical conductivity; OC: Organic carbon PrM: Pre monsoon; M- monsoon; PsM- Post monsoon.

From the above tables, the values indicated that high abundance was recorded for both the species from site 1 than site 2. In the present study, the species *Heterometrus scaber* from site 1 has high abundance in Pre-monsoon with 4.3 at temperature 30.1°C, whereas during Monsoon and Post-monsoon the species exhibited moderate abundance, 2.5 and 2.7 respectively. Likewise, the species *Lychas laevifrons* showed high abundance (2.3) in Pre-monsoon, but during monsoon, the abundance (0.7) was very low when compared to *Heterometrus scaber*, and the low abundance recovered slightly on a slight increase in temperature. From this, it is clear that both species were influenced by temperature in site 1. Generally, scorpions are thermophilic arthropods and each species having their own thermal preferences as documented by Warburg and Polis (1990) which supported the above data. Besides, in site 2 the abundance was low for both the species, even the temperature was high during Monsoon and Pre-monsoon periods when compared to site 1. This may be due to the disturbance caused by anthropogenic activities. Prendini (2001) also pointed out that many scorpion species are range-restricted, which exposed their risk for extinction by the results of human activities.

In case of pH, the two sites exhibited average pH ranging from 4.8 to 6.1. According to Wu et al. (2011) reported low arthropod abundance at low pH. The same was observed on two sites, low pH exhibited low abundance.

Electrical conductivity has no significance in abundance in site 1 and site 2. A similar observation by Pahari et al. (2007) pointed out that soil EC has no wide range of variation with the change of season but have no significant impact on abundance.

In the present study, Pre-monsoon reported high OC and positively influenced the abundance of two sites. Ghosh and Roy (2004) supported the

previous observation and documented that soil organic carbon positively supports the abundance of soil-dwelling arthropods.

5.3 Associated fauna of scorpions observed from the study area

During the present study, diverse fauna associated with scorpions were observed in the field, which included earthworms, spiders, centipedes, soil beetles, larvae of firefly, termites, millipedes, cockroaches, leeches and earwigs. Besides associated fauna, the remains of spiders, cockroach, millipedes, and centipedes were found from scorpion's microhabitats. Apart from this, ants are one of the predators, which affected the scorpions very badly. During the present study, it was noticed that the ants attacked the scorpions and killed them **(Plate 56, Fig. a)**.

5.4 Microhabitat preferences of scorpions

Scorpions have distinct microhabitat preferences depending upon the species, which provide suitable conditions for their life. Within a habitat, particular species is found in specific microhabitats. Scorpions are roughly divided into ground and vegetation dwelling. Microhabitat preferences may change according to the situation for every species. During the present study, some microhabitat observations were noted and presented in the table below.

Table 6.7 Different microhabitats of scorpions in Kerala

Species name	Grass	Under rock	Crevices/ cracks	logs	Leaf litter	Tree bark	Burrow	Coconut husk	Tree hole
Buthoscorpio chinnarensis		+							
*Charmus indicus**									
Hottentotta rugiscutis		+							
Hottentotta tamulus		+							
Hottentotta keralaensis		+							
Isometrus (Isometrus) maculatus					+	+			+
Isometrus (Isometrus) thurstoni		+		+					
Isometrus (Isometrus) wayanadensis sp. nov.				+	+	+			
Isometrus (Isometrus) sureshani sp. nov.						+			+
Isometrus (Reddyanus) brachycentrus		+			+	+			
Lychas albimanus		+		+	+				
*Lychas hendersoni**									
Lychas laevifrons		+		+	+			+	
Lychas tricarinatus		+		+	+				
Chiromachetes fergusoni		+	+						
Chiromachetes bastawadei sp. nov.		+	+						
Chiromachetes manikandani sp. nov.		+	+						

Species name	Grass	Under rock	Crevices/ cracks	logs	Leaf litter	Tree bark	Burrow	Coconut husk	Tree hole
Iomachus laeviceps			+		+				
Iomachus mathikettanensis sp. nov.			+						
Iomachus vazhachalensis sp. nov.		+	+						
*Liocheles australasiae**									
*Heterometrus swammerdami**									
Heterometrus scaber	+	+		+			+	+	+
*Heterometrus phipsoni**									
*Heterometrus gravimanus**									
Heterometrus kanaraensis		+		+			+		
Heterometrus barberi		+		+			+		
Heterometrus flavimanus		+					+		
Heterometrus keralaensis		+		+			+		
Heterometrus lourencoi sp. nov.		+							
Heterometrus thattekkadensis sp. nov.	+	+					+		
Rugodentus keralaensis		+							

*** Scorpion species which are not collected from the state during the study.**

5.5 Observations on the distribution patterns of scorpions across altitudinal gradients.

According to the distribution of scorpions, in the present study, the localities of Kerala are divided into seven altitudinal gradients. From the study, it was observed that the altitude 1-200 m has the highest number of species (18 species) and the next high species number at the altitudinal zone of 400-600 m (13 species). The altitudinal zones of 200-400 m and 800-1000 m reported equal number of species (8 species). Least number of species (3 species) was observed at the altitude of 1200-1400 m.

Table 6.8 Relative abundance of scorpions across altitudinal gradients

Altitude gradient (Meters asl)	Number of species	Relative abundance
1-200	18	56.3 %
201-400	8	25%
401-600	13	40.6%
601-800	10	31.3%
801-1000	8	25%
1001-1200	5	15.63%
1201-1400	1	3.13%
1401 and above	6	18.8%

5.6 Observations on parental care

Parental care of scorpions of India is not much studied yet. Tikader and Bastawade (1983) discussed on parental care in general, but a detailed communication on reproduction and parental care on a particular species was not documented. During the present study, parental care of two scorpion species *Lychas laevifrons* and *Heterometrus scaber* were recorded.

Lychas laevifrons with scorpiolings were observed from a mixed plantation at Narayamkulam, Kozhikode district, Kerala in the month of February 2015. During the time of collection, the mother was found inhabiting about 7cm under the soil surface under a medium sized rock and the soil temperature was noted as 27°C. About 10-13 scorpiolings were found sitting on mother's mesosoma even on the space on carapace excluding the lateral eyes. The scorpiolings were protected by the mother's metasoma by keeping above the youngones **(Plate 56, Fig. b)**. Average litter size under the order Scorpiones about 26 was recorded by Polis and Sissom (1990). On disturbance, the mother scorpions run away rapidly with the youngones without any fall of them and hide under the leaf litters.

On another occasion, an individual of the scorpion species *Heterometrus scaber* was observed along with 20 scorpionlings on the back covering the whole metasoma and carapace excluding the lateral eyes **(Plate 56, Fig. c)**. This was recorded from Narikuni, Kozhikode district, Kerala in the month of September 2015. During the time of observation, the mother scorpion and scorpiolings were found under a big boulder. After the removal of the boulder, the mother scorpion was very aggressive in nature to protect the young ones. The same was reported by Vannini et al. 1978. The mother scorpion was trying to defend with her poisonous telson and chelae by moving to and fro. But the movement did not alter the position of the scorpiolings.

5.7 Observations on moulting/ecdysis of scorpions

The moulting in scorpions has been poorly studied especially in India. Many moults were observed and collected during the present study. The moulting specimens were very shy and inactive in nature. One such specimen was collected from Alempatty, Chinnar Wildlife Sanctuary, Idukki district, Kerala in the month of June, 2015. The locality was a hilly area, fortunately,

the collected specimen belonged to a new species *Heterometrus lourencoi* sp. nov. The whole moulting process was observed and recorded in the laboratory and which lasted for 3 hours 16 minutes.

Before ecdysis, the scorpion became inactive, even on disturbance, no activity could be observed. The scorpion was brought to the laboratory for further study. The cuticle first rupture from the front margin of the carapace, then the pedipalp was withdrawn from the cuticle and the process ended at the telson. The same process was documented Polis and Sissom in 1990. The scorpion body emerges out of the cuticle with short vigorous movement followed by long relaxation. After the complete shedding of the cuticle, the scorpion with smooth exoskeleton appeared inactive and exoskeleton hardens and acquired its colour gradually **(Plate 56, Fig. d)**. Many moults were collected from different sites along with specimens **(Plate 56, Fig. e)**.

5.8 Observations on ectoparasitism in scorpions

Apart from predation, scorpions act as hosts for nematode and mite parasites. During the present study, such observation was recorded. At the time of identification of scorpions under microscope, mites could be observed on *Hottentotta rugiscutis* and *Heterometrus* species. Parasitism by Acari mites was recorded earlier. In most of the specimens Acari mites were observed on the pectine, genital operculum and the membranes in between mesosomal tergites **(Plate 56, Fig. f, g)**. Polis and Sissom (1990) reported many nematode and mite species parasitizing scorpions.

5.9 Observations on feeding through captivity

The scorpions exhibit healthy predation, its prey ranges from small insects to small mammals. The present study included the feeding behaviour of two scorpion species *Hottentotta keralaensis* and *Heterometrus scaber* in captivity. During the study both the species were kept in transparent plastic

boxes. In the beginning, the boxes were filled with sand and small stones, but some ants entered into the box. Since disturbances caused by ants affect the scorpions very badly, the box was cleared. The study was conducted for one year on the species *Hottentotta keralaensis* and six months on *Heterometrus scaber*. Both species were fed with a variety of food, which included grasshopper, spiders, earwigs, cockroaches, and earthworms. From the study it was clear that both scorpions prefered only live specimens, they did not even touch the dead prey.

Hottentotta keralaensis was fed in two weeks intervals and avoided frequent feeding. One cockroach was enough for two weeks. The scorpion paralysed or killed the prey using sting and held the same with pedipalps, then consumed using its chelicerae **(Plate 56, Fig. h)**. It was noted that the head of the prey was consumed first. Even if the thorax was facing to the mouth of the scorpion, the prey was rotated using pedipalp and consumed the head first. Similar observations were documented by Polis (1979). The feeding of an adult cockroach lasted for 1-2.5 hours. The scorpion avoided big grasshopper, earwigs and earthworms.

Heterometrus scaber was fed with cockroaches **(Plate 56, Fig. i)**, grasshoppers, spiders and earthworms, but except earthworms, others were eaten by the scorpion. Apart from stinging, the prey was killed using pedipalp. Unlike *Hottentotta keralaensis* no particular orientation of prey consumption was noted. The feeding of an adult cockroach ended in 1-2 hours.

Besides captivity studies, some field observations were also noted. During night *Heterometrus* scorpion lived in burrows, which stayed in the burrow mouth and waited for its prey to capture. After getting the prey, scorpion ate them from outside the burrow. During the study, many body remains of prey could be seen outside the burrow.

5.10 Observations on fluorescence in scorpions

During the present study, few night collections were conducted using a black light torch. Since scorpions are nocturnal in habit and fluoresce under black light, night collections were quite easy when compared to day collections. Non-burrowing scorpions such as *Isometrus* scorpions were found frequently under black light than *Heterometrus* scorpions living in burrows.

CHAPTER 6
SUMMARY

The major objectives of the study included a complete systematic revision of scorpions of Kerala state including the part of southern Western Ghats through extensive field surveys, collection of samples from different ecosystems, describing new taxa and re-describing known taxa based on the collected samples and the deposited samples in the faunal depository of Zoological Survey of India, Western Ghat Regional Centre, Kozhikode. Preparation of identification keys to the scorpions collected from Kerala up to species level and also provided a basic knowledge on the ecology of scorpions of Kerala.

During the present study, 14 districts of Kerala state were explored through stratified random sampling. Apart from the present study, collections of unidentified and identified specimens deposited in the faunal depository of Zoological Survey of India, Western Ghat Regional Centre, Kozhikode were also included. Two sites from Kozhikode district of Kerala state were selected for the ecological studies viz. Site 1- Kakkavayal, Kozhikode (11.49306′N & 75.9739’E, Elevation 55m asl) and Site 2- Cherukkad, Balussery, Kozhikode (11.52719’ N, 75.82993’ E, Elevation 116.2m asl). The ecological study included the species abundance of scorpions and soil analysis, which was performed from December 2015 to November 2016. The soil sampling and soil analysis were performed in Pre Monsoon, Monsoon and Post Monsoon periods. The soil properties such as soil temperature, soil pH, electrical conductivity and organic carbon were analyzed and their influence on scorpion species abundance was studied.

The study revealed the occurrence of 32 species from the study area. From this 32 species, 10 species were described as new to science out of which descriptions of two species were published. The ten new species

described are *Buthoscorpio chinnarensis* Aswathi et al. 2015, *Hottentotta keralaensis* Aswathi et al. 2016 b, *Isometrus (Isometrus) wayanadensis* sp. nov., *Isometrus (Isometrus) sureshani* sp. nov., *Chiromachetes bastawadei* sp. nov., *Chiromachetes manikandani* sp. nov., *Iomachus mathikettanensis* sp. nov., *Iomachus vazhachalensis* sp. nov., *Heterometrus lourencoi* sp. nov. and *Heterometrus thattekkadensis* sp. nov. The species *Hottentotta tamulus* (Fabricius, 1798), *Lychas laevifrons* (Pocock, 1897) and *Heterometrus flavimanus* (Pocock 1900) were reported for the first time from the state. The taxonomic account provided the diagnosis, description of the species, identification keys up to species, materials examined, distribution and habitat of the species.

The results of the ecological study revealed that high species abundance was present in the natural habitat forest (site 1) than the disturbed rubber plantation (site 2). The study based on the soil analysis revealed that a positive influence of temperature, pH and organic carbon (OC) on species abundance of scorpions in both site 1 and site 2. But the electrical conductivity (EC) has no significant influence on species abundance in both sites. Observations on parental care, moulting, ectoparasitism, feeding, fluorescence of scorpions and distribution in accordance with altitudinal gradients were also included.

Before the present study only 21 species of scorpions were reported from the state and after the study, the number of species has gone to 32. The ecological observations made here on scorpions of Kerala are of the first kind from the state which revealed some important findings. The present documentation on scorpions of Kerala may provide a base for initiating further studies on various aspects of taxonomy, ecology, ethology etc on scorpions.

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GLOSSARY

Abdomen consisting of seven mesosomal and five metasomal segments. The opisthosoma also bears the genital pore and opercula (1st segment), the pectines (2nd segment), and four pairs of book lung openings on the sternites.

Aculeus the curved stinger arising distally from the telson vesicle. The aculeus is hollow and bears a small distal opening to allow venom from the internal venom glands of the vesicle to be injected for predation or defense.

Basal pectinal piece a rectangular plate on the underside of mesosomal segment II to which the pectines attach.

Basitarsus the proximal portion of the tarsus, located between the tibia and telotarsus.

Book Lungs the internal respiratory structures of scorpions.

Carapace the dorsal plate of the cephalothorax, bearing the lateral and median eyes.

Carinae cuticular ridges on body surfaces, often associated with attachment of internal musculature. The strength and granulation of carinae are of considerable taxonomic importance.

Cephalothorax the anterior of the two main body regions of a scorpion, serving as a combined head and thorax. The prosoma bears the carapace dorsally and the coxosternal region ventrally; the chelicerae, pedipalps, and four pairs of legs are associated with the prosoma.

Chela the pincer of the pedipalp, comprising the chela palm and the fixed and movable fingers.

Chelicerae the anterior most set of appendages in the scorpion, comprising the mouthparts. The chelicerae of scorpions are chelate and

Coxa the proximal segment of the appendage (chelicera, pedipalp, leg) which joins the appendage to the body. The coxae in modern scorpions, together with the sternum, make up the coxosternal region on the underside of the cephalothorax.

Femur the third leg or pedipalp segment from the base. The femur is the first long segment. On the pedipalp, the femur bears trichobothria, setae, and carinae of taxonomic importance.

Fixed finger the immovable digit of the chelicera or pedipalp chela. The cheliceral fixed finger bears a basal bicusp, a subdistal tooth, and a distal tooth; on its underside is a weak to moderate longitudinal carina which may bear denticles or crenulations. The fixed finger of the pedipalp chela bears trichobothria and a variety of setae; in addition it bears the primary denticle row, which forms its cutting edge (or dentate margin) with the movable finger.

Genital opercula a pair of small flaps that cover the genital pore, the two together forming an oval structure.

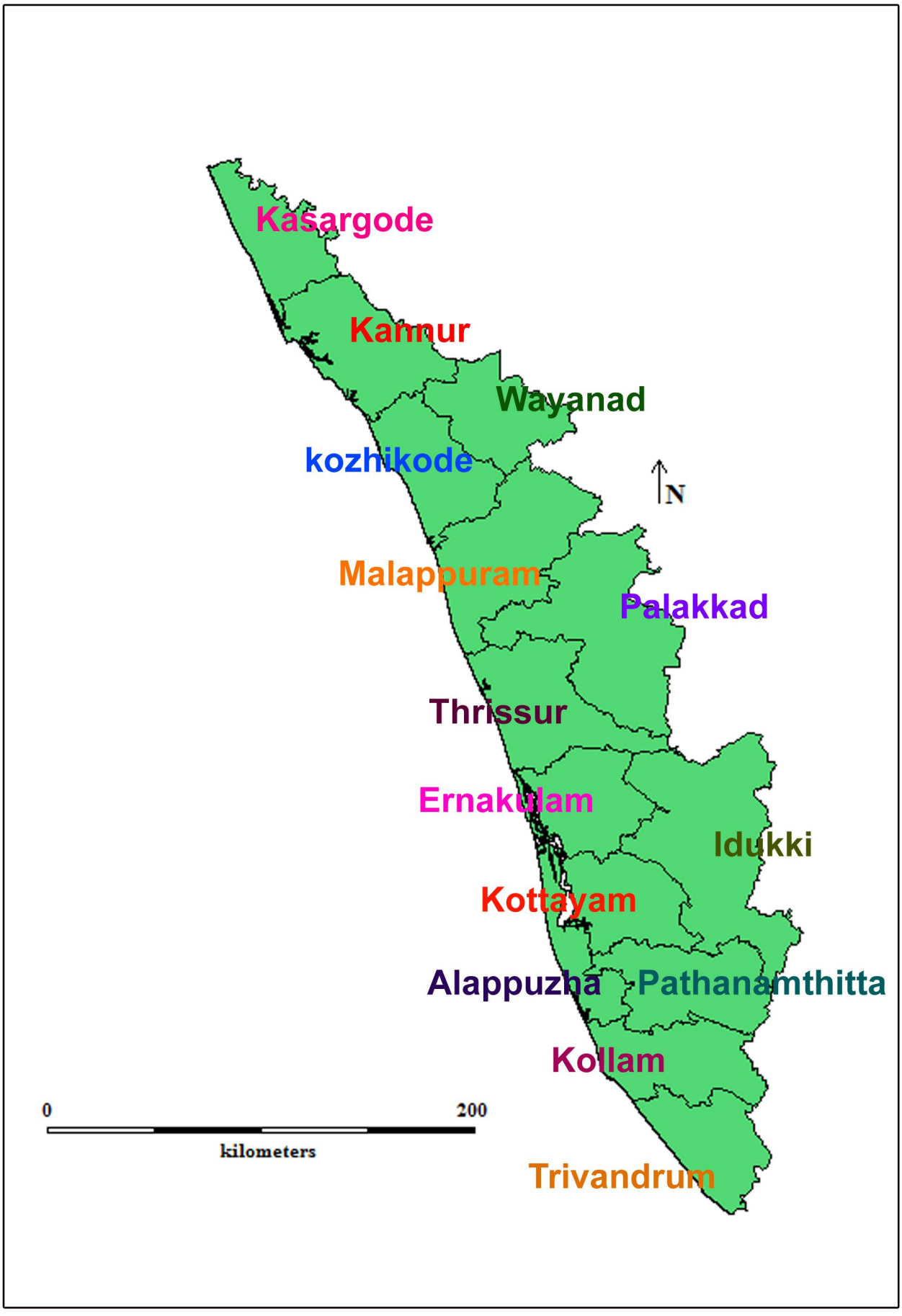
Genital papillae small fingerlike projections that are associated with the membrane of the genital pore of the male scorpion and protrude from beneath the distal margins of the genital opercula.

Genital pore the genital opening concealed by the genital opercula.

Hemispermatophore one of a pair of formative internal male reproductive structures, secreted by the paraxial organ. During courtship, the two

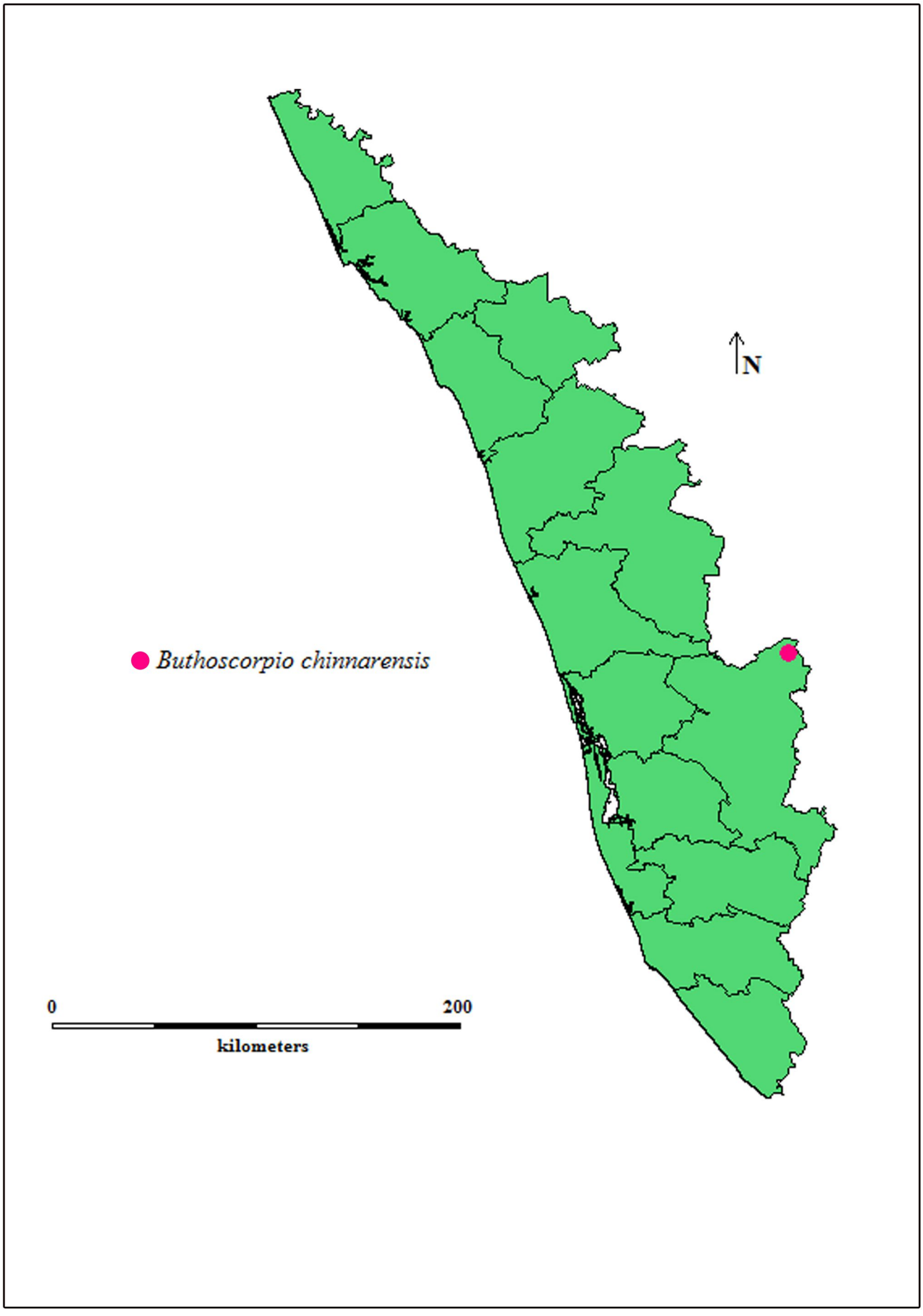
	hemispermatophores are cemented together to form the spermatophore, which carries a sperm packet and is deposited on the substrate.
Inner accessory denticles	denticles flanking the primary denticle row of the chela fingers, usually more or less paired with an enlarged primary row denticle.
Interocular triangle	the area on the carapace surface lying between the median and lateral eyes.
Intersegmental Membrane	soft cuticle between adjacent tergites or sternites on the mesosoma.
Keels	cuticular ridges on body surfaces, often associated with attachment of internal musculature. The strength and granulation of carinae are of considerable taxonomic importance.
Lateral Eyes	the paired cluster of small eyes at the anterolateral corners of the carapace.
Manus	the palm of the chelicera or of the pedipalp chela. Attached distally to the palm are the fixed and movable fingers of these two chelate appendages.
Median eyes	the pair of larger eyes situated middorsally on the carapace.
Mesosoma	the "body" of the scorpion, comprising the first seven of the opisthosomal (abdominal) segments. A given mesosomal segment is provided dorsally with a tergite and ventrally with the genital opercula (1st mesosomal segment), pectines (2nd mesosomal segment), or sternite (segments III-VII). The tergites and sternites are joined together by softer cuticle called intersegmental membranes; the tergites and sternites are connected by similar soft cuticle referred to as the pleural membrane.

Map 1
Study area- Kerala



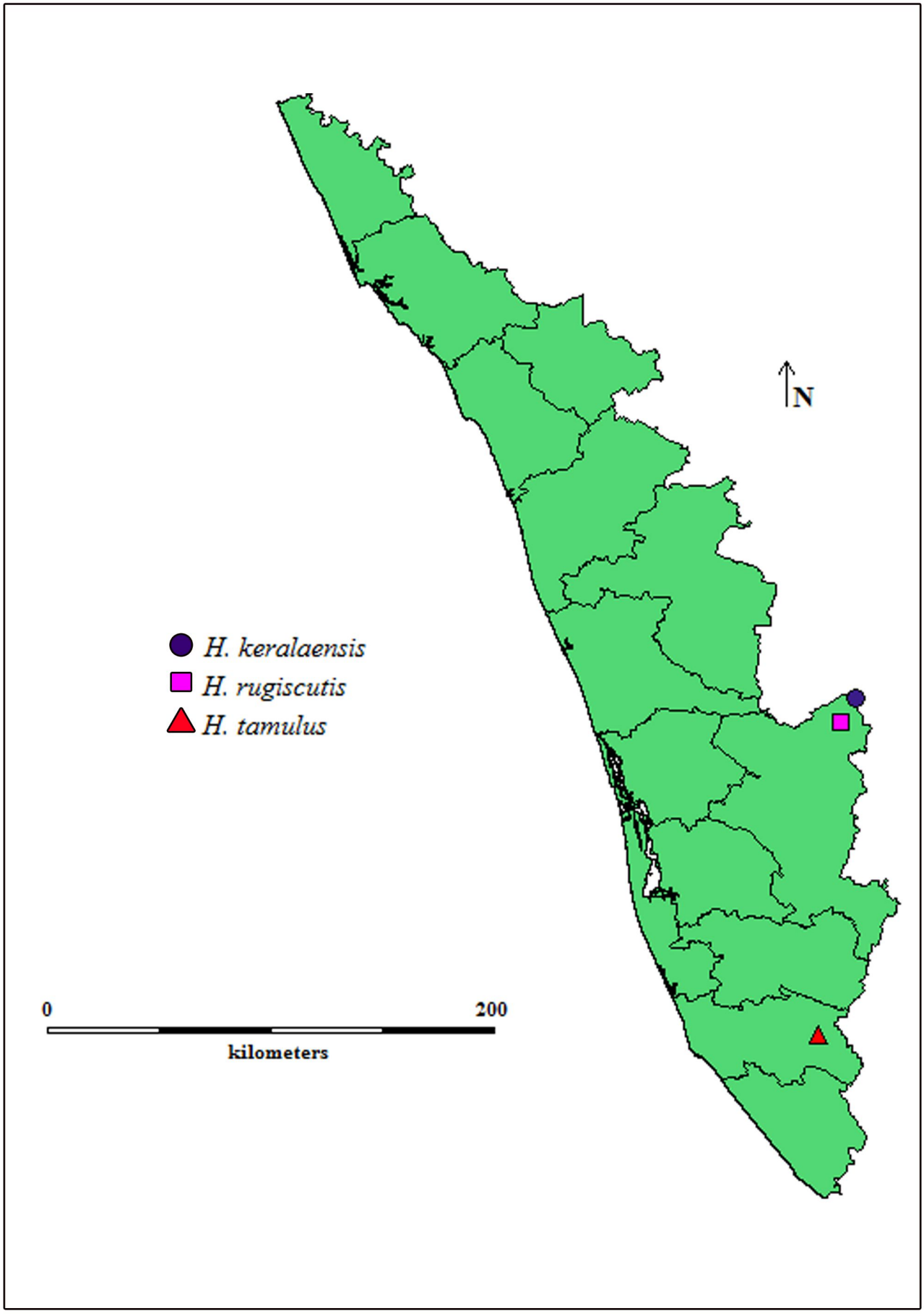
Map 2

Distribution of *Buthoscorpio* Werner species in Kerala



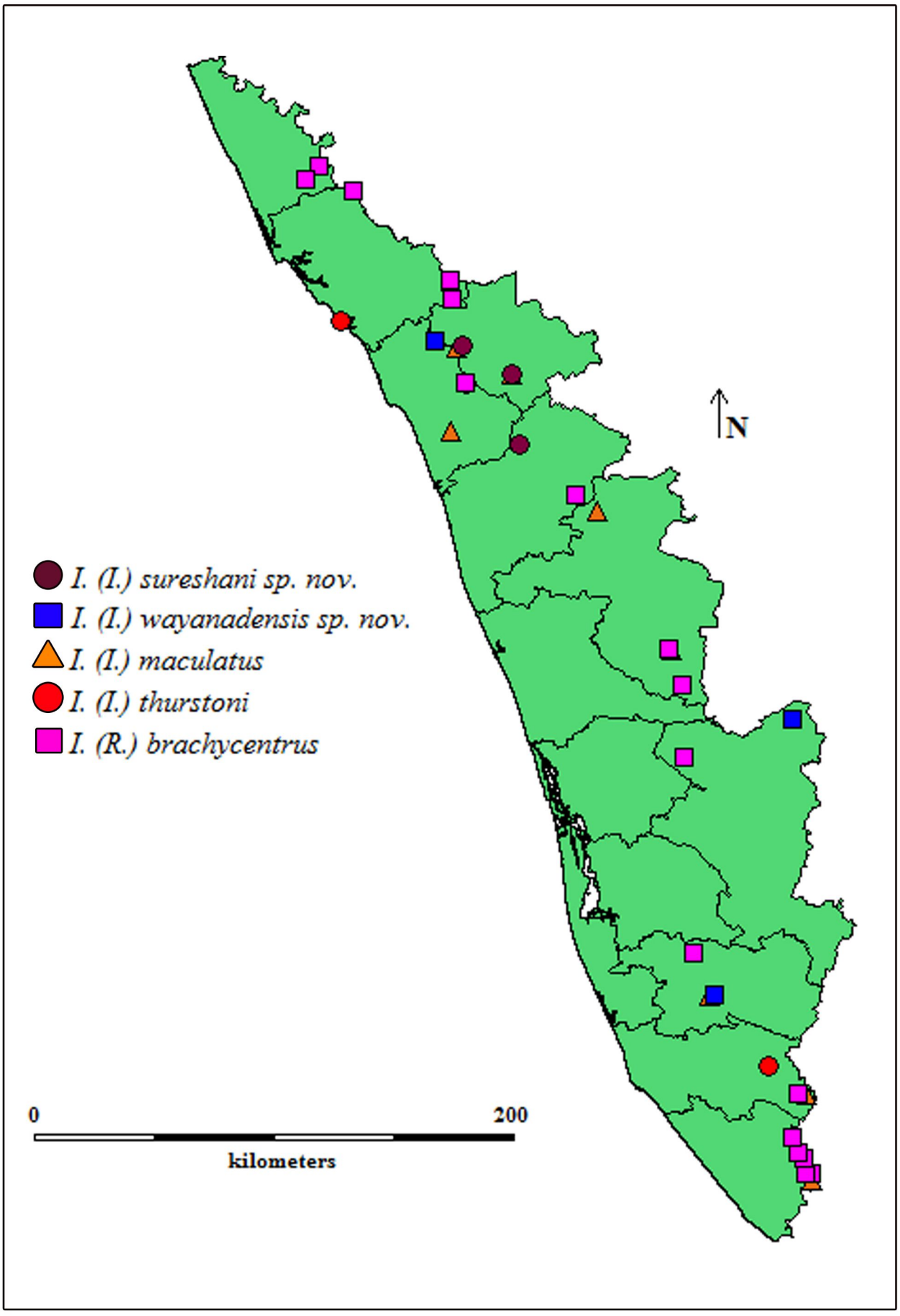
Map 3

Distribution of *Hottentotta* Birula species in Kerala



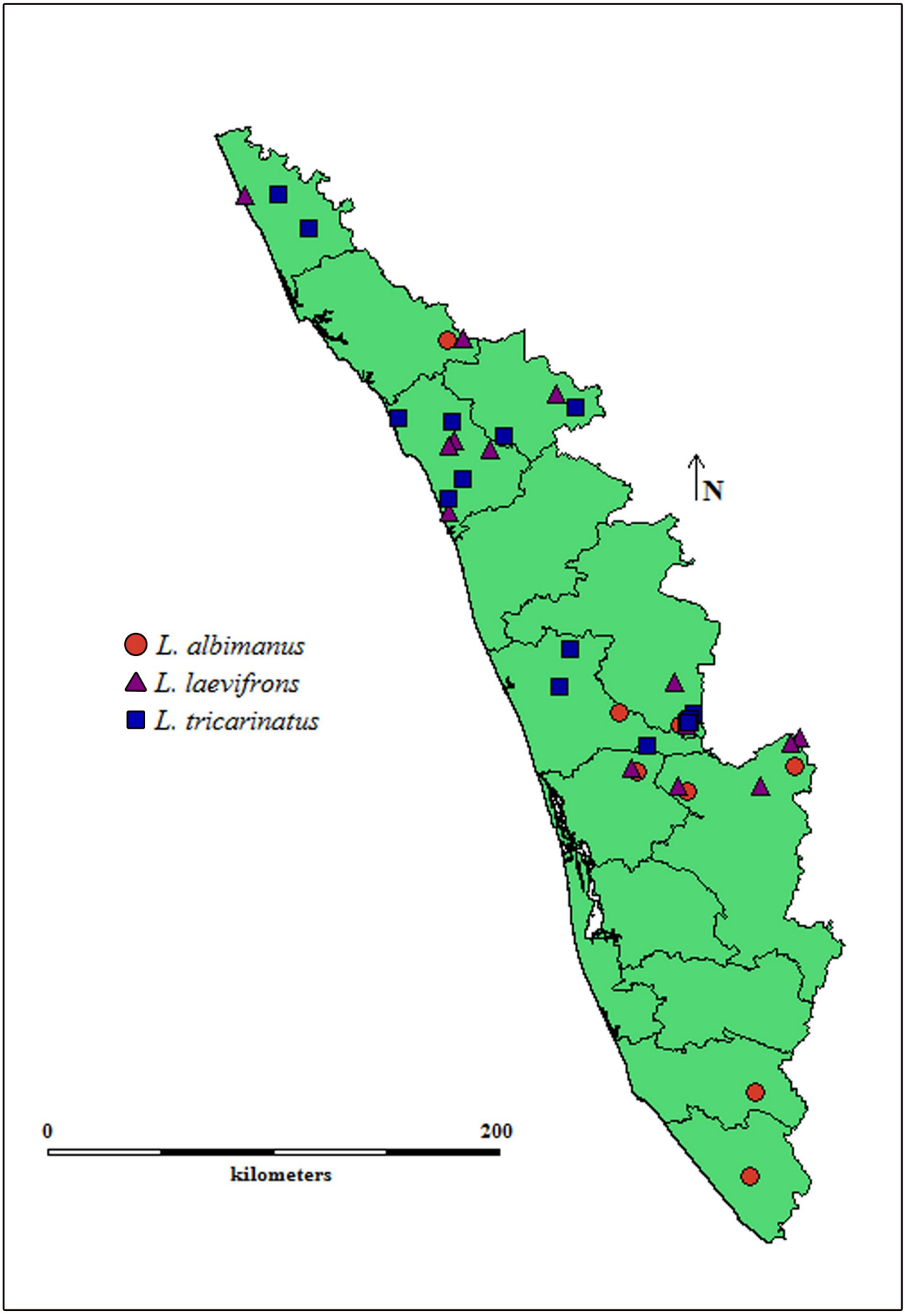
Map 4

Distribution of *Isometrus* Ehrenberg species in Kerala



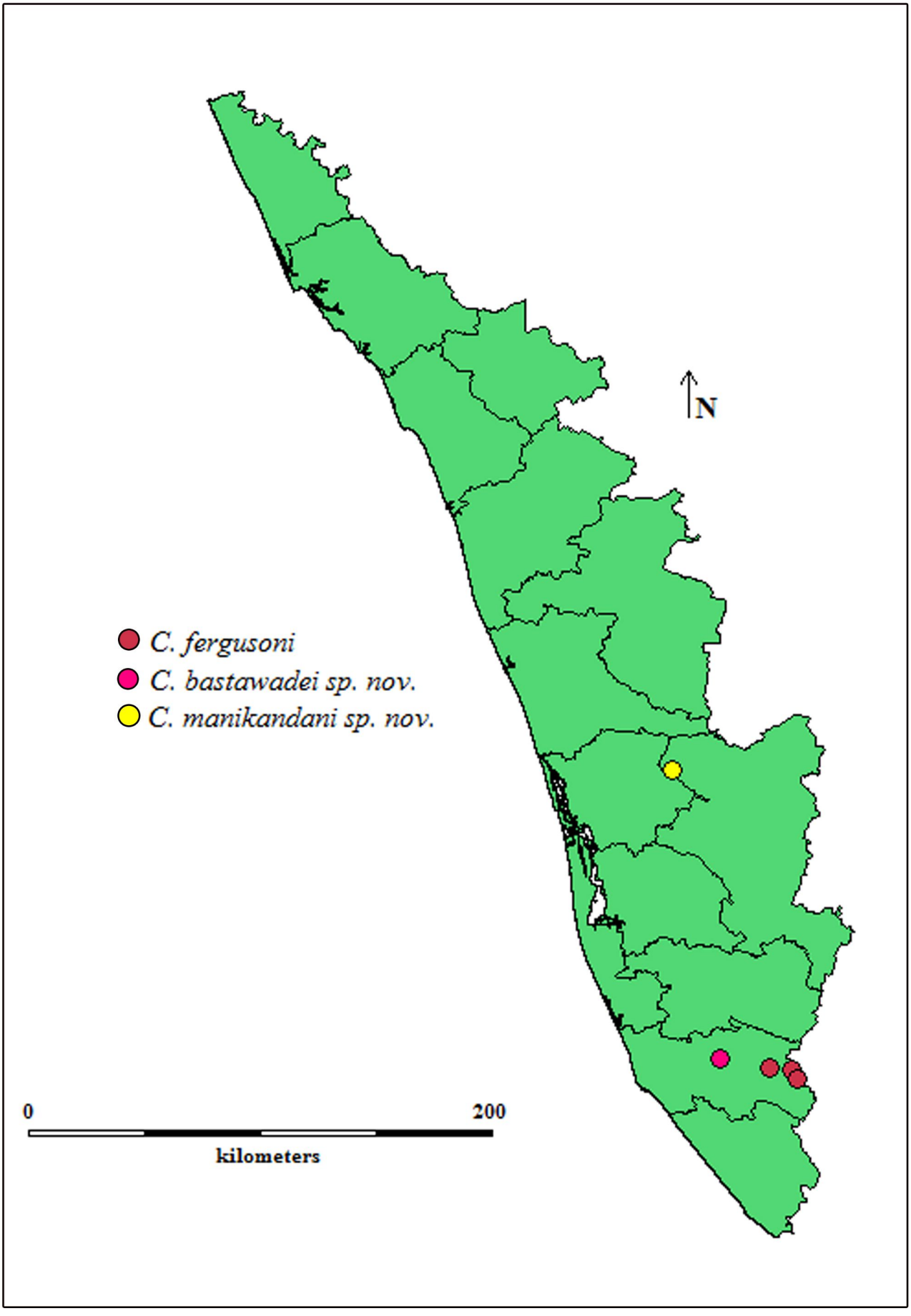
Map 5

Distribution of *Lychas* Koch species in Kerala



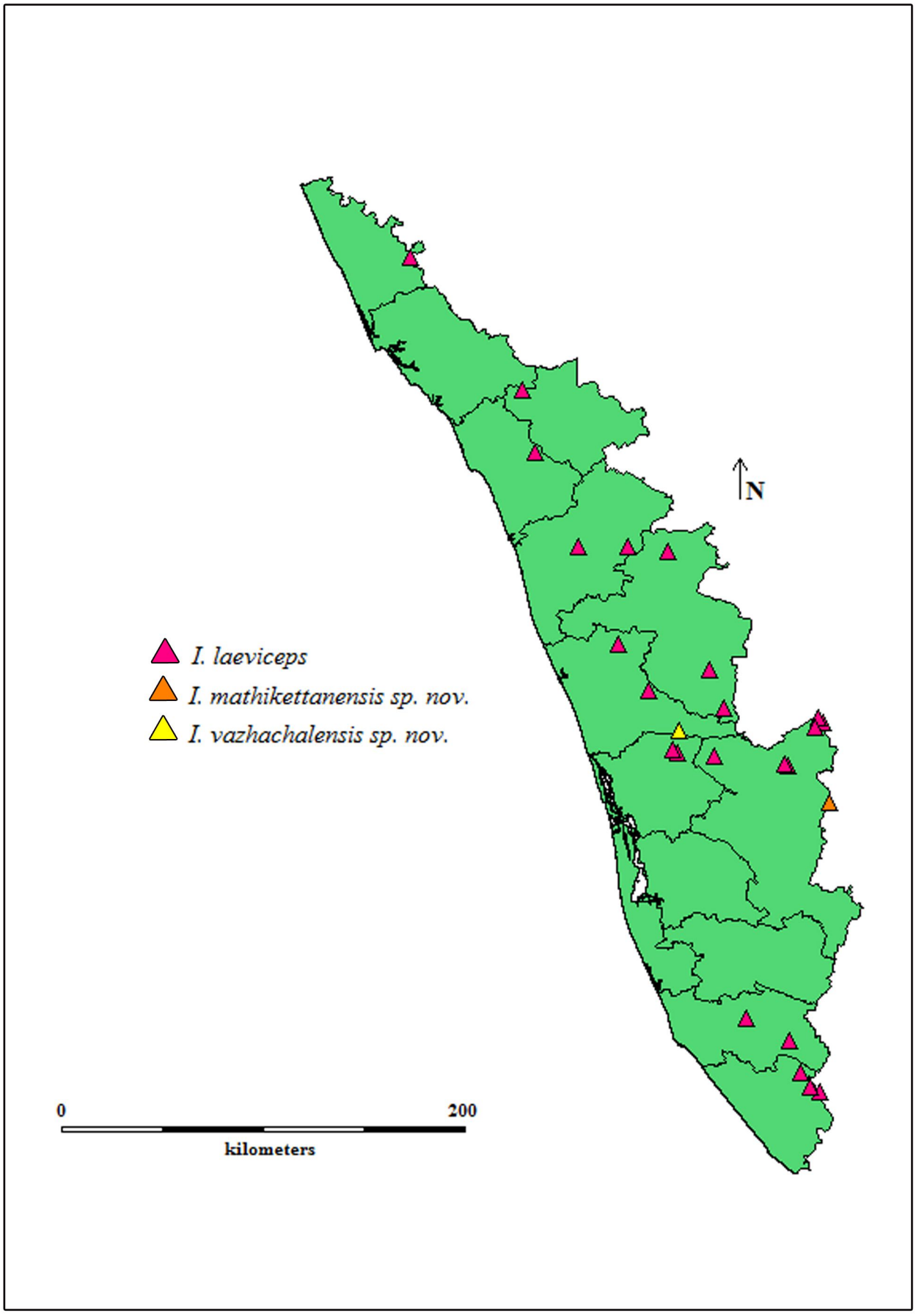
Map 6

Distribution of *Chiromachetes* Pocock species in Kerala



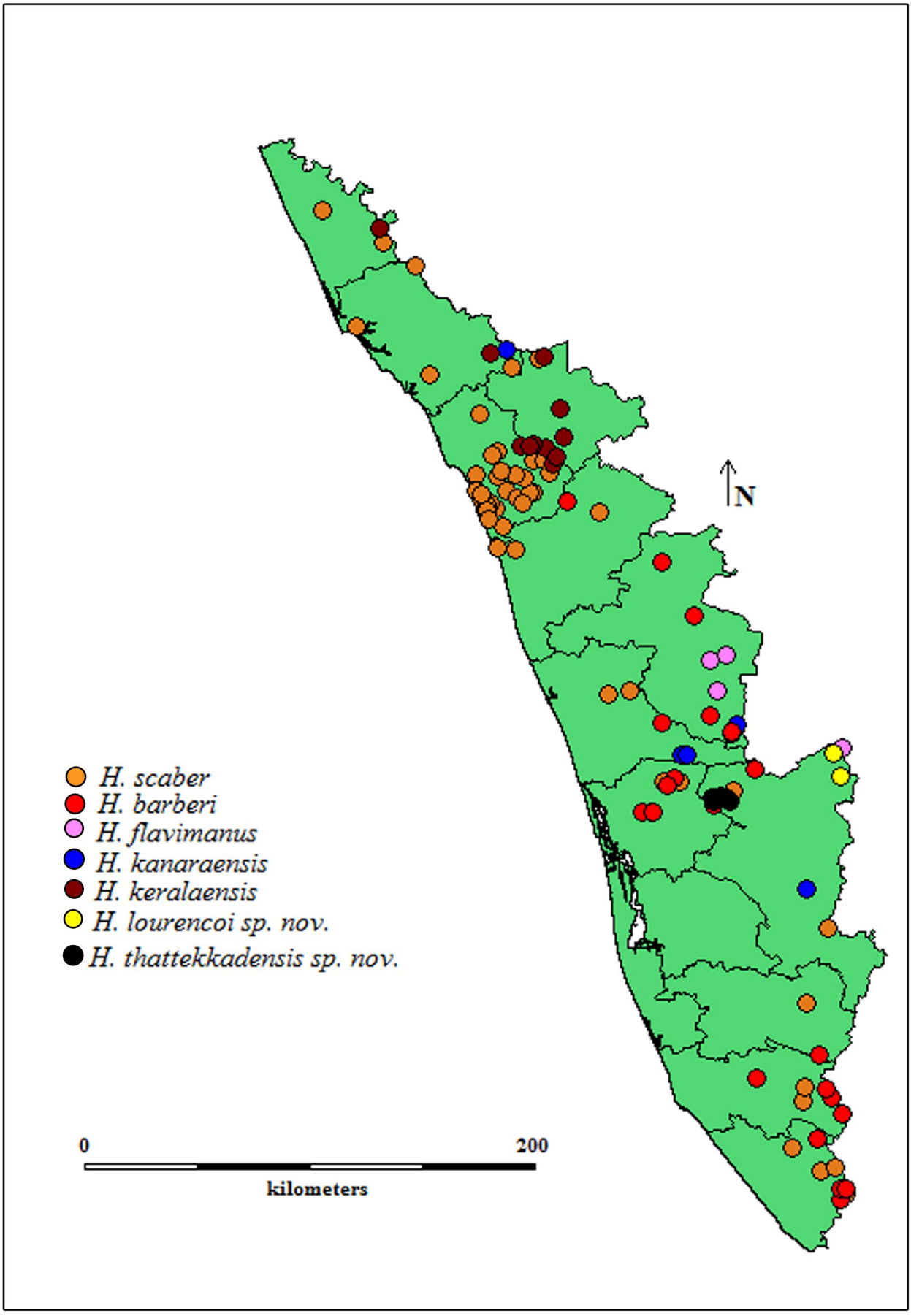
Map 7

Distribution of *Iomachus* Pocock species in Kerala



Map 8

Distribution of *Heterometrus* Ehrenberg species in Kerala



Map 9

Distribution of *Rugodentus* Bastawade, Sureshan & Radhakrishnan species in Kerala

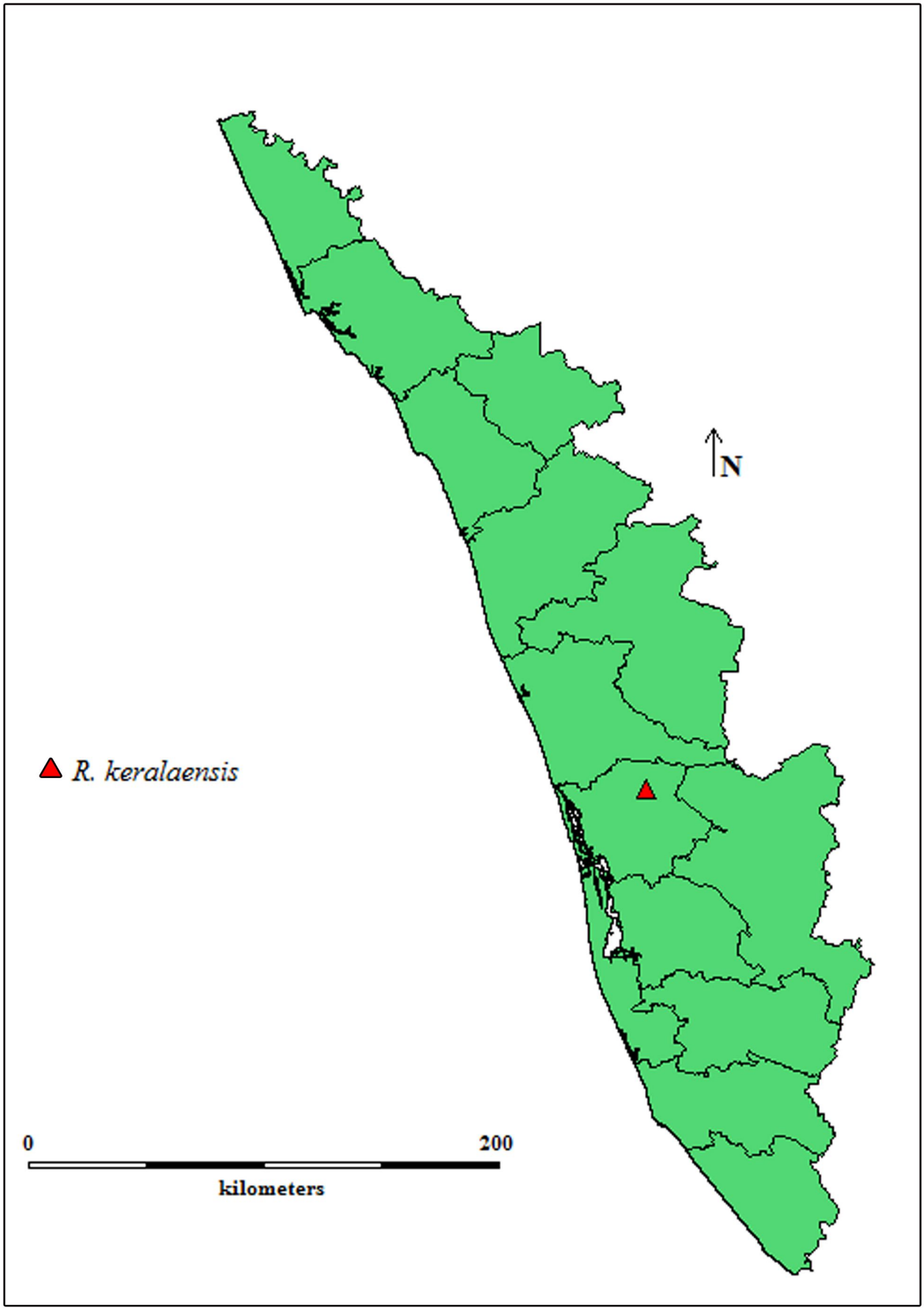
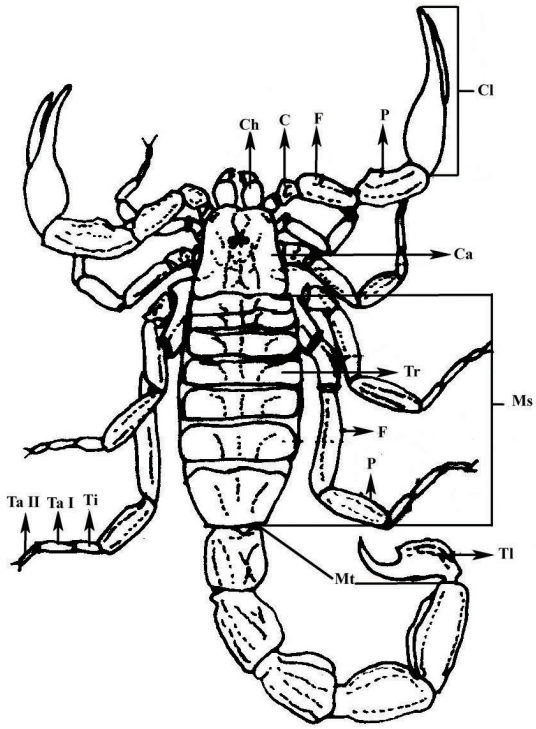
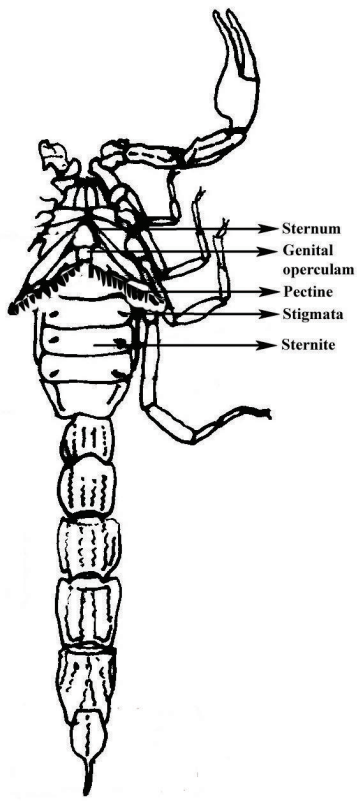


PLATE 1
TERMINOLOGY



a



b

Fig. a: Scorpion Dorsal view; Ch- chelicera, C- coxa, F- femur, P- patella, Cl- chela, Ca- carapace, Tr- tergite, Ms- mesosoma, Mt- metasoma, Tl- telson, Ta I- tarsomere I, Ta II- tarsomere II, Ti- tibia; **Fig. b:** Scorpion Ventral view.

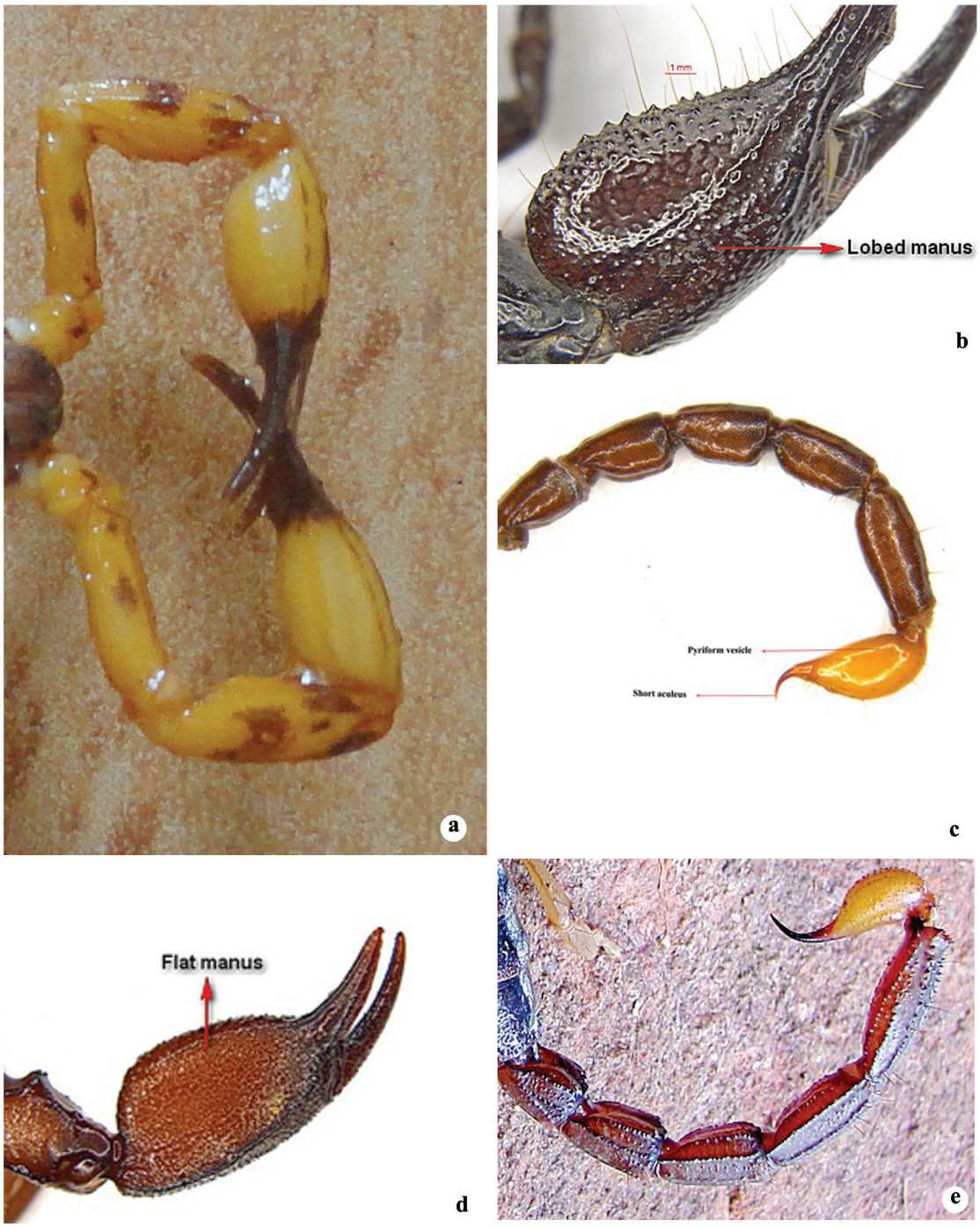
PLATE 2

HABITATS OF SCORPIONS

PLATE 3

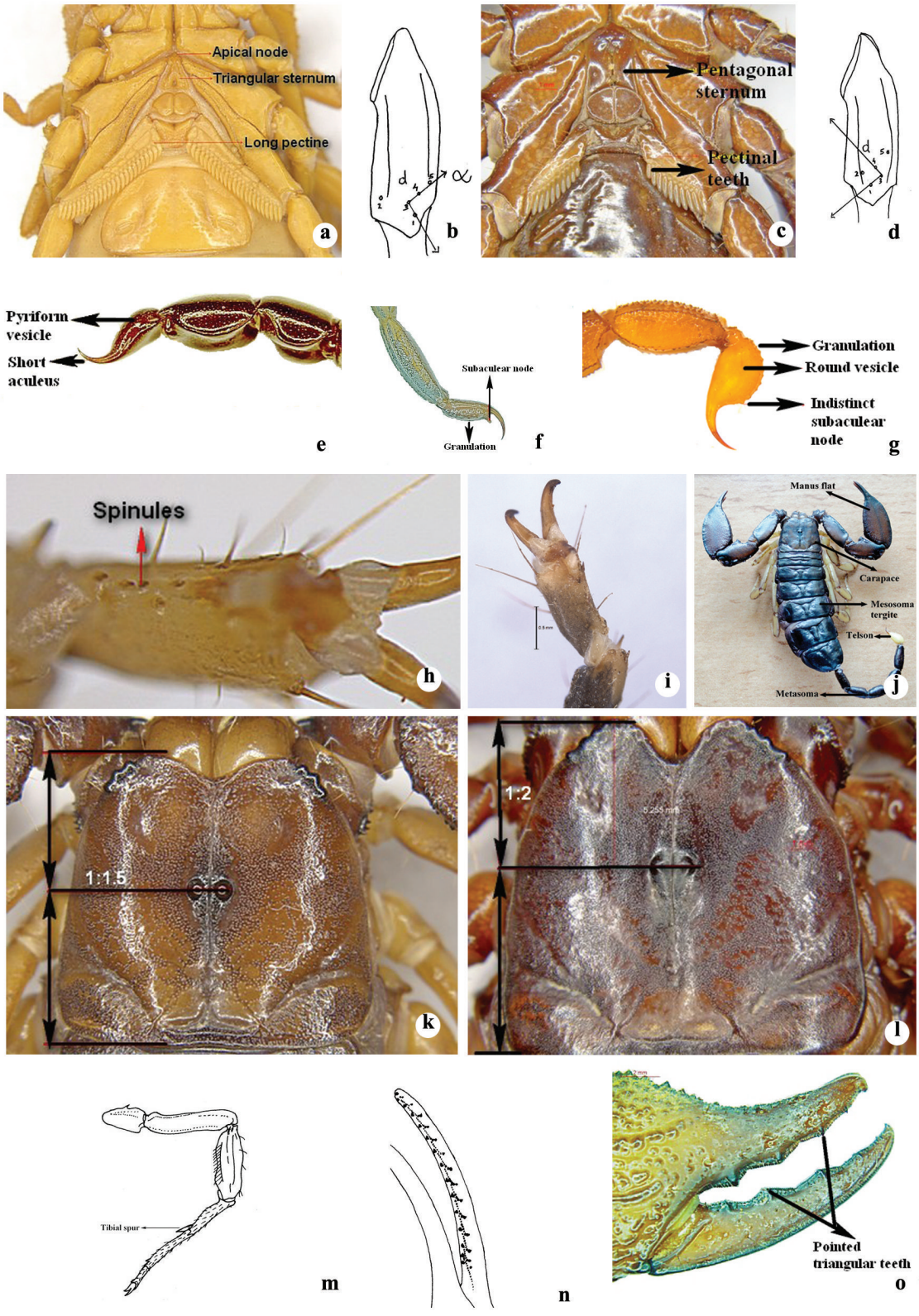
Preservation, Identification and Photographic equipments

PLATE 4
KEY CHARACTERS



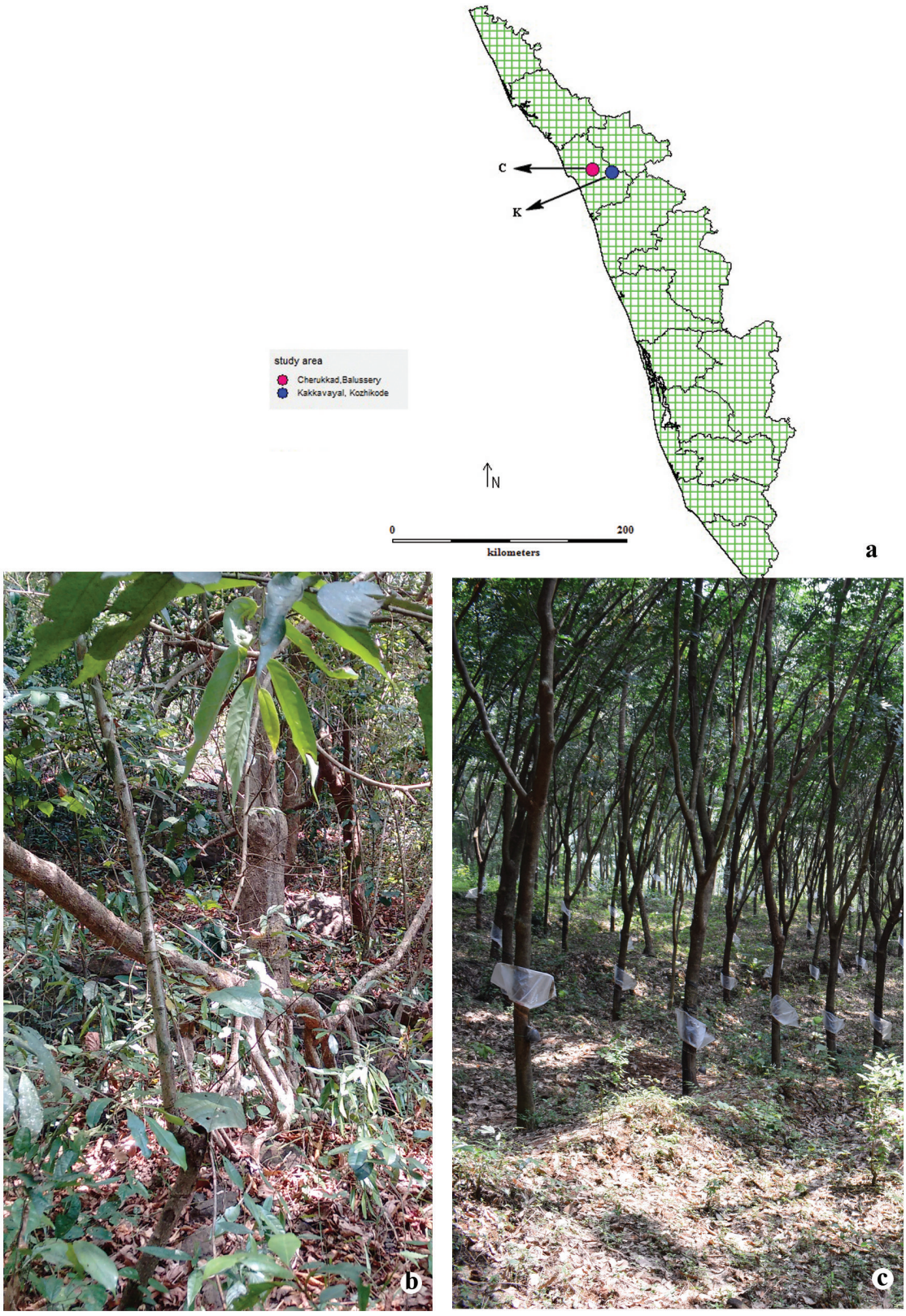
a. slender pedipalp; **b.** wide pedipalp chela; **c.** narrow metasoma; **d.** flat pedipalp manus; **e.** thick metasoma

PLATE 5
KEY CHARACTERS



a. Triangular sternum; **b.** α configuration on femur; **c.** sub pentagonal sternum; **d.** β configuration on femur; **e.** pyriform vesicle with short aculeus; **f.** subaculear tooth, pyriform vesicle with granulation ventrally; **g.** weak subaculear tooth; **h.** tarsomere II ventrally with row of spinules; **i.** tarsomere II ventrally without row of spinules; **j.** dorso ventrally flat body; **k.** median eye situated anteriorly in the ratio 1:1.5; **l.** Median eye situated anteriorly in the ratio 1:2; **m.** Tibial spur on leg; **n.** chela fingers with oblique rows of granules; **o.** chela fingers with triangular denticles

PLATE 6
LOCALITIES SELECTED FOR ECOLOGICAL STUDIES



a. Map showing study areas for ecological studies; **b.** Site 1: Kakkavayal, Kozhikode, Kerala; **c.** Site 2: Cherukkad, Balussery, Kozhikode, Kerala.

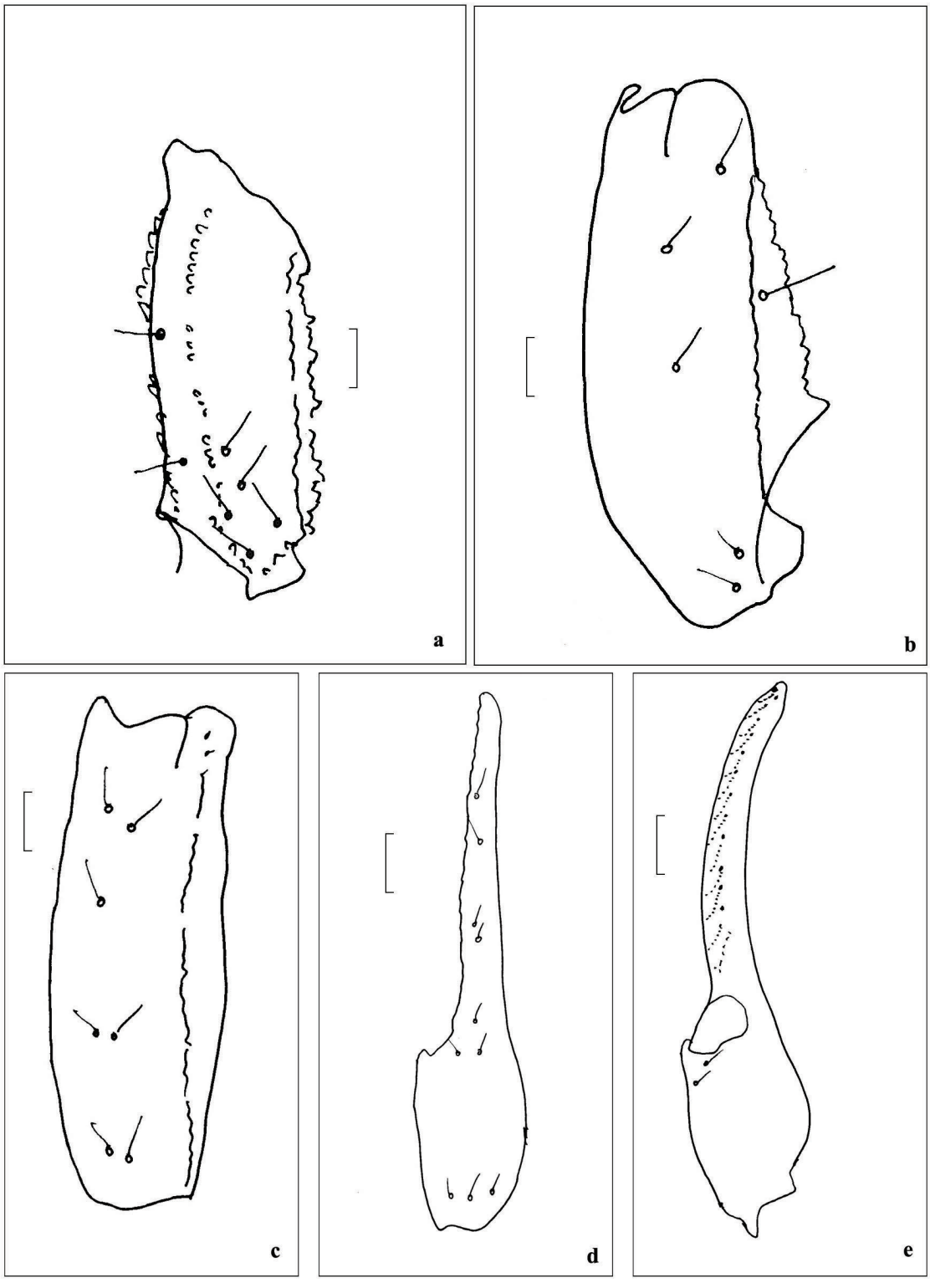
PLATE 7

a. *Buthoscorpio chinnarensis* Aswathi, Sureshan & Lourenco, 2015 (in life); **b.** carapace with scattered granulation; **c.** prominent tubercles on femur; **d.** dorsal carinae on metasomal segments; **e**. pectines

PLATE 8

a. *Hottentotta rugiscutis* (Pocock); **b.** carapace with carinae; **c**. telson vesicle with granulation and weak subaculear node; **d**. pectines; **e.** cheliceral dentition; **f.** chela finger dentition

PLATE 9

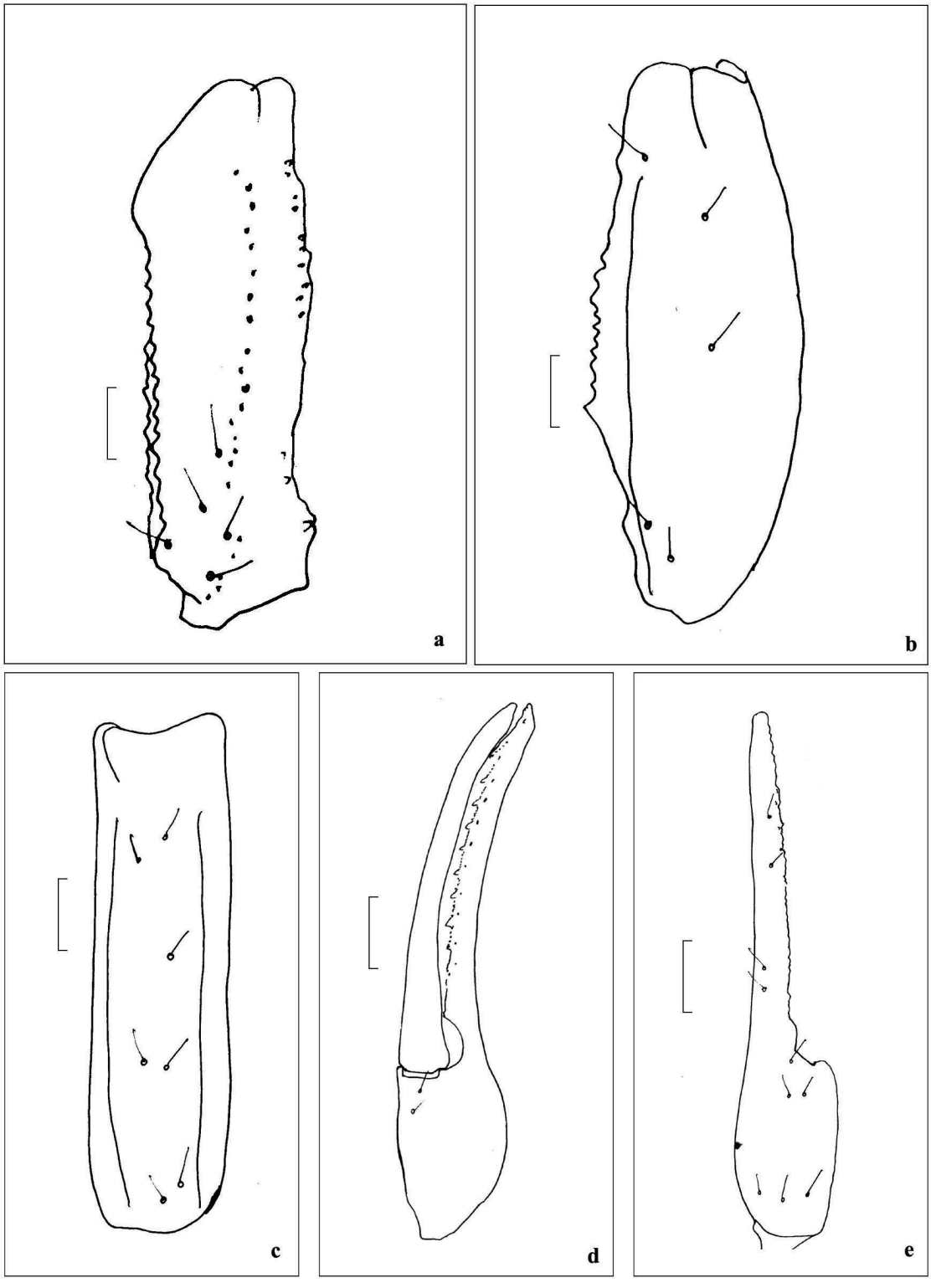


Hottentotta rugiscutis (Pocock); **a.** femur dorsal view; **b.** patella dorsal view; **c.** patella exterior view; **d.** chela dorso-exterior view; **e.** chela ventral view

PLATE 10

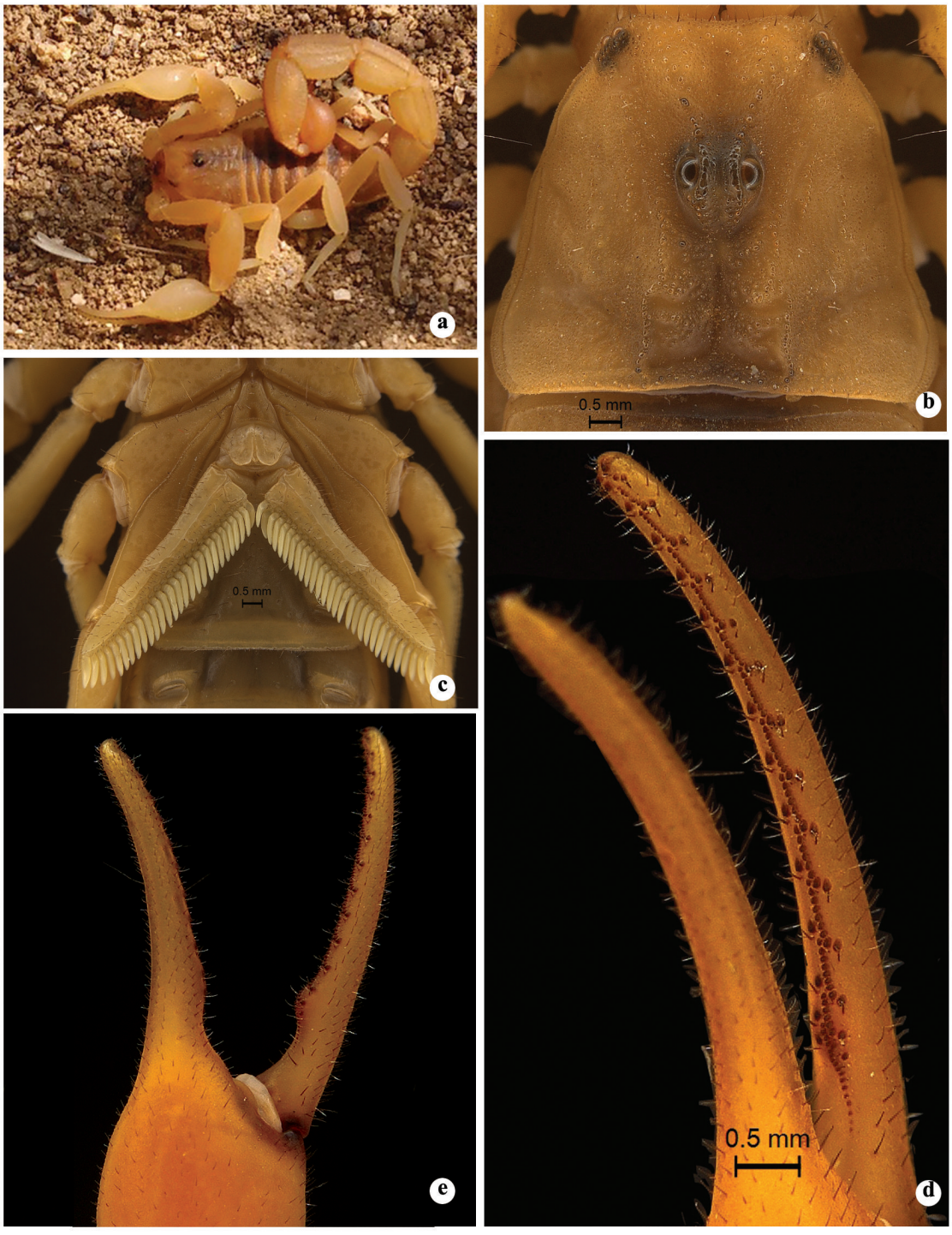
a. *Hottentotta tamulus* (Fabricius) ♀; **b.** carapace with carinae; **c**. telson with weak subaculear tubercle; **d**. pectines; **e**. chela finger dentition

PLATE 11



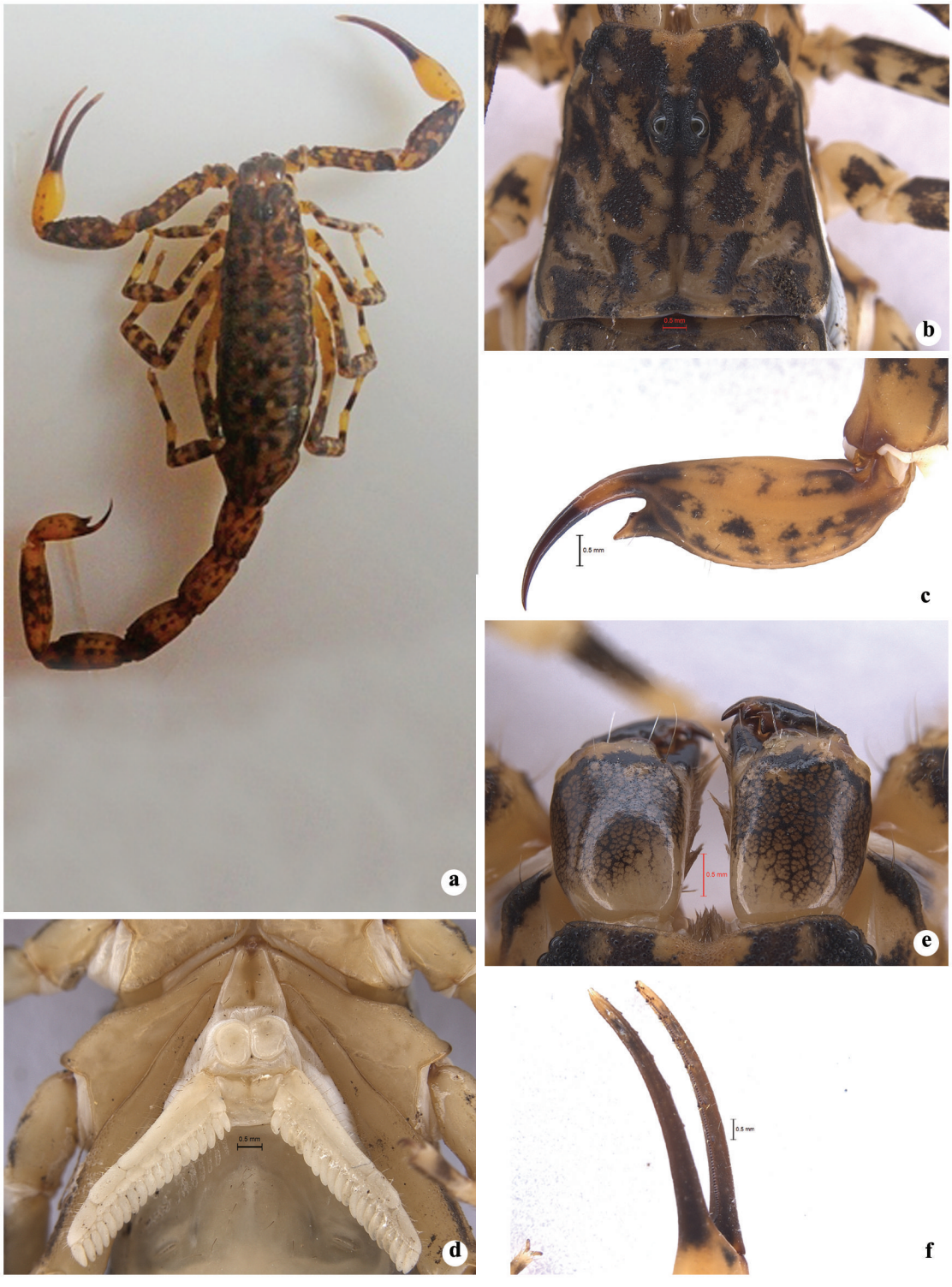
Hottentotta tamulus (Fabricius) ♀ **a.** femur dorsal view; **b**. patella dorsal view; **c**. patella exterior view; **d**. chela ventral view; **e**. chela dorso-exterior view

PLATE 12



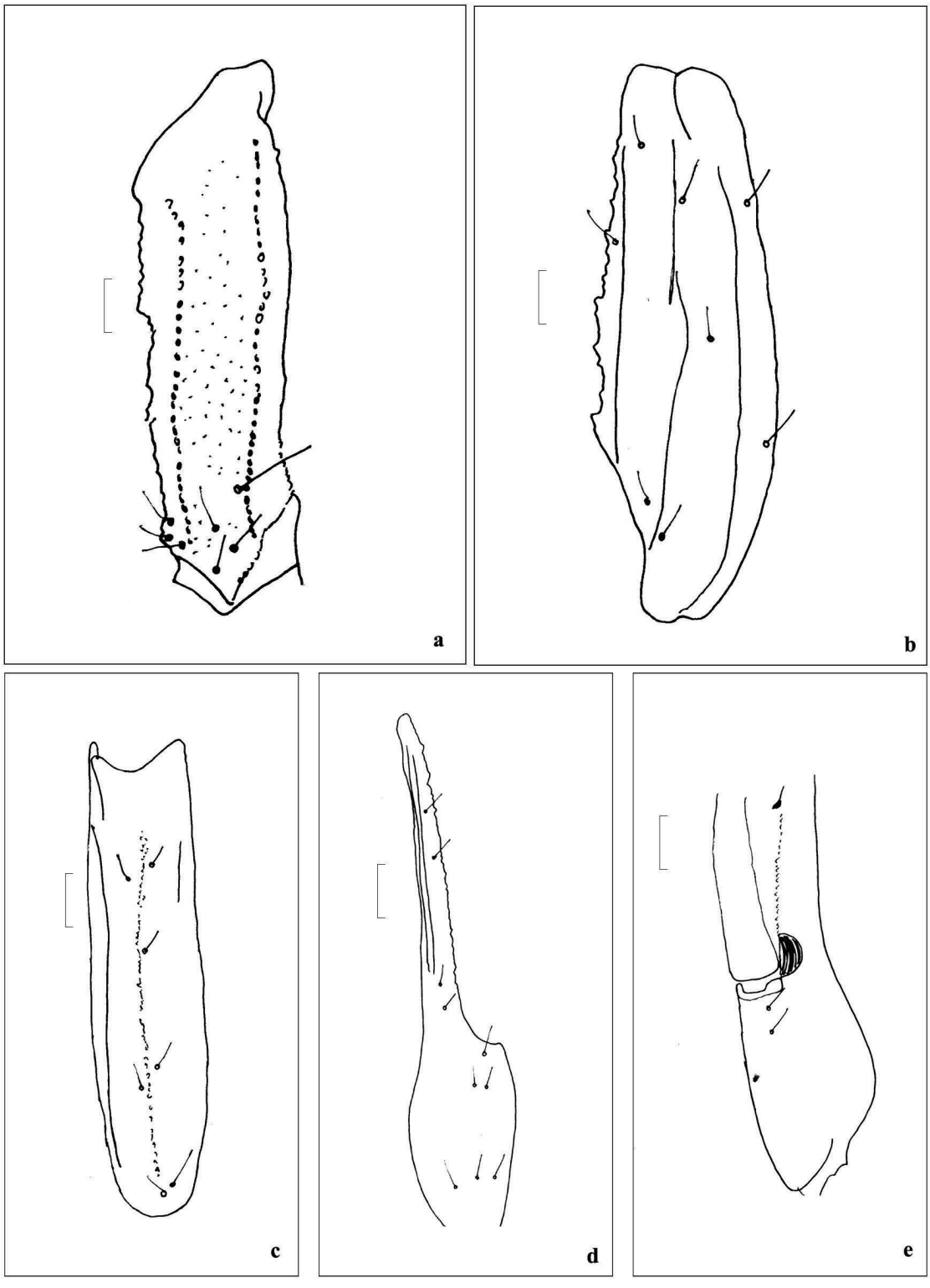
a. *Hottentotta keralaensis* Aswathi, Sureshan & Lourenço (in life); **b**. carapace with carinae; **c**.pectines; **d**. chela finger dentition; **e.** scallope at the base of chela movable finger

PLATE 13



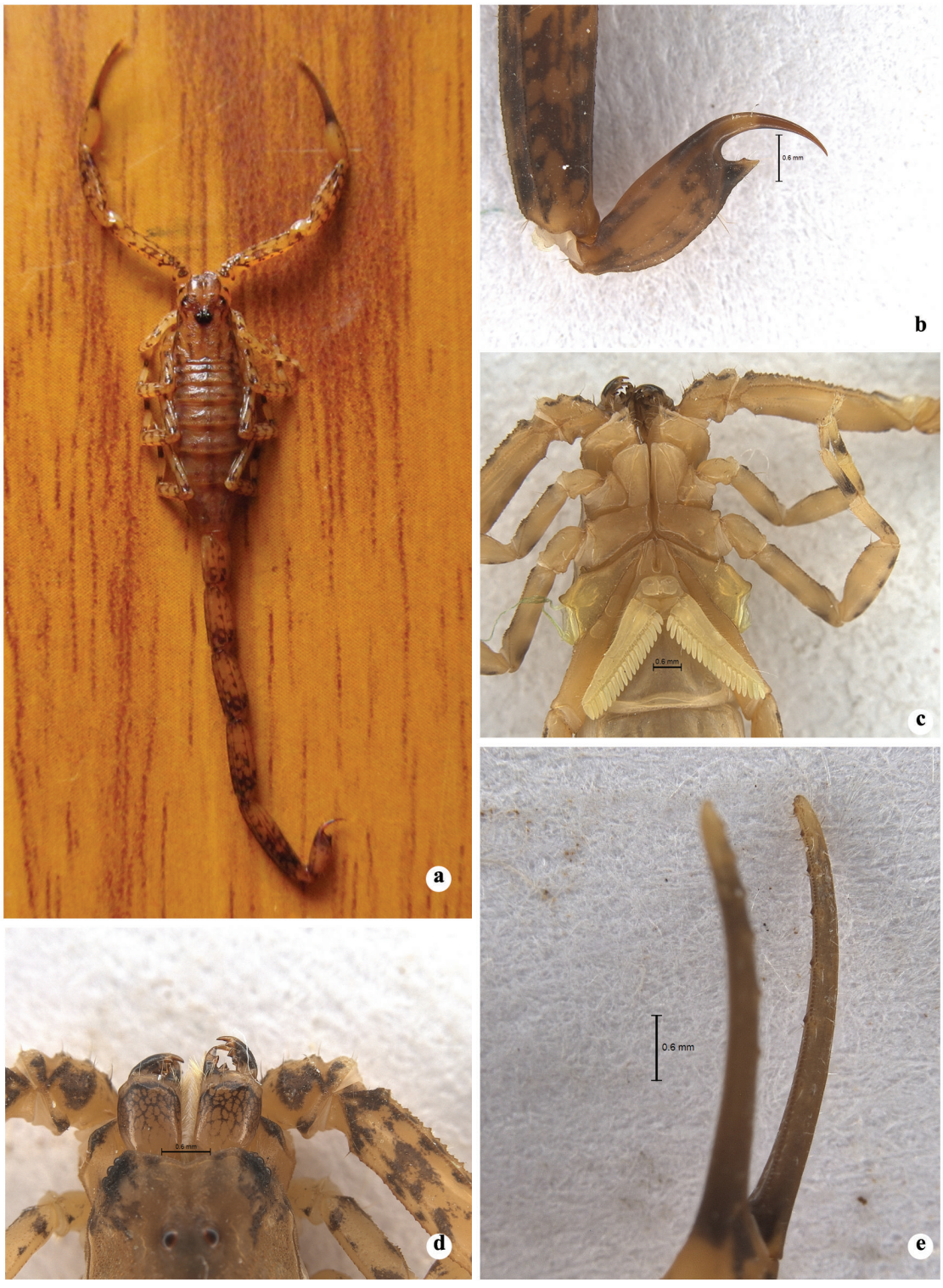
a. *Isometrus (Isometrus) maculatus* (De Geer) ♀; **b**. carapace with carinae; **c**. telson with subaculear tubercle; **d**. pectines; **e**. cheliceral finger dentition; **f**. chela finger dentition.

PLATE 14



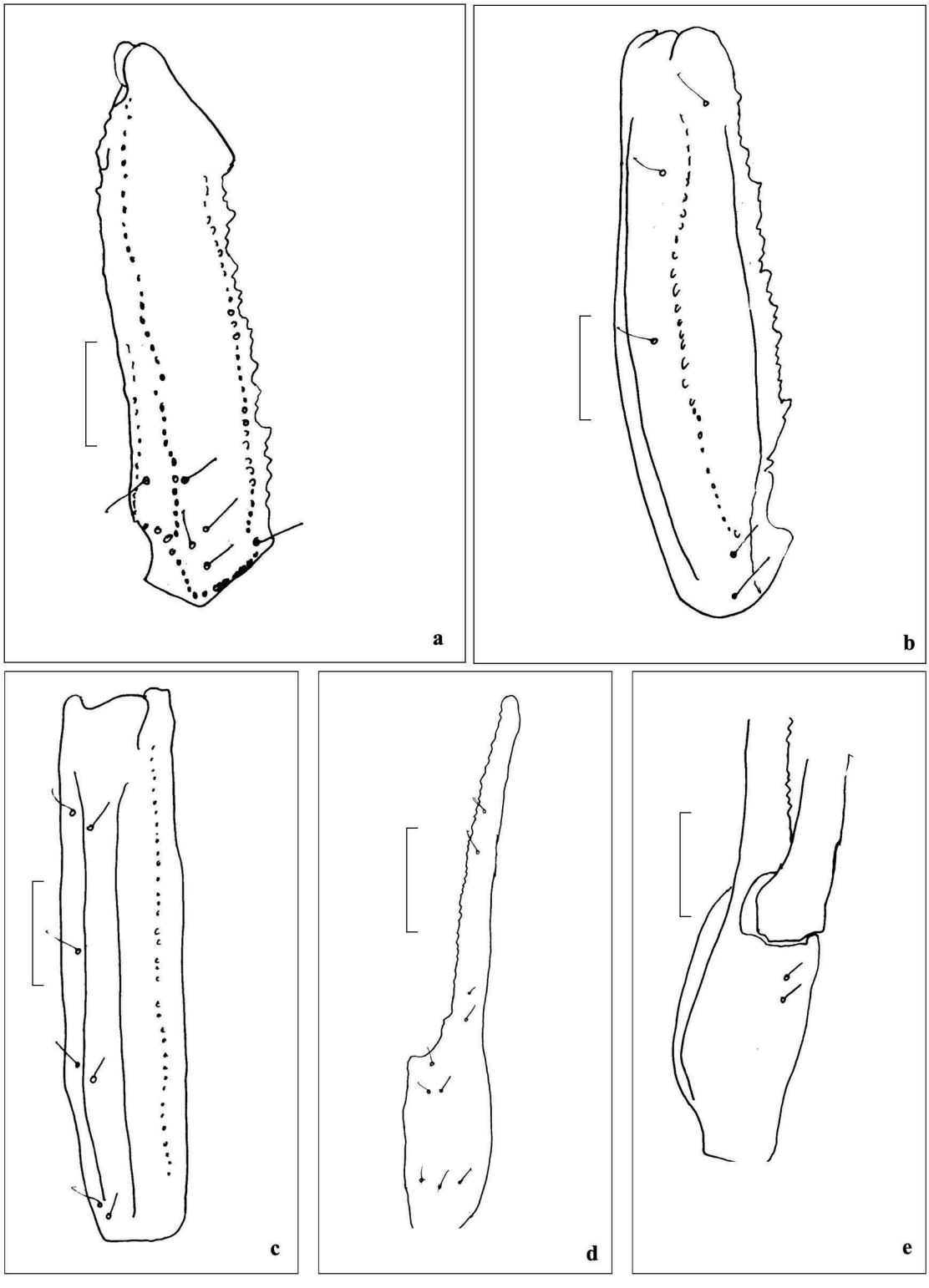
Isometrus (Isometrus) maculatus (De Geer) ♀; **a.** femur dorsal view; **b**. patella dorsal view; **c**. patella exterior view; **d**. chela dorso-exterior view; **e**. chela ventral view

PLATE 15



a. *Isometrus (Isometrus) thurstoni* Pocock ♂; **b**. telson with subaculear tubercle; **c**. pectines; **d**. cheliceral finger dentition; **e**. chela finger dentition

PLATE 16

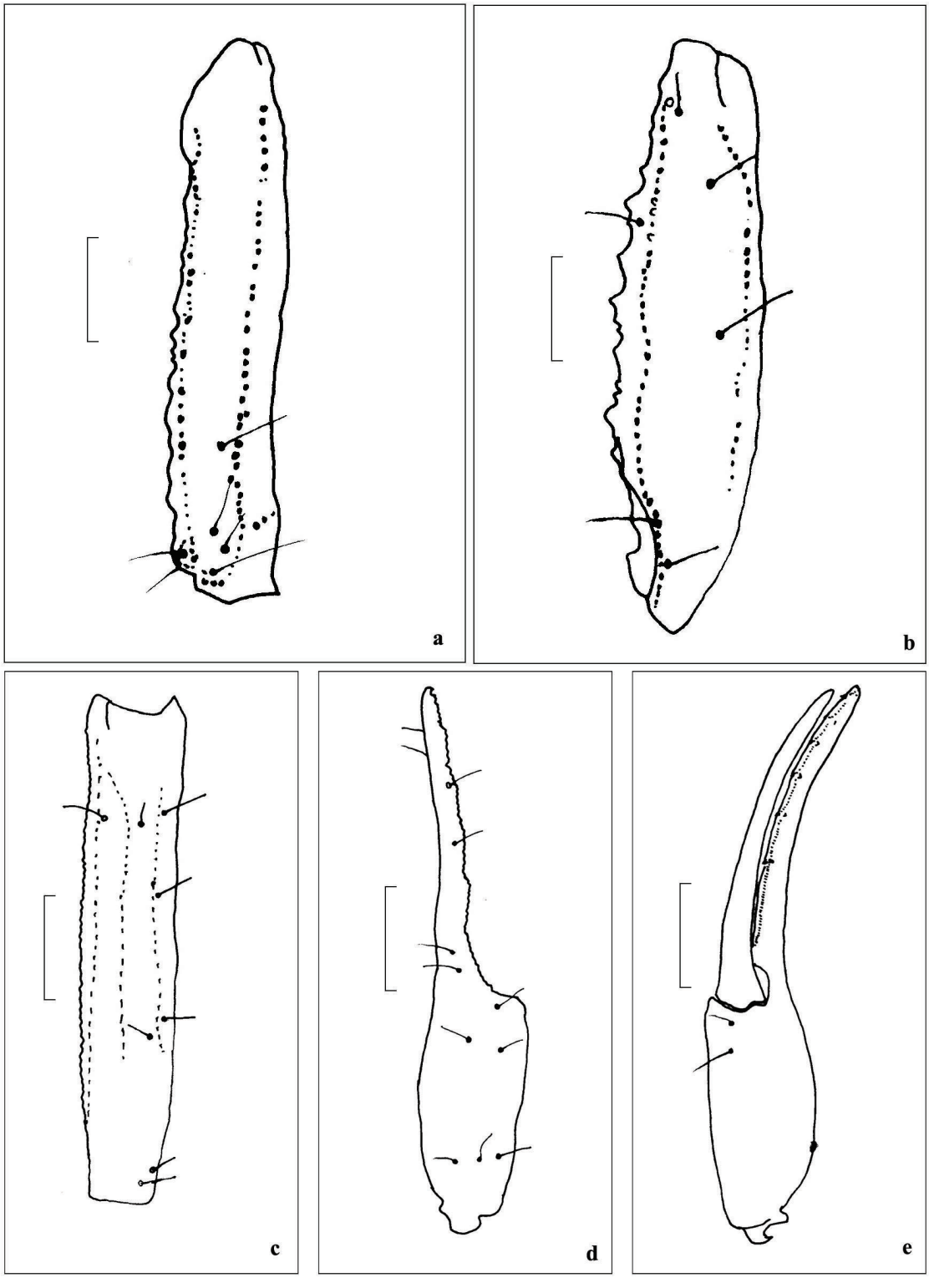


Isometrus (Isometrus) thurstoni Pocock ♂; **a.** femur dorsal view; **b.** patella dorsal view; **c**. patella exterior view; **d**. chela dorso-exterior view; **e**. chela ventral view.

PLATE 17

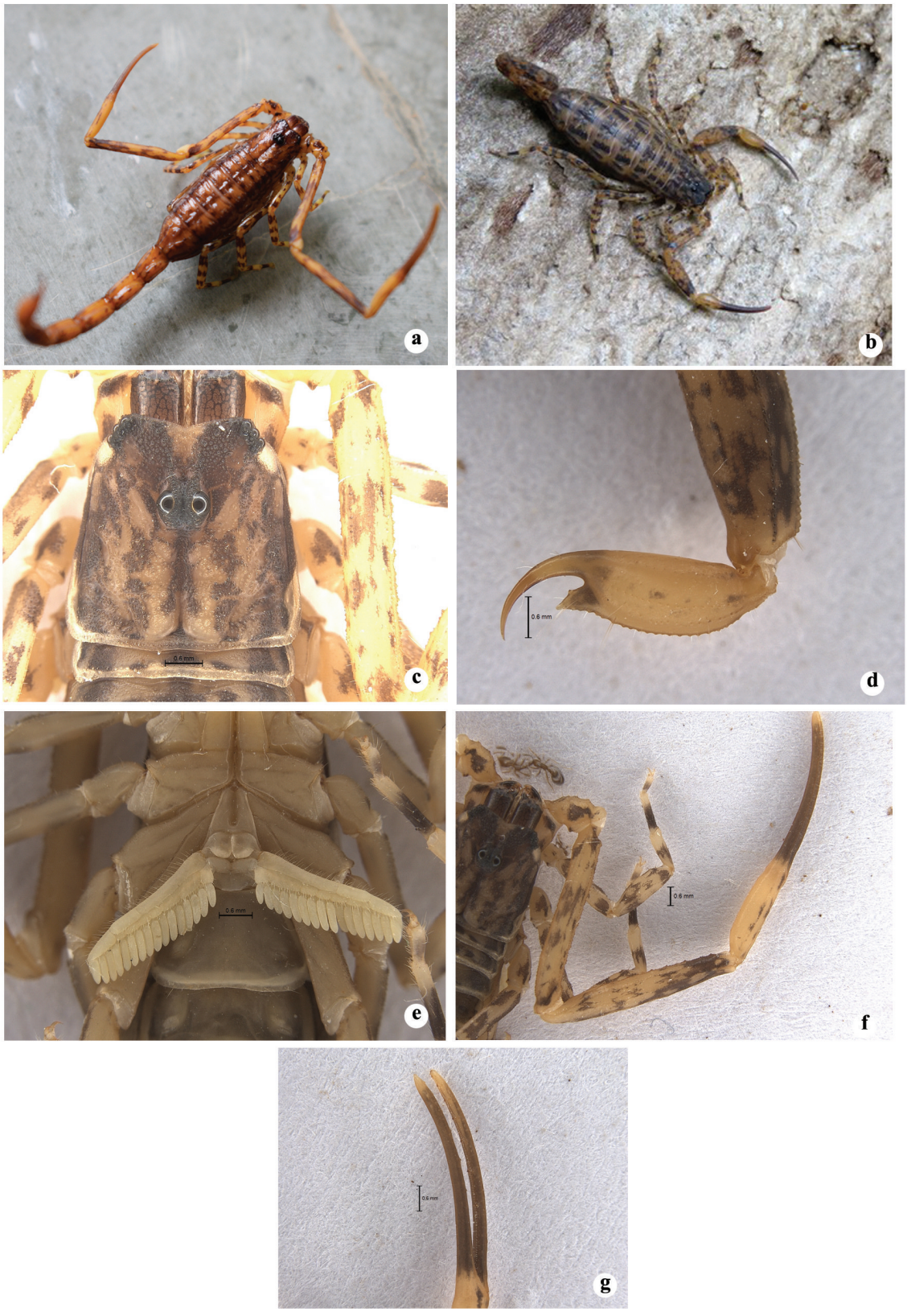
a. *Isometrus (Isometrus) wayanadensis* sp. nov.; **b**. carapace with carinae; **c.** telson with subaculear tubercle; **d**. pectines; **e**. cheliceral finger dentition; **f**. chela finger dentition

PLATE 18



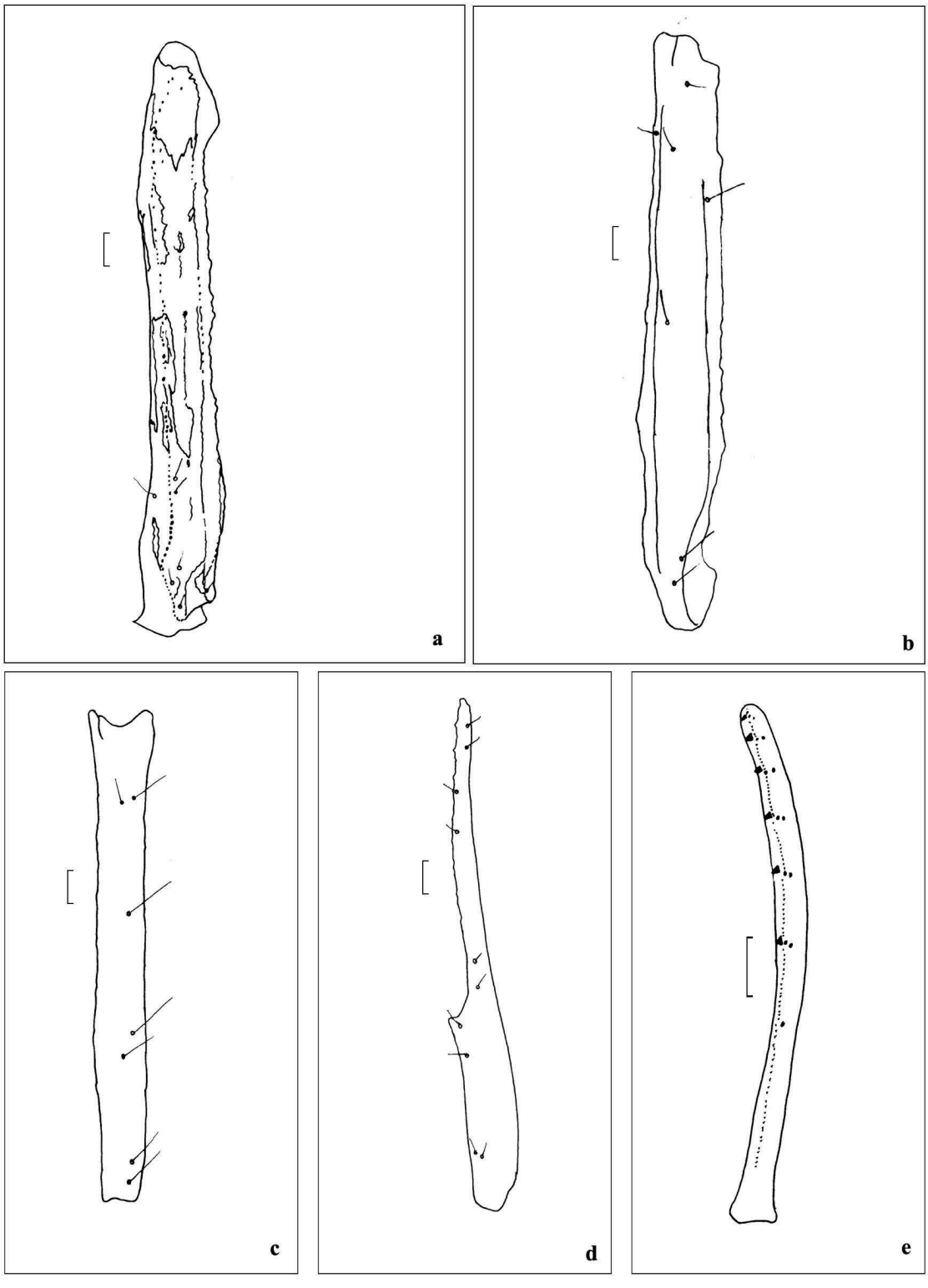
Isometrus (Isometrus) wayanadensis sp. nov.; **a.** femur dorsal view; **b**. patella dorsal view; **c.** patella exterior view; **d**. chela dorso-exterior view; **e**. chela ventral view

PLATE 19



a. *Isometrus (Isometrus) sureshani* sp. nov. ♂; **b**. *Isometrus (Isometrus) sureshani* sp. nov. ♀; **c**. carapace with carinae; **d**. telson with subaculear tubercle; **e**. pectines; **f**. slender pedipalp; **g**. chela finger dentition

PLATE 20

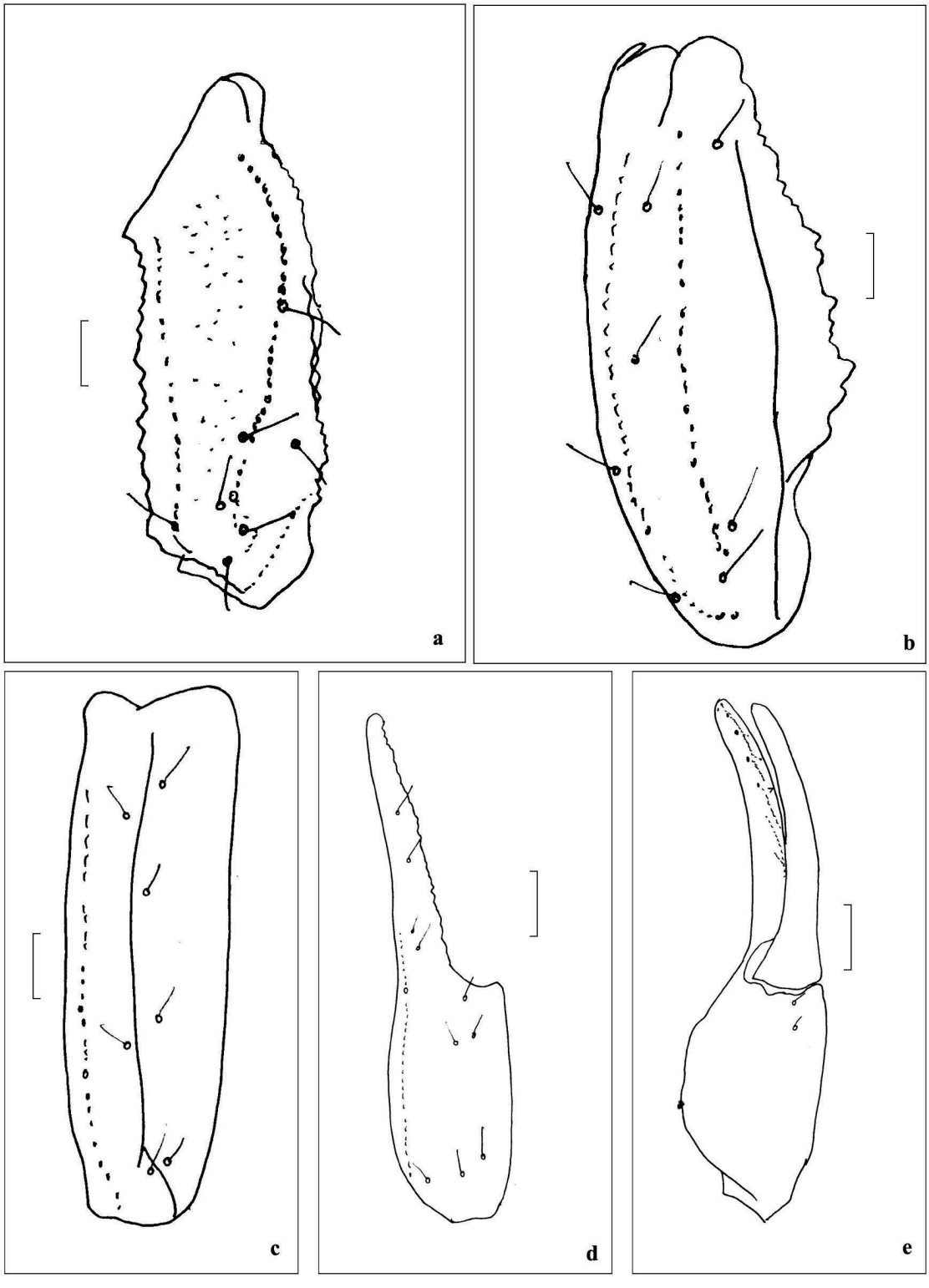


Isometrus (Isometrus) sureshani sp. nov. ♂; **a.** femur dorsal view; **b.** patella dorsal view; **c**. patella exterior view; **d**. chela dorso-exterior view; **e**. chela finger dentition

PLATE 21

a. *Isometrus (Reddyanus) brachycentrus* Pocock (in life); **b.** carapace with carinae; **c.** mesosoma; **d**. telson with subaculear tubercle; **e**. pectines; **f**. chela finger dentition

PLATE 22

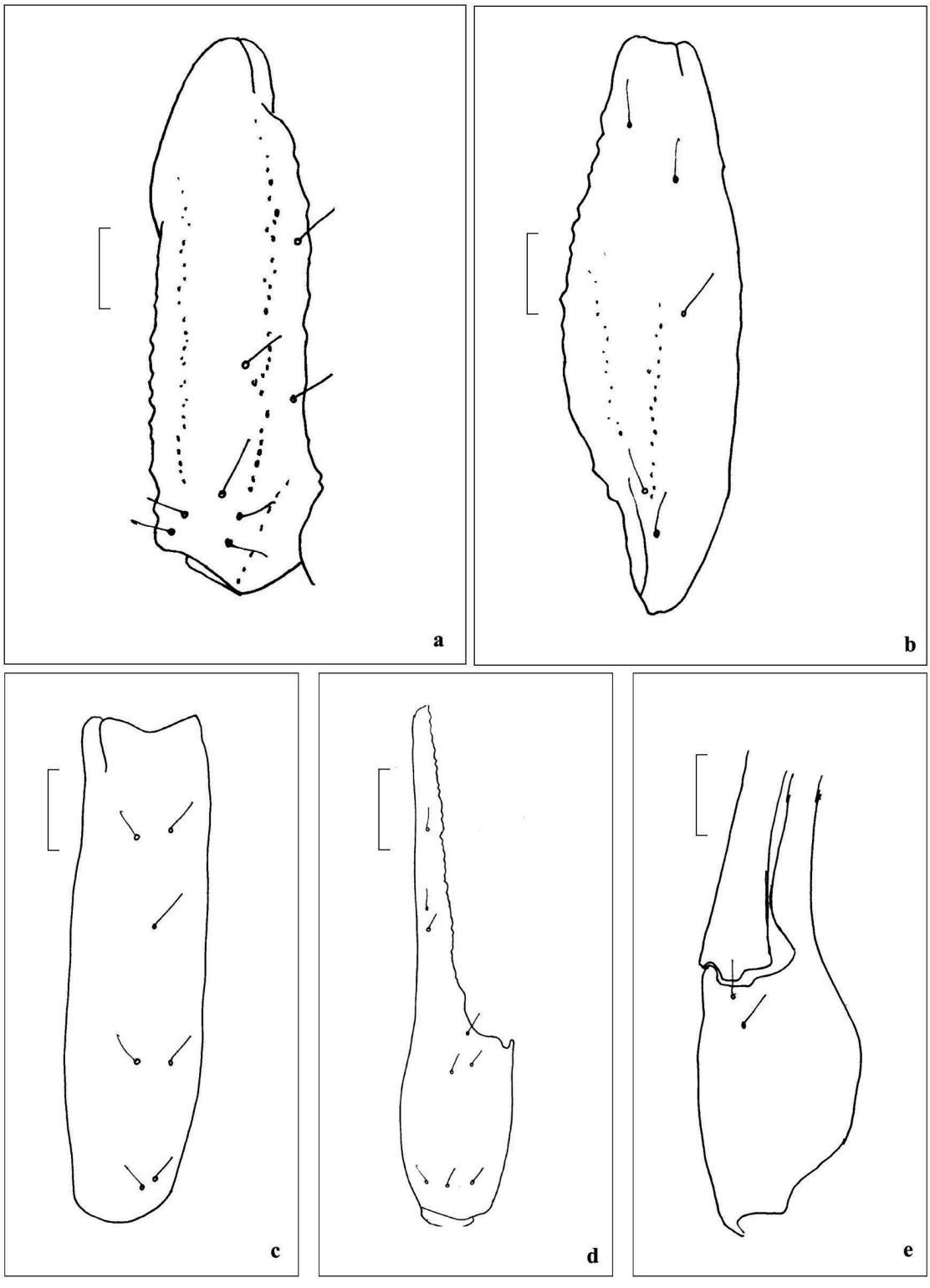


Isometrus (Reddyanus) brachycentrus Pocock **a**. femur dorsal view; **b**. patella dorsal view; **c**. patella exterior view; **d**. chela dorso-exterior view; **e**. chela ventral view

PLATE 23

a. *Lychas albimanus* Henderson ♂; **b**. manus of chela with yellow colour; **c**. carapace with carinae; **d**. mesosoma; **e**. telson with subaculear tubercle; **f**. pectines; **g**. chela finger dentition

PLATE 24

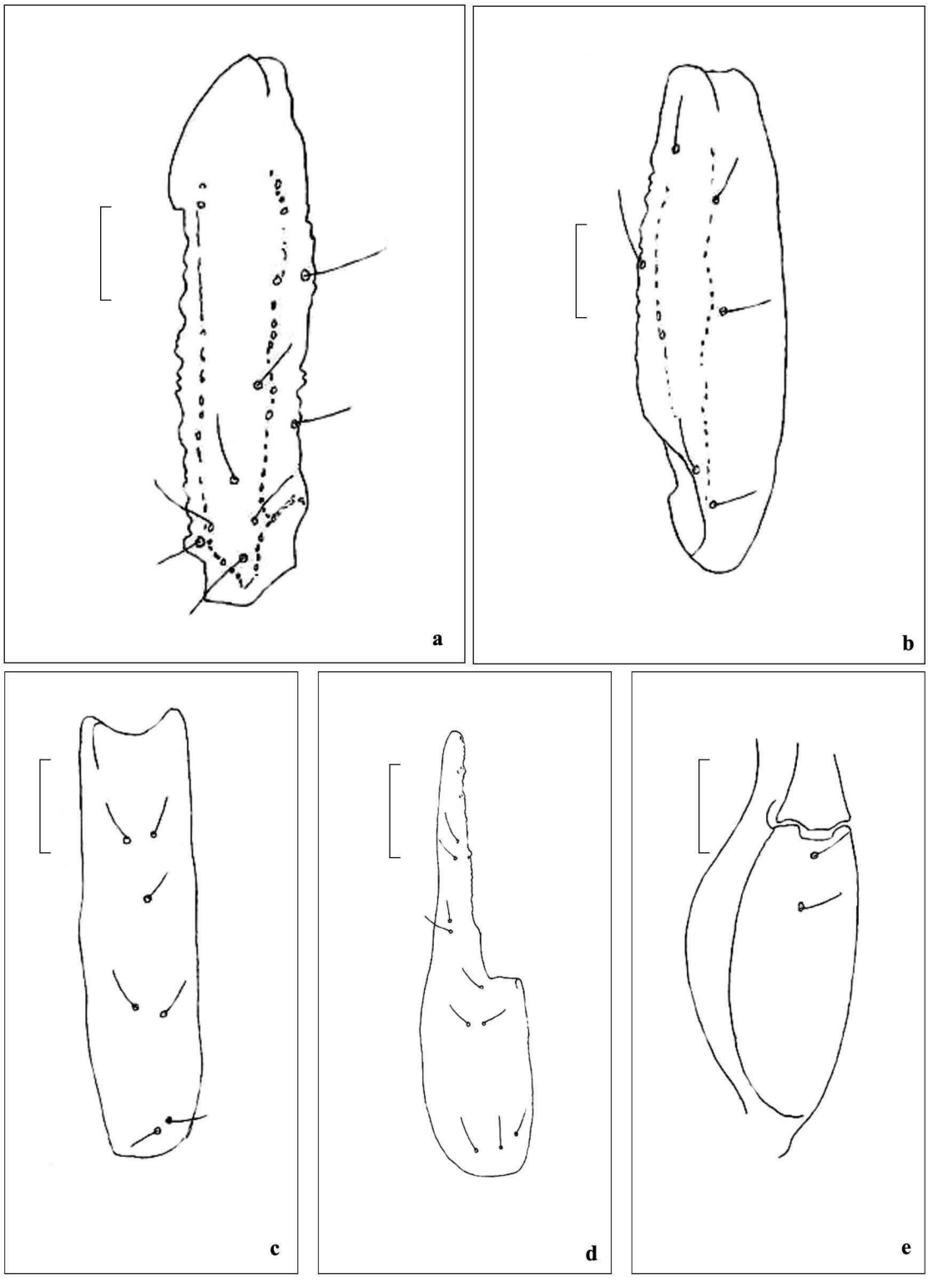


Lychas albimanus Henderson ♂; **a.** femur dorsal view; **b.** patella dorsal view; **c**. patella exterior view; **d**. chela dorso-exterior view; **e**. chela ventral view

PLATE 25

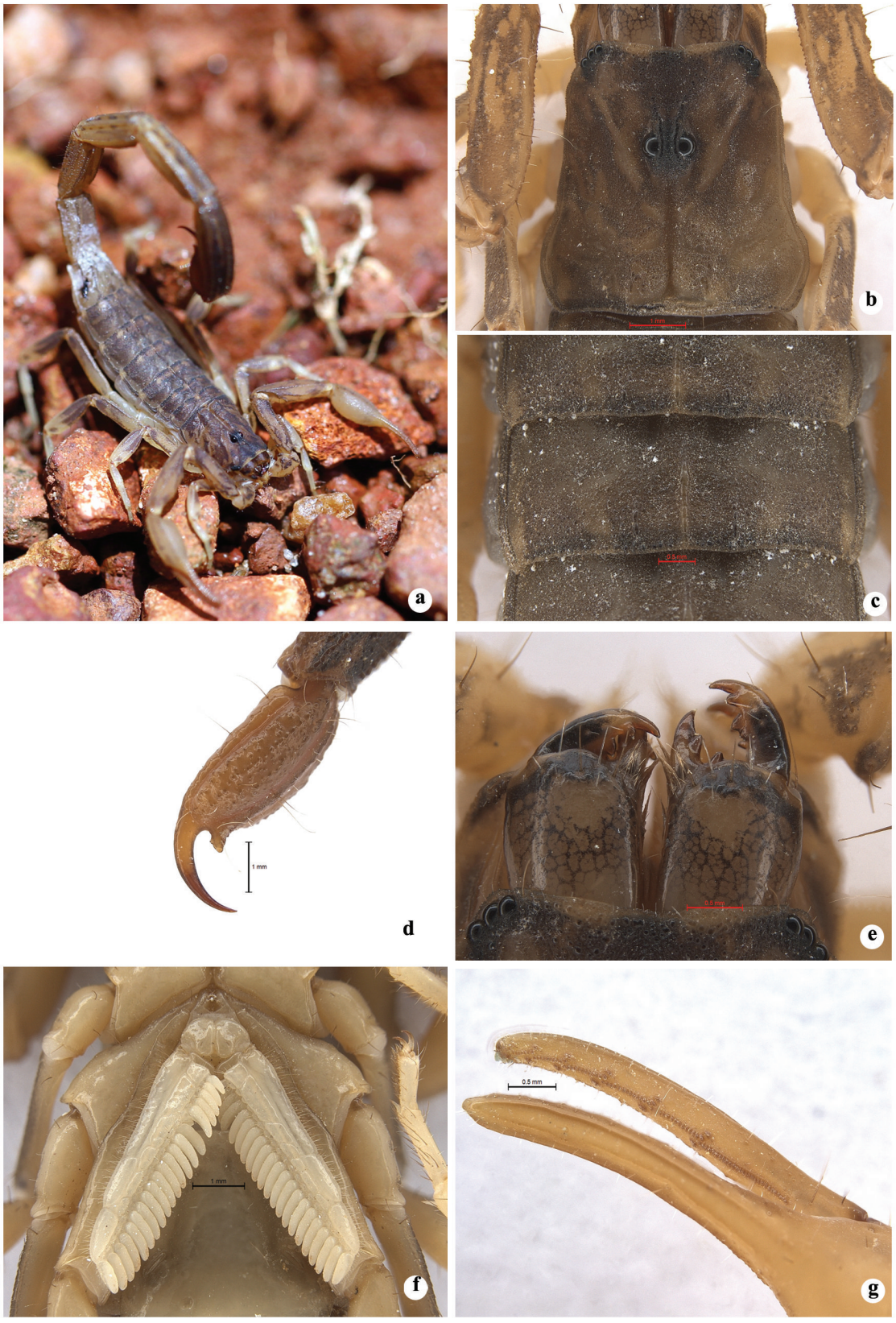
a. *Lychas laevifrons* (Pocock) (in life); **b**. carapace with carinae; **c**. telson vesicle with subaculear tubercle; **d**. pectines; **e.** cheliceral dentition; **f**. chela finger dention

PLATE 26



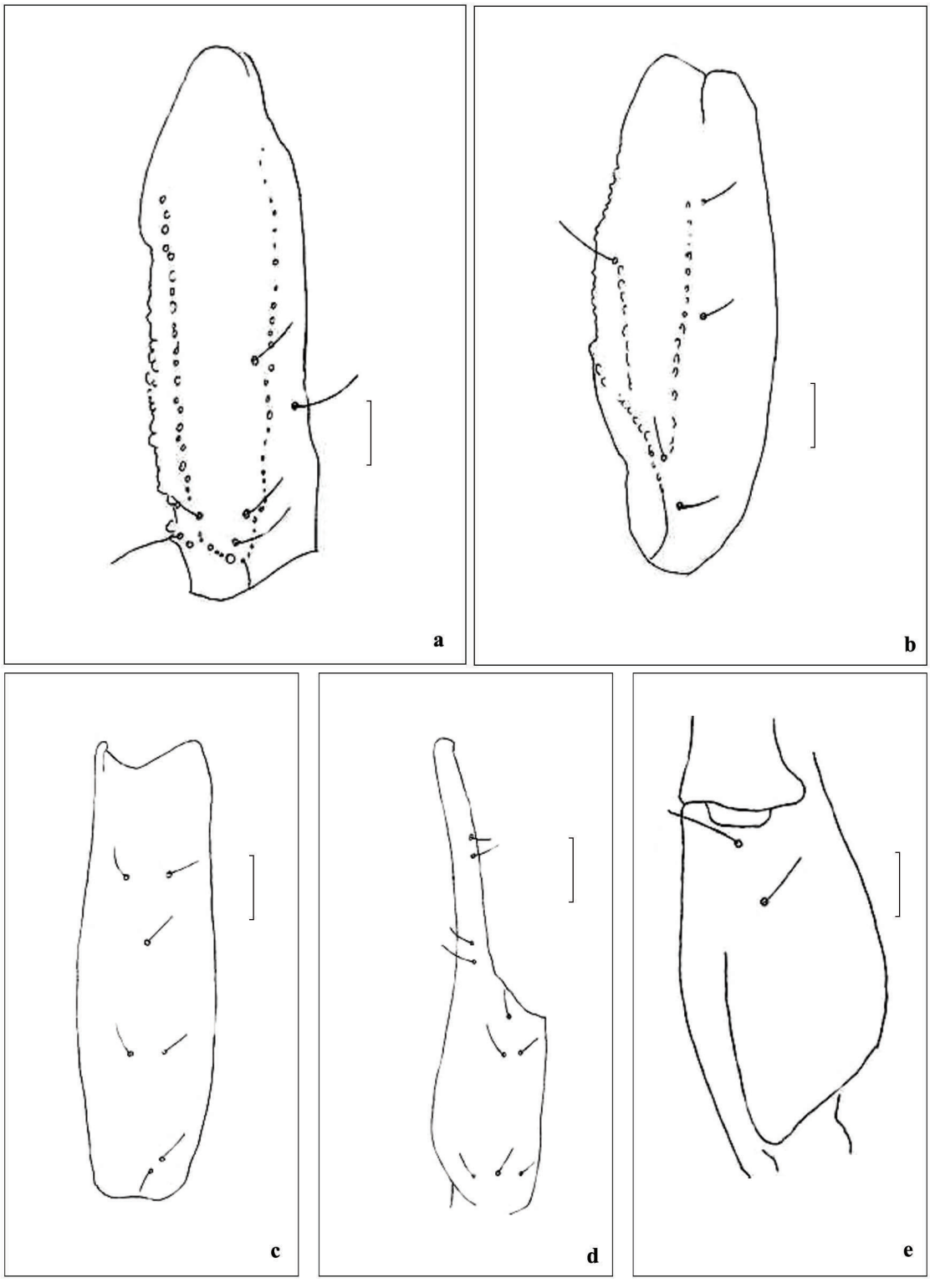
Lychas laevifrons (Pocock) **a**. femur dorsal view; **b**. patella dorsal view; **c**. patella exterior view; **d**. chela dorso-exterior view; **e**. chela ventral view

PLATE 27



a. *Lychas tricarinatus* (Simon) (in life); **b**. carapace with carinae; **c**. tergite with tricarinae; **d**. telson vesicle with subaculear tubercle; **e**. cheliceral dentition; **f**. pectines; **g.** chela finger dention

PLATE 28

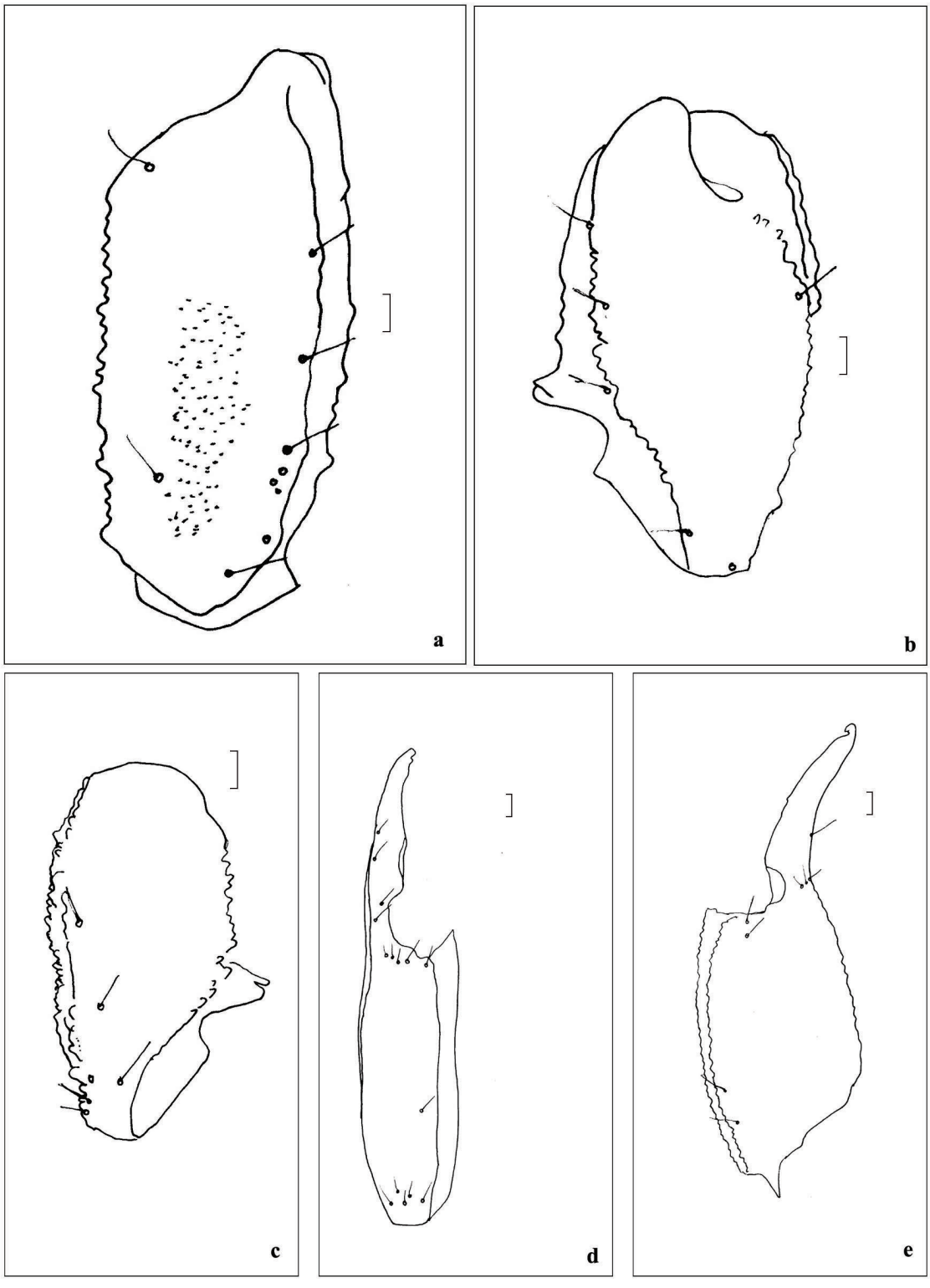


Lychas tricarinatus (Simon); **a.** femur dorsal view; **b**. patella dorsal view; **c**. patella exterior view; **d**. chela dorso-exterior view; **e**. chela ventral view

PLATE 29

a. *Chiromachetes fergusoni* Pocock♀; **b.** carapace without carinae; **c**. telson vesicle without subaculear tubercle; **d.** cheliceral dentition; **e.** pectines; **f.** distinct scallope at the base of the chela movable finger

PLATE 30

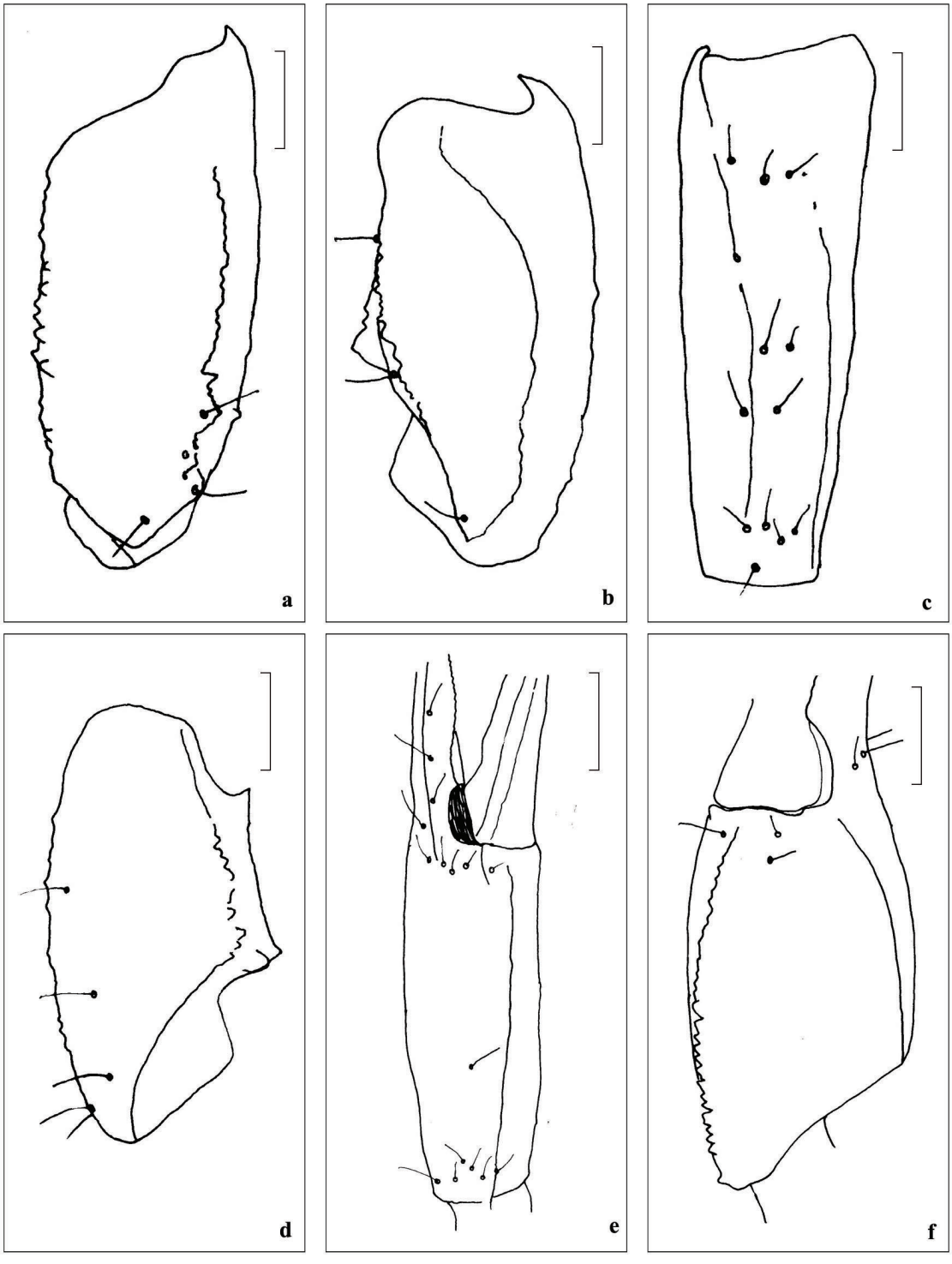


Chiromachetes fergusoni Pocock ♀; **a.** femur dorsal view; **b.** patella dorsal view; **c.** patella ventral view; **d.** chela exterior view; **e.** chela ventral view

PLATE 31

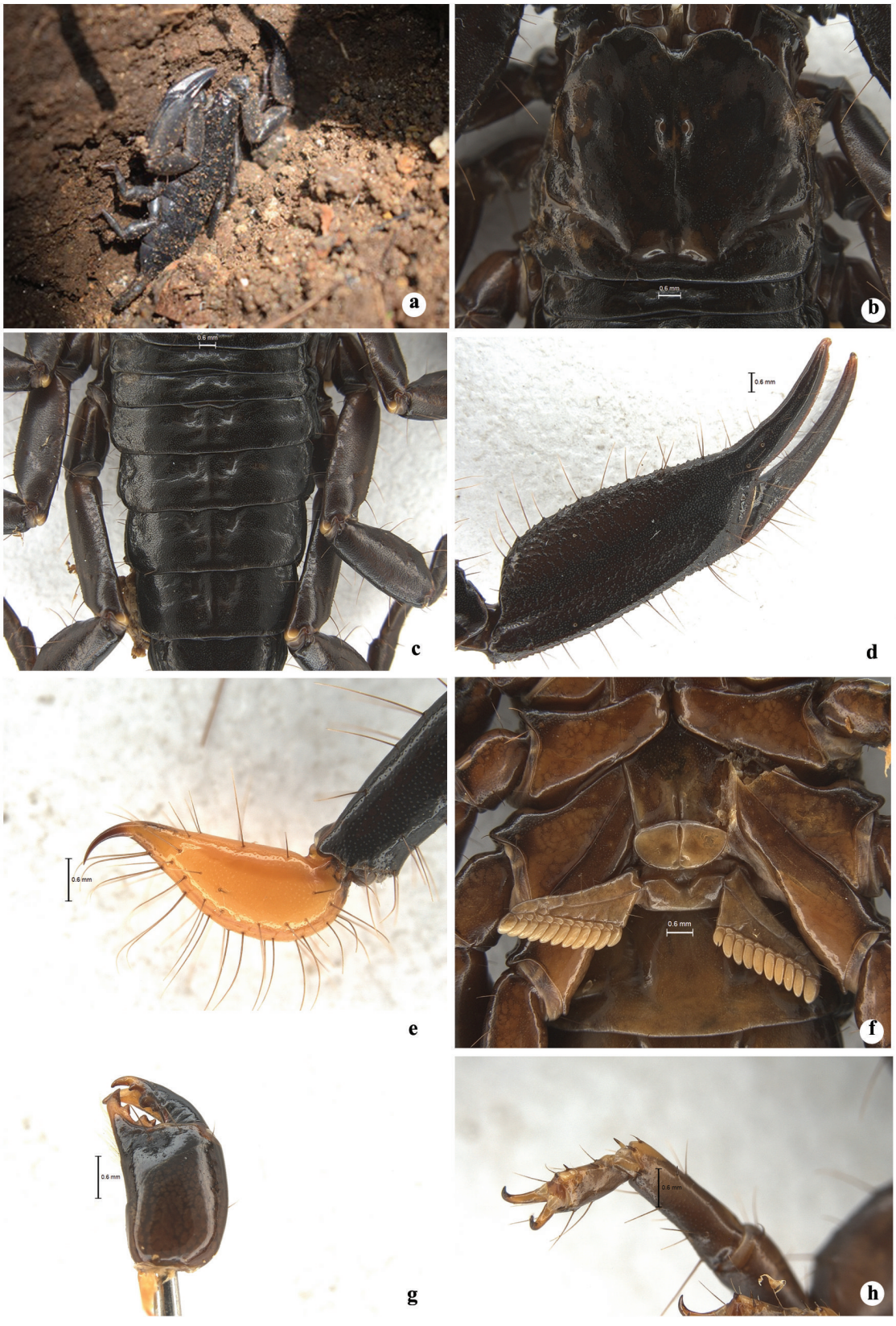
a. *Chiromachetes bastawadei* sp. nov.; **b.** carapace without carinae; **c.** pyriform vesicle without subaculear tubercle; **d.** pectines; **e.** cheliceral dentition; **f.** weak scallope at the base of the chela movable finger; **g.** tarsomere II without row of spinules

PLATE 32



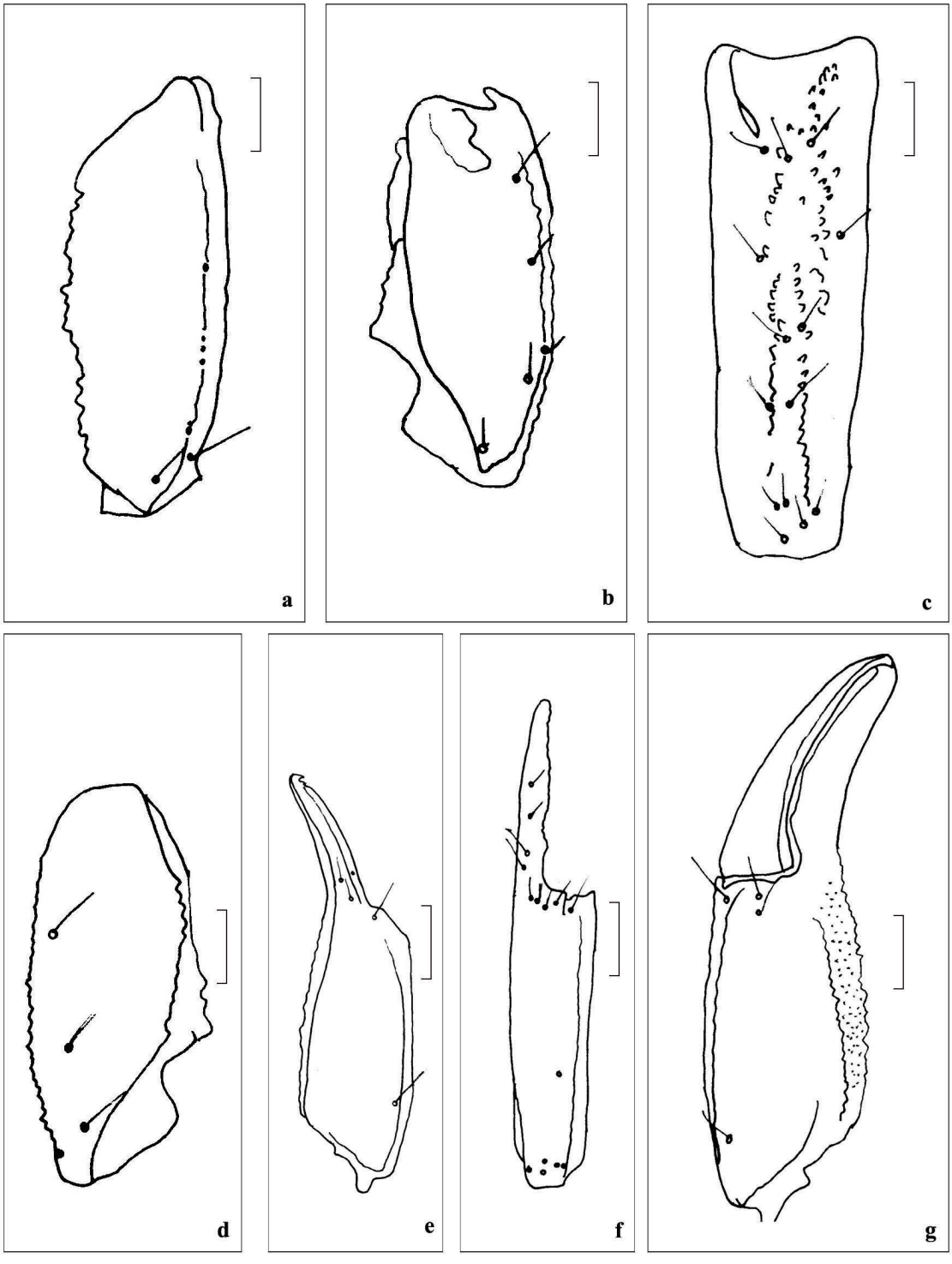
Chiromachetes bastawadei sp. nov.; **a.** femur dorsal view; **b.** patella dorsal view; **c.** patella exterior view; **d.** patella ventral view; **e.** chela exterior view; **f.** chela ventral view

PLATE 33



a. *Chiromachetes manikandani* sp. nov. (in life); **b.** carapace without carinae; **c.** tergites with median elevation; **d.** slender chela; **e.** pyriform vesicle without subaculear tubercle; **f.** pectines; **g.** cheliceral dentition; **h.** tarsomere II ventrally without row of spinules

PLATE 34

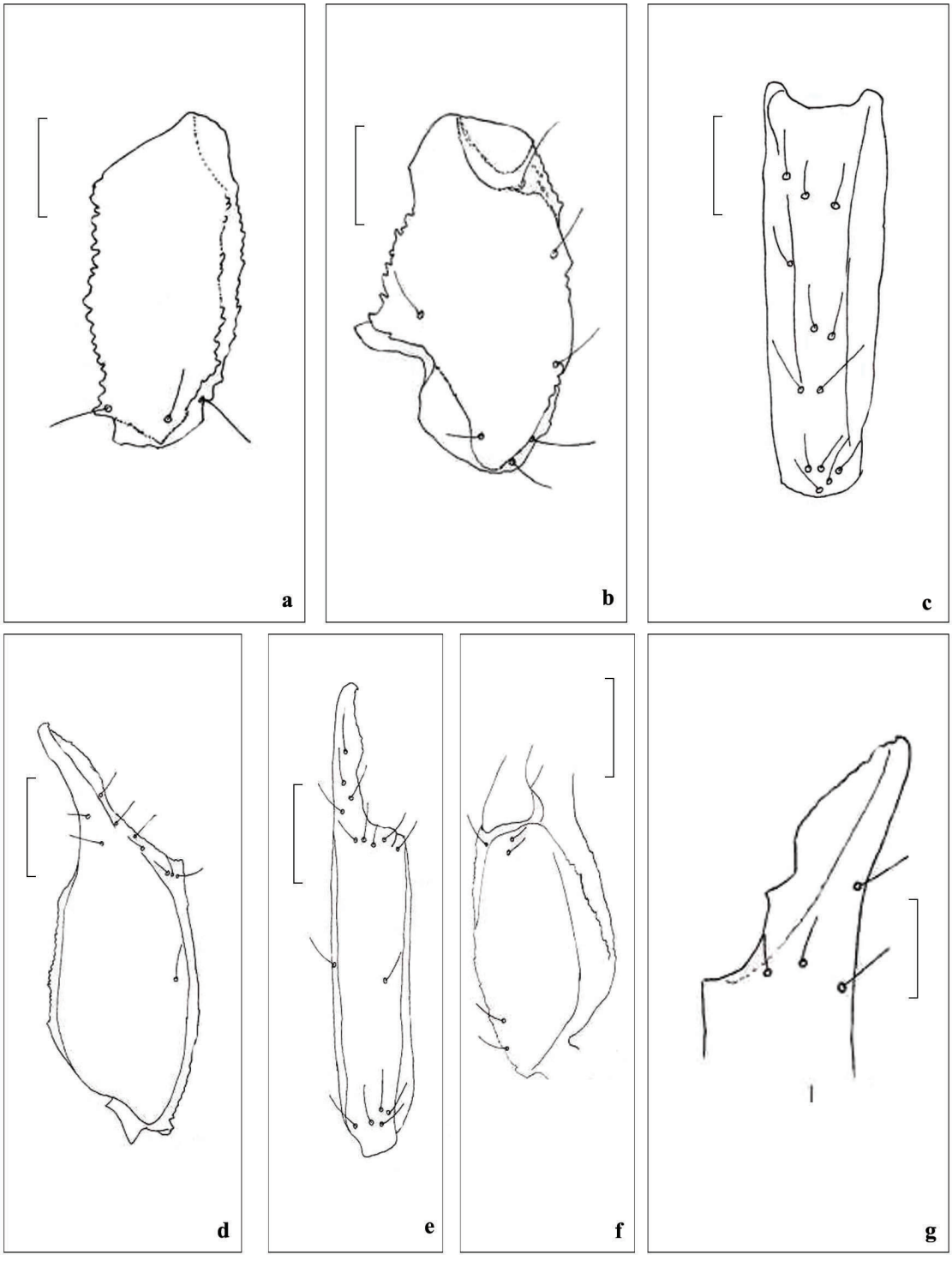


Chiromachetes manikandani sp. nov.; **a.** femur dorsal view; **b.** patella dorsal view; **c.** patella exterior view; **d.** patella ventral view; **e.** chela dorsal view; **f.** chela exterior view; **g.** chela ventral view

PLATE 35

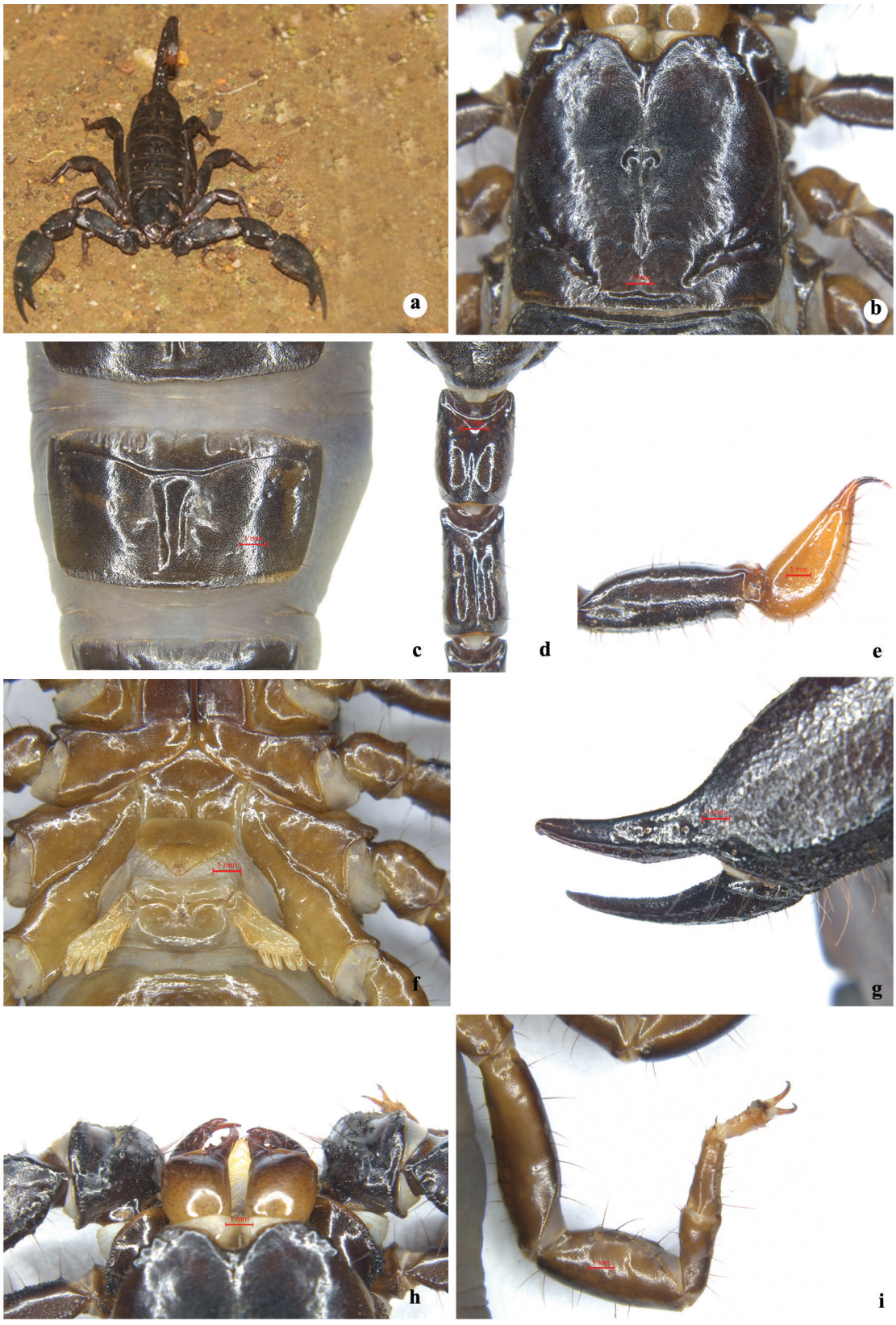
a. *Iomachus laeviceps* (Pocock) (in life); **b.** carapace without carinae; **c.** pyriform vesicle without subaculear tubercle; **d.** pectines; **e.** cheliceral dentition; **f.** distinct scallope at base of the chela movable finger; **g.** tarsomere II ventrally with row of spinules

PLATE 36



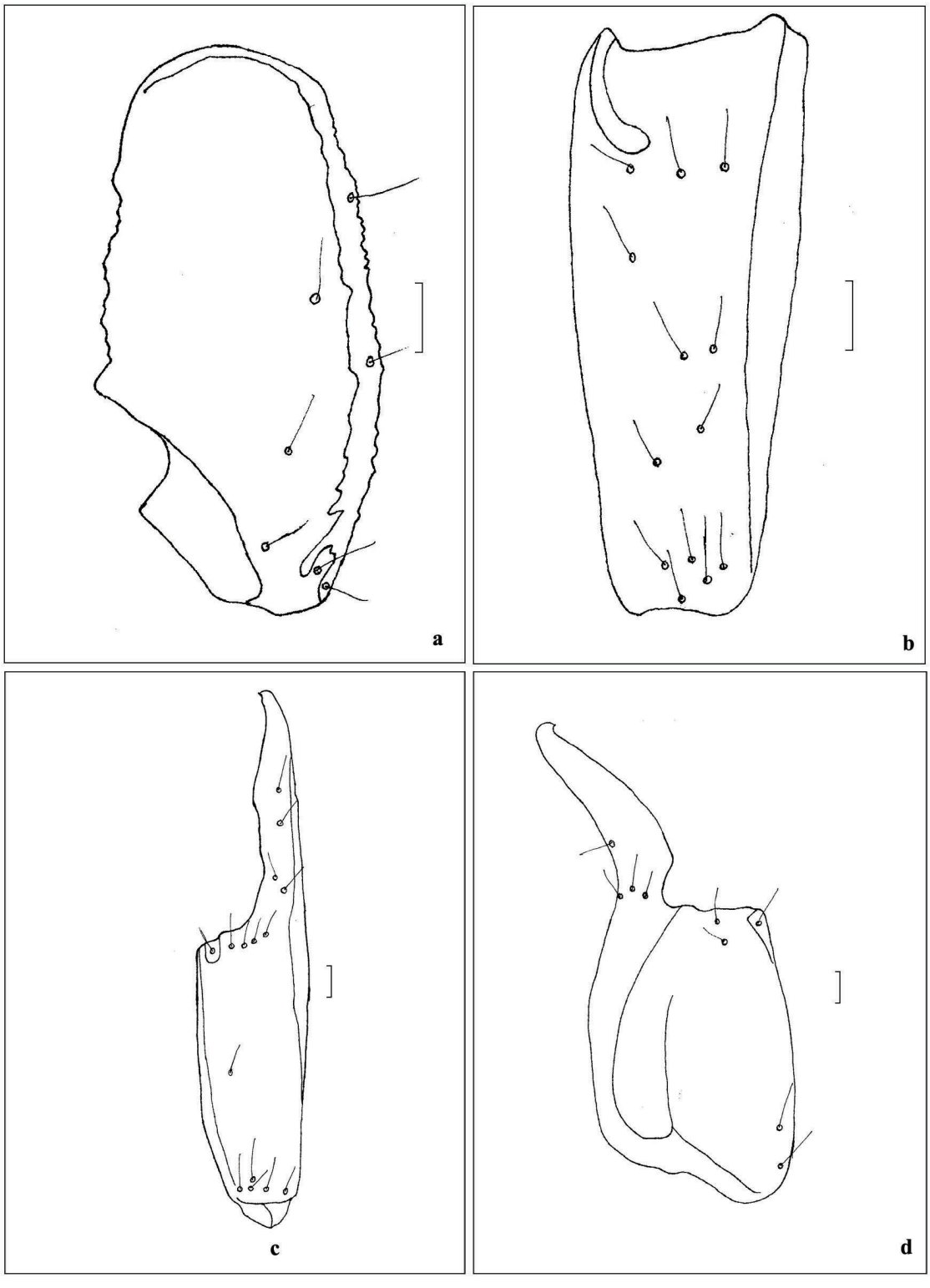
Iomachus laeviceps (Pocock) **a.** femur dorsal view; **b.** patella dorsal view; **c.** patella exterior view; **d.** chela dorsal view; **e.** chela exterior view; **f.** chela ventral view; **g.** chela movable finger interior view

PLATE 37



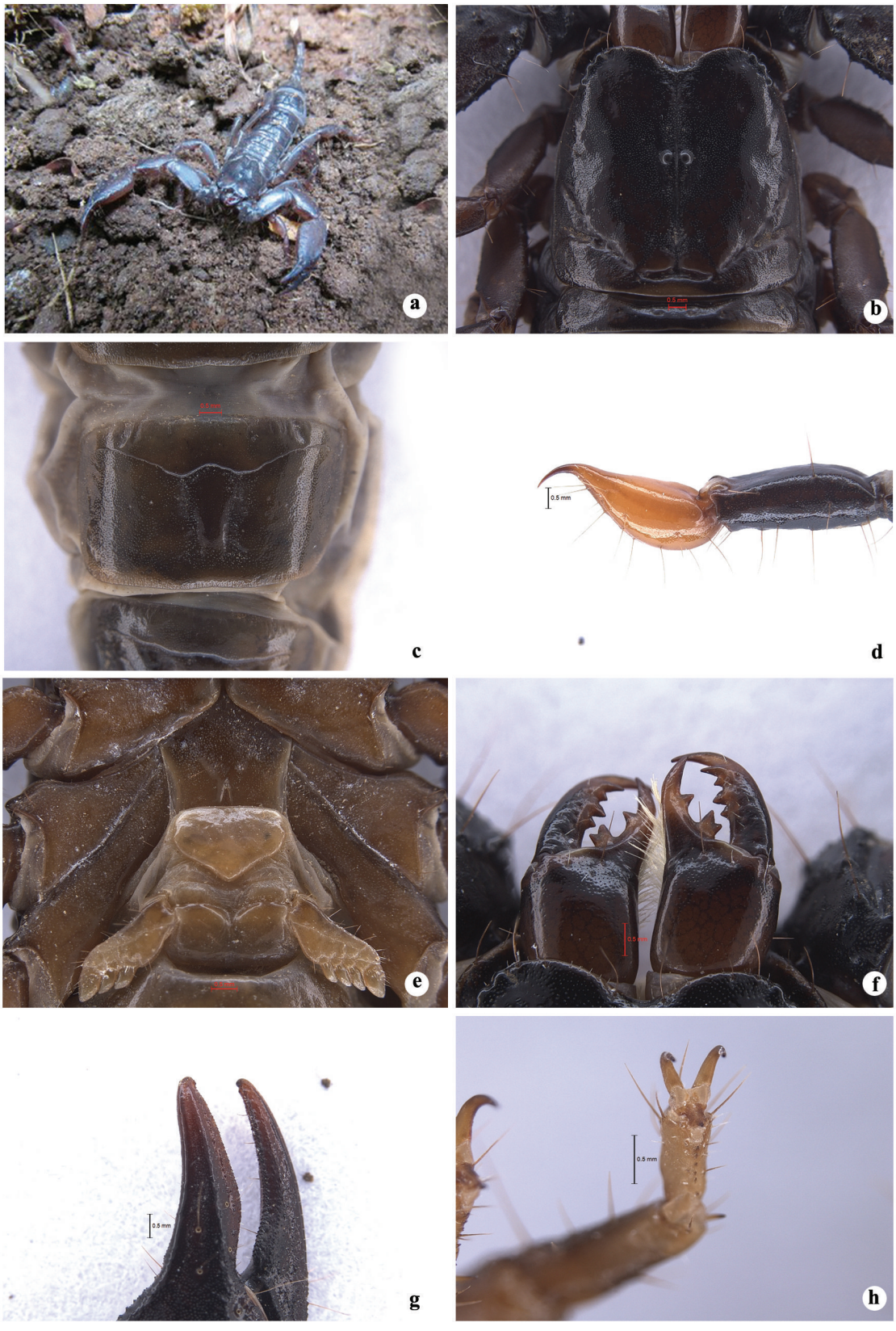
a. *Iomachus mathikettanensis* sp. nov (in life); **b.** carapace without carinae; **c.** terigite with distinct median projection; **d.** metasomal segments; **e.** pyriform vesicle without subaculear tubercle; **f.** pectines; **g.** scallope absent on the chela of movable finger; **h.** cheliceral dentition; **i.** tarsomere II ventrally with row of spinules

PLATE 38



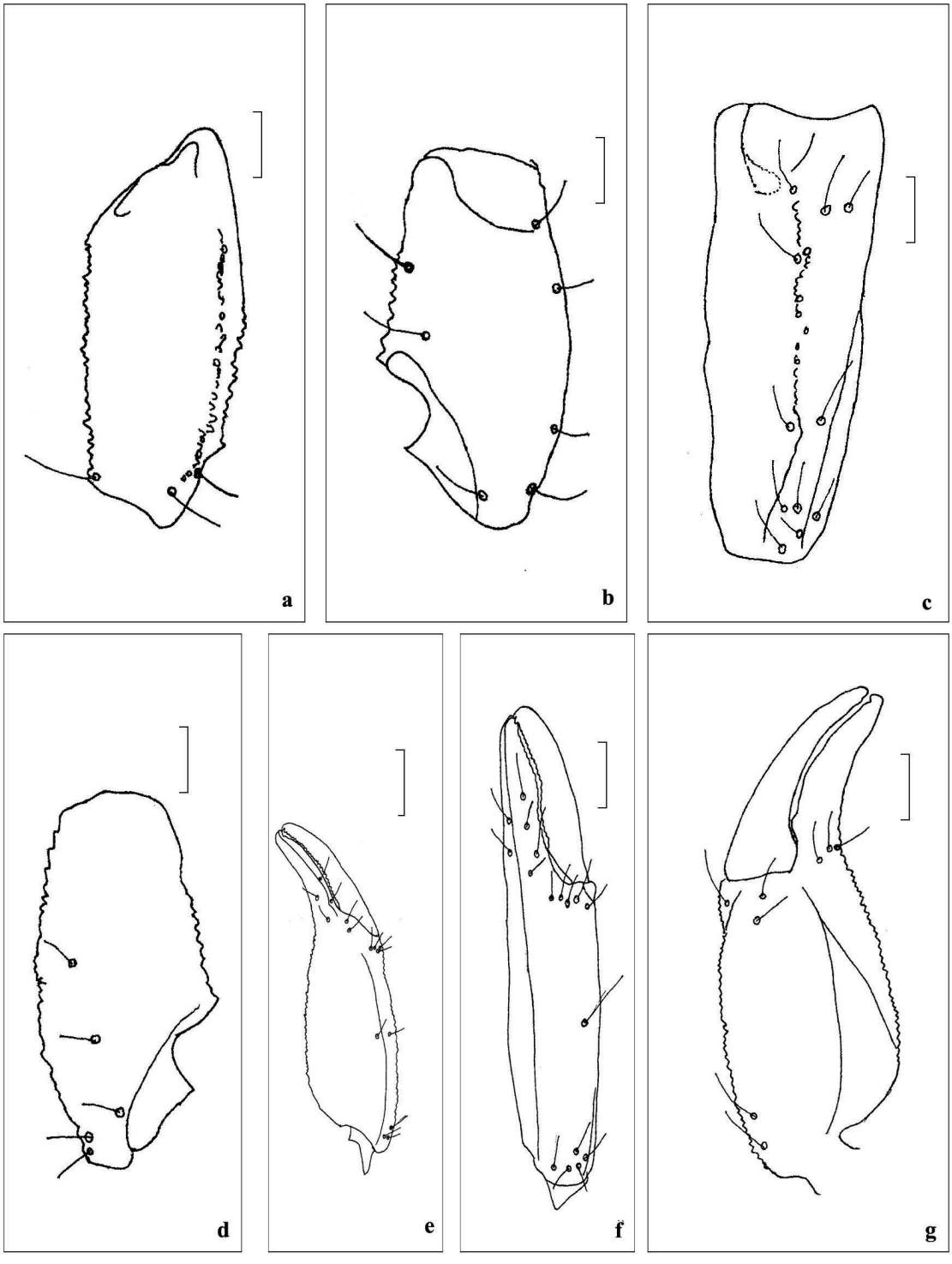
Iomachus mathikettanensis sp. nov **a.** patella dorsal view; **b.** patella exterior view; **c.** chela exterior view; **d.** chela interio-ventral view

PLATE 39



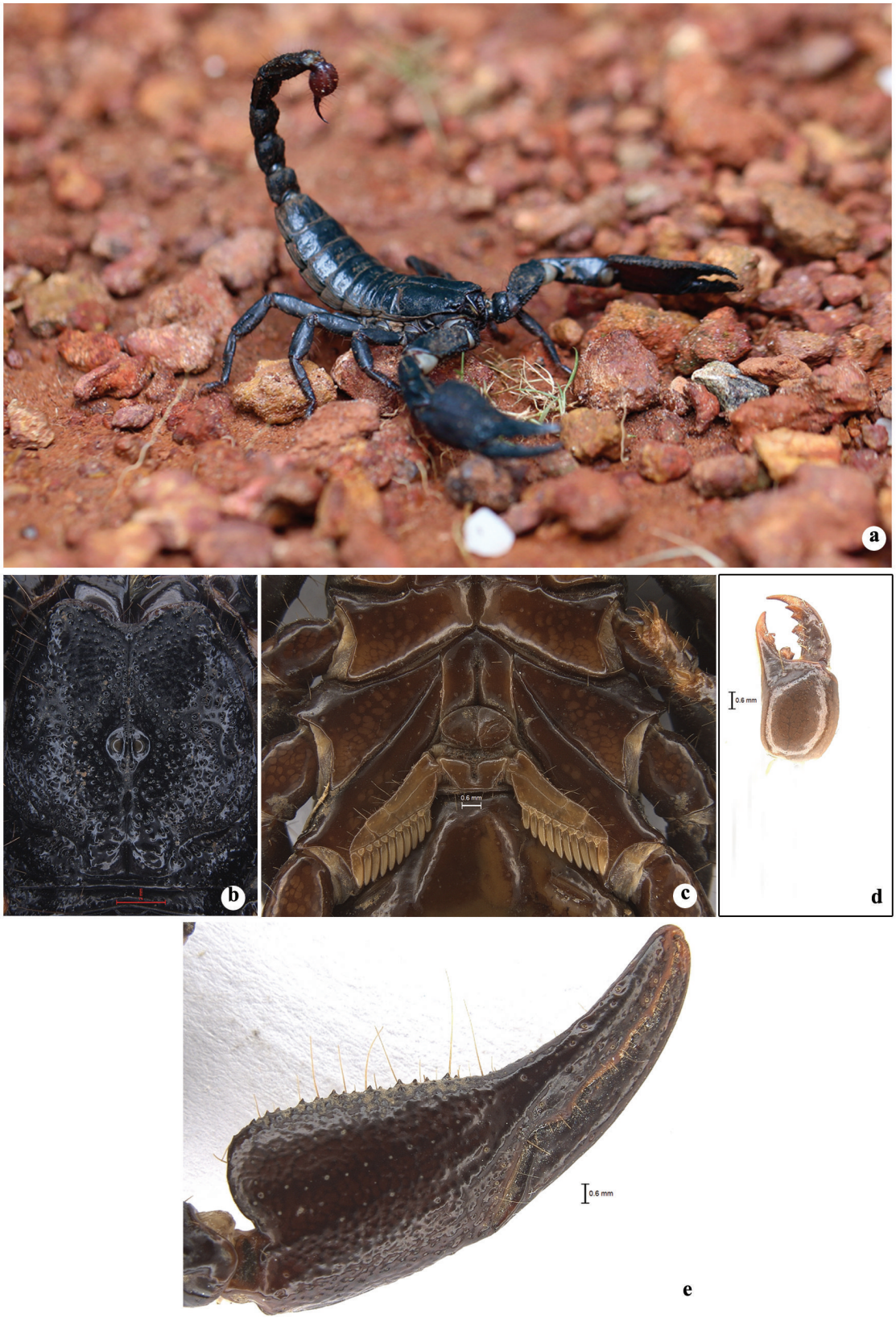
a. *Iomachus vazhachalensis* sp. nov (in life); **b.** carapace without carinae; **c.** terigite with median projection; **d.** pyriform vesicle without subaculear tubercle; **e.** pectines **f.** cheliceral dentition; **g.** scallope absent on the chela of movable finger; **h.** tarsomere II ventrally with row of spinules

PLATE 40



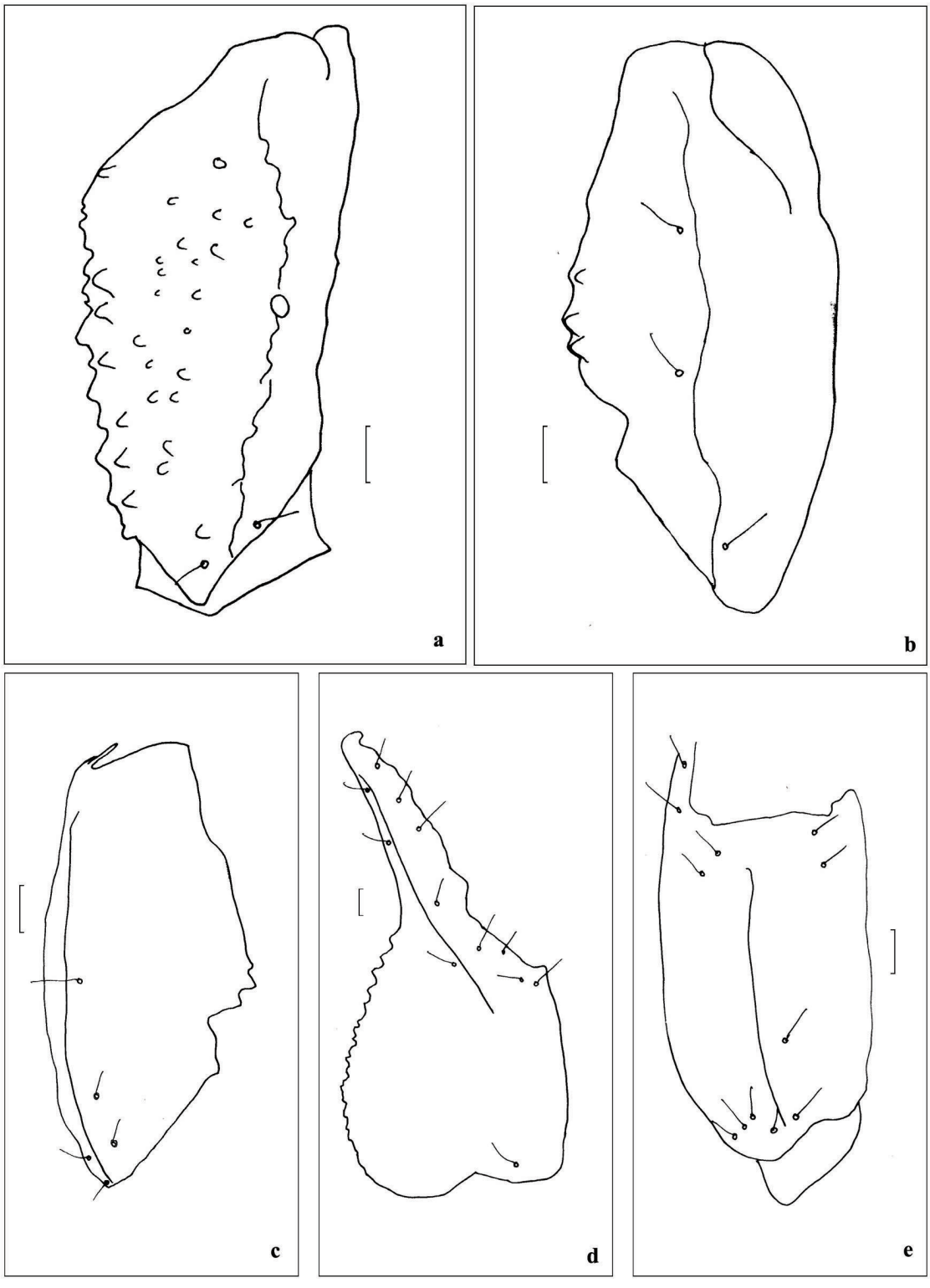
Iomachus vazhachalensis sp. nov **a.** femur dorsal view; **b.** patella dorsal view; **c.** patella exterior view; **d.** patella ventral view; **e.** chela dorsal view; **f.** chela exterior view; **g.** chela ventral view

PLATE 41



a. *Heterometrus scaber* (Thorell)(in life); **b.** carapace with granulation; **c.** pectines; **d.** cheliceral dentition; **e.** chela with lobed manus

PLATE 42

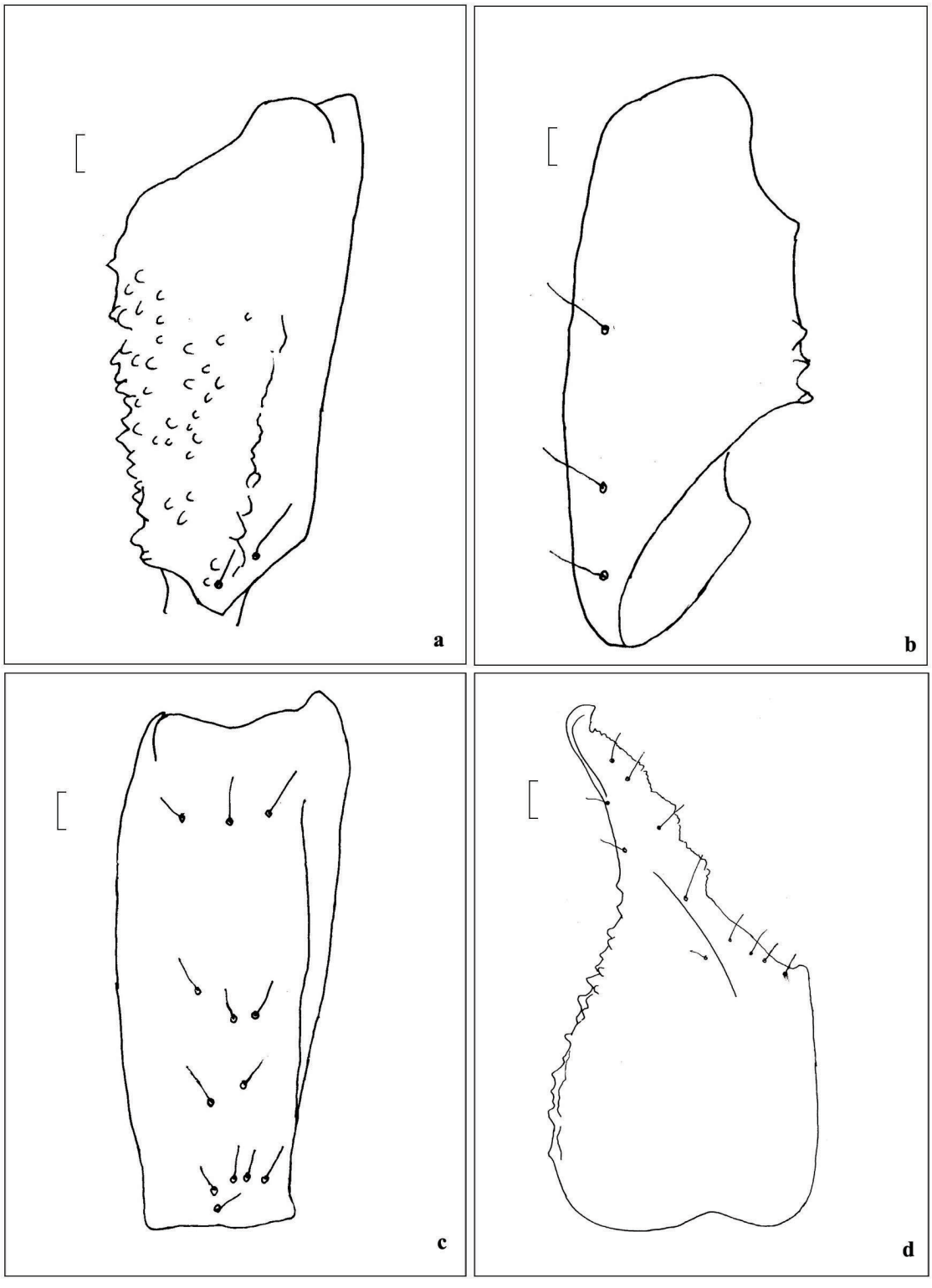


Heterometrus scaber (Thorell) **a.** femur dorsal view; **b.** patella dorsal view; **c.** patella ventral view; **d.** chela dorsal view; **e.** chela exterior view

PLATE 43

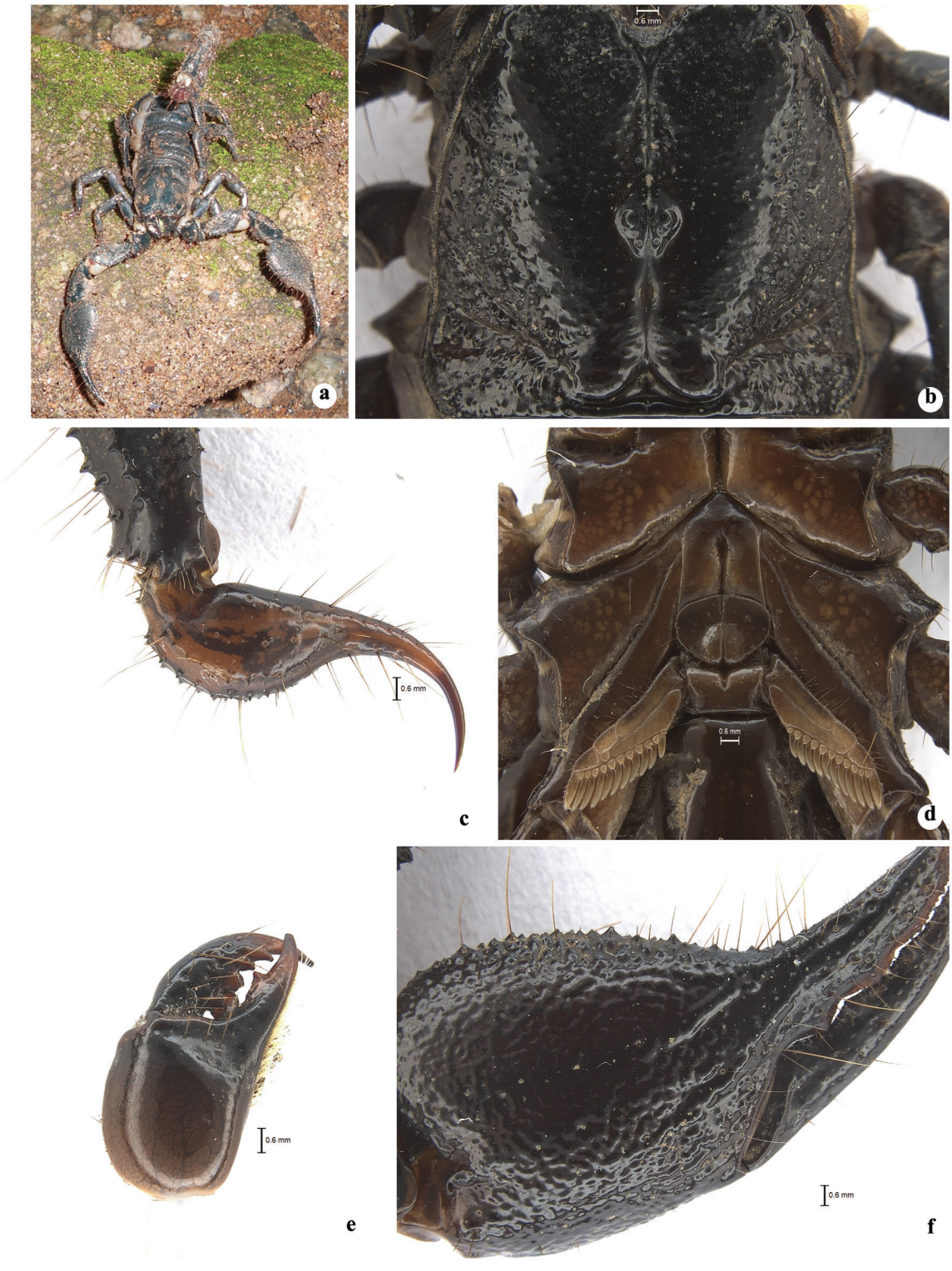
a. *Heterometrus kanaraensis* (Pocock) ♀; **b**. carapace with granulation; **c**. telson with granulation ventrally; **d**. pectines; **f**. cheliceral dentition

PLATE 44



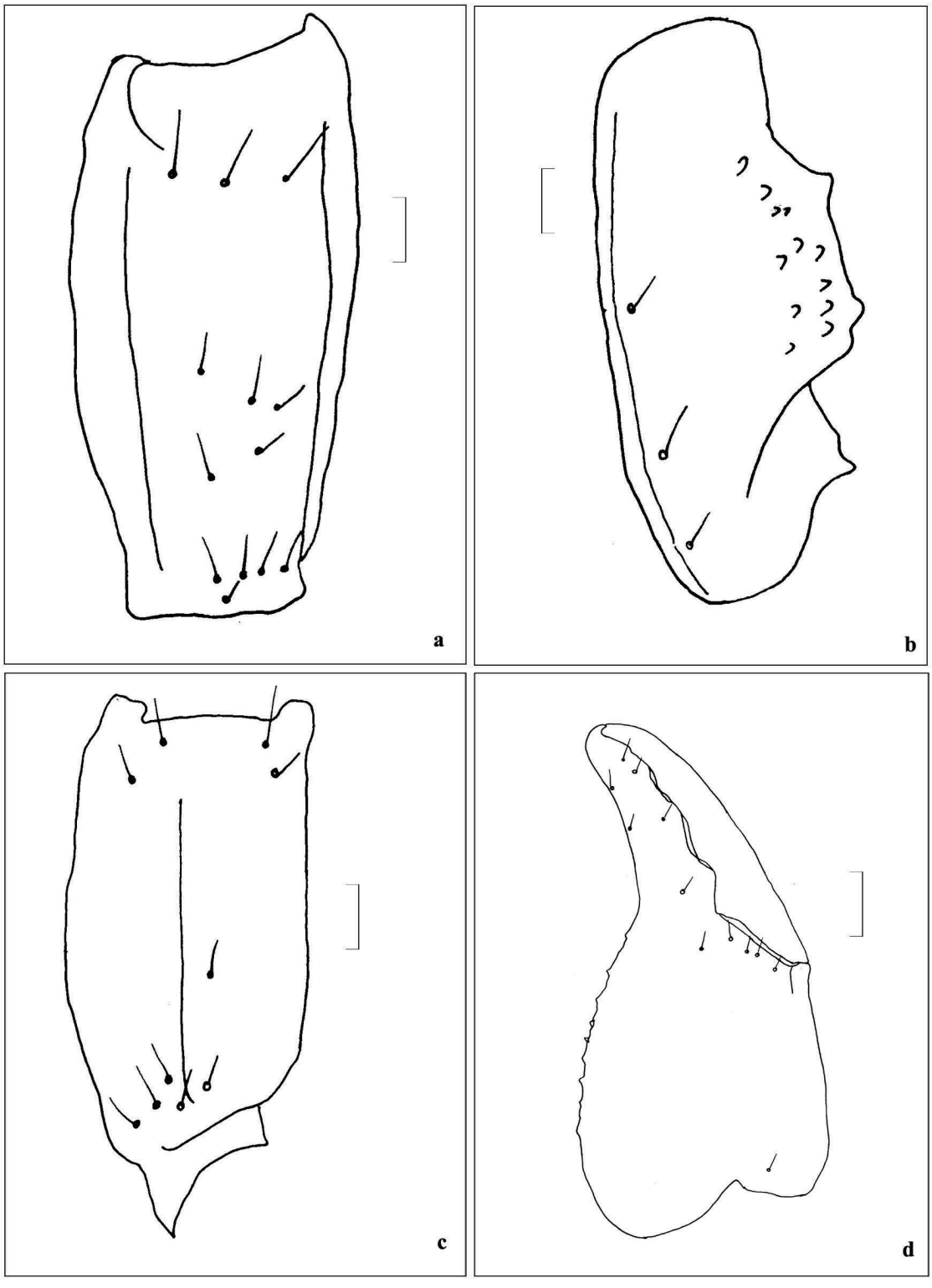
Heterometrus kanaraensis (Pocock) ♀ **a.** femur dorsal view; **b.** patella ventral view; **c.** patella exterior view; **d.** chela dorsal view

PLATE 45



a. *Heterometrus barberi* (Pocock)(in life); **b.** carapace with scattered granulation; **c.** telson with granulation ventrally; **d.** pectines; **e.** cheliceral dentition; **f.** chela manus lobed

PLATE 46

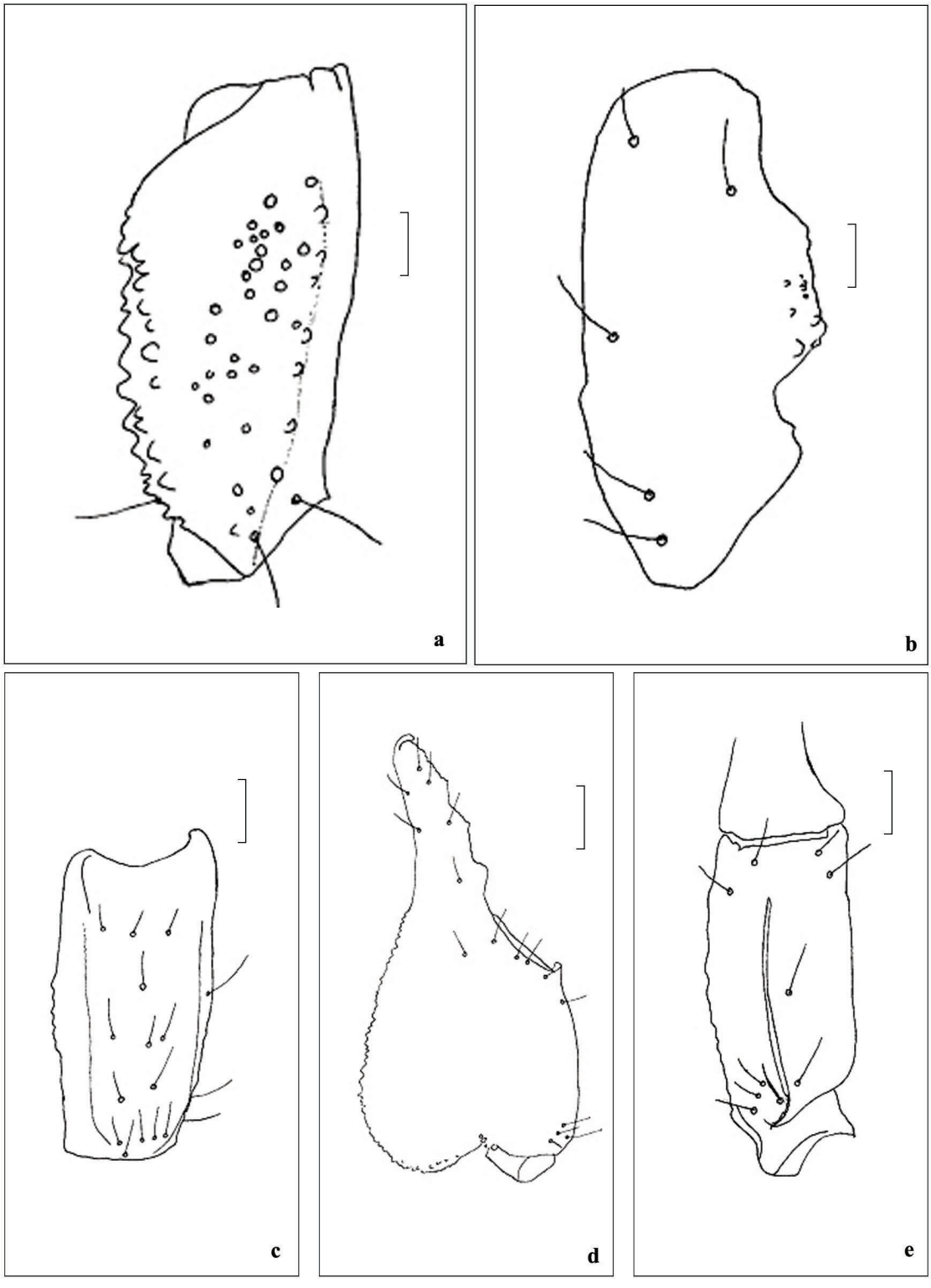


Heterometrus barberi (Pocock) **a.** patella exterior view; **b.** patella ventral view; **c.** chela ventral view; **d.** chela dorsal view

PLATE 47

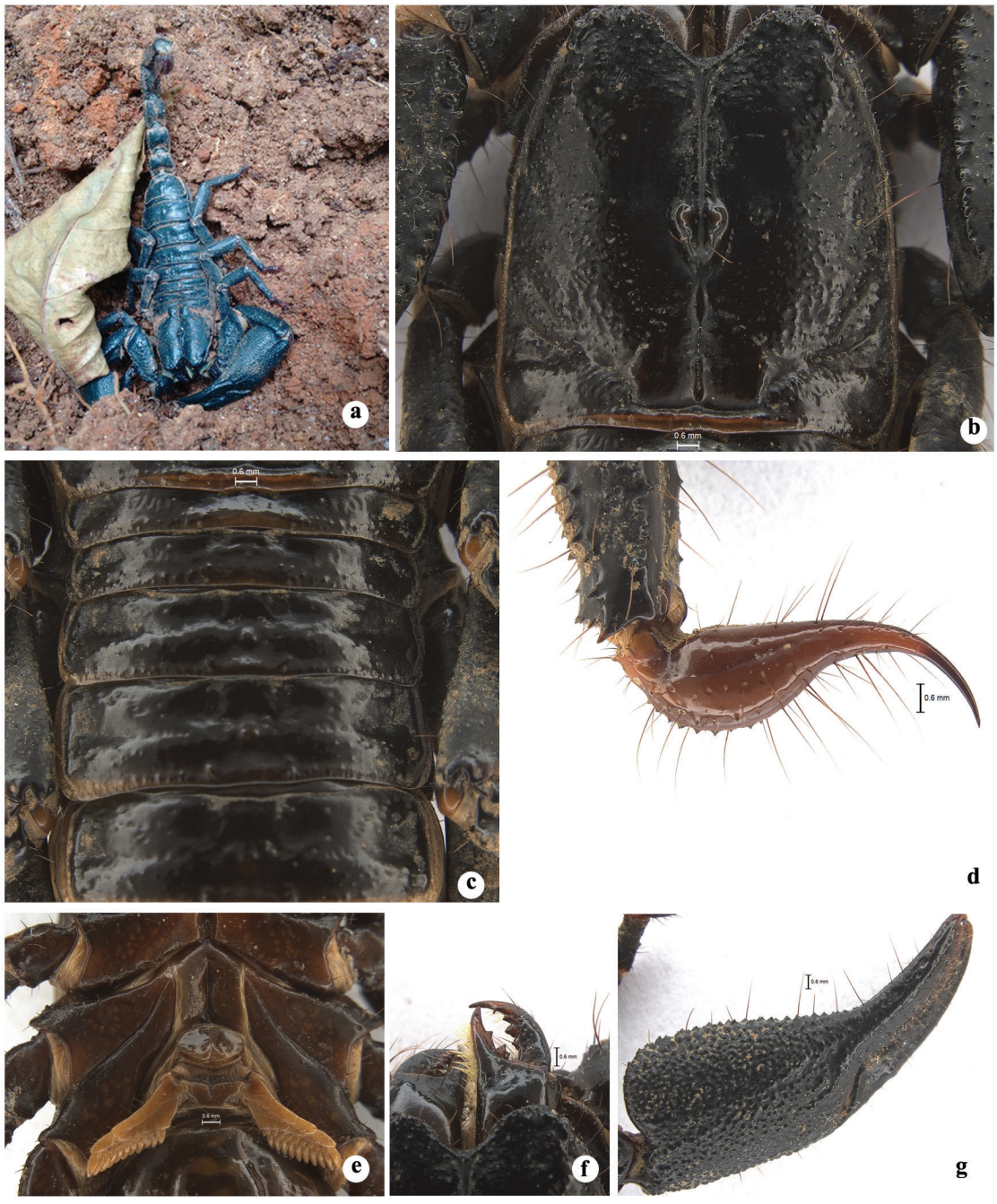
a. *Heterometrus flavimanus* (Pocock)(in life); **b.** carapace with dense granulation; **c.** telson with granulation ventrally and laterally; **d.** pectines; **e.** cheliceral dentition; **f.** chela manus lobed

PLATE 48



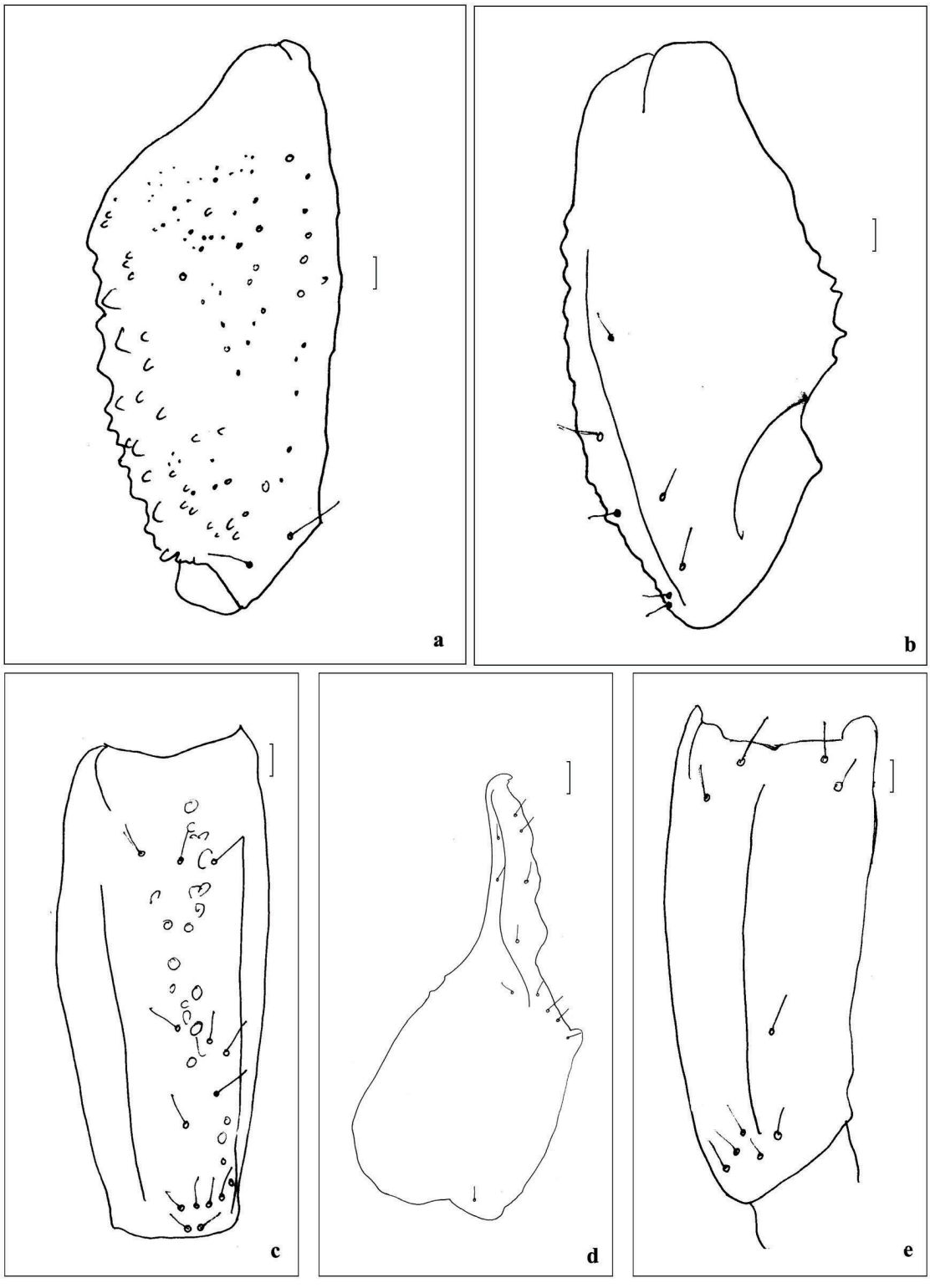
Heterometrus flavimanus (Pocock) **a.** femur dorsal view; **b.** patella ventral view; **c.** patella exterior view; **d.** chela dorsal view; **e.** chela exterior view

PLATE 49



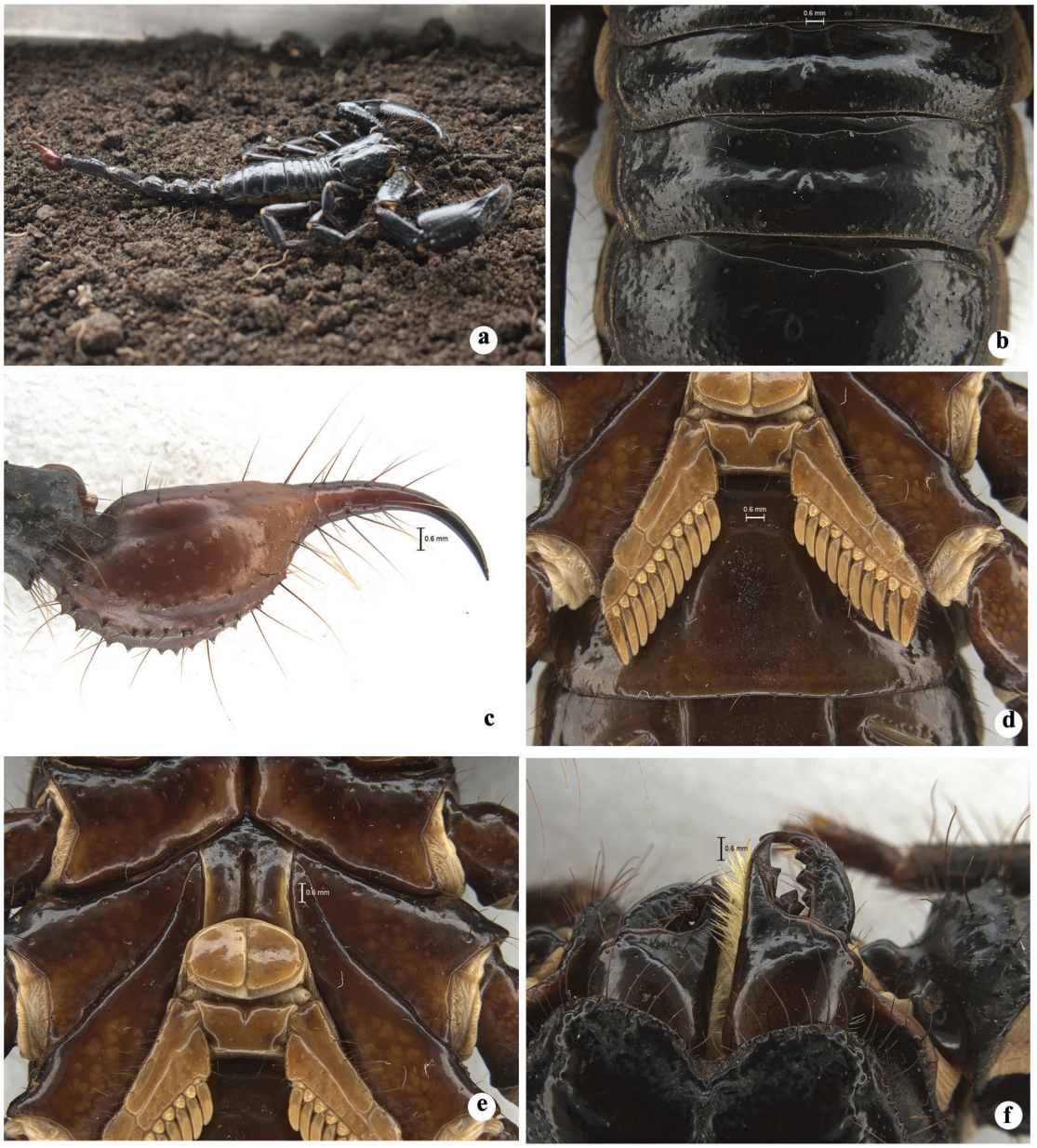
a. *Heterometrus keralaensis* Tikader and Bastawade (in life); **b.** carapace with granulation; **c.** smooth tergites; **d.** telson with granulation ventrally; **e.** pectines; **f.** cheliceral dentition; **g.** chela manus lobed

PLATE 50



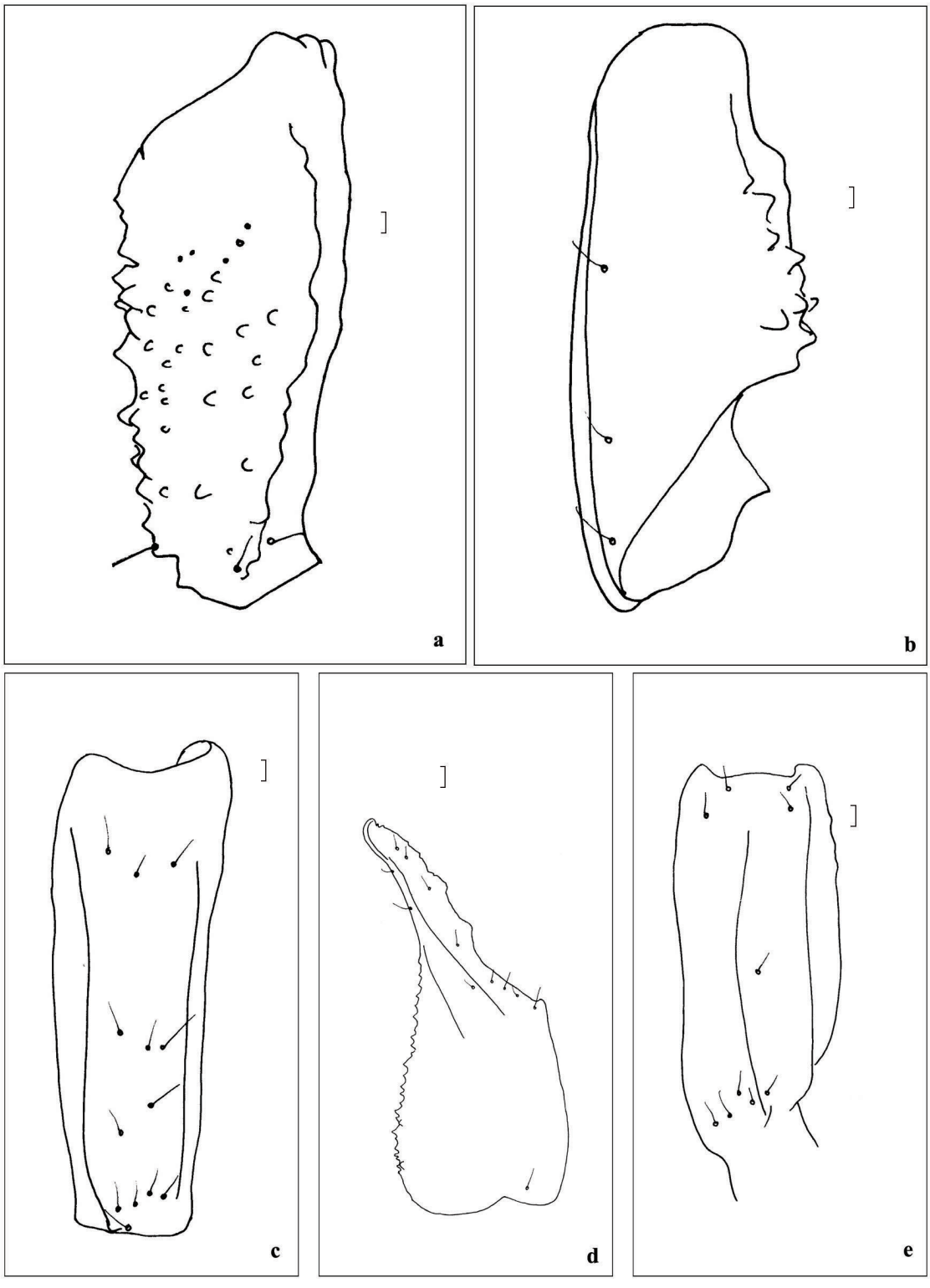
Heterometrus keralaensis Tikader and Bastawade **a.** femur dorsal view; **b.** patella ventral view; **c.** patella exterior view; **d.** chela dorsal view; **e.** chela exterior view

PLATE 51



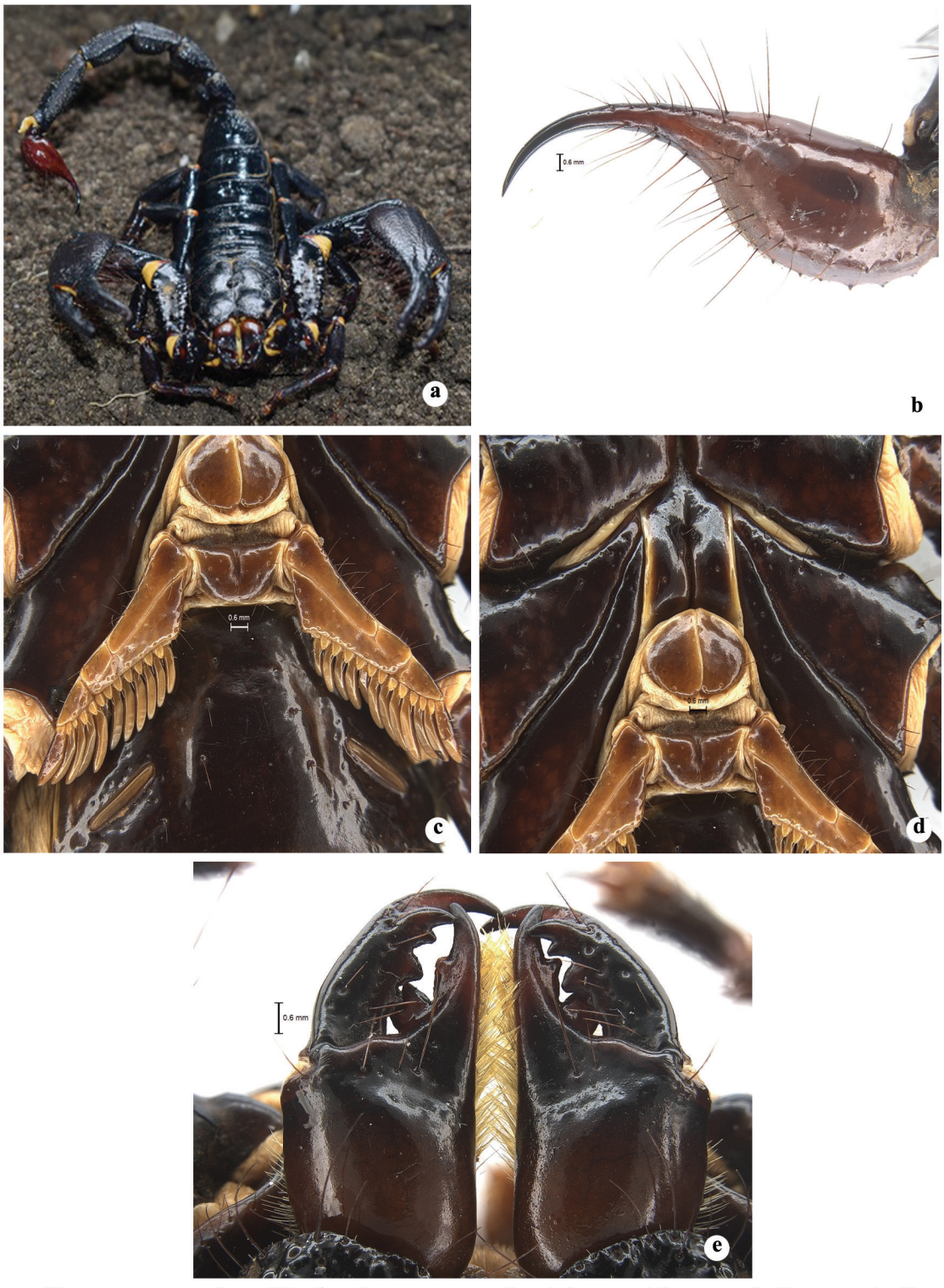
a. *Heterometrus lourencoi* sp. nov.; **b**. tergites with slight granulation; **c**. telson with granulation ventrally; **d**. pectines; **e**. genital operculum and sternum; **f.** cheliceral dentition

PLATE 52



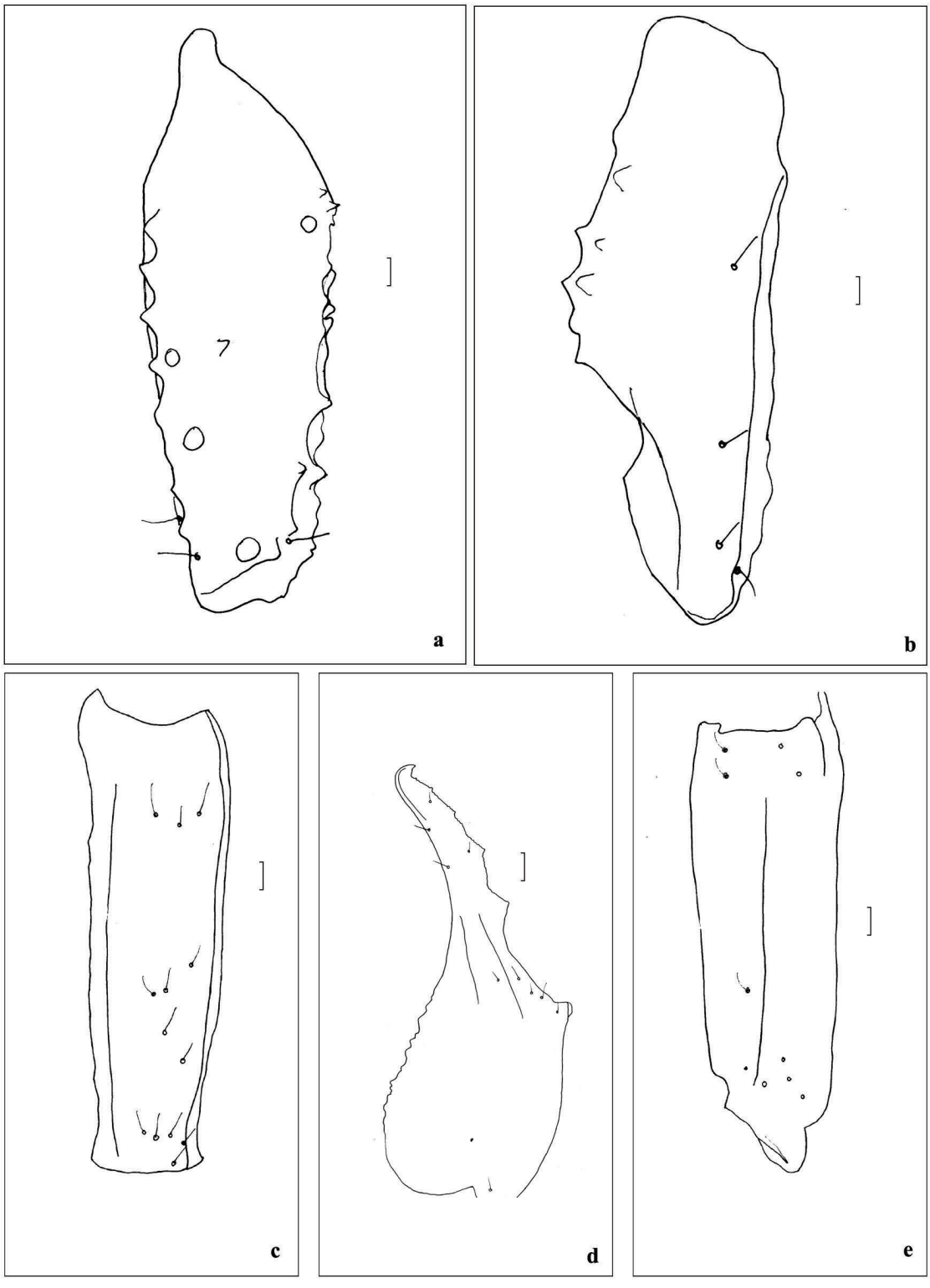
Heterometrus lourencoi sp. nov. **a.** femur dorsal view; **b**. patella ventral view; **c.** patella exterior view; **d**. chela dorsal view; **e.** chela exterior view

PLATE 53



a. *Heterometrus thattekkadensis* sp. nov.; **b**. telson with granulation ventrally; **c**. pectines; **d**. genital operculum and sternum; **e**. cheliceral dentition

PLATE 54



Heterometrus thattekkadensis sp. nov. **a.** femur dorsal view; **b.** patella ventral view; **c.** patella exterior view; **d**. chela dorsal view; **e.** chela exterior view

PLATE 55

b

a. *Rugodentus keralaensis* Bastawade, Sureshan and Radhakrishnan ♂; **b**. telson with granulation ventrally; **c.** pectines; **d.** globular chela manus; **e.** cheliceral dentition

PLATE 56

a. Scorpion killed by ants; **b & c**. parental care in *Lychas laevifrons* and *Heterometrus scaber*; **d.** moult of *Heterometrus lourencoi* sp. nov. **e.** moult of *Hottentotta keralaensis;* **f & g**. Acari mites in *Hottentotta rugiscutis;* **h & i**. *Hottentotta keralaensis* and *Heterometrus scaber* feed on cockroach