

Hemiptera, Cicadomorpha

Fulgoromorpha

5800 , , 89,

Order Hemiptera, Suborder Fulgoromorpha and Cicadomorpha in Alfalfa Agrocenosis

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Review paper

Cicadomorpha Fulgoromorpha
Hemiptera

42 000

SUMMARY

Suborders Fulgoromorpha and Cicadomorpha in Hemiptera order are a highly diverse group of insects containing about 42,000 species described from around the world. They are spread everywhere, and all cicada species eat and damage plants.

The literature review covered the composition of species of cicada insects in alfalfa agrocenosis. They are diverse and numerous group that causes direct and indirect plant damage. Main and economically important cicadas are presented in different regions of the world and in Bulgaria, which as a result of their nutritional activities lead to a decrease in productivity and its quality.

It is described the damage mechanism to the dominant species and the injury occurring as a response in the plant organism. Cicada ability to transfer phytopathogenic organisms (viruses, mycoplasma, spiroplasma, bacteria) that

Cicadomorpha, : Fulgoromorpha,

cause various plant diseases is underlined.

Key words: Fulgoromorpha, Cicadomorpha, cicadas, damage, alfalfa agroecosis

Cicadomorpha Fulgoromorpha Hemiptera -
42 000 (Mifsud et al., 2010; Cryan and Urban, 2011).

STUDIES ABROAD

Fulgoromorpha and Cicadomorpha suborder (order Hemiptera) are extremely diverse group of insects, containing about 42,000 described species worldwide (Mifsud et al., 2010; Cryan and Urban, 2011). They are everywhere spread and eat and damage plants.

(Hall, 2009).

Their common feature is the send out of clear and strong signals or specific vibration as a form of communication and reproductive behavior (Hall, 2009). Species of the two subdivisions have different degrees of specialization. Some of them are very broad polyphagous, others are oligophagous and third - monophagous, specialized on only one host species.

and Grimaldi, 2004). (2004) Ritzmann

These insects have a high reproductive ability, pronounced sexual dimorphism, ability to fly, great species diversity and distribution, small size (ngel and Grimaldi, 2004). According to Ritzmann et al. (2004) their last feature allowed settling in almost all ecosystems.

Fulgoromorpha -
10 000 20 (Holzinger et al., 2003).

Fulgoromorpha suborder covers a large group of phytophagous insects that are distributed worldwide. It includes about 10, 000 described species, divided into 20 families (Holzinger et al., 2003).

This suborder is represented by some of the most harmful cicadas in major crops in the world. The relationship of this group to host plants is particularly important, because they use the plant organism not only as a source of food but also as a suitable site for fecundation and egg production, and as a means of communication (Holzinger et al., 2003).

(Holzinger et al., 2003).
Fulgoromorpha

(Kastal'eva et al., 2016).

Cixiidae

Delphacidae

(Nickel, 2003).

Fulgoromorpha species damage plants by egg-laying and passing eggs into plant tissues, when fed with phloem cell juice, as well as in the transmission of various plant pathogens (Kastal'eva et al., 2016).

According to the authors, Cixiidae species were carriers of phytoplasma infections, while Delphacidae species are carriers of viruses primarily. These insect pests cause serious damage to crops and infectious diseases.

Cicadas are insect pests that can cause serious damage in the cultivation of crops, including alfalfa.

However, in most of Western and Central Europe, the damage to crops is limited, and the cicadas role in the functioning of the ecosystem is direct and indirect because they feed on the plant juice from xylem and phloem and are the transmission of pathogenic microorganisms (Nickel, 2003).

However, their importance and presence should not be underestimated, as insects have to consume large amounts of vegetable juice to receive the necessary nutrients.

Direct damage associated with feeding, whereby cicadas suck tissue juices (which slows down the growth and development of the plant organism) as well as associated with egg-laying, which causes mechanical damage.

Common symptoms of damage often resemble the aging process, and they appear after eating, regardless of species identification. These symptoms include wilting in young plants, leaf chlorosis (yellowing or browning of the leaves), followed by premature leaf fall, and inhibiting plant growth caused by the reduction of stem elongation (Backus et

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| <p>(Backus et al., 2005).</p> | <p>al., 2005). Although the leaf chlorosis is the more visible and quickly establishing feature, the most important one for</p> |
| <p>-</p> | <p>reduced yield is suppressed vegetative and reproductive growth and development.</p> |
| <p>, Backus</p> | <p>Backus et al. (2005) found that alfalfa development during the growing season was of particular importance in the</p> |
| <p>(2005)</p> | <p>formation of forage production such as hindering or stopping the growth directly led to a proportional decrease in yield.</p> |
| <p>,</p> | <p>-</p> |
| <p>,</p> | <p>The damage to the cicada feeding is related not only to a decrease in the forage production but also to a change in the forage quality.</p> |
| <p>,</p> | <p>-</p> |
| <p>, <i>Empoasca</i></p> | <p>Recent studies involving the influence of <i>Empoasca</i> cicadas on forage quality showed a decrease in digestible protein concentration with increasing cicada density (Rethwisch, 2000).</p> |
| <p>(Rethwisch, 2000).</p> | <p>One of the main vectors for spreading the Stolbur phytoplasma disease are the Cicadellidae species</p> |
| <p>- Cicadellidae (Weintraub and Beanland, 2006).</p> | <p>(Weintraub and Beanland, 2006). They can cause substantial plant damage and productivity losses in a wide variety of crops, including alfalfa (Alhudaib et al., 2007). The most common characteristic symptom of this disease is reducing leaf mass and reproductive organs.</p> |
| <p>,</p> | <p>-</p> |
| <p>(Alhudaib et al., 2007).</p> | <p>The vegetative organs and seeds weight decreases by more than 50%, and depending on the damage degree, flower buds and seeds may not form (Girsova et al., 2017).</p> |
| <p>,</p> | <p>-</p> |
| <p>50%,</p> | <p>-</p> |
| <p>(Girsova et al., 2017).</p> | <p>Mazzoni (2005) examined the species diversity of cicadas in the Tuscany region, Italy, depending on plant</p> |
| <p>Mazzoni (2005)</p> | <p>hosts and observed the high prevalence of monophagous and polyphagous species. The author found that in alfalfa</p> |
| <p>,</p> | <p>mainly dominated by 9 species, in</p> |

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Empoasca decipiens Paoli,
Euscelis lineolata, *Psammotettix alienus*
 Dahlbom, *Aphrodes makarovi* Zachvatkin,
Austroagallia sinuata Mulsant & Rey,
Empoasca alsiosa Ribaut, *Reptalus*
quinguecostatus Dufour

Macrosteles laevis, *Psammotettix*
alienus, *Empoasca pteridis*, *Javesella*
pellucida Fabricius *Laodelphax striatellus*
 Fallen

(Malenovský and Auterer, 2002).
 (Nickel, 2003; Nickel and
 Hildebrandt, 2003),

Empoasca fabae

(Sulc and Lamp, 2007).

220 26 (62%)
 Fabaceae (Lamp
 et al., 1994).

Empoasca

(2008)
Empoasca decipiens Paoli

M. sativa.

(2005) 4
 (*Cercopis sanguinolenta* Scopoli,

particular *Empoasca decipiens* Paoli,
Euscelis lineolata, *Psammotettix alienus*
 Dahlbom, *Aphrodes makarovi* Zachvatkin,
Austroagallia sinuata Mulsant & Rey,
Empoasca alsiosa Ribaut, *Reptalus*
quinguecostatus Dufour and others. Also,
 he concluded that the ecology of the
 species depending on various factors
 such as the stage of development,
 climate, season, and the host plant
 presence.

Macrosteles laevis, *Psammotettix*
alienus, *Empoasca pteridis*, *Javesella*
pellucida Fabricius and *Laodelphax*
striatellus Fallen were dominant cicada
 species in arable fields, and mainly alfalfa,
 in the Czech Republic (Malenovský and
 Auterer, 2002). According to some
 authors (Nickel, 2003; Nickel and
 Hildebrandt, 2003), those species easily
 migrated to agroecosystems with disturbed
 habitats in the early successional stages.

Empoasca fabae is one of the most
 serious economic pests affecting forage
 production of alfalfa in the Midwest and
 the United States and the species
 reached the economic threshold of harm
 every year (in summer) (Sulc and Lamp,
 2007). Cicada has a rich and diverse
 range of hosts, including 220 species of
 plants from 26 families, and the majority
 of plants (62%) belong to the Fabaceae
 family (Lamp et al., 1994).

Empoasca genus is the most
 common and reported alfalfa pest
 worldwide. In a study conducted in
 different regions of Egypt, Shebl et al.
 (2008) found that *Empoasca decipiens*
 Paoli was the only major species with
 economic importance among cicadas in
M. sativa.

In Albania, Kullaj et al (2005) studied the
 alfalfa entomofauna and reported 4 cicada
 species (*Cercopis sanguinolenta* Scopoli,
Ceresa bubalus Fabricius, *Cicadella*

Ceresa bubalus Fabricius, *Cicadella viridis* Linnaeus, *Empoasca* spp., *Philaenus spumarius* Linnaeus),

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-
Empoasca.
E. pteridis

,
Lepyronia coleoptrata
Linné *Euscelis plebeia* Fallén,
- *Sonronius binotata*
Sahlberg *Philaenus spumarius* (Girsova et al., 2015).

, *E. pteridis*
(Bogoutdinov et al., 2008; Bogoutdinov, 2012; Bakunov and Dmitrieva, 2015; Br án, 2012).

Cicadella viridis (Cicadellidae)

(Duduk et al., 2008; Ando et al., 2010; Janse and Obradovic, 2010; Trivellone et al., 2012).

. *viridis*,

Macrosteles laevis Ribaut,
Cicadellidae,

(Remane, 2005).

Macrosteles,

(Nickel, 2003).

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(Tóthová et al., 2004, Olivier et al., 2009, Girsova et al., 2015).

Euscelis plebejus Fallén

viridis Linnaeus, *Empoasca* spp., *Philaenus spumarius* Linnaeus). They found that the most numerous were *Empoasca* genus. In the Moscow region, *E. pteridis* predominated in the second half of the alfalfa growing season, together with *Lepyronia coleoptrata* Linné and *Euscelis plebeia* Fallén, and in the first half of the season- *Sonronius binotata* Sahlberg and *Philaenus spumarius* (Girsova et al., 2015).

A number of authors reported that *E. pteridis* is a carrier of Stolbur phytoplasma in alfalfa (Bogutdinov et al., 2008; Bogutdinov, 2012; Bakunov and Dmitrieva, 2015; Br án, 2012).

Cicadella viridis (Cicadellidae) is one of important insect pests and carrier of pathogens in economically important crops (corn, vineyards, carrots, some fruit, alfalfa) (Duduk et al., 2008; Ando et al., 2010; Janse and Obradovic, 2010; Trivellone et al., 2012).

The species is polyvoltine whose development goes through five larval stages. There is a growing interest in the study of the microbial community associated with *C. viridis* as with other insect vectors to identify micro-organisms that can be used as alternative control strategies.

Macrosteles laevis Ribaut, a representative of the Cicadellidae, occurred in high numbers in modern agroecosystems in Europe and was one of the main species in the new pastures (Remane, 2005). The cicada, like other *Macrosteles* species, preferred and inhabited disturbed habitats as well as fertilized pastures (Nickel, 2003). *Macrosteles laevis* is a polyphagous and carrier of stolbur and develops three generations per year (Tóthová et al., 2004, Olivier et al., 2009, Girsova et al., 2015).

Euscelis plebejus Fallén is another common species in alfalfa, and the

(Girsova et al., 2015).
Psammotettix striatus Linnaeus
 ,
 (Kastalyeva
 et al., 2016).
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 22 , 10 -
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Medicago sativa
P. striatus,
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Paraphlepsius apertinus Osborn &
 Lathrop (Nielson, 1968) *Paraphlepsius*
(Sabix) irroratus Say (Chiykowski, 1985),
 .
Austroagallia sinuata Mulsant &
 Rey ,
 ,
 (Nickel,
 2003; Mazzoni, 2005).
 Aphrophoridae,
Philaenus spumarius Linnaeus
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 (Yurtsever,
 2000).
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 ,
 (Ossiannilsson, 1978).

biology of the species is well known (Girsova et al., 2015).

Psammotettix striatus Linnaeus is a major pest of wheat and other cereal crops such as barley, oats, and alfalfa at the same time (Castaleva et al., 2016). As a result of a nine-year study, the authors reported that 22 plant species from 10 families were hosts of the species among them *Medicago sativa* is one of the main hosts. *Psammotettix striatus* is a carrier of stolbur on the plants too.

Paraphlepsius apertinus Osborn & Lathrop (Nielson, 1968) and *Paraphlepsius (Sabix) irroratus* Say (Chiykowski, 1985) also were reported as important harmful species among alfalfa cicadas in studies of the last century (Chiykowski, 1985). The latter cicada was a common species in clover and various grass and weed species.

Austroagallia sinuata Mulsant & Rey is a species found in various hosts, including alfalfa in Germany, Italy, Turkey (Nickel, 2003; Mazzoni, 2005).

Philaenus spumarius Linnaeus (Aphrophoridae) is one of the most frequently occurring species in legumes. As a result of interesting aspects of its biological development, for decades the species had received much attention from biologists.

The species was one of the most widely studied species in the ecology and genetics area (Yurtsever, 2000). Cicada had a cosmopolitan distribution, a wide variety of habitats and strong sexual dimorphism (depending on different geographical areas). *Philaenus spumarius* sucked the plant juice from the xylem, and the nymphs, through salivary separation, formed a foamy mixture on the leaves. The foamy mixture surrounded their delicate and soft body and provided some protection from drying and predator attack (Ossiannilsson, 1978). The species was characterized by hundreds of hosts

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| | <i>P. spumarius</i> | - | ranging from grasses to tree species in Europe, including meadow plants, herbs, and shrubs due to its great flexibility and adaptability (Yurtsever, 1999). |
| (Yurtsever, 1999). | | - | The nitrogen-fixing herbaceous legumes and some others that contain high concentrations of amino acids were the most preferred by cicadas (<i>Medicago sativa</i> , <i>Trifolium</i> spp., <i>Vicia</i> spp., <i>Xanthium strumarium</i>) (Byers et al., 2001). |
| | | - | <i>Philaenus spumarius</i> was a multivoltine species, and in some parts of Greece, the British Isles and some areas in Turkey, the species exhibited as a bivoltine (Yurtsever, 1999). |
| (<i>Medicago sativa</i> , <i>Trifolium</i> spp., <i>Vicia</i> spp., <i>Xanthium strumarium</i>) (Byers et al., 2001). | | - | <i>Hyalesthes obsoletus</i> Signoret (Cixiidae) is a widespread polyphagous that prefer herbaceous hosts, including alfalfa (Milanesi et al., 2005; Riolo et al., 2012). The species wintered in a larval stage and only perennial plant species served as hosts although adult individuals can be found on a wide range of additional crops as food sources. |
| | | - | The species was a carrier of stolbur and once infected, remained a carrier of phytoplasma infections for the rest of its life (B ežíková and Linhartová, 2007; Weintraub, 2010). |
| | | - | <i>Reptalus panzeri</i> Low (Cixiidae) was also polyphagous, which appeared at the same time with <i>H. obsoletus</i> but was not as widespread (Weintraub, 2010). In Serbia, Jovi et al. (2009) found that <i>R. panzeri</i> may be a vector of phytoplasma infections causing stolbur. |
| | | - | Membracidae Rafinesque (Hemiptera: Cicadomorpha) is a large family and includes some 3500 known species in the world (Dietrich, 2008; Deitz et al., 2011). The species from that family are interesting not only for their strange shapes but also for their unusual behavior. Many of them form large and |
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al., 2011).

Meneguzzi (2009) reported that *Ceresa nigripectus* Remes Lenicov (Membracidae)

Ceresa bubalus Fabricius

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(wierczewski and Stroi ski, 2011).

Fulgoromorpha Cicadomorpha

(Holzinger et al., 2003; Nickel, 2003).

(Mazzoni, 2005).

Yosifov (1962)

20 : *Empoasca pteridis*, *Laodelphax striatellus* (*Psammotettix striatus*), *Macrosteles laevis* Ribaut, *Aphrodes costatus* Panzer, *Lepironia coleoptrat* Linnaeus, *Limotettix* (*Scleroracus*) *corniculus* Marshall, *Hardya*

often noticeable clusters of larvae or adults. In addition, some species exhibit mutualism together with social ants, which associations may be beneficial to plants (Deitz et al., 2011). In general, the species are not considered to be serious agricultural or forestry insect pests, although some of them mechanically damage the plant stems during the oviposition.

Meneguzzi (2009) reported that *Ceresa nigripectus* Remes Lenicov (Membracidae) was one of the most common alfalfa cicadas in Argentina and the species is also a carrier of phytoplasma infections.

Ceresa bubalus Fabricius was another common member of that family, preferring to lay their eggs on 1-3-year-old branches of deciduous trees and shrubs. Crops such as alfalfa and red clover served as the best source of food for the larvae (wierczewski and Stroi ski, 2011).

The awareness for species from the Fulgoromorpha and Cicadomorpha suborder in alfalfa through a faunal ecological study in Central Europe has been considerably improved in recent decades thanks to advances in knowledge of both their taxonomy and biology (Holzinger et al., 2003; Nickel, 2003). The knowledge provided additional information about the relationship between species and their typical habitat (Mazzoni, 2005).

STUDIES IN BULGARIA

In Bulgaria, the first information on the species composition of cicadas in alfalfa was reported by Yosifov (1962). He found 20 species: *Empoasca pteridis*, *Laodelphax striatellus* (*Psammotettix striatus*), *Macrosteles laevis* Ribaut, *Aphrodes costatus* Panzer, *Lepironia coleoptrat* Linnaeus, *Limotettix* (*Scleroracus*) *corniculus* Marshall, *Hardya*

(Hardya) *tenuis* Germar, *Caligypona minuscula* Horvath, *Selenocephalus obsoletus* Germar, *Hysteropterum grylloides* F., *Psammotettix confinis* Dahlb., *Tettigometra reticulates* Pnz., *Euscelis plebeia* Fallén, *siraca clavicornis* Fabricius, *Dryodukgades reticulates* Sign, *Balclutha punctata* Fabricius, *Balclutha saltuella* Kirschbaum, *Hyalesthes obsoletus* Signoret, *Cicadella viridis* Linnaeus, *Dikraneura mollicula* Boh.

Empoasca pteridis *Psammotettix striatus*.

- , Bajryamova (1976, 1982)

Empoasca pteridis, *Macrosteles laevis*, *Euscelis plebeia* Fallén, *Aphrodes bicinctus* Schrank, *Cicadella viridis* Linnaeus, *Philaenus spumarius* Linnaeus, *Psammotettix alienus* Dahlbom, *P. provincialis* Ribaut. Popova (1968)

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: *Cicadella viridis* Linnaeus, *Lepironia coleoptrat* Linnaeus, *Aphrodes bicinctus* Schrank, *Reptalus quinguecostatus* Dufour, *Ceresa bubalus* Fabricius, *Asiraca flavicornis* F., *Philaenus spumarius* Linnaeus, *Cixium desertorum* Fibr., *Macrosteles laevis* Ribaut, *Scleroracus decumanus* Kontk., *Empoasca pteridis*, *Deltocephalus* sp., *Anacerataquallia* sp., *Artianus* sp., *Philaenus spumarius* Linnaeus, *Cercopis sanguinolenta* Scopoli, *Macrosteles* sp., *Macrosteles quadripunctata* Kbn., *Aphrodes fuscifascitus* Gn., *Selenocephalus obsoletus* Germar.

E.

pteridis

Atanasova (2011),

Cicadella viridis, *Empoasca pteridis*, *Philaenus spumarius* *Cercopis vulnerata* Rossi (Cercopidae).

M. sativa

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(Hardya) *tenuis* Germar, *Caligypona minuscula* Horvath, *Selenocephalus obsoletus* Germar, *Hysteropterum grylloides* F., *Psammotettix confinis* Dahlb., *Tettigometra reticulates* Pnz., *Euscelis plebeia* Fallén, *siraca clavicornis* Fabricius, *Dryodukgades reticulates* Sign, *Balclutha punctata* Fabricius, *Balclutha saltuella* Kirschbaum, *Hyalesthes obsoletus* Signoret, *Cicadella viridis* Linnaeus, *Dikraneura mollicula* Boh.

Among them, *Empoasca pteridis* and *Psammotettix striatus* were in the highest numbers.

Later, Bayryamova (1976, 1982) reported as characteristic cicada pests in alfalfa *Empoasca pteridis*, *Macrosteles laevis*, *Euscelis plebeia* Fallén, *Aphrodes bicinctus* Schrank, *Cicadella viridis* Linnaeus, *Philaenus spumarius* Linnaeus, *Psammotettix alienus* Dahlbom, *P. provincialis* Ribaut. Popova (1968) identified 18 species of cicadas in alfalfa: *Cicadella viridis* Linnaeus, *Lepironia coleoptrat* Linnaeus, *Aphrodes bicinctus* Schrank, *Reptalus quinguecostatus* Dufour, *Ceresa bubalus* Fabricius, *Asiraca flavicornis* F., *Philaenus spumarius* Linnaeus, *Cixium desertorum* Fibr., *Macrosteles laevis* Ribaut, *Scleroracus decumanus* Kontk., *Empoasca pteridis*, *Deltocephalus* sp., *Anacerataquallia* sp., *Artianus* sp., *Philaenus spumarius* Linnaeus, *Cercopis sanguinolenta* Scopoli, *Macrosteles* sp., *Macrosteles quadripunctata* Kbn., *Aphrodes fuscifascitus* Gn., *Selenocephalus obsoletus* Germar.

The author reported *E. pteridis* as dominant species and presented the population dynamics of cicadas in alfalfa. Atanasova (2011), studying the harmful entomofauna of Multifoliate and trifoliate alfalfa varieties, reported following cicadas: *Cicadella viridis*, *Empoasca pteridis*, *Philaenus spumarius* and *Cercopis vulnerata* Rossi (Cercopidae)

In Bulgaria, information on that group of cicadas in *M. sativa* is scarce. Most cicadas studies focused on cereals

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| (Karadjova and Krusteva, 2017; Karadjova and Krusteva, 2016). | - | (Karadjova and Krasteva, 2016; Karadjova and Krusteva, 2017). Attention to the problem of cicadas was also given to some other crops, such as vegetable and annual legumes (Bogatsevskaja et al., 2008; Zhekova, 2012). |
| (Bogatsevskaja et al., 2008; Zhekova, 2012). | - | The need for a more in-depth study of alfalfa cicadas is the result of insufficient information on these species. |
| | - | Until now, studies have been conducted on the r Fulgoromorpha and Cicadomorpha (Hemiptera) suborder species in different geographical regions of the country. |
| Fulgoromorpha (Hemiptera) | Cicadomorpha | Determination of the species composition and population density of alfalfa cicadas will help to find rational solutions for controlling their numbers and setting the term for plant protection. |

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