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ORIGINAL PAPER

First record of the invasive spotted wing Drosophila infesting berry crops in Africa

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Abstract

The spotted wing drosophila, *Drosophila suzukii* Matsumura (Diptera: Drosophilidae), is an invasive pest native to Asia that has recently invaded Europe and the Americas. This pest can seriously compromise fruit production in infested crops and has a remarkable ability to invade new areas with a diverse range of environments. We report for the first time *D. suzukii* infestations in African crops. We sampled 101 fields cultivated with soft-skinned fruits in two regions of northwestern Morocco. Morphological and molecular analyses confirmed the occurrence of *D. suzukii* in this area. In 2017 and 2018, approximately 15% of the surveyed farms growing small berries were infested by *D. suzukii*. A total of 61.11% of the surveyed raspberry fields were infested, followed by blueberries (22.22%), strawberries (11.11%) and mulberries (5.56%). Peak infestations were between March and June and in November and December. We carried out preliminary mass trapping in a raspberry tunnel, and of the two traps used, the red-colored trap baited with baker's yeast and sugar was the most effective. The results are discussed in the light of the invasion potential for the African continent and integrated pest management (IPM) perspectives for soft fruit production in Morocco.

Keywords *Drosophila suzukii* · Invasive pest · Integrated pest management · Mass trapping · Morocco

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Key message

- We found evidence of the presence of *Drosophila suzukii* in northwestern of Morocco since, at least, 2017.
- *Drosophila suzukii* damage was found in raspberry, blueberries, strawberries and mulberries crops.
- Flying *D. suzukii* adults mainly occurred in the spring and late fall.
- Mass trapping showed potential effectiveness for *D. suzukii* control strategies in raspberry tunnels.
- Future research is urgently needed on the biology of *D. suzukii*, its wild and cultivated host, as well as natural enemies under local conditions.

Introduction

Invasive arthropod pests are increasingly establishing outside of their native ranges worldwide mainly due to increasing global commercial exchanges and global warming (Seebens et al. 2016; Kirichenko et al. 2019; Santana et al. 2019;

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Biological characteristics of *Orthonama obstipata* (Fabricius, 1794) (Lepidoptera: Geometridae), an emerging defoliator of mint (*Mentha spicata* L., 1753) in Morocco

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Abstract

The looper caterpillar, *O. obstipata* is one of the defoliator species of cultivated mint in Morocco. Its identification and its biology constitute the preliminary step for the development of a program aiming at its integrated management. The larvae were collected from a plot of mint grown in a region of northern central Morocco, and reared in the laboratory. The identification of the species was based on comparing the male aedeagus and the female spermatheca to the reference slides. In this study, the elements of biology and morphological characteristics of the different ecophases of *O. obstipata* are clarified and discussed. The life cycle of the species, from egg to egg, is completed in 31.3 ± 2.16 days. The emergence occurs linearly in time after the 27th and 28th days of oviposition according the sex. The sex ratio (Male/Female) is 0.88:1. The fecundity of the females is positively correlated with their lifespan. Females have an average fecundity of 210 eggs and a fertility rate of 97%. Adults live on average 22.0 ± 6.3 days. The highest mortality rates occur in the last larval instar and pupa.

Keywords: *Orthonama obstipata*, Biology, Reproduction, *Mentha spicata*

INTRODUCTION

Migratory Geometrid pests are widely distributed around the world (Skou, 1986; Scoble *et al.*, 1995; Scoble, 1999; Thibaudeau *et al.*, 2013). The looper caterpillars are polyphagous. They feed on a wide variety of herbaceous and cultivated or spontaneous woody taxa (strawberry, cabbage, plum, green onion, Chinese bellflower, golden ragwort, etc.) (Choi, 2012; Thibaudeau *et al.*, 2013). The larvae of some species are closely associated with herbaceous plants (Brehm and Fiedler 2005; Brehm *et al.*, 2005; Axmacher *et al.*, 2009). Some geometrid species cause damage to crops such as fodder crops (*Ptychopoda herbariata*) (Balachowsky, 1972) and apple trees (*Chloroclystis rectangulata* L.) (Balachowsky, 1966). In Morocco, some other species like *Gymnoscelis pumilata* have been reported on the flowers of Citrus (Balachowsky, 1966), *Gymnoscelis pumilata* Hubner on the cotton plant (Le Gall, 1965) and *O. obstipata* on cultivated spearmint (*M. spicata* L.) (Eddaya, 2015). Moroccan mint is cultivated on an area of about 3352 ha producing 98704 t with a yield of about 29 t/ha (FAO, 2018). The crop is attacked by various harmful biological agents (Eddaya *et al.*, 2015) during its development. Among the pests associated with cultivated mint, *O. obstipata* is an emerging defoliator that is increasingly attracting the attention of producers.

O. obstipata is known for a remarkable sexual dimorphism. It is cosmopolitan, polyvoltine (Ford, 1972; Skou, 1986) and migratory (Soli, 1986; Pohl *et al.*, 2010). *O. obstipata* was reported in several countries such as: the United States, southern Canada, Spain, France, India, China, South Korea, Malaysia, Turkey, Morocco, etc. (Albu and Metzler 2004; Schulze and Fiedler 2004; Ayberk, 2010; Bachelard and Fournier, 2010; Choi 2010; Pohl *et al.*, 2010; Zamora-manzur *et al.*, 2011; Eddaya, 2015). It frequents wasteland and gardens even in the heart of cities, meadows, agrosystems and urban parks (Schulze and Fiedler, 2004; Lim *et al.*, 2009; Ayberk, 2010). *O. obstipata* accomplishes several generations from March to November (Skou, 1986). The development from egg to imago of *O. obstipata* lasts about a month under optimal conditions (Edelsten and Fletcher, 1961).

Some geometridae species have already been studied (King and Montesinos, 2017), e.g. *Abraxas pantaria* (Pernek *et al.*, 2013), *Ectropis* sp (Prasad *et al.*, 2013), *Sangalopsis veliterna* (Hernández *et al.*, 2014) and *Drymoea veliterna* (Hernández *et al.*, 2017). However, to our knowledge, the biology and morphology of *O. obstipata* have not been described in detail. Therefore, in an attempt to develop an integrated and sustainable management approach of *O. obstipata*, it is more appropriate to start by verifying its identity and specifying its elements of biology in Moroccan conditions. Thus, the aim of this work is to provide the morphological description and the biological characteristics of *O. obstipata* (*viz.* fecundity, fertility, sex ratio, longevity of adults and mortality rates of each stage) under laboratory conditions.

Variabilité des huiles essentielles et de l'ADN de deux souches de *Mentha spicata* L. (glabre et pubescente) de la région de Meknès

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Résumé

Mentha spicata constitue l'une des 4 espèces du genre *Mentha* cultivées pour, entre autres, la production d'huiles essentielles. Les parcelles de la menthe connaissent l'apparition d'une souche pubescente (Sp) suite à la germination des graines produite par la souche glabre (Sg), initialement cultivée dans la région de Meknès. Pour comparer ces deux souches de *M. spicata*, des analyses chimiques des composés volatils et génétiques ont été entreprises. Les huiles essentielles ont été extraites par hydrodistillation des feuilles sèches et leur composition chimique a été analysée par CPG/SM. Le polymorphisme de l'ADN des deux souches a été caractérisé par l'AFLP (Amplified Fragment Length Polymorphism). Les rendements en huiles essentielles de Sp et Sg sont, respectivement, de l'ordre de 1,61 et 2,32% (v/w). Les nombres de composés chimiques identifiés chez la Sp et la Sg sont respectivement de 47 et 37. La souche Sp se démarque par sa richesse en limonène (7,7%) et gemacrène-D (3,12%) et sa faible teneur en carvone (62,2), comparativement à la souche cultivée (75,6). La souche Sp est caractérisée par 44 bandes uniques et la Sg n'en possède que 18.

Mots clés: *Mentha spicata*, Huiles essentielles, CPG/SM, ADN, AFLP, Polymorphisme

Variability of essential oils and DNA of two strains of *Mentha spicata* L. (hairless and pubescent) from Meknes region

Abstract

Mentha spicata is one of four species of the genus *Mentha* cultivated for, among others, the production of essential oils. The mint plots are experiencing the appearance of a pubescent strain (Sp) following the germination of seeds produced by the hairless strain (Sg) initially cultivated in the Meknes region. To compare these two strains of *M. spicata*, chemical and genetic analysis of volatile compounds were undertaken. The essential oils were extracted by hydrodistillation of dry leaves and their chemical composition was analyzed by GC/MS. The DNA polymorphism of the two strains was characterized by AFLP (Amplified Fragment Length Polymorphism). The essential oil yields of Sp and Sg are 1.61 and 2.32% (v/w), respectively. The numbers of chemical compounds identified in the Sp and Sg are 47 and 37, respectively. Sp strain is distinguished by its richness in limonene (7.7%) and gemacrene-D (3.12%) and its low carvone content (62.2) compared to the cultivated strain (75.6). Sp strain is characterized by 44 unique bands and Sg has only 18.

Keywords: *Mentha spicata*, Essential oils, CPG / MS, DNA, AFLP, Polymorphism

INTRODUCTION

Mentha *spicata* L. est un hybride interspécifique fertile issu du croisement de M. *suaveolens* et M. *longifolia* (Harley et Brighton, 1977; Gobert *et al*., 2002). Plusieurs variétés et hybrides de cette espèce (Gobert *et al*., 2002; Shasany *et al*., 2005; Hua *et al*., 2011; Hua *et al*., 2013) sont cultivés ou poussent à l'état spontané sur les 5 continents sauf l'Antarctique (Kokkini et Vokou, 1989; Gobert *et al*., 2002; Liu et Lawrence, 2007; Tucker Arthur et Naczi Robert, 2007). *M. spicata* est l'une des 4 espèces cultivées pour la production des huiles essentielles (Harley et Brighton, 1977). Les huiles essentielles de cette espèce sont utilisées dans plusieurs domaines d'importance économique (médecine, industrie alimentaire, pharmacie et phytoprotection) (Akdoan *et al*., 2007; Znini, 2011).

L'origine parentale de *M. spicata* lui confère une grande diversité morphologique, cytologique, génétique et chimique (Kokkini et Vokou, 1989; Gobert *et al*., 2002). Parmi ses populations, il peut y avoir des individus glabres et d'autres pubescents (Harly, 1967, cité dans Gobert *et al*., 2002). La présence de souches pubescentes constitue un matériel végétal recherché par les améliorateurs de plantes (Ashouri *et al*., 2001; Pomponb *et al*., 2010). Les poils constituent un système de défense contre des bioagresseurs comme les pucerons (Ashouri *et al*., 2001; Moghadam *et al*., 2013), ravageurs de *M. spicata* (Özdemýr, 2006; Kaygin *et al*., 2009). Par ailleurs, certains terpenoides comme le limonène, α-Pinene, β-Pinene, (*E*)-β-ocimene et germacrene D sont utilisés par les plantes comme système de défense contre les bioagresseurs, dans l'activation de l'expression des gènes de défense ou pour l'attraction des parasitoïdes et prédateurs des ennemis de cultures (Bohlmann *et al*., 1997; Fäldt *et al*.; 2003; Boachon *et al*., 2018; Li *et al*., 2021).

Le chimio-phénotype, le phénotype et le rendement des huiles essentielles des plantes sont affectés par les facteurs endogènes, dont le génotype de la plante (Murray, 1960; Kokkini et Vokou, 1989; Kokkin, 1991; Marks, 1997; Özgüven et Kirici, 1999; Boachon *et al*., 2018; Bornowski *et al*., 2020). La connaissance de la diversité génétique d'une plante fournit une base pour la sélection de cultivars très performants (Schlotterer, 2004). Pour ce faire, différentes techniques moléculaires sont utilisées pour évaluer la diversité génétique de la menthe (Vos *et al*., 1995; Khanuja *et al*., 2000; Fenwick et Ward, 2001; Shasany *et al*., 2005; Hua *et al*., 2011; Al-Rawashdeh, 2011; Hua *et al*., 2013). Pour *M. spicata*, la diversité génétique intra-spécifique a été étudiée par, entre autres, l'AFLP. Au Maroc, la caractérisation moléculaire de *M. spicata* seule ou en association avec celle des composés volatils n'a jamais fait, à notre connaissance, l'objet d'étude.

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Essential oil chemical diversity of Moroccan mint (*Mentha spicata* L.)

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Abstract

Spearmint (*Mentha spicata* L.) is one of the best known aromatic and medicinal plants. The characterization of essential oil variation is of commercial importance as well as helpful for appropriate use of *M. spicata*. Thirteen strains of cultivated or spontaneous mints were collected from 10 Moroccan regions and acclimatized for two years in Meknes. Their leaves collected at full flowering were dried for hydro-distillation. Essential oil yields were found to vary from 1.32 % to 5.83 %. Analysis of these oils by GC/MS indicated a large variation in chemical composition among the studied strains of Moroccan *M. spicata* (9 to 51 compounds). The highest yields characterize the cultivated strains of Agadir (5.83 %), S2 of Larache (4.84 %) and the spontaneous strain S3 of Ifrane (4.17%). The richest strain in number of compounds is S3 of Ifrane with 51 compounds whereas uncultivated S2 from the same region has only 9 compounds. Some strains are rich in carvone such as the cultivated strain of Ouarzazate (65.94%) and the spontaneous S2 of Ifrane (72.3 %). Others are rich in eucalyptol, pulegone or 3-Cyclopenten-1-one, 2-hydroxy-3-(3-methyl-2-butenyl) such as those of Marrakech (21.1 %), Agadir (30.7 %) and S1 of Larache (22.1 %), respectively. The strains of Settat and Ifrane (S1) have high levels of limonene (17.8-18.1%).

Keywords: *Mentha spicata*, Essential oils, Carvone, Eucalyptol, Cluster analysis, GC/MS

INTRODUCTION

Spearmint, *Mentha spicata* L cv. viridis (khanuja *et al.*, 2000) or *Mentha viridis* L. (Chadefaud and Emberger, 1960), is a perennial plant of the labiate or Lamiaceae family (Chadefaud and Emberger, 1960) including 200 genera (Good, 1974; Hedge, 1992; Heywood, 1978). The genus Mentha is composed of 25 to 30 species (Dorman *et al.*, 2003). Some authors present *M. spicata* as a fertile interspecific hybrid resulting from the crossing of *M. suaveolens* and *M. longifolia* (Harley and Brighton, 1977; Gobert *et al.*, 2002). However, some others suggest that there is no genetic evidence for this descent and recommend revising the taxonomic status of *M. spicata*, including its lectotype (Heylen *et al.*, 2021). Several varieties and hybrids of this species (Gobert *et al.*, 2002; Shasany *et al.*, 2005; Hua *et al.*, 2011; Hua *et al.*, 2012) are cultivated or grow spontaneously on the continents of the globe except Antarctica (Kokkini and Vokou, 1989; Gobert *et al.*, 2002; Liu and Lawrence, 2006; Tucker Arthur and Naczi Robert, 2006). In Morocco, spearmint is cultivated in all regions among which Tiznit, Settat, Meknes and Larache (Tanji, 2008; Eddaya, 2015) characterized by a high production and it also exists in the wild state (Carlier-Loy, 2015). Moroccan spearmint is sold in national markets and also exported to several countries. The production of essential oils is the main objective for the intensification of its cultivation in several countries. Essential oil production of the genus Mentha is ranked second after that of citrus fruits on a global scale (Jullien, 2007).

Mint (*M. spicata* L.) is one of the best-known aromatic and medicinal plants since antiquity (Tazi, 1986). Indeed, it is used to treat many disorders including the most common ones: colds, coughs, sinusitis, fever, bronchitis, nausea, vomiting, indigestion, intestinal colic, loss of appetite. Obviously, mint is used as a culinary herb to delicately flavour tea, confectionery, chocolates, etc. (Vokou *et al.*, 1993; Lev and Amar, 2000 and 2002; Leporatti and Ivancheva, 2003; Lardos, 2006; Akdoğan *et al.*, 2007; Rhazi *et al.*, 2012; Mahboubi, 2021). These culinary and medicinal properties can be attributed to its richness in several compounds: flavonoids, alkaloids, terpenoids, terpenoid glycosides (spicatoside A and spicatoside B), sterols, steroids, coumarins, caryophyllene, tannins and phenols (eugenol , caffeic acid, rosmarinic acid, α-tocopherol), carvone, linalool, piperitone oxide, carvone-dihydrocarvone, menthone, etc. (Kokkini and Vokou, 1989; Tucker, 1992; Eddaya, 2015). Indeed, many of these compounds are constituents of essential oils used in several fields of economic importance such as medicine, industry, pharmacy and plant protection as biopesticides (Akdoğan *et al.*, 2007; Koul et al., 2008; Omar *et al.*, 2009 Znini *et al.*, 2011; Kapp *et al.* 2020).

The yield and chemical composition of essential oils of *M. spicata* are affected by endogenous, and exogenous or environmental factors (Hua *et al.*, 2011; Eddaya, 2015). Indeed, the composition of essential oils depends on the development stage of the plant (Rodrigues *et al.*, 2013; Maffei *et al.*, 1989) and the growth conditions (Maffei and Scannerini, 1999; Karray-Bouraoui *et al.* , 2009). The flowering period of mint, in summer, is an optimal period for the production of essential oils (Vaverková *et al.*, 2009). The essential oils composition of *M. spicata* L. accessions from several geographical origins are different from each other (Orav *et al.*, 2004; Oyedeji and Afolayan, 2006; Hajlaoui *et al.*, 2010). This is due to the interaction of the genotype with the various environmental factors (Patel *et al.*, 2015).