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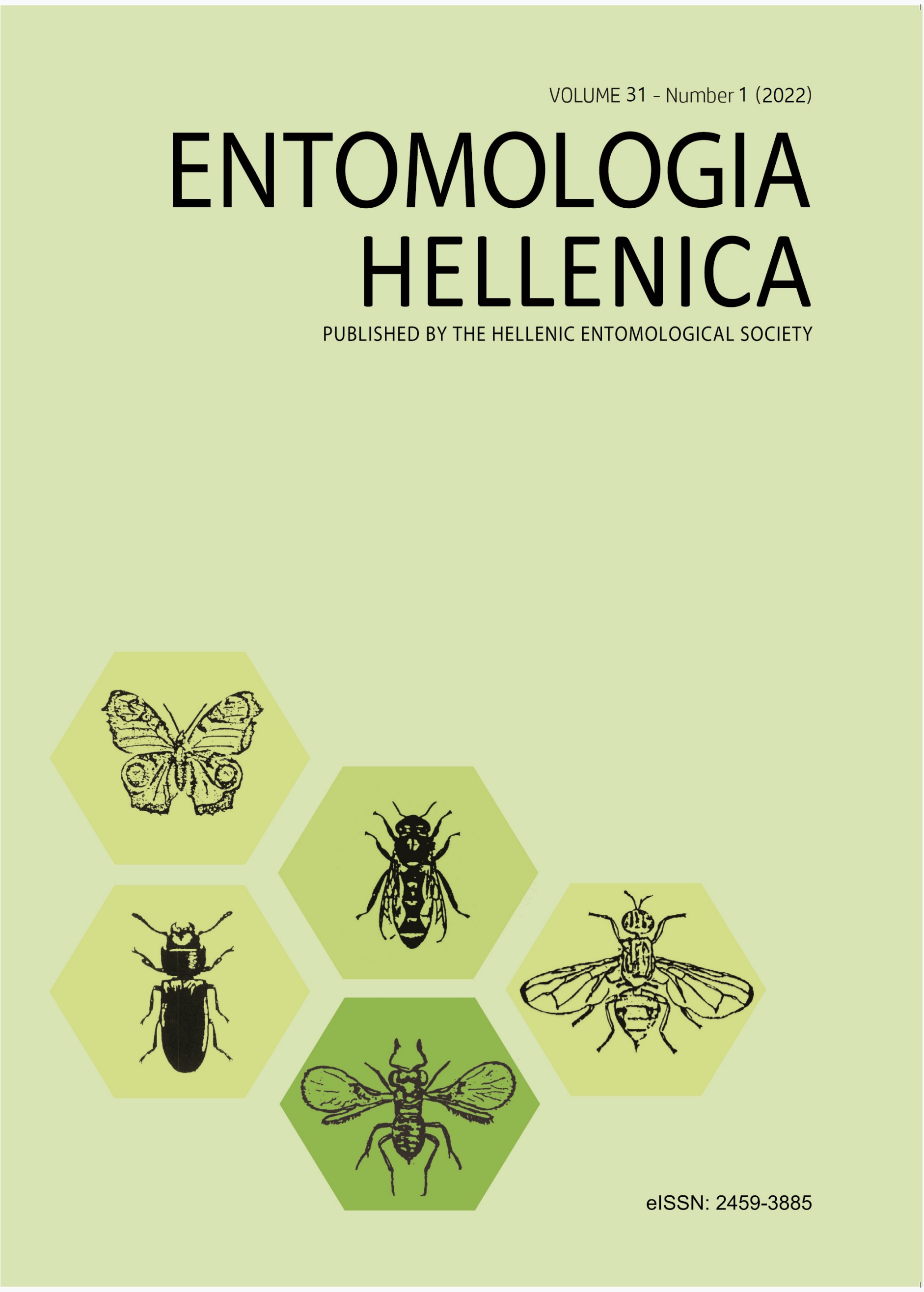

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A review of the oriental hornet *Vespa orientalis* (Hymenoptera: Vespidae: Vespinae) Linnaeus, 1771 distribution in the islands of Greece

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ABSTRACT

Records of *Vespa orientalis* Linnaeus, 1771 for 28 islands of Greece are given: in 18 islands (Agistri, Euboea, Folegandros, Kalamos, Kalymnos, Karpathos, Kos, Leros, Lefkada, Naxos, Nisyros, Paros, Patmos, Pserimos, Telendos, Tilos, Tinos, Sifnos), these occurrences are the first record of the species for them. The total number of Greek islands in which *V. orientalis* is known becomes 33.

KEY WORDS: distribution, faunistics, Greek islands, wasp.

Introduction

The genus *Vespa* Linnaeus, 1758 consists of 22 species of large eusocial wasps, most of which with a distribution restricted to Asia (Carpenter & Kojima 1997; Archer 2012; Perrard et al. 2013). In Europe only two species are native (Gusenleitner 2013), but during the recent years two alien species have been added in the continent (see Castro 2019; Laurino et al. 2019).

In Greece, the genus is represented by two species native in Europe: *Vespa crabro* Linnaeus, 1758 and *V. orientalis* Linnaeus, 1771 (Gusenleitner 2013). The latter species is originally distributed from southern Europe and northern Africa (up to the Horn of Africa in the south), across the Middle East to India, Nepal, central Asia and western China (Carpenter & Kojima, 1997; Ćetković, 2004; Archer, 2012). In the recent years it has been introduced in several countries—for a summary on the current non-native distribution see Zachi & Ruicănescu (2021), Gereyes et al. (2021), Werenkraut et al. (2021) and Ceccolini (2021). A complete review of the distribution of *V. orientalis* in Greece was published by Ćetković (2004) who reported all known records from both literature sources and material examined by himself: in this work the occurrence of this hornet was reported from 15 islands, as well as from the mainland. This number appears to be a consequence of undersampling and seems to be quite inadequate to represent the real distribution of the species in the Greek islands, considering that this country has some thousands of islands of which about one hundred extend over areas of at least 5 km^2 (https://www.statistics.gr).

Herein, new records of *V. orientalis* from several Greek islands are reported and an updated list of the islands of Greece in which the species is known is provided.

Materials and Methods

The examined material originates from the web platform iNaturalist (www.inaturalist.org).

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Specimens of *Vespa orientalis* can easily be identified by photos because of the habitus of the species, which is well recognizable by its entirely largely reddish-brown colour with yellow markings on the face and the presence of a yellow band across the gaster (Archer 2012; Smith-Pardo et al. 2020).

For each site, the following information is given: locality, geographical coordinates, date, number of specimens, photo authority. For each locality, geographical coordinates are in decimal degrees (datum WGS84). Number of decimals varies according to the accuracy of the data. Uncertainty (abbreviated as un.) of the data (in metres) was indicated according to the point-radius method (Wieczorek et al. 2004). Each record was identified or confirmed by the author.

Material examined

Ionian Islands:

Cephalonia: Epar. Od. Argostoliou, 38.205341° N 20.488084° E (un. not recorded), 8.VIII.2021, 1 ex., photo by Mark Carter; near Skala, 38.085194° N 20.799897° E (un. = 22 m), 2.VII.2020, 1 ex., photo by "paulie_m_smith".

Corfu: Old Fortress, 39.623417° N 19.929603° E (un. = 251 m), 3.X.2020, 1 ex., photo by "Sotiria Mb".

Kalamos: near Kalamos, 38.631022° N 20.941387° E (un. = 5 m), 11.VII.2019, 1 ex., photo by "tikitu"

Lefkada: near Kariotes, 38.80303° N 20.72695° E (un. = 2 m), 2.IX.2019, 1 ex., photo by Nikolaos Papageorgiou; Kariotes, 38.796111° N 20.718158° E (un. = 24 m), 19.XI.2018, 1 ex., photo by Nikolaos Papageorgiou; Katouna, 38.782749° N 20.707281° (un. = 5 m), 24.VIII.2019, 1 ex., photo by "pieman"; Kallithea, 38.7047° N 20.709074° E (un. = 2 m), 10.VI.2019, 1 ex., photo by Nikolaos Papageorgiou; Vassiliki, 38.629353° N 20.608667° E (un. = 91 m), 29.X.2021, 1 ex., photo by Alexandra Haritou.

Zakynthos: Laperda Beach, 37.856068° N 20.746983° E (un. not recorded), 2.VIII.2020, 1 ex., photo by "Věra Sz."; Stasi Leoforiou, 37.718478° N 20.858282° E (un. = 190 m), 26.IX.2021, 1 ex., photo by Royce Cumming.

Saronic Islands:

Agistri: Dragonera Beach, 37.696955° N 23.33197° E (un. = 5 m), 7.VIII.2019, 1 ex., photo by Jonathan Riedel.

Euboea and surrounding islands

Euboea: near Petries, 38.410807° N 24.186692° E (un. = 526 m), 15.VIII.2019, 1 ex., photo by Mist Mask; idem, 38.410949° N 24.193677° E (un. = 24 m), 17.VI.2020, 1 ex., photo by Fabrizio Benedetti.

Aegean Islands:

Dodecanese

Folegandros: Karavostasis, 36.615377° N 24.949651° E (un. = 14 m), 22.VIII.2018, 1 ex., photo by Nick Leggatt.

Kalymnos: Emporeios, 37.04657° N 26.927795° E (un. = 24 m), 4.X.2021, 1 ex., photo by "spinyurchin"; between Emporeios and Church Saint Panormitis, 37.043622° N 26.944581° E (un. not recorded), 1.X.2021, 1 ex., photo by Calliope Hummer; near Arginontas Beach, 37.012499° N 26.974628° E (un. = 149 m), 4.VIII.2020, 1 ex., photo by Ioannis Gkourogiannis.

Karpathos: 35.575949° N 27.14014° E (un. = 526 m), 15.VII.2021, 1 ex. (Fig. 2), photo by Benoît Segerer.

Kos: Tigaki, 36.883858° N 27.179944° E (un. = 977 m), 17.XII.2019, 1 ex., photo by Harrys Reisis; Igrotopos - Akti Psalidiou, 36.885837° N 27.340292° E (un. not recorded), 5.X.2019, 1 ex., photo by Almut Martens; near Agios Fokas Beach, 36.859731° N 27.34821° E (un. = 2 m), 7.VII.2020, 1 ex., photo by "mnauky"; near Chapel St John Perigialiti, 36.832264° N 27.06107° E (un. = 8 m), 23.IX.2019, 1 ex., photo by "manroth"; Kardámaina, 36.774457°N 27.133121° E (un. = 35 m), 16.VIII.2019, 1 ex., photo by "anlias"; Kefalos, 36.744239° N 26.967029° E (un. = 77 m), 1.V.2021, 1 ex., photo by "expatp".

FIG. 1: Specimen of *Vespa orientalis* from Karpathos Island (photo by Benoît Segerer).

<u>Leros</u>: Agia Marina, 37.149375° N 26.86138° E (un. = 10 m), 11.IX.2021, 1 ex., photo by Chrystèle Bréat.

<u>Lesbos</u>: Mithymna, 39.368931° N 26.168726° E (un. = 4 m), 20.VIII.2021, 1 ex., photo by Savvas Zafeiriou; near Skala Kallonis, 39.202462° N 26.16703° E (un. = 1650 m), 17.V.2006, 1 ex., photo by Paul Cools; Skala Kallonis, 39.207571° N 26.203773° E (un. = 65 m), 1 ex., 3.VII.2019, photo by "hassel"; Pirgi Thermis, 39.175626° N 26.504504° E (un. = 8 m), 21.VII.2021, 1 ex., photo by Savvas Zafeiriou; idem, 39.175336° N 26.503779° E (un. = 31 m), 19.VIII.2019, 1 ex., photo by Savvas Zafeiriou; idem, 39.17567° N 26.502881° E (un. = 31 m), 13.VIII.2019, 1 ex., photo by Savvas Zafeiriou; idem, 39.173344° N 26.503018° E (un. = 644 m), 18.VIII.2018, 1 ex., photo by Savvas Zafeiriou; idem, 39.172557° N 26.504195° E (un. = 15 m), 19.V.2020, 1 ex., photo by Savvas Zafeiriou.

<u>Milos</u>: Agathia Beach, 36.72726° N 24.341413° E (un. = 4 m), 27.VIII.2018, 1 ex., photo by "g-natural".

<u>Naxos</u>: surroundings of Chalki, 37.064632° N 25.482313° E (un. = 5850 m), 30.IX.2021, 1 ex., photo by "dementieva"; Kastraki, 37.005159° N 25.397018° E (un. = 5 m), 12.VIII.2020, 1 ex., photo by "georgedros"; Pyrgaki Beach, 36.977015° N 25.396956° E (un. = 9 m), 10.IX.2018, 1 ex., photo by Nick Leggatt.

<u>Nisyros</u>: Emporios, 36.603213° N 27.177195° E (un. not recorded), 23.VIII.2019, 1 ex. (Fig. 3), photo by Giorgos Nikolakakis; near Stefanos Crater, 36.579618° N 27.167563° E (un. not recorded), 28.IX.2019, 1 ex., photo by Almut Martens.

FIG. 2: Specimen of *Vespa orientalis* from Nisyros Island (photo by Giorgos Nikolakakis).

<u>Paros</u>: Paros Park near Monastery of St. John's of Deti, 37.146605° N 25.224112° E (un. = 22 m), 20.VII.2021, 1 ex., photo by "mammal"; Naousa, 37.120594° N 25.230848° E (un. = 2 m), 1.VII.2019, 1 ex., photo by "mammal"; Parikia, 37.085643° N 25.148832° E (un. = 1350 m), 6.X.2020, 1 ex., photo by Micha Baum.

<u>Patmos</u>: northern part of the island, 37.36662° N 26.575962° E (un. = 5 m), 17.VIII.2021, 1 ex., photo by "elisareddavid".

Pserimos: Avlakia, 36.934553° N 27.13725° E (un. = 407 m), 29.VII.2020, 1 ex., photo by Ioannes Marnierakis.

Rhodes: Rhodes city, Nihori, 36.446896° N 28.226871° E (un. not recorded), 18.IX.2021, 1 ex., photo by "robayne"; idem, Monte Smith, 36.44144° N 28.220266° E (un. = 2 m), 30.VI.2020, 1 ex., photo by Eleftherios Katsillis; idem, 36.439472° N 28.217107° E (un. not recorded), 1.V.2021, 1 ex., photo by Eleftherios Katsillis; idem, Rodini Park, 36.426833° N 28.219918° E (un. = 124 m), 16.VI.2020, 1 ex., photo by Eleftherios Katsillis; Theologos, 36.38583° N 28.033966° E (un. not recorded), 22.IX.2021, 1 ex., photo by "Jochen"; near Kathara Bay, 36.320842° N 28.203558° E (un. = 5 m), 17.VIII.2019, 1 ex., photo by "elliotl8on"; Kolympia, 36.259847° N 28.162959° E (un. = 30 m), 22.VIII.2017, 1 ex., photo by "d7p"; idem, 36.253392° N 28.1713° E (un. not recorded), 22.VIII.2021, 1 ex., photo by Žygimantas Valiuška; idem, 36.249925° N 28.169163° E (un. = 20 m), 4.X.2020, 1 ex., photo by "rickyn"; near Seven Springs Waterfall, 36.254247° N 28.115785° E (un. = 4 m), 28.VIII.2019, 1 ex., photo by Stefano Aguzzi; near Agia Agathi Monastery, 36.173412° N 28.098864° E (un. not recorded), 5.X.2021, 1 ex., photo by "petroc"; Limni Fragmatos Gadoura, 36.168563° N 27.970317° E (un. not recorded), 29.VIII.2021, 1 ex., photo by Giacomo Assandri; idem, 36.157498° N 27.997815° E (un. not recorded), 27.VIII.2021, 1 ex., photo by Giacomo Assandri; Lindos, 36.091814° N 28.088476° E (un. = 178 m), 13.VIII.2020, 1 ex., photo by "tamma"; idem, 36.088272° N 28.087898° E (un. not recorded), 11.VII.2021, 1 ex., photo by "cozza_dt".

Samos: near Paleo Karlovasi, 37.785912° N 26.686138° E (un. = 10 m), 3.XI.2021, 1 ex., photo by "deleuze"; Kokkari, 37.77322° N 26.879496° E (un. = 598 m), 26.VII.2019, at least 4 exx., photo by "ellavg"; near Kampos Marathokampos, 37.716602° N 26.654806° E (un. = 243 m), 7.X.2021, 1 ex., photo by "phup"; Ormos Marathokampos, 37.710462° N 26.704823° E (un. = 116 m), 10.VIII.2021, 1 ex., photo by "vydysh".

Serifos: Moni Taxiarchon, 37.19182° N 24.509175° E (un. = 10 m), 4.IX.2021, 1 ex., photo by "naturaliste".

Sifnos: Exambela, 36.974124° N 24.731714° E (un. = 172 m), 22.X.2010, 2 adults and 1 larva (Fig. 1), photo by Kim Moore.

FIG. 3: Adults and larva of *Vespa orientalis* from Sifnos Island (photo by Kim Moore).

Telendos: Telendos village, 36.99817° N 26.92092° E (un. = 10 m), 12.IX.2018, 1 ex., photo by "libertyruth".

The Cyclades

Tilos: Livadia, 36.415111° N 27.384746° E (un. = 10 m), 3.IX.2016, 1 ex., photo by Magne Flåten.

Tinos: Volax, 37.592318° N 25.178175° E (un. = 337 m), 3.VIII.2021, 1 ex., photo by Ioannis Gkourogiannis.

Cretan islands

Crete: Kissamos, 35.48424° N 23.57867° E (un. = 92 m), 11.IX.2021, 1 ex., photo by "lasmalla"; near Maléme airport, 35.528938° N 23.825171° E (un. = 31 m), 8.IX.2018, 1 ex., photo by John Cree; near Gouverneto Monastery, 35.57216° N 24.133874° E (un. = 977 m), 2.XII.2020, at least 3 exx., photo by "fotis-samaritakis";

Souda, 35.466868° N 24.115777° E (un. = 24 m), 1.IX.2021, 1 ex, photo by "dirkey"; Gavalohori, 35.424256° N 24.215506° E (un. not recorded), 9.VIII.2021, 1 ex, photo by Haydn Fox; Kryonerida, 35.359987° N 24.210125° E (un. = 4 m), 25.VIII.2021, 1 ex., photo by "danp7"; Georgioupoli, 35.362798° N 24.257562° E (un. = 4 m), 4.X.2021, 1 ex., photo by "wormsy"; near Georgioupoli, 35.3548° N 24.284431° E (un. = 15 m), 29.IX.2021, 1 ex., photo by "wormsy"; Kournas Lake, 35.334658° N 24.276715° E (un. = 7 m), 9.VIII.2020, 1 ex., photo by "clemoune"; idem, 35.332163° N 24.279988° E (un. = 145 m), 28.VII.2021, 1 ex., photo by rkjakobsen"; idem, 35.331434° N 24.276198° E (un. = 725 m), 4.IX.2019, 1 ex., photo by Alister Puddifer; Agios Georgios, 35.295037° N 24.456555° E (un. = 5 m), 17.X.2020, 1 ex., photo by "sbibby117"; near Halevi Monastery, 35.344898° N 24.508403° E (un. not recorded), 1.IX.2021, 1 ex., photo by "felixf"; Vlichada, 35.396256° N 24.785499° E (un. not recorded), 25.X.2008, 1 ex, photo by Sandy Rae; Chersonissos, 35.2179° N 25.421487° E (un. = 3 m), 13.VII.2021, 1 ex., photo by Markus Döring; Plaka Beach, 35.301567° N 25.726912° E (un. not recorded), 23.VII.2018, 1 ex., photo by "eoa"; Pissidos, 35.204051° N 25.715043° E (un. = 581 m), 7.IX.2019, 1 ex., photo by "jukkajarvi"; near Kritsa, 35.16993° N 25.643743° E (un. not recorded), 6.X.2020, 1 ex., photo by Felicia Seichter; Kritsa, 35.156113° N 25.64302° E (un. = 12 m), 21.IX.2021, 1 ex., photo by "fuerchtegott"; Melisses, 35.119085° N 25.88209° E (un. not recorded), 29.IX.2020, 1 ex., photo by "fuerchtegott"; Richtis Gorge, 35.182881° N 25.986864° E (un. = 1800 m), 2.IX.2021, 1 ex., photo by Marina Roth; Piskokefalo, 35.182932° N 26.088463° E (un. = 298 m), 16.VIII.2021, 1 ex., photo by "arkim"; Hidden church, 35.208572° N 26.198578° E (un. not recorded), 17.VIII.2020, 1 ex., photo by "arkim"; near Zakros Gorge, 35.099888° N 26.242462° E (un. not recorded), 3.VIII.2021, 1 ex., photo by "hanaemori"; near Agiou Georgiou church, 35.1188° N 26.074806° E (un. not recorded), 29.VIII.2020, 1 ex., photo by "arkim"; near Handras, 35.08595° N 26.107231° E (un. not recorded), 26.VIII.2020, 1 ex., photo by "arkim"; Epar Od Kato Choriou – Sitias, 35.055294° N 25.908852° E (un. = 488 m), 17.IX.2017, 1 ex., photo by Steve Daniels; Schinokapsala, 35.052753° N 25.881606° E (un. not recorded), 24.VIII.2021, 1 ex., photo by "arkim"; near Timiou Stavrou church, 35.06328° N 25.848323° E (un. = 321 m), 13.X.2016, 1 ex., photo by Steve Daniels; Ferma, 35.017749° N 25.856795° E (un. = 15 m), 20.IX.2017, 1 ex., photo by Steve Daniels; Kalamafka, 35.075644° N 25.655486° E (un. = 1580 m), 11.IX.2020, 1 ex., photo by Josef Wirth; near Panagia Selakaniotissa, 35.089177° N 25.541505° E (un. not recorded), 4.X.2020, 1 ex., photo by Felicia Seichter; near Zaros, 35.1243° N 24.9123° E (un. not recorded), 10.X.2015, 1 ex., photo by "djhiker"; near Ampelouzos, 35.063107° N 24.947212° E (un. = 10 m), 16.VII.2019, 1 ex., photo by Emily Dent; Kouses, 35.01761° N 24.830345° E (un. = 33 m), 4.X.2018, 1 ex., photo by "Katrin"; Lentas, 34.930275° N 24.924791° E (un. not recorded), 7.X.2019, 1 ex, photo by Davide Berton; near Frati, 35.2032° N 24.4881° E (un. not recorded), 6.X.2015, 1 ex, photo by "djhiker"; Kato Moni Preveli, 35.170559° N 24.465981° E (un. not recorded), 25.IX.2019, 1 ex, photo by Davide Berton; near Kleidisi Beach, 35.174616° N 24.415306° E (un. not recorded), 10.VIII.2009, 1 ex., photo by Pavel Trhoň; Kokkina Chorafia, 35.174751° N 24.413519° E (un. not recorded), 22.IX.2021, 1 ex., photo by "petersc"; near Greleskas Observatory, 35.317717° N 23.841426° E (un. not recorded), 15.V.2017, 1 ex., photo by Pascal Dubois; near Koustogerako, 35.280925° N 23.82141° E (un. = 828 m), 7.X.2021, 1 ex., photo by "matpfalz"; Sougia, 35.249112° N 23.81162 E (un. = 96 m), 16.IX.2021, 1 ex., photo by "daxkifa"; Pelekanos, 35.23463° N

23.688736° E (un. = 23 m), 20.IX.2021, 1 ex., photo by Julian Kokott; Elafonisi (island), 35.268862° N 23.533225° E (un. = 5 m), 27.IX.2019, 1 ex., photo by "elenor"; Epar. Od. Kastelliou – Kefaliou, 35.358031° N 23.562308° E (un. = 95 m), 13.IX.2021, 1 ex., photo by "lasmalla".

Gavdos: 34.839272° N 24.089732° E (un. = 6450 m), 5.VII.2020, 1 ex., photo by Alexandros Quartarone.

The list of the Greek islands in which *V. orientalis* is known is reported in Table 1.

TABLE 1. List of the islands (in alphabetical order) in which *Vespa orientalis* is known. Islands marked with an asterisk are reported for the first time in the present work. Only references with original data are quoted.

Island	References
Agistri*	Present work
Cephalonia	Giordani Soika 1953; Ćetković 2004; Present work
Chios	Alfken et al. 1934
Corfu	Giordani Soika 1953; Present work
Crete	Giordani Soika 1953; Blüthgen & Gusenleitner 1970; Ćetković 2004; Present work
Euboea*	Present work
Folegandros*	Present work
Gavdos	Ćetković 2004; Present work
Ikaria	Alfken et al. 1934; Giordani Soika 1953
Kalamos*	Present work
Kalymnos*	Present work
Karpathos*	Present work
Kos*	Present work
Leros*	Present work
Lesbos	Alfken et al. 1934; Ćetković 2004; Present work
Lefkada*	Present work
Milos	Alfken et al. 1934; Present work
Naxos*	Present work
Nisyros*	Present work
Ophidhousa	Giordani Soika 1953
Paros*	Present work
Patmos*	Present work
Pserimos*	Present work
Rhodes	Giordani Soika 1953; Erlandsson 1974; Ćetković 2004; Present work
Telendos*	Present work
Thasos	Atanassov 1942; Ćetković 2004
Tilos*	Present work
Tinos*	Present work
Samos	Alfken et al. 1934; Giordani Soika 1953; Present work
Serifos	Alfken et al. 1934; Present work
Sifnos*	Present work
Siros	Giordani Soika 1953
Zakynthos	Giordani Soika 1953; Present work

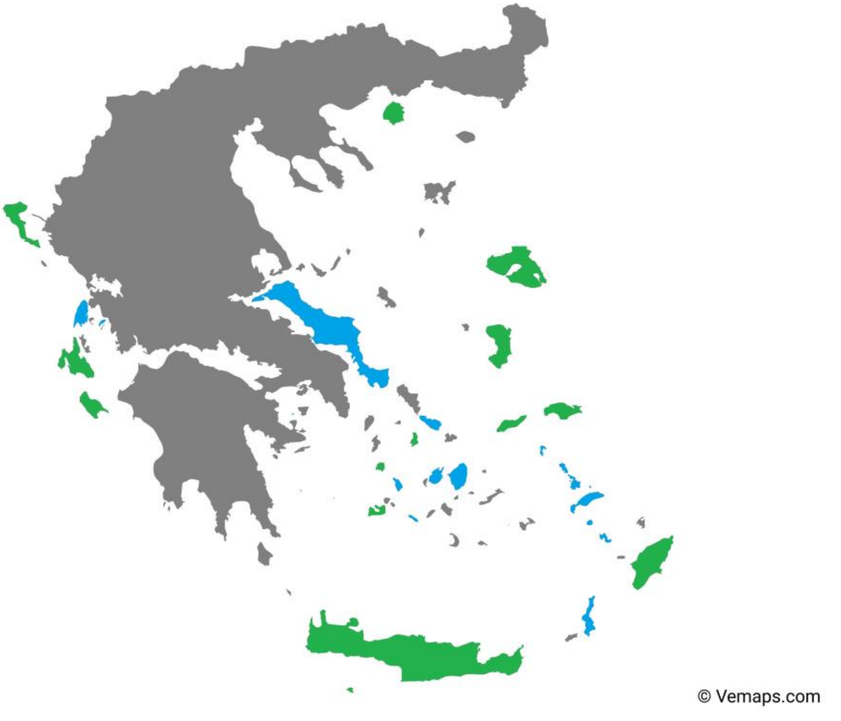

FIG. 4: Updated distribution of *Vespa orientalis* in the islands of Greece. Green colored: islands where the species was already documented in literature; blue colored: islands where the species is recorded for the first time through the present work (original map: © Vemaps.com).

Conclusions

With the present work, the occurrence of *Vespa orientalis* in 28 Greek islands is documented. This includes first records for 18 islands. Currently, also considering references sources, the number of islands of Greece in which *V. orientalis* is documented is 33, as summarized in Fig. 4 and Table 1. Therefore, the knowledge of *V. orientalis* distribution in insular Greece is now more than doubled (from 15 to 33 islands). Further research might show even more widespread presence of this highly successful overseas colonizer.

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Ανασκόπηση της παρουσίας της σφήκας *Vespa orientalis* Linnaeus, 1771 (Hymenoptera: Vespidae: Vespinae) στα νησιά της Ελλάδας

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ΠΕΡΙΛΗΨΗ

Στην παρούσα εργασία δίνονται καταγραφές της παρουσίας του είδους *Vespa orientalis* Linnaeus, 1771 από 28 νησιά της Ελλάδας, στα 18 από τα οποία (Αγκίστρι, Εύβοια, Φολέγανδρος, Κάλαμος, Κάλυμνος, Κάρπαθος, Κως, Λέρος, Λευκάδα, Νάξος, Νίσυρος, Πάρος, Πάτμος, Τελένδος, Ψέρημος, Τήνος, Σίφνος), τα περιστατικά αυτά αποτελούν πρώτες καταγραφές για την τοποθεσία. Ο συνολικός αριθμός των ελληνικών νησιών στα οποία είναι πλέον καταγεγραμμένη η παρουσία του *V. orientalis* ανέρχεται στα 33.

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First record of the genus *Scelio* (Hymenoptera: Platygastridae, Scelionidae, Scelioninae) egg parasitoids in tomato greenhouses of southeastern Algeria

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ABSTRACT

This is the first record of genus *Scelio* (Latreille, 1805) in Algeria. Within the two-year period 2019-2020, two species of *Scelio*, i.e *S. poecilopterus* (Priesner, 1951) and *S. vulgaris* (Kieffer, 1908), were collected from tomato greenhouses in El Alia and El Hadjeb regions of the Biskra province, in southeastern Algeria, using yellow pan traps, yellow bottles and Barber traps, followed by laboratory methods or preservation and identification. Photographic material and information on these species are presented and described on female specimens to expand the knowledge about the distribution and biodiversity of egg parasitoids in the country.

KEY WORDS: distribution, first record, *Scelio, Scelio poecilopterus, Scelio vulgaris,* south-eastern Algeria.

Introduction

Scelioninae is the most important subfamily of Platygastridae (Norman et al. 2019). It's a cosmopolitan taxon comprising more than 3000 species belonging to 160 genera (Masner and Lars 1989; Aguiar et al. 2013), all primary egg endoparasitoids of other insect species or spiders (Ghahari et al. 2015; Madl 2016). Because of their biology, some members contribute significantly to pest biological control (Popovici et al. 2014), such as of grasshoppers and crickets (Orthoptera), gypsy moths (*Lymantria dispar* Linnaeus), sunn pests (*Eurygaster integriceps* Puton), bedbugs (*Triatoma* spp. Laporte; *Rhodnius* spp. Stal) and horse flies (*Tabanus* spp. Linnaeus) (Samin et al. 2011; Galloway et al. 1992; Ghahari et al. 2015). Members of this large family are very diverse in appearance, with respect to the shape and size of the host egg from which they emerge: cylindrical to depressed, elongated and fusiform to short and stocky (Galloway et al. 1992; Samin et al. 2011).

In fact, parasitoid wasps of the genus *Scelio* (Latreille, 1805) are solitary and obligate parasites of Acrididae eggs in agricultural and natural habitats (Baker et al. 1996; Dangerfield et al. 2001; Yoder et al. 2009, 2014), with a parasitism rate varied from 10% to 15% (Greathead et al. 1994; Baker et al. 1996). Despite their importance, these tiny wasps have been largely ignored and are still poorly known

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in many countries due to classification difficulties (Buhl et al. 2016), as well as the difficulty in accumulating new material of these species for re-examination them, especially in the African countries (Yoder et al. 2014; Asadi-Farfar et al. 2021). Recent research shows that the genus *Scelio* (Latreille, 1805) comprises 255 valid species, among 500 species that have been estimated worldwide (Yoder et al. 2014). In the Afrotropical zone, 18 species in the pulchripennis group were reviewed by Yoder et al. in 2009; Then, 62 species were treated and classified into the groups of ernstii (12 species, 9 new), howardi (23 species, 19 new), ipomeae (6 species, 5 new), irwini (4 species, 3 new), simoni (3 new species) and walkeri (12 species, 9 new) in 2014 (Yoder et al. 2014), but the geographic range of treated species remained limited to Sub-Saharan Africa and Madagascar (Yoder et al. 2009, 2014). While the range and taxonomy of this genus in North African fauna has been poorly and sporadically studied, with the exception of rare records in Egypt, Mauritania, Mali, and Niger (Irshad et al. 1978; Yoder et al. 2014), these parasitoid wasps are previously not recorded in Algeria. So, the aim of this paper is to document and describe the first records of *Scelio* (Latreille) species in Biskra province and to create the first database of Scelioninae fauna in the country.

Materials and Methods

Study area: Sampling was carried out in the province of Biskra (34°51′01"N, 5°43′40"E) in southeastern Algerian Sahara, at two communes, El Alia (34°50'43.9332" N, 5° 44'53.5092" E) and El Hadjeb (34°48'24.3" N, 5°39'16.3" E) (Fig.1), where tomato crops (*Lycopersicon esculentum* Mill.) were cultivated in greenhouses and surrounded by palm trees. It is part of the Saharan bioclimatic stage, with an annual precipitation rate of 125 mm (maximum of 21 mm in winter and a minimum of 0 mm during the dry period) (Harrat and Moussi 2007).

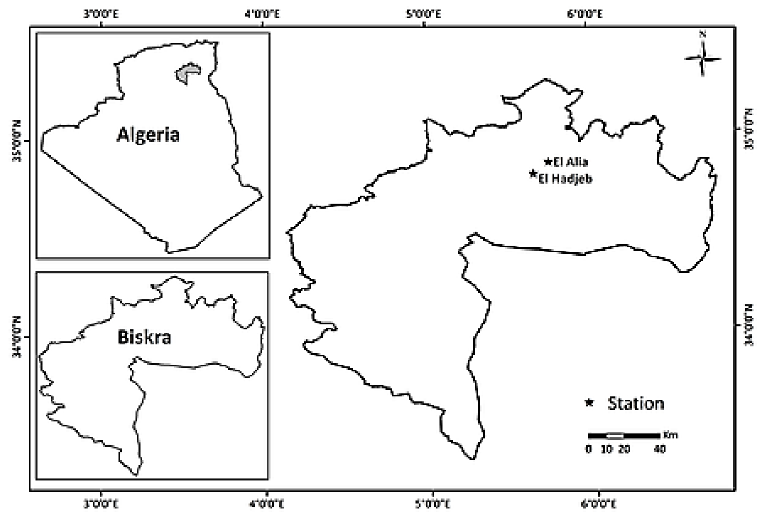

FIG.1: Locations of the study area in Biskra.

Sampling and laboratory methods: Insects were randomly collected under the tomato greenhouses over the cultivation periods of 2019-2020, using yellow pans and barber traps filled with water and a few drops of liquid soap (Mukundan & Rajmohana 2016; Selmane et al. 2016), in addition to placing yellow bottles on stakes at plant level, where each bottle was filled with sweet liquid (water + sugar) (Roth 1972). For morphological observation, all ethanol preserved specimens were cleared in Histo-Clear and permanently observed with Wild M10 stereomicroscope objectives of 40X, 60X magnifications, and photographs were taken with a Leica Q2 digital camera attached to a stereomicroscope. The specimens have been deposited in the Laboratory of DEDSPAZA, University Mohamed Khider, Biskra, Algeria.

Identification keys: Species taxonomy was discussed according to morphological characteristics such as structure and colorization of the different parts of the body (a) head characteristics: frontal depression, mandibles, position of lateral ocelli, antennal form and segments (b) mesosomatic characteristics: wing venation, form of tibial spur (c) metasomatic characteristics: shape and general structure of the metasoma. Generally, Afrotropical *Scelio* (Latreille, 1805) species are classified in the pulchripennis group, the key of which can be found in Yoder et al. (2009) which is specific to females and many males. Also, several keys were followed to identify specimens to family, genus and species level, for example: Revision of Scelionidae (Hymenoptera) (Kieffer 1908); A synopsis of the African species of *Scelio* (Latreille) (Nixon 1958); Monograph of the Afrotropical species of *Scelio* (Latreille) (Yoder et al. 2014), Key to genera of Scelionidae of the Holarctic region, with descriptions of new genera and species (Masner 1980).

Abbreviations used in figures: The morphological terms and abbreviations used throughout this work are principally those used by Masner (1980), and the following terms require further explanation (see figures).
LOL- lateral ocellar line; **OOL-** ocular ocellar line; **POL**- posterior ocellar line; **md**- mandible; **T1, T2,…-** Tergites; **io**- inner orbit; **ao**- anterior ocellus.

Results and Discussion

Species Group – *Scelio pulchripennis*
Nixon (Nixon 1958)
Order Hymenoptera
Super family Platygastroidea Haliday (Haliday 1833)
Family Scelionidae Haliday (Haliday 1839)
Subfamily Scelioninae Haliday (Haliday 1839)
Genus *Scelio* Latreille (Latreille 1805)

***Scelio poecilopterus* (Priesner, 1951)**

Materials examined: Algeria: Biskra, El Alia, 34°50'43.9332"N, 5° 44'53.5092"E, –120 m, yellow pan trap, in tomato greenhouses, 08.03.2020, 1♀; El Hadjeb, 34°48'24.3"N, 5°39'16.3"E, –125 m, yellow pan trap, in tomato greenhouses, 22.03.2020, 2♀ (Afissa), UMKB coll.

Description: female specimens in medium size compared to other *Scelio* species, body length 4 mm; with a body of different colours and a completely smooth black head at the dorsal level (Fig. 2A) characterized by uniform areas of sculpture on the head (Fig. 3A), and an orange mesoscutum, sometimes brown to dark brown medially, without any trace of metallic coloration (Fig. 2B); The setae of upper frons usually oriented laterally or dorsally, and the antennae of females, according to Kozlov (1988) and Yoder et al. (2009), are brown to dark brown coloration. The mandible for each female has a slightly extended lower tooth with a slight extension of the internal-ventral margin (Fig. 3A); general sculpture softly imprinted, often effaced by plates; sculpture of the medial mesoscutum mostly smooth and shiny except for the hair pits, posterior margin is adjacent to the mesoscutellum with short parallel grooves of variable length, it's largely separated from the medial mesoscutum (Fig. 2B); propodeum slightly flattened, clearly visible in dorsal view with longitudinal reticulate ridges, its surface uniformly covered, propodeum angles relatively uniformly rounded (Fig. 2B, 3B); in the lateral view of metasoma, more or less symmetrical tergites and sternites, slightly convex, often irregularly reticulate, with some longitudinal tendency fine to gross sculpture. The colour in female metasoma is orange at the base (typically T1- T3) to brown until dark brown at the apex (Fig. 2C, 3C); the thorax and abdomen have straight brownish hairs. Forelegs often lighter in color than the middle and posterior legs with fine sculpture erased by traces. Female coxa colour is orange-brown to dark brown and female leg colour beyond coxa is orange-brown to dark-brown, the legs without spines or other evident structure, smooth behind the femur, with distinct lines of raised setae along the anterior and dorsoventral margins. The wing is surrounded by at least one transverse hyaline fascia cutting immediately above the stigma and usually a second cutting across the radial cell, the basal pigmented spot on the wing that has a very light coloration, with a clear decrease in the venation of the wings (Fig. 3D).

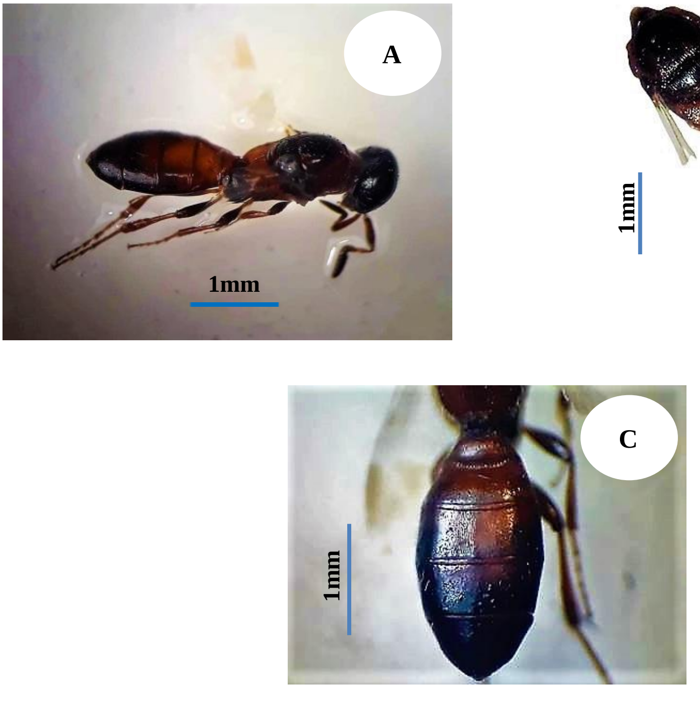

FIG. 2: *Scelio poecilopterus* (Priesner, 1951), ♀: (A) lateral view of specimen; (B) thorax and abdomen, dorsal view; (C) abdominal tergites, dorsal view.

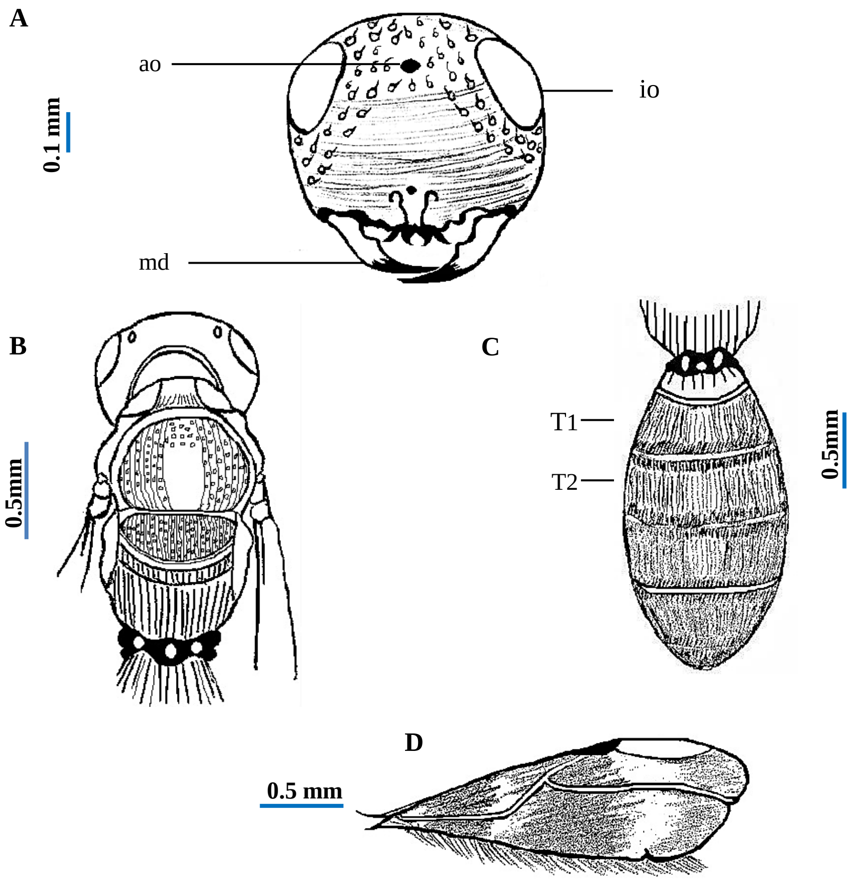

FIG. 3: Diagram of *Scelio poecilopterus* (Priesner, 1951), ♀: (A) head, frontal view; (B) thorax, dorsal sculpture; (C) abdomen, dorsal sculpture; (D) forewing ((md- mandible; T1, T2,…- Tergites; io- inner orbit; ao- anterior ocellus).

Differential diagnosis: The pigmentation of forewing transverse and longitudinal fascia in our female specimens is significantly lighter compared to other Oriental species, such as the specimens of Egypt, Saudi Arabia and United Arab Emirates.

Dimensions (in mm): Head length 0.5, head width 1; Pronotum length 0.7, pronotum width 1.1; Mesonotum length 0.3; Metanotum length 0.5; Total thorax length 1.5; abdomen length 2; Abdomen width 1.3; Antenna length 1.

Etymology: The specific epithet is composed of two Greek words: "ποικιλ-" ("poecil-" = variegated) and "πτερόν" ("pteron" = wing).

Hosts: Parasitoid of the eggs of *Acrotylus longipes* (Charpentier) (Orthopterans: Acrididae, Oedipodinae); *Diabolocatantops axillaris* (Thunberg) (Orthopterans: Acrididae, Catantopinae; cited as *Catantops* *axillaris*); *Ochrilidia gracilis* (Krauss) (Orthopterans: Acrididae, Gomphocerinae); *Heteracris littoralis* (Rambur) (Orthoptera: Acrididae, Eyprepocnemidinae; cited as *Thisoicetrus littoralis*); *Locusta migratoria* (Linnaeus) (Nixon 1958).

Distribution: Egypt, Eritrea, India, Saudi Arabia, United Arab Emirates, Spain, Yemen, Oman (Yoder et al. 2009, 2014). *Scelio poecilopterus* recently documented with a strong representation in the Arabian Peninsula of the Ethiopian region (Priesner 1951; Abhilash and Rajmohana 2014); Iran; Turkmenistan (Samin et al. 2011; Ghahari et al. 2015); Algeria (first records).

***Scelio vulgaris* (Kieffer, 1908)**

Materials examined: Algeria: Biskra, El Alia, 34°50'43.9332"N, 5° 44'53.5092"E, –120 m, yellow pan trap, in tomato greenhouses, 23.02.2020, 2♀; El Hadjeb, 34°48'24.3"N, 5°39'16.3"E, –125 m, Barber traps, in tomato greenhouses, 22.12.2019, 3♀ (Afissa), UMKB coll.

Description: Female body length 3 mm, completely black in color, with a transverse or subquadrate head and a smooth frons along the sides of the head which has an abundance of setae (Fig. 4A); Antennae as in Fig. 4A are apically clavate (Kozlov 1988); Occiput more or less concave, while lateral ocelli close to the eye margins. The oral apparatus is characterized by short three-segmented maxillary palps and very short two-segmented labial palps, while, the mandibles are very long, curved and bidentate, with equal length teeth. The back of the thorax is slightly reticulated, but the mesothorax without any trace of parapsidal grooves, the mesoscutum is large and longitudinally striated, and the scutellum separated from the metanotum by a line of deep punctures, followed by a smooth area (Fig. 4B, 5B). The sessile and lateral margins of the abdomen are acute, six tergites are present in the female abdomens, covered by tiny light-coloured hairs whereas the last two tergites are very short; The parallel carinae of the abdominal tergites are dense and prominent with oblique lines divided longitudinally (Fig. 4C, 5A). The leg is defined by a coxa anteriorly with three oblique repli, a trochanter with some short hairs, a femur in black coloration then a short setae; Tibiae and tarsi are brown with fine short setae (Kieffer 1908; Ogloblin 1927). The forewings are transparent with a pale yellow stigma (Figs.4D, 5C).

Differential diagnosis: *Scelio vulgaris* is closely similar regarding the morphological characteristics to *S. rugosulus* (Latreille, 1805) as described by Shamsi et al. (2015), but the females of *S. vulgaris* are clearly differentiated by wings without transverse hyaline bands.

Dimensions (in mm): Head length 0.5, head width 1; Pronotum length 0.5, pronotum width 0.6; Mesonotum length 0.2; Metanotum length 0.3; Total thorax length 1; Abdomen length 1.5; Abdomen width 0.6; Antenna length 1.

Etymology: The epithet vulgaris is a Latin adjective for usual, common, or vulgar.

Hosts: The hosts are the eggs of various species of grasshoppers (Orthoptera: Acrididae), including the small marsh grasshopper *Chorthippus albomarginatus* (De Geer) (O'Connor and Notton 2013); *Aeropedellus variegatus* (Fischer von Waldheim), *Chorthippus apricarius* (Linnaeus), *Gomphocerus sibiricus* (Linnaeus), *Stenobothrus nigromaculatus* (Herrich-Schäffer), *Stenobothrus spp*, *Stauroderus scalaris* (Fischer de Waldheim) (Dangerfield et al. 2001) and *Locusta migratoria* (Linnaeus) (Ferrière 1951; Yoder et al. 2014).

Distribution: West Africa, Ireland (Buhl et al. 2016); Europe (Ferrière 1951); Western Europe (Kozlov 1988); Austria, several European countries, Azerbaijan, Georgia and Turkey (O'Connor and Notton 2013); Algeria (first records).

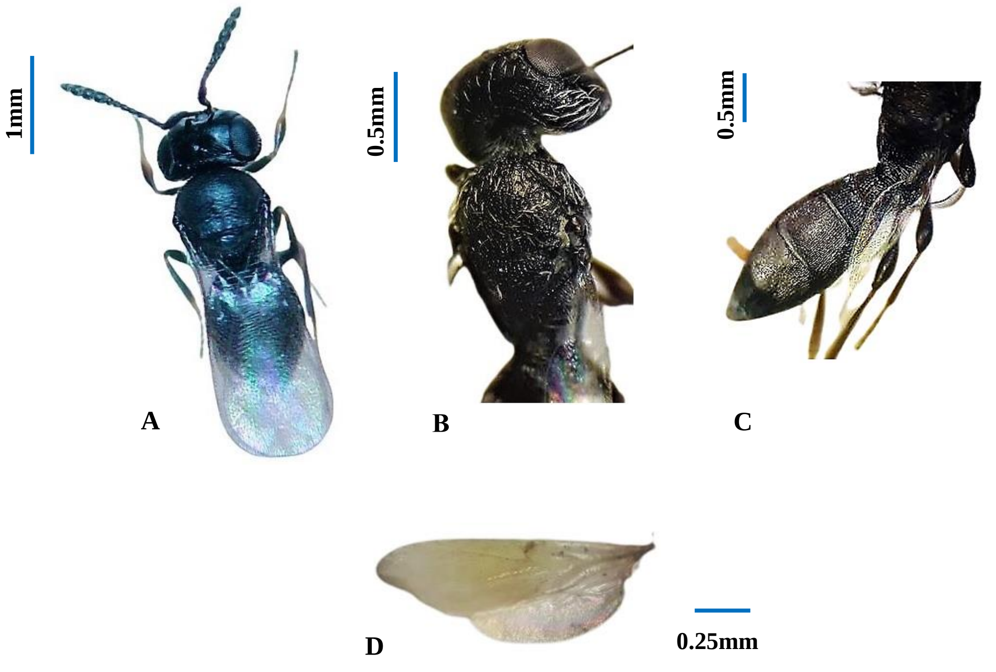

FIG. 4: *Scelio vulgaris* (Kieffer, 1908), ♀: (A) dorsal view of the specimen; (B) sculpture of the mesoscutum, dorsal view; (C) abdomen, dorsal view; (D) anterior wing.

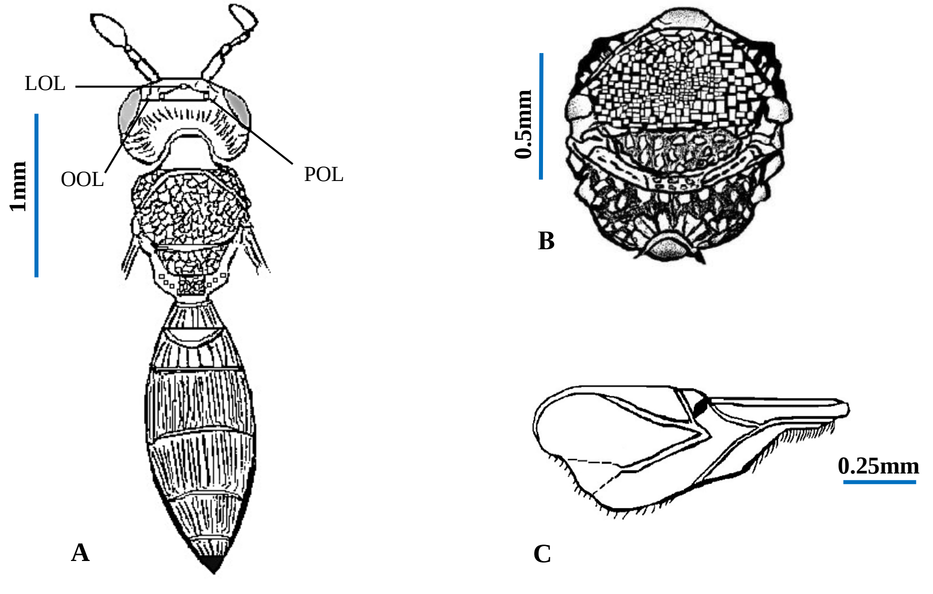

FIG. 5: Diagram of *Scelio vulgaris* (Kieffer, 1908), ♀: (A) dorsal view of the specimen; (B) thorax sculptures, dorsal view; (C) forewing (LOL- lateral ocellar line; OOL- ocular ocellar line; POL- posterior ocellar line.

Conclusion

The genus *Scelio* (Latreille, 1805) is one of the most important genera of the subfamily Scelioninae with an estimated total of over 500 species (Yoder et al. 2009). The pulchripennis group was first recognized and diagnosed by Nixon (1958) on the African species of *Scelio*, and then the group is readily diagnosed far from the global species by Yoder et al. (2009). Species in this genus are found worldwide, and the available host data suggest that they are exclusively parasitoids of orthopteran eggs (Dangerfield et al. 2001), and some *Scelio* species have been used as important biological control agents of migratory locusts in Niger and Mali (Popov 1959; Greathead et al. 1994; Lomer and Jürgen 2001). In this paper, the two species *Scelio poecilopterus* (Priesner) and *Scelio vulgaris* (Kieffer) are identified as the first records in the North African countries in general and in the oases of Biskra province (southeastern Algeria) especially, with a total description of their distribution and morphological characteristics, taking into account the differences that exist in the appearance compared to African and oriental species, where it seems likely that *Scelio* is composed of several distinct species groups.

Although the current study confirms the presence of Scelioninae fauna in the south of the country in small numbers, some habitats in the north, northwestern and central parts of the country have not yet been studied and the real number is expected to be much higher. Therefore, it is necessary to collect more samples to provide a clearer picture of how these species are distributed and established in arid and Mediterranean areas, also to increase the knowledge of their diversity, the parasitism rate on local hosts and the possibility of applying this important group of parasitoids in the lab and the field of this area, which is often susceptible to the invasion of African locusts at all cultivation seasons.

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First record of the genus *Scelio* (Hymenoptera: Platygastridae, Scelionidae, Scelioninae) egg parasitoids in tomato greenhouses of southeastern Algeria

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ΠΕΡΙΛΗΨΗ

Πρόκειται για την πρώτη καταγραφή του γένους *Scelio* (Latreille, 1805) στην Αλγερία. Μέσα την διετία 2019-2020, δύο είδη του γένους *Scelio*, τα *S. poecilopterus* (Priesner, 1951) και *S. vulgaris* (Kieffer, 1908), συλλέχθηκαν από θερμοκήπια τομάτας στις περιοχές El Alia και El Hadjeb regions της επαρχίας Biskra, στη νοτιοανατολική Αλγερία. Στην παρούσα εργασία παρουσιάζεται φωτογραφικό υλικό και πληροφορίες για δείγματα θηλυκών, ώστε να διευρυνθούν οι γνώσεις σχετικά με τη διασπορά και τη βιοποικιλότητα των ωοπαρασιτοειδών στη χώρα.

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Efficiency of Some Insecticides in Controlling Citrus Leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae)

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ABSTRACT

The toxicity of four commercial insecticides (mineral oil, azadirachtin, phenthoate and abamectin) in addition to mint oil (variety of terpenoids), against the citrus leaf-miner, *Phyllocnistis citrella*, larvae, was tested under laboratory conditions using the leaf-dipping method. The bioassay data indicated that abamectin was the most toxic insecticide against *P. citrella* larvae, followed by azadirachtin, phenthoate, mint oil and finally mineral oil. On the other hand, field evaluation showed that the highest larval mortality was 94.79 and 83.87% induced by abamectin and azadirachtin, respectively, five days after the 2nd application. Mineral oil and phenthoate showed a 72.43 and 61.4% mortality respectively, at 11 days after the 2nd application, and finally mint oil, 49.82% three days after the 1st application.

KEY WORDS: *Phyllocnistis citrella*; Toxicity; Insecticides; Mint oil; Egypt.

Introduction

The citrus leaf miner (CLM), *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) is an important insect in many regions of the world (Hoy and Nguyen, 1997). This insect has become the most important pest of citrus in Egypt (El-Saadany and Wahed, 2002). *Phyllocnistis citrella* goes through four developmental stages: eggs, larvae, pupae, and adults, with total developmental duration from eggs to adult emergence at 13- 52 days and has 6-13 generations per year depending on weather conditions (Heppner, 1993). It attacks the new leaves of seasonal flushes and in severe cases causes complete loss of new foliage. Although *P. citrella* is an indirect pest, the nature of its attack makes it a serious threat for young trees. Infested leaves curl down and may drop prematurely (Sponagel and Diaz, 1994).

CLM control practices comprise application of insecticides as well as biological control. Effective chemical control is difficult because the larvae are protected from insecticides by the leaf cuticle (Legaspi et al., 1999). Furthermore, CLM has a long history of resistance development against many insecticides, which makes it difficult to obtain sufficiently effective control (Mafi and Ohbayashi, 2006). Moreover, due to its multiple generations per year, there is a need for frequent applications of insecticides to improve control, due to the multiple generations of the insect per year (Yumruktepe et al., 1996). Mineral oil can

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be used as a surfactant and can be very beneficial for managing *P. citrella* by reducing the protective effect of the leaf epidermis to the insect (Dias et al., 2005). Mineral oils are the most common alternative to managing *P. citrella* and are recommended for use in home gardens, nurseries and orchards (Khalid et al., 2012). However, petroleum oils are commonly sprayed in summer to control CLM in many countries, but oil sprays after late July should be avoided owing to the decrease of the Brix content of fruits (Ujiye, 2000). Several insecticides, such as indoxicarp, buprofezin, pyriproxifen, diflubenzuron over phosalone and etrimfos have been used (Jafari, 1996; Amiri- Besheli, 2006). However, chemical insecticides have toxic effects on natural enemies and environment (Huang and Li 1989).

Although biological control is generally a promising option against major insect pests and there is an increasing trend of using it as an alternative to conventional insecticides (Lacey et al., 2001), such effective control of CLM is complicated because of its high migration ability from the periphery of orchards and its high fertility potential, as well as the fact that the citrus leaf epidermis offers substantial protection for the insect (Sarada et al., 2014). Bioinsecticides comprise several types of pesticides deriving from different natural materials and include biochemical pesticides, microbial pesticides, and plant-incorporated-protectants. These are inherently less harmful to non-target organisms and more specific to target pests (EPA, 2011; Isman, 2006), while additionally they are effective in small doses and decompose quickly, without leaving undesirable residues (EPA, 2011), thus they can reduce the use of conventional insecticides as a major component of IPM programs (Bravo et al, 2011). For example, Spinosad and azadirachtin have high efficacy in controlling *P. citrella* on young citrus plants, within seven days post treatment (Perovic and Hrncic, 2008a). Also, imidacloprid, thialoprid, acetamiprid and thiametoxam have successfully achieved effective control against these species (Perovic and Hrncic, 2008b). Therefore, the present study aims to evaluate the efficacy of specific insecticides against citrus leaf miner larvae, in the laboratory as well as at the field.

Materials and Methods

Bioassay: Toxicity of the tested insecticides against *P. citrella* larvae was conducted at the Toxicology Laboratory, Faculty of Agriculture, Ain Shams University, Qalyubia Governorate, Egypt, using commercial insecticides: mineral oil (kZ 95% EC Kafr El Zayat pesticides and chemicals co), azadirachtin (Achook 0.15% EC Godrej Agrovet Ltd), phenthoate (Elsan 50% EC, Arysta LifeScience Corporation), abamectin (Bermectin 1.8% EC, Agromen Chemicals Co. Ltd) and mint oil 100% (raw material, from Agriculture Research Center, Cairo, Egypt), containing l-menthol, menthone, isomenthone, neomenthone and a variety of other terpenoids. 53-year-old citrus seedlings were placed in the center of a *P. citrella* infested orchard (untreated during the latest years), pruned, fertilized and watered to promote the flush of new leaves until infection occurred. Infected leaves were further used for the present bioassay.

The tested concentration series were determined following a preliminary study using (1/100) of the field application rate according to the recommendations of the Ministry of Agriculture (Table 1). For the mint oil, a preliminary assessment of different concentrations (10, 5, 2, and 1 ppm) emulsified with Tween 80 was conducted. Based on the mortality rates obtained from this preliminary study, the tested concentrations were as follows: mineral oil: 142.5, 285, 570, 1000 and 1425 ppm; abamectin: 0.072, 0.144, 0.252, 0.324 and 0.432 ppm; azadirachtin: 0.22, 0.33, 0.44, 0.55 and 0.66 ppm; phenthoate: 2.25, 3.75, 5.25, 6.75 and 8.25 ppm and mint oil: 0.25, 0.5, 1, 2 and 5 ppm.

The bioassay method was applied as described by Amiri-Besheli (2008) with some modifications. The leaf-dip technique was used to test insecticide toxicity. Only leaves with actively feeding 2nd stage leaf miner larvae (because the response to insecticides is higher at this stage) were completely excised from the petioles from Washington citrus trees and used for bioassays. To keep leaves turgescent during the bioassay, each petiole was covered with wet cotton. Leaves were dipped individually, for approximately 10 sec into each dilution, air-dried for approximately 2h and placed at the bottom of plastic Petri dishes (9 cm ø), previously lined with wet filter paper. The experiment for each concentration was replicated five times and each replicate included 10 leaves, along with a control group, for which the leaves were treated with distilled water. All Petri dishes were incubated at 26±1°C, 65± 5% RH with 16:8 h (L:D) photoperiod. 24, 48 and 72 h post treatment, the numbers of living and dead larvae for each replicate were counted under a stereomicroscope. Abbott's (1925) formula was used to correct the mortality in larval density of P. citrella.

Effect of the tested insecticides on the reduction of the target insect: The efficacy of the tested insecticides against P. *citrella* under field conditions was estimated according to the method used by Raga et al (2001) with some modifications, i.e., a randomized complete block design with 4 replicates, one tree plot, at a navel orange orchard (*Citrus sinensis* L. var. Washington), at El Qualubia Governorate, season 2011. The commercial insecticides used are summarized in Table 1. The insecticides were applied using a knapsack sprayer (20L capacity, nozzle diffuser). About 4–5L were sufficient to ensure complete coverage of all the parts of a tree till run-off. Each tested insecticide was applied separately at the rate recommended by the Ministry of Agriculture in Egypt. The products were applied on the 6th and 16th of September. Control trees were sprayed with water. Ten immature leaves from each replicate were randomly picked from different sides of the treated trees on the 6th (pre-treatment), 9th, 13th, 21st and 27th of September. The leaves were kept in plastic bags and transferred to the laboratory where they were examined with a stereomicroscope. Infestation reduction levels were calculated using the formula of Henderson and Tilton (1955).

Table 1. Insecticides used in the bioassay experiment

Insecticide	Active ingredient	Chemical class	MOA	a.i.%	FAR[a] (/100L)
KZ oil	Mineral oil	Aliphatic hydrocarbons	Suffocation	95%	1.5 l
Bermectin	Abamectin	Avermectin	Glutamate-gated chloride channel (GluCl)	1.8%	40 ml
Achook	Azadirachtin	Biochemical	Antifeedant and Insect Growth Disruptor	0.15%	750 ml
Elsan	Phenthoate	Organophosphate	AChE inhibitor	50%	45 ml
Mint oil	Variety of terpenoids	Plant extract	Unknown	100%	0.5 g

[a] FAR= Field application rate

Statistical analysis: The data were analyzed using the program of the SAS Institute (1999) with a 5% significant difference. Comparison between the effectiveness of the tested insecticides against the insect under laboratory and field conditions was analyzed by ANOVA. Means were separated by Tukey's honestly significant difference (HSD). Lethal concentration (LC_{50}) values of the tested stage were calculated according to Finney (1971). From these concentrations the corresponding toxicity lines were estimated (LDP line program) and the relative efficiency of LC_{50} values and slope values of the tested insecticides was determined, using the following two equations (Sun, 1950):

Toxicity index = LC_{50} of the most effective compound / 100 x LC_{50} of the tested compound

Relative toxicity = LC_{50} of the lowest effective compound / LC_{50} of the other compound.

Results

Bioassay: Leaf-dip technique: the toxicity of the five insecticides was determined by using five different concentrations of each test compound against *P. citrella* larvae and recording mortality after 24, 48 and 72h. The LC_{50} and LC_{90} values and regression coefficient (slope) after 72h were calculated. Results are represented in Table 2. The comparison between the *P. citrella* larval LC_{50} for the tested insecticides shows that abamectin was the most toxic by a.i. weight unit (0.26 ppm) followed by azadirachtin (0.46 ppm), phenthoate (5.91 ppm), mint oil (7.16 ppm as value expected by Ldp Line program) and mineral oil (944.85). The LC_{50} values differed significantly at 0.05 level of probability (x^2= 1838.8, df= 2, P= 0.0001). On the other hand, the LC_{90} values of these insecticides were 0.74, 0.93, 11.95, 102.44 and 3784.88 ppm for abamectin, azadirachtin, phenthoate, mint oil and mineral oil respectively. As for slope values, the steepest toxicity line of azadirachtin possessed the highest slope value (4.22), which indicates higher homogeneity of the tested population, whereas the flattest line of mint oil possesses the lowest slope value (1.11). The remaining values were 2.78 for abamectin, 4.19 for phenthoate and 2.13 for the mineral oil.

Regardless the concentrations, the obtained data presented in Table 3 show clearly that the lowest mean number of living larvae was the observed for abamectin, at all time lapses, with significant difference to the other tested insecticides. At 24h post treatment, abamectin was the most effective (mean=8.84) followed by the mineral oil (mean=9.08), then mint oil, phenthoate, and finally azadirachtin, with means 9.28, 9.52, 9.6852 respectively. At 48h post treatment, again abamectin was the most effective (mean=7.24) followed by the mineral oil (mean=7.68), then phenthoate, mint oil and azadirachtin with means 8.16, 8.2 and 8.8 respectively. Also, at 72h post treatment, abamectin was the most effective (mean=4.4) followed by mineral oil, phenthoate and azadirachtin (means = 5.36, 5.08 and 5 respectively), with no significant difference to each other, whereas mint oil was the least effective (mean= 6.52). Regardless the number of days, the results showed that abamectin was significantly more effective (mean number of living larvae = 6.83), followed by mineral oil, phenthoate, azadirachtin then mint oil (mean number of living larvae = 7.37, 7.59, 7.83, 8 respectively).

These results show that there is a correlation between the LC_{50} value and the recommended application rate. More specifically, when the application rate decreases, the insecticide LC_{50} value decreases. The toxicity of abamectin was found to be the highest, with a toxicity index 100% compared to the other insecticides. On the other hand, the relative efficiency showed that abamectin toxicity was 3634-fold greater than the mineral oil toxicity. The application rate of azadirachtin was 18 times higher than that of abamectin, but the toxicity of abamectin was 1.8- fold greater than that of azadirachtin. The application rate of phenthoate was close to that of abamectin, but the toxicity of abamectin was 22.7-fold greater than of phenthoate.

Table 2. LC_{50} and LC_{90} values in ppm (ug/ ml) for *P. citrella* larvae treated with the insecticides 72h post treatment, under laboratory conditions.

Insecticide	LC_{50} ppm	LC_{90} ppm	Slope± SE	*Toxicity index (%)	** Relative toxicity (fold)
Abamectin	0.26	0.74	2.78± 0.43	100	3634.04
Azadirachtin	0.46	0.93	4.22± 0.61	56.52	2054.02
Phenthoate	5.91	11.95	4.19± 0.61	4.4	159.87
Mint oil	7.16	102.44	1.11± 0.25	3.63	131.96
Mineral oil	944.85	3784.88	2.13± 0.34	0.03	1

*= index compared with abamectin; **= Relative toxicity compared with mineral oil

Table 3. Mean of living *P. citrella* larvae exposed to insecticides (dipping method bioassay) at 24, 48 and 72h regardless of the series of concentrations

Treatment	*Mean living larvae			Total of mean
	After 24 h.	After 48 h.	After 72 h.	
Abamectin	8.84±0.6a	7.24±1.6 a	4.4±2.9 a	6.83 a
Mineral oil	9.08±0.7 ab	7.68±1.6 ab	5.36±3 b	7.37 b
Phenthoate	9.52±0.3 c	8.16± 1.2 bc	5.08±2.9 b	7.59 bc
Azadirachtin	9.68±0.3 cd	8.8±0.7 d	5±2.8 b	7.83 cd
Mint oil	9.28±0.5 bc	8.2± 1.2 c	6.52± 2 c	8 d
Control	10 d	10 e	9.96 d	9.99 e
Mean **	9.4 c	8.35 b	6.05 a	

* Means with the same letter within a column are not significantly different (Tukey HSD test, at 5%); ** Means with the same letter within a row column are not significantly different (Tukey HSD test, at 5%)

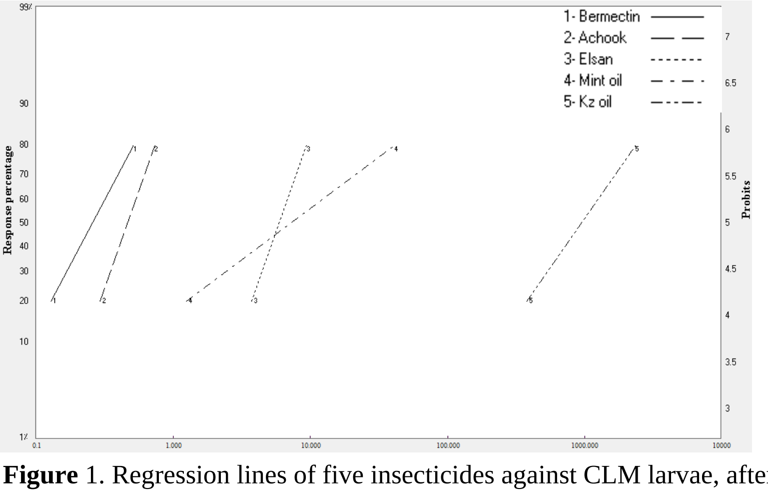

Figure 1. Regression lines of five insecticides against CLM larvae, after 72 h., under laboratory conditions (leaf- dip technique).

Efficiency of the tested insecticides in controlling *P. citrella*: The field experiment against CLM was conducted on navel orange var. Washington autumn flushes during 2011. The insecticides and respective concentrations applied were: abamectin - 40ml/100L, azadirachtin - 750ml/100L, phenthoate - 45ml/100L, mineral oil - 1.5L/100L and mint oil - 0.5g/100L. The results showed that the mean number of larvae before application varied between 7.5 and 8.5, where no significant difference was observed amongst treatments (Table 4).

At 3 days after the 1st application, abamectin significantly increased the mortality of *P. citrella* larvae, with a 93.06 % reduction rate (Table 5). No significant differences were recorded between the other treatments and the control.

When compared with the unsprayed control, all treatments differed significantly 7 days after the 1st application, with a reduction rate ranging from 31.32 (mint oil) to 84.88% (abamectin). In this evaluation, abamectin caused the highest reduction; azadirachtin provided good control (75%), while mint oil was the least effective. No significant difference was observed in the number of living larvae between mineral oil and phenthoate.

At 5 days after the 2nd application, abamectin and azadirachtin provided significant reduction in the larval population (94.79 and 83.87% respectively). In the same evaluation, mineral oil, phenthoate and mint oil showed significantly lower larval density (50.98, 50.98 and 40.86% of reduction respectively) compared to the control.

At 11 days after the 2nd application, abamectin, mineral oil and phenthoate reduced the larval population by 76.56, 72.43 and 61.4% respectively. No significant difference was observed between azadirachtin and mint oil treatments.

On the other hand, the reduction rate for each treatment, with respect to the reading date, indicated that the reduction rate differences induced by abamectin were not significantly different. For mineral oil, the highest reduction rate was recorded 11 days after the 2nd application, while there were no significant differences between the first three readings. Azadirachtin provided a significant larval population reduction 5 days after the 2nd application, while its effectiveness clearly decreased after 11 days. Finally, the effectiveness of phenthoate increased slowly after each application, whereas mint oil provided larval population reduction immediately after each application, which then decreased.

Discussion

Amiri-Besheli (2009) showed that the efficacy of Tracer (spinosyn) + oil, Runner (methoxyfenozide) + oil and Tondixer (pepper extract) + oil (after 72 hours after, against the 2nd and 3rd stage larvae of *P. citrella*) was 98 ± 3.2, 98 ± 8.1 and 93 ± 5%, respectively, compared to mineral oil alone, Tondixer and Sirinol (insecticidal emulsion)+ oil with death rates of 85 ± 8.3, 81 ± 7.2 and 78.25 ± 8.2%, respectively. Also, the overall death rate after 72 hours was more significant compared to the death rate after 24 and 48 hours. However, the biocides penetrate the tunnels and kill larvae, as reported by Shapiro et al. (1998). George et al. (2017) reported that among six insecticides tested against the 2nd instars of *P. citrella* larvae collected from Nagpur mandarin/ acid lime cultivars, during 2013–2016, abamectin was the most toxic insecticide at the initial year (LC50 values ranged from 20.99 to 49.00ppm), while dimethoate (LC50 of 36.57–160.95ppm) and thiamethoxam (39.90–71.96ppm) were consistently effective against P. citrella larvae for the rest of the period.

On the other hand, Halawa et al. (2007) indicated that an increase of the concentration of peppermint oil from 0.13 to 1% increased larval mortalities of *Sesamia cretica* Led. (Lepidoptera: Noctuidae) from 40 to 93% and the LC50 value was 2.1. However, mortality of target insects may be due to the effect of allelochemicals of the family Lamiaceae, such as essential oils which were demonstrated to be behaviorally active against several insect pests (Isman, 2000).

Furthermore, the results of field evaluation indicated that abamectin and azadirachtin provided a significant reduction of the larval population with a reduction percentage of 94.79 and 83.87%, respectively, 5 days after the 2nd application, whereas mineral oil and phenthoate provided a reduction of 72.43 and 61.4% respectively and mint oil reduced the population by 49.8% 3 days after the 1st application. Raga et al. (2001) indicated that ten days is the maximum period of efficacy for all tested insecticides at field conditions. P. citrella larval stage can occupy only 4-5 days and the period from egg to adult is as short as 14 days (Browning et al., 1999). Also, Peña (1994) observed that, two weeks after application, all insecticide treatments had a similar effect as the untreated control on the larvae. Thus, they suggested the use of alternative insecticides in order to prevent the development of pesticide resistance in *P. citrella*. Van de Veire et al. (2002) found that abamectin was much more persistent in spring than in summer. Spray deposits (at the recommended rate of 10 ppm a.i. for leafminer control) were toxic for 1 month in spring, whereas they were no longer toxic after 2 weeks in summer.

Table 4. Efficacy of insecticides against citrus leaf miner, *P. citrella*, (Mean± SE)

Treatments	Mean number of living larvae/ 10 leaves /replicate					Mean
	1 DBFS*	3 DAFS	7 DAFS	5 DASS	11 DASS	
Abamectin	8 ± 0.41 a (b)	0.5 ± 0.29 a (a)	1.25± 0.41 a (a)	0.25± 0.25 a (a)	1± 0.41 a (a)	2.2± 1.4 a
Azadirachtin	7.75± 0.75 a (c)	3.25± 0.48 b (b)	2± 0.41 ab (ab)	0.75± 0.25 a (a)	2.5± 0.29 bc (ab)	3.25± 1.2 b
Mineral oil	8.5± 0.5 a (c)	4± 0.41 b (b)	3± 0.41 b (b)	2.5± 0.29 b (ab)	1.25± 0.25 ab (a)	3.85± 1.2 bc
Phenthoate	8.5±0.29 a (d)	4.5± 0.29 b (c)	3.5± 0.29 b (bc)	2.5± 0.64 b (ab)	1.75± 0.25 abc (a)	4.15± 1.2 c
Mint oil	7.75± 0.75 a (c)	3.5± 0.29 b (a)	5.5± 0.29 c (b)	2.75± 0.25 b (a)	2.75± 0.25 cd (a)	4.45± 0.9 c
Control	7.5± 0.64 a (b)	6.75± 0.25 c (b)	7.75± 0.25 d (b)	4.5± 0.29 c (a)	4± 0.41 d (a)	6.1± 0.8 d
Mean	8± 0.2 (c)	3.75± 0.8 (b)	3.83± 0.9 (b)	2.21± 0.6 (a)	2.21± 0.4 (a)	4± 1.1
F	0.51	34.73	43.89	18.18	12.27	51.62
Significance	0.76	0.0001	0.0001	0.0001	0.0001	0.0001

*DBFS- Day before first spray, DAFS- Days after first spray, DASS- Days after second spray
Means with the same letter within a column are not significantly different; Letters in parentheses = Means with the same letter within a row are not significantly different.

Table 5. Reduction (%) of *P. citrella* larvae by insecticides under field condition, on navel orange, at El Qualubia Governorate

Treatments	Reduction %				Mean
	3 *DAFS	7 DAFS	5 DASS	11 DASS	
Abamectin	93.06	84.88	94.79	76.56	87.32
Azadirachtin	53.41	75.03	83.87	39.52	62.96
Mineral oil	47.71	65.84	50.98	72.43	59.24
Phenthoate	41.18	60.15	50.98	61.4	53.43
Mint oil	49.82	31.32	40.86	33.47	38.87

*DAFS Days after first spray; DASS- Days after second spray

Raga et al. (2001) reported that the petroleum oil spray residues reduced infestations of *P. citrella* by preventing oviposition, and its effect depended on the concentration of the oil and the time of spraying. However, the efficacy of petroleum-derived spray oils used as oviposition deterrents to control CLM is related to the time of application, the oil dose and the persistence of oil molecules on sprayed surfaces. Low toxicity of the mineral oil may be due to different factors including cuticle properties, ambient temperature and the size and volume of the oil molecules. Amiri-Besheli (2008) reported that emergence of *P. citrella* is very low in spring, thus its control is not necessary before late June, in most citrus growing regions in Northern Iran, but it is really important to protect the new shoots of the young or top grafting citrus trees against infestation by summer and autumn P. citrella generations. On the other hand, azadirachtin showed significant death rates when used against *P. citrella* larvae compared to others, and this may be due to the rapid penetration of neem oil through the surface tissues (Mujica et al., 2000). Our findings were supported by IIHR (2006) who reported that neem oil showed a death rate of 65.9% of CLM larvae, and the results of Cañarte-Bermúdez et al. (2020) who reported a high mortality rate of CLM, caused by a 77.17% aqueous extract of neem oil, which was observed 48 hours after application, suggesting inhibition of feeding.

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Αποτελεσματικότητα ορισμένων εντομοκτόνων στον έλεγχο του φυλλορύκτη των εσπεριδοειδών, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae)

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ΠΕΡΙΛΗΨΗ

Η τοξικότητα τεσσάρων εμπορικών εντομοκτόνων (ορυκτέλαιο, αζαδιραχτίνη, phenthoate και αμπαμεκτίνη), καθώς και του ελαίου μέντας (μίγμα τερπενοειδών), εναντίον του φυλλορύκτη των εσπεριδοειδών, *Phyllocnistis citrella*, δοκιμάστηκε σε εργαστηριακές συνθήκες με τη μέθοδο εμβάπτισης φύλλων. Τα δεδομένα των βιοδοκιμών έδειξαν ότι η αμπαμεκτίνη ήταν το πιο τοξικό εντομοκτόνο εναντίον των προνυμφών *P. citrella*, ακολουθούμενη από την αζαδιραχτίνη, το phenthoate, το έλαιο μέντας και τέλος το ορυκτέλαιο. Από την άλλη πλευρά, τα αποτελέσματα της αξιολόγησης πεδίου έδειξαν ότι η υψηλότερη θνησιμότητα προνυμφών ήταν 94,79 και 83,87% οφειλόμενη στην αμπαμεκτίνη και την αζαδιραχτίνη αντίστοιχα, πέντε ημέρες μετά τη 2η εφαρμογή. Το ορυκτέλαιο και το phenthoate έδωσαν θνησιμότητα 72,43 και 61,4% αντίστοιχα, 11 ημέρες μετά τη 2η εφαρμογή, και τέλος το έλαιο μέντας, 49,82% τρεις ημέρες μετά την 1η εφαρμογή.

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Steppe Habitats' Entomofauna At Ouled Djellal-Algeria

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ABSTRACT

Statistical analysis was performed on the data obtained from a study carried out on 97 species classified into 8 orders of 44 families belonging to the Insecta class, collected from the Ouled Djellal steppe ecosystem. By using the Principal Component Analysis (PCA) and the Ascendant Hierarchical Classification (AHC) of the XLSTAT software (2016 v. 3.1), we obtained a highest cumulative inertia (25.44%) explained by axis F1, represented by winter months (December, January, February) and summer months (June and July) and correlated with 31 species from a total of 97. In addition, more than eight (8) groups were obtained from the simultaneous representation of months and insect species. Using the AHC, four groups were validated, with a high indication for the second that groups 48 species, among which were *Dicranocephalus Albipes* (Fabricius, 1781), *Polistes gallicus* (Linnaeus, 1767), *Papilio saharae* (Oberthür, 1879), *Broscus cephalotes* (Linnaeus 1758) and *Sphaerophoria scripta* (Linnaeus, 1758), belonging to different orders.

KEY WORDS: Ouled Djellal, steppe, insects, ecosystem, Ziban.

Introduction

In the alarming context of global warming (Fontier *et al*., 2008) and destruction of natural habitats (Belhamra *et al.*, 2020), a spectacular increase in the oasis and a decline of the natural steppe areas (from 20 million hectares in 1970 to 600 thousand) was observed during the last years (Le Houerou, 1985; Aidoud, 1989; Kadi-Hanifi, 1998, Aouissi *et al.*, 2021). The soil constitutes an essential element of biotopes, and its chemical and biological composition has an influence on the distribution of plants and animals. Steppes that are clearly distinct from the surrounding desert environments and marked by poor soils, limited natural resources and discontinuous plant formations (Halitim, 1988; El Zerey *et al*., 2009), are also significant and play an important role in fixing dunes and maintaining a wild animal life (Schhiffers, 1971; Deghiche-Diab *et al*., 2016).

Resulting from the new agrarian dynamics during the latest years, aggravated by increasing pressure on the natural resources - by the spread of invasive species and pollution - hampered by the lack of knowledge on the distribution, function, taxonomy and ecology of insect species. A few studies have evaluated the status of certain insect groups (Fontier *et al*., 2008) in natural ecosystems. In the Algerian steppe and with the change of the modality of land use, questions are raised about the possible impact on the biological diversity in the natural habitats in Ouled Djellal region.

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Therefore, our study has as main objective the focus on the effect of habitat on the distribution of species according to the conditions of natural steppe habitats.

Materials and Methods

Study area and sampling sites: Established in 2019 and formalized in 2021, Ouled Djellal is a province (wilaya) located in the Algerian Sahara covering an area of 131,220 km². It is delimited to the north by the M'sila province, to the east by the Biskra and El M'Ghair provinces, to the west by the Djelfa province and to the south by the Ouargla province.

For collecting information about the effect of soil composition on the distribution of insect species, a survey was carried out at the steppe habitats (Fig. 1). We chose three (3) plots for our study (34 ° 32'05.12 "N5 ° 5 ° 04'08.54" E raised to 213 m). They were represented by the bushy steppe of *Haloxylon articulatum* in association with *Astragalus armatus* in the highly degraded facies (Farhi, 2014, Deghiche-Diab, 2019) that occupy vast areas (Ras El Mied, Basbes, Ouled Djellal, El Ghrous and Doucen) and represent a transition between the steppe sagebrush and that of Alfa (Deghiche-Diab and Deghiche, 2016).

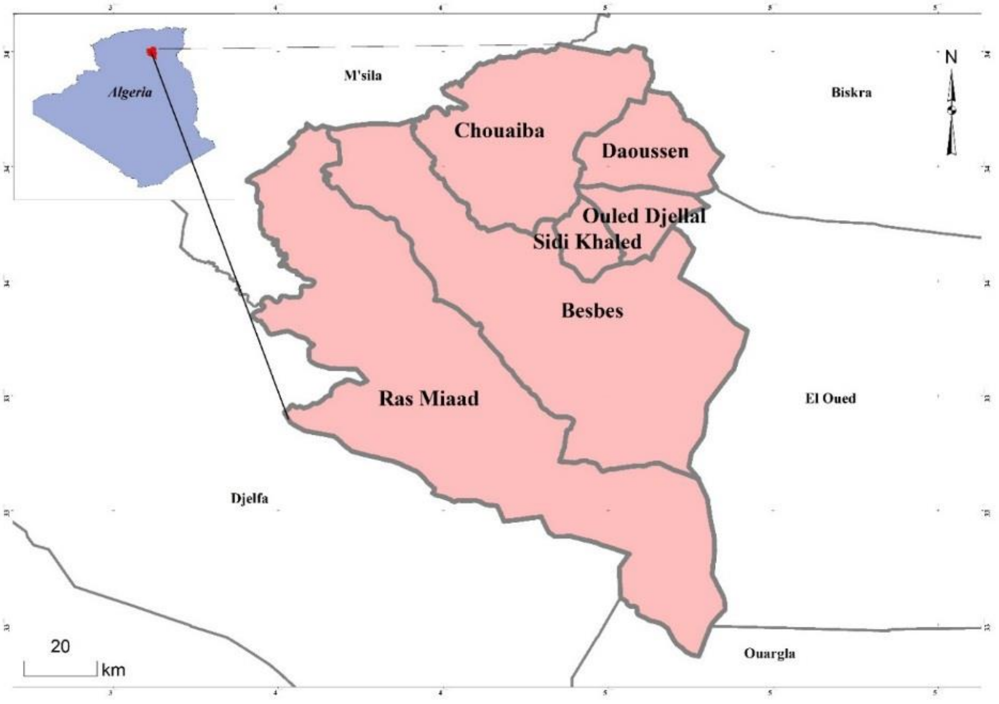

FIG. 1: Location of the study area

Sampling methods and identification: In order to collect insects in the selected habitat, a passive technique that does not exert any action of attraction and collects only insects that move on the surface of the ground or those in flight (Roume, 2001) was chosen. Pitfall traps are the most widely used sampling means to collect insects (Hertz, 1927; Barber, 1931; Benkhelil, 1990, Deghiche-Diab, 2009), so three (3) transparent cylindrical pots, 15cm deep and 20cm wide were 2/3 filled with water containing a detergent were and installed in three plots chosen within an area of 1 ha (Fig. 3) with a distance of 3-5m between pots and 10-30m between plots (Fig. 2).

Insects were captured and collected 4 times / month, then transferred to tubes containing 75% alcohol to be identified using appropriate keys (Chopard, 1943; Villiers, 1946; Blackman et Eastop, 1994; Blackman et Eastop, 2000) and guides (Chinery, 1993; Didier et Guyot, 2011; Saharaoui *et al*, 2014-2017; Hampt and Hampt, 1998; La Planches and Gorge, 2008; Brague-Bouragba, 2010; Dozière *et al*., 2017).

Data treatment: The obtained results of sampling insect species from the steppe ecosystem between 2018 and 2019 were treated using a statistical processing with XLSTAT sofware (2016.V.3.1).

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is one of the most widely used multivariate data analysis methods. It is a factorial dimension reduction technique when studying **p** quantitative variables, it makes better plane representations of individuals and variables (Dufour and Lobry, 2010; Rakotomalala, 2015). Its objective is to represent in a simplified graphical form, the maximum information of the data and the variables (variables in reduced number contained in a table of quantitative data) resulting from a sampling procedure (Rakotomalala, 2015). This reduction in the number of variables causes a loss of information; PCA makes certain that this loss is as low as possible (Legendre and Legendre, 1998).

Also, PCA provides both optimal visualization of variables and data, and biplots mixing the two (Champely, 2005). These representations are reliable only if the sum of the percentages of variability associated with the axes of the representation space is sufficiently high. If the percentage is low, it is advisable to make representations on several pairs of axes, to consolidate the interpretation made on the first two factorial axes.

Interpretation of graphs

The graphical representation of the variables in the k-factor space makes it possible to visually interpret the correlations between the variables on the one hand, and between the variables and the factors on the other. Observations and variables are represented as two distant points in k-dimensional space, but which may appear close to a 2-dimensional space depending on the direction used for the projection. We may consider that the cosine as an indicator of the proximity of a point to an axis in a plane, the closest to 1. The squared cosines are displayed in the results proposed by XLSTAT, to avoid any misinterpretation. It is interesting to study the relative contribution expressed in percentage or in proportion of the different variables to the construction of each of the factorial axes (XLSTAT).

Ascending Hierarchical Classification (AHC)

The Ascending Hierarchical Classification (AHC) consists of gradually aggregating individuals according to their resemblance, it produces a series of nested partitions of the set of objects to be classified, measured using an index of similarity or dis-similarity (a measure of distance). The AHC produces a binary classification tree (dendrogram), the root of which corresponds to the class by grouping together all the individuals.

Results and Discussion

For an assessment of 45 samples during a study period that extended from September 2018 to August 2019, the entomo-faunistic composition led to a collection of 97 species unequally classified into 44 families of 8 orders as represented in Table 1.

TABLE 1. Collected insect species in steppe habitat during the study period

Order	Family	Species	Code
Coleoptera	Tenebrionidae	*Erodius emondi* ssp. *laevis* (Solier, 1834)	Co01
		Akis lusitanica (Solier, 1836)	Co02
		Pimelia sp.	Co03
		Pimelia payraudi (Latreille, 1829)	Co04
		Stenocara sp.	Co05
		Blaps gigas (Linnaeus, 1767)	Co06
	Curculionidae	Curculionidae	Co08
		Lixus angustatus (Fabricius, 1775)	Co09
		Larinus sp.	Co10
	Meloidae	Meloidae	Co11
		**Mylabris* sp.	Co12
	Coccinellidae	*Hippodamia variegata* (Goeze, 1777)	Co13
		Coccinella septempunctata (Linné, 1758)	Co14
	Brachyceridae	*Brachycerus algirus* (Olivier, 1790)	Co15
		Brachycerus undatus (Fabricius, 1798)	Co16
	Buprestidae	*Anthaxia nitidula* (Linné, 1758)	Co17
	Carabidae	*Graphipterus serrator* (Forskal, 1775)	Co18
		Anthia sexmaculata (Fabricius, 1787)	Co19
		Anthia duodecimguttatum (Bonelli, 1813)	Co20

		Brachinus explodens (Duftschmid, 1812)	Co21
		Lophyra flexuosa (Fabricius, 1787)	Co22
		Calosoma inquisitor (Linné, 1758)	Co23
		Chlaenius decipiens (L.Dufour, 1820)	Co24
		Timarcha sp.	Co25
		Broscus cephalotes (Linnaeus 1758)	Co26
		Chlaenius (*Trichochlaenius*) *chrysocephalus* (Rossi, 1790)	Co27
		Brachinus sp.	Co28
		Calathus sp.	Co29
	Geotrupidae	*Geotrupes intermedius* (Casta, 1827)	Co30
	Scarabaeidae	*Scarabaeus sacer* (Linné, 1758)	Co31
		Rhizotrogus pallidipennis (Blanchard, 1850)	Co32
		Ochadeus gigas (Merseul, 1913)	Co33
		Theroctes rugatulus (Jekel,1865)	Co34
	Staphylinidae	*Othius* sp.	Co35
	Elateridae	Elateridea	Co36
Lepidoptera	Papilionidae	*Papilio saharae* (Oberthür, 1879)	Le01
	Nymphalidae	*Venessa cardui* (Linné, 1758)	Le02
		Danaus chrysippus (Linné, 1758)	Le03
		Venessa cardui (Linné, 1758)	Le04
	Lycaenidae	Lycaenidae	Le04*
		Plebejus argyrognomon (Bergsträsser, 1779)	Le05

		Pieris rapae (Linné, 1758)	Le06
	Pieridae	*Pieris brassicae* (Linné, 1758)	Le07
		Colias crocea (Fourcroy, 1785)	Le08
	Pterophoridae	*Emmelina monodactyla* (Linné, 1758)	Le09
	Arctiidae	*Utetheisa pulchella* (Linnaeus, 1758)	Le10
	Apoidae	**Xylocopa violacea* (Linné, 1758)	Hy01
		Tetramorium biskrensis kahenae (Menozzi 1934)	Hy02
		Tapinoma sp.	Hy03
		Messor capitatus (Latreille, 1798)	Hy04
		Messor barbara (Linné, 1767)	Hy05
		Tapinoma nigerrimum (Nylander, 1856)	Hy06
	Formicidae	**Cataglyphis bicolor* (Fabricius, 1793)	Hy07
		Cataglyphis bombycinus ((Roger, 1859))	Hy08
Hymenoptera		*Camponotus aethiops* (Latreille, 1798)	Hy09
		Camponotus forelli (Emery, 1881)	Hy10
		Monomorium subopacum (Smith, F., 1858)	Hy11
	Vespidae	*Polistes dominula* (Christ, 1791)	Hy12
		**Polistes gallicus* (Linnaeus, 1767)	Hy13
	Scolitidae	*Megascolia maculata* (Drury, 1773)	Hy14
	Colletidae	*Hylaeus affinis* (Smith, 1853)	Hy15
	Andrenidae	*Andrena* sp.	Hy16
	Pompilidae	*Cryptocheilus notatus* (Rossius, 1792)	Hy17

		Arachnospila sp.	Hy18
	Ichneumonidae	*Ophion luteus* (Linnaeus, 1758)	Hy19
	Halictidae	*Stelis punctulatissima* (Kirby, 1802)	Hy20
		Dufourea sp.	Hy21
	Tenthredinidae	Tenthredinidae	Hy22
Orthoptera	Gryllidae	*Gryllus campestris* (Linnaeus, 1758)	Or01
	Gryllotalpidae	*Gryllotalpa gryllotalpa* (Linnaeus, 1758)	Or02
	Acrididae	*Sphingonotus rubescens* (Walker, 1870)	Or03
		Chorthippus biguttulus (Linné, 1758).	Or04
		Melanoplus bivittatus (Say, 1825)	Or05
		Acrida pellucida algeriana (Dirsh, 1949)	Or06
		Duroniella lucasi (Bolivar, 1881)	Or07
		Locusta migratoria (Linné, 1758)	Or08
Hemiptera	Pentatomidae	*Codophila varia* (Fabricius, 1787)	He01
		Graphosoma italicum (Müller,1766)	He02
		Ancyrosoma leucogrammes (Gmelin, 1790)	He03
	Aphididae	*Aphis craccivora* (Koch, 18541)	He04
		Rhopalosiphum maidis (Fitch, 1856)	He05
		Myzus persicae (Sulzer, 1776)	He06
	Stenocephalidae	*Dicranocephalus albipes* (Fabricius, 1781)	He07
	Nabidae	*Himacerus* sp. (1)	He08
		Himacerus sp. (2)	He09

	Psyllidae	*Cacopsylla* sp.	He10
Thysanoptera	Thripidae	*Odontothrips loti* (Haliday, 1852)	Th01
		Odontothrips confusus (Priesner, 1926)	Th02
	Aeolothripidae	*Aeolothrips intermedius* (Bagnall, 1934)	Th03
	Phlaeothripidae	*Liothrips vaneeckei* (Priesner, 1920)	Th04
Diptera	Syrphidae	*Sphaerophoria scripta* (Linnaeus, 1758).	Di01
	Muscidae	*Musca domestica* (Linné, 1758)	Di02
	Bombyliidae	*Systoechus vulgaris* (Loew, 1863)	Di03
Neuroptera	Myrmeleontidae	*Myrmeleon formicarius* (Linné, 1767)	Ne01
	Chrysopidae	**Chrysoperla oculata* (Say, 1839)	Ne02
	Osmylidae	*Osmylus fulvicephalus* (Scopoli, 1763)	Ne03
8	**44**	**97**	

Co: Coleoptera, Le: Lepidoptera, Hy: Hymenoptera, Or: Orthoptera, He: Hemiptera, Th: Thysanoptera, Di: Diptera, Ne: Neuroptera(*) Protected species in Algeria

TABLE 2. Eigenvalues of species present in the steppe habitat At Ouled Djellal-Algeria

Axes	F1	F2	F3	F4	F5
The eigenvalues	24,167	17,298	11,906	10,420	8,211
Variability (%)	25,439	18,208	12,533	10,968	8,643
% cumulated	**25,439**	**43,647**	**56,180**	**67,148**	**75,792**

An unequal distribution of species was observed in the steppe habitat where the most abundant species belonged to Hymenoptera: *Tetramorium biskrensis kahenae* (15.89%) and Coleoptera: *Erodius emondi* (7%), *Hippodamia variegata* (5.19%), *Coccinella septempunctata* (5.84%) and *Anthaxia nitidula* (4.36%). Among the above 97 species, 11 were constant, 20 accessory species and 32 accidental and classified as sporadic, from which 17 species were rare.

The eigenvalues

The eigenvalues obtained for the species of the steppe habitat are mentioned in Table 2. The obtained results lead us to select the 5 axes, which retain more than 75% of the total inertia and which allow interpretation of all data.

Contribution of observations (months) to the formation of axis

To determine the observations (months) that contribute the most to the factors of the steppe habitat, we use the square cosine. Each of the points on the plane of the factorial map presents indications on the values corresponding to each of the observations. The highest cosine squared values are the most indicative (contributory).

The interpretation of the factorial axis was done sequentially, for each axis and each cloud of points, by looking at the contributions to the formation of the axes. The variables that contribute the most to the formation of the axis are those whose coordinates on this axis are close to 1 in absolute value (XLSTAT).

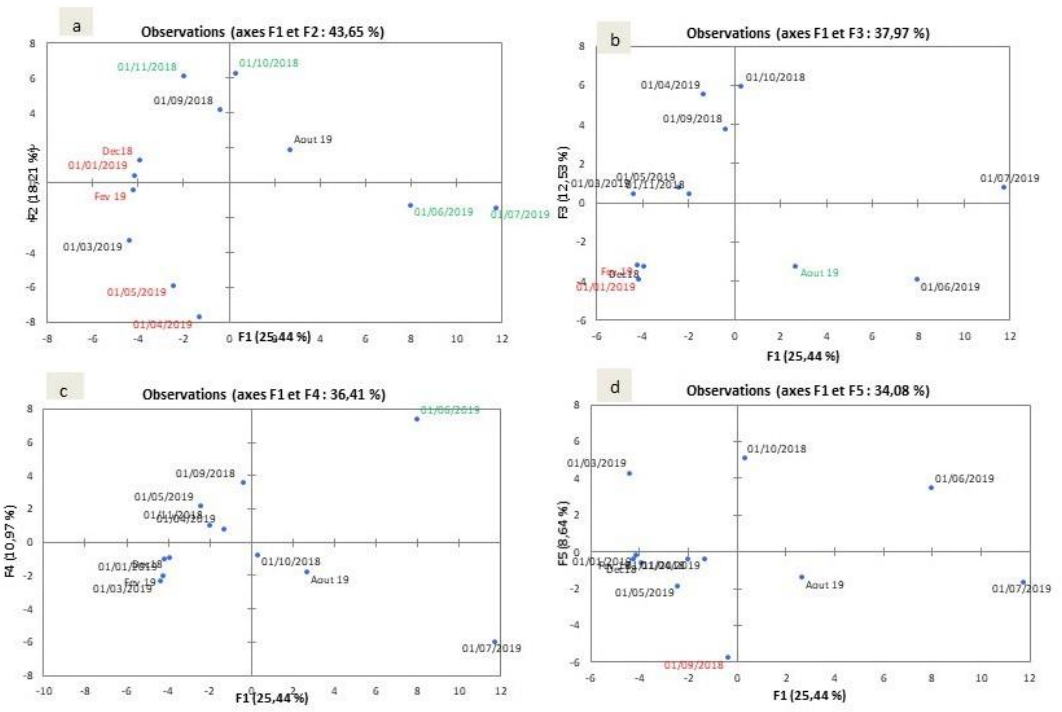

FIG.2: Representation of observations (months) on PCA factorial plan

From Figure 2a**,** axis F1 explains 25.44% of the total information we noticed from the contribution of December, January and February to the formation of this axis opposed to June and July which are in the positive part of the same axis. For the F2 axis that explains 18.21% of the overall information with the contribution of October and November in the positive part, whereas April and May also contribute to the formation of the F2 axis but are presented in the negative side of the same axis. The axis F3 explains 12.53% (Figure 2b) of the overall information, where we observe the contribution of January, February, and August to the formation of this axis. In distinction from January and February, August contributes to the formation of axis, in the positive side. The F4 axis explains 10.97% of the overall information of the total sample with the highest contribution of June (Figure 2c) in the positive side. On the other hand, F5 axis explains only 8.64% of the overall information of the sample (Figure 2d) where we notice the presence of September in the negative side of the axis.

Contribution of variables to the formation of axes

The obtained figures from processing the results from the insects collected at the steppe habitat using PCA of the XLSTAT program (v.2016.3.1) are reported below.

In figure 3a, 31 different species, including *Brachycerus undatus, Geotrupes intermedius, Pieris brassicae, Emmelina monodactyla, Camponotus aethiops* and *Chorthippus biguttulus* contribute to the formation of F1 axis that explains 25.44% of the overall information of our sample. In addition, 24 species, including *Pimelia payraudi, Blaps gigas, Brachycerus algirus, Lophyra flexuosa, Broscus cephalote, Plebejus argyrognomon, Cataglyphis bicolor, Gryllus campestris, Gryllotalpa gryllotalpa, Aphis craccivora, Chrysoperla oculate* and *Musca domestica* contribute to the formation of F2 axis that

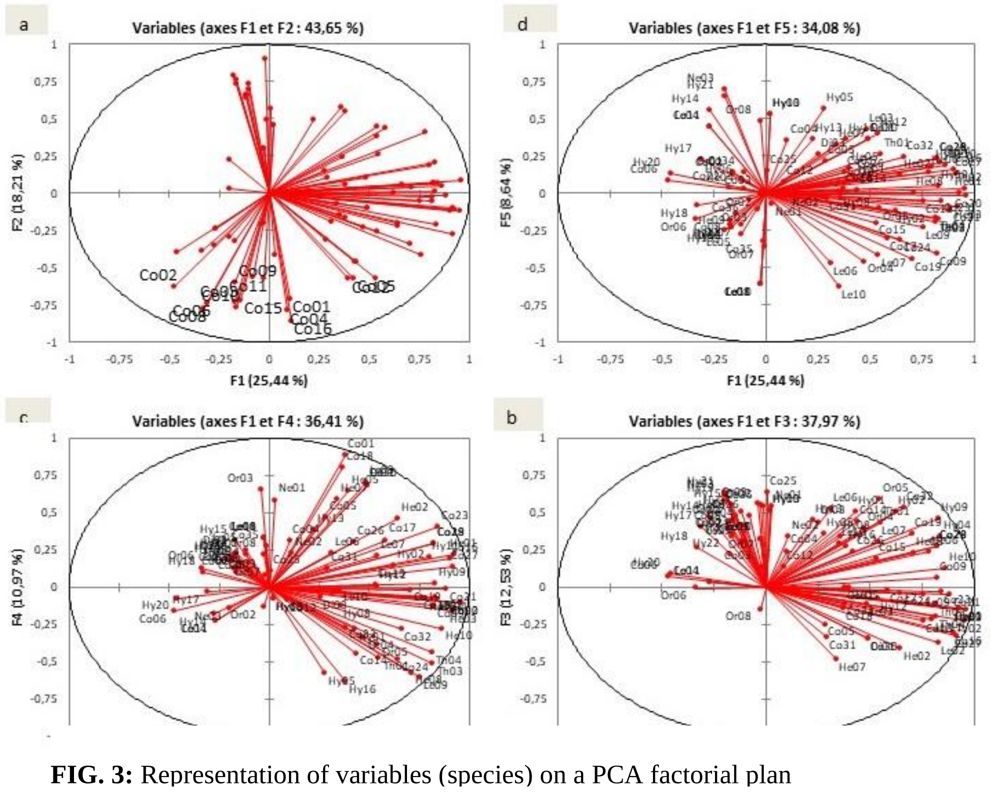

FIG. 3: Representation of variables (species) on a PCA factorial plan

explain 18.21% of the overall information of our sample (Fig. 3a).

Biplots representation of variables and observations on PCA

Figure 4 represents the simultaneous representations of observations (months) and variables (species) on the same plane of a PCA that is more informative.

Two groups were observed on the PCA plan, where the first is represented by the correlation of December, January, February and comprises: *Blaps gigas*, Elatearidae species, *Arachnospila* sp. And *Himacerus* spp. (two species). December, January and February were on the negative side of the F1 axis and this is explained by the negative correlation of these months with the low temperature that influences negatively the activity of the insects where we note a low entomological diversity. The correlation of species to the coldest months of the year can be explained by their adaptation to low temperatures, as insects, which are poikilothermic, change their activity depending on the temperature of the surrounding environment (Bale *et al.*, 2002), and according to Sparks and Parish (1995), the presence of some species during winter is probably linked to the presence of their hosts (animal or plant) adapted to steppe conditions characterized by the presence of few number of adapted plants, or because perhaps, they are just visitors seeking shelter (Joshua *et al.*, 2007) due to low ambient temperature.

June and July (Fig. 4a) correlate with *Hippodamia variegata*, *Anthia sexmaculata*, *Calathus* sp., *Odontothrips confusus, Aeolothrips intermedius, Liothrips vaneeckei, Camponotus aethiops, Monomorium subopacum, Messor capitatus* etc., because these months are characterized by temperature elevation and this explains their position on the positive side of the F1 axis. Therefore, the activity of insects is influenced, and higher populations are recorded (Deghiche-Diab, 2020). Ramade (1984) has also confirmed the positive effect of temperature to control all the metabolic phenomena of insects, as well as their distribution (Dreux, 1980).

October and November contribute to the formation of the F2 axis in the positive direction (Fig. 4a) and correlate to *Cheilosia variabilis, Tapinoma* sp.*, T. nigerrimum, Glaucopsyche melanops, Harpalus rufipes, Coccinella septempunctata*, *Akis lusitanica*, *Pimelia payraudi*, etc., the presence of which during this time of the year is probably correlated to availability of seeds and roots of different plant species present (Grangier, 2008) and thus the presence of certain species such as ants is promoted. Their presence can also be related to rainfall water that contributes to the spread of many species (Bachelier, 1978).

April and May contribute to the formation of the F2 axis; they are on the negative direction (Fig. 4a) and correlate to *Aspidapion aeneum*, *Tropinota squalida*, *Eumenidae sp*, *Hylaeus affinis*, etc. which are phytophagous species linked to the environmental architecture, the variety of plant species and the diversity of ecological niches (Barbault, 1981) in the steppe area. This is also in correlation with (Jaworski and Hilszczański, 2013) who indicate reported that long and intense droughts, which are one of the results of the average temperature increase, have a negative impact on the condition of plants, thus increasing their susceptibility to phytophagous insects.

Figure 4b shows that February and January that are in the negative part of the F3 axis are opposite to August that is in the positive part of the same axis and correlated to *Timarcha* sp.*, Othius* sp.*, Pieris rapae, Xylocopa violacea, Hylaeus affinis* and *Melanoplus bivittatus*. The presence of these species during summer, especially during August, can be related to the climate effect in this region, that is characterized by height temperatures, low and irregular rainfalls, intense luminosity, high evaporation and intense temperature fluctuation (Ozenda, 1991), which may favor the development of certain species with strong resistance to rising temperatures (Dajoz, 1985; Ward, 2009). On the opposite of the axis, we have a negative correlation of other species with January and February that could be explained by the inverse influence of temperature on their activity.

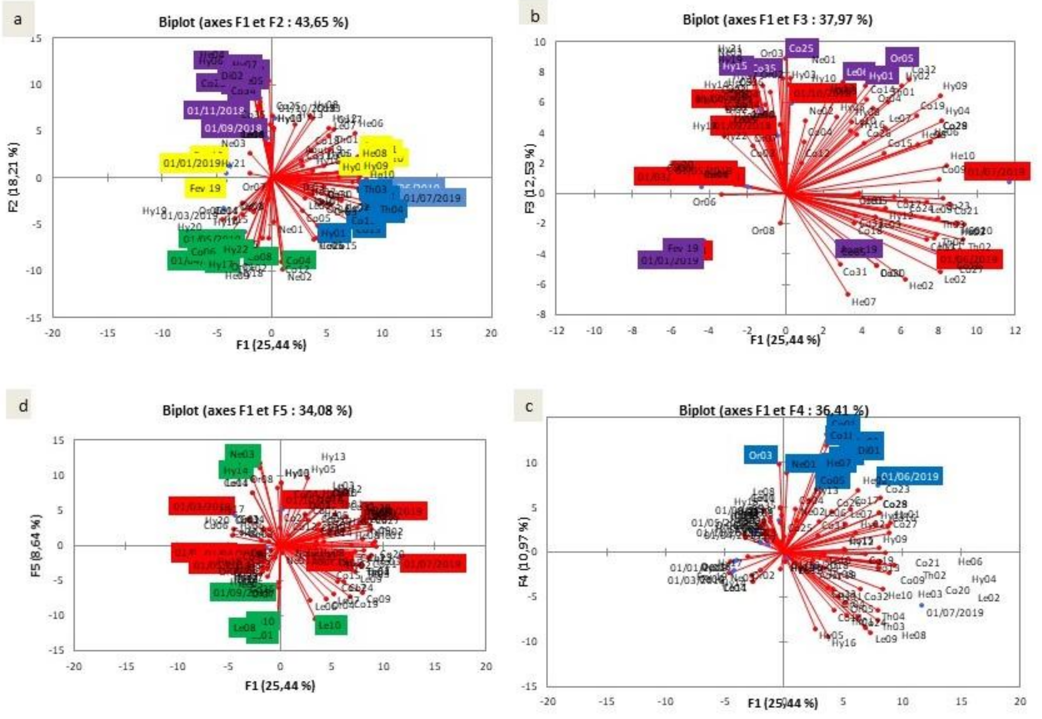

FIG. 4: Simultaneous representation of variables and observations on the PCA plan

June was correlated to *Myrmeleon formicarius, Sphaerophoria scripta, Dicranocephalus albipes, Rhopalosiphum maidis, Sphingonotus rubescens, Andrena* sp., *Messor barbara, Venessa cardui, Geotrupes intermedius, Danaus chrysippus, Graphipterus serrator, Stenocara* sp. and *Erodius emondi* (Fig. 4c). It should be noted that June is characterized by a significant activity of insect species indicated by higher populations as compared to other months, explained by the environmental conditions that have improved due to rainfalls during the preceding months. Likewise, as indicated by Cachan (1960), humidity that depends on temperature, precipitation and wind is one of the most important factors for insect survival, distribution and reproduction. Soil texture may also be a reason for certain species presence, such as ants (Bardgett *et al.*, 2005) that can survive during high temperature periods.

The F5 axis represents the September correlation with *Osmylus fulvicephalus, Papilio saharae, Tapinoma* sp., *Camponotus forelli, Megascolia maculata, Dufourea* sp., *Utetheisa pulchella, Colias crocea,* and *Larinus* sp. (Fig. 4d). In fact, water is an ecological factor of fundamental importance (Ramade, 1983) that exerts an influence on insect population density

(Ramade, 1984). During September, we observed insect activity commencement, following vegetation cover emergence induced by rainfalls. Likewise, the presence of certain species, such as *Utetheisa pulchella*, is probably linked to the presence of its host *Echium trygorrhizum* (Borraginaceae), characteristic of steppes (Deghiche-Diab and Deghiche, 2016; Deghiche –Diab *et al*., 2020) that appear after precipitation. Also, *Zizyphus lotus*, another characteristic shrub from steppe habitats was recorded to be inhabited by *Tarucus theophrastus* Fabricius, 1793 feeding on its leaves (Deghiche-Diab *et al*., 2021a). This species has also been recorded from different localities in the North of Algeria (Koçak and Kamel, 2015). Because of the large number of species that contribute to the formation of the five axes, it is important to study our results using the ACH and to validate the most homogeneous groups.

The dendrogram obtained for the collected species from Ouled Djellal steppe shows the presence of four homogeneous groups (Fig. 5). To proceed to the cut of the obtained tree from the ascending hierarchical classification, it is important to have an idea about the species that contribute to the construction of the partition, which is not optimal but interesting. This partition (cutoff) is good if the intra-class partition (or within-class variability) is small compared to that of the inter-class (or between-class variability), which should be higher. We note that individuals from the same class should be similar (or close). When moving from one class to another, a loss of inertia is observed, so the tree is cut where the loss is large and must be compared to the cumulative information obtained from the axes constituting the PCA plan and that helps interpretation of our results.

The tree cut was obtained at a distance of 75, where observe four groups: the second being more homogeneous than the others, indicated by the low distance between grouped species; it includes 48 species from different orders. The third group is represented by Meloidae species, *Brachycerus algirus, Graphipterus serrator, Lophyra flexuosa, Broscus cephalotes*, *Geotrupes intermediu*, *Papilio saharae*, *Vanessa cardui*, *Plebejus argyrognomon*, *Emmelina monodactyla*, *Tapinoma* sp., *Cryptochellilus notatus*, *Camponotus* sp., *Grycephalus* spp., *Sphaerophoria scripta, Myrmeleon formicarius*, etc. that were indicated as sporadic species in the region (Deghiche-Diab, 2020). The fourth group was obtained from the comparison of *Systoechus vulgaris, Cataglyphis bombycinus, Messor capitatus, Lophyra flexuosa*, etc. that qualify as the most abundant species in the habitat (Deghiche-Diab, 2020). One ant species, *Tetramorium biskrensis kahenae*, that shows good adaptation to steppe conditions, forms the first group. In their study on ants' diversity, Chemala *et al*. (2017) postulate that the greatest diversity of ants was observed in two arid ecosystems, one natural and one cultivated. Our results also agree with studies carried out at the Biskra arid region on ant species that can adapt to different areas; natural (Cagniant, 1966), cultivated (Cagniant, 1970) or even dune (Cagniant, 2006).

Conclusions

In general, the desert or/and Saharan zones support a relatively low number of species per unit (Ozenda, 1983; Catalisano, 1986). However, the Ouled Djellal that is an arid region presents a surprising and diversified fauna on which few studies are devoted because of the difficulty to observe them due to their homochromic coloring and nocturnal behavior (Vial and Vial, 1974). In general, a low total variation of species is observed in steppe environments that is poor in water and plant diversity.

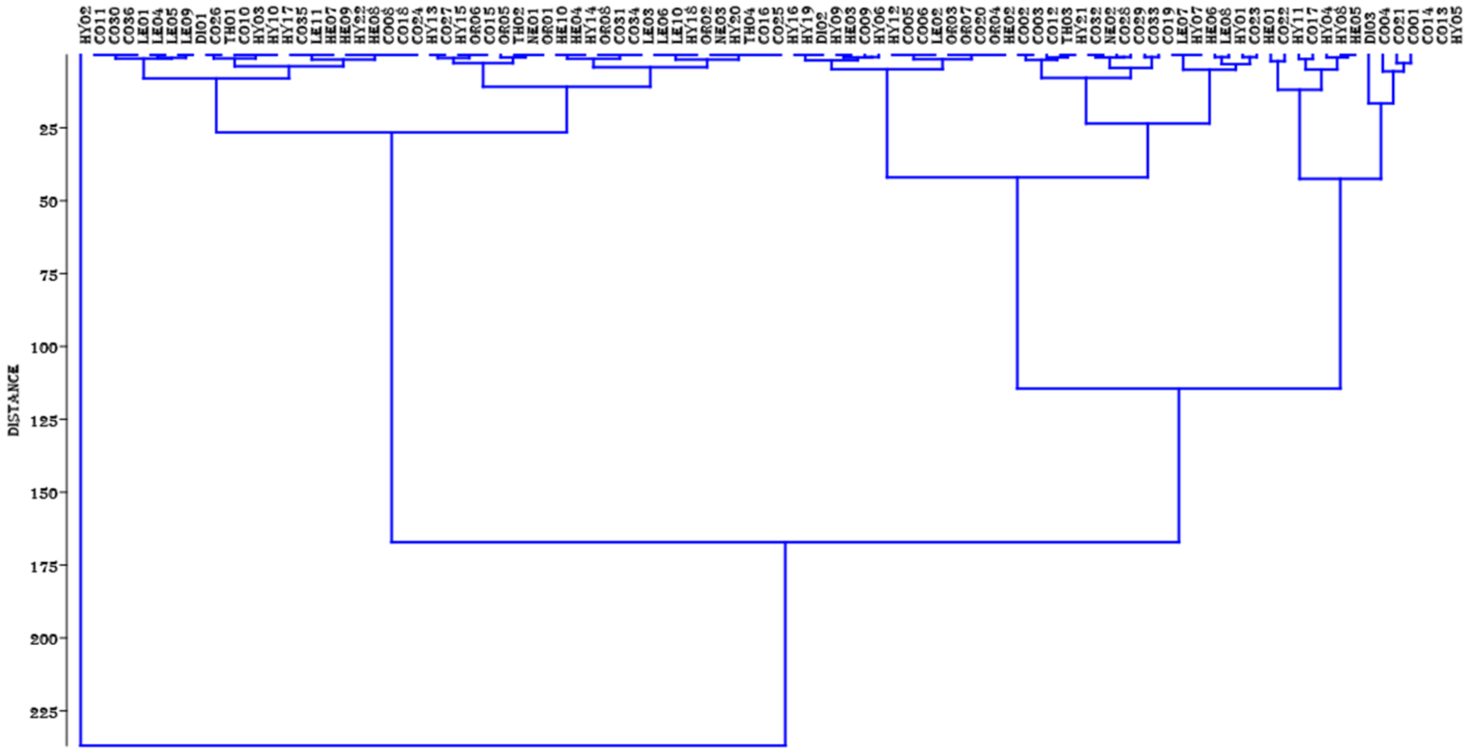

FIG. 5: Hierachical Ascending Classification (HAC) of species from steppe habitat

All obtained results during this study show that steppe is a natural habitat surrounded by a desert environment, that is characterized by rain scarcity, high temperatures and winds that can constitute limiting ecological factors for insect survival (Ramade, 1984). The wind which increases evapotranspiration, contributes to atmosphere drying out (Mutin, 1977) and inhibits plant growth (Mackenzie *et al*., 2000; Monod, 1992) has an influence on the existence and the activity or development of certain insect species (Faurie *et al*., 1984; Ramade, 1983). Vegetation cover is strongly associated with insect accumulation (Sperber *et al*., 2004). Thus, certain species can adapt to the harshest climatic conditions in the region by building their own ecological niches behind natural resources (Brague-Bouragba, 2010) by feeding on seeds of growing species (Grangier, 2008; Deghiche-Diab *et al.*, 2015a,b), by using indigenous plants as host plants (Deghiche-Diab *et al.*, 2021b), or maybe for egg laying (Deghiche-Diab and Deghiche, 2021a). The soil texture can be also one of the conditions that has great effect on the distribution and presence of species in the steppe region (Bardgett *et al*., 2005; Deghiche-Diab *et al*, 2020b).

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