

Research Article

Review of the genus *Necremnus* Thomson, 1878 (Hymenoptera: Eulophidae) in Iran

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Abstract: Species of the genus *Necremnus* Thomson, 1878 (Hymenoptera: Eulophidae) in Iran are reviewed based on published data and the newly collected specimens in West Azarbaijan province. The genus in Iran is represented by only two species *N. leucarthros* (Nees, 1834) and *N. tidius* (Walker, 1839). Hereby, two additional species *N. artynes* (Walker, 1839) and *N. cosmopterix* Ribes & Bernardo, 2015 are also identified as new records for the fauna of Iran. *Necremnus tidius* (Walker, 1839) was also found in Northwestern Iran as a new local distributional record. An illustrated key for identifying the known *Necremnus* species from Iran and a short description of the newly recorded species are provided. The distribution map of the Iranian species is also presented.

Keywords: biological control, fauna, Eulophinae, new record, parasitoid

Introduction

The genus *Necremnus* Thomson, 1878 belongs to Eulophidae Westwood, 1829 (Noyes, 2020). Research on the identification of parasitoids that control pests has a long tradition. Recent studies revealed the economic importance of the genus *Necremnus* in controlling some serious pests such as *Ceutorhynchus obstrictus* (Coleoptera: Curculionidae) (Gibson *et al.*, 2005; Dorsdall *et al.*, 2006; Noyes, 2020) and *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) (Desneux *et al.*, 2010; Delvare *et al.*, 2011; Ferracini *et al.*, 2012; Calvo *et al.*, 2013; Chailleux *et al.*, 2013; Abbes *et al.*, 2014). Revision of the genus *Necremnus* for the first time was carried out by Gahan (1941).

Next, Bouček (1959) and Graham (1959) provided identification keys for the European species. To the same, Askew (1968) published the key of eight European species. Subsequently, Askew and Bouček (1968) presented a taxonomical note about Palaearctic species, and Trjapitzin (1978) provided a key for ten European species. Recently an integrative study on *Necremnus* in Europe and North America was carried out by Gebiola *et al.* (2015), and along with this, an identification key was presented for 23 species. The genus *Necremnus* is mainly distributed in the Holarctic region, and among 40 identified species of this genus in the world, 33 species are distributed in the Palaearctic ecozone (Noyes, 2020). So far, the family Eulophidae in Iran has 178 species belonging to 45 genera (Hesami *et al.*, 2018; Darsouei *et al.*, 2018; Marouf and Ebrahimi, 2019). Nevertheless, in Iran, only two species of this genus have been identified (Hesami *et al.*, 2018). This research aims to review the

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species of the genus *Necremnus* in Iran and report new species for Iranian fauna and West Azarbaijan province and present an illustrated identification key for Iranian species.

Materials and Methods

Sampling was carried out in 2018 in different regions of West Azarbaijan province. Specimens were collected using a sweep net and then used aspirator to collect specimens from the sweep net. Subsequently, collected specimens were transferred into 75% alcohol. To find *Necremnus* species, specimens were inspected under the stereomicroscope ZEISS-Stemi SV8. Specimens were treated using the method suggested by Noyes (1982) so that dehydration was managed using alcoholic series of 75%, 85%, and 96%. Subsequently, for the drying phase to prevent specimens from shriveling, the CPD (critical point drying) method was utilized. The acetic acid bath was used because of the convenient utilization of the specimens during card-mounting. Rectangular cards with dimensions of 0.5 × 1.4 cm were used for card-mounting and water-soluble glue to fix specimens on the rectangular cards (Noyes, 1982). The microscope slides were prepared to observe and compare sensorial area and pores on the antennal scape in male specimens (Noyes, 1982; Gebiol *et al.*, 2015). Morphological characters of specimens and photomicrographs were examined under an Olympus SZH stereomicroscope. Identification at generic and species levels was made using identification keys in Bouček (1988), Gibson *et al.* (1997), and Gebiola *et al.* (2015), respectively. The Terminology of morphological characters was studied using Gibson (1997) and Yoder *et al.* (2010). Identified species were deposited in the Plant Protection Department of Urmia University (PPDUU). Abbreviations F1-F3 are used for funicle segments 1-3.

Results

Three species were identified among the West Azarbaijan province materials in the

present study. *Necremnus artynes* (Walker, 1839) and *Necremnus cosmopterix* Ribes & Bernardo, 2015, are new records for the Iranian fauna.

Genus *Necremnus* Thomson, 1878

Necremnus Thomson, 1878: 208, 234. Type species, *Eulophus leucarthros* Nees, 1834 by subsequent designation of Ashmead 1904: 358.

Diagnosis. (Female). Funicle and clava formula 3, 3 (Figs 1A, 2A, 3A, B); scape approximately twice as long as the distance between posterior ocelli. The anterior margin of clypeus entire. Notauli incomplete; mesoscutellum without grooved lines. Propodeum with median carina frequently rudimentary, with or without plicae, costula absent (Figs 2B, 3C). First tarsomere longer than second. Forewings with or without fuscous areas, postmarginal vein at least 1.5 × as long as stigmal vein (Figs 2C, 3D).

Male. Similar to females except funicle and clava formula 4,2 with long and slim rami over F1-F3 (Figs 4A, B, 1B).

***Necremnus artynes* (Walker, 1839)** (Fig. 4)

Eulophus artynes Walker, 1839: 163-164. Lectotype ♀, BMNH, United Kingdom; *E. subcontiguus* Thomson, 1878: 231-232. Lectotype ♀, LUZN, Sweden; synonymy under *N. artynes* by Bouček, 1959: 150.

Material examined. IRAN • 2 ♂ (PPDUU): West Azarbaijan province, Khoy; 38°33'01" N, 44°57'08" E; July 7, 2018; swept on herb-rich meadow; M. Jafarlu leg.

Short description. Female. Flagellum elongate with F3 more than 1.5 × as long as broad; F1+anelli usually more than 1.9 × as long as pedicel and at least 2.8 × as long as broad. Forewing infusate or bimaculate; speculum usually closed; postmarginal vein 1.4-1.7 × as long as stigmal vein. Tegula uniformly dark. Meso- and metatibiae pale; tarsi with basal tarsomeres pale. Propodeum coriaceous; spiracles close to margin of metanotum. Gaster 2.6-3.2 × as long as broad; syntergum 0.9-1.3 × as long as broad (Gebiola *et al.*, 2015).

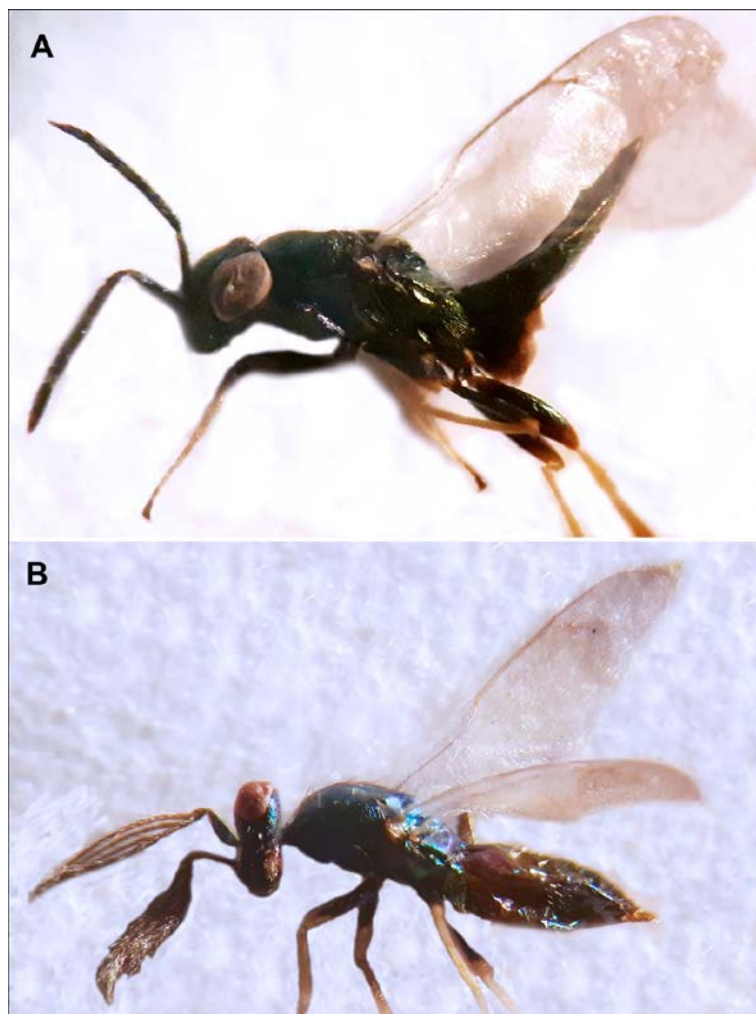


Figure 1 *Necremnus cosmopterix*, General habitus, lateral view: **A.** Female; **B.** Male.

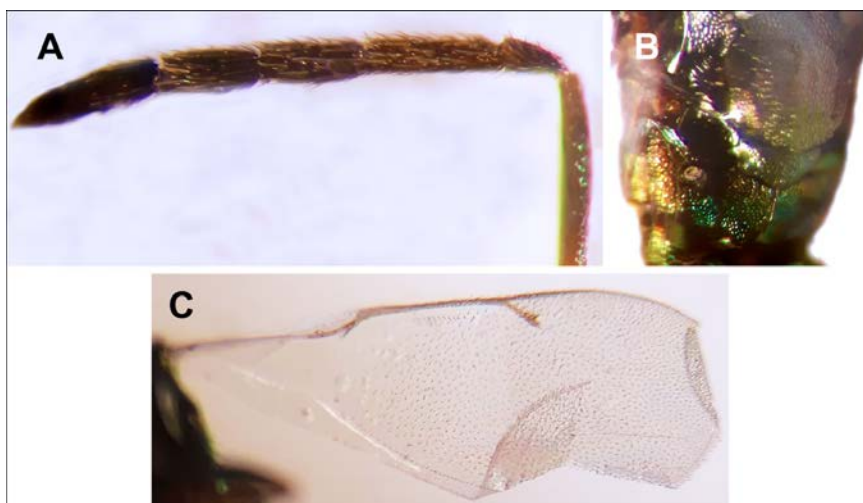


Figure 2 *Necremnus cosmopterix*, female: **A.** Antenna; **B.** propodeum, dorsal view; **C.** Forewing.

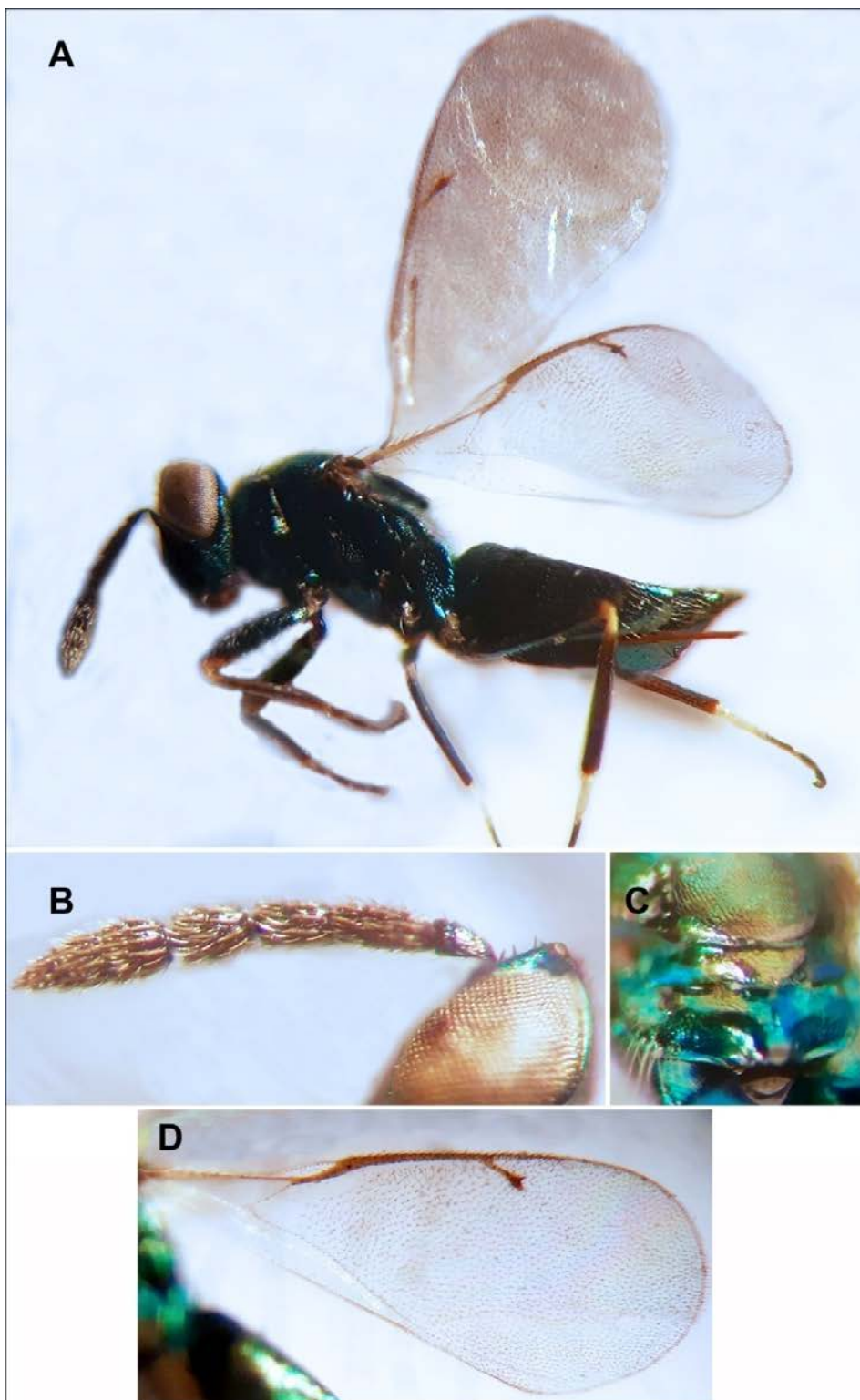


Figure 3 *Necremnus tidius*, female: **A.** General habitus, lateral view; **B.** Antenna; **C.** Propodeum, dorsal view; **D.** Forewing.

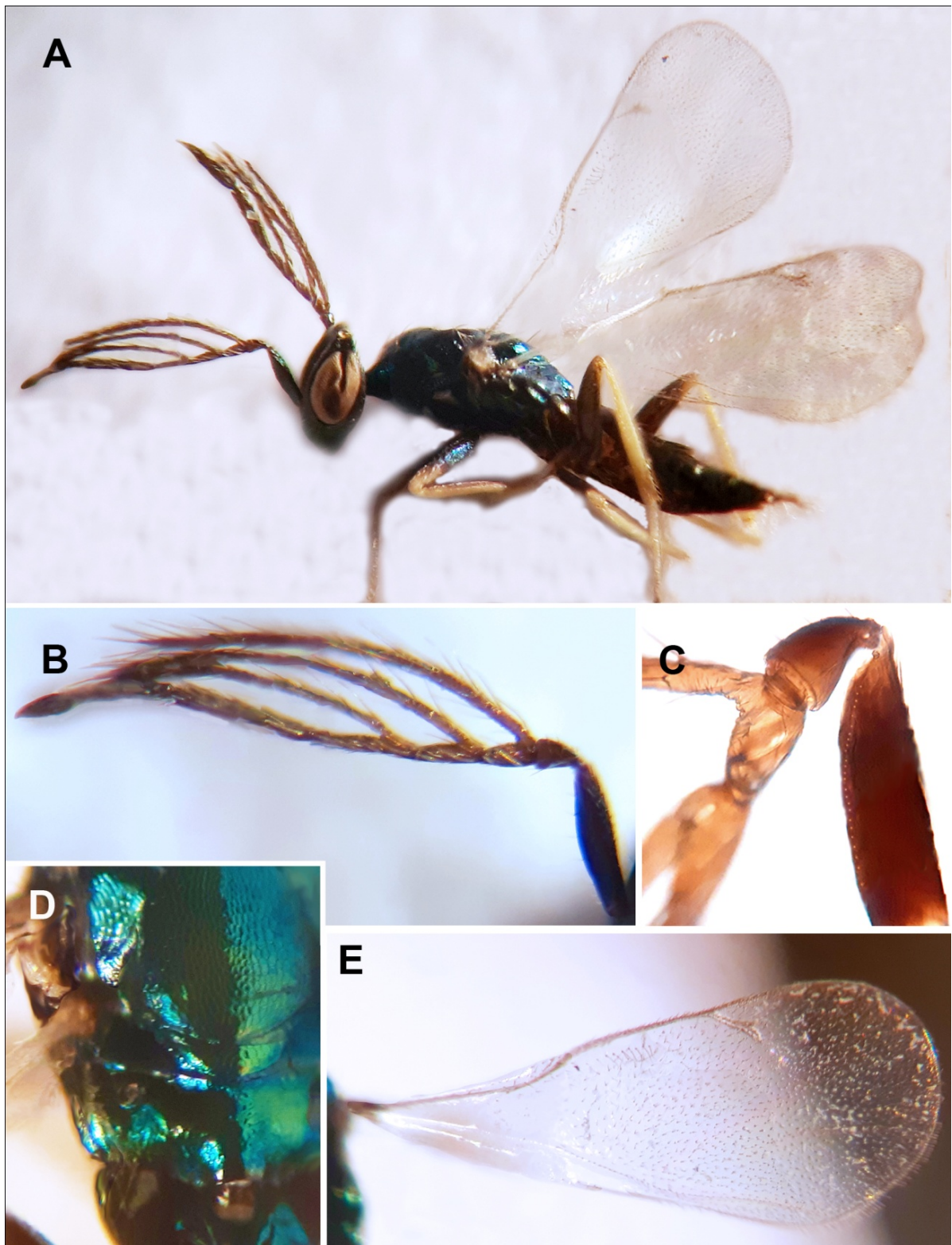


Figure 4 *Necremnus artynes*, male: **A.** General habitus, lateral view; **B.** Antenna; **C.** Scape and pedicel; **D.** Propodeum, dorsal view; **E.** Forewing.

Male. Flagellum with long setae on rami, clava, and all over funicle; all rami having multiporous plate sensilla but with less density on the first ramus; clava $4.5 \times$ as long as broad (Fig. 4B); antennal scape with slim and dark sensorial area along the anterior margin of scape; sensorial pores small and arranged in only one row with distances greater than pore size (Fig. 4C). Postmarginal vein $1.6 \times$ as long as stigmal vein; marginal vein $2.6 \times$ as long as stigmal vein; costal cell with five setae on dorsal part of its apex (Fig. 4E). Tegula uniformly dark brown (Fig. 4A). Meso- and metatibiae pale; tarsi with only telotarsus dark brown (Fig. 4A). Propodeum coriaceous and only superficially reticulate; spiracles large oval and separated from the margin of metanotum slightly but distinctly (Fig. 4D).

Distribution. Nearctic: North America; Palaearctic: Europe, Mongolia, Turkey (Noyes, 2020), Iran (**new record**) (Fig. 5).

Necremnus cosmopterox Ribes & Bernardo, 2015 (Figs 1, 2)

Necremnus cosmopterox Ribes & Bernardo, 2015: 364, 366, 371-375. Holotype ♀, BMNH, Italy.

Material examined. IRAN-West Azarbaijan province • 6 ♂♂, 6 ♀♀ (PPDUU): Urmia; $37^{\circ}33'19''$ N, $45^{\circ}04'21''$ E; August 22, 2018; box trap containing tomato leaves; M. Jafarlu leg. • 1 ♀ (PPDUU): Chaldoran; $39^{\circ}04'22''$ N, $44^{\circ}23'14''$ E; September 18, 2018; Sweep net; M. Jafarlu leg. • 1 ♀ (PPDUU): Khoy; $38^{\circ}33'01''$ N, $44^{\circ}57'08''$ E; August 16, 2018; same data as for preceding • 1 ♀ (PPDUU): Mahabad; $36^{\circ}45'47''$ N, $45^{\circ}43'20''$ E; June 11, 2018; same data as for preceding.

Short description. Female. Flagellum elongate with F1 + anelli $2.3 \times$ as long as pedicel and $4 \times$ as long as broad (Fig. 2A). Forewing hyaline; postmarginal vein $1.9 \times$ as long as stigmal vein (Fig. 2C). Tegula dark brown (Fig. 1A). Meso- and metatibiae within apical two-thirds infuscate to testaceous; tarsi with two basal tarsomeres pale (Fig. 1A). Propodeum uniformly reticulate but not strongly; spiracles large oval and distant from margin of metanotum at least half-length of the diameter of the spiracle (Fig. 2B).

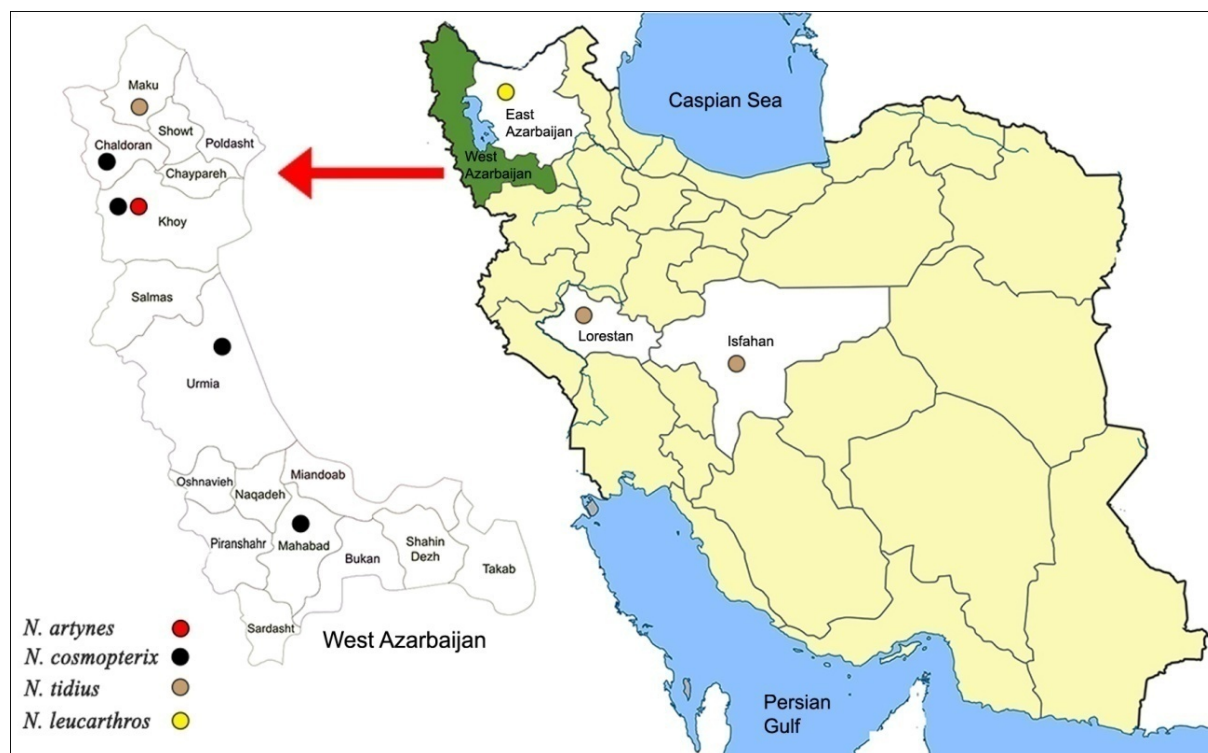


Figure 5 Distribution map of *Necremnus* Thomson, 1878 species in Iran and West Azarbaijan province.

Male. Similar to the female, but in the following characteristic features different: Postmarginal vein $1.8 \times$ as long as stigmal vein; marginal vein $3.2 \times$ as long as stigmal vein; costal cell with 12 setae on dorsal part of its apex. Propodeum coriaceous. Meso- and metatibiae pale to yellowish; tarsi with three basal tarsomeres pale (Fig. 1B).

Distribution. Palaearctic: Italy (Gebiola et al., 2015), Turkey (Bayram et al., 2016), Iran (new record) (Fig. 5).

Necremnus leucarthros (Nees, 1834)

Eulophus leucarthros Nees, 1834: 172. Described ♀ (unknown type condition), Stuttgart und Tübingen, Germany; *E. cornu copiae* Förster, 1841: 44. Syntypes ♂, NHMV, ZSMM, Germany; *E. anaxippus* Walker, 1846: 182. Lectotype ♀, BMNH, United Kingdom; *E. teratocerus* Förster, 1861: 37. Syntypes ♀ and ♂, Switzerland; *Necremnus leucarthros* Thomson, 1878: 234 (New combination for *Eulophus leucarthros*).

Short description. Female. Flagellum short with F3 at most $1.5 \times$ as long as broad; F1+anelli at most $1.8 \times$ as long as pedicel and less than $2.8 \times$ as long as broad. Forewing with speculum partly broad; subcubital fold with only one row of setae along most of its length. Tegula dark brown. Meso- and metatibiae entirely dark except for extreme base; tarsi with only basal tarsomere pale. Propodeum coriaceous; spiracles close to the margin of metanotum or slightly touching (Gebiola et al., 2015).

Male. Similar to the female, but flagellum with all rami having multiporous plate sensilla separated from each other with setae as long as multiporous plate sensilla and width of the ramus (Gebiola et al., 2015).

Distribution. Oriental: India; Nearctic: North America; Palaearctic: Algeria, Armenia, Europe, Turkey (Noyes, 2020), and Iran (Akbari-Noushad, 1995) (Fig. 5).

Necremnus tidius (Walker, 1839) (Fig. 3)

Eulophus tidius Walker, 1839: 146-147. Lectotype ♂, BMNH, United Kingdom; *E.*

zeugma Walker, 1839: 183. Syntypes ♂, United Kingdom; *E. metanira* Walker, 1839: 183-184. Lectotype ♀, HDOU, United Kingdom; *E. mamurius* Walker, 1848: 232. Lectotype ♂, BMNH, United Kingdom; synonymy under *Necremnus tidius* by Graham, 1959: 184.

Material examined. IRAN • 1 ♀ (PPDUU): West Azarbaijan province, Maku; $39^{\circ}17'43''$ N, $44^{\circ}31'00''$ E; May 19, 2018; swept on alfalfa; M. Jafarlu leg.

Short description. Female. Flagellum short with F3 $1.7 \times$ as long as broad; F1 + anelli $1.8 \times$ as long as pedicel and $2.8 \times$ as long as broad (Fig. 3B). Forewing hyaline; speculum narrow; subcubital fold with three rows of setae along half of its length (Fig. 3D). Tegula dark brown (Fig. 3A). Meso- and metatibiae entirely dark and only pale in basal portion proximal to knee; tarsi with three apical tarsomeres infuscate (Fig. 3A). Propodeum coriaceous; spiracles close to the margin of metanotum but slightly separated (Fig. 3C).

Male. Similar to the female, but different in the following characteristic features: Flagellum with sensorial pores along the ventral margin of scape and with multiporous plate sensilla at least on the third ramus and often on the second ramus. Tegula occasionally partially yellow. Spiracles often touching the margin of the metanotum (Gebiola et al., 2015).

Distribution. Nearctic: Canada, North America; Palaearctic: Europe, Middle East (Noyes, 2020).

Key to the Iranian species of the genus *Necremnus* Thomson, 1878 (based on female).

1. Antenna comparatively short with a combined length of F1 + anelli at most $1.8 \times$ as long as pedicel (Fig. 3B); mesosoma often compact and $1.3-1.6 \times$ as long as broad; meso- and metatibiae infuscate or pale in only a small portion proximal to the knee (Fig. 3A);..... 2.
- Antenna usually elongate with a combined length of F1 + anelli at least $1.9 \times$ as long as pedicel (Fig. 2A); mesosoma more elongate and $1.5-1.8 \times$ as long as broad; meso- and

metatibiae with basal half or more portion pale (Fig. 1A) 3.
 2. Forewing with speculum narrow, subcubital fold along its most length having two or more rows of setae (Fig. 3D).....

***Necremnus tidius* (Walker, 1839)**

- Forewing with speculum relatively broader, subcubital fold having one row of setae at least on basal half

.....***Necremnus leucarthros* (Nees, 1834)**

3. Propodeum uniformly but not strongly reticulate (Fig. 2B); postmarginal vein at least $1.8 \times$ as long as stigmal vein (Fig. 2C); male: [marginal vein $3.3-4 \times$ as long as stigmal vein, costal cell dorsally with a row of marginal hairs composed of 11–12 setae on its apex (Fig. 1B)]......

.....***Necremnus cosmopterix* Ribes & Bernardo, 2015**

- Propodeum variable but not reticulate; postmarginal vein at least $1.4 \times$ as long as stigmal vein; syntergum $0.9-1.3 \times$ as long as broad; male: [propodeum coriaceous, or superficially and slightly reticulate (Fig. 4D); postmarginal vein at most $1.8 \times$ as long as stigmal vein, marginal vein at most $2.7 \times$ as long as stigmal vein, costal cell dorsally with a row of marginal hairs composed of 3–6 setae on its apex (Fig. 4E); antennal scape with slim sensorial area along anterior margin of scape, sensorial pores small and located in only one row with distances greater than pores diameter (Fig. 4C)].***Necremnus artynes* (Walker, 1839)**

Discussion

Two species, including *N. cosmopterix* and *N. artynes* are reported for the first time from Iran. These reports increase the number of the known *Necremnus* species in Iran to four. The species *N. tidius* had already been recorded from Isfahan and Lorestan provinces (Yefremova *et al.*, 2007). The recent detection of *N. tidius* in West Azarbaijan province represents a more expanded distribution of this species in the country (Fig. 5). Both previously reported species from Iran, *N. tidius* and *N. leucarthros*, are classified in *N. tidius* species group (Gebiola *et al.*, 2015). The two newly recorded

species are members of the *N. artynes* species group, which is also considered a newly detected group in Iran. *Necremnus artynes* extremely resembles *N. tutae* and *N. navonei* in terms of apparent morphological characters. The most important characteristic feature in males of these three species is an arrangement of sensorial pores on the antennal scape. According to this fact, in the present essay, with the preparation of microscope slides of the male antenna (Fig. 4C), examined species was specified as *N. artynes*. There are distinct differences in color patterns, particularly in forewings and tibiae compared to species described in the world, probably due to body size and seasonal generations. Therefore the data provided in the present research can be considered a promising aspect for identifying valid species in Iran. As for the host range, both previously reported species in Iran are ectoparasitoids of lepidopterous, coleopterous and dipterous families. Whereas both species found for Iranian fauna in this essay are only ectoparasitoids of lepidopterous families so that the primary hosts of *N. artynes* are composed of the families Gelechiidae and Momphidae, whilst *N. cosmopterix* is a parasitoid of the family Tortricidae in addition to the two latter families (Noyes, 2020).

We would like to sum up by stating that since both newly recorded species for Iranian fauna are operational in controlling *Tuta absoluta* (Delvare *et al.*, 2011; Ferracini *et al.*, 2012; Gebiola *et al.*, 2015; Bayram *et al.*, 2016), a serious pest of crops and even *N. artynes* is massively reared and released at an extensive level (Ferracini *et al.*, 2012; Urbaneja *et al.*, 2012). Therefore, our findings constitute a new subject matter that provides an interesting topic for researchers in biological control so that additional works can be conducted to evaluate the efficiency of these parasitoids against this invasive pest.

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مرور جنس *Necremnus* Thomson, 1878 (Hymenoptera: Eulophidae) در ایران

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چکیده: گونه‌های جنس *Necremnus* Thomson, 1878 (Hymenoptera: Eulophidae) در ایران براساس داده‌های منتشر شده و نمونه‌های تازه جمع‌آوری شده در استان آذربایجان غربی مرور شد. این جنس در ایران شامل دو گونه *N. leucarthros* (Nees, 1834) و *N. tidius* (Walker, 1839) بود. در این تحقیق دو گونه دیگر *N. artynes* (Walker, 1839) و *N. cosmopterix* Ribes & Bernardo, 2015 نیز به‌عنوان گزارش‌های جدید برای فون ایران شناسایی شدند. گونه *N. tidius* (Walker, 1839) نیز در شمال غربی کشور به‌عنوان یک گزارش محلی جدید پیدا شد. کلید شناسایی مصور برای شناسایی گونه‌های *Necremnus* شناخته شده از ایران به‌همراه توصیف مختصر گونه‌های گزارش شده ارائه شده و نقشه پراکنش جغرافیایی گونه‌های ایران تهیه شد.

واژگان کلیدی: کنترل بیولوژیک، فون، Eulophinae، گزارش جدید، پارازیتوئید