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Morphology and Distribution of *Empoasca decipiens* Paoli and *Asymmetrasca decedens* (Paoli) (Hemiptera: Cicadellidae), in Jordan

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Abstract

A survey was carried out from May 2018 to November 2019 to collect the green leafhoppers from different ecosystems in Jordan using a battery-operated vacuum device or a sweeping net from 27 localities in Jordan. The collected specimens were identified as *Empoasca decipiens* Paoli or *Asymmetrasca decedens* (Paoli). Both species were found widely distributed and overlap in their range. Accurate species identification depended only on the microscopic examination of male genitalia. Data on the distribution, collecting dates and morphology of these two species were given including color images of adults and male genitalia.

Keywords: Leafhoppers, survey, male genitalia, Typhlocybinae, Empoascini.

1. Introduction

The genus *Empoasca* Walsh, 1862 includes more than 643 species distributed worldwide while genus *Asymmetrasca* includes 17 species restricted to the Palearctic and Oriental regions (http://dmitriev.speciesfile.org, Liu *et al*., 2014). The green leafhoppers, *Empoasca decipiens* and *A. decedens* are widely distributed in the Middle East, North Africa, central Asia and most of Europe (Raupach *et al*., 2002). Both species are considered pests on economically important agricultural crops, including grape, tomato, potato, corn and other host plants (Raupach *et al*., 2002; Atakan, 2011; Emam *et al*., 2020). However, misidentifications of the two species caused confusion over their identity due to high morphological similarity to each other and closely related species (Poos, 1932; Karimzadeh and Dworakowska, 2011; Aguin-Pombo, 2014; Qin *et al*., 2015). For example, *E. punjabensis* has often been misidentified as *E. decipiens* (Karimzadeh and Dworakowska 2011). Al-Asady (2002) illustrated the morphology of male and female adults and the male genitalia of *A. decedens*.

The objectives of this study were to survey, identify the species of the green leafhoppers and contribute to their morphology to facilitate their identification.

2. Materials and Methods

Specimens were collected from 27 localities from various habitats in the Jordan including the highlands, Jordan Valley and desert areas from May 2018 to November 2019. In addition, specimens collected previously and preserved at the University of Jordan Insect Museum (UJIM) were examined. Locality names, their coordinates, host plants, collecting dates, number of males, number of unidentified females and the total number of specimens are given in Table 1. Coordinates were taken by Global Position System. Leafhoppers were sampled mainly by a battery-operated vacuum device (InsectaZooka, BioQuip products, Rancho Dominguez, CA) and occasionally by a sweeping net. Collected specimens were preserved in alcohol or pinned on cards and housed at the University of Jordan Insect Museum. Male genitalia of all collected specimens were removed and soaked in hot 10% KOH for 3-8 min, washed in distilled water, and then transferred to glycerin for further dissection and identification. Specimens were identified using the key of Le Quesne and Payne (1981) and the interactive key at (http://dmitriev.speciesfile.org), which included relevant literature about Jordan or other adjacent areas. Color photographs were taken for adult insects by Canon EOS 40 attached to Leica M165 C Stereomicroscope provided with Dome LED illumination. Male genitalia were photographed using the same camera mounted on a Leica DMLS binocular microscope. Body length for adults was measured from the tip of the head to the tip of the wings.

3. Results

A total of 368 specimens of leafhoppers were collected from 27 different locations on 28 host plants including grasses, fruit trees, vegetables, ornamentals and wild plants. Sampling sites, their coordinates, collecting dates, male and unidentified female numbers of both species are given in Table 1. Distribution of both species is shown in Figure 1. The examination of all male genitalia (Plates 1, 2 and 3) from each sample revealed that they belonged to

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either *Empoasca decipiens* and/or *Asymmetrasca decedens*. Morphological differences between *E. decipiens* and *A. decedens* male genitalia were shown in Table 2.

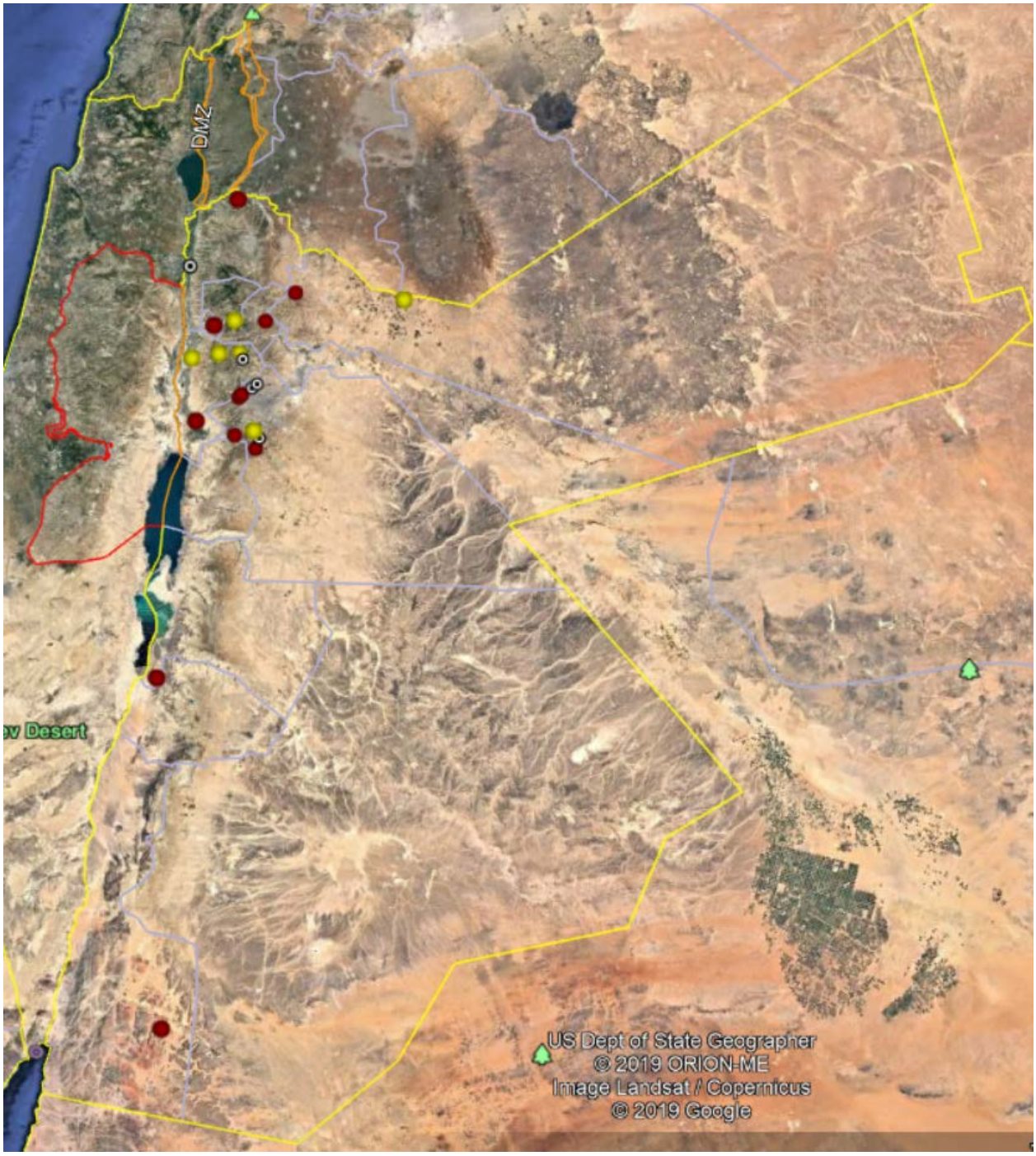


Figure 1. Map of Jordan showing the distribution of *E. decipiens* (Red) and *A. decedens* (yellow). The Black and white circle shows areas of overlapping populations. Source: Google Earth (US Dept. of State Geographer, accessed March 2020).

Table 1. Collecting localities, dates, hosts, number of males and total numbers of *E. decipiens* and *A. decedens*.

Locality	Coordinates	Host plant Common name, scientific name (family)	Collecting date	No. of *E. decipiens* male specimens	No. of *A. decedens* male specimens	No. of undetermined Female specimens	Total No. of specimens
Ash Shūnah ash Shamālīyah	N32° 28.15 E 35° 35.44	Citrus *Citrus* spp. (Rutaceae)	19/12/2017	4	2	8	14
Al Jubayhah, UJ* Campus	N32°00.695 E35°52.380	Field bindweed *Convolvulus arvensis* L. (Convolvulaceae)	30/5/2018	5	3	13	21
Al Jubayhah, UJ Campus	N32°00.695 E35°52.380	Rosemary *Salvia rosmarinus* Spenn. (Lamiaceae)	30/5/2018	2	-	6	8
Al Jubayhah, UJ Campus	N32°00.695 E35°52.380	Bermuda grass *Cynodondactylon* (L.) Pers. (Poaceae)	3/6/2018	-	1	1	2
Al Jubayhah, UJ Campus	N32°00.695 E35°52.380	Rosemary	3/6/2018	3	-	3	6
Al Jubayhah, UJ Campus	N32°00.695 E35°52.380	Johnson grass *Sorghum halepense* (L.) Pers. (Poaceae)	3/6/2018	3	-	4	7
Al Yadodah	N31°49.499 E35°54.465	Field bindweed *Convolvulus arvensis* L. and Mint *Mentha* sp. (Lamiaceae)	22/7/2018	3	-	4	7
Al Jubayhah, UJ* Campus	N32°00.695 E35°52.380	Citrus	1/8/2018	-	3	1	4
Ammān	N31°98.832 E35°83.039	Olives *Olea europaea* L. (Oleaceae)	6/8/2018	1	-	3	4
Ammān	N31°51.061 E35°52.888	Almond *Prunus dulcis* (Mill.) D. A. Webb (Rosaceae)	9/8/2018	-	1	-	1
Al Jubayhah, UJ Campus	N32°00.695 E35°52.380	Rose *Rosa* sp. (Rosaceae)	12/8/2018	6	4	15	25
Al Jubayhah, UJ Campus	N32°00.695 E35°52.380	Grape vine *Vitis vinifera* L. (Vitaceae) with *Convolvulus arvensis* beneath	12/8/2018	12	-	16	28
Al Jubayhah, UJ Campus	N32°00.695 E35°52.380	Rose	14/8/2018	1	-	4	5
Shafa Badran	N32°02.753 E35°89.996	False yellowhead *Inula graveolens* L. (Asteroideae)	14/8/2018	15	6	51	72
Al Yadodah	N31°49.499 E35°54.465	Silverleaf nightshade *Solanum elaeagnifolium* Cav. (Solanaceae)	19/8/2018	6	7	31	44
'Ayn ‘Aqrabah	N32°43.00 E35°48.00	Pomegranate *Punica granatum* L. Lythraceae	31/10/2018	3	-	3	6
Slaihi	N32°07.149 E35°49.886	Nettle *Urtica dioica* L. (Urticaceae)	20/1/2019	-	7	1	8
Dayr 'Alla, Damya	N32°07.149 E35°49.886	Potato *Solanum tuberosum* L. (Solanaceae)	26/1/2019	-	2	1	3
Tal ar Rummān	N32°07.149 E35°49.886	Brambles *Rubus canescens* DC. (Rosaceae)	30/1/2019	3	-	2	5

UJ Farm, Ghawr Kabid	N32°05.071 E35°35.706	Alfalfa *Medicago sativa* L. (Fabaceae)	13/2/2019	3	-	2	5
Dead Sea- Mādabā Road (Panorama)	N31°39.688 E35°34.964	Saltwort *Seidlitzia rosmarinus* Bunge ex Boiss. (Amaranthaceae)	20/2/2019	-	-	1	1
Dead Sea Hotels area	N31°44.340 E35°35.794	Purslane-leaved aizoon *Aizoon canariense* L. (Aizoaceae)	20/2/2019	-	-	4	4
Ghawr Fīfah	N30°55.640 E35°27.555	Toothbrush tree *Salvadora persica L.* (Salvadoraceae)	20/2/2019	2	-	1	3
Al Rawda	N31°50.001 E35°47.775	Thorny burnet *Sarcopoterium spinosum* L. (Rosaceae)	25/2/2019	2	-	2	4
UJ Farm, Ghawr Kabid	N32°05.071 E35°35.706	*Sorghum halepense* (L.) Pers. (Poaceae)	13/3/2019	2	-	3	5
UJ Farm, Ghawr Kabid	N32°05.071 E35°35.706	*Hopbush Dodonaea viscosa* Jacq. (Sapindaceae)	31/3/2019	-	-	3	3
Ash Shūnah al Janūbiyah	N31°53.215 E35°37.418	Grape vine	4/4/2019	3	-	7	10
Wādī Ramm	N29°36.809 E35°29.262	Devil's thorn *Rumex spinosus* L. (Polygonaceae)	12/4/2019	1	-	-	1
Aqaba	N30°07.833 E35°24.459	Ephedra *Ephedra* sp. (Ephedraceae)	3/5/2019	-	-	9	9
Ajlūn	N32°15.736 E35°47.506	Olives	8/5/2019	-	3	8	11
Rajeb	N32°14.601 E35°42.013	Oriental plane *Platanus orientalis* L. (Platanaceae)	8/5/2019	2	-	2	4
Slaihi	N32°08.573 E35°48.884	Thorny burnet	12/5/2019	-	1	-	1
Al Mafraq	N32°20.323 E36°32.521	Grape vine	19/5/2019	-	2	-	2
Umm al ‘Amad	N31°47.079 E35°53.414	Olives	29/5/2019	1	-	2	3
Jerash	N32°15.558 E35°55.758	Olives	11/6/2019	1	-	-	1
Al Jubayhah, UJ Campus	N32°00.695 E35°52.380	Rosemary	14/6/2019	-	1	-	1
Al Yadodah	N31°49.499 E35°54.465	Eggplant *Solanum melongena* L. (Solanaceae)	24/6/2019	-	3	7	10
Al Yadodah	N31°49.499 E35°54.465	Bermuda grass	24/6/2019	3	-	5	9
Wādī Bayodah	N32°08.326 E35°43.376	Oak *Quercus* sp. Fagaceae	11/7/2019	-	2	2	4
Wādī as Sīr	N31°58.487 E35°48.851	Oleander *Nerium oleander* L. (Apocynaceae)	20/9/2019	1	-	1	2
Al Mafraq	N32°21.934 E36°47.036	Bermuda grass	16/11/2019	1	-	4	5

*UJ: University of Jordan.

Table 2. Comparison between morphological characteristics of *E. decipiens* and *A. decedens* male genitalia.

Genitalia Structure	*E. decipiens*	*A. decedens*
Anal styli	Strongly curved, narrows gradually to a sharp point (Plate 2. A)	Slightly curved, end rounded not sharp (Plate 2. B)
Aedeagus	Symmetric, simple without a projection (Plate 2. A)	Asymmetric, with L-shape projection situated laterally and slightly beneath the apex. (Plate 2. C)
Paramere	Slightly curved in lateral view, distal part slightly curved tapered (Plate 2. D)	Almost straight in lateral view, distal part strongly curved (Plate 2. E)
Subgenital plate	Distal part slightly curved and narrow (Plate 2. F)	Distal part almost straight and truncated (Plate 2. G)
Pygofer appendage	Tapers to the middle part, then widens, and tapers again at the tip (Plate 3. A)	Tapers from the base gradually to a sharp tip (Plate 3. B)

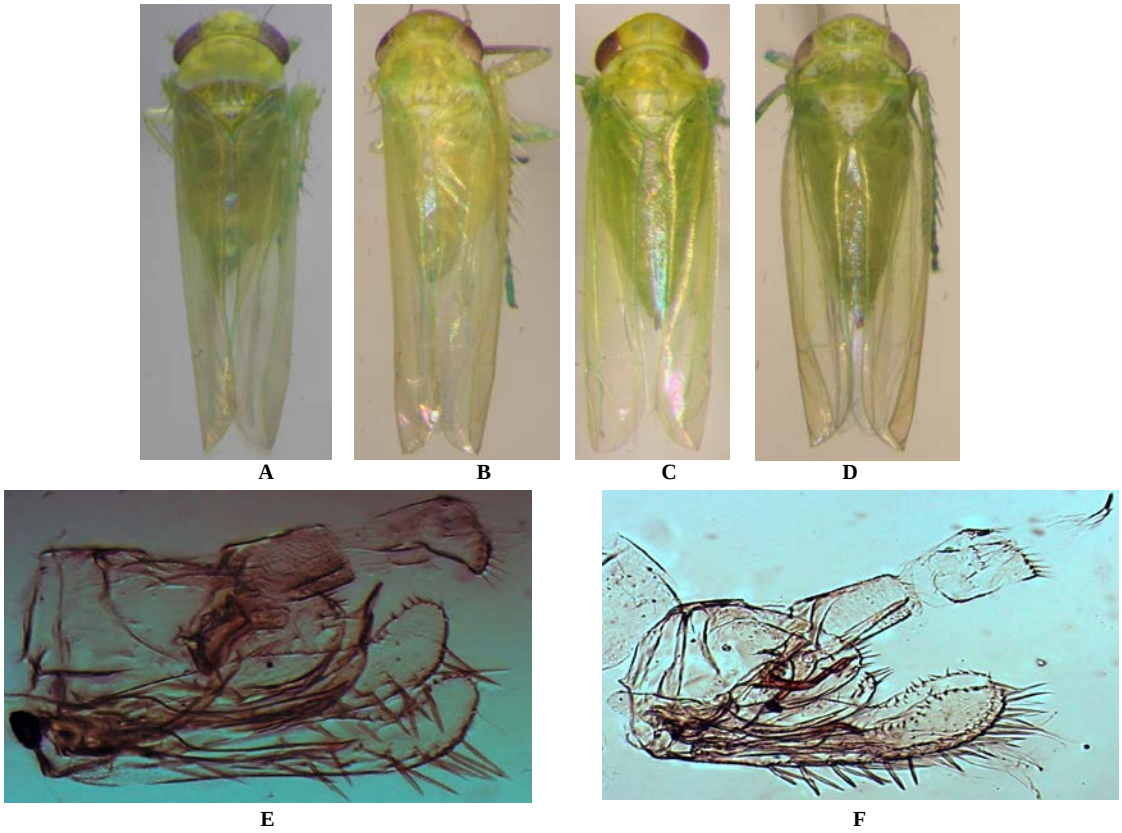


Plate 1. (A) Male of *E. decipiens*, dorsal view. (B) Male of *A. decedens*, dorsal view. (C) Female of *E. decipiens*, dorsal view. (D) Female of *A. decedens*, dorsal view. (E) Pygofer of *E. decipiens*, lateral view. (F) Pygofer of *A. decedens*, lateral view. Total body length: (A, C) = 3.3 to 4.1 mm, Total body length: (B, D) = 3.1 to 3.9 mm

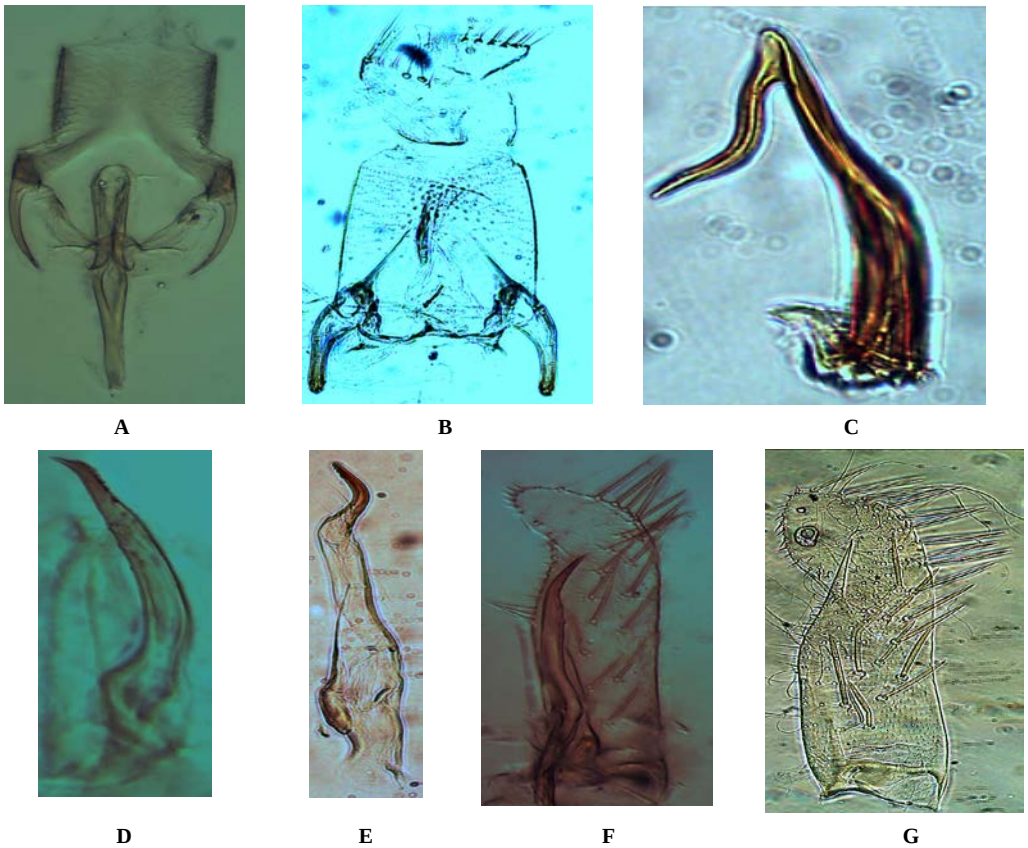
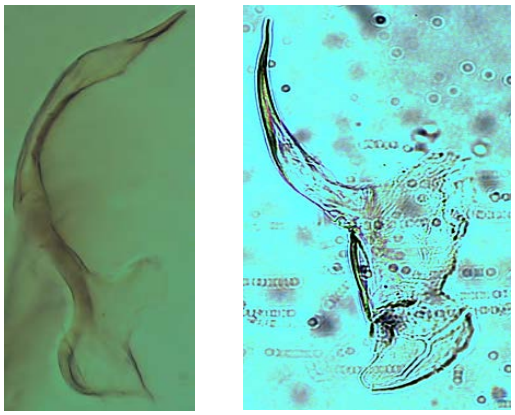


Plate 2. (A) Anal styli and Aedeagus of *E. decipiens* (B) Anal tube and styli of *A. decedens* (C) Aedeagus of *A. decedens* (D) Paramere of *E. decipiens* (E) Paramere of *A. decedens* (F) subgenital plate of *E. decipiens* (G) subgenital plate of *A. decedens.*



A B

Plate 3. (A) Pygofer appendage of *E. decipiens* (B) Pygofer appendage of *A. decedens.*

4. Discussion

Obtained data revealed that *E. decipiens* and *A. decedens* are widely distributed in Jordan and can be found on grasses, shrubs, ornamentals, fruit trees and vegetables (Table 1). *E. decipiens* was collected from pomegranate, brambles, alfalfa, toothbrush tree, devil's thorn, oriental plane and oleander. While *A. decedens* was collected from Almond, nettle, potato, eggplant and oak. However, either species could be found eventually on hosts of the other species since both are known to be highly polyphagous (Atakan, 2011; El-Wakeil *et al*., 2015; Emam *et al*., 2020).

The number of collected specimens of both species was relatively low; this could be attributed to the application of pesticides. Interestingly, in the arid nature of southern Jordan desert, *E. decipiens* was recorded form Wādī Ramm Reserve on *Rumex spinosus*. Moreover, it was found in Ghawr Fīfah on *Salvadora persica*, which faces habitat degradation due to intensive agriculture. In most cases, *E. decipiens* and *A. decedens* were found associated together on many hosts in different localities (Table 1).

The morphological similarity between the two species was high and both species can be misidentified by non-specialists. The two species were similar in size and color including the whitish patterns on the vertex and pronotum (Plate 1. A-D). Their identification is mainly based on the examination of male genitalia only. *A. decedens* can be distinguished from *E. decipiens* by the asymmetric aedeagus with L-shape projection situated laterally and slightly beneath the apex (Plate 2. C), unlike the simple aedeagus in *E. decipiens* (Plate 2. A). In lateral view, the distal part of *A. decedens* subgenital plate is almost straight and truncated (Plate 2. G), while in *E. decipiens* is narrow and curved (Plate 2. F). In *E. decipiens*, the tapered tips of the pygofer appendages are curved upward extending pygofer apex in lateral view (Plate 1. E) and (Plate 3. A). The ventral view of the anal stylus in *A. decedens* is slightly curved with thick rounded end (Plate 2. B), but in *E. decipiens* it is evenly curved with sharp end (Plate 2. A).

In general, the identification of cicadomoprphan species is difficult because of their homogeneity and lack of comprehensive identification keys and taxonomic literature (Dietrich, 2009). An increasing number of studies are using molecular markers as powerful tool for the identification of taxonomically difficult species in attempts to understand phylogenetic relationships and population structure (Demichelis *et al*., 2010 and Emam *et al*., 2020). Loukas and Drosopoulos (1992) distinguished *E. decipiens* from *A. decedens* populations in six different hosts using allozymes and male morphological examination. Such molecular techniques could be applied to female populations such as the ones collected from Aqaba, the Dead Sea and Ghawr Kbed.

Several studies confirmed *E. decipiens* and *A. decedens* as a potential vector of phytoplasma on different crops (Alhudaib, 2009; Alhudaib *et al*., 2009; Dakhil *et al*., 2011; Alsaleh *et al*., 2014). In Lebanon, it has been recorded as a potential vector of almond witches 'broom phytoplasma (AlmWB) (Dakhil *et al*., 2011). Galetto *et al* (2011) reported *E. decipiens* as a potential vector of *Chrysanthemum* yellows phytoplasma (CYP, "Ca. Phytoplasma asteris", 16SrI-B) in Italy.

5. Conclusion

E. decipiens and *A. decedens* are widely distributed in Jordan, collected from a wide host range, found almost all the year around which increasing their potential role in plant disease transmission. They could be accurately identified and differentiated by the examination of male genitalia. Further sampling in locations not included in this study can contribute to a detailed distributional range of both species in Jordan.

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