



We have two of them: A review of the genus *Mastigusa* (Araneae: Cybaeidae) in Bulgaria

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Abstract

In the present study, we review the status of the genus *Mastigusa* Menge, 1854 in Bulgaria. We identified two species from the country, namely *M. arietina* (Thorell, 1871) and *M. macrophthalma* (Kulczyński, 1897). This is the first record of *M. arietina* from Bulgaria. Furthermore, we report a male palpal polymorphism in *M. arietina* in the populations around the Black Sea. We also provide molecular support for our conclusions, combining newly generated DNA sequences with information available in GenBank.

Key words: faunistics, myrmecophilous, phylogeny, spiders

Introduction

Mastigusa Menge, 1854 is a genus with a documented fossil history from the Baltic Amber (Wunderlich 1986). Its peculiar male genital morphology with a very elongate and slender palpal conductor and a similarly elongate embolus has remained relatively unchanged for millions of years. Currently, the genus comprises four extant species (World Spider Catalog 2025) and has an exclusively West Palaearctic distribution, extending eastwards to Iran.

The genus was recently revised by Castellucci *et al.* (2024), who defined and updated the diagnostic traits of the extant species. As has been documented for other Cybaeidae (as well as other spider genera and a wide range of other animals that rely upon internal fertilization; see Bennett 2006 and included references), the male palps of *Mastigusa* bear morphological diagnostic characters while the female genitalia are of very little taxonomic use at the species level. In addition, somatic traits such as relative eye size are variable and are of limited importance for diagnosing species of *Mastigusa*.

Castellucci *et al.* (2024) detected numerous misidentifications in the literature and therefore decided to remove all country records for which they were unable to examine voucher material, including those from Bulgaria, which prompted us to conduct the present study. The species *Mastigusa macrophthalma* (Kulczyński, 1897) was previously reported from Bulgaria by Deltshv (1990) from Pirin Mountains, by Deltshv & Blagoev (1992) from Zemen Mountains, and by Deltshv *et al.* (2011) from West Rhodopes Mountains, albeit from females only from Pirin Mountains and Rila Mountains. As none of this material was examined by Castellucci *et al.* (2024), these records had been disregarded by them. Our collecting efforts, however, not only reliably confirmed the presence of *Mastigusa macrophthalma* in Bulgaria but also discovered *Mastigusa arietina* (Thorell, 1871), which is the first record of the species for the country, thus confirming the presence in Bulgaria of two of the four European species.

TABLE 1. Specimens included in the molecular analyses, along with their corresponding NCBI or BOLD accession codes for each gene, countries, and sources.

Voucher code	Species	Accession numbers						Country	Source
		COXI	12S	16S	H3	18S	28S		
UB-MD2844		MW998118	*	*	*	*	Spain	Domenech <i>et al.</i> 2022	
DD198	<i>M. arietina</i>	PV785491	PV790558	PV789459	*	*	Bulgaria	This study	
MMHR4	<i>M. macrophthalma</i>	OP956100	OQ085104	OP964780	OP957311	OP964469	Croatia	Castellucci <i>et al.</i> 2023	
MMHR5	<i>M. macrophthalma</i>	OP956101	OQ085105	OP964781	OP957312	OP964487	Croatia	Castellucci <i>et al.</i> 2023	
MAUK01	<i>M. diversa</i>	OP956099	*	*	OP957317	OP964470	UK	Castellucci <i>et al.</i> 2023	
MAUK06	<i>M. diversa</i>	OP956104	*	*	OP957318	OP964471	UK	Castellucci <i>et al.</i> 2023	
MT607807_1	<i>M. arietina</i>	MT607807	*	*	*	*	Spain	Macias-Hernandez <i>et al.</i> 2020	
MD372	<i>M. diversa</i>	OP956096	OQ085101	*	OP957314	OP964467	Spain	Castellucci <i>et al.</i> 2023	
MASN01	<i>M. diversa</i>	OP956105	OQ085100	OP964782	OP957308	OP964480	Spain	Castellucci <i>et al.</i> 2023	
MASN02	<i>M. diversa</i>	OP956107	OQ085102	OP964783	OP957323	OP964468	Spain	Castellucci <i>et al.</i> 2023	
MAGE04	<i>M. arietina</i>	OP956108	*	*	OP957326	OP964479	Georgia	Castellucci <i>et al.</i> 2023	
MAGE05	<i>M. arietina</i>	OP956109	*	*	OP957327	OP964475	Georgia	Castellucci <i>et al.</i> 2023	
MAGE06	<i>M. arietina</i>	OP956110	*	*	OP957324	OP964472	Georgia	Castellucci <i>et al.</i> 2023	
FIN3	<i>M. arietina</i>	OR509854	*	*	*	*	Finland	Castellucci <i>et al.</i> 2023	
FIN4	<i>M. arietina</i>	OR509855	*	*	*	*	Finland	Castellucci <i>et al.</i> 2023	
DD193	<i>M. arietina</i>	PV759451	PV790575	PV789458	*	PV789380	Bulgaria	This study	
DD194	<i>M. arietina</i>	PV759518	*	*	*	*	Bulgaria	This study	
DD195	<i>M. arietina</i>	PV785487	*	*	*	*	Bulgaria	This study	
DD196	<i>M. arietina</i>	PV785489	PV790561	*	*	*	Bulgaria	This study	
DD200	<i>M. arietina</i>	PV752600	PV790559	PV789466	*	PV789379	Bulgaria	This study	
EDBA1	<i>M. arietina</i>	OP956102	OQ085107	*	*	OP964484	Italy	Castellucci <i>et al.</i> 2023	
MAS_IT_01	<i>M. arietina</i>	OP956094	OQ085098	*	OP957320	OP964465	Italy	Castellucci <i>et al.</i> 2023	
MAS_DK_01	<i>M. arietina</i>	OP956093	OQ085108	*	OP957310	OP964476	Denmark	Castellucci <i>et al.</i> 2023	
MAS_DK_03	<i>M. arietina</i>	OP956106	OQ085099	*	OP957322	OP964483	Denmark	Castellucci <i>et al.</i> 2023	
MAVSC1	<i>M. arietina</i>	OP956097	*	*	OP957315	OP964485	Italy	Castellucci <i>et al.</i> 2023	
TRD-ARA131	<i>M. macrophthalma</i>	ARTRD131-14	*	*	*	*	Norway	https://portal.boldsystems.org/record/ARTRD131-14	
MABE01	<i>M. arietina</i>	OP956091	*	*	OP957328	OP964477	Belgium	Castellucci <i>et al.</i> 2023	
MABE02	<i>M. arietina</i>	OP956111	*	*	OP957307	OP964478	Belgium	Castellucci <i>et al.</i> 2023	
MABE03	<i>M. arietina</i>	OR509878	*	*	*	*	Belgium	Castellucci <i>et al.</i> 2023	
MABE04	<i>M. arietina</i>	OR509877	*	*	*	*	Belgium	Castellucci <i>et al.</i> 2023	
ENT.2024.44.21	<i>M. arietina</i>	TPWMI009-24	*	*	*	*	UK	https://portal.boldsystems.org/record/TPWMI009-24	

Materials & methods

Specimens acquisition and morphological examination. The specimens were collected during the period September 2022 – January 2025 using pitfall traps or by hand sampling (mostly under stones and dead wood). In the case of pitfall traps, propylene glycol was used as a preservative. The traps were collected every two weeks. The material was then transferred for preservation to 75% ethanol. Female epigynes were cleared with lactic acid to study their inner structures. Specimens were examined and measured under a Zeiss Stemi 508 stereomicroscope. Photographs were taken with a Canon EOS 1100D digital camera attached to the stereomicroscope, stacked using Helicon Focus software, and then further processed in Photoshop. The map was generated using the QGIS v. 3.34.15-Prizren (retrieved from <http://qgis.org>). The morphological terminology follows Castellucci *et al.* (2024).

DNA extraction and sequencing. One or two legs were removed from one side of each specimen and used for the extraction. Genomic DNA was extracted from ethanol-preserved specimens using Qiagen DNeasy Blood and Tissue Kit, following the manufacturer's protocol. The extractions were then sent to NOVOGENE for library preparation and genome skimming (low coverage shotgun sequencing) on an Illumina platform. The obtained raw paired reads were filtered and trimmed using the program fastp 0.23.4 (Chen 2023). Cleaned reads were then used to assemble mitochondrial genomes with NVOPlasty v 4.3.4 (Dierckxsens *et al.* 2017) using a COX1 sequence from *Mastigusa arietina* as a seed. The obtained assemblies were annotated online on the Galaxy portal using MITOS2 (Donath *et al.* 2019). We repeated the same procedure for two specimens, providing 28S as a seed, to get the nuclear genes 18S and 28S. We then combined the target genes (mitochondrial COX1, 12S, 16S, and nuclear 18S and 28S) with selected sequences of *Mastigusa* and the outgroup *Cryphoeca silvicola* (C. L. Koch, 1834) available in GenBank. We also downloaded and used the available H3 sequences from the selected voucher specimens, although we could not sequence any H3 from our samples. The NCBI accession numbers of the sequences used in the analyses are available in Table 1.

Phylogenetic analyses. Sequences of each gene were aligned individually using MAFFT v7.503 (Kato and Standley, 2013). Protein-coding genes (COX1 and H3) were aligned using the L-INS-i algorithm, while the X-INS-i algorithm was used for the ribosomal genes (12S, 16S, 18S, and 28S). The alignments of the individual genes were inspected and concatenated in a single supermatrix using the program Geneious Prime v2025.0.3. Phylogenetic relationships were inferred using Maximum Likelihood (ML) and Bayesian Inference (BI). We first run PartitionFinder v2.1.1 (Lanfear *et al.* 2017) to select the best partition scheme and evolutionary model for each partition. We performed a ML analysis using the IQ-TREE 2.0.7 software (Minh *et al.* 2020), assessing the best partition scheme by splitting the concatenated matrix by gene and codon (in the case of the protein-coding genes) and estimating nodal support with 1000 replicates of ultrafast bootstrapping (Hoang *et al.* 2018). For the BI, we used the software MrBayes 3.2.7a (Ronquist *et al.* 2012). The analysis was run for 3 million generations, sampling every 1000, with four simultaneous Markov Chain Monte Carlo (MCMC) chains, and an initial burn-in of 10%. Support values were calculated as posterior probabilities. The results were monitored in Tracer 1.7 (Rambaut *et al.* 2018).

Abbreviations. Morphology: CdP, conductor dorsal process; RTA, retrolateral tibial apophysis; VTA, ventral tibial apophysis.

Depositories: CSI—private collection S. Indzhov, Sofia, Bulgaria; CVS—private collection V. Střeštík, Praha, Czech Republic; NMNHS—National Museum of Natural History, Sofia.

Results

Taxonomy

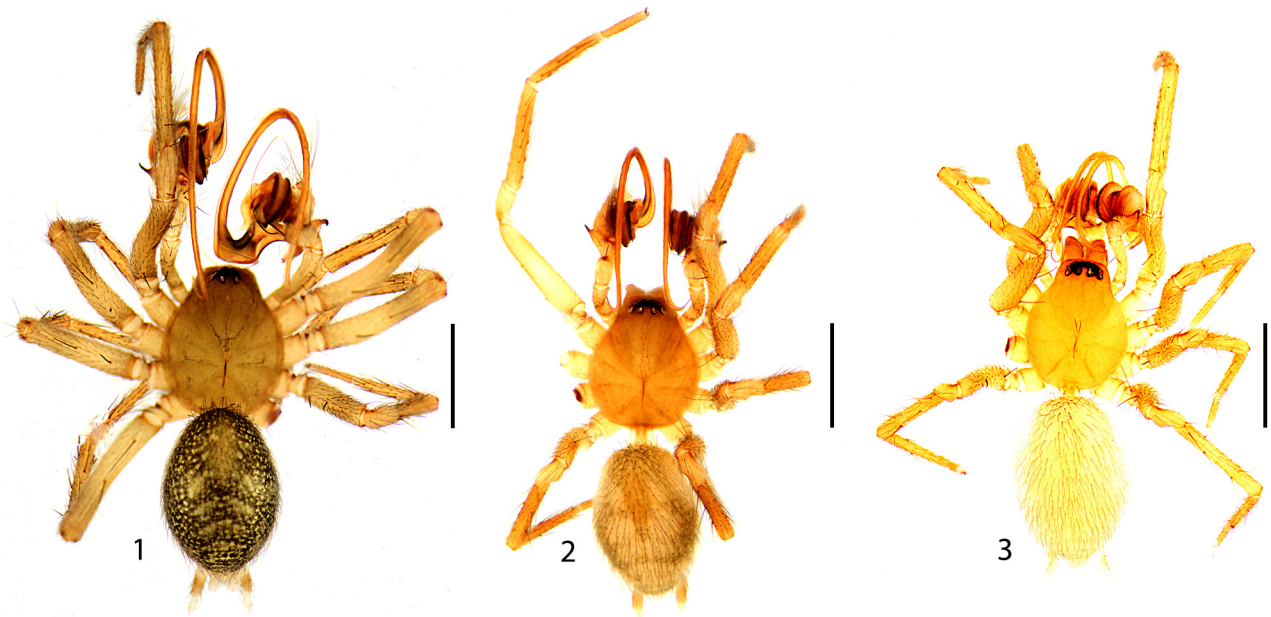
Cybaeidae Banks, 1892

Mastigusa Menge, 1854

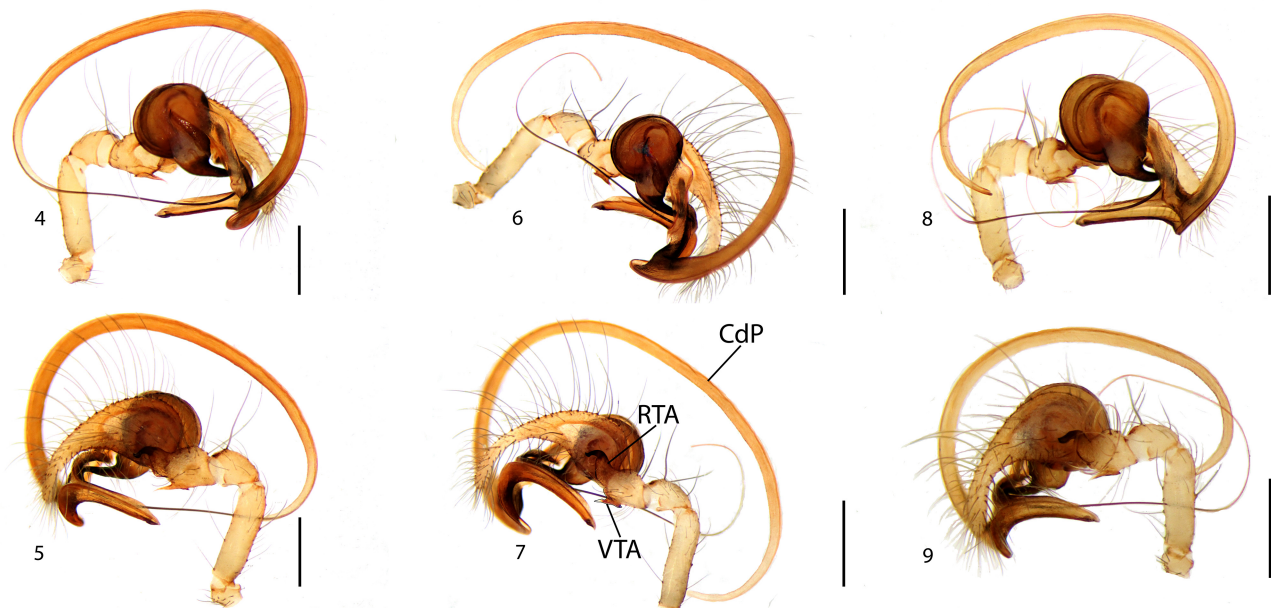
Mastigusa arietina (Thorell, 1871)

Figs 1, 2, 4–7, 10, 11, 13–18, 22

Material examined. Bulgaria: 1♂, Pirin Mts., 41.7877, 23.3248, *Pinus* forest, under stone, 23 August 2023, leg. Viktor Střeštík (CVS); 1♀ (DD196), Sofia Basin, Balsha Village 42.85854, 23.25959, xerothermic grassland, inside a *Messor* sp. ant nest under a stone, 15 March 2024, leg. Simeon Indzhov (NMNHS); 1♂, Vitosha Mts., Knyazhevo 42.65573, 23.240804, old growth *Pinus* forest plantation, under stone, 12 November 2024, leg. Simeon Indzhov (NMNHS); 1♀ (DD200), Belasitsa Mts., above Kongura Hut, 41.3414, 23.1853, *Fagus* forest, pitfall trap, 15 November 2024, leg. Vihra Haynadhieva (NMNHS); 1♀ (DD194), Sofia Basin, Sofia, Seminary Wall 42.67644, 23.33653, 30 January 2025, leg. Simeon Indzhov (NMNHS); 3♂♂ (DD193), 1♀ (DD195), Black Sea Coast, Nessebar 42.66570, 27.71162, beach, in a rotting log, 17 November 2024, leg. Galin Ivanov (NMNHS). (<https://www.inaturalist.org/observations/251684457>).



FIGURES 1–3. Habitus dorsal, males. 1, 2. *M. arietina*. 3. *M. macrophthalma*. Scale line: 1 mm.



FIGURES 4–9. Male palps (left). 4–7. *M. arietina*. 8–9. *M. macrophthalma*. 4, 6, 8. prolateral; 5, 7, 9. retrolateral. Scale line: 0.5 mm.

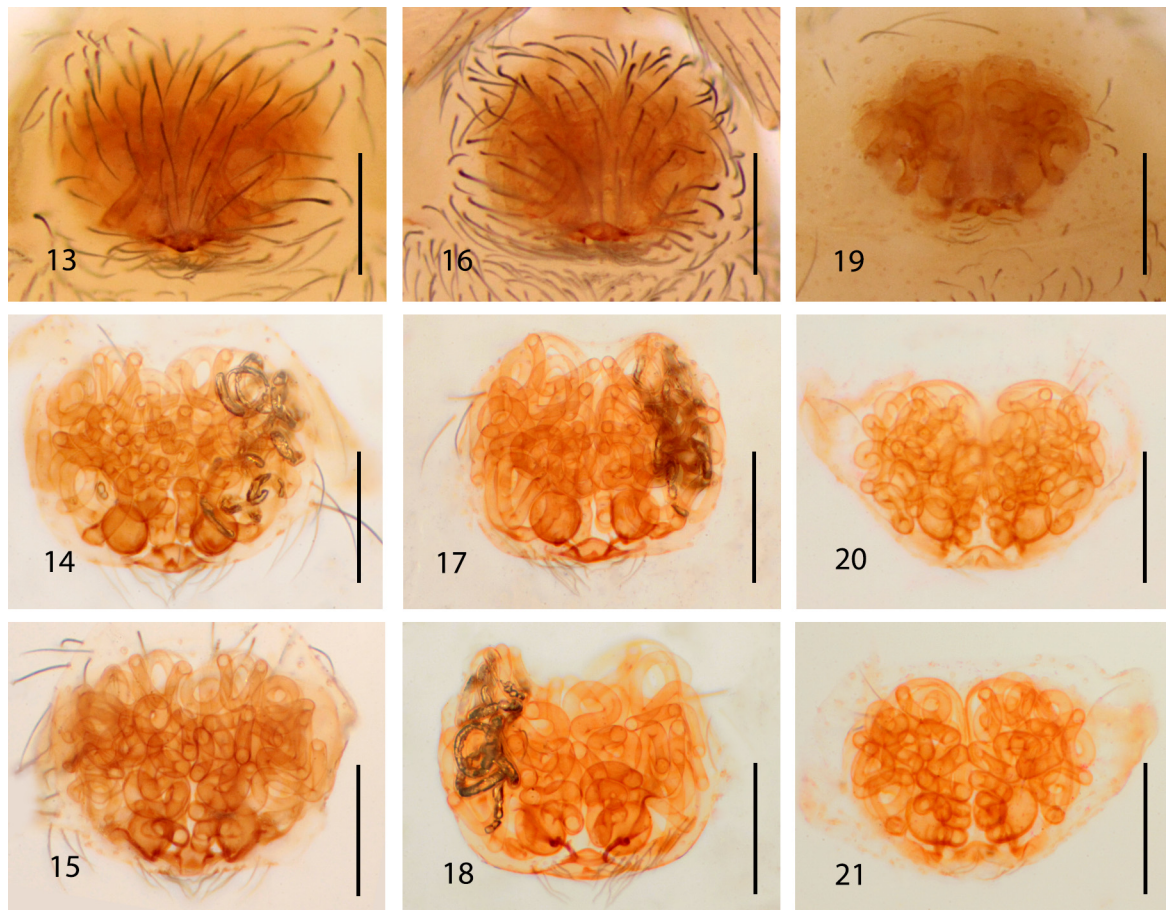


FIGURES 10–12. Habitus dorsal, females. 10–11. *M. arietina*. 12. *M. macrophthalma*. Scale line: 1 mm.

Diagnosis. Diameter of conductor of male palp above 1.5 mm; conductor diameter / cephalothorax length ratio >1 (see Castellucci *et al.* 2024), RTA with a hook-shaped tip and VTA long and thin (Figs 5, 7). Female vulva approximately 0.33 mm long, copulatory ducts with multiple dense coils and wide lumen (Figs 13, 16). Posterior eyes variable but small, usually separated by at least one eye diameter (Figs 1, 2, 10, 11).

Remarks. This species is currently known from several localities in Bulgaria, primarily located in the Western part of the country, with the exception of the somewhat different population from the Black Sea coast (Fig. 22). However, the territory of Bulgaria has not been completely sampled and further faunistic research is needed. The species is generally considered myrmecophilous but most individuals we collected were not found near ant nests, except specimen DD196 from the vicinity of Balsha, which was found in the nest of *Messor cf. structor*. The male from Knyazhevo was found under a stone, not near an ant nest. As the area has been searched by the first author multiple times over the years, this species may be generally subterranean and difficult to find, with only wandering males occasionally being found under stones. Nests of black-coloured *Lasius* sp (Formicidae: Formicinae) were found in the general area. It is also unclear whether the specimen from the Pirin Mts. was found in an ant nest, as the collector does not recall observing ants at the collection spot. Both male specimens were found in pine forests/ plantations. The specimen from the city of Sofia was walking on the outer wall of a building in broad daylight, so it was presumably disturbed and was not in its typical microhabitat. As the old and forest-covered park Borisova Gradina is in the immediate vicinity, it is likely a population exists there.

Although the individuals from Western Bulgaria fit into the clade containing the other European specimens in the tree, the ones from the Black Sea coast form a distinct subclade but are still within the *M. arietina* clade (DD193 + DD195; Fig. 23). The support for this subclade is very low. There are subtle differences in the male palp morphology, with a more curved VTA and a longer and slimmer CdP (Figs 6, 7), more similar to *M. diversa* (Figs 8, 9) than to the typical *M. arietina* (Figs 4, 5). No other differences were observed, neither in the shape of the RTA, nor in the female morphology or eye size (Figs. 10, 11, 13–18), between this population and the typical *M. arietina*. Given that Castellucci *et al.* (2024) did not split the genetically much more distinct populations from Georgia and Finland into separate species, we consider these differences a polymorphism until further material, ideally from a broader area is available.



FIGURES 13–21. Female genitalia. 13–18. *M. arietina*. 19–21. *M. macrophthalma*. 13, 16, 19 epigyna; 14, 17, 20 vulva ventral, 15, 18, 21 vulva dorsal. Scale line: 0.2 mm.

***Mastigusa macrophthalma* (Kulczyński, 1897)**

Figs 3, 8, 9, 12, 19–21, 22

?*Mastigusa macrophthalma*: Deltshv & Blagoev, 1992 [not examined]

Material examined. Bulgaria: 1♂, West Balkan Mts., near Druzhevo Vill. 43.13906, 23.38246, *Fagus* forest, 18 September 2022, leg. Simeon Indzhov (CSI); 1♂, 1♀ (pair, female DD198), 3♀♀, West Balkan Mts., Vrachanski Balkan, Borov Kamak 43.1654, 23.5040, *Fagus* forest, 24 September 2022, leg. Simeon Indzhov (NMNHS, CSI); 2♂♂, 1♀, West Balkan Mts., near Gara Lakatnik 43.08916, 23.38098, *Carpinus-Quercus* forest, 07 September 2023, leg. Simeon Indzhov (CSI); (<https://www.inaturalist.org/observations/185178787>).

Diagnosis. Diameter of conductor of male palp below 1.5 mm; conductor diameter / cephalothorax length ratio < 1 (see Castellucci *et al.* 2024), RTA with a blunt tip (Fig. 9). Female vulva approximately 0.27 mm long, copulatory ducts with less dense coils and narrower lumen than in *arietina* (Figs 20, 21). Posterior eyes variable but usually large separated by less than one eye diameter (Figs 3, 12)

Remarks. This species likely shows a contiguous distribution in Bulgaria across the karstic parts of the West Balkan Mt. (Fig. 22). There it lives on the forest floor of *Carpinus* and *Fagus* forests under stones and can be locally common. None of the specimens observed were found in ant nests.

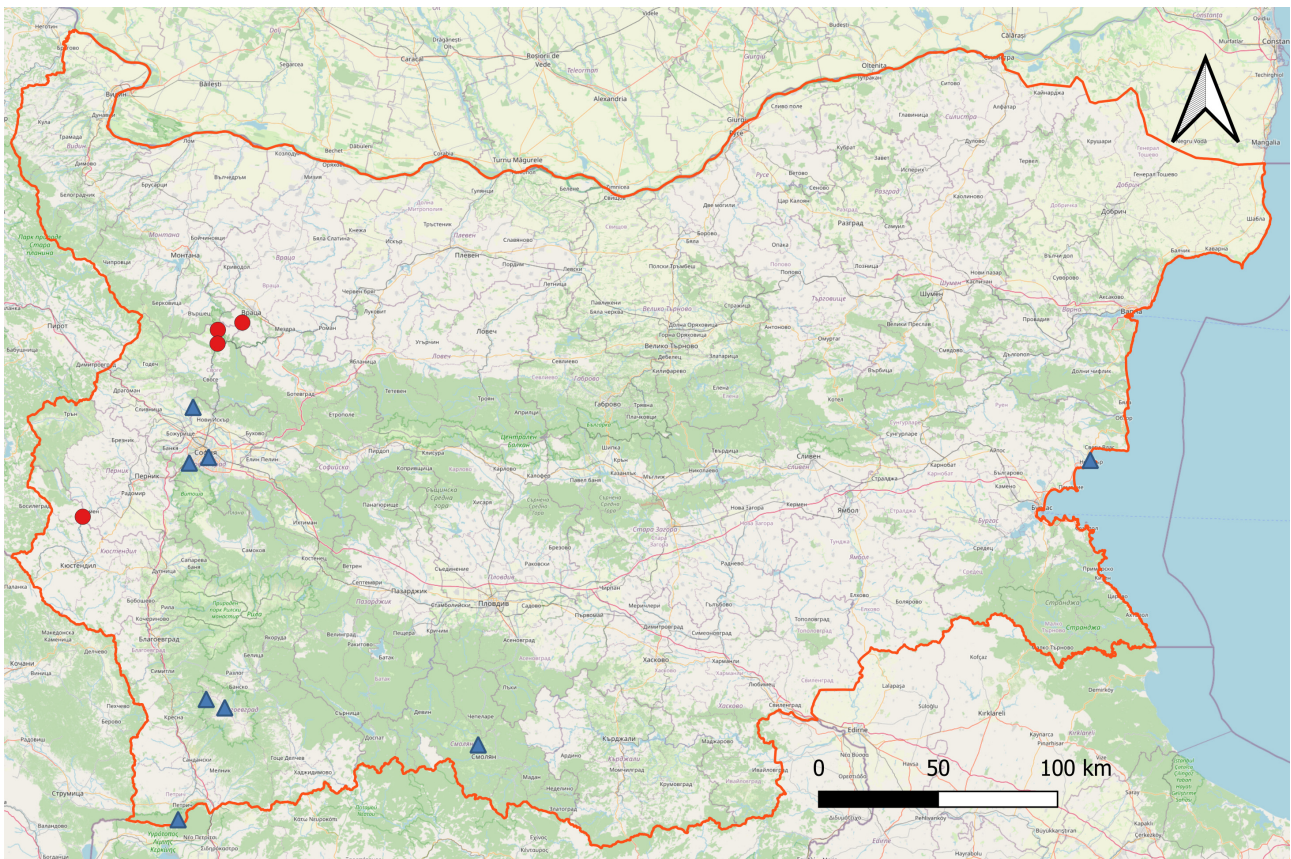


FIGURE 22. Distribution map of *M. arietina* (blue triangle) and *M. macrophthalma* (red circle).

Phylogenetic analysis

We have sequenced six specimens and combined the obtained information with sequences of selected specimens from GenBank. The final molecular data matrix includes 32 terminals, 6 genes, and 4344 base pairs. Both Maximum Likelihood and Bayesian Inference produced the same topology and have high similarity in the support values (Fig. 23). The two independent runs of Mr Bayes converged and were combined to produce the final tree after discarding 10% as burn-in. All parameters in the BI analysis reached an effective sampling size well above 200.

All specimens of *M. arietina*, *M. diversa*, and *M. macrophthalma* form well-supported clades. Three of the specimens included from the public databases (colored red) are placed in clades of species that do not correspond to their original taxonomic assignment (Fig. 23), suggesting that these specimens have been misidentified.

Discussion

In light of the presence of two species of *Mastigusa* in Bulgaria, the older records also required a reassessment. The authors could re-examine the specimen from the Pirin Mountains and the one from the Western Rhodopes Mountains, both female. Although no sequencing was attempted due to the material's age and conservation quality, the morphological evaluation strongly suggest these two individuals belong to *Mastigusa arietina* and not to *Mastigusa macrophthalma*, as initially published in Deltshev (1990), Deltshev & Blagoev (1997), and Deltshev *et al.* (2011). They have small PME separated by more than one diameter and sclerotized epigynes.

The reports from Deltshev & Blagoev (1992) from the Zemen Gorge, on the other hand, could refer to *M. macrophthalma* as the habitats in this area (*Carpinus* forests on limestone) are similar to those in the Iskar Gorge in the Balkan Mountains, where *Mastigusa macrophthalma* was found. This material could not be located in the NMNHS collection and was not reexamined. Until further material is available from the area of Zemen Gorge, this record will be considered as belonging to *M. macrophthalma*, albeit with uncertainty.

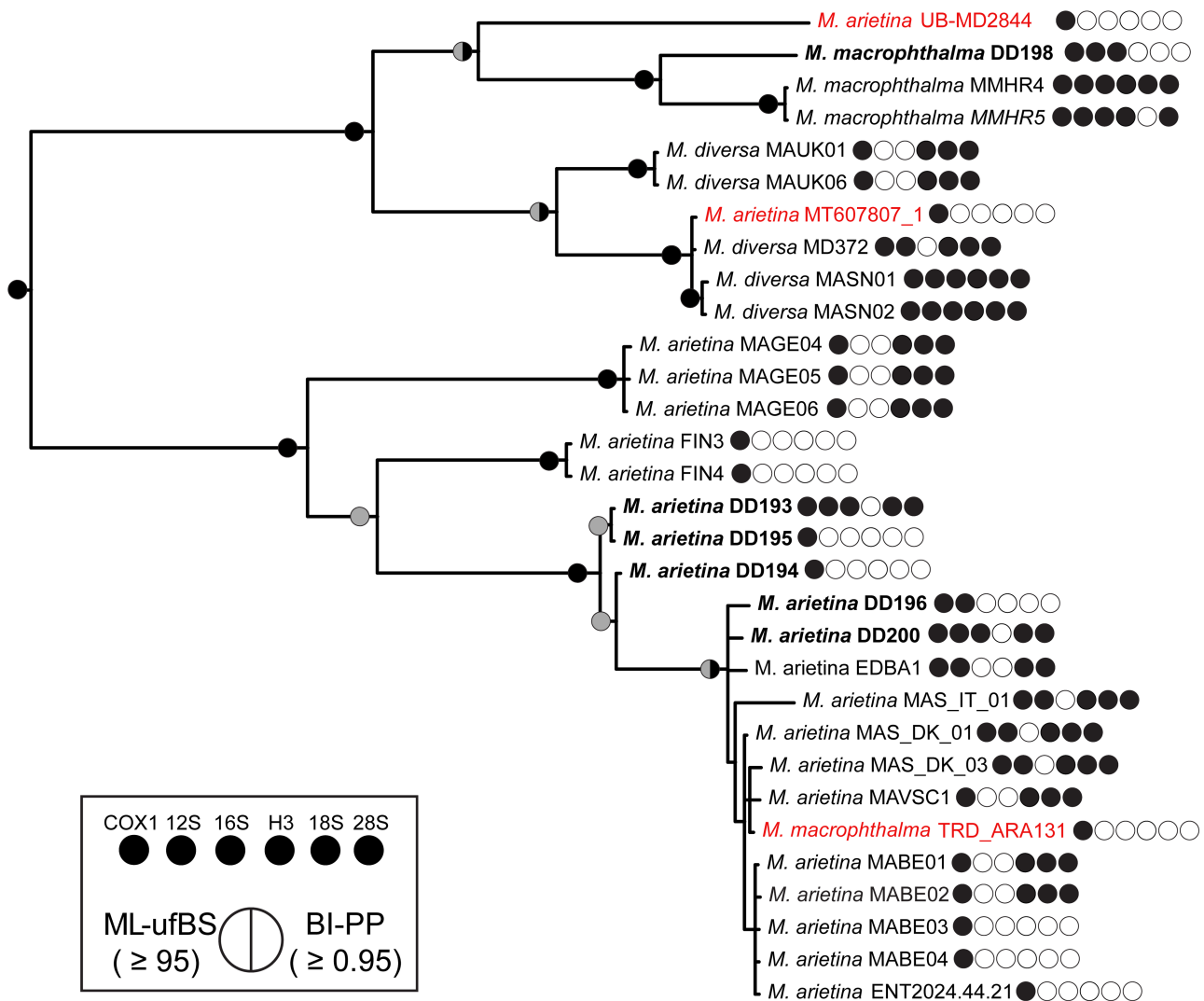


FIGURE 23. Consensus tree of the Bayesian inference of the concatenated molecular supermatrix. Dots next to the specimen's labels indicate whether the particular gene was sequenced for the specimen (black) or not (white). Gene order is shown in the legend. Pie charts on branches denote support for the specific clade as follows: left is maximum likelihood ultrafast bootstraps (ML-ufBS), right is posterior probability (BI-PP). Black indicates support ≥ 95 and ≥ 0.95 for ML-ufBS and BI-PP, respectively. Grey indicates clade recovered but below former threshold values. Specimens added in the present study are in bold. Misidentified specimens in GenBank are in red. The outgroup (*Cryphoea silvicola*) is removed from the tree.

Our phylogenetic analyses fully supported the morphological identification of the examined specimens and confirmed the presence of both *M. arietina* and *M. macrophthalma* in Bulgaria. Both ML and BI analyses also find that the populations of *M. arietina* from the Black Sea region and those from Western Bulgaria belong to different subclades, which is consistent with the morphological variation we observed among specimens from these populations. Our results also suggest that at least some of the older records of *Mastigusa* species and some of the sequences available in GenBank may be misidentified, as previously discussed by Castellucci *et al.* (2024).

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