



The first records of eleven species of the genus *Megaselia* Rondani, 1856 from Morocco (Diptera, Phoridae)

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Abstract. We provide new records of scuttle flies, family Phoridae (Diptera), from Morocco, which has been very little studied. Eleven phorid species belonging to the immense genus *Megaselia* Rondani, 1856 are newly reported from the country, increasing the number of known species in Morocco to 12, and the number of Phoridae to 14. Information on the distribution and ecology of each species is provided.

Key words. Megadiverse genus, new records, scuttle fly

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INTRODUCTION

The family Phoridae, or scuttle flies, is one of the most biologically diverse groups among the order Diptera, suborder Brachycera. Thus, it is the prime candidate for being the most abundant and diverse family of insects on the planet (Disney 1990, 1994).

The Phoridae currently includes 260 genera and more than 4000 described species (Ament and Brown 2016; Disney 2021), the majority of which belong to the genus *Megaselia* Rondani, 1856 and have a wide range of ecological lifestyles and morphological characteristics (Disney 1994). Compared to other families of Palaearctic dipterans, phorids are one of the least studied and most neglected families (Rabieh et al. 2013). So far, about 950 species of phorids are known in the Palaearctic, but this number may be much lower than the actual number (Pape et al. 2009). Phorid flies can be found in a variety of indoor and outdoor habitats, aquatic habitats, and microhabitats, including caves, crops, meadows and pastures, moorlands, forests, and woodlands (Disney 1994).

Phoridae represent a biologically diverse family, of ecological significance, which play an essential role in forensic entomological evidence frequently used to estimate the minimum time since the death of a murder victim (Disney 1994; Reibe and Madea 2010). Some species are important pollinators of plants, while others have proved useful as biological pest-control agents. Because of their diversity in most terrestrial habitats, combined with their biological diversity, phorids are an excellent family to employ in conservation strategies (Disney 1994; Morrison 2000).

Megaselia is a rich genus that represents the one of the most biologically diverse and taxonomically challenging genera in the entire animal kingdom (Marshall 2012); it has more than 1700 species worldwide (PCAT 2019), and it is the insect genus that displays a greater diversity of larval habits than any other. They feed on microorganisms in aquatic habitats, as well as on feces, carrion (including human corpses), fungi, and green plants; they are also predators, kleptoparasites, parasitoids, and parasites (Disney 1994; Lee et al. 2001; Mathis and Phillipott 2012). *Megaselia* species have also been proposed as bioindicators in disturbed tropical forests (Idris and Saiap 2002). The role of *Megaselia* flies as natural enemies of hymenopterans has long been underestimated, and only associations with wasps and burrowing bees have been demonstrated (Disney et al. 2000; Polidori et al. 2001). Furthermore, *Megaselia* species have also proved to be of great medical and forensic importance (Disney 2008).

Despite of their great diversity and ecological importance, very little had been published on the Phoridae of Morocco compared to other Diptera families (Kettani et al. 2022), probably because of their small size and the difficulties with their identification. So far, only three species have been recorded in Morocco by foreign researchers, and these records are very old (Kettani et al. 2022). The first contribution to the fauna of Moroccan Phoridae was made by Meigen (1830), who listed one species, *Diplonevra crassicornis*.



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Eighteen years later, Zetterstedt (1848) reported *Megaselia minor*, and then Becker and Stein (1914) added *Diplonevra tangeriana*. Since then, there has been no additional study of this family of insects in Morocco.

Recent fieldwork in several areas from Morocco has uncovered many species not previously known (Kettani et al. 2022). Here, we aim to fill the gap in our knowledge of the phorid fauna, and particularly the genus *Megaselia*, of Morocco. We present new records of Phoridae from Morocco and increase the number of known species.

METHODS

The materials were collected between 2010 and 2021, from January to October. The specimens were collected using entomological sweep nets (SN) and Malaise traps (MT), then transferred to bottles using aspirators. Identification of the collected materials, previously preserved in alcohol, was based on slide-mounted specimens according to the methods of Disney (1994, 2001). Morphological terminology follows that of Disney (1994).

Entomological field surveys carried out to collect samples covered a wide variety of habitats belonging mainly to the region of the Rif mountains in northern Morocco. The surveys comprised 42 sites (Figure 1) at altitudes of 3–1696 m. Figure 1 was produced using ArcGis v. 10.7. The locations, habitat types, and geographic coordinates of the sites are summarised in Table 1.

We collected 306 specimens of Phoridae in our field sampling. The materials examined are deposited in the Museum of Zoology in Cambridge (UCMZ).

RESULTS

Examination of the 306 specimens led to the identification of 11 species of *Megaselia* genus.

Family Phoridae Curtis, 1833

Genus *Megaselia* Rondani, 1856

Megaselia albicaudata (Wood, 1910)

Material examined. MOROCCO – RIF • Jbel Bouhachem, Lemtahane, Dar Abdesalam; 35°16'13.3"N, 005°26'05.0"W; 966 m a.s.l.; 7.V–30.V.2017; K. Kettani leg.; Malaise trap; 1♂, UCMZ 053.

Distribution. Newly recorded from Morocco. China, Denmark, England, Finland, France, Hungary, Italy, Iran, Ireland, Israel, Norway, Poland, Portugal, Russia (west of the Urals), Scotland, Spain, Sweden, Wales, Yemen.

Ecology. Adults have been reported visiting flowers of *Tamarix canariensis* Wil. (Tamaricaceae) in the

Figure 1. Location of the studied sites in Morocco.

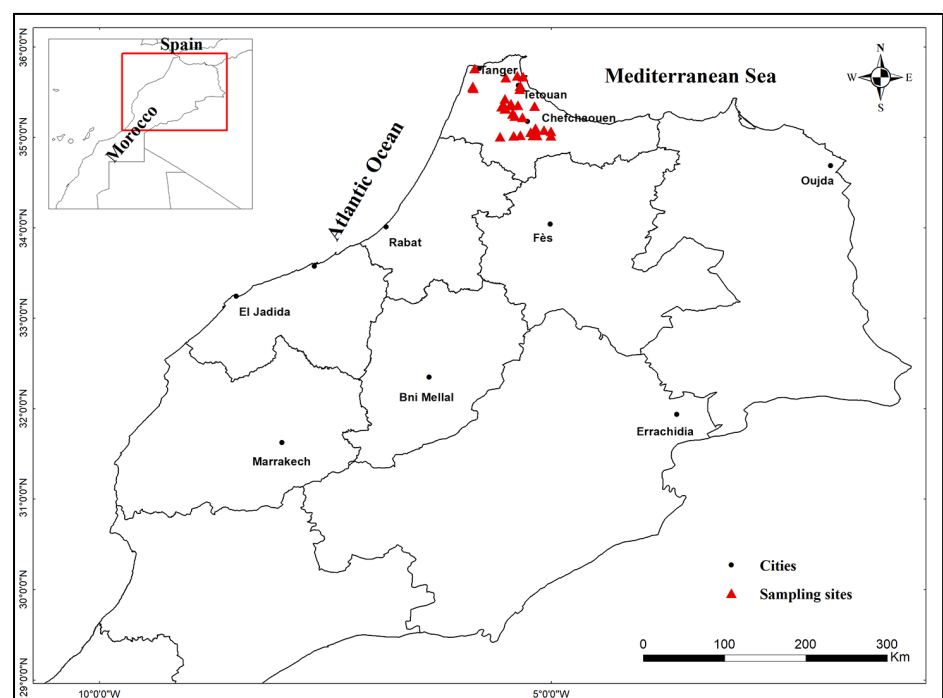


Table 1. Sampling sites in this study, with habitat, elevation, and geographic coordinates included.

Province, locality, collecting site	Geographic coordinates	Altitude (m)	Habitat
Al Hoceima, Issaguen, Maison forestière	34°54'49.22"N, 004°34'35.53"W	1543	Cedar forest
Chefchaouen, Afertane, Oued Afertane	35°20'56"N, 005°11'18"W	50	Riverbank
Chefchaouen, Ametrasse, Oued Ametrasse	35°05'01"N, 005°05'03"W	841	Riverbank
Chefchaouen, Azilane, Tissemlal	35°11'39.2"N, 005°12'42.9"W	1050	Mixed forest
Chefchaouen, Beni Salah, Anassar	35°16.60"N, 005°00'35.16"W	1440	Pond
Chefchaouen, Beni Salah, Bab Tariouant	35°01'7.68"N, 005°0'36.00"W	1429	Tauzin oak forest
Chefchaouen, Beni Selmane, Zawya	35°04'07.29"N, 005°00'27.65"W	1076	Meadow
Chefchaouen, Beni Zid, Ikadjouen	35°3'34.86"N, 005°13'59.25"W	704	Meadow adjacent to the stream
Chefchaouen, Bni Hassane, Triwa	35°16'50.7"N, 005°22'01.6"W	654	Meadow
Chefchaouen, Bni Salah, Merj Sidi Lhaj	35°00'40.54"N, 005°34'19.20"W	858	Swamp
Chefchaouen, Coatina, Kharouba	35°21'29.32"N, 005°22'21.54"W	530	Meadow
Chefchaouen, Fifi, Bni Barou	35°01'29.0"N, 005°12'25.0"W	1205	Cork oak forest
Chefchaouen, Fifi, Bouzate	35°01'35.25"N, 005°20'55.93"W	1265	Mixed forest
Chefchaouen, Forêt Bab Hammou, Dayat Bayn Widyane	35°1'27.71"N, 005°09'44.13"W	700	Mixed forest
Chefchaouen, Stehat, Beach Stehat	35°20'37.15"N, 005°57'02.00"W	4	Beach
Chefchaouen, Talassemrane, Maison forestière	35°21'23"N, 005°26'55"W	1696	Fir forest
Chefchaouen, Talassemrane, Maounzel	35°04'23"N, 005°11'04"W	1000	Mixed forest
Chefchaouen, Taria, Beni Faghloom	34°55'54.3"N, 005°06'55.5"W	894	Cork oak forest
Chefchaouen, Tissouka, Mechkralla	35°8'08.00"N, 005°13'39.00"W	981	Pine forest
Chefchaouen, Zaouiet El Habtiyien, Maggou	35°06'09.72"N, 005°10'44.34"W	932	Riverbank
Larache, Beni Arouss, Riba	35°13'32.30"N, 005°19'24.35"W	1421	Mixed forest
Larache, Beni Arouss, Tazia	35°20'33"N, 005°33'12"W	733	Cork oak forest
Larache, Beni Arouss, Zaouiet My Abdelsalam	35°19'02"N, 005°30'25"W	1283	Mixed forest
Larache, Beni Leit, Remla	35°14'12"N, 005°24'28"W	958	Pine forest
Larache, Douar El Hamma, Masjid El Hamma	35°23'05"N, 005°30'46"W	338	Mixed forest
Larache, Laghdir, Oued Koub	35°01'17.88"N, 005°25'19.98"W	149	Riverbank
Larache, My Abdelsalam, Ain Kchour	35°19'04"N, 005°31'10"W	1157	Cork oak forest
Larache, Taghzout, Adrou	35°13'32.30"N, 005°19'24.35"W	556	Mixed forest
Larache, Taghzout, Amghart	35°21'32.0"N, 005°28'59.6"W	424	Mixed forest
Larache, Taghzout, Centre forestier PNPB	35°15'04.5"N, 005°25'23.1"W	987	Mixed forest
Larache, Taida, Oued Andalous	35°21'12"N, 005°31'57"W	501	Riverbank
Tanger, Hjar Nhal, Ain Jdioui	35°34'4.44"N, 005°55'29.94"W	55	Pond
Tanger, Rmilet, Perdicaris	35°47'26.68"N, 005°51'12.94"W	223	Urban park
Tanger, Tahaddart, Tahaddart estuary	35°34'32.9"N, 005°59'15.9"W	4	Estuary
Tétouan, Beni Leit, Lemtahane (Dar Abdelslam)	35°16'13.3"N, 005°26'05.0"W	966	Pine forest
Tétouan, Beni Leit, Oued Tkaraa	35°16'03.78"N, 005°25'49.74"W	959	Riverbank
Tétouan, Jbel Bouhachem, Amsemlil	35°15'36.84"N, 005°25'56.58"W	1059	Peat bog
Tétouan, Khemis Anjra, Oued Khemis	35°39'51.00"N, 005°30'29.00"W	61	Riverbank
Tétouan, M'hannech, Oued M'hannech	35°34'07"N, 005°20'58"W	3	Riverbank
Tétouan, M'Diq, Barrage Smir	35°41'6.49"N, 005°22'50.88"W	27	Riparian zone at the dam
Tétouan, M'Diq, Koudiat Taifour	35°40'28.71"N, 005°19'1.84"W	100	Pine forest
Tétouan, Touta, Oued Touta	35°34'20"N, 005°20'49"W	3	Riverbank

Canary Islands and *Aristolochia paucineris* Po. (Disney et al. 2010). In Morocco, we captured *M. albicaudata* in a meadow covered with Asteraceae and Poaceae and dotted with fruit trees growing on siliceous soil in a forest.

***Megaselia berndseni* (Schmitz, 1919)**

Material examined. MOROCCO – RIF • My Abdesalam, Tazroute, Adrou; 35°13'32.30"N, 005°19'24.35"W; 556 m a.s.l.; 8.I.2020; K. Kettani leg.; sweep net; 1 ♂, UCMZ 038.

Distribution. Newly recorded from Morocco. Afrotropical, Oriental, Palearctic, and Nearctic regions. Austria, Belgium, Bulgaria, Canary Islands, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Poland, Portugal, Russia (west of the Urals), Spain, Sweden, Switzerland, Turkey.

Ecology. This species has been reared from the sporophores of a greater range of fungi than any other species; an example includes *Agaricus bitorquis* (Quél.) Sacc. (Ševčík 2001, 2004, 2010; Disney and Ševčík 2008, 2009). Adults have been recorded visiting flowers of *Conium maculatum* L. (Apiaceae), *Tamarix canariensis* W. (Tamaricaceae), and *Saxifraga diapensoides* Bell. var. *lutea* (Saxifragaceae) (Parmenter 1965; Disney 1994).

We found this species in a mixed forest composed of *Quercus ilex* L., *Quercus suber* L. (Fagaceae), *Pinus pinaster* Aiton. (Pinaceae) with an undergrowth dotted by *Cistus* spp. (Cistaceae) and *Pistacia lentiscus* L. (Anacardiaceae).

***Megaselia clemonsi* (Disney, 1984)**

Material examined. MOROCCO – RIF • Jbel Bouhachem, Beni Arouss, Riba; 35°13'32.30"N, 005°19'24.35"W; 1421 m a.s.l.; 29.IV–22.V.2019; K. Kettani leg.; sweep net; 1 ♂, UCMZ 054.

Distribution. Newly recorded from Morocco. Croatia, Denmark, England, France, Germany, Isle of Man, Israel. Portugal, Scotland, Spain, Sweden.

Ecology. In the literature, adults were reported visiting flowers of *Crataegus monogyna* Jacq. (Rosaceae) (Disney 1994). In Morocco, we captured *M. clemonsi* in a mixed forest with diverse tree species, including *Quercus faginea* Lam., *Q. suber*, and *Pinus pinsaster* ssp. *maghrebiana*, as well as *Pistacia lentiscus* shrubs.

***Megaselia halterata* (Wood, 1910)**

Material examined. MOROCCO – RIF • Oued Laou, Oued Afertane; 35°20'56"N, 005°11'18"W; 150 m a.s.l.; 5.I.2013; K. Kettani leg.; sweep net; 1 ♂, UCMZ 057.

Distribution. Newly recorded from Morocco. Algeria, Arabia, Australia, Austria, Azores, Belgium, Czech Republic, Denmark, England, Finland, France, Germany, Greece, Hungary, Isle of Man, Israel, Ireland, Italy, New Zealand, Poland, Portugal, Russia (west of the Urals), Spain, Sweden, Turkey.

Ecology. This is an infamous pest of cultivated *Agaricus* mushrooms. The larvae primarily exploit the mycelium of *Agaricus bisporus* (J.E.Lange), *A. bitorquis* (Quél.), and *A. campestris* L. (Disney 1994; Ertler and Polat 2008; Sahin et al. 2008).

We found this species in Morocco in the riparian zone of a wide pondweed river bordered by *Tamarix* sp., *Nerium oleander* L., and *Tetraclinis articulata* (Vahl) Mast.

***Megaselia hibernans* (Schmitz, 1934)**

Material examined. MOROCCO – RIF • Jbel Bouhachem, Lemtahane, Dar Abdesalam; 35°16'13.3"N, 005°26'05.0"W; 966 m a.s.l.; 7V–30.V.2017; K. Kettani leg.; Malaise trap; 1 ♂, UCMZ 053.

Distribution. Denmark, England, Finland, France, the Netherlands, Poland, Scotland, Sweden. **Newly recorded from Morocco.**

Ecology. Schmitz (1934) reported *M. hibernans* overwintering in rabbit burrows. We captured this species in the same locality as *M. albicaudata*.

***Megaselia involuta* (Wood, 1910)**

Material examined. MOROCCO – RIF • Chefchaouen, Fifi, Bni Barou; 35°01'29.0"N, 005°12'25.0"W; 1205 m a.s.l.; 16.V–17.VI.2014; K. Kettani leg.; Malaise trap; 1 ♂, UCMZ 032.

Distribution. Newly recorded from Morocco. Austria, Belgium, Czech Republic, Denmark, England, Finland, France, Germany, Greece, Hungary, Italy, the Netherlands, Poland, Portugal, Russia (west of the Urals), Spain (including Majorca), Sweden, Switzerland, the former Yugoslavia.

Ecology. This species has been reared from a rothole in *Salix alba* L. (Disney and Withers 2011). Adults have been recorded visiting flowers of *Heracleum sphondylium* L. (Apiaceae) and *Crataegus monogyna* Jacq. (Rosaceae) (Disney 1994). In this study, we collected *M. involuta* in a *Fagus* L. sp. (Fagaceae) in a forest dominated by siliceous soil covered by a dense herbaceous cover.

***Megaselia lata* (Wood, 1910)**

Material examined. MOROCCO – RIF • Jbel Bouhachem, Beni Arouss, Riba; 35°13'32.30"N, 005°19'24.35"W; 1421 m a.s.l.; 29.IV–22.V.2019; K. Kettani leg.; Malaise trap; 1 ♂, UCMZ 054.

Distribution. Newly recorded from Morocco. Austria, British Isles, Czech Republic, Denmark, Finland, France, Germany, Hungary, Madeira, Majorca, Norway, Poland, Portugal, Russia (west of the Urals), Spain, Sweden, Switzerland.

Ecology. Adults have been reared from the sporophores of fungi belonging to the families Agaricaceae, Amanitaceae, Boletaceae, Cortinariaceae, and Russulaceae (Ševčík 2001, 2004, 2006), as well as Suillaceae (Disney 1994). We found *M. lata* in the same locality as *M. clemensi*.

***Megaselia nigra* (Meigen, 1830)**

Material examined. MOROCCO – RIF • Chefchaouen, Beni Selmane, Zawya; 35°04'07.29"N, 005°00'27.65"W; 1076 m a.s.l.; 17. VI.2018; F.Z. Sliman leg.; sweep net; 1 ♂, UCMZ 010.

Distribution. Newly recorded from Morocco. Austria, British Isles, Bulgaria, Canary Islands, China, Czech Republic, Denmark, Faroe Islands, Finland, France, Germany, Hungary, Israel, Malta, the Netherlands, Norway, Poland, Portugal (including the Azores and Madeira), Russia (west of the Urals), Spain, Sweden; also in the Nearctic.

Ecology. Larvae feed on the gill and cap tissues of the developing sporophores of Agaricaceae, Bolbitaceae, Boletaceae (Ševčík 2001, 2004), Coprinaceae, Coriolaceae, Cortinariaceae, Exidiaceae, Morchellaceae, and Tricholomataceae (Disney and Evans 1999). This species has also been reared from a dead *Cochlodina laminata* Mon. (Montagu, 1803) snail (Evans and Disney unpublished data). In Morocco, we captured *M. nigra* near a marabout surrounded by a mixed forest dominated by *Quercus suber* and *Pinus* sp.

***Megaselia rufipes* (Meigen, 1804)**

Material examined. MOROCCO – RIF • Bouhachem, Lemtahane, Dar Abdesalam; 35°16'13.3"N, 005°26'05.0"W; 966 m a.s.l.; 7V–30.V.2017; K. Kettani leg.; Malaise trap; 1 ♂, CUMZ 053.

Distribution. Newly recorded from Morocco. This species is native to the Palaearctic Region, but it has been carried around the world by humankind. Nearctic populations have *COI* barcodes that have diverged from those of Europe (Boehme et al. 2010). Austria, Belgium, British Isles, Bulgaria, Czech Republic, Denmark, Fair Isle, Faroe Islands, Finland, France, Germany, Gough Island, Hungary, Iran, Italy, Malta, the Netherlands, Norway, Poland, Portugal, Russia (west of the Urals), Spain, Scotland (St. Kilda), Sweden, Switzerland, the former Yugoslavia; in every biogeographic region except the Orient and Antarctic.

Ecology. The larvae feed on rotting plants, ripe and rotting sporophores of *Agaricus campestris* L., *Lactarius deliciosus* L., *Phallus impudicus* L., *Bolbitis vitellinus* (Pers.), and *Meripilus giganteus* (Pers.) (Ševčík 2010), and vertebrate frass, dead insects, and vertebrate carrion, including human corpses. Disney (2005) presented data on the duration of larval development under naturally fluctuating temperature regimes. Larvae have been repeatedly observed feeding on detritus in the nests of honey bees (Disney 1994) and as facultative parasitoids (Dutto and Ferrazzi 2014; Vercelli et al. 2019). Facultative parasitism of beetles and cases of myiasis in humans have also been recorded. Adult flies have been reported on a human corpse (Lutz et al. 2021). In addition, adult flies have been observed visiting flowers of the families Apiaceae, Aristolochiaceae, Liliaceae, and Oxalidaceae (Parmenter 1965). Adults were observed in caves in Spain (Disney and Pérez 2014) and Hungary (Disney et al. 2014).

We captured this species in the same Moroccan locality as *M. albicaudata*

***Megaselia scalaris* (Loew, 1866)**

Material examined. MOROCCO – RIF • M'Diq, Koudiat Taifour; 35°40'28.71"N, 005°19'01.84"W; 150 m a.s.l.; 31.V–14.VI.2018; K. Alcadouri leg.; Malaise trap; 1 ♂, UCMZ 009.

Distribution. Newly recorded from Morocco. Afrotropical, Nearctic, Neotropical, Oriental, and Palearctic; Antarctica, Ascension Island, Arabia, Austria, Belgium, Cape Verde Islands, China, Cyprus, Denmark, England, France, Galapagos Islands, Germany, Hawaii, Hungary, Iran, Israel, Italy, Japan, Malta, Ireland, Scotland, Poland, Spain (including the Canary Islands), Sweden, Turkey, Thailand.

Ecology. The larvae are the ultimate polyphagous saprophages, feeding on human corpses and fungi, and facultatively parasitic on aquatic invertebrates and vertebrates (Disney 2008). Sardar et al. (2021) reviewed a wide range of resources exploited by the larvae. *Megaselia scalaris* was found to be the dominant species in rat carcasses during the dry-remains stage in a suburban habitat in Bengal (Bhattacharjee et al. 2021). Charabidze and Martin-Vega (2021) recorded it in pug carcasses, and Sharif and Qamar (2021)

documented it in goat carcasses. This species has been recorded as a facultative parasitoid of the desert scorpion *Mesobuthus eupeus mongolicus* (Zhang et al. 2017) and of the crop pest *Eurygaster integriceps* Puton in Iran (Ebrahimi et al. 2023). Adults reported visiting the flowers of *Aristolochia microstoma* Boiss. & Spruner (Rupp et al. 2021).

Ahmad et al. (2019) analysed the nutritional value of larvae, pupae, and adults for nest swiftlets (*Aerodramus*). Anthony et al. (2020) provide data on wing-shape variation.

We captured *M. scalaris* in a *Pinus halepensis* Mill. and *P. pinaster* forest with an understory of a wide variety of shrubby plants, including *Pistacia lentiscus*, *Tetraclinis articulata*, *Erica arborea* L., *Cistus* spp., and *Chamaerops humilis* L.

***Megaselia sylvatica* (Wood, 1910)**

Material examined. MOROCCO – RIF • Tetouan, Oued Touta; 35°34'20"N, 005°20'49"W; 3 m a.s.l.; 26.X.2010; K. Kettani leg.; sweep net; 1 ♂, UCMZ 015.

Distribution. Newly recorded from Morocco. Austria, Balearic Islands, British Isles, Bulgaria, Denmark, Finland, France, Germany, Hungary, the Netherlands, Poland, Portugal, Russia (west of the Urals), Spain, Sweden, Switzerland.

Ecology. It has been reared from the sporophores of many fungi, including *Pleurotus* sp., *Pluteus cervinus* (Schaeff.), *P. podospileus* Sacc. & Cub., *P. Umbrosus* (Pers.), and *P. hispidulus* (Fr.) Gillet (Ševčík 2010).

We captured this species in the riparian zone of the Oued Touta, which is bordered by *Nerium oleander* (Apocynaceae) and runs alongside the city of Tétouan.

Additional taxa

Furthermore, 45 undescribed species of *Megaselia* were also found as part of this study and will be described as a second contribution to the study of Moroccan *Megaselia* within a molecular study.

ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

No ethical statement is reported.

Funding

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Author contributions

Conceptualization: FZS, KK. Data curation: FZS. Funding acquisition: FZS. Investigation: FZS, DRHL. Methodology: FZS. Resources: FZS, KK. Supervision: KK. Visualization: KK. Validation: DRHL. Writing – original draft: FZS. Writing – review and editing: FZS, KK, DRHL.

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Data availability

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

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