



Sinaiella azadi sp. nov. (Mantodea: Toxoderidae); a new praying mantis species from Western Asia (Iran and Armenia)

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Abstract

The Mantodea fauna of Iran comprises nine families and at least 40 species. Scientific surveys conducted by Iranian entomologists have recently led to an increased knowledge on the diversity and biology of mantises. Among the Mantodea species dispersed in Iran, the family Toxoderidae has been regarded as a group of highly cryptic praying mantids with greatly elongated bodies in common. Up to now, six species of this family have been reported from Iran, entirely from the southern half of the country. Herein, we describe *Sinaiella azadi* sp. nov. from the Markazi Province, in central Iran. Moreover, our *ex-situ* investigation led to the identification of this new species from a preserved collection in Armenia. These findings considerably extend the known distribution of the genus *Sinaiella* Uvarov, 1924 beyond the Arabian Peninsula. We also discuss the genus and include a proposed dichotomous key to the *Sinaiella* species.

Key words: Arabian Peninsula, *Lobothespis vignai*, Markazi Province, Persian Plateau, Yerevan

Introduction

Including 25 genera from the Oriental, Afrotropical, and southern Palearctic realms (Schwarz & Roy 2019, Otte *et al.* 2022), Toxoderidae represents a group of medium to very large mantids. Previously restricted to large species with conical eyes (often with terminal spines), vertex with strong furrows, long to very long prothorax, laterally-compressed metazona, elongate foretibiae, a reduction of the first discoidal spine, and flattened cerci (Beier 1968; Ehrmann 2002; Roy 2009), since the 2019 systematic rearrangement the family Toxoderidae also includes the Oxyothespini, previously placed among Mantidae (Schwarz & Roy 2019). The latter group consists of medium-sized, predominantly Sahelian and Eremic species, and extends the distribution of the family deep into the drier parts of North Africa, the Arabian Peninsula, and Central Asia.

Based on previous literature, six species of Toxoderidae have been identified in Iran (Kolnegari 2023), namely *Lobothespis vignai* La Greca and Lombardo, 1987, *Oxyothespis persica* Bolívar, 1913 (Ghahari and El-Den Nasser 2014; Rabieh *et al.* 2016), *Oxyothespis wagneri* (Kittary, 1849) (Ehrmann 2002), *Severinia nigrofasciata* Kaltenbach, 1982 (Mofidi-Neyestanak 2015), *Aethalochroa ashmoliana* (Westwood, 1841) (Kaltenbach 1984; Mofidi-Neyestanak 2015) and *Pareuthyphlebs palmonii* (Uvarov, 1939) (Mofidi-Neyestanak 2015). Excluding the latter species, whose presence in Iran is doubtful due to the significant separation between its recognized range and the location indicated in Iran (Kolnegari 2023), the other five toxoderid species were recorded only from the southern parts of Iran (Ehrmann 2002; Kolnegari 2023), which share a relatively similar climate (*i.e.*, hot dry coastal, and hot dry desert; Vaghefi *et al.* 2019).

Our recent field survey in the semi-mountainous habitats of the Markazi Province (Fig. 1), located in central Iran, led to the discovery of a juvenile male and three juvenile female oxyothespine mantids (Fig. 2A, B, D). The

specimens were reared until reaching their adult stage (Figs. 2, 3). According to available literature and examination of their morphology, the specimens are assigned to *Sinaiella* Uvarov, 1924, while exhibiting some characteristics distinguishing it from their congeners. Therefore, we here describe *Sinaiella azadi* **sp. nov.**, providing morphological and genital descriptions along with high-resolution photographs.



FIGURE 1. Gurehzar, Shazand County, Markazi Province, Iran, type locality of *Sinaiella azadi* **sp. nov.**

Materials and methods

Regions sampled. Ghare-Chay highland is named for Ghare-Chay, the longest river in Markazi province, flowing 540 km from the Shazand highlands through the Markazi Province to the Namak Lake of Ghom Province. Regions of Shazand County beside the Ghare-Chay River encompass hills and mountains with elevation of 1950–3350 m, with around 600 mm annual precipitation (SSN 2021). Mighan Desert Wetland covers around 500 km² of a salt desert and seasonal lake, located in Arak County, Markazi Province, Central Iran.

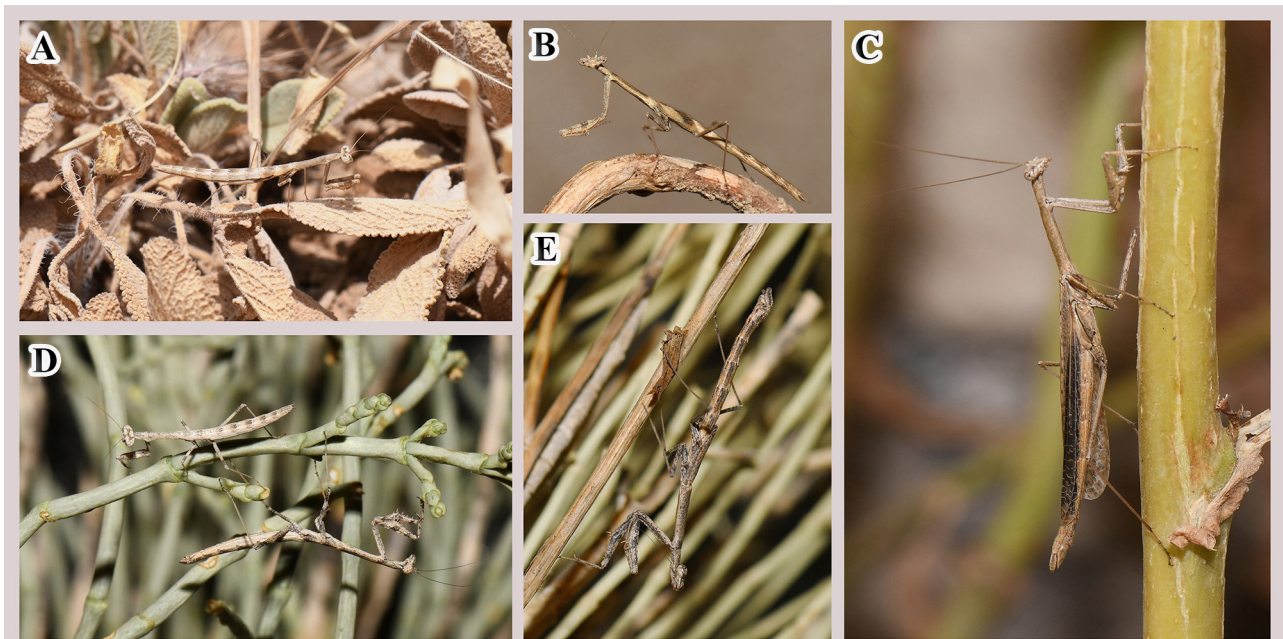


FIGURE 2. *Sinaiella azadi* **sp. nov.** A–C) Holotype male. A) Antepenultimate instar. B) Last instar. C) Adult. D, E) Allotype female. D) Antepenultimate instar. E) Adult.



FIGURE 3. *Sinaiella azadi* sp. nov. Holotype male and allotype female, dorsal view of preserved specimens. Scale = 5 mm.

Descriptive conventions. The species treatment within this study provides a brief diagnosis and character descriptions. To describe morphological characteristics, we followed Brannoch *et al.* (2017), except for the following: head length includes the labrum, foretibia length includes the apical claw, and total length was measured from the vertex of the head to the tip of the abdomen. Genitalia preparation and terminology follow Schwarz & Roy (2019). All measurements were obtained using a caliper and a Müller stereo-microscope and are presented in millimeters.

Imaging. Habitus images were captured using a Nikon D850 SLR, Nikon macro lens (105 mm), and Speedlight sb-700 flash or a Canon EOS 60D, Canon macro lenses (60 and 100 mm), and a Speedlight 430EX II with a custom-made diffuser. Images were processed in Adobe Photoshop CS6 Extended to adjust levels, contrast, exposure, sharpness, and add scale bars. Minor adjustments were made using the stamp tool to correct background aberrations and remove distracting debris.

Taxonomy

Family Toxoderidae Saussure, 1869

Genus *Sinaiella* Karsch, 1892

General characteristics of genus *Sinaiella*. Male medium-sized. Slender, rod-shaped mantids. Color yellow to brown. Head broad. Lower frons strongly transverse. Compound eyes rounded, without spines. Ocelli large,

elevated. Antennae ciliated. Vertex grooved. Pronotum slender, longer than forecoxa, lateral margins smooth, finely ciliated, without denticles or thorns. Supracoxal extension distinct. Metazona keeled. Flight organs not reaching the end of the abdomen. Forefemora with four (rarely three) discoidal and four posteroventral spines, claw groove located proximal to middle of femur. Walking legs slender. Cerci flattened, distal segment rounded or truncate. Genitalia of eremiaphiloid type (Schwarz & Roy 2019); anterior lobe of phalloid apophysis sclerotized, with irregular protuberances; posterior lobe of phalloid apophysis bifid, with the exception of *S. raggei*.

Female like the male, but more robust. Ocelli small, not elevated. Antennae shorter. Wings strongly brachypterous (Kaltenbach 1982).

Examined material. Abbreviations: IZAY—Institute of Zoology Armenia Yerevan. KSMA—King Saud University Museum of Arthropods. MFNB—Museum für Naturkunde, Berlin. MNHN—Museum National d’Histoire Naturelle, Paris. NMNHGR—National Museum of Natural History and Genetic Resources (Tehran). NMB—Naturhistorisches Museum Basel. NHMUK (formerly BMNH)—Natural History Museum United Kingdom, London.—SMNK—Staatliches Museum für Naturkunde, Karlsruhe. ZFMK—Zoologisches Forschungsmuseum Alexander Koenig, Bonn.

1. *Sinaiella nebulosa* Uvarov, 1924 (Figs 4A, 5B, D, F, 6C, D, 7C, D).

Saudi Arabia: 1 ♂, Wadi Sirhan, 12.V.1962, G. Popov (NHMUK). 1 ♂, Wadi Durmah, Saudi Arabia, 28.XII.1975, leg. W. Büttiker; det. A. Kaltenbach 1980; genitalia preparation M. Borer Nr. 0002 (NMB Manto0001441). 1 ♂, Baha, 26.VI.1982, W. Büttiker (NMB). 1 ♂, Thumamah Nature Park, 90 km NE Riyadh, III.–IV.1985, leg. J. Szijj & H. Kessler; ex. coll. J. Szijj, ZFMK; det. R. Ehrmann V.2011 (SMNK Mant-08530).

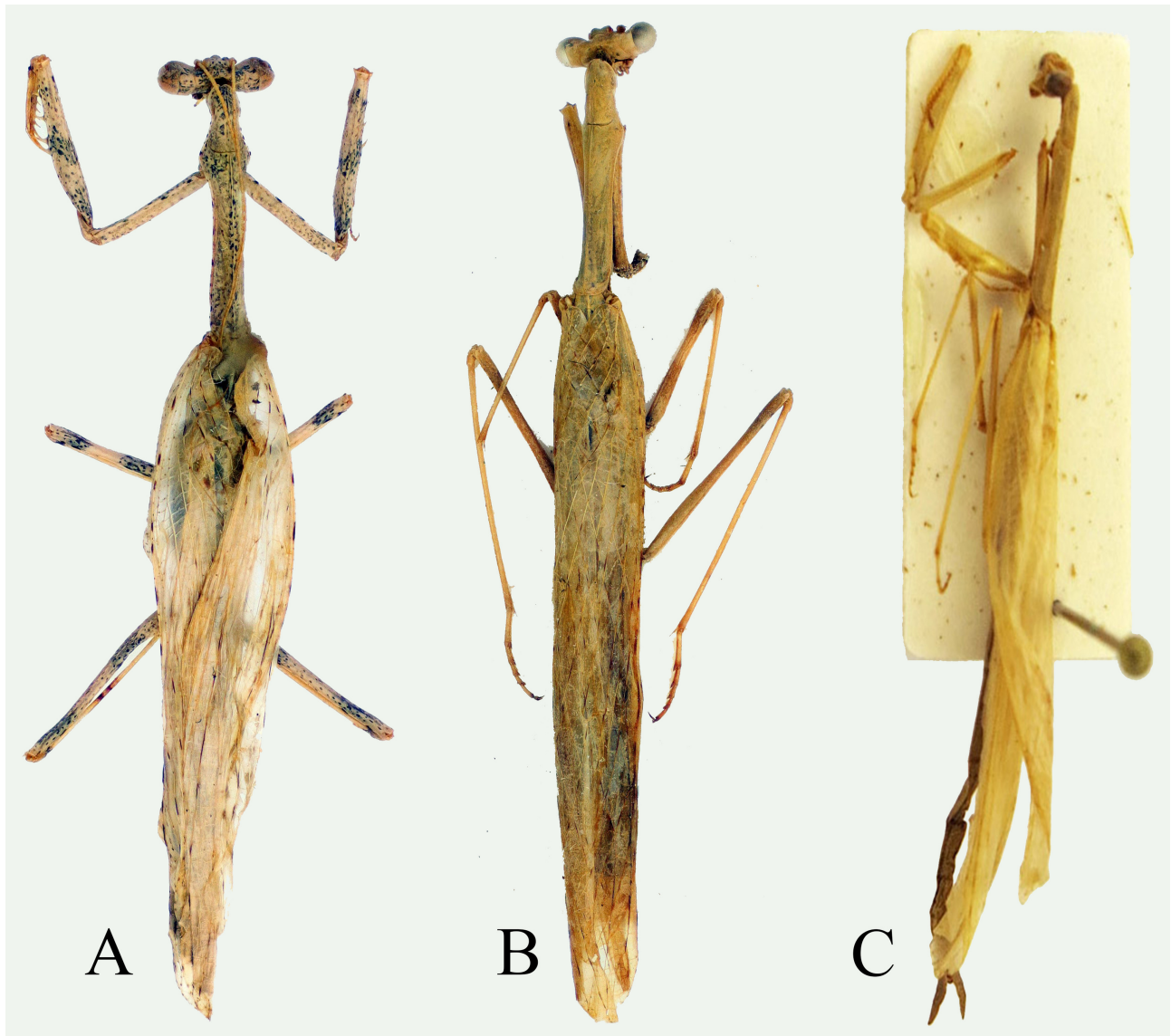


FIGURE 4. The three hitherto known species of *Sinaiella*. A) *S. nebulosa*. B) *S. sabulosa*. C) *S. raggei*.

Oman: 2 ♂, Wadi Quryat, Ag. Stn. 500m (5.III.1976), K. Guichard) (NHMUK).

Type locality: Mohammedia, Northern Sinai, Egypt (Uvarov 1924). Global distribution: Egypt, Saudi Arabia and Oman.

2. *Sinaiella sabulosa* Uvarov, 1939 (Figs 4B, 6E, F, 7E, F)

Saudi Arabia: 1 ♂, 1 ♀, Saudi Arabia, Arq Zaza Sands, Southern Rub al' Khali, 17.05N, 47.30 E, II.1952, G. Popov (NHMUK). 1 ♂, Saudi Arabia, Bisha, 25.VI.1962, G. Popov (NHMUK). 1 ♂, Saudi Arabia, Araïda, "Selouly's Farm", 30.X.1975, W. Büttiker (NMB MANTO0001448). 3 ♂♂, Saudi Arabia, Dawadminy, 20.XII.1976, W. Büttiker, genitalia preparation M. Borer Nr. 0003 (NMB MANTO0001445), genitalia preparation M. Borer Nr. 0004 (NMB MANTO0001446), genitalia preparation M. Borer Nr. 0005 (NMB MANTO0001447). 1 ♂, Wadi Al Ammariya, Saudi Arabia, XII.1977; det. A. Kaltenbach 1980; genitalia preparation M. Borer Nr. 0001 (NMB MANTO0001444). 2 ♂♂, Saudi Arabia, 30km N Medina, 500 m, 27.IV.1979, Exp. N. Hedjaz (literature, Kaltenbach 1982). 1 ♂, Arabie Saoudite, Mahazal Al Said, Rumrumriyah, réserve enclose 6 ans, 22°09'57"N, 41°52'73"E, 1100m, 08/09.VI.1992, M. Donskoff rec., genitalia preparation M. Borer Nr. 0006 (MNHN). 1 ♂, Arabie Saoudite, Mahazal Al Said, Rumrumriyah, réserve enclose 6 ans, zone à Maerua, Acacia et graminées, 22°09'57"N, 41°52'73"E, 1100m, 08/09.VI.1992, M. Donskoff rec., genitalia preparation M. Borer Nr. 0007 (MNHN).

Type locality: Shudhaib, Saudi Arabia (Uvarov 1939). Global distribution: Saudi Arabia.

3. *Sinaiella raggei* Kaltenbach, 1991 (Figs 4C, 5G, H, 7G, H)

Holotype ♂, At Tawil, Saudi Arabia; 29°16' N, 39°34' E, 840 m; 21.–22.XI.1984, leg. W. Büttiker; genitalia preparation M. Borer Nr. 0073 (NMB MANTO0001443). 1 ♂, Saudi Arabia, Muzahimiyah, Al Khararah, 14.XI.2011, Light Trap, N: 24°24'21" / E: 46°14'4", Y. Drayhim, H. AlDhafer, A. Al Gharbawy & M. Alharbi (KSMA).

Type locality: Al Tawil (= Al Tawilah), Saudi Arabia. Global distribution: Saudi Arabia.

Sinaiella azadi Kolnegari & Schwarz sp. nov.

Figs. 2, 3, 5A, C, E; 6A, B; 7A, B

Type material and repositories. Holotype labels: Gurehzar, Shazand, Markazi Province, Central Iran. 34°04'45.1" N, 49°19'51.9" E, elev. 2130 m; 12.VII.2021, leg. juv. M. Kolnegari. Genitalia preparation Schwarz No. 628. Repository: Natural History Museum, Basel.

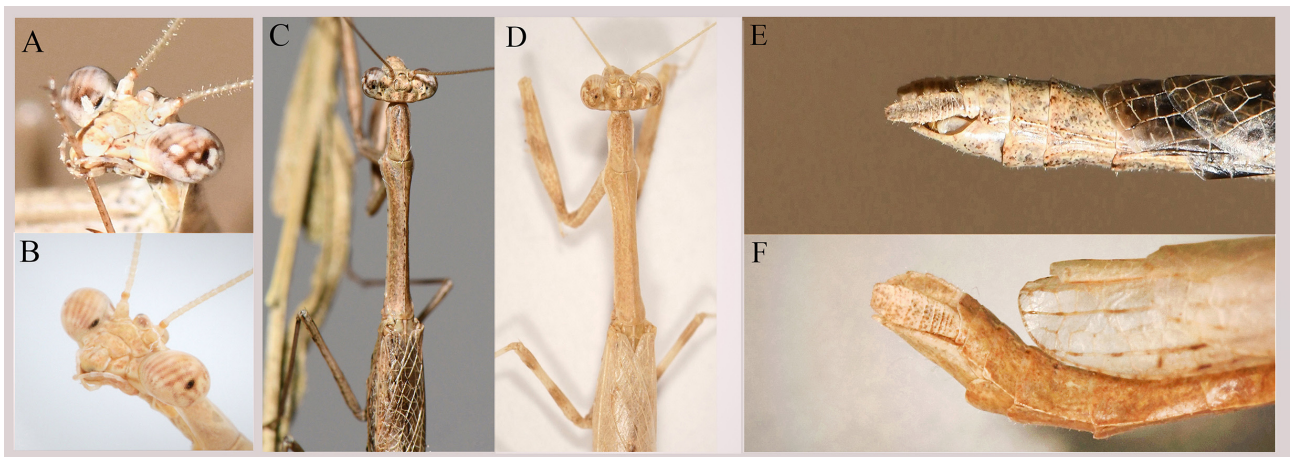


FIGURE 5. Comparison of two *Sinaiella* species. A, C, E) *S. azadi* sp. nov., holotype male. B, D, F) *Sinaiella nebulosa*. Photo credits: Mahmood Kolnegari and Amir Weinstein.

Paratype labels: 1 ♂, Yerevan outskirts. Zoo., Armenia, 2.IX.[19]55; Avetyan H. (IZAY); 1 ♂, Yerevan outskirts, Armenia. 30.VIII.1952. E. Poghosyan (IZAY); 1 ♂, Yerevan outskirts, Armenia. 21.VIII. 1952. Avetyan H. (IZAY).

Allotype labels: Mighan Desert Wetland, Arak, Markazi Province, Central Iran. Elev. 1700 m; 5.VII.2024, leg. juv. M. Kolnegari MMTT-Art-4240 (NMNHGR). Repository: National Museum of Natural History and Genetic Resources (Tehran).

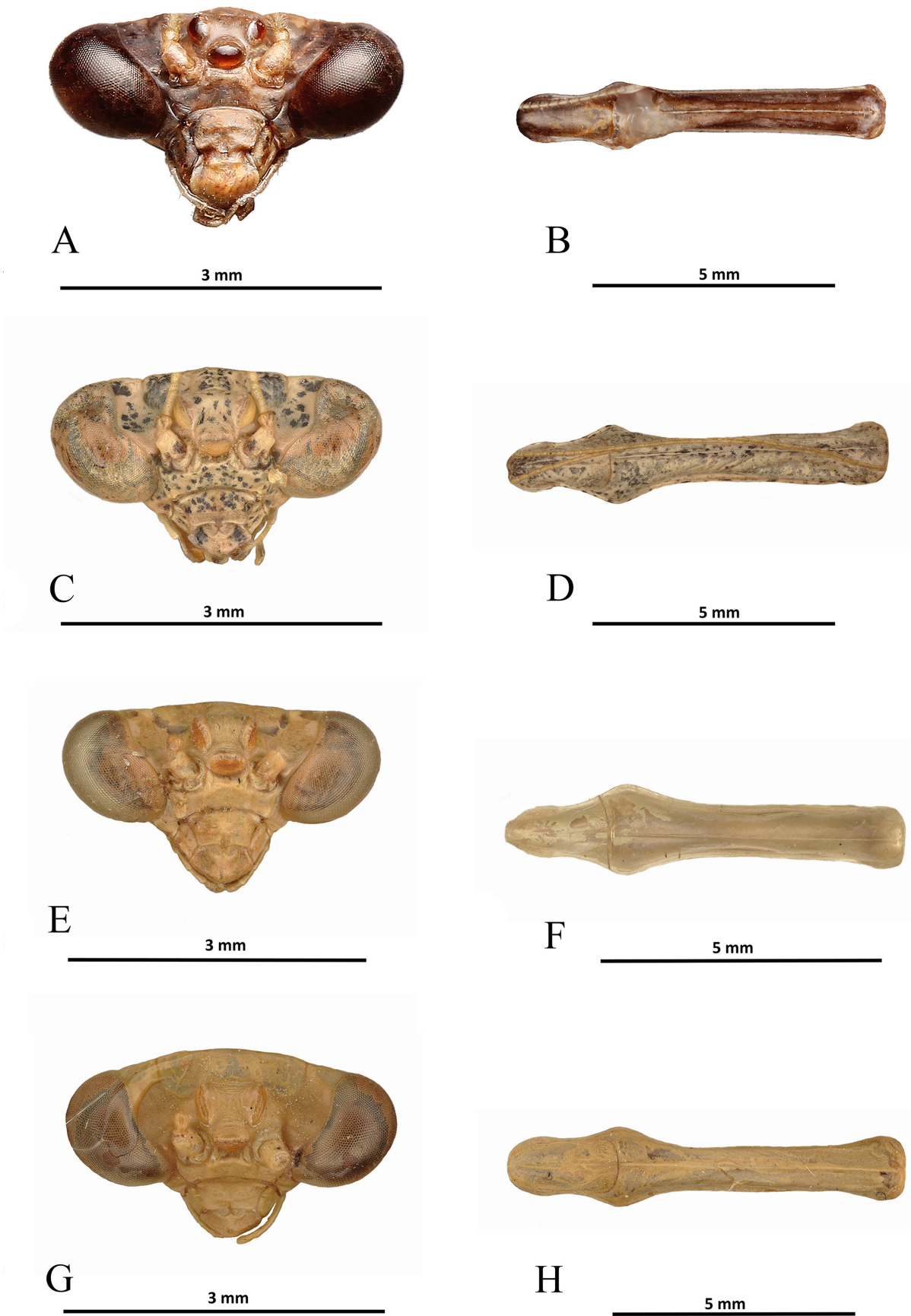


FIGURE 6. Head and pronotum of *Sinaiella* spp. A, B) *S. azadi* sp. nov. C, D) *S. nebulosa*. E, F) *S. sabulosa*. G, H) *S. raggei*.

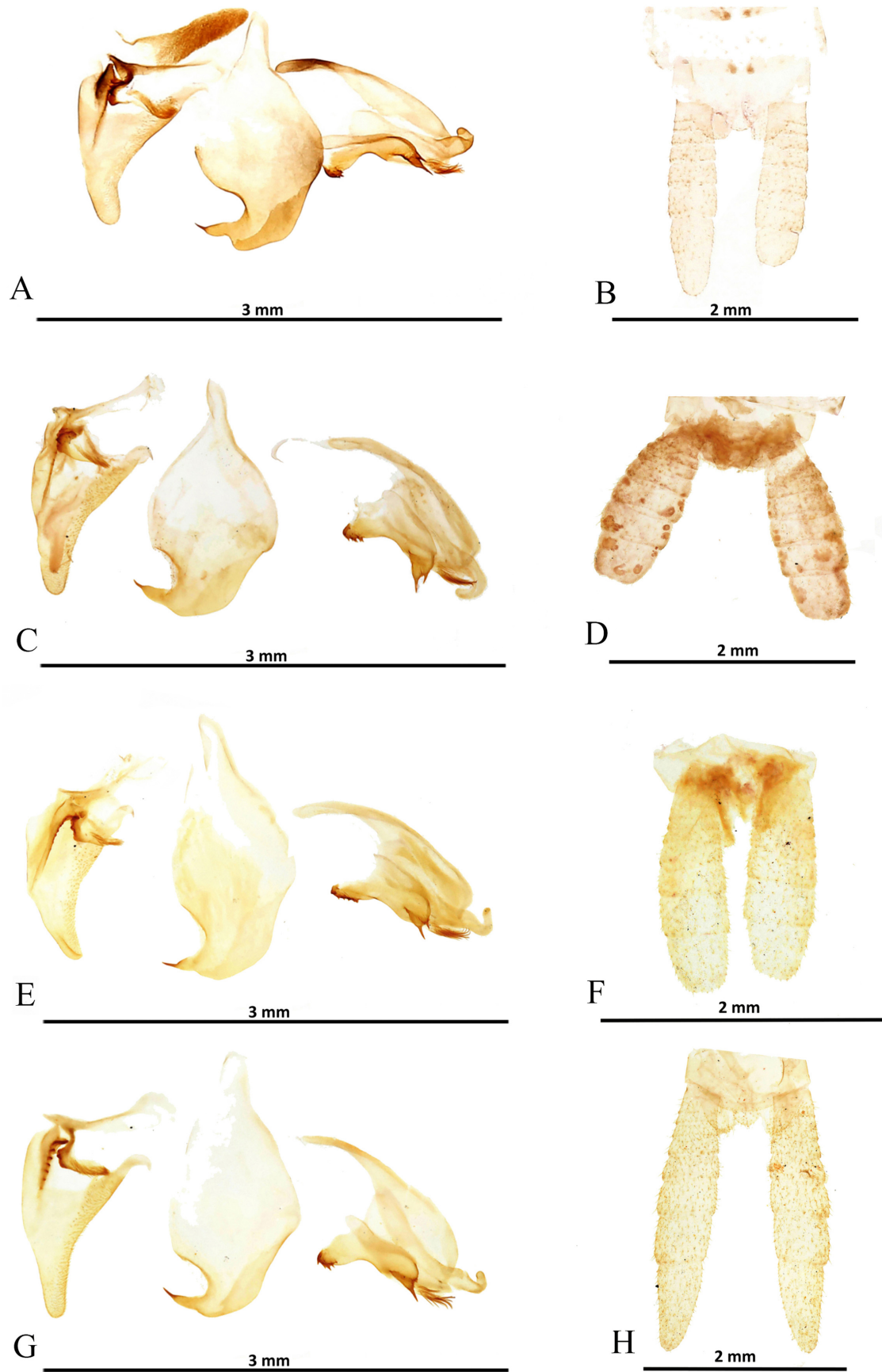


FIGURE 7. Genitalia and cerci of *Sinaiella* spp. A, B) *S. azadi* sp. nov. C, D) *S. nebulosa*. E, F) *S. sabulosa*. G, H) *S. raggei*.

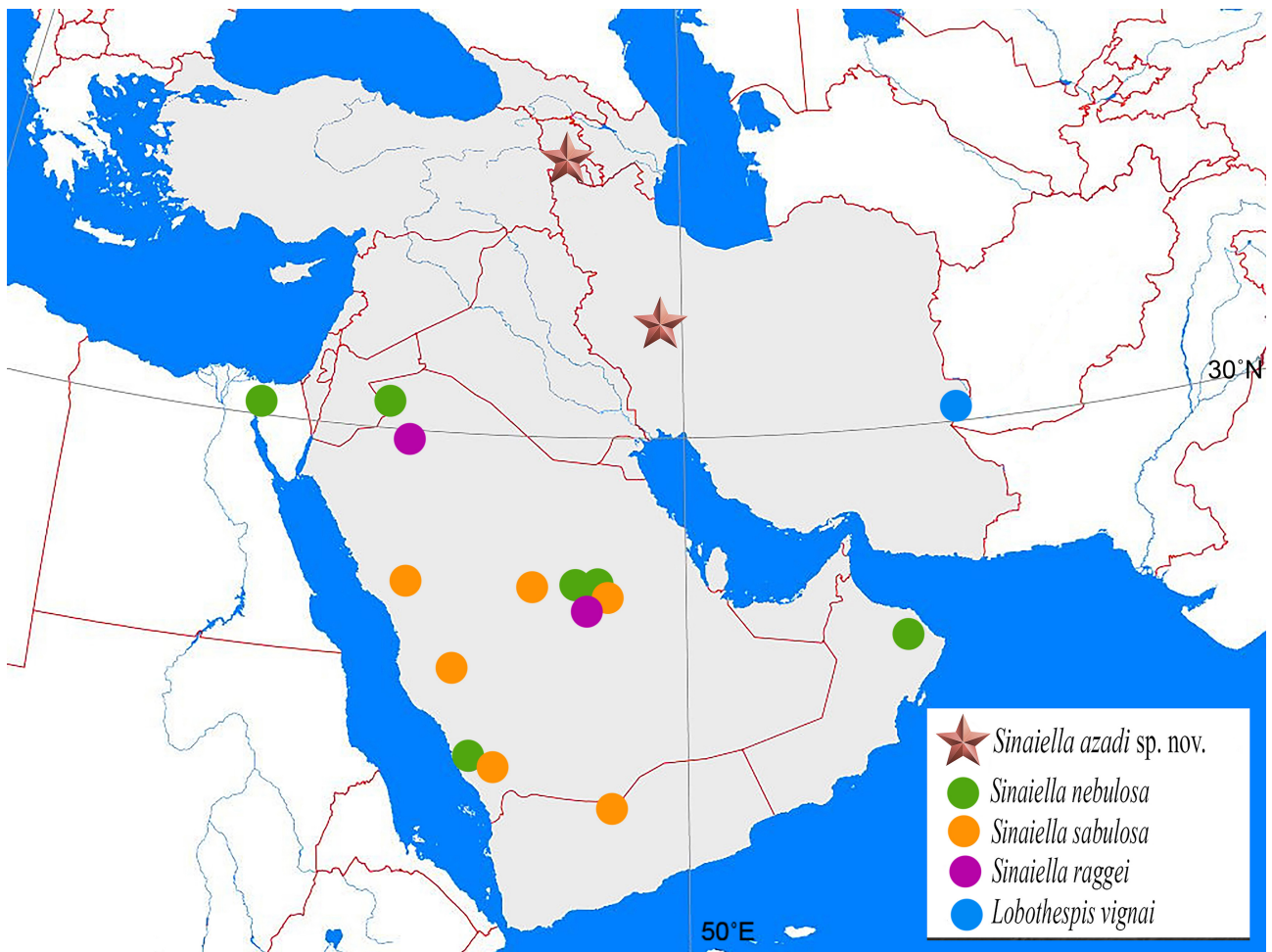


FIGURE 8. Map of Western Asia highlighted in grey and known localities of the genera *Sinaiella* and *Lobothepsis*.

Diagnosis. The new species is characterized by the dark, fully infumated hindwings with paler apical and basal area.

Male. Body length 25–32.0; head length 2.0; head width 3.2–3.3; lower frons width 1.0; lower frons height 0.4; antennae 15.0; pronotum length 7.5–7.6; prozone length 1.9–2; metazone length 5.7; pronotum width 1.5; forecoxae length 4.3–4.6; forefemora length 5.0–5.5; foretibiae length 3.2–3.4; mesofemora length 4.6; mesotibiae length 5.5; metafemora length 7.3; metatibiae length 8.4; tegmina length 18.3; tegmina width 3.5; alae length 17.4.

Head (Fig. 6A) distinctly wider than long. Compound eyes exophthalmic, with dark stripes (faded in preserved specimen). Ocellar area considerably elevated, with large ocelli. Vertex slightly convex, with 4 evident furrows. Lower frons trapezoid, strongly transverse, lower margin arched, dorsal edge rounded; surface with two shallow depressions. Antennae filiform, brownish, scape with a dark black patch; flagellum covered with light-colored setae.

Pronotum (Fig. 6B) slender, longer than forecoxa, with a well-marked supracoxal dilatation. Metazona three times as long as prozona. Metazona with a median keel, without granulations. Pronotum disk and lateral margins smooth, the latter finely ciliated. Greatest width of pronotum at supracoxal dilatation.

Forelegs brownish, with a few irregular darker patches. Forecoxae shorter than metazona, without dorsal spines; apical lobes divergent. Forefemora moderately slender, all spines with blackish tips; claw groove slightly proximal of middle of femur. Ventral side of femur with a row of tubercles. All tibial spines rather short and spaced well apart, posteroventral ones starting some distance from the base. Meso- and metathoracic legs slender, femora with two dorsal and two ventral carinae but without subapical lobes. Femoral spination = 4DS/11AvS/4PvS; Tibial spination = 9AvS/6PvS.

Wings reaching the seventh abdominal segment. Forewings subhyaline, except distal part between subcosta and radius anterior, which is subopaque; discoidal field and main veins with brownish spots in the distal two-thirds.

Hindwings surpassing tegmina when at rest, infumated with hyaline base; distalmost part of the discoidal field pale subopaque, patterned like the tegmina; AA2 veins dark, intercalary and crossveins pale.

Abdomen slender, with parallel margins, keeled medially. Dorsal side in life with a distinct pattern, each tergite having a pale basal and dark apical half, and a pair of whitish paramedian markings crossing the border to the previous tergite (visible already in the sub-adult stage). Supraanal plate roughly triangular, rounded at the tip. Cerci dark due to dense dark markings, flattened, slightly surpassing subgenital plate, consisting of seven visible cercomeres. Distal cercomere of left cercus elongate, with conical, rounded apex, possibly consisting of two fused cercomeres, about twice the length of the penultimate cercomere. Distal cercomere of right cercus short and rounded, presumably due to regeneration (Fig. 7B). Cerci and abdomen end of paratypes missing. Subgenital plate asymmetrical, with a small dorsal keel at apex, between the styli. Styli short.

Genital complex of eremiaphiloid type (Fig. 7A). Right phallomere with pilose apex and left margin, with two additional pilosity fields anteriad and posteriad of **R3**. Ventral phallomere relatively elongate, with distinct, rounded **sdpm**; **sdpl** digitiform with a sharply demarcated terminal spine. Left phallomere typical for the group, with short, strongly curved **paa**, setose **loa** and deeply bifurcated, well-sclerotized phalloid apophysis; **afa** typical for the genus, with rugose **aafa** and bifid, acute **pafa**.

Female. Body length 31.6–33.1; head length 1.9; head width 3.8; antennae 11.2; pronotum length 8.7; prozone length 2.1; metazone length 6.6; pronotum width 1.6; forecoxae length 6.2; forefemora length 6.0; foretibiae length 4.8; mesofemora length 5.9; mesotibiae length 6.9; metafemora length 8.6; metatibiae length 9.6; tegmina length 7; tegmina width 2.3; alae length 5.1.

Pigmentation similar to male, with dark greyish brown body (variable from grayish to brownish tints) and very short wings not exceeding second abdominal tergite. Forewings opaque, apical half broad, with dark-spotted veins especially on costal area. Hindwings fan-like, brown, with large dark spot, fading gradually at costal and apical margins. Subgenital plate not pointed. Last segment of cerci approximately as long as the penultimate segment. Femoral spination = 4DS/11AvS/4PvS; Tibial spination = 9AvS/7PvS.

Etymology. Freedom is the essence of human life. Taxonomists require freedom to communicate, cooperate, and collaborate across geographic and political boundaries to correctly place species within the taxonomic tree of life. Honoring that, we have named this species *azadi*, Persian for freedom, representing and embodying the struggle for freedom by the people of Iran. The species name is used as a noun in apposition.

Differential diagnosis. *Sinaiella azadi* **sp. nov.** is immediately distinguishable from its congeners by its infumated hindwings with pale apex. This pattern seems to be ancestral to the whole superfamily, as it is also seen in other Toxoderidae like *Compsiothespis* Saussure, 1872, basal members of Tarachodinae (*Ariusia* Stål, 1877) and most Rivetinidae, while derived conditions (either hyaline or with dark concentric lines around an anal field patch) are prevalent across the whole group. Among congeners, *Sinaiella nebulosa* has a slightly infumated patch in the anal field (Uvarov 1924), while the two other known species have hyaline hindwings. *S. raggei* is immediately distinguishable from the other species by its simple, not bifid **pafa**. The closely related Iranian genus *Lobothespis* La Greca & Lombardo, 1987 also has an infumated anal field spot and similar genitalia. However, it is clearly distinguishable from *Sinaiella azadi* **sp. nov.** by a more robust pronotum, less extensively infumated hindwings, and distinctly lobate mesofemora.

Sinaiella azadi **sp. nov.** appears to be the only *Sinaiella* species outside the Arabian Peninsula (Fig. 8). Substantial habitat separation of this species from its congeners, and proximity to the distribution range of the genera *Lobothespis* La Greca & Lombardo, 1987, *Oxythespis* Saussure, 1870, and *Severinia* Finot, 1902, underlie the importance of this species in phylogenetic studies.

Key to species (males)

- | | | |
|---|--|------------------------------|
| 1 | Last segment of cerci rounded | 2 |
| - | Last segment of cerci truncate | <i>nebulosa</i> |
| 2 | Last segment of cerci approximately twice as long as the penultimate segment. Body brownish. | 3 |
| - | Last segment of cerci approximately as long as the penultimate segment. Body yellowish | <i>sabulosa</i> |
| 3 | Body pale brownish without darker patterns. Hindwings hyaline, all veins pale. Posterior lobe of phalloid apophysis with one spine | <i>raggei</i> |
| - | Body color variable from brownish with dark spots and patterns to pale yellow. Hindwings infumated, convex veins dark. Posterior lobe of phalloid apophysis bifurcate. | <i>azadi</i> sp. nov. |

Natural history

The juvenile specimens were collected from *Phlomis* sp. (Lamiaceae) and *Anabasis* sp. (Amaranthaceae) during the daylight. The specimens showed side-to-side movements (relatively similar to *Empusa* spp.), a considerable ability to catch flying prey, and were mostly hanging from an elevated point. The specimens were fed with *Musca domestica* and emerged as adults after three molts in late summer.

In the laboratory, we noticed an interesting case of thanatosis in female nymphs, which has been observed to various degrees in other members of the order (pers. obs.). When they are disturbed, they throw themselves to the ground, remain immovable and take a specific posture by bringing the antennae closer to the body and extending the legs along the body. This behavior lasts from ten seconds to more than five minutes (Fig. 9).



FIGURE 9. Thanatosis behavior displayed by female nymphs in the laboratory.

Remarks on *Sinaiella sabulosa*

R. Ehrmann & K. Schütte (in Mohammad *et al.* 2011) synonymized *Miomantis* (*Calidomantis*) *ehrenbergi* described by Werner in 1928 with *Sinaiella sabulosa* Uvarov, 1939. The two type specimens are males (Fig. 10) and perfectly match the species description, including Figure 4A, of *S. nebulosa* (Uvarov, 1924). We would assign them to *S. nebulosa* rather than to *S. sabulosa*. However, the morphological criteria of the two species, as well as the coloration, are variable and not beyond all doubt. Therefore, we still share Uvarov's doubts expressed in the species description of *S. sabulosa* 1939: "Possibly represents only a subspecies of *S. nebulosa*, ...".

Acknowledgments

We thank James F. Dwyer, Julio Rivera, Amir Weinstein, Mandana Hazrati and Evgeny Shcherbakov for their valuable opinions. We also thank Roger Roy, Hathal AlDhafer and Areej Al Khalaf for providing specimens, Reinhard Ehrmann for valuable information and the pictures of *Miomantis* (*Calidomantis*) *ehrenbergi* (Werner, 1928), and Maurizio Mei for the pictures of *Lobothespis vignai*. We would like to extend our gratitude to Natural History Museum Basel for covering the open access charges of this article.

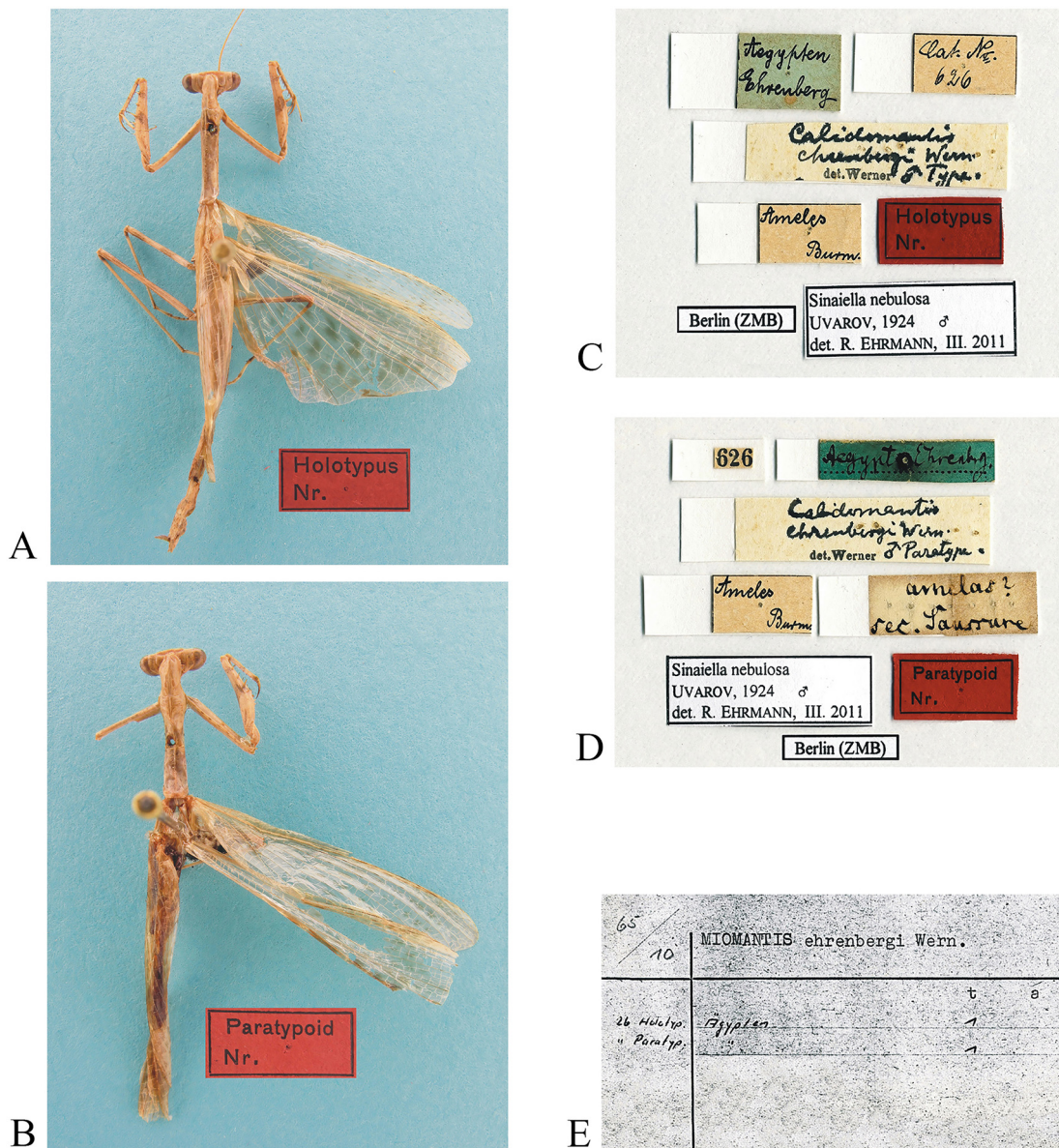


FIGURE 10. *Miomantis (Calidomantis) ehrenbergi* (Werner, 1928) in MFNB: A) Holotype specimen, dorsal view. B) Paratype, dorsal view. C) Labels for holotype. D) Labels for paratype. E) Index card from collection inventory. Photo credit: Reinhard Ehrmann.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Funding

No funding was received for conducting this study.

Author contributions

Mahmood Kolnegari: collecting and rearing specimens, writing original draft of the manuscript, Christian J. Schwarz, Matthias Borer: revision of manuscript, measurements, genitalia preparations and editing. Tigran Ghrejan: identification of paratypes.

Data availability

All of the data that support the findings of this study are available in the main text.

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چکیده

فون مانتیس‌های ایران شامل نه خانواده و حداقل ۴۰ گونه است. بررسی‌های علمی اخیر توسط پژوهشگران ایرانی دستاوردهایی را در زمینه تنوع و زیست‌شناسی مانتیس‌ها به همراه داشته است. در میان مانتیس‌های ایران، خانواده *Toxoderidae* به داشتن بدنی باریک و کشیده و استتاری فوق‌العاده شهرت دارند. تاکنون شش گونه از این خانواده از ایران گزارش شده است. در این مقاله، ما گونه *Sinaiella azadi* sp. nov. را به عنوان گونه‌ای جدید به جهان علم معرفی می‌کنیم. کشف این گونه جدید در زیستگاه‌های طبیعی استان مرکزی صورت گرفته است. علاوه بر آن، بررسی‌های ما در کلکسیون راسته مانتیس‌ها در ارمنستان، موجب یافتن این گونه جدید در آن کشور شد. این یافته‌ها پراکنش جنس *Sinaiella* Uvarov, 1924 را بطور قابل ملاحظه‌ای به فراتر از شبه‌جزیره عربستان گسترش می‌دهد. ما همچنین در مورد این جنس از مانتیس‌ها بحث‌هایی را مطرح می‌کنیم و کلید شناسایی برای آن ارائه می‌دهیم.