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# A new species of cave-dwelling pseudoscorpions of the genus *Neobisium* Chamberlin, 1930 (Pseudoscorpiones: Neobisiidae) from Morocco

# Новый вид пещерных ложноскорпионов рода *Neobisium* Chamberlin, 1930 (Pseudoscorpiones: Neobisiidae) из Марокко

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КЛЮЧЕВЫЕ СЛОВА: морфология, таксономия, арахниды, трогломорфные виды, подземные биотопы, Средиземноморье, карстовые пещеры.

ABSTRACT. A new species of pseudoscorpions, *Neobisium* (*Neobisium*) *berberorum* sp.n., from Ain Danu Cave located in the Rif Mountains (Morocco) is described with a detailed diagnosis and illustrations. Diagnostic characters and ecological traits of this species are presented and discussed; the new species is compared with related species of this genus living in caves of the Atlas Mountains in North Africa. A distribution map of all known cave-dwelling species of the family Neobisiidae Chamberlin, 1930 in the Rif Mountains and the Atlas Mountains is presented.

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РЕЗЮМЕ. Описывается новый вид ложноскорпионов, *Neobisium* (*Neobisium*) *berberorum* sp.n., из пещеры Айн Дану расположенной в горах Риф (Марокко), с подробным диагнозом и иллюстрациями. Приводятся и обсуждаются диагностические признаки и экологические особенности этого вида, и также новый вид сравнивается с близкими видами этого рода, обитающими в пещерах гор Атлас в Северной Африке. Представлена карта распространения всех известных пещерных видов семейства Neobisiidae Chamberlin, 1930 для гор Риф и Атлас.

## Introduction

The genus *Neobisium* Chamberlin, 1930 of the family Neobisiidae Chamberlin, 1930 is the most species-rich among the pseudoscorpions, with 257 extant species found in the Euro-Mediterranean region, extending east to Iran, Turkmenistan and Kazakhstan, as well as to Socotra Island (Yemen). There are records of this genus from other parts of the World (viz., India and Kenya), representing introduced species from their native ranges. Many representatives of the genus are hypogean species living in caves, including specialised troglomorphic species [WPC, 2023]. Until recently, the genus *Neobisium* comprised six subgenera: *Neobisium* Chamberlin, 1930, *Blothrus* Schiödte, 1847, *Ommatoblothrus* Beier, 1956,


Fig. 1. The habitat of *Neobisium* (*Neobisium*) *berberorum* sp.n.: A — a dry limestone canyon surrounded by mediterranean forest in which the entrance to Ain Danou Cave is located; B — external view of the horisontal passage of Ain Danou Cave where the holotype was collected. Photographs by Andrey Przhiboro.

Рис. 1. Внешний вид биотопов *Neobisium* (*Neobisium*) *berberorum* sp.n.: A — сухой известняковый каньон, окруженный средиземноморским лесом, в котором находится вход в пещеру Айн Дану; B — внешний вид горизонтального хода пещеры Айн Дану, где был собран голотип. Фотографии Андрея Пржиборо.

*Heoblothrus* Browning, 1965, *Neoccitanobisium* Callaini, 1981 and *Pennobisium* Ćurčić, 1988. However, Gardini [2023] synonymised *Neobisium* (*Ommatoblothrus*), *N*. (*Heoblothrus*), and *N*. (*Pennobisium*) to the nominate subgenus.

The pseudoscorpion fauna of Morocco includes 35 recorded species from 10 families. The genus *Neobisium* is represented by three species [WPC, 2023], of which one species is known from subterranean habitats, *N*. (*N*.) *atlasense* Leclerc, 1989 from the caves of the Middle Atlas Range [Leclerc, 1989]. The following troglomorphic and troglophilic species of this genus are known from the Atlas Mountains with the exception of Morocco: *N*. (*N*.) *algericum* (Ellingsen, 1912), *N*. (*N*.) *dumitrescoae* Heurtault, 1990, and *N*. (*Blothrus*) *peyerimhoffi* Heurtault, 1990, all from the caves of Algeria [Ellingsen, 1912; Heurtault, 1990].

A new troglomorphic species of *Neobisium* was discovered during the surveys of karst caves in Morocco in 2019, and it is described in the present paper.

## Material and methods

The only known specimen (holotype) of the new species described here has been collected from the wall of a wet horisontal passage being about 3–6 m high and situated at a distance ca. 150 m of the entrance into the cave, at a depth ca. 40 m below the surface (Fig. 1B). The entrance of the cave is situated near the bottom of mostly dry limestone canyon surrounded by a mediterranean forest (Fig. 1A). No other pseudoscorpion specimens were found in different parts of the same cave, as well as in the Kef d'Ensough ou d'Asough Cave situated in several km from this one. The locality (Ain Danou Cave) is situated in the Ouestiyine massif of the Rif Mountains, Morocco. The collected specimen of the new species was missing right legs I and II.

For morphological examination using light microscopy, the holotype of the new species was cleared in 100% lactic acid and temporarily mounted on a slide in glycerol. The holotype was examined and dissected for a more detailed study of the chelicerae, pedipalps and legs I and IV using a Biomed MC-2 binocular stereo microscope and measured using an ocular micrometer installed on a Biomed 6 (variant 3) microscope. The photographs of habitus were taken with a Leica MC170 HD (12MPs) digital microscope camera using the extended focus technology; the final image was compiled from multiple layers using Helicon Focus 7.7.4. Morphological drawings were processed using Adobe Photoshop CS6 (ver. 13.0.1.3) based on the images of these structures obtained using an Euromex Color HD-Ultra (5MPs) digital microscope camera connected to a Bioptic C-400 microscope. After examination, the holotype and its dissected body parts were preserved in a vial with 96% ethanol.

The distribution map (Fig. 5) was created using Google Earth Pro (ver. 7.3.4.8248) and Adobe Photoshop CS6.

The holotype is deposited at the Zoological Institute of the Russian Academy of Sciences, Saint Petersburg, Russia (ZISP).

The measurements were made with an ocular micrometer using the reference points proposed by Chamberlin [1931] and are given in millimeters (mm). All measurements are presented either as length/width ratios (carapace, chelicera and pedipalp) or as length/depth ratios (legs).

Morphological terminology follows Chamberlin [1931], with amendments proposed by Harvey [1992], Harvey & Edward [2007], Judson [2007; 2017], Kolesnikov *et al.* [2022] and Gardini [2023].

## Results

Class Arachnida Lamarck, 1801
Order Pseudoscorpiones de Geer, 1778
Family Neobisiidae Chamberlin, 1930
Genus *Neobisium* Chamberlin, 1930
Subgenus *Neobisium* Chamberlin, 1930

*Neobisium* (*Neobisium*) *berberorum* **sp.n.**
Figs 2–4.

HOLOTYPE: ♀ (ZISP ARA_PSE_0000031), Morocco, Chefchaouen Province, between villages Azilane and Imizzare, Ain Danou Cave, entrance ca. 35.186234°N 5.181615°W (ca. 1000 m a.s.l.), 27.III.2019, A. Boukhajjou, A. Przhiboro & M.Y.E. Ouahabi leg.

ETYMOLOGY. The new species is named after the Berbers, indigenous people of North Africa now living from the western borders of Egypt in the east to the Atlantic Ocean in the west and from the Niger River in the south to the Mediterranean Sea in the north. Berbers is an English word derived via the Arabic word بَرْبَرِيّ (barbariyy) from the ancient Greek word βάρβαρος. Bereberorum is a latinised noun in the plural genitive case.

DIAGNOSIS Adult (♀, ♂ unknown).

A subterranean, troglomorphic species that differs in the following combination of characters: carapace trapezoidal, with four eyes without tapetum, anterior ones with convex lens, posterior ones reduced, with weak lens; sternites V–XI with uniseriate setae; chelicera 2.0 times as long as broad; palm of chelicera with 5 acuminate setae; large medial tooth on movable finger of chelicera absent; rallum with 7 blades; manducatory process with 4 acuminate setae; pedipalpal femur 1.87 mm long (5.34 times as long as broad), patella 1.40 mm long (3.78 times as long as broad); chela with pedicel 5.77 times as long as broad; fixed chelal finger with 78 large pointed erected teeth, more or less rounded in proximal quarter of finger; nodus ramosus subterminal; movable chelal finger with 85 teeth, pointed and erected in distal half, rounded and contiguous in proximal part of the teeth; all teeth with dental canals; sensillum closer to trichobothrium *sb* than to *st*; trichobothrium *ist* distal to *st* but proximal to *t*; trichobothrium *isb* proximal to *sb*; ratio between movable finger and hand of chela with pedicel 1.62; ratio between pedipalpal femur and movable finger 1.35; ratio between pedipalpal femur and carapace 1.87; ratio between pedipalpal femur and patella 1.33; legs I and IV with small dorsal accessory tooth (*dat*).

DESCRIPTION. Adult (♀, ♂ unknown).

Carapace, chelicerae, trochanter and femur of pedipalp light brown, remainder of body golden yellow (Fig. 2); pedipalps smooth, pleural membrane granular.

Carapace (Fig. 3A) trapezoidal, width and length equal, with four eyes without tapetum, anterior ones with convex lens (diameter 0.07 mm), posterior ones reduced, with weak lens (diameter 0.05 mm); distance from anterior eyes to anterior margin of carapace 0.17 mm, distance from anterior to posterior eyes 0.05 mm; carapace with 29 macrosetae, its anterior margin with 5 (2 left and 3 right) macrosetae, 1 preocular macroseta on each side, 13 central macrosetae of carapace arranged in 3 rows, posterior margin with 7 (3 left and 4 right) macrosetae, chaetotaxy of carapace: 5:4:13:7; epistome prominent (triangular) (Fig. 4D); anterolateral corners with two small protuberances located below carapace surface; carapace with 5 microlyrifissures: 3 situated (1 left and 2 right) in ocular zone, close to anterior eyes, and one pair located at posterior margin.

Tergites weakly sclerotised; all setae simple; chaetotaxy of tergites I–XII: 9:9:12:13:13:12:12:13:12:15:10:2.


Fig. 2. Habitus of *Neobisium* (*Neobisium*) *berberorum* sp.n., ♀ holotype.
Рис. 2. Общий вид *Neobisium* (*Neobisium*) *berberorum* sp.n., голотип ♀.

Sternites entirely smooth, weakly sclerotised; sternite II of female with 7 (3 left and 4 right) anterior and 22 posterior setae (Fig. 4H). All setae simple; those on sternites V–XI uniseriate; chaetotaxy of sternites II–XI: 7+22:(3)16(3):(3)13(3):13:15:1 5:13:13:14:4:2.

Chelicera (Figs 3B, 4C): 2.0 times as long as broad; palm 5 with acuminate setae; galea knob-like, with poorly developed hyaline convexity; palm smooth with pointed corners; small tooth (*tis*) under interior seta (*is*) present, triangular (Fig. 4C); fixed finger with 19 teeth reaching its distal part; movable finger with 10 teeth reaching distal to middle of segment, large medial tooth absent; spinneret largely prominent and rounded; serrula interior with 32 blades, serrula exterior with 35 blades; rallum with 7 blades: 2 distal ones denticulate and 5 posterior ones simple, smooth and acuminate, of which 3 proximal blades smallest (Fig. 3F).

Manducatory process with 4 acuminate setae. Coxal setae: pedipalp 13–13, I 11–11, II 11–12, III 9–10, IV 13–13; anteromedial process broadly rounded, with denticles (Fig. 4G). Each coxa of legs with one lyrifissure; pedipalpal coxa with one maxillary lyrifissure.

Pedipalp (Figs 3C–E, H, I; 4A, B): trochanter with small dorsal tubercle 2.15 times as long as broad; femur with short pedicel, 5.34 times as long as broad, weakly enlarged distally; patella distinctly shorter than femur, patella 3.78 times as long as broad, club gradually enlarged distally, with 3 lyrifissures basally; chela with pedicel 5.77 times as long as broad; hand of chela with pedicel 2.30 times as long as broad, with long oval profile, just widened towards base, with greatest width in proximal quarter (dorsal view); retrolateral surface of hand with 2 glandular pores located near trichobothrium *eb*; fixed finger with one lyrifissure located near trichobothrium *ib*; movable finger with 3 lyrifissures; fixed chelal finger with 78 large pointed erected teeth, these teeth more or less rounded in proximal quarter of finger; nodus ramosus subterminal; movable chelal finger with 85 teeth, teeth pointed and erected in distal half of finger, rounded and contiguous in its basal half; all teeth with dental canals; sensillum closer to trichobothrium *sb* than to *st*; trichobothrium *ist* distal to *st* but proximal to *t*; trichobothrium *isb* proximal to *sb*; ratio between movable finger and hand of chela with pedicel 1.62; ratio between pedipalpal femur and movable finger 1.35; ratio between pedipalpal femur and patella 1.33; ratio between pedipalpal femur and carapace 1.87.

Legs I and IV with small dorsal accessory tooth (*dat*), all claws of legs arolia simple and shorter than claws (Fig 4E, F). Leg I femur 5.58 and patella 4.11 times as long as deep, femur

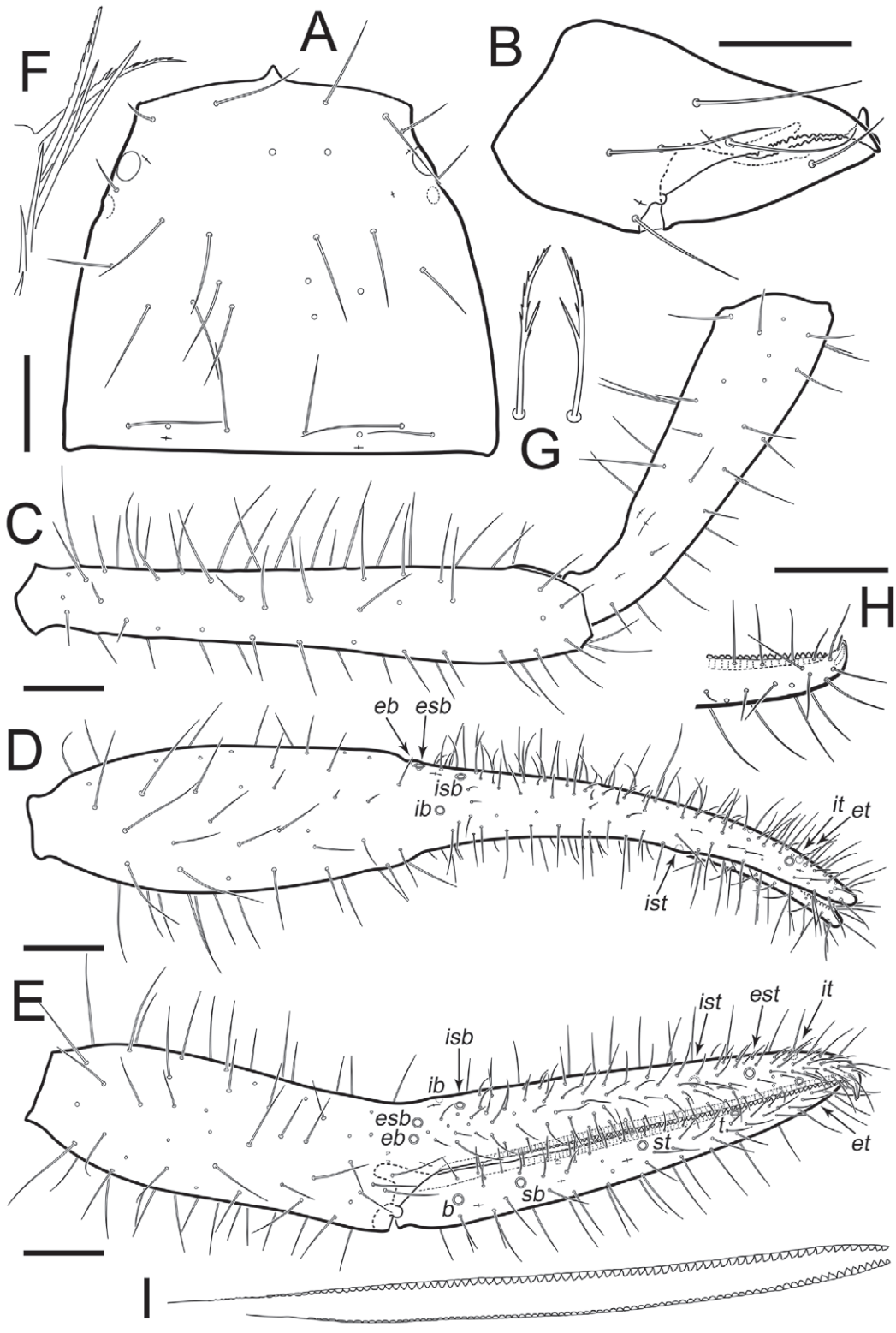


Fig. 3. *Neobisium* (*Neobisium*) *berberorum* sp.n., ♀ holotype: A — carapace, dorsal view; B — right chelicera, dorsal view; C — right femur and patella of pedipalp, dorsal view; D — left chela, dorsal view; E — right chela, lateral view; F — rallum, ventral view; G — subterminal setae of the telotarsi of legs I (on the left) and IV (on the right); H — distal part of movable chelal finger, lateral view; I — teeth of chelal fingers (no scale). Scale bars: 0.25 mm.

Рис. 3. *Neobisium* (*Neobisium*) *berberorum* sp.n., голотип ♀: A — карапакс, вид сверху; B — правая хелицера, вид сверху; C — правые фемур и пателла педипальпы, вид сверху; D — левая хела, вид сверху; E — правая хела, вид сбоку; F — раллум, вид снизу; G — субтерминальные щетинки телотарсов I (слева) и IV (справа) ног; H — дистальная часть подвижного пальца хелы, вид сбоку; I — зубы хелальных пальцев (без масштаба). Масштаб: 0,25 мм.

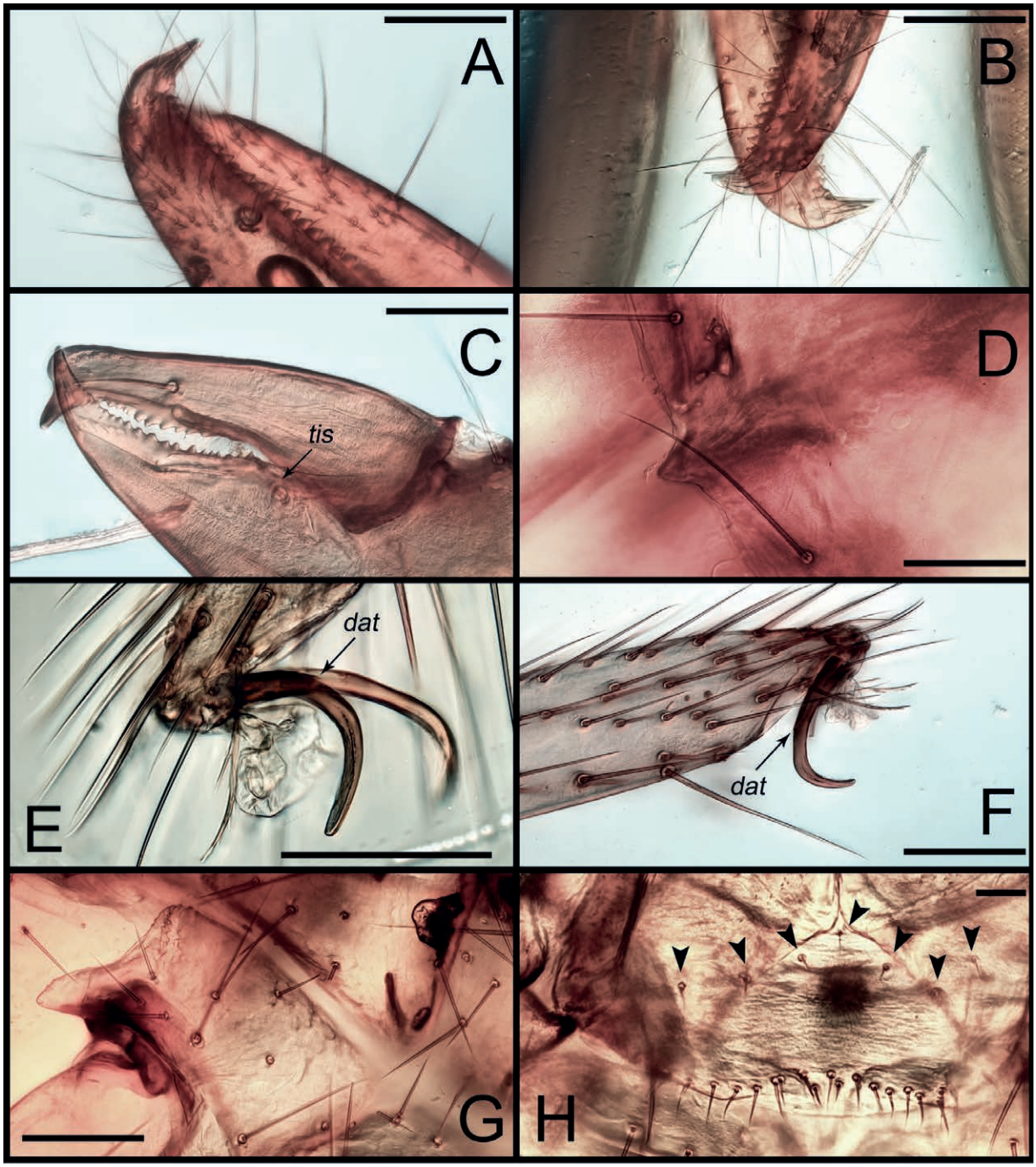


Fig. 4. *Neobisium* (*Neobisium*) *berberorum* sp.n., ♀ holotype: A — distal part of fixed chelal finger, lateral view; B — distal part of movable chelal finger, medial view; C — cheliceral fingers, dorsal view; D — epistome, dorsal view; E — distal part of left pedal tarsus I, dorsal view; F — distal part of left pedal tarsus IV, dorsal view; G — anterolateral processes on coxae of leg I, ventral view; H — sternite II (arrows mark the anterior row of setae), ventral view. Scale bars: 0.25 mm.

Рис. 4. *Neobisium* (*Neobisium*) *berberorum* sp.n., голотип ♀: A — дистальная часть фиксированного пальца хелы, вид сбоку; B — дистальная часть подвижного пальца хелы, вид изнутри; C — хелицеральные пальцы, вид сверху; D — эпистом, вид сверху; E — дистальная часть предплюсны левой ноги I, вид сверху; F — дистальная часть предплюсны левой ноги IV, вид сверху; G — передне-боковые отростки на тазиках ноги I, вид снизу; H — стернит II (стрелками отмечен передний ряд щетинок), вид снизу. Масштаб: 0,25 мм.

1.35 times as long as patella, tibia 6.25, metatarsus 4.16 and tarsus 5.16 times as long as deep, tarsus 1.24 times as long as metatarsus; leg IV femur 2.16, patella 3.06, tibia 8.52, metatarsus 4.11 (TS = 0.12) and tarsus 4.82 (TS = 0.40) times as long as deep, tarsus 1.17 times as long as metatarsus; subterminal setae furcate (Fig. 3G).

Measurements (mm) and ratios. Body length 3.00. Carapace 1.00 × 1.00 anteriorly. Chelicera 0.72 × 0.36; movable finger length 0.43. Pedipalp: femur 1.87 × 0.35; patella 1.40 × 0.37; chela with pedicel 2.77; hand with pedicel length 1.20; hand width 0.48; hand deep 0.46; movable finger length 1.62. Leg I: femur 0.95 × 0.17, patella 0.70 × 0.17, tibia 0.75 × 0.12,

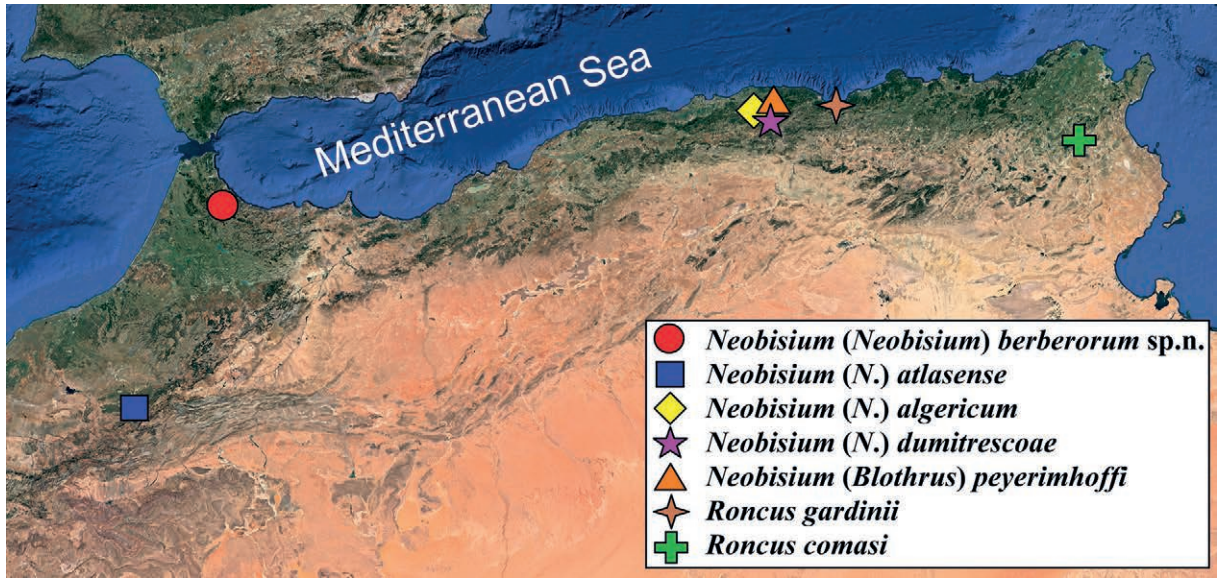


Fig. 5. Distribution map of cave-dwelling Neobisiidae in the Rif Mountains and the Atlas Mountains, North Africa.
Рис. 5. Карта распространения пещерных Neobisiidae в горах Риф и Атлас, Северная Африка.

metatarsus 0.50 × 0.12, tarsus 0.62 × 0.12. Leg IV: femur 0.65 × 0.30, patella 0.92 × 0.3, femur+patella 1.57, tibia 1.45 × 0.17, metatarsus 0.70 × 0.17, tarsus 0.82 × 0.17.

DISTRIBUTION. Currently known only from the type locality.

COMPARISON. Due to the limited range of most cave-dwelling *Neobisium* (e.g., Gardini [2023]; Hlebec *et al.* [2023]), it is advisable to compare the new species only with other troglomorphic and troglophilic species of this genus known from North Africa.

From *Neobisium* (*N.*) *atlasense* known from the caves Morocco [Leclerc, 1989], the new species is distinguished by the following characters: epistome present (*vs.* epistome absent in *N.* (*N.*) *atlasense*); anterior eyes ones with convex lens, posterior ones reduced, with weak lens (*vs.* two pairs of well-developed eyes, in *N.* (*N.*) *atlasense*); cheliceral fixed finger with 19 teeth, movable finger with 10 teeth (*vs.* 15–16 and 13 teeth, respectively, in *N.* (*N.*) *atlasense*); rallum with 7 blades (*vs.* 8–9 blades in *N.* (*N.*) *atlasense*); pedipalpal femur 5.34 times as long as broad (*vs.* 7.58–8.22 in *N.* (*N.*) *atlasense*); fixed chelal finger with 78 and movable chelal finger with 85 teeth (*vs.* 51 teeth in both sexes and 30–32 teeth in males and 44 in females, respectively, in *N.* (*N.*) *atlasense*); trichobothrium *it* at same level with *et* (*vs.* trichobothrium *et* proximal to *it* in *N.* (*N.*) *atlasense*); chelal hand tapering only basal quarter of chelal hand (*vs.* tapering noticeably in basal half in lateral aspect in *N.* (*N.*) *atlasense*).

From *Neobisium* (*N.*) *algericum* known from the caves of Algeria [Ellingsen, 1912; Heurtault, 1990], the new species is distinguished by the following characters: chaetotaxy of carapace 5:4:13:7 (*vs.* 4:6:6:6 in *N.* (*N.*) *algericum*); anterior eyes ones with convex lens, posterior ones reduced, with weak lens (*vs.* two pairs of eyes of with weak lens, in *N.* (*N.*) *algericum*); palm of chelicera with 5 acuminate setae (*vs.* 6 acuminate setae in *N.* (*N.*) *algericum*); trichobothrium *it* at same level with *et* (*vs.* trichobothrium *et* proximal to *it* in *N.* (*N.*) *algericum*).

From *Neobisium* (*N.*) *dumitrescoae* known from the caves of Algeria [Heurtault, 1990], the new species is distinguished by the following characters: chaetotaxy of carapace 5:4:13:7 (*vs.* 4:6:6:6 in *N.* (*N.*) *dumitrescoae*); fixed chelal finger with 78 teeth and movable chelal finger with 85 teeth (78 and 90 teeth, respectively, in *N.* (*N.*) *dumitrescoae*); chela with pedicel 5.77 times as long as broad (*vs.* 4.30 times in *N.* (*N.*) *dumitrescoae*); leg IV femur 2.16 times as long as deep (*vs.* 3.86 times in *N.* (*N.*) *dumitrescoae*).

From *Neobisium* (*Blothrus*) *peyerimhoffi* known from the caves of Algeria [Heurtault, 1990], the new species is distinguished by the following characters: chaetotaxy of carapace 5:4:13:7 (*vs.* 4:6:6:6 in *N.* (*B.*) *peyerimhoffi*); anterior eyes ones with convex lens, posterior ones reduced, with weak lens (*vs.* eyes absent in *N.* (*B.*) *peyerimhoffi*); fixed chelal finger with 78 teeth and movable chelal finger with 85 teeth (*vs.* 133 and 137 teeth, respectively in *N.* (*B.*) *peyerimhoffi*); trichobothrium *t* distal to *ist* (*vs.* trichobothrium *t* at same level with *ist* in *N.* (*B.*) *peyerimhoffi*); chelal hand tapering only basal quarter of chelal hand (*vs.* tapering noticeably in basal half in lateral aspect in *N.* (*B.*) *peyerimhoffi*).

## Discussion

The Rif Mountains and the neighbouring Atlas Mountains are a part of the Mediterranean zoogeographical region with a typical climate for the region; through the Strait of Gibraltar, they are closely connected with European Mediterranean floristic and faunal complexes, with common elements at the genus and species levels [Ketenchiev, 2013]. This also applies to a greater extent to the fauna of pseudoscorpions: for example, the genera known from both the Rif Mountains and the Atlas Mountains and the entire Euro-Mediterranean region are *Ephippiochthonius* Beier, 1930 and *Occidenchthonius* Zaragoza, 2017 (Chthoniidae Daday, 1889), *Mesochelifer* Vachon, 1940 (Cheliferidae Risso, 1827), *Microcreagrina* Beier, 1961 (Syarinidae Chamberlin, 1930), *Roncus* L. Koch, 1873 and *Neobisium* (Neobisiidae), etc. [WPC, 2023]. This was partly noticed by Heurtault [1990], who showed that cave-dwelling pseudoscorpions of the family Neobisiidae known from the Atlas Mountains are similar to those in the Mediterranean fauna.

The distribution of the known species of cave-dwelling Neobisiidae in the Rif Mountains and Atlas Mountains is extremely uneven (see Fig. 5): *Neobisium* (*Neobisium*) *berberorum* sp.n. is described from the Rif Mountains in Morocco (this study); *N*. (*N*.) *algericum* is described from the Middle Atlas Range in Morocco [Leclerc, 1989]; *N*. (*N*.) *atlasense*, *N*. (*N*.) *dumitrescoae* and *N*. (*Blothrus*) *peyerimhoffi* are described from the Tell Atlas Range in Algeria [Ellingsen, 1912; Heurtault, 1990]. Also, two troglomorphic neobisiid species of the genus *Roncus* are known from the caves of the Atlas Mountains: *R. gardinii* Heurtault, 1990 is described from the Tell Atlas Range in Algeria [Heurtault, 1990] and *R. comasi* Mahnert, 1985 is described from the southern spurs of the Tunisian Tell Range in Tunisia [Mahnert, 1985].

As can be seen from the above, studies of the cave-dwelling Neobisiidae of the region have always been fragmentary, in contrast to the neighbouring regions of the Mediterranean, from where many species of this family have been described [WPC, 2023]. Therefore, the description of *Neobisium* (*Neobisium*) *berberorum* sp.n. from the caves of Morocco adds to our knowledge of the pseudoscorpion fauna of the Rif Mountains as a region of the Mediterranean.

**Compliance with ethical standards**

CONFLICT OF INTEREST: The authors declare that they have no conflict of interest.

**Ethical approval:** No ethical issues were raised during our research.

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