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An Identification key to the species of Auchenorrhyncha of Iranian fauna recorded as pests in orchards and a review on the pest status of the species

FARIBA MOZAFFARIAN

Insect Taxonomy Research Department, Iranian Research Institute of Plant Protection, Agricultural Research, Education and Extension Organization, P.O. Box 1454, 19395 Tehran, Iran. E-mail: mozaffarian@iripp.ir, faribamozaffarian@gmail.com

Abstract

An illustrated dichotomous identification key for a total of 54 Auchenorrhyncha species of Iran is presented. The studied species have been recorded as pests and vectors of diseases to fruit trees. Twenty nine records were contributed to Iranian orchards and 25 of which were from other parts of the world. Hence, the latter group can be considered as potential pests and vectors in Iran. Reviewing the published information on the former group suggests 12 species as pests (4, 2 and 6 species with significant, minor, and unknown recorded economic damage levels, respectively). The pest status of 14 recorded pest species were quite doubtful and 3 of them could not be present in Iran due to the lack of evidence or their limited distribution in other parts of the world. The 4 species which were recognized as well known and significantly important pests belonged to the families: Tropiduchidae (*Ommatissus lybicus* Bergevin, 1930), Cicadidae (*Cicadatra alhageos* (Kolenati, 1857)), and Cicadellidae (*Hishimonus phycitis* (Distant, 1908) and *Neoaliturus haematoceps* (Mulstant et Rey, 1855)). One species *Orosanga japonicus* is recording for the first time from Iran and added to the key.

Key words: Cicadas, hoppers, fruit trees, Iran

Introduction

The concept of a pest species is often difficult to define. It may be anthropocentric with no ecological validity (Metcalf & Luckmann 1982; Immig 2000) and biased according to varying human values. Various definitions address the same meaning with different words but the commonly accepted concept of a "pest" is: Any life form that is harmful to a human or human property (Hill 1976, 1990; Immig 2000; Quarcoo *et al*. 2014). Although the undesirability of pest organisms and their competition with human beings for resources are common in all definitions, the importance of limiting pest damage to a tolerable level has always been emphasized. Obviously this tolerable level may vary according to culture, economy, education, gender, age etc (Quarcoo *et al*. 2014). In agriculture, this level is known as an economic threshold, which justifies the cost of control measures (Hill 1976, 1990, Quarcoo *et al*. 2014). Thus, even a high population of an insect may not be enough to consider it as a pest (Norton & Conway 1977).

Leafhoppers, planthoppers cicadas and spittlebugs (Hemipteran suborder Auchenorrhyncha), are insects of varied sizes, which may reduce crop yield by feeding from plant fluid and weakening the terminal young branches by laying eggs into the plant tissue. In addition, by feeding from phloem or xylem sap the transmission of pathogenic microorganisms such as viruses, phytoplasmas and bacteria may occur. Since phytoplasmas are phloem-limited organisms (Wilson & Weintraub 2007), the phloem-feeding Auchenorrhyncha (e.g. Fulgoromorpha and most of Cicadellidae species) are considered suitable vectors. Weintraub & Beanland (2006) believe this success is particularly due to the similar morphology and habitat of their nymphs and adults, their selective feeding on certain plant tissues and having symbiotic organisms which are transovarially transmitted. The transmission of pathogenic viruses has also been recorded to be by phloem-feeders (Nault & Ammar 1989) but certain bacteria are transmitted by xylem-feeders (eg. Cercopoidea) (Nault & Ammar, 1989). On the other hand, large numbers of Auchenorrhyncha in nature makes them considerable components of food webs (Schmidt-Entling & Siegenthaler 2009).

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Tchouvakhin (1949) was the first to consider Auchenorrhyncha species as pests in the orchards of Iran. The typhlocybine leafhopper *Edwardsiana rosae* (Linnaeus, 1758) was considered to be a pest of fruit trees and ornamental plants and its morphology, biology, distribution and control methods were described. A few years later, Gardenhire (1958) recorded *Ommatissus lybicus* Bergevin, 1930 as a pest on date palm. Then, Farahbakhsh (1961) included *Hyalesthes mlokosiewiczi* Signoret, 1879, *Edwardsiana rosae* (Linnaeus, 1758), *Sulamicerus stali* (Fieber, 1868), *Chloropsalta ochreata* (Melichar, 1902) and *Psalmocharias querula* as pests on grape and pistachio in a list of economically important pests in Iran. Various aspects of the ecology of some pests have been subjected to many studies later (Babaii 1967; Mostaan & Akbarzadeh 1995; Pezhman & Rajabi 2002, etc).

Up to the present, 29 Auchrnorrhyncha species have been recorded as pests with different level of importance in the orchards of Iran. In addition, 25 species can be considered as potential pests in Iran, due to their recorded pest status in other parts of the world. The goal of this paper is to facilitate future assessment of the actual pest status of the recorded species and to provide tools for identifying potential Auchenorrhyncha pests and vectors in the orchards of Iran. Therefore, an identification key is provided for identifying all Auchenorrhyncha species occurring in Iranian fauna that have either been recorded as pests and vectors in Iran, or have been reported as such in other parts of the world. A list of fruit trees with their recorded Auchenorrhyncha of Iran as pests is presented and probable pest status of the species in Iran is discussed.

Material and methods

A list of Auchenorrhyncha of Iran recorded as pests was compiled from the literature along with the recorded damage and pest status in Iran and other parts of the world and their distribution in Iran. The characters used in the identification key were extracted by examining the specimens in Hayk Mirzayans Insect Museum, Tehran and also from the published literature: Linnavuori (1962), Emeljanov (1967), Asche & Wilson (1989), Fletcher (2009) Aghagoli Marzijarani *et al*. (2013), Holzinger *et al*. (2003), Dietrich (2005), Biedermann & Niedringhaus (2009), Zahniser & Dietrich (2013), Mozaffarian & Wilson (2015) and Mozaffarian & Sanborn (2015, 2016). Photos were made using a Canon 650D Camera connected to an Olympus SZH Stereomicroscope. Male genitalia of the species were prepared after boiling the terminal segments of the body in KOH 10% and illustrated. An assessment of actual pest status for each species was made according to the literature records of their feeding damage or reports of vector capacity. Previous reports were assessed for validity, taking into account reports of the same species from other countries, Iranian distribution records and possible misidentifications of species. The subfamily and tribal classification of family Cicadellidae was applied according to Dietrich (2005) and Zahniser & Dietrich (2008).

Results

A total of 54 Auchenorrhyncha species of Iranian fauna have been recorded on fruit trees in Iran and other parts of the world. A list of the fruit trees and associated Auchenorrhyncha is provided in Table 1.

Identification key of Auchenorrhyncha of Iran recorded as pests in orchards

(Figs. 1–75)

1. Antennae beneath compound eyes, pedicel wider than scape; tegula nearly always present (Infraorder Fulgoromorpha, Figs 1–19) 2
- Antennae situated on front of head between eyes, pedicel not wider than scape; tegula absent (Infraorder Cicadomorpha, Figs 20–75) 12
2. Hind tibia with large moveable spur apically (Family Delphacidae), habitus and male genitalia as in Figs 4 and 15a–b. . . . . *Laodelphax striatellus*
- Hind tibia without a large moveable spur apically 3
3. Second tarsomere of hind leg with row of small dark spines 4
- Second tarsomere of hind leg without row of small dark spines 7
4. Head prolonged noticeably anteriorly (Family Dictyopharidae), length of vertex more than 2.5 times longer than width (Fig. 5) . . . . . *Dictyophara europaea*

- Head not prolonged noticeably anteriorly (Figs 1–3, Family Cixiidae) 5
5. Male stylus with right angle on apical third and quite sharp apex (Figs 12a and 13a) 6
- Male stylus not as above, with 3 lobes on apex (Fig. 14a); habitus and male genitalia as in Figs 3 and 14a–c. . . . . *Reptalus quinquecostatus*
6. Stylus without median tooth on stem; habitus and male genitalia as in Figs 1 and 12a–b . . . . . *Hyalesthes mlokosiewiczi*
- Stylus with a median tooth on the stem, habitus and male genitalia as in Figs 2 and 13a–b . . . . . *Hyalesthes obsoletus*
7. Second tarsomere of hind leg straight apically with small dark spine at each side 8
- Second tarsomere of hind leg round apically with no spine; Forewings wide and triangular (Family Ricaniidae), veins Sc and R on forewing with common stem; habitus and male genitalia as in Figs 9 and 18a–b. . . . . *Orosanga japonicus*
8. Forewing membranous (Family Tropiduchidae); upper part of face and lateral part of pronotum with two distinct black spots (Fig. 11); habitus and male genitalia as in Figs 11 and 19 . . . . . *Ommatissus lybicus*
- Forewing opaquely sclerotized 9
9. Clavus of forewing with distinct prominant granules (Family Flatidae, Figs 6–7) 10
- Clavus without distinct prominant granules 11
10. Broadest part of the forewing on the apical half (Fig. 6b); habitus and male genitalia as in Figs 6a–b and 16a–c . . . . . *Mesophantia pallens*
- Broadest part of the forewing on the basal half (Fig. 7b); habitus and male genitalia as in figs 7a–b and 17a–c . . . . . *Persepolia columbaria*
11. Body flattened dorsoventrally (Family Tettigometridae); habitus as in Fig. 10 . . . . . *Tettigometra costulata*
- Body not flattended dorsoventrally (Family issidae); habitus and as in Fig. 8. . . . . *Iranodus amygdalinus*
12. Three ocelli present, arranged in triangle on crown; large insects; forewings hyaline (Family Cicadidae, Figs 61–75) 13
- Two or no ocelli present in various arrangements; small insects; forewings usually not hyaline 22
13. Basal cell of forewing quadrangular, vein RA1 of forewing and associated cell spoon shaped (Genus *Pagiphora*), habitus as in Fig. 65 . . . . . *Pagiphora annulata*
- Basal cell of forewing pentagonal, vein RA1 and associated cell not as above 14
14. Male timbals completely covered, habitus and male genitalia as in Figs 68 and 75 . . . . . *Tibicen plebejus*
- Male timbals partially or entirely exposed 15
15. Apical edge of first and second cubital cells of hindwing subequal in length . . . . . *Tibicina haematodes*
- Apical edge of first cubital cell of hindwing longer than that of second cell 16
16. Cross veins on apical part of forewing with dark infuscation (Figs 66 and 67) 17
- Cross veins on apical part of forewing without dark infuscation 18
17. General color of body light greenish; habitus and male genitalia as in Figs 66 and 73 . . . . . *Psalmocharias flava*
- General color of body dark brownish, habitus and male genitalia as in Figs 67 and 74. . . . . *Psalmocharias querula*
18. Timbal without cover and completely exposed; habitus and male genitalia as in Schedle (2003: Fig. 3 and Abb. 3). . . . . *Klapperichicen viridissimus*
- Timbal with incomplete cover 19
19. Timbal cover large, partially covering tymbal (Genus *Cicadatra*) 20
- Timbal cover very small, timbal completely exposed (Genus *Chloropsalta*) 21
20. General color of body greenish or yellowish, vein RA1 of forewing straight; habitus and male genitalia as in Figs 63 and 71. . . . . *Cicadatra alhageos*
- General color of body blackish, vein RA1 obviously curved; habitus and male genitalia as in Figs 64 and 72 . . . . . *Cicadatra persica*
21. Basal part of forewing vein M nearly as long as M1+2; aedeagus with two broad membranous parts apically; habitus and male genitalia as in Figs 62 and 70 . . . . . *Chloropsalta smaragdula*
- Basal part of forewing vein M longer than M1+2; aedeagus without two broad membranous parts apically; habitus and male genitalia as in Figs 61 and 69 . . . . . *Chloropsalta ochreata*
22. Pronotum, extended posteriorly, partially covering forewings and abdominal tergites (Family Membracidae), pronotum extended laterally; body triangular, greenish before death . . . . . *Stictocephala bisonia*
- Pronotum not as above 23
23. Hind coxae conical, hind tibia short with 2 lateral thick spines and crownlike complex of spines apically, Forewings without black and red pattern (Family Aphrophoridae, Figs 20–25) 24
- Hind coxae transverse, hind tibia elongate with one or more rows of spine-like setae (Family Cicadellidae, Figs 26–60) . . . 26
24. Body longer than 9 mm 25
- Body shorter than 9 mm; habitus and male genitalia as in Figs 22–23. . . . . *Philaenus spumarius*
25. Vertex longer than wide; male with 2 elongate subgenital plates (Fig. 25e); habitus and male genitalia as in Figs 24 and 25a–e . . . . . *Poophilus costalis*
- Vertex wider than long, male without elongate subgenital plates; habitus and male genitalia as in Figs 20 and 21a–b . . . . . *Aphrophora alni*
26. First tarsomere of hind tarsi conical apically; forewing without cross veins on the basal half (Subfamily Typhlocybinae) . . 27
- First tarsomere of hind tarsi truncate apically; forewing with cross veins on the basal half 36
27. Hindwing with submarginal vein apically (Tribe: Empoascini) 28
- Hind wing without submarginal vein apically 32
28. Male aedeagus in lateral view wide apically. 29
- Male aedeagus in lateral view not wide apically. 31

29. Process of male pygofer denticulate and cheliform apically . . . . . *Jacobiasca lybica*
- Process of male pygofer simple (Genus *Empoasca*) 30
30. Anal hook narrow, curved posteroventrad, denticulate apically . . . . . *Empoasca decipiens*
- Anal hook broad basally, narrow apically, curved anterad, without denticuli . . . . . *Empoasca fabae* (Harris, 1841)
31. Apex of aedeagus simple with no appendages . . . . . *Kyboasca maligna*
- Apex of aedeagus with narrow asymmetrical appendage . . . . . *Asymmetrasca decedens*
32. Vannal vein in hindwing not branched, inner apical cell in forewing extended to wing apex (Tribe Erythroneurini) 33
- Vannal vein in hindwing with two branches, inner apical cell in forewing short (Tribe Typhlocybini) 35
33. Vertex with two rather regular spots dorsally, dorsal surface of body without orange patterns (Figs 42–43) 34
- Vertex without regular spots; dorsal surface of body with orange patterns; Male genitalia illustrated in Beamer (1938) . . . . . *Erythroneura comes*
34. Scutellum with two distinct black marks on each side; habitus and male genitalia as in Figs 42 and 58a–b. . . . . *Arboridia kermanshah*
- Scutellum without distinct black marks; habitus and male genitalia as in Figs 43 and 59a–c . *Frutioidia (Frutioidia) bisignata*
35. Forewing with a dark area apically . . . . . *Zyginella pulchra*
- Forewing without dark area apically; habitus and male genitalia as in Figs 44 and 60a–c . . . . . *Edwardsiana rosae*
36. Ocelli on the face. 37
- Ocelli on the vertex or transition between vertex and face 41
37. Face with distinct frontoclypeus suture reaching from antennae to ocelli (Subfamily Idiocerinae) 38
- Face without distinct frontoclypeus suture from antennae to ocelli, supraantennal keels do not reach eyes (Subfamily Megophthalminae) 39
38. Scutellum with two distinct dark spots; habitus and male genitalia as in Figs 38a–c and 54a–b . . . . . *Idioscopus clypealis*
- Scutellum without distinct dark spots; habitus and male genitalia as in Figs 39 and 55a–b . . . . . *Sulamicerus stali*
39. Vertex and face with two distinct keels converging x- shaped (Tribe Megophtahalmini) . . . . . *Megophthalmus scabripennis*
- Vertex and face not as above (Tribe Agalliini) 40
40. Two circular spots on the anterior half of pronotum; habitus and male genitalia as in Figs 40 and 56 . . . *Anaceratagallia laevis*
- Two circular spots on the posterior half of pronotum; habitus and male genitalia as in Figs 41 and 57 . . *Austroagallia sinuata*
41. Frons swollen (Subfamily Cicadellinae); vertex with two big pentagonal spots; habitus and male genitalia as in Figs 26 and 45 . . . . . *Cicadella viridis*
- Frons not swollen (Subfamily Deltocephalinae) 42
42. Aedeagus with two gonopores (Tribe: Opsiini) 43
- Aedeagus with a main shaft and one gonopore. 45
43. Forewing with a dark semicircular area on the posterior half, mostly on clavus; habitus and male genitalia as in Figs 31 and 49a–c . . . . . *Hishimonus phycitis*
- Forewing not as above. 44
44. Apical branches of aedeagus rather short and not reaching each other; habitus and male genitalia as in Figs 32 and 50 . . . . . *Neoaliturus fenestratus*
- Apical branches of aedeagus long, semicircular and nearly reaching each other, habitus as in Figs 33 . . . . . *Neoaliturus haematoceps*
45. Connective T shape (Tribe stegelytrini); Aedeagus with one pair narrow long branched appendage; habitus and male genitalia as in Figs 37 and 53. . . . . *Stegelytra neveosparsa*
- Connective U or Y shaped, if Y shaped, with diverged or not diverged arms 46
46. Connective U shape. 47
- Connective Y shape with diverged or not diverged arms 50
47. Male aedeagus not branched apically (Tribe Selenocephalini). 48
- Male aedeagus branched apically (Tribe Macrostelini) 49
48. Aedeagus with symmetric triangular spine like appandages on the lateral sides of main shaft; habitus and male genitalia as in Figs 36 and 52 . . . . . *Selenocephalus kyrosicus*
- Aedeagus without symmetric triangular appandages; habitus as in Fig. 35 . . . . . *Selenocephalus dareicus*
49. Aedeagus with two short branches near the base of two long apical branches, habitus as in Fig. 29 . . . . . *Macrosteles quadripunctulatus*
- Aedeagus with only two long apical branches, habitus and male genitalia as in Figs 30 and 48a–b . . . *Macrosteles sexnotatus*
50. Arms of connective diverged 51
- Arms of connective not diverged (Tribe Paralimnini), habitus and male genitalia as in Figs 34 and 51 . . . *Psammotettix striata*
51. Branches of connective with very wide angle (Tribe Fieberiellini) 52
- Branches of connective close or parallel (Tribe Athysanini) 53
52. Penis with flattened stem and minutely serrate apex (illustrated in Figs. 34a–c in Linnavuori, 1962) . . . *Fieberiella macchiae*
- Penis without flattened stem and minutely serrate apex . . . . . *Fieberiella florii*
53. Vertex medially longer than twice of the distance between eyes; aedeagus with long outer appendages; habitus and male genitalia as in Figs 27 and 46. . . . . *Platymetopius shirazicus*
- Vertex medially shorter than twice of the distance between eyes; aedeagus without long outer appendages . . . . . *Euscelis lineolatus*

TABLE 1. List of Auchenorrhyncha in the Iranian fauna, recorded as pest on fruit trees in Iran and other parts of the world- sorted according to the fruit trees.

Fruit trees	Recorded pest species
Almond	**Cicadellidae:** *Asymmetrasca decedens* (Paoli, 1932), *Edwardsiana rosae* (Linnaeus, 1758), *Empoasca decipiens* Paoli, 1930, *Fiebriella macchiae* Linnavuori, 1962, *Frutioidia* (*Frutioidia*) *bisignata* (Mulstant et Rey, 1855), *Platymetopius shirazicus* Dlabola, 1974. **Cicadidae:** *Cicadatra alhageos* (Kolenati, 1857), *Psalmocharias flava* Dlabola, 1970. **Flatidae:** *Mesophantia pallens* Melichar, 1902†, *Persepolia columbaria* Dlabola & Safavi, 1972. **Issidae:** *Iranodus amygdalinus* Dlabola, 1980.
Apple	**Cicadellidae:** *Cicadella viridis* (Linnaeus, 1758), *Edwardsiana rosae* (Linnaeus, 1758), *Empoasca fabae* (Harris: 1841), *Fieberiella florii* (Stål, 1864), *Zyginella pulchra* Löw, 1855. **Cicadidae:** *Chloropsalta ochreata* (Melichar, 1902), *Cicadatra alhageos* (Kolenati, 1857), *Cicadatra persica* Kirkaldy, 1909, *Psalmocharias flava* Dlabola, 1970.
Appricot	**Cicadellidae:** *Asymmetrasca decedens* (Paoli, 1932), *Zyginella pulchra* Löw, 1855. **Cicadidae:** *Cicadatra alhageos* (Kolenati, 1857).
Cherry	**Cicadellidae:** *Edwardsiana rosae* (Linnaeus, 1758). **Cicadidae:** *Chloropsalta ochreata* (Melichar, 1902), *Cicadatra alhageos* (Kolenati, 1857).
Citrus	**Cicadellidae:** *Asymmetrasca decedens* (Paoli, 1932), *Hishimonus phycitis* (Distant, 1908), *Neoaliturus haematoceps* (Mulstant et Rey, 1855).
Date palm	**Tropiduchidae:** *Ommatissus lybicus* Bergevin, 1930.
Fig	**Cixiidae:** *Hyalesthes mlokosiewiczi* Signoret, 1879. **Ricaniidae:** *Orosanga japonicus* Melichar, 1898.
Grapevine	**Aphrophoridae:** *Philaenus spumarius* (Linnaeus, 1758). **Cicadellidae:** *Anaceratagallia laevis* (Ribaut, 1935), *Arboridia kermanshah*, *Austroagallia sinuata* (Mulsant Rey, 1855), *Edwardsiana rosae* (Linnaeus, 1758), *Empoasca fabae* (Harris: 1841), *Erythroneura comes* (Say, 1825), *Euscelis lineolatus* Brullé, 1832, *Fieberiella florii* (Stål, 1864), *Jacobiasca lybica* (Bergevin & Zanon, 1922), *Macrosteles quadripunctulatus* (Kirschbaum, 1868), *Macrosteles sexnotatus* (Fallen, 1806), *Megophthalmus scabripennis* Edwards, 1915, *Neoaliturus fenestratus* (Herrich- Schäffer, 1834), *Neoaliturus haematoceps* (Mulstant et Rey, 1855), *Psammotettix striata* (Linnaeus, 1758). **Cicadidae:** *Chloropsalta ochreata* (Melichar, 1902), *Chloropsalta smaragdula* Haupt, 1920, *Klapperichicen viridissimus* (Walker, 1858), *Psalmocharias querula* (Pallas, 1773), *Cicadatra alhageos* (Kolenati, 1857). **Cixiidae:** *Hyalesthes mlokosiewiczi* Signoret, 1879, *Hyalesthes obsoletus* Signoret, 1865, *Reptalus quinquecostatus* (Dufour, 1833). **Delphacidae:** *Laodelphax striatellus* (Fallén, 1826) **Dictyopharidae:** *Dictyophara* (*Dictyophara*) *europaea* (Linnaeus, 1767) **Ricaniidae:** *Orosanga japonicus* Melichar, 1898.
Hawthorn	**Cicadidae:** *Cicadatra alhageos* (Kolenati, 1857).
Hazelnut	*Frutioidia* (*Frutioidia*) *bisignata* (Mulstant et Rey, 1855).
Kiwifruit	**Ricaniidae:** *Orosanga japonicus* Melichar, 1898.
Mango	**Cicadellidae:** *Idioscopus clypealis* (Lethierry, 1889).
Mulberry	**Cicadidae:** *Chloropsalta ochreata* (Melichar, 1902).
Olive	**Aphrophoridae:** *Aphrophora alni* (Fallen, 1805). **Cicadellidae:** *Asymmetrasca decedens* (Paoli, 1932), *Edwardsiana rosae* (Linnaeus, 1758), *Empoasca decipiens* Paoli, 1930, *Neoaliturus haematoceps* (Mulstant et Rey, 1855), *Zyginella pulchra* Löw, 1855. **Cicadidae:** *Tibicen plebejus* (Scopoli, 1763), *Tibicina haematodes* (Scopoli, 1763).
Peach	**Cicadidae:** *Chloropsalta ochreata* (Melichar, 1902), *Cicadatra alhageos* (Kolenati, 1857).
Pear	**Cicadellidae:** *Cicadella viridis* (Linnaeus, 1758), *Edwardsiana rosae* (Linnaeus, 1758), *Empoasca fabae* (Harris: 1841), *Selenocephalus dareicus* Dlabola, 1981, *Selenocephalus kyrosicus* Dlabola, 1981, *Stegelytra neveosparsa* (Ghauri, 1972), *Zyginella pulchra* Löw, 1855. **Cicadidae:** *Chloropsalta ochreata* (Melichar, 1902), *Cicadatra alhageos* (Kolenati, 1857). **Tettigometridae:** *Tettigometra costulata* Fieber, 1865.

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TABLE 1. (Continued)

Fruit trees	Recorded pest species
Pistachio	**Cicadellidae:** *Sulamicerus stali* (Fieber, 1868).
Plum	**Cicadellidae:** *Cicadella viridis* (Linnaeus, 1758), *Zyginella pulchra* Löw, 1855. **Cicadidae:** *Cicadatra alhageos* (Kolenati, 1857).
Pomegranate	**Cicadidae:** *Cicadatra alhageos* (Kolenati, 1857).
Rosaceae (In general)	**Cicadellidae:** *Frutioidia (Frutioidia) bisignata* (Mulstant et Rey, 1855).
Sore cherry	**Cicadellidae:** *Edwardsiana rosae* (Linnaeus, 1758). **Cicadidae:** *Psalmocharias flava* Dlabola, 1970.
Stone fruit trees	**Cicadelleidae:** *Fieberiella florii* (Stål, 1864).
Walnut	**Cixiidae:** *Hyalesthes mlokosiewiczi* Signoret, 1879.
Fruit trees (in general)	**Cicadellidae:** *Erythroneura comes* (Say, 1825), *Kyboasca maligna* (Walsh, 1862). **Cicadidae:** *Pagiphora annulata* (Brullé, 1832), *Tibicina haematodes* (Scopoli, 1763). **Aphrophoridae:** *Poophilus costalis* (Walker, 1851). **Membracidae:** *Stictocephala bisonia* Kopp et Yonke, 1977

Infraorder: Fulgoromorpha

Family: Cixiidae

***Hyalesthes mlokosiewiczi* Signoret, 1879** (Figs 1 and 12a–b)

Recorded damage and economic importance in the orchards of Iran: Mild and unknown. Recorded from leaves and branches of grapevine, fig and walnut (Farahbakhsh 1961).

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: North, northwest, southern slopes of Alborz and southwest (Mozaffarian & Wilson 2011).

Conclusion: Pest status of the species needs to be studied.

***Hyalesthes obsoletus* Signoret, 1865** (Figs 2 and 13a–b)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: Vector for Bois noir disease in grape, and tested positive for Aster yellows (AY) in western Palaearctic (Wilson & O'Brien 1987; Alma 2002; Batlle *et al*. 2000; Orenstein *et al*. 2003; Wilson 2005; Weintraub & Beanland 2006; Bertin *et al*. 2010a; Landi *et al*. 2013).

Recorded distribution in Iran: Northeast, north, northwest, south slope of Alborz, west and southwest (Mozaffarian & Wilson 2011).

Conclusion: Pest and vector status need to be studied in Iran.

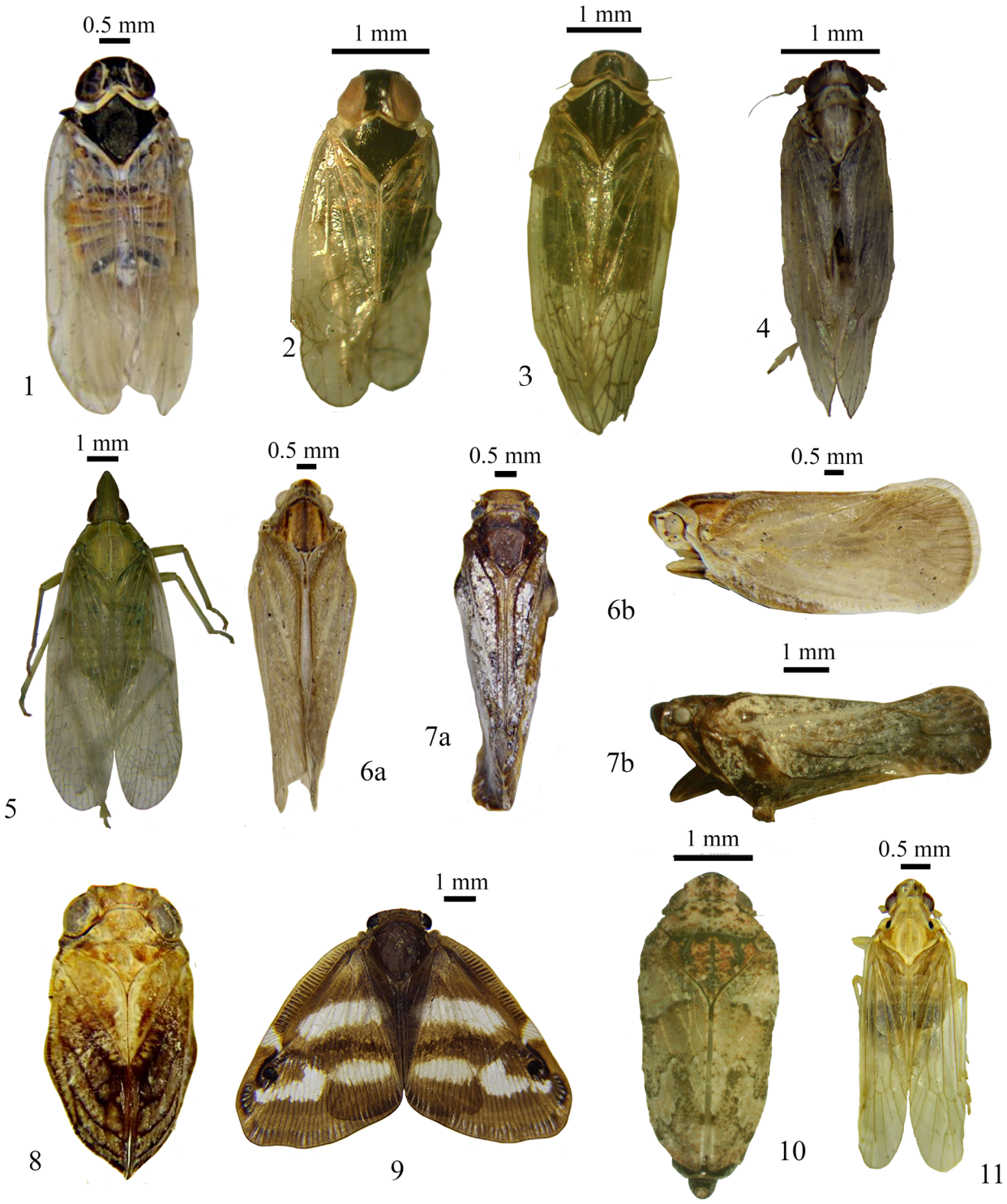
***Reptalus quinquecostatus* (Dufour, 1833)** (Figs 3 and 14a–c)

Recorded damage and economic importance in the orchards of Iran: The species was not recorded as pest on the Iranian fruit trees. However, it has been recorded as pest with mild economic importance on leaves of *Salix* spp. (Abaii 2000).

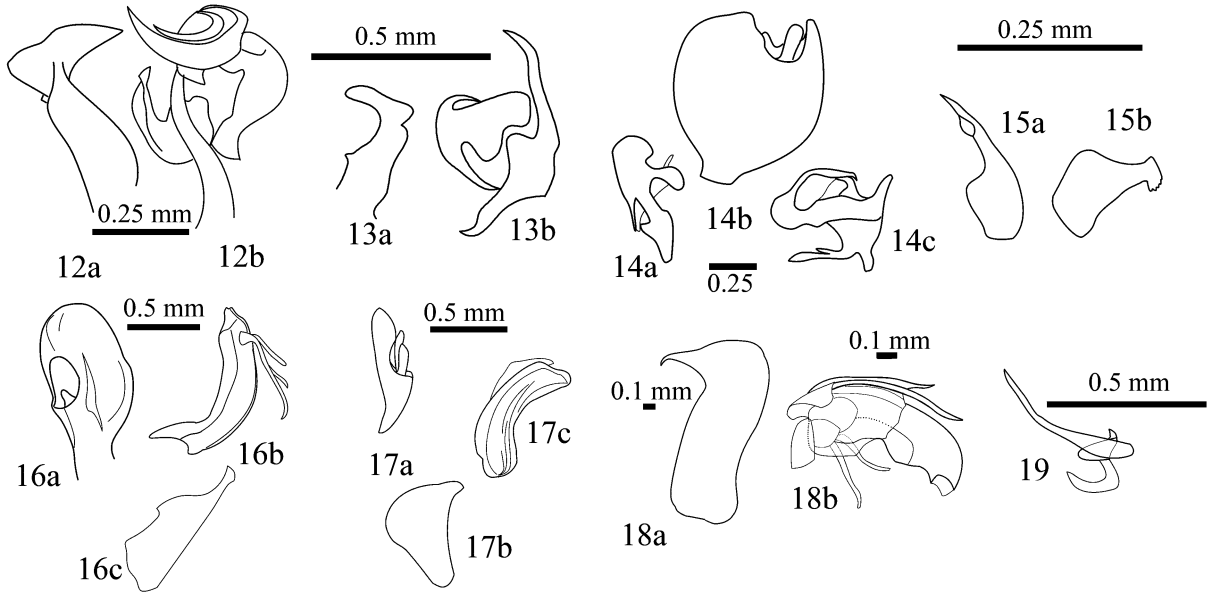
Recorded damage in the orchards of other parts of the world: The species was reported to have a potential role as a vector for phytoplasma: positive to phytoplasma of Bois noir in grapevine and a potential vector in Serbian vineyards, with the ability of transmitting the stobur phytoplasma in artificial condition and an important vector of stolbur phytoplasma in potatoes in Romania and Southern Russia (Bertin *et al*. 2010b, Cvrkovic *et al*. 2011, Pinzauti *et al*. 2008).

Recorded distribution in Iran: North (Mozaffarian & Wilson 2011).

Conclusion: Due to the records in other parts of the world, status as a potential phytoplasma vector in Iran needs to be studied.



FIGURES 1–11. Habitus of Fulgoromorpha of Iran recorded as pests in orchards: 1. *Hyalesthes mlokosiewiczi*; 2- *H. obsoletus*; 3. *Reptalus quinquecostatus*; 4. *Laodelphax striatellus*; 5. *Dictyophara europaea*; 6. *Mesophantia pallens*, a: dorsal b: lateral; 7. *Persepolia columbaria*, a: dorsal, b: lateral; 8. *Iranodus amygdalinus*; 9. *Orosanga japonicus*; 10. *Tettigometra costulata*; 11. *Ommatissus lybicus.*



FIGURES 12–19. Male genitaliae of Fulgoromorpha of Iran recorded as pests in orchards: 12. *Hyalesthes mlokosiewiczi*, a: stylus, lateral view, b: aedeagus, lateral view; 13. *H. obsoletus*, a: stylus, lateral view, b: aedeagus, lateral view; 14. *Reptalus quinquecostatus*, a: stylus, dorsal view, b: anal tube, dorsal view, c: aedeagus, lateral view; 15. *Laodelphax striatellus* a: stylus, laterl view, b: aedeagus, lateral view; 16. *Mesophantia pallens*, a: anal tube, dorsal view, b: aedeagus, lateral view, c: stylus, lateral view; 17. *Persepolia columbaria*, a: anal tube, lateral view, b: stylus, lateral view, c: aedeagus, lateral view; 18. *Orosanga japonicas*, a: stylus, lateral view, b: aedeagus, lateral view; 19. *Ommatissus lybicus*, aedeagus, lateral view.

Family: Delphacidae

***Laodelphax striatellus* (Fallén, 1826)** (Figs 4 and 15a–b)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: It is recorded as a potential vector for Bois noir/ Stolbur phytoplasma. The species tested positive to Aster yellows in vineyards in the Czech Republic (Batlle *et al*. 2000; Orsagova *et al*. 2011).

Recorded distribution in Iran: Nearly all of Iran (Mozaffarian & Wilson 2011).

Conclusion: The species is widely distributed in Iran. Due to the records of its vector status elsewhere, it needs to be investigated in Iran as well.

Family: Dictyopharidae

***Dictyophara* (*Dictyophara*) *europaea* (Linnaeus, 1767)** (Fig. 5)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: The species is considered as a candidate vector of phytoplasmas (Bois noir) to grapevine in Serbian vineyards and other parts of the world. Although it is able to transmit phytoplasmas, it is not considered a major vector in grapevines (Lessio & Alma 2008; Filippin *et al*. 2009; Cvrkovic *et al*. 2011).

Recorded distribution in Iran: North, northwest, centre and southwest (Mozaffarian & Wilson 2016).

Conclusion: Pest status in Iran needs to be studied.

Family: Flatidae

***Mesophantia pallens* Melichar, 1902** (Figs 6a–b and 16a–c)

Recorded damage and economic importance in the orchards of Iran: Causing mild economic damage to leaves and branches of almond (Rajabi 1991).

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: From south slopes of Alborz Mountain to Persian Gulf (Mozaffarian & Wilson 2011).

Conclusion: The species is endemic to Iran and its pest status needs to be studied.

***Persepolia columbaria* Dlabola & Safavi, 1972** (Figs 7a–b and 17a–c)

Recorded damage and economic importance in the orchards of Iran: Causing mild economic damage on leaves of almond (Rajabi 1991).

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: Southwest (Mozaffarian & Wilson 2011).

Conclusion: The species is endemic to Iran and its pest status needs to be studied.

Family: Issidae

***Iranodus amygdalinus* Dlabola, 1980** (Fig. 8)

Recorded damage and economic importance in the orchards of Iran: Causing mild economic damage on leaves of almond (Rajabi 1991).

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: South, southeast and southwest (Mozaffarian & Wilson 2011).

Conclusion: The species is endemic to Iran and its pest status needs to be studied.

Family: Ricaniidae

***Orosanga japonicus* Melichar, 1898** (Figs 9 and 18a–b)

Recorded damage and economic importance in the orchards of Iran: This is the first record of this species in Iran. It was first collected in the north of the country (Mazandaran province, 7♂, 1♂, and 47 nymphs) in 2010. During 2013, 2015 and 2016 many specimens were collected among large populations on Kiwi fruit and fig in other localities in the north. The large populations of the nymphs and adults along with the damage caused by their direct feeding and anecdotal reports of heavy deposits of "honey dew" on leaves, suggest the potential for economic damage but its pest status remains unknown.

Recorded damage in the orchards of other parts of the world: The species has been recorded on grapevine and fig in Turkey and as an agricultural pest in Ukraine and Georgia (Demir 2009; Gjonov 2011; Gjonov & Shishinova 2014).

Recorded distribution in Iran: North, along the shores of Caspian Sea.

Conclusion: Given the recent discovery of large populations of the species in the north of Iran and its recorded pest status in adjacent countries, the species may be considered invasive. The economic damage made by the species and the necessity of using control methods need to be investigated urgently.

Family: Tettigometridae

***Tettigometra costulata* Fieber, 1865** (Fig. 10)

Recorded damage and economic importance in the orchards of Iran: On pear (Rajabi 1991).

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: Northwest, north, west, central and southeast (Mozaffarian & Wilson 2011).

Conclusion: Rajabi (1991) mentioned this species in the list of pests of Rosaceous fruit trees after observing a population of the species on pear in the north of Iran. Therefore, pest status of the species needs further study. Although Rajabi (1991) observed large populations on pear in north, no records of economic damage is known from Iran or other parts of the world so the pest status of this species needs to be evaluated.

Family: Tropiduchidae

***Ommatissus lybicus* Bergevin, 1930** (Figs 11 and 19)

Recorded damage and economic importance in the orchards of Iran: The species has been recorded as a very serious and a key pest on date palm in all Iranian palm growing areas on leaves and fruits of palm trees (Gardenhire 1958; Farahbakhsh 1961; Gharib 1966 and 1998; Behdad 1991; Dlabola 1994; Abaii 2000; Payandeh *et al*. 2008; Lashkari *et al*. 2008a, b; Assari *et al*. 2012; Koliayee *et al*. 2012; Arbabtafti *et al*. 2014).

Recorded damage in the orchards of other parts of the world: Economic importance on date palm throughout west Palaearctic (Wilson & O'Brien 1987; Asche & Wilson 1989; Wilson 2005).

Recorded distribution in Iran: From central Iran to the coasts of Persian Gulf and Oman Sea in all palm growing areas (Gharib 1998).

Conclusion: The economic importance of this species is widely documented in Iran and west Palaearctic. It is considered as a serious pest in Iran.

Infraorder: Cicadomorpha

Family: Aphrophoridae

***Aphrophora alni* (Fallen, 1805)** (Figs 20 and 21a–b)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A potential vector for the bacterium *Xylella fastidiosa* which infests olive trees in New Zealand (Anonymous 2013).

Recorded distribution in Iran: North and centre (Mozaffarian & Wilson 2015).

Conclusion: The role of the species in transmitting *Xylella fastidiosa* needs to be evaluated in Iran.

***Philaenus spumarius* (Linnaeus, 1758)** (Figs 22 and 23a–c)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A potential vector for *X. fastidiosa* and elm yellows phytoplasma. The species also tested positive for Aster yellows in vineyards in Czech Republic (DeLong & Severin 1950; EFSA 2013; Orsagova *et al*. 2011; Rosa *et al*. 2014).

Recorded distribution in Iran: Norh, northwest, southwest and south (Mozaffarian & Wilson 2015).

Conclusion: Although the species has not been recorded as a pest in Iranian orchards, the ability of the species to transmit diseases needs to be investigated due to the records in other parts of the world and its wide distribution in Iran.

***Poophilus costalis* (Walker, 1851)** (Figs 24 and 25a–e)

Recorded damage and economic importance in the orchards of Iran: Pest causing minor damage on fruit trees (Koliayee *et al*. 2012).

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: Nearly all of Iran (Mozaffarian & Wilson 2015).

Conclusion: Koliayee *et al*. (2012) stated that the species injured fruit trees previously but significant populations have not been observed in recent years.

Family: Cicadellidae

Subfamily Cicadellinae

Tribe Cicadellini

***Cicadella viridis* (Linnaeus, 1758)** (Figs 26 and 45)

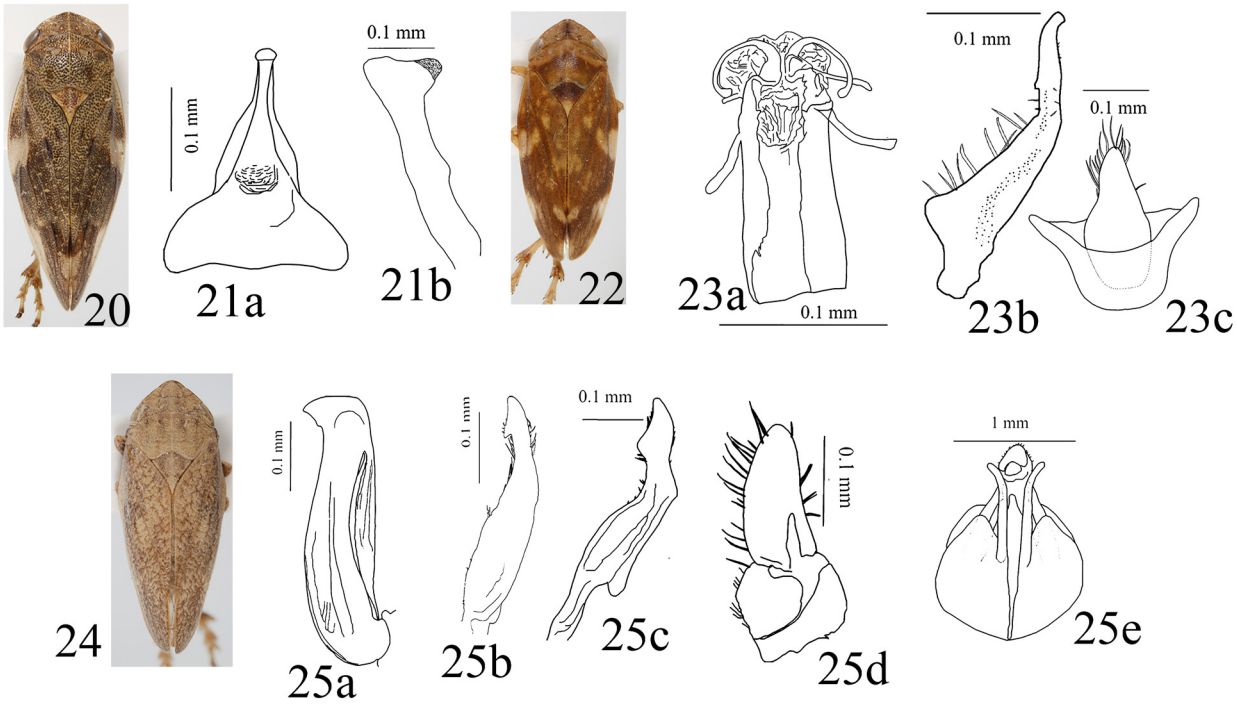
Recorded damage and economic importance in the orchards of Iran: The species has been recorded as a

pest with little or no economic importance on apple, pear, and plum (Rajabi 1989), Behdad 1992; Koliayee *et al*. 2012).

Recorded damage in the orchards of other parts of the world: A pest on hazelnut in Europe, with damage to stems and leaves in vineyards of Italy and minor importance on grapevine and young fruit trees such as apple, pear, cherry, peach and plum elsewhere. In Turkey the species is recorded as a potential pest in olive orchards. It is also recorded as a vector for *Xylella fastidiosa* which is known to be lethal for grapevines (Schindler 1960; Cavalloro 1987; Snare 2006; Bozbuga & Elekcioglu 2008; Alford 2014).

Recorded distribution in Iran: North, northwest, west and centre (Mozaffarian & Wilson 2016).

Conclusion: It has been recorded to cause little or no economic damage in the orchards of Iran. However, its status as a disease vector has not been studied in Iran.



FIGURES 20–25. Habitus and male genitaliae of Aphrophoridae of Iran recorded as pests in orchards (already published in: Mozaffarian & Wilson 2015): 20–21. *Aphrophora alni*, 20. Habitus, 21. Male genitalia, a: aedeagus, dorsal view, b: stylus, laterl view; 22–23. *Philaenus spumarius*, 22. Habitus, 23. Male genitalia, a: aedeagus, ventral view, b: stylus, lateral view, c: anal tube ventral view; 24–25. *Poophilus costalis*, 24. Habitus, 25. Male genitalia, a: aedeagus, lateral view, b, c: stylus, lateral view, d. anal tube, lateral view, e. genital plate, ventral view.

Subfamily Deltocephalinae

Tribe Athysanini

***Platymetopius shirazicus* Dlabola, 1974** (Figs 27 and 46)

Recorded damage and economic importance in the orchards of Iran: Mild economic importance on almond (Rajabi 1991).

Recorded damage in the orchards of other parts of the world: Not recorded

Recorded distribution in Iran: Central Alborz and southwest (Mozaffarian & Wilson 2016).

Conclusion: The species is endemic to Iran but its pest status needs to be evaluated more thoroughly.

***Euscelis lineolatus* Brullé, 1832**

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: The species is recorded as a vector for Aster yellows and stolbur phytoplasma of Bois noir in Europe (Weintraub & Beanland 2006, Landi *et al*. 2013; Minuz *et al*. 2013).

Recorded distribution in Iran: Northeast and centre (Mozaffarian & Wilson 2016).

Conclusion: The status of this species as a potential disease vector in Iran needs to be studied.

Tribe Fieberiellini

***Fieberiella florii* (Stål, 1864)**

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A vector for Apple proliferation, Aster yellows, Western X-disease and Eastern X-disease on Apple, stone fruit trees in Europe and North America and a vector for phytoplasmas in vineyards which may play a role in Grapevine Yellow (GY) epidemiology. The species was shown to be infected by *Candidatus* Phytoplasma mali in nature, producing apple proliferation in Italy and to be able to transmit it to healthy apple seedlings in the laboratory (Weintraub & Beanland 2006; Bosco *et al*. 2008; U.S. Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection and Quarantine 2012).

Recorded distribution in Iran: No specific locality was mentioned in previous reports of this species from Iran.

Conclusion: The distribution and vector capacity of the species in Iran need further study.

***Fiebriella macchiae* Linnavuori, 1962** (Figs 28 and 47)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A potential career of almond witches' broom phytoplasma (AlmWB) in Lebanon (Dakhil *et al*. 2011).

Recorded distribution in Iran: North and centre (Mozaffarian & Wilson 2016).

Conclusion: The vector capacity of this species has not been studied.

Tribe: Macrostelini

***Macrosteles quadripunctulatus* (Kirschbaum, 1868)** (Fig 29)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: It tested positive for stolbur phytoplasma in vineyards (Orenstein *et al*. 2003; Orsagova *et al*. 2011).

Recorded distribution in Iran: South of Alborz to Persian Gulf (Mozaffarian & Wilson 2016).

Conclusion: The status of this species as a potential phytoplasma vector needs to be studied in Iran.

***Macrosteles sexnotatus* (Fallen, 1806)** (Figs 30 and 48 a–b)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: Recorded as a potential vector for Bois noir/ Stolbur phytoplasma and Grapevine Yellow (GY) in vineyards of Europe (Bosco *et al*. 2008; Batlle *et al*. 2000).

Recorded distribution in Iran: Centre and south (Mozaffarian & Wilson 2016).

Conclusion: The status of the species needs to be studied in Iran.

Tribe Opsiini

***Hishimonus phycitis* (Distant, 1908)** (Figs 31and 49a–c)

Recorded damage and economic importance in the orchards of Iran: A vector for Witches' broom disease of lime (WBDL), the most destructive disease in lime in Southern Iran (Bagheri *et al*. 2009; Faghihi *et al*. 2011; Faghihi *et al*. 2011; Samavi *et al*. 2012).

Recorded damage in the orchards of other parts of the world: The species recorded as a vector for WBDL throughout the Middle East (Queiroz *et al*. 2017).

Recorded distribution in Iran: South (Mozaffarian & Wilson 2016).

Conclusion: *H. phycitis* is considered as a serious pest in Iran due to its confirmed status as a disease vector.

***Neoaliturus fenestratus* (Herrich- Schäffer, 1834)** (Figs 32 and 50)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A phytoplasma vector which is commonly found in vineyards and may play a role in transferring Grapevine Yellows (GY), Bois noir/ Stolbur and Aster yellows (AY) (Batlle *et al*. 2000; Orenstein *et al*. 2003; Bosco *et al*. 2008; Landi *et al*. 2013; Minuz *et al*. 2013).

Recorded distribution in Iran: Southern slopes of Alborz to south and southwest (Mozaffarian & Wilson 2016).

Conclusion: The vector status of *N. fenestratus* needs further study in Iran. Dehghan *et al*. 2012 showed transmission of Lettuce Phyllody (LP) by this species.

***Neoaliturus haematoceps* (Mulstant et Rey, 1855)** (Fig. 33)

Recorded damage and economic importance in the orchards of Iran: A vector of citrus stubborn disease and also sesame phyllody (Omidi *et al*. 2011).

Recorded damage in the orchards of other parts of the world: A potentional pest of olive orchards in Turkey. A vector for *Spiroplasma citri* in Europe and a potential vector for stolbur (Stol) and Aster yellows (AY) in vineyards and a phytoplasma disease in carrot fields of Israel (Orenstein *et al*. 2003, Bozbuga & Elekcioglu 2008).

Recorded distribution in Iran: Widely distributed (Mozaffarian & Wilson 2016).

Conclusion: The species is a serious disease vector in the orchards of Iran and other parts of the world.

Tribe Paralimnini

***Psammotettix striata* (Linnaeus, 1758)** (Figs 34 and 51)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A potential pest of olive orchards in Turkey. A potential vector for Bois noir/ Stolbur phytoplasma (Batlle *et al*. 2000; Bozbuga & Elekcioglu 2008; Drobnjaković *et al*. 2010).

Recorded distribution in Iran: Southern slopes of Alborz to Persian Gulf (Mozaffarian & Wilson 2016).

Conclusion: The pest status of the species needs to be studied in Iran.

Tribe Selenocephalini

***Selenocephalus dareicus* Dlabola, 1981** (Fig. 35)

Recorded damage and economic importance in the orchards of Iran: Mild economic importance on *Pyrus* sp. (Rajabi 1991, Abaii 2000).

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: Southwest (Mozaffarian & Wilson 2016).

Conclusion: The species is endemic to Iran and limited to Fars and Khuzestan provinces. Its pest status in Iran needs further confirmation.

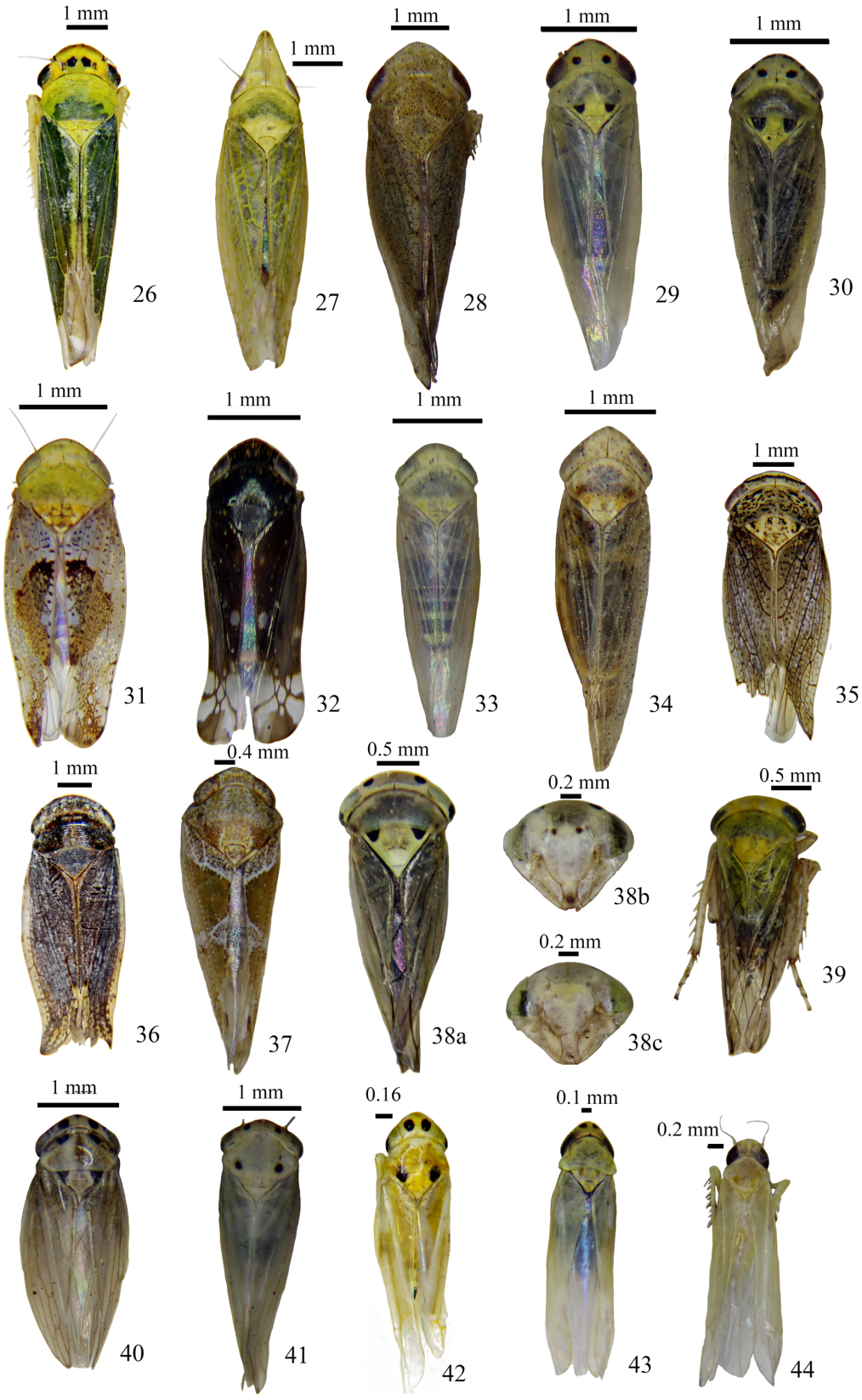
***Selenocephalus kyrosicus* Dlabola, 1981** (Figs 36 and 52)

Recorded damage and economic importance in the orchards of Iran: With mild economic importance on *Pyrus* sp. (Rajabi 1991; Abaii 2000).

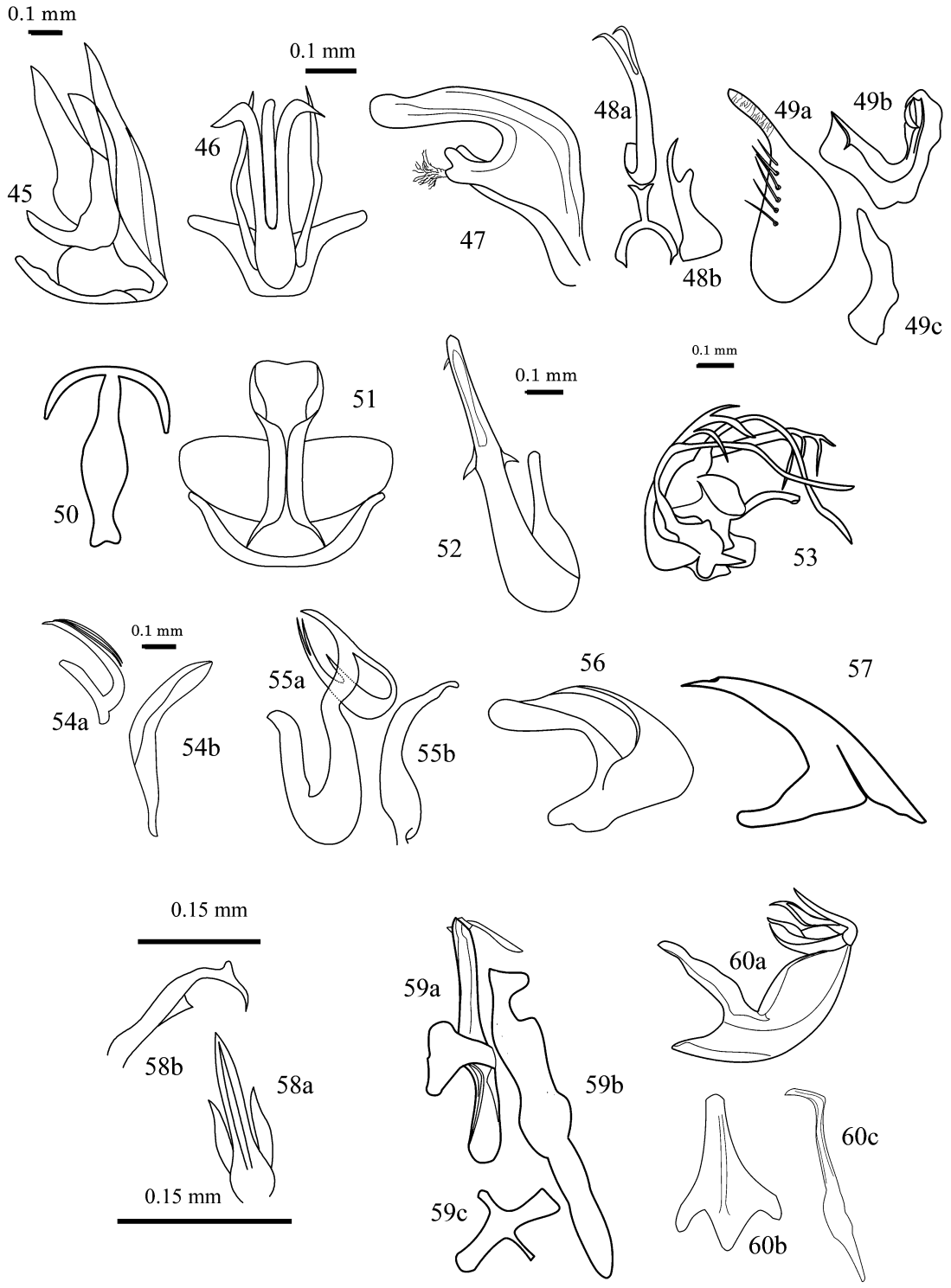
Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: Southwest (Mozaffarian & Wilson 2016).

Conclusion: The species is endemic to Iran and limited to Fars province. Its pest status in Iran needs further confirmation.



FIGURES 26–45. Habitus of Cicadellidae of Iran recorded as pests in orchards: 26. *Cicadella viridis*; 27. *Platymetopius shirazicus*; 28. *Fieberiella macchiae*; 29. *Macrosteles quadripunctulatus*; 30. *Macrosteles sexnotatus*; 31. *Hishimonus phycitis*; 32. *Neoaliturus fenestratus*; 33. *Neoaliturus haematoceps*; 34. *Psammotettix striata*; 35. *Selenocephalus dareicus*; 36. *Selenocephalus kyrosicus*; 37. *Stegelytra neveosparsa*; 38. *Idioscopus clypealis*, a: dorsal b,c: face; 39. *Sulamicerus stali*; 40. *Anaceratagallia laevis*; 41. *Austroagallia sinuata*; 42. *Arboridia kermanshah*; 43. *Frutioidia* (*Frutioidia*) *bisignata*; 44. *Edwardsiana rosae*.



FIGURES 45–60. Male genitaliae of Cicadellidae of Iran recorded as pests in orchards: 45: *Cicadella viridis*, aedeagus, lateral view; 46: *Platymetopius shirazicus*, aedeagus, dorsal view; 47. *Fieberiella macchiae*, aedeagus, lateral view; 48. *Macrosteles sexnotatus*, a: aedagus, ventral view and connective, b: stylus, lateral view; 49. *Hishimonus phycitis*, a: subgenital plate, ventral view b: aedeagus, ventral view, c: stylus, lateral view; 50. *Neoaliturus fenestratus*, aedeagus, dorsal view; 51. *Psammotettix striata*, aedeagus, ventral view; 52. *Selenocephalus kyrosicus*, aedeagus, dorsolateral view; 53. *Stegelytra neveosparsa*, aedeagus, lateral view; 54. *Idioscopus clypealis*, a: aedeagus, lateral view b: stylus, lateral view; 55. *Sulamicerus stali,* a: aedeagus, lateral view b: stylus, lateral view; 56. *Anaceratagallia laevis*, aedeagus, lateral view; 57. *Austroagallia sinuata*, aedeagus, lateral veiew; 58. *Arboridia kermanshah,* a: aedeagus, dorsal view, b: stylus, lateral view; 59. *Frutioidia* (*Frutioidia*) *bisignata*, a: aedeagus, lateral view, b: stylus, lateral view c: connective 60. *Edwardsiana rosae*, a: aedeagus, lateral view, b: connective, c: stylus, lateral view.

Tribe Stegelytrini

***Stegelytra neveosparsa* (Ghauri, 1972)** (Figs 37 and 53)

Recorded damage and economic importance in the orchards of Iran: Moderate economic importance damage on *Pyrus* sp. (Rajabi 1991; Abaii 2000)

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: North and southwest (Mozaffarian & Wilson 2016).

Conclusion: Its pest status in Iran needs further confirmation. It was previously recorded under the name *Stegelytra sororcula* Dlabola, a junior synonym of *S. neveosparsa*.

Subfamily Idiocerinae

***Idioscopus clypealis* (Lethierry, 1889)** (Figs 38 a–c and 54a–b)

Recorded damage and economic importance in the orchards of Iran: A pest on mango and tropical fruits (Pezhman & Rajabi 2002; Koliayee *et al*. 2012; Saeed *et al*. 2013)

Recorded damage in the orchards of other parts of the world: An economic pest in Pakistan, India, southeast Asia and Australia (Fletcher & Dangerfield 2002; Varshneya & Ranam 2008)

Recorded distribution in Iran: Southeast (Mozaffarian & Wilson 2016).

Conclusion: Pezhman & Rajabi (2002) mentioned the species as the most serious pest on mango and the main factor of crop losses in Southern Iran. However, according to Koliayee *et al* (2012), in spite of the high density of the population on mango, it does not injure the tree economically.

***Sulamicerus stali* (Fieber, 1868)** (Figs 39 and 55a–b)

Recorded damage and economic importance in the orchards of Iran: Previously known as a serious pest in pistachio gardens with severe economic damage, but as a secondary pest in recent years (Farahbakhsh 1961; Esmaili 1984; Behdad 1991; Kolyayee *et al*. 2012; Nourbakhsh *et al*. 2012)

Recorded damage in the orchards of other parts of the world: A pest on pistachio in Greece and Turkey which causes leaf whitening and blight of young panicles in large populations (Lodos & Kalkandelen 1982; Mourikis *et al*. 1998).

Recorded distribution in Iran: Southern slopes of Alborz to Persian Gulf (Mozaffarian & Wilson 2016).

Conclusion: Koliayee *et al*. (2012) mentioned the population size of the species, hence, its economic importance, has declined recently.

Subfamily Megophthalminae

Tribe Agalliini

***Anaceratagallia laevis* (Ribaut, 1935)** (Figs 40 and 56)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: In Europe**,** the species has been recorded as a potential vector for Bois noir/ Stolbur phytoplasma, Aster yellows (AY) in vineyards, the yellows phytoplasma to *Catharantus roseus* and potato plants and 16SrI-A phytoplasmas in carrot fields (Batlle *et al*. 2000; Drobnjaković *et al*. 2010; Orenstein *et al*. 2003; Orenstein *et al*. 2003).

Recorded distribution in Iran: North, centre and west (Mozaffarian & Wilson 2016).

Conclusion: The vector status of this species in Iran needs further study.

***Austroagallia sinuata* (Mulsant Rey, 1855)** (Figs 41 and 57)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: Tested positive for Aster yellows (AY) in vineyards in Europe (Orenstein *et al*. 2003).

Recorded distribution in Iran: Generally distributed (Mozaffarian & Wilson 2016).

Conclusion: The vector status of this species in Iran needs further study.

Tribe: Megophthalmini

***Megophthalmus scabripennis* Edwards, 1915**

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A potential pest in olive orchards in Turkey and a potential vector for Aster yellows (AY) in vineyards (Bozbuga & Elekcioglu 2008; Orenstein *et al*. 2003).

Recorded distribution in Iran: North (Mozaffarian & Wilson 2016).

Conclusion: The vector status of this species in Iran needs further study.

Subfamily Typhlocybinae

Tribe Empoascini

***Asymmetrasca decedens* (Paoli, 1932)**

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: An occasional pest on citrus in Yugoslavia, Italy and Spain. A potentional pest in olive orchards in Turkey. A vector of '*Ca*. Phytoplasma prunorum' (European stone fruit yellow phytoplasma), a potential career of almond witches' broom phytoplasma (AlmWB) and tested positive to apricot chlorotic leaf roll (ACLR) and phytoplasma in Lebanon (Reuther 1989; Bozbuga & Elekcioglu 2008; Dakhil *et al*., 2011; U.S. Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection and Quarantine 2012).

Recorded distribution in Iran: West and northeast (Mozaffarian & Wilson 2016).

Conclusion: The vector status of this species in Iran needs further study.

***Empoasca decipiens* Paoli, 1930**

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: An occasional pest on apple and a potentional pest in olive orchards in Turkey. A vector for Aster yellows and a potential career of almond witches' broom phytoplasma in Lebanon (AlmWB) (Alford 1992, Bozbuga & Elekcioglu 2008, Dakhil *et al*. 2011).

Recorded distribution in Iran: Generally distributed (Mozaffarian & Wilson 2016).

Conclusion: The vector status of the species in Iran needs further study.

***Empoasca fabae* (Harris, 1841)**

Recorded damage and economic importance in the orchards of Iran: A pest on apple, pear, grapevine (Esmaili 1984; Rajabi 1991). Rajabi (1991) believes it doesn't have any economic importance.

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: Southern slope of Alborz Mountain (Tehran) (Mozaffarian & Wilson 2016).

Conclusion: The confirmed distribution of the species is limited to the New World; thus previous Iranian records of this species may be based on misidentifications (Mozaffarian & Wilson 2016).

***Jacobiasca lybica* (Bergevin & Zanon, 1922)**

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A pest on grapevine in Southern Europe due to its direct damage (Alma 2002).

Recorded distribution in Iran: Southwest (Mozaffarian & Wilson 2016).

Conclusion: Pest status of the species in Iran needs further study.

***Kyboasca maligna* (Walsh, 1862)**

Recorded damage and economic importance in the orchards of Iran: Pest of fruit trees with unknown economic importance (Esmaili 1984).

Recorded damage in the orchards of other parts of the world: Pest with no economic importance in Czech (Malenovsky & Lauterer 2010).

Recorded distribution in Iran: No locality record is published.

Conclusion: None of the records of the presence of this species are according to the published examined material. The species is invasive in Europe but there isn't any evidence on the existence of this species in Iran (Mozaffarian & Wilson 2016).

Tribe Erythroneurini

***Arboridia kermanshah* (Dlabola, 1963)** (Figs 42 and 58a–b)

Recorded damage and economic importance in the orchards of Iran: A pest in vineyards (Mostaan & Akbarzadeh 1995; Latifian *et al*. 2004).

Recorded damage in the orchards of other parts of the world: The species of this genus have been recorded as well known pests on vineyards in the world (Pombo 2001; Viggiani 2002).

Recorded distribution in Iran: West, centre and northeast (Mozaffarian & Wilson 2016).

Conclusion: *A. kermanshah* is an endemic species with a rather wide recorded distribution in Iran. It was recorded as a common species and a pest in Iranian vineyards of the country. The economic injury level for the species was determined by Latifian *et al*. (2005). However, there isn't any record available to indicate the damage level of the species in the vineyards.

***Erythroneura comes* (Say, 1825)**

Recorded damage and economic importance in the orchards of Iran: A pest on grapevine and other fruit trees (Behdad 1991; Esmaili 1984).

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: South of Central Alborz Mountain (Mozaffarian & Wilson 2016).

Conclusion: The species is a Nearctic species and the records may be due to a misidentification (Mozaffarian & Wilson 2016).

***Frutioidia* (*Frutioidia*) *bisignata* (Mulstant et Rey, 1855)** (Figs 43 and 59a–c)

Recorded damage and economic importance in the orchards of Iran: Mild and sometimes significant damage on Poaceae. The phytoplasma responsible for Almond Witches' broom disease could not be transmitted by this insect (Esmaili 1984; Rajabi 1991, Taghizadeh & Salehi 2002; Koliayee *et al*. 2012).

Recorded damage in the orchards of other parts of the world: A pest on hazelnut in Europe and a potential pest in olive orchards in Turkey (Snare 2006; Bozbuga & Elekcioglu 2008).

Recorded distribution in Iran: Northwest and centre (Mozaffarian & Wilson 2016).

Conclusion: Modarres Awal (1994) mentioned the name: "*Erythroneura albisignata*" as a synonym with Z. *bisignata* which is the synonym of the present species. It has been repeated in some agricultural websites consequently as a pest on Poaceae. However, this is not a valid name. The economic injury level caused by the species is unclear.

Tribe Typhlocybini

***Zyginella pulchra* Löw, 1855**

Recorded damage and economic importance in the orchards of Iran: Not noticeable economic damage on pear, apricot, plum, apple and other trees in cold regions (Rajabi 1991; Rajabi & Mirzayans 1989; Koliayee *et al*. 2012).

Recorded damage in the orchards of other parts of the world: A potentional pest in olive orchards in

Turkey (Bozbuga & Elekcioglu 2008).

Recorded distribution in Iran: Centre (Mozaffarian & Wilson 2016).

Conclusion: The pest status of the species needs further study.

***Edwardsiana rosae* (Linnaeus, 1758)** (Figs 44 and 60 a–c)

Recorded damage and economic importance in the orchards of Iran: Causing various degrees of economic damage on apple, pear, almond and grapevine (Tchouvakhin 1949; Farahbakhsh 1961; Esmaili 1984; Behdad 1991; Rajabi 1991; Abaii 2000; Koliayee *et al*. 2012; Nourbakhsh *et al*. 2012).

Recorded damage in the orchards of other parts of the world: Bozbuga & Elekcioglu (2008) mentioned the species as a potential and not economic pest in olive orchards in Turkey.

Recorded distribution in Iran: North, west and centre (Mozaffarian & Wilson 2016).

Conclusion: The damage level caused by this species needs to be studied due to the variable records in Iran and other parts of the world.

Family: Cicadidae

***Chloropsalta ochreata* (Melichar, 1902)** (Figs 61 and 69)

Recorded damage and economic importance in the orchards of Iran: Mild, moderate or severe pests on roots and branches of on grapevine, pear, apple, peach and cherry (Farahbakhsh 1961; Esmaili 1984).

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: Needs further study.

Conclusion: Reviewing the Iranian literature shows the name of this species as a pest has nearly always been used instead of *Cicadatra alhageos* (Kolenati, 1857) and even sometimes the two valid species are mentioned as synonyms (Babaii 1967; Behdad 1991). During the recent years, none of the specimens which were collected by the author, those which were already deposited in Hayk Mirzayans Insect Museum and the others which were sent to be identified from different parts of Iran were really *Ch. ochreata.* In addition, none of the published records of *Ch. Ochreata* as a pest has been confirmed by a taxonomist. At the moment the only trustable record for this species in Iran is the original description by Melichar (1902) from the vineyards in southeast. Hence, the true pest status of the species needs to be studied after the correct identifications.

***Chloropsalta smaragdula* Haupt, 1920** (Figs 62 and 70)

Recorded damage and economic importance in the orchards of Iran: Considering two species (*Cicadatra alhageos* and *Chloropsalta ochreata*) as “grape cicadas" in Iran, *Chloropsalta smaragdula* was introduced as the third species of grape cicada by Aghagoli Marzijarani *et al*. (2013). There isn’t any record on the injury level caused by this species.

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: Generally distributed.

Conclusion: Due to the extreme similarity of the habitus of the three cicadas in vineyards of Iran (*Cicadatra alhageos, Chloropsalta ochreata* and *Chloropsalta smaragdula*), it is quite necessary to determine the damage level caused by the species after the correct identification.

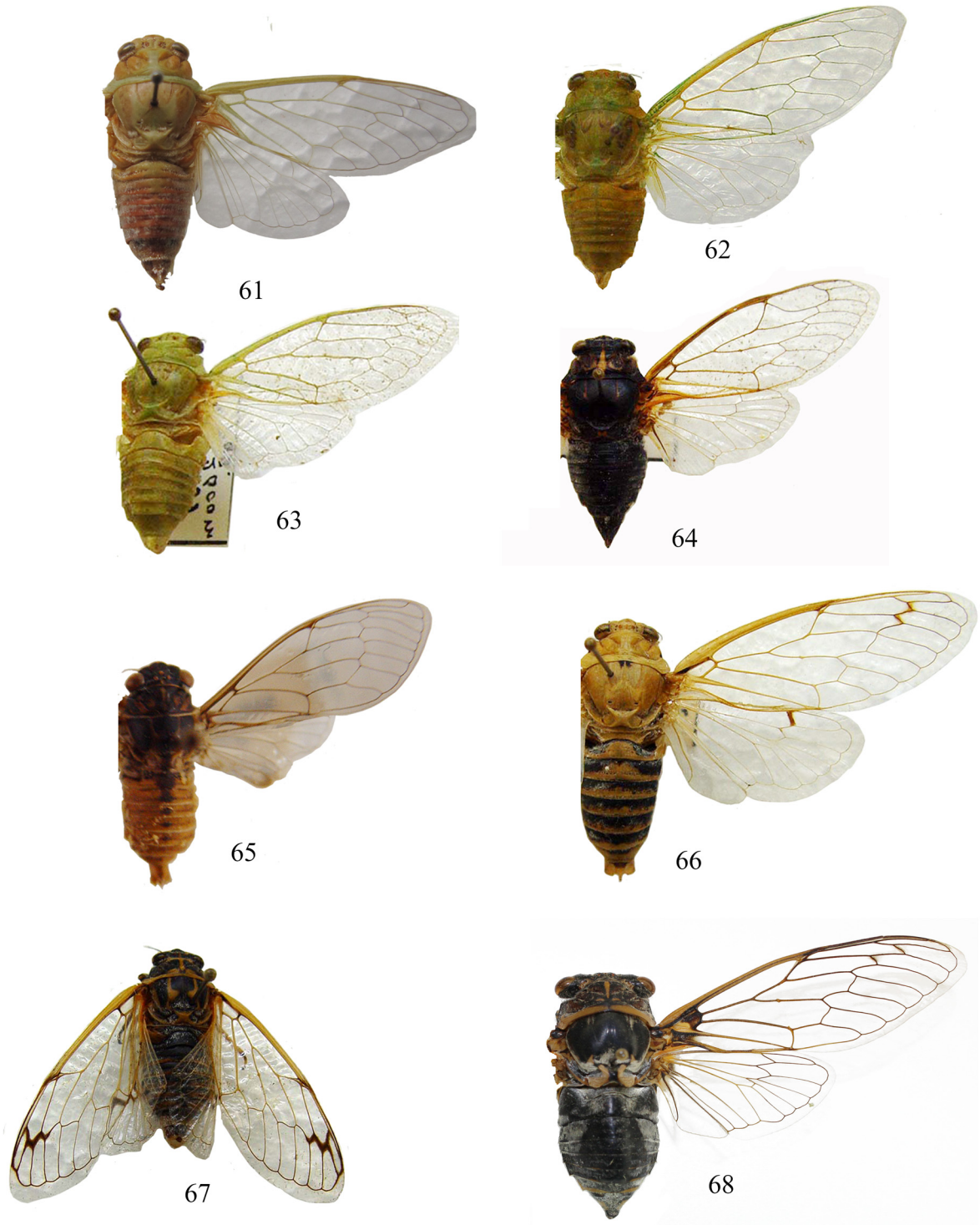
***Cicadatra alhageos* (Kolenati, 1857)** (Figs 63 and 71)

Recorded damage and economic importance in the orchards of Iran: A serious pest on roots and branches due to the nymphal feeding and female oviposition on grapevine, apple, pear, plum, almond, apricot, cherry, peach, pomegranate etc (Babaii 1967; Farazmand *et al*. 2012; Koliayee *et al*. 2012; Rajabi 1991; Shekarian & Rezwani 2001).

Recorded damage in the orchards of other parts of the world: A destructive pest in Turkey, Uzbekistan and Turkmenia on grapevine and other fruit trees.

Recorded distribution in Iran: Widely distributed.

Conclusion: The species has been collected in large numbers from different parts of Iran, including agricultural ecosystems frequently by the author and other colleagues in Hayk Mirzayans Insect Museum. The species is known as one of the most important agricultural pests in Iran.



FIGURES 61–68. Habitus of Cicadidae of Iran recorded as pests in orchards: 61. *Chloropsalta ochreata*; 62. *Chloropsalta smaragdula*; 63. *Cicadatra alhageos*; 64. *Cicadatra persica*; 65. *Pagiphora annulata*; 66. *Psalmocharias flava*; 67. *Psalmocharias querula*; 68. *Tibicen plebejus* (already published in: Mozaffarian & Sanborn 2016).

***Cicadatra persica* (Kirkaldy, 1909)** (Figs 64 and 72)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A destructive pest in the apple orchards of Syria (Dardar *et al*. 2012).

Recorded distribution in Iran: Northwest, west, southwest, centre and southeast.

Conclusion: In spite of the wide distribution of the species in Iran, large populations and the activity of species as pest have never been recorded.

***Klapperichicen viridissimus* (Walker, 1858)**

Recorded damage and economic importance in the orchards of Iran: Not recorded

Recorded damage in the orchards of other parts of the world: Pest on *Vitis* sp in Syria (Talhouk 1959; Schedl 2003).

Recorded distribution in Iran: North and northwest (Mozaffarian & Sanborn 2010).

Conclusion: Schedl (2003) published images from habitus and male genitalia of lectotype of this species which was collected from Iraq. In spite of the record of the species in Iran, there isn't any Iranian specimen available to examine. However due to the extreme similarity of the habitus of the lectotype in Schedl (2003) with *C. alhageos*, and the fact that the latter species is a well known pest in Iranian vineyards, it may be useful to re-examine the specimens from north and northwest of Iran.

***Pagiphora annulata* (Brullé, 1832)** (Figs 65)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A pest with considerable damage in fruit trees in Bulgaria due to the oviposition (Arabadzhiev 1970).

Distribution in Iran: Southwest.

Conclusion: Oviposition of the females of this family may cause damage to the fruit on the apical parts of the branches. However, the damage may be significant in large populations of the species and there isn't any record of emerging noticeable populations of this species in Iran.

***Psalmocharias flava* Dlabola, 1970** (Figs 66 and 73)

Recorded damage and economic importance in the orchards of Iran: Pest on almond, apple and soure cherry (Rajabi 1991).

Recorded damage in the orchards of other parts of the world: Not recorded.

Distribution in Iran: Widely distributed

Conclusion: There isn't any published record available on the noticeable damage of the species. However, their significant damage on the fruit trees has been observed during their mass emerges in the west of Iran by the author and reported by the gardeners as well.

***Psalmocharias querula* (Pallas, 1773)** (Figs 67 and 74)

Recorded damage and economic importance in the orchards of Iran: Unknown economic importance on young twigs and stems of grapevine (Farahbakhsh, 1961).

Recorded damage in the orchards of other parts of the world: Not recorded.

Distribution in Iran: Widely distributed.

Conclusion: The specimens of this species appear in mass emerge in some years. However, the pest status of the species and the vitality for controlling the species in the agro-ecosystems have not ever been recorded.

***Tibicen plebejus* (Scopoli, 1763)** (Figs 68 and 75)

Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A pest (recorded as potential pest as well) on olive in Turkey (Lodos & Kalkandelen 1981; Bozbuga & Elekcioglu 2008).

Distribution in Iran: North (Mozaffarian & Sanborn 2016).

Conclusion: There isn't any record available from Iran and other parts of the world to confirm the economic importance of the damage caused by this species.

***Tibicina haematodes* (Scopoli, 1763)**

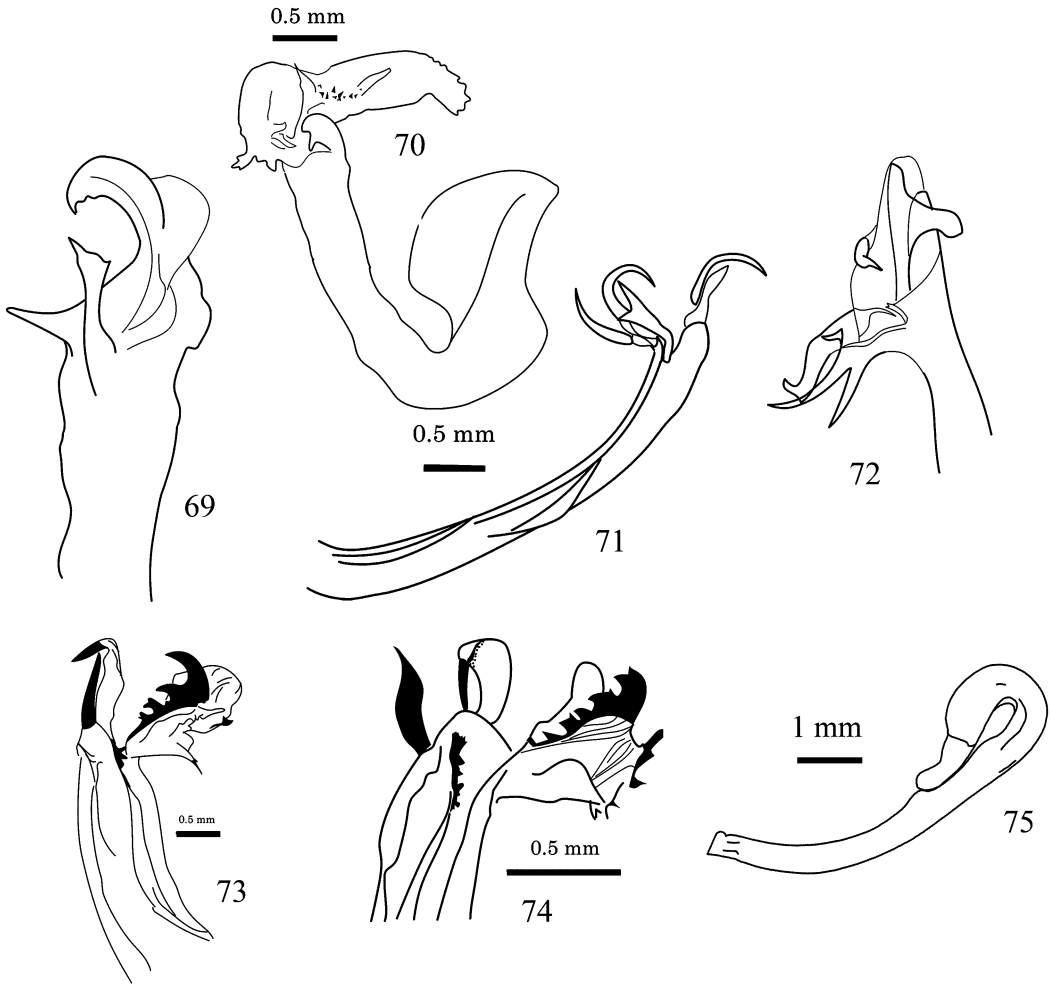
Recorded damage and economic importance in the orchards of Iran: Not recorded.

Recorded damage in the orchards of other parts of the world: A pest on forest and fruit trees in Moldavia, Bulgaria Ukrain and Turkey. It is also mentioned as a potential pest with no economic importance in Turkish olive

orchards (Arabadzhiev 1963; Boucek 1963; Boucek 1963; Apostolov & Topciev 1970; Abaii 2000).

Distribution in Iran: No locality is recorded.

Conclusion: The identification source of this species in Abaii (2000) is not clear and there isn't any other published evidence for the existence of this species in Iran.



FIGURES 69–75. Male genitaliae of Cicadidae of Iran recorded as pests in orchards: 69. *Chloropsalta ochreata*, apical part of aedeagus, ventral view; 70. *Chloropsalta smaragdula*, aedeagus, lateral view; 71. *Cicadatra alhageos*, laeral view; 72. *Cicadatra persica*, apical part of aedeagus, lateral view; 73. *Psalmocharias flava*, apical part of aedeagus, lateral view; 74. *Psalmocharias querula*, apical part of aedeagus, lateral view; 75. *Tibicen plebejus*, Aedeagus, lateral view.

Family: Membracidae

***Stictocephala bisonia* Kopp et Yonke, 1977**

Recorded damage and economic importance in the orchards of Iran: Non significant damage on fruit trees (Esmaiili 1984; Rajabi 1991).

Recorded damage in the orchards of other parts of the world: Not recorded.

Recorded distribution in Iran: South slope of central Alborz

Conclusion: Both recordsof the species as pest (Esmaiili 1984 and Rajabi 1991) were under the name "*Ceresa bubalus* Fabricius, 1794". These authors noted a lack of significant damage caused by the species suggested there is no necessity of any control method. In addition, the recorded distribution of the species is very limited and the reason of recording the species as 'pest' is not clear. Therefore, the pest status of the species needs further study.

Discussion

According to the literature, 29 Auchenorrhyncha species were recorded as "pests" in the orchards of Iran. However, many of these species do not satisfy the commonly accepted criteria for considering a particular species an "agricultural pest." This is because the reported damage levels caused by these species in Iranian orchards has not been shown to reach the required economic threshold necessary for being considered as a "pest". Mere presence of an insect in any agricultural ecosystem, even in high population levels (Norton & Conway 1977) does not justify classifying it as a pest. My review of the literature on species which were recorded as pests in Iran suggests the necessity of further investigation to ascertain the true pest status of 14 species: (*Stictocephala bisonia* Kopp & Yonke, 1977, *Chloropsalta ochreata* (Melichar, 1902), *Hyalesthes mlokosiewiczi* Signoret, 1879, *Iranodus amygdalinus* Dlabola, 1980, *Mesophantia pallens* Melichar, 1902, *Persepolia columbaria* Dlabola & Safavi, 1972, *Platymetopius shirazicus* Dlabola, 1974, *Psalmocharias flava* Dlabola, 1970, *Psalmocharias querula* (Pallas, 1773), *Selenocephalus dareicus* Dlabola, 1981, *Selenocephalus kyrosicus* Dlabola, 1981, *Stegelytra neveosparsa* (Ghauri, 1972), *Tettigometra costulata* Fieber, 1865 and *Zyginella pulchra* Löw, 1855). In addition, 3 other recorded "pest" species were probably based on misidentifications and their identities still need to be established (*Empoasca fabae* (Harris: 1841), *Erythroneura comes* (Say, 1825) and *Kyboasca maligna* (Walsh, 1862)). 12 other species are recorded as pests with mild (*Cicadella viridis* (Linnaeus, 1758) and *Poophilus costalis* (Walker, 1851)), significant (*Cicadatra alhageos* (Kolenati, 1857), *Hishimonus phycitis* (Distant, 1908), *Neoaliturus haematoceps* (Mulstant et Rey, 1855) and *Ommatissus lybicus* Bergevin, 1930) and unknown (*Arboridia kermanshah*, *Chloropsalta smaragdula* Haupt, 1920, *Edwardsiana rosae* (Linnaeus, 1758), *Frutioidia* (*Frutioidia*) *bisignata* (Mulstant et Rey, 1855), *Idioscopus clypealis* (Lethierry, 1889) and *Sulamicerus stali* (Fieber, 1868)) economic importance. 25 other Auchenorrhyncha species recognized among the recorded fauna of Iran were recorded as pests and vectors harmful to fruit trees in other parts of the world but their pest status in Iran remains unknown (*Anaceratagallia laevis* (Ribaut, 1935), *Aphrophora alni* (Fallen, 1805), *Asymmetrasca decedens* (Paoli, 1932), *Austroagallia sinuata* (Mulsant Rey, 1855), *Cicadatra persica* Kirkaldy, 1909, *Dictyophara* (*Dictyophara*) *europaea* (Linnaeus, 1767), *Empoasca decipiens* Paoli, 1930, *Euscelis lineolatus* Brullé, 1832, *Fieberiella florii* (Stål, 1864), *Fiebriella macchiae* Linnavuori, 1962, *Hyalesthes obsoletus* Signoret, 1865, *Jacobiasca lybica* (Bergevin & Zanon, 1922), *Klapperichicen viridissimus* (Walker, 1858), *Laodelphax striatellus* (Fallén, 1826), *Macrosteles quadripunctulatus* (Kirschbaum, 1868), *Macrosteles sexnotatus* (Fallen, 1806), *Megophthalmus scabripennis* Edwards, 1915, *Neoaliturus fenestratus* (Herrich- Schäffer, 1834), *Orosanga japonicus* Melichar, 1898, *Pagiphora annulata* (Brullé, 1832), *Philaenus spumarius* (Linnaeus, 1758), *Psammotettix striata* (Linnaeus, 1758), *Reptalus quinquecostatus* (Dufour, 1833), *Tibicen plebejus* (Scopoli, 1763) and *Tibicina haematodes* (Scopoli, 1763)). It worth mentioning that the existence of the last mentioned species in Iran is doubtful due to the unclear source of identification of the only available record. Although the above 25 species have not been recorded as a danger to Iranian orchards, it would be useful to study their pest status and particularly their ability for transmitting diseases in the country. The submitted identification key included all above species to facilitate identifying so called pests in the Iranian orchards to facilitate further studies including investigations on their real pest status and their ability for transmitting diseases.

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