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December 2017

Environmental management, land use, biodiversity

FROM CONTENTS

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Dear Reader,

You are holding the last, fourth issue of volume XXVI. of the Hungarian Agricultural Research's newspaper in your hands. As you may recall, we have drawn your attention to the extension of the journal's subjects in the prologue of our first issue. In this context and keeping in mind the importance of sustainable agricultural production, this year the issues of environmental management, land-use and biodiversity were touched upon in the journal. The positive and supportive feedback from our readers and authors corroborate the rightness of the decision.

In this current paper two topics are highlighted. We consider it important to feature present situation and the development opportunity of farms, our country's characteristic settlement from a land-use and landscape maintenance point of view, also to display the results of the past 6 years of the Farm Development Programme run by the Ministry of Agriculture.

Three articles are dealing with biodiversity in this current journal. One of them is about the uptake of spotted wing drosophila (Drosophila suzukii), a non-native, highly invasive and in Europe rapidly spreading species. The second writing covers the possibilities and results of biological protection against the common, worldwide known invasive pest, the sweet chestnut gallwasp (*Dryocosmus kuriphilus*). The third writing addresses the topic of the connection between sustaining biodiversity and the densely populated settlements, describing the mortality of the river clubtail (Gomphus flavipes) in Budapest, taking into consideration the vessel traffic along the Danube and other disturbing factors.

We sincerely hope that these relevant writings, but also the new thematic of the paper will appeal to you and we can welcome you as a reader or even as an author in the future!

HUNGARIAN
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DEVELOPMENT POSSIBILITIES AS PART OF THE FARMSTEAD DEVELOPMENT PROGRAM

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ABSTRACT

Hungary has got its own special settlement types' structure which over the past few decades has already experienced prosperous and declining periods as well. The population living in farm areas reached its maximum in the 1945 Land Reform, since then there has been a continuous decline in the number of people living there. Parallel to the demographic decline, an economic restructuring also took place. At the same time with the transformation of the farm system, there were significant changes in the types and roles of farms.

keywords: farmstead, development

INTRODUCTION

In view of the experience gained over the last fifty years, it is considered that with the residential population decline the population in peripheral areas has also declined steadily. Table 1 shows the population change in peripheral areas located in counties in the Hungarian Great Plain according to the data of population census between 1960 and 2011. Based on the data of population census carried out in 2011, it is considered that approximately 300.000 people live in peripheral areas, and 200.000 of them live on farms in Hungary. However it must be stressed that since the population census was carried out in 1990, it has been a problematic issue to survey the exact number of people living on farms, because since that year the Hungarian Central Statistical Office has not used anymore the expression of farmstead and treated peripheral areas and farm together (Font, 2006), therefore the size of the farmstead population can only be estimated.
According to Table 1, with the continuous decline of the population in peripheral areas, the types of farmsteads have also changed. Besides traditional farmstead management, new functions (for instance journeyman riding), and

Figure 1: New functions appeared on a farm in Homokhát (photographed by Róbert Romvári)

Table 1: The change of the population in the peripheral areas in the Hungarian Great Plain between 1960 and 2011 (Edited by Róbert Romvári)

County	1960	1970	1980	1990	2001	2011
Bács-Kiskun	211 954	165 220	101 610	68 192	66 009	66 132
Békés	106 220	63 336	33 537	22 677	19 713	15 800
Csongrád	121 165	91 177	56 937	37 414	39 125	34 783
Hajdú-Bihar	72 921	53 632	26 674	17 501	18 806	24 471
Jász-Nagykun-Szolnok	89 824	54 992	23 414	14 051	12 065	10 541
Szabolcs-Szatmár-Bereg	83 226	64 748	36 125	24 162	41 775	20 173
Total	685 310	493 105	278 297	183 997	197 493	171 900

source: TEIR

other complementary activities (artisanal activities) have also appeared as the part of farm management (*Figure 1*).

While in the past the farm was the scene of agriculture, now only one-quarter of the farm population lives by farming according to surveys (Kozma, 2011). After the functional change, the rural farm-village tourism has been treated by more farmers as an earning opportunity which is based on the existing traditional agriculture. The farmstead tourism is an important part of the rural development, thus with the development of the farm tourism it could be reached to stop migration from farm areas and to lay the future of the younger generation living on farms. Besides the natural and built environment, the presentation of traditional agricultural activity, local lifestyle, folk customs and traditions as possible attraction connected to the typical settlement types of the Hungarian Great Plain can constitute an important part of tourism.

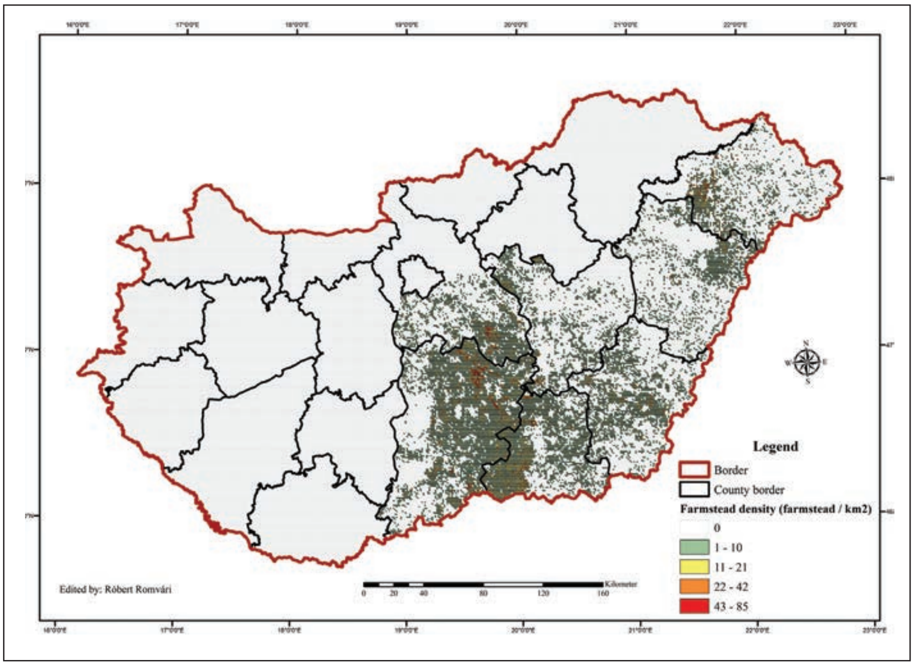

Figure 2: Farmsteads' spatial distribution according to the farm survey in the Great Plain in 2016 (Edited by Róbert Romvári)

GEOGRAPHICAL DISPLAY OF FARMS

Until the spring of 2016 it was a huge problem, that there were no reliable data available of the exact location and current condition of the Hungarian farms, which caused significant problems for developing the infrastructure and the general condition of farms. In recognition of this fact, and in line with the government's objective (of ensuring electricity supply for all farms and ensuring road networks in order all isolated farms can be accessed until 2020), in March and April of 2016 a centrally organised survey on farms was carried out relating to the entire Hungarian Great Plain (724 settlements), under which 95 thousand data sheets were recorded. The data sheets contained questions regarding the environment status; demographic, economic and infrastructure characteristics of homesteads. The main aim of the survey was a compilation of a database in which all farmsteads' geographic locations in the Hungarian Great Plain can be identified by using theirs GPS coordinates. Using farmsteads' GPS coordinates and ArcGIS 10.4.1 program, a density map was created which divided the Great Plain into square nets of 1x1 km (*Figure 2*).

According to Figure 2, comparison data on the population density in farm areas does not show any discrepancy between the results of the survey and the findings of previous technical literature. In view of this, it must be said that the typical areas of the country inhabited mostly by farmers are located near the settlements of Homokhátság, Nyíregyháza and Békéscsaba. These three hubs were established not by chance, and based on plot layout we can distinguish three different types of farm areas: 1. settlements so called „*szórvány*" near the city of Kecskemét („*szórvány*": the main feature of this type of settlement is that the residential buildings are separated or are in small groups (up to 10 or 20) and their establishment is usually linked to agriculture), 2. settlements so called „*sortanya*" typically located in the County of Békés („*sortanya*": the main feature of this type of settlement is that the residential buildings are concentrated in one line alongside a road or waterfront) and 3. settlements so called „*bokortanya*" in the Nyíregyháza Region („*bokortanya*": the main feature of this type of settlement is that the residential buildings lie between arable lands, on the land borders in small group). Another important objective of the cited farm survey was to measure the range of farms without electricity and to draw up options, proposals on the issue in regard to energy supply. During the survey, approximately 4800 residential buildings and homesteads with farming function were identified without connecting to any public electricity network or having an electric (power) generator in island mode operation.

THE FARMSTEAD DEVELOPMENT PROGRAM

In 2011, the Hungarian Government launched the Farmstead Development Program in order to renew the traditional farm management, to reduce the disadvantages of the farming lifestyle, and to sustainably develop and improve farm areas. This tender opportunity contributes to the governmental objectives of providing electricity and ensuring approachable roads for all isolated farms until 2020. The resources of the Program are national resources each year, which are part of Hungary's budget for the given year. Present study concentrates on the introduction of those target areas of the Program, which specifically aim the development of farm areas (in the following: farm tender). The wide range of settlements entitled to apply for subsidies proves the popularity of the farm tender (*Figure 3)*.

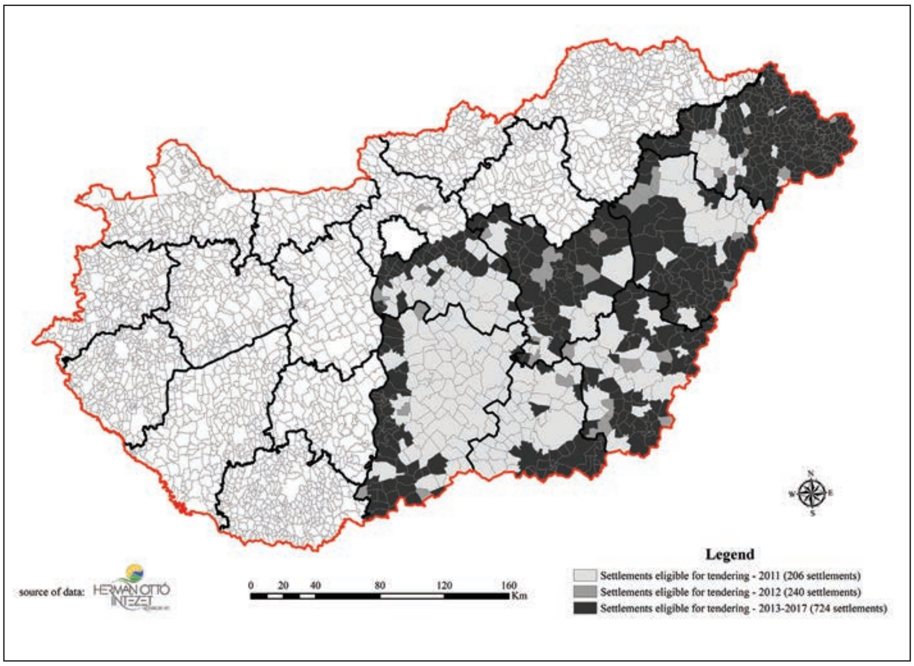

Figure 3: The extension of the range of settlements eligible for applying (Edited by Róbert Romvári)

The definition of a farm is interpreted by the Farmstead Development Program as follows: *„an area of land with a size of one hectare at most, located on the outer belt area of a settlement. In addition a residential building, and an outbuilding or such a group of buildings belong to the land all devoted to the primary objective of producing plants and animals, as well as processing and storing related products; or such an area of land which was registered as farm in the land registry."*.

In accordance with Figure 3, in the year of the farm tender inception, applications could be submitted by local governments and individual farmers from 206 settlements in the Hungarian Great Plain. The vast majority of the eligible settlements have village (the number of the residents is at least 300) or small town (the number of the residents is at least 5000) status, but five settlements with county seat status (Debrecen, Szeged, Hódmez vásárhely, Kecskemét, Nyíregyháza) are also on the list of settlements entitled to apply. From 2012, after extending the settlements entitled to apply with 34 new settlements (including Békéscsaba as a county town), the total number of settlements entitled to apply has reached 240 in the Great Plain ("*Alföld*") region. Since 2013, all settlements in the Hungarian Great Plain have become eligible to apply for farm subsidies which means that a total of 724 settlements were on the eligible settlements list.

Table 2 provides summarized data to the farm tender for the period from 2011 to 2017. According to the successful tenderers, this application opportunity provides a real chance for farmers to carry out essential developments.

According to Table 2, since the farm tender commencement in 2011, more than 1 938 applicants have been received non-repayable grants in the amount of 8.3 billion Forints.

Table 2: The main features of the farm tender (Edited by Róbert Romvári)

Year	The number of settlements entitled to apply for subsidies	The number of applications being submitted	The number of applications being accepted	The number of applications being funded	The amount of subsidies funded (M Ft)
2011	206	441	290	201	930
2012	240	422	311	205	1 017
2013	724	1 004	776	515	3 373
2014	724	218	124	117	297
2015	724	1 735	1 330	360	1 216
2016	724	478	358	253	728
2017	724	475	394	287	807
Total		4 773	3 583	1 938	8 368

Source: Herman Ottó Institute Nonprofit Ltd.

Table 3: The winners of the farm tender according to target areas between 2011 and 2015 (Edited by Róbert Romvári)

Year	Target area 1	Target area 2	Target area 3	Target area 4	Total
	Municipal and regional developments	Supporting the development of farming	Supporting farming start-ups	Supporting individual developments to secure residential buildings' basic energy supply located on farms without electricity	
2011	70	131	did not start	did not start	201
2012	84	121	did not start	did not start	205
2013	186	196	70	63	515
2014	did not start	89	did not start	28	117
2015	99	159	76	26	360
Total	439	696	146	117	1 398

Source: Herman Ottó Institute Nonprofit Ltd.

Table 4: The winners of the farm tender according to target areas between 2016 and 2017 (Edited by Róbert Romvári)

	1. target area	2. target area	3. target area	Total
	Municipal and regional developments	Supporting farming start-ups and agriculture developments with a small amount of money	Individual developments for renovation residential buildings located on the farms, and for ensured residential and property security	
2016	67	146	40	253
2017	114	142	31	287
Total	181	288	71	540

Source: Herman Ottó Institute Nonprofit Ltd.

Between 2011 and 2015, local governments and farmers were able to apply for four different target areas. Table 3 shows the winner applications for the period from 2011 to 2015 broken down by target areas.

Nearly 31.5 % of the winning applications were those which were launched only for local governments in target area of „*municipal and regional developments*". More than 60 % of the winning applications were launched in the target areas of 'supporting the development of farming' and 'supporting farming start-ups. The winning applicants in the fourth target area which were opened only for individuals living on farms without electricity, represented just 8.5 % of the total sample size.

Since 2016 the Ministry of Agriculture – the authority issuing the tender for the Farmstead Development Program – has been aligning the applications with the Rural Development Program to avoid duplicate funding. Therefore, the development of outback roads, purchase of road maintenance machines, support of electricity, water and sewage investments are no longer parts of the applicable goals of the Program. In consequence of the aforementioned changes in 2016 and 2017 applications were accepted for the following three target areas:

- 1st target area: Municipal and regional development;
- 2nd target area: Supporting farming start-ups and agriculture developments with a small amount of money;
- 3rd target area: Individual developments for renovating residential buildings located on the farms, and for ensured residential and property security.

Table 4 contains data about the winner tenderers of 2016 and 2017 according to target areas.

33.5 % of the winner tenders were submitted in the first target area, 53.3 % in the second area and 13.2 % in the third target area. Within the framework of „*municipal and regional development*", „*the development of farm caretaker services*" was the most popular sub-target (75 tender – support of 158.9 million Forints).

Figure 4 was prepared after processing tenders received during 2011 and 2017 and the announcement of results, which shows the geographical location of the 1 938 winner tenders received subsidies during the period considered.

The winner tenders were submitted from 293 settlements, and seven applications were registered (1 -from Pécs, 6 - from Budapest) by the employees of the Herman Ottó Institute Nonprofit Ltd. which were not eligible to tender based on headquarters, but they were eligible to tender for the subsidies based on the location of implementation (settlements marked with red on Figure 4). Farms located in Kiskunmajsa (83), Kecskemét (55), Mórahalom (54), Csólyospálos (39), and Mezőtúr (38) hosted the greatest number of successful applicants.

After examining the last closed seven years (2011-2017), about the tender winners we can say that „*supporting farming start-ups and agriculture developments with a small amount of money*" was the most popular target area (most applications were submitted for this purpose) with its 1 130 winning applications and 2.8 billion Forints granted aim. The „*support of farming products getting to*

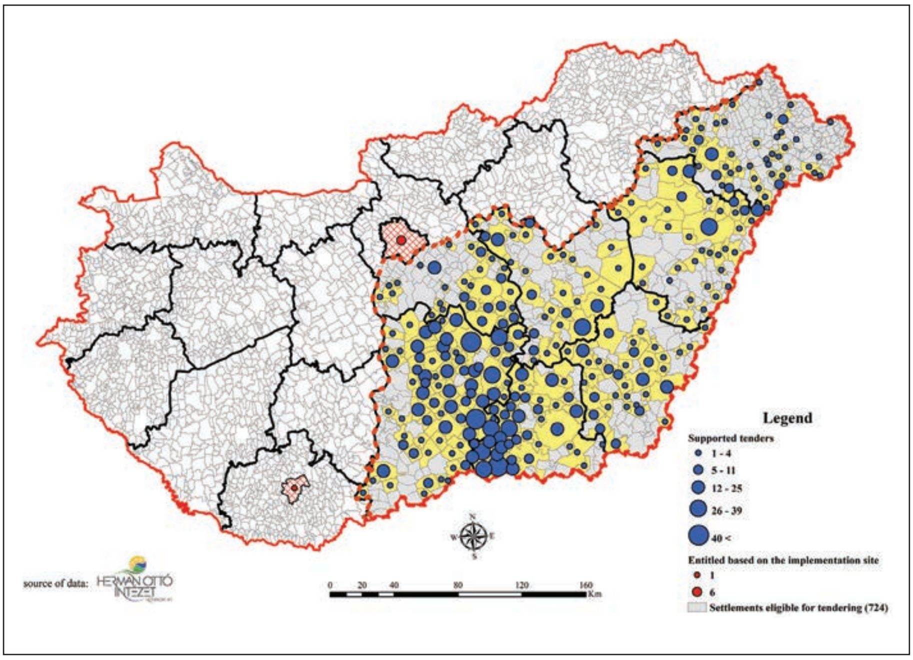

Figure 4: Winner tenders received subsidies during 2011-2017 (Edited by Róbert Romvári)

the market" sub-target must be mentioned as a curiosity because over the 3 years mentioned above 78 winning applications were published with 2.6 billion Forints granted aim connected to this sub-target area. In the sub-target area such as „*the implementation of county-farm survey*" and „*the introduction, development of trademark and quality system for farming products*" registered the lowest number of supported applications (2 and 5). It must be added that both targets were launched only once.

Finally, it is important to stress that a pivotal question regarding the future of the examined type of settlement, is what kind of complex programs are able to solve the special requirements arising in the improvements of farms. Therefore, special emphasis shall be placed in particular on the application resources (both domestic and EU) which make it possible to improve the lack of essential services and the bad infrastructure situation in farmlands.

In order to solve this problem, the Ministry of Agriculture intends to launch a new tender connected to the Farmstead Development Program in the year 2018. In connection with the future of the Farmstead Development Program, Zsolt V. Németh, the Minister of State for Environmental Affairs, Agricultural Development and Hungaricums of the Ministry of Agriculture reported on a press conference in November 2017 that the portfolio has set apart 1.2 billion Forints for supporting the developments in 2018. It is also a priority aim to support traditional – sustainable – farm management methods, to extend the basic infrastructure network, and to ensure access to basic services in farmlands. It is also among the goals of the Ministry of Agriculture to simplify the tendering system and to digitalize the application process as much as possible, contrary to the previous, largely paper-based process.

CONCLUSION

Over the last half century, the number of people living on farms has dramatically reduced. In parallel with the dwindling population, the demographic, social and infrastructural situation of farmed areas have also deteriorated. At the same time the traditional rural farming function has also altered, in some regions it has completely disappeared. Partly due to the altered employment structure, partly due to the development of the settlement network, new, so far unknown functions have appeared in farming life. These new functions could also be a great opportunity for the future, if the adequate infrastructural background was ensured.

The financial resources of the Farmstead Development Program could help achieve these goals. With regard to the Farmstead Development Program, the comments concern the efficiency of government actions undertaken hitherto: it appears that after long decades a successful support line has managed to launch which can give hope for farmers. This finding is confirmed by the facts that there is a growing intend to submit tenders, and there is a continuous expansion of available funds which reflect the firm commitment of the Government to the Farmstead Development Program.

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RESULTS OF THE SURVEY FOR THE INVASIVE *DROSOPHILA SUZUKII* (MATSUMURA) (DIPTERA: DROSOPHILIDAE) IN HUNGARY

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ABSTRACT

The spotted wing drosophila, *Drosophila suzukii* (Diptera: Drosophilidae) is a polyphagous fruit pest of great economic importance. This pest became widespread throughout Hungary, within three years after its first appearance in 2012. Extensive national monitoring has been carryied out for *D. suzukii* since 2013. The main aim of the survey is to track the nationwide spread of the species in fruit plantations, in the highways and in forest areas, as well as to reveal the risk factors for its increased damage and to clarify its ecology under Hungarian climatic conditions. In Hungary between 2014-2016 *D. suzukii* occurred mostly in the traps located in plum, cherry, peach, nectarine and blackberry orchards. Furthermore the situation that *D. suzukii* is present also in the forests, far from the inhabited area, and in alternative hosts, could strengthen the role of non-cultivated wild host plants in maintaining the populations of this pest. Meteorological factors can also have a remarkable effect on the number of *D. suzukii* individuals in our country.

Keywords: *Drosophila suzukii*, spotted wing drosophila, invasive pest, fruit damage

INTRODUCTION

Drosophila suzukii (Diptera: Drosophilidae) is a polyphagous fruit pest that has become nowadays widespread in Europe, furthermore has a great economic importance in many countries in Europe, Asia and both in the North- and South-America. Its rapid spread is an outstanding example of the biological invasion processes prevalent in the Western Hemisphere. The rapid spread of *D. suzukii* across both North-America and Europe could result from human-assisted movement of products, long-distance migration, or a combination of the two (Asplen et al. 2015). According to Cini et al. (2012), this species means one of the biggest threats for fruit plantations under moderate climates. *D. suzukii* belongs to those few Drosophilidae species that are able to lay their eggs into the healthy ripening or ripe fruits with their serrated ovipositor (Mitsui et al. 2006; Lee et al. 2011). Due to the development and the feeding of the larvae, the fruit becomes unproductive (Cini et al. 2014). Spotted wing drosophila possesses a broad host range including thin-skinned berries (e.g. caneberries, blueberries, strawberries) and stone-fruits (e.g. cherries, peaches, apricots, plums) being particularly susceptible to infestation (Bellamy et al. 2013). Despite its relatively recent detection, *D. suzukii* has already caused severe yield losses in several small fruit crops grown across southern Europe, such as sweet cherries, strawberries, raspberries, blackberries, and blueberries. Extreme damage has been reported for locations in Northern Italy (Trentino) and France, with up to 100 % damages on caneberries, strawberries, and sweet cherries (Cini et al. 2012; Weydert and Mandrin 2013). The wide polyphagy of the species – including a number of wild berries –, may also contribute to its easy establishment in new areas (Poyet et al. 2015). The efficient flight activity of *D. suzukii* promotes its rapid spread (Calabria et al. 2012). As for the passive way – that is more important for its spread – spotted wing drosophila could easily spread by commercial distribution of its host plants, because of the hidden development of the eggs and the larvae in the fruits (Cini et al. 2012). *D. suzukii* came from Southeast Asia (Kanzawa et al. 1939 – cit. Cini et al. 2014) and appeared almost simultaneously in 2008 in the USA, California (Hauser et al. 2009) and in Europe, Spain (Calabria et al. 2012). Since then, it has become a key pest in both continents. After then it has spread rapidly and has appeared in many European countries (Cini et al. 2012; Asplen et al. 2015). In Hungary the first appearance of spotted wing drosophila was observed in a highway service area, near Balaton, in Táska (Fig 1), in autumn 2012 by Kiss et al. (2013), away from the orchards and urban areas. In 2013, the species occurred more frequently in the traps placed out in the Hungarian highway service areas, however in that year this pest was absent in the different fruit orchards (Lengyel et al. 2015). This phenomenon also points to the prominent role of the motorways as they could contribute to the passive spread of some invasive pests in the international trade of commodities (Kiss et al. 2016). In 2016, *D. suzukii* caused sensible damages in blackberries and raspberries in different parts of Hungary (Kiss et al. 2017). The Plant Protection Institute of the Centre for Agricultural Research of the Hungarian Academy of Sciences and the National Food Chain Safety Office, Plant Health and Molecular Biology National Reference Laboratory has been carrying out extensive national monitoring for *D. suzukii* since 2013. The main aim of the survey is to track the nationwide spread of the species in fruit plantations, in the highways and in forest areas, as well as to reveal the risk factors for its increased damage and to clarify its ecology under Hungarian climatic conditions.

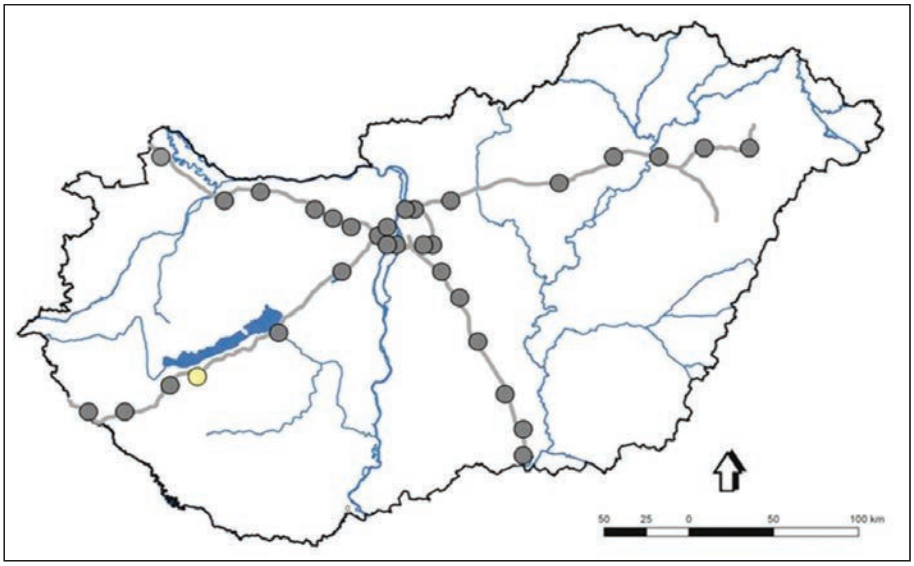

Figure 1. Sampling locations in the highway service areas (Yellow spot means the first appearance of *Drosophila suzukii* in Hungary in 2012)

MATERIAL AND METHODS

The official survey of *D. suzukii* in orchards was conducted parallel with the survey in highway service areas and in forest habitats in Hungary. Between 2013-2016, the plant protection inspectors carried out official survey of *D. suzukii* in two sampling places per county. The trapping period lasted seven months from the placing of the traps, starting in the beginning of May. The traps consisted of transparent plastic bottles of 500 ml, with tiny holes (d=3 mm) on the upper third, on one side. The traps contained 100 ml commercial apple cider vinegar with 5% acid content as attractant and trapping substrate. The bottles were hung on trees or bushes at 1.5 m high. The samples were collected and transported to the laboratory in every three weeks, where the numbers of males and females of *D. suzukii* were counted. In the survey in highway service areas identical traps were installed at 34 sites, representing two transects of the country (Fig 1). The traps in highways were working during three weeks in September between 2013 – 2016 (and for another three week period in November 2015). Trapping in wild areas was carried out in the surroundings of four locations (Dömös, Pilisvörösvár, Sándorfalva and Szeged), in eleven different forest habitats. The sampling sites were 1-2 km far from the inhabited area. Installation of the traps (four traps/sampling site) was between 10.10.2015 and 27.10.2015 and three weeks later the samples were collected and transported to the laboratory to count *D. suzukii* individuals.

RESULTS AND DISCUSSION

In 2013, in the official traps no *D. suzukii* individuals were captured. In 2014 the catches of spotted wing Drosophila increased dramatically from August in the traps located in the fruit orchards throughout the country. By 2016 the species spread over most parts of the country, except for the Eastern-North-Eastern regions (Fig. 2). In 2014, 2015 and 2016 a total of 91,955, 4523 and 82,250 individuals were captured by the traps, respectively. The tendency was the same in the highway service areas according to the trapping results. The average number of the captured *D. suzukii* individuals during autumn periods was much higher in 2014 and 2016 than in 2015 (Fig. 3). The sex ratio of *D. suzukii* was approximately 50% in all sampling location throughout Hungary (Kiss et al. 2016).
In 2014-2016 *D. suzukii* occurred in the largest number in Somogy and Nógrád counties. In 2016, the catching data of Komárom-Esztergom and Zala counties were also remarkably high. Swarming *D. suzukii* individuals could be captured in 2014 from the end of August, in 2015 from mid-August, in 2016 from early July to early December. In all three years, the majority of individuals occurred in the second to third decade of October all over the country (Fig. 4). By comparison, according to the observations of Julius Kühn Institute (JKI) in 2012 in Germany (Fig. 5), *D. suzukii* individuals were captured in a mixed berry plot from the beginning of August until the beginning of December, and the peak flight of individuals was in mid-October (Asplen et al. 2015). This situation is similar in most Mediterranean areas, relatively low populations are observed in spring but the numbers increased rapidly during the summer months, peaking in late autumn (Weydert and Mandrin 2013). In Germany high post-harvest adult

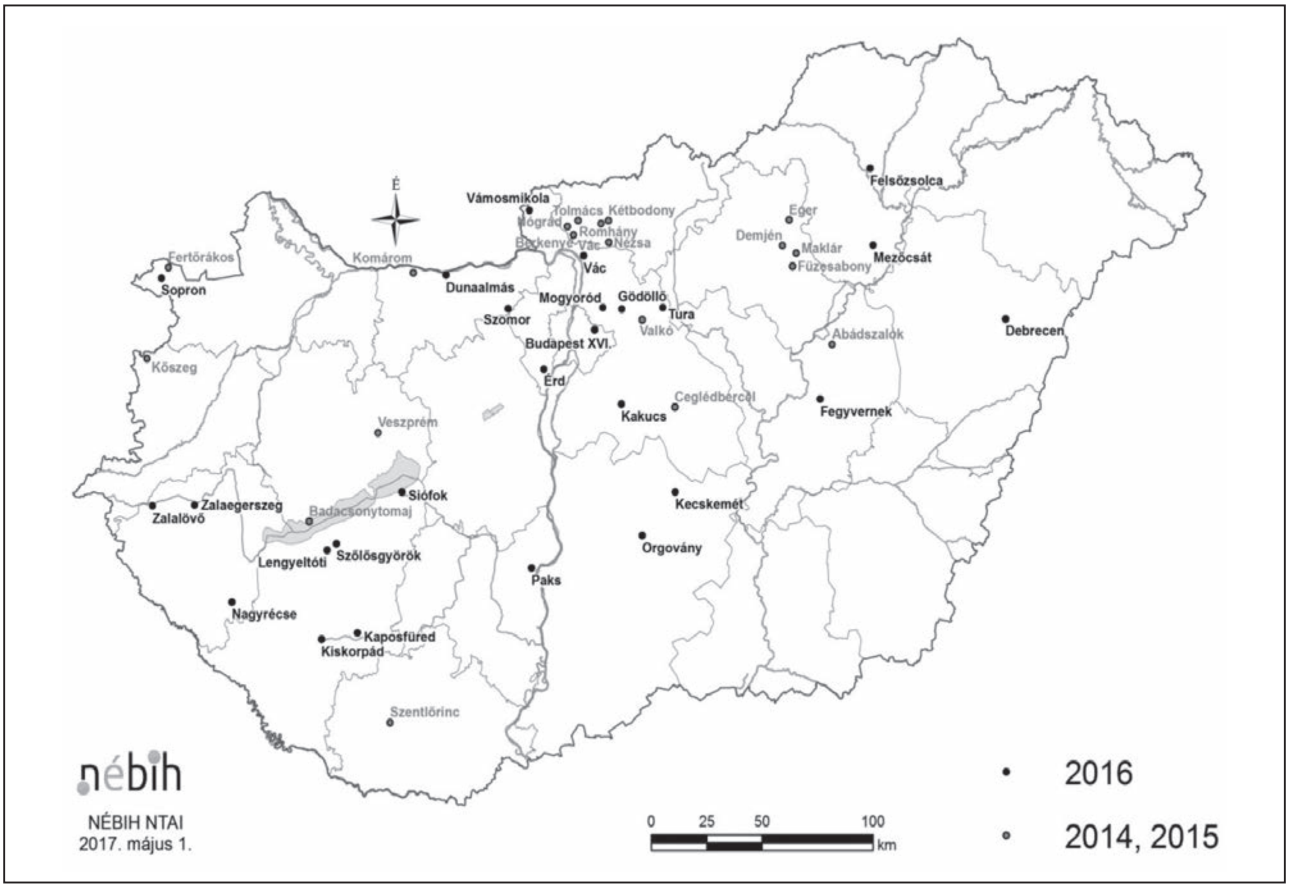

Figure 2. Occurrence of *Drosophila suzukii* captured by official traps in Hungary

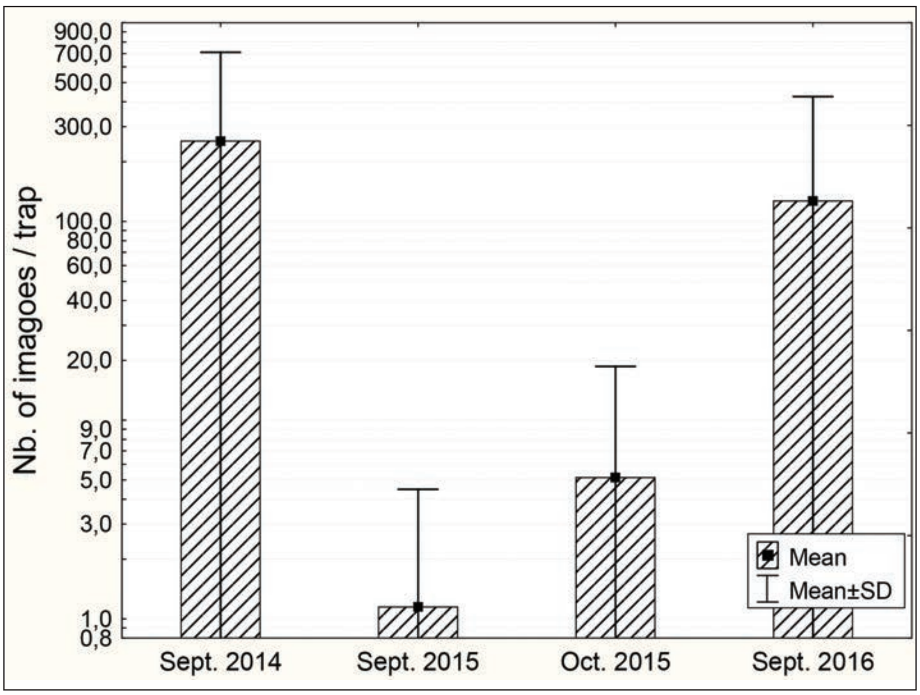

Figure 3. Average catching data of D. *suzukii* in highway service areas during autumn periods

capture rates were found both in orchards (cherry or apple) and in wild areas (Briem et al. 2015). In autumn, increased captures of *D. suzukii* could relate to decreasing temperatures serving as a stimulus to search for suitable overwintering habitats (Asplen et al. 2015). It can be seen that the tendency of spotted wing drosophila phenology is similar throughout Europe.

\s Figure 3. Average catching data of *D. suzukii* in highway service areas during autumn periods

In Hungary between 2014-2015 *D. suzukii* occurred mostly in the traps located in plum, cherry and blackberry orchards. The trapping results were remarkable in 2014 in nectarines, and in 2016 in peach orchards as well (Table 1). By comparison, the largest numbers of the pest in Belgium were found in sweet

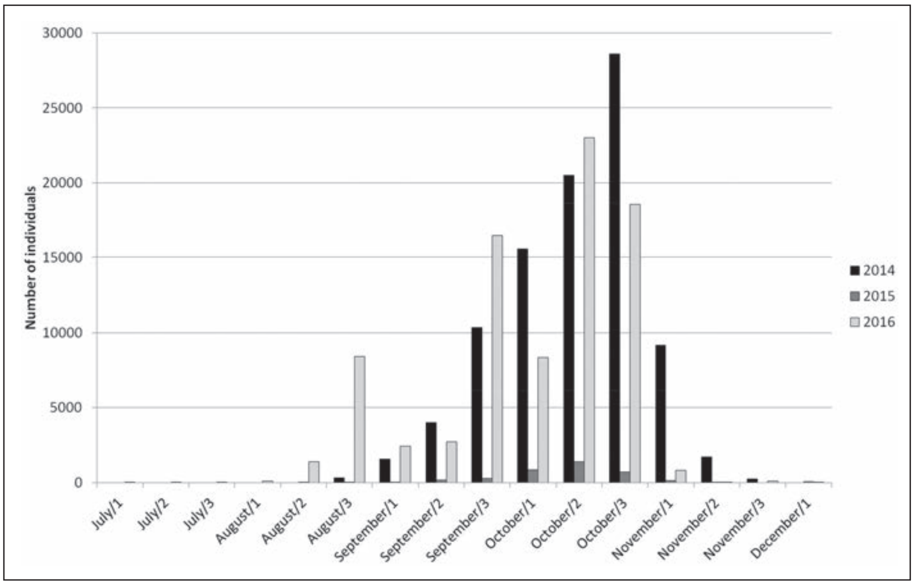

Figure 4. Phenology of *D. suzukii* according to the catching data of the official traps

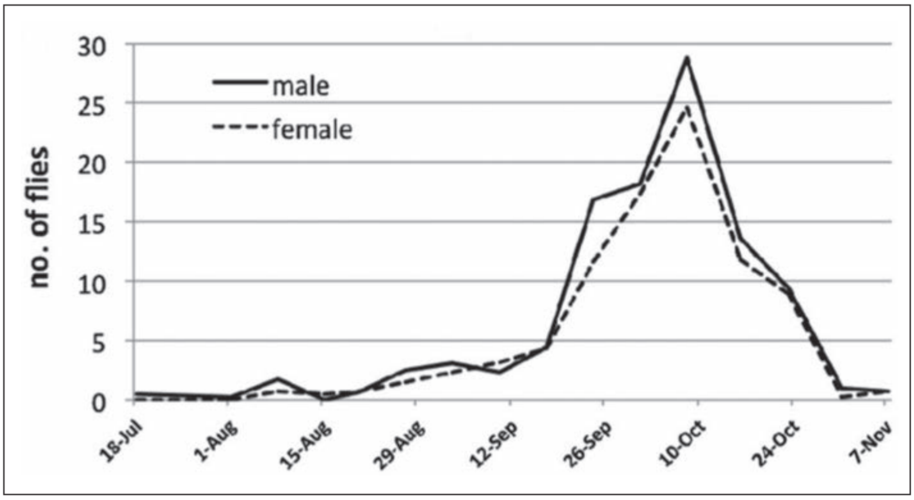

Figure 5. Average number of adult *D. suzukii* captures per trap in a mixed berry plot (raspberry, blackberry red/black currants) (JKI Dossenheim, Germany, 2012; after Asplen et al. 2015)

Table 1. Catching data (number of individuals) of D. suzukii in the traps located in different host plants

Host plants	2014 average catching data	2015 average catching data	2016 average catching data
apple	44	-	28
elderberry	-	-	4090
cherry	-	12	-
raspberry	100	52	34
sour cherry	3123	31	759
nectarine	3053	-	38
peach	92	18	572
blackberry	-	13	25
strawberry	2450	119	921
plum	1956	171	1378
grapes	6	23	66

cherries, but *D. suzukii* was also present in plums, strawberries, raspberries, and blueberries (Belien 2013). In Austria, the main hosts appear to be elderberries, late ripening raspberries, and blackberries, however neither captures nor fruit infestations have been reported from grapes (Lethmayer 2012).

Considering the fact that these fruits are the published hosts of *D. suzukii* (Cini et al. 2012; Asplen et al. 2015), the high number of individuals captured by the traps could also be an important risk factor for the affected area and orchards. Therefore, it is very important in the next years to focus on the plum, cherry and blackberry orchards that could be a risk factor for fruit species in Hungary for spotted wing drosophila, and to plan further studies for investigating the damages of this pest. In Hungary, Kiss et al. (2017) already observed the damage of *D. suzukii* on Sugana-type raspberries, which can reach up to 100% under favourable conditions for the species. It is noteworthy that in October 2016 we counted 4090 individuals in a single trap located in elderberry plantations in Bács-Kiskun county (Table 1). Based on this result it can be assumed that wild hosts can also play a prominent role in the survival and spread of *D. suzukii*. From many invaded areas have been reported high trap counts in wild areas suggesting an important role for non-cultivated host plants in maintaining spotted wing drosophila populations. In European forests, *D. suzukii*-infested raspberries, blackberries, and other wild plants are common (Asplen et al. 2015). Also in our study spotted wing drosophila occurred in every sampling sites in the wild in Hungary (Table 2). A total of 183 specimens were captured from the eleven

Table 2. Catching data of *D. suzukii* in the traps located in forest habitats					
Time of sampling	**Locations of wild areas**	**Altitude (m)**	**Distance from inhabited area (m)**	**Number of D. suzukii male specimens**	**Number of D. suzukii female specimens**
17.11.2015	Dömös - deep in the forest (beech)	275	1426	1	0
17.11.2015	Dömös - road for tourists (hornbeam)	175	1040	0	8
17.11.2015	Dömös - border of the town	136	0	2	4
17.11.2015	Visegrád-Hills - public road	315	1961	9	9
31.10.2015	Pilisvörösvár - deep in the forest	316	1979	0	1
31.10.2015	Pilisvörösvár - deep in the forest 1 (wild berries)	318	1961	8	6
31.10.2015	Pilisvörösvár - deep in the forest 2 (wild berries)	316	1861	11	8
31.10.2015	Pilisvörösvár - edge of the forest	233	565	6	19
31.10.2015	Pilisvörösvár - border of the village	222	0	14	23
15.11.2015	Újszeged - small forest	76	284	15	14
15.11.2015	Sándorfalva - deep in the forest	81	1219	11	14
	Total			77	106
				183	

sampling locations during the autumn period of 2015. This situation that *D. suzukii* is present also in the forests, far from the inhabited area, could strengthen the role of non-cultivated wild host plants in maintaining the populations of this pest.
Meteorological factors can also have a significant effect on the number of *D. suzukii* individuals (Wiman et al. 2014; Kiss et al. 2016). According to Kimura (2004), *D. suzukii* has weak cold tolerance under continental climatic conditions. Therefore particularly the cold winter can strongly decrease the number of overwintering specimens (Kiss et al. 2016). In summer, the high temperature (above 30 °C) and the low humidity can lead to decreased reproduction and even to the mortality of *D. suzukii* individuals (Asplen et al. 2015; Kiss et al. 2016). According to Dalton et al. (2011) low temperature (10 °C) may be a critical threshold for the biology of adults. Our results are in line with the literature data that point to the environmental needs of this pest indicating that the milder and humid summer with more precipitation and the milder winter than the average could play an important role in the increased reproduction of *D. suzukii* in 2014 and 2016, while in 2015 the dry and hot summer did not favour for the survival and reproduction of the pest. So as in the case of pest management, in general, it could also be true for *D. suzukii* that the meteorological conditions favouring the development of the species, mean an important risk factor for the pest damage. Additional studies are however needed for clarifying the biology and the phenology of this species and to find out more precisely which range of host plants this pest could potentially damage under continental climate conditions in Hungary.

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BIOLOGICAL CONTROL OF THE INVASIVE *DRYOCOSMUS KURIPHILUS* (HYMENOPTERA: CYNIPIDAE) IN HUNGARY

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ABSTRACT

Sweet chestnut gallwasp, *Dryocosmus kuriphilus*, is a globally invasive insect pest, spreading very quickly in new habitats and making serious damage to sweet chestnut stands and orchards in all European countries where sweet chestnut grows, including Hungary. Indigenous parasitoid species trophically associated with oak gallwasps have adapted to this new host but can not effectively regulate its population density. Classical biological control using parasitoid *Torymus sinensis* has been proven to be the only effective method of controlling the populations of *D. kuriphilus* and has been successfully applied in Japan, South Korea, the USA, Italy, France, Slovenia, Croatia and Hungary. A three years' report of release and establishment of *T. sinensis* to sweet chestnut forests in Hungary is available. Possible negative effects of *T. sinensis* on native parasitoid fauna and risks that could influence the successful establishment of *T. sinensis* in Hungary are discussed. Previous experiences have shown that *T. sinensis* can successfully control the population density of *D. kuriphilus,* slowing down the spread and mitigating negative impact of this invasive chestnut pest and keeping the damage of *D. kuriphilus* under economic threshold.

Keywords: sweet chestnut gallwasp, *Dryocosmus kuriphilus*, *Torymus sinensis*, classical biological control, Hungary

INTRODUCTION

Dryocosmus kuriphilus (further: DK) (Hymenoptera; Cynipidae) is a globally invasive insect pest, spreading very quickly in new habitats and making serious damage to sweet chestnut forests in Hungary and in all other European countries since the introduction to Italy in 2002 (Brussino et al. 2002, EFSA 2010, Matošević et al. 2014). It is considered as one of the major pest on sweet chestnut causing yield losses up to 80% (EFSA 2010). In its native range in China DK populations are kept at low, non-damaging levels by natural enemies (Aebi et al. 2007, Gibbs et al. 2011). This is not the case in the invaded countries (Japan, South Korea, the USA, Italy, Slovenia, Croatia, Hungary and France) where indigenous parasitoids have already shifted onto new host but their parasitism rates are low (Aebi et al. 2007, Santi & Maini 2012, Quacchia et al. 2012, Matoševi & Melika 2013).

Indigenous parasitoid species trophically associated with oak gallwasps have adapted to this new host but cannot effectively regulate its population density (Csóka et al. 2017). The average percentage of parasitism is low, around 2 - 4.5% (Matošević & Melika 2013, Quacchia et al. 2008) *Torymus sinensis* Kamijo (further: TS) (Hymenoptera: Torymidae) is a univoltine, host specific parasitoid coming from China like its host. Classical biological control using parasitoid TS has been proven to be the only effective method of controlling the populations of DK and has been successfully applied in Japan, South Korea, USA, Italy, France, Slovenia, Croatia and Hungary (Kriston et al. 2014, 2015; Matošević et al. 2014, 2015, 2017).

MATERIAL AND METHODS

Sampling of DK galls for rearing native parasitoids

Sampling of DK galls took place from March to April (overwintering galls) and from late May to the first half of June (collecting newly formed galls) from 2005 to 2016, in Italy, Slovenia, and Croatia and since 2014 in Hungary also. Prolong 10 years authors collected thousand hundreds of DK galls. Galls were subsequently transported to the Plant Health and Molecular Biology Laboratory, Hungary. Rearing boxes were checked weekly and, after emergence, wasps from each sample were preserved in 70% ethanol and were identified by G. Melika. For adult parasitoids, identification an unpublished key generated by R. R. Askew (Manchester, UK) was used which is a basic identification tool in use for decades in the research of parasitoid communities of oak gall wasps (Askew et al. 2013).

Rearing and release of TS

Withered DK galls with TS larvae were collected in March 2014 and 2015 in Borgo d'Ale, Piemonte, Italy in a sweet chestnut orchard. More than 12.000 galls were collected. The parasitism rates of TS in collected galls were more than 90% (17, G. Bosio, personal communication). After collection, the galls were stored in the refrigerator at 4°C, in glass jars with aerated tops, app. 70 galls per jar in Plant Health and Molecular Biology Laboratory, National Food Chain Safety Office, Hungary. On 1st April 2014 and 2015 the galls were taken out from the fridge and kept at room temperature (20-22°C, L:D 12:12) until the emergence of adults. After emergence wasps were fed with drops of liquid honey and were kept at 14°C (L:D 12:12) until release. Less than three week old females were released. Field releases were done in April in 2014 and in 2015. In February 2016 DK galls infested by TS were collected in (Iharosberény, Somogy County). TS were reared in laboratory in a way mentioned above. Reared TS than were released onto different sites: on April 21st 600 matted females were released onto10 trees in Nagymaros (Pest County), on April 22nd 2000 females were released onto 20 trees in Iharosberény (Somogy County), the same chestnut orchard as in 2015). TS released was done also in April 2016 in Diósjenő (Pest County) – 120 females, in Pilismarót (Pest County) – 500 females. In August-September 2014-2016 infested DK galls were collected in sites of TS releases and their efficacy (parasitisation rates) was were calculated. Identification of the final-instar larvae of TS and other *Torymus* species was done based on the external morphology (Gómez et al. 2008).

Figure 1: *Dryocosmus kuriphilus* female

Figure 2: *Dryocosmus kuriphilus* galls (Gy. Csóka), (G. Melika)

RESULTS

The target organism, *Dryocosmus kuriphilus* Yasumatsu

The sweet chestnut gallwasp, *Dryocosmus kuriphilus* Yasumatsu, 1951) (Hymenoptera, Cynipidae: Cynipini) (DK), is the most important pest of chestnut trees (*Castanea* spp.) worldwide, inducing galls on leaves and shoots, causing decline in vigour of trees and significantly reducing fruit yield (EFSA 2010). DK belongs to the gallwasp family Cynipidae, to so-called oak gallwasps (Cynipini tribe). 1300 species in 46 genera are known worldwide, majority of which are distributed in the temperate zone of the Northern Hemisphere and induce complex galls on different Fagaceae (mainly *Quercus* L., *Lithocarpus* Blume and *Castanopsis* Miller). Only two species, *Dryocosmus kuriphilus* and recently described *Dryocosmus zhuili* Liu & Zhu, 2015, are known to associate with the genus *Castanea* Mill. and induce integral leaf galls. *Dryocosmus zhuili*, recently described from Southeastern China (Fujian province), is known from the sexual generation only and induces integral leaf galls on *Castanea henryi* (Zhu et al. 2015). For DK the parthenogenetic reproduction is known and only females are known while males are unknown. DK attacking the Japanese (*Castanea crenata* Sieb. & Zucc.), American (*C. dentata* [Marsh.]), European (C. *sativa* Mill.) and the Chinese chestnut (*C. mollisima* Blume), and their hybrids.

Females lay eggs into buds in June-August (Brussino et al.

2002). Larvae started to develop only after overwintering, at the bud burst. Larvae after 20–30 days pupate in June-July. After 10 days pupa phase, females are emerging (Fig. 1). Subglobular, succulent, and fleshy integral multilocular galls are formed on young buds, leaf petioles or midribs of leaves close to leaf base on new shoots; about 8–15 mm in width by 8–25 mm in length (Fig. 2).

Dryocosmus kuriphilus distribution in the World, Europe, Hungary

The DK is native to China. It was found for the first time in Japan in 1941, then it was accidentally introduced to Korea in 1961 (Gibbs et al. 2011). It was found in Georgia State in the USA in 1974 and since spread all over the Atlantic Coast up to Canada (Cooper & Rieske 2007). In 1999 it was found in Nepal and in 2014 in Bhutan. In Europe DK was detected in 2002 in Italy, Piedmont Region and by 2011 it distributed all over Italy (Brussino et al. 2002, Melika et al. 2003). In the following years, it became widely spread and established in France and Switzerland. Its presence has also been confirmed in the Netherlands (2010), Austria (2011), Czech Republic (2012), Slovakia (2012), Spain (2012) and Germany (2012) (Quacchia et al., 2014). In 2005 it was found in Slovenia, in Croatia (2010), Slovakia and Czech Republic (2011), Spain (2012), Portugal (2014), Romania and Turkey (2014), Great Britain (2015), and Russia (Krasnodar Kraj) (2016) (Radócz et al. 2015, Csóka et al. 21017, Gninenko et al. 2017).

In Hungary DK was detected for the first time in May 2009 in Pest County, in Üröm on a tree imported from Italy (the tree with DK galls was eradicated by the authorities) (Csóka et al. 2009). In 2010 it was found again in Pécs with imported tree and again was successfully eradicated. In May 2013 it was detected in Budapest and again on a tree imported from Italy (the tree with DK galls was eradicated). In 2013 large population of DK was found in Zala, county, where it arrived from Slovenia and Croatia (Szabó et al. 2014). In 2014 it was detected in Baranya, Győr-Moson-Sopron, Somogy, and Vas counties. In 2016 DK distributed all over Hungary and was found everywhere, where sweet chestnut grows (Kriston et al. 2015).

Possible Control Measures against DK

Tight control of the movement of infested plant material will undoubtedly reduce long-distance dispersal of DK to new areas within Europe, but there are limited options available for managing existing DK populations and to reduce the magnitude of their impact and spread on European chestnut plantations (EFSA 2010). More than a decade-long Italian experience have been showed that agrotechnical measurements, such as pruning and burning of DK-infested shoots, nursing propagation material in glass-houses and different insecticide treatments are not effective enough to control DK populations and suppress its populations under an economic threshold (EFSA 2010). Since the larval and pupal stages of DK are protected within the galls formed by this species; conventional chemical control is regarded as largely ineffective (EFSA 2010).

Developing resistant varieties of *Castanea* spp. and their hybrids could potentially be a viable management option, but this will only be beneficial for new planting and will not help existing chestnut plantations (EFSA 2010). A DK resistant Japanese-European hybrid, *Castanea crenata* x *Castanea sativa*, „Bouche de Betizac", was successfully selected recently in France. The question is for how long? (EFSA 2010; Quacchia et al. 2008, 2012; Knapič et al. 2010).

Natural enemies of DK

In its native range in China, 11 species of Hymenoptera parasitoids effectively regulate the DK populations (Aebi et al. 2007); in Japan and Korea – 24 parasitoid species were found on DK (Yasumatsu & Kamijo 1979). In the USA, where DK was accidentally introduced in 1974, prolonged for more than 30 years only 5 native parasitoid species were able to shift onto the new host, DK (Cooper & Rieske 2007, 2011). All the parasitoid species reared from galls of DK in Europe are species known to be common parasitoids of oak cynipid gall wasps (Quacchia et al. 2012, Askew et al. 2013; Matošević & Melika 2013).

During 2002-2015 we reared 44 chalcid (Chalcidoidea) parasitoid species in six families (Eurytomidae, Pteromalidae, Torymidae, Eupelmidae, Ormyridae and Eulophidae) from DK galls; Italy – 39 (Quacchiaet al. 2012), in Slovenia – 28 species (Kos et al. 2015), in Croatia – 20 species (Matošević & Melika 2013). In Hungary in 2013 11 species were known and in 2015 number of reared parasitoid species increased to 17. The parasitisation rate of DK in Hungary was 2.0-4.7% (Szabó et al. 2014). In Italy, Slovenia, Croatia it is also low, usually around 2%, in rare cases it can go up to 32% (Santi & Maini 2011). Thus, the indigenous parasitoids are ineffective against DK (Kos et al. 2015, Quacchia et al. 2012, Matošević & Melika 2013).

Classical Biological Control

Parasitoid *Torymus sinensis* Kamijo (Hymenoptera; Torymidae) (TS) has successfully been used as biological control agent against invasive insect pest DK and extensive classical biological control programmes have been implemented in Japan, the USA, Italy, France, Slovenia, Croatia and Hungary (Moriya et al. 2003; Cooper & Rieske 2011; Borowiec et al. 2014; Kriston et al. 2014, 2015; Ferracini et al. 2015; Matošević et al. 2014, 2015, 2016, 2017).

Figure 3: Female of *Torymus sinensis*

Figure 4: Final-instar larva of *Torymus sinensis*
(Gy. Csóka), (M. Bozsó)

Torymus sinensis a viable option for classical biological control

TS is native to China and is the only parasitoid of DK known to be host specific and phenologically well adapted to the biology of its host (Fig. 3) (Kamijo 1982; Moriya et al. 2003; Cooper & Rieske 2007, 2011; Gibbs et al. 2011; Bosio et al. 2013). The parasitoid has one generation per year as its host. TS adults emerge from withered galls, mate and females lay eggs in the newly developed galls of DK in spring, mostly in late April. Each female can lay 70 eggs on average. The emergence is synchronized with the budburst of sweet chestnut and development of new galls (Quacchia et al. 2008). Females locate the host with a combination of visual and olfactory stimuli from fresh galls and chestnut foliage which could also explain its specificity to DK (Graziosi et al. 2013). Parasitoid larva feeds ectoparasitically and pupates in late winter the following year. The parasitoid larva overwinters as final larval or early pupal stage (Fig. 4) (Shiga 2009). Females' lifespan is 37 days in the field (Piao & Moriya 1999); in laboratory – up to 4 months (G. Melika, personal observation). TS selects the body surface of the host larva for oviposition rather than the chamber wall as observed in other *Torymus* species (Piao & Moriya 1999).

One of the adaptive advantages of TS when compared to other univoltine parasitoids present in the invasion range (e. g. *Torymus beneficus* Yasumatsu & Kamijo) of DK is only one emergence period without peaks which makes this species better synchronized with its host. This very fine phenological difference together with other morphological features (ovipositor length) makes TS highly efficient as biological agent against DK. TS has a specific strategy to survive temporary extinction of its host – a prolonged diapause over 2 years which makes it species specific and less likely to parasitize other members of Cynipidae family (e. g. oak gall wasps, Cynipini) (Quacchia et al. 2014b). TS track the expanding populations of DK (Bosio et al. 2013, Matošević et al. 2014, 2015; Kriston et al. 2014, 2015). During the early years of the release, population of TS disperse very slowly and, over the years, the dispersion becoming faster and exponential (Bosio et al. 2013).

Biological control of *Dryocosmus kuriphilus* with *Torymus sinensis* in different countries

The introduction of TS is regarded as a successful case of classical biological control of invasive species in Japan (Moriya et al. 2003) After the introduction of TS the infestation rates decreased steadily from 43% to less than 1% which is the result of established population of introduced TS (Moriya et al. 2003).DK was first observed in USA in 1974 and TS was introduced for biological control (Cooper & Rieske 2007). Recent study confirmed that TS is dominant parasitoid of DK in eastern USA (Cooper & Rieske 2011).

First releases of TS in Italy were done in 2005 and 2006 (Quacchia et al. 2008). The increase of parasitoid populations has been exponential, surpassing 90% in 5–7 years after release, which is significantly bigger than the parasitism rate of native parasitoids of 3–5% (Quacchia et al. 2008, 2014a). The parasitisation rates nowadays often exceed 85–90% with a significant reduction of number of infested leaves and shoots (Quacchia et al. 2008, 2014a). TS has been implemented in France since 2011 and the rate of establishment of TS is high (app. 80%) (Borowiec et al. 2014).

The biological control of DK in Croatia has started in spring 2014. A natural sweet chestnut forest in Pazin (locality Lovrin) (area 12 ha) on Istria Peninsula was chosen as a site of first release of TS. The parasitism rate after first year release on Pazin site was 7.3 %. In 2015 a second TS release was done on the same site and the parasitism rate after two year releases was 75.58 % (Matošević et al. 2015). In 2015 TS was released across 37 sites in continental and coastal Croatia (Matošević et al. 2015).

The first release of TS in Slovenia was in 2015 in Vrtojba (Matošević et al. 2015). Morphological identification confirmed the occurrence of parasitoid TS throughout the country (Baske, Orehovica, Ljubljana, Kostanjevica, Čatež ob Savi, Log and Rogatec), that probably due to the natural disperse of TS (Matošević et al. 2015, 2017).

Biological control in Hungary

In Hungary the first release of TS was done in 2014 in three localities, Dobri, Kerkateskánd and Tornyiszentmiklós (Zala county) in isolators from fine mesh put out onto branches, with 50-80 buds enclosed into each. In autumn, 10-10 galls were collected from each branch, earlier covered with isolators, dissection of the galls showed the presence of TS larvae.

In 2015 TS was released in Zala and Somogy counties. In Tornyiszentmiklós (Zala), and vicinities of Iharosberény (Somogy) (Kriston et al. 2014, 2015). In August 2015 DK galls were taken from trees onto which TS were released. One hundred DK galls were collected from each control tree. In Dobri where we released TS twice, in 2014 and 2015, samples were taken from two trees onto which earlier we released and TS females and samples were taken from trees located 250 m away from release sites of TS. In Tornyiszentmiklós samples were taken also from three sites: two trees with release of TS in 2014 and 2015 and one tree located 250 m away from release sites of TS. At the same time samples were taken from Iharosberény, where we released 1950 TS females in 2015. In Dobri and Tornyiszentmiklós, where TS was released twice, in 2014 and 2015, the parasitisation rate was 68.4–90.8%, while on sampled trees 250 m away from the release points the parasitisation rate was slightly lower, 65.1–80.6%. In Iharosberény, with one TS release in 2015, the parasitisation rate was 29.2–68.0% (Kriston et al. 2015).

In 2016 further TS releases were done in different parts of Hungary: Nagymaros, Diósjenő, Pilismarót (Pest County), Iharosberény (same chestnut orchard as in 2015). The parasitisation rates, counted in August-September 2016, were the next: in Nagymaros – 84.3–929%; in Diósjenő– 77.0%; in Pilismarót – 70.0–74.6%. In Iharosberény where TS release was done in 2015 and 2016, the parasitisation rate was 76.9–93.7%. No doubts, the high parasitisation rate in Diósjenő, Pilismarót, Nagymaros, where only one release of TS was done, can be explain with earlier presence of TS in those sites, prior to our releases.

In 2016 the parasitisation rates all over the country were high and we decided that no more TS releases are in need in 2017. No doubts, the TS populations will increase prolong next years.

Potential risk from the introduction of *Torymus sinensis*

The biocontrol of DK with TS (EFSA 2010, Aebi et al. 2011, Gibbs et al. 2011) has raised some important questions: (i) the general risk that TS could shift to native gall wasps related to DK and (ii) could hybridize with native *Torymus* species. Host specificity tests were done with TS females offering them alternative host galls: *Mikiola fagi* Hartig (Diptera: Cecidomyiidae) developing on *Fagus*, galls of asexual generation of oak gallwasps as *Cynips quercusfolii* Linnaeus and *Andricus kollari* Hartig (Hymenoptera: Cynipidae) and no oviposition was recorded (Quacchia et al. 2008). These tests were considered insufficient (EFSA 2010, Gibbs et al. 2011) so additional host range tests have been performed (Quacchia et al. 2014b). Seven species of oak cynipids (Cynipidae: Cynipini) which occur at similar times in the field as DK were tested*: Andricus crispator* (Tschek), *A. curvator* (Hartig), *A. cydoniae* (Giraud), *A. grossulariae* (Giraud), *A. multiplicatus* (Giraud), *Biorhiza pallida* (Olivier), and *Dryocosmus cerriphilus* (Giraud). All the seven mentioned oak gallwasp species are known to have two alternate generations per year; in spring the sexual generations are developing. These species were chosen for the host specificity tests, proposed by EFSA (2010) according to their ecological similarity, spatial and temporal attributes and accessibility and availability for TS at the period of parasitation. Few and brief ovipositor pricking were observed on *A. cydoniae, B. pallida* and *D. cerriphilus* galls but no eggs were laid (Quacchia et al. 2014b). These results additionally confirmed the host specificity of TS. TS was introduced to USA in late 70s (Cooper & Rieske 2007), to Japan in 1979 (reviewed in Aebi et al. (2007)), to Italy in 2004 (Quacchia et al. 2008). However, no other host than DK was ever mentioned in the literature to be parasitized by introduced TS (Aebi et al. 2013). The risk assessment of possible shift of TS onto other hosts (native oak gallwasps) was discussed in details in Gibbs et al. (2011). Hybridization of a biological control agent with native species is considered as an environmental risk to non-target species (Gibbs et al. 2011). Till now, the only reported case of TS hybridization is with the native *T. beneficus* in Japan: TS and *T. beneficus* were successfully crossed in the laboratory to produce fertile hybrid females (Moriya et al. 1992); hybrids were also detected in the field and proved with molecular markers (Yara et al. 2000). The probability of hybridization with native European *Torymus* species (Hymenoptera: Toymiidae) was tested in mating experiments on *Torymus flavipes (*Walker)*, T. auratus* (Muller)*, T. affinis* (Fonscolombe) and *T. geranii* (Walker), however, no mating was recorded (Quacchia et al. 2014b). Recently the risk of hybridisation between TS and native *Torymus* species was evaluated and the hybridisation between TS and *Torymus cyaneus* was documented in one case (Aebi et al. 2013), however, this conclusion must be confirmed.

DISCUSSION

The experiences from Italy (Quacchia et al. 2008; Bosio et al. 2013; Ferracini et al. 2015; Paparella et al. 2015), Croatia, Slovenia and Hungary (Kriston et al. 2014, 2015; Matošević & Melika 2013; Matošević et al. 2013, 2015, 2017) showed that TS is highly specialized and efficient biocontrol agent that causes severe drop in the population density of its host.

Recently developed mathematical models predict that TS would quickly control the pest in Europe (Paparella et al. 2015). TS have rapidly spread across Slovenia, Croatia and Hungary. TS have been confirmed on release and non-release sites in all three countries with unexpectedly high parasitism rates. The first releases were done in Croatia and Hungary in 2014 on only one site per country, while extensive releases in Slovenia, Croatia and Hungary on several sites were performed in 2015 and 2016 (Matošević et al. 2015, 2017). However, these high parasitism rates cannot be exclusively attributed to release efforts. As TS appeared simultaneously on several sites in Slovenia, Croatia and Hungary in spring 2015 prior to intensive releases (Matošević et al. 2015), it is not possible that the recorded parasitism rates are result of these release efforts. The high parasitism rates on majority of investigated sites could be explained as naturally established populations induced by long distance dispersal of TS from Italy, where it has been widely released since 2005 (Quacchia et al. 2008, Bosio et al. 2013). Long distance dispersal of DK as well as of TS is aided by human-assisted activities and wind (EFSA 2010, Paparella et al. 2015). Recent detailed study by Colombari & Battisti (2015) showed that TS is able to reach over 70 km from release site in few days. Rapid natural invasion of TS in Slovenia, Croatia and Hungary could be attributed to long distance wind dispersal, supported by the resource distribution and availability of the host. TS has the ability of rapid spatial response to the distribution of its host and it has rapidly occupied its host's range in Slovenia, Croatia and Hungary due to great dispersal abilities.

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MORTALITY DURING EMERGENCE IN *GOMPHUS FLAVIPES* (ODONATA: GOMPHIDAE) ALONG A LARGE RIVER IN URBAN ENVIRONMENT (THE DANUBE AT BUDAPEST, HUNGARY)

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ABSTRACT

The mortality at emergence of *Gomphus flavipes* (Odonata: Gomphidae) was studied along the Danube in the large city of Budapest, where dragonflies are exposed to high vessel traffic and other human disturbance on river-banks. The main aim was to estimate the ratios of mortality due to different causes under such urban conditions. We also aimed to find out whether abundances are decreased due to river-bank alterations along the Danube section in Budapest. For collections and observations of *G. flavipes* four different sampling sites were selected ranging from close-to-natural to strongly modified. The samplings were made mostly daily between 3 July and 3 August in 2013. To estimate the numbers of emerged dragonflies, all the exuviae found on sampling sites were collected. To quantify daily mortality rates, at a given sampling site efforts were made to follow up the moult of each individual of the daily emergence and mortality events were recorded. Based on our results, adverse effect of river-bank alterations (riprap and stone) on abundance of *G. flavipes* is well indicated by the significantly lower numbers of emerged individuals compared to close-to-natural sites. The total ratio of mortality at emergence was 28.15%, which is high compared to other studies. The causes of mortality were primarily predation (8.89%) and anthropogenic

factors (13.33%), especially ship-induced waves. Hence, the natural losses during emergence were much increased by anthropogenic factors, which should be taken into account in protection of this Natura 2000 species.

Keywords: riverine dragonflies, exuviae, anthropogenic factors, shipping

INTRODUCTION

It is well known that the emergence of dragonflies is a short but critical period, during which heavy mortality can occur, in general ranging between 3–30% (Corbet 1999). This risky period, during which the dragonfly is extremely vulnerable and almost unprotected to predators, conspecifics and unfavourable physical conditions as well, begins when the larva crawl out from the water and lasts until the first flight of the teneral. The causes of mortality at emergence are classified into three groups: (1) physical factors; (2) predators; (3) overcrowding due to competition for emergence supports, either directly or indirectly (sensu Corbet 1999).

Both the ratio and the causes of mortality may vary widely according to species or habitat characteristics (e.g. Bennett and Mill 1993, Gribbin and Thompson 1990, Kern 1999, Müller 1995). In species with diurnal emergence – such as gomphids – mortality during emergence is attributed mainly to predators (e.g. aquatic and terrestrial arthropods, amphibians, reptilians, fish, birds). In Europe the predators preying on emerging gomphid individuals are especially birds (Corbet 1983; Suhling and Müller 1996), which may cause losses up to 25% in the emerging population (Müller 1995, Suhling and Müller 1996).

Although there are many studies dealing with mortality at emergence in dragonflies (e.g. Bennett and Mill 1993, Gribbin and Thompson 1990, Mathavan and Pandian 1977, Purse and Thompson 2003) and even in gomphid species (Jakob and Suhling 1999, Kern 1999, Müller 1995, Farkas et al. 2011, 2012), little is known about how anthropogenic factors may shape losses in the emerging population. In riverine dragonflies several examples have been recorded on serious deformations caused by ship-induced waves that washed emerging individuals (Ehmann 1992, Reder and Vogel 2000, Schorr 2000), but few attempts were made to quantify the mortality. At some sampling dates at Jagst river (Germany) Schmidt (1996 – cit. Schorr 2000) found 9–18% of emerging individuals of *Onychogomphus forcipatus* that were washed and damaged or died directly. In *Gomphus flavipes* Farkas et al. (2012) reported 2.16% loss of emerging population due to artificial waves induced by watercrafts along close-to-natural section of the Danube upstream Budapest. In this study we aimed to survey the mortality at emergence along the Danube under urban conditions: in the capital Budapest, where riverine dragonflies are exposed to high vessel traffic for recreational and transport purposes and to other human disturbance on river-banks. The main aim was to estimate the ratios of mortality due to different causes, by intensive monitoring of emergence. On the other hand, in urban areas dragonflies face other unfavourable conditions, such as alteration of the river-bed and river-bank (Aliberti Lubertazzi and Ginsberg 2010, Paul and Meyer 2001), but the exact effects on natural assemblages and abundances are scarcely studied. Therefore, we also aimed to find out whether abundances of gomphids are decreased due to river-bank alterations along the Danube section in Budapest.

MATERIAL AND METHODS

Our study was carried out along the Danube section within the large city of Budapest, capital of Hungary. This river section gives place for high vessel traffic both for recreational and transport purposes (hydrofoils, barges, cruise ships, smaller motorboats), while river-banks are frequented by anglers, walkers and holiday-makers. For collections and observations of riverine dragonflies four different sampling sites were selected ranging from close-to-natural to strongly modified (Table 1, Fig. 1). Taking samplings started after the record-high flood in early

Table 1: Sampling sites along the Danube at Budapest (listed downstream) with exact geographical co-ordinates and main characteristics.

Code	Sampling site	Co-ordinate		Characteristics
		N	E	
BP1	Danube, right bank, Ró-mai bank	47°34′45.00″	19°03′59.90″	north side of the capital; close-to-natural site; flat slope bank with gravel and sand sediment length: 60 m
BP2	Danube, left bank, Margit Bridge	47°30′40.45″	19°02′44.92″	city centre; artificial site with riprap and steep stone stairway; sand sediment length: 200 m
BP3	Danube, right bank, Erzsé-bet Bridge	47°29′21.83″	19°02′54.45″	city centre; artificial site with riprap and steep stone stairway; gravel and sand sediment length: 250 m
BP4	Danube, left bank, Csepel	47°24′50.57″	19°02′51.51″	south side of the capital on Csepel Island; close-to-natural site; flat slope bank with sand and gravel sediment length: 152 m

Figure 1: Sampling sites: (a) BP1, (b) BP2, (c) BP3, (d) BP4 along the Danube at Budapest (for codes see Table 1).

summer had passed and they were done mostly daily between 3 July and 3 August in 2013. Because of the flood the first emerging *Gomphus vulgatissimus* was missed from the samples, and the emergence of *G. flavipes* could have been studied.

To estimate the numbers of emerged dragonflies, all the exuviae found on sampling sites were collected at each visit and later counted. To quantify daily mortality rates, at a given sampling site efforts were made to follow up the moult of each individual of the daily emergence, in order to ascertain whether emergence succeeded or not, and in the latter case to determine the exact cause of failure. Accordingly, emerging individuals were searched continuously from 6:30 to 17:30 (CET), which therefore could be repeated on the same sampling site every fourth day (28 sampling days, 7 days at each site). Mortality events included not only dead individuals, but also damaged or deformed ones that were unable to fly (and accordingly to reproduce), and therefore would have been died shortly after the collection. In mortality events when dead larvae were found and their cuticle had not split yet, the exact cause of mortality is not unambiguous in every case, since both endogenous and exogenous factors may be responsible (Jakob and Suhling 1999). In these cases the cause of mortality was termed as 'unknown'.

The sampling sites differed in length (ranging between 60–250 m) depending on accessibility and sediment type (easy/hard to check for moulting individuals). In analyses the numbers of exuviae calculated for a 20 m long stretch of the river-bank were used. The differences in numbers of individuals at each sampling site were analysed by Kruskal-Wallis test and post hoc Mann-Whitney pairwise tests. To compare ratios of mortality between sampling sites Kruskal-Wallis test was also used, but one sampling site (Erzsébet Bridge) was not included in the analysis since no mortality occurred there (see in Results).

RESULTS

During collections a total of 365 exuviae and larvae (some specimens that died or damaged in larval stage or still in the exuvia) were found belonging to the four gomphid species that occur in Hungary: *G. flavipes* (Charpentier, 1825), *G. vulgatissimus* (Linnaeus, 1758), *Onychogomphus forcipatus* (Linnaeus, 1758) and *Ophiogomphus cecilia* (Fourcroy, 1758). Among them *G. flavipes* was abundant (361 exuviae); for the other three species only one or two exuviae were found. Detailed faunistical data were given in Farkas et al. (2014).

In *G. flavipes* total numbers of individuals on a 20 m long stretch were significantly (Kruskal-Wallis test: $H = 20.97$, p

< 0.001) lower at the artificial sites (BP2 = 6.8, BP3 = 0.8 individuals, respectively) than at the close-to-natural sites (BP1 = 19.3, BP4 = 29.6). Mann-Whitney pairwise tests showed significant ($p < 0.05$) differences in all cases with the exception of the two close-to-natural sites.

During the daily follow-ups of emergence a total of 135 emerging individuals were counted, out of which 28.15% failed. Both anthropogenic factors and predation accounted for high mortality rates, but other physical factors caused little loss in the emerging population (Table 2). Anthropogenic factors included ship-induced waves (83%) and human tread in some cases (17%, Fig. 2c). Predators observed preying on emerging individuals were *Motacilla alba* (67%, Fig. 2e) and wasps (33%, Fig. 2d).

Table 2: Ratios of mortality at emergence in *G. flavipes* due to different causes, at all sampling sites (All sites) and at each site separately (with the exception of BP3 site where no mortality event was observed).

Causes of mortality	Ratios of mortality (%)			
	All sites	BP1	BP2	BP4
Physical: arthropogenic	13.33	14.29	19.44	10.67
Physical: natural	1.48			2.67
Predation	8.89	4.76		14.67
Unknown	4.44		2.78	6.67
Total numbers of emerged individuals	135	21	36	75
Total mortality (%)	28.2	19.05	22.22	34.67

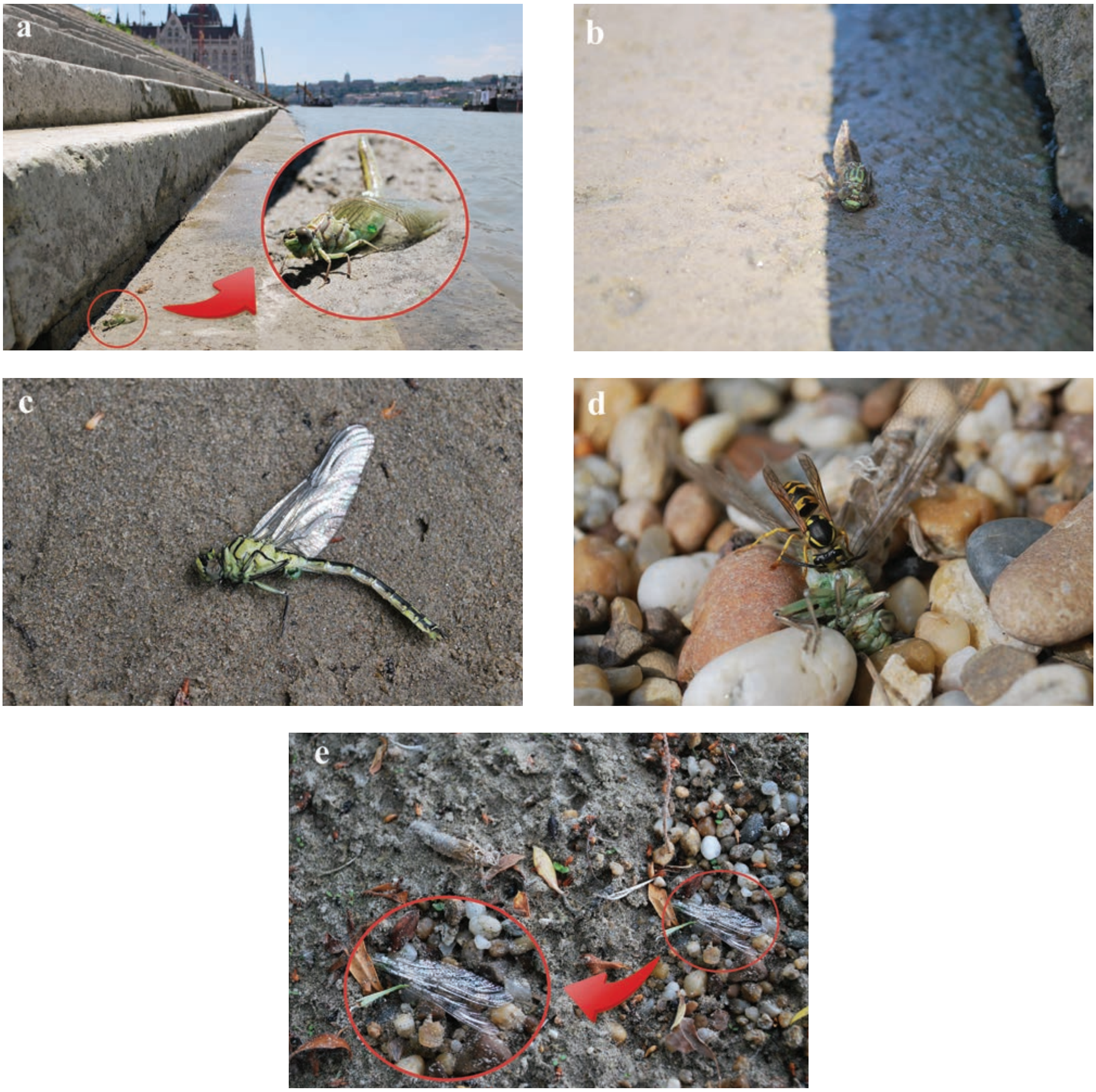

Figure 2: Various mortality events of emerging *G. flavipes*: (a) freshly emerged adult deformed by ship-induces waves; (b) direct mortality caused by ship-induced waves during early phase of emergence; (c) mortality caused by human tread; (d) mortality caused by wasp; (e) dragonfly wings left behind by bird predator.

Non-anthropogenic physical factors were adverse weather conditions, especially heavy wind. Ship-induced waves caused failure to expand wings and abdomen resulting in crumpled or stuck wings and/or curved abdomen in most cases (87%, Fig. 2a), and failure to moult in much less individuals (13%, Fig. 2b).
The total ratios of mortality differed between sampling sites. At BP3, in accordance with the small number of exuviae, no mortality event was observed, while at the other three sites ratios ranged from 19.05 to 34.67% (Table 2). Though, comparing the daily mortality rates of sampling sites the difference was not significant, which may be due to the small sample sizes.
Similarly, the causes of mortality also differed in ratios between the sampling sites: at the strongly modified site (BP2) anthropogenic factors dominated, while at the close-to natural sites predation also occurred in higher (BP4) or lower (BP1) ratios (Table 2). No significant difference was shown in the ratios of anthropogenic mortality between sampling sites.

DISCUSSION

The adverse effect of river-bank alterations (riprap and stone) on abundance of *G. flavipes* is well indicated by the significantly lower numbers of emerged individuals compared to close-to-natural sites, though the sample sizes were small. Similarly to our results, Dévai et al. (2010) and Farkas (2013) reported the negative effect of riprap on the numbers of emerged individuals of *G. flavipes* at non-urban sections of the Danube and Tisza rivers.
The total ratio of mortality (28.15%) found at emergence in *G. flavipes* is high compared to the results of other studies in odonates (Corbet 1999). Also in *G. flavipes* much lower ratios have been reported: total mortality ranged 3.4–12.5% at the Oder river (Germany) in six consecutive years (Müller 1995); 11.24% mortality was recorded along the Tisza river (Farkas et al. 2011) and 6.37% along the Danube (Farkas et al. 2012) in Hungary. Although caution should be made in comparison (due to differences in sampling frequency and intensity), our results indicate a much higher mortality rate along urban river-section compared to the results of earlier studies made under close-to-natural conditions.
Among the causes of mortality, overcrowding due to competition for emergence supports was not observed in *G. flavipes*. This result corresponds well with other studies that found overcrowding negligible in riverine dragonflies (Farkas et al. 2011, 2012, Jakob and Suhling 1999, Müller 1995). On the one hand, a high ratio of mortality was attributed to predation at the close-to-natural sampling sites (4.76 and 14.67%). Similarly, other studies commonly showed high ratios of predation in *G. flavipes* and other gomphids, despite the fact that riverine dragonflies are among the fastest emerging species (Jakob and Suhling 1999). In contrast, at the strongly modified sampling sites no predation was observed, which may be attributed to artificial conditions and higher human disturbance in the city centre, less favourable for predator species. On the other hand, *G. flavipes* suffered significant losses during emergence due to anthropogenic factors, especially ship-induced waves, either at close-to-natural or strongly modified sites. The larvae of this species usually emerge close to the water line (Farkas 2014) and are exposed to the risk of wash during the total 15–65 minutes needed to complete the last moult in *G. flavipes* (Farkas et al. 2012, Suhling and Müller 1996).
Our results highlight that the natural losses (which are often high in themselves) can be significantly increased by mortality due to anthropogenic factors during emergence of dragonflies. In terms of nature conservation, *G. flavipes* is a species of community interest in need of strict protection (listed on Annex IV of the Habitats Directive of the European Union) and suffered severe declines from the 1960s, especially in Western and Central Europe (Askew 2004, Dijkstra 2006, Kalkman et al. 2010). According to our results the anthropogenic factors should be taken into account in protection of the species and conservation planning. This should also be considered in other gomphid species that emerge close to water line (such as several gomphid species; e.g. Farkas et al. 2011) in riverine habitats with intensive shipping and water sport activities, exposed to the risk of being washed during the critical period of emergence.

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ERASMUS+ STRATEGIC PARTNERSHIP FOR SOCIAL FARMING IN HIGHER EDUCATION

What is Social Farming?

Social Farming (SF) is a way of using an agricultural enterprise as a setting for therapy, integration, rehabilitation or occupation of people with special needs. For the farmer it represents an opportunity to diversify income and labour sources and to take social responsibility.

Why Social Farming in Higher Education?

In recent years an increasing number of Farmers and Social Workers are becoming interested in SF as a new branch of a Farming or Social Enterprise. However, neither agricultural nor socio-educational university courses are able to respond sufficiently to this trend. In most European countries, only a few pioneering projects offer further education at University level. SF is interdisciplinary -- agricultural knowledge, management skills, as well as socio-educational competences are necessary. Thus, SF is based on different professions which have had very little contact so far.

There is a high demand for scientific research as well as educational innovations and teaching material supporting SF. Subjects such as Agriculture, Social Work, Psychology or Forestry can benefit from offering knowledge and skills needed for running a Social Farm, as more and more of their members will encounter it in the future.

What are our project aims?

The project consortium aims at empowering rural communities and rural economies across Europe by increasing the quantity, and above all, the quality of Social Farms. This outcome will be realised by giving universities the tools to teach the necessary SF skills by defining **Quality Standards in teaching SF**, followed by developing a **Curriculum on SF in Higher Education**, and especially by offering **teaching material** tailored to the needs of various target groups, education about SF will be greatly improved.

Project duration: September 2017 - August 2020

Project partners:

- Thüringer Ökoherz e.V. Organic Farmers and Environmental Association, Germany (coordinator)
- Eberswalde University for Sustainable Development, Germany
- Academy of Social Pedagogy and Theology, Czech Republic

- University of South Bohemia, Czech Republic
- Szent István University, Hungary
- University College for Agrarian and Environmental Pedagogy, Austria
- Norwegian University College of Agriculture and rural Development

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