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Revision of the species of the *Merodon nanus* group (Diptera: Syrphidae) including three new species

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Abstract

The *nanus* group of the genus *Merodon* Meigen (Diptera, Syrphidae) is revised, yielding an illustrated key, a discussion of taxonomic characters and morphological diagnosis for the five species of this group. Three new cryptic species are described, *Merodon kopensis* Vujić et Hayat **sp. n.**, *M. neonanus* Vujić et Taylor **sp. n.** and *M. rasicus* Vujić et Radenković **sp. n.** New diagnostic characters are given for *M. nanus* Sack and *M. telmateia* Hurkmans. In addition, environmental profiles for each investigated species have been defined and compared, and maps of distribution and richness created. Niche dissimilarity was found for each species. Eastern Anatolia and the southern Aegean region of Turkey are reported as the most species rich regions for the *nanus* group.

Key words: *Merodon kopensis* **sp. n.**, *Merodon neonanus* **sp. n.**, *Merodon rasicus* **sp. n.**, environmental niches, principal component analysis (PCA)

Introduction

The genus *Merodon* Meigen (Diptera: Syrphidae: Merodontini) became the largest genus of European hoverflies based on taxa described here, and presently comprises 120 species, three more than the second largest genus *Cheilosia* Meigen (Speight 2014). Turkey contains the highest number of listed *Merodon* species (63 species), and the highest endemism for this taxon in the Mediterranean Basin (Vujić *et al.* 2011; Hayat & Vujić 2014).

This genus includes diverse bumblebee and bee mimicking Diptera with great species diversity in the Mediterranean region. Larval development takes place in the bulbs or rhizomes of Liliaceae and Amaryllidaceae (Hurkmans 1993; Ricarte *et al.* 2008). Adults of the genus *Merodon* feed on pollen and nectar and visit the flowers of a wide range of plant species (Marcos-García *et al.* 2007), including those of bulbous plants. It is known that adults of both *Merodon nanus* Sack and *M. telmateia* Hurkmans prefer flowers of *Ornithogalum* and *Euphorbia*, and that *M. nanus* also visits the flowers of *Trifolium*, *Malus*, and various Asteraceae and Apiaceae (Hurkmans & Hayat 1997; Vujić *et al.* 2011; Speight 2014). Larval stages of these taxa are still undescribed (Speight 2014).

Over the last few years, many publications covering the integrative taxonomy, diversity and distribution of some groups of the genus have been published (Marcos-García *et al.* 2007, Marcos-García *et al.* 2011; Radenković *et al.* 2011; Stahls *et al.* 2009; Vujić *et al.* 2012, Vujić *et al.* 2013).

The present study focuses on one small group of species related to *M. nanus*, mainly distributed in the Anatolian Peninsula. Sack (1928–32) described *Lampetia nana* (Sack 1931) as a species with a short and wide

body shape, moderately hairy, without a spike on the hind trochanter and without a spur on the hind tibia, and lacking transverse pollinose bands on the abdominal tergites. Information concerning this taxon is scarce in the recent literature. According to Speight (2014), *M. nanus* has a mainly north-eastern Mediterranean distribution, and is recorded in Turkey, Iran and Iraq, as well as the Caucasus (Georgia, Armenia). Hurkmans (1987) described *M. telmateia* from eastern Turkey, and considered it close to a species of the *M. aeneus* group (currently the *M. aureus* group in the sense of Radenković *et al.* 2011), but also compared it with *M. nanus*. In this paper we examined all available materials of the morphologically related taxa *M. nanus* and *M. telmateia* (members of *nanus* group as defined here) from European museums and recently collected specimens.

The ecology of these related species is not well explored. In the absence of information about ecological preferences, obtaining climate data from occurrence points can help in defining and comparing environmental profiles of the species being studied. It has been shown that climatic profiles of closely related and cryptic species are unique for each of these (Penman *et al.* 2005). Additionally, Funk *et al.* (2006) found highly consistent and significant positive associations between ecological divergence and reproductive isolation across taxa. Based on these, the degree of ecological differences could be an important source of evidence in species delimitation (Penman *et al.* 2005; Rissler & Apodaca 2007; Stockman & Bond 2007; Bond & Stockman 2008; Padial *et al.* 2010; Sánchez-Fernández *et al.* 2011; Gurgel-Gonçalves *et al.* 2011; Zhu *et al.* 2013; Petersen 2013).

In the present study, descriptions and identification features of the recognized taxa within the *M. nanus* species group are provided, as well as distributional data and environmental preferences to characterised studied species.



FIGURE 1. Habitat of *Merodon neonanus* sp. n. Locality information: Turkey, Muğla, near Çakmak. Male on flower of *Leontodon* sp. Photo by Ačanski Jelena.

Material and methods

Morphological studies. The present study is based on examination of all available material of the *M. nanus* group found in collections, both published and unpublished, deposited in the museums, universities and private collections listed below. The following acronyms of museums and private entomological collections are used in the text:

A.S. coll.	Axel Ssymank collection, Germany
BMNH	Natural History Museum, London, UK
EMIT	Entomological Museum of Isparta, Turkey
FSUNS	Faculty of Sciences, Department of Biology and Ecology, University of Novi Sad, Serbia
J.S. coll.	John Smit collection, The Netherlands
MAegean	The Melissotheque of the Aegean, University of the Aegean, Mytilene, Greece
MMNHS	Macedonian Museum of Natural History, Skopje, FRY of Macedonia
M. H. coll.	Martin Hauser collection, USA
M.R. coll.	Menno Reemer collection, The Netherlands
M. J. S. coll.	Malcolm. J. Smart collection, UK
MZH	Zoological Museum of the Finnish Museum of Natural History, Helsinki, Finland
NHMW	Museum of Natural History Wien, Austria
RMNH	Naturalis, National Museum of Natural History, Leiden, Netherland
SZMN	Siberian Zoological Museum, Novosibirsk, Russia
TAU	Tel Aviv University, Israel
V.W. coll.	Van Weyer collection, The Netherlands
WML	World Museum Liverpool, UK, containing Mike Taylor collection
ZMA	Zoological Museum, Amsterdam, The Netherlands
ZHMB	Zoological Museum of Humboldt University of Berlin, Germany
ZMC	Zoological Museum, Natural History Museum of Denmark, University of Copenhagen, Denmark

The characters used in the key, descriptions, and drawings employ the terminology established by Thompson (1999) and those relating to male genitalia are as used by Hurkmans (1993), Doczkal (1996) and Marcos-García *et al.* (2007). Colour characters are described from dry mounted specimens. To study male genitalia, specimens were relaxed in a closed pot with a high level of humidity and the genitalia were extracted using an entomological pin with a hooked tip. Genitalia were stored in microvials containing glycerol after clearing in warm 10% potassium hydroxide (KOH) for a few minutes and washing in distilled water. Drawings were made with a FSA 25 PE drawing tube attached to a binocular microscope.

Distribution and environmental niche comparison. In total, 487 specimens from the *M. nanus* group from Armenia, Azerbaijan, FRY of Macedonia, Greece, Iran, Israel, Lebanon, Russia, Serbia, Turkey and Ukraine were analysed. The environmental preferences of five species from the *M. nanus* group were compared through principal component analysis (PCA) using Statistica® for Windows (StatSoft 2012: version 12.0). Only specimens with precise distributional data were used. Localities with geographic coordinates were used without modification, while other localities were geo-referenced in Google Earth (Google Inc., 2013). All localities were represented in DivaGis (v7.5), and distributional and richness maps were created. Satellite-derived land cover data and shaded relief was applied using Natural Earth, free vector and raster map data. Nineteen bioclim variables plus elevation data (2.5 arc-minutes resolution) were generated for each locality on the basis of the WoldClim data set (Hijmans *et al.* 2005). PCA was carried out applying a normal varimax rotation of factor loadings. Only factors with an eigenvalue greater than 1 were considered to be significant. Climate variables with a factor loading greater than 0.8 were interpreted as meaningfully correlated with the factor. A scatter plot of PCA mean score values was used to graphically display the positions of five species of *M. nanus* group in environmental space. Analysis of variance (ANOVA) was conducted to compare derived factor scores between the species.

Results

Diagnosis of the *M. nanus* group. The *M. nanus* group belongs to the *M. aureus* clade (sensu lato) in the sense of Mengual *et al.* (2006). The main morphological characters of the *M. aureus* clade (sensu lato) are: pilose posterior part of the mesocoxa, an area with pile on the anterior anepisternum below the postpronotum and the specific structure of male genitalia with an undeveloped anterior surstyle lobe.

The *M. aureus* group (sensu stricto) according to Radenković *et al.* (2011) comprises species of small size with a short rounded abdomen, a distinct spike on the metatrochanter in males and the characteristic structure of male genitalia: narrow, elongated, sickle-shaped hypandrium without lateral sclerite of aedeagus.

The characteristics for distinguishing the *M. nanus* group from the *M. aureus* group (sensu stricto) are as follows: terga with transverse fasciae of pale pile instead of pollinose fasciae (rarely with indistinct pollinosity); the absence of a spike on the metatrochanter (Fig. 4A, B), in male genitalia: hypandrium broad (as on Fig. 5B) with the apical part of the aedeagus large and structured, here named as the aedeagal box (as on Fig. 5C).

Species of the *M. nanus* group resemble in their habitus members of *M. aureus* clade (sensu lato) and species *M. spinitarsis* Paramonov and *M. syriacus* Paramonov, from which they can be easily distinguished by the presence of mostly pale tibiae and tarsi (in *M. spinitarsis* and *M. syriacus* only the basal third and tip of tibiae and basitarsi can be paler), and the structure of the male genitalia (in *M. spinitarsis* and *M. syriacus* hypandrium slender with wrinkled theca and modified spiny apical part and ctenidium; posterior lobe of the surstylus narrow and pointed). Additionally, *M. spinitarsis* has baso-ventral processus on metatarsus of metaleg.

We recognized five taxa within the *M. nanus* group. The observed morphological characters in all taxa show high morphological similarity. The exception is *M. telmateia* which has completely pale and unicolorated tarsi (Fig. 4C), which clearly separate this taxon from all other members of the *M. nanus* group. The four taxa can be distinguished by differences in the structure of male genitalia. These genital characters are subtle but stable, and support the existence of four different closely related species.

General description of the *M. nanus* group. MALE. Body length: 8–12 mm; wing length: 5–8 mm (n = 76). **Head.** Antenna (Fig. 2B: a) brown-orange, basoflagellomere elongated, 1.9–2.2 times as long as wide, 1.7–1.9 times longer than pedicel, with dorsal margin convex basally and concave apically; arista 1.3 times longer than the basoflagellomere. Face and frons dark with metallic shine, covered with long whitish-yellow pile and sparse silver-white pollinosity. Oral margin shiny brown-black, well-protruded (Fig. 2B: b). Vertical triangle isosceles, shining black, except for silver gray pollinosity near eye contiguity, covered with yellow or mixed yellow and black pile; ocellar triangle equilateral or slightly isosceles (Fig. 3A). Eye contiguity 10–14 ommatidia long. The ratio between the lengths of vertical triangle : eye contiguity : ocellar triangle (in dorsal view) = 2 : 1 : 2. Eye pile dense, grayish. Occiput golden or blue shiny with whitish-yellow pile, with dense white pollinosity along the eye margin. **Thorax.** Mesonotum shiny black with expressed metallic golden lustre, covered with dense, erect yellow pile. Pleurae partly covered with pale pollinosity. Proepimeron, posterior anepisternum, anteroventral and posterodorsal part of katepisternum, anepimeron, metasternum and katatergum with long yellow pile. Wing hyaline, with dense, brown microtrichia; veins yellow-brown. Calypter bright yellow with dense long yellow marginal pile. Haltere yellow. Femora black, yellow only on tip. Metafemur not thickened, about 4.5 times as long as wide (Fig. 4). Tibiae and tarsi yellow: tibia with dark annulus (ring) in the middle, most expressed in metaleg; apical two tarsomeres can be partly darkened dorsally. Pile on legs yellow (metatrochanter with a patch of short orange pile in *M. neonanus* sp. n. and *M. kopensis* sp. n.). **Abdomen.** Broad and short, as long as mesonotum. Terga dark, shiny with metallic golden lustre; without distinct pollinose fasciae; with adpressed golden to grayish-yellow pile, except triangular black pile areas in central parts of terga 2 and 3. Sterna shiny, covered with pale pile. **Genitalia.** Anterior lobe of the surstylus absent; posterior lobe of the surstylus oval (as in Fig. 5A: ps), ventral margin of surstylus S-form; cercus rectangular, without prominences (as on Fig. 5A: c). Hypandrium broad, curved; ctenidium situated subapically (Fig. 5B). Aedeagal box well developed, with bilobate apex (Fig. 5B: ab, 5C). Ejaculatory apodeme narrow triangular (as on Fig. 5B: e). Shapes of the posterior lobe of the surstylus and aedeagal box are diagnostic at the species level. **FEMALE** (Figs. 2B, 3B, 4B). Similar to the male except for normal sexual dimorphism and for the following characteristics: basoflagellomere 1.5–1.8 times as long as wide, 1.9–2.1 times longer than pedicel; frons shiny with a median longitudinal groove; frons about 0.25 width of head; terga with more extensive black pile on central part. Females of the *Merodon nanus* group are inseparable by morphological features, except for *M. telmateia* with completely pale tarsi.

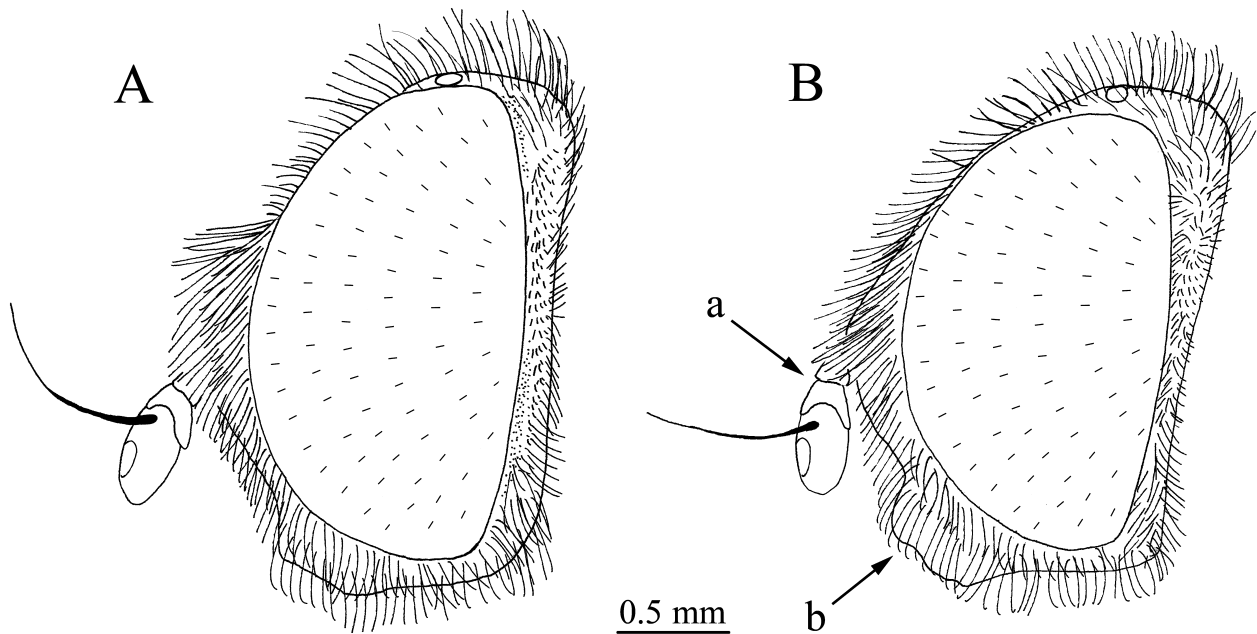


FIGURE 2. *Merodon nanus*, head, lateral view; A. male; B. female; a—antenna; b—oral margin.

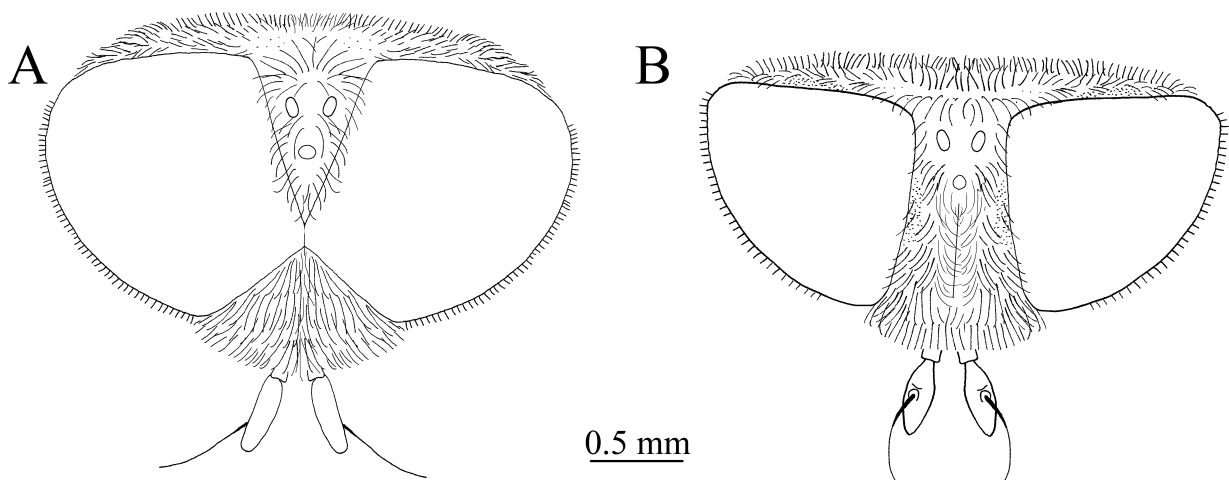


FIGURE 3. *Merodon nanus*, head, dorsal view; A. male; B. female.

***Merodon kopensis* Vujić et Hayat sp. n.**

Diagnosis. Male genitalia (Fig. 6, 7B): posterior lobe of surstylus parallel sided, narrow tip; ventral margin strongly S-shaped with distinct convex part of the curve (Fig. 6A). Cercus large, larger than half the length of surstyle (Fig. 6A). Aedeagal box short, 1/4 of length of hypandrium (Fig. 6B: ab); aedeagal apodeme attached to the theca in the middle of dorsal margin (Fig. 6B: n). Inner edge of apical part of hypandrium straight, unsclerotized (Fig. 7B: x). Inner processes settled in apical 1/3 of hypandrium (Fig. 6B: ih). Species is similar to *M. neonaus* sp. n. from which it differs in a few characters mentioned in the key. The most clear difference is in the shape of the inner edge of the apical part of the hypandrium (Figs. 7A: x, 7B: x) and smaller posterior surstyle lobe (Figs. 6A, 8A).

Type material. HOLOTYPE: Turkey: ♂, Bayburt, Kop mountain pass, 15.vii.1992 (RMNH). PARATYPES: Turkey: Aksaray, Güzelyurt, ♂, 13.vi.1999 (V.W. coll.), Bayburt, ♂, ♀, Demirözü, 30.vii.1991 (EMIT), 3 ♂, Kop mountain pass, 15–16.vii.1992, Erzincan, 4 ♂, Kızıldağ pass, 12.vii.1992 (RMNH), Erzurum, ♀, İspir, Madenköprübaşı, 18. vi. 1994 (EMIT), Kars, Sarıkamış, ♂, 26. vii. 1997, ♂, Kars Stream, 30.vi.–5.vii. 1986

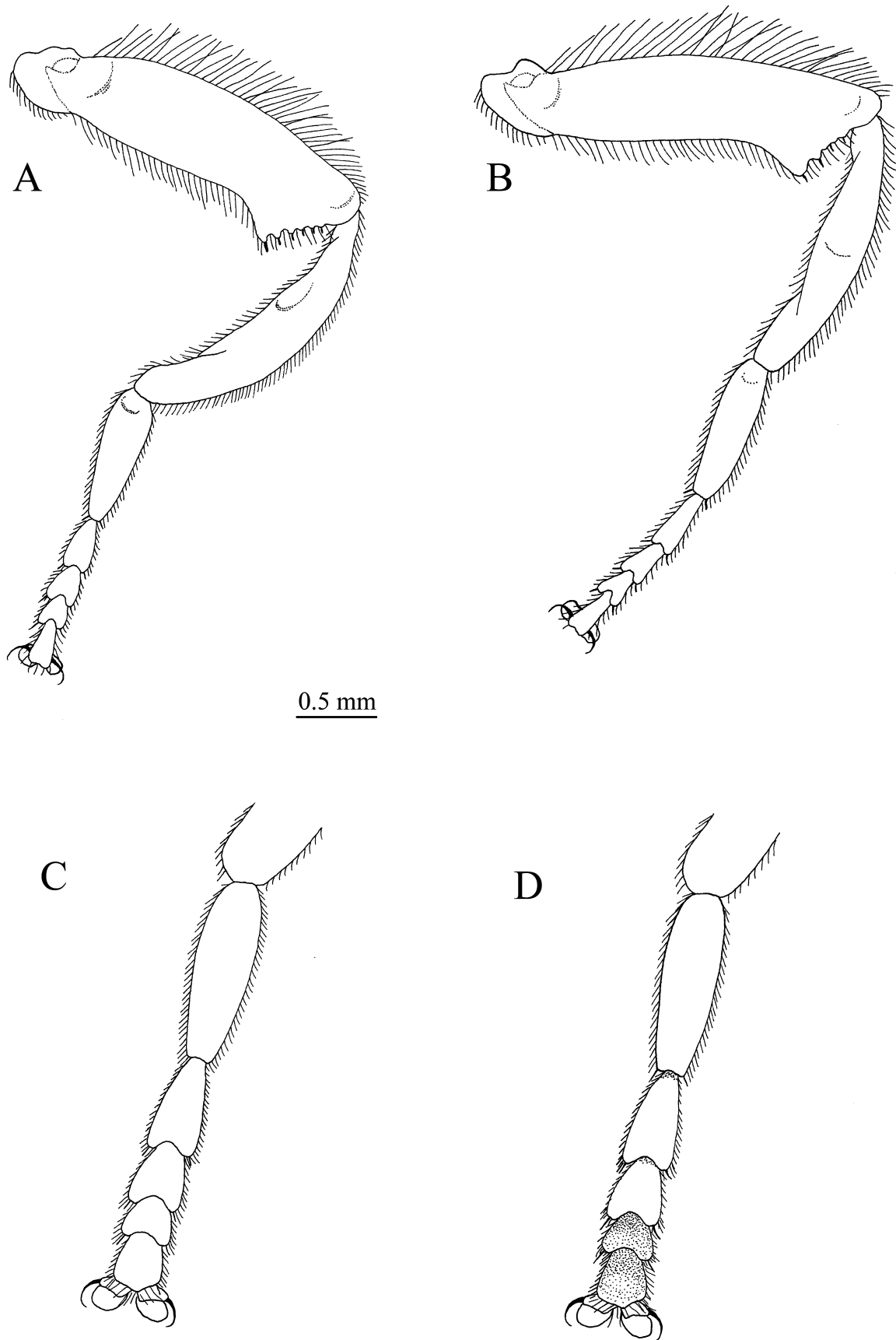


FIGURE 4. *Merodon nanus*, hind leg, lateral view; A. male; B. female. Tarsi of the hind leg of female, dorsal view; C. *M. telmateia*; D. *M. nanus*. Dotted areas indicate darkly pigmented cuticle.

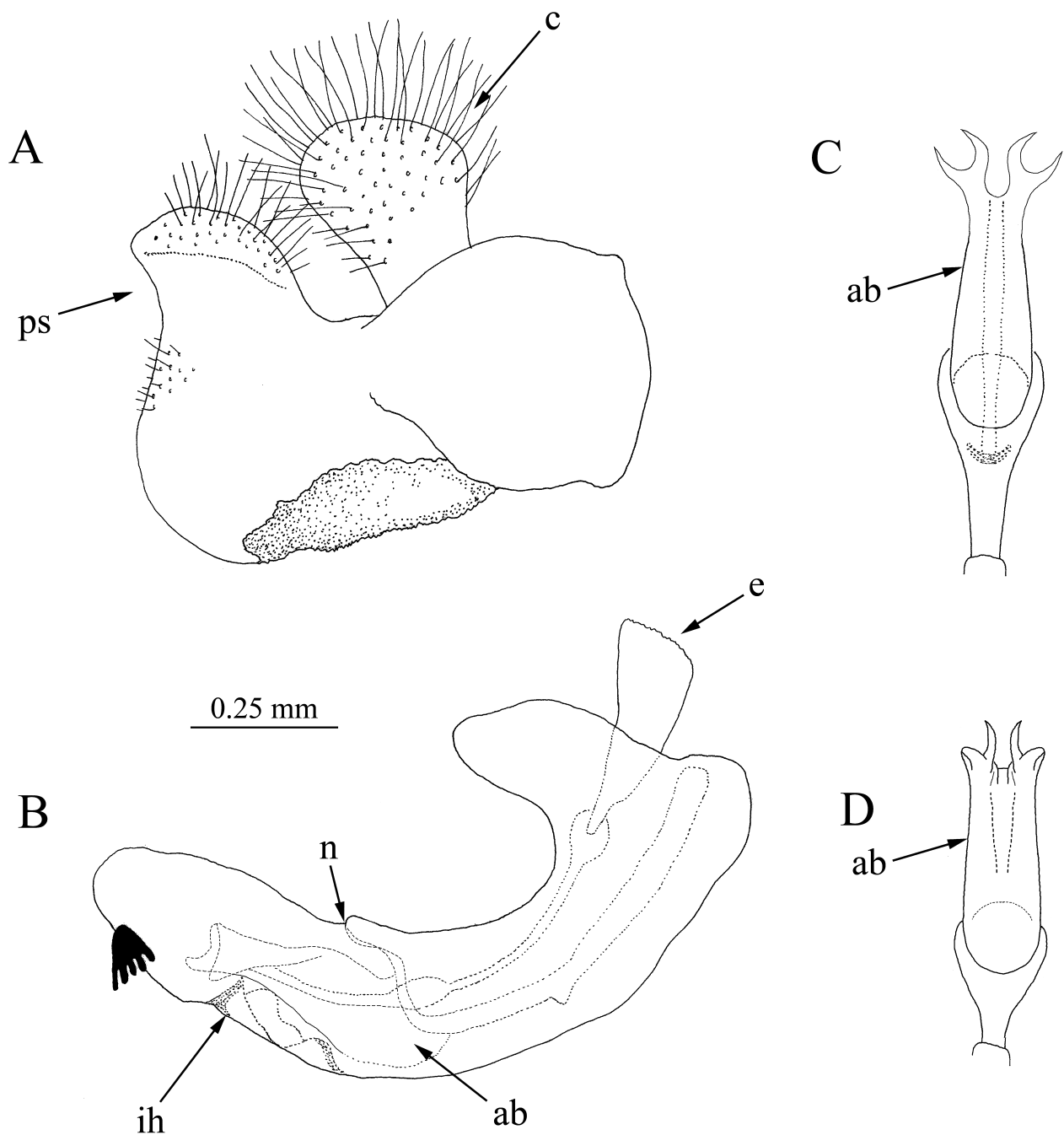


FIGURE 5. Male genitalia. A–C. *Merodon nanus*; D. *M. rasicus* sp. n. A. Epandrium, lateral view; B. hypandrium, lateral view; C–D. distal end of the aedeagus, ventral view; ps–posterior surstyle lobe; c–cercus; ih–inner processes of the hypandrium; ab–aedeagal box; n–notch on theca to which is attached the aedeagal apodeme; e–ejaculatory apodeme.

(Paratype of *M. telmateia* Hurkmans) Muğla, 2 ♂, Ortaca, Dalaman Stream, 23.v.2000 (RMNH), ♂, Yeşilüzümlü, Kırkpınar, 28.v.2000 (M.R. coll.).

Etymology. The word *kopensis* refers to the type locality of the species, Kop Mountain in Turkey.

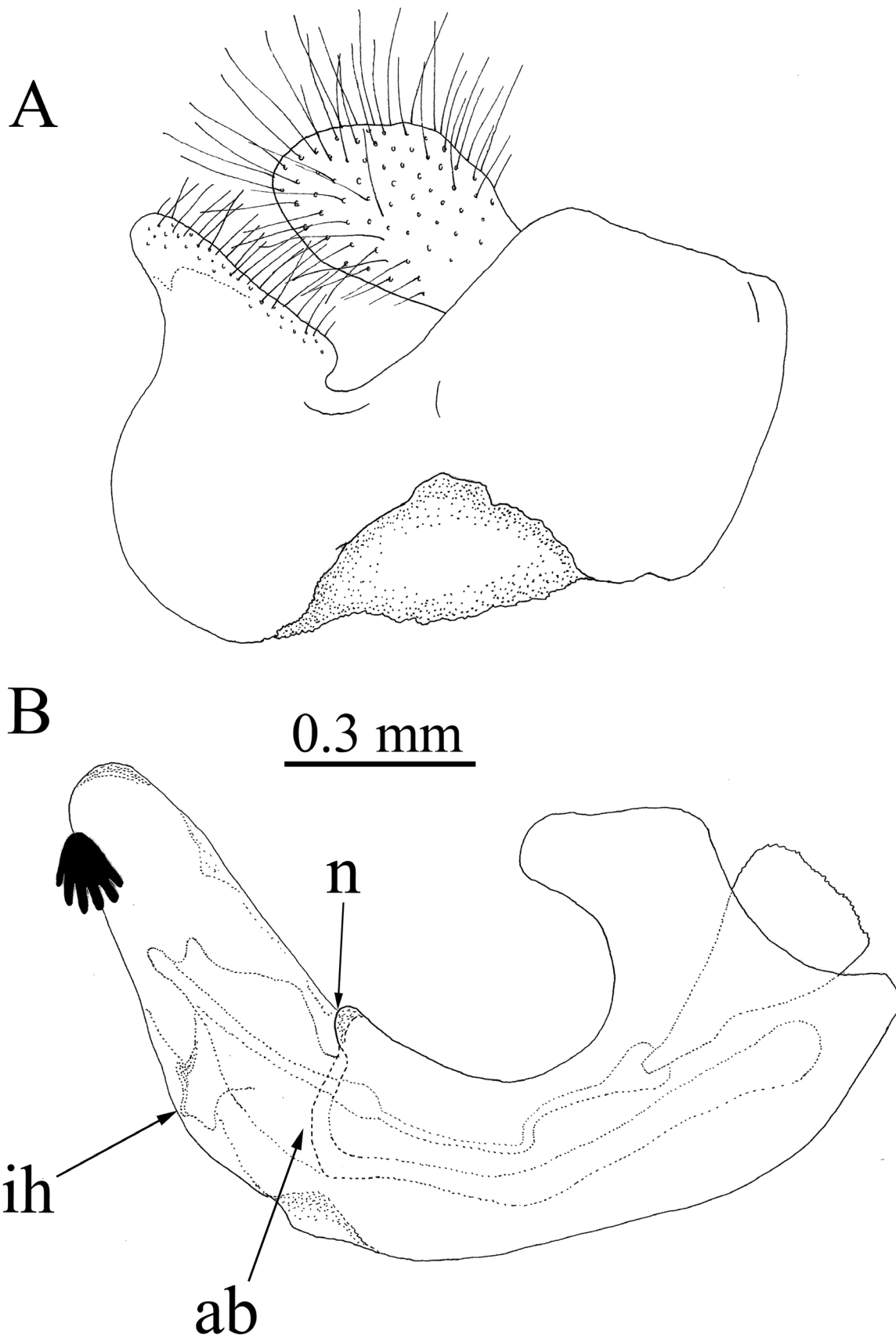


FIGURE 6. Male genitalia of *Merodon kopensis* sp. n., lateral view. A. epandrium; B. hypandrium; ab—aegeal box; n—notch on theca to which is attached the aedeagal apodeme; ih—inner processes of the hypandrium.

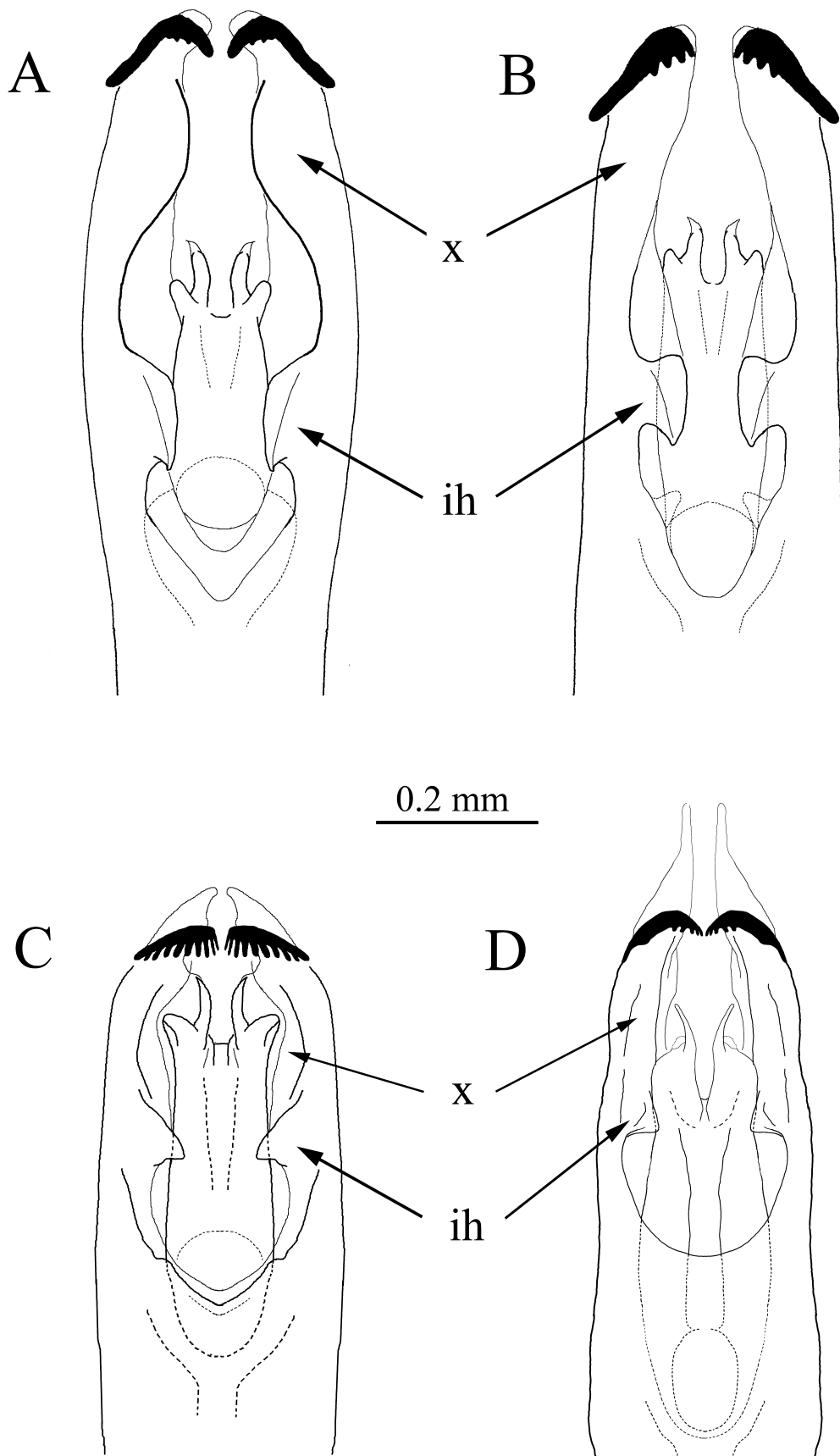


FIGURE 7. Apical part of hypandrium, anterior view. A. *Merodon neonanus* sp. n.; B. *M. kopensis* sp. n.; C. *M. rasicus* sp. n.; D. *M. telmateia*; x—inner edge of the apical part of the hypandrium; ih—inner processes of the hypandrium.

Merodon nanus Sack

Diagnosis. Male genitalia: tip of posterior lobe of the surstylus rounded, directed anteriorly (Fig. 5A: ps). Aedeagal box elongated, 1/3 of length of hypandrium (Fig. 5B: ab; 5C: ac); distal end of the aedeagal box is strongly bifurcated in the ventral view (Fig. 5C). This latter character is very stable in all analyzed populations across a wide range of species, from Lesvos through Turkey as far as Israel, Iran and Armenia; and is the main diagnostic character that distinguishes *M. nanus* (Fig. 5C) from closely related *M. rasicus* sp. n. (Fig. 5D). In addition, the rounded posterior surstyle is a unique character within this group (the posterior margin of the posterior surstyle is convex, contrary to all other species where it is more or less straight). Inner processes are settled in the apical 1/4 of the hypandrium (Fig. 5B: ih).

Type material. LECTOTYPE, ♂, “Kurdistan-Kasikopov”, “Lectotype ♂ *Merodon nanus* Sack-designated 1988 W. Hurkmans”, “*Merodon nana* Sack Type ♀”, “Typus”, “Syntypus”, “Coll. DEI Eberswalde”, “03351”, “WM601” = Iran (ZHMB).

Additional material. Armenia: ♀, Caucasus, Araxesthal, Reitter (ZHMB); Greece: Lesvos, 2 ♂, ♀, Ag. Ermogenis, 2.v.2008 (FSUNS); 2 ♂, 2 ♀, Mytilene, 7–11.v.2004 (FSUNS), 100m; ♀, Panagia island, Tokmakia, 24.iv.2004 (FSUNS), 5m; ♂, ♀, Sifnaios, 30.iv.2008, 75m; (MAegean); Iran: ♂, Tang Razianeh, 11.v.2006, 1100m (B.G. coll.); Israel: Haifa, 2♂, 1km E from Hurfeish, 15.v.1996, Schmid-Egger ISR hur (RMNH), ♂, 1km E from Hurfeish, 15.v.1996, Schmid-Egger ISR hur (M. H. Coll.); ♀, Tivon, 13.iv.1962; Golan, Har Dov, ♂, 8.vi.1983; 2 ♂, 21.v.1986, 5 ♂, ♀, Nahal Nimrod, 19.v.1983, ♀, Qala'at Nimrod, 19.v.1983, Hefa, Ma Yan Zevi (Ma`yan Zevi), 22 ♂, 23 ♀ #, 17.iv.1980; 3 ♂, 17.ii.1980 (RMNH), ♂, ♀, 17.iv.1980 (ZMA), Jerusalem, ♀, Kiryat Anavim, 3.v.1968, ♀, Ein Karem, 12.v.1976, 6♂, ♀ Mount Hermon, 9.vi.1975 (TAU), ♂, ♀, 3.vi.1979, ♂, 29.v.1984, ♂, Western Galilee, Ga`aton, 21.iv.1973, Mount Meiron, ♀, 20.v.1972, ♂, 22.iv.1973, 4 ♂, 13.v.1973, ♀, 6.vi.1973, 2 ♀, 14.v.1974, ♂, ♀, 11.vi.1974, ♀, 11.vii.1974, ♂, 28.v.1981, N. Bet- Oren, ♂, 6.v.1972, ♂, Nahal Dishon, 14.v.1973, ♂, Nahal Oren, 23.iv.1988, ♀, Nahal-kziv, 21.iv.1973, Ramot Naftali, ♀, 8.v.1969, ♀, 15.v.1973 (TAU); Lebanon: ♀, Mount Leban, Brumana, 26.v.1953, ♀, Jezzine, 3.vi.1953 (FSUNS); Palestine: ♀, Petach Tikvah, 30.iii.1925, O. Theodor (TAU); Syria: 4 ♂, 1856 (RMNH); Turkey: ♂, ♀, Mersin, Mut, Çömelek village, 40 km E from Mut, 29.v.1996 (FSUNS), 3 ♂, Kahramanmaraş, Afşin, 9.vi.1984 (RMNH), ♀, Hatay, Antakya, 10.v.2000 (TAU), ♂, Bingöl, Buğlan pass, 30.vii.1992, ♂, Hakkari, Cilo mountains, 16.vi.1984, ♂, Aksaray, Doğantepe village, Yalnızagaç, 30.vi.1997 (RMNH), ♂, Erzurum, Kargapazarı mountains, 27.vi.1996 (BMNH), ♀, Bingöl, Çermük village vi.1914 (NHMW).

Merodon neonanus Vujić et Taylor sp. n.

Diagnosis. Male genitalia (Figs. 7A, 8): posterior lobe of surstylus extremely large, with posterior margin straight, narrow tip; ventral margin strongly S-shaped with distinct convex part of the curve (Fig. 8A); the shape of posterior lobe of the surstylus can vary slightly (Fig. 8B). Aedeagal box short and broad (Fig. 12B), 1/4 of length of hypandrium (Fig. 8C: ab); aedeagal apodeme attached to the theca before the middle of the dorsal margin (Fig. 8C: n). Inner edge of apical part of hypandrium S form, strongly sclerotized (Fig. 7A: x). Inner processes settled in apical 1/2.5 of hypandrium (Fig. 8C: ih). Species is similar to *M. kopensis* sp. n. from which it differs by very large posterior lobe of surstylus, more than 2 times longer than cercus (Fig. 8A); and aedeagal apodeme attached to the theca before the middle of dorsal margin (Fig. 8C: n). The shape of the inner edge of the apical part of the hypandrium (Figs. 7A, 7B: x) is the most striking difference, along with the conspicuously large posterior lobe of the surstylus (Figs. 8A, 6A).

Type material. HOLOTYPE: Turkey: ♂, Muğla, Köyceğiz lake, 30.iv.2014 (FSUNS). PARATYPES: Greece: ♀, Samos, Pyrgos, 8.vi.2012 (FSUNS), Chios, ♂, 1 km W from Trachili, 27.iv.2000, 2♂, 2♀, 3 km W from Issidoros, 1.v.2000 (M.J.S. coll.), 2♂, near Issidoros, 5.v.1998, 6♂, ♀, Amades, 24.v.2002 (WML), 2♂, Avgonima, 25.iv.2002, Fyta, ♀, 7.vii.1999, ♂, ♀, 1.v.2000 (M.J.S. coll.), 2♂, 4.vi.2001, ♂, ♀, 27.v.2010, 2♂, near Fyta, 7.vi.1998 (WML), 2 ♂, 24.v.2009 (MZH), ♂, Kampia Gorge, 21.v.2003 (WML), ♂, Kipouries, 13.v.1995 (M.J.S. coll.), Mountain Pelinaeon, 5♂, 14.v.2003, 8♂, 13.v.2010, 2 ♂, 29.iv.2010 (WML), 2 ♂, 14.v.2009, ♂, 23.v.2009 (MZH), near Armolia, ♂, 1.vi.1998, ♀, 5.v.2001, ♂, Thimiana, 5.x.1995 (WML); FRY Macedonia: ♂, Skopje, Breznica, 24.v.2003 (MMNHS); Turkey: ♂ (ZHMB), 2 ♂, Bayburt, Kop mountain pass, 16.vii.1992, ♂, Erzurum,

Şenkaya, Turnalı, 20.vi.1997 (RMNH), ♂, ♀, Muğla, Köyceğiz lake, 30.iv.2014 (FSUNS), 2 ♂, 2 ♀, Manisa, Spildağ, 13.vi.2008 (A.S. coll.), Muğla, near Çakmak, ♂, 6.iii.2014, 2 ♀, 6.v.2014 (FSUNS), 3 ♂, Ortaca, Dalaman Stream, 23.v.2000 (J.S. coll.), 2 ♂, Yeşilüzümlü, Kırkpınar, 28.v.2000 (M.R. coll.).

Etymology. The word *neonanus* is derived from the Greek adjective *neos* meaning new and the name *nanus*, referring to a new species related to *M. nanus*, which received its name because of its small size.

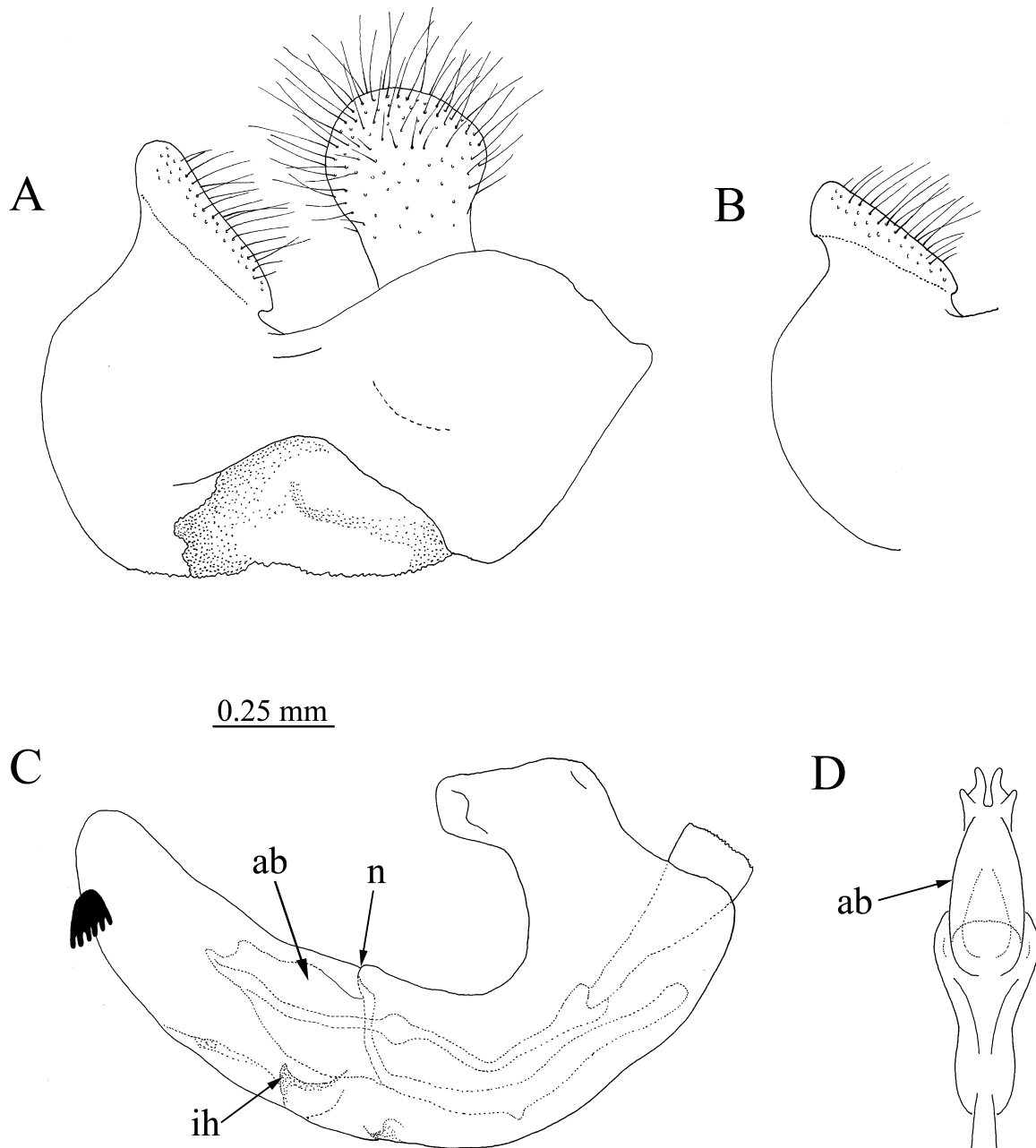
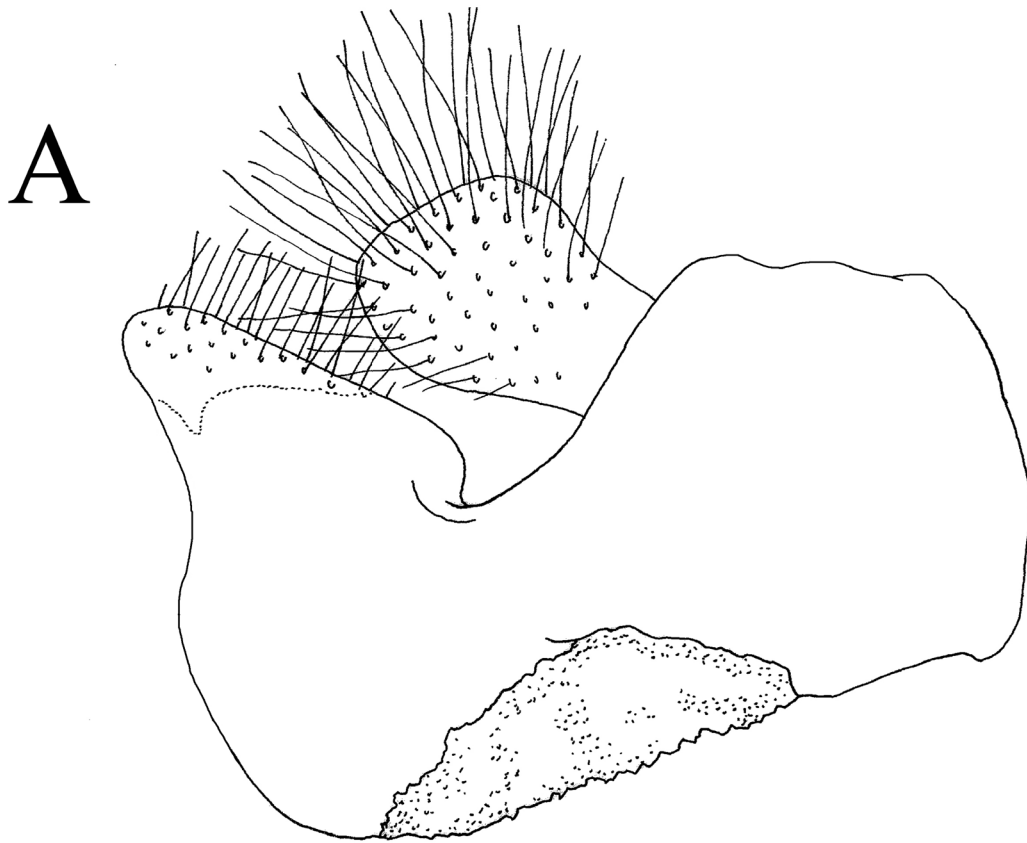


FIGURE 8. Male genitalia of *Merodon neonanus* sp. n. A–B. epandrium, lateral view; C. hyandrium, lateral view; D. distal end of aedeagus, ventral view; A—Greece; B—FRY of Macedonia; ab—aedeagal box; n—notch on theca to which is attached the aedeagal apodeme; ih—inner processes of the hyandrium.

***Merodon rasicus* Vujić et Radenković sp. n.**

Diagnosis. Male genitalia: tip of posterior lobe of the surstylus triangular, entire posterior lobe of the surstylus relatively small (Fig. 9A). Aedeagal box elongated, 1/2 to 1/3 of length of hyandrium (Fig. 9B: ab); shape of aedeagal box with small variations in apical part (Fig. 10). Inner processes settled in apical 1/4 of hyandrium (Figs. 6C, 8B:ih).



B

0.25 mm

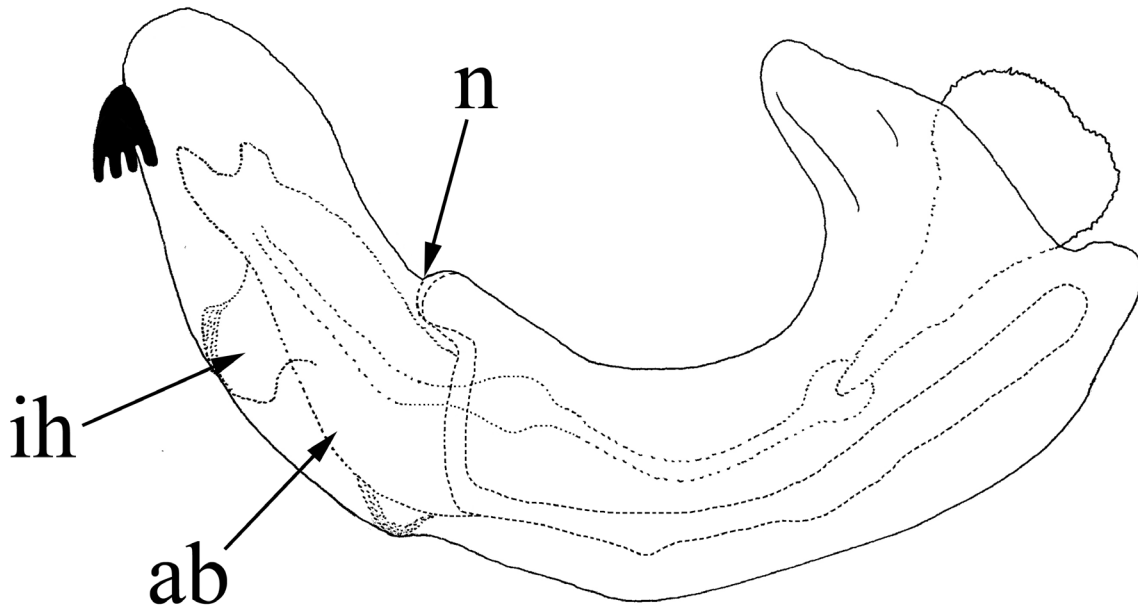


FIGURE 9. Male genitalia of *Merodon rasicus* sp. n., lateral view. A. epandrium; B. hypandrium; ab— aedeagal box; n— notch on theca to which is attached the aedeagal apodeme; ih— inner processes of the hypandrium.

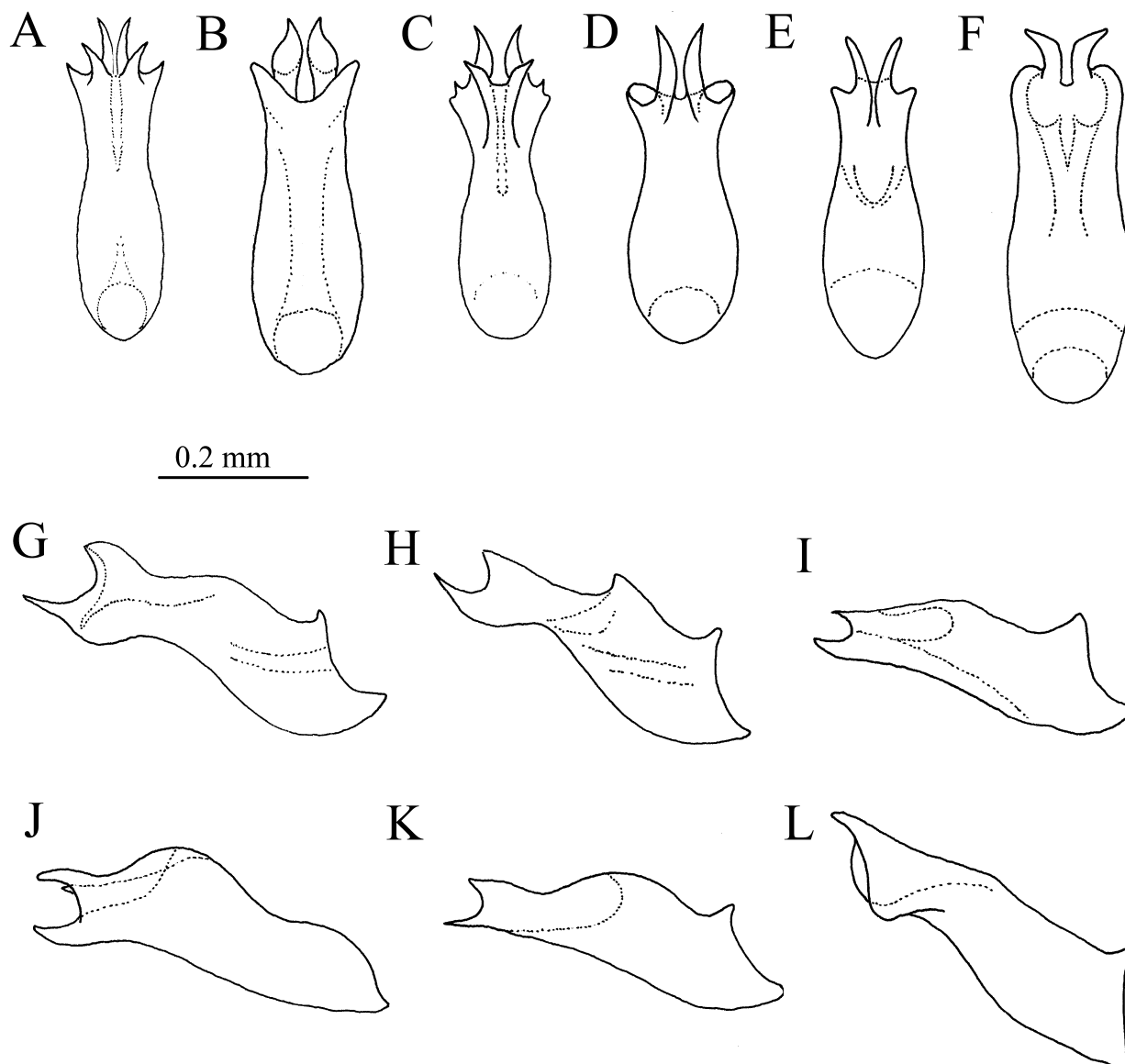


FIGURE 10. Aedeagal box of *Merodon rasicus* sp. n. A–L. ventral view; A–F. lateral view; G–L. Turkey, Hakkari: A,G. Iran, Fars Darab: B,H. Greece, Kavala: C,I. Turkey, Mardin: D,J. Serbia, Kopaonik: E, K. “Poland”: F, L.

This is a species with a broad range, from Serbia through Greece and Turkey to the Caucasus and Iran. Different populations show small variations in the shape of their aedeagal box (Fig. 10) and posterior lobe of the surstylus, which can indicate the presence of more geographically isolated populations; however, based on the identical structure of other male genitalia features, we described *M. rasicus* sp. n. as one taxon.

Type material. HOLOTYPE: Serbia: ♂, Kopaonik, Kukavica, 14.vii.2012 (FSUNS). PARATYPES: Greece: ♂, Kavala, Granites, 10.vii.1932 (BMNH), ♂, Evros, Mountain Sapka, 6.vii.2010 (FSUNS); Azerbaijan: ♂, Caucasus, Kusary, vi.1984 (FSUNS); Iran: ♂, Fars Darab, Rostagh Khasham Olva, 18.iv.2006 (NHMW); Poland: ♂, South Poland "Polonia meridiou" (R. Trojan 1957; *Lampetia aenea*, BMNH); Serbia: 5♂, ♀, Kopaonik, Kukavica, 14.vii.2012 (FSUNS), Turkey: ♂, Giresun Mountains, Tamdere, 14–17.vii.1986 (Paratype of *M. telmateia* Hurkmans), Hakkari, 6♂, 7♀, Cilo Mountains, 16.vi.1984, ♀, Sat Mountains, 17.vi.1984 (RMNH), ♂, İçel, Mut–Kırobası area, 1.v.1993 (ZMC), Kastamonu, Hanönü, ♂, Çakırçay village, 9.vi.1996, 2♂, Kuyuluş village, 30.v.1999, ♂, Tosya, 8.vi.1996 (FSUNS), ♂, Mardin, Midyat, 25.v.1983 (RMNH); Ukraine: ♂, Krim, Artek, 18.vii. 1966 (ZMC).

Etymology. The word *rasicus* refers to the type locality of the species. Ras is the former name of the region in Serbia containing Mt. Kopaonik as type area.

Merodon telmateia Hurkmans

Diagnosis. All tarsi pale (if darker, always uniformly colored; except in some specimens from Mugla mountain in Turkey, which may have dark apical two tarsomeres). Male genitalia: posterior lobe of the surstylus relatively small, with wide rounded tip slightly pointed anteriorly and the posterior margin more or less straight; ventral margin of surstylus slightly concave, not S-shaped (Fig. 11A). Hypandrium tapering towards sharp apex (Figs. 7D, 11B), contrary to all other species of group; inner processes of hypandrium settled in the apical 1/4 (Fig. 11B: ih); aedeagal box elongated, about half the length of hypandrium (Fig. 11B: ab).

Type material. HOLOTYPE: Turkey: ♂, Kars, Sarıkamış, Kars Stream, 30.vi. to 7.vii.1986 (RMNH). PARATYPES: Turkey: Kars, 2 ♀, 25 km W from Sarıkamış, 6.vii.1985 (TAU), 2♀, 5 km E from Sarıkamış, Kars Stream, 30.vi. to 5.vii.1986 (ZHMB), ♀, 30.vi. to 5.vii.1986 (RMNH), ♂, 30.vi. to 5.vii.1986 (M.H. coll.), ♀, 30.vi. to 5.vii.1986 (NHMW).

Additional material. Greece: Samos, ♂, Ambelos, near Agios Ioannis, 15.v.2010, near Manolates, ♂, 14.v.2010, 4 ♂, 2 ♀, 15.v.2010, ♂, ♀, 8.vi.2010, ♂, Pyrgos, 8.vi.2012 (FSUNS); Israel: ♀, Galilee, Kfar Shamai, 27.v.1980 (TAU); Pakistan: 2 ♀, Makri (ZHMB); Russia: ♂, Kabardino-Balkar, Khulamo-Bezengiyevskiy Rayon, 8.viii.2000 (SZMN); Turkey: Bayburt, Kop mountain pass, 2 ♂, 20.vii.1989, ♂, Agri, ♂, Patnos, ♀, Artvin, 5 km S from Kılıçkaya, ♀, Ardahan, 20.vii.1977, 3 ♀, Bayburt, Demirözü, 23.vii.1991, ♂, 4 ♀, 30.vii.1991, ♀, 4.vi.1992, ♂, 30.vii.1992, 2 ♂, Demirözü, Eymir village, 6.viii.1992, Kop Mountain, 12 ♂, 12 ♀, 28.vi.1990, 13 ♂, 14 ♀, 10.viii.1991, 4 ♀, 12.vii.1992, ♂, ♀, 15.vii.1992, 7 ♂, 7 ♀, 12.viii.1992, ♂, ♀, throughout river, 21.vi.1992 (EMIT), Çankırı, Yumaklı village, 2 ♂, 22.vii.1997 (FSUNS), ♀, Erzurum, Çat, Çirişli pass, 22.vi.1987, ♂, Alaybeyi village, 11.vii.1990, ♀, Aşkale, Kop Mountain, 25.vi.1990, ♂, ♀, Şehitlik fountain, 20.vii.2005, ♀, Pırnakapan, 28.vi.1990 (EMIT), ♂, Ilıca, Atlıkonak village, 12.vii.1997 (RMNH), 13 ♂, 28 ♀, 11.vi.2000, 2 ♀, Karagöbek Mountain, 5.vii.1989 (EMIT), ♂, Kargapazarı Mountains, ♂, Pasinler, Rabat ♂, Pass SW from Oltu (RMNH), ♂, Palandöken Mountain, 17.viii.1988, ♀, Kümbet village, 11.vii.1990, ♀, Özbek village, 11.vii.1990, ♂, Pazaryolu, 18.vi.1994 (EMIT), Şenkaya, 2♂, ♀, 14.vii.1997, (RMNH), 2 ♀, 3.vii.1990, ♂, 7.viii.1988, Turnalı, 2 ♂, ♀ 2.vii.1990, 4♂, 5♀ 3.vii.1990, ♀, 25.vi.1991(EMIT), ♀, 20.vi.1997 (FSUNS), ♀, Tekman, 30.vi.1997, ♂, Tortum, 10.viii.1988 (EMIT), ♂, Yumaklı, ♂, Umudum (RMNH), ♂, Şehitlik Fountain, 20.vii.2005 (FSUNS), Kars, ♂, 5 km E from Sarıkamış, Kars Stream, ♂, 8 km W from Sarıkamış, ♂, Handere, 20 km W from Sarıkamış, ♂, Soğanlı, W from Sarıkamış, ♂, Yeniköy (RMNH), Marmaris, ♂, (FSUNS), 2 ♀, (ZHMB), Muğla, ♂, Köyceğiz, (RMNH), ♂, Kale, 18.vi.1998 (FSUNS), ♂, 3♀, “Lamnan Stream”, 1.vi.2000 (M.R. coll.), near Çakmak, 10 ♂, 15 ♀, 6.v.2014, 3 ♀, 6.iii.2014 (FSUNS), ♂, Reşadiye Yarımadası, 01.vi.2000, (V.W. coll.), ♂, Pamphylia (Antalya), Murtiçi 25 km S from Akseki, 1.vi.1991 (ZMC), Rize, 3 ♂, 8 ♀, İkizdere, Ovit Mountaion, 29.vii.2000 (EMIT), ♀, Artvin, Maedow above Ardanuç, 23.vi.1999 (WML).

Key for species of *M. nanus* group (males)

- 1 All tarsi pale (Fig. 4C) (if darker, always uniformly coloured; with the exception of some specimens from Mugla mountain, Turkey). Male genitalia: hypandrium with strongly pointed, sharp apex (Figs. 7D, 11B) *Merodon telmateia*
- At least apical two tarsomeres brown or dark dorsally (as on Fig. 4D). Male genitalia: hypandrium with rounded or slightly pointed apex (Figs. 5B, 6B, 8C, 9B) 2
- 2 Hind trochanter without such patch. Aedeagal box elongated (Figs. 10C–10E), from 2 to 3 times shorter than the length of hypandrium (Figs. 4B, 8B, 9B:ab); inner processes of hypandrium settled in apical 1/4 (Figs. 5B, 9B); ventral margin of posterior lobe of surstylus moderately convex or almost straight (Figs. 5A, 9A) 4
- Hind trochanter with a patch of short thick orange pile. Aedeagal box short and broad (Fig. 12A, 12B), at least 4 times shorter than the length of the hypandrium (Figs. 6B, 8C: ab); inner processes of hypandrium settled in apical 1/2.5–3 (Figs. 6B, 8C: ih); ventral margin of posterior lobe of surstylus strongly convex (Figs. 6, 8) 3
- 3 Posterior lobe of surstylus very large, more than 2 times longer than cercus (Fig. 8A). Inner edge of apical part of hypandrium S-shaped, strongly sclerotized (Fig. 7A: x); aedeagal apodeme attached to the theca before the middle of dorsal margin (Fig. 8C: n) *Merodon neonanus* sp. n.
- Posterior lobe of surstylus smaller, less than 2 times longer than cercus (Fig. 6A). Inner edge of apical part of hypandrium straight, unsclerotized (Fig. 7B: x); aedeagal apodeme attached to the theca in the middle of dorsal margin (Fig. 6B: n) *Merodon kopensis* sp. n.
- 4 Distal end of aedeagal box strongly bifurcated in ventral view (Fig. 5C). Tip of posterior lobe of surstyle rounded, directed anteriorly, with convex posterior margin (Fig. 5A) *Merodon nanus*
- Distal end of aedeagal box without strong lateral processes in ventral view (Fig. 5D). Tip of posterior lobe of surstyle triangular, more narrow, with straight posterior margin (Fig. 9A) *Merodon rasicus* sp. n.

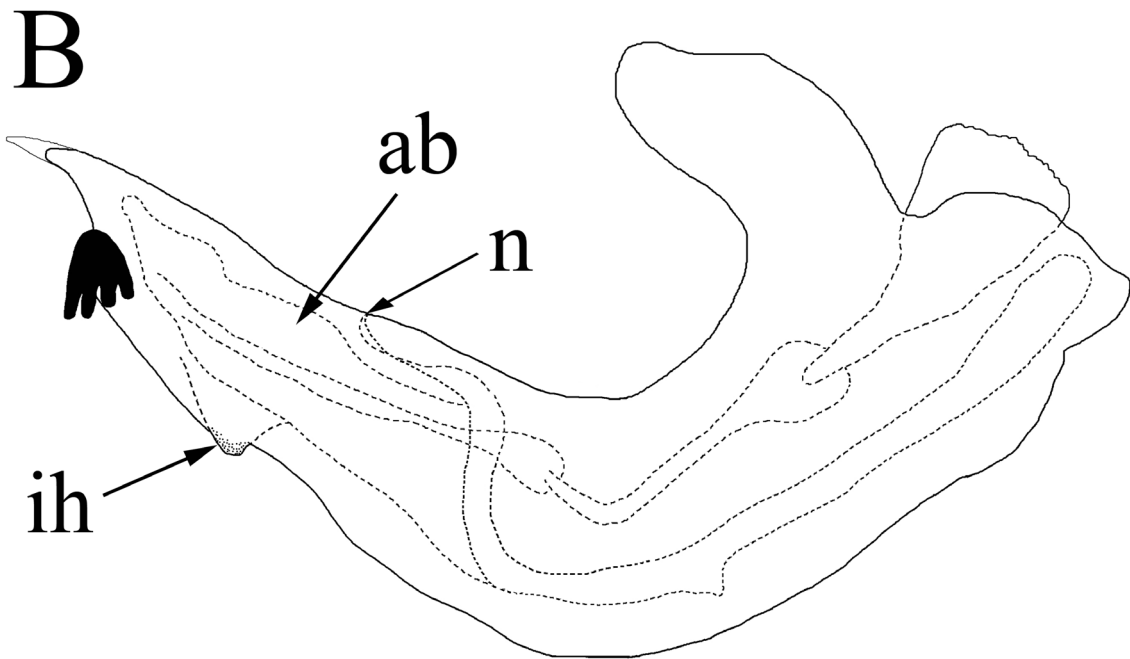
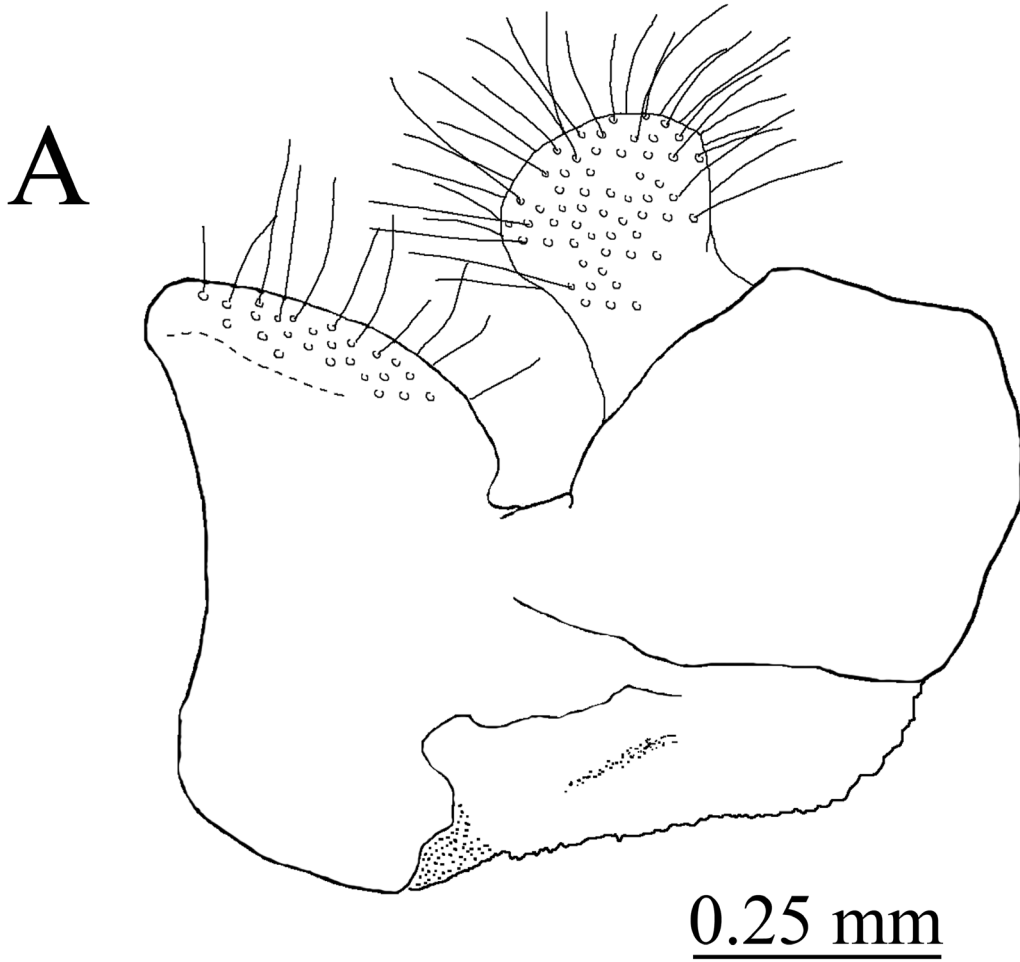


FIGURE 11. Male genitalia of *Merodon telmateia*, lateral view. A. epandrium; B. hypandrium; ab— aedeagal box; n— notch on theca to which is attached the aedeagal apodeme; ih— inner processes of the hypandrium.

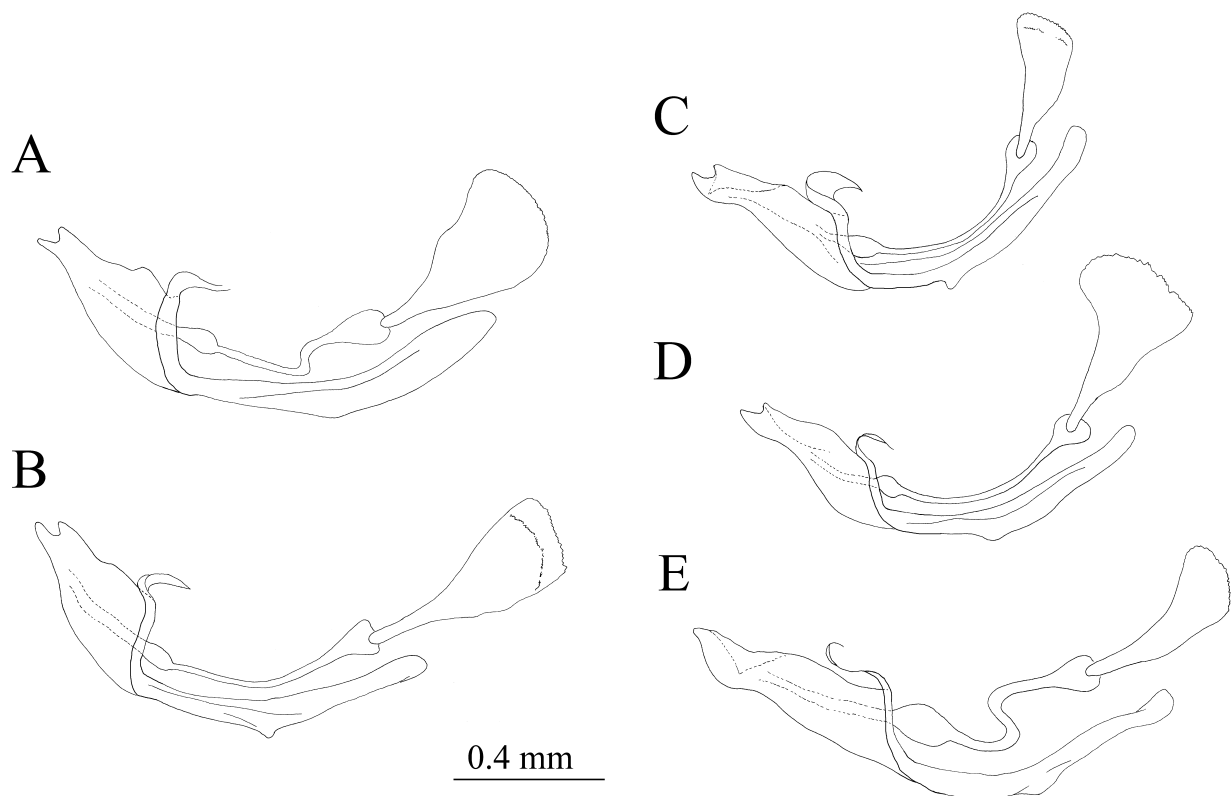


FIGURE 12. Aedeagus with accessory structures, lateral view. A. *Merodon kopensis* sp. n.; B. *M. neonanus* sp. n.; C. *M. nanus*; D. *M. rasicus* sp. n.; E. *M. telmateia*.

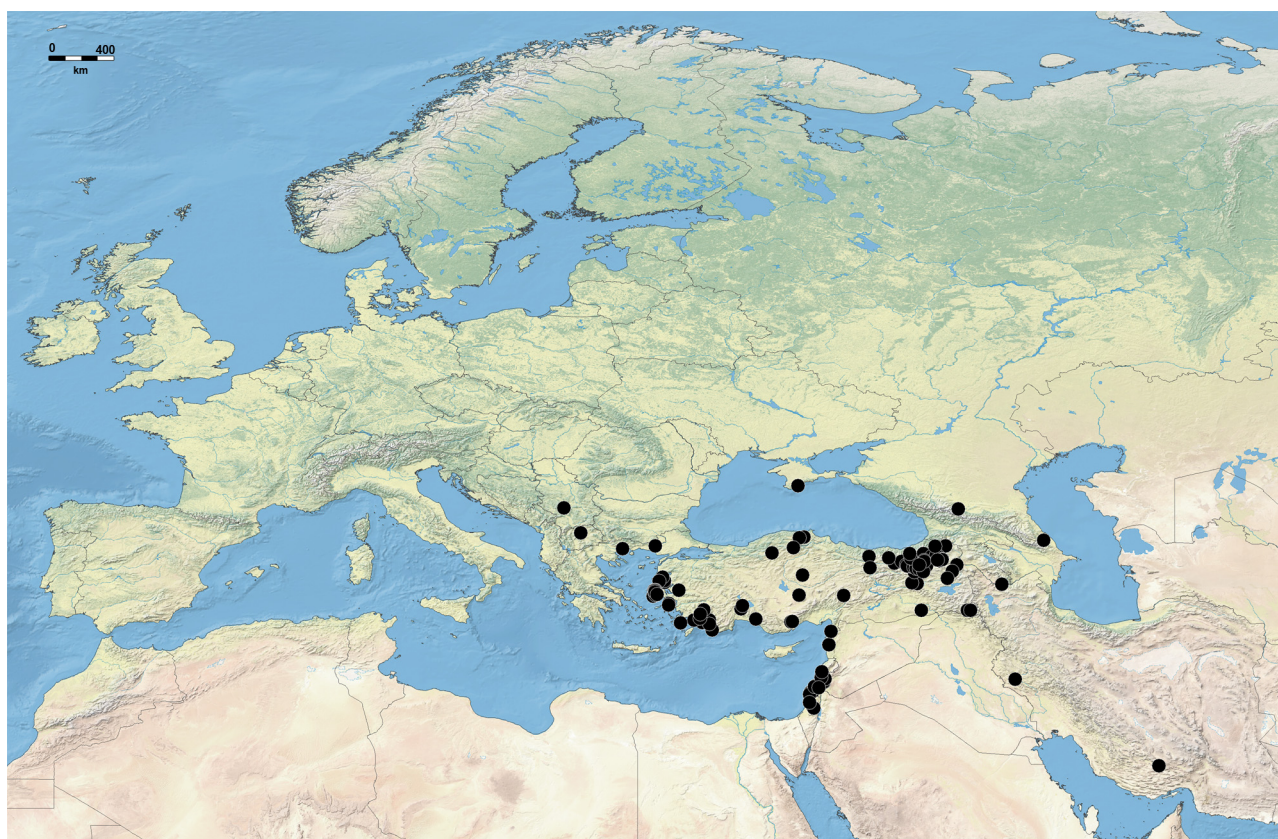


FIGURE 13. Distribution of *Merodon nanus* group.

Distribution and environmental analysis. Species from the *M. nanus* group are widely distributed across the Anatolian Peninsula, which represents the centre of their biodiversity. Besides the Anatolian Peninsula, this species group has expanded its range to the west including Greece, FRY of Macedonia and Serbia, to the north to the Caucasus region (Russia, Armenia and Azerbaijan) and Crimean Peninsula, and to the east and south to Syria, Lebanon, Israel and Iran (Fig. 13).

The elevation range of the group is from sea level to approximately 2,900 m (Fig. 14). Specimens that occur at lower elevation (0–1,500 m) are associated with island and coastal localities, while those which were recorded at altitudes above 2,000 m are mainly connected to the eastern mountains of Turkey.

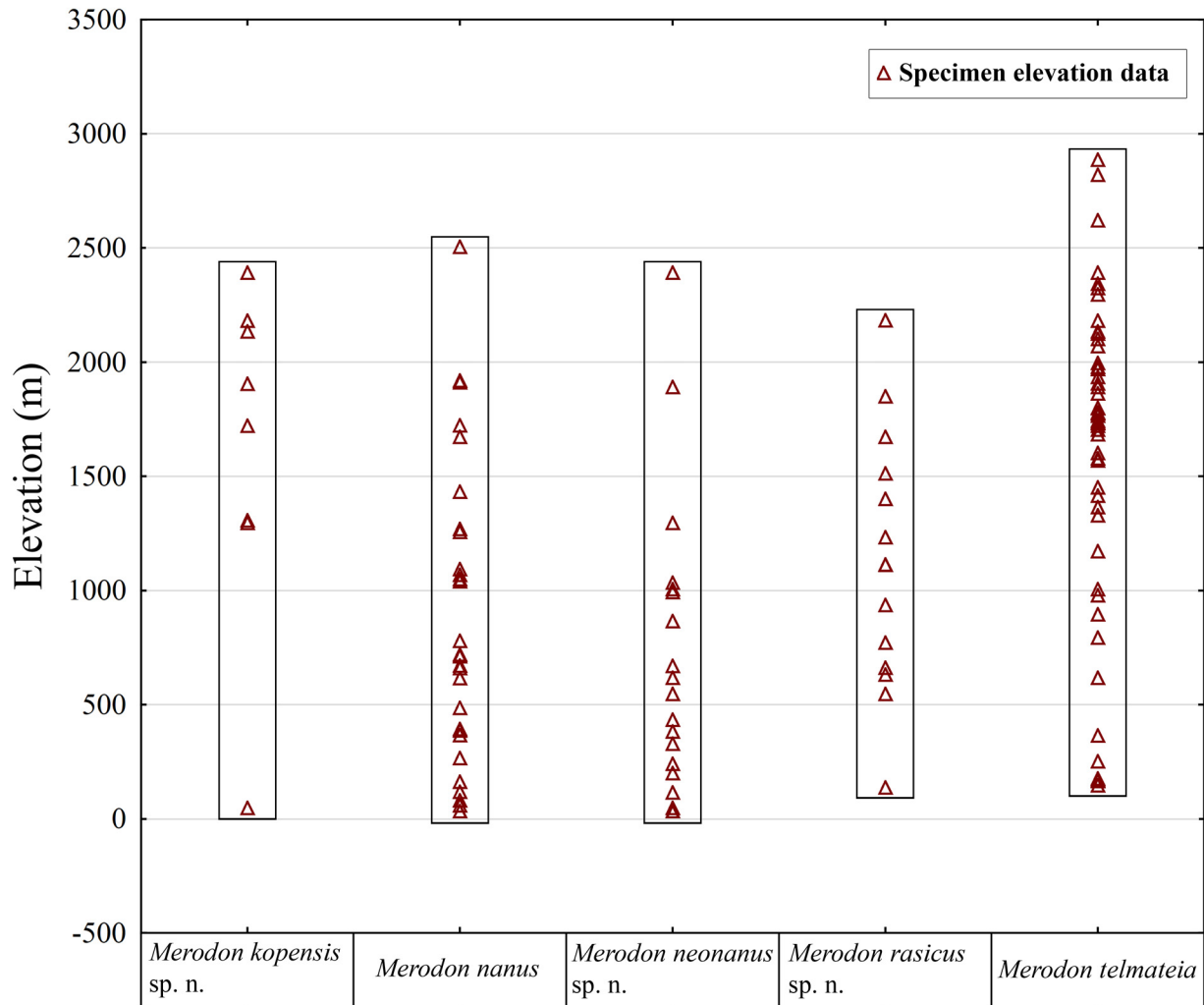


FIGURE 14. Variability plot of elevation gradient.

The sampled species richness map indicates that eastern Anatolia and the southern Aegean region of Turkey are the most species rich regions, with three of five species from the *M. nanus* group (Fig. 15).

***Merodon kopensis* sp. n.**

Endemic species of the Anatolian Peninsula. Populations of this species appear on higher mountains of central and eastern Turkey, up to 2,400 m, and at eastern Mediterranean localities, on the mountains near Mugla (Fig. 16).

***Merodon neonanus* sp. n.**

Species with a disjunctive range, recorded in FYR of Macedonia, the Greek islands of Chios and Samos, the western (Aegean and Mediterranean regions) and eastern part of Turkey (Erzurum) (Fig. 17). Elevation range starts from sea level up to 2,400 m. It is primarily found on lower mountains, up to 1,500 m (Fig. 17). During new

investigations in Turkey, adults of *M. neonanus* **sp. n.** and a *M. telmateia* have been found on flowers of *Leontodon* sp. (Şenol S.G., pers. comm.) (Fig. 1).

***Merodon rasicus* sp. n.**

Mountain species with a wide distribution: from Iran, Turkey, Azerbaijan and Crimean Peninsula in the east, to Greece and Serbia to the west (Fig. 18).

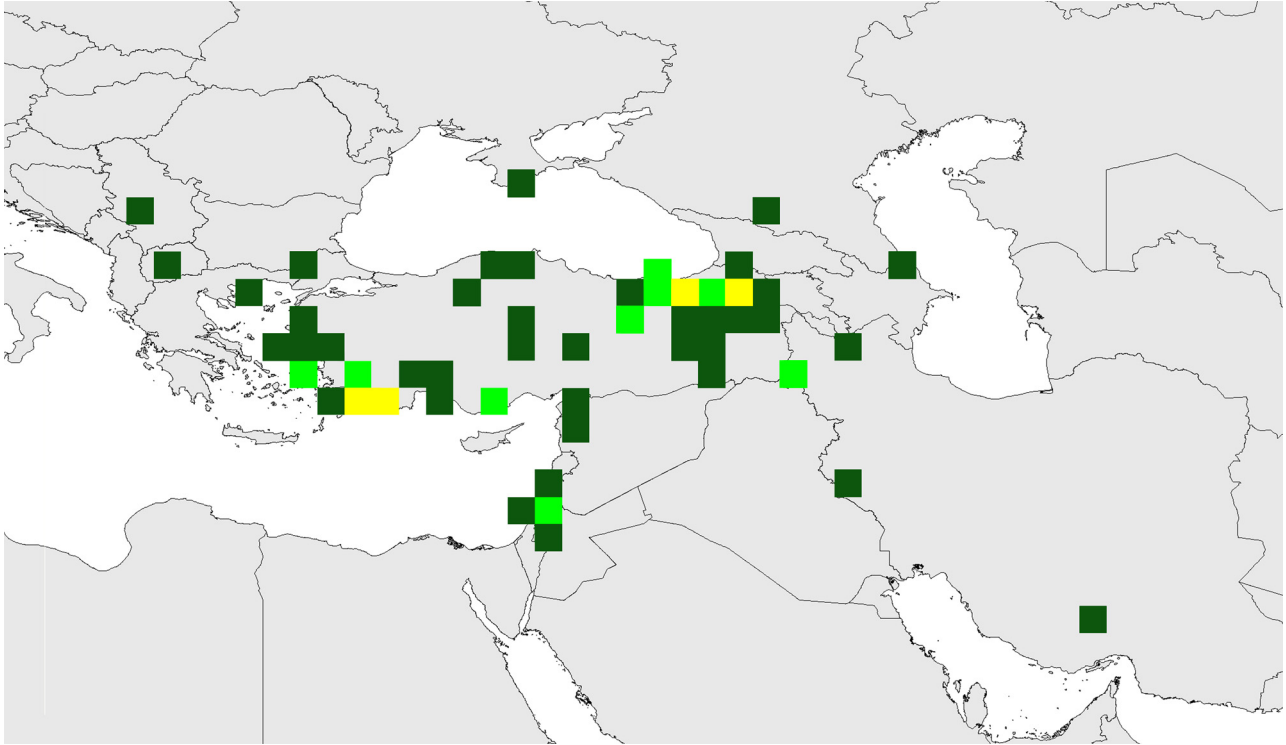


FIGURE 15. Richness of species from the *Merodon nanus* group. Lighter areas indicate greater richness (value range 1–3).



FIGURE 16. Distribution of *Merodon kopensis* **sp. n.**



FIGURE 17. Distribution of *Merodon neonanus* sp. n.



FIGURE 18. Distribution of *Merodon rasicus* sp. n.

Merodon telmateia

Species with a discontinuous range. Distributed on the Greek island of Samos, the Mediterranean region of Turkey in the west, Israel to the south and eastern Turkey and Caucasus Mountains, with a gap in the central Anatolian Region (Fig. 19). This species has a greater elevation range, up to 2,900 m (Fig. 14).



FIGURE 19. Distribution of *Merodon telmateia*.



FIGURE 20. Distribution of *Merodon nanus*.

Merodon nanus

Species with a wide range that occurs on the Greek island of Lesbos, the central and eastern part of Turkey, the Caucasus mountains (“Araxesthal”), Syria, Israel and Iran (Fig. 20). Elevation range is up to 2,500 m, but most records were collected from lower mountains (Fig. 20).

Niche comparisons in environmental space. To improve our understanding of species distribution, climatic profiles for all five species from *M. nanus* group were studied. Principal component analysis showed that species from this group differ in three environmental dimensions (three PCs with an eigenvalue greater than 1), which together explain 89% of the total variation. ANOVA showed overall significant differences in factor scores of all three PCs among species (PC1: $F_{4,482}=53.51$, $p<0.00000$; PC2: $F_{4,482}=7.74$, $p<0.00093$; PC3: $F_{4,482}=33.97$, $p<0.00000$). PC1 carries the greater part of the variability (68%) and is in positive correlation with the mean temperature of the wettest quarter (Bio8) and isothermality (Bio3), while PC2 and PC3 are correlated with precipitation variables. PC2 and PC3 possess a similar percent variability: 11% and 10% respectively. PC2 positively correlates with annual precipitation (Bio12), precipitation in the wettest quarter (Bio16) and month (Bio13), while PC3 represent precipitation in the warmest quarter (Bio18), precipitation in the driest month (Bio14) and quarter (Bio17). 3D scatter plot of mean values of factor scores illustrate the position of five species from *M. nanus* group in environmental space (Fig. 21). PC1 enables clear distinction between *M. nanus* and other investigated species on the basis of temperature in the wettest quarter. Species with a northern distribution, *M. rasicus* sp. n. and *M. neonanus* sp. n., are clearly separated by PC2 from all others while *M. neonanus* sp. n. and *M. nanus*, which have a mostly coastal distribution, are distinguished by PC3 from other investigated species.

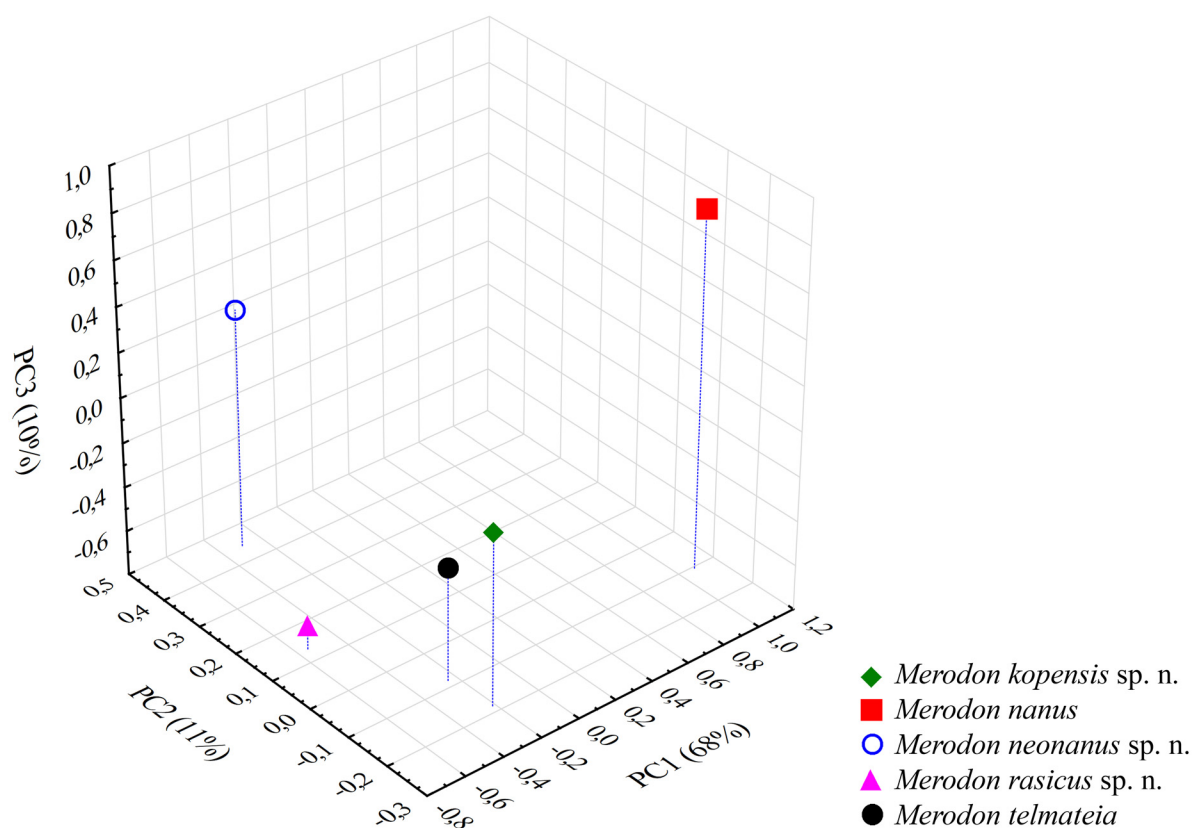


FIGURE 21. Principal component analysis of 19 variables associated with occurrences of five species from *M. nanus* group. Symbols represent the mean values of factors scores related with species in 3D dimensions.

Discussion

Taxonomy. There are relatively few publications dealing with the species *M. nanus* and *M. telmateia*, and no previously published studies on grouping these taxa. Ståhls *et al.* (2009) published a key and mitochondrial DNA COI barcodes for Lesvos (Greece) species of the genus *Merodon* (including *M. nanus*) (see also Ricarte *et al.* 2012). Vujić *et al.* (2011) reported these two species for Turkey and gave data concerning preferred adult habitats and visiting flowers.

Hurkmans (1987), who described *M. telmateia* from Turkey, discussed its separation from resembling species *M. aeneus* Meigen (synonym of *M. aureus*), *M. fulcratus* Becker, *M. minutus* Strobl, *M. nanus*, *M. spinatarsis* and *M. syriacus*, but considered the newly described species to be most similar to *M. aeneus*. Later, Hurkmans and Hayat (1997) pointed out that the easiest way to distinguish *M. nanus* from *M. spinatarsis*, *M. telmateia* and *M. syriacus* is its silvery (vs. golden or coppery) appearance, thus suggesting that these were regarded by the authors as highly related.

Analyses of the type material and all available material in the surveyed collections of both taxa confirm their separate position from other related species and groups, supported by several characteristics presented in the results, and revealed few cryptic taxa, different only in male genitalia features. Because of its small size and metallic lustre on the thoracic dorsum, this group of closely related species resembles members of the *M. aureus* group (sensu stricto, according to Radenković *et al.* 2011), as well by the presence of pile on the posterior part of the mesocoxa and the lack of an anterior surstyle lobe in the epandrium of male genitalia. But some other specific features of male genitalia and the absence of a spike on the metatrochanter make this group unique.

The *M. nanus* group consists of several cryptic species, whose clear separation is only possible by the structure of male genitalia. In comparison with some other recently studied groups of the genus *Merodon*, such as the *M. nigritarsis* group (Radenković *et al.* 2011; Vujić *et al.* 2013), the *M. natans* group (Radenković *et al.* 2011), the *M. ruficornis* group (Vujić *et al.* 2012) and the *M. equestris* group (Marcos-García *et al.* 2011), the *M. nanus* group shows high morphological similarity. This fact indicates that these species recently diverged from each other. Studies of distribution and comparison of environmental niches detected five ecologically distinct taxa.

Distribution. The Anatolian Peninsula is a biologically diverse region, because of its topography and climate which encompasses many different types of habitat, and rich geological history during which it became an important refugium (Çiplak 2003). Additionally, the region serves as a bridge which connects different geographic regions between Asia and Europe, providing passage for spreading species. The Anatolian Peninsula, together with the Iberian Peninsula, represent the main centre of *Merodon* biodiversity (Vujić *et al.* 2011). All species from the *M. nanus* group are distributed in the eastern Mediterranean, with the Anatolian Peninsula as the centre of biodiversity. *Merodon kopensis* **sp. n.** is endemic to Turkey, while others spread their range to the east, south and west. The most species rich areas are the eastern Anatolian and southern Aegean regions. The eastern part of Turkey is characterized by high plant and animal diversity. It is a mostly mountainous district with high elevations and narrow and deep valleys, and possesses one of the most attractive landscapes of the Anatolia region (Çoruh *et al.* 2014).

Of all the studied species, *M. nanus* occupies the warmest and driest habitats with higher mean temperatures during the wettest quarter and lower precipitation level in the wettest, warmest and driest quarters. *Merodon nanus* and *M. kopensis* **sp. n.** occur on sites with the lowest precipitation levels. They are distributed in the central and eastern regions of Turkey, which receive lower annual rainfall, and have cold winters and warm summers. Niche space between *M. nanus* and *M. neonanus* **sp. n.** was differentiated in one environmental dimension that is connected with annual precipitation and precipitation levels in the wettest quarter, which can be related with the narrower range of *M. neonanus* **sp. n.** *M. rasicus* **sp. n.** occurs on sites with the highest precipitation levels and is predominantly distributed near the coasts of the Aegean, Mediterranean, Caspian, Black and Red seas. In Turkey, the mountain range parallel with the Black Sea and Taurus Mountain to the south form a barrier for rain clouds, preventing their movement inland, and resulting in a mild, damp climate. The climate of Kopaonik Mountain (Serbia) (type locality of *M. rasicus* **sp. n.**) is continental-montane with a sub-Mediterranean influence. In a biogeographical sense, Kopaonik lies on the border between the biome of European mostly coniferous boreal type forest and the biome of south-European, mostly broad-leaved woodlands with oromediterranean elements (following Matvejev & Puncer 1989).

Precipitation levels of *M. telmateia* are around the centre of precipitation of the entire group. This species has a discontinuous range, one population group occurs in the Aegean and Mediterranean regions, and a second in eastern Anatolia. Climatic preferences of these occupying regions are different. The Aegean and Mediterranean regions are characterized by warm climate, tepid, rainy winters and hot and dry summers. On the contrary, Eastern Anatolia has a more severe climate, with long winters and short summers. This can be indicative of the presence of two independent taxa in *M. telmateia*, but morphological results do not support this hypothesis. Future integrative approaches, with additional molecular and morphometric data should provide more insight into the possible origin and structure of the group.

Acknowledgements

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