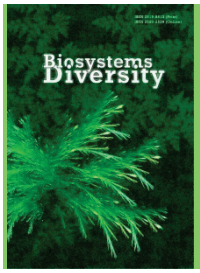

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Distribution of black fungus gnats (Diptera, Sciaridae) in Morocco, with an updated list of species and an emphasis on Moroccan crop pest species

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The present work deals with the spatial distribution of the sciarid species (black fungus gnats) recorded from Morocco throughout the major biogeographical regions: Rif, Eastern Morocco, Atlantic Plain, Middle Atlas, High Atlas, and Anti-Atlas, providing for the first time an atlas of the distribution of Moroccan sciarid fauna. The analysis of the species distribution showed differences between the regions, revealing that the High Atlas and the Rif hosted the greatest specific richness. Of the surveyed sites, forests, crop fields, and aquatic habitats seem to be the most favourable for supporting many sciarid species. Ecological preferences for each species are discussed, indicating a clear preference for medium altitudes ranging from 500 to 1000 m. Alongside the study on the distribution of species, a review of the species recorded in Morocco and gathered from the literature has enabled us to update the checklist of sciarid species, which comprises 65 so far in Morocco. Particular emphasis focused on black fungus gnats considered potentially harmful, with the aim of assessing their distribution in the country, has revealed that *Bradysia transitata*, *B. trivittata*, *B. xenoreflexa*, *Lycoriella sativae*, *Scatopsciara subarmata* were collected from strawberry greenhouses (Rosaceae: strawberries), *Bradysia placida*, *B. santorina*, *B. scabricornis*, *B. tilicola*, *B. trivittata* and *Camptochaeta jeskei* were collected from fruit trees (Rosaceae: almond trees), *Bradysia santorina*, *Corynoptera saccata* and *C. semipedestris* were found on palms (Arecaceae: date palms), *Scatopsciara atomaria* and *S. curvilinea* were captured in crop fields (Poaceae, Fabaceae), *Bradysia scabricornis*, *Bradysiopsis vittata* were collected from Liliaceae, *Scatopsciara atomaria* was also found on Asteraceae and Solanaceae, and *Corynoptera praeparvula* was exclusively reported from Solanaceae.

Keywords: Sciaroidea; biodiversity; ecology; species spreading; Africa.

Introduction

Each animal or plant species is determined as much by its morphological and physiological peculiarities as by its distribution on the surface of the earth, therefore the conservation of Key Areas for biodiversity and associated species is a planetary issue that necessarily requires a good knowledge of the distribution of fauna and flora and knowledge of their ecological requirements. Knowledge of the distribution of species in an area and its distinct ecological requirements represents one of the main elements to ensure and guide good conservation planning, considering that nowadays natural ecosystems are subject to many problems that endanger the survival of several species.

The Sciaridae Billberg, 1820 or black fungus gnats are a family of lower Diptera, which are a globally species-rich group of inconspicuous, dark-coloured nematocerans, most only 2–3 mm long. They are easily recognizable as specimens, due to their simple but characteristic wing venation (Mohrig et al., 2012). They play an important role in natural ecosystems (Menzel & Mohrig, 2000; Menzel & Schulz, 2007; Menzel et al., 2020) where larvae are involved in the decomposition of forest litter (Hövemeyer, 1989; Deleporte & Rouland, 1991; Deleporte & Charrier, 1996; Menzel et al. 2020) whereas adults are implicated in the transmission of fungal basidiospores (Schmidt, 1979; Menzel et al., 2020) and in plant pollination (Vogel & Martens, 2000; Rulik et al., 2008; Menzel et al., 2020). However, these small insects are not always beneficial for some ecosystems, because they are the most common greenhouse pests in the order Diptera, damaging edible mushrooms and vegetables. Sciarid larvae that damage edible mushrooms mainly belong to *Lycoriella* Frey, 1942 and *Bradysia* Winnertz, 1867 genera (White et al., 2000). Sciarids are also well-known as common inhabitants of potted plants in homes (Broadley et al., 2018). Several studies have been carried out on Sciaridae pest species, such as *Lycoriella pleuroti* Yang and Zhang, 1987, one of the main species infecting edible mushrooms. Adults of this species crawl, mate, and lay eggs in culture compost and sporocarps, while the larvae move into the nearest substrates and sporocarps, then feed on mushroom mycelium directly where the young mushrooms break through (Ye et al., 2017).

In severe cases, the commercial value of mushrooms can be completely lost due to the impact of pest species (Ye et al., 2017) such as in the case of *Bradysia odoriphaga* which was first identified and described by (Yang & Zhang, 1985) because of the severe damage it causes to the Chinese vegetable crop "Garlic chives", which wither and die. Its larvae also feed on green onions, garlic, cucumbers, lettuces, and Chinese cabbages in Northern China, as well as Sichuan, Hubei, Zhejiang, and Jiangsu (Mei et al., 2003). Larvae that feed on bulbs, roots, and young stems can decrease crop yields by 30–80% (Gao et al., 2016; Ye et al., 2017). *Bradysia difformis* Frey, 1948 [= *B. impatiens* (Johannsen, 1912)] is a common greenhouse crop pest that causes serious economic losses worldwide (White et al., 2000; Hurley et al., 2007; Santos et al., 2012). In China, it is a common indoor species that emerges from flowerpots and causes serious agricultural damage to ornamental plants and mushroom houses (Ye et al., 2017).

In the Holarctic region, eight sciarid species are common pests, feeding on living plants and fungi in nurseries, greenhouses, mushroom farms, and homes with plant pots (Broadley et al., 2018). These are *Bradysia impatiens* (Johannsen, 1912), *B. ocellaris* (Comstock, 1882), *B. tilicola* (Loew, 1850), *Cosmosciara hartii* (Johannsen, 1912), *Lycoriella agraria* (Felt, 1897), *L. ingenua* (Dufour, 1839), *L. sativae* (Johannsen, 1912), and *Pnyxia scabiei* (Hopkins, 1895). In the Nearctic Region, about 10 species of Sciaridae (*Bradysia impatiens*, *B. ocellaris*, *B. pallipes* (Fabricius, 1787), *B. tilicola*, *Lycoriella agraria*, *L. ingenua*, *L. sativae*, *Pnyxia scabiei*, *Sciara fulviventris* Wiedemann, 1821 [= *Odontosciara* (*Odontosciara*) *nigra* (Wiedemann, 1821)], *Sciara nigra* Wiedemann,

1821 [= *Odontosciara* (*Odontosciara*) *nigra* (Wiedemann, 1821)]) are known to be major economic pests (Mohrig et al., 2012), due to their predominantly phytosaprophagous larvae that feed on living plants, damaging roots and sometimes stems and leaves of cultivated plants and cuttings (Hungerford, 1916; Hussey et al., 1968; Mead, 1978; Han et al., 2015; Broadley et al., 2018). In the Australasian realm, Loudon (1978) described *Lycoriella agarici* Loudon, 1978 [= *L. sativae* (Johannsen, 1912)] as the major pest of protected mushroom cultivation, and noted an additional two mushroom pest species, *Lycoriella agraria*, and *L. multiseta* (Felt, 1897) [= *L. agraria* (Felt, 1897),]. Furthermore, Clift (1979) reported *Lycoriella solani* (Winnertz, 1871) [= *L. ingenua* (Dufour, 1839)] from a mushroom farm.

Bradysia impatiens was recorded in Australia for the first time by Greenslade & Clift (2004) as *B. difformis* from a mushroom farm and pot plant. *Bradysia ocellaris* first appeared in a checklist of insects from a glasshouse (Greenslade & Clift, 2004), and was subsequently recorded in Queensland (Menzel et al., 2003). According to Shamshad (2010), *Bradysia ocellaris* and *Lycoriella ingenua* are the major mushroom pests in Australia. In 2012, Mohrig et al. have added through their study one plant and mushroom pest species, *Lycoriella sativae*. In 2018, Broadley et al. have added two new pest species, *Bradysia impatiens* and *Cosmosciara hartii*, also two species, *Sciara jeanneli* Séguy 1940 and *S. solispina* Hardy 1956, they added as synonyms to *L. sativae*.

In South Africa, only one study has been carried out and revealed the presence of *B. impatiens* in greenhouses of cucumbers, *Cucumis sativus* and tomatoes, blueberries, and various other cuttings, *Lycoriella sativae* and *L. ingenua* in mushrooms (Katumanyane et al., 2019).

In the Western Palaearctic Region, only eight species are known to be common and widespread pests that feed on living plants in greenhouses and in houses (potted plants), or on cultivated mushrooms (Broadley et al., 2018). These species belong to three genera: *Bradysia* (*B. cellarum*, *B. nomica* Mohrig & Röschmann, 1996, *B. procera* Winnertz, 1868), *Lycoriella* (*L. sativae*), and *Pnyxia* (*P. scabiei*). Some of these pest species attack mushrooms (*Lycorie sativae*) in Russia (Gerbatchevskaya, 1963), onions (*Bradysia cellarum*) in China (Ye et al., 2017), ginseng (*Bradysia procera*) in South Korea (Shin et al., 2008), and there is another crop pest (*Bradysia nomica*) in Spain (Rodríguez-Rodríguez et al., 2005).

In Morocco, no similar study dealing with the pest aspects of these black flies has been undertaken so far, nor elsewhere in North Africa. Furthermore, no study has been carried out to date on the distribution of these flies either. In this regard, we are interested in this work in studying the distribution and the pest aspect of the Moroccan sciarid fauna.

The main objective of this atlas is to present the geographical distribution of sciarid species present in Morocco, including those suspected of being pest species, in order to provide a reference knowledge database on this fauna, for planning and management conservation, and to fight against pests if necessary.

Material and methods

Study area. The work covered the main biogeographical areas of Morocco represented by the four main mountain ranges (Rif, Middle Atlas, High Atlas, and Anti-Atlas), the Atlantic plains and Eastern Morocco which are the result of the geological history of Morocco due to its geographical position. The country has a remarkable variety of bioclimates, ranging from humid in the Rif and the Middle and High Atlas to very arid in the Sahara in the south and to the sub-humid and semi-arid in plains and foothills, which accounts for the country's faunal and floristic diversity of exceptional heritage value.

The Moroccan Rif, extending from the Strait of Gibraltar to the Moulouya Valley, has a complex geological past (Tawadros, 2012; Ivanovic et al., 2013), which led to the formation of a chain of mountains whose relief is very rugged, with very steep slopes and very deep wadis and valleys. Its latitudinal situation, its geology, its orography, and its exposure to humid maritime influences represent the main factors of its natural originality (Benabid, 1982).

The Oriental Region occupies the entire eastern end of the country and covers an area of 90 127 km^2. This region is home to the most important Maghreb river, which is the Moulouya, which extends over a length of 520 km, and flows into the Mediterranean Sea. This region covers all six Mediterranean bioclimatic stages defined in the synthetic classification of Emberger, which encourages the formation of natural vegetation made up of various biological types from forest groups to formations degraded steppes (e.g. *Noaea mucronate* (Forsk.) Ascherson & Schweinf.), through matorrals (e.g. *Quercus ilex* L. & *Tetraclinis articulata* (Vahl) Mast.; *Quercus ilex*, *Arbutus unedo* L. & *Pistacia terebinthus* L; *Juniperus oxycedrus* L., *Phillyrea angustifolia* L., *Cistus villosus* L., *Genista* sp.; *Tetraclinis articulata*, *Cistus libanotis* L., *Pistacia lentiscus* L. & *Fumana thymifolia* (L.) Spach ex Webb and tree steppes (e.g. *Tipa tenacissima* L., *Rosmarinus officinalis* L., *Olea europea* L., *Juniperus oxycedrus*, *Chamærops humilis* L. & *Cistus villosus* L.) (Acherkouk et al., 2010).

The Atlantic plain is a vast territory characterized by a slightly uneven relief which varies between 1 m and 700 m in altitude. In terms of bioclimatic variation according to Emberger, this plain presents a semi-arid bioclimate in the south to sub-humid in the north. This area has a very important ecosystem richness characterized by the presence of a vast cork oak forest (*Quercus suber* L.) the Mâamora forest (Fennane & Ibn Tattou, 1981) in the northern part, and steppes and matorral of *Chamaerops humilis* L. in the southern part. The Sebou basin (36 000 km²), which constitutes an important hydrographic network for this region, is made up of low plateaus, rivers, a few hills and fertile plains that allow agriculture.

The Middle Atlas is a mountainous massif in the centre of the country stretching over 350 km, from the southwest to the northeast of Morocco, and essentially consisting of medium altitude plateaus rising gradually towards the northeast to culminate at 3340 m at Jbel Bou Naceur. This region is known for a high rainfall and therefore it is covered with forests of cedars, holm oaks and pines.

The High Atlas, 740 km long, begins as small hills at the edge of the Atlantic towards the eastern plateaus, then rapidly rises to more than 2000 m and reaches 4,165 m at Mount Toubkal, the culminating point of Morocco and in all Saharan North Africa. The northern slope is relatively humid, and largely covered with holm oak forests. It is snow-covered in winter from 1200 m. The aridity of the southern slope allows only steppe vegetation of mugwort and esparto.

The Anti-Atlas is the southernmost section of the backbone of the Atlas Mountains in North Africa. It is a chain that extends from the Atlantic towards Goulmime, to Jbel Sargho in the North-East. This area is quite different from the rest of Morocco by its landscapes with a Saharan character, its discontinuous vegetation, the scarcity, or absence of running water, then in the far south the real desert.

Plant communities are mainly composed by wooded steppes with *Acacia raddiana* [= *Vachellia tortilis* subsp. *raddiana* (Savi) Kyal. & Boatwr.], *Artemisia herba-alba* Asso and *Stipa tenuissima* Trin., interspersed with thuriferous juniper (*Juniperus thurifera* L.) at the top of the slopes (Piqué, 1994). The vegetation is also represented by two formations that partially interpenetrate each other: groves of the Argan tree (*Argania spinosa* (L.) Skeels) and the *Euphorbia* steppe (*Euphorbia echinus* Hook.f. & Coss.).

Origin of the material. The species involved in this work were gathered from the Moroccan literature on Sciaridae, mainly from the latest works dealing with this family of Diptera by El Ouazzani et al. (2019) and Kettani et al. (2022), which update the inventory of Sciaridae recorded to date in Morocco. All 65 sciarid species recorded so far in Morocco are considered in this study. For each species, a map is provided with observations on its distribution and ecological preferences.

Realization of geographic distribution maps. All species locations were checked and corrected using Google Maps integrated in QGIS v3.4.2. to properly map their spatial distribution across Morocco via the GIS (Geographical Information System) platform. The Digital Elevation Model, 3 arc second SRTM (Shuttle Radar Topography Mission) and the 90 m spatial resolution (available in www.earthexplorer.usgs.gov) were used in the background to show the distribution of the Moroccan relief relative to the locations of each species.

Abbreviations. SBEIBS: Site of Biological and Ecological Interest of Beni Snassen; NPHAO: National Park of High Atlas Oriental; PNPB: Project of Natural Park of Bouhachem; NPTS: National Park of Talassemtane; NPTB: National Park of Toubkal.

Results

***Bradysia* Winnertz, 1867**

Bradysia alpicola (Winnertz, 1867)

Distribution in Morocco: Middle Atlas (Ouiouane Lake) (Fig. 1).

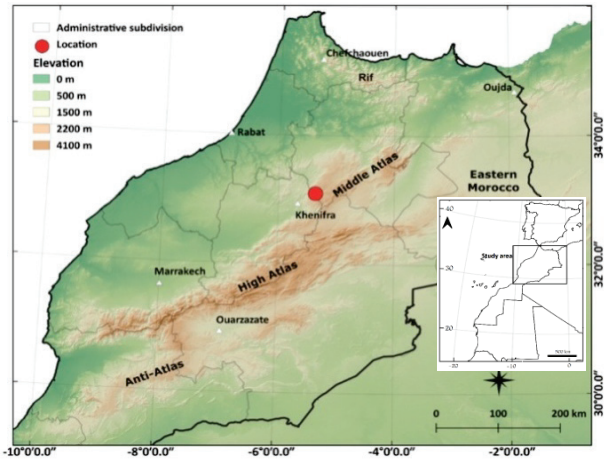

Fig. 1. Geographical distribution of *Bradysia alpicola*

Distribution outside Morocco: Common in Europe.

Ecology: this species was collected at a high altitude (1914 m) from the riparian banks of a lake surrounded by *Quercus ilex*.

Bradysia bulbigera Mohrig & Kauschke, 1994

Distribution: Rif (Oued Ouara (NPTS), Oued Ametrasse, Merzouk Bni Salah, Dayat Bayn widane); High Atlas (Ouirgane (NPTB)) (Fig. 2).

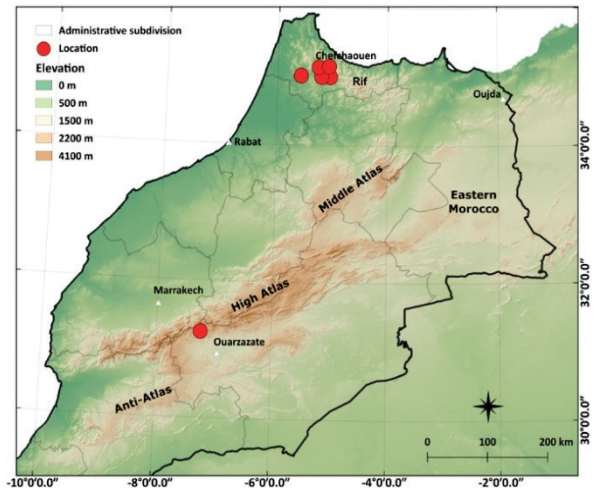

Fig. 2. Geographical distribution of *Bradysia bulbigera*

Distribution outside Morocco: Europe (Italy, Malta, Spain).

Ecology: this species has been captured over a wide altitude ranging from 429 to 1593 m, in several places on the banks of wetlands surrounded by dense vegetation, in a mixed forest with high floristic diversity with herbaceous, shrub and tree cover, and also in a thuriferous forest at high altitude.

Bradysia cavernicola Mohrig & Eckert, 1999

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 3).

Distribution outside Morocco: Germany.

Ecology: this species was found in a single site in a thuriferous forest in Ouirgane at an altitude of 1593 m.

Bradysia cinerascens (Grzegorzek, 1884)

Distribution: Rif (Issaguen, Anissar); Middle Atlas (Mont Habri, Fig. 4).

Distribution outside Morocco: common in Europe.

Ecology: this species has shown a clear preference for high altitudes (up to 2092 m) covered by cedar and holm oak forest.

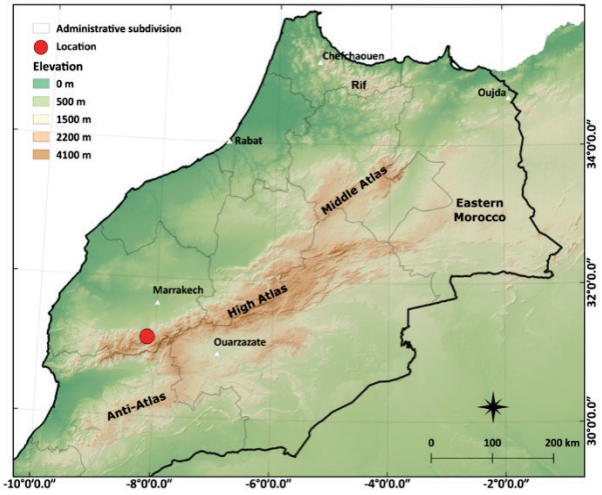

Fig. 3. Geographical distribution of *Bradysia cavernicola*

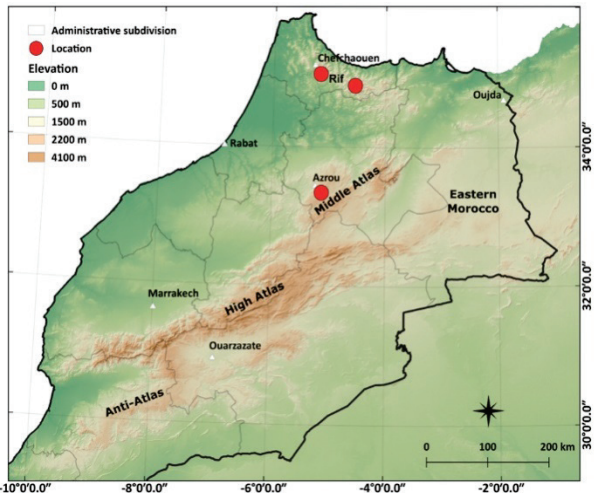

Fig. 4. Geographical distribution of *Bradysia cinerascens*

Bradysia crinita Mohrig & Hövemeyer, 1992

Distribution: Rif (Issaguen, Douar Hamma) (Fig. 5).

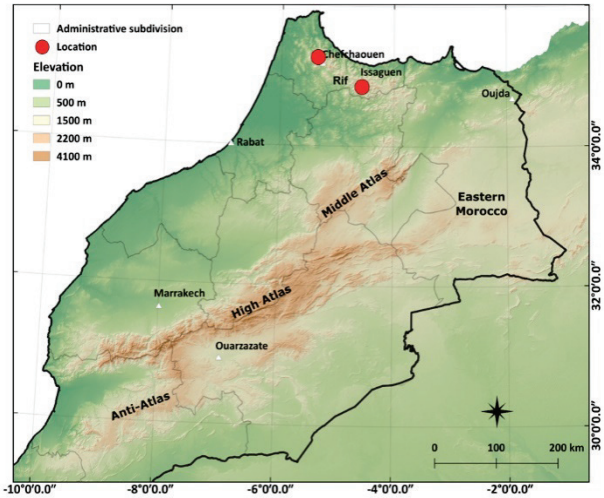

Fig. 5. Geographical distribution of *Bradysia crinita*

Distribution outside Morocco: common in Europe.

Ecology: this species has been found at a medium altitude (200 m) in a cork oak forest as well as at high altitude (1543 m) in a cedar forest.

Distribution: Rif (Perdicaris park (Rmilat)) (Fig. 6).

Distribution outside Morocco: Holarctic Region.

Ecology: This species was captured in a single locality in a mid-altitude urban forest (237 m) in Tangier, characterized by high floristic diversity with herbaceous, shrub and tree formations dominated by *Pinus pinaster* Aiton and *Pinus halepensis*.

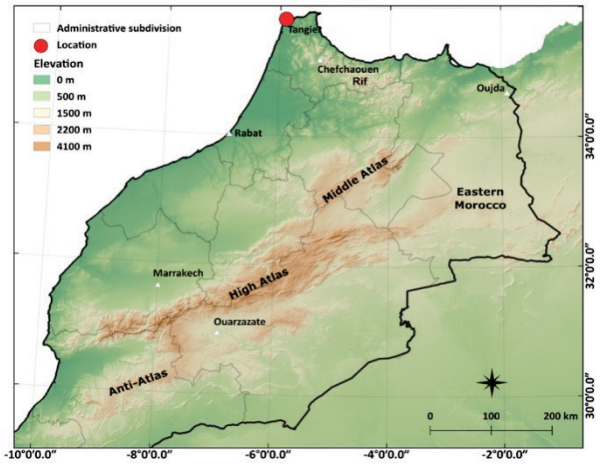

Fig. 6. Geographical distribution of *Bradysia fenestralis*

Bradysia flavipila Tuomikoski, 1960
Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 7).

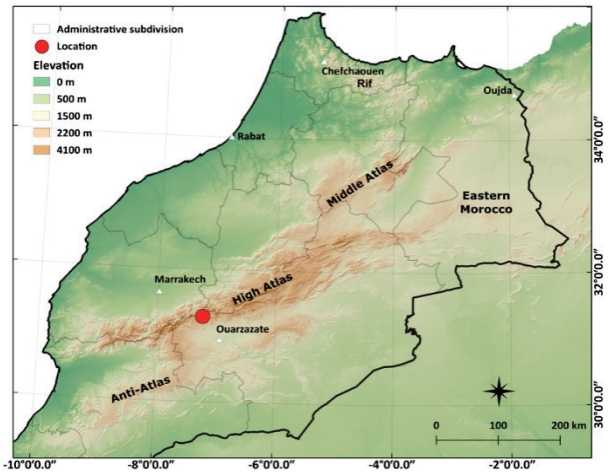

Fig. 7. Geographical distribution of *Bradysia flavipila*

Distribution outside Morocco: Common in Europe.
Ecology: This species was found at a single site in a thuriferous forest in Ouirgane at an altitude of 1593 m.
Bradysia iberiana Rudzinski & Baumjohann, 2009
Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 8).

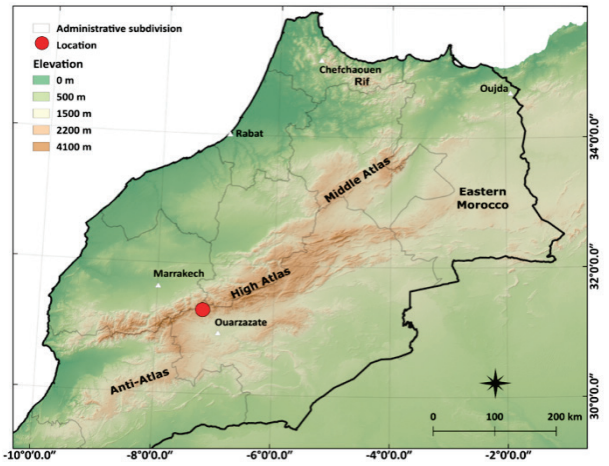

Fig. 8. Geographical distribution of *Bradysia iberiana*

Distribution outside Morocco: Mediterranean (Spain).
Ecology: this species was found at a single site in a thuriferous forest in Ouirgane at an altitude of 1593 m.
Bradysia lucichaeta Mohrig & Krivosheina, 1989
Distribution: Anti-Atlas (Sidi Rbat) (Fig. 9).

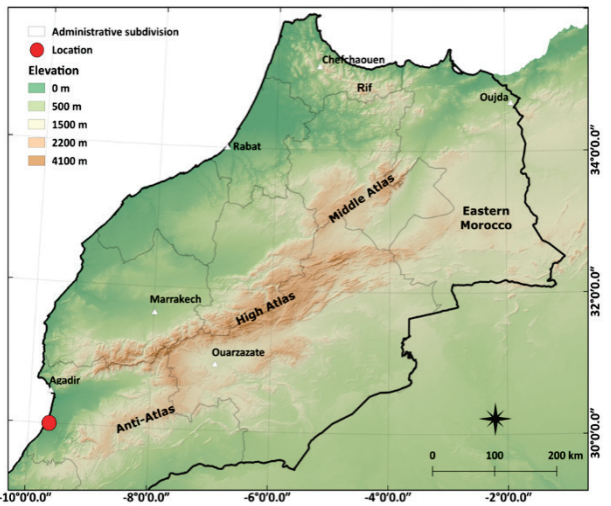

Fig. 9. Geographical distribution of *Bradysia lucichaeta*

Distribution outside Morocco: Albania, Egypt, Germany, and Great Britain.
Ecology: This species was found in one locality in the southern part of the Atlantic plain in Sidi Rbat at 232 m on a riverside with halophytes such as *Tamarix* sp., *Juncus* sp. and *Euphorbia* sp.
Bradysia lucida Mohrig & Mamaev, 1989
Distribution: High Atlas (Gerifoden (NPTB), Setti Fatma (NPTB)) (Fig. 10).

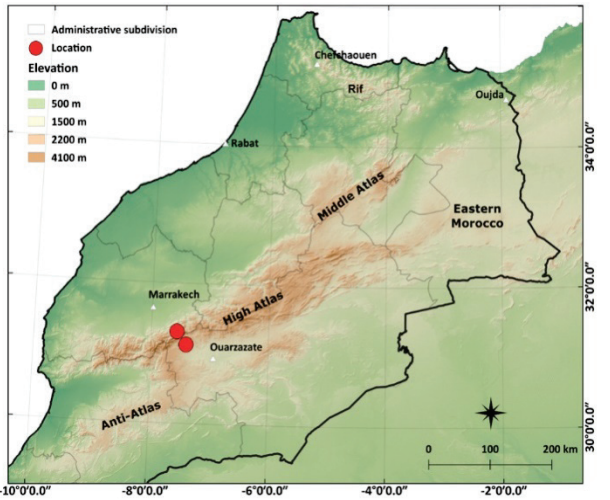

Fig. 10. Geographical distribution of *Bradysia lucida*

Distribution outside Morocco: Europe (Czech Republic, Denmark, Germany, Greece, Italy, United Kingdom); Asia (Turkmenistan), Middle East (United Arab Emirates).
Ecology: This species has been found at high altitude (1470 m) from the riparian vegetation of Oued Setti Fatma at Jbel Toubkal and from a crop field.
Bradysia mediterranea Mohrig & Menzel, 1992
Distribution: High Atlas (Ouirgane (NPTB)); Anti-Atlas (Sidi Rbat) (Fig. 11).
Distribution outside Morocco: Europe (Spain and Italy).
Ecology: this species was found in a thuriferous forest in Ouirgane at an altitude of 1593 m, and in the southern part of the Atlantic plain at Sidi Rbat at 232 m on a riverside with halophytes such as *Tamarix* sp., *Juncus* sp. and *Euphorbia* sp.

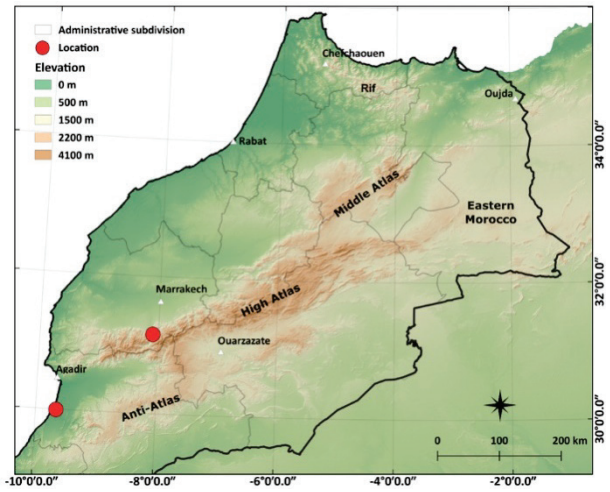

Fig. 11. Geographical distribution of *Bradysia mediterranea*

Bradysia nitidicollis (Meigen, 1818)

Distribution: Rif (Jbel Zemzem, Oued Tkarâa (PNPB), Ben Karrich, Dayat Tazia, Perdicaris Park, Amsemlil Bog (PNPB), Oued Zaouya) (Fig. 12).

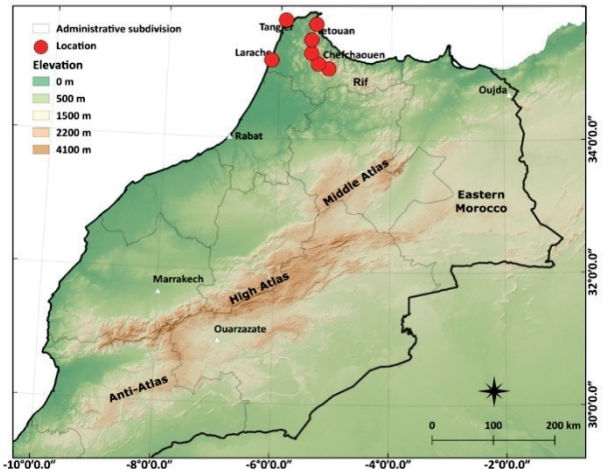

Fig. 12. Geographical distribution of *Bradysia nitidicolis*

Distribution outside Morocco: Common in Europe.

Ecology: This species seems to colonize many kinds of terrestrial habitats such as mixed forests and urban parks as well as borders of wetlands like bogs, ponds, and rivers with a wide range of altitude (40–1067 m).

Bradysia pectoralis (Staeger, 1840)

Distribution: Middle Atlas (Ouiouane Lake); High Atlas (Ouirgane (NPTB)) (Fig. 13).

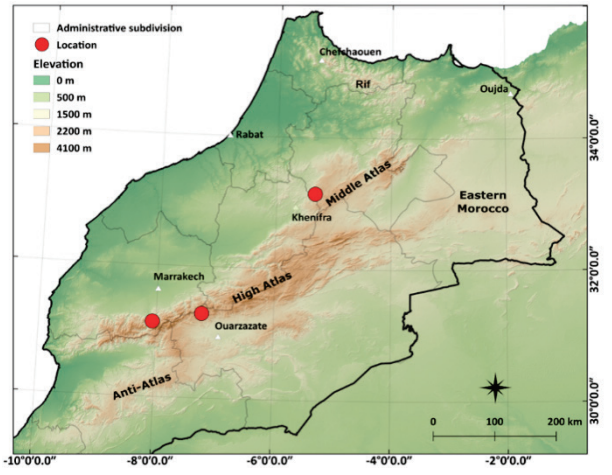

Fig. 13. Geographical distribution of *Bradysia pectoralis*

Distribution outside Morocco: Europe.

Ecology: This species was collected from the riparian banks of a high-altitude lake (1914 m) surrounded by *Quercus ilex*. It was also found in a thuriferous forest at Ouirgane (1593 m).

Bradysia placida (Winnertz, 1867)

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 14).

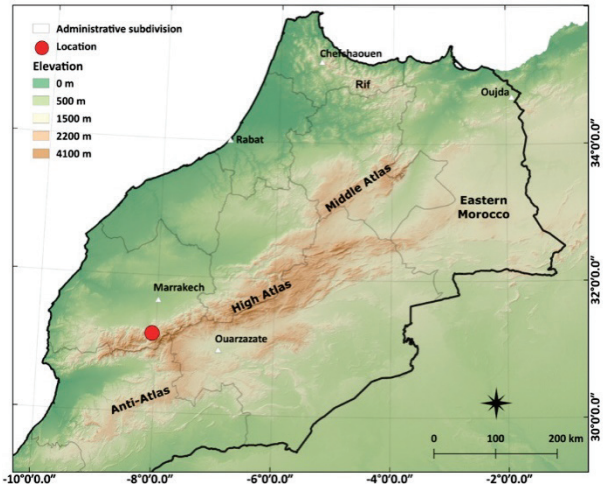

Fig. 14. Geographical distribution of *Bradysia placida*

Distribution outside Morocco: Holarctic Region.

Ecology: this species was collected once from almond trees in Ouirgane (1593 m).

Bradysia promissa Mohrig & Röschmann, 1999

Distribution: Rif (Beni Barou, Anissar, Oued Tkarâa ((PNPB), Taida, Marabout Moulay Abdelsalam, Oued Bayine, Tourbière Amsemlil (PNPB)) (Fig. 15).

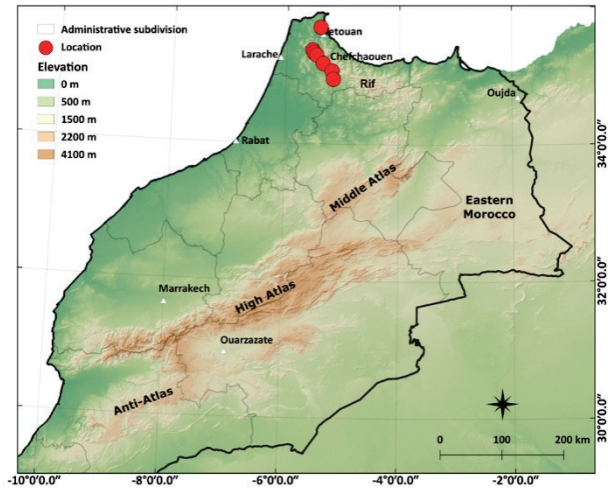

Fig. 15. Geographical distribution of *Bradysia promissa*

Distribution outside Morocco: Europe (Albania, France [Corsica only], Greece, Spain).

Ecology: This species was mainly captured in forest habitat in medium to high altitudes (590–1543 m) in the Project of Natural Park of Bouhachem which is characterized by siliceous substratum and a wide diversity of oak trees (*Quercus suber*, *Quercus canariensis* Willd. and *Quercus ilex*). It was also collected at low altitude (53 m) at the riparian banks of a small stream (Oued Bayine) composed of *Neriem oleander* L.

Bradysia reflexa Tuomikoski, 1960

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 16).

Distribution outside Morocco: Europe.

Ecology: This species was collected in a single location, in a thuriferous forest in Ouirgane at an altitude of 1593 m.

Bradysia ruginosa Mohrig, 1994

Distribution: Rif (Jbel Lakrâa (NPTS), Ain El Fakir); High Atlas (Amizmiz (NPTB), Aïn Azerou) (Fig. 17).

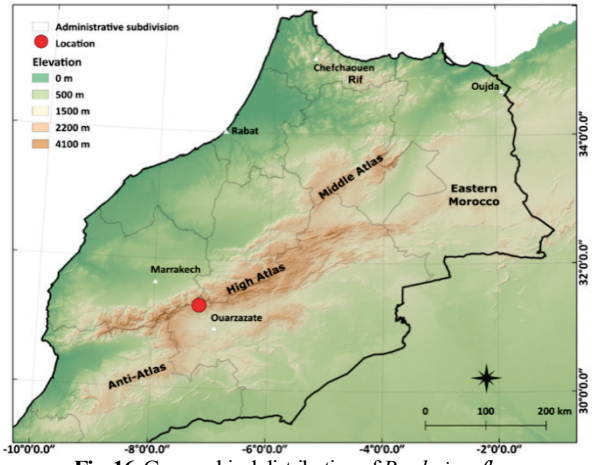

Fig. 16. Geographical distribution of *Bradysia reflexa*

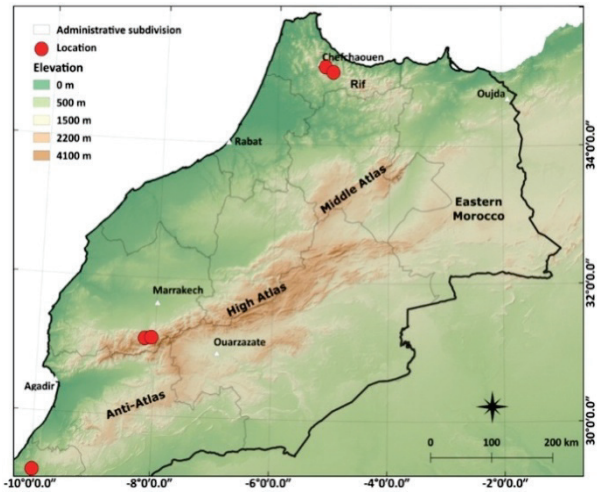

Fig. 17. Geographical distribution of *Bradysia ruginosa*

Distribution outside Morocco: Europe (Greece, Italy, Spain).

Ecology: This species seems to prefer elevated altitudes (989–1200 m) and colonizes a variety of habitats such as forests, riparian vegetation of springs, and agriculture fields.

Bradysia santorina Mohrig & Menzel, 1992

Distribution: High Atlas (Anezal (Ouarzazate)); Anti-Atlas (Guelmim) (Fig. 18).

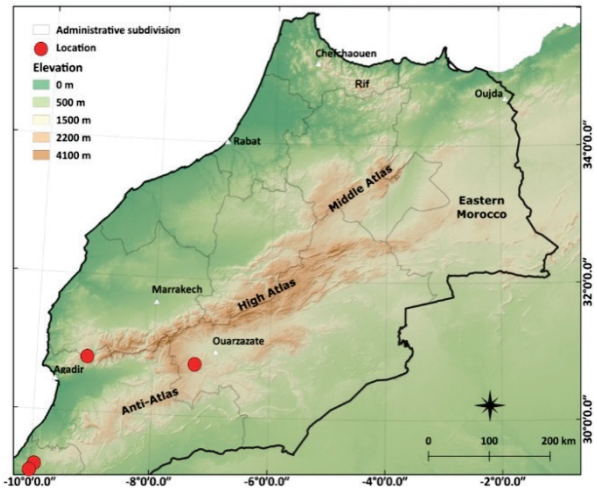

Fig. 18. Geographical distribution of *Bradysia santorina*

Distribution outside Morocco: Europe.

Ecology: it seems that this species is a colonizer of the date palm trees because it was found in two different localities in southern Morocco on date palms, namely in Guelmim (456 m) under-desert climate, and Ouarzazate (2106 m) in an arid climate.

Bradysia scabricornis Tuomikoski, 1960

Distribution: Rif (Oued Ouara (NPTS), Oued Azla, Douar Hamma, Oued Maggou (NPTS); High Atlas (Ouirgane (NPTB), Setti Fatma (NPTB), Oued Imlil) (Fig. 19).

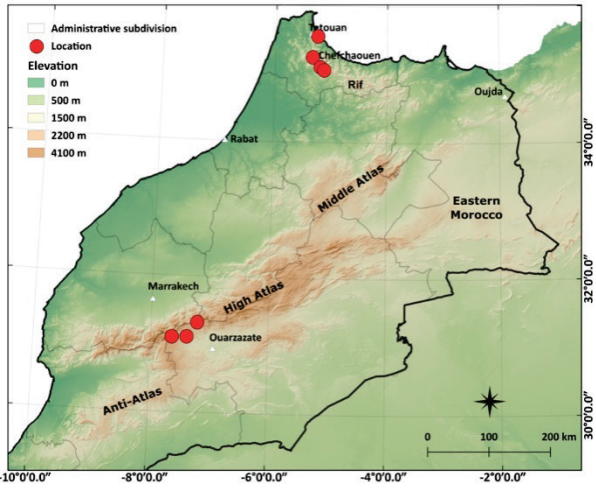

Fig. 19. Geographical distribution of *Bradysia scabricornis*

Distribution outside Morocco: Holarctic Region.

Ecology: this species has shown a clear preference for wetlands, where it has been collected in the riparian vegetation of many rivers and streams over a wide altitude range (2–1370 m), and from almond trees.

Bradysia subrufescens Mohrig & Krivosheina, 1989

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 20).

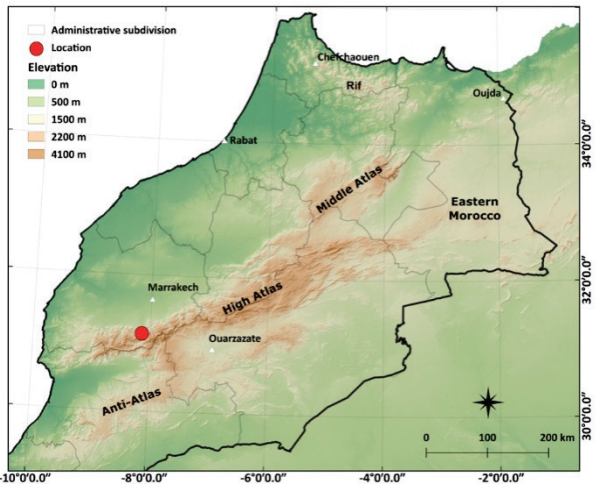

Fig. 20. Geographical distribution of *Bradysia subrufescens*

Distribution outside Morocco: Europe.

Ecology: this species was collected in a thuriferous forest in Ouirgane at an altitude of 1593 m.

Bradysia subsantorina Mohrig & Kauschke, 1997

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 21).

Distribution outside Morocco: Canary Islands.

Ecology: this species was collected in a thuriferous forest in Ouirgane at an altitude of 1593 m.

Bradysia tilicola (Loew, 1850)

Distribution: Rif (Douar Tissouka, Oued Touta); Middle Atlas (Ouiouane Lake); High Atlas (Ouirgane (NPTB)) (Fig. 22).

Distribution outside Morocco: Cosmopolitan.

Ecology: This species is widely spread in Morocco where it has been found in the Rif and in the Atlas domain. In the Rif, it has been collected in a pine forest (*Pinus halepensis*) at high altitude (1530 m) as well as on the riparian banks of the River Touta which crossies the city of Tétouan. In the Atlas domain, it was collected at the shore of Ouiouane Lake

(1914 m) whose margins are covered by *Quercus ilex*, and from almond trees in Ouirgane (1593 m).

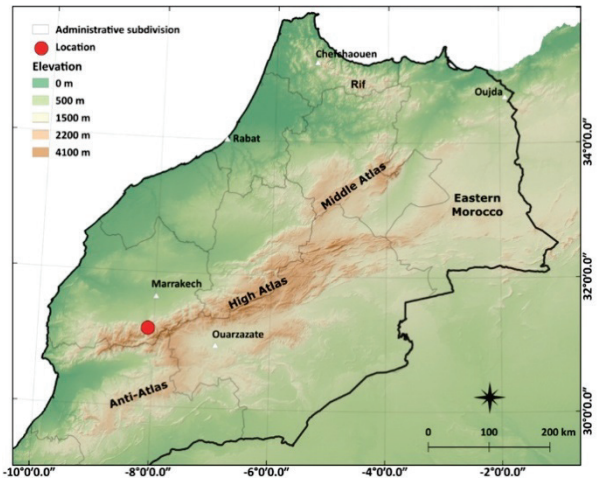

Fig. 21. Geographical distribution of *Bradysia subsantorina*

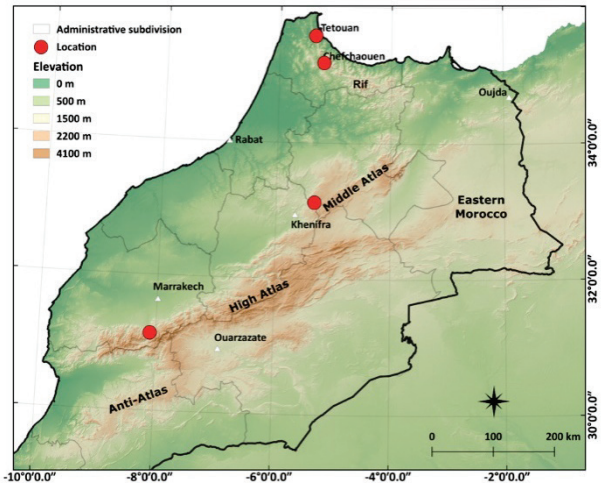

Fig. 22. Geographical distribution of *Bradysia tilicola*

Bradysia transitata Rudzinski & Baumjohann, 2013

Distribution: Rif (Oued Ez-zarka, Oued Tkarâa (PNPB), Oued Laou, Oued Touta); Atlantic Plain (Larache: strawberry farm, Kenitra Mâamora Forest); Anti-Atlas (Barrage Aoulouz, Assif Tifnou) (Fig. 23).

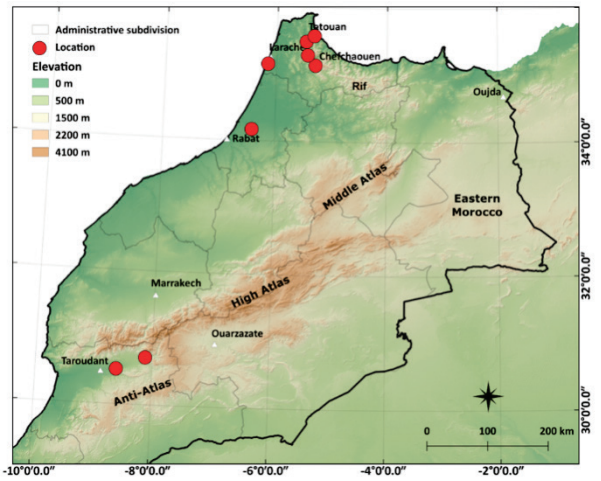

Fig. 23. Geographical distribution of *Bradysia transitata*

Distribution outside Morocco: Europe (Germany).

Ecology: this species is widely distributed in Morocco. In the Rif, it mainly colonizes the riparian banks of many rivers and streams. In the Atlantic Plain, it was collected in a cork oak forest (Mâamora) and at a strawberry farm (Larache). In the south of Morocco, it seems to prefer the surrounding areas of wetlands.

Bradysia trivittata (Staeger, 1840)

Distribution: Rif (Oued Ez-zarka, Ain Tayatine, Oued Bayine, Beni Barou, Douar Hamma, Oued Ametrasse, Tétouan); Atlantic Plain (Larache: strawberry farm); High Atlas (Télouet (NPTB), Ouirgane (NPTB)); Middle Atlas (Ouiouane Lake); Anti-Atlas (Taghazout, Vallée du Paradis, Sidi Rbat) (Fig. 24).

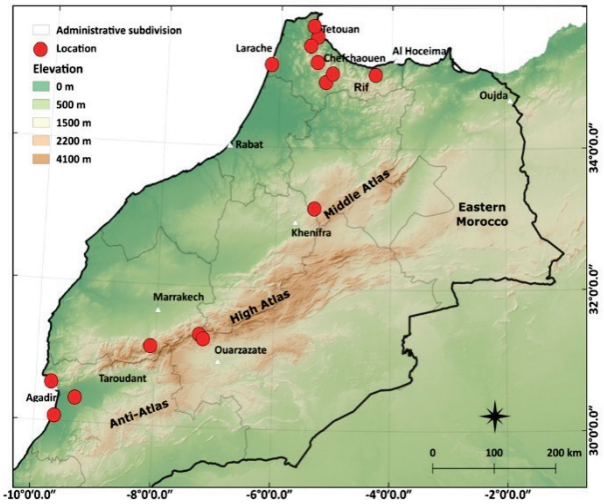

Fig. 24. Geographical distribution of *Bradysia trivittata*

Distribution outside Morocco: Common in the Palaearctic, also known from Algeria, Afghanistan, Canary Islands.

Ecology: this species has a wide distribution across the main biogeographical areas of Morocco where it colonizes a large variety of ecosystems. It was collected in many terrestrial habitats such as forests, meadows, oases of date palms, almond trees and a strawberry farm, and the shores of lakes, rivers, waterfalls, and springs bordered by *Tamarix* sp., *Juncus* sp., *Euphorbia* sp. It was also captured on the seashore spreading thus over a wide altitudinal range.

Bradysia vagans (Winnertz, 1868)

Distribution: Rif (Ain Fouara); High Atlas (Ouirgane (NPTB), Fig. 25).

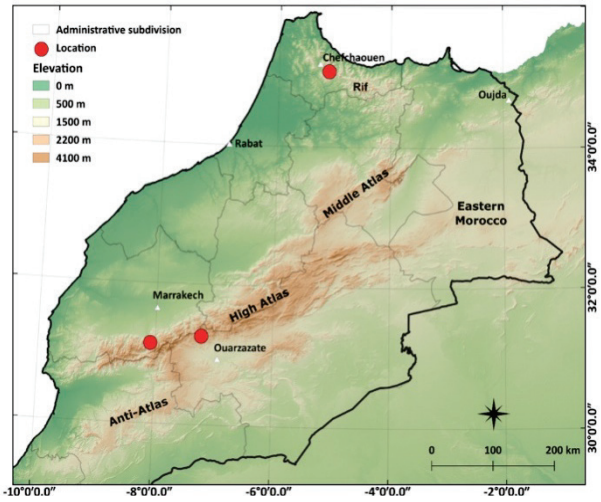

Fig. 25. Geographical distribution of *Bradysia vagans*

Distribution outside Morocco: Holarctic Region.

Ecology: this species was collected at the edge of a spring at a medium altitude (944 m) in the Rif, while it was also collected in a thuriferous forest in Ouirgane at a high altitude (1593 m) in the High Atlas.

Bradysia xenoreflexa Mohrig & Menzel, 1993

Distribution: Rif (Aïn Jdioui); Atlantic Plain (Larache: strawberry farm, Kenitra Mâamora forest) (Fig. 26).

Distribution outside Morocco: Europe (Czech Republic, France, Greece, Italy, Slovakia, Spain, Sweden, Uzbekistan).

Ecology: this species was collected in terrestrial habitats at low altitudes (34–76 m) in a meadow in the Rif and in a cork oak forest at Mâamora as well as in a strawberry farm in Larache.

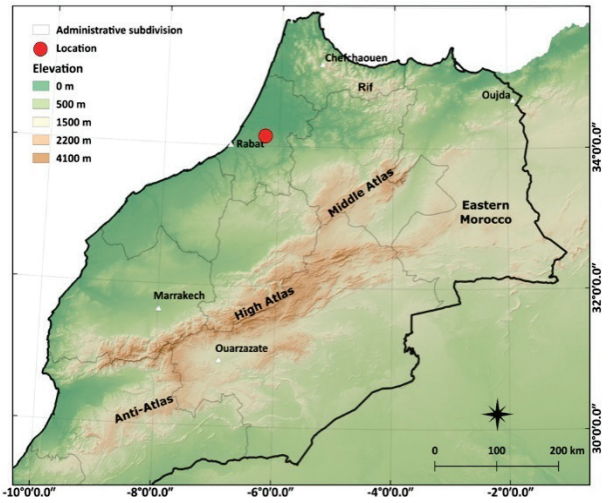

Fig. 26. Geographical distribution of *Bradysia xenoreflexa*

***Bradysiopsis* Tuomikoski, 1960**

Bradysiopsis vittata (Meigen, 1830)

Distribution: High Atlas (Setti Fatma (NPTB)) (Fig. 27).

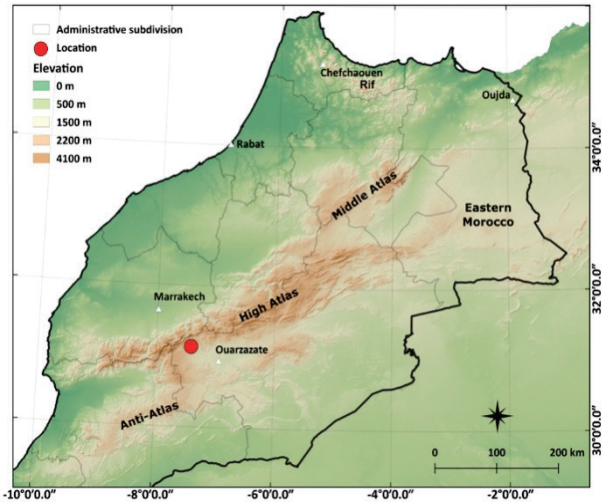

Fig. 27. Geographical distribution of *Bradysiopsis vittata*

Distribution outside Morocco: common in the Holarctic Region.

Ecology: this species was only found in the High Atlas, in Setti Fatma (1470 m) in an agricultural field on Jbel Toubkal.

***Camptochaeta* Hippa & Vilkamaa, 1994**

Camptochaeta jeskei (Mohrig & Röschmann, 1993)

Distribution: High Atlas (Télouet (NPTB)) (Fig. 28).

Distribution outside Morocco: Mediterranean (Spain).

Ecology: this species of *Camptochaeta* was only found at a single station in the High Atlas at a high altitude (1800 m) on an almond tree.

***Corynoptera* Winnertz, 1867**

Corynoptera andalusica Hippa, Vilkamaa & Heller, 2010

Distribution: Rif (Oued El Hamma); Middle Atlas (Ouiouane Lake); High Atlas (Ouirgane (NPTB)) (Fig. 29).

Distribution outside Morocco: Europe (Greece, Spain).

Ecology: collected both at mid-altitude (200 m) in a mixed forest dominated by *Quercus suber*, and at high-altitude in the Middle Atlas from riparian banks of Lake Ouiouane (1914 m) whose shores are covered by *Quercus ilex*, and in a thuriferous forest in Ouirgane at an altitude of 1593 m in the High Atlas.

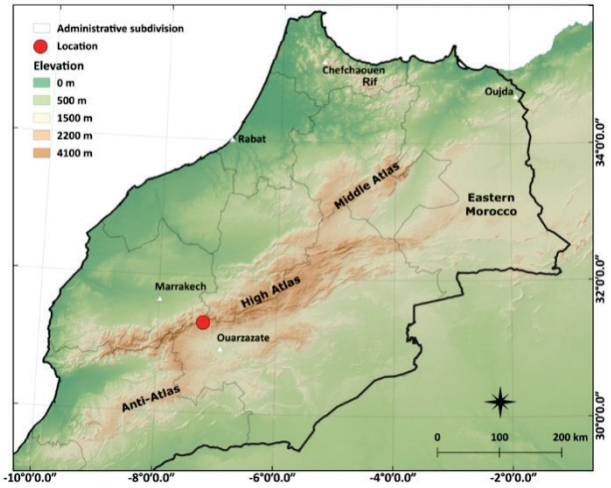

Fig. 28. Geographical distribution of *Camptochaeta jeskei*

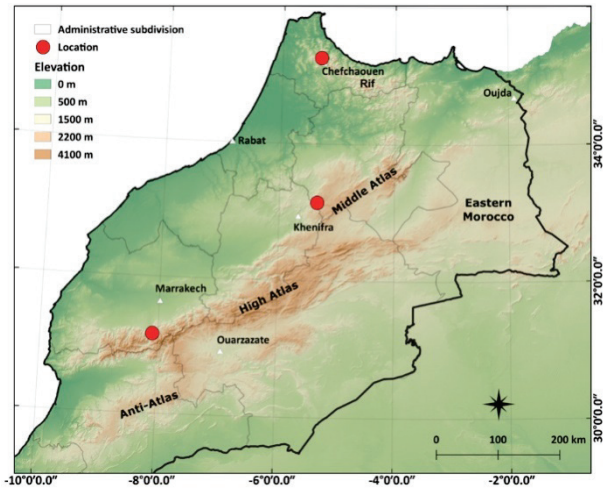

Fig. 29. Geographical distribution of *Corynoptera andalusica*

Corynoptera bicuspidata (Lengersdorf, 1926)

Distribution: Middle Atlas (Ouiouane Lake), High Atlas (Ouirgane (NPTB)) (Fig. 30).

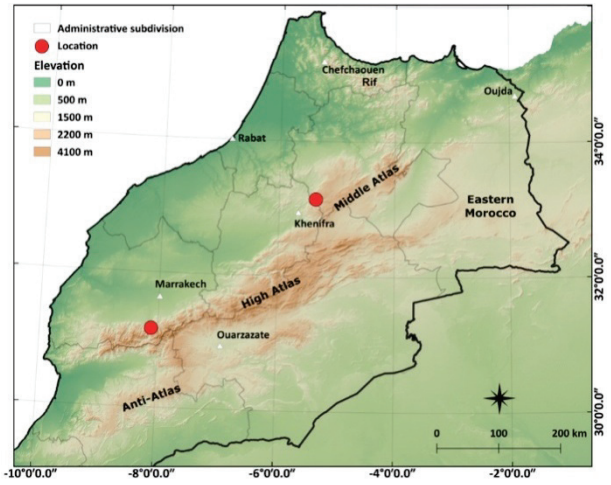

Fig. 30. Geographical distribution of *Corynoptera bicuspidata*

Distribution outside Morocco: Common in Europe.

Ecology: this species was collected from two sites, in the Middle Atlas from riparian banks of Lake Ouiouane (1914 m) which is bordered by *Quercus ilex* and the other site in the High Atlas from a thuriferous forest in Ouirgane (1593 m).

Corynoptera bispinulosa Mohrig & Dimitrova, 1992

Distribution: Eastern Morocco (Tafoughalt) (Fig. 31).

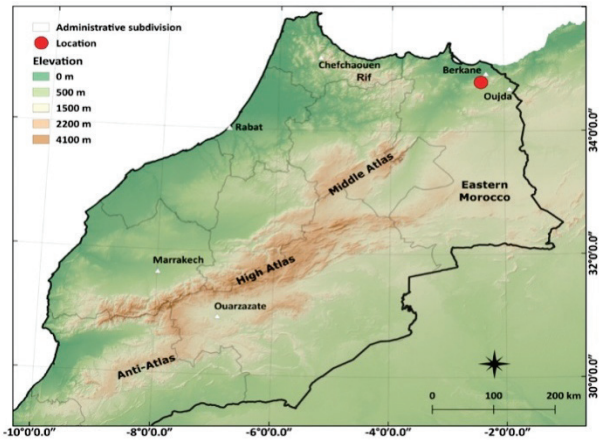

Fig. 31. Geographical distribution of *Corynoptera bispinulosa*

Distribution outside Morocco: Europe (Bulgaria, Germany, Spain [Balearic Islands only]); Africa (Canary Islands).

Ecology: *Corynoptera bispinulosa* was the first *Corynoptera* found in the Eastern part of Morocco. It was captured in a dense holm oak forest in Beni Snassen at 786 m.

Corynoptera caesula Hippa & Menzel, 2004

Distribution: Rif (Aïn Kchour), Atlantic Plain (Forest of Mâamora, Fig. 32).

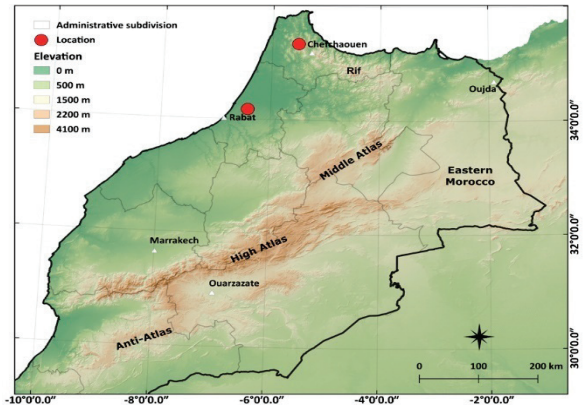

Fig. 32. Geographical distribution of *Corynoptera caesula*

Distribution outside Morocco: Europe (Malta, Spain).

Ecology: this species seems to prefer cork oak habitats where it was only found at two sites, in the forest of Aïn Kchour (1157 m) and in the Forest of Mâamora (34 m) despite the large altitudinal difference.

Corynoptera cincinnata Mohrig & Blasco-Zumeta, 1996

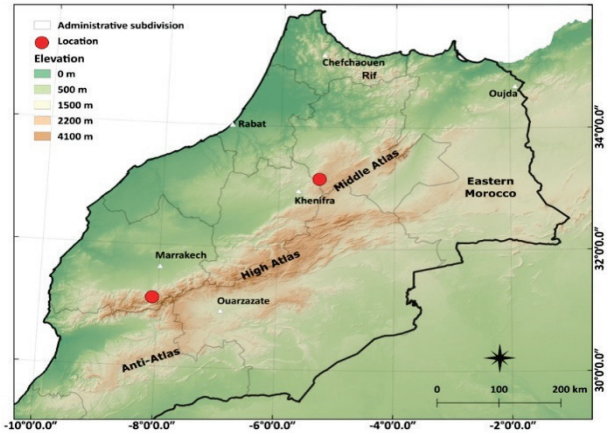

Fig. 33. Geographical distribution of *Corynoptera cincinnata*

Distribution: Middle Atlas (Ouiouane Lake); High Atlas (Ouirgane (NPTB)) (Fig. 33).

Distribution outside Morocco: Italy.

Ecology: collected from riparian banks of Ouiouane Lake (1914 m) which is bordered by *Quercus ilex* and in a thuriferous forest in Ouirgane at an altitude of 1593 m.

Corynoptera dentiforceps (Bukowski & Lengersdorf, 1936)

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 34).

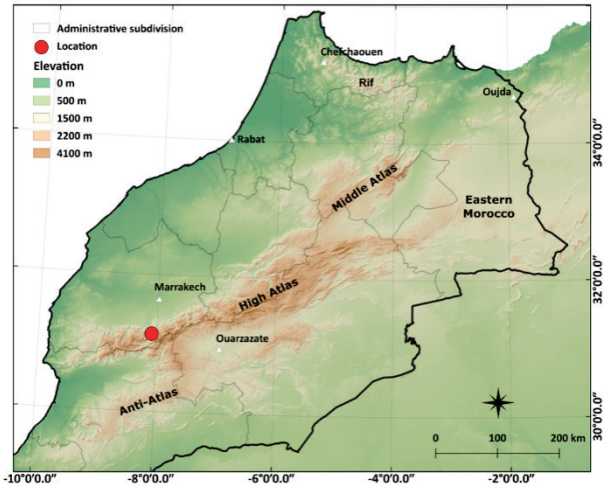

Fig. 34. Geographical distribution of *Corynoptera dentiforceps*

Distribution outside Morocco: Europe.

Ecology: this *Corynoptera* was collected at a single site in the High Atlas, at Ouirgane which is represented by a thuriferous forest at 1593 m of altitude.

Corynoptera deserta Heller & Menzel, 2006

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 35).

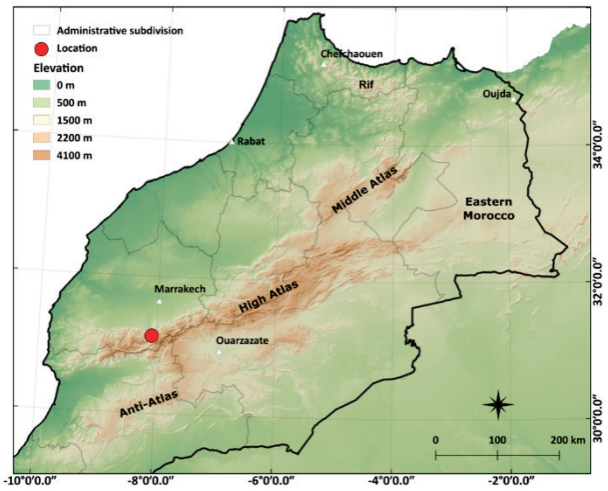

Fig. 35. Geographical distribution of *Corynoptera deserta*

Distribution outside Morocco: Europe.

Ecology: the same as *C. dentiforceps*, *Corynoptera deserta* was also captured at a single site at Ouirgane from a thuriferous forest at a high altitude (1593 m).

Corynoptera fatigans (Johannsen, 1912)

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 36).

Distribution outside Morocco: worldwide distribution.

Ecology: like *C. dentiforceps* and *C. deserta*, *Corynoptera fatigans* only occurs at Ouirgane (1593 m) in a thuriferous forest.

Corynoptera gemina (Hippa & Vilkamaa, 1994)

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 37).

Distribution outside Morocco: Palaearctic Region.

Ecology: as well as the other *Corynoptera* spp. occurring only in Ouirgane, *Corynoptera gemina* follows the same geographical pattern, and thrives at the same site in a thuriferous forest at 1593 m of altitude.

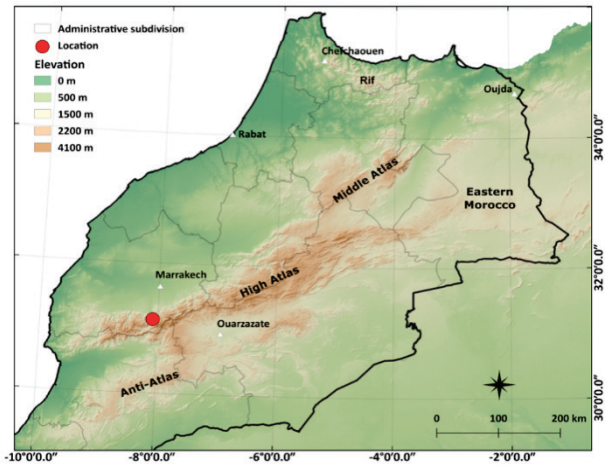

Fig. 36. Geographical distribution of *Corynoptera fatigans*

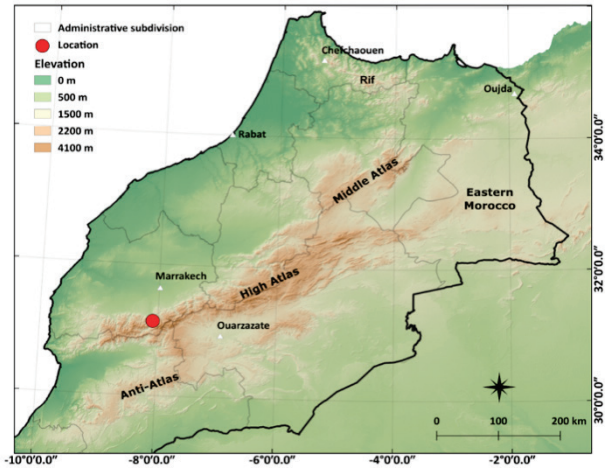

Fig. 37. Geographical distribution of *Corynoptera gemina*

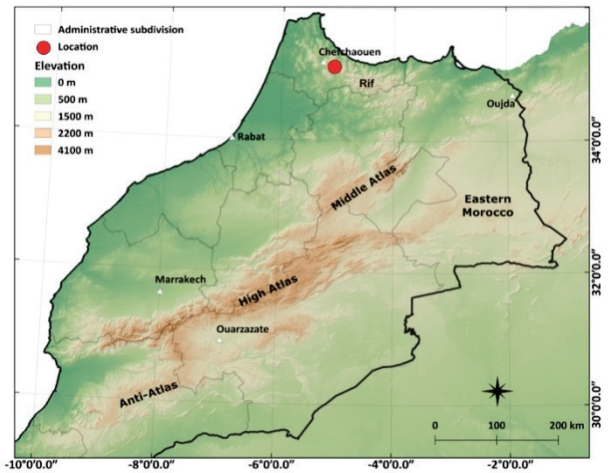

Fig. 38. Geographical distribution of *Corynoptera globiformis*

Corynoptera globiformis (Frey, 1945)

Distribution : Rif (Maison forestière (NPTS)) (Fig. 38).

Distribution outside Morocco: widespread in Europe.

Ecology: this species of *Corynoptera* has only been collected in a fir forest (*Abies maroccana* Trab.) at the National Park of Talassemtane at 1696 m.

Corynoptera hemiacantha Mohrig & Mamaev, 1992

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 39).

Distribution outside Morocco: Europe.

Ecology: like the other *Corynoptera* spp. reported exclusively in Ouirgane, *Corynoptera hemiacantha* inhabits the same habitat (thuriferous forest) at 1593 m.

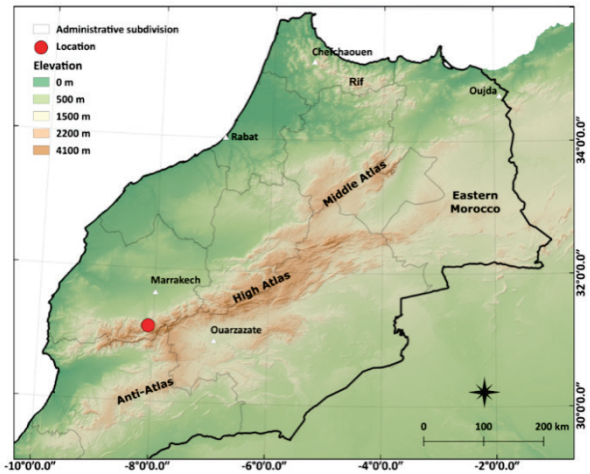

Fig. 39. Geographical distribution of *Corynoptera hemiacantha*

Corynoptera iberica Hippa, Vilkamaa & Heller, 2010

Distribution: Rif (Ain Kchour, tourbière Amsemlil (PNPB)); Atlantic Plain (Mâamora forest, Sidi Boughaba); Anti-Atlas (Vallée du Paradis) (Fig. 40).

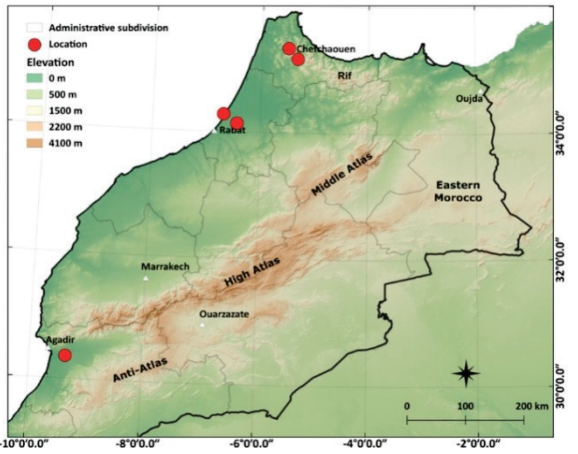

Fig. 40. Geographical distribution of *Corynoptera iberica*

Distribution outside Morocco: Mediterranean (Spain).

Ecology: this species of *Corynoptera* seems to be widely distributed but was mainly collected in cork oak forests in the Rif at high altitudes as well as in the Atlantic Plain at low altitudes. In the Anti-Atlas, it was found on the banks of the waterfalls of the Paradise Valley (587 m) which was surrounded by palm trees.

Corynoptera inclinata Hippa, Vilkamaa & Heller, 2010

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 41).

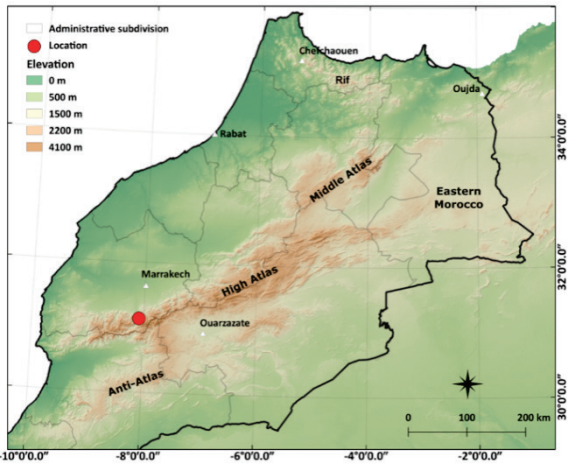

Fig. 41. Geographical distribution of *Corynoptera inclinata*

Distribution outside Morocco: known only from Morocco.

Ecology: as the other species of *Corynoptera* which exclusively occur in Ouirgane, this species seems also to be inhabiting the same site (thuriferous forest) at 1593 m.

Corynoptera irmgardis (Lengersdorf, 1930)

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 42).

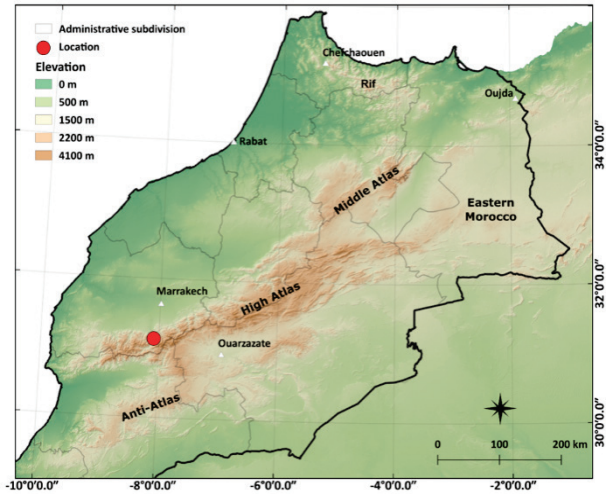

Fig. 42. Geographical distribution of *Corynoptera irmgardis*

Distribution outside Morocco: Common in Europe.

Ecology: The same habitat is observed for this species such as the other species of *Corynoptera* occurring in Ouirgane (thuriferous forest, 1593 m).

Corynoptera postglobiformis Mohrig, 1993

Distribution: Rif (Maison forestière (NPTS)); High Atlas (Ouirgane (NPTB)) (Fig. 43).

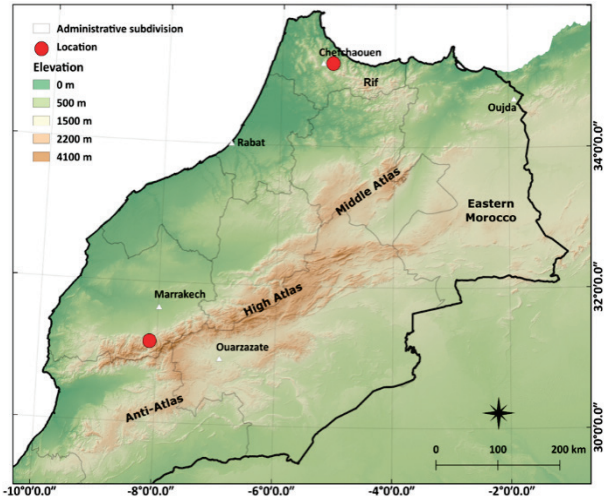

Fig. 43. Geographical distribution of *Corynoptera postglobiformis*

Distribution outside Morocco: Europe.

Ecology: this species was collected in the fir forest (*Abies marocca-na*) of the National Park of Talassemtane at 1696 m of altitude, and in Ouirgane represented by a thuriferous forest at 1593 m of altitude.

Corynoptera praeparvula Mohrig & Krivosheina, 1983

Distribution: High Atlas (Ouirgane (NPTB), Amzmiz (NPTB)) (Fig. 44).

Distribution outside Morocco: Europe (Andorra, Bulgaria, Czech Republic, Germany, Greece, Italy, Malta, Slovakia, Spain, Ukraine, United Kingdom); Asia (Asian part of Turkey, Turkmenistan).

Ecology: this species was only collected at high altitudes in the High Atlas, from a thuriferous forest (1593 m), and from an agriculture field (1000 m).

Corynoptera saccata Tuomikoski, 1960

Distribution: Anti-Atlas (Guelmim) (Fig. 45).

Distribution outside Morocco: Europe.

Ecology: this species was only collected in the southern part of Morocco, in Guelmim whose habitat is represented by an oasis of date palms at 210 m of altitude.

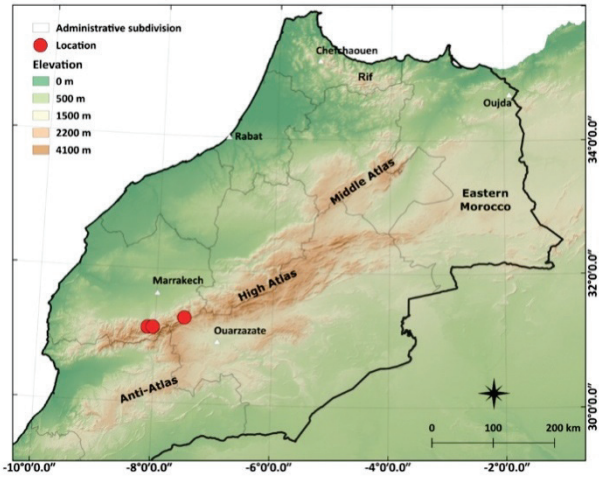

Fig. 44. Geographical distribution of *Corynoptera praeparvula*

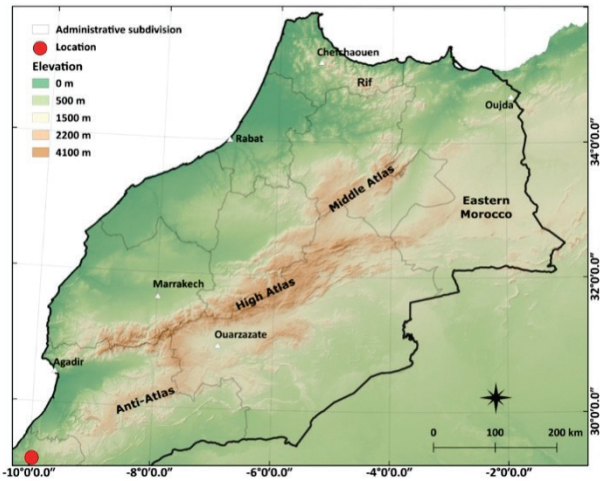

Fig. 45. Geographical distribution of *Corynoptera saccata*

Corynoptera semipedestris Mohrig & Blasco-Zumeta, 1996

Distribution: Anti-Atlas (Guelmim) (Fig. 46).

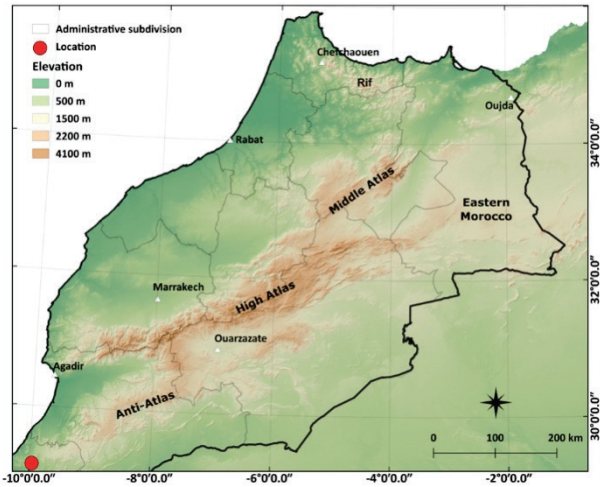

Fig. 46. Geographical distribution of *Corynoptera semipedestris*

Distribution outside Morocco: Mediterranean (Spain).

Ecology: like *Corynoptera saccata*, this species was only collected in Guelmim from an oasis of palm trees.

Corynoptera spiciceps Hippa, Vilkamaa & Heller, 2010

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 47).

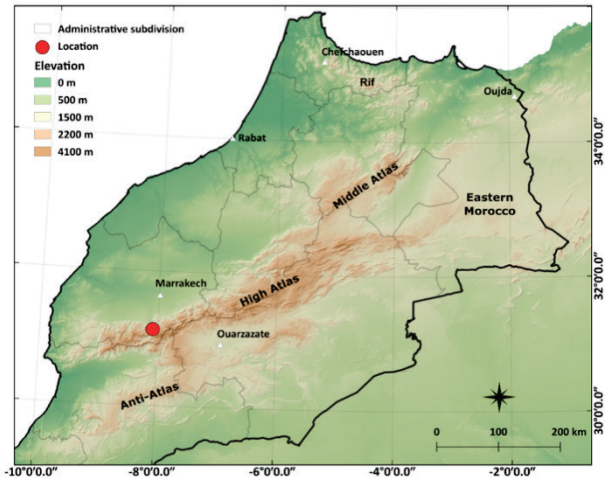

Fig. 47. Geographical distribution of *Corynoptera spiciceps*

Distribution outside Morocco: no further records are known.

Ecology: this species also occurs exclusively in Ouirgane (thuriferous forest, 1593 m).

Corynoptera stipidaria Mohrig, 1994

Distribution: Middle Atlas (Ouiouane Lake) (Fig. 48).

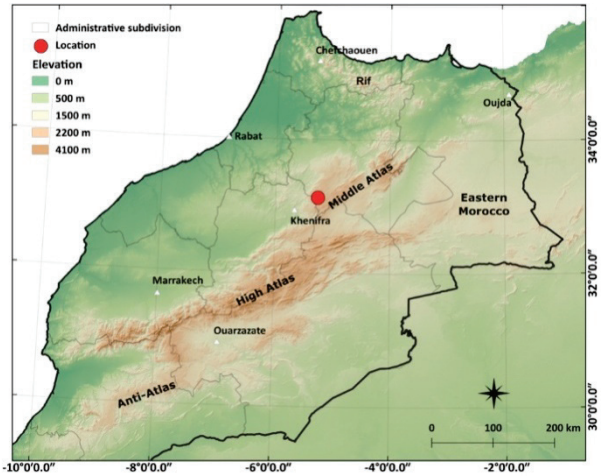

Fig. 48. Geographical distribution of *Corynoptera stipidaria*

Distribution outside Morocco: Mediterranean (Spain).

Ecology: this species of *Corynoptera* was collected in one site in the Middle Atlas at a high altitude (1914 m) from riparian banks of Lake Ouiouane which is bordered by *Quercus ilex*.

Corynoptera subcavipes Menzel & Smith, 2007

Distribution: Rif (Maison forestière (NPTS), Oued El Hamma, Fig. 49).

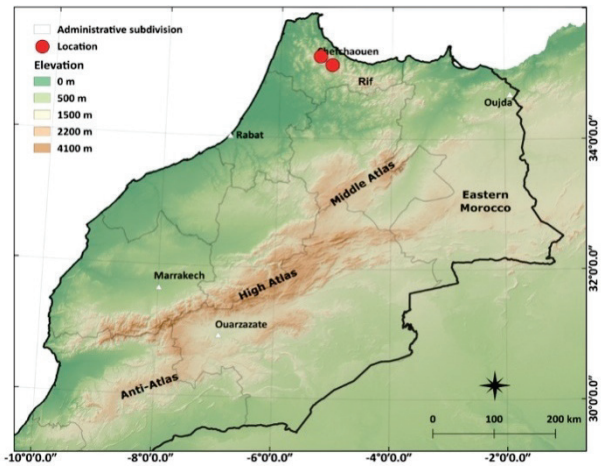

Fig. 49. Geographical distribution of *Corynoptera subcavipes*

Distribution outside Morocco: Europe.

Ecology: this species was collected in the fir forest (*Abies marocca-na*) of the National Park of Talassemtane at 1696 m of altitude, and in a mid-altitude mixed forest dominated by *Quercus suber* (200 m) at Oued El Hamma.

Corynoptera subparvula Tuomikoski, 1960

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 50).

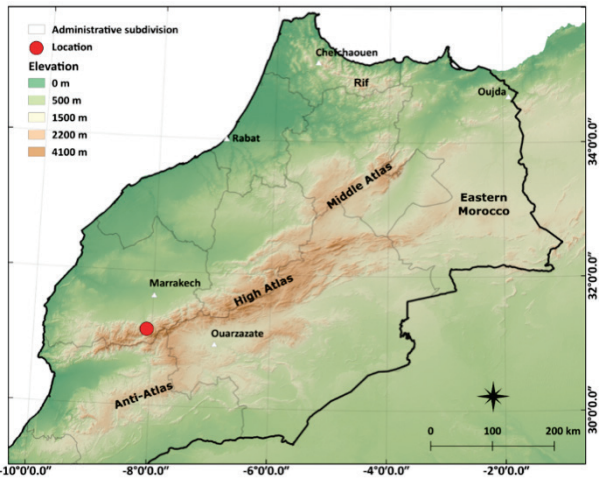

Fig. 50. Geographical distribution of *Corynoptera subparvula*

Distribution outside Morocco: Holarctic Region.

Ecology: this species is added to the list of the other species of *Corynoptera* that colonize exclusively the site of Ouirgane (thuriferous forest, 1593 m).

***Hirtipennia* Mohrig & Menzel, 1997**

Hirtipennia parcepilosa (Strobl, 1900)

Distribution: Atlantic Plain (Sidi Boughaba) (Fig. 51).

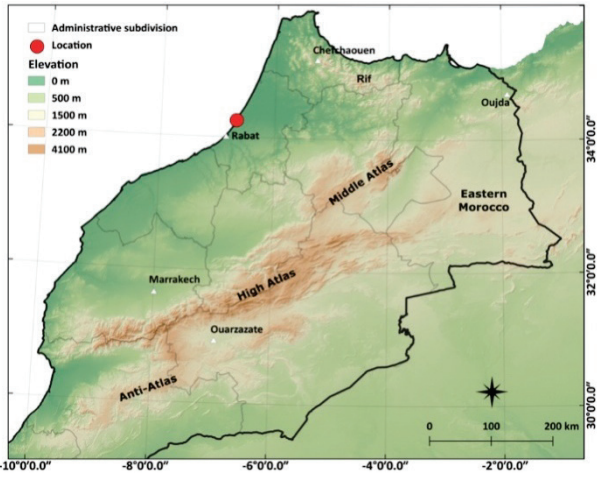

Fig. 51. Geographical distribution of *Hirtipennia parcepilosa*

Distribution outside Morocco: Europe (Croatia, Germany, Spain, United Kingdom); Asia (Asian part of Turkey); Africa (Canary Islands).

Ecology: this species has been only found in the Atlantic Plain at low altitudes (18 m) in the vegetation around Lake Sidi Boughaba.

Hirtipennia tomentosa Mohrig & Kauschke, 1994

Distribution: Atlantic Plain (Mâamora forest) (Fig. 52).

Distribution outside Morocco: Europe (Croatia, France, Greece, Italy, Portugal).

Ecology: like *H. parcepilosa*, this second species of Hirtipennia recorded from Morocco was also found in the Atlantic Plain in the cork oak Forest of Mâamora.

***Leptosciarella* Tuomikoski, 1960**

Leptosciarella dives (Johannsen, 1912)

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 53).

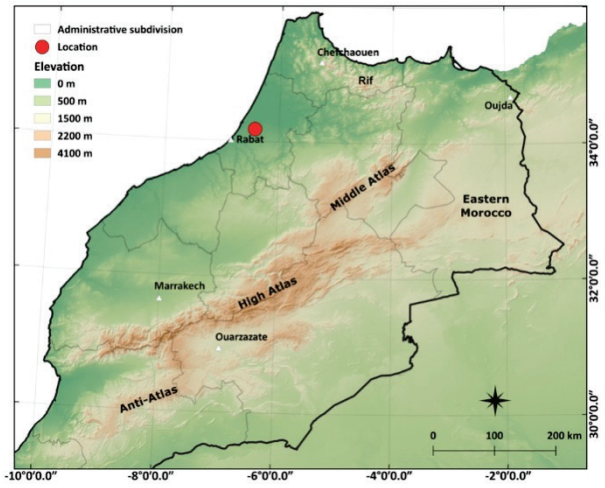

Fig. 52. Geographical distribution of *Hirtipennia tomentosa*

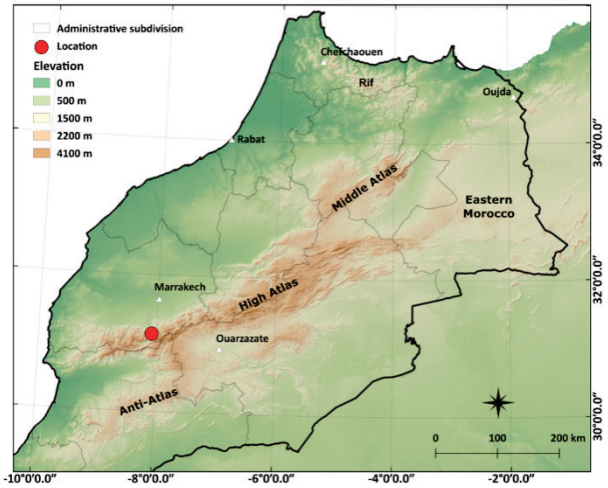

Fig. 53. Geographical distribution of *Leptosciarella dives*

Distribution outside Morocco: America, Europe.

Ecology: this species of *Leptosciarella* was collected at a high altitude (1593 m) in a thuriferous forest.

Leptosciarella subviatica Mohrig & Menzel, 1997

Distribution: High Atlas (Ouirgane (NPTB)) (Fig. 54).

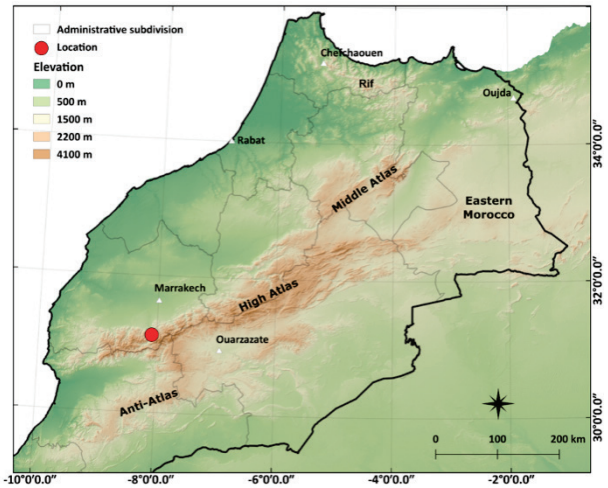

Fig. 54. Geographical distribution of *Leptosciarella subviatica*

Distribution outside Morocco: Europe.

Ecology: similarely to *L. dives*, this second species of *Leptosciarella* was also collected at a high altitude (1593 m) in Ouirgane, in a thuriferous forest.

***Lycoriella* Frey, 1942**

Lycoriella agraria (Felt, 1898)

Distribution : Rif (Douar Tissouka) (Fig. 55).

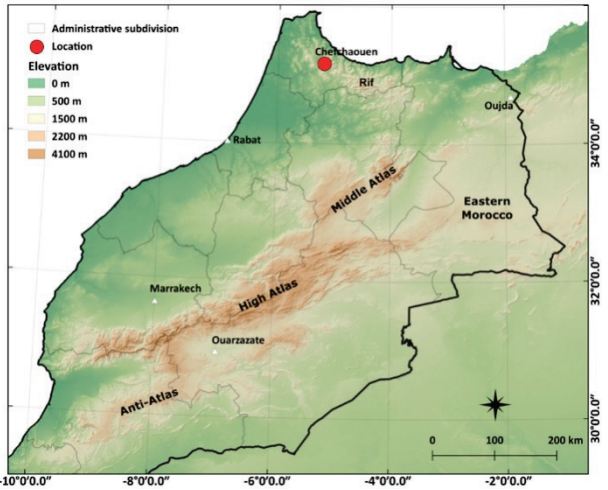

Fig. 55. Geographical distribution of *Lycoriella agrarian*

Distribution outside Morocco: cosmopolitan.

Ecology: this *Lycoriella* has only been found in the National Park of Talassemtane in the Rif, in a pine forest (*Pinus halepensis*) at high altitude (1696 m).

Lycoriella sativae (Johannsen, 1912)

Distribution: Rif (Oued Zaouya, M'Diq); Atlantic Plain (Larache (strawberry farm)); High Atlas (Ouirgane (NPTB)) (Fig. 56).

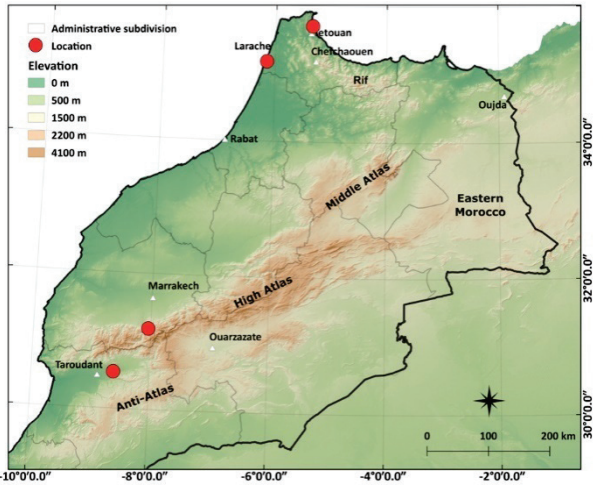

Fig. 56. Geographical distribution of *Lycoriella sativae*

Distribution outside Morocco: cosmopolitan and very common in the Holarctic, also known from Afghanistan.

Ecology: this second species of *Lycoriella* seems to have a wider distribution across Morocco and colonizes diverse habitats such as the banks of rivers, streams and lagoon, a strawberry farm, and thuriferous forest, over a wide altitudinal ranging from 1 to 1593 m.

***Pseudolycoriella* Menzel & Mohrig, 1998**

Pseudolycoriella morenae (Strobl, 1900)

Distribution: Rif (Perdicaris park, Bab Tariouant, Oued Maggou (NPTS); Eastern Morocco (Tafoughalt); High Atlas (Ouirgane (NPTB)) (Fig. 57).

Distribution outside Morocco: Europe (Spain, Ukraine); Asia (Turkmenistan).

Ecology: this unique species of *Pseudolycoriella* recorded from Morocco has been found in many sites across the main biogeographical areas. It was collected in a thuriferous forest at a high altitude (1593 m), and in tauzin oak trees (*Quercus pyrenaica* Willd.) at Bab Tariouant (1415 m), in a pine forest (*Pinus halepensis*) at Maggou (768 m), in a holm oak tree

(*Quercus ilex*) at 786 m in Tafoughalt and in an urban forest at Perdicaris Park (237 m).

***Scatopsciara* Edwards, 1927**

Scatopsciara (*Scatopsciara*) *atomaria* (Zetterstedt, 1851)

Distribution: Rif (Oued Ez-zarka, Oued Tkarâa (PNPB), Oued Kallet, Marécage Lamtahene, Oued Ametrasse, Issaguen, Talassemtane (Maison forestière), Douar Hamma, Ain Fouara, Oued Souk El Had, Merzouk Bni Salah, Oued Maggou (NPTS)); Atlantic Plain (Mâamora Forest, Sidi Boughaba); High Atlas (Assif Tifnout (NPTB), Armed (NPTB), Amzmiz (NPTB), Gerifodene (NPTB), Tislit Lake (NPHAO), Aïn Taferaout (NPTB), Takharkhourt (NPTB), Télouet (NPTB)); Anti Atlas (Barrage Mokhtar Soussi) (Fig. 58).

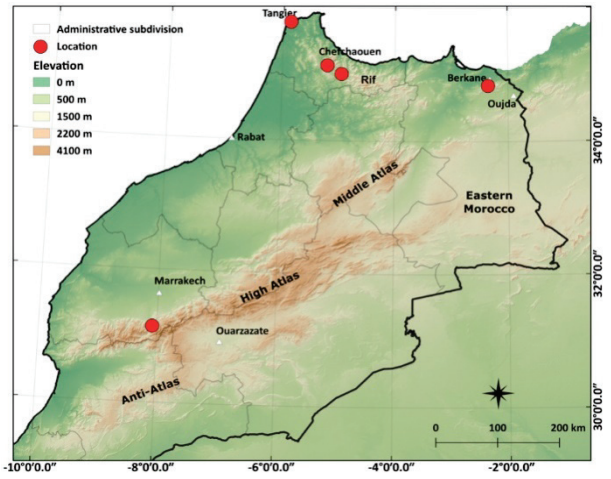

Fig. 57. Geographical distribution of *Pseudolycoriella morenae*

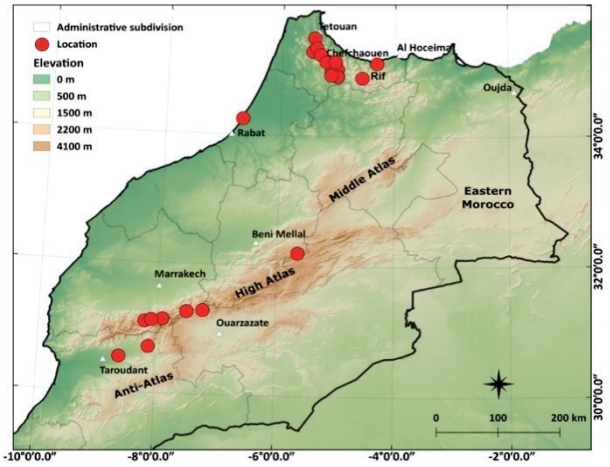

Fig. 58. Geographical distribution of *Scatopsciara* (*Scatopsciara*) *atomaria*

Distribution outside Morocco: cosmopolitan and, very common in the Holarctic.

Ecology: according to the literature, this *Scatopsciara* is a cosmopolitan species (Speight, 2018). Indeed, it is the most widespread species that occupies different regions of Morocco and different types of habitats such as wetlands including bogs, ponds, rivers, springs and lakes, meadows, lowlands, agricultural fields and forests with oak, pine, cedar, and fir trees. The altitudinal range occupied by this Scatopsciara is wide, ranging from 18 to 2106 m.

Many sites occupied by this species belong to protected areas such as the Project of Natural Park of Bouhachem, the National Park of Talassemtane and the National Park of Toubkal.

Scatopsciara (*Scatopsciara*) *nana* (Winnertz, 1871)

Distribution: Rif (Oued Ez-zarka, Oued Maâmala, Oued Aârkob, Merja Sidi Lhaj Merzouk, Ben Karrich Forest); High Atlas (Ouirgane (NPTB)); High Atlas Oriental (Anafgou (NPHAO)) (Fig. 59).

Distribution outside Morocco: common in the Holarctic Region.

Ecology: this *Scatopsciara* dominates mainly in the Rif where it colonizes the banks of rivers and streams as well as cork oak forests spreading over an altitudinal range from 23 to 1949 m. Within the Rif, it was also collected upstream of the estuary of Oued Aârkob. Only one report of this species was recorded in the High Atlas, where it was found in Ouirgane, in a thuriferous forest at 1593 m. From the other regions of Morocco, this species is considered to be the only sciarid species collected in the National Park of High Atlas Oriental (NPHAO) at Anafgou (1949 m).

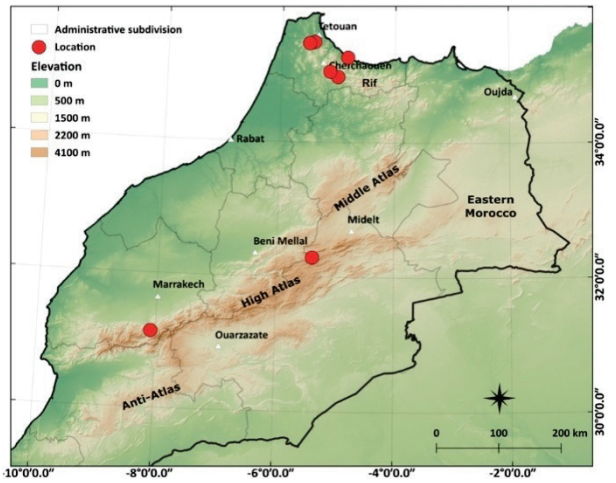

Fig. 59. Geographical distribution of *Scatopsciara* (*Scatopsciara*) *nana*

Scatopsciara (*Scatopsciara*) *vitripennis* (Meigen, 1818)

Distribution: Rif (Oued Tkarâa (PNPB), Oued Aoudour, Oued Ametrasse, Oued Aârkoub, Oued Boumarouil, Ben Karrich, Dayat Tazia, Ain El Fakir, Azib de Khmis Mdik, Merzouk Bni Salah, Oued Souk El Had, Oued Maggou (NPTS), El Malâab (NPTS)); Atlantic Plain (Sidi Boughaba); Middle Atlas (Ouiouane Lake); High Atlas (Ouirgane (NPTB)); Anti-Atlas (Barrage Aoulouz, Assif Tifnout, Barrage Mokhtar Soussi) (Fig. 60).

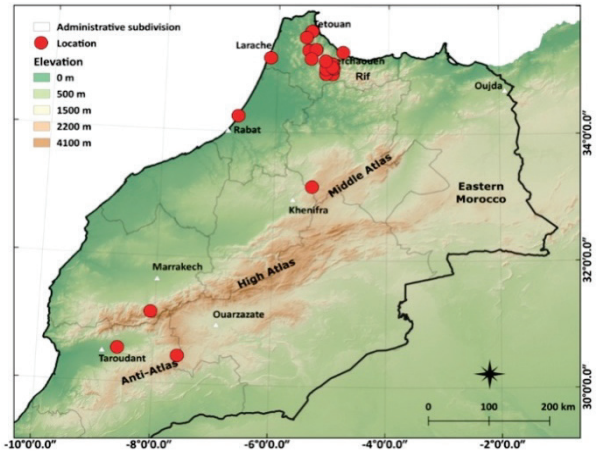

Fig. 60. Geographical distribution of *Scatopsciara* (*Scatopsciara*) *vitripennis*

Distribution outside Morocco: common in the Holarctic Region, including China (Tibet).

Ecology: this species has a very large distribution across Morocco and does not appear to have any ecological preferences since it colonizes diverse kinds of habitats such as the surrounding areas of wetlands, meadows and forests of fir, pine, cork and holm oak trees in a fairly wide altitudinal range (20–1914 m).

Scatopsciara (*Xenopygina*) *curvilinea* (Lengersdorf, 1934)

Distribution: Atlantic Plain (Sidi Boughaba); High Atlas (Ain Taferaout (NPTB), Amizmiz (NPTB)); Anti-Atlas (Assif Tifnout, Barrage Mokhtar Soussi) (Fig. 61).

Distribution outside Morocco: Europe (Czech Republic, Germany, Spain, United Kingdom); Asia (Turkmenistan).

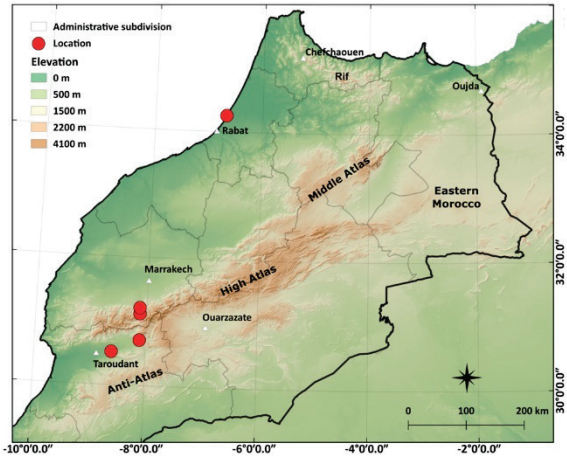

Fig. 61. Geographical distribution of *Scatopsciara* (*Xenopygina*) *curvilinea*

Ecology: this species occupies a wide range of altitudes ranging from 18 m in Sidi Boughaba to 1237 m in Ain Taferaout where it colonizes mainly the shores of lakes and springs as well as agricultural fields and forests dominated mainly by cork oak trees.

Scatopsciara (*Xenopygina*) *maroccoensis* (Mohrig & Jaschhof, 1997)

Distribution: Anti-Atlas (Sidi Rbat) (Fig. 62).

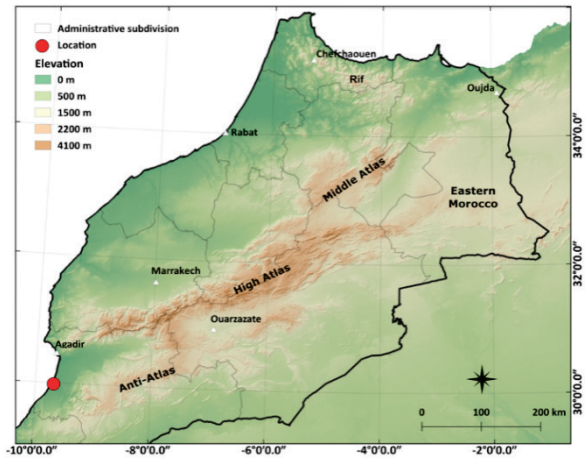

Fig. 62. Geographical distribution of *Scatopsciara* (*Xenopygina*) *maroccoensis*

Distribution outside Morocco: Europe (Corsica)

Ecology: this species was found in one locality in the southern part of the Atlantic Plain in Sidi Rbat at 232 m on a riverside with halophytes such as *Tamarix* sp., *Juncus* sp. and *Euphorbia* sp.

Scatopsciara (*Xenopygina*) *subarmata* Mohrig & Mamaev, 1983

Distribution: Rif (Oued Amsa); Atlantic Plain (Larache: a strawberry farm); Middle Atlas (Mont Habri); High Atlas (Ouirgane (NPTB)); Anti-Atlas (Id Aissa, Tissint) (Fig. 63).

Distribution outside Morocco: Europe (Malta); Asia (Turkmenistan).

Ecology: this species seems widely spread in Morocco where it colonizes the main biogeographical areas, even though with few occurrences in each area. It has been collected at very low altitude on the banks of a small stream (Oued Amsa) as well as from the summit (2072 m) of Jbel Habri (Mont Habri) which is covered by cedar trees, and in a thuriferous forest in Ouirgane (1593 m).

***Schwenckfeldina* Frey, 1942**

Schwenckfeldina carbonaria (Meigen, 1830)

Distribution: Middle Atlas (Forest of Timelil); High Atlas (Taroudant) (Fig. 64).

Distribution outside Morocco: widespread in Europe.

Ecology: this unique species of the genus *Schwenckfeldina* recorded in Morocco tends to have ecological requirements which tend towards forests of high altitudes up to more than 1800 m.

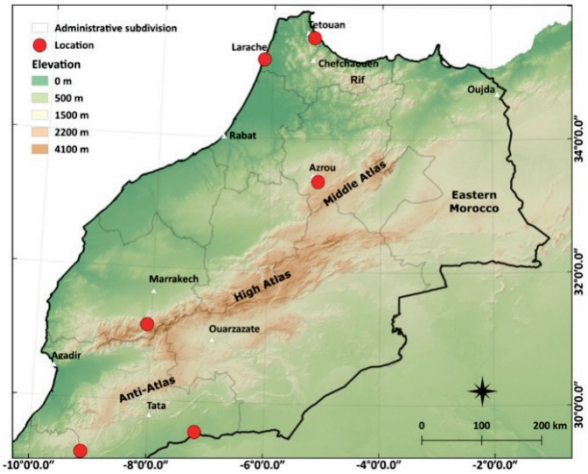

Fig. 63. Geographical distribution of *Scatopsciara* (*Xenopygina*) *subarmata*

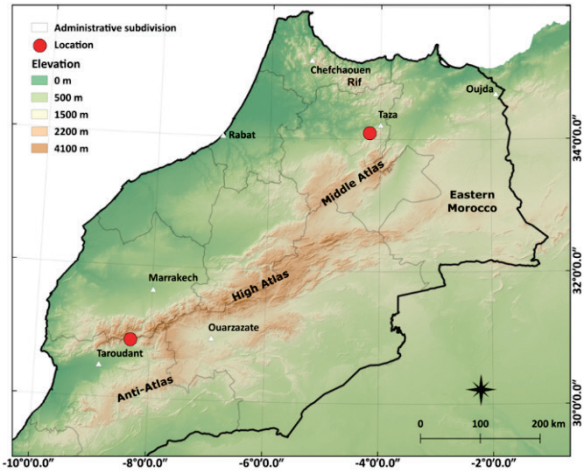

Fig. 64. Geographical distribution of *Schwenckfeldina carbonaria*

***Sciara* Meigen, 1803**

Sciara hemerobioides (Scopoli, 1763)

Distribution: Rif (Tanger) (Fig. 65).

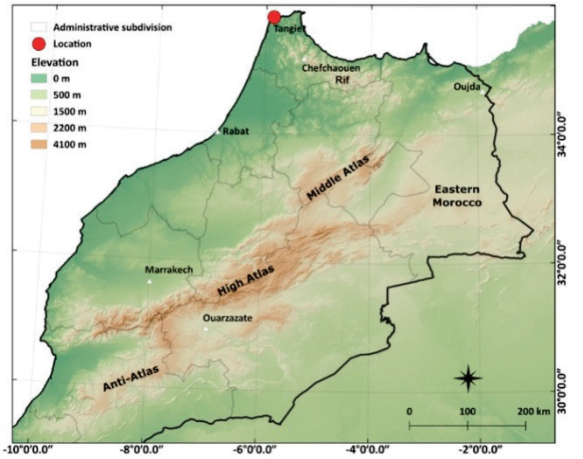

Fig. 65. Geographical distribution of *Sciara hemerobioides*

Distribution outside Morocco: worldwide distribution.

Ecology: not given.

Discussion

This Atlas provides the geographical distribution and ecology of 65 species that currently represent the updated faunal records taken from

the recently published Moroccan literature on the sciarid fauna (El Ouazzani et al., 2019). This updated checklist made it possible to remove some erroneous species quoted in the first checklist in El Ouazzani et al. (2019) such as *Austrosciara hyalipennis* (Meigen, 1804) [El Ouazzani et al., 2019: 279, Fig. 3A–D], *Bradysia lembkei* Mohrig & Menzel, 1990 [El Ouazzani et al., 2019: 288], *Bradysia regularis* (Lengersdorf, 1934) [El Ouazzani et al., 2019: 280], *Epidapus atomarius* (De Geer, 1778) [El Ouazzani et al., 2019: 284, Fig. 5A–D] and *Sciara flavimana* Zetterstedt, 1851 [El Ouazzani et al., 2019: 288, Fig. 8A–D]. Other changes have concerned corrections to nomenclature and synonyms (Frank Menzel, pers. comm.) for one species cited in the first checklist *Bradysia lucida* [misidentified as *Bradysia nigrispina* Menzel, 2006 in El Ouazzani et al. (2019): 288], as well as for some genera such as *Hirtipennia parcepilosa* [as *Leptosciarella parcepilosa* in El Ouazzani et al. (2019): 284] and *Hirtipennia tomentosa* [as *Leptosciarella tomentosa* in El Ouazzani et al. (2019): 284]. An omitted species (*Sciara hemerobioides* recorded by Becker & Stein (1913) was missing in the first inventory established by El Ouazzani et al. (2019) and is added in this updated checklist. Following all these changes, the total of sciarid species recorded till now in Morocco is 65.

The distribution of the recorded species shows a clear difference between the different biographical areas. Thus, the High Atlas is home to the greatest specific richness (38%), of which 71% comes from the Ouirgane site, followed by the Rif region with 27%, then the Atlantic Plain, Middle Atlas, and Anti-Atlas with a fair specific richness (11%), and finally Eastern Morocco which only hosts 2% of the species richness (Fig. 66). These results reflect the important biodiversity in the region of Al Haouz and Midelt (High Atlas) in sciarid fauna since, although few stations were surveyed (14% of the prospected sites), the number of species recorded in this region of Morocco is significant compared to other biogeographical areas. About the number of the surveyed sites, the Rif is the only region that has benefited from the maximum number of investigations (74% of sites), however the number of species recorded is less than the High Atlas (Fig. 67). For the other regions, the recorded results clearly reflect the limited investigations.

The 65 species that were mapped in this study included 20 species that were only found in the High Atlas, and 10 species collected only in the Rif (Table 1). *Corynoptera saccata*, *Corynoptera semipedestris*, and *Scatopsciara maroccoensis* were only collected in the Anti-Atlas, while *Bradysia alpicola* and *Corynoptera stipidaria* were exclusively reported from the Middle Atlas. It is worth highlighting that only four species *Bradysia trivittata*, *Scatopsciara* (*Scatopsciara*) *atomaria*, *Scatopsciara* (*Scatopsciara*) *vitripennis*, *Scatopsciara* (*Xenopygina*) *subarmata* were widely spread and common in the different biogeographical areas except for Eastern Morocco (Table 1). Some genera such as *Corynoptera* and *Scatopsciara* were widely distributed through the country and recorded from the six biogeographical areas or almost from all of them except in Eastern Morocco such as the genus Bradysia, while others such as *Lycoriella* and *Pseudolycoriella*were moderately spread through those areas Other genera were only recorded from the Atlasic domain such as *Schwenckfeldina*, or exclusively collected from one region like the genus *Hirtipennia*, which is represented by two species, *Hirtipennia parcpilosa* and *Hirtipennia tomentosa*, captured in the Atlantic Plain, the genus *Leptosciarella*, collected strictly in the High Atlas, and the genus *Sciara* which has been only reported from the Rif.

Table 1
Distribution of Sciaridae according to the biogeographical areas of Morocco

Species	Rif	Eastern Morocco	Atlantic Plain	Middle Atlas	High Atlas	Anti–Atlas
Bradysia Winnertz, 1867						
Bradysia alpicola (Winnertz, 1867)	–	–	–	+	–	–
Bradysia bulbigera Mohrig & Kauschke, 1994	+	–	–	–	+	–
Bradysia cavernicola Mohrig & Eckert, 1999	–	–	–	–	+	–
Bradysia cinerascens (Grzegorzek, 1884)	+	–	–	+	–	–
Bradysia crinita Mohrig, 1992	+	–	–	–	–	–
Bradysia fenestralis (Zetterstedt, 1838)	+	–	–	–	–	–
Bradysia nitidicollis (Meigen, 1818)	+	–	–	–	–	–
Bradysia flavipila Tuomikoski, 1960	–	–	–	–	+	–
Bradysia iberiana Rudzinski & Baumjohann, 2009	–	–	–	–	+	–
Bradysia lucichaeta Mohrig & Krivosheina, 1989	–	–	–	–	–	+
Bradysia lucida Mohrig & Mamaev, 1989	–	–	–	–	+	–
Bradysia mediterranea Mohrig & Menzel, 1992	–	–	–	–	+	+
Bradysia pectoralis (Staeger, 1840)	–	–	–	+	+	–
Bradysia placida (Winnertz, 1867)	–	–	–	–	+	–
Bradysia promissa Mohrig & Röschmann, 1999	+	–	–	–	–	–
Bradysia reflexa Tuomikoski, 1960	–	–	–	–	+	–
Bradysia ruginosa Mohrig, 1994	+	–	–	–	+	–
Bradysia santorina Mohrig & Menzel, 1992	–	–	–	–	+	+
Bradysia scabricornis Tuomikoski, 1960	+	–	–	–	+	–
Bradysia subrufescens Mohrig & Krivosheina, 1989	–	–	–	–	+	–
Bradysia subsantorina Mohrig & Kauschke, 1997	–	–	–	–	+	–
Bradysia tilicola (Loew, 1850)	+	–	–	+	+	–
Bradysia transitata Rudzinski & Baumjohann, 2013	+	–	+	–	–	–
Bradysia trivittata (Staeger, 1840)	+	–	+	+	+	+
Bradysia vagans (Winnertz, 1868)	+	–	–	–	+	–
Bradysia xenoreflexa Mohrig & Menzel, 1993	+	–	+	–	–	–
Bradysiopsis Tuomikoski, 1960						
Bradysiopsis vittata (Meigen, 1830)	–	–	–	–	+	–
Camptochaeta Hippa & Vilkamaa, 1994						
Camptochaeta jeskei (Mohrig & Röschmann, 1993)	–	–	–	–	+	–
Corynoptera Winnertz, 1867						
Corynoptera andalusica Hippa, Vilkamaa & Heller, 2010.	+	–	–	+	+	–
Corynoptera bicuspidata (Lengersdorf, 1926)	–	–	–	+	+	–
Corynoptera bispinulosa Mohrig & Dimitrova, 1992	–	+	–	–	–	–
Corynoptera caesula Menzel, 2004	+	–	+	–	–	–
Corynoptera cincinnata Mohrig & Blasco-Zumeta, 1996	–	–	–	+	+	–
Corynoptera dentiforceps (Bukowski & Lengersdorf, 1936)	–	–	–	–	+	–
Corynoptera deserta Heller & Menzel, 2006	–	–	–	–	+	–
Corynoptera fatigans (Johannsen, 1912)	–	–	–	–	+	–
Corynoptera gemina (Hippa & Vilkamaa, 1994)	–	–	–	–	+	–
Corynoptera globiformis (Frey, 1945)	+	–	–	–	–	–
Corynoptera hemiacantha Mohrig & Mamaev, 1992	–	–	–	–	+	–
Corynoptera iberica Hippa, Vilkamaa & Heller, 2010	+	–	+	–	–	+
Corynoptera inclinata Hippa, Vilkamaa & Heller, 2010	–	–	–	–	+	–

Species	Rif	Eastern Morocco	Atlantic Plain	Middle Atlas	High Atlas	Anti–Atlas
Corynoptera irmgardis (Lengersdorf, 1930)	–	–	–	–	+	–
Corynoptera postglobiformis Mohrig, 1993	+	–	–	–	+	–
Corynoptera praeparvula Mohrig & Krivosheina, 1983	–	–	–	–	+	–
Corynoptera saccata Tuomikoski, 1960	–	–	–	–	–	+
Corynoptera semipedestris Mohrig & Blasco-Zumeta, 1996	–	–	–	–	–	+
Corynoptera spiciceps Hippa, Vilkamaa & Heller, 2010	–	–	–	–	+	–
Corynoptera stipidaria Mohrig, 1994	–	–	–	+	–	–
Corynoptera subcavipes Menzel & Smith, 2007	+	–	–	–	–	–
Corynoptera subparvula Tuomikoski, 1960	–	–	–	–	+	–
Hirtipennia Mohrig & Menzel, 1997						
Hirtipennia parcepilosa (Strobl, 1900)	–	–	+	–	–	–
Hirtipennia tomentosa Mohrig & Kauschke, 199400	–	–	+	–	–	–
Leptosciarella Tuomikoski, 1960						
Leptosciarella dives (Johannsen, 1912)	–	–	–	–	+	–
Leptosciarella subviatica Mohrig & Menzel, 1997	–	–	–	–	+	–
Lycoriella Frey, 1942						
Lycoriella agraria (Felt, 1898)	+	–	–	–	–	–
Lycoriella sativae (Johannsen, 1912)	+	–	+	–	+	–
Pseudolycoriella Menzel & Mohrig, 1998						
Pseudolycoriella morenae (Strobl, 1900)	+	+	–	–	+	–
Scatopsciara Edwards, 1927						
Scatopsciara (*Scatopsciara*) *atomaria* (Zetterstedt, 1851)	+	–	+	+	+	+
Scatopsiara (*Scatopsciara*) *nana* (Winnertz, 1871)	+	–	–	–	+	–
Scatopsciara (*Scatopsciara*) *vitripennis* (Meigen, 1818)	+	–	+	+	+	+
Scatopsciara (*Xenopygina*) *curvilinea* (Lengersdorf, 1934)	–	–	+	–	+	+
Scatopsciara (*Xenopygina*) *maroccoensis* (Mohrig & Jaschhof, 1997)	–	–	–	–	–	+
Scatopsciara (*Xenopygina*) *subarmata* Mohrig & Mamaev, 1983	+	–	+	+	+	+
Schwenckfeldina Frey, 1942						
Schwenckfeldina carbonaria (Meigen, 1830)	–	–	–	+	+	–
Sciara Meigen, 1803						
Sciara hemerobioides (Scopoli, 1763)	+	–	–	–	–	–

Note: (+) presence; (–) absence.

The comparison of the number of species that have been recorded in the protected areas (National Park, Project of Natural Park, Sites of Biological and Ecological Interest) (Table 2) compared to those reported in non-protected areas shows unexpectedly in the case of our study that the protected areas include less diversity (35%) compared to the unprotected areas which host more diversity in sciarid fauna (65%, Fig. 68). This result is probably due to the scarcity of investigations conducted in the protected areas. Indeed, only 15% of the recorded species are reported from the National Park of Talassemtane and 10% from the Project of Natural Park of Bouhachem (Fig. 69). The Site of Biological and Ecological Interest of Beni Snassen and the National Park of High Atlas Oriental, for their part, only shelter 4% and 3% of the species. The only park with a significant sciarid population is the National Park of Toubkal which is home to 68% of the recorded species.

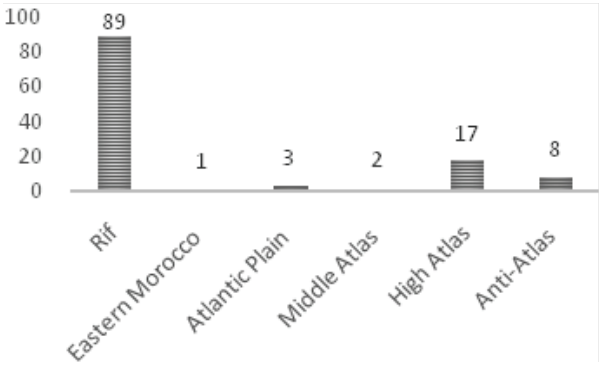

Fig. 67. Number of sites surveyed in each biogeographical area

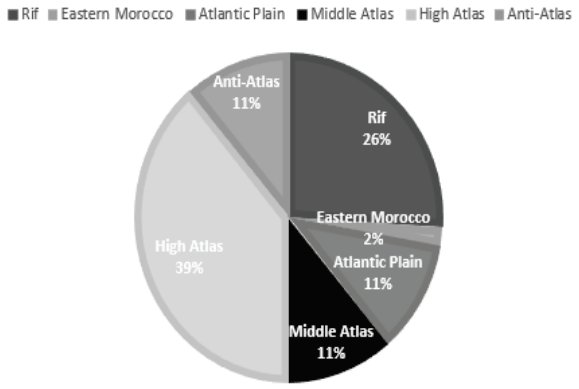

Fig. 66. Distribution of species between biogeographical areas

From an ecological point of view, the surveyed sites spread across the biogeographical areas of Morocco represent different biotopes offering favourable conditions for the development of Sciaridae, where each species is distributed according to its ecological preferences in its suitable habitat, namely forests, aquatic environments, steppes, but also in the anthropogenic ecosystems, notably the crop fields. Forests seem to harbour many sciarid species, followed by crop fields and finally the aquatic habitats. The steppes seem less suitable for the development of this fauna.

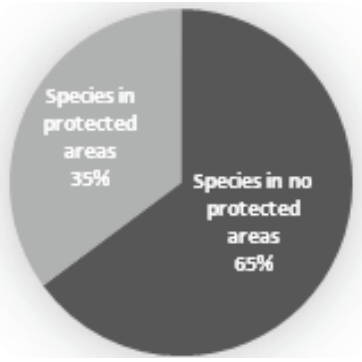

Fig. 68. Distribution of sciarid species in protected and non-protected areas

On the other hand, we noticed a remarkable difference in the altitudinal requirements which can range from 1 m for certain species up to 2254 m for others with the possibility that a species can live at a wide range of altitudes like *Lycoriella sativae*, which has been found at 4 m and 1593 m, *Scatopsiara nana*, which has been found between 20 to 1949 m, and *Scatopsciara atomaria*, found from 23 to 2254 m. The analysis of the affinities with respect to the altitudinal range of the 65 recorded species leads us to deduce that this family of Diptera has a clear preference for

medium altitudes ranging from 500 to 1000 m (Fig. 70), less preference for altitudes ranging from 0 to 500 m and from 1000 to 1500 m, and becomes more rare at altitudes ranging from 1500 to 2254 m, where we recorded the highest altitude for Sciaridae. The chorological survey of the recorded species (Fig. 71) revealed that 39 species (60%) are common in Europe, 10 species (15%) have Holarctic distribution, 9 species (13%) are Mediterranean, 6 species (9%) are Cosmopolitan, and 2 species (3%) have Palaearctic distribution.

Table 2
Distribution of species according to protected areas

Species	National Park of Talassemtane	Project of Natural Park of Bouhachem	Site of Biological and Ecological Interest of Beni Snassen	National Park of High Atlas Oriental	National Park of Toubkal
Bradysia bulbigera	+	–	–	–	+
B. cavernicola	–	–	–	–	+
B. nitidicollis	–	+	–	–	–
B. flavipila	–	–	–	–	+
B. iberiana	–	–	–	–	+
B. mediterranea	–	–	–	–	+
B. lucida	–	–	–	–	+
B. pectoralis	–	–	–	–	+
B. placida	–	–	–	–	+
B. promissa	–	+	–	–	–
B. reflexa	–	–	–	–	+
B. ruginosa	+	–	–	–	+
B. scabricornis	+	–	–	–	+
B. subrufescens	–	–	–	–	+
B. subsantorina	–	–	–	–	+
B. tilicola	–	–	–	–	+
B. transitata	–	+	–	–	–
B. trivittata	–	–	–	–	+
B. vagans	–	–	–	–	+
Bradysiopsis vittata	–	–	–	–	+
Camptochaeta jeskei	–	–	–	–	+
Corynoptera andalusica	–	–	–	–	+
C. bicuspidate	–	–	–	–	+
C. bispinulosa	–	–	+	–	–
C. cincinnata	–	–	–	–	+
C. dentiforceps	–	–	–	–	+
C. deserta	–	–	–	–	+
C. fatigans	–	–	–	–	+
C. gemina	–	–	–	–	+
C. globiformis	+	–	–	–	–
C. hemiacantha	–	–	–	–	+
C. iberica	–	+	–	–	–
C. inclinata	–	–	–	–	+
C. irmgardis	–	–	–	–	+
C. postglobiformis	+	–	–	–	+
C. praeparvula	–	–	–	–	+
C. spiciceps	–	–	–	–	+
C. subcavipes	+	–	–	–	–
C. subparvula	–	–	–	–	+
Leptosciarella dives	–	–	–	–	+
L. subviatica	–	–	–	–	+
Lycoriella sativae	–	–	–	–	+
Pseudolycoriella morenae	+	–	+	–	+
Scatopsciara (*Scatopsciara*) *atomaria*	+	+	–	+	+
S. (*S.*) *nana*	–	–	–	+	+
S. (*S.*) *vitripennis*	+	+	–	–	+
S. (*Xenopygina*) *curvilinea*	–	–	–	–	+
S. (*X.*) *subarmata*	–	–	–	–	+

Note: (+) presence; (–) absence.

As a result of our work, it appears that among the 65 species recorded in the country, some species showed synanthropic attraction. Thus, a total of 18 species have been collected from crops (Table 3), and could be considered as potential crop pests, since damage was observed on some crops during our surveys. However, further studies are needed to decide on the pest aspect of these species.

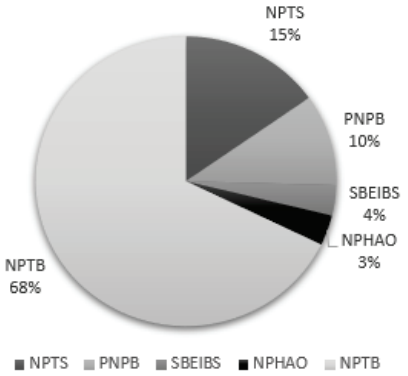

Fig. 69. Distribution of sciarid species between protected areas

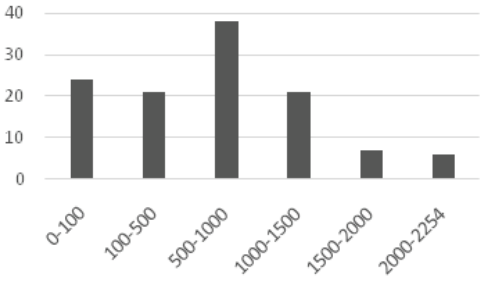

Fig. 70. Altitudinal preference of Moroccan sciarid species

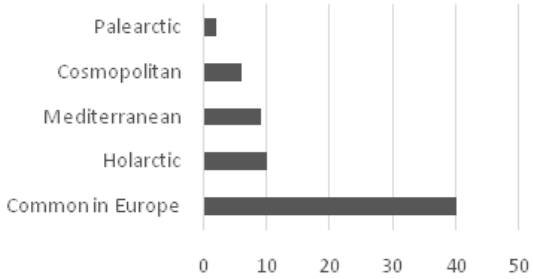

Fig. 71. Chorology of Moroccan sciarids

Table 3
List of species of Sciaridae collected in cultures

Types of crops	Crops	Species
Greenhouses	Rosaceae: strawberries	*Bradysia transitata*, *B. trivittata*, *B. xenoreflexa*, *Lycoriella sativae*, *Scatopsciara gracilipennis*, *S. subarmata*
Fruit trees	Rosaceae: almond trees	*Bradysia placida*, *B. santorina*, *B. scabricornis*, *B. tilicola*, *B. trivittata*, *Camptochaeta jeskei*
	Arecaceae: date palms	*Bradysia santorina*, *Corynoptera saccata*, *C. semipedestris*
Crop fields	Asteraceae: common sunflower	*Scatopsciara atomaria*
	Fabaceae: broad bean	*Bradysia ruginosa*
	Liliaceae: onion	*Bradysia scabricornis*, *Bradysiopsis vittata*
	Poaceae: wheat	*Scatopsciara atomaria*, *S. curvilinea*
	Solanaceae: Potato	*Scatopsciara atomaria*, *Corynoptera praeparvula*

Our surveys in the greenhouses of strawberries in Larache region confirm the presence of five species of Sciaridae belonging to 3 genera: *Bradysia* (*B. transitata*, *B. trivittata*, *B. xenoreflexa*), *Lycoriella* (*L. sativae*) and *Scatopsciara* (*S. gracilipennis*, *S. subarmata*). However, an equivalent survey conducted in tomato greenhouses in the Oriental region, banana greenhouses in Mnasra, asparagus greenhouses in Sidi yahia du Gharb, blueberry greenhouses in Sidi Slimane, pepper greenhouses in Ait Baha revealed the total absence of damage as farmers use insecticides and

other anti-insect tricks. On the fruit trees examined, nine species belonging to three genera were recorded. Five species of *Bradysia* (*B. placida*, *B. santorina*, *B. scabricornis*, *B. tilicola*, *B. trivittata*), and one species of *Camptochaeta* (*C. jeskei*) were found on almond trees (Rosaceae) at Ouirgane, and one species of *Bradysia* (*B. santorina*), and two species of *Corynoptera* (*C. saccata*, *C. semipedestris*) on date palms (Arecaceae) in Ouarzazate and Guelmim (Table 3). Collections from agricultural fields resulted in the recording of *Scatopsciara atomaria* at Amzmiz from a common sunflower (Asteraceae) field, at a wheat (Poaceae) field, on which *Scatopsciara curvilinea* was also found, and at a potato field (Solanaceae) accompanied by *Corynoptera praeparvula* at Gerifodene (Table 3). In the same region (Amzmiz), we noted the presence of *Bradysia ruginosa* in a broad bean crop field (Fabaceae), and in Setti Fatma (localité globale) we noted the presence of *Bradysia scabricornis* and *Bradysiopsis vittata* in two onion fields (Liliaceae) (Table 3).

According to the literature, *Lycoriella sativae* has been recorded in four regions of the world (Holarctic, Nearctic, Realm of Australasia, Palaearctic) as a common and widespread economic pest species, feeding on live plants and fungi in nurseries, greenhouses, mushroom houses and houses (pot cultures) (Broadley et al., 2018). Concerning *Bradysia tilicola*, it is widespread in the Holarctic Region (Broadley et al., 2018), and strongly associated with humans, as its larvae live in the soil of plant pots in homes, in greenhouses and in mushroom cultivations (Mohrig et al., 2012). It is also present in rotting onions, and in agricultural land (Menzel et al., 2006).

Among species of sciarids which show synanthropic attraction and have been recorded in anthropogenic habitats is *Scatopsciara atomaria*, which is ubiquitous in areas of anthropogenic influence (Mohrig et al., 2012). It was found in the countryside near the rotting remains of a walnut branch, which may indicate trophic links of their larvae with rotting wood (Babytskiy et al., 2022). From rotten wood, harvested in the countryside, male imagoes of *Bradysia placida* were reared from the larvae (Babytskiy et al., 2022). The other species such as *B. ruginosa*, *B. santorina*, *B. scabricornis*, *B. transitata*, *B. trivittata*, *B. xenoreflexa*, *Bradysiopsis vittata*, *C. jeskei*, *C. praeparvula*, *C. saccata*, *C. semipedestris*, *S. atomaria*, *S. curvilinea*, *S. subarmata*, found in agricultural areas based on our study, are not yet described as pests anywhere to our knowledge, and may be potential candidates for the status as crop pests in Morocco – further studies are required to clarify this.

Among the list of species mapped in this atlas, two species are listed as pests in other parts of the world and can also be crop pests in Morocco, while in our work they have not been collected in the cultivated areas. One of these is *Bradysia fenestralis*, which has been reported as a pest of tomatoes and cucumbers and was found in a greenhouse in the Altay and in a vegetable store in Kazakhstan (Gerbachevskaja, 1963, 1969; Komarova, 2003; Sataeva, 2006), whereas in Morocco, it has been recorded in an urban forest dominated by *Pinus halepensis*, the second species is *Corynoptera dentiforceps*, which was found in the countryside near the rotting remains of a walnut tree branch in Ukraine, which may indicate trophic links of their larvae with decaying wood (Babytskiy et al., 2022), while in Morocco it has been collected in a thuriferous forest at Ouirgane. The last species, *Lycoriella agraria*, which was listed among the eight common pest species, feeding on live plants and fungi in nurseries, greenhouses, mushroom houses, and houses with plant pots in the Holarctic region (Broadley et al., 2018), was found in a pine forest (*Pinus halepensis*) in our country.

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