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Research article

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Description of a new trapdoor spider species from southern Spain that exhibits an as yet unknown defence strategy (Araneae: Mygalomorphae: Nemesiidae)

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Abstract. The description of the new trapdoor spider species *Nemesia shenlongi* sp. n. is provided, together with details of its habitat and burrow structure. The spider uses a round ball made of soil particles and saliva to plug part of its burrow and leave an isolated chamber for protection. The ball differs from all known 'burrow-blocking structures' produced by Nemesiidae, for example, *Nemesia manderstjernae* Koch, 1871, and *N. fagei* (Frade & Bacelar, 1931), in that it is not packed in silk and is not attached to the burrow wall. The new species is compared with morphologically similar *Nemesia* spp. as well as with *N. fagei*.

Keywords. Ecology, Nemesiidae, phenology, taxonomy, trapdoor spiders, western Mediterranean.

Descripción de una especie nueva de araña trampera del sur de España que presenta una estrategia de defensa hasta ahora desconocida (Araneae: Mygalomorphae: Nemesiidae)

Resumen. Se aporta la descripción morfológica de la nueva especie de araña trampera *Nemesia shenlongi* sp. n. junto a detalles de su hábitat y la estructura de su madriguera. Esta araña utiliza una bola que fabrica con partículas de suelo y saliva para bloquear parte de su madriguera y dejar una cámara aislada donde protegerse. La bola difiere de todas las 'estructuras de bloqueo de madrigueras' conocidas que la familia Nemesiidae fabrica, por ejemplo, *Nemesia manderstjernae* Koch, 1871, y *N. fagei* (Frade & Bacelar, 1931), en que no está envuelta en seda y no está unida a la pared de la madriguera. La nueva especie se compara con otras especies morfológicamente similares, así como con *N. fagei*, que muestra un comportamiento similar.

Palabras clave. Arañas tramperas, ecología, fenología, Mediterráneo occidental, Nemesiidae, taxonomía.

INTRODUCTION

Trapdoor spiders conceal their burrow with a hinged cover at the entrance. Their life takes place almost entirely inside these burrows, where they feed, develop and breed; only the mature males leave the safety of their nest to look for females to mate (Buchli 1969). Among trapdoor spiders, the genus *Nemesia* Audouin, 1826 currently contains 68 named species, mostly distributed in the western Mediterranean basin (World Spider Catalog 2022). Historically the identification of *Nemesia* species has been a challenge because the descriptions of some species are imprecise and ambiguous, based on a single sex, even on a single specimen; moreover, the type material of some taxa is lost. Interspecific differences are very subtle in many cases (Bond et al. 2006) and the hidden life in a burrow make the study of these spiders even more difficult. Some of the recent publications incorporate data on the behaviour and type of burrows built by each species (Decae & Huber 2017; Luis de la Iglesia 2019; Luis de la Iglesia et al. 2021; Calvo 2020, 2021). The structure of the nest could help with species level identification (Mora 2015: 31, 76, 304), as some of the *Nemesia* species build very characteristic burrows. Most informative in this respect are those species that construct special, presumably defensive, devises inside their burrows (Moggridge 1873, 1874; Frade & Bacelar 1931). *Nemesia fagei* is so far the only Iberian species for which such a devise has been formally reported, although several unpublished reports exist in which Iberian *Nemesia* species are indicated to construct internal burrow plugging devises. *Nemesia fagei* constructs a silk packed, bullet-shaped clay plug

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that is attached to the internal silk lining of the burrow (see Frade & Bacelar 1931 for a description of the plug and the associated defence behaviour) Here we describe a second Iberian species that, in contrast to all known types of burrow-plugging devices, constructs a burrow plug that is not packed in silk and is not attached to the silken burrow lining.

In this respect, the here described burrow-plugging device appears unique within fossorial mygalomorph spiders as they are known today.

MATERIAL AND METHODS

The specimens of the new species were collected in the area of Torrecera, Jerez de la Frontera, Spain. Males were collected by dropping traps with water and salt as preservation medium, while females were collected directly by searching their burrows. Specimens collected by both methods were preserved in 70% alcohol and deposited in the collections of the Museo Nacional de Ciencias Naturales (MNCN) and the personal collection of the first author (CPC).

Photographs were taken with a Finepix S camera, a Nikon D3300 camera coupled with an adapter to the stereomicroscope Euromex SB.1903-P and a Bresser ocular camera. Morphological characters proposed in previous works were considered for description (Decae et al. 2007; Isaia & Decae 2012; Decae & Huber 2017; Zontein 2017; Luis De La Iglesia 2019; Calvo 2020, Luis De La Iglesia et al. 2021), including the copulatory organs of both sexes. The spermathecae of females were observed by cleaning the epigastric area with microdissection scissors and a hypodermic needle. The copulatory organs of specimens of both sexes were extracted to generate an image by photo stacking. In addition, the epiandric area, the ratio length/width of the tibia of the palpus (Fig. 1) and the ratio number of epiandric fusillae/carapace length were studied in males, and the corresponding means and standard deviations of these metrics were calculated.

Spine formulae of palps and legs are indicated by the number of spines on left member segment and the number of spines on the same segment of the right member, both numbers separated by a dot. Variations are given with the same formula but between parentheses.

Abbreviations of body and legs parts

AER	=	anterior eye row, length
ALE	=	anterior lateral eye, length
AME	=	anterior median eye, length
Bl	=	body, length
Bul	=	bulb, length (Fig. 1)
Cal	=	caput, length
Ch	=	caput, height
Cl	=	carapace, length
Clyl	=	clypeus, length
Cw	=	carapace, width
Cyl	=	cymbium, length
El	=	eye, length
Eml	=	embolus, length (Fig. 1)
Ew1	=	embolus, width 1 (Fig. 1)
Ew2	=	embolus, width 2 (Fig. 1)
Ew3	=	embolus, width 3 (Fig. 1)
Fel	=	femur, length
Ll	=	labium, length
Lw	=	labium, width
Ml	=	maxillae, length
Mel	=	metatarsus, length
MTF4 ratio	=	relative lengths of metatarsus, tibia and femur of leg IV
Mw	=	maxillae, width
Pal	=	patella, length
PER	=	posterior eye row, length
PLE	=	posterior lateral eye, length
PLS	=	posterior lateral spinnerets
PME	=	posterior median eye, length
PMS	=	posterior median spinnerets
POP	=	pattern of the deep black pigmentation on the ocular process
PSP	=	prolateral spines of patella
RSP	=	retrolateral spines of patella
Sl	=	sternum, length
Sw	=	sternum, width
Tal	=	tarsus, length
Th	=	thorax, height
Til	=	tibia, length (Fig. 1)
Tiw	=	tibia of the palp, width (Fig. 1)

RESULTS

Taxonomy

Nemesia shenlongi sp. n.

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Figs 2–4

Holotype

SPAIN: Torrecera, Jerez de la Frontera, 36.5968, -5.9686, alt. 15 m., ♂, MNCN 20.02/20440, 21.ix.2021.

Paratypes

SPAIN: Torrecera, Jerez de la Frontera, 36.5968, -5.96864, alt. 15 m, 3 ♂♂ (CPC), 21.ix.2021; 5 ♂♂ (CPC), 26.ix.2021; 1 ♀ (CPC), 1.xii.2019; 2 ♀♀ (CPC), 6.ix.2020; 1 ♀ MNCN 20.02/20441, 20.viii.2020; 1 ♀ (CPC), 4.iv.2021.

Etymology. The species is named after the wish-granting mythological dragon, Shenlong, that can be summoned by collecting all seven Dragon Balls.

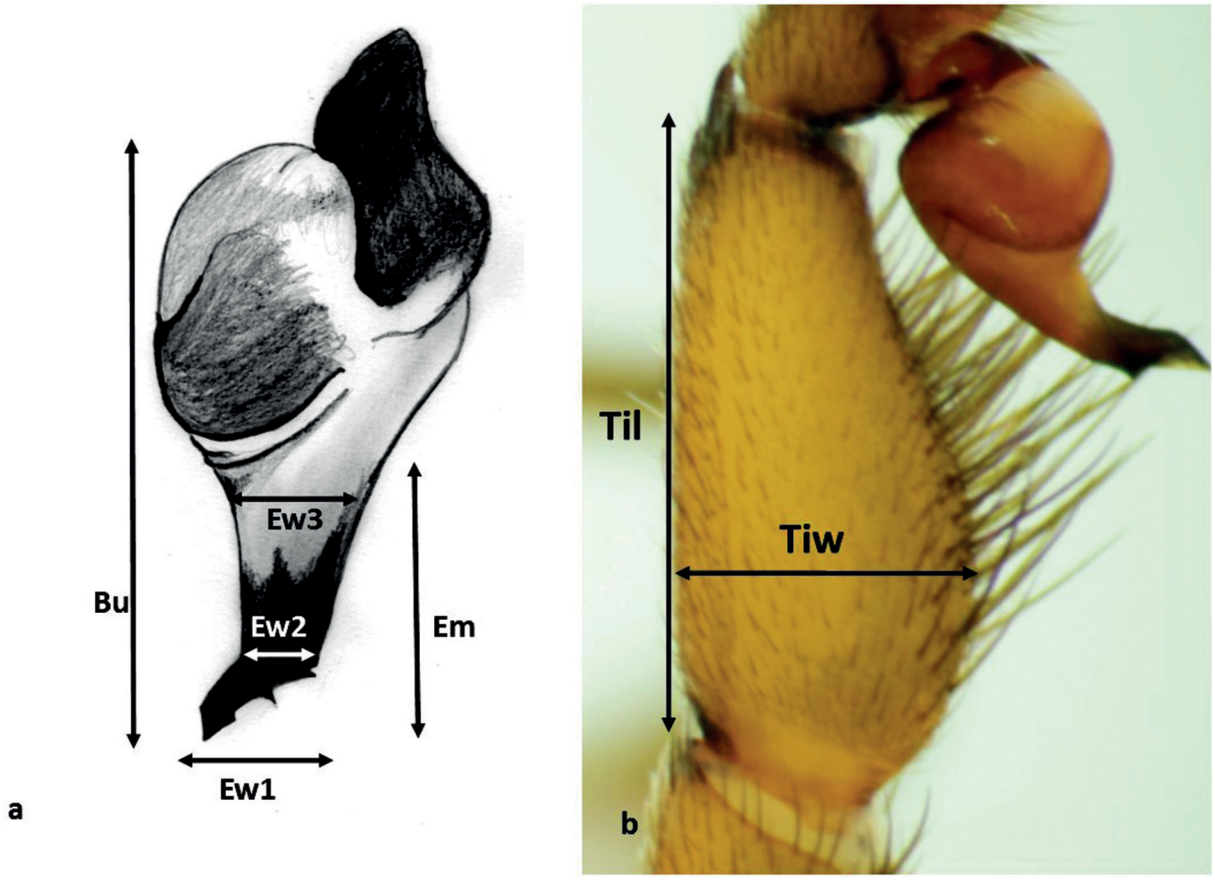

Fig. 1. a. *Nemesia uncinata* (Bacelar, 1933), copulatory bulb. **b**. *N. uncinata*, male palpal tibia. Abbreviations: see Material and methods.

Diagnosis. Within *Nemesia*, *N. shenlongi* sp. n. fits in a morphologically well-defined species group containing *N. dorthesi* (Thorell, 1875), *N. santeugenia* (Decae, 2005), *N. santeulalia* (Decae, 2005), *N. uncinata* (Bacelar, 1933), and *N. valenciae* (Kraus, 1955) characterized by filiform posterior median spinnerets, females with sac-like or potato-shaped spermathecae and males with dorsal spines on the tibiae and metatarsi, and globose and ornamented bulbs (Zonstein 2017, 2019). Males of *N. shenlongi* sp. n. demonstrate a very characteristic morphology never described before, possessing the conical embolus with a flat duckbill-shaped tip (Fig. 2). The spermathecae in *N. shenlongi* sp. n. resemble two mounds divided by a deep depression (Fig. 2). In males of other species of this group, the basic part of the embolus is fairly cylindrical and curved towards their apical half, whereas in *N. shenlongi* sp. n. this area is flat and wide. On the other hand, the spermathecae in the new species may resemble those of *N. santeugenia*, *N. santeulalia*, and *N. uncinata*. The morphology of the receptacles of *N. uncinata* resembles two rounded mounds with the glandular tissue distributed from the apical zone to the middle of the spermatheca. The spermathecae of the other two species are potato-shaped in their distal half and differ from each other by the section in the middle of the receptacle of *N. santeulalia*. Despite this, the overall shape of the spermatheca of *N. shenlongi* sp. n. is more elongated at the end than in *N. uncinata* and lacks a sectioned area as in *N. santeugenia* and *N. santeulalia*. The burrow of *N. shenlongi* sp. n. could be considered an important diagnostic character, because none of other congeners was previously known to build a flask-shaped burrow provided with a spherical plug of soil, in addition to the typical thin flexible trapdoor.

Description

Male (holotype)

General habitus. Prosoma brown with dark pilosity on the edges of the cephalic area, the fovea and the posterior area. Opisthosoma yellowish with a dark cardiac mark and five to six chevrons dorsally, and light yellow with several dark dots ventrally (Fig. 3).

Prosoma. Clypeus dark with seven bristles and white pubescence. POP broken between AME. Caput slightly elevated. Crest zone light brown with seven bristles. Shallow fovea. Chelicerae black, with two stripes of whitish pubescence. Cheliceral rastellum of six spikes.

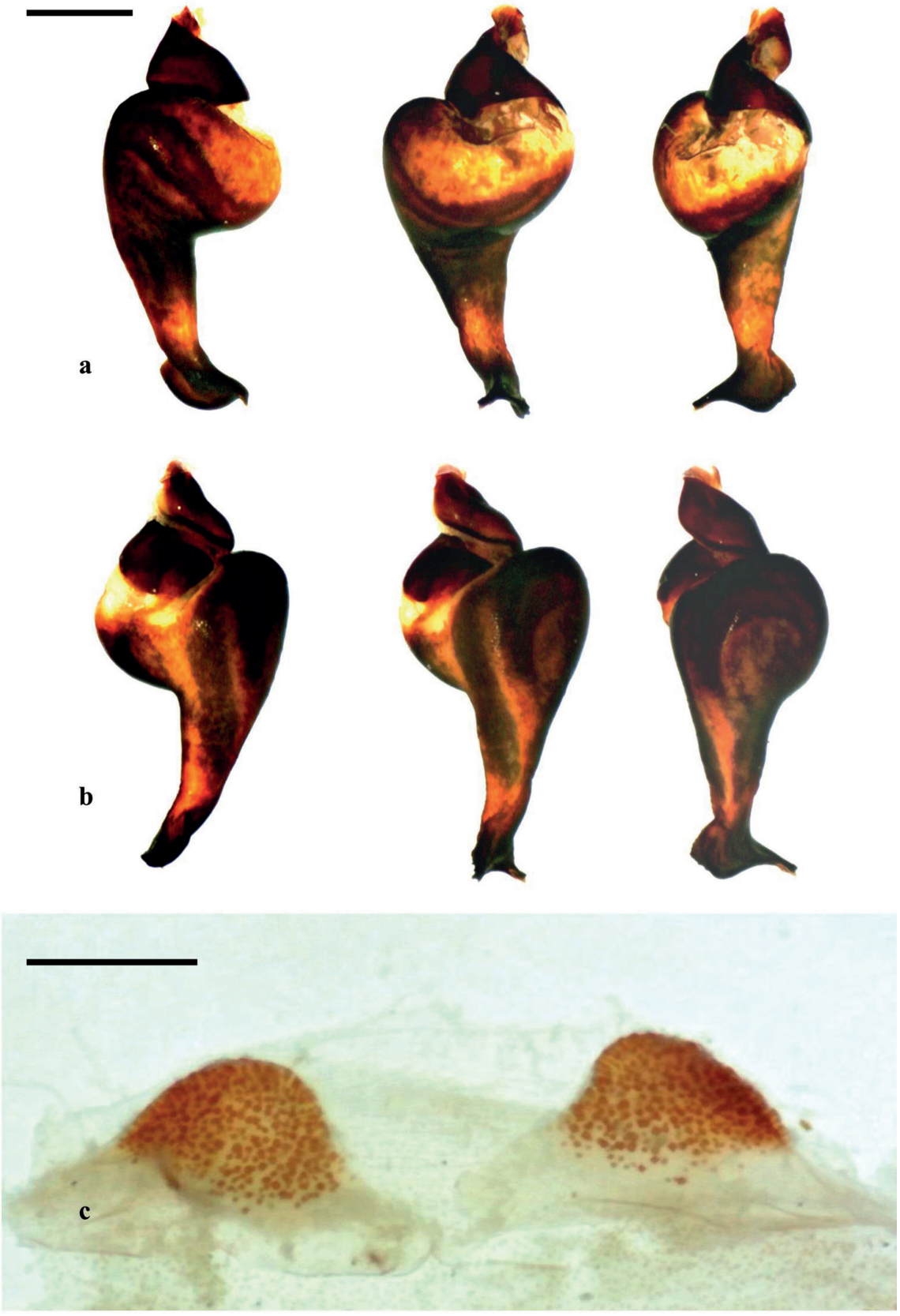

Fig. 2. *Nemesia. shenlongi* sp. n., male and female copulatory organs. **a**. Retroventral, ventral and proventral aspects of bulb. **b**. Prodorsal, dorsal and retrodorsal aspects of bulb. **c**. Ventral view of spermathecae. Scale bars: 0.5 mm.

Smooth fang ridge. Cheliceral furrow with six promarginal denticles. Sternum yellowish brown with circular to oval sigilla, the two first pairs of sigilla marginal and the third pair submarginal. Maxillae dark brown with some probasal strong bristles, but in other males two to seven cuspules. Labium and coxae dark brown (Fig. 3).

Palp and legs I–IV. Cymbium with dorsal patch of 18–19 spines in holotype, 19–27 in other males. Bulb globular and embolus with duckbill-shaped tip (Fig. 3). Palp tibia ratio 2.35±0.14. Palpal tibia dorsally with apical patch of 13 spines (11–17 in other males). Clasper hooked. Clasper field with scopula. Metatarsus I slightly curved. Palp and legs femora black, the other segments brown. Scopula extends from distal tibiae to tarsi I–II; on legs III–IV present only on tarsi. MTF4 ratio: tibia> femur> metatarsus, usually tibia> metatarsus> femur.

Prolateral and retrolateral spination. Leg I, prolateral side Pa: 2(1). 2(1); Ti: 3(4). 3(2–4); Met: 4(2). 4(3) and retrolateral side Pa: 2(1). 2(1); Ti: 3. 3; Met: 3(1–2). 2(1–3). Leg II, prolateral side Pa: 2(1–3). 2; Ti: 3(2–4). 4(2–3–5); Met: 4. 3(2–4) and retrolateral side Pa: 1(2). 1(0); Ti: 3. 3(2); Met: 3(2–4). 3(2). Leg III, prolateral side Pa: 2(0–3). 2(1); Ti: 5(3–4). 4(3); Met: 3(4). 3(4) and retrolateral side Pa: 1.1; Ti: 3(2).3(2); Met= 3.3(4). Legs IV, prolateral side Pa: 3(2). 3(2); Ti: 6(7–8). 9(5–7–8); Met: 3(4–5). 3(4–5) and retrolateral side Pa: 1.1; Ti: 5(3–4–7). 3(4–6–9); Met: 4(3–5–9). 5(3–4–6–7).

Patellar spine formulae, PSP [p: 1. 1; I: 2. 2; II: 2. 2; III: 2. 2; IV: 3. 3]. RSP [p: 0.0; I: 2. 2; II: 1. 1; III: 1. 1; IV: 1. 1]. Variations (n=8) PSP [p: 1. 1; I: 2. 2(1); II: 1–2–3.2; III: 2(3). 2; IV: 3(2). 3(2)]. RSP [p: 0.0; I: 1(2).1(2); II: 1(2). 1(0); III: 1. 1; IV: 1. 1].

Opisthosoma. In the holotype, epiandrous fusillae: 65; trapezoid-triangular epiandric area of 1.23 mm^2 (Fig. 3); density: 52.85 epiandrous fusillae/mm^2; ratio carapace length/number of epiandrous fusillae 0.11. The remaining males, epiandrous fusillae: 63±6; epiandric area: 0.99±0.12 mm^2; density: 64.12±6.24 epiandrous fusillae/mm^2; ratio carapace length/number of epiandrous fusillae 8.71±1.16. Spinneret morphology: PLS: basal segment longer than middle segment+ distal segment. PMS cone-shaped.

Measurements (mm). Bl: 16.25 (14.09–16.75); dorsal area of prosoma: Cal: 4.47 (3.95–4.88); Ch: 2.2 (1.85–2.43); Cl: 7.64 (7.68–8.07); Cw: 6.12 (4.89–6.38); Th: 1.74 (1.48–1.94); Clyl: 0.33 (0.19–0.31); ocular group: AER: 0.21 (1.07–1.15); PER: 1.09 (1.14–1.2); ALE: 1.16 (0.28–0.34); PLE: 0.29 (0.2–0.32); AME: 2.23 (0.18–0.31); PME: 0.19 (0.16–0.27); El: 0.17 (0.54–0.59); ventral area of prosoma: Mal: 2.16 (1.88–2.49); Maw: 1.35 (1.16–1.41); Lal: 0.67 (0.6–0.79); Law: 1.27 (1–1.27); Sl: 3.92 (3.0–3.92); Sw: 2.91 (2.14–2.61); Palp: Bulb: 1.78 (1.58–1.86); Eml: 0.93 (0.82–1); Ew1: 0.61 (0.57–0.69); Ew2: 0.24 (0.22–0.25); Ew3: 0.4 (0.4–0.49); Cyl: 1.61 (1.18–1.61); Til: 2.83 (2.42–2.9); Tiw: 1.27 (1.03–1.27); Pal: 2.0 (1.62–2.07); Fel: 3.7 (3.11–3.95); TOTAL: 10.14 (9.02–10.14); Leg I: Tal: 2.6 (2.55–2.97); Mel: 4.08 (3.48–4.11); Til: 4.18 (3.52–4.39); Pal: 3.54 (2.92–3.54); Fel: 5.77 (5.21–6.18); TOTAL: 20.17 (18.23–21.03); Leg II: Tal: 2.54 (2.18–2.69); Mel: 4.25 (3.64–4.25); Til: 3.97 (3.54–3.97); Pal: 3.04 (2.89–3.27); Fel: 5.03 (5.03–5.83); TOTAL: 18.83 (17.57–19.64); Leg III: Tal: 2.43 (2.43–3.05); Mel: 4.62 (4.36–5.06); Til: 3.74 (3.23–3.79); Pal: 2.75 (2.25–2.75); Fel: 4.75 (3.85–5.05); TOTAL: 18.29 (16.96–19.2); Leg IV: Tal: 3.23 (2.81–3.23); Mel: 6.54 (5.97–7.05); Til: 6.58 (6.43–7.1); Pal: 3.88 (3.14–3.88); Fel: 6.57 (5.61–6.57); TOTAL: 26.8 (24.44–27.29).

Female

General appearance. Alive specimens light to dark brownish grey. Carapace entirely covered with whitish pubescence; black medal-shaped pubescence present on cephalic area and around fovea, with orange brownish background in alcohol (Fig. 4b). Opisthosoma light yellowish, dorsally with darker brownish cardiac mark and three to seven chevrons; ventrally with several darker dots.

Prosoma. Clypeus dark coloured with a row of six marginal setae. POP black. Caput elevated. Crest zone lightly pigmented with a row of five to seven bristles. Fovea shallow. Chelicerae as in holotype. Cheliceral rastellum of six to seven strong spikes. Fang ridge smooth. Cheliceral furrow with six to eight promarginal teeth. Maxillae dark brown, three to seven cuspules. Labium of same colour as maxillae. Sternum as in holotype (Fig. 4c).

Palp and legs I–IV. Legs and palps dark brown on proximal segments to orange brownish on distal ones. Scopula extends from tarsus to distal tibia on palp and legs I–II; present only on tarsi of legs III–IV. MTF4 ratio usually tibia> femur> metatarsus, but Tibia> metatarsus> femur in one specimen.

Prolateral and retrolateral spination. Palp, prolateral side: Pa: 2.2; Ti: 2.2; leg I, prolateral side Pa: 2(1).2(1); Ti: 3(2).3(2). Leg II, prolateral side Pa: 2(1).2; Ti: 3.3(2); Met: 1(2).1(0). Leg III, prolateral side Pa: 2(1).2(1); Ti: 2(3).2(3); Met: 3(4).3 and retrolateral side Ti: 2.2; Met: 3.3(4). Legs IV, prolateral side Met: 2.2, retrolateral Ti: 3 (2).2(3); Met: 3.3.

Patellar spine formulae, variations (n=5) PSP [p: 2(3). 2; I: 2(1). 2(1); II: 2(1).2; III: 2(0–1). 2(1); IV: 2. 2]. RSP var [p: 0.0; I: 0.0; II: 0.0; III: 0.0; IV: 0.0].

Opisthosoma. Spinneret morphology: PLS: as in male. Maculae present on basal segment, sometimes poorly visible. PMS: cone-shaped (Fig. 4). Spermathecae: mound-shaped with deep depression between both mounds (Fig.4).

Measurements (mm). Bl: 16.84–20.87; dorsal area of prosoma: Cal: 4.7–5.33; Ch: 2.21–2.91; Cl: 7.68–8.07; Cw: 5.8–6.31; Th: 1.17–1.63; Clyl: 0.23–0.39; ocular group: AER: 1.21–1.36; PER: 1.3–1.42; ALE: 0.34–0.45; PLE: 0.26–0.38; AME: 0.18–0.31; PME: 0.14–0.24; El: 0.61–0.73; ventral area of prosoma: Mal: 2.41–2.99;

Fig. 3. *Nemesia shenlongi* sp. n., ♂, holotype (MNCN 20.02/20440). **a**. Body, dorsal. **b**. Maxillae, labium and sternum, ventral. **c**. Bulb, proventral. **d**. Palp, prolateral. **e**. Opisthoma, ventral. **f**. Metatarsus I, with the clasper area marked with an arrow, prolateral. **g.** Epigastric area with epiandrous fussillae, ventral. Scale bars: a = 5 mm; b, d, f–g = 1 mm; c = 0.5; e = 2 mm.

Fig. 4. *Nemesia shenlongi* sp. n., ♀, paratype (MNCN 20.02/20441). **a**. Living specimen. **b**. Carapace, dorsal. **c**. Maxillae; labium and sternum, ventral. **d**. Spinnerets, ventral. **e**. Spermathecae, ventral. Scale bars: b = 5 mm; c–d = 1 mm; e = 0.5 mm.

Fig. 5. a. Habitat where *Nemesia shenlongi* sp. n. was found. **b**. First section of a burrow. **c**. Detail of the ball blocking the chamber. **d**. Ball. Scale bar: 5 mm.

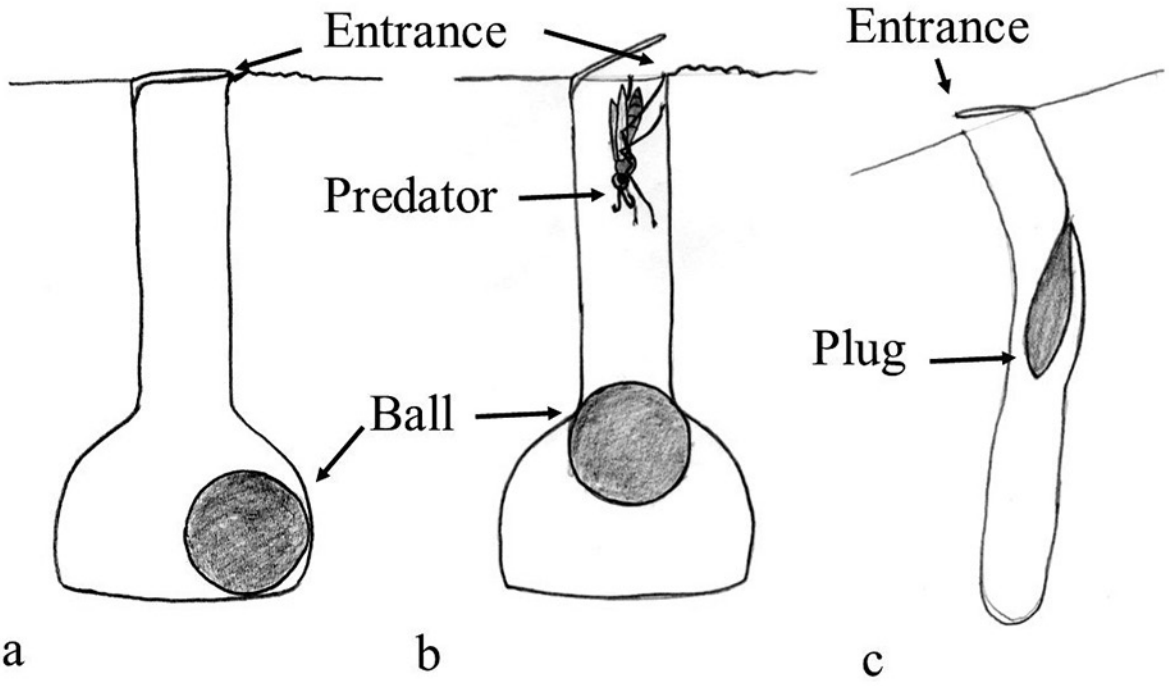

Fig. 6. Comparison of burrows. **a**. Burrow of *N. shenlongi* sp. n. **b**. Burrow of *N. shenlongi* sp. n. with the security chamber closed in presence of predator. **c**. Burrow of *N. fagei* (Frade & Bacelar, 1931) based on the figure by Decae (1996).

Maw: 1.36–1.77; Lal: 0.75–0.93; Palp: Tal: 1.99–2.6; Til: 2.15–2.68; Pal: 1.87–2.31; Fel: 3.08–4.16; TOTAL: 9.52–11.67; Leg I: Tal: 1.82–2.22; Mel: 2.87–3.15; Til: 3.48–3.89; Pal: 3.14–3.52; Fel: 5.11–5.57; TOTAL: 16.94–17.95; Leg II: Tal: 1.81–2.06; Mel: 2.73–2.97; Til: 3.13–3.37; Pal: 2.69–3.35; Fel: 4–5; TOTAL: 15.24–16.53; Leg III: Tal: 1.87–2.06; Mel: 3.12–3.27; Til: 2.29–2.62; Pal: 2.44–2.7; Fel: 3.87–4.1; TOTAL: 13.77–14.45; Leg IV: Tal: 2.02–2.44; Mel: 4.73–5.14; Til: 5.51–6.3; Pal: 3.51–3.87; Fel: 4.94–5.49; TOTAL: 20.95–22.88.

Ecology

This species was found in an open 'dehesa' formed by mastic, *Pistacia lentiscus* L., wild olive, *Olea europaea* var. *sylvestris* (Mill.) Lehr, and fan palm, *Chamaerops humilis* L., with a poor grass layer on the soil. *Nemesia shenlongi* sp. n. shares its habitat with other mygalomorph spiders such as *Macrothele calpeiana* (Walckenaer, 1805), spiders belonging to the genus *Ummidia* (Thorell, 1875) and *Iberesia* (Decae & Cardoso, 2005), *N. uncinata*, and other unidentified *Nemesia* species. The nest is covered with a thin flexible trapdoor in the entrance and a silk-linked flask-shaped burrow about 18 cm deep. In addition, this spider builds a sphere reminiscent of a marble of soil particles bound with saliva which it uses to close the narrow area of the burrow as a safe room (Fig. 5b–d). All found specimens tried to close their burrow with particles of soil and silk when the ball was removed. The spiders usually demonstrated a defensive behaviour when removed from their nests.

Males were collected between the 21th and 26th of September of 2021. No specimens were collected in the pitfall traps during the preceding season. Only the female collected on 1st of December of 2019 had been seen with offspring.

DISCUSSION

The copulatory organ morphology of both sexes and the novel protection system described above – the duckbill-shaped embolus of males, the mound-shaped spermathecae with deep depression between both and the marble-shaped plug – allow to distinguish this species from other species of the genus *Nemesia*.

Several species of *Nemesia* build a supplementary structure to protect itself as an internal door in its burrow or a plug (Moggridge 1873, 1874; Frade & Bacelar 1931). The internal doors are integrated in the wall of burrow with silk and could be closed in case of danger, for example in *N. manderstjernae* and *N. meridionalis* (Costa, 1835) (based on figures of Moggridge 1873 and 1874), meanwhile the plugs are an auxiliary piece used to block the nest. *Nemesia fagei* is the only previously described species known to build a supplementary structure to plug the entrance to the burrow. In *N. fagei* the plug is bullet-shaped rather than round, and it is attached with silk to the wall of the burrow at a short distance from the entrance, which facilitates obstructing the entrance (Fig. 6c). *Nemesia shenlongi* sp. n. makes a marble-like

plug that the spider usually lets loose at the bottom of the burrow. In case of danger, the spider takes the ball and plugs the narrow part of the burrow, leaving the tubular area free and the wider part completely isolated and protected (Fig. 6a–b). Despite having a similar strategy of protection, the morphology of *N. fagei* shows important differences being compared with *N. shenlongi* sp. n., especially in the structure of the copulatory organs.

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