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Data on the Orthoptera assemblages of characteristic agricultural landscape in the Carpathian Lowland

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SUMMARY

Orthoptera fauna and assemblages of natural and semi-natural grasslands of the Hungarian Lowland are well-known, however, little is known about assemblages living in agricultural and anthropogenic habitats such as arable lands, roadsides, hedges, and riverbanks. Due to climate change, intensification of agriculture, and change of habitat use, these habitat types become increasingly important.

To collect data on these mainly unknown habitat types, a three-year study was carried out on the Orthoptera fauna and assemblages of the firth region of the Tisza and Sajó rivers. This area was mainly unknown, and our research contributes to increasing knowledge and provides a base for further investigations.

In the 40 sampling sites of the studied region, an occurrence of 30 Orthoptera species was recorded based on 2241 sampled individuals. In this study, we provide 540 new distribution data records of orthopterans that means an almost eightfold increase of the known data. Orthoptera assemblages of different agricultural habitat types showed significant differences considering both species richness and composition. Data suggested that non-cultivated habitat patches of dirt-roads, roadsides and stubble fields and even extensively used pastures, hayfields and alfalfa, red clover, and even wheat fields can preserve relatively species-rich Orthoptera assemblages. Contrary weedy sites of these cultivars and intensively used arable lands (maize, sunflower and rape fields) showed extremely low species diversity.

Keywords: *Orthoptera; faunistical data; lowland; agriculture; distribution; species composition*

INTRODUCTION

The intensification of agriculture and increasing use of pesticides started at the beginning of the 20th century led to fragmentation, isolation, and habitat and biodiversity loss of natural and even semi-natural landscape (Foley et al., 2011; CBD, 2014; Batáry, 2018). The human population growth, consumption and quality requirements of customers present a severe problem to agriculture. The human population will increase by 30% while in the case of the food demand, this value will increase by 70% by 2050 (Conforti, 2011; Fróna, 2018). In Hungary, the efficiency of agriculture should be developed since the cultivated area can be expanded by up to 5% (Agrárgazdasági Kutató Intézet, 2013). Therefore, the negative effect of this further intensification must be compensated with the intensification of ecosystem services and landscape protection (IPBES, 2016).

Changes of mixed agricultural and natural landscape can be monitored with species assemblages which are especially sensitive and can indicate the changes of their environment with changes of their qualitative and quantitative composition (Wiens, 1989; Pearson, 1994; McGeoch, 1998). Orthopterans are such kind of indicators considering their easy identification and sampling and relatively high species diversity. They are widely used in ecological and conservation biological studies mainly in grasslands and other opened habitats (Báldi and Kisbenedek, 1997; Kisbenedek, 1997; Batáry et al., 2007; Báldi et al., 2013; Torma et al., 2014; Kenyeres et al., 2020). Their diversity also well indicates the general species richness of their habitat thus their data can be used in conservation planning and decision-making (Noss, 1990).

Orthoptera fauna and assemblages of protected areas, natural and semi-natural habitats, and different project areas are relatively well known in Hungary (Nagy and Rácz, 2007). Arable- and wastelands and other anthropogenic habitats are poorly known due to the lack of sufficient studies conducted on these habitats (Nagy, 1953; Koppányi, 1957; Nagy, 1992; Nagy, 1993; Nagy et al., 2009) and in other sources only scattered data can be found (Nagy, 1943; Zilahi-Sebess, 1956; Garai, 1995; Báldi and Kisbenedek, 1997; Kenyeres et al., 2004; Kenyeres, 2006; Kenyeres, 2010; Szövényi et al., 2010; Kenyeres and Rácz, 2011). However due to agricultural intensification the importance and ecological functions of these artificial habitats are increasing day by day (Agócs et al., 2015). Barnabás Nagy already in the 1950s wrote about the unfavourable effect of stubble cultivation and decreased habitat diversity on the orthopterans of agricultural landscapes (Nagy, 1953). Although the intensive tillage also decreases diversity and abundance of Orthoptera assemblages (Koppányi, 1957), it has an important role in pest management (Arnóczkyné et al., 2020).

Orthoptera species show different sensitivity to various methods and intensity of cultivation. Change of intensity, methods, and even the crop rotation in a given site can dramatically change the composition of the Orthoptera assemblages and in some cases it can lead to local extinction of many sensitive and vulnerable species (Nagy, 1992, Kenyeres, 2006).

Survey and systematic monitoring of Orthoptera assemblages living in agricultural landscape is an important task in the point of view of both nature conservation and pest management. In our study, the first steps of such investigation were taken in the firth

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region of Sajó and Tisza Rivers between 2018 and 2020 and here we present the first results of this study.

MATERIALS AND METHODS

Sampling sites

Orthoptera assemblages of 40 sampling sites in the firth region of Sajó and Tisza rivers were investigated in a 3-year study between 2018 and 2020 (*Figure 1*). Four sampling sites (2, 8, 18, 26) were studied only in 2018 (*Table 1*). Samplings were carried out twice a year (in summer and early autumn) in the surroundings of Tiszaújváros, Sajószöged, Sajóörös, and Kesznyéten. Characteristic agricultural landscape elements (habitat types) were studied such as stubble-lands, pastures, hayfields, dirt-roads, roadsides, ruderal sites and maize, sunflower, wheat, alfalfa, and red clover fields.

Data collection and samplings

Sampling was carried out with a sweep net (45 cm in diameter) done 200 sweeps in each sampling site. The net was emptied after 100 sweeps to protect the sampled specimens. The caught orthopterans were soon released after identification in the fields. Sweep net samplings were completed with 10 minutes direct search. In the habitats where sweep net could not be used (maize and sunflower fields and in tall, dense vegetation) only extended (30–40 minutes) direct search was used. Base on their different selectivity and effectiveness, these two methods well complete each other considering both quantitative and qualitative features of assemblages (Nagy et al., 2007).

Sampling sites were in the EU00 and EU01 10×10 km UTM cells. To compare the sampled fauna with known assemblages of the surroundings, previously published data of these and neighbouring UTM cells (DU90, DU91, EU00, EU01, EU10 and EU11) were collected. In this case, actualized database of Nagy and Rácz (2007) was used. Till now only 4 articles (listed below) were published on the Orthoptera fauna of the studied region and its surroundings.

We built a database from newly collected and previously published distribution data. In case of published data, the following source codes were used:

[G] = Garai, A. (1995): Adatok Magyarország Orthoptera faunájához. Folia Entomologica Hungarica. 56: 231–234.
[J] = Jablonowski, J. (1910): A nagy hortobágyi sáskairtás eredményei. Természettudományi Közlöny. 42 (509): 513–525.
[N] = Nagy, A.–Bozsó, M.–Kisfali, M.–Rácz, I. A. (2008): Data on the Orthoptera fauna of the Tisza district. Tiscia, Vegetation and Fauna of River Tisza Basin II: 1–22.
[R] = Rácz, I.A.–Varga, Z. (1978): Beitrage zur Kenntnis der Orthopteren-Fauna des Sandgebietes bei Igrici. Acta Biologica Debrecina. 15: 33–39.

The distribution data are presented in this paper as follows: code of sampling site (see *Tables 1* and *2*) / date of sampling or publication, habitat type (if it is known), source code (in case of published data).

In case of nomenclature, the Orthoptera Species File online database was followed (Orthoptera Species File, 2020).

Table 1. **List of the 40 sampling sites of the Orthoptera assemblages investigated during the 3-year study between 2018 and 2020 in the firth region of the Sajó and Tisza rivers**

Sampling site	GPS: N	GPS: E	UTM (10×10 km)	Habitat		
				2018	2019	2020
1	47°56'32.70"	21°1'58.99"	EU00	stubble	maize field	stubble
2	47°56'29.81"	21°2'3.82"	EU00	dirt-road		
3	47°56'37.48"	21°1'50.60"	EU01	sunflower field	rape field	maize field
4	47°56'41.33"	21°1'44.57"	EU01	stubble	stubble	stubble
5	47°56'47.97"	21°1'43.94"	EU01	alfalfa field	wheat field	sunflower field
6	47°56'46.87"	21°1'40.65"	EU01	dirt-road	dirt-road	dirt-road
7	47°56'14.40"	21°0'21.68"	EU01	dirt-road	dirt-road	dirt-road
8	47°56'13.31"	21°0'23.96"	EU00	wheat field		
9	47°56'23.31"	21°0'27.29"	EU00	dirt-road	dirt-road	dirt-road
10	47°56'22.47"	21°0'29.23"	EU00	stubble	maize field, stubble	maize field
11	47°56'21.11"	21°0'27.52"	EU00	stubble	wheat field	sunflower field
12	47°56'26.56"	21°0'30.71"	EU00	stubble	maize field	sunflower field
13	47°56'46.74"	21°0'33.00"	EU01	alfalfa field	alfalfa field	alfalfa field
14	47°56'48.15"	21°0'35.66"	EU01	stubble	wheat field	maize field
15	47°56'47.18"	21°0'36.90"	EU01	dirt-road	dirt-road	dirt-road

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Table 1. continued

Sampling site	GPS: N	GPS: E	UTM (10×10 km)	Habitat		
				2018	2019	2020
16	47°58'56.58"	21°3'19.58"	EU01	pasture	pasture	pasture
17	47°59'18.88"	21°4'4.88"	EU00	pasture	pasture	pasture
18	47°59'20.28"	21°4'8.32"	EU01	stubble		
19	47°59'13.44"	21°4'20.34"	EU01	hayfield	hayfield	hayfield
20	47°59'15.54"	21°4'30.84"	EU01	hayfield	hayfield	wheat field
25	47°57'53.70"	21°4'51.62"	EU01	red clover field	ruderal site	weedy red clover field
26	47°57'49.78"	21°4'44.69"	EU01	dirt-road		
27	47°57'50.82"	21°4'57.53"	EU01	red clover field	weedy alfalfa field	weedy red clover field
28	47°57'50.52"	21°4'29.04"	EU01	red clover field	weedy alfalfa field	weedy red clover field
29	47°57'50.40"	21°4'22.02"	EU01	alfalfa field	alfalfa field	alfalfa field
30	47°55'55.15"	21°1'12.29"	EU00	roadside	roadside	roadside
31	47°56'12.18"	21°1'0.06"	EU00	stubble	sunflower field	maize field
32	47°56'16.31"	21°1'0.43"	EU00	stubble	maize field	wheat field
33	47°56'8.16"	21°0'43.20"	EU00	roadside	roadside	roadside
34	47°56'53.69"	21°0'35.04"	EU01	roadside	roadside	roadside
35	47°57'26.77"	21°0'54.90"	EU01	hayfield	hayfield	hayfield
36	47°57'26.57"	21°0'57.67"	EU01	stubble	maize field	maize field
37	47°56'49.26"	21°2'10.85"	EU01	stubble	wheat field	maize field
38	47°56'49.28"	21°1'59.42"	EU01	stubble	maize field	maize field
39	47°56'49.86"	21°2'1.33"	EU01	roadside	roadside	roadside
40	47°56'42.05"	21°1'56.09"	EU01	alfalfa field	alfalfa field	stubble

Table 2. **Orthoptera sampling sites of the formerly published investigations in the surroundings of the studied area in the firth region of Sajó and Tisza rivers**

Sampling site	UTM (10×10 km)	UTM (2.5×2.5km)	Township	Date	Source code	Habitat
41	DU90	B2	Igrici	1972	R	sandy grassland
42	DU90	B2	Igrici	1973	R	sandy grassland
43	DU90	B2	Igrici	1974	R	sandy grassland
44	EU01	B2	Kesznyéten	1993	G	moved meadow
45	EU01	B2	Kesznyéten	1993	N	
46	EU01	B2	Kesznyéten	1994	G	moved meadow
47	EU01	B2	Kesznyéten	1994	N	
48	EU00	D4	Polgár	1908	J	
49	DU91	C2	Sajóhidvég	1993	N	
50	DU91	C2	Sajóhidvég	1994	N	
51	DU91	C2	Sajóhídvég	1993	G	stubble
52	DU91	C2	Sajóhídvég	1994	G	stubble

Source codes refer to the published sources

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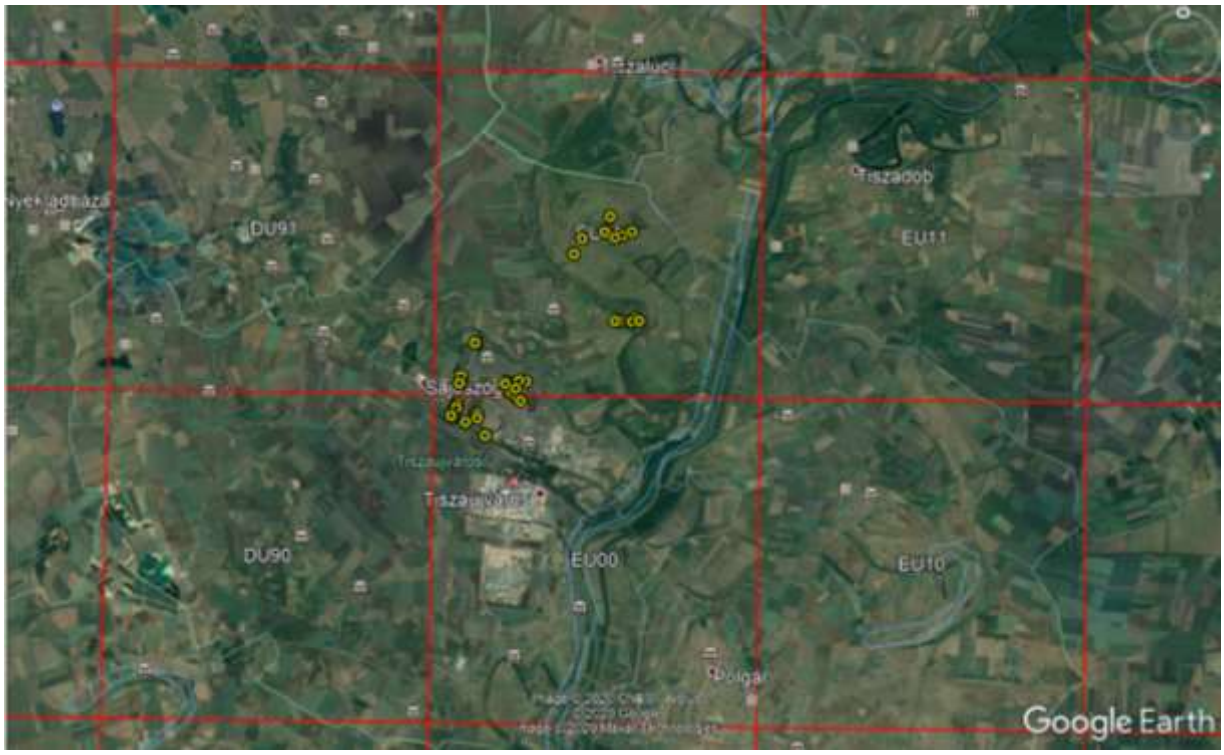
Figure 1. **Location of the orthopterological sampling sites studied between 2018 and 2020 in the firth region of Sajó and Tisza rivers (yellow dots), and the 10×10 km UTM cells covering the studied area and its surroundings**



Source: GoogleEarth 2020

RESULTS AND DISCUSSION

Distribution data of Orthoptera species

***Phaneroptera nana* (Fieber, 1853)**
19/2020 hayfield, 20/2020 wheat field, 41/1972[R]

***Leptophyes albovittata* (Kollar, 1833)**
7/2019 dirt-road, 7/2020 dirt-road, 18/2018 stubble, 19/2018 hayfield, 19/2019 hayfield, 20/2019 hayfield, 33/2019 roadside

***Conocephalus fuscus* (Fabricius, 1793)**
1/2020 stubble, 5/2019 wheat field, 6/2020 dirt-road, 7/2018dirt-road, 7/2019 dirt-road, 7/2020dirt-road, 9/2018dirt-road, 9/2019 dirt-road, 13/2019 alfalfa field, 14/2018 sunflower field, 15/2019 dirt-road, 19/2019 hayfield, 19/2020 hayfield, 21/2019 wheat field, 21/2020 wheat field, 28/2019 weedy alfalfa field, 30/2019 roadside, 33/2019 roadside, 33/2020 roadside, 35/2018 hayfield, 35/2020 hayfield, 39/2020 roadside

***Ruspolia nitidula* (Scopoli, 1786)**
9/2020 dirt-road, 15/2020 dirt-road, 19/2018hayfield, 19/2020 hayfield, 20/2019 hayfield, 21/2019 wheat field, 30/2020 roadside, 31/2018 roadside, 34/2020 roadside, 35/2018hayfield, 35/2020hayfield

***Tettigonia viridissima* (Linnaeus, 1758)**
5/2018 alfalfa field, 6/2020 dirt-road, 14/2019 wheat field, 19/2019 hayfield, 19/2020 hayfield, 20/2019 hayfield, 21/2019 wheat field, 25/2018 red clover field, 31/2019 sunflower field

***Platycleis grisea* (Fabricius, 1781)**
44/1993[G], 45/1993[N], 46/1994[G], 47/1994[N]

***Platycleis affinis* (Fieber, 1853)**
4/2018 stubble, 6/2018 dirt-road, 7/2018 dirt-road, 9/2018 dirt-road, 43/1974[R]

***Tessellana* veyseli (Koçak, 1984)**
8/2018 wheat field

***Montana montana* (Kollar, 1833)**
43/1974[R]

***Bicolorana bicolor* (Philippi, 1830)**
9/2020 dirt-road, 17/2019 pasture, 30/2018 roadside, 33/2018 roadside, 33/2019 roadside, 33/2020 roadside, 35/2018 hayfield

***Roeseliana roeseli* (Hagenbach, 1822)**
2/2018 dirt-road, 5/2019 wheat field, 6/2019 dirt-road, 7/2019 dirt-road, 7/2020 dirt-road, 9/2019 dirt-road, 9/2020 dirt-road, 11/2019 wheat field, 13/2020 alfalfa field, 15/2019 wheat field, 15/2020 dirt-road, 16/2018 pasture, 16/2019 pasture, 17/2018 pasture, 17/2019 pasture, 18/2018 stubble, 19/2018 hayfield, 19/2019 hayfield, 19/2020 hayfield, 20/2018 hayfield, 20/2019 hayfield, 20/2020 wheat field, 21/2018 hayfield, 21/2019 wheat field, 23/2019 pasture, 25/2019 ruderals, 28/2019 weedy alfalfa field, 29/2019 alfalfa field, 30/2019 roadside, 30/2020 roadside, 32/2020 wheat field, 33/2019 roadside, 34/2019 roadside, 35/2018 hayfield, 35/2019 hayfield, 35/2020 hayfield, 37/2019 wheat field

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***Gampsocleis glabra* (Herbst, 1786)**
9/2019 dirt-road, 13/2018 alfalfa field, 16/2019 pasture, 19/2019 hayfield, 20/2020 wheat field, 22/2019 pasture, 23/2019 pasture, 24/2018red clover field,24/2020red clover field

***Gryllus campestris* (Linnaeus, 1758)**
3/2018 sunflower field, 4/2018 stubble, 10/2018 stubble, 10/2019 maize field than stubble, 13/2018 alfalfa field, 28/2020 weedy red clover field, 32/2019 maize field

***Melanogryllus desertus* (Pallas, 1771)**
28/2018 red clover field, 35/2019 hayfield, 36/2018 stubble, 44/1993[G], 45/1993[N], 46/1994[G], 47/1994[N]

***Oecanthus pellucens* (Scopoli, 1763)**
14/2018 sunflower field, 17/2018 pasture, 19/2019 hayfield, 20/2019 hayfield, 37/2019 wheat field, 39/2018 roadside

***Calliptamus italicus* (Linnaeus, 1758)**
2/2018 dirt-road, 4/2018 stubble, 4/2020 stubble, 5/2018 alfalfa field, 5/2019 wheat field, 6/2018dirt-road, 6/2019dirt-road, 9/2018dirt-road, 9/2019dirt-road, 9/2020dirt-road, 10/2018 stubble, 11/2018 stubble, 11/2019 wheat field, 13/2018alfalfa field, 13/2019 alfalfa field, 13/2020alfalfa field, 14/2019 wheat field, 15/2018dirt-road, 15/2019 dirt-road, 15/2020dirt-road, 18/2018 stubble, 21/2018 hayfield, 24/2018 red clover field, 25/2018 red clover field, 25/2020 weedyred clover field, 27/2020 weedyred clover field, 28/2019 weedyalfalfa field, 29/2019 alfalfa field, 30/2018 roadside, 30/2019 roadside, 30/2020 roadside, 32/2020 wheat field, 33/2018 roadside, 34/2018 roadside, 34/2019 roadside, 34/2020 roadside, 37/2018 stubble, 38/2018 stubble, 38/2020 maize field, 39/2018 roadside, 39/2019 roadside, 39/2020roadside, 40/2018 alfalfa field, 40/2019 alfalfa field, 40/2020 stubble; 49/1993[N], 50/1994[N], 51/1993[G], 52/1994[G]

***Celes variabilis* (Pallas, 1771)**
19/2019 hayfield

***Oedaleus decorus* (Germar, 1825)**
42/1973[R], 43/1974[R]

***Oedipoda caerulescens* (Linnaeus, 1758)**
41/1972[R], 42/1973[R], 43/1974[R]

***Aiolopus thalassinus* (Fabricius, 1781)**
16/2018 pasture, 16/2019 pasture, 17/2018 pasture, 18/2018 stubble, 22/2018 pasture, 23/2018pasture, 23/2019 pasture, 23/2020pasture, 27/2018 red clover field, 37/2018 stubble, 41/1972[R], 44/1993[G], 45/1993[N], 6/1994[G], 47/1994[N]

***Mecostethus parapleurus* (Hagenbach, 1822)**
15/2020 dirt-road, 17/2018 pasture, 20/2018 hayfield, 20/2019 hayfield, 24/2020 red clover field, 25/2020 weedy red clover field, 26/2018 dirt-road, 27/2018 red clover field, 27/2019 weedy alfalfa field, 27/2020 weedy red clover field, 28/2019 weedy alfalfa field, 29/2018 alfalfa field, 29/2020 alfalfa field, 35/2019 hayfield, 35/2020 hayfield

***Acrida ungarica* (Herbst,1786)**
4/2018 stubble, 7/2018 dirt-road, 9/2019 dirt-road, 23/2019 pasture, 23/2020 pasture, 41/1972[R], 42/1973[R], 43/1974[R]

***Chrysochraon dispar* (Germar, 1834)**
35/2018 hayfield, 35/2019 hayfield

***Stenobothrus crassipes* (Charpentier, 1825)**
41/1972[R], 43/1974[R]

***Stenobothrus nigromaculatus* (Herrich-Schaeffer, 1840)**
41/1972[R], 43/1974[R]

***Stenobothrus stigmaticus* (Rambur, 1838)**
41/1972[R]

***Omocestus rufipes* (Zetterstedt, 1821)**
6/2020 dirt-road, 7/2018dirt-road, 7/2019 dirt-road, 7/2020 dirt-road, 9/2018 dirt-road, 9/2020 dirt-road, 10/2018 stubble, 13/2018 alfalfa field, 15/2018 dirt-road, 15/2019 dirt-road, 15/2020 dirt-road, 16/2018 pasture, 16/2019 pasture, 16/2020 pasture, 17/2018 pasture, 17/2019 pasture, 17/2020pasture, 19/2018hayfield, 19/2019 hayfield, 19/2020 hayfield, 20/2019 hayfield, 20/2020 wheat field, 21/2018 hayfield, 21/2019 wheat field, 21/2020 wheat field, 22/2018pasture, 22/2019 pasture, 22/2020pasture, 23/2018pasture, 23/2019 pasture, 23/2020 pasture, 24/2019 ruderals, 25/2020 weed yred clover field, 27/2019 weedy alfalfa field, 27/2020 weedy red clover field, 28/2019 weedy alfalfa field, 29/2019 alfalfa field, 29/2020 alfalfa field, 30/2018 roadside, 30/2019 roadside, 30/2020 roadside, 33/2018 roadside, 33/2019 roadside, 33/2020 roadside, 34/2018 roadside, 34/2019 roadside, 34/2020 roadside, 35/2019 hayfield, 35/2020 hayfield, 39/2018 roadside, 39/2019 roadside, 39/2020 roadside, 40/2019 alfalfa field, 41/1972[R], 42/1973[R], 43/1974[R]

***Omocestus haemorrhoidalis* (Charpentier, 1825)**
2/2018 dirt-road, 4/2018 stubble, 6/2019, dirt-road, 7/2018 dirt-road, 7/2019 dirt-road, 9/2018 dirt-road, 9/2019dirt-road, 10/2018 stubble, 11/2018 stubble, 13/2018 alfalfa field, 13/2019alfalfa field, 14/2018 stubble, 14/2019 wheat field, 15/2018dirt-road, 15/2019dirt-road, 16/2020 pasture, 17/2018 pasture, 21/2018 hayfield, 24/2018 red clover field, 24/2019 ruderals, 25/2018 red clover field, 25/2019 ruderals, 27/2018 red clover field, 27/2019 weedy alfalfa field, 28/2018 red clover field, 28/2019 weedy alfalfa field, 30/2018 roadside, 30/2020roadside, 31/2018 stubble, 33/2018 roadside, 34/2018 roadside, 35/2018 hayfield, 37/2018 stubble, 38/2018 stubble, 39/2018 roadside, 40/2018 alfalfa field, 41/1972[R], 43/1974[R], 44/1993[G], 45/1993[N], 46/1994[G], 47/1994[N]

***Omocestus petraeus* (Brisout de Barneville, 1856)**
43/1974[R]

***Chorthippus biguttulus* (Linnaeus, 1758)**
6/2019 dirt-road, 7/2019 dirt-road, 10/2018 stubble, 16/2019 pasture, 32/2018 stubble, 33/2018 roadside, 34/2019roadside, 34/2020roadside, 35/2019 hayfield, 37/2019 wheat field, 39/2020 roadside, 41/1972[R], 42/1973[R], 43/1974[R]

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***Chorthippus brunneus* (Thunberg, 1815)**

1/2018 stubble, 1/2020 stubble, 3/2019 rape field, 4/2018 stubble, 4/2020 stubble, 5/2019 wheat field, 6/2018 dirt-road, 6/2019 dirt-road, 6/2020 dirt-road, 7/2018 dirt-road, 7/2019 dirt-road, 7/2020 dirt-road, 9/2018 dirt-road, 9/2019 dirt-road, 9/2020 dirt-road, 11/2019 wheat field, 13/2018 alfalfa field, 13/2019 alfalfa field, 13/2020 alfalfa field, 14/2018 stubble, 14/2019 wheat field, 15/2018 dirt-road, 15/2019 dirt-road, 15/2020 dirt-road, 21/2019 wheat field, 21/2020 wheat field, 24/2019 ruderals, 24/2020 red clover field, 25/2019 ruderals, 25/2020 weedy red clover field, 27/2018 red clover field, 27/2020 weedy red clover field, 28/2020 weedy red clover field, 29/2020 alfalfa field, 30/2019 roadside, 30/2020 roadside, 31/2018 stubble, 32/2020 wheat field, 33/2019 roadside, 34/2018 roadside, 34/2019 roadside, 34/2020 roadside, 35/2018 hayfield, 35/2019 hayfield, 35/2020 hayfield, 38/2018 stubble, 39/2019 roadside, 39/2020 roadside, 39/2018 roadside, 40/2019 alfalfa field, 40/2020 stubble, 41/1972[R],42/1973[R], 43/1974[R]

***Chorthippus mollis* (Charpentier, 1825)**

41/1972[R], 43/1974[R]

***Chorthippus dorsatus* (Zetterstedt,1821)**

2/2018 dirt-road, 5/2019 wheat field, 6/2018 dirt-road, 6/2019 dirt-road, 6/2020 dirt-road, 7/2018 dirt-road, 7/2020 dirt-road, 9/2018 dirt-road, 9/2019 dirt-road, 9/2020 dirt-road, 10/2018 stubble, 13/2018 alfalfa field, 13/2019 alfalfa field, 13/2020 alfalfa field, 14/2019 wheat field, 15/2018 dirt-road, 15/2019 dirt-road, 15/2020 dirt-road, 16/2018 pasture, 16/2019 pasture, 16/2020 pasture, 17/2018 pasture, 17/2019 pasture, 17/2020 pasture, 18/2018 stubble, 19/2018 hayfield, 19/2019 hayfield, 19/2020 hayfield, 20/2018 hayfield, 20/2019 hayfield, 21/2018 hayfield, 21/2020 wheat field, 22/2020 pasture, 23/2019 pasture, 23/2020 pasture, 24/2018 red clover field, 24/2019 ruderals, 24/2020 red clover field, 25/2019 ruderals, 26/2018 dirt-road, 27/2018 red clover field, 27/2020 weedy red clover field, 28/2019 weedy alfalfa field, 29/2020 alfalfa field, 30/2018 roadside, 30/2019 roadside, 30/2020 roadside, 33/2018 roadside, 33/2019 roadside, 33/2020 roadside, 34/2018 roadside, 34/2019 roadside, 34/2020 roadside, 35/2018 hayfield, 35/2019 hayfield, 35/2020 hayfield, 37/2018 stubble, 39/2019 roadside, 39/2020 roadside, 40/2019 alfalfa field, 41/1972[R], 43/1974[R], 44/1993[G], 45/1993[N], 46/1994[G], 47/1994[N]

***Chorthippus loratus* (Fischer von Waldheim, 1846)**

43/1974[R] * Revised by Nagy 2003.

***Chorthippus dichrous* (Eversmann, 1859)**

9/2020 dirt-road, 13/2019 alfalfa field, 17/2018 pasture, 19/2018 hayfield, 19/2020 hayfield, 20/2018 hayfield, 20/2020 wheat field, 21/2018 hayfield, 21/2020 wheat field, 26/2018 dirt-road, 27/2018 red clover field, 27/2019 weedy alfalfa field, 28/2018 red clover field, 30/2018 roadside, 33/2018 roadside, 35/2018hayfield, 35/2020hayfield, 39/2018 roadside, 43/1974[R]

***Chorthippus oschei* (Helversen, 1986) (formerly published as *C. albomarginatus* (DeGeer, 1773))**

4/2018 stubble, 6/2018 dirt-road, 7/2018 dirt-road, 9/2018dirt-road, 9/2019dirt-road, 10/2018 stubble,13/2018 alfalfa field, 15/2018 dirt-road, 16/2018pasture, 16/2020 pasture, 17/2018 pasture, 17/2020 pasture, 19/2018 hayfield, 19/2019 hayfield, 19/2020 hayfield, 20/2018 hayfield, 20/2019hayfield, 21/2018 hayfield, 23/2018 pasture, 23/2019 pasture, 23/2020 pasture, 29/2018 alfalfa field, 30/2018 roadside, 33/2018 roadside, 34/2018 roadside, 35/2018 hayfield, 39/2018 roadside, 43/1974[R]

***Pseudochorthippus parallelus* (Zetterstedt, 1821)**

2/2018 dirt-road, 6/2020 dirt-road, 7/2018 dirt-road, 7/2020 dirt-road, 9/2018 dirt-road, 9/2019 dirt-road, 9/2020 dirt-road, 11/2019 wheat field, 13/2020 alfalfa field, 15/2019 dirt-road, 15/2020 dirt-road, 16/2018 pasture, 16/2019 pasture, 16/2020 pasture, 17/2018 pasture, 17/2019 pasture, 17/2020 pasture, 19/2018 hayfield, 19/2019 hayfield, 19/2020 hayfield, 20/2018 hayfield, 20/2019 hayfield, 20/2020 wheat field, 21/2018 hayfield, 21/2019 wheat field, 22/2018 pasture, 22/2019 pasture, 23/2019 pasture, 24/2020 red clover field, 25/2019 ruderals, 25/2020 weedy red clover field, 26/2018 dirt-road, 28/2019 weedy alfalfa field, 29/2018 alfalfa field, 29/2020 alfalfa field, 30/2018 roadside, 30/2019 roadside, 30/2020 roadside, 33/2018 roadside, 33/2019 roadside, 33/2020 roadside, 34/2018 roadside, 34/2019 roadside, 34/2020 roadside, 35/2018hayfield, 35/2019 hayfield, 35/2020 hayfield, 37/2018 stubble

***Euchorthippus declivus* (Brisout de Barneville, 1848)**

2/2018 dirt-road, 6/2018 dirt-road, 7/2018 dirt-road, 7/2020 dirt-road, 9/2018 dirt-road, 9/2019 dirt-road, 9/2020 dirt-road, 13/2018 alfalfa field, 15/2018 dirt-road, 15/2020 dirt-road, 16/2018 pasture, 17/2018 pasture, 19/2018 hayfield, 20/2018 hayfield, 21/2018 hayfield, 23/2019 pasture, 29/2019 alfalfa field, 30/2018 roadside, 30/2020 roadside, 33/2018 roadside, 33/2019 roadside, 33/2020 roadside, 34/2019 roadside, 35/2018 hayfield, 35/2019 hayfield, 35/2020 hayfield, 37/2018 stubble, 39/2018 roadside, 43/1974[R]

***Euchorthippus pulvinatus* (Fischer de Waldheim, 1846)**

41/1972[R]

***Myrmeleotettix maculatus* (Thunberg, 1815)**

41/1972[R], 42/1973[R]

***Dociostaurus maroccanus* (Thunberg, 1815)**

48/1908[J]

***Dociostaurus brevicollis* (Eversmann, 1848)**

17/2019 pasture, 23/2019 pasture, 23/2020 pasture, 41/1972[R], 43/1974[R]

***Tetrix depressa* (Brisout de Barneville, 1848)**

29/2020 alfalfa field

***Tetrix subulata* (Linnaeu, 1758)**

46/1994[G], 47/1994[N]

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In the 4 published sources data of 12 sampling sites could be found. These sources mentioned 29 Orthoptera species in the study area and its surroundings. It means that only 69 data records of orthopterans were available from this area before our investigations. The occurrence of *Chorthippus loratus* in Hungary was revised by Nagy (2003), and data of *Chorhippus albomarginatus* should be added to newly recorded *C. oschei* based on Orczi 2002. Thus, the revised list of formerly published occurrences contains 28 species.

During our 3-year study, 2241 specimens of 30 Orthoptera species were sampled in the 40 sampling sites of agricultural landscape and most of the sampled specimens were adults (1762) which could be identified at species level. With this large amount of data, we provide 540 new distribution data records of orthopterans that means an almost eightfold increase in the number of data records. It showed that this area was a relatively poorly known part of the lowland and that the agricultural lands are very poorly represented in faunistical and different entomological studies.

The number of the formerly known and newly sampled species was nearly equal, but there were only 15 species that appeared in both checklists. It showed that in the former studies agricultural land was not studied or was poorly represented. Only Garay (1995) discuss data of *Calliptamus italicus* population living in stubble fields where we also detected this species sometimes with large abundance (Arnóczkyné et al., 2020).

13 species mentioned only in published sources are *Platycleis grisea*, *Montana montana*, *Oedaleus decorus*, *Oedipoda caerulescens*, *Stenobothrus crassipes*, *S. nigromaculatus*, *S. stigmaticus*, *Omocestus petraeus*, *Chorthippus mollis*, *Euchorthippuspulvinatus*, *Myrmeleotettix maculatus*, *Dociostaurus maroccanus* and *Tetrix subulata*. Most of them are characteristic mainly for open sandy grasslands which habitat type was not investigated in recent study.

In case of newly studied habitats, we could record 15 new species compared to published data: *Leptophyes albovittata*, *Conocephalus fuscus*, *Ruspolia nitidula*, *Tettigonia viridissima*, *Tessellana veyseli*, *Bicolorana bicolor*, *Roeseliana roeselii*, *Gampsocleisglabra*, *Gryllus campestris*, *Oecanthus pellucens*, *Celes variabilis*, *Mecostethus parapleurus*, *Chrysocraon dispar*, *Pseudochorthippus parallelus* and *Tetrix depressa*. Many of them can be characteristic to mesic and in some cases to humid habitats that can explain differences of former and newly recorded species lists.

First and last the actualized revised Orthoptera fauna of the studied area and its surroundings contain 43 Orthoptera species that is about a third of the Hungarian Orthoptera fauna.

In this area, three protected species, *Gampsocleis glabra*, *Acrida ungarica* and *Celes variabilis* can be found while most of the species are common and even abundant in Hungary especially in lowlands. According to Nagy and Rácz (2007) *Montana montana*, *Melanogryllus desertus*, *Chorthippus dichrous*, *Myrmeleotettix maculatus*, *Dociostaurus maroccanus and Tetrix depressa* are scattered, while *Ruspolia nitidula*, *Gampsocleis glabra*, *Gryllus campestri*, *Celes variabilis*, *Mecostethus parapleurus* and *Euchorthippus pulvinatus* are rare in Hungary, based on their spatial constancy. In the studied sites *G. glabra*, *M. parapleurus* and *C. dichrous* showed larger frequency than at country level. Among them *G. glabra* characteristic for mesic tall grasslands of lowlands, *M. parapleurus* prefer high dense vegetations of meadows and wet grasslands while *C. dichrous* also distributed mainly in the lowlands that can explain their higher local frequencies.

Orthopterans of different habitat types

Orthoptera assemblages of different habitat types showed significant differences considering both their species richness and composition. The most species-rich habitats were hayfields and dirt-roads, while wheat fields also showed relatively large species diversity. In these habitats, at least half of the recorded species occurred. Species richness of alfalfa fields, roadsides, stubble fields, and pastures were both larger than 10 species/site. In contrast in sunflower fields, the number of caught species was 4 while in the also intensively cultivated maize and rape fields only 1–1 species could be found (*Table 3*). In case of the rape seed field, only one sampling was carried out in 2019 (sampling site 3), but it can only partly explain the especially low species diversity.

Weedy sites of red clover and alfalfa fields were characterized separately from properly treated ones. In degraded sites can maintain less diverse Orthoptera assemblages especially in case of the alfalfa field, where changing of vegetation structure decrease the total number of species from 14 to 8 species (*Table 3*). In ruderals and weedy fields mainly widely distributed generalists could be found such as *Chorthippus dorsatus*, *Pseudochorthippus parallelus*, *Calliptamus italicus* and *Omocestus rufipes*, while less common species of these habitat types e.g. *Gampsocleis glabra*, *Tettigonia viridissima*, *Chorthippus oschei* and *Chorthippus biguttulus* were absent in these sites.

The more widely distributed species of the studied region were *Calliptamus italicus*, *Chorthippus dorsatus*, *Pseudochorthippus parallelus*, *Chorthippus brunneus*, *Omocestus haemorrhoidalis* and *Omocestus rufipes*. One third of the caught species could be found more than half of the studied habitat types, while the other third of the species occupied up to 3 from the studied 14 habitat types (*Table 3*). These latest mentioned species are less common also in the fauna of the Hungarian lowland and the whole country. These locally moderately rare and rare species could be found in non-cultivated and extensively used habitats such as hayfields, pastures, alfalfa, and red clover fields. Cultures with intense cultivation and intensive use of agrochemicals had only species-poor orthopteran assemblages.

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Table 3. **List of the Orthoptera species sampled between 2018 and 2020 in the firth region of the Sajó and Tisza rivers by the sampled agricultural habitat types. Species are sorted by the decreasing number of occupied habitat types, while habitat types are sorted based on their decreasing cumulated species richness**

	hayfield	dirt-road	wheat field	alfalfa field	roadside	stubble	pasture	red clover field	weedy alfalfa field	weedy red clover field	ruderals	sunflower field	rape field	maize field	**Number of occupied habitat types**
Chorthippus dorsatus	1	1	1	1	1	1	1	1	1	1	1				**11**
Pseudochorthippus parallelus	1	1	1	1	1	1	1	1	1	1	1				**11**
Calliptamus italicus	1	1	1	1	1	1		1	1	1				1	**10**
Chorthippus brunneus	1	1	1	1	1	1		1		1	1		1		**10**
Omocestus haemorrhoidalis	1	1	1	1	1	1	1	1	1		1				**10**
Omocestus rufipes	1	1	1	1	1	1	1		1	1	1				**10**
Roeseliana roeseli	1	1	1	1	1	1	1		1		1				**9**
Chorthippus dichrous	1	1	1	1	1		1	1	1						**8**
Conocephalus fuscus	1	1	1	1	1	1			1			1			**8**
Mecostethus parapleurus	1	1		1			1	1	1	1					**7**
Chorthippus oschei	1	1		1	1	1	1								**6**
Euchorthippus declivus	1	1		1	1	1	1								**6**
Gampsocleis glabra	1	1	1	1			1	1							**6**
Chorthippus biguttulus	1	1	1		1	1	1								**6**
Tettigonia viridissima	1	1	1	1				1				1			**6**
Gryllus campestris				1		1				1		1		1	**5**
Oecanthus pellucens	1		1		1		1					1			**5**
Bicolorana bicolor	1	1			1		1								**4**
Leptophyes albovittata	1	1			1	1									**4**
Ruspolia nitidula	1	1	1		1										**4**
Acrida ungarica		1				1	1								**3**
Aiolopus thalassinus						1	1	1							**3**
Melanogryllus desertus	1					1		1							**3**
Platycleis affinis		1				1									**2**
Tessellana veyseli			1												**2**
Celes variabilis	1														**1**
Chrysochraon dispar	1														**1**
Dociostaurus brevicollis							1								**1**
Phaneroptera nana			1												**1**
Tetrix depressa				1											**1**
Species number	**18**	**17**	**15**	**14**	**13**	**13**	**12**	**9**	**8**	**6**	**6**	**4**	**1**	**1**	

CONCLUSIONS

Our results drew attention to that the Orthoptera assemblages of agricultural habitats are generally poorly investigated and known. The recent 3-year study could provide large amount of faunistical data on a poorly known firth region of the Sajó and Tisza rivers containing data of three protected species (*Gampsocleis glabra*, *Acrida ungarica* and *Celes variabilis*). The amount of the known records was increased eightfold.

Analysis showed that the non-cultivated habitats as dirt-roads, roadsides, stubble fields, and extensive lands of hayfields and pastures can maintain species-rich habitats in agricultural lands. The less intensive cultures e.g. alfalfa and red clover fields and even the grasses and whet field also can preserve relatively diverse Orthoptera fauna that indicates also species-rich herbivorous insect community of these habitat types. Contrary to the intensively cultivated maize, sunflower, and rapeseed fields lost nearly their whole Orthoptera and other non-pest herbivores, thus in intensive agricultural lands even the less intensive cultures and other artificial habitats can become the last remains of former natural and semi-natural insect assemblages.

Since changes in agricultural landscape structure are driven by the economic environment, agricultural policy and climate change have further negative effects on insect diversity including diversity beneficial organisms as predators, parasites, and pollinators. Orthopterans as indicators can be used in planning and decision making both in conservation biology and landscape planning and even in the monitoring of the effect of our activities and can help us to form a more sustainable cultivation system.

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