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Floristic composition and conservation value of the stubble-field weed community, dominated by *Stachys annua* in western Hungary

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Abstract: The stubble-field weed community, dominated by *Stachys annua*, was generally distributed in Hungary until the 1950s on mid-heavy and heavy, base-rich soils. *Stachys annua* is an excellent nectar-producer, and from the nectar collected in its habitats popular stubble-honey was produced. This vegetation type has suffered significant decline, mainly due to the early ploughing of stubbles associated with the intensification of agriculture. In the present study, the floristic composition of this community is assessed based on 213 phytosociological records, and its distribution in the past ten years in western Hungary is mapped. Sixty-five percent of the species are of Eurasian, European and Mediterranean elements, and the largest proportion of the species are spring-germinating summer annuals. The proportion of insect-pollinated plant species is approximately 70%, and the species composition also offers significant seed food sources for farmland birds, e.g. *Coturnix coturnix* and *Perdix perdix*. Therefore this community should deserve a high conservation priority for biodiversity. The factors that offer the greatest threats to the continuing existence of this community type are intensive agricultural management and the increasing spread of *Ambrosia artemisiifolia*.

Key words: farmland birds; pollinators; rare weeds; stubble-honey.

Introduction

The agricultural intensification that has been occurring throughout Europe since the 1950s has largely impoverished the biodiversity of arable habitats. Particularly affected by this process have been the arable weed flora and its accompanying insect fauna and farmland birds. With regard to changes in weed vegetation, the following factors are primarily responsible: modern seed cleaning methods, the development of harvesting and threshing technologies, intensive soil cultivation, early stubble ploughing, enlargement of arable fields, the abandonment of extreme arable habitats, and the application of fertilizers and herbicides. The effects of these factors on the weed flora have been reviewed in several European works, e.g. in Germany by Eggers (1984), Albrecht & Bachthaler (1990), Hilbig & Bachthaler (1992), Schneider et al. (1994), Hofmeister & Garve (1998), Elsen et al. (2006), Baessler & Klotz (2006); in the UK by Wilson (1992), Sutcliffe & Kay (2000), Robinson & Sutherland (2002); in Denmark by Andreasen et al. (1996), in the Czech Republic by Lososová (2003) and Pyšek et al. (2005); in Poland by Kornaś (1988); in Slovenia by Šilc & Čarni (2005); in Slovakia by Eliáš & Baranec (2005); and in Hungary by Pinke (2004), Pinke & Pál (2005), and Király et al. (2006).

Intensive agricultural management systems consider stubble as one of the main suitable habitats for the build-up of weeds and other pests. Thus in Hungary since the 1950s both large-scale farms, and a significant proportion of small-scale farms, have tended to plough the stubble as soon as possible after the harvesting of cereals. As a consequence, the range and population size of weeds typical for stubble fields has reduced significantly, because these species fail to flower and set seeds. An example of one such typical stubble-weed species is *Stachys annua*, which before agricultural intensification in Hungary frequently covered stubble fields in dominant stands during late summer and early autumn. This species is an outstanding nectar-producer and it was one of the most important honey plants in Hungary until the 1950s (Nyárády 1958). The decease in production of stubble-honey caused by early ploughing dramatically affected bee-keepers and this led to conflicts between agricultural managers and bee-keepers in the 1950s. But the professional advisers of industrial agriculture regarded the benefits of stubble-honey to bee-keepers as low in comparison with the necessity of stubble-ploughing for weed control (Ujvárosi & Halász 1952).

Present Hungarian agriculture is characterised by a peculiar ambivalence. Large- and small-scale farms working with modern methods – and accordingly almost free from weeds – mostly prevail; however, the proportion of "untidy" arable fields is also remark-

Table 1. Some characteristics of the records in the surveyed regions. L = Lesser Plain of north-western Hungary; T-W= Transdanubian Mountain range and West-Hungarian margin territory; S = Somogy region; B = Baranya-Tolna region.

	L	T-W	S	B	Range	Average	Total
Number of records	85	46	12	70	–	–	213
Range of altitude (m)	100–180	120–350	110–270	110–350	100–350	–	–
Mean soil pH (H_2O)	8.2	7.9	8	7.8	7.8–8.2	8	–
Mean soil pH (KCl)	7.4	7.3	7.2	7.2	7.2–7.4	7.3	–
Mean number of species	34	31	31	24	24–34	30	–

able. These latter habitats, which include unploughed stubble, are increasingly being invaded by *Ambrosia artemisiifolia*, which is responsible for strong allergies, and by other problem weeds. This phenomenon serves to further emphasise the importance of early ploughing of stubble, and eradication campaigns publicised through the popular media have raised public awareness of the necessity for total weed control. Nevertheless, arable habitats not treated with herbicides and unploughed stubble can provide refugia for several rare and threatened weed species that are susceptible to the methods of intensive agriculture. In addition, the more common weed species occurring within the "untidy-weedy" sites can also provide valuable food sources and nesting habitats for several insect and bird species.

The aims of this study were: (i) to examine the still-existing stands of the stubble-field weed community, dominated by *Stachys annua*, and to map its distribution; (ii) to analyse its floristic composition and asses its significance for pollinators and farmland birds; and (iii) to provide recommendations for the maintenance of these habitats.

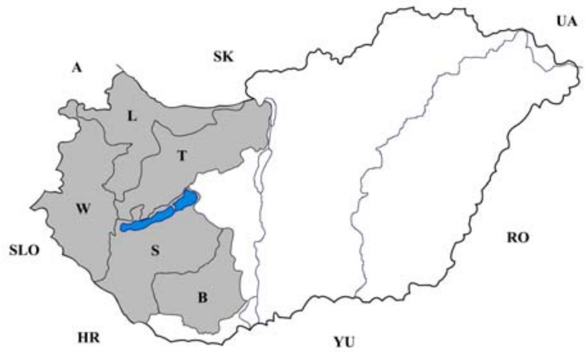

Fig. 1. Location of the study area, indicating the surrounding countries and the regions surveyed. L = Lesser Plain of north-western Hungary; T = Transdanubian Mountain range; W = West-Hungarian margin territory; S = Somogy region; B = Baranya-Tolna region.

Material and methods

Study area

Western Hungary consists of four main geographic areas: the Lesser Plain of north-western Hungary, the Transdanubian Mountain range, the West-Hungarian margin territory and the hilly land of southern Transdanubia. The latter is divided into the Somogy and Baranya-Tolna regions (Fig. 1). The altitude of western Hungary ranges between 100 and 880 m, and the total land area is 31100 km^2. Because of the presence of plains, hilly lands and mid-mountains, the landscape is very heterogenic. The overall climate of the entire territory is continental but the western parts show Subatlantic effects, whilst the southern parts and the southern slopes of the mid-mountains show Submediterranean effects. In the driest regions the mean annual precipitation is below 600 mm, while in the most humid western regions it is about 800–900 mm. The mean monthly temperatures at the coldest sites are about −4 °C in January and 17 °C in July, whilst at the warmest sites they are 0 °C and 22.5 °C, respectively. There is a great variety in bedrocks and in soil types, associated with the diverse geographical forms; sand, loam and also clay can be found, with acid, neutral or basic pH in many different combinations and types (Marosi & Somogyi 1990).

The extent of habitats that are close to being natural is low, the major part of the surveyed area being characterised by large-scale arable fields. Extensively managed small-scale fields can be found adjacent to some settlements, but they are increasingly declining in number due to intensification, abandonment and building development.

Methods

This work forms part of a comprehensive research study that surveyed the weed vegetation on extensively managed fields in the western part of Hungary, based on 1698 phytosociological records collected between 1995 and 2005, in the Lesser Plain of north-western Hungary (Pinke 2000), in the Transdanubian Mountain range and West-Hungarian margin territory (Pinke 2007), in the Somogy region (Pinke & Pál 2006) and in the Baranya-Tolna region. Altogether 15 vegetation units were described, and its diagnostic species were determined with statistical fidelity measures (Pinke & Pál 2008). This paper focuses on 213 records that were collected from stands of stubble-field weed communities dominated by *Stachys annua* (Table 1). The size of individual plots was 50 m^2, and a plot was placed within a field where the most diagnostically important species were present. Consequently the selection of plots was not random, but rather subjective and deliberately. Our aim was thus to make an inventory from the best developed remnant stands of this unique community. Phytosociological samples were set up in stubble of different crops (Table 2) during late August and September, according to the method of Braun-Blanquet (Dierschke 1994, p. 160). In plots soil samples were collected and their pH was measured in distilled water and KCl (Table 1). The recorded plant species, their frequencies, percentage-cover values, and other attributes are listed in Appendix 1 (species below 1% frequency are not shown and were not included in the evaluation). The mean percentage-cover values were obtained by the transformation of the Braun-Blanquet scale, according to the method of Dierschke (1994 p. 272). The distribution data were encoded according to Niklfeld (1971) by using the CEU mapping (Király &

Table 2. The percentage of different crop plants in the records and the time of their sowing.

Crop plants	Time of sowing	Number of records	Percentage
Triticum aestivum	autumn or spring	75	35.2
Hordeum distichon	mainly spring	74	34.7
Triticale rimpaui	autumn or spring	23	10.8
Avena sativa	mainly spring	18	8.4
Hordeum vulgare	mainly autumn	15	7.0
Secale cereale	Autumn	3	1.4
Brassica napus	Autumn	3	1.4
Linum usitatissimum	Spring	1	0.5
Fallow	–	1	0.5

Table 3. Species number of the twelve most species-rich families of the surveyed weed community and their importance in farmland bird diet, according to Marshall et al. 2003.

Family	Species number		Importance in farmland bird diet
	Absolute	Percentage	
Asteraceae	28	18.2	important
Poaceae	12	7.8	very important
Lamiaceae	11	7.1	important
Leguminosae	10	6.5	–
Brassicaceae	10	6.5	very important
Scrophulariaceae	8	5.2	present
Euphorbiaceae	8	5.2	present
Boraginaceae	7	4.5	important
Chenopodiaceae	6	3.9	very important
Apiaceae	6	3.9	–
Polygonaceae	5	3.9	very important
Caryophyllaceae	5	3.9	very important
Total	116	76.6	–

Horváth 2000) (Fig. 2). The nomenclature and chorological areas of plant species are based on Simon (2000), the life forms are based on Ujvárosi (1973), the mode of pollination is based on Soó (1964–1980), the Red List classification follows Király (2007) and the bird food-source importance is based on Keve et al. (1953) and Faragó (1997) (Appendix 1).

The calculation of spectra (in the case of life forms, chorological units and modes of pollination) were conducted according to Dierschke (1994, p. 290) on the basis of group-participation ('Gruppenanteil') and group-weight-participation ('Gruppenmengeanteil'). The first takes into account the frequencies of species in percentage terms, and the second the mean percentage-cover values of the species.

Because the number of records varied considerably between the four regions in the study area, average values were calculated both with respect to frequency and to mean cover in order to avoid over- or under-representation of any individual region (Appendix 1).

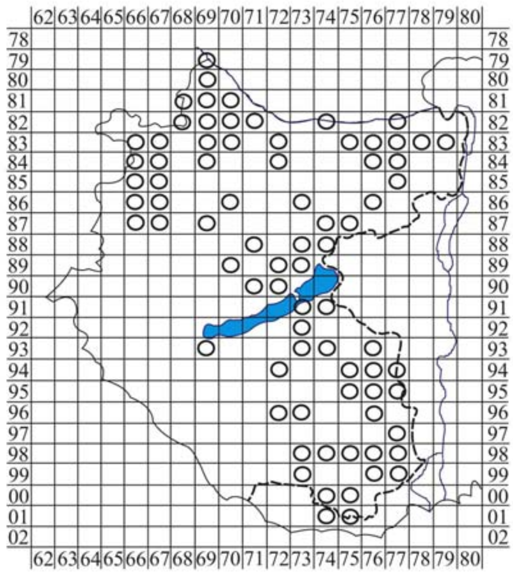

Fig. 2. Distribution of the stubble-field weed community dominated by *Stachys annua* in the study area.

Results

Floristic composition

In total, 227 species occurred within the 213 records examined, but only 154 reached the 1% frequency level or above, and the evaluation was based only on these species. The 154 species belonged to 36 families, the twelve most important being: *Asteraceae* (28 species), *Poaceae* (12 species), *Lamiaceae* (11 species), *Leguminosae* (10 species), *Brassicaceae* (10 species), *Scrophulariaceae* s.l. (8 species), *Euphorbiaceae* (8 species), *Boraginaceae* (7 species), *Chenopodiaceae* (6 species), *Apiaceae* (6 species), *Polygonaceae* (5 species), and *Caryophyllaceae* (5 species). These made up 76.6% of the total plant species (Table 3).

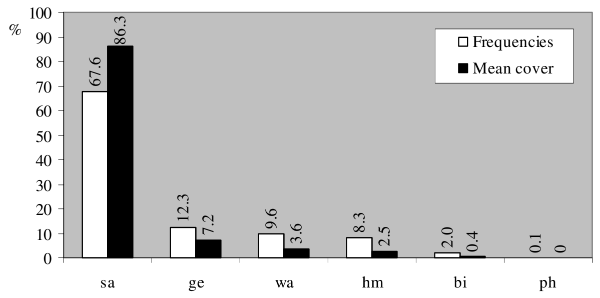

Fig. 3. Life form spectra of the surveyed weed community on the basis of frequency and mean cover percentage. sa = summer annuals; ge = geophytes; wa = winter annuals; hm = hemicryptophytes; bi = biennials; ph = phanerophytes.

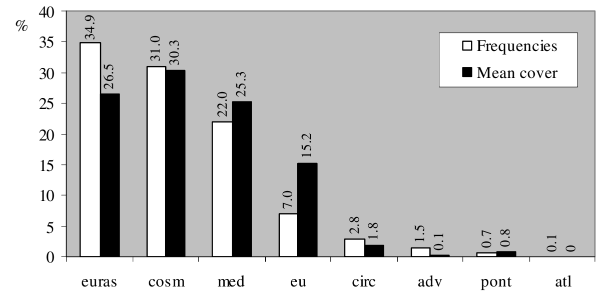

Fig. 4. Spectra of chorological units of the surveyed weed community on the basis of frequency and mean cover percentage. euras = Eurasian; cosm = cosmopolitan; med = Mediterranean; eu = European; circ = Circumpolar; adv = adventive; pont = Pontian; atl = Atlantic.

Life form spectra
The proportions of life forms are presented in Fig. 3. Both on the basis of frequency and of mean cover value, a pronounced dominance of summer annuals was represented (frequency 67.6%; mean cover 86.3%). Geophytes (12.3%; 7.2%), winter annuals (9.6%; 3.61%) and hemicryptophytes (8.3% 2.4%) were also important. Biennials and seedlings of phanerophytes showed a negligibly low presence.

Spectra of chorological areas
As shown in Fig. 4, both on the basis of frequency and of mean cover value, the most significant chorological elements were as follows: Eurasian (frequency 34.9%; mean cover 26.45%), cosmopolitan (31%; 30.28%), Mediterranean (22%; 25.29%) and European (6.97%; 15.19%). In addition, there are also Circumpolar, adventive, Pontian and Atlantic elements present in very low amounts.

Spectra of pollination modes
The largest proportion was insect-pollinated species, both on the basis of frequency (69.8%) and of mean cover value (68.3%). The proportion of wind-pollinated species was 21% and 26.9% in terms of frequency and mean cover, respectively, while that of self-pollinated species was 9.21% and 4.85%, respectively (Fig. 5).

It should be noted that alternative self-pollination [denoted by "(s)" in Appendix 1)] was not included in these calculations, the aim being limited to determination of the proportions of potential insect- and wind-pollinated species.

Species for farmland birds
Of the twelve most important plant families of the weed community surveyed by the present study, ten are significant in the diet of farmland birds. Among them, five (*Poaceae*, *Brassicaceae*, *Chenopodiaceae*, *Polygonaceae* and *Caryophyllaceae*) have been classified as "very important" (Table 3). The most significant 30 species are listed in Table 4; the twelve most frequent and most dominant species of the surveyed community and their importance for seed-eating birds can be seen in Figs 6 and 7.

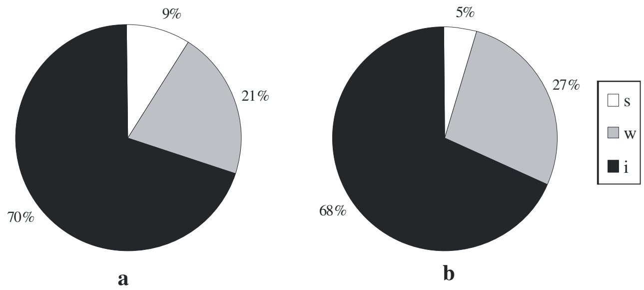

Fig. 5. Spectra of the mode of pollination of the surveyed weed community on the basis of frequency (a) and mean cover percentage (b). s = self-pollinated; w = wind-pollinated; i = insect-pollinated.

Discussion

Dynamics, habitat, diagnostic species and distribution of the community
The community examined by the present work based on the current phytosociological nomenclature is termed *Stachyo annuae–Setarietum pumilae* Felföldy 1942 corr. Mucina 1993 (Borhidi 2003). Depending on soil moisture it can be divided into two variants. This work focuses only on the typical variant, because in the wetter variant *Stachys annua* no longer assumes a dominant role (Pinke 2000).

Diagnostic species of the weed community in order of fidelity are as follows: *Stachys annua, Ajuga chamaepitys, Euphorbia falcata, Anagallis foemina, Reseda lutea, Kickxia elatine, Setaria viridis, Anagallis arvensis, Euphorbia exigua, Microrrhinum minus, Kickxia spuria, Mercurialis annua, Silene noctiflora, Cerinthe minor, Medicago lupulina, Setaria pumila, Thymelaea passerina, Solanum nigrum, Sonchus asper, Heliotropium europaeum* and *Fallopia convolvulus* (Pinke & Pál 2008). The most frequent species (above 70% frequency) were: *Stachys annua, Anagallis arvensis, Chenopodium album, Fallopia convolvulus, Ambrosia artemisiifolia, Convolvulus arvensis, Ajuga chamaepitys, Anagallis femina, Polygonum aviculare, Setaria pumila* and *Setaria viridis* (Appendix 1). The most dominant species in the layer from the soil surface up to 20–40 cm height was *Stachys annua.* In a

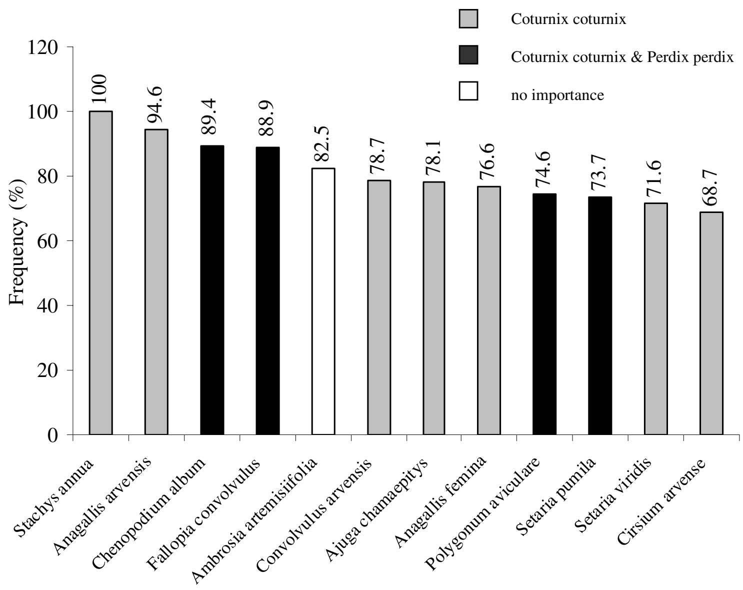

Fig. 6. The twelve most frequent species of the surveyed community and their importance for seed-eating birds.

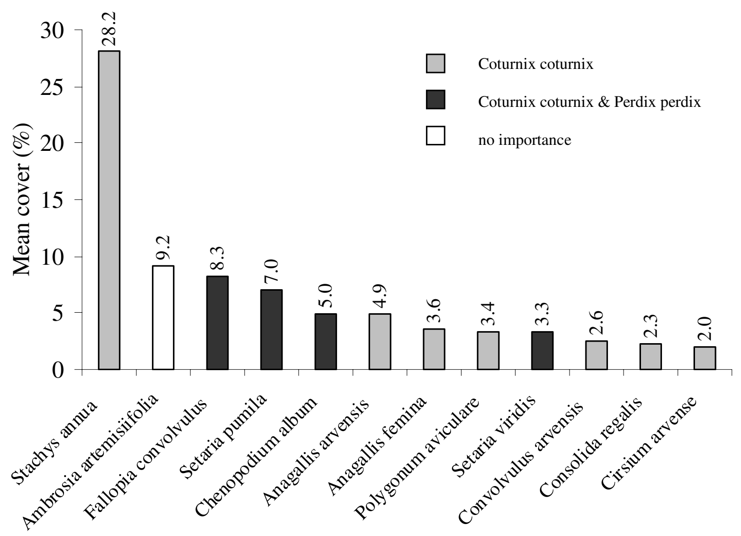

Fig. 7. The twelve most dominant species of the surveyed community and their importance for seed-eating birds.

higher layer, usually in 30–60 cm height, the following species may also be significant in terms of percentage cover: *Ambrosia artemisiifolia*, *Setaria pumila*, *S. viridis* and *Chenopodium album*. Dominant species close to the soil surface were: *Fallopia convolvulus*, *Anagallis arvensis*, *A. femina*, *Polygonum aviculare* and *Convolvulus arvensis*. 13 Hungarian Red List species were recorded in this community, but only two of them exceeded the 1% frequency level: *Misopates orontium* and *Bifora radians*. Red list species under 1% frequency were: *Anthemis cotula, Bombycilaena erecta, Brassica elongata, Galium tricornutum, Herniaria hirsuta, Lathyrus aphaca, Legousia speculum-veneris, Melampyrum arvense, Solanum villosum, Teucrium botrys* and *Thesium dollineri.*

The *Stachys annua*-dominated stubble-field weed community is a species-rich (mean number of species 30 per 50 m^2), typical stubble association with a seasonal peak in late summer and early autumn. In fact the development of the community starts in May, within the lower herb layer under the shelter of the cereal stands. But at this time its species are only usually aggregating in a synusiae on the soil surface; they start to grow only after harvest, in response to the favourable light conditions created by the removal of the dense crops. Late-summer rainfalls are also required for the development of this weed community (Ubrizsy 1954; Nyárády 1958), the stands of which grow up in the stubble of both autumn- and spring-sown cereals; on the basis of our field observations, spring cereals seem to be more favourable. Thus all of the diagnostic species and the largest proportion (67.6% and 86.3%, frequency and mean cover, respectively) of the entire species composition are spring-germinating summer annuals (Fig. 3). Soil cultivation in spring is well suited to the life cycle of these species, and in addition it can provide more

Table 4. The importance of weed species of the surveyed community in the seed diet of *Coturnix coturnix* (from Keve et al. 1953) and *Perdix perdix* (from Faragó 1997). Only the 30 most significant bird seed-food species are shown, ranked by their frequency in the diet of *C. coturnix.*

Weed species	*Coturnix coturnix*			*Perdix perdix*	Rank in the surveyed community	
	No. of cases	Frequency (%)	No. of seeds		Frequency	Mean cover
Setaria pumila	181	63.3	15432	important	10	4
Setaria viridis	123	43	12791	important	11	9
Stachys annua	86	30	7310	–	1	1
Fallopia convolvulus	57	19.9	434	important	4	3
Centaurea cyanus	46	16	451	–	90	112
Polygonum aviculare	45	15.7	1506	–	9	8
Anagallis arvensis	44	15.4	598	–	2	6
Anagallis femina				–	8	7
Reseda lutea	35	12.2	1441	–	16	15
Chenopodium album	33	11.5	2200	important	3	5
Ajuga chamaepitys	33	11.5	241	–	7	14
Persicaria lapathifolia	24	8.4	161	–	46	44
Panicum miliaceum	19	6.6	1000	–	34	47
Echinochloa crus-galli	17	5.9	121	important	28	29
Consolida regalis	15	5.2	353	–	13	11
Euphorbia falcata	15	5.2	161	–	14	13
Viola arvensis	15	5.2	72	–	15	25
Persicaria maculosa	14	4.9	86	–	62	59
Euphorbia exigua	13	4.5	313	–	23	20
Medicago lupulina	13	4.5	43	–	19	26
Solanum nigrum	12	4.2	731	–	24	46
Plantago lanceolata	12	4.2	27	–	92	114
Cannabis sativa	10	3.5	343	–	42	45
Digitaria sanguinalis	10	3.5	144	–	84	72
Hibiscus trionum	9	3.2	47	–	50	42
Amaranthus retroflexus	8	2.8	2373	important	37	64
Mercurialis annua	6	2	165	–	33	16
Cirsium arvense	6	2	110	–	12	12
Rubus caesius	6	2	40	–	65	53
Convolvulus arvensis	6	2	6	–	6	10

favourable germinating conditions that are free from competition with winter annuals. The crop species associated with the plots were identified on the basis of ear remains during the fieldwork, but it was impossible to determine whether the given crop was sown in autumn or spring. It was not possible in practical terms to locate the landowner of each plot to answer this question, so our assumption that spring-sown cereals are more favourable to this weed community cannot be proved quantitatively. Nevertheless, from the proportion of crop species in the records (Table 2), some conclusions can be made. In Hungary the most current varieties of *Hordeum distichon* and *Avena sativa* are spring-sown, together making up 43% of the crop spectra (Table 2). *Triticum aestivum* and *Triticale rimpaui*, which together make up 46% of the crop spectra, can be sown both in autumn and spring. So the proportion of the spring-sown cereals is probably between 50 and 70%.

The weed community generally grows on extensively managed small-sized arable fields, but it also occasionally evolves on large-scale fields. This is most likely to be in situations where there has been a relatively early herbicide application at a time when the stubble weed species are mostly still present as seeds, which start to germinate only later, after the application.

The stubble weed community has a Continental-Mediterranean character, with about 65% of the species being Eurasian, European or Mediterranean in nature (Fig. 4). The community occurs within the area of study on mid-heavy and heavy, base-rich soils (mean pH values: 8/H_2O/ and 7.3/KCl/), between altitudes of 100–350 m (Table 1). Within the area surveyed, arable habitats exist only within this altitude range and so the stubble weed community effectively occurs throughout its entire potential range. The community is totally absent from the south-western landscapes (Fig. 2), mainly due to unfavourable abiotic conditions: acidic soil types prevail, and the climate shows a Subatlantic character. The community is substituted by other vegetation types on stubble fields in these areas (Pinke 2007).

This association occurs throughout Hungary, but the current distribution in eastern Hungary still remains to be fully determined. It has also been described as the *Stachys annua–Ajuga chamaepitys* community, and under several other synonym names as well in neighbouring Vojvodina (Yugoslavia), Slovakia, Czech Republic and Austria; its diagnostic species also occur in other Central-European communities in varying combinations (Slavnić 1951; Mucina 1993; Hüppe & Hofmeister 1990; Mochnacký 2000; Lososová 2004; Šilc 2005; Kropáč 2006; Šilc & Čarni 2007). The distributional range of *Stachys annua* also stretches into

Eurasia, e.g. in Russia it can be found sparsely within cereal and row-crop fields, sometimes being more frequent within spring-cereals (Kästner et al. 2001).

Likely origin and recent retreat of the community, and invasion by Ambrosia artemisiifolia

It is notable that *Stachys annua* is an archaeophytic species in Hungary, its archaeobotanical remains being detected from the Neolithic, iron ages and medieval times (Hartyányi et al. 1968; Gyulai 2001). Although it is very difficult to draw any conclusions from these remains regarding the early phytosociological behaviour of this species, it is perhaps likely that the community dominated by *Stachys annua* could have evolved in its original form at the time of the three-field rotation systems in the Middle Ages. The plentiful occurrence of stubble and fallows at that time may have ensured periods long enough for flowering and seed ripening, and thus replenishment of the soil seed banks of these species. The grazing of stubble and fallows would have caused some disturbance, but it was not likely to been significantly harmful. On the contrary, it could greatly encourage the spread of weed species, as has been demonstrated in the work of Bonn & Poschlod (1998). It should be mentioned that in some regions of Europe, for example in Southern France stubble are still grazed today (Gerbaud et al. 2001).

The honey-producing potential of these weed assemblages was perhaps recognized and utilized in the medieval times. The stands of *Stachys annua* provided excellent foraging for bees and thus provided beekeepers with profitable stubble-honey until the 1950s (Nyárády 1958).

Felföldy (1942), the original descriptor of this weed association, characterized *Stachyo annuae–Setarietum pumilae* in the 1940s as a species-rich, generally distributed vegetation type throughout Hungary. Due to early ploughing of stubble and increasing cropping of maize in monocultures, the weed community has declined significantly since the 1950s. In the major part of its potential habitats the typical stubble weed species are already almost totally absent and in their place common and noxious weeds are prevailing, most frequently: *Ambrosia artemisiifolia*, *Amaranthus chlorostachys*, *A. retroflexus*, *Datura stramonium, Echinochloa crus-galli*, *Galinsoga parviflora*, *Panicum miliaceum* and *Tripleurospermum inodorum.* In particular the large expansion of *Ambrosia artemisiifolia* seriously threatens the existence of the *Stachys annua* community, not only because it is invading more and more habitats of *Stachys annua*, but also because it's allergenic effects has resulted in greater emphasis being placed on the importance of early ploughing of stubbles. Unfortunately this species already has the second largest mean percentage-cover even in the most developed remnant stands of *Stachys annua* examined by the present work. In recent decades *Ambrosia artemisiifolia* has became the most noxious weed species in Hungary, and its cover is rising increasingly. It occurs mainly in sunflower and stubble in large monodominant stands (Kőmives et al. 2006; Tamás et al. 2006). This weed species is of North-American origin and it is also expanding in other European countries, its large quantities of allergenic pollen causing several health problems (e.g. Laidi et al. 2003; Bohren et al. 2006; Peternel et al. 2006).

Importance of the community for insect pollinators

It is known that insect populations show similar patterns to those in associated arable weed vegetation. The insect assemblages reach their peak directly before the flowering of cereals and then decline directly after harvest. As the stubble weed community gradually starts to grow, so the number of insect species rises and usually reaches its second peak at the end of August (Jermy & Szelényi 1958). The methods of intensive agriculture in recent decades, mainly in relation to herbicides, pesticides and the destruction of nesting sites, has dramatically reduced the insect-pollinator fauna linked to weed species (e.g. Benedek 1997; Kearns et al. 1998; Goulson et al. 2005). In contrast, the still-existing arable habitats that are managed by extensive, traditional methods may have beneficial effects through having greater floral diversity for pollinator communities (Petanidou & Lamborn 2005; Pinke et al. 2008).

As is shown in the pollinator range of the weed community examined in the present study, the proportion of insect-pollinated plant species is about 70% (Fig. 5). Therefore, the maintenance of the still-existing habitats of the *Stachys annua* community should have a major conservation importance for insect pollinators. Within the agro-ecosystems impoverished due to the industrial agriculture of recent decades, the habitats of the *Stachys annua* community might function as "refugia isles for insect biodiversity". In addition, this community produces nectar and pollen even in the autumn period, when other nectar plants are scarcely flowering. It is worth mentioning that *Stachys annua* and other, more common species could have a major role in the survival of rarer plants; thus Gibson et al. (2006) have documented that the long-term survival of rare plant populations is likely to depend on the more common species in the community via shared pollinators.

Importance of the community for farmland birds

Weeds are an important food source for farmland birds, both directly through seeds and through the insects that are associated with the weeds (Wilson et al. 1999). Most farmland birds feed largely on seeds and other plant material as adults, but require invertebrate food to nourish their chicks (Marshall et al. 2003). In Hungary, as throughout Europe, populations of farmland birds have suffered a dramatic decline as a consequence of agricultural intensification since the 1950s (Faragó 1997).

In Hungary, Keve et al. (1953) summarized data for weed seeds that were present in the diet of *Coturnix coturnix*, investigated over a 60–year period before the 1950s. According to this study, 64 species of the weed community surveyed by the present work could be found in the diet of *C. coturnix* (Appendix 1). Of these, the most significant 30 species are listed in Table 4. Although results of similar detailed investigations are not available in the Hungarian literature, Faragó (1997) found that seeds of nine species of the community surveyed in this study were significant in the diet of *Perdix perdix* (Appendix 1, Table 4). According to Keve et al. (1953), the seed diet of these two bird species are very similar, so all of the weed species recorded as consumed by *C. coturnix* might also be present in the diet of *P. perdix*. With regard to the occurrence in bird diets (Table 4) and also on the basis of rankings of frequency and mean cover values, the most significant species in the surveyed community are as follows: *Setaria pumila*, *S. viridis*, *Stachys annua*, *Fallopia convolvulus*, *Polygonum aviculare*, *Anagallis arvensis*, *A. femina*, *Reseda lutea*, *Chenopodium album* and *Ajuga chamaepitys*. Fig. 6 shows the twelve most frequent species in the surveyed community and Fig. 7 shows the twelve most dominant, and it can be seen that each of these species except *Ambrosia artemisiifolia* is present in the seed diets of the two farmland birds. It should be mentioned that the acceptance of *Ambrosia artemisiifolia* by wild birds was also proved by other researchers (Vitalos & Karrer 2008), but this weed species was not widespread in Hungary at the time of the investigation of Keve et al. (1953).

These data suggest that the species composition of the *Stachys annua* community offers a very significant source of seeds for farmland birds, especially for *Coturnix coturnix* and also *Perdix perdix*. Stubble covered by this vegetation type are very important foraging habitats in late summer and autumn before the migration *C. coturnix*, and also throughout the winter for *P. perdix*.

Studies in the UK have also shown that the seeds of weed vegetation associated with stubble are a remarkable food source for farmland birds. The function of stubble as a foraging habitat for farmland birds is enhanced by increasing its structural heterogeneity and by allowing it to remain unploughed during the winter. A number of agri-environment schemes prescribe retaining stubble into mid-February, and in these habitats an increase in farmland bird populations has been observed (Chamberlain et al. 2000; Robinson & Sutherland 2002; Evans et al. 2004; Butler et al. 2005). It is also important to note that compact patches of weeds on stubble fields are used as shelter by birds, providing them favourable wintering conditions and protection from predators (Orlowski 2006; Orlowski & Czarnecka 2007).

In conclusion we can state that although the stubble-field weed community dominated by *Stachys annua* has declined significantly due to intensification of farmland use, the present study has revealed that several remnant habitats still exist in western Hungary, and these habitats should merit a high conservation priority for biodiversity. On fields where *Stachys annua* occurs in dominant stands, and there is not significant infestation by *Ambrosia artemisiifolia*, the time of stubble ploughing should be postponed until November, or even until mid-February in order to benefit over-wintering of farmland birds. In these fields cropping of maize and sunflower should be avoided if possible and the crop rotation should be predominated by cereals, and preferably by spring varieties. It would be worthwhile to attempt to reinitiate the produce of stubble-honey in cooperation with bee-keepers, thus hopefully making it a more attractive conservation option for landowners; however, apiary should be practiced in moderation, so that honey bees do not over-compete to the detriment of wild pollinators. Further studies are required to determine the composition of the invertebrate fauna linked to this community, and to find strategies to discourage the invasion and further expansion of *Ambrosia artemisiifolia* in these habitats.

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Appendix 1. Floristic composition and attributes of species of the surveyed weed community.

Species	Frequency (%)					Mean cover of percentage					Life form	Area	Polli-nation	Bird food Source	Family
	L	T-W	S	B	Average	L	T-W	S	B	Average					
Stachys annua	100.00	100.00	100.00	100.00	**100.00**	24.79	27.40	37.29	23.32	**28.20**	sa	med-eu	i (s)	c	Lamiaceae
Anagallis arvensis	98.00	89.10	100.00	91.40	**94.60**	6.06	2.44	5.67	5.50	**4.92**	sa	euras	i (s)	c	Primulacea
Chenopodium album	98.00	97.80	92.00	70.00	**89.40**	4.19	6.56	5.25	3.86	**4.97**	sa	cosm	w	c, p	Chenopodiaceae
Fallopia convolvulus	94.00	84.80	100.00	77.10	**88.90**	3.76	5.73	16.70	6.88	**8.27**	sa	euras-med	i (s)	c, p	Polygonaceae
Ambrosia artemisiifolia	65.00	76.10	92.00	97.10	**82.50**	2.69	7.09	11.28	15.77	**9.21**	sa	cosm	w	–	Asteraceae
Convolvulus arvensis	81.00	87.00	67.00	80.00	**78.70**	1.91	4.34	1.51	2.56	**2.58**	ge	cosm	i (s)	c	Convolvulaceae
Ajuga chamaepitys	80.00	82.60	100.00	50.00	**78.10**	1.64	3.68	0.50	0.93	**1.69**	sa	med	i	c	Lamiaceae
Anagallis femina	79.00	80.40	100.00	47.10	**76.60**	3.04	3.40	6.47	1.46	**3.59**	sa	euras	i (s)	c	Primulacea
Polygonum aviculare	82.00	91.30	58.00	67.10	**74.60**	2.14	5.97	0.06	5.31	**3.37**	sa	cosm	s	c	Polygonaceae
Setaria pumila	73.00	78.30	75.00	68.60	**73.70**	4.30	9.86	6.28	7.50	**6.99**	sa	cosm	w	c, p	Poaceae
Setaria viridis	73.00	87.00	75.00	51.40	**71.60**	1.73	5.59	2.76	3.06	**3.28**	sa	euras	w	c, p	Poaceae
Cirsium arvense	88.00	67.40	58.00	61.40	**68.70**	4.10	1.57	0.26	2.21	**2.03**	ge	euras-med	i (s)	c	Asteraceae
Consolida regalis	40.00	65.20	92.00	74.30	**67.90**	0.27	2.75	2.98	3.22	**2.30**	wa	euras	i	c	Ranunculaceae
Euphorbia falcata	82.00	69.60	75.00	40.00	**66.60**	1.39	2.12	2.56	0.81	**1.72**	sa	euras	i (s)	c	Euphorbiaceae
Viola arvensis	72.00	54.30	67.00	50.00	**60.80**	0.24	0.59	1.31	0.58	**0.68**	wa	euras	i (s)	c	Violaceae
Reseda lutea	71.00	71.70	67.00	31.40	**60.30**	0.77	3.68	1.31	0.81	**1.64**	sa	euras-med	i (s)	c	Resedaceae
Tripleurospermum inodorum	51.00	58.70	50.00	58.60	**54.60**	0.16	2.27	0.25	1.07	**0.94**	sa	euras	i (s)	–	Asteraceae
Kickxia elatine	61.00	34.80	67.00	52.80	**53.90**	2.16	0.90	0.27	1.39	**1.18**	sa	med-eu	i (s)	–	Scrophulariaceae
Medicago lupulina	61.00	63.00	50.00	31.40	**51.30**	1.48	0.97	0.05	0.13	**0.66**	sa	euras-med	i (s)	c	Leguminosae
Conyza canadensis	48.00	39.10	58.00	37.10	**45.50**	0.28	0.96	0.26	0.32	**0.45**	sa	cosm	s	–	Asteraceae
Artemisia vulgaris	28.00	43.50	67.00	40.00	**44.60**	0.03	0.10	0.07	3.56	**0.94**	hm	circ-med	0	–	Asteraceae
Lathyrus tuberosus	52.00	45.70	42.00	38.60	**44.60**	0.37	0.53	0.24	0.39	**0.38**	ge	euras-med	i	–	Leguminosae
Euphorbia exigua	61.00	47.80	58.00	2.80	**42.40**	0.93	1.88	1.50	0.00	**1.08**	sa	med-eu	i (s)	c	Euphorbiaceae
Solanum nigrum	51.00	15.20	75.00	27.10	**42.00**	0.49	0.02	0.08	0.24	**0.20**	sa	cosm	i	c	Solanaceae
Sonchus asper	59.00	28.30	42.00	35.70	**41.20**	1.34	0.03	0.04	0.01	**0.35**	sa	cosm	i	c	Asteraceae
Taraxacum officinale	67.00	32.60	33.00	31.40	**41.00**	0.54	0.36	0.03	0.07	**0.25**	hm	euras-med	i	–	Asteraceae
Microrrhinum minus	54.00	32.60	58.00	18.50	**40.70**	0.22	0.14	0.66	0.12	**0.28**	sa	med-eu	s	c	Scrophulariaceae
Echinochloa crus-galli	53.00	37.00	33.00	30.00	**38.20**	0.83	0.74	0.03	0.10	**0.42**	sa	cosm	w	c, p	Poaceae
Plantago major	45.00	30.40	33.00	37.10	**36.40**	0.10	0.35	0.03	0.60	**0.27**	hm	euras-med	w	–	Plantaginaceae
Silene noctiflora	68.00	65.20	–	–	**33.30**	2.16	2.86	–	–	**1.26**	sa	euras	i (s)	–	Caryophyllaceae
Elymus repens	52.00	50.00	8.30	22.80	**33.30**	1.74	2.04	0.01	1.01	**1.20**	ge	circ	w	–	Poaceae
Chenopodium hybridum	51.00	28.30	42.00	8.50	**32.40**	0.31	0.08	0.04	0.01	**0.11**	sa	euras-med	w	c	Chenopodiaceae
Mercurialis annua	78.00	37.00	–	1.40	**29.10**	4.59	0.84	–	0.21	**1.41**	sa	cosm	w, i	c	Euphorbiaceae
Panicum miliaceum	25.00	21.70	50.00	17.10	**28.40**	0.08	0.50	0.05	0.12	**0.19**	sa	euras	w	c	Poaceae
Sonchus oleraceus	38.00	39.10	25.00	11.40	**28.40**	0.09	0.04	0.03	0.01	**0.04**	sa	cosm	i	c	Asteraceae
Lactuca serriola	38.00	23.90	25.00	24.30	**27.80**	0.07	0.02	0.03	0.02	**0.03**	sa	euras-med	i (s)	–	Asteraceae
Amaranthus retroflexus	47.00	37.00	8.30	14.20	**26.60**	0.08	0.25	0.01	0.05	**0.09**	sa	cosm	i, w	c, p	Amaranthaceae
Euphorbia helioscopia	20.00	28.30	42.00	11.40	**25.40**	0.02	0.03	0.04	0.22	**0.08**	sa	cosm	i (s)	c	Euphorbiaceae
Amaranthus chlorostachys	52.00	32.60	8.30	8.50	**25.30**	0.34	0.73	0.01	0.01	**0.27**	sa	cosm	i, w	–	Amaranthaceae
Cerinthe minor	27.00	26.10	25.00	21.40	**24.90**	0.75	1.32	0.23	0.91	**0.80**	hm	pont-med	i	c	Boraginaceae
Sinapis arvensis	22.00	23.90	42.00	11.40	**24.90**	0.05	0.02	0.04	0.01	**0.03**	sa	cosm	i (s)	c	Brassicaceae
Cannabis sativa	25.00	10.90	58.00	–	**23.50**	0.64	0.01	0.26	–	**0.23**	sa	euras	w	c	Cannabaceae
Heliotropium europaeum	3.50	15.20	50.00	22.80	**22.80**	0.00	0.02	0.05	0.30	**0.09**	sa	med-eu	i	c	Boraginaceae
Kickxia spuria	44.00	34.80	–	11.40	**22.50**	1.34	0.52	–	0.08	**0.48**	sa	med-eu	s	–	Scrophulariaceae
Sorghum halepense	–	6.52	33.00	50.00	**22.40**	–	0.01	0.23	0.82	**0.26**	ge	euras	w	–	Poaceae

Appendix 1 (continued)

Species	Frequency (%)					Mean cover of percentage					Life form	Area	Polli-nation	Bird food Source	Family
	L	T-W	S	B	Average	L	T-W	S	B	Average					
Persicaria lapathifolia	22.00	15.20	25.00	24.30	**21.60**	0.73	0.02	0.03	0.16	**0.23**	sa	circ-med	i	c	Polygonaceae
Capsella bursa-pastoris	29.00	19.60	17.00	18.60	**21.00**	0.03	0.02	0.02	0.02	**0.02**	wa	cosm	s	p	Brassicaceae
Veronica persica	18.00	30.40	17.00	17.10	**20.60**	0.05	0.13	0.02	0.12	**0.08**	wa	cosm	i (s)	–	Scrophulariaceae
Carduus acanthoides	29.00	26.10	17.00	10.00	**20.50**	0.03	0.03	0.02	0.01	**0.02**	bi	eu-med	i	–	Asteraceae
Hibiscus trionum	15.00	13.00	42.00	11.40	**20.30**	0.07	0.88	0.04	0.05	**0.26**	sa	euras-med	i	c	Malvaceae
Linaria vulgaris	12.00	15.20	25.00	25.70	**19.50**	0.04	0.02	0.03	0.52	**0.15**	ge	euras-med	i	–	Scrophulariaceae
Stellaria media	33.00	28.30	–	15.70	**19.20**	0.12	0.46	–	0.12	**0.17**	wa	cosm	i (s)	c, p	Caryophyllaceae
Silene latifolia subsp. *alba*	19.00	21.70	17.00	12.80	**17.60**	0.02	0.07	0.02	0.01	**0.03**	hm	euras-med	i	c	Caryophyllaceae
Nigella arvensis	3.50	17.40	25.00	22.80	**17.10**	0.03	0.88	0.03	2.97	**0.98**	sa	pont-med	i	–	Ranunculaceae
Daucus carota	14.00	21.70	8.30	22.80	**16.70**	0.45	0.02	0.01	0.19	**0.17**	bi	cosm	i	c	Apiaceae
Atriplex patula	25.00	26.10	8.30	7.10	**16.60**	0.06	0.45	0.01	0.04	**0.14**	sa	circ-med	i (s)	–	Chenopodiaceae
Erigeron annuus	4.70	10.90	25.00	25.70	**16.60**	0.00	0.01	0.03	0.16	**0.05**	sa	adv	0	–	Asteraceae
Sonchus arvensis	21.00	8.70	25.00	4.20	**14.70**	0.28	0.33	0.03	0.00	**0.16**	ge	cosm	i	–	Asteraceae
Thymelaea passerina	9.40	19.60	17.00	10.00	**14.00**	0.01	0.45	0.22	0.01	**0.17**	sa	euras-med	i (s)	c	Thymelaeceae
Galinsoga parviflora	25.00	19.60	–	11.40	**14.00**	0.52	0.72	–	0.22	**0.37**	sa	cosm	i	–	Asteraceae
Chondrilla juncea	–	17.40	17.00	21.40	**13.90**	–	0.07	0.02	0.12	**0.05**	hm	euras	i	–	Asteraceae
Persicaria maculosa	14.00	15.20	8.30	17.10	**13.60**	0.36	0.07	0.01	0.05	**0.12**	sa	euras-med	i (s)	c	Polygonaceae
Datura stramonium	16.00	6.50	25.00	5.70	**13.30**	0.48	0.01	0.03	0.01	**0.13**	sa	cosm	i (s)	–	Solanaceae
Diplotaxis muralis	5.90	17.40	25.00	–	**12.00**	0.01	0.72	0.03	–	**0.19**	sa	eu-med	i (s)	–	Brassicaceae
Rubus caesius	3.50	8.70	8.30	27.10	**11.90**	0.03	0.01	0.01	0.59	**0.16**	ge	euras-med	i (s)	c	Rosaceae
Aethusa cynapium	27.00	17.40	–	2.80	**11.80**	0.64	0.02	–	0.42	**0.27**	sa	eu	i (s)	–	Apiaceae
Abutilon theophrasti	1.20	4.30	33.00	8.50	**11.70**	0.00	0.00	1.28	0.01	**0.32**	sa	euras	i	–	Malvaceae
Veronica polita	35.00	2.10	8.30	1.40	**11.70**	0.15	0.00	0.01	0.00	**0.04**	wa	euras	s	–	Scrophulariaceae
Melilotus officinalis	5.90	26.10	8.30	5.70	**11.50**	0.01	0.03	0.01	0.54	**0.14**	bi	euras-med	i	–	Leguminosae
Arenaria serpyllifolia	14.00	10.90	17.00	1.40	**10.80**	0.04	0.39	0.02	0.00	**0.11**	wa	euras-med	i (s)	c	Caryophyllaceae
Papaver rhoeas	8.20	4.30	25.00	5.70	**10.80**	0.01	0.00	1.27	0.01	**0.32**	wa	euras	i	c	Papaveraceae
Cynodon dactylon	4.70	2.10	25.00	4.30	**9.00**	0.03	0.33	1.27	0.00	**0.41**	ge	cosm	w	–	Poaceae
Epilobium tetragonum	8.20	2.10	17.00	8.50	**8.90**	0.01	0.00	0.02	0.01	**0.01**	ge	euras-med	i (s)	–	Onagraceae
Achillea millefolium	9.40	13.00	8.30	1.40	**8.00**	0.01	0.01	0.01	0.00	**0.01**	ge	cosm	0	–	Asteraceae
Galium aparine	22.00	6.50	–	2.80	**7.80**	0.05	0.01	–	0.00	**0.01**	wa	circ-med	i (s)	–	Rubiaceae
Asclepias syriaca	–	–	25.00	5.70	**7.70**	–	–	0.03	0.01	**0.01**	ge	adv	i	–	Asclepiadaceae
Oxalis stricta	18.00	10.90	–	1.40	**7.60**	0.02	0.01	–	0.00	**0.01**	ge	eu-med	s	–	Oxalidaceae
Trifolium repens	11.00	8.70	–	10.00	**7.40**	0.04	0.01	–	0.01	**0.01**	hm	cosm	i	–	Leguminosae
Solidago gigantea	8.20	8.70	8.30	4.20	**7.30**	0.01	0.06	0.01	0.00	**0.02**	ge	adv	0	–	Asteraceae
Setaria verticillata	3.50	2.10	17.00	5.70	**7.00**	0.00	0.00	0.02	0.01	**0.01**	sa	cosm	w	–	Poaceae
Odontites rubra	–	6.50	8.30	12.80	**6.90**	–	0.01	0.01	0.29	**0.08**	sa	euras-med	i (s)	–	Scrophulariaceae
Anthemis austriaca	5.90	17.40	–	4.20	**6.80**	0.01	0.02	–	0.00	**0.01**	wa	eu	i	–	Asteraceae
Cardaria draba	12.00	15.20	–	–	**6.80**	0.04	0.07	–	–	**0.03**	ge	euras-med	i (s)	–	Brassicaceae
Digitaria sanguinalis	7.10	4.30	8.30	7.10	**6.70**	0.04	0.00	0.01	0.22	**0.07**	sa	cosm	w	c	Poaceae
Senecio vulgaris	11.00	4.30	8.30	2.80	**6.60**	0.01	0.00	0.01	0.00	**0.01**	wa	euras	s	–	Asteraceae
Erodium cicutarium	15.00	10.90	–	–	**6.40**	0.04	0.06	–	–	**0.03**	wa	cosm	i (s)	–	Geraniaceae
Verbena officinalis	9.40	2.10	–	14.30	**6.40**	0.07	0.00	–	0.01	**0.02**	hm	cosm	i (s)	c	Verbenaceae
Mentha longifolia	2.60	–	–	21.40	**6.00**	0.03	–	–	0.34	**0.09**	ge	euras-med	i	–	Lamiaceae
Reseda phyteuma	2.60	8.70	8.30	2.80	**5.60**	0.00	0.38	0.01	0.00	**0.10**	sa	med-eu	i (s)	–	Resedaceae
Centaurea cyanus	1.20	6.50	8.30	5.70	**5.40**	0.00	0.01	0.01	0.01	**0.01**	wa	cosm	i	c	Asteraceae

Appendix 1 (continued)

Species	Frequency (%)					Mean cover of percentage					Life form	Area	Polli-nation	Bird food Source	Family
	L	T-W	S	B	Average	L	T-W	S	B	Average					
Myosotis arvensis	–	2.10	8.30	10.00	**5.10**	–	0.00	0.01	0.01	**0.01**	wa	euras	i (s)	c	Boraginaceae
Plantago lanceolata	2.60	6.50	8.30	2.80	**5.00**	0.00	0.01	0.01	0.00	**0.00**	hm	euras	w	c	Plantaginaceae
Galeopsis angustifolia	7.10	13.00	–	–	**5.00**	0.27	0.12	–	–	**0.10**	sa	euras	i (s)	–	Lamiaceae
Erucastrum gallicum	20.00	–	–	–	**5.00**	0.28	–	–	–	**0.07**	sa	atl-med	i	–	Brassicaceae
Chenopodium polyspermum	7.10	4.30	–	8.50	**4.90**	0.04	0.00	–	0.15	**0.05**	sa	euras-med	w	c	Chenopodiaceae
Lappula squarrosa	11.00	8.70	–	–	**4.90**	0.04	0.01	–	–	**0.01**	sa	euras-med	i (s)	–	Boraginaceae
Euphorbia virgata	–	15.20	–	4.30	**4.90**	0.00	0.02	–	0.00	**0.01**	hm	euras	i (s)	–	Euphorbiaceae
Arctium lappa	4.70	4.30	8.30	1.40	**4.70**	0.00	0.00	0.01	0.00	**0.00**	bi	euras-med	0	–	Asteraceae
Misopates orontium	7.10	8.70	–	2.80	**4.60**	0.04	0.06	–	0.00	**0.02**	sa	euras	i	–	Scrophulariaceae
Amaranthus blitoides	9.40	–	8.30	–	**4.40**	0.07	–	0.01	–	**0.02**	sa	adv	i, w	–	Amaranthaceae
Falcaria vulgaris	2.60	6.50	8.30	–	**4.30**	0.00	0.01	0.01	–	**0.00**	hm	euras-med	i	–	Apiaceae
Nonea pulla	2.60	4.30	–	10.00	**4.20**	0.00	0.00	–	0.01	**0.00**	hm	euras	i	–	Boraginaceae
Salsola kali subsp. *ruthenica*	5.90	10.90	–	–	**4.20**	0.80	0.39	–	–	**0.30**	sa	euras-med	s, i, w	–	Chenopodiaceae
Sisymbrium orientale	2.60	4.30	8.30	1.40	**4.10**	0.00	0.00	0.01	0.00	**0.00**	wa	euras-med	s	–	Brassicaceae
Clematis vitalba	2.60	8.70	–	4.30	**3.90**	0.00	0.06	–	0.00	**0.02**	ph	eu-med	0	–	Ranunculaceae
Euphorbia platyphyllos	9.40	2.10	–	2.80	**3.60**	0.01	0.00	–	0.00	**0.00**	sa	med-eu	i (s)	c	Euphorbiaceae
Torilis arvensis	–	–	–	14.30	**3.60**	–	–	–	0.08	**0.02**	wa	med-eu	i	–	Apiaceae
Diplotaxis tenuifolia	7.10	–	–	5.70	**3.20**	0.04	–	–	0.04	**0.02**	sa	eu-med	i (s)	–	Brassicaceae
Calystegia sepium	8.20	4.30	–	–	**3.10**	0.24	0.00	–	–	**0.06**	ge	cosm	i (s)	–	Convolvulaceae
Ballota nigra	5.90	2.10	–	4.20	**3.00**	0.01	0.00	–	0.00	**0.00**	hm	med-eu	0	–	Lamiaceae
Trifolium pratense	4.70	–	–	7.10	**2.90**	0.00	–	–	0.01	**0.00**	hm	euras-med	i	c	Leguminosae
Sideritis montana	2.60	8.70	–	–	**2.80**	0.00	0.01	–	–	**0.00**	sa	euras	s	–	Lamiaceae
Rumex crispus	2.60	6.50	–	1.40	**2.60**	0.00	0.01	–	0.00	**0.00**	hm	cosm	w (s)	c	Polygonaceae
Acinos arvensis	–	2.10	8.30	–	**2.60**	–	0.00	0.01	–	**0.00**	wa	eu	i (s)	–	Lamiaceae
Cirsium vulgare	–	–	8.30	1.40	**2.40**	–	–	0.01	0.00	**0.00**	hm	euras-med	i (s)	–	Asteraceae
Hypericum perforatum	–	–	8.30	1.40	**2.40**	–	–	0.01	0.00	**0.00**	hm	euras-med	i (s)	–	Hypericaceae
Xanthium strumarium	–	–	8.30	1.40	**2.40**	–	–	0.01	0.00	**0.00**	sa	cosm	w	–	Asteraceae
Equisetum arvense	2.60	4.30	–	2.80	**2.40**	0.21	0.00	–	0.07	**0.07**	ge	circ	0	–	Equisetaceae
Carduus nutans	9.40	–	–	–	**2.30**	0.21	–	–	–	**0.05**	bi	euras-med	i	c	Asteraceae
Vicia angustifolia	5.90	2.10	–	1.40	**2.30**	0.01	0.00	–	0.00	**0.00**	wa	adv	i (s)	c	Leguminosae
Eragrostis minor	3.50	4.30	–	1.40	**2.30**	0.03	0.00	–	0.00	**0.01**	sa	cosm	w	c	Poaceae
Raphanus raphanistrum	2.60	6.50	–	–	**2.20**	0.00	0.01	–	–	**0.00**	sa	eu	i	c	Brassicaceae
Anchusa officinalis	–	4.30	–	4.20	**2.10**	–	0.00	–	0.07	**0.02**	bi	eu-med	i (s)	c	Boraginaceae
Silene vulgaris	–	4.30	–	4.20	**2.10**	–	0.00	–	0.22	**0.06**	h	euras-med	0	–	Caryophyllaceae
Camelina microcarpa	2.60	–	–	5.70	**2.00**	0.00	–	–	0.01	**0.00**	wa	euras	s	c	Brassicaceae
Linum austriacum	–	–	8.30	–	**2.00**	–	–	0.01	–	**0.00**	hm	euras	0	–	Linaceae
Sherardia arvensis	2.60	4.30	–	1.40	**2.00**	0.00	0.00	–	0.00	**0.00**	sa	euras	i (s)	c	Rubiaceae
Lolium perenne	5.90	2.10	–	–	**2.00**	0.01	0.00	–	–	**0.00**	hm	cosm	w	c	Poaceae
Securigera varia	–	6.50	–	1.40	**1.90**	–	0.01	–	0.00	**0.00**	hm	eu-med	i	c	Leguminosae
Lamium amplexicaule	3.50	4.30	–	–	**1.90**	0.00	0.00	–	–	**0.00**	wa	euras-med	i (s)	c, p	Lamiaceae
Oxalis dillenii	1.20	6.50	–	–	**1.90**	0.00	0.01	–	–	**0.00**	sa	adv	s	–	Oxalidaceae
Descurainia sophia	4.70	–	–	2.80	**1.80**	0.00	0.00	–	0.00	**0.00**	wa	euras-med	i (s)	–	Brassicaceae
Glechoma hederacea	4.70	–	–	2.80	**1.80**	0.00	–	–	0.00	**0.00**	hm	euras	0	–	Lamiaceae
Picris hieracioides	–	–	–	7.10	**1.80**	–	–	–	0.54	**0.14**	hm	euras-med	0	–	Asteraceae
Vicia villosa	3.50	2.10	–	1.40	**1.70**	0.00	0.00	–	0.00	**0.00**	wa	euras-med	i	c	Leguminosae

Appendix 1 (continued)

Species	Frequency (%)					Mean cover of percentage					Life form	Area	Polli-nation	Bird food Source	Family
	L	T-W	S	B	Average	L	T-W	S	B	Average					
Crepis rhoeadifolia	2.60	–	–	4.30	**1.70**	0.00	–	–	0.00	**0.00**	sa	euras-eu	0	–	Asteraceae
Euphorbia esula	2.60	4.30	–	–	**1.70**	–	0.00	–	–	**0.00**	ge	eu	i (s)	c	Euphorbiaceae
Polycnemum arvense	–	6.50	–	–	**1.60**	–	0.01	–	–	**0.00**	sa	euras-med	w	–	Chenopodiaceae
Euphorbia tauriensis	–	6.50	–	–	**1.60**	–	0.01	–	–	**0.00**	sa	eu-med	i (s)	–	Euphorbiaceae
Symphytum officinale	3.50	–	–	2.80	**1.50**	0.00	–	–	0.00	**0.00**	hm	eu	i (s)	c	Boraginaceae
Tanacetum vulgare	–	–	–	5.70	**1.40**	–	–	–	0.01	**0.00**	hm	euras-med	0	–	Asteraceae
Xanthium italicum	–	–	–	5.70	**1.40**	–	–	–	0.01	**0.00**	sa	adv	w	–	Asteraceae
Salvia verticillata	–	4.30	–	1.40	**1.40**	–	0.00	–	0.00	**0.00**	hm	euras-med	0	–	Lamiaceae
Mentha arvensis	3.50	2.10	–	–	**1.40**	0.03	0.00	–	–	**0.01**	ge	circ	i	–	Lamiaceae
Bifora radians	2.60	–	–	2.80	**1.30**	0.00	–	–	0.04	**0.01**	wa	eu	0	–	Apiaceae
Trifolium arvense	–	2.10	–	2.80	**1.20**	–	0.00	–	0.04	**0.01**	sa	euras-med	i (s)	–	Leguminosae
Avena fatua	2.60	2.10	–	–	**1.20**	0.00	0.00	–	–	**0.00**	sa	euras-med	w	–	Poaceae
Humulus lupulus	2.60	2.10	–	–	**1.20**	0.00	0.00	–	–	**0.00**	hm	circ	0	–	Cannabaceae
Artemisia absinthium	–	4.30	–	–	**1.00**	–	0.00	–	–	**0.00**	hm	euras-med	0	–	Asteraceae
Thesium ramosum	–	4.30	–	–	**1.00**	–	0.00	–	–	**0.00**	hm	euras	i (s)	–	Santalaceae
Trifolium campestre	–	4.30	–	–	**1.00**	–	0.00	–	–	**0.00**	sa	eu-med	i	–	Leguminosae
Knautia arvensis	–	–	–	4.20	**1.00**	–	–	–	0.00	**0.00**	hm	euras	i	–	Dipsacaceae
Amaranthus albus	2.60	–	–	1.40	**1.00**	0.00	–	–	0.04	**0.01**	sa	adv	i, w	c	Amaranthaceae
Pastinaca sativa	1.20	–	–	2.80	**1.00**	0.00	–	–	0.00	**0.00**	bi	euras	0	–	Apiaceae

Surveyed regions: L = Lesser Plain of north-western Hungary; T-W= Transdanubian Mountain range and West-Hungarian margin territory; S = Somogy region; B = Baranya-Tolna region. Species are ranked by decreasing frequency. Diagnostic species are in bold. Life forms: ph = phanerophytes; hm = hemicryptophytes; ge = geophytes; wa = winter annuals; sa = summer annuals; bi = biennials. Chorological areas: euras = Eurasian; med = Mediterranean; eu = European; circ = Circumpolar; cosm = cosmopolitan; pont = Pontian; atl = Atlantic; adv = adventive. Pollination modes: i = insect-pollinated; w = wind-pollinated; s = self-pollinated; (s) = alternatively self-pollinated; 0 = species occurring only in vegetative form. Bird food sources: c = *Coturnix coturnix*; p = *Perdix perdix*. (See Methods for details.)