Zoological Studies **65**:02 (2026)
doi:10.6620/ZS.2026.65-02

Zoological Studies

Open Access

Review of *Calocheiridius* Beier & Turk, 1952 (Pseudoscorpiones: Olpiidae) of Iran with Descriptions of Two New Species

Zahra Latifi[1], Mansour Aliabadian[1,2], and Omid Mirshamsi[1,2,*]

[1]*Department of Biology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran.*
**Correspondence: E-mail: mirshams@um.ac.ir (Mirshamsi)*
E-mail: latifi.za@mail.um.ac.ir (Latifi); aliabadi@um.ac.ir (Aliabadian)
[2]*Research Department of Zoological Innovations, Institute of Applied Zoology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran*

urn:lsid:zoobank.org:pub:47B1C57F-8FBA-4DFC-8698-DE61368A655E
Received 5 June 2025 / Accepted 22 December 2025 / Published 10 March 2026
Communicated by Jen-Pen Huang

The diversity of *Calocheiridius* Beier & Turk, 1952 in Iran is still thought to be uncommon; with only two species reported recently: *C. centralis* (Beier, 1952), and *C. iranicus* Nassirkhani, 2014. The current research is devoted to representatives of the genus *Calocheiridius* from Iran, and led to the identification and description of two novel species: *Calocheiridius rectilineatus* sp. nov. and *C. persicus* sp. nov. The novel species were differentiated from their relatives using molecular and morphological analyses, based mainly unique morphometric features, variations in the number of setae along tergite I and the posterior end of the carapace and, trichobothrial patterns, among others. Furthermore, these species exhibit a mitochondrial DNA *COI* K2P genetic distance that varies from 12.7% to 14% when compared to the nearest relative, *C. centralis*. Phylogenetic analyses utilising the mitochondrial *COI* gene and nuclear 28S rDNA, and molecular species delimitation methods, further support description of these new species as separate taxonomic entities. An updated interactive identification key for all species of the genus *Calocheiridius*, created using DELTA software and based on various numeric and multistate characters, is also provided.

Keywords: Interactive key, mtDNA, Morphology, ntDNA, Taxonomy

BACKGROUND

Pseudoscorpions inhabit diverse environments, including soil, decaying wood, leaf litter, beneath stones, and in nests of many birds and mammals and dark caves (Weygoldt 1969; Belozerov 2013; Prado and Ferreira 2024). Their minute size and restricted movement have led these arachnids to evolve various dispersal strategies, including phoresy and rafting (Weygoldt 1969; Poinar et al. 1998). Thought third in diversity among the orders within Arachnida, much less taxonomic and phylogenetic attention has been paid to them, thus emphasizing the need for further scientific investigation on this group (Benavides et al. 2019; Cameron and Buddle 2019). Currently, the order comprises 26 families with over 4,200 recognized species in 454 genera (World Pseudoscorpiones Catalog 2025).

The family Olpiidae Banks, 1895, is much more widespread and is typically found in arid environments under tree bark, stones, or in leaf litter (Harvey and Leng 2008). This family includes 24 extant genera and 211 valid species globally, with four genera and nine valid species are found in Iran (World Pseudoscorpiones Catalog 2025). The genus *Calocheiridius* under Olpiidae includes 30 valid species distributed across the Palaearctic and Oriental regions, alongside Eastern, Central, and Western Africa, and parts of south-eastern

Cittation: Latifi Z, Aliabadian M, Mirshamsi O. 2026. Review of *Calocheiridius* Beier & Turk, 1952 (Pseudoscorpiones: Olpiidae) of Iran with descriptions of two new species. Zool Stud **65**:02. doi:10.6620/ZS.2026.65-02.

and western Europe. Two *Calocheiridius* species have been reported from Iran, namely *Calocheiridius centralis* and *C. iranicus* Nassirkhani, 2014 (World Pseudoscorpiones Catalog 2025). *C. centralis* was initially misidentified as *Olpium pallipes* (Lucas, 1849) by Redikorzev (1949), but it was later accurately described by Beier (1952) based on specimens from Afghanistan, who established it as the type species of the genus *Minniza* under the name *M. centralis*. *C. iranicus* was described from Markazi province in central Iran (Nassirkhani 2014a).

DNA barcoding, the identification technique supported to pinpoint problematic, hard-to-identify species, uses as a molecular marker the mitochondrial cytochrome *c* oxidase subunit I gene (*COI*). Although morphological identification remains fundamental in pseudoscorpion taxonomy, it has several limitations. It often relies on minute and variable characters—particularly of the pedipalps and chelicerae—that can be altered by preservation methods or slide preparation (*e.g.*, Harvey 2014; Sakayori 2014). Such variation can obscure true species boundaries and mask cryptic diversity. To provide a more stable basis for species delimitation, DNA barcoding has become a key complementary tool (Ohira et al. 2018). Within arachnid taxonomy, DNA barcoding is being increasingly combined with morphological data to delimit novelties (Hebert et al. 2003; Moulds et al. 2007). Furthermore, investigations into arachnid systematics have demonstrated that *COI* and 28S ribosomal RNA (28S) serve as effective genetic markers (Hormiga et al. 2003; Cosgrov et al. 2016; Harvey 2023; Hlebec et al. 2023).

The principal aim of this research is to conduct a comprehensive review of the *Calocheiridius* species found of Iran. The specific objectives include the description of two novel species, *i.e.*, *Calocheiridius rectilineatus* sp. nov. and *C. persicus* sp. nov., based on morphological data complemented with two molecular markers, *COI* and 28S, and also with molecular species delimitation methods. Additionally, the study further seeks to generate an identification key to all *Calocheiridius* species by employing DELTA software, hence enabling the development of both traditional and interactive keys for identification purposes.

MATERIALS AND METHODS

Specimen collection and specimen examination

The selection of collection sites was informed by the geographical regions and specific habitats in which the species of to the genus are most probebly to be found (Fig. 1). In the course of this research, specimens were gathered using tweezers from beneath stones. Additionally, specimens inhabiting within the litter and soil also pulled out by employing a standard hand sieve. The specimens were maintained in an 80% ethanol solution in the field, and on arrival in the laboratory, one of the appendages—a chela or pedipalp—was amputated for the purpose of DNA extraction. This appendage was fixed straight away in absolute ethanol, and the remainder of the sample was left in a PCR tube in 75% ethanol.

Photograph of the specimens was taken using an Olympus DP-71 camera mounted on an Olympus SZH-10 stereomicroscope. specimens were then mounted on microscope slides for morphological identification. For adult specimens, the pedipalps, chelicerae, and the leg I and leg IV were resected, treated with 70% solution of lactic acid to enhance clarity, then

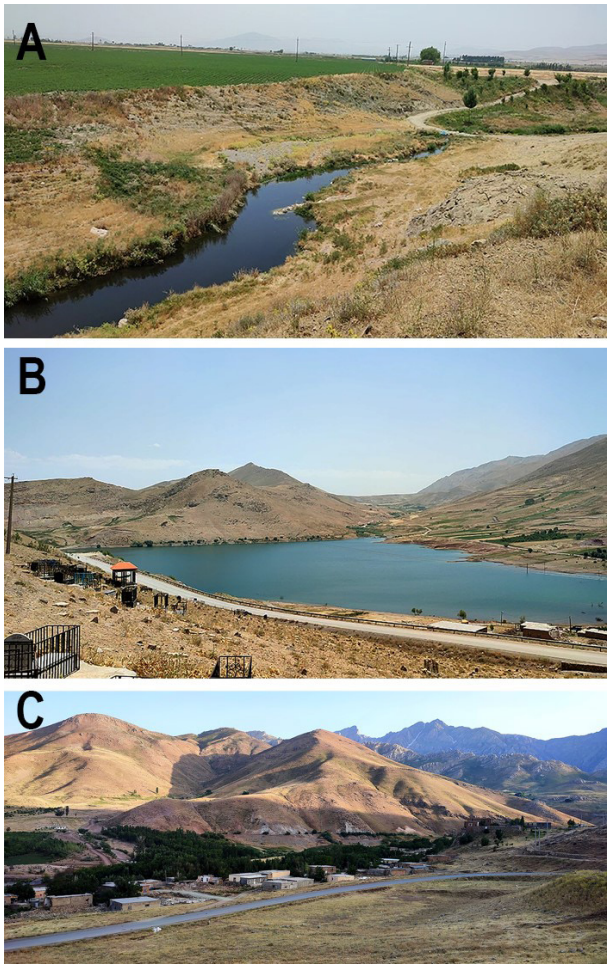

Fig. 1. Collecting sites of genus *Calocheiridius* of Iran. A) Markazi province, Shazand County, locality of *C. centralis*; B) Lorestan province, Azna County, Kamandan dam, type locality of *C. rectilineatus* sp. nov.; C) Lorestan province, Aligudarz County, type locality of *C. persicus* sp. nov.

mounted permanently on slides with Swann's medium. Observation and illustration were done with an Olympus CH–2 compound microscope fitted with a tube. All measurements were made in millimeters, utilising an Olympus micrometer ocular lens (OSM-4) attached on an Olympus SZ40 optical stereomicroscope.

Only adults specimens were taken into account in morphological measurements due to the difficulties in distingusging nymphs based on their morphological features and exactly identifying their species. Terminology and measurement standards were those of Chamberlin (1931), Harvey (1992), and Judson (2007). The specimens collected during our study have been kept in the pseudoscorpion collection of the Zoological Museum Ferdowsi University of Mashhad, Iran (ZMFUM).

To develop the species distribution maps, we employed QGIS version 3.16.14, incorporating point locality data from various collection sites as illustrated in figure 2.

Identification key

The entities mentioned in the character list are referred to as "items." Taxa or specimens are described based on characters, which are composed of a set of states. The DELTA software supports various kind of characters, including unordered and ordered multistate, integer numeric and real numeric. When you describe an item in code, it is necessary to record the values of the character states exhibited by the item, either for some or all of the characters. In DELTA, the state values that correspond to a particular item and character are known as attributes. Each character description begins with an attribute description. For multistate characters, this is followed by state descriptions. numeric characters, may require the definition of units (*e.g.*, "mm") for measuring the character (Dallwitz et al. 2006). We applied a variety of numeric and multistate characters in the traditional and interactive keys that we created with DELTA software programs. The genus *Calocheiridius* identification key made with the DELTA software relied on literature accounts of the type species for identifying the characteristic features of various species. Information available for certain species was sparse, so we evaluated additional species in conjunction with the type species (Table 1). In order to build a classical key, we found that 29 characters would suffice to differentiate between different taxa. Regarding external characters, a higher reliability value (8) is assigned, while a lesser value (1) is used for internal and challenging characters. Reliable characters are those state values that can be easily allocated to a specimen, allowing for a more accurate separation of taxa. For characters 1–29, the character reliability for the conventional key in DELTA was detailed as follows: 1,3; 2,5; 3–4,7; 5,1; 6–11,7; 12,8; 13–17,5; 18–27,7; 28–29,3. The reliability value for the interactive key was based on the default value of 5. For reliable characters, weights were allotted for identification; in the interactive key, these characters

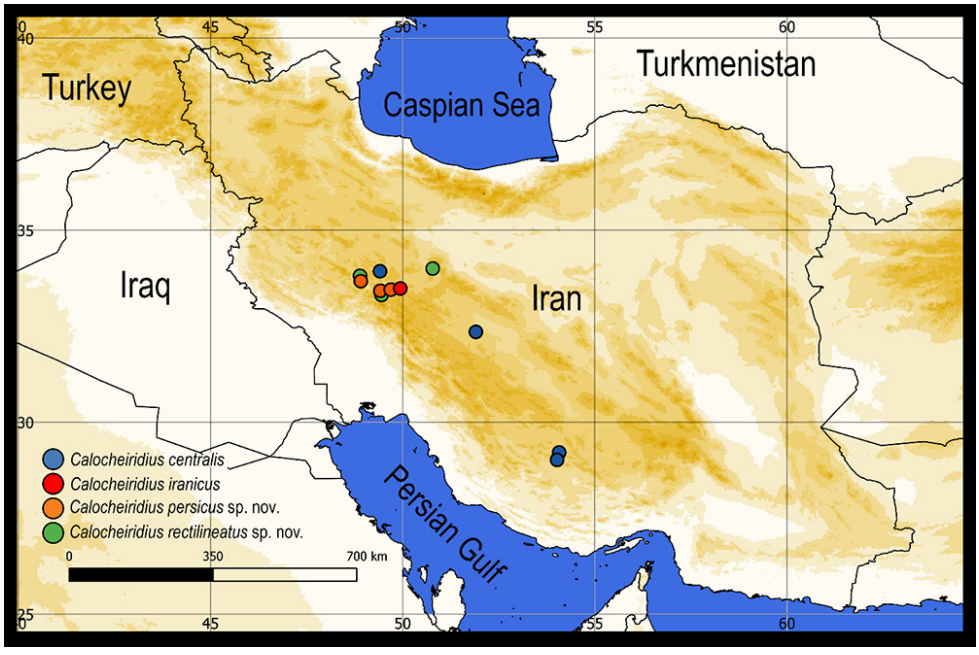

Fig. 2. Collecting localities of genus *Calocheiridius* in Iran. locality records were obtained from fieldwork and the literature. blue circles assessed to *C. centralis*; red circles assessed to *C. iranicus*; orange circles assessed to *C. persicus* sp. nov. and green circles assessed to *C. rectilineatus* sp. nov.

have priority.

DNA extraction, amplification and sequencing

Genomic DNA was extracted from a pedipalp or a chela according to the kit (Sinapure, Tehran, Iran). One nuclear locus, 28S rDNA, and one mitochondrial gene locus, cytochrome *c* oxidase subunit I, were conducted for sequencing. Total of 25 µl comprised of 3 µl template DNA, 8.5 µl of double-distilled water, 12.5 µl Master Mix, and 0.5 µl of primer: each forward and reverse at 10 µM concentration was used for PCR volume preparation. The *COI* gene fragment was amplified using the primers LCO1490 and HCO2198 (Folmer et al. 1994). The 28S rRNA gene fragment was amplified using the primers 28SpsF1 and 28SpsR1 (Murienne et al. 2008). Details of the primers and PCR conditions used for mitochondrial and nuclear gene amplification are summarized in table 2.

The thermal cycling conditions for both gene regions were as follows. For *COI*: initial denaturation at 95°C for 2 min; 35 cycles of denaturation at 94°C for 30 sec, annealing at 44°C for 90 sec, and extension at 72°C for 60 sec; followed by a final extension at 72°C for 5 min. For 28S: initial denaturation at 94°C for 5 min; 39 cycles of denaturation at 95°C for 1 min, annealing at 63°C for 1 min, and extension at 70°C for 1 min; followed by a final extension at 72°C for 7 min. The 13 sequences analysed in this study comprise both novel sequences and sequences from two outgroup species of the family Olpiidae downloaded from GenBank: *Beierolpium bornemisszai* Beier, 1966 and *Olpium pallipes* (Table 3).

Table 1. Cataloge of species of the genus *Calocheiridius* assessed for the creation of the identification key: (T) denotes species assessed from literature of the type species, (*) indicates species assessed from other literature due to limited information available for species, and (-) indicates species that could not be assessed due to insufficient information

Species assessed	References
Calocheiridius africanus Beier, 1955	(Mahnert 1982) *
Calocheiridius amrithiensis Sivaraman, 1980	(Sivaraman 1980) T
Calocheiridius antushi Krumpál, 1983	(Dashdamirov and Schawaller 1993) *
Calocheiridius badonneli Heurtault, 1983	(Heurtault and Rebiere 1983) T
Calocheiridius beieri (Murthy, 1960)	(Beier 1967) *
Calocheiridius braccatus Beier, 1959	(Mahnert 1982)*
Calocheiridius centralis (Beier, 1952)	(Beier 1952) T
Calocheiridius congicus (Beier, 1954)	(Beier 1954) T
Calocheiridius crassifemoratus Beier, 1955	_
Calocheiridius elegans Murthy &Ananthakrishnan, 1977	(Murthy and Ananthakrishnan 1977) T
Calocheiridius gabbutti Murthy &Ananthakrishnan, 1977	(Murthy and Ananthakrishnan 1977) T
Calocheiridius gracilipalpus Mahnert, 1982	(Mahnert 1982) T
Calocheiridius granulatus Sivaraman, 1980	(Sivaraman 1980) T
Calocheiridius hygricus Murthy &Ananthakrishnan, 1977	(Murthy and Ananthakrishnan 1977) T
Calocheiridius indicus Beier, 1967	(Beier 1967) T
Calocheiridius intermedius Sivaraman, 1980	(Sivaraman 1980) T
Calocheiridius iranicus Nassirkhani, 2014	(Nassirkhani 2014a) T
Calocheiridius libanoticus Beier, 1955	(Beier 1955) T
Calocheiridius loebli Beier, 1974	(Beier 1974a) T
Calocheiridius murthii Sivaraman, 1980	(Sivaraman 1980) T
Calocheiridius mussardi Beier, 1973	(Beier 1973) T
Calocheiridius nepalensis Beier, 1974	-
Calocheiridius olivieri (Simon, 1880)	(Heurtault 1981) *
Calocheiridius orientalis Murthy & Ananthakrishnan, 1977	(Murthy and Ananthakrishnan 1977) T
Calocheiridius persicus sp. nov	This study
Calocheiridius rectilineatus sp. nov.	This study
Calocheiridius rhodesiacus Beier, 1964	(Beier 1964a) T
Calocheiridius somalicus (Caporiacco, 1941)	(Mahnert 1982) *
Calocheiridius sulcatus Beier, 1974	(Beier 1974b) T
Calocheiridius termitophilus Beier, 1964	(Beier 1964b) T
Calocheiridius viridis Murthy & Ananthakrishnan, 1977	(Murthy and Ananthakrishnan 1977) T

Molecular data analyses

Genetic sequences were initialy aligned using the MAFFT v.7.463 tool followed by edits performed with BIOEDIT v.7.2 software (Hall 1999). To identify variable sites within the sequence alignments, we used DnaSP 5 software (Rozas et al. 2003). The genetic distance for each gene was computed through MEGA X (Kumar et al. 2018) with the Kimura two-parameter (K2P) model. Analysing the optimal nucleotide substitution model by Akaike Information Criterion (AIC) in jModelTest v.2 (Posada 2008) was performed. According to AIC the TVM+G model was most suitable for analysis mitochondrial and nuclear markers. The Maximum Likelihood (ML) analyses were performed using RAxML version 7.2.6 with 1,000 bootstrap replicates, and BI was performed using MrBayes version 3.2.7, with two independent MCMC runs that totaled 30 million generations. Bayesian tree, along with their posterior probabilities were derived through a majority-rule consensus. After the burn- in phase, initial 25% of trees were excluded, the remaining data was consolidated to construct a 50% majority-rule consensus tree.

Molecular species delimitation

To delimit species using DNA data, two approaches using distance matrices of *COI* alignments and a single approach based on the *COI* phylogenetic tree were employed. The initial two methods derived genetic distance matrices from the *COI* alignments utilising Kimura's 2-parameter model as input for Assemble Species by Automatic Partition (ASAP, Puillandre et al. 2021) and Automatic Barcode Gap Discovery (ABGD, Puillandre et al. 2012). ABGD was performed at ABGD Web with parameters: P_{min} = 0.001, P_{max} = 0.1, steps = 100, X = 1.5, and Nb bins = 100. ASAP species delimitation was performed at ASAP Web, focusing on models with the minimum ASAP score. Rrgarding the tree-based approach, a Bayesian framework of the multi-rate Poisson tree process (mPTP, Kapli et al. 2017) was utilised at mPTP Web.

Table 2. Primers used for the amplification and sequencing of the COI and 28S rRNA gene fragments in this study

Gene region	Primer name	Primer (5'–3')	Annealing temperature
COI	LCO1490	GGTCAACAAATCATAAAGATATTGG	44°C
	HCO2198	CTAAACTTCAGGGTGACCAAAAAATCA	
28S	28SpsF1	ATTACCCGCCGAATTTAAGC	63°C
	28SpsR1	TCGGAGGGAACCAGCTAC	

Table 3. Samples collected and specimens utilising in the molecular analysis, along with their GenBank accession numbers

Species	Location	Latitude (N)	Longitude (E)	Voucher	Accession number 28s	Accession number *COI*
C. centralis	Markazi, Shazand	33°55'58.89"	49°24'24.29"	ZMFUM-PSC 1143		PX943889
				ZMFUM-PSC 1144	PX956673	PX943890
				ZMFUM-PSC 1165		PX943891
C. rectilineatus	Markazi, Naragh	34°00'15.25"	50°46'58.96"	ZMFUM-PSC 11139		PX943887
	Lorestan, Azna	33°18'47.13"	49°26'47.50"	ZMFUM-PSC 11132		PX943884
				ZMFUM-PSC 11133		PX943886
				ZMFUM-PSC 11137	PX956674	PX943888
	Lorestan, Borujerd	33°48'50.69"	48°53'20.82"	ZMFUM-PSC 11134		PX943885
C. *persicus*	Lorestan, Azna	33°25'11.4"	49°25'00.15"	ZMFUM-PSC 11155		PX943882
	Lorestan, Aligudarz	33°27'10.15"	49°41'14.03"	ZMFUM-PSC 11142		
				ZMFUM-PSC 11145	PX956675	PX943880
	Lorestan, Dorud	33°40'14.07"	48°54'39.32"	ZMFUM-PSC 11146		PX943881
Beierolpium bornemisszai	Australia	-	-	DNA103129	EU559486	EU559545
Olpium pallipes	-	-	-	-	ON950306	ON842076

RESULTS

Genetic diversity and Phylogenetic analysis

COI DNA sequences (635 bp) revealed 196 variant sites, while the 28S gene (510 bp), displayed 51 variant positions. No stop codons or gaps were detected in the final alignment. The ML and BI phylogenetic trees, based on mtDNA (*COI*) and nuclear (28S) genes, exhibited congruent topology, with minor variations in their support values (Fig. 3).

Clade A, comprising samples from *Calocheiridius rectilineatus* sp. nov., Clade B comprising samples from *C. centralis* and Clade C comprising samples from *C. persicus* sp. nov. These Clades represents three distinct species with well supported (Fig. 3).

Molecular species delimitation methods, including ABGD, ASAB, and mPTP, indicate that *Calocheiridius rectilineatus* sp. nov. and *C. persicus* sp. nov. are genetically distinct species from *C. centralis*, according to the phylogenetic analysis (Fig. 3).

Genetic distances

Regarding the *COI* gene, the average K2P genetic distance between the species of clades A and B is 14.0% ± 17.0 S.E., between the species of clades A and C is 12.7% ± 16.0 S.E., and between the species of clades B and C is 13.8% ± 17.0 S.E. (Table 4). For the nuclear 28S gene, the average K2P genetic distance is significantly lower than that of the mitochondrial markers. Concerning the 28S gene, the average genetic distance between the species of clades A and B is 2.8%, between the species of clades A and C is 2.4%, and between the species of clades B and C is 3.8%.

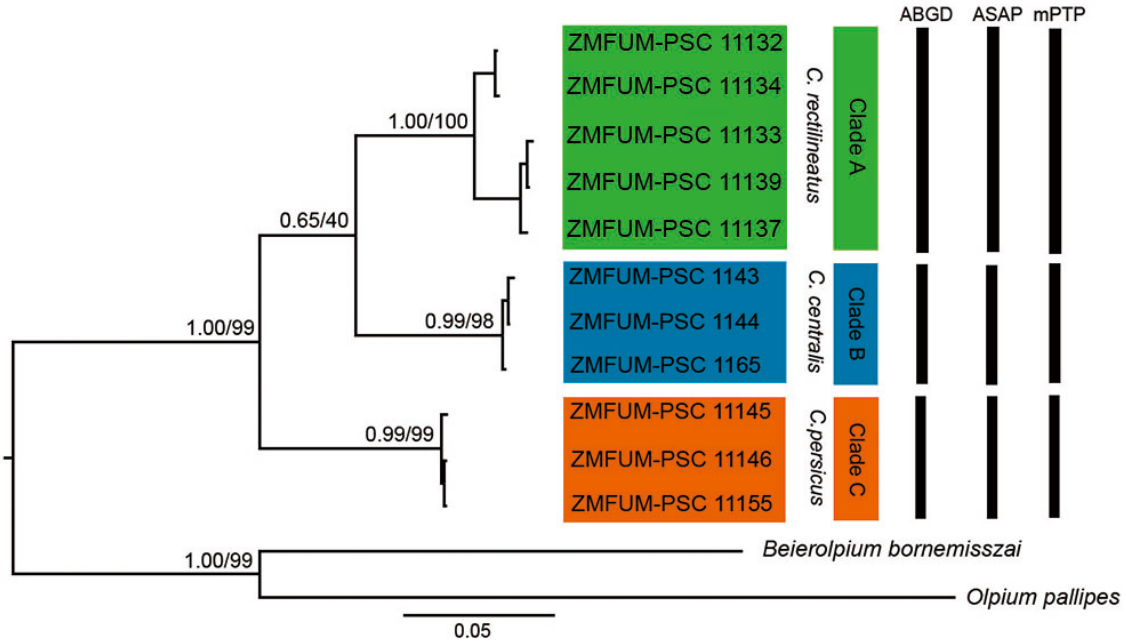

Fig. 3. Bayesian Inference phylogeny of *Calocheiridius centralis*, *C. rectilineatus* sp. nov., *C. persicus* sp. nov. and the outgroups, *Beierolpium bornemisszai* and *Olpium pallipes* based on 1145 bp aligned nucleotide of nuclear and mitochondrial DNA showing the results of species delimitation algorithms. The vertical bars indicate species delimitation analyses; Nodal support values above branches represent posterior probability values from Bayesian Inference and bootstrap values from Maximum likelihood analyses, respectively.

Table 4. Pairwise divergence values (K2P) for *COI*

Species	*Beierolpium bornemisszai*	*C. centralis*	*C. rectilineatus*	*C. persicus*
C. rectilineatus	0.127			
C. centralis	0.138	0.140		
Beierolpium bornemisszai	0.253	0.279	0.274	
Olpium pallipes	0.288	0.284	0.280	0.243

TAXONOMY

Phylum: Arthropoda; Gravenhorst, 1843
Class: Arachnida; Lamarck, 1801
Order: Pseudoscorpiones; De Geer, 1778
Family Olpiidae Banks, 1895
Subfamily Olpiinae Banks, 1895
Genus Calocheiridius Beier and Turk, 1952
Type Genus: *Calocheiridius mavromoustakisi* Beier and Turk, 1952

Diagnosis: The genus *Calocheiridius* is identified through a a distinctive set of these traits: Carapace with or without a distinct median transverse furrow; tergites are somewhat sclerotised, whereas the initial ones are only weakly sclerotised, undivided; the chelicerae have all five setae, subapical tooth in movable finger of the chelicera is separated into two lobes; pseudotactile setae are located on the palpal femur, with one situated subasally and the other located distally from the middle; the location *ib* is unusually positioned, typically proximally close to end of the finger in particular cases; trichobothria *eb*, *esb*, and *isb* cluster together at the end of the finger; *est* is positioned at a similar level as it or is situated somewhat distally to it; regarding the movable finger trichobothria, the location of *st* is proximal and much further away from *t*, forming a cluster with *sb* and *b*; In the fixed finger, the nodus ramosus is situated distally to *et*; on leg I, patella is somewhat shorter than the femur, and the arolia are simple (summarized in Beier and Turk 1952; Sivaraman 1980; Dashdamirov and Schawaller 1993).

Calocheiridius centralis (Beier, 1952)

(Figs. 4A–C; 5A–F)

Material examined: 3 male. Markazi province, Shazand County, Iran, September 6, 2022. ZMFUM-PSC-1143,1144,1165; 33°55'58.89"N, 49°24'24.29"E; 1905 m a.s.l; Z. Latifi leg; Under stone.

Type locality: Afghanistan, Kabul, Paghman.

Type repository: ZMUC.

Distribution: *Calocheiridius centralis* is widely distributed throughout the Palearctic and Oriental regions. This species is throughout central Asia. It was reported from Afghanistan, Azerbaijan, India, Iran, Pakistan, Turkmenistan, and Uzbekistan (World Pseudoscorpiones Catalog 2025).

Description: *Carapace*. reddish brown, the posterior end is slightly lighter in colour compared to the anterior margin; absolutely smooth; L/W 1.23–1.25 mm; possessing two pairs of corneate eye; posterior transverse furrow indistinct, the setae are simple and acute, following the pattern of 4:4:4:4:2:4, with 12 lyrifissures (Fig. 5A).

Tergites: yellowish brown; lighter than carapace; undivided; tergite IX with two long setae; tergite X and XI with four tactile setae; chaetotaxy: 2:2:4:4:6:4:4–5:4:5–6:8:10:2.

Sternites: smooth; lightly sclerotized; sternite X and XI with four tactile setae; chaetotaxy: 8:4:4:4:4:4:4–5:4:6:8:10:2.

Chelicera: brown; hand with all five setae; galea possessing three rami (two apical and one sub-apical rami); rallum with three blades, distal one largest; fixed finger with six teeth, the apical one short and pointed, followed by larger medial tooth, terminal teeth short and blunt; single curved apical lobe and two pointed sub-apical teeth on the movable finger (Fig. 5B); serrula exterior with 17–18 blades.

Pedipalps: reddish brown; distinctly lighter than carapace; chela slightly darker than the other segments; femur and patella completely smooth; trochanter with dorsal hump; femur with two pseudotactile setae (Fig. 5C); chela distinctly granulated; chela with distinct pedicel; movable finger noticeably shorter than hand (including pedicel); fixed chelal finger with 23–26 cusped teeth followed by 6–7 indistinct teeth; movable

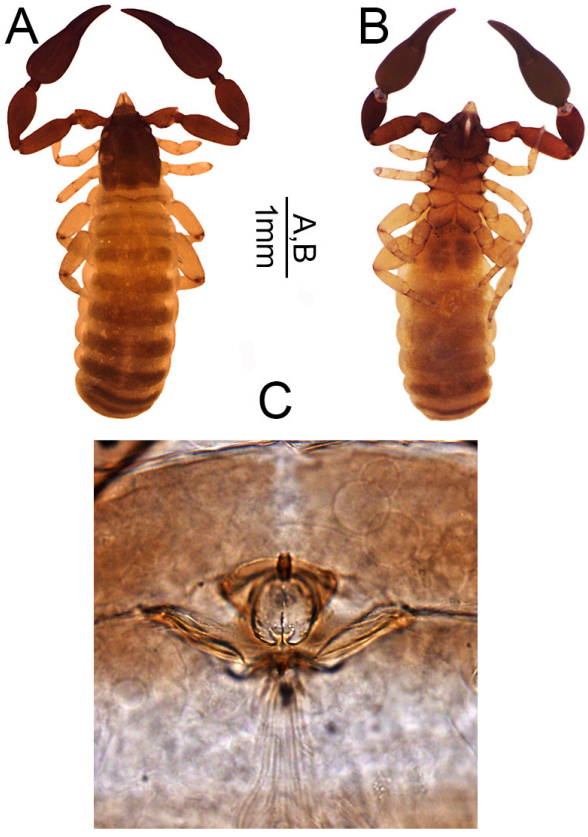

Fig. 4. Male *C. centralis*: A) Dorsal view; B) Ventral view; C) Male genitalia, ventral view.

chelal finger with 23–26 cusped teeth (Fig. 5D); nodus ramosus in the movable finger distinctly distal to *t*, in the fixed finger clearly proximal to *et*; femur L/W 2.52–2.70 ×; patella L/W 2.87–3.0 ×; hand (including pedicel) L/W 1.70–1.96 ×.

Trichobothriotaxy: fixed finger with eight trichobothria, movable with four; trichobothria *eb*, *esb*, and *isb* grouped near the end of the finger; *isb* positioned on retrolateral aspect of finger; *ist* positioned anterior to *isb*; *ist* situated nearer to *ib* than to *it*; *et* situated near tip of finger; *it* somewhat situated at a similar level as *est*; trichobothrium *est* situated posterior to *et*; trichobothrium *est* situated nearer to *it* than to *et*; movable finger with trichobothrium *sb* approximately situated between *b* and *st* with formed a triangle cluster; *t* positioned between *st* and tip of finger; venom ducts short; nodus ramosus positioned anterior to *et* in the fixed finger (Fig. 5E).

Legs: brown; noticeably lighter in colour compared to body; smooth; claws stout, short and symmetric; arolium plain and more elongated than claws; Leg I femur L/W 1.70–1.80 ×; patella L/W 1.45–1.54 ×; tibia L/W 2.10–2.22 ×; basitarsus L/W 2.0–2.20 ×; telotarsus L/W 2.20–2.40 ×; Leg IV femur+ patella L/W 2.17–2.18 ×; tibia L/W 3.40–3.50 ×; basitarsus L/W 2.14–2.28 ×; telotarsus L/W 2.28–2.42 ×.

Measurements (mm): Body length: 2.49–2.53; Carapace: 0.52–0.55/0.42–0.44; Pedipalp: trochanter 0.26–0.29/0.21–0.24; femur 0.46–0.48/0.17–0.19; patella 0.45–0.46/0.15–0.16; chela (with pedicel) L.

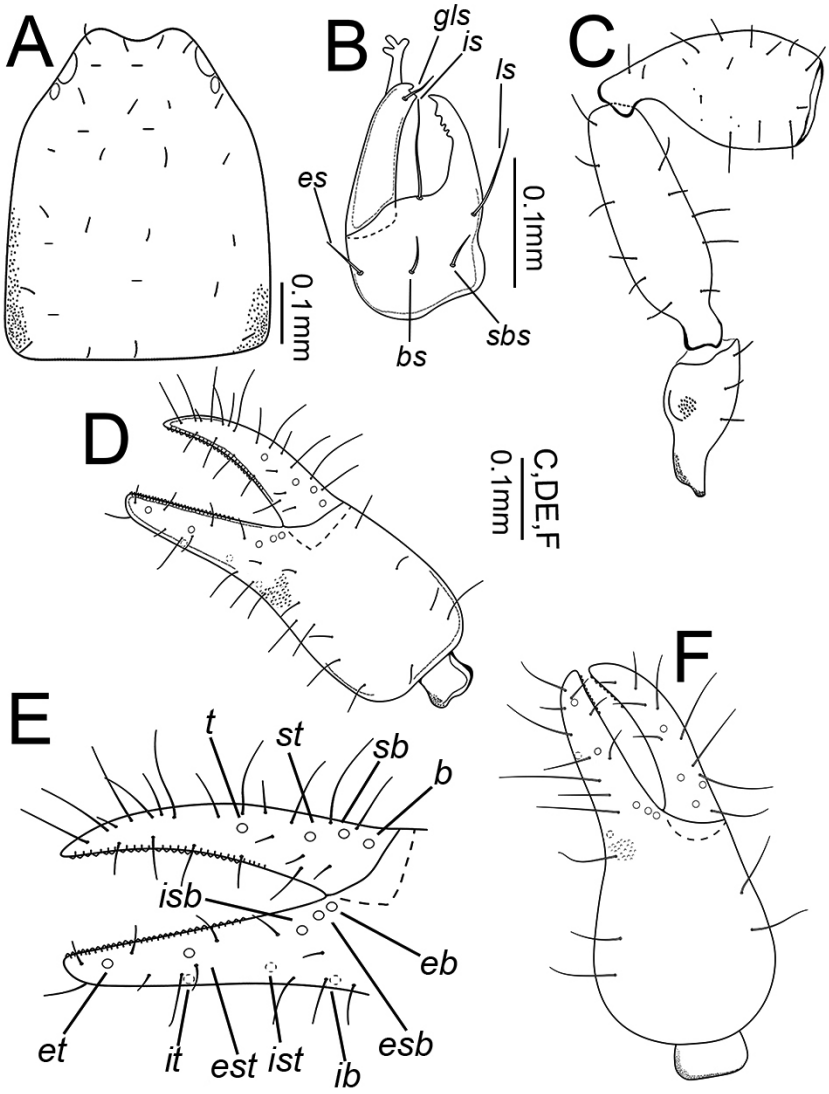

Fig. 5. Male *C. centralis*. A) Carapace, dorsal view; B) Left chelicera, dorsal view; C) Right pedipalp, dorsal view; D) Right pedipalpal chela, lateral view; E) Right pedipalpal chela with the trichobothrial pattern, lateral view; F) Holotype, ♀ from Afghnistan (ZMUC), pedipalpal chela with the trichobothrial pattern, lateral view.

0.81–0.85; hand (with pedicel) 0.49–0.51/0.25–0.30; movable finger L. 0.35–0.37; Leg I: femur 0.17–0.18/0.10; patella 0.16–0.17/0.11; tibia 0.20–021/0.09–0.10; basitarsus 0.10–0.11/0.05; telotarsus 0.11–0.12/0.05; Leg IV: femur + patella 0.48–0.50/0.22–0.23; tibia 0.34–0.35/0.10; basitarsus 0.15–0.16/0.07; telotarsus 0.16–0.17/0.07.

Remarks: The *Calocheiridius centralis* specimens examined in this study were found to be morphologically congruent with the type specimen from Afghanistan (ZMUC), mainly in terms of their setal number on the posterior margin of carapace and tergite I (Table 5), shape of the pedipalps, and trichobothrial patterns. *it* situated at a similar level as *est*; trichobothria *b*, *sb*, and *st* in the movable finger formed a triangular cluster, with *sb* positioned between *b* and *st* just as in the type specimen (Fig. 5E, F). In contrast, specimens studied from Central Asia evidence a very different distribution of trichobothria, which *it* located anterior to *est* (cf. Dashdamirov and Schawaller 1993: figs. 6; 7).

Calocheiridius iranicus Nassirkhani, 2014

(Fig. 6A–E)

Material examined: *Holotype*: 1 Male. Markazi province, Deh-e-No, Khorzan Village, Iran, September, 2013. M. Nassirkhani leg.; leaf litter.

Paratype: 1 Male. collected together with holotype. Type repository; IAUA.

Diagnosis: *Calocheiridius iranicus* is set apart from others within its genus by several characteristics: posterior end of carapace and tergite I has two setae; the surface of the chelal hand features distinct granules, while other pedipalpal podomeres completely smooth; pedipalpal femur possessing three pseudotactile; *it* is situated anterior to *est*; *ist* positioned at a similar level as *isb*; *ib* situated posterior to *eb*; fixed finger has 22–23 teeth and movable finger has 25–27 teeth; size of the pedipalp: femur L/W 2.68–2.80 ×; patella L/W 1.22–2.26 ×, chela L. (including pedicel) 0.75–0.76 mm, hand (including pedicel) L/W 1.72–1.90 ×, movable chelal finger L. 0.36–0.38 mm.

Distribution: Central Iran

Description: *Carapace.* dark brown; completely smooth; longer than broad; L/W 1.43–1.45 ×; possessing two pairs of corneate eye; the setae are simple and acute; arranged: 4:6:4:4:2:2 (Fig. 6A).

Tergites: smooth; undivided and sclerotized; lighter in colour than carapace; setae simple and acute; tergites X and XI with two tactile setae; chaetotaxy: 2:4:4:4:4:4:4:4:6:6:8:2.

Sternites: Smooth, poorly sclerotized; sternite X and sternite XI with four long tactile setae; chaetotaxy: 8–9:5–6:5:4:4:4:4:4:4:4:6:9:2.

Chelicera: brown; hand with five setae; galea with three rami (two apical and one sub-apical rami); rallum possessing three blades, distal one widest with short lateral denticulations; serrula exterior possessing 17–19 blades; fixed finger with five teeth, with larger medial tooth and terminal teeth short and blunt; single curved apical lobe and two pointed sub-apical teeth on the movable finger (Fig. 6B).

Pedipalps: Brown, distinctly lighter in colour than carapace, chela darker than other segmentes; hand granulated, other podomeres completely smooth; trochanter with dorsal hump, all setae simple; femur with three pseudotactile setae (Fig. 6C); chela with distinct pedicel; movable finger distinctly shorter than hand (including pedicel); fixed finger with 22–23 and movable finger with 25–27 teeth (Fig. 6D); venom ducts short in both fingers; nodus ramosus in movable chelal distal to *t*, in fixed chelal finger clearly proximal to *et*; femur L/W 2.68–2.80 ×; patella L/W 1.22–2.26 ×; hand (including pedicel) L/W 1.72–1.90 ×.

Trichobothriotaxy: fixed finger with eight trichobothria,movable finger with four; fixed finger trichobothria *eb*, *esb*, and *isb* grouped at the end of the fixed finger; *ib* situated posterior to *eb* on the end of finger; *ist* nearer to *ib* than *it*; *ist* situated at a similar level as *isb*; *est* situated posterior to *et*; *it* situated

Table 5. Morphological measurements (in millimeters) alongside pattern of setae in the species *Calocheiridius centralis*

	Pedipalp			Chaetotaxy		
C. centralis	Pedipalpal femur	Tergit I	PM of carapace	Hand with pedicle (L/W)	Chela with pedicle (L/W)	Femur (L/W)
Holotype	3.00 ♀	3.20 ♀	–	4	2	2
Iranian specimens	2.50–2.88 ♂	2.90–3.56 ♂	1.67–2.04 ♂	4	2	2
(Nassirkhani 2016a)	2.61–2.63 ♀	2.83–2.87 ♀	1.66–1.67 ♀			
Present study	2.52–2.70 ♂	2.83–3.24 ♂	1.70–1.96 ♂	4	2	2

PM = posterior margin.

anterior to *est*; *et* situated nearer to tip of finger; movable finger with trichobothrium *st* nearer to *sb* than *t*; *st* situated posterior to *t* (Fig. 6D).

Legs: Light brown; lighter in colour than body; smooth; all setae simple and acute; claws symmetrical, stout and short; arolium plain and more elongated than claws (Fig. 6E). Leg I femur L/W 2.0–2.25 ×; patella L/W 1.66–1.75 ×; tibia L/W 2.85 ×; basitarsus L/W 1.60–1.80 ×; telotarsus L/W 1.80–2.0 ×; Leg IV femur + patella L/W 3.25–3.90 ×; tibia L/W 3.11–3.40 ×; basitarsus L/W 2.40–2.60 ×; telotarsus L/W 3.50 ×.

Measurements (mm): Body length: 2.07–2.17; Carapace: 0.53–0.54/0.37; Pedipalp: trochanter 0.26–0.27/0.13–0.14; femur 0.42–0.43/0.15–0.16; patella 0.40–0.43/0.18–0.19; chela L. (with pedicel) 0.75–0.76; hand (with pedicel) 0.42–0.43/0.22–0.25; movable finger L. 0.36–0.38; Leg I: femur 0.16–0.18/0.08; patella 0.14–0.15/0.08–0.09; tibia 0.20/0.07; basitarsus 0.08–0.09/0.05; telotarsus 0.09–0.10/0.05; Leg IV: femur + patella 0.39–0.52/0.10–0.16; tibia 0.28–0.31/0.09; basitarsus 0.12–0.13/0.05; telotarsus 0.14/0.04.

***Calocheiridius rectilineatus* sp. nov.**

(Figs. 7A–D; 8A–F)

urn:lsid:zoobank.org:act:E19DFE05-6673-43E2-AD59-2FEA8C8F8E11

Material examined: *Holotype*: 1 Male. Lorestan province, Azna County, Kamandan dam, Iran, July 18, 2023. ZMFUM-PSC 11132; 33°18'47.13"N, 49°26'47.50"E; 2066 m a.s.l; Z. Latifi leg.; under stone.

Paratype: 2 Male. collected together with holotype. ZMFUM-PSC 11133, 11137.

Other material studied: 1 Female. Lorestan

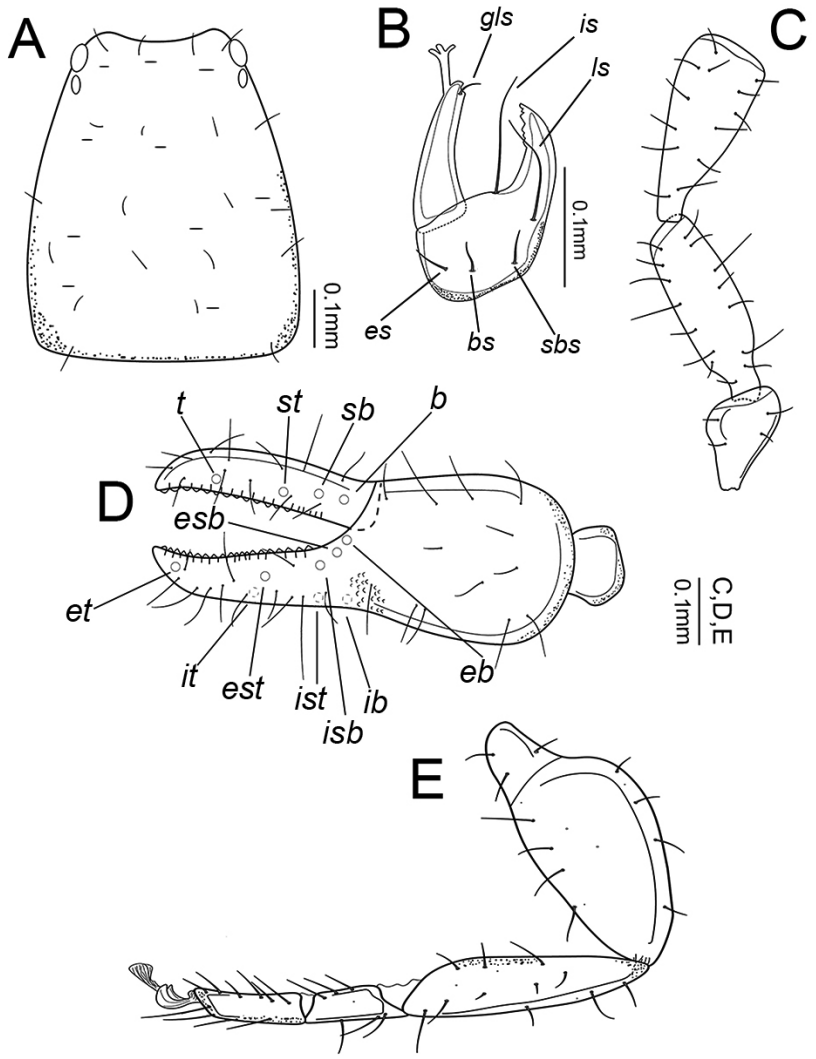

Fig. 6. Male *C. iranicus*. A) Carapace, dorsal view; B) Left chelicera, dorsal view; C) Left pedipalp, dorsal view; D) Left pedipalpal chela with the trichobothrial pattern, lateral view; E) Right leg IV, dorsal view.

province, Borujerd County, Deh Kord village, Iran, July 21, 2023. ZMFUM-PSC 11134; 33°48'50.69" N, 48°53'20.82"E; 1764 m a.s.l; Z. Latifi leg.; leaf litter; 1 Male. Markazi province, Naragh County, Iran, July 23, 2023. ZMFUM-PSC 11139; 34°00'15.25"N, 50°46'58.96"E; 1744 m a.s.l; Z. Latifi leg.; under stone.

Diagnosis: *Calocheiridius rectilineatus* sp. nov. is clearly differentiated from other species within its genus by these distinguishing characteristics: the posterior margin of the carapace with four setae; tergite I with two setae; the surface of the trochanter slightly granulated, pedipalpal femur, and patella is smooth and the chelal hand with distinct granules; *it* is located at a similar level as *est*; *ist* located at a similar level as *isb*; in the movable finger of chela, *sb* located between *b* and *st* and formed a triangle cluster; fixed finger has 28–29 teeth; movable finger has 29–30 teeth; size of the pedipalp is as follows: femur L/W 2.45–2.47 × (2.20 × in female); patella L/W 2.12–2.17 × (2.30 × in female); chela (including pedicel) L. 0.94–0.97 (1.10 in female) mm; hand (including pedicel) L/W 1.52–1.78 × (1.63 × in female); movable finger L. 0.46–0.48 (0.48 in female) mm.

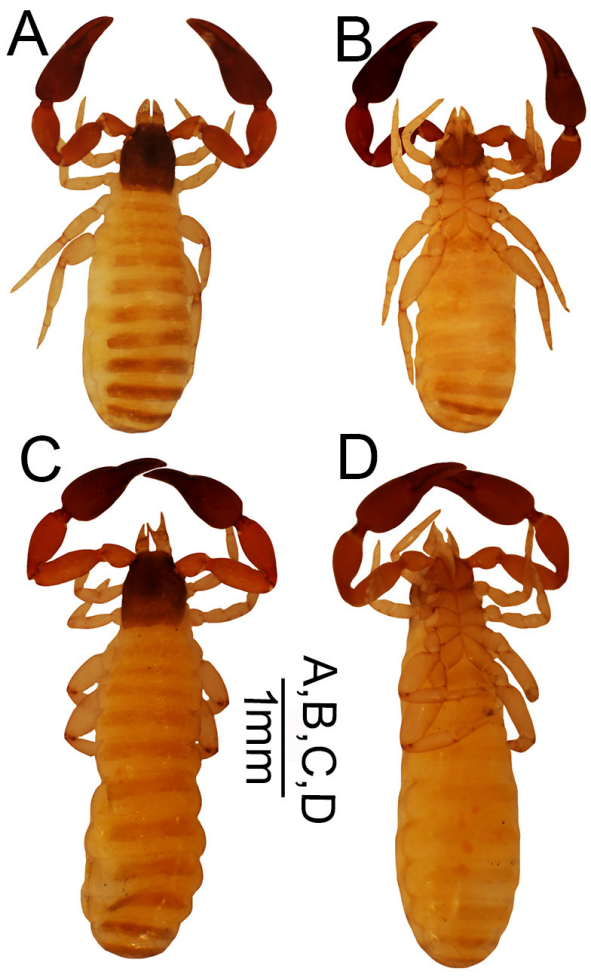

Fig. 7. Male *C. rectilineatus* sp. nov. A) Dorsal view; B) Ventral view; Female *C. rectilineatus* sp. nov. C) Dorsal view; D) Ventral view.

Etymology: The particular name is rooted in a the combination of Latin words rectus, meaning straight, and linea, meaning line. This indicates that the trichobothrium *it* is positioned at a simiar level as *est*, similarly *ist* is situated at a similar level as *isb*.

Distribution: Central, and Western Iran.

Description: Carapace. reddish brown; absolutely smooth; L/W 1.02–1.03 × (1.07 × in female); with two pairs of corneate eye, anterior eyes noticeably larger than posterior; posterior transverse furrow indistinct; setae simple and acute, following the pattern of 4:4:2:4:4:4, with 12 lyrifissures (Fig. 8A).

Tergites: yellowish brown; lighter than carapace; tergite X with four tactile setae; tergite XI with six tactile setae; chaetotaxy: 2:2:4:4:6:4–5:4:4–5:6:10:8:2.

Sternites: entirely smooth; lightly sclerotized; sternite X and XI with four tactile setae; chaetotaxy: 4:4:4:4:4–5:4:4:4:7–8:8:10:2. Coxa I with 4–5 setae, coxa II 5–6, coxa III with 5–7 setae, coxa IV with 8–10 setae (Fig. 8B).

Chelicera: brown; galea with three rami (two apical and one sub-apical rami); hand with five setae; rallum possessing three blades, distal one largest; fixed finger possessing six teeth, the first one short and pointed, followed by larger medial tooth, terminal teeth short and pointed; single curved apical lobe and two pointed sub-apical teeth on the movable finger (Fig. 8C); serrula exterior with 18 blades.

Pedipalps: reddish brown; distinctly lighter than carapace; trochanter granulated, femur and patella smooth; trochanter with dorsal hump; femur with two pseudotactile setae (Fig. 8D); chela distinctly granulated; movable finger distinctly shorter compared to hand (including pedicel); fixed finger has 28–29 teeth; movable finger has 29–30 teeth; in movable finger (Fig. 8E); nodus ramosus located distinctly distal to *t* while in the fixed finger it is clearly proximal to *et*. femur L/W 2.45–2.47 × (2.20 × in female); patella L/W 2.12–2.17 × (2.30 × in female); hand (including pedicel) L/W 1.52–1.78 × (1.63 × in female).

Trichobothriotaxy: fixed finger bears eight trichobothria while movable one carries four; fixed finger trichobothria *eb*, *esb*, and *isb* grouped near the end of the finger; *esb* positioned closer to *isb* than *eb*; *ib* positioned somewhat posterior to *eb*; *ist* closer to *ib* than *it*; *ist* located at a similar level as *isb*; *est* situated at a similar level as *it*; *et* located near tip of finger; in the movable finger, *sb* positioned between *b* and *st* and formed a triangle cluster; *st* located near *sb* compared to *t*; *st* situated posterior to *t*; trichobothrium *t* positioned

approximally near tip of finger than *st* (Fig. 8F).

Legs: brown; noticeably lighter than body; smooth; claws almost stout and symmetric; arolium plain and more elongated than claws.

Leg I femur L/W 2.0 × (1.73 × in female); patella L/W 1.69–1.76 × (1.78 × in female); tibia L/W 2.70–2.88 × (2.60 × in female); basitarsus L/W 2.40–2.60 × (2.0 × in female); telotarsus L/W 2.60–2.80 × (2.16 × in female); Leg IV femur + patella L/W 1.85–1.92 × (2.26 × in female); tibia L/W 2.06–2.12 × (2.18 × in female); basitarsus L/W 2.83–3.0 × (2.25 × in female); telotarsus L/W 2.83–3.0 × (2.37 × in female).

Measurements (mm): Body length: 2.50–3.0 (3.50 ♀); Carapace: 0.50–0.53/0.49–0.51 (0.60/0.56 ♀); Pedipalp: trochanter 0.25–0.27/0.20–0.22 (0.25/0.22 ♀); femur 0.52–0.54/0.21–0.22 (0.55/0.25 ♀); patella 0.50–0.53/0.23–0.25 (0.53/0.23 ♀); chela L. (including pedicel) 0.94–0.97 (1.10 ♀); hand (including pedicel) 0.50–0.52/0.28–0.34 (0.54/0.33 ♀); movable finger L. 0.46–0.48 (0.48 ♀); Leg I: femur 0.24–0.26/0.12–0.13 (0.26/0.15 ♀); patella 0.22–0.23/0.13 (0.25/ 0.14 ♀); tibia 0.26–0.27/0.09–0.10 (0.26/0.10 ♀); basitarsus 0.12–0.13/0.05 (0.12/0.06 ♀); telotarsus 0.13–0.14/0.05 (0.13/0.06 ♀); Leg IV: femur + patella 0.48–0.50/0.25–0.27 (0.52/0.23 ♀); tibia 0.33–0.34/0.16 (0.35/0.16 ♀); basitarsus 0.17–0.18/0.06 (0.18/0.08 ♀); telotarsus 0.17–0.18/0.06 (0.19/0.08 ♀).

Remarks: *Calocheiridius rectilineatus* sp. nov. was compared with its morphologically most similar and geographically closest known congeners.

Calocheiridius rectilineatus sp. nov. differs from *C. antushi* by the presence of granules on the chela of

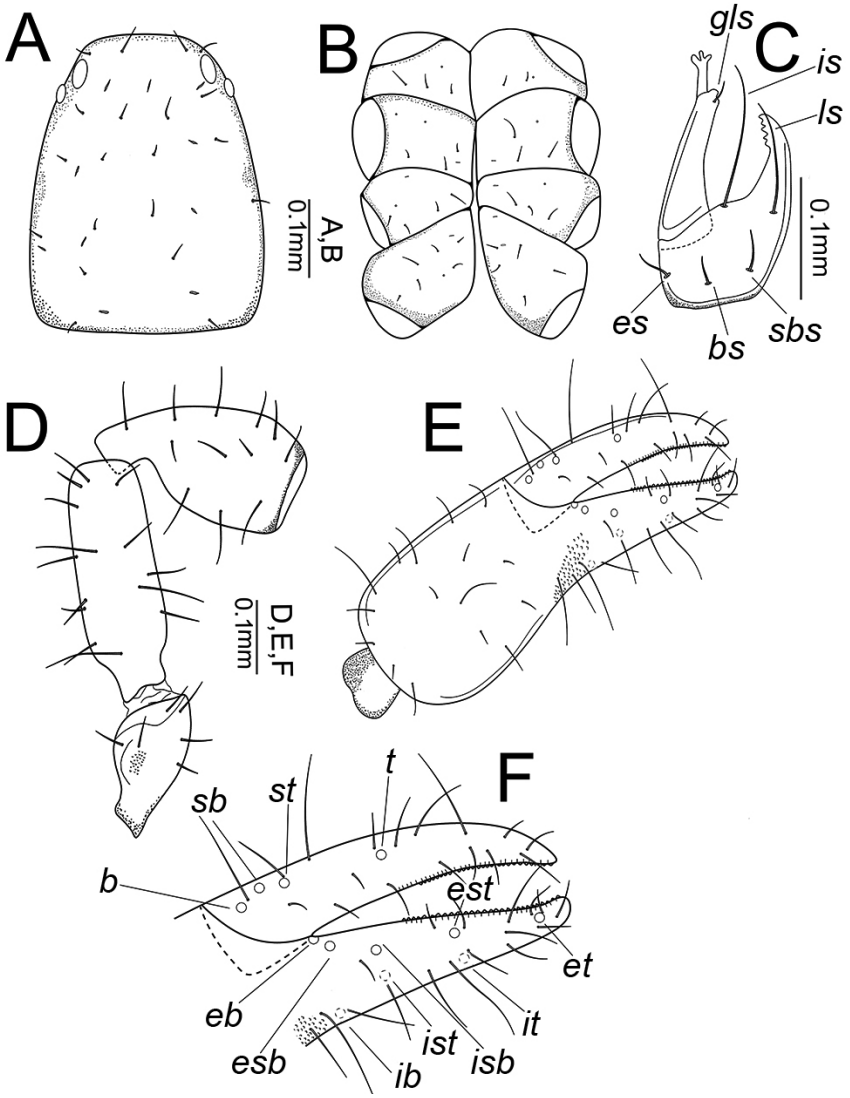

Fig. 8. Male *C. rectilineatus* sp. nov. A) Carapace, dorsal view; B) Coxa, ventral view; C) Left chelicera, dorsal view; D) Left pedipalp, dorsal view; E) Left pedipalpal chela, lateral view; F) Left pedipalpal chela with the trichobothrial pattern, lateral view.

the pedipalps (smooth in *C. antushi*); the position of the fixed finger trichobothrium *ist*, which is same level with *isb* (*ist* located anterior to *isb* in *C. antushi*); stouter pedipalpal femur with a length/width ratio of 2.45–2.47 (more slender femur with a ratio of 4.04 in *C. antushi*); having four setae on the posterior margin of carapace (compared to only two setae in *C. antushi*).

The new species most closely resembles *Calocheiridius centralis* by having four setae on the posterior margin of carapace and two setae on tergite I; trichobothrium *est* situated at a similar level as *it*; on the movable finger of the chela, *sb* located between *b* and *st*, forming a triangular cluster.

Calocheiridius rectilineatus sp. nov. differs from *C. centralis* in the position of trichobothrium *ist* which is same level with *isb* (*ist* located anterior to *isb* in *C. centralis*); stouter pedipalp femur L/W 2.45–2.47 × (2.52–2.70 × in *C. centralis*), pedipalp patella L/W 2.12–2.17 × (2.87–3.0 × in *C. centralis*), chelal hand (with pedicel) L/W 1.52–1.78 × (1.70–1.96 × in *C. centralis*); fixed finger with 28–29 cusped teeth, and movable finger with 29–30 cusped teeth (fixed finger with 23–26 plus 6–7 indistinct teeth, movable with 23–26 teeth in *C. centralis*).

Calocheiridius rectilineatus sp. nov. differs from *C. iranicus* by two pseudotactile setae on pedipalpal femur (three pseudotactile setae on pedipalpal femur in *C. iranicus*); trichobothrium *it* located same level with *est* (*it* located anterior to *est* in *C. iranicus*); stouter pedipalp femur L/W 2.45–2.47 × (2.68–2.80 × in *C. iranicus*), pedipalpal patella L/W 2.12–2.17 × (2.22–2.26 × in *C. iranicus*), chelal hand (with pedicel) L/W 1.52–1.78 × (1.72–1.90 × in *C. iranicus*).

Calocheiridius rectilineatus sp. nov. distinguished from *C. libanoticus* by two setae on tergite I (compared to four setae in *C. libanoticus*); galea with two apical and one sub-apical rami (galea with three short rami in *C. libanoticus*); pedipalpal femur L/W 2.45–2.47 × (3.1 × in *C. libanoticus*); chelal hand (with pedicel) L/W 1.52–1.78 × (1.6 × in *C. libanoticus*); fingers distinctly shorter than hand (with pedicel) (chelal fingers length equal to that of hand in *C. libanoticus*); fixed finger with 28–29 and movable finger with 29–30 cusped teeth (both fingers with 26–27 strongly flattened marginal teeth in *C. libanoticus*).

***Calocheiridius persicus* sp. nov.**

(Figs. 9A–D; 10A–F)

urn:lsid:zoobank.org:act:61498A17-B17F-418C-A370-F7FF867E7DEF

Material examined: Holotype: 1 Male. Lorestan province, Aligudarz County, Iran, July 18, 2023. ZMFUM-PSC 11142; 33°27'10.15"N, 49°41'14.03"E; 2062 m a.s.l; Z. Latifi leg.; leaf litter.

Paratype: 1 Male. Collected together with holotype. ZMFUM-PSC 11145.

Other material studied: 1 Female. Lorestan province, Azna County, Gorji village, Iran, July 18, 2023. ZMFUM-PSC11155; 33°25'11.4"N, 49°25'00.15"E; 1870 m a.s.l; Z. Latifi leg.; under stone; 1 Male; Lorestan province, Dorud County, Chalanchulan, Iran, July 18, 2023. ZMFUM-PSC 11146; 33°40'14.07"N, 48°54'39.32"E; 1510 m a.s.l; Z. Latifi leg; under soil.

Diagnosis: *Calocheiridius persicus* sp. nov. is set apart from others within its genus by these distinguishing characteristics: posterior end of carapace and tergite I with two setae; surface of pedipalpal trochanter, femur completely smooth; patella smooth; chelal hand with fine granules; in the fixed finger of chela, *it* is located anterior to *est*; *ist* located anterior to *isb*; movable chelal finger, *b* located posterior *sb*; trichobothria *b*, *sb*, and *st* are far apart; fixed finger has 28–30 teeth; movable finger has 27–29 teeth; size of the pedipalp: femur L/W 2.47–2.55 × (2.30 × in female); patella L/W 2.04–2.09 × (2.12 × in female); chela (including pedicel) L. 0.93–0.95 (0.97 in female) mm; hand (with pedicel) L/W 1.59–1.66 × (1.43 × in female); movable finger L. 0.44–0.45 (0.45 in female) mm.

Etymology: this name refers to Persia which corresponds to modern-day Iran, one of the oldest inhabited places in the world located in the southwestern Asia. The epithet is an adjective.

Distribution: Western Iran.

Description: Carapace. reddish brown; entirely smooth; L/W 1.03–1.04 × (1.06 × in female); slightly more extended than wide; with two pairs of corneate eyes; posterior transverse furrow indistinct; the setae simple and acute, arranged: 4:4:2:2:4:2, with 10 lyrifissures (Fig. 10A).

Tergites: yellowish brown; lighter than carapace; smooth; undivided; tergite X and XI with four tactile setae; chaetotaxy: 2:4:4:4:4:4–5:4:4:5–6:6:6:2.

Sternites: entirely smooth; lightly sclerotized; sternite X and XI with four tactile setae; chaetotaxy: 4–5:4:4:4:4:4:4:4:5–6:8:6:2. Coxa I with 3–4 setae, coxa II 5–6, coxa III with 4–5 setae, coxa IV with 6–8 setae.

Chelicera: brown; hand with all five setae; galea with three rami (two apical and one subapical rami); rallum possessing three blades, distal one largest; serrula exterior possessing 19–18 blades (Fig. 10B); fixed finger with six teeth, the first one short and pointed, followed by larger medial tooth, terminal teeth short and pointed; single curved apical lobe and two pointed sub-apical teeth on the movable finger.

Pedipalps: reddish brown; distinctly lighter than

carapace; bicoloured,chela slightly darker than the other podomeres; hand distinctly granulated, other segmentes entirely smooth; trochanter with dorsal hump; femur with two pseudotactile setae (Fig. 10C); chela with distinct pedicle; movable chelal finger distinctly shorter than hand (incuding pedicel); fixed finger with 28–30 teeth; movable finger with 27–29 teeth (Fig. 10D); venom ducts short in both fingers; nodus ramosus in movable finger distinctly distal to *t*, in the fixed finger proximal to *et*; femur L/W 2.47–2.55 × (2.30 × in female); patella L/W 2.04–2.09 × (2.12 × in female); hand (with pedicel) L/W 1.59–1.66 × (1.43 × in female).

Trichobothriotaxy: fixed finger with eight and movable finger with four trichobothria; fixed finger trichobothria *eb*, *esb*, and *isb* grouped near the end of the finger; *esb* closer to *eb* than *isb*; *ist* located anterior to *isb*; *ib* located posterior to *eb*; *ist* positioned near *ib* than *it*; *et* positioned near tip of the finger than *it*; trichobothrium *it* is located anterior to *est*; *est* situated posterior to *et*; on the movable finger *sb* closer to *b* than *st*; trichobothrium *st* located nearer to *sb* than *t*; *st* located posterior to *t*; trichobothrium *t* between tip of finger and *st* (Fig. 10E).

Legs: brown; noticeably lighter in colour than body; smooth; claws almost stout and symmetric; arolium plain and more elongated than claws (Fig. 10F).

Leg I femur L/W 1.9–2.1 × (1.76 × in female); patella L/W 1.54–1.63 × (1.58 × in female); tibia L/W 1.54–1.58 × (2.77 × in female); basitarsus L/W 1.60–1.80 × (2.0 × in female); telotarsus L/W 1.60–1.80 × (1.66 × in female); Leg IV femur + patella L/W 2.45–2.47 × (2.31 × in female); tibia L/W 2.0–2.16 × (2.76 × in female); basitarsus L/W 2.60–2.80 × (2.50 × in female); telotarsus L/W 1.66–1.83 × (2.66 × in female).

Measurements (mm): Body length: 2.90–3.10 (3.50 ♀); Carapace: 0.52–0.53/0.50–0.51 (0.53/0.50 ♀); Pedipalp: trochanter 0.23–0.24/0.20 (0.25/0.21 ♀); femur 0.51–0.52/0.20–0.21 (0.53/0.23 ♀); patella 0.46–0.47/0.22–0.23 (0.51/0.24 ♀); chela L. (with pedicel) 0.93–0.95 (0.97 ♀); hand (with pedicel) 0.50–0.51/0.30–0.32 (0.53/0.37 ♀); movable finger L. 0.44–0.45 (0.45 ♀); Leg I: femur 0.19–0.21/0.10 (0.23/0.13

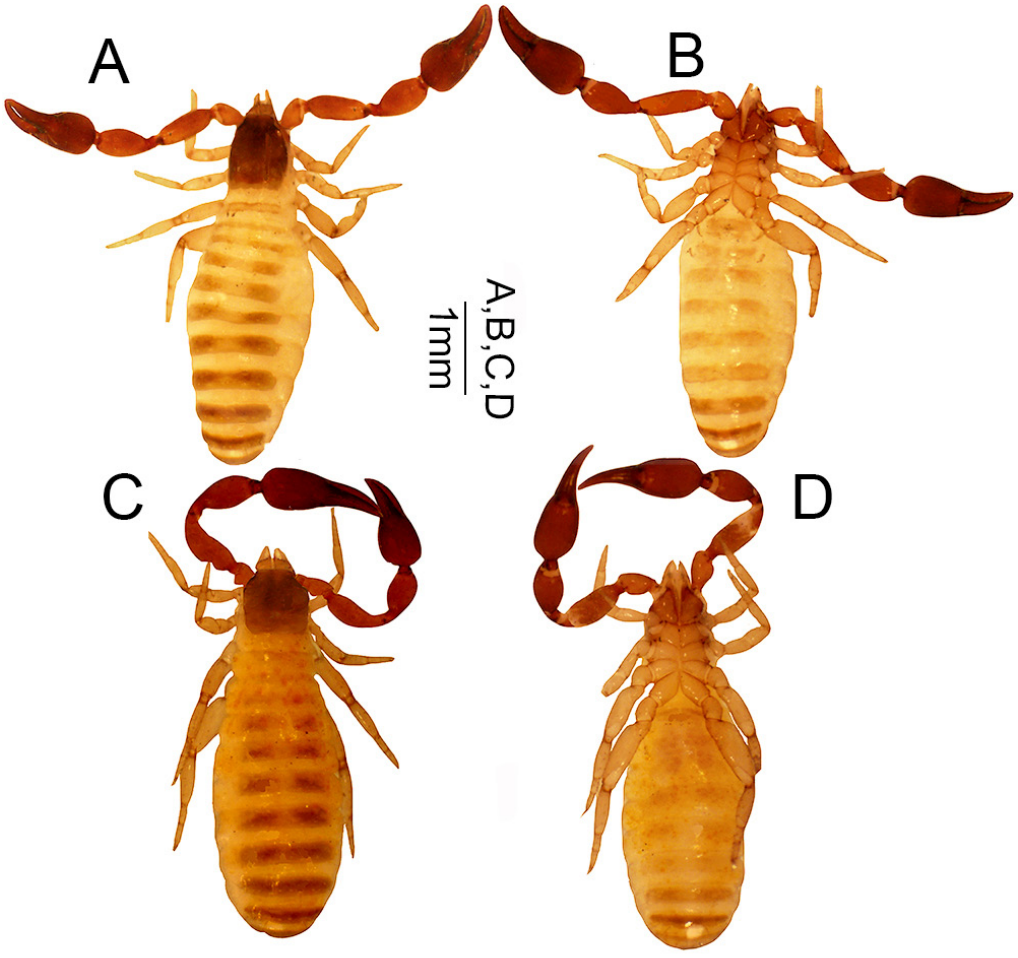

Fig. 9. Male *C. persicus* sp. nov. A) Dorsal view; B) Ventral view; Female *C. persicus* sp. nov. C) Dorsal view; D) Ventral view.

♀); patella 0.17–0.18/0.11 (0.19/0.12 ♀); tibia 0.17–0.19/0.11–0.12 (0.25/0.09 ♀); basitarsus 0.08–0.09/0.05 (0.10/0.05 ♀); telotarsus 0.08–0.09/0.05 (0.10/0.06 ♀); Leg IV: femur + patella 0.49–0.52/0.20–0.21 (0.51/0.22 ♀); tibia 0.26–0.28/0.12–0.14 (0.36/0.13 ♀); basitarsus 0.13–0.14/0.05 (0.15/0.06 ♀); telotarsus 0.10–0.11/0.06 (0.16/0.06 ♀).

Remarks: *Clocheiridius persicus* sp. nov. most closely resembles *C. antushi* in possessing two setae on the posterior margin of the carapace and two setae on tergite I.

Clocheiridius persicus sp. nov. differs from *C. antushi* by the presence of granulation on the chela (smooth in *C. antushi*); stouter pedipalp femur L/W 2.47–2.55 × (4.04 × in *C. antushi*); the fixed finger trichobothrium *it* positioned anterior to *est* (located same level with *est* in *C. antush*); the movable finger trichobothrium *t* situated nearer to the fingertip than *st* (*t* located between *st* and the fingertip in *C. antushi*).

Calocheiridius persicus sp. nov. differs from *C. centralis* by having two setae on posterior margin of the carapace (compared to four setae in *C. centralis*). It differs further by the fixed finger trichobothrium *it* positioned anterior to *est* (*it* located same level with *est* in *C. centralis*); on the movable finger, trichobothria *b*, *sb*, and *st* being separated, with *sb* closer to *b* than to *st* (forming a triangular cluster with *sb* between *b* and *st* in *C. centralis*); pedipalp femur L/W 2.47–2.55 × (2.52–2.70 × in *C. centralis*); pedipalp patella L/W 2.04–2.09 × (2.87–3.0 × in *C. centralis*); chelal hand with pedicel L/W 1.59–1.66 × (1.70–1.96 × in *C. centralis*); fixed finger with 28–30 cusped teeth, movable finger with

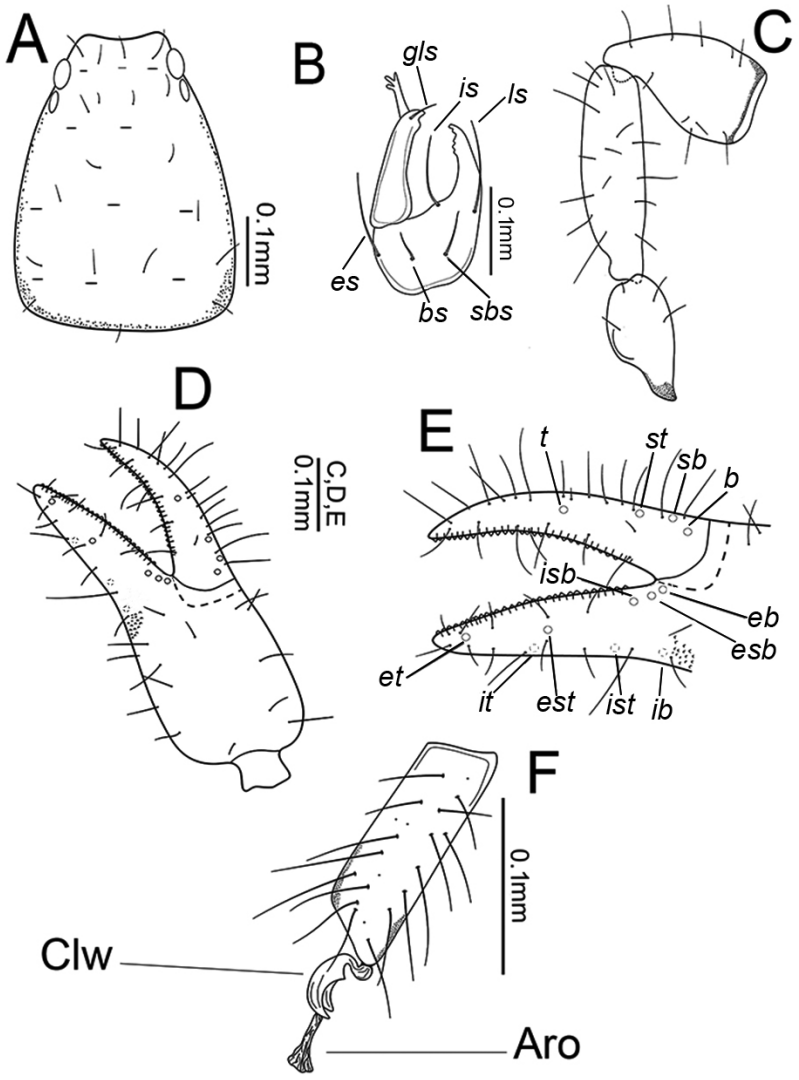

Fig. 10. Male *C. persicus* sp. nov. A) Carapace, dorsal view; B) Left chelicera, dorsal view; C) Right pedipalp, dorsal view; D) Right pedipalp chela, lateral view; E) Right pedipalp chela with the trichobothrial pattern, lateral view; F) Left leg IV, telotarsus, dorsal view with claws and arolia.

27–29 cusped teeth (fixed finger with 23–26 teeth, movable finger with 23–26 plus 6–7 indistinct teeth in *C. centralis*).

Calocheiridius persicus sp. nov. differs from *C. iranicus* by having two pseudotactile setae on the pedipalpal femur (three pseudotactile setae on the pedipalpal femur in *C. iranicus*); the fixed finger trichobothrium *ist* positioned anterior to *isb* (*ist* located same level with *isb* in *C. iranicus*); the movable finger trichobothria *b*, *sb*, and *st* being widely separated (forming a triangular cluster in *C. iranicus*). It is further distinguished by its larger size and differing proportions, body length 2.47–2.55 mm (2.07–2.17 mm in *C. iranicus*); carapace L/W 1.03–1.04 × (1.43–1.45 × in *C. iranicus*); pedipalpal femur L/W 2.47–2.55 × (2.68–2.80 × in *C. iranicus*); pedipalpal patella L/W 2.04–2.09 × (2.22–2.26 × in *C. iranicus*); chelal hand (with pedicel) L/W 1.59–1.66 × (1.72–1.90 × in *C. iranicus*); and a longer movable finger, 0.44–0.46 mm (0.36–0.38 mm in *C. iranicus*).

Calocheiridius persicus sp. nov. differs from *C. libanoticus* by having two setae on tergite I (compared to four setae in *C. libanoticus*); galea with two apical and one sub-apical rami (galea with three short rami in *C. libanoticus*); the presence of granulation on the pedipalps (completely smooth in *C. libanoticus*); less slender pedipalpal femur, L/W 2.47–2.55 × (3.1 × in *C. libanoticus*); chelal hand (with pedicel) L/W 1.59–1.66 × (1.6 × in *C. libanoticus*); chelal fingers distinctly shorter than the hand (chelal fingers length equal to that of hand in *C. libanoticus*); fixed finger with 28–30 cusped teeth, movable finger with 27–29 cusped teeth (fixed finger with 26–27 teeth, movable finger with 26–27 teeth in *C. libanoticus*); on the movable finger, trichobothria *b*, *sb*, and *st* being widely separated from each other (forming a distinct group that is widely separated from *t* in *C. libanoticus*).

Calocheiridius persicus sp. nov. most closely resembles *C. rectilineatus* sp. nov. in possessing two setae on tergite I, two pseudotactile setae on the pedipalpal femur, and a galea with two apical and one sub-apical rami. Both species also share a granulated chelal hand while other pedipalpal segments are smooth.

Calocheiridius persicus sp. nov. differs from *C. rectilineatus* sp. nov. by the fixed finger trichobothrium *ist* positioned anterior to *isb* (*ist* located same level with *isb* in *C. rectilineatus* sp. nov.); the fixed finger trichobothrium *it* positioned anterior to *est* (*it* located same level with *est* in *C. rectilineatus* sp. nov.); the movable finger trichobothria *b*, *sb*, and *st* being separated, with *sb* nearer to *b* (forming a triangular cluster with *sb* between *b* and *st* in *C. rectilineatus* sp. nov.); pedipalpal femur L/W 2.47–2.55 × (2.45–2.47 × in *C. rectilineatus* sp. nov.); chelal hand L/W 1.59–1.66 × (1.52–1.78 × in *C. rectilineatus* sp. nov.), pedipalpal patella L/W 2.04–2.09 × (2.12–2.17 × in *C. rectilineatus* sp. nov.).

Key to the species of the *Calocheiridius* genus

1. Trichobothrium *it* at a similar level as *est* 2
- Trichobothrium *it* anterior to *est* 10
- Trichobothrium *it* posterior to *est* 22
2. Posterior end of the carapace possessing 2 setae 3
- Posterior end of the carapace possessing 4 setae 6
3. Chelal hand including pedicle as long as the finger .... *Calocheiridius indicus* Beier, 1967
- Chelal hand including pedicle longer than fingers 4
- Chelal hand including pedicle shorter than fingers .... *Calocheiridius antushi* Krumpál, 1983
4. Chelal hand smooth; trichobothria *b*, *sb* and *st* formed a triangular cluster; *st* nearer to *sb* than to *t*; carapace with 22 setae 5
- Chelal hand granulate; trichobothria *b*, *sb* and *st* are quite far apart; *st* halfway between *sb* and *t*; carapace with 20 setae .... *Calocheiridius rhodesiacus* Beier, 1964
5. Fixed finger of chelicera possessing 3 terminal toothed edges, with 4 triangular teeth; *esb* closer to *isb* than *eb*; *ist* closer to *ib* than to *it*; carapace L/W 1.40–1.50 ×; pedipalpal femur L/W 3.0–3.20 ×; pedipalpal patella L/W 2.50–2.70 ×; chelal hand L/W 1.70–1.80 ×; fixed finger with 37–39 teeth; movable finger with 32–35 teeth .... *Calocheiridius orientalis* Murthy and Ananthakrishnan, 1977
- Fixed finger of chelicera possessing 2 terminal toothed edges, with 4 triangular teeth; *esb* between *eb* and *isb*; *ist* halfway between *ib* and *it*; carapace L/W 1.20–1.40 ×; pedipalpal femur L/W 2.70–2.80 ×; pedipalpal patella L/W 2.20–2.30 ×; chelal hand L/W 1.50 ×; fixed finger with 28–29 teeth; movable finger with 32–33 teeth .... *Calocheiridius gabbutti* Murthy and Ananthakrishnan, 1977
6. Chelal hand smooth 7
- Chelal hand granulate 9
7. Tergit I with 2 setae; trichobothria *b*, *sb* and *st* are quite far apart 8
- Tergit I with 4 setae; trichobothria *b*, *sb* and *st* formed a triangular cluster .... *Calocheiridius hygricus* Murthy and Ananthakrishnan, 1977
8. Galea with 3 equal terminal rami; *ist* halfway between *isb* and *it*; pedipalpal femur L/W 3.50 ×; pedipalpal patella L/W 2.80 ×; chelal hand L/W 1.80 × ..... *Calocheiridius mussardi* Beier, 1973
- Galea with a single submedian lateral and 2 terminal rami; *ist* nearer to *isb* than to *it*; pedipalpal femur L/W 3.0–3.10 ×; pedipalpal patella L/W 2.50–2.60 ×; chelal hand L/W 1.60–1.70 × ..... *Calocheiridius viridis* Murthy and Ananthakrishnan, 1977
9. Trochobothrium *esb* between *eb* and *isb*; *ist* anterior to *isb*; *st* closer to *sb* than to *t*; carapace L/W 1.40 ×; pedipalpal femur L/W 3.0 ×; pedipalpal patella L/W 2.40 ×; chelal hand L/W 1.70–1.96 ×; fixed finger with 20–27 teeth; movable finger with 20–27 teeth ..... *Calocheiridius centralis* (Beier, 1952)
- Trochobothrium *esb* closer to *isb* than *eb*; *ist* at a similar level as *isb*; *st* halfway between *sb* and *t*; carapace L/W 1.02–1.03 ×; pedipalpal femur L/W 2.45–2.47 ×; pedipalpal patella L/W 2.12–2.17 ×; chelal hand L/W 1.52–1.78 ×; fixed finger with 28–29 teeth; movable finger with 29–30 teeth .... *Calocheiridius rectilineatus* sp. nov.
10. Posterior end of the carapace possessing 2 setae 11
- Posterior end of the carapace possessing 4 setae 17
11. Trichobothria *b*, *sb* and *st* formed a triangular cluster 12

- Trichobothria *b*, *sb* and *st* are quite far apart 14
12. Femur possessing 2 long setae on the dorsal side; *ist* nearer to *isb* than to *it*; *ist* anterior to *isb* 13
- Femur possessing 3 long setae on the dorsal side; *ist* nearer to *it* than to *isb*; *ist* at a similar level as *isb* .... *Calocheiridius iranicus* Nassirkhani, 2014
13. Chelal hand including pedicle with the same length as the fingers; carapace with 20 setae; carapace L/W 1.30 ×; pedipalpal femur L/W 3.10 ×; pedipalpal patella L/W 2.50 ×; chelal hand L/W 1.60 ×; fixed finger with 26–27 teeth; movable finger with 26–27 teeth ..... *Calocheiridius libanoticus* Beier, 1955
- Chelal hand including pedicle longer than fingers; carapace with 22 setae; carapace L/W 1.40–1.60 ×; pedipalpal femur L/W 2.90–3.10 ×; pedipalpal patella L/W 2.40–2.60 ×; chelal hand L/W 1.50–1.70 ×; fixed finger with 25–33 teeth; movable finger with 29–33 teeth ..... *Calocheiridius africanus* Beier, 1955
- Chelal hand including pedicle shorter than fingers; carapace with 21 setae; carapace L/W 1.40 ×; pedipalpal femur L/W 2.60 ×; pedipalpal patella L/W 2.20 ×; chelal hand L/W 1.60 ×; fixed finger with 23 teeth; movable finger with 24 teeth .... *Calocheiridius braccatus* Beier, 1959
14. Trochobothrium *sb* nearer to *b* than to *st* 15
- Trochobothrium *sb* midway between *b* and *st* 16
15. Galea with 3 equal terminal rami; *ist* midway between *isb* and *it*; *st* nearer to *sb* than to *t*; carapace L/W 1.30 ×; pedipalpal femur L/W 2.60–2.70 ×; pedipalpal patella L/W 2.20 ×; chelal hand L/W 1.80–1.90 × ..... *Calocheiridius beieri* (Murthy, 1960)
- Galea with a single submedian lateral and 2 terminal rami; *ist* closer to *isb* than to *it*; *st* halfway between *sb* and *t*; carapace L/W 1.03–1.04 ×; pedipalpal femur L/W 2.47–2.55 ×; pedipalpal patella L/W 2.04–2.09 ×; chelal hand L/W 1.59–1.66 × .... *Calocheiridius persicus* sp. nov.
16. Carapace L/W 1.10 ×; pedipalpal femur L/W 2.70 ×; pedipalpal patella L/W 2.40 ×; chelal hand L/W 1.88 × .... *Calocheiridius termitophilus* Beier, 1964
- Carapace L/W 1.50–1.70 ×; pedipalpal femur L/W 3.0–3.30 ×; pedipalpal patella L/W 2.50–2.70 ×; chelal hand L/W 1.50–1.80 × ..... *Calocheiridius gracilipalpus* Mahnert, 1982
17. Chelal hand smooth 18
- Chelal hand granulate 20
18. Chelal hand including pedicle longer than fingers .... *Calocheiridius loebli* Beier, 1974
- Chelal hand including pedicle shorter than fingers 19
19. Pedipalpal femur possessing 2 long setae on the dorsal side; fixed finger of chelicera possessing 3 terminal toothed edges, with 6 triangular teeth; *ist* nearer to *it* than to *isb*; trichobothria *b*, *sb* and *st* are quite far apart; carapace with 22 setae; carapace L/W 1.50–1.60 ×; pedipalpal femur L/W 3.20–3.30 ×; pedipalpal patella L/W 2.40–2.55 ×; chelal hand L/W 1.70–1.80 ×; fixed finger with 25 teeth; movable finger with 28 teeth .... *Calocheiridius murthii* Sivaraman, 1980
- Pedipalpal femur possessing 3 long setae on the dorsal side; fixed finger of chelicera possessing 4 teeth; *ist* nearer to *isb* than to *it*; trichobothria *b*, *sb* and *st* formed a triangular cluster; carapace with 22 setae; carapace L/W 1.12 ×; pedipalpal femur L/W 3.04 ×; pedipalpal patella L/W 2.53 ×; chelal hand L/W 1.59 ×; fixed finger with 34 teeth; movable finger with 31 teeth .... *Calocheiridius intermedius* Sivaraman, 1980
20. Tergit I with 2 setae; trichobothria *b*, *sb* and *st* formed a triangular cluster ..... *Calocheiridius somalicus* (Caporiacco, 1941)
- Tergit I with 4 setae; trichobothria *b*, *sb* and *st* are quite far apart 21
21. Trochobothrium *sb* nearer to *b* than to *st*; pedipalpal patella L/W 2.50–2.60 ×; chelal hand L/W 1.70 × .... *Calocheiridius congicus* (Beier, 1954)
- Trochobothrium *sb* midway between *b* and *st*; pedipalpal patella L/W 2.50 ×; chelal hand L/W 1.80 × .... *Calocheiridius sulcatus* Beier, 1974
22. Trochobothrium *ist* halfway between *ib* and *it* 23
- Trochobothrium *ist* nearer to *it* than to *ib* .... *Calocheiridius olivieri* (Simon, 1880)
- Trochobothrium *ist* nearer to *ib* than to *it* .... *Calocheiridius elegans* Murthy and Ananthakrishnan, 1977
23. Pedipalpal femur possessing 2 long setae on the dorsal side; *ist* nearer to *isb* than to *it* 24
- Pedipalpal femur possessing 3 long setae on the dorsal side; *ist* halfway between *isb* and *it* .... *Calocheiridius amrithiensis* Sivaraman, 1980
24. Galea with 3 equal terminal rami; trichobothria *b*, *sb* and *st* formed a triangular cluster; *st* nearer to *sb* than to *t*; pedipalpal femur L/W 3.0 ×; pedipalpal patella L/W 2.50 ×; chelal hand L/W 1.68 ×; fixed finger with 25–26 teeth; movable finger with 29 teeth ..... *Calocheiridius badonneli* Heurtault, 1983
- Galea with a single submedian lateral and two terminal rami; trichobothria *b*, *sb* and *st* are quite far apart; *st* between *sb* and *t*; pedipalpal femur L/W 2.19 ×; pedipalpal patella L/W 2.19 ×; chelal hand L/W 1.52 ×; fixed finger with 24 teeth; movable finger with 25 teeth .... *Calocheiridius granulatus* Sivaraman, 1980

DISCUSSION

Traditionally, the genus *Calocheiridius* from Iran comprises two species, *C. centralis* and *C. iranicus*. Their validity was confirmed based on their morphology (Beier 1952; Nassirkhani 2014a). In this study, two new species of *Calocheiridius* are described using combined morphological and molecular evidence. Furthermore, the absence of an identification key for this ambiguous genus has hindered the accurate identification of its species. To address this need, we have developed an identification key for the genus *Calocheiridius*, which utilizes various numerical and polymorphic characteristics.

Morphological features, including the chaetotaxy of the carapace, tergite I, and the trichobothrial pattern, frequently serve as diagnostic characteristics of species. The molecular phylogenetic analyses, based on *COI* and 28S markers indicated results consistent with molecular species delimitation methods, including ABGD, ASAB, and mPTP (Fig. 3), were consistent with the morphological data (Figs. 5; 8; 10). Both Maximum Likelihood and Bayesian Inference analyses corroborated the monophyly of the previously identified *C. centralis* and offered further evidence for the identification of two new species.

These new species are found in the Central and western of Iran: *C. persicus* sp. nov. from Lorestan province and *C. rectilineatus* sp. nov. from Markazi and Lorestan provinces (Fig. 1; Table 3). The recent findings increase the total number of known *Calocheiridius* species to four, three of which are endemic to the

Iranian Plateau. Molecular analysis revealed that the *COI*-based genetic divergence among the three clades of *Calocheiridius* was 12.7–14% (Table 4), supporting their recognition as distinct species. This divergence is markedly higher than typical within-species genetic variation (Astrin et al. 2016), and also substantially exceeds the optimal identification thresholds established for other pseudoscorpion families in the region—4.7% for Chthoniidae and 3.6% for Neobisiidae (Hlebec et al. 2023). So far, comprehensive systematic research on the pseudoscorpion species in Iran has been inadequate. This study is the first molecular study on Iranian pseudoscorpions. However, the preceding morphological studies have unanimously demonstrated the species diversity contained within the country (Nassirkhani 2014b; Nassirkhani 2016b; Nassirkhani and Doustaresharaf 2019; Latifi et al. 2020; Nassirkhani 2021; Nassirkhani 2022; Latifi and Mirshamsi 2024). It highlights the importance of combining morphological and molecular approaches to investigate undocumented species. Future research that incorporates extensive sampling and morphological evaluations, alongside molecular techniques, will enhance our understanding of the potential new species and/or species complexes present across this area.

CONCLUSIONS

This study provides a taxonomic review of the pseudoscorpion genus *Calocheiridius* in Iran, based primarily on a morphological revision and supplemented by molecular data (*COI* and 28S rRNA). The work led to the identification and description of two new species, *C. rectilineatus* sp. nov. and *C. persicus* sp. nov. from the region. Notable genetic divergences and consistent morphological distinctions clearly separate these newly proposed species from *C. centralis*, confirming their independent specific status. The results unambiguously delineate the boundaries among the three taxa. A revised identification key to all species of the genus is provided to aid future research. These findings highlight the value of an integrative approach in revealing hidden diversity and refining species limits within the Iranian pseudoscorpion fauna. This work establishes a foundational framework for further taxonomic and biogeographic studies on this genus in Iran.

List of abbreviations

Aro, arolia.
b, basal trichobothrium.
bs, basal seta.
Clw, claws.
esb, external sub-basal trichobothrium.
IAUA, Islamic Azad University of Arak, Iran.
eb, external basal trichobothrium.
ib, internal basal trichobothrium.
est, external sub- terminal trichobothrium.
et, external terminal trichobothrium.
es, external seta.
gls, galeal seta.
isb, internal sub-basal trichobothrium.
is, interior seta.
ist, internal sub-terminal trichobothrium.
L, length.
it, internal terminal trichobothrium.
ls, laminal seta.
mm, millimeter.
sb, sub-basal trichobothrium.
sbs, sub-basal seta.
si, serrula interior.
st, sub-terminal trichobothrium.
t, terminal trichobothrium.
W, width.
ZMFUM, Zoological Museum, Ferdowsi University of Mashhad, Mashhad, Iran.
ZMUC, Zoological Museum University of Copenhagen, Denmark.

Acknowledgments: We thank Dr. Nikolaj Scharf (ZMUC) for sending photographs of the type specimen of *Calocheiridius centralis*. We would also wish to express our heartfelt thanks to Dr. Mahrad Nassirkhani (IAUA), for providing the holotype and paratype specimens of *C. iranicus*. This study was supported by the Office of Research Affairs, Ferdowsi University of Mashhad, Iran (Project number: 3/58132), which is gratefully acknowledged.

Authors' contributions: ZL: Conceptualisation, methodology, molecular analysis, original draft. MA: Resources, review, editing. OM: Conceptualisation, review Resources, review, editing.

Competing interests: The author declare that there are no competing interests.

Availability of data and materials: All datasets generated or analyzed during this study are available from the corresponding author upon reasonable request.

Consent for publication: Not applicable.

Ethics approval consent to participate: Not applicable.

REFERENCES

Astrin JJ, Höfer H, Spelda J, Holstein J, Bayer S, Hendrich L, Muster C et al. 2016. Towards a DNA barcode reference database for spiders and harvestmen of Germany. PLoS ONE **11:**e0162624. doi:10.1371/journal.pone.0162624.

Beier M. 1952. The 3rd Danish Expedition to Central Asia. Zoological Results 7. Pseudoscorpionidea (Chelicerata) aus Afghanistan. Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening i Kjøbenhavn **114:**245–250.

Beier M. 1954. Pseudoscorpioniden aus dem Belgischen Congo. Annales du Musée du Congo Belge. Sciences Zoologiques **1:**132–139.

Beier M. 1955. Über Pseudoscorpione aus Syrien und Palästina. Annalen des Naturhistorischen Museums in Wien **60:**212–219.

Beier M. 1964a. Weiteres zur Kenntnis der Pseudoscorpioniden-Fauna des südlichen Afrika. Annals of the Natal Museum **16:**30–90.

Beier M. 1964b. Ein neuer Pseudoscorpion aus Termiten-Bauten. Revue de Zoologie et de Botanique Africanes **69:**198–200.

Beier M. 1967. Pseudoscorpione vom kontinentalen Südost-Asien. Pacific Insects **9:**341–369.

Beier M. 1973. Pseudoscorpionidea von Ceylon. Entomologica Scandinavica **4:**39–55.

Beier M. 1974a. Pseudoscorpione aus Sudindien des Naturhistorischen Museums in Genf. Revue suisse de Zoologie **81:**999–1017.

Beier M. 1974b. Pseudoscorpione aus Nepal. Senckenbergiana Biologica **55:**261–280.

Beier M, Turk FA. 1952. On two collections of Cyprian Pseudoscorpionidea. Annals and Magazine of Natural History **5:**766–771.

Belozerov VN. 2013. Seasonal aspects of the life cycles of pseudoscorpions (Arachnida, Pseudoscorpiones). Entomological review **93:**634–652.

Benavides LR, Cosgrove JG, Harvey MS, Giribet G. 2019. Phylogenomic interrogation resolves the backbone of the Pseudoscorpiones tree of life. Mol Phylogenet Evol **139:**106509. doi:10.1016/j.ympev.2019.05.023.

Cameron E, Buddle CM. 2019. Pseudoscorpiones and Scorpiones of Canada. ZooKeys **819:**67. doi:10.3897/zookeys.819.27121.

Chamberlin JC. 1931. The arachnid order Chelonethida. Stanford University Publications. Biological Sciences **7:**1–284.

Cosgrove JG, Agnarsson I, Harvey MS, Binford GJ. 2016. Pseudoscorpion diversity and distribution in the West Indies: sequence data confirm single island endemism for some clades, but not others. J Arachnol **1:**257–271. doi:10.1636/R15-80.1.

Dallwitz MJ, Paine T, Zurcher E. 2006. User's Guide to the DELTA System: A General System for Processing Taxonomic Descriptions. Available at: https://www.delta-intkey.com/www/uguide.pdf. (Accessed 15 Jul. 2021).

Dashdamirov S, Schawaller W. 1993. Pseudoscorpions from Middle Asia, Part 3 (Arachnida: Pseudoscorpiones). Stuttgarter Beiträge zur Naturkunde **496:**1–14.

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek RC. 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Mol Mar Biol Biotechnol **3:**294–299.

Hall TA. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. In Nucleic acids symposium series **41:**95–98.

Harvey MS. 1992. The phylogeny and classification of the Pseudoscorpionida (Chelicerata: Arachnida). Invertebr Syst **6:**1373–1435. doi:10.1071/IT9921373.

Harvey MS, Leng MC. 2008. The first troglomorphic pseudoscorpion of the family Olpiidae (Pseudoscorpiones), with remarks on the composition of the family. Rec West Aust Mus **24:**387–394. doi:10.18195/issn.0312-3162.24(4).2008.387-394.

Harvey MS. 2014. A review and redescription of the cosmopolitan pseudoscorpion *Chelifer cancroides* (Pseudoscorpiones: Cheliferidae). J Arachnol **42:**86–104. doi:10.1636/K13-57.1.

Harvey MS. 2023. A preliminary phylogeny for the pseudoscorpion family Garypinidae (Pseudoscorpiones: Garypinoidea), with new taxa and remarks on the Australasian fauna. Invertebr Syst **37:**623–676. doi:10.1071/IS23029.

Hebert PD, Cywinska A, Ball SL, DeWaard JR. 2003. Biological identifications through DNA barcodes. Proc R Soc Lond B Biol Sci **270:**313–321. doi:10.1098/rspb.2002.2218.

Hlebec D, Podnar M, Kučinić M, Harms D. 2023. Molecular analyses of pseudoscorpions in a subterranean biodiversity hotspot reveal cryptic diversity and microendemism. Sci Rep **13:**430. doi:10.1038/s41598-022-26298-5.

Heurtault J. 1981. Présence et signification dans la France méditerranéenne des espèces des genres *Beierochelifer*, *Cheirochelifer* et *Calocheiridius* (Arachnides, Pseudoscorpions). Atti della Società Toscana di Scienze Naturali, Memorie **88:**209–222.

Heurtault J, Rebiere J. 1983. Pseudoscorpions de Côte d'Ivoire. Revue Arachnologique **5:**1–27.

Hormiga G, Arnedo M, Gillespie RG. 2003. Speciation on a conveyor belt: sequential colonization of the Hawaiian Islands by *Orsonwelles* spiders (Araneae, Linyphiidae). Systematic Biology **52:**70–88. doi:10.1080/10635150390132786.

Judson ML. 2007. A new and endangered species of the pseudoscorpion genus *Lagynochthonius* from a cave in Vietnam, with notes on chelal morphology and the composition of the Tyrannochthoniini (Arachnida, Chelonethi, Chthoniidae). Zootaxa **1627:**53–68. doi:10.11646/ZOOTAXA.1627.1.4.

Kapli P, Lutteropp S, Zhang J, Kobert K, Pavlidis P et al. 2017. Multi-rate Poisson tree processes for single-locus species delimitation under maximum likelihood and Markov chain Monte Carlo. Bioinformatics **33:**1630–1638. doi:10.1093/bioinformatics/btx025.

Kumar S, Stecher G, Li M, Knyaz C, Tamura K. 2018. MEGA X: molecular evolutionary genetics analysis across computing platforms. Mol Biol Evol **35:**1547. doi:10.1093/molbev/msy096.

Latifi Z, Nassirkhani M, Mirshamsi O. 2020. A new epigean pseudoscorpion species (Pseudoscorpiones: Neobisiidae) from northeast of Iran, with an identification key to the species of the family Neobisiidae from Iran. Turkish Journal of Zoology **44:**230–237. doi:10.3906/zoo-1912-23.

Latifi Z, Mirshamsi O. 2024. *Withius hispanus* (L. Koch, 1873) new to the fauna of Iran: with an identification key of *Withius* Kew, 1911 in the Palaearctic (Pseudoscorpione; Withiidae). Iran J Anim Biosyst **20:**89–100. doi:10.22067/IJAB.2024.90505.1086.

Mahnert V. 1982. Die Pseudoskorpione (Arachnida) Kenyas: 3. Olpiidae. Monitore Zoologico Italiano. Supplemento **16:**263–304. doi:10.1080/00269786.1982.11758556.

Moulds TA, Murphy N, Adams M, Reardon T, Harvey MS et al. 2007. Phylogeography of cave pseudoscorpions in southern Australia. J Biogeogr **34:**951–962. doi:10.1111/j.1365-2699.2006.01675.x.

Murienne J, Harvey MS, Giribet G. 2008. First molecular phylogeny of the major clades of Pseudoscorpiones (Arthropoda: Chelicerata). Mol Phylogenet Evol **49:**170–2184. doi:10.1016/j.ympev.2008.06.002.

Murthy VA, Ananthakrishnan TN. 1977. Indian Chelonethi. Oriental Insects Monograph **4:**1–210.

Nassirkhani M. 2014a. A new pseudoscorpion species of the genus *Calocheiridius* Beier & Turk (Arachnida: Pseudoscorpiones: Olpiidae) from Iran. Zoology in the Middle East **60:**353–361. doi:10.1080/09397140.2014.966520.

Nassirkhani M. 2014b. A new pseudoscorpion species of the genus *Geogarypus* (Arachnida: Pseudoscorpiones) from Iran. Acta Arachnologica **63:**99–103. doi:10.2476/asjaa.63.99.

Nassirkhani M. 2016a. Redescription of the widely distributed species in the Middle East and central Asia, *Calocheiridius centralis* (Beier) (Pseudoscorpiones: Olpiidae). The Journal of Zoology Studies **3:**102–108.

Nassirkhani M. 2016b. A new pseudoscorpion species of the genus *Allochernes* Beier, 1932 (Pseudoscorpiones: Chernetidae) from Southern Iran. Arachnology **17:**95–100. doi:10.13156/arac.2006.17.2.95.

Nassirkhani M. 2021. Description of a new pseudoscorpion, *Nudochernes limusensis* sp. n. (Pseudoscorpiones: Chernetidae) from northern Iran, with a key to all Lamprochernetinae genera. Zoology in the Middle East **67:**73–80. doi:10.1080/09397140.2021.1877384.

Nassirkhani M. 2022. Description of a new pseudoscorpion, *Withius leggi* sp. n. (Pseudoscorpiones: Withiidae) from northern Iran. Zoology in the Middle East **68:**272–279. doi:10.1080/09397140.2022.2077560.

Ohira H, Kaneko S, Faulks L, Tsutsumi T. 2018. Unexpected species diversity within Japanese *Mundochthonius* pseudoscorpions (Pseudoscorpiones: Chthoniidae) and the necessity for improved species diagnosis revealed by molecular and morphological examination. Invertebr Syst **32:**259–277. doi:10.1071/IS17036.

Poinar Jr. GO, Curcic BP, Cokendolpher JC. 1998. Arthropod phoresy involving pseudoscorpions in the past and present. Acta Arachnol **47:**79–96. doi:10.1080/09397140.2022.2077560.

Posada D. 2008. jModelTest: phylogenetic model averaging. Mol Biol Evol **25:**1253–1256. doi:10.1093/molbev/msn083.

Prado GC, Ferreira RL. 2024. Two new species of cave-dwelling Pseudoscorpions *Pseudochthonius* Balzan, 1892 (Pseudoscorpiones, Chthoniidae) from Northeastern Brazil: Shedding light on the Troglobitic status of some Brazilian species. Zool Stud **63:**21. doi:10.6620/ZS.2024.63-21.

Puillandre N, Lambert A, Brouillet S, Achaz GJME. 2012. ABGD, Automatic Barcode Gap Discovery for primary species delimitation. Mol Ecol **21:**1864–1877. doi:10.1111/j.1365-294X.2011.05239.x.

Puillandre N, Brouillet S, Achaz G. 2021. ASAP: assemble species by automatic partitioning. Mol Ecol Res **21:**609–620. doi:10.1111/1755-0998.13281.

Redikorzev V. 1949. Pseudoscorpionidea of Central Asia. Travaux de l'Institute de Zoologique de l'Académie Sciences de l'URSS **8:**638–668.

Rozas J, Sánchez-DelBarrio JC, Messeguer X, Rozas R. 2003. DnaSP, DNA polymorphism analyses by the coalescent and other methods. Bioinformatics **19:**2496–2497. doi:10.1093/bioinformatics/btg359.

Sakayori H. 2014. Redescription of *Allochthonius* (*Allochthonius*) opticus collected from Okayama city, West Honshu, Japan (Pseudoscorpionida, Chthoniidae). Bulletin of Ibaraki Nature Museum **17:**1–6.

Sivaraman S. 1980. Pseudoscorpions from South India: new genus and some new species of the super-family Garypoidea Chamberlin (Pseudoscorpionida: Diplosphyronida). Oriental Insects **14:**325–343. doi:10.1080/00305316.1980.10434812.

Weygoldt P. 1969. The Biology of Pseudoscorpions. Harvard University Press, Cambridge MA. World Pseudoscorpiones Catalog. 2025. Natural History Museum Bern. Available at: http://wac.nmbe.ch.