

Honeydew producing insects in some forests of Turkey and their potential to produce of honeydew honey*

SELMA ÜLGENTÜRK^{1*}, BENJAMIN COSIĆ¹, IŞIL ÖZDEMİR², AHMET İPEK³ AND KADRİYE SORKUN⁴

¹ Department of Plant Protection, Faculty of Agriculture, Ankara University, 06110 Ankara, Turkey

² Ministry of Agriculture and Forestry, Directorate of Plant Protection Central Research Institute, 06172 Ankara, Turkey

³ Ministry of Agriculture and Forestry, General Directorate of Management Desertification and Erosion, 06172 Ankara, Turkey

⁴ Hacettepe University, Faculty of Biology, 06800 Beytepe, Ankara, Turkey

* Corresponding author: ulgentur@agri.ankara.edu.tr

Ülgentürk, S., Cosic, B., Özdemir, I., İpek, A. and Sorkun, K. 2020. Honeydew producing insects in some forests of Turkey and their potential to produce of honeydew honey. *Baltic Forestry* 26(1): article id 397. <https://doi.org/10.46490/BF397>.

Received 11 July 2019 Revised 29 April 2020 Accepted 29 April 2020

Abstract

The commercial interest in honeydew honey is increasing because of its higher therapeutic properties than most flower-based honeys. *Marchalina hellenica* Gennadius (Hemiptera: Marchalinidae) is one of the important scale insects to produce of honeydew honey and its honeydew in large quantities is collected by honeybees and used in pine honey in Turkey. The aim of this study was to survey and identify honeydew producing insects' habitats that source of honeydew honey in pure fir forest in Bolu, spruce forests in Giresun (Black Sea region), oaks forest in Kırklareli (Thracian region) and cedar forest in Antalya (Mediterranean region). In accordance with these results, we found 20 honeydew producers and among of them are *Cinara cedri* Mimeur on *Cedrus libani*, *Marchalina caucasica* Hadzibejli on *Abies nordmanniana* subsp *nordmanniana*, and *Picea orientalis*; *Nemolecanium abietis* Borchsenius, *Physokermes hellenicus* Kozar & Gounari and *Schizolachnus pineti* on *Abies bornmuelleriana*; *Lachnus roboris* Linnaeus and *Parthenolecanium rufulum* (Cockerell) on *Quercus* spp. and *Castanea sativa*; *Metcalfa pruinosa* Say (Hemiptera: Flatidae) and *Ricania simulans* (Walker) (Hemiptera: Ricaniidae) on different host plants. All these insects produce large amount of honeydew depending on their population size. The article discusses the potential for these insects to produce honeydew honey.

Keywords: *Picea orientalis*, *Abies nordmanniana*, *Ricania simulans*, *Eulecanium sericeum*, *Metcalfa pruinosa*, *Marchalina caucasica*

Introduction

Honeydew is a sugar excretion from the alimentary organ and is released out the anus by phloem feeders such as aphids, psyllids, most scale insects and whiteflies. In general, honeydew is composed of water, sugars, amino acids, alcohols, auxin and salts (Bogdanov 2009). Chemical composition of honeydew is varied in accordance with species and age of sap feeding insects, population density of insects, plant species on which they feed, the existence of secondary metabolites in plants, visiting frequency of ants, the existence of symbionts and parasitism (Durovic and Ülgentürk 2014).

Honeybee, *Apis mellifera* Linnaeus (Hymenoptera: Apidae) produces flower honey by collecting flower nectar

in nature, or produces honeydew honey by collecting insect honeydew and the honeydew which is secreted from leaves, fruits, and branches of a plant. Honeydew honey has a darker colour and contains more physicochemical characters (EC acidity, pH and ash, higher oligosaccharides content and lower content of monosaccharides) than flower honey (Bogdanov 2009). The existence of melezitose and raffinose that are absent in flower honeys is considered as an indicator of insect honeydew (Von der Ohe and Von der Ohe 1996). There is a number of researches suggesting honeydew honey has therapeutic properties and a positive impact on human health (Pita-Calvo and Vázquez 2018). As a result, there is currently an increased interest in honeydew honey.

* The article was presented in the 3rd international symposium on Euroasian biodiversity, 5–8 July 2017 Minsk Belarus and appears in the abstract book of that meeting.

Pine honey obtained from *Marchalina hellenica* Gennadius (Hemiptera: Marchalinidae) consists of about 60% of total the honey produced in Turkey and Greece (Bacandritsos et al. 2004). Turkey is the largest producer of pine honey, with approximately 15,000 tons of production each year (Sunay 2009). It comes mainly from Muğla province, and other locations including Antalya, Aydın, Balıkesir and İzmir in Turkey (Ülgentürk et al. 2012b). *Lecanodiaspis sardoa* Targioni- Tozzetti (Hemiptera: Lecanodiaspididae), *Puto israiliensis* Ben-Dov (Hemiptera: Putoidae) and *Cinara cedri* Mimeur (Hemiptera: Aphididae) were recorded as alternative honeydew producer depending on their population size on forest areas of western Turkey (Ülgentürk et al. 2013b).

There are some dark coloured and various-flavoured honeys that are produced in different regions of Turkey such as oak and chestnut honeys. According to the Bee keeper union, bees collect honey from cedar, fir, oak and spruce and production fluctuates depending on the year and the region, and these honeys are dark-coloured and various-flavoured (personal interview, Workshop of Forestry and Apiculture, 1–3 December 2015, Bolu, Turkey). In this study, we aimed the honeydew producer insects, which might be the source of these different types of honey and as a result of this, we intend to identify places of botanical and geographical importance in Turkey.

Material and methods

Requested by beekeepers to establish honey sources, pure or almost-pure fir, *Abies bormuelleriana* Mattif. (in Bolu), *Abies nordmanniana* (Steven) subsp. *nordmanniana* and spruce *Picea orientalis* (L.) (in Giresun), cedar *Cedrus libani* A. Richard (Pinaceae) (in Antalya), oak *Quercus* L. (Fagaceae) (in Kırklareli) forests have been chosen (Figure 1). In addition to these pure stands, we investigated some neighbouring areas featuring single or assorted types of *Acer campestre* L., *Acer platanoides* L.

(Sapindaceae), *Castaneum sativa* Mill. (Fagaceae), *Corylus avellana* L. (Betulaceae), *Fraxinus* L. (Oleaceae), *Tilia tomentosa* Moench, *Tilia* spp. (Malvaceae) and other forest trees. Surveying in these regions was conducted from spring to autumn months between 2016 and 2018, during season of honey production in accordance with feedback obtained from the local beekeeper unions. A portion of the insects feeding on the mentioned plants was put into ethanol (70%), and labelled and brought to Ankara University Faculty of Agriculture, Plant Protection Department Coccidology laboratory for identification. Scale insect's slides were mounted using Kosztarab and Kozár (1988) and identifications were made according to keys from Kosztarab and Kozár (1988), Danzig (2003), Hodgson and Gounari (2006) and Kozár et al. (2012). Hille Ris Lambers (1950) method was used for the preparation of aphids and identified using Blackman and Eastop (2018). Other species were sent to their experts to be identified. Mounted materials are deposited in Ankara University, Agricultural Faculty, Plant Protection Department, and The Department of Plant Protection, and Ministry of Food, Agriculture and Livestock, Directorate of Plant Protection Central Research Institute, Ankara, Turkey.

Results

As a result of this study we identified twenty insect species that excrete honeydew; 7 aphid species, 11 scale insect species (2 Pseudococcidae, 6 Coccidae and 1 Kermesidae, 1 Eriococcidae, 1 Marchalinidae, 1 Flatidae, and 1 Ricaniidae in pure cedar, fir, oak, spruce forests, and neighbor areas.

Aphids (Hemiptera: Aphidomorpha)

Aphididae

Cinara cedri Mimeur

The cedar aphid is found in small populations on cedar trees with very little amount of honeydew between the years 2016 and 2017, but in autumn 2018, a large popula-

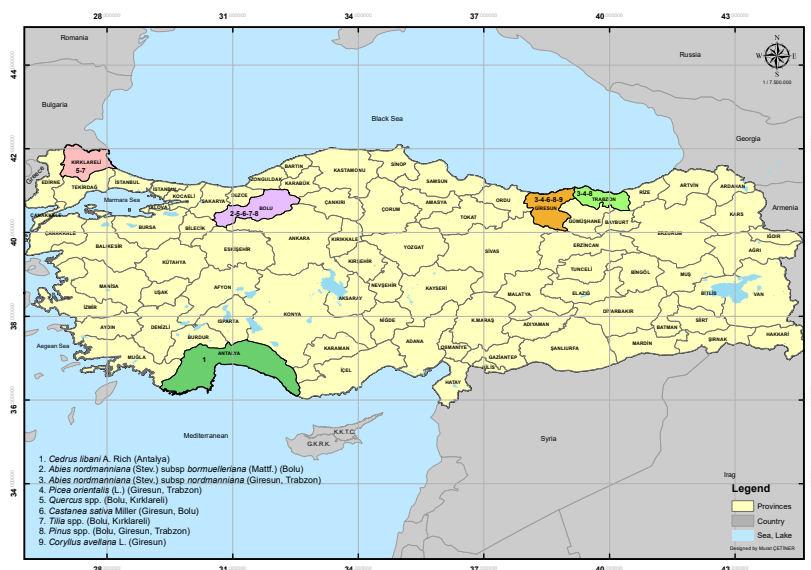


Figure 1. Map of studying pure or almost-pure forest areas and plant species in Turkey

tion of cedar aphid is occurred on cedar trees and excreted very huge honeydew (Figure 2a,b). In this study *C. cedri* is found in Antalya/Elmalı-Çamkuyusu 36°59'55"N 30°02'59"E, *Cedrus libani*, 1610 m, 23.vi./2016; Antalya/Elmalı-Alaşar 36°56'22"N 30°00'24"E, *C. cedri*, 1722 m, 27.vii.2017; Antalya/Elmalı-Alaşar, 36°56'22"N 30°00'24"E, *C. cedri*, 1722 m, 16.vii.2018; Antalya/Elmalı-Çamkuyu, 36°59'55"N 30°02'95"E, *C. cedri*, 1610 m, 16.vii.2018; Antalya/Elmalı-Ziğircik, 36°35'34"N 30°02'14"E, *C. cedri*, 1801 m, 17.vii.2018; Antalya/Elmalı-Gökpınar, 36°45'11"N 29°57'42"E, *C. cedri*, 1185 m, 17.vii.2018; Antalya/Elmalı-Hüseyin Kuyusu, 36°35'48"N 30°02'25"E, *C. cedri*, 1679 m, 17.vii.2018; Antalya/Kaş, 36°26'17"N 029°43'11"E, 1657 m, *C. cedri*, 6.x.2018; Antalya/Elmalı, 36°56'22"N 30°00'24"E, 1700 m *C. cedri*, 6.x.2018.

Eulachnus rileyi (Williams)

E. rileyi is detected only in Bolu/Kızıklı, 40°31'02.5"N 31°34'00.5"E, *Pinus sylvestris* L. (Pinaceae), 1652 m, 12.vi.2017.

Eucallipterus tiliae (Linnaeus)

The linden aphid is recorded in Kırklareli/Çağlayık, 41°52'18"N 26°59'27"E, *T. tomentosa*, *Tilia* sp., 334 m, 27.vi.2018.

Lachnus roboris Linnaeus

Variegated oak aphid is a relatively large aphid species and feeds on branches. In this study *L. roboris* is found in Bolu/Kuzgölcük, 40°33'11"N 31°33'56"E, *Quercus* sp., 1236 m, 17.vi.2016; Kırklareli/ Longoz forest, 41°49'19"N 27°57'58"E, *Q. frainetto*, 2 m, 24.vi.2016; Kırklareli/Çağlayık, 41°52'18"N 26°59'27"E, *Quercus petraea* (Matt) (Fagaceae), 334 m, 21.v.2017; Kırklareli/Çağlayık, 41°53'18"N 26°59'27"E, *Q. robur* subsp. *robur*, *Q. frainetto*, 333 m, 27.vi.2018; Giresun/Keşap, 40°53'00"N 38°34'36.28"E, *C. sativa*, 502 m, 25.vi.2018; Kırklareli/Demirköy-Sislioba, 41°96'70"N 27°91'50"E, *Q. robur*, 43 m, 27.vi.2018.

Myzocallis (Agriopis) castanicola Baker

In this study *M. castanicola* is recorded in Bolu/Aladağ, 40°38'43"N 31°37'36"E, *C. sativa*, 964 m, 16.5.2016; Giresun/Keşap, 40°53'10"N 38°32'28"E, *C. sativa*, 430 m, 15.vi.2016, 26.vi.2018.

Schizolachnus pineti (Fabricius)

S. pineti is determined on young shoot of fir with honeydew drops (Figure 2c). It is found in Bolu/Aladağ, 40°38'43"N 31°37'36"E, *Abies bornmuelleriana*, 1360 m, 16.vi.2016; Bolu/Gölcük National Park, 40°36'59"N 31°35'13"E, *A. bornmuelleriana*, 1230 m, 16.vi.2016; Bolu/Kuzgöl-



Figure 2. *Cinara cedri* (a) and its honeydew's drop (b), *Schizolachnus pineti* (Fabricius) (c), *Eulecanium sericeum* (d), *Nemolecanium abietis* (e), *Physokermes hellenica* (f), *Acanthococcus roboris* (g), *Kermes* sp. nr *vermillio* (h), *Marchalina caucasica* (i) and nymphs of *Metcalfa pruniosa* and its honeydew on the leaves (k)

cük, 40°31'54"N 31°33'04"E, *A. bornmülleriana*, 1235 m, 17.vi.2016, 12.vi.2017.

***Thelaxes suberi* (del Guercio)**

T. suberi is sampled only in Giresun/Keşap, 40°53'00"N 38°34'36"E, *C. sativa*, 502 m, 26.vi.2018.

Scale insects (Hemiptera: Coccoomorpha)

Coccidae

***Eulecanium tiliae* Linneaus**

Young female of *E. tiliae* is produced large amount of honeydew. It is sampled in Bolu/Kuzgölcük, 40°31'54"N 31°33'04"E, *Malus communis*, 1230 m, 13.vi.2016, 12.vi.2017.

***Eulecanium sericeum* (Lindinger)**

Only five females are collected from the twigs of fir (Figure 2d). It is determined in Bolu/Kızıklı, 40°31'02"N 31°34'00"E, *A. bornmuelleriana*, 1650 m, 12.vi.2017; Bolu/Akkayabaşı, 40°54'88"N 31°55'25"E, *A. bornmuelleriana*, 1650 m, 12.vi.2017. Also, this species was collected Kahramanmaraş, (Başkonuş Yayla, 37°34'03"N 36°34'59"E, *Abies cilicica* (Antoine & Kotschy) Carrière, 1325 m, 28.6.2011, 3♀♀ by Ülgentürk S. (unpublished data). *E. sericeum* is recorded first time in Turkey.

***Nemolecanium abietis* Borchsenius**

N. abietis has moderate to large level population on fir trees. It excretes large drop of honeydew (Figure 2e). This species is sampled in Bolu/Gölcük National Park, 40°64'53"N 31°62'67"E, *Abies bornmuelleriana*, 1231 m, 16.v.2016; Bolu/Aladağ, 40°36'00"N 31°40'33"E, *A. bornmuelleriana*, 1360 m, 12.6/2017; Bolu/Gölcük-National Park, 40°64'53"N 31°62'67"E, *A. bornmuelleriana*, 1230 m, 12.vi.2017; Bolu/Kızıklı, 40°31'02"N 31°34'00"E, *A. bornmuelleriana*, *A. nordmanniana* subsp. *bornmuelleriana*, 1345 m, 12.vi.2017.

***Parthenolecanium corni* (Bouché)**

European fruit lecanium has moderate level population on fruit and nut trees. It is determined in Bolu/Kuzgölcük, 40°33'11"N 31°33'56"E, *Malus communis* L., *Prunus domestica* L. (Rosaceae), *Juglans regia* L. (Juglandaceae), 1236 m, 24.vi.2016; Giresun/Keşap, 40°53'10"N 38°32'28"E, *C. avellana*, 275 m, 13.vi.2017.

***Parthenolecanium rufulum* (Cockerell)**

Young females of *P. rufulum* are excreted large amount of honeydew. The oaks soft scale is recorded in Bolu/Kuzgölcük-Namazgah, 40°33'11"N 31°33'56"E, *Quercus* sp., 1618 m, 13.vi.2016; Bolu/Akkayabaşı, 40°54'88"N 31°55'25"E, *Quercus* sp., 1650 m, 11.vi.2017; Bolu/Gölköy, 42°45'6"N 31°30'58"E, *Quercus* sp., 826 m, 11.vi.2017; Bolu/Kuzgölcük, 40°33'11"N 31°33'56"E, *Quercus* sp., 1592 m, 11.vi.2017; Giresun, 40°50'45"N 38°18'36"E, *Castaneum sativa*, 300 m, 24.v.2016; Giresun/Bulancak, 40°89'41"N 38°55'37"E, *C. sativa*, 405 m, 10.vii.2017; Kırklareli/Sislioba, 41°96'70"N 27°91'50"E, *Q. frainetto*, *C. sativa*, *C. avellana*, 43 m, 24.vi.2016; Giresun/Keşap, 40°53'10"N 38°32'28"E, *C. sativa*, 499 m, 26.vi.2018.

***Physokermes hellenicus* (Kozar & Gounari)**

It is detected that population levels of *P. hellenicus* are

moderate to high levels (Figure 2f). *P. hellenicus* is sampled in Bolu (Centrum), 40°38'43"N 31°37'36"E, *A. bornmuelleriana*, 743 m, 16.vi.2016; Bolu/Gölcük Nature Park, 40°64'53"N 31°62'67"E, *A. bornmuelleriana*, 1234 m, 25.vi.2016; Bolu/Karacasu, 40°64'53"N 31°62'67"E *A. bornmuelleriana*, 801 m, 12.vi.2017; Bolu/Aladağ 40°40'56"N 31°37'52"E, *A. bornmuelleriana*, 1358 m, 12.vi.2017; Bolu/Aladağ-Zincirlikuyu, 40°31'02"N 31°34'00"E, *A. bornmuelleriana*, 1434 m, 11.vi.2017; Bolu/Gölköy, 42°45'60"N 31°30'58"E, *A. bornmuelleriana*, 824 m, 11.vi.2017.

Eriococcidae

***Acanthococcus roboris* Goux**

A. roboris is found only 3 females (Figure 2g) in Bolu/Kuzgölcük-Namazgâh, 40°33'11"N 31°33'56"E, *Quercus* sp., 1617 m, 12.vi.2017.

Kermesidae

***Kermes* sp. nr *vermillio* Planchon**

Young females of *Kermes* sp. nr *vermillio* are exuded relatively large honeydew drops (Figure 2h). Moderate level population of *Kermes* sp. is detected only in Bolu/Kuzgölcük-Namazgâh, 40°33'11"N 31°33'56"E, *Quercus* sp., 1620 m, 12.vi.2017.

Marchalinidae

***Marchalina caucasica* Hadzibejli**

M. caucasica is recorded first time in Turkey (Figure 2i). It is quite common in eastern forest of Black Sea region. It is collected in Giresun/Bicik, 40°41'10"N 38°13'12"E, *Abies nordmanniana* subsp. *nordmanniana*, *Piceae orientalis*, 1760 m, 12.vi.2016; Giresun/Bicik-Çamalan, 40°39'04"N 38°18'23"E *A. nordmanniana* subsp. *nordmanniana*; *P. orientalis*, 1826 m, 12.vi.2016; Giresun/Akçabel-Kullakkaya, 40°41'46"N 38°19'54"E, *P. orientalis*, 1757 m, 10.vii.2017; Trabzon/Vakfikebir-Karadağ, 40°57'27"N 39°25'74"E, *P. orientalis*, 1464 m, 27.vii.2017; Trabzon/Maçka-Bekçiler, 40°42'24"N 39°27'79"E, *P. orientalis*, 1325 m, Trabzon/Akçaabat-Hıdırnebi Yaylası, 40°57'27"N 39°25'12"E, *P. orientalis*, 1464 m, 26.vii.2017; Giresun/Bicek-Çamalan, 40°39'04"N 38°18'23"E, *A. nordmanniana* subsp. *nordmanniana*, *P. orientalis*, 1826 m, 26.vi.2018; Trabzon/Maçka, 40°42'24"N 39°27'79"E, *P. orientalis*, 1325 m, 7.vii.2018; Trabzon/Hamsiköy, 40°40'46"N 39°25'402"E, *P. orientalis*, 1628 m, 7.viii.2018; Trabzon/Akçaabat-Hıdırnebi Yaylası, 40°57'27"N 39°25'742"E, *P. orientalis*, 1464 m, 7.viii.2018; Giresun/Bicik, 40°41'18"N 38°14'58"E, *A. nordmanniana* subsp. *nordmanniana*, *P. orientalis*, 1798 m, 19.x.2018.

Pseudococcidae

***Phenacoccus arambourgi* Balachowsky**

P. arambourgi is common on cedar trees but its population was low during these periods. It is found in Antalya/Elmalı, Sütleglen, 36°24'59"N 29°38'12"E, *C. libani*, 1280 m, 23.vi.2016; Antalya/Elmalı-Çamkuyusu, 36°59'55"N 30°02'95"E, *C. libani*, 1610 m, 23.vi.2016;

Antalya/Elmalı-Alaşar, 36°56'22"N 30°00'24"E, *C. cedri*, 1722 m, 27.vii.2017; Antalya/Elmalı-Beylerköyü, 36°39'20"N 29°52'11"E, *C. cedri*, 1037 m, 28.vii.2017; Antalya/Elmalı-Kabaseki, 36°28'07"N 29°38'31"E, *C. cedri*, 1228 m, 17.vii.2018; Antalya/Elmalı- Hüseyin kuyusu, 36°35'48"N 30°02'25"E, *C. cedri*, 1679 m, 17.vii.2018.

***Phenacoccus querculus* Borshsenius**

It is sampled only in Bolu/Kuzgölcük-Namazgah, 40°33'11"N 31°33'56"E, *Quercus* sp., 1617 m, 12.vi.2017.

Planthoppers (Hemiptera: Fulgoromorpha)

Flatidae

***Metcalfa pruniosa* (Say)**

It is very common and has high population levels especially in Kıyıköy, Sislioba (Figure 2j,k) where it produces oak honey in Kırklareli. *M. pruniosa* is detected very easily due to waxy excretion and black coat (fumagine) covered the plant. We observed honeybees during collecting of very rich honeydew of *M. pruniosa* on plants leaves in Sislioba in 2017 and 2018. *M. pruniosa* is collected in Kırklareli/Longoz Forest, 41°49'19"N 27°57'58"E, *A. campestre*, *Crateagus monogyna* Jacq., *Rubus fruticosus* L. (Rosaceae), *Urtica dioica* (Urticaceae), 40 m, 24.vi.2016; Kırklareli/Demirköy-Sislioba, 41°96'70"N 27°91'50"E, *A. campestre*, *A. platanoides*, *Alnus* spp., *Carpinus betulus* L. (Betulaceae), *Fagus orientalis* L., *Quercus robur* subsp. *robur* (Fagaceae), *Q. frainetto*, *R. fruticosus*, *Prunus spinosa* L. (Rosaceae), *Palius spinachristi* Miller (Rhamnaceae), *Fraxinus excelsior* L. (Olaceae), 43 m, 13.vii.2017; Düzce/Akçakoca, 41°05'14"N 31°06'23"E, *Ficus carica* L., *Morus alba* L. (Moraceae), *Fraxinus* sp., *Hedera helix* L. (Araliaceae), *Prunus laurocerasus* L. (Rosaceae), 23 m, 18.vii.2016; Kırklareli/Demirköy-Sislioba, 41°96'7"N 27°91'5"E, *Fraxinus* sp., *A. campestre*, *Cornus mas* L. (Cornaceae), *C. avellana*, *C. monogyna*, *Q. robur* subsp. *robur*, *P. spina-christi*, *P. spinosa*, *Rubus* sp., *Pyrus communis* L., *Sorbus aucuparia* L. (Rosaceae), *Ulmus* spp. (Ulmaceae), *Tilia* spp., *Mentha* spp. (Laminaceae), *Salix* spp. (Salicaceae), 43 m, 17.vi.2018; İstanbul/Şile, 41°08'45"N 29°41'21"E, *Cydonia oblonga* Mill. (Rosaceae), *Vitis vinifera* L. (Vitaceae), *Smilax excelsa* L. (Smilacaceae), 62 m, 10.vii.2018; Giresun/ Centrum, 40°54'27"N 38°21'47"E, *H. helix*, *Liriodendron tulipifera* L. (Magnoliaceae), *M. alba*, *Prunus domestica* L. (Rosaceae), *P. laurocerasus*, 1 m, 25.vi.2018.

Ricaniidae

***Ricania simulans* (Walker)**

R. simulans is found in Giresun/ Centrum, 40°55'17"N 38°23'23"E, *Acer pseudoplatanus* L. (Aceraceae), *Ailanthus altissima* (Mill.) (Simaroubaceae), *Citrus* spp., *C. avellana*, *Fraxinus* sp., *F. carica* L., *Robinia pseudoacacia* L. (Fabaceae), *R. fruticosus*, *S. excelsa*, *Urtica* sp. 53 m, 25.v.2017; Giresun/ Centrum, 40°54'27"N 38°21'47"E, *L. tulipifera*, *M. alba*, *Pittosporum tobira* (Thumb) (Pitosporaceae), *P. domestica*, *P. laurocerasus*, 1 m, 25.vi.2018.

Discussion and conclusions

Twenty insect species that excrete honeydew; 7 aphid species, 11 scale insect species are found in pure cedar, fir, oak, spruce forests, and neighbor areas. In accordance with these results, oak trees host 7 species excreting honeydew and boast the richest fauna. *P. rufulum* populations are available in medium to high density in Bolu oak forests while in Kırklareli oak forests, population density is low to medium. We observed that in 2018, in Giresun chestnut forests, both *P. rufulum* and *L. roboris* populations were dense enough to contribute chestnut honey. Colonies of both species are occur on the branches of host plants and visited by ants. Young females of *P. rufulum* excrete huge amount of honeydew in April and May, and bees collect the honeydew during this season. Ülgentürk et al. (2013a) noted that forests located in the western part of Turkey, *P. rufulum* and *L. roboris* are among the species excreting honeydew and major source of honeydew May-July in mid Europe (Crane and Walker 1985). Georgiev et al. (2008) recorded *L. roboris*, *L. pallipes*, *Tuberculatus querceus* (Kaltenbach) and *T. annulatus* (Harting) (Hemiptera: Aphididae) were aphid species, which feed on oak trees in Strandzha mountains in Bulgaria. He noted that population density of these species changed in parallel with special climate conditions and consequently, production amount of honeydew honey was affected by this. One of interesting insects, which has attracted attention in this study, is *M. pruniosa*. We observed that *M. pruniosa* excretes a huge amount of honeydew on oaks beside of other trees and honey bees collect this honeydew. Honey bees collect honeydew actively in early mornings and in evenings because the honeydew dries quickly during other hours of the day. They produced dark coloured honey. Local bee keepers in Kırklareli (Sislioba, Kıyıköy etc.) stated that this insect had not been known until 3–4 years ago and that it was seen on plants grown in low altitude, humid (sea side, river banks) warm areas and mixed other trees of forests. Barbattini et al. (2001) noted that the honeydew of *M. pruniosa* was very attractive for honey bees, and they produced 40 kg of honey per hive in this region and period where there was no other nectar source. It is marketed as Metcalfa honey in Italy. Can et al. (2015) was remarked that oak honey is darker in colour and higher in the total phenolic content, antioxidant capacity than pine honey.

The results show that not only honeydew of aphids and scale insect, but mainly contribution to honeydew production on oaks and other plants comes from *M. pruniosa* in the production of oak honey in Kırklareli. The other important finding is that fruits of *Q. frainetto* Ten. have got a great number of secretory glandular trichomes, which produce sweet secretions in oak forest of Kırklareli (Özkök et al. 2019). These findings show that oak honey of Kırklareli is a mixture of both insect honeydew and plant excretions.

In studies conducted on pure cedar forests in Antalya, we recorded *Cinara cedri* and *P. arambourgi* species excreting honeydew. However, during the two years of this study, we have seen that the population of these two species has been in low level. Fortunately, in the autumn of 2018, a large population of *C. cedri* and a large amount of honeydew are found. In interviews with local bee keepers in Antalya, they reported that in some years honeybees made honey from cedar trees, and this honey was quite dark. It has been sold as cedar honey in domestic markets in Antalya. *C. cedri* constitutes a potential honey source to *M. hellenica* especially in Mediterranean and Aegean regions, where cedar forests occur.

On fir trees (*A. bormuellerina*) in Bolu forest, four species excreting honeydew (*S. pineti*, *E. sericeum*, *N. abietis*, *P. hellenicus*) have been seen. We have found that among these species *S. pineti*, *N. abietis* and *P. hellenicus* have enough of a population to contribute to fir honey in Bolu fir trees. Feeding on fir trees (*Abies cephalonica* Loudon) in Greece, *Cinara pectinate*, *Mindarus abietis*, *E. sericeum*, *P. hellenicus* and *P. hemicyrphus* are important species which are the source of forest honey (Santas 1983, Kozár et al. 2012). Due to its peculiar physicochemical properties, honeydew obtained from *P. hellenica* and *P. hemicyrphus* in Southern Greece is called “forest honey vanilla”. The honey is protected under this name and has is of economic importance (Kozár et al. 2012). It will be highly meaningful to analyze the dark colored honeys obtained from Bolu forests and to identify their physio-chemical properties.

In areas, where *A. nordmaniana* and *P. orientalis* form pure and mixed stands in Giresun forests and *P. orientalis* in Trabzon, both plants have been found to be infested with *M. caucasica*. *M. caucasica* was reported on *Abies nordmanniana* and *Piceae orientalis* in Georgia (Hadzibejli 1969). Therefore, we suppose that *M. caucasica* is distributed naturally in the Black Sea Region. Last stage nymphs of *M. caucasica* produce large drops of honeydew feeding on fir and spruce trees in the last week of May in Giresun. Its population on oriental spruce trees is denser than that of fir trees. Both of trees infested with *M. caucasica* are found in mixed forest above the altitude of 1,500 m, where the weather is cool and wet. We anticipate that these climatic conditions might restrict honey bee activities at these altitudes.

In this study, *R. simulans* is another important honeydew producer species that damaged some cultivated plants in Giresun. It was reported that there is a considerable increase in the amount of honeydew honey in the Eastern Black Sea region between August and September. Therefore, Çakır et al. (2017) was investigated honeydew honey of *R. simulans* and reported that this honey is quite viscous, dark coloured and blackish, high in minerals, phenolic components and antioxidants. Both *M. pruniosa* and *R. simulans*, are invasive insects that could be a new source of honeydew honey in Turkey.

It should not be forgotten that some species detected in this study cause significant damage to agricultural areas and forestry. For instance, *P. corni* and *P. rufulum* are considered to be a dangerous pest in hazelnut and chestnut areas, and its population tried to be suppressed and controlled through various methods (Anonymous 2017). *R. simulans* is considered as a pest in tea and other plants in Eastern Black Sea Region too (Ak et al. 2015). As *M. pruniosa* is, on the other hand, prolific and a flying insect, it spreads quickly in warm and humid coasts of Turkey (Günçan 2014). For this reason, in forest areas neighbouring agricultural fields, measures should be taken to restrict the spread of insects.

In conclusion, we identified 20 species excreting honeydew in pure stand cedar, fir, oak, spruce forests and neighbor forests. The contribution of these species to honeydew honey is depended on their population density. Insect population dynamics are confined to a host of factors mainly to climatic conditions, their natural enemies and inter and intra species competitions. Excessive heat and precipitation in recent years are among the most important factors restricting the population level of insects. It is evident that the same factors also restrict the activities of honeybees in searching and collecting of honeydew. Contents of honeydews and honeys obtained from these areas and biology of the species we examined, will also contribute to the identification of honey with botanical and geographical markers and to their protection, as well.

Acknowledgements

This study was part of the project “Origin and characterization of cedar, fir, oak and spruce honeydew honeys” supported by General Directorate of Forestry, Ministry of Agriculture and Forestry, Turkey. The authors wish to thank Prof. Dr. Ünal Zeybekoğlu (University of 19 Mayıs) for the determination of Fulgoroidea species; Murat Çetiner who made map of studying localities (General Directorate of Forestry, Ministry of Agriculture and Forestry) and chiefs and technical staff of Directorate of Forestry of Antalya, Bolu, Giresun, Kırklareli and Trabzon for the logistic and invaluable hospitality during this study. The authors are grateful to Dr. Malkie Spodek, Dr. Mevlüt Emekçi and anonymous referees for reviewing this paper.

References

- Anonymous. 2017. Fındık entegre mücadele teknik talimatı [Instruction integrated pest management of Hazelnut]. TC. Gıda Tarım ve Hayvancılık Bakanlığı, Tarımsal Araştırmalar ve Politikalar genel Müdürlüğü, Ankara, Turkey, 135 pp. (in Turkish).
- Ak, K., Güçlü, Ş., Eken, C. and Sekban, R. 2015. *Ricania simulans* (Walker, 1851) (Hemiptera: Ricaniidae) a new pest for Turkey. *Journal of Turkish Entomology* 39(2): 179–186.
- Bacandritsos, N., Saitanis, C. and Papanastasiou, I. 2004. Morphology and life cycle of *Marchalina hellenica* (Gennadius) (Hemiptera: Margarodidae) on pine (Parnis Mt.) and fir (Helmos Mt.)

- forests of Greece. *Annales Societe Entomologique de France* 40(2): 169–176. <https://doi.org/10.1080/00379271.2004.10697413>.
- Barbattini, R., Gazzola, F., Greatti, M., Grillenzoni, F., Marizza, S. and Sabatini, A.** 2001. Metcalpha pruniosa (Say): Biology and honey derived from the honeydew. *Proc. 37th Int. Apic. Congr.*, 2001: 1–3.
- Blackman, R.L. and Eastop, V.F.** 2018. Aphids of the World's Plants: An Online Identification and Information Guide. <http://www.aphidsonworldsplants.info>. Last accessed 27 September 2018.
- Bogdanov, S.** 2009. Honey Composition. Available at: www.bee-hexagon.com. Last accessed 12 August 2018.
- Can, Z., Yıldız, O., Şahin, H., Turumtay, E.A., Silici, S. and Kolaylı, S.** 2015. An investigation of Turkish honeys: their physico-chemical properties, antioxidant capacities and phenolic profiles. *Food chemistry* 180: 133–144.
- Crane, E., and Walker, P.** 1985. Honey sources and their honey. *Bee World* 66(3): 105–112.
- Çakır, H.E., Şirin, Y., Can, Z. and Kolaylı, S.** 2017. Characteristic features of honeydew honey that produced at Blacksea region. *Aricılık Araştırma Dergisi* 9(1): 24–31.
- Danzig, E.** 2003. Mealybug of the *Phenacoccus* Ckll. (Homoptera: Pseudococcidae) in the fauna of Russia and adjacent countries. *Entomological Review* 83(1): 38–68.
- Durovic, G. and Ülgentürk, S.** 2014. Ballı madde salgısı [Honeydew]. *Bulletin of Turkish Entomology* 4(2): 121–137 (in Turkish with English abstract).
- Georgiev, G., Tsankov, G., Mirchev, P. and Petkov, P.** 2008. Honeydew producers in oak forests of Strandzha mountain, Bulgaria. *Silva Balcanica* 9: 95–60.
- Güncan, A.** 2014. Türkiye kivi bahçelerinde yeni bir zararlı, *Metcalpha pruinosa* (Say, 1830) (Hemiptera: Flatidae) [*Metcalpha pruinosa* (Say, 1830) (Hemiptera: Flatidae), a new pest in kiwifruit orchards of Turkey]. *Akademik Ziraat Dergisi* 3(1): 41–44 (in Turkish with English abstract).
- Hadzibejli, Z.K.** 1969. On *Marchalina caucasica*, sp. n. (Homoptera, Coccoidea) from the Caucasus. *Entomological Review* 48: 391–398.
- Hille Ris Lambers, D.** 1950. On mounting aphids and other Soft skinned insects. *Entomologische Berichten* 13: 55–58.
- Hodgson, C. and Gounari, S.** 2006. Morphology of *Marchalina hellenica* (Gennadius) (Hemiptera: Coccoidea: Marchalinidae) from Greece, with a discussion on the identity of *M. caucasica* Hadzibeyli from the Caucasus. *Zootaxa* 1196: 1–32.
- Kosztarab, M. and Kozár, F.** 1988. Scale Insects of Central Europe. Akademiai Kiado, Budapest, 455 pp.
- Kozár, F., Gounari, S., Hodgson, C., Fetyko, K. and Goras, G.** 2012. A new species of *Physokermes* Targioni Tozzetti (Hemiptera: Coccoidea: Coccidae) from Greece. *Zootaxa* 3566: 23–38.
- Özkök, A., İpek, A. and Sorkun, K.** 2019. The Origin of the Oak Honeydew Honey Produced from *Quercus frainetto* Ten. *Fresenius Environmental Bulletin* 28(4): 2650–2655.
- Pita-Calvo, C. and Vazquez, M.** 2018. Honeydew Honeys: A Review on the Characterization and Authentication of Botanical and Geographical Origins. *Journal of Agricultural and Food Chemistry* 66(11): 2523–2537.
- Santas, L.A.** 1983. Insects producing honeydew exploited by bees in Greece. *Apidologie* 14(2): 93–103.
- Sunay, A.E.** 2009. Authenticity and sensorial properties of pine honey from Turkey. 1st World Honeydew Honey Symp, Tzarevo, Bulgaria, 2008, p. 12.
- Ülgentürk, S., Şahin, Ö., Ayhan, B., Sarıbaşak, H. and Kaydan, M.B.** 2012a. Scale insects species of Taurus cedar in Turkey. *Turkish Journal of Entomology* 36: 113–121.
- Ülgentürk, S., Evren, N., Ayhan, B., Dostbil, Ö., Dursun, O. and Civelek, H.S.** 2012b. Scale insect (Hemiptera: Coccoidea) species on pine trees of Turkey. *Turkish Journal of Zoology* 36: 623–636.
- Ülgentürk, S., Kaydan, M.B., Kozár, F. and Ben-Dov, Y.** 2013a. Coccoidea (Hemiptera) species on oaks in Turkey. *Turkish Bulletin of Entomology* 3(1): 13–31.
- Ülgentürk, S., Özdemir, I., Kozar, F., Kaydan, M.B., Dostbil, Ö., Sarıbaşak, H. and Civelek, H.S.** 2013b. Honeydew producing insect species in forest areas in Western Turkey. *Turkish Bulletin of Entomology* 3: 125–133.
- Von der Ohe, W. and Von der Ohe, K.** 1996. Charakterisierung von Honigtauhonig anhand spezifischer Saccharide. *Apidologie* 27(4): 270–272 (in German with English abstract).