University doctoral (PhD) theses

INVESTIGATION OF EUROPEANSTONE FRUIT YELLOWS (ESFY) AND ITS SPREAD

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1. PREVIOUS RESEARCHE AND MAIN OBJECTIVES

European stone fruit yellows (ESFY) causes enormous damage to stone fruit plantations in Europe every year. The causal agent of the disease is the '*Candidatus* Phytoplasma prunorum' from the apple proliferation group (16SrX) (Poggi-Pollini et al. 2001). The plum psyllid (*Cacopsylla pruni* Scopoli, 1763) transmits the phytoplasma in a persistent-propagative way (Thébaud et al. 2009). Up to five months elapse between the time the vector introduces the pathogen into the plant and the symptoms appear on the host (Carraro et al. 1998). The pathogen causes enormous economic losses in apricot, Japanese plum and peach plantations (Desviges – Cornaggia, 1982; Dosba et al. 1991; Marcone et al. 1996). In the most susceptible species, such as Japanese plum or apricot, the phytoplasma is able to eradicate 100% of the infected trees (Carraro – Osler, 2003). The pathogen of the disease (and the phytoplasmas in general) still cannot be stably cultivated in axenic culture under laboratory conditions (Contaldo et al. 2012; Contaldo et al. 2016), due to its obligate parasitic nature. As our climate continues to change, and this process is now accelerating, we can predict that the diseases caused by phytoplasmas will become more prevalent. This phenomenon favours vector species that prefer warmer areas (Hogenhout et al. 2008). There is still no curative treatment against phytoplasmas, so the main methods are aimed at prevention.

It is pivotal to find integrated protection and prevention approaches against the pathogen and its vector. A better understanding of the biology and behaviour of both the vector and the pathogen is key to achieving this goal. The exploration of more and more information about the vector and the pathogen could help to develop a complex, integrated method against the disease caused by this phytoplasma. There are several examples of the incompleteness of our knowledge of *C. pruni*: for example, its vision, its antennal responses to volatiles, or the exact mechanism by which it finds host plants, and also the reason for its switching between host and shelter plants during the year.

As our first target (1) two apricot orchards in the region of Boldogkőváralja were inspected for symptoms of ESFY.

Our second aim (2), was to study an isolate of the pathogen '*Candidatus* Phytoplasma prunorum' in an infected apricot tree in the region of Boldogkőváralja was examined.

In the case of the plum psyllid (*Cacopsylla pruni*) as the vector of '*Ca*. Phytoplasma prunorum' our aim (3) was to identify its overwintering sites, and to record other jumping plant-louse species occurring in the same habitats. To do this, we collected jumping plant-

lice from conifers at different sites, and later identified the species from the collected material.

As our fourth objective (4) in the case of the psyllid vector of the pathogen, was to investigate the migration pattern of *Cacopsylla pruni* on *Prunus* species, and to identifiy other psyllid species occurring on the vector's host plants during the same period.

Our fifth objective (5) was to define the biotype and the infection rate of the plum psyllids collected.

Yellow coloured sticky traps are widely used to trap psyllids (Krysan – Horton 1991; Tedeschi et al. 2002; Sabaté et al. 2007; Brown et al. 2009; Sabaté et al 2016), as many researchers believe that they are a nutrient-rich young food sources for these insects (Krysan – Horton 1991; Döring – Chittka, 2007). Despite the widespread use of yellow-coloured sticky traps, we have hypothesised as our sixth objective (6), that there might be a more affective colour to lure C. *pruni*. According to this hypothesis an experiment was set up in an apricot orchard, with 5 different sticky (4 coloured: red, white, yellow, fluorescent yellow and 1 transparent as control) sheets (ten replicates of each) to determine which colour was more effective.

In many cases, it has been mentioned that both *Cacopsylla pruni* and *Cacopsylla melanoneura* are common on *Prunus* species (Warabieda et al. 2018; Lethmayer et al. 2011; Jarausch et al. 2009; Navrátil et al. 2004; Tedeschi et al. 2008). Based on this fact, a comparison was made between the two psyllids during the experiments. Finding similarities or dissimilarities between the two species could be helpful in understanding the behaviour of the plum psyllid. This would give us a chance to develop a high-quality protection method. Our aim was to find the missing information that could help to develop a proper protection method.

2. MATERIAL AND METHOD

2.1. Survey of symptoms in two apricot orchards in the region of Boldogkőváralja

Two different apricot orchards in the Boldogkőváralja region were surveyed for infection symptoms between 09.13.2018. and 09.24.2018. During this survey, all trees of the orchards were checked for symptoms and classified according to a five-point scale.

2.2. Molecular analysis of a pathogenic isolate from an ESFY-infected apricot

Our second objective (2), was the molecular investigation of an isolate collected from an ESFY infected apricot tree in Boldogkőváralja. The sample was taken from the phloem of the tree trunk. DNA was isolated by the Delladoyle MLO enrichment method (Ahrens-Seemüller, 1992). PCR templates were made with the universal primer pair fP1/rP7. The amplified product was cloned into pJET plasmid (Thermo Fisher Scientific). Both strands of the positive clones were amplified with pJET 1.2 forward and reverse primer pairs (Macrogen Europe, Amsterdam, the Netherlands), and sequenced. The resulting sequence was compared to the GenBank database using the BLAST algorithm (http://blast.ncbi.nlm. nih.gov/Blast.cgi).

2.3. Collection of plum psyllids and other jumping plant-lice on conifers, identification of collected jumping plant-lice

Our third objective (3) was, to look for overwintering sites of the vector (*Cacopsylla pruni*). During our work, we collected jumping plant-lice on conifers in the following places: Alsótekeres, Balatonvilágos, Boldogkőváralja, Budakeszi arboretum, Fenyőfő, in the near of Gyöngyöspata – Valley of Eszter spring, Júlia-Major – the outskirt of Nagykovácsi, Kecskemét, Martonvásár, Mátrafüred, Nagykovácsi, Nagyszakácsi, Páty, Piliscsaba, Somogytúr, Soroksár, Sóskút, and Verpelét. Other jumping plant-louse species collected were also identified. The collection was carried out between 2014 and 2020, during the winter months, with an insect net attached to a five-metre telescopic handle or with a garden leaf suction machine equipped with a flexible suction pipe attached to a spliced bamboo pole that can be adjusted to the height of the trees (up to 10-

metres hight). Collected material was stored in 70% ethanol, in labelled (location, date and plant species) Eppendorf tubes. The specimens were identified according to the keys of Ossiannilsson (1992) and Hodkinson –White (1992), while their classification was carried out according to the work of Burckhardt and co-workers (2021) under an Olympus SZ40 stereo-microscope, at 4x magnification.

2.4. Collection of plum psyllids and other jumping plant-lice on *Prunus* species and on other host plants during the migration period of *C. pruni*

Our fourth objective (4) was to collect plum psyllid and other jumping plant-lice in Boldogkőváralja, Bekecs and Nagyvárad during the migration period of the vector on *Prunus* species and on other host plants. The collection was carried out from 2018 to 2022, during the migration period of *Cacopsylla pruni*, using the one-by-one method. Specimens found on plants were captured in 1.5- or 2-ml Eppendorf tubes containing 70% ethanol for molecular biology tests, or in empty tubes for insect rearing. Individuals were then transferred to laboratory or to insect rearing cages. Other plants in the vicinity of *Prunus* hosts of *Cacopsylla pruni* were also examined at this time to look for other psyllid species. Plants in the busdh edge were often so close to each other that their branches touched each other. Collected jumping plant-lice were identified according to the keys of Ossiannilsson (1992) and Hodkinson –White (1992) and their taxonomic classification based on the work of Burckhardt and co-workers (2021).

2.5. Infection ratio and biotype classification of plum psyllids

Our fifth objective (5) was, to classify the biotype and the infection ratio of plum psyllids collected in 2018 in the region of Boldogkőváralja, Bekecs and Nagyvárad. DNA extraction was performed according to the general vector extraction method. Infection status was determined using the primer pair R16F2n/R16R2 (1241 bp) for standard PCR, and fU5/rU3 (876 bp) for nested-PCR. The CpA425R (293 bp), CpA425R (293 bp) and Cp135F primer complexes were used for biotype testing.

2.6. Sticky trap experiment

Our sixth objective (6) was, to find a colour that would attract C. *pruni* more than the yellow one. An experiment was carried out with five different coloured sticky traps to find a more effective colour for trapping *Cacopsylla pruni*.

Experimental design: The study was conducted in an apricot (*Prunus armeniaca*) orchard (mixture of several cultivars of different ages) near Boldogkőváralja (48°21′00.8″N 21°13′44.3″E). The orchard was mostly surrounded by crop fields and natural hedgerows (blackthorn –*Prunus spinosa,* and hawthorn–*Crataegus monogyna,* were the dominant species). One corner of the orchard was a mixed woodland area (where several conifer species were also present). Although the orchard had reached the age of yield, no pesticides had been used in the area in the previous three months and during the study in 2020. Different colored sticky traps ("SZ" series, 10×16 cm, produced by CSALOMON®, Plant Protection Institute, CAR, Budapest, Hungary) were used in the study. The applied four colors and a control used were the following: yellow, fluorescent yellow, red, white and transparent (unpainted sticky trap as control), to test the traps' efficiency in catching and monitoring the re-immigrant specimens of the vector. We did not use any volatile or other attractants for trapping.

The reflectance spectrum of the traps was previously described by Roth and co-workers (2016).

For each trap two coloured sticky traps were attached back-by-back with metal wires, with their sticky sides facing outwards. In the experimental design, five different traps were placed in a random order in a row (parallel to the rows of trees), in ten repelicates, so that the total number of traps was 50 (ten traps of each colour). Each trap was fixed to the tree branches at 1.5 meter above ground. To avoid the edge effect, all traps were placed at least 15 m from any edge of the orchard. The minimum distance between traps, on the plantation was 10-15 metres in each direction. Traps and the actual phenological stages of the plants (Meier, 2009) were regularly checked and recorded at 2-3 days intervals. If the condition of traps made it necessary, they were all replaced simultaneously on the same day. During these replacements all traps were swap to the same one. Two weeks before the start of the study, the presence of *Cacopsylla pruni* in in the surrounding area was checked daily with indicator traps (one of each colour) and also by personal observation. The trapping period (with the 10 replicates) started on the day, when the first specimens of the vector specimens appeared (2020.03.25). The study

lasted until the end of the re-migration period, but did not include the period when the new generation of imagoes started to migrate to conifers. Traps were replaced five times during the study as follows: 2020.04.01., 2020.04.07., 2020.04.15., 2020.04.29. and 2020.05.08. The traps were removed at the end of the day on 2020.06.06. as no overwintered individuals could be found in them.

The jumping plant-lice specimens were counted and identified according to the keys of Ossiannilsson (1992), their classification was done according to the work of Burckhardt and co-workers (2021).

Cacopsylla pruni and *C. melanoneura* were the most abundant species among the collected jumping plant-lice. Thus, all other members of the genus *Cacopsylla*, and those specimens that could not be identified due to damaged identification marks were considered as "other *Cacopsylla* spp.".

Statistical methods: To test the effect of colors on psyllid catches the number of specimens captured by colors was summed over replicates throughout the observation period. The distributions of the response variables and their residuals were identified using QQ plots, data were transformed when the distributions of the response variables were different from the normal distribution. Best fitting statistical models were selected based on AIC values and/or by ANOVA. The total number of *C. pruni* captured was logarithmically transformed, and then we fitted with generalised least squares (GLS) models (R package "nlme") (Pinheiro et al., 2022). We fitted the GLS model to the total number of *C. melanoneura* captured without data transformation. We performed pairwise tests using Tukey-adjusted P values in the R package "EMmeans" when comparing the total number of catches on each color within both species (Searle et al., 2012). We compared the total number of *C. pruni* and *C. melanoneura* individuals in yellow traps after square root transformation and in white traps after logarithmic transformation, by fitting GLS models.

Based on the results, we distinguished a sub-period during the survey, called the main immigration period (IM), which lasted from 2020.03.25. (Day 0 of the whole observation period) to 2020.04.15. (Day 20 of the observation period). As for the whole period, we summarized the number of captured individuals of each color by row/replicate for the IM. We fitted GLS models after square root transformation on the number of *C. pruni* individuals in white and yellow traps and on the number of *C. pruni* and *C. melanoneura* individuals caught by white traps, during IM. The catches of *C. melanoneura* in white and yellow traps during IM were compared using the GLS model after logarithmic

transformation. All statistical procedures were performed using R (#R Studio 1.4, R Core Team 2016, R), and data visualization was performed using R and JMP (16.1.0, SAS Inc.).

3. RESULTS

3.1. Survey of symptoms in two apricot orchards at the region of Boldogkőváralja (1)

The infection index of the first examined orchard was 2,9. After examination of the orchard, 201 out of 300 trees showed symptoms, which means that 68,60% of the trees were symptomatic.

In the case of the second orchard, the infection index was 2,052. In this orchard, 853 trees showed infection symptoms, which means that 62,6% of the trees were symptomatic.

3.2. Molecular study of a pathogenic isolate from an ESFY-infected apricot (2)

Our second objective (2) was to study an isolate originated from a symptomatic apricot plant. The DNA sample gave a clear positive result in the PCR test. The sequence analysis was of good quality, a 1784bp product was amplified from both directions. As result of the analysis, we found that the isolate had the highest similarity with the ESFY-G2 strain of '*Candidatus* Phytoplasma prunorum'.

3.3. Collection plum psyllids and other jumping plant-lice on conifers, identification of collected jumping plant-lice (3)

A total of 1600 jumping plant-lice were collected on conifers between 2014 and 2020, of which 25 specimens were *Cacopsylla pruni* collected on Norway spruce (*Picea abies*) and on Douglas fir (*Pseudotsuga menziesii*). Five collected jumping plant-lice could not be identified due to damaged identification marks. During the sampling period, 20 different jumping plant-louse species were collected from 18 different localities. The collected material could be classified into three families (Psyllidae, Aphalaridae and Triozidae). They were found on the following plant species: Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), Serbian spruce (*Picea omorika*), Nordmann's fir (*Abies nordmanniana*), giant redwood (*Sequoidendron giganteum*), Atlas cedar (*Cedrus atlantica*), common yew (*Taxus baccata*), Douglas fir (*Pseudotsuga menziesii*), European

black pine (*Pinus nigra*), blue spruce (*Picea pungens* f. *glauca*), mixed conifers, savin's juniper (*Juniperus sabina*), and Leyland cypress (*Cupressocyparis leylandii*). We found the following jumping plant-lice: *Aphalara avicularis* (Ossiannilson, 1981), *Aphalara calthae* (Linnaeus, 1761), *Aphalara polygoni* (Foerster, 1848), *Bactericera albiventris* (Foerster, 1848), *Bactericera curvatinervis* (Foerster, 1848), *Bactericera femoralis* (Foerster, 1848), *Cacopsylla crataegi* (Schrank, 1801), *Cacopsylla melanoneura* (Foerster, 1848), *Cacopsylla peregrina* (Foerster, 1848), *Cacopsylla pruni* (Scopoli, 1763), *Cacopsylla pyricola* (Foerster, 1848), *Cacopsylla pyrisuga* (Foerster, 1848), *Cacopsylla rhamnicola* (Scott, 1876), *Cacopsylla saliceti* (Foerster, 1848), *Trioza apicalis* (Foerster, 1848), *Trioza neglecta* (Loginova, 1978), *Trioza remota* (Foerster, 1848), *Trioza rhamni* (Schrank, 1801), *Trioza rotundata* (Flor, 1861) and *Trioza urticae* (Linnaeus, 1758). The following species were found on mixed coniferous trees: *T. remota* (one specimen in Martonvásár, and four in Sóskút), *C. melanoneura* (one specimen in Soroksár, and three in Budakeszi). The genus *Trioza* was the most common, mainly found on European black pine and on Norway spruce. *Trioza remota* was collected in the largest number (972), followed by *T. urticae* (174).

The second most common genus was the *Cacopsylla*, including *C. melanoneura* (221), *C. pruni* (25), and *C. crataegi* (17). From the genus *Bactericera* which was the third most abundant group, *B. albiventris* (106) was the most abundant species. We found the overwintering sites of 20 from the 80 reported Psylloidea species from Hungary. The overwintering localities of the following species were not previously known in Hungarian literature: *A. avicularis*, *A. calthae*, *A. polygoni*, *C. rhamnicola*, *C. saliceti*, *B. curvatinervis*, *B. albiventris*, *B. femoralis*, *T. neglecta*, *T. remota*, *T. rhamni*, *T. rotundata*. In the case of *C. peregrina*, *C. pyricola*, *C. pyrisuga* and *T. apicalis* we found new overwintering localities (Norway spruce at the Mátra) as an addition to those previously recorded by Hungarian researchers.

3.4. Collection of plum psyllids, and other jumping plant-lice on *Prunus* species and other host plants during the migration period of *C. pruni* (4)

Collection of plum psyllids on *Prunus* species: 2063 specimens of *Cacopsylla pruni* were collected between 2018 and 2022 during the migration period of *C. pruni* on

different *Prunus* species (wild plum – *Prunus myrabolana*, apricot – *Prunus armeniaca*, myrobalan sucker, blackthorn – *Prunus spinosa*, and plum – *Prunus domestica*).

Specific dates of the life cycle of *C. pruni* were determined during the years of study: Appearance of the first overwintered adults: 2018.IV.13., 2019.IV.18., 2020.III.20., 2021.III.31., 2022.III.26. Mating individuals: 2020.III.28. Date of oviposition: 2016.IV.9., 2020.IV.8. Appearance of immature specimens: 2020.IV.17., reaching L5 stage on 2020.V.22. After 2020.VI.6. no overwintered (darker coloured) adults could be found in the apricot orchards.

Other jumping plant-louse species collected during the migration period of *C. pruni*:

The following jumping plant-lice were collected on different *Prunus* species: *Cacopsylla melanoneura* (blackthorn – *P. spinosa*, apricot – *P. armeniaca*, plum – *P. domestica*, and myrobalan sucker), *Cacopsylla crataegi* (apricot – *P. armeniaca* and plum – *P. domestica*).

Cacopsylla rhamnicola (Scott, 1876) was not collected on *Prunus*, but on common buckthorn (*Rhamnus cathartica*) during the period of vector migration.

3.5. Biotype classification and infection rate study of plum psyllid (5)

Investigation of the infection status:

As a result of the PCR tests to investigate the infection status of the psyllids, 95 of the 155 adult plum psyllid specimens were infected with the '*Ca*. Phytoplasma prunorum' (Table 1). In Bekecs 7 out of 15 specimens were infected, and in Boldogkőváralja 87 out of 139 specimens were infected (one specimen was not included in the table because of damaged genitalia, but it was also found to be infected). Only one infected individual was found in Nagyvárad. The infection rate of the vectors was 46,67% in Bekecs, and 67,44% in Boldogkőváralja.

Table 1: Infected *Cacopsylla pruni* specimens in the year of 2018 in different localities

Localities	male		female	
	negative	positive	negative	positive
Nagyvárad	0	0	0	1
Bekecs	1	3	7	4
Boldogkőváralja	10	16	42	70

Biotype classification:

As a result of the biotype tests, all specimens collected at all sites (Nagyvárad, Boldogkőváralja and Bekecs) proved to be B biotype.

3.6. Sticky trap experiment (6)

The plum psyllid trapping experiment in 2020, was carried out on apricot trees for 11 weeks, from March to June. 1517 jumping plant-lice specimens of the family Psyllidae were identified (see Table 2.).

Table 2. Summary of *Cacopsylla* sepcimens caught by colored sticky traps

Trap colour	Summarized number of *Cacopsylla* spp. individuals	Summarized number of *C. pruni* by colors	Summarized number of *C. melanoneura* by colors	Summarized number of other *Cacopsylla sp*. by colors	Share of *C. pruni*	Share of *C. melanoneura*	Other *Cacopsylla sp.*
White	390	249	84	57	63.85%	21.54%	14.62%
Yellow	367	158	139	70	43.05%	37.87%	19.07%
Fluorescent yellow	262	86	139	37	32.83%	53.05%	14.12%
Red	191	50	125	16	26.18%	65.45%	8.38%
Transparent	307	87	174	46	28.34%	56.68%	14.98%
All	1517	630	661	226	41.52%	43.57%	14.89%

Most of the captured specimens belonged to the genus *Cacopsylla*, while the second most common group was *Triozidae* with a total of 33 captured specimens. There were no significant by-catches in case of other insect families, or in case of pollinators. First overwintering specimens of *Cacopsylla pruni* were caught in sticky traps on 2020.03.29. (Figure 1). The peak of immigration (migration from shelter plants to *Prunus* species) of *C. pruni* was in mid-April (day 22. in Fig 1). There was no difference between the number of males and females (based on a sample of 300 individuals, approximately 56% of the vectors were females). No juveniles were observed in the traps. The first new generation adult (which has not yet overwintered), based on personal observation, appeared on 05.16.2020. Only nine specimens were caught in the traps by the end of the survey, which is a negligible number, and was not included in the analysis. The end of the trapping

period did not coincide with the emigration of plum psyllids from the plantation, but with the time when overwintering adults were no longer found in the plantation.

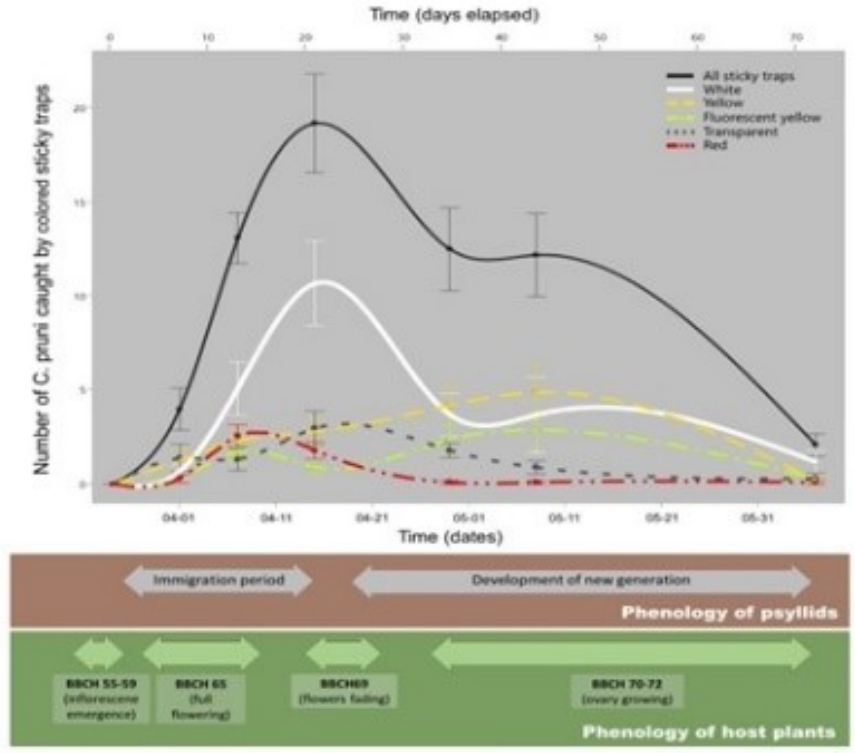

Figure 1. The mean number of *C. pruni* adults caught by sticky traps calculated from the 10 repetitions (y axis) by the different colors over the entire observation period and the change in color preference over time (X axis). Catches were summarized across all colours (black line) or within colours (coloured lines) for trap replacement periods and the means were calculated from 10 repetitions. Bottom boxes indicate phenological phases of *C. pruni* and apricot trees based on field observations throughout the study. Dots represent means with error bars as standard errors. The spline is fitted continuously. The lower X-axis marks dates, the upper one the days elapsed since the start of the study.

A total of 630 overwintering *C. pruni* adults were caught in the traps. The total number of plum psyllids trapped by colours over the entire trapping period, showed significant differences between them (Fig 2a.).

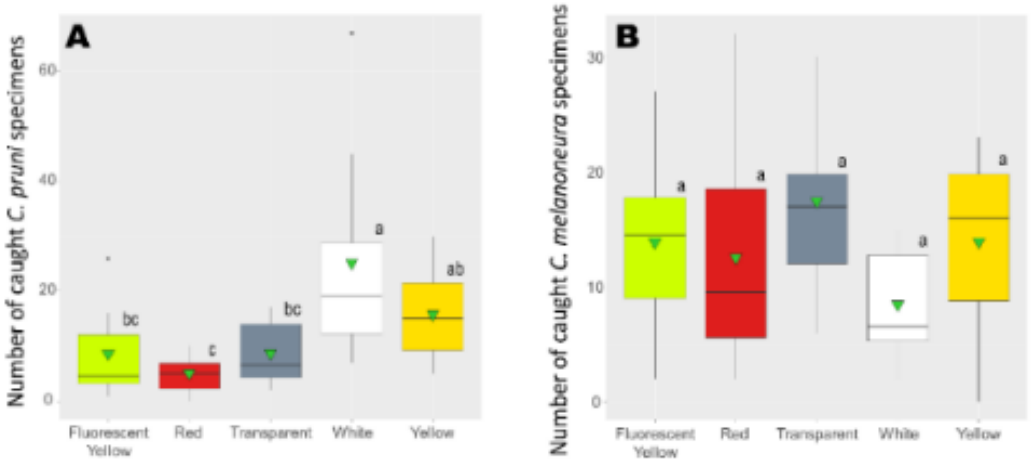

Figure 2. Color preferences of the two most abundant *Cacopsylla* species in the apricot orchard, *C. pruni* (A) and *C. melanoneura* (B). The graphs show the mean number of catches by each coloured sticky trap (Y-axis) during the whole observation period. The X-axis shows colours of the traps. Horizontal bars represent the median, vertical bars represent the standard error of means. Statistical means are represented by triangles and interquartile ranges are indicated by boxes and outliers (if present) by black dots. Different letters 7indicate significant differences between colours.

In pairwise comparisons, white traps caught significantly more than red, transparent and fluorescent yellow traps did, while yellow traps catches were only significantly higher than red traps (Table 3). Throughout the observation period, white traps caught the most *C. pruni* specimens, but there was no significant difference between catches on yellow and white traps. There was no difference in catches between red, transparent and fluorescent yellow traps (Figure 2a).

Table 3. Summary of the applied statistical procedures and their results.

Multiple comparisons

Observation period	Subject	Compared variables		Model	Data transformation	Results of test statistics	d.f.	p - value
Full	*C. pruni*	all color	all color	GLS	log	t = 9.23	50	<0.000*
Full	*C. melanoneura*	all color	all color	GLS	-	t = 5.68	50	<0.005*

Pairwise comparisons

Observation period	Subject	Compared variables		Model	Data transformation	Results of test statistics	d.f.	p – value
Full	White sticky traps	*C. pruni*	*C. melanoneura*	GLS	log	t = 3.49	20	0.002*
Full	Yellow sticky traps	*C. pruni*	*C. melanoneura*	GLS	sqrt	t = 0.68	20	0.5
Immigration period	*C. pruni*	White	Yellow	GLS	sqrt	t = -3.05	20	0.006*
Immigration period	*C. melanoneura*	White	Yellow	GLS	log	t = 0.15	20	0.879
Immigration period	White sticky traps	*C. pruni*	*C. melanoneura*	GLS	sqrt	t = 3.04	20	0.006*

The most abundant species in the apricot orchard was *C. melanoneura* with a total of 661 catches. We compared the cumulative number of *C. melanoneura* adults caught on the five different coloured sticky traps. For this species, the applied trap colour had no effect on catch (Figure 3b, Table 3 and 4).

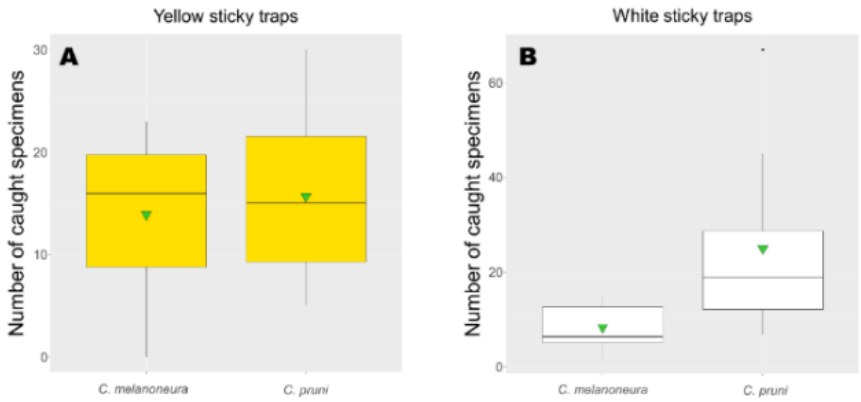

Figure 3. Comparison of the effectiveness of yellow (A) and white (B) sticky traps in catching *C. pruni* and *C. melanoneura* specimens. The graphs show the cumulative catches of each colour during the entire observation period. Horizontal bars represent the medians, vertical bars represent the standard error of means. Statistical means are shown by triangles, interquartile ranges are indicated by boxes and outliers (if present) by black dots.

To detect any difference in colour preference between the two psyllids, we compared the aggregated numbers of *C. pruni* and *C. melanoneura* specimens on white and yellow traps. The white colour had more *C. pruni* specimens than *C. melanoneura* (Figure 3b), in contrast to the yellow (Figure 3a, Table 3).

The difference between *C. pruni* catches on white and yellow traps was not constant throughout the trapping period (Figure 3, Table 3). White traps caught noticeably (and significantly) more specimens than yellow traps during the first three weeks of observation (Immigration Period, IM), while the yellow-coloured traps were more effective after mid-April (Figure 3). The period in which white catches outnumbered those of the other colours corresponded to the flowering stages, their proportion increasing with the mid-flowering stage (BBCH 65) of apricot (when the flower petals of the neighbouring blackthorn became visible at BBCH 58), and their proportion decreasing with the end-flowering stage (BBCH 69-70) of both plants (Figure 3). Yellow traps reached their maximum level – comparable to that of white traps – during leaf expansion, i.e., after petal fall. Therefore, in order to find the best sticky trap colour for the timing of pesticide treatments, we compared the effect of colours on *C. pruni* and *C. melanoneura* catches during the immigration period (IM) (Figure 4, Table 3).

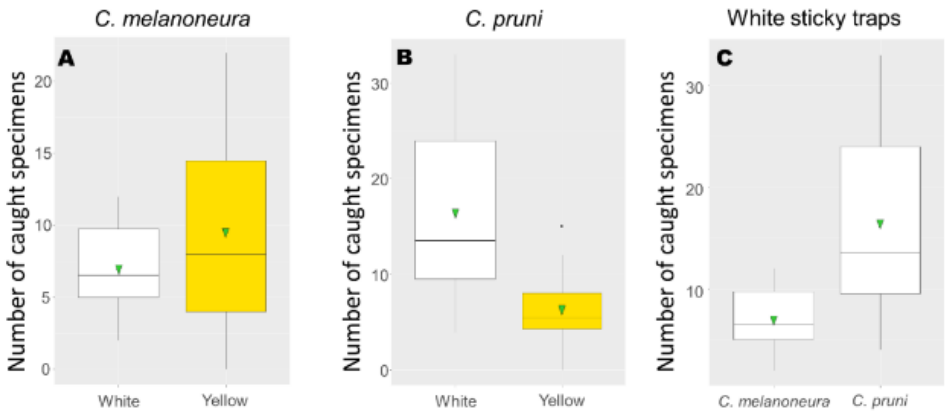

Figure 4. Color efficiency of sticky traps (means of summed catches) during the immigration period (IM). Comparison of *C. melanoneura* (A) and *C. pruni* (B) numbers on yellow and white sticky traps. Comparison of *C. melanoneura* and *C. pruni* catches on white sticky traps during the IM (C). Horizontal bars represent the medians, vertical bars represent the standard error of means. Statistical means are shown by triangles and interquartile ranges are indicated by boxes, and outliers (if present) by black dots.

Neither of our colour sticky traps nor the transparent control traps caught honey bees (*Aphis mellifera*), although there were several colonies in the vicinity of the plantation during the study.

4. NOVEL SCIENTIFIC RESULTS

1.

We found, that 68.60 % of the trees in the first orchard, and 62.6 % of the trees in the second orchard showed symptoms consistent with phytoplasma infection. The proportion of trees showing symptoms of infection that we observed was slightly lower than the proportion previously observed in the region (77 %) (Tarcali et al. 2010; Tarcali et al. 2022).

We found, that the infection index was 2.9 in the first plantation and it was 2.052 in the second.

We found that the phytoplasma isolate from the apricot orchard studied showed the highest similarity to the ESFY-G2 strain of '*Candidatus* Phytoplasma prunorum', which is a highly virulent strain. This strain was described in Dossenheim (Germany) (Seemüller – Schneider, 2004). Before our experience, this strain was found in apricot (Spain – Torres et al. 2010), cherries in Poland (Cielśińska – Smolarek, 2019) and plums in Iran (Allahverdi et al. 2014).

We found that the plum psyllids in the investigation areas belonged to the B biotype which is the same as previously found in our country (Mergenthaler et al. 2017). The phytoplasma infection rate of the plum psyllid specimens we collected in the study areas (67.4 % in the case of Boldogkőváralja, and 46.7 % in the case of Bekecs) are similar or slightly lower than the rates previously experienced in the same regions (77 % in the case of Boldogkőváralja, and 75-80 % in the case of Bekecs) (Tarcali et al. 2010; Tarcali et al. 2022). However, their infection rate with the pathogen '*Ca*. Phytoplasma prunorum' was higher than in other previously studied areas of the country (around 15 %) (Mergenthaler et al. 2017) and in the international context: The national average in France was around 3 %, and in some areas of the country was 15 % (Yvon et al. 2004), while in Turkey this ratio was around 23 % (Serçe et al. 2011).

2.

We found that *Cacopsylla crataegi* and *Cacopsylla melanoneura* could also have been found on different *Prunus* species during the migration period of the vector *C. pruni*.

We found that *Cacopsylla rhamnicola* could have also been found on common blackthorn during the vector's migration period. This psyllid is rare in our country.

3.

We have identified the overwintering sites of the vector *Cacopsylla pruni* on Norway spruce and on Douglas fir during the winter period.

We identified the overwintering sites of a further 19 species (*A. avicularis*, *A. calthae*, *A. polygoni*, *C. rhamnicola*, *C. saliceti*, *B. curvatinervis*, *B. albiventris*, *B. femoralis*, *T. neglecta*, *T. remota*, *T. rhamni*, *T. rotundata*, *C. peregrina*, *C. pyricola*, *C. pyrisuga* and *T. apicalis*) on different conifer species during the winter period. With regard to the overwintering sites of the 80 jumping plant louse species found in our country (Kontschán et al. 2020), of which 20 jumping plant louse species were identified on conifers during our studies, no such information was available in the Hungarian literature for 14 species. As the collection methods are not yet sophisticated enough, further studies are needed to evaluate the exact role of each tree species in overwintering.

4.

We found that the white colour trap caught significantly more plum psyllids (249 specimens) than the yellow (158 specimens) or the other colours (red – 50 specimens, fluorescent yellow – 86 specimens) and the transparent control trap (87 specimens) during the immigration period (IM).

We also found that the effectiveness of the white coloured sticky trap varies according to the phenological stages of the host plant. Its outstanding catching period corresponds to the flowering stages of the host plant, and then its effectiveness began to decrease at the petal fall stage (BBCH 69-70) dropping to a level similar to that of the yellow sticky trap.

The phenological synchrony, that we have found in the case of *C. pruni* was not previously reported in the literature.

We have thus, added new information for a more accurate method of swarm tracking method and for better planning of the timing of defence against the vector.

5. RESULTS WITH PRACTICAL ADVANTAGES

1.

The use of white sticky traps has practical advantage based on our results. On the one hand, it is more effective than the yellow colour previously described in the literature, and on the other hand, the white trap indicates the appearance of the plum psyllid earlier in the apricot orchards, than other colours.

Although beating and netting are commonly used methods to collect plum psyllids and monitor their migration (Mergenthaler et al. 2017; Viczián et al. 2015), the effectiveness of these methods depends on local weather conditions (e.g., rain, wind). Sticky traps are more stable, and effective in a given period of time, even between extreme conditions as well. This method is also less labour intensive and easier to standardise. It is also practical not only for collecting or monitoring the migration, but also for recording the density of the given species and also for monitoring the migration dynamics (Krüger – Fiore, 2019).

Taking into account the results and conclusions described above, we recommend the use of the white sticky trap instead of the yellow one recommended in the literature for trapping the most common psyllid species (*C. pruni* és *C. melanoneura*) in apricot orchards, from the beginning of budding until the end of flowering of the host plant.

The white trap is also more effective in that it starts catching the vector in large numbers earlier than the widely used yellow trap.

The use of the white sticky trap is also important in phytosanitary practice, as preventing the transmission of the pathogen is a key step in slowing down and stopping the spread of the European Stone Fruit Yellows disease, as mentioned in the section on vector and disease control options.

Integrated pest management helps to improve the timing and thereby reduce the number of chemical applications. This is not only cost-effective, but also reduces the ecological footprint.

This trap is also recommendable for organic plantations, as it does not trap beneficial insects or pollinators. Ecesis and unperturbed life of these insects in these plantations is a very important element of plant protection.

2.

From a practical point of view, it is of great importance that the isolate studied in Boldogkőváralja region, was highly similar to the virulent ESFY-G2 strain of the pathogen, which causes severe symptoms on apricot trees.

The high infection rate of both symptomatic trees and the *Cacopsylla pruni* in the region, draws the attention of growers to the fact that the coexistence of a virulent strain of the pathogen and a highly infected vector population leads to high risk, if no appropriate strategy is available to control them.

3.

Our results related to the *C. melanoneura* species are consistent with the phenomena described by others (Mayer – Gross, 2007), while in the case of *C. pruni* we found an extremely useful novelty from a practical point of view, which complements and explains the existing knowledge on the biology of the species (Gallinger et al. 2019a).

The large difference observed in the colour preference of *Cacopsylla pruni* (the vector of ESFY) and *Cacopsylla melanoneura* (the vector of AP) is an interesting phenomenon, as both species belong to the same genus.

This may indicate that there may be other aspects, even very different behaviours, within the genus, so it would be worthwhile in the future to compare the vector species belonging to this genus from another point of view. The experience gained in this way may later contribute to a deeper understanding of the vector's behaviour and thus to the development of better protection strategies.

Taking into account the changes in swarming dynamics observed during the study years as a result of weather anomalies, as well as the possible opportunities for the pathogen to invade the plantation, which were revealed by Marie-Jeanne and co-workers (2020) (see subsection 2.4.2 of the theses), it can be recommended that in a given area, we must first spend time getting to know and understand the typical conditions of the area.

As local weather conditions are becoming increasingly variable, and these anomalies also affect the swarming dynamics of the vector (e.g., time of the swarm start, start of egg laying), it is important to learn as much as possible about the behavioural motives of the species in the given area as deeply as possible and to monitor them closely, in order to gain site-specific experience, that will help in

finding the right defence method. This is the only way to develop a defence strategy that will help prevent the spread of the pathogen.

REFERENCES

Ahrens, U. – Seemüller, E..: 1992. Detection of DNA on plant pathogenic mycoplasmalike organisms by polymerase chain reaction that amplifies a sequence of the 16S rRNA gene. *Phytopathology*. 82: 828-832.

Brown, R.L. – Landolt, P.J. – Horton, D.R. – Zack, R.S.: 2009. Attraction of *Cacopsylla pyricola* (Hemiptera: Psyllidae) to a female psylla in pear orchards. *Environmental Entomology*. 38: 815-822.

Burckhardt, D. - Ouvard, D. - Precy, D.M.: 2021. An updated classification of the jumping plant-lice (Hemiptera: Psylloidea) integrating molecular and morphological evidence. European Journal of Taxonomy. 736: 137–182.

Carraro, L. – Osler, R. – Loi, N. – Ermacora, P. – Rafetti, E.: 1998. Transmission of European stone fruit yellows phytoplasma by *Cacopsylla pruni*. *Journal of Plant Pathology*. 80(3): 233-239.

Carraro, L. – Osler, R.: 2003. European stone fruit yellows: a destructive disease in the Mediterranean Basin. In: Myrta, A. – Di Terlizzi, B. – Savino, V. (eds.) Virus and virus-like disease of stone fruit with particular reference tot he Mediterranean region, CIHEAM. Options Mediterraneenes Serie B. 45: 113-117.

Contaldo, N. – Bertaccini, A. – Paltrinieri, S. – Windsor, H.M. – Windsor, G.D.: 2012. Axenic culture of plant pathogenic phytoplasmas. *Phytopathol. Mediterr*. 51: 607-617.

Contaldo, N. – Satta, E. – Zambon, Y. – Paltrinieri, S. – Bertaccini, A: 2016. Development and evaluation of different complex media for phytoplasma isolation and growth. J. *Microbiol. Methods*. 127: 105-110.

Desvignes, J.C. – Cornaggia, D.: 1982. Observation on apricot chlorotic leaf roll (ACLR): sensitiveness of different *Prunus* species detection, spread in plum orchards. *Acta Horticulturae*. 130: 249-256.

Dosba, F. – Lansac, M. – Mazy, K. – Garnier, M. – Eyquard, J.P.: 1991. Incidence of different diseases associated with mycoplasmalike organisms in different species of *Prunus*. *Acta Horticulturae*. 283: 311-320.

Döring, T.F. – Chittka, L.: 2007. Visual ecology of aphids – a critical review on the role of colours in host finding. *Arthropod-Plant Interactions*. 1: 3-16.

Hodkinson, I.D. – White, I.M: 1979. Homoptera (Psylloidea). In: Watson, A. eds. Handbooks for the identification of British insects. II(5a). Royal Entomological Society of London, London SW7 5HU. pp. 1-108.

Hogenhout, S.A. – Oshima, K. – Ammar, E.D. – Kakizawa, S. – Kingdom, H.N. – Namba, S.: 2008. Phytoplasmas: bacteria that manipulate plants and insects. *Mol. plant Pathol*. 9: 403-423.

Jarausch, B. – Buckhardt, D. – Lauterer, P. – Jarausch, W.: 2009. Psyllids (Hemiptera, Psylloidea) captured in commercial apple and stone fruit orchards in southwest Germany, eastern France and northwest Switzerland. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft*. 82: 205-2015.

Krüger, K. – Fiore, N.: 2019. Sampling Methods for Leafhopper, Planthopper, and Psyllid Vectors, in Rita Musetti and Laura Pagliari (eds.), Phytoplasmas: Methods and Protocols in Molecular Biology vol. 1875

Krysan, J.L. – Horton, D.R.: 1991. Seasonality of catch of pear psylla *Cacopsylla pyricola* (Homoptera:Psylloidae) on yellow traps. *Environmental Entomology*. 20: 624-634.

Lethmayer, C. – Hausdorf, H. – Suarez-Mahecha, B. – Reisenzein, H.: 2011. The importance of psyllids (Hemiptera: Psyllidae) as vectors of phytoplasas in pome and stone fruit trees in Austria. *B. Insectol*. 64: S255-S256.

Marcone, C. – Ragozzino, A. – Seemüller, E.: 1996. European stone fruit yellows phytoplasmas as the cause of peach vein enlargement and other yellows and decline diseases of stone fruits in southern Italy. Phytopathology. 144: 559-564.

Meier, U. - Bleiholder, H. - Buhr, L. - Feller, C. - Hack, H. - Hess, M. - Lancashire, P.D. - Schnock, U. - Stauss, R. - Van Den Boom, T. - Weber, E - Zwerger, P.: 2009. The BBCH system to coding the phenological growth stages of plants-history and publications. Journal fur Kulturpflanzen 61, 41-52.

Mergenthaler E. – Kiss B. – Kiss E. – Viczián O.: 2017. Survey ont he occurence and infection status of *Cacopsylla pruni*, vector of European stone fruit yellows in Hungary. Bulletin of Insectology. 70: 171-176.

Mergenthaler E. – Kiss B. –Kiss E. – Viczián O.: 2017. Survey ont he occurence and infection status of Cacopsylla pruni, vector of European stone fruit yellows in Hungary. Bulletin of Insectology. 70: 171-176.

Navrátil, M. – Fialová, R. – Kocourek, F. – Lauterer, P. – Válová, P. – Šafářová, D. – Poncarová- Voráčková, Z.: 2004. Problems of European stone fruit yellows phytoplasma in the Czech Republic. *Acta Fytotechnica et Zootechinca*. 7: 217-219.

Ossiannilsson, F.: 1992. The psylloidea (Homoptera) of Fennoscandia and Denmark. Fauna Entomologica Scandinavica, Leiden, New York, Köln. Vol. 26. pp.1-104.

Pinheiro, J. – Bates, D. – Team, R.C. nlme.: 2022. Linear and Nonlinear Mixed Effects Models. R package version 3.1-157.

Poggi-Pollini, C. – Bisanni, R. – Glunchedi, L.: 2001. Occurence of European stone fruit yellows phytoplasma (ESFYP) infection in peach orchards in Northern–Central Italy. *Journal of Phytopathology*. 149(11-12): 725-730.

Roth, F. – Galli, Z. – Toth, M. – Fail, J. – Jenser, G.: 2016. The hypothesized visual system of *Thrips tabaci* Lindman and *Frankliniella occidentalis* (Pergande) based on different coloured traps' catches. *North Western Journal of Zoology*. 12: 40-49.

Sabaté, J. – Laviña, A. – Batlle, A.: 2007. A survey of *Cacopsylla pruni* on different fruit trees producing areas of Spain. *Bulletin of Insectology* 60(2): 193-194.

Sabaté, J. – Laviña, A. – Batlle, A.: 2016. Incidence and distribution of '*Candidatus* Phytoplasma prunorum' and its vector *Cacopsylla pruni* in Spain: an approach to the epidemiology of the disease and the role of wild *Prunus*. Plant Pathology. 65: 837-846.

Searle, S.R. – Speed, F.M. – Milliken, G.A.: 2012. Population Marginal Means in the Linear Model: An Alternative to Least Squares Means. *The American Statistician*. 34:216-221.

Tedeschi, R. – Bosco, D. – Alma, A.: 2002. Population dynamics of Cacopsylla melanoneura (Homoptera:Psylloidae), a vector of apple proliferation phytoplasma in northwestern Italy. *Journal of Economic Entomology*. 95: 544-551.

Tedeschi, R. – Dermaria, D. – Cesano, A. – Tota, F. – Vittone, G. – Alma, A.: 2008. Spread of European stone fruit yellows in Piedmont (northwestern Italy) and presence of *Caopsylla pruni* Scopoli in plum and apricot orchards. In the 7th IOBC conference of Integrated Fruit Production at Avignon in 2008. pp. 224-227.

Thébaud, G. – Ivony, M. – Alary, R. – Sauvion, N. – Labonne, G.: 2009. Efficient transmission of '*Candidatus* Phytoplasma prunorum' is delayed by eight months due to long latency in its host–alternating vector. *Phytopathology*. 99: 256-273.

Viczián O. – Mergenthaler E. – Kiss E. – Kiss B.: 2015. Monitoring population of *Cacopsylla pruni* (Heiptera: Psyllidae), a vector of European stone fruit yellows in Hungary, 7th European Hemiptera Congress and 9th International Workshop on Leafhoppers and Planthoppers of Economic Importance, July 19th-24th 2015, Graz, Austria, Programme, Abstract of Talks and Posters.

Warabieda, W. – Soika, G. – Cieślińska, M.: 2018. Cacopsylla pruni in Poland and its significance as vector of '*Candidatus* Phytoplasma prunorum'. *Zemdirbyate-Agriculture*. 105: 177-182.

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List of publications related to the dissertation

Hungarian book chapters (1)

1. Tarcali, G., Kövics, G., Biró, G., Mergenthaler, E., **Bodnár, D.**: A csonthéjasok fitoplazmás megbetegedésének hazai helyzete.
In: Növényorvos képzés Debrecenben. Szerk.: Tarcali Gábor, Kövics György, Radócz László, Debreceni Egyetem Mezőgazdaság-, Élelmiszertudományi és Környezetgazdálkodási Kar, Debrecen, 250-273, 2021. ISBN: 9789634903475

Foreign language international book chapters (1)

2. Tarcali, G., Szalai, B., Csüllög, K., Nagy-Szalárdi, T., **Bodnár, D.**: Investigations of phytoplasma diseases on apricot and grapevine in Hungary and Central Europe.
In: Precision Agriculture and Sustainable Crop Production. Ed.: H. K. Chourasia, K. Acharia, V. K. Singh, Today & Tomorrow's Printers and Publishers, New Delhi, 27-52, 2020. ISBN: 9788170196679

Hungarian scientific articles in Hungarian journals (3)

3. Kontschán, J., **Bodnár, D.**, Ripka, G.: Új adatok a hazai levélbolhák (Insecta:Psylloidea) előfordulásához III.
Növényvédelem. 58 (9), 394-397, 2022. ISSN: 0133-0829.

4. Ott, P. G., Mergenthaler, E., Viczián, O., **Bodnár, D.**: Az ESFY kutatás története.
Növényvédelem. 55 (7), 304-310, 2019. ISSN: 0133-0829.

5. **Bodnár, D.**, Mergenthaler, E., Viczián, O., Tarcali, G.: A csonthéjasok európai sárgasága (European stone fruit yellows, ESFY) fitoplazma vektorának, a szilva levélbolhának (Cacopsylla pruni Scopoli) vizsgálata Boldogkőváralja környékén = Examination of the plum psyllid (Cacopsylla pruni Scopoli), a vector of European Stone Fruit Yellows (ESFY) phytoplasma in the countryside of Boldogkőváralja (Hungary).
Agrártud. Közl. 71, 5-11, 2017. ISSN: 1587-1282.
DOI: https://doi.org/10.34101/actaagrar/71/1560

Foreign language scientific articles in Hungarian journals (4)

6. **Bodnár, D.**, Viczián, O., Juhász, A., Fodor, J., Ott, P. G., Mergenthaler, E.: A survey of jumping plant-lice (Hemiptera: Psylloidea) overwintering on conifers in Hungary.
Acta Phytopathol. Entomol. Hung. 57 (2), 106-114, 2022. ISSN: 0238-1249.
DOI: http://dx.doi.org/10.1556/038.2022.00156

7. **Bodnár, D.**, Szalai, B., Tarcali, G., Viczián, O., Mergenthaler, E.: Phytoplasma infection status survey in plum psyllid (Cacopsylla pruni) population.
Agrártud. Közl. 2, 45-48, 2019. ISSN: 1587-1282.
DOI: http://dx.doi.org/10.34101/actaagrar/2/3678

8. **Bodnár, D.**, Csüllög, K., Tarcali, G.: Review of the biology of plant psyllid (Cacopsylla pruni, Scopoli 1763), and its role in the spreading of European stone fruit yellows, ESFY-phytoplasma with Hungarian data.
Agrártud. Közl. 74, 25-33, 2018. ISSN: 1587-1282.
DOI: https://doi.org/10.34101/actaagrar/74/1660

9. **Bodnár, D.**, Tarcali, G.: European stone fruit yellows (ESFY) and its vector (Cacopsylla pruni, Scopoli) presence in Borsod-Abaúj-Zemplén County.
Georgicon Agric. 21 (1), 76-91, 2017. ISSN: 0239-1260.

Foreign language scientific articles in international journals (1)

10. **Bodnár, D.**, Koczor, S., Tarcali, G., Tóth, M., Ott, P. G., Tholt, G.: Cacopsylla pruni (Hemiptera, Psyllidae) in an apricot orchard is more attracted to white sticky traps dependent on host phenology.
Biodivers. Data J. 10, 1-16, 2022. ISSN: 1314-2836.
DOI: http://dx.doi.org/doi: 10.3897/BDJ.10.e93612
IF: 1.54 (2021)

Hungarian abstracts (1)

11. Varga, M., Viczián, O., Mergenthaler, E., **Bodnár, D.**, Tarcali, G.: Északkelet-magyarországi kajszi ültetvények fitoplazma fertőzöttségének vizsgálata.
In: 27. Tiszántúli Növényvédelmi Fórum : Program és Összefoglalók. Szerk.: Kövics György, Tarcali Gábor, Debreceni Egyetem Mezőgazdaság-, Élelmiszertudományi és Környezetgazdálkodási Kar, Debrecen, 56-57, 2022.

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12. Viczián, O., Fodor, J., **Bodnár, D.**, Mergenthaler, E.: Az amerikai lepkekabóca (Metcalfa pruinosa): Igazoltan új fitoplazma vektor: Rövid áttekintés az amerikai lepkekabócáról, amelynek igazoltuk az AY fitoplazma átviteli szerepét bársonyvirágon.
Növényvédelem. 57 (1), 12-18, 2021. ISSN: 0133-0829.

13. Tarcali, G., **Bodnár, D.**, Csüllög, K.: Növényorvosok élelmünkért, egészségünkért: Beszámoló a 12. Növányorvos Napról.
Növényvédelem. 53 (78), 550-556, 2017. ISSN: 0133-0829.

Foreign language scientific articles in Hungarian journals (1)

14. Kovács, G. E., **Bodnár, D.**, Tarcali, G., Radócz, L.: Biological control of sweet chestnut on Pécsbánya, Hungary.
Agrártud. Közl. 2018 (74), 77-81, 2018. ISSN: 1587-1282.
DOI: http://dx.doi.org/10.34101/actaagrar/74/1668

Foreign language scientific articles in international journals (1)

15. Mergenthaler, E., Fodor, J., Kiss, E., **Bodnár, D.**, Kiss, B., Viczián, O.: Biological and molecular evidence for the transmission of aster yellows phytoplasma to French marigold (Tagetes patula) by the flatid planthopper Metcalfa pruinosa.
Ann. Appl. Biol. 176 (3), 249-256, 2020. ISSN: 0003-4746.
DOI: http://dx.doi.org/10.1111/aab.12582
IF: 2.75

Hungarian conference proceedings (1)

16. Csüllög, K., **Bodnár, D.**, Albert, R., Tarcali, G.: A paprika száraz magházkorhadása (Alternaria alternata (Fr.) Keissl.) és a kalciumhiány okozta nekrózis kapcsolata.
Georgicon Agric. 22 (1), 7-12, 2018. ISSN: 0239-1260.

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17. Kovács, G. E., **Bodnár, D.**, Radócz, L.: Dissemination of Cryphonectria parasitica (Murr.) Barr fungus, and the possibilities of protection of a chestnut ochard in Romania. *Georgicon Agric. 23* (1), 21-28, 2019. ISSN: 0239-1260.

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