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First report of a synanthropic silverfish of the genus *Namunukulina* Wygodzinsky, 1957 in Europe (Zygentoma: Lepismatidae)

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Abstract – The genus *Namunukulina* Wygodzinsky, 1957 (Zygentoma: Lepismatidae: Silvestrellatinae) and the species *Namunukulina congolense* (Mendes, 1982) are reported for the first time from Hungary, representing the first records of the genus and the species from Europe.

Key words – new record, faunistics, distribution, identification, domestic species

INTRODUCTION

The order Zygentoma includes five extant families (Mendes 2018) and about 650 described species worldwide (Bednár *et al.* 2023). The most thoroughly researched family is Lepismatidae, including domestic silverfish. The genus *Namunukulina* Wygodzinsky, 1957 belongs to the subfamily Silvestrellatinae of Lepismatidae (Mendes 1991); the subfamily contains four genera with only seven valid species (Molero-Baltanás *et al.* 2024*a*).

Very little data is available about the distribution and ecology of species of *Namunukulina*. It was considered monotypic in the mid-twentieth century; the only known species, *N. funambuli* (Wygodzinsky, 1957) was first collected in Ceylon (now Sri Lanka) from a nest of the Indian palm squirrel, *Funambulus palmarum* (Linnaeus, 1766) (Mammalia: Sciuridae) (Wygodzinsky 1957). Since then, this species has been recorded from other geographic areas, mainly from South American countries (Smith 2017), and two additional species have been described: *N. congolense* (Mendes, 1982) from Zaire (now the Democratic Republic of the Congo), and *N. sudanica* (Mendes, 1993) from Sudan.

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Another species, *N. domestica* (Sukumar et Livingstone, 1992), has also been described from India; however, its identity has remained doubtful, as its original description is confusing (especially the abdominal chaetotaxy that was evidently misinterpreted by its authors) and provides characters that do not match with the genus *Namunukulina*, such as the presence of submedian urotergal combs (in *Namunukulina* the submedian position has only isolate macrosetae). Accordingly this species is considered here as a species of uncertain identity.

It is doubtful whether *Namunukulina* species can be regarded as synanthropic: although they have been also recorded in peridomestic habitats, they have been mainly found in other, non-domestic habitats (Molero-Baltanás *et al.* 2024*b*). So far, no species belonging to this genus has been recorded from Europe. *Namunukulina congolense* was described from Zaire (Mendes 1982) and later has been found in other African countries such as Cape Verde (Mendes 1992), Gambia (Irish 1986), and Namibia (Irish 1996). In this paper we present the first record of this species from Hungary, representing its first record from Europe as well.

MATERIAL AND METHODS

The voucher specimens were examined with a Zeiss Axio Zoom.V16 stereomicroscope (Plan Z 1.0X/0.25 FWD 60mm objective) and photographed with a camera Axiocam 208 color (EDF mode, Zen core program). Two specimens were dissected by the first author and mounted on slide to observe their chaetotaxy with light microscope (some setae were detached and only their insertions were visible). Micrographs were taken with a Nikon DS-Fi1 digital camera attached to a Nikon Labophot light microscope. For observing some characters scanning electron microscope (SEM) was used. Two specimens were dehydrated with absolute ethanol, air dried from hexamethyldisilazane (Ubero-Pascal *et al.* 2005), coated with gold, and examined and imaged using a JEOL JSM 6300 SEM in the microscopy service of the Servicio Central de Apoyo a la Investigación (SCAI), University of Córdoba (Spain). The characters of the specimens, especially the chaetotaxy, were compared with those described for the previously known species of the genus, mainly following the original descriptions of *N. funambuli*, *N. congolense*, and *N. sudanica* (Wygodzinsky 1957, Mendes 1982, Mendes 1993).

RESULTS

Namunukulina congolense Mendes, 1982
(Figs 1–6)

Material examined – Hungary: Budapest, 14th District, Nagy Lajos király street 19/B, from 3 apartments, 12.VI.2024 (2 specimens), 14.VI.2024 (1 specimen), 28.X.2024 (5 specimens), 29.X.2024 (4 specimens), 5.XI.2024 (3 specimens), 25.XII.2024 (2 specimens), leg. J. Fiam; altogether 17 specimens were collected, all from inside of human-inhabited buildings. Four specimens are preserved in ethanol, two specimens are mounted on slides, and two specimens are mounted for SEM examination are available at the entomological collection of the Departamento de Zoología, University of Córdoba (Spain) (in total 8 specimens). Seven voucher specimens are preserved in ethanol and deposited in the Soil Zoological Collection of the Hungarian National Museum Public Collections Centre – Hungarian Natural History Museum, Budapest (HNHM).

Remarks – First records for Hungary and for the Palaearctic Region. *Namunukulina congolense* has been known from the Afrotropical Region so far.

DISCUSSION

The specimens examined in course of this study evidently belong to the subfamily Silvestrellatinae due to the developed thoracic sternites, the reduced prosternum (as compared to mesosternum and metasternum), plumose macrosetae, the lack of anterior margin of pronotum and setal collar, the short and conical ovipositor provided with hyaline, straight spines, and the arrangement of the papillae of the apical article of labial palps (in two rows (2+3)). The voucher specimens correspond to the genus *Namunukulina* due to their abdominal chaetotaxy: most urotergites are provided with 1+1 isolated macrosetae in lateral and submedian positions, inserted very close to their hind margin (Figs 1A, 1B), and most urosternites lack median combs (with the exception of one abdominal sternite, usually the second or the third, cf. Fig. 2B). Their specific identity as *N. congolense* is also determined by abdominal chaetotaxy: the main differences between this species and the other two valid species of the genus are shown in Table 1. *Namunukulina domestica* is considered here as a species of uncertain identity, and thus excluded from the valid species of the genus; nevertheless, characters that can be extracted from its original description (Sukumar & Livingston 1999) are also given in Table 1 to demonstrate its doubtful status. The studied specimens from Budapest match with the characters presented for *N. congolense* provided in Table 1: the position of its abdominal macrosetae is shown in Fig. 1 (urotergites VI and VII) and Fig. 2B (ventral chaetotaxy).

Table 1. Diagnostic characters of *Namunukulina* species regarding chaetotaxy (number of macrosetae). Roman numerals indicate the abdominal segment. The number of macrosetae is only provided only for one side of the body (i.e., for example, urotergite II of *N. congolense* has 1+1 macrosetae in lateral position, meaning 1 on the left side and 1 on the right side). Positions where there are differences between valid species are marked with bold. Positions marked with asterisk "*" indicate a row of 2–4 macrosetae; the term "comb" is usually used for this row in the taxonomy of Zygentoma. A question mark "?" means that the concrete number of macrosetae of the group/comb is not clearly described.

	Urotergites (dorsal plates)			**Urosternites (ventral plates)**	
Species	**Infralateral** position*	**Lateral** position	**Submedian** position	**Median** position	**Lateral** position*
N. congolense	I: 2 II: 2 III: 2–4 IV: 2–4 V: 2–4 VI: 2–4 VII: **4** VIII: **4**	I: 0 II: 1 III: 1 IV: 1 V: 1 VI: 1 **VII: 0** **VIII: 0** IX:0 X: 1	I: 0 **II: 0** III: 1 IV: 1 V: 1 VI: 1 VII: 1 **VIII: 1**	**II: 3*** **III: 0** IV–VIII: 0	I: 0 II: 0 **III: 3–4** IV: 3–4 V: 3–4 VI: 3–4 VII: 3–4 VIII: 3–4 IX: 0 or overlooked
N. sudanica	I: 1–2 II: 1–2 III: 1–2 IV: 1–2 V: 1–2 VI: 1–2 VII: **1–2** VIII: **1–2**	I: 0 II: 1 III: 1 IV: 1 V: 1 VI: 1 **VII: 0** **VIII: 0** IX: 0 X: 1	I: 0 **II: 1** III: 1 IV: 1 V: 1 VI: 1 VII: 1 **VIII: 1**	**II: 2*** **III: 0** IV–VIII: 0	I: 0 II: 0 **III: 2** IV: 2 V: 2 VI: 2 VII: 2 VIII: 2 IX: 0 or overlooked

Table 1. (continued).

	Urotergites (dorsal plates)			**Urosternites (ventral plates)**	
Species	**Infralateral** position*	**Lateral** position	**Submedian** position	**Median** position	**Lateral** position*
N. funambuli	I: 2 II: 2 III: 2–3 IV: 2–3 V: 2–3 VI: 2–3 VII: **2–3** VIII: **2–3**	I: 0 II: 1 III: 1 IV: 1 V: 1 VI: 1 **VII: 1** **VIII: 1** IX: 0 X: 1–2	I: 0 **II: 0** III: 1 IV: 1 V: 1 VI: 1 VII: 1 **VIII: 0**	**II: 0** **III: 3*** IV–VIII: 0	I: 0 II: 0 **III: 0** IV: 3 V: 3 VI: 3 VII: 3 VIII: 3 IX: **1**
N. domestica (species inquirenda)	I: ? II: ? III: ? IV: ? V: ? VI: ? VII: ? VIII: ?	No visible in the figure and considering the key absent (perhaps overlooked?) This may be explained by an error of the authors considering the infralateral group as associated to urosternites	I: 0 II: 0 or overlooked III–VIII: apparently more than 1 (combs) If these are actually combs and not isolated setae, perhaps the insect does not belong to *Namunukulina*	In plate XVII, the sternite I is not drawn or the median comb is on urosternite I. Assuming the first option: II: ? III: 0 But the key indicates that the median comb is in III	The sternite I is not drawn or the first lateral comb is on urosternite I (which contradicts the key). Assuming the first option: II: 0 **III: ?** IV: ? V: ? VI: ? VII: ? VIII: ? **IX: more than 1**

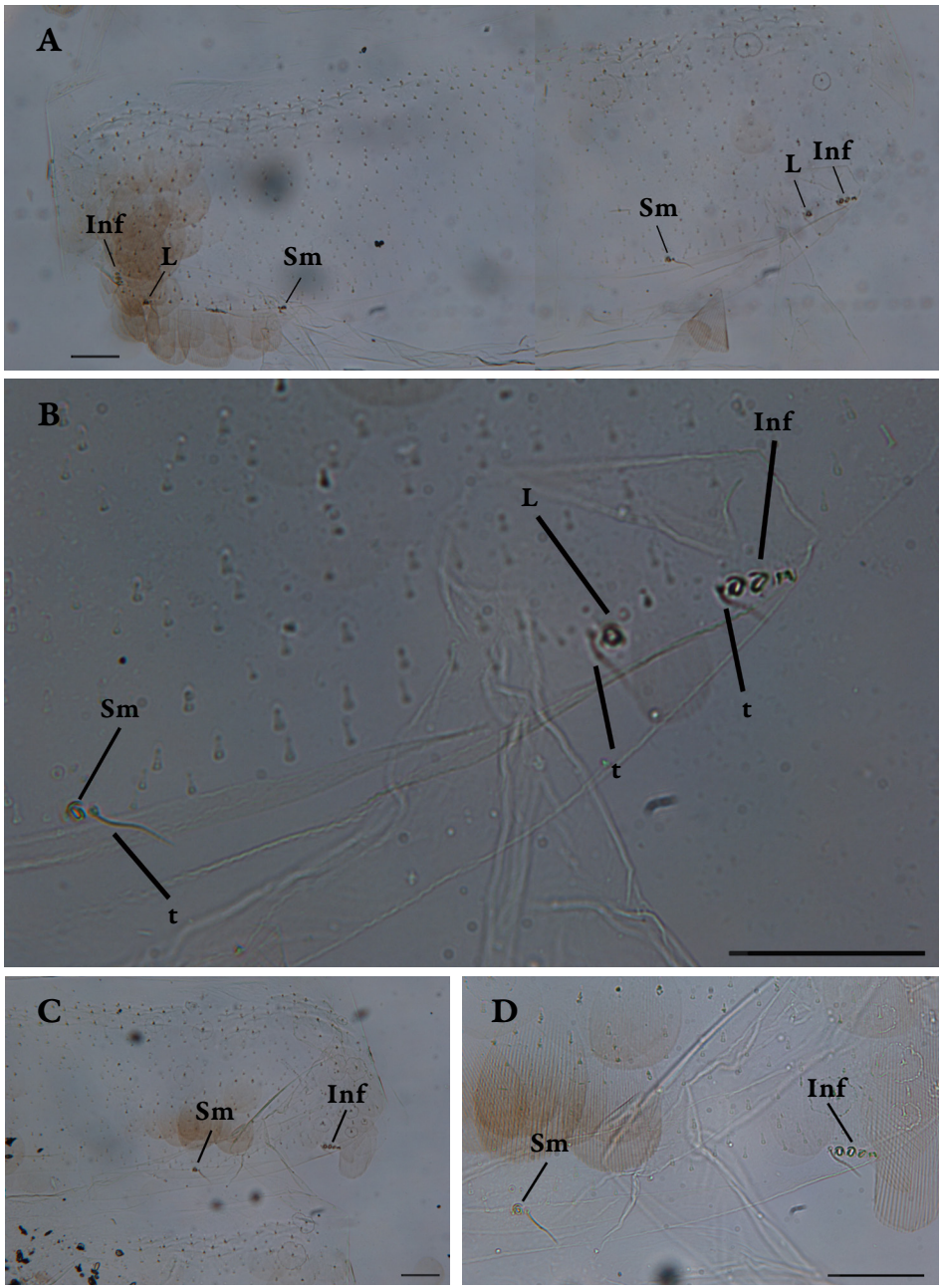

Fig. 1. Micrographs of the urotergal (dorsal abdominal) chaetotaxy of a *Namunukulina congolense* (Mendes, 1982) specimen collected in Budapest. A = urotergite VI, showing the position (sockets) of the infralateral group of macrosetae (Inf), the lateral macroseta (L) and the

(*continued in the opposite page* ►)

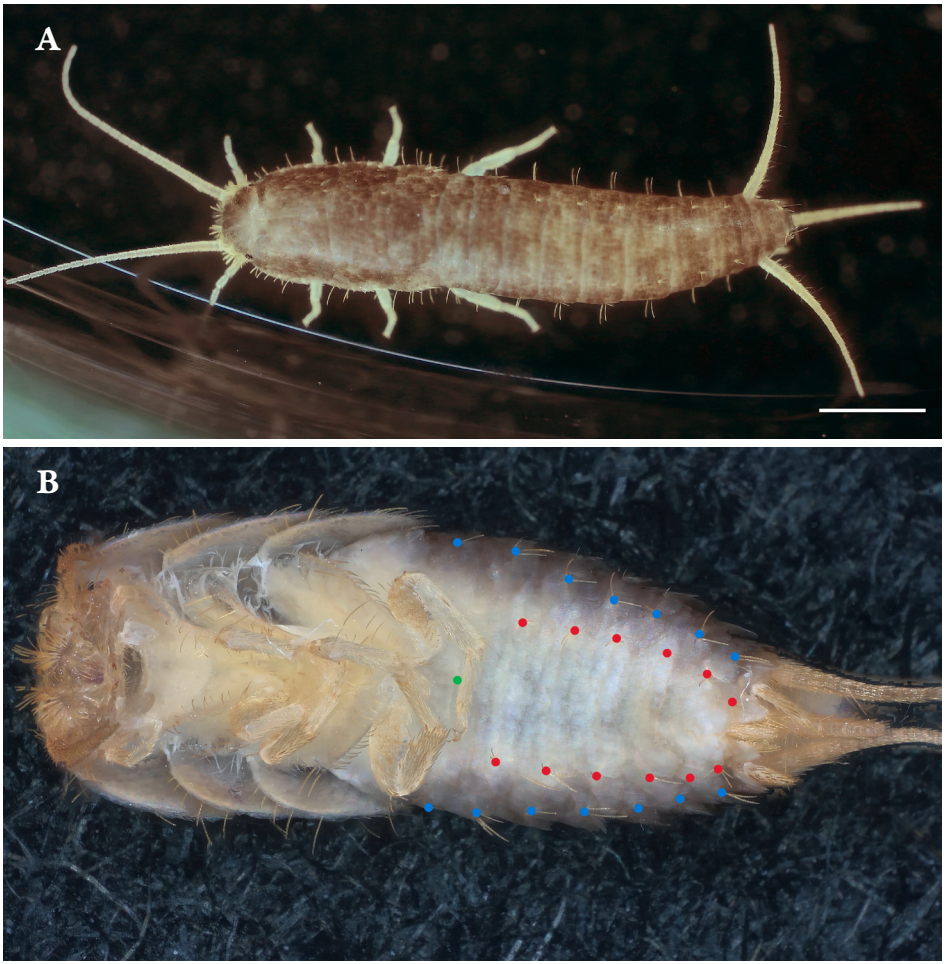

Fig. 2. *Namunukulina congolense* (Mendes, 1982) individuals collected in Hungary. A = dorsal habitus photo, scale bar = 1 mm; B = ventral habitus photo, the position of infralateral groups is marked with blue (small rows of 2–4 macrosetae inserted on the most lateral part of the dorsal plates that is bent downwards covering the most lateral part of the ventral plates), the position of lateral combs of urosternites is marked with red, and the position of the unique median comb on urosternite II is marked with green (photos by Judit Fiam). Image not to scale.

(◂ *continued from the opposite page*)
submedian macroseta (Sm); B = detail of the same urotergite (right side, hind margin), showing the insertions of macrosetae, the thin hairs are trichoid sensilla (t); C = right side of urotergite VII, where the lateral seta is absent; D = detail of the hind margin of the right side of the urotergite VII. Scale bars = 0.1 mm (photos by Rafael Molero-Baltanás)

SEM images allow an accurate documentation and description of the characteristics of scales and sensilla (mainly those of the appendages) in the genus *Namunukulina*. The macrosetae are feathered, with several rows of short branches (Fig. 3A). A second type of flattened macroseta with points at both sides is detected; they resemble the "scale-macrosetae" of MENDES (2008) mentioned for another genus of Silvestrellatinae, *Hemikulina* Mendes, 2008; this type of macrosetae has been observed on the antennae (Fig. 3B), palps (Fig. 3C), tibiae (Fig. 3D), tarsi (Fig. 3E), styli (Fig. 3F), and terminal filaments (usual macrosetae are also present on the latter, cf. Fig. 3A). Apart from flattened macrosetae, several types of sensilla have been observed on the antennal flagellum (Fig. 4): trichobothria with short hairs (Fig. 4A), striated trichoid sensilla (Fig. 4B, 4C), basiconic sensilla which can match with types A (or D), B (Figs 4B–4D, respectively), and type C or F proposed by ADEL (1984) (Figs 4E, 4F). Coeloconic sensilla (Fig. 4E) and rosette-like pores (Fig. 4G) have also been observed. The rounded sensilla described as typical of the subfamily Silvestrellatinae (MENDES, 2008) actually correspond to thin-walled basiconic sensillum type C or F with porose tegument (Figs 4E, 4F) that have been mentioned by some authors as "Silvestri's sensilla" or (incorrectly) "campaniform sensilla". Trichobothria have also been observed on cerci. A small, cylindrical, pronged sensillum with a short base and 2–3 finger-like apical projections has been observed on the apex of the last article of the maxillary palp (Fig. 5A).

The cephalic scales are typical in shape, rounded or more elliptical or subrectangular, with numerous parallel or subparallel ribs and orbicular base (surrounding posteriorly the socket of the scales), increasing in size from the occipital area to the frontal part of the head (Fig. 5B). Similar rounded scales can be observed covering the body dorsally and ventrally, as well as on coxae (Fig. 5C). Femoral scales are different, ovoid with denticulate margins, not orbicular in their basal part, very likely representing a transition between the usual rounded orbicular scales and the flattened scale-macrosetae of tibiae (Figs 5D, 5E). The pretarsal claws are smooth, with striated ventral margin and microtrichia on their basal part (Fig. 5F).

SEM micrographs of the ovipositor show long and thin setae inserted on the apical divisions of gonapophyses (Fig. 6A), and a small cluster of elongate and acute spines on the apex of gonapophyses IX (Fig. 6B).

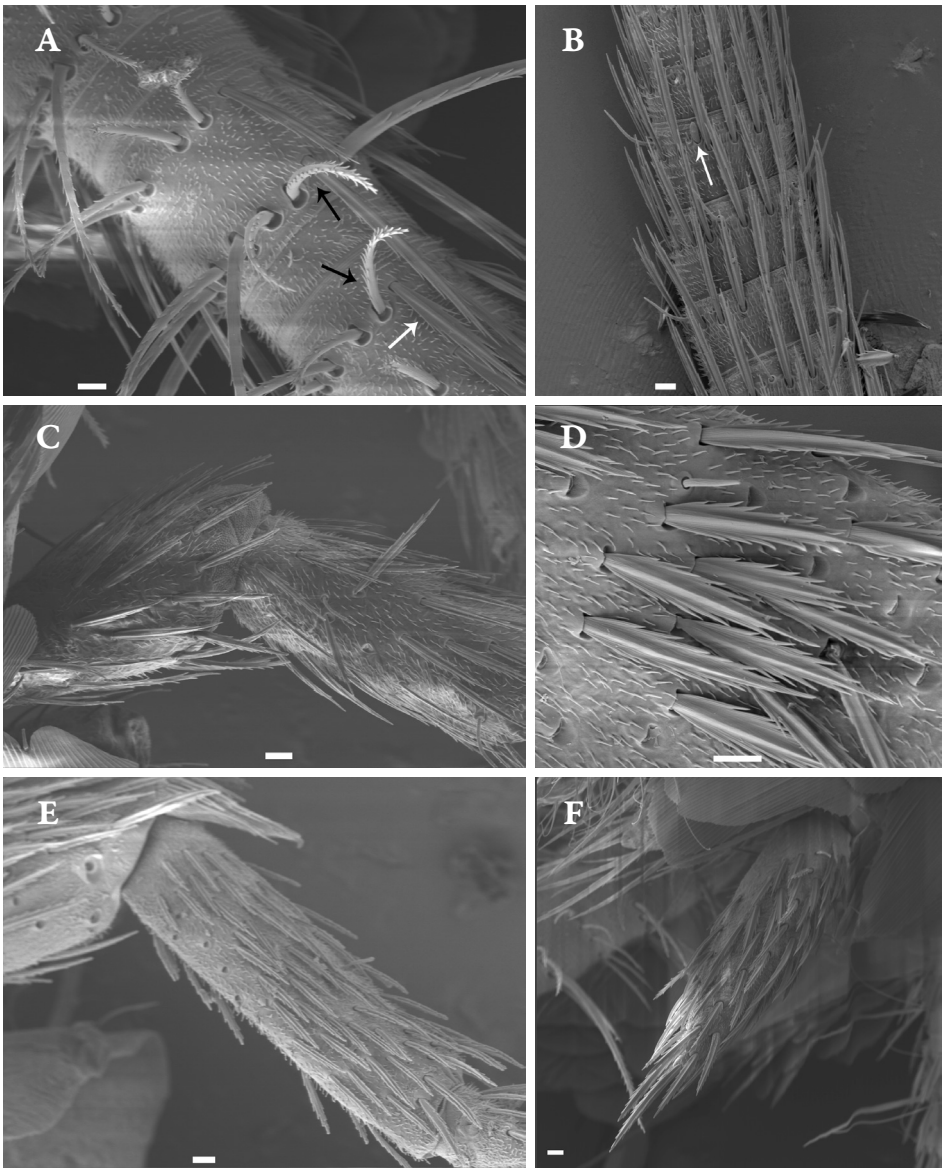

Fig. 3. *Namunukulina congolense* (Mendes, 1982) specimen collected in Budapest, SEM micrographs of appendages where flattened scale-macrosetae have been detected. A = a section of the cercus showing normal plumose macrosetae (black arrows) and flattened scale-macrosetae (white arrow); B = a portion of the antennal flagellum showing some flagellomeres, each one with a ring of flattened scale-macrosetae, white arrow indicates a pair of basiconic sensilla (types A and C); C = two basal articles of the maxillary palp; D = inner (ventral) surface of a tibia; E = first tarsal article of a leg, F = stylus IX. Scale bars = 10 μm (photos by Rafael Molero-Baltanás)

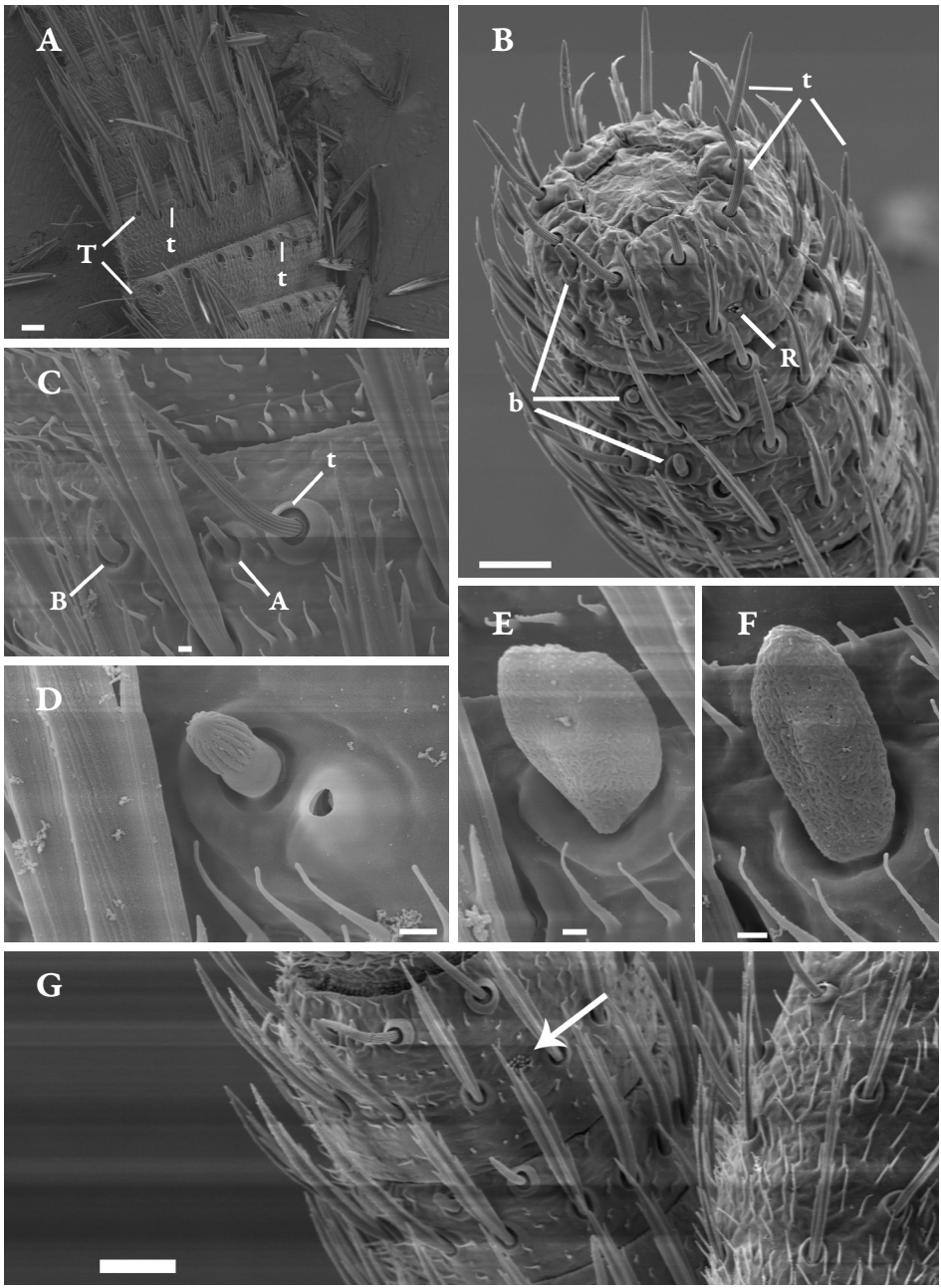

Fig. 4. *Namunukulina congolense* (Mendes, 1982) specimen collected in Budapest, SEM micrographs of the antennal sensilla (the scale-macrosetae indicated in Fig. 3 are not commented). A = flagellomeres where some trichobothria (T) can be observed, trichoid sensilla (t) are also present; B = apex of the antenna showing several basiconic sensilla type B

(*continued in the opposite page* ►)

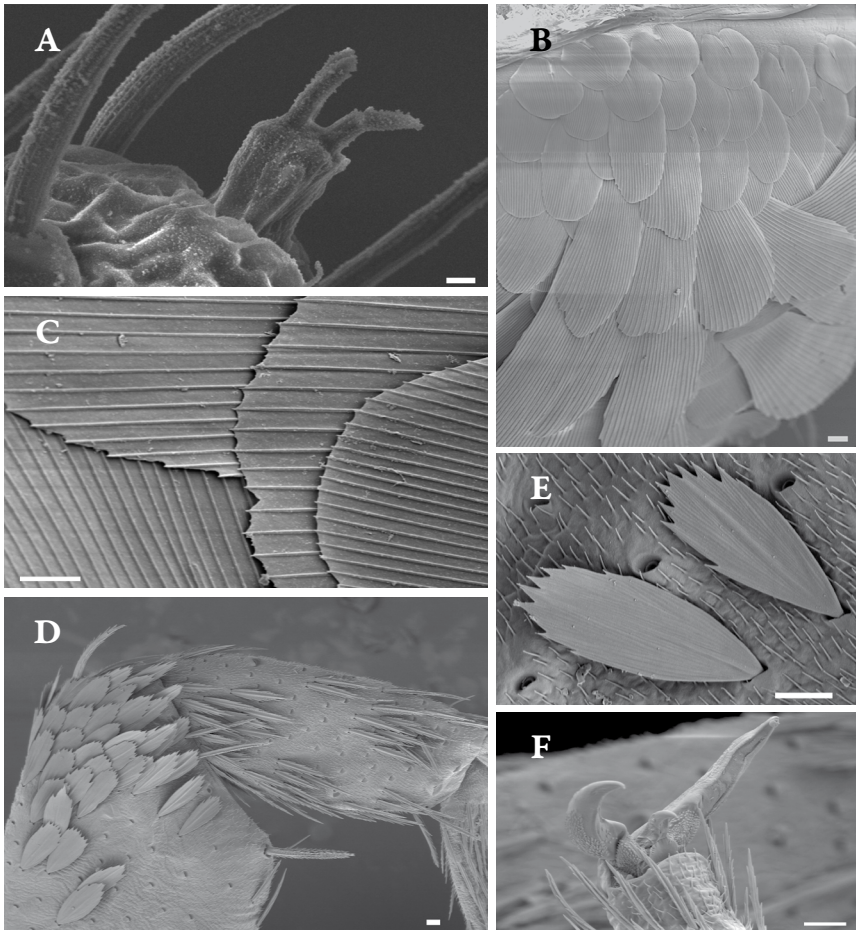

Fig. 5. *Namunukulina congolense* (Mendes, 1982) specimen collected in Budapest, SEM micrographs. A = pronged sensillum of the apex of maxillary palp; B = cephalic scales (the occiput is in the upper part of the image and the frontal area is below, with the size of scales increasing towards the frons); C = parallel ribs of orbicular rounded scales of the body, observed dorsally and ventrally (these on the image are ventral); D = profemur and protibia, inner side, showing femoral ovoid scales with denticulated margin compared with tibial flattened scale-macrosetae; E = detail of femoral scales; F = pretarsal claws. Scale bars = 10 μm, except for A scale bar = 1 μm) (photos by Rafael Molero-Baltanás)

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(three of them marked with b) and striated trichoid sensilla (three of them marked with t), a rosette-like pore (R) is also visible; C = a striated trichoid sensillum (t) inserted besides a basiconic sensillum type D (or A, marked with A), a basiconic sensillum type B (marked with B) is also visible on the left; D = a pair of sensilla (diad) composed of a basiconic type B and a coeloconic (on the right); E and F = two rounded basiconic sensilla that can be interpreted as C or F type; G = flagellomere where a rosette pore has been detected (arrow). Scale bars = 1 μm, except for A, B and G scale bars = 10 μm (photos by Rafael Molero-Baltanás)

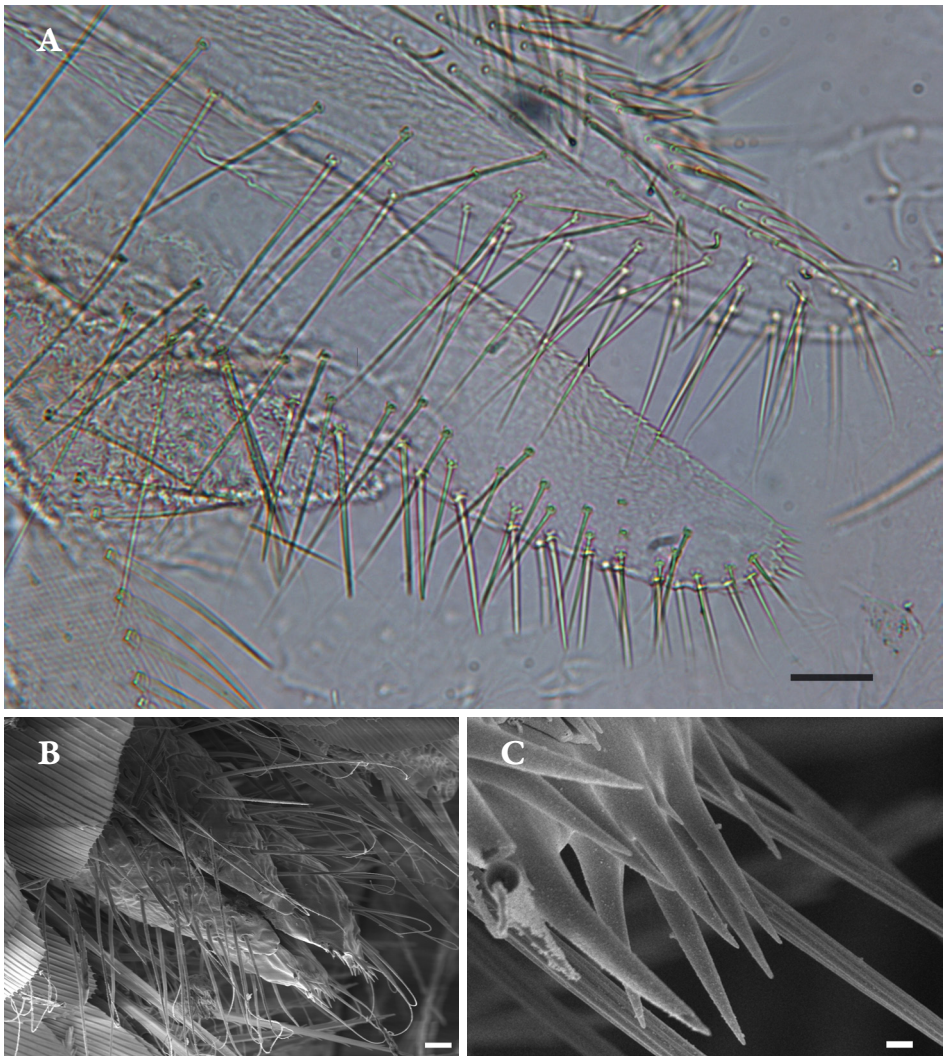

Fig. 6. *Namunukulina congolense* (Mendes, 1982) specimen collected in Budapest, ovipositor. A = micrograph of the apex of the ovipositor, scale bar = 0.1 mm; B = SEM micrograph of the apical part of gonapophyses, scale bar = 10 µm; C = detail of the cluster of acute spines on the apex of gonapophyses IX, scale bar = 1 µm (photos by Rafael Molero-Baltanás)

Based on the above detailed characteristics, an identification key is provided here to the three valid species *Namunukulina*.

1 Abdominal segment VII dorsally with only 1+1 macrosetae apart from infralateral group (these urotergal macrosetae are inserted on submedian or sublateral position); urosternite II with a small comb of macrosetae; urosternite III lacking median comb and with 1+1 small lateral combs of 2–4 macrosetae 2

– Abdominal segment VII dorsally with 2+2 macrosetae apart from infralateral group (1+1 urotergal macrosetae on submedian position and 1+1 additional macrosetae on lateral position); urosternite II without setae; urosternite III with a comb of about 3 macrosetae but lacking lateral combs; epidermal pigment absent or light yellowish, sometimes darker on lateral parts of thoracic nota ..... *N. funambuli* (Wygodzinsky, 1957)

2 Abdominal segment II dorsally with only 1+1 macrosetae apart from infralateral group (these urotergal macrosetae are inserted on lateral position); epidermal pigment light yellowish; infralateral groups of macrosetae usually with 2–4 macrosetae, those of segments VII and VIII usually with 4 macrosetae; lateral combs of urosternites usually with 3–4 macrosetae .. .. *N. congolense* (Mendes, 1982)

– Abdominal segment II dorsally with 2+2 macrosetae apart from infralateral group (1+1 urotergal macrosetae on submedian position and 1+1 additional macrosetae on lateral position); epidermal pigment violet, intense; infralateral groups of macrosetae usually with only 1–2 macrosetae, those of segments VII and VIII never with 4 macrosetae; lateral combs of urosternites with 2 macrosetae ..... *N. sudanica* (Mendes, 1993)

The bodies of the three valid *Namunukulina* species are elongated and narrow, and the thorax is not or only slightly detached from the base of the abdomen. These species are relatively small: *N. funambuli* is 6 mm, *N. congolense* is 5.5 mm, and *N. sudanica* is 4.9 mm long (maximum lengths reported). Their dorsal coloration, due to scale cover, is light, silvery greyish, yellowish or brownish, and they are usually whitish ventrally. The antennae are medium-sized, shorter than body length (Wygodzinsky 1957, Mendes 1982, Mendes 1993). These characters are similar to those of young individuals of *Lepisma saccharinum* (Linnaeus, 1758), which raises the possibility that *N. congolense* might be more widespread in Europe, but has remained unnoticed due to confusion with the small *L. saccharinum*. Nevertheless, the head of *Namunukulina* species bears dense tufts of macrosetae on the marginal and submarginal region anterior to the eyes, and with 1+1 irregular groups on frons sublaterally (Fig. 2); the head of *L. saccharinum* lacks dense tufts, only bears disperse setae.

N. congolense was described based on a female holotype and two juvenile specimens collected in 1958 (Mendes 1982). The description is primarily based on the holotype, which has a very light, whitish, or slightly yellowish body but the dorsal scales preserved are brown (Mendes 1982). This is similar to what

has been observed in the specimens found in Hungary: the epidermal pigment, visible ventrally where the scales are almost transparent (Fig. 2B), is whitish (at most light yellowish) and the scales are of silvery sheen and slightly brownish hue on the dorsal part (Fig. 2A) (consider that the silvery grey colour usually turns to brown when preserved in alcohol, which was the case of the specimens studied by Mendes). The antennae and caudal filaments of the holotype lack pigmentation, which is not the case of the Hungarian specimens; the latter ones have yellowish appendages, but this difference may be attributed to the long time spent by the holotype in ethanol. Nevertheless, size and colour are not the most relevant characters for identifying Zygentoma. It is of crucial importance that the abdominal chaetotaxy of the Hungarian specimens coincides with that described for *N. congolense* (Table 1). Identifying specimens on the basis of abdominal chaetotaxy can be challenging, because in some cases the macrosetae are not clearly seen if specimens are not fresh, and only their insertions are visible using light microscopy. Moreover, it is necessary to interpret correctly the positioning of the outer group of urotergal macrosetae located on the lateral part of the tergum, which typically bends ventrally and is visible from a ventral perspective (Fig. 2B). That is why the term "infralateral group" is used in the taxonomy of Lepismatidae to refer to this group of setae on urotergites. Zygentoma specialists are generally aware of this; however, Sukumar & Livingstone (1993) probably misinterpreted the infralateral group as inserted on ventral plates in *N. domestica*, and accordingly erroneously indicated that this species has 2+2 urotergal and 2+2 urosternal combs in most urotergites. Therefore, this species should be redescribed in the future based on a proper examination of the type material.

The SEM micrographs provided in the present work represent the first study of any member the subfamily Silvestrellatinae using this type of microscopy. SEM images of some characteristics, as scales shape and distribution (especially of appendages), sensilla of antennae and maxillary palp, contribute to a better understanding of the morphology of these insects, and are expected to facilitate future comparisons with other silverfish genera.

Whether *N. congolense* is a synanthropic species has remained uncertain for a long time due to the scarce information available (Molero-Baltanás *et al.* 2024*b*). However, the appearance of this species in Hungary can clearly be linked to a human-inhabited environment.

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