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A new remarkable species of *Leiurus* Ehrenberg, 1828 from Saudi Arabia (Scorpiones: Buthidae)


BASSAM ABU AFIFEH¹, ABDULHADI ALOUFI², MOHAMMAD AL-SARAIHEH³,
AHMED BADRY^{4, 5}, ABDULMANI H. AL-QAHTNI⁵ & ZUHAIR S. AMR^{6,*}


¹ Al Rumman Secondary School, Ministry of Education, Amman, Jordan.  <https://orcid.org/0009-0002-2131-3981>

² Department of Biology, Faculty of Science, Taibah University, Al-Madinah Al-Munawwarah, Kingdom of Saudi Arabia.  <https://orcid.org/0000-0001-8850-5713>


³ Oncology Department, Royal Medical Services, Amman, Jordan.  <https://orcid.org/0000-0002-0560-5469>

⁴ Department of Zoology, Faculty of Science, Al-Azhar University, Cairo, Egypt.

 <https://orcid.org/0000-0002-2610-2019>

⁵ Department of Invertebrates, National Center for Wildlife, Saudi Arabia.  <https://orcid.org/0009-0002-6072-7773>

⁶ Department of Biology, Jordan University of Science & Technology, Irbid, Jordan.

E-mail: amrz@just.edu.jo;  <https://orcid.org/0000-0002-4778-2308>

Received 18 October 2023 | Accepted by V. Pešić: 16 November 2023 | Published online 19 November 2023.

Abstract

A new remarkable buthid scorpion, *Leiurus nigellus* sp. nov., was discovered in Al Ula Governorate, north of Al Madinah Al Monawwarah Province, Saudi Arabia. The new species is described, fully illustrated, and compared with other species of the genus *Leiurus* reported from the Arabian Peninsula. Notes on its habitats are provided.

Key words: Scorpions, *Leiurus nigellus*, Buthidae, Al Ula, Saudi Arabia.

Introduction

Leiurus was created by Ehrenberg in Hemprich & Ehrenberg (1828, 1829) as a subgenus of *Androctonus* that included species with slender metasomal segments. Vachon (1949) elevated *Leiurus* to the genus level. For long, this genus was considered monotypic with *Leiurus quinquestriatus* (Ehrenberg, 1828) as the only species with a wide range of distribution across North Africa and the Middle East (Vachon, 1949; 1966). Two subspecies were considered to be valid by Vachon (1949); *Leiurus quinquestriatus quinquestriatus* (Ehrenberg, 1828) from Egypt including Sinai and Sudan and *Leiurus quinquestriatus hebraeus* (Birula, 1908) from Jordan, Palestine and Syria (Levy *et al.*, 1970; Lowe *et al.*, 2014). The taxonomic position of the two subspecies was reconsidered by Levy & Amitai (1980). Another subspecies, *Leiurus quinquestriatus brachycentrus* (Ehrenberg, 1829), was described from Yemen (Lowe *et al.*, 2014).

Other newly described species of this genus from the Middle East were followed; *Leiurus jordanensis* Lourenço, Modrý & Amr, 2002 from Jordan and Saudi Arabia (Lourenço *et al.*, 2002;

Hendrixson, 2006; Abu Afifeh *et al.*, 2022); *Leiurus abdullahbayrami* Yağmur, Koç & Kunt 2009 from Turkey Syria and Lebanon (Yağmur *et al.*, 2009; Khalil & Yağmur, 2010; Borges & Yağmur, 2022), *Leiurus kuwaiti* Lourenço, 2020 from Kuwait (Lourenço, 2020); *Leiurus aegyptiacus* Lourenço & El-Hennawy, 2021 from Egypt (Lourenço & El-Hennawy, 2021), *Leiurus maculatus* Lourenço, 2022 from Iraq (Lourenço, 2022) and recently *Leiurus sinai* Badry, Saleh, Lourenço & Ythier from Sinai (Badry *et al.*, 2023). All these species replaced what was traditionally known as *L. quinquestriatus* in the Middle East.

Previously, Vachon (1979) considered that *L. quinquestriatus* is the only representative of the genus *Leiurus* in Saudi Arabia. Lowe *et al.* (2014) presented the most comprehensive treatment of the genus *Leiurus* in the Arabian Peninsula. *Leiurus nasheri* Kovařík, 2007 is considered as a junior synonym for *Leiurus brachycentrus* (Lowe *et al.*, 2014), *Leiurus quinquestriatus hebraeus* (Birula, 1908) was raised to species level as *Leiurus hebraeus*, and four new species were described; *Leiurus arabicus* Lowe, Yağmur & Kovařík, 2014, distributed in central Najd plateau in Saudi Arabia, the western coast of the Arabian Gulf including Bahrain, and Jeddah; *Leiurus macroctenus* Lowe, Yağmur & Kovařík, 2014 from coastal fog desert of Jiddat al Harasis in Oman; *Leiurus haenggii* Lowe, Yağmur & Kovařík, 2014, known to occur along the western mountains parallel to the Red Sea coast (Hijaz and Asir) of Saudi Arabia and Hadramaut in Yemen, reaching as far as to Dhofar mountains in Oman; *Leiurus heberti* Lowe, Yağmur & Kovařík, 2014, confined to Samhan mountains in Dhofar, Oman, and *Leiurus brachycentrus* (Ehrenberg, 1829) distributed along Tihamah plain on the Red Sea coast of western Yemen and southwestern Saudi Arabia. Recently, a new species, *Leiurus hadb* Al-Qahtni, Al-Salem, Alqahtani & Badry, 2023, was described from Majami al-Hadb Protected Area, Saudi Arabia (Al-Qahtni *et al.*, 2023).

Leiurus nigellus sp. nov., shows predominantly blackish coloration pattern. Only two other species of *Leiurus* equally have a dark pattern of coloration, *Leiurus ater* Lourenço, 2019 from the mountains in Chad (Lourenço & El Hennawy, 2021), and *L. jordanensis* known from southern Jordan and north-western Saudi Arabia (Lourenço *et al.*, 2002; Hendrixson 2006). All the other known species of *Leiurus* show a rather pale pattern of coloration, predominantly yellow with more or less dark markings.

Recently, the scorpions of Saudi Arabia were the focus of several studies over the past few years. Several new species were described within two years, including two species of the genus *Compsobuthus* (Abu Afifeh *et al.*, 2021; Ythier & Lourenço, 2023), two species of the genus *Orthochirus* (Kovařík & Just, 2022; Ythier & Lourenço, 2023), one *Barbaracurus* (Kovařík *et al.*, 2022), one *Androctonus* (Alqahtani *et al.*, 2023), and one *Nebo* (Abu Afifeh *et al.*, 2023). By now, 36 species of scorpions in Saudi Arabia have been reported.

Other studies on the distribution and systematics of scorpions in Saudi Arabia were published (El-Hennawy, 2009 & 2014; Hendrixson, 2006; Alqahtani & Badry, 2021; Aloufi *et al.*, 2022a, b; Alqahtani *et al.*, 2022a, b, c). So far, the genus *Leiurus* includes 22 species distributed over North Africa and the Middle East.

The present study describes a new species of the genus *Leiurus* from Al Ula Governorate, Al Madinah Province in Saudi Arabia, along with a comparison with other species of this genus in the Arabian Peninsula.

Material and methods

The specimens were collected during July and August 2023. Scorpions were collected by ultraviolet (UV) detection, photographed and preserved in 80% alcohol. Holotype female and other paratypes are deposited in Bassam Abu Afifeh, private collection (BAPC).

Illustrations and measurements were made with the aid of stereoscopic microscope with a camera and an ocular micrometer (efix). Measurements follow Stahnke (1970) and are given in mm. Illustration under UV illumination was after Volschenk (2005). Trichobothrial notations follow Vachon (1974, 1975) and morphological terminology mostly follows Vachon (1952) and Hjelle (1990).

For the Slenderness factor (*F_s*), we adopted measurement given by Lowe *et al.* (2014). The slenderness of various body parts of *Leiurus* species exhibits potentially informative taxonomical characters that can be used for distinguishing species within this genus. Lowe *et al.* (2014) designated a specified formula to merge the values of slenderness of three scorpion's parts to quantify the overall slenderness; $F_s = (\text{pedipalp patella } L/W) \times (\text{leg III patella } L/D) \times (\text{metasoma III } L/W)$, they used this factor mainly to biometrically separate adult females of *L. haenggii* and *L. arabicus*.

Systematics

Family Buthidae C. L. Koch, 1837

Genus *Leiurus* Ehrenberg, 1828

Leiurus nigellus sp. nov. Abu Afifeh, Aloufi & Al-Saraireh

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(Figures 1-7; Tables 1 and 3)

Type material examined: Saudi Arabia: holotype: 1 ♀, BAPC 0250, Al Buriakah, beside old Tabuk-Al Ula highway, Al Ula Governorate, Al Madinah Al Monawwarah Province, 27° 19' 53.99"N, 37° 47' 31.11"E, 1109 m a.s.l., 5 August 2023, *leg.* A. Aloufi. **Paratypes:** 1 ♀, BAPC 0251, 1 juv. ♀, BAPC 0254, Al Buriakah, beside old Tabuk-Al Ula highway, Al Ula Governorate, Al Madinah Al Monawwarah Province, 27° 19' 53.99"N, 37° 47' 31.11"E, 1109 m a.s.l., 29 July 2023, *leg.* A. Aloufi. 2 ♀♀, BAPC 0252-0253, 1 subadult ♀, BAPC 0255, 3 ♂♂, BAPC 0256-0258, 1 subadult ♂, BAPC 0259, Al Buriakah, beside old Tabuk-Al Ula highway, Al Ula Governorate, Al Madinah Al Monawwarah Province, 27° 19' 53.99"N, 37° 47' 31.11"E, 1109 m a.s.l., 5 August 2023, *leg.* A. Aloufi.

Comparative material examined:

Saudi Arabia: *Leiurus arabicus*: 1 ♂, BAPC 0150, 1 ♀, BAPC 0151, Alaab, Al Madinah Al Monawwarah Province, 24° 06' 13.08"N, 38° 55' 48.13"E, 412 m a.s.l., 21 March 2019, *leg.* A. Aloufi. 1 ♀, BAPC 0149, Wadi Al Jala'b, Al Madinah Al Monawwarah Province, 24° 44' 25.80"N, 39° 42' 57.29"E, 838 m a.s.l., 6 August 2017, *leg.* A. Aloufi. ***Leiurus haenggii*:** 1 ♂, BAPC 0200, 1 ♀, BAPC 02011, Wadi Reem (Al Aseel), Al Madinah Al Monawwarah Province, 23° 55' 06.50"N, 39° 18' 05.50"E, 1090 m a.s.l., 23 May 2022, *leg.* A. Aloufi. 1 ♀, BAPC 02021, Al Fegrah (Wadi Mzaber), Al Madinah Al Monawwarah Province, 24° 21' 44.34"N, 38° 57' 44.75"E, 1551 m a.s.l., 28 August 2022, *leg.* A. Aloufi. **Jordan: *Leiurus jordanensis*:** 1 ♂, 2 ♀♀, BAPC 0100-0102, Al Mudawwarah, Ma'an Governorate, 29° 23' 05.7" N 35° 54' 10.2" E, 24 October 2020, *leg.* B. Abu Afifeh & M. Al-Saraireh. 4 ♀♀, BAPC 0102-0105, Wadi Rum, 13 km SE Al Ghal, Aqaba Governorate, 29° 26' 00.1" N, 35° 40' 56.8" E, 890 m a.s.l., 15 July 2022, *leg.* B. Abu Afifeh & R. Abu Afifeh. 6 ♀♀, BAPC 0106-0111, Batn El-Ghol, Ma'an Governorate, 29° 42' 48.4" N, 36° 08' 53.6" E, 879 m a.s.l., 7 July 2023, *leg.* B. Abu Afifeh & R. Abu Afifeh. ***Leiurus hebraeus*:** 2 ♀♀, BAPC 0300-0301, Wadi Shueib, Balqa Governorate, 31° 56' 10.0" N 35° 39' 55.0" E, -5 m a.s.l. 20 July 2023, *leg.* B. Abu Afifeh & M. Al-Saraireh.

Etymology: The specific epithet from Latin “*nigellus*” is masculine adjective, diminutive of “*niger*” (Black), which refers to the predominantly blackish colour of the new species.

Diagnosis: Large *Leiurus*, adults 81-104 mm in total length, carapace of female reaching 11.40 mm in length; body colour is predominantly black; carapace, mesosoma, metasoma and telson, pedipalps and proximal segments of legs black to blackish-brown; distal third of pedipalp chela fingers and the three most distal segments of legs dark yellow to yellowish-brown; anterior margin of carapace slightly concave; all carapace carinae strongly developed; central lateral and posterior median carinae fused to form lyre shaped row of granules. chelicerae with characteristic buthid dentition (Vachon, 1963); tergites I–II, VII pentacarinata, III–VI tricarinate; sternites III with weak to moderate median carinae in females; strong in males; pectinal tooth counts ranging from 36-39 in males and 29-33 in females. Pedipalps slender; femur L/W 4.25 in male, 3.80-3.96 in females; patella L/W 4.00 in male, 3.35-3.60 in females; chela L/W 7.96 in male, 7.00-7.60 in females; fixed and movable finger of pedipalps with 12-13 rows of granules and marked accessory granules; trichobothrial pattern orthobothriotaxic, type A-β (Vachon, 1974, 1975); pedipalp chela fixed finger with trichobothrium *db* distal to *est*; metasoma I–III with 10 carinae, median lateral carinae complete on I, reduced on II–III; metasoma IV with 8 carinae; metasoma V with 7 carinae; metasoma slender, metasoma I L/W 1.36 in male, 1.27-1.30 in females, metasoma II L/W 1.91 in male, 1.78-1.86 in females; metasoma III L/W 2.16 in male, 1.97-2.10 in females; metasoma IV L/W 2.81 in male, 2.52-2.62 in females; metasoma V L/W 3.40 in male, 2.97-3.11 in females. *F_s* (slenderness factor) of adult females ranging from 27.78–32.32.

Description: Based on female holotype and paratypes. Measurements are in Table (1).

Coloration. Generally black (Figs. 1 & 2), carapace black to blackish-brown; tergites black to blackish-brown; venter yellowish-brown except sternite VII blackish-brown; metasomal segments black to blackish-brown; vesicle black to blackish-brown; aculeus dark reddish-brown at the base and dark black at its extremity; chelicerae retrodorsal surface dark yellow to yellowish-brown; prodorsal surface reticulated with dense dark spots; teeth blackish; pedipalps black to blackish-brown overall excepted for the chela fingers which are gradually turn to yellowish-brown on the distal third; rows of granules on the dentate margins of the fingers dark red; legs with black to blackish-brown proximal segments and the three most distal becoming lighter.



Figure 1. *Leiurus nigellus* sp. nov., female paratype from Al Buriakah, Al Ula governorate, Saudi Arabia.

Morphology

Prosoma (Figs. 3 & 4). Anterior margin of carapace slightly concave; all carapace carinae strongly developed, granulose, including central median, posterior median, anterior median, central lateral and central median; central lateral and posterior median carinae fused to form lyre shaped row of granules. Intercarinal spaces with very few irregular granules and almost smooth laterally and distally; median ocular tubercle only slightly anterior to the centre of the carapace, almost in a central position; median eyes separated by slightly more than two ocular diameters; five pairs of lateral eyes; (3 large, 2 small) on each side.

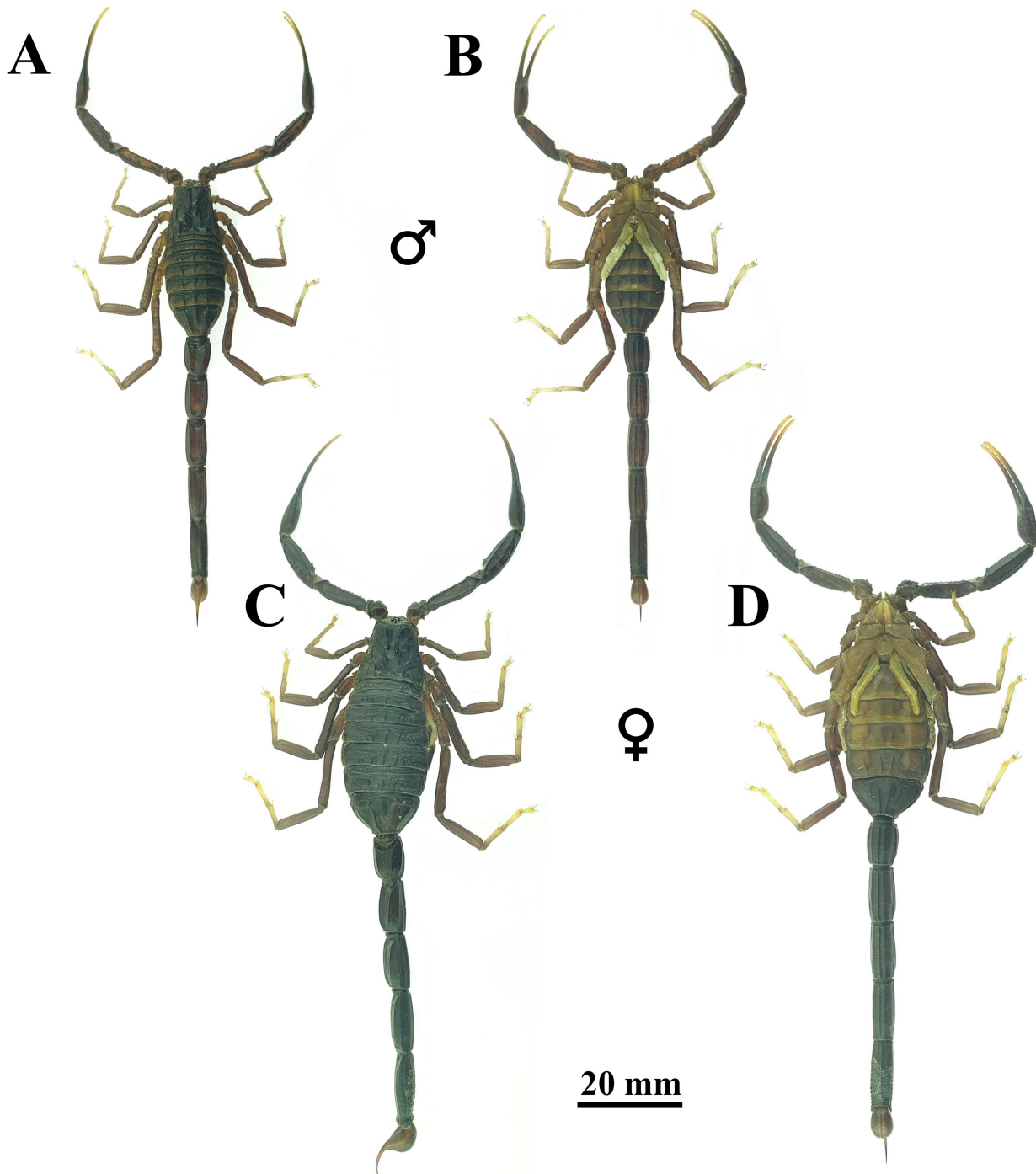


Figure 2. Habitus of *Leiurus nigellus* sp. nov., male paratype and female holotype. **A.** male in dorsal view. **B.** male in ventral view. **C.** female in dorsal view. **D.** female in ventral view. Scale bar = 20 mm.

Mesosoma (Figs. 3 & 4). Tergites I, II and VII pentacarinat; III and IV tricarinate; all carinae strong, granular; median carina on I moderate to strong; on II-VI strong, crenulate; terminating distally on each segment with a spinoid process that extends very slightly beyond the posterior margin of the tergite; tergite VII with 5 strong, granular carinae; inner and outer lateral carinae joined anteriorly by transverse granule rows; median carina present on anterior one-half to 2/3 of the total length, moderate to strong. Intercarinal spaces weakly granular, almost smooth, excepted for the lateral margins of tergites III-VI which are strongly

NEW SPECIES OF *LEIURUS* FROM SAUDI ARABIA

Table 1. Measurements for adult males and females of *Leiurus nigellus* sp. nov. and *Leiurus jordanensis*. Measurements and morphometric are in mm. (L: Length, W: Width, D: Depth, AW: Anterior width, PW: Posterior width)

Measurements	<i>Leiurus nigellus</i> sp. nov.					<i>Leiurus jordanensis</i>				
	♂	♀	♀	♀	♀	♂	♀	♀	♀	♀
	paratype BAPC0251	holotype BAPC0250	paratype BAPC0252	paratype BAPC0253	paratype BAPC0254	MNHN	BAPC0100	BAPC0101	BAPC0102	BAPC0103
Total length	81.25	104.21	100.90	96.77	85.80	95.90	100.93	100.34	98.65	97.09
Carapace L	8.76	11.40	11.16	11.16	9.00	9.70	11.34	11.40	10.44	11.16
Carapace AW/PW	5.16/9.48	6.60/12.73	6.84/13.09	6.60/12.61	5.52/10.68	7.10/10.80	6.60/12.24	6.84/12.36	6.72/11.40	6.72/12.00
Mesosoma L	18.37	29.65	24.01	22.49	22.80	24.80	25.09	22.81	26.77	21.85
Metasoma I L/W	6.36/4.68	7.66/5.88	7.80/6.00	7.44/5.76	6.24/4.92	7.80/5.40	7.86/5.64	8.28/5.88	7.68/5.40	8.04/5.88
Metasoma II L/W	7.80/4.08	9.18/5.04	9.36/5.04	8.76/4.92	7.44/4.02	9.70/4.60	9.24/4.68	9.48/4.80	8.76/4.56	9.36/4.86
Metasoma III L/W	8.04/3.72	9.60/4.62	9.84/4.68	9.24/4.68	7.80/3.72	9.80/4.20	9.60/4.32	9.96/4.44	9.36/4.26	9.84/4.44
Metasoma IV L/W	9.12/3.24	10.68/4.08	10.92/4.20	10.44/4.08	8.76/3.48	11.10/3.80	11.04/4.08	11.28/4.20	10.44/3.84	10.92/3.96
Metasoma V L/W/D	10.20/3.00/2.88	12.24/3.96/3.72	12.61/4.08/3.96	12.12/4.08/3.60	10.44/3.36/3.00	12.70/3.40/3.20	12.48/3.84/3.48	12.61/3.96/3.72	11.64/3.72/3.36	12.12/3.66/3.48
Telson L	9.00	10.80	11.16	11.52	9.36	10.30	11.28	11.52	10.56	10.80
Vesicle W/D	3.12/3.00	4.08/3.96	3.96/3.84	4.44/3.96	3.48/3.24	3.50/3.70	3.96/3.84	4.44/4.20	3.84/3.66	3.84/3.72
Pedipalp Femur L/W	10.20/2.40	11.40/3.00	12.30/3.12	11.64/2.94	9.84/2.52	11.40/2.40	11.76/2.88	12.61/2.88	11.40/2.70	11.64/2.88
Pedipalp Patella L/W	11.04/2.76	12.73/3.60	13.57/3.84	12.48/3.72	10.80/3.00	13.10/2.90	13.09/3.36	13.81/3.48	12.48/3.36	12.97/3.36
Pedipalp Chela L/W/D	20.05/2.52/2.64	23.65/3.18/3.78	24.61/3.24/3.84	22.69/3.24/3.72	20.05/2.64/3.00	21.60/2.40/2.70	23.05/3.00/3.60	24.25/3.12/3.60	22.57/2.88/3.12	22.57/2.883.48
Movable finger L	13.45	16.57	16.69	15.49	13.45	15.20	15.37	16.45	15.37	15.01
Leg III patella L/D ♀		9.60/2.28	10.20/2.34	9.60/2.28	8.16/1.92		10.08/2.22	10.56/2.28	9.96/2.10	10.20/2.16

granulated; sternites: lateral carinae absent from sternite III; moderate to strong on sternites IV-VI; strong, crenulate on VII; median carinae on sternite III weak to moderate, irregularly granular; on IV weak; on V weak to obsolete; on VI moderate; on VII strong crenulate. Pectines long; reaching to or slightly beyond coxa-trochanter joint of leg IV in the female, well beyond this articulation in males; pectinal tooth count 36-39 in males and 29-33 in females. Pectines with 3 marginal lamellae, 9 middle lamellae, marginal and middle lamellae with dense cover of short reddish macrosetae; fulcrum with 4-7 setae.

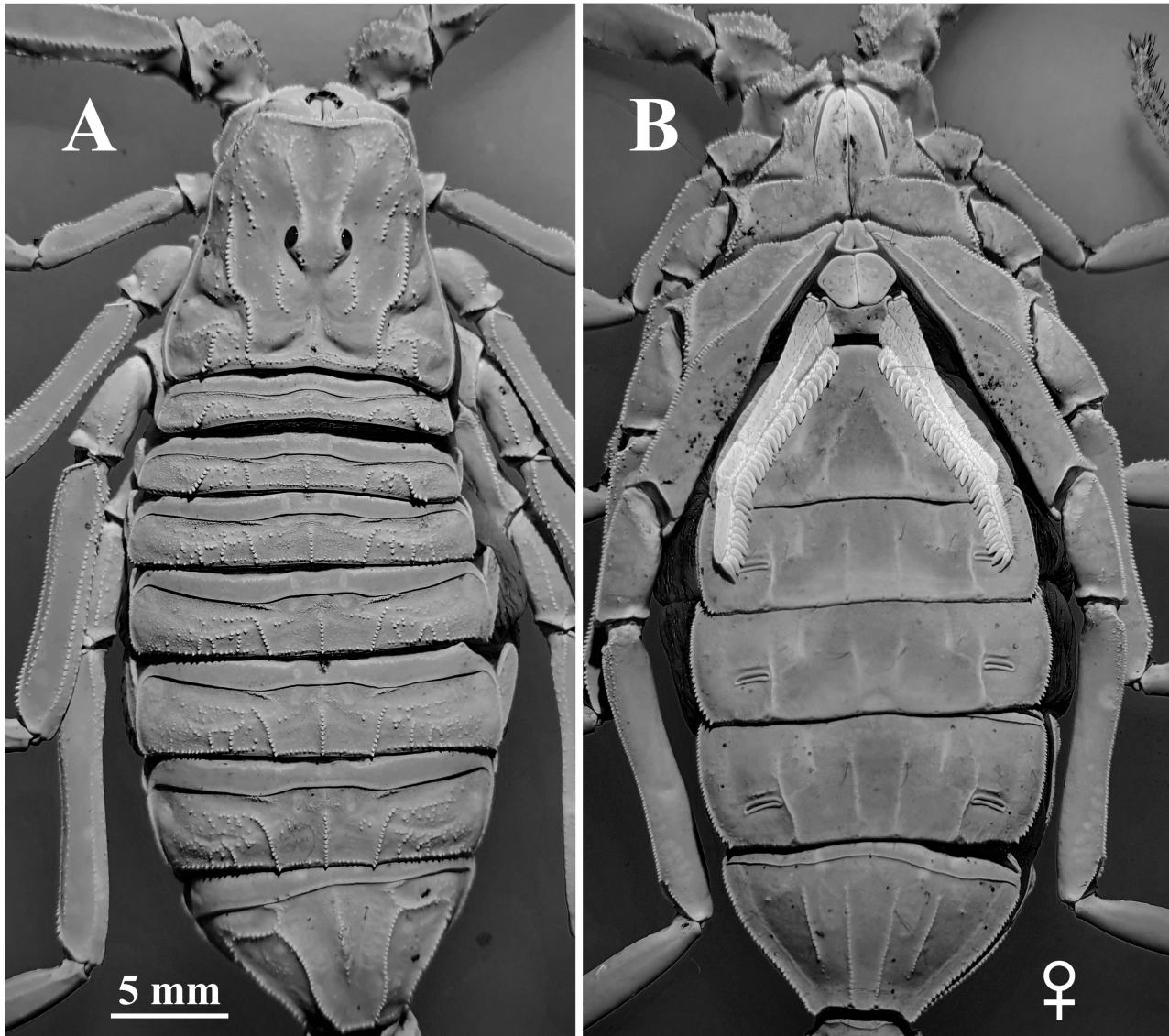


Figure 3. *Leiurus nigellus* sp. nov., female holotype under UV light. **A.** carapace and mesosoma. **B.** sternopectinal area and ventral of mesosoma. Scale bar = 5 mm.

Metasoma (Fig. 5). Metasomal segments I to III with 10 carinae, crenulate; median lateral carinae on I moderate to strong, crenulate; on II present on posterior one-third, crenulate; on III limited to posterior one-fifth; IV with 8 carinae; dorsosubmedian carinae moderate on I-II, weak on III-IV; dorsolateral and ventrolateral carinae moderate on I-IV; ventromedian carinae moderate on segments I to IV. Segment V with 7 carinae; dorsolateral carinae very weak, faintly granulated, ventrolateral carinae strong with dentate granules increasing in size posteriorly, with several slightly enlarged subtriangular denticles, ventrosubmedian carinae marked by series of small to medium dentate granules on anterior 2/3 of segment, ventromedian carina strong, armed with small to large more spinoid than lobate granules; anal arch with 3 lateral spinoid lobes and 12-13 irregular, transverse crenulations on ventral margin. Dorsal furrows of all

segments moderately to weakly developed with a thin granulation, almost smooth; intercarinal surfaces smooth on segment I, smooth to minutely shagreened on II-III, sparsely, finely shagreened on IV-V.

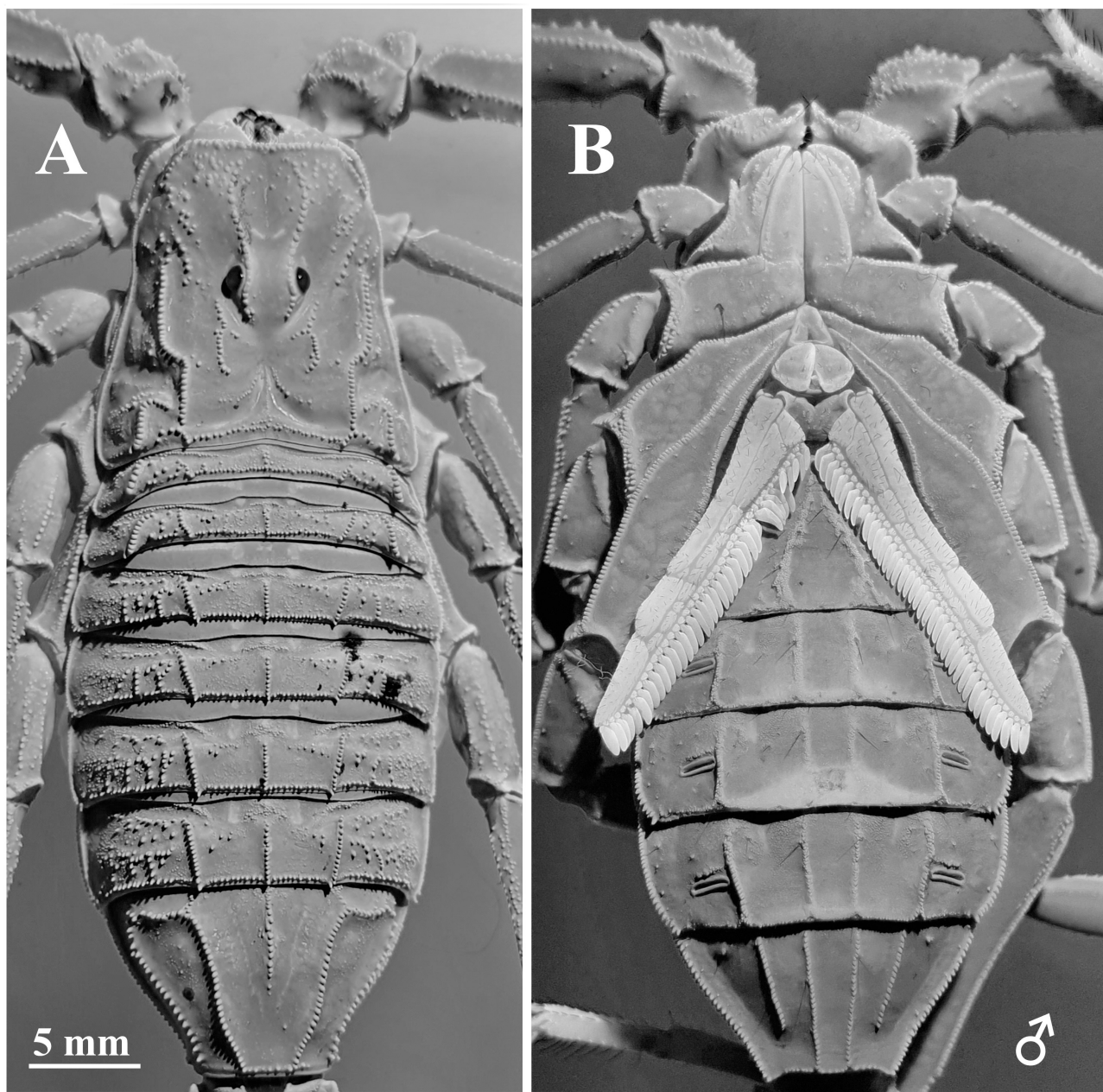


Figure 4. *Leiurus nigellus* sp. nov., male paratype under UV light. **A.** carapace and mesosoma. **B.** sternopectinal area and ventral of mesosoma. Scale bar = 5 mm.

Telson (Fig. 5). Vesicle smooth, bulbous; ventral surface with scattered fine microsetae and several short macrosetae; aculeus slightly shorter than vesicle, subaculear tubercle absent.

Chelicerae: Dorsal surface of manus smooth, convex, prodorsal margin finely granular; retrodorsal surfaces smooth; prolateral and ventral surfaces densely setose; fingers with normal buthid dentition (Vachon, 1963), fixed finger dorsal and ventral surfaces densely setose, dorsal margin bears 4 teeth: distal, subdistal, median, and basal; ventral margin with basal and median denticles; movable finger dorsal surface smooth; ventral surface densely setose; dorsal margin bears 5 teeth: distal, subdistal, median, and a pair of basal denticles fused in bicuspid; ventral margin with distal, median, and basal teeth. The movable finger always ends in two distal teeth—one dorsal and one ventral—between which is inserted the distal tooth of the fixed finger.

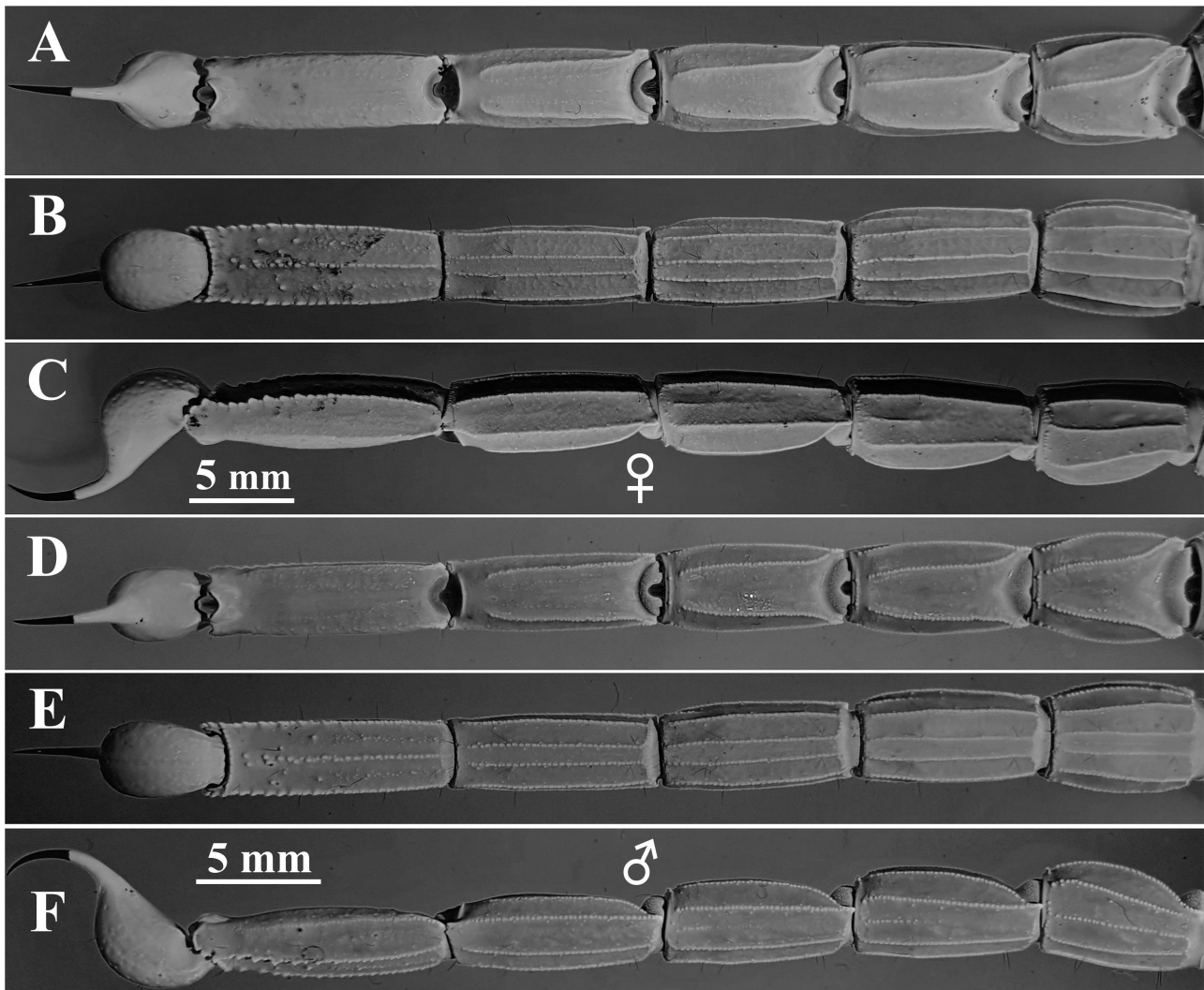


Figure 5. *Leiurus nigellus* sp. nov. female holotype under UV light. **A.** metasoma and telson dorsal view. **B.** metasoma and telson ventral view. **C.** metasoma and telson lateral view. Male paratype under UV light. **D.** metasoma and telson dorsal view. **E.** metasoma and telson ventral view. **F.** metasoma and telson lateral view. Scale bar = 5 mm.

Pedipalps

Femur (Figs. 6 A-B, G-H) slender, $L/W = 3.8$; with five carinae; dorsoexternal, dorsointernal and ventrointernal carinae strong with regular large conical granules; internal carina strong, with irregular large granules; external carina obsolete, a smooth ridge with isolated large dentate granules; dorsal and internal surfaces finely, sparsely shagreened, ventral and external surfaces nearly smooth.

Patella (Figs. 6 C-D, I-J) slender, $L/W = 3.8$; with seven carinae; dorsointernal carinae moderate to strong, with one conspicuous spinoid granule and several smaller granules; dorsomedian carina weak, finely granular; dorsoexternal, external and ventroexternal carinae weak, smooth; ventromedian carina weak, with fine granules; ventrointernal carina weak, with well-spaced medium to small granules and ventral patellar spur; internal carina moderate, with closely spaced small granules and dorsal patellar spur.

Chela (Figs. 6 E-F, K-L). slender, $L/W = 7.44$; with elongated fingers; all carinae almost vestigial. Dentate margins of fixed and movable fingers composed of 12-13 almost linear rows of granules and conspicuous accessory granules (Figs. 7, C-D, G-H).

Trichobothrial pattern orthobothriotaxic (Fig. 6). type A (Vachon, 1974); dorsal trichobothria of femur in beta configuration (Vachon, 1975); pedipalp chela fixed finger with trichobothrium *db* distal to *est*.

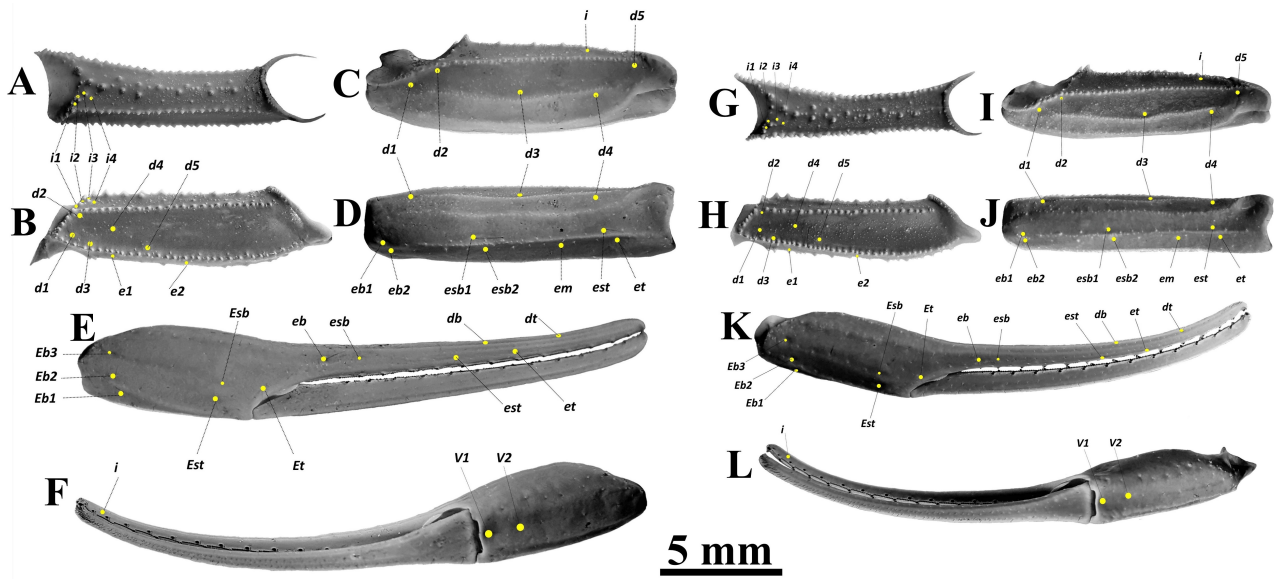


Figure 6. *Leiurus nigellus* sp. nov., pedipalp segments, female holotype (A-F), A. femur internal view. B. femur dorsal view. C. patella dorsal view. D. patella external view. E. chela external view. F. chela ventral view; male paratype (G-L), G. femur internal view. H. femur dorsal view. I. patella dorsal view. J. patella external view. K. chela external view. L. chela ventral view. Trichobothrial pattern indicated by yellow circles. Scale = 5 mm.

Legs: (Figs. 7, A-B, E-F). with ventral aspect of tarsi presenting numerous thin setae not well arranged in rows. retrolateral setae on basitarsus III counts 12-15. Tibial spurs present on legs III and IV strong. Pedal spurs present, strong on all legs, prolateral spurs basally bifurcate.

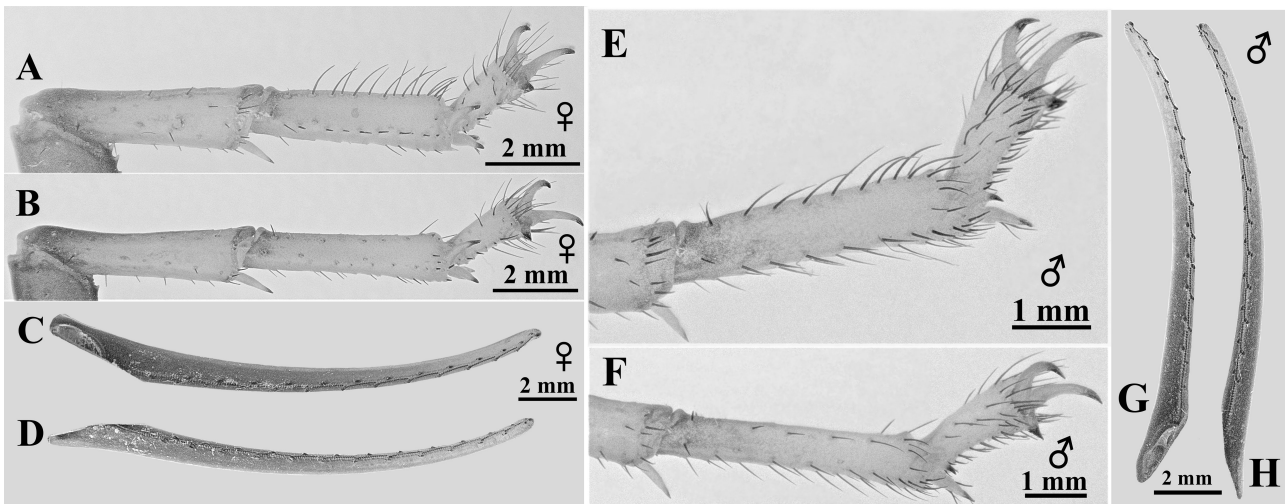


Figure 7. *Leiurus nigellus* sp. nov., right tibia, basitarsus, and telotarsus, retrolateral view, female holotype, A. leg III. B. leg IV. C. pedipalp chela fixed finger. D. pedipalp chela movable finger; male paratype. E. leg III. F. leg IV. G. pedipalp chela fixed finger. H. pedipalp chela movable finger.

Sexual dimorphism:

Males differed from females as follows: Males with more robust carination on tergites and sternites III–V, more slender pedipalps and metasoma, longer pectines with larger teeth.

Affinities

Leiurus nigellus sp. nov. is distinguished from most other species of *Leiurus* known from the Arabian Peninsula by its distinctive predominantly blackish colour pattern, the new species differs from *L. jordanensis* by having: **(a)**. less slender body parts, including metasomal segments, legs and pedipalps (Table 3); and by combining morphometric ratios describing slenderness of three segments (leg, pedipalp and metasomal segments) of adult females resulted in *Fs* that ranged from 27.78–32.32 ($n=4$) in *L. nigellus* sp. nov., 35.06–41.78 ($n=12$) in *L. jordanensis*; **(b)**. sternite III with median carinae weak to moderate, irregularly granular, sternites IV–V with lateral carinae moderate, granular, median carinae weak in females of the new species, whereas sternite III with median carinae strong, granular, sternites IV–V with lateral carinae strong, granular, median carinae moderate in females *L. jordanensis*; **(c)**. different colour pattern, with vesicle of telson black to blackish brown in adults, and it is light black in juveniles, whereas the vesicle is yellow in adults and juveniles of *L. jordanensis*, also pedipalp fingers of the new species are black to blackish brown overall except for the distal third with yellowish-brown, but they are completely yellow in *L. jordanensis*.

Leiurus arabicus is distinguished from *L. nigellus* sp. nov. by having: **(a)**. less slender metasomal segments, and less slenderness factor in adult females (Table 2 & 3); *Fs* ranged from 26.24–26.27 in females ($n=2$); **(b)**. different colour pattern, base colour is yellow, with less or more dark reddish-brown pigmentation on carapace, tergites and metasoma V, in contrast the new species is black to blackish-brown overall; **(c)**. ventrolateral carinae of metasoma V with enlarged triangular or subtriangular denticles, whereas in *L. nigellus* sp. nov. ventrolateral carinae of metasoma V with slightly enlarged subtriangular denticles.

Leiurus haenggii is distinguished from *L. nigellus* sp. nov. by having **(a)**. less slender metasomal segments, legs and pedipalps (Table 2 & 3); *Fs* ranged from 20.02–21.23 in females ($n=2$); **(b)**. sternite III with median carinae very weak, smooth, almost obsolete; sternites IV–V with weak, finely granulated lateral carinae, obsolete median carinae; whereas sternite III with median carinae weak to moderate, irregularly granular, sternites IV–V with lateral carinae moderate, granular, median carinae weak in females of the new species; **(c)**. different colour pattern, base colour is yellow, with less or more dark reddish-brown pigmentation on carapace, tergites and metasoma V, in contrast *L. nigellus* sp. nov. is black to blackish-brown overall; **(d)**. ventrolateral carinae of metasoma V with enlarged subtriangular or lobate denticles, whereas in *L. nigellus* sp. nov. ventrolateral carinae of metasoma V with slightly enlarged subtriangular denticles.

Habitat

The collection site is located in Al Buriakah village (1109 m a.s.l.), 130 km north of Al Ula Governorate, north of Al Madinah Al Monawwarah Province. *Leiurus nigellus* sp. nov. was collected from an arid environment with sparse vegetation. The habitat is a flat desert covered with thin layer of sand on top of gravel with scattered sandstone bed rocks of various sizes, with several deserted rodent burrows (Fig. 8). More to the west, sandstone deserts become more prominent interrupted by narrow wadi systems, with few vegetation of *Haloxylon salicornicum*, *Retama raetam*, *Panicum* sp. and *Citrullus colocynthis*. Other scorpions found in the same area include *Androctonus crassicauda* (Olivier, 1807), *Vachoniolus globimanus* Levy, Amitai & Shulov, 1973, and *Buthacus* sp.

Discussion

The vast area of Saudi Arabia and its geological formation offers many different habitats for the formation of isolated population of scorpion species. The description of several scorpion taxa within the past years represents evidence for the presence of other possible new species in the Arabian Peninsula. *Leiurus jordanensis* is an example of a species with confined distribution in southern Jordan and northern Saudi Arabia, where it does not overlap with other *Leiurus* species (Lowe *et al.*, 2014; Aloufi *et al.*, 2022a). Within the Arabian Peninsula, species of the genus *Leiurus* are isolated, whereas *L. arabicus* is confined to central Najd plateau in Saudi Arabia and the western coast of the Arabian Gulf, *Leiurus haenggii* with a wide range of distribution along the western mountains parallel to the Red Sea coast reaching as far as Hadramout and Dhofar mountains (Lowe *et al.*, 2014). *Leiurus macroctenus* has a confined distribution in the desert of Jiddat al Harasis in Oman, while *L. heberti* is restricted to Samhan mountains in Dhofar. Also, *L. brachycentrus* is known along Tihamah plain on the Red Sea coast of western Yemen and southwestern Saudi Arabia (Lowe *et al.*, 2014).

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Table 2. Measurements for adult males and females of *Leiurus arabicus* and *Leiurus haenggii*. Measurements and morphometric are in mm. (L: Length, W: Width, D: Depth, AW: Anterior width, PW: Posterior width)

Measurements	<i>Leiurus arabicus</i>			<i>Leiurus haenggii</i>		
	♂ BAPC0150	♀ BAPC0151	♀ BAPC0149	♂ BAPC0200	♀ BAPC0201	♀ BAPC0202
Total length	81.13	105.43	95.17	83.29	89.53	90.79
Carapace L	9.24	11.40	11.40	9.60	10.68	10.20
Carapace AW/PW	5.40/9.36	6.84/12.36	6.60/12.00	5.40/9.84	6.48/12.00	6.48/11.76
Mesosoma L	17.77	28.81	21.85	18.61	19.81	21.85
Metasoma I L/W	6.60/5.28	7.86/6.54	7.44/6.36	6.84/5.88	7.20/6.42	7.02/6.12
Metasoma II L/W	7.80/4.44	9.24/5.52	8.76/5.40	8.04/5.28	8.40/5.64	8.40/5.28
Metasoma III L/W	8.04/4.20	9.36/4.92	9.00/5.04	8.28/4.92	8.64/5.28	8.64/4.92
Metasoma IV L/W	9.12/3.72	10.56/4.56	10.32/4.68	9.36/4.44	9.84/4.92	9.84/4.68
Metasoma V L/W/D	10.20/3.96/3.48	12.24/4.44/4.20	12.00/4.56/4.20	10.80/3.96/3.96	11.28/4.80/4.20	11.28/4.44/4.32
Telson L	9.36	11.04	11.40	9.36	11.28	10.56
Vesicle W/D	3.48/2.48	4.44/4.38	4.50/4.26	3.96/3.60	4.56/4.20	4.32/3.84
Pedipalp Femur L/W	9.72/2.28	11.40/3.06	11.16/2.88	9.54/2.52	10.44/2.94	10.44/3.12
Pedipalp Patella L/W	10.44/2.76	12.48/3.84	12.12/3.60	10.80/3.00	11.40/3.60	11.28/3.72
Pedipalp Chela L/W/D	19.21/2.28/2.64	22.21/3.24/3.84	21.97/3.36/3.72	19.45/2.52/2.88	21.13/3.12/3.60	20.77/3.24/3.78
Movable finger L	13.09	14.89	14.41	12.48	14.17	13.81
Leg III patella L/D ♀		10.20/2.40	10.44/2.40		9.24/2.40	9.24/2.28

Table 3. Variation in morphometric ratios for *Leiurus nigellus* sp. nov., *Leiurus jordanensis*, *Leiurus arabicus*, and *Leiurus haenggii*.

Measurements	<i>Leiurus nigellus</i> sp. nov.		<i>Leiurus jordanensis</i>		<i>Leiurus arabicus</i>		<i>Leiurus haenggii</i>	
	♂ (n=1)	♀ (n=4)	♂ (n=1)	♀ (n= 12)	♂ (n=1)	♀ (n=2)	♂ (n=1)	♀ (n=2)
Total length (mm)	81.25	85.80–104.21	95.90	91.80–101.20	81.13	95.17–105.43	83.29	89.53–90.79
Metasoma I L/W	1.36	1.27–1.30	1.44	1.37–1.42	1.25	1.17–1.20	1.16	1.12–1.15
Metasoma II L/W	1.91	1.78–1.86	2.11	1.92–1.98	1.76	1.62–1.67	1.52	1.49–1.59
Metasoma III L/W	2.16	1.97–2.10	2.33	2.14–2.24	1.91	1.79–1.90	1.68	1.64–1.76
Metasoma IV L/W	2.81	2.52–2.62	2.92	2.69–2.76	2.45	2.21–2.32	2.11	2.00–2.10
Metasoma V L/W	3.40	2.97–3.11	3.74	3.13–3.31	2.58	2.63–2.76	2.73	2.35–2.54
Pedipalp femur L/W	4.25	3.80–3.96	4.75	4.04–4.38	4.26	3.73–3.88	3.79	3.35–3.55
Pedipalp patella L/W	4.00	3.35–3.60	4.52	3.64–4.00	3.78	3.25–3.37	3.60	3.03–3.17
Pedipalp chela L/W	7.96	7.00–7.60	9.00	7.68–7.84	8.43	6.54–6.85	7.72	6.41–6.77
Movable finger L/chela L	0.67	0.67–0.70	0.70	0.67–0.68	0.68	0.66–0.67	0.64	0.66–0.67
Leg III patella L/D ♀		4.21–4.36		4.47–5.00		4.25–4.35		3.85–4.05
<i>Fs</i>		27.78–32.32		35.06–41.78		26.24–26.27		20.02–21.23



Figure 8. Habitat of *Leiurus nigellus* sp. nov. in Al Buriakah village, Al Ula Governorate, Al Madinah Al Monawwarah Province, Saudi Arabia.

Leiurus nigellus sp. nov. differs from all Arabian species of the genus *Leiurus* in many characters as indicated in the differential diagnosis. Its black colouration stands as the most distinctive and striking character, along with slenderness factor (*Fs*) that is quite different from other species. It ranged from 27.78–32.32 for *L. nigellus* sp. nov., as compared to 35.06–41.78 for *L. jordanensis*, 23.57–37.61 for *L. hadb*, 26.24–26.27 for *L. arabicus*, 20.02–21.23 for *L. haenggii* and 16.08–16.27 for *L. hebraeus*.

Lowe *et al.* (2014) stated that the genus *Leiurus* consists of a group of allopatric or parapatric species distributed across a wide geographical range, however they are separated by physical barriers, and predicted additional new species. The presence and description of new species across the Middle East; *L. abdullahbayrami* from Turkey (Yağmur *et al.*, 2009), *L. kuwaiti* (Lourenço, 2020) from Kuwait, *L. maculatus* from Iraq (Lourenço, 2022), and *L. sinai* from Sinai (Badry *et al.*, 2023) confirms predictions of Lowe *et al.* (2014).

Certainly, geological events that shaped the Middle East and the Arabian Peninsula played a major role in the evolutionary history of the genus *Leiurus*. These events, for example, created the Arabian shield that extends along the western Arabian Peninsula, the Arabian shelf that includes north and central Arabia reaching the Empty Quarter, the interior platform covering eastern Arabia and the basins to the south including Oman and the United Arab Emirates (Kent, 1978). Along with these events, microhabitats were formed to accommodate new species.

Badry *et al.* (2023) showed based on a molecular study that both *L. sinai* from Sinai and *L. hebraeus* from Jordan exhibited a monophyletic clade that is very distinct from other *Leiurus* species recorded from Saudi Arabia, Turkey and Oman with a range from 9.0–18.0%.

Further studies based on molecular analysis and morphological characteristics of new species of *Leiurus* should be continued to reveal the status of this ambiguous genus

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