Action A5

Diet analysis of the LWfG in selected sites of the Hortobágy National Park (Hungary) for the identification of habitat requirements

LIFE10 NAT/GR/000638
Safeguarding the Lesser White-fronted Goose Fennoscandian population in key wintering and staging sites within the European flyway

Final Research Report

Safeguarding the Lesser White-fronted Goose

LIFE10 NAT/GR/000638

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INTRODUCTION

We have information about the diet selection of Lesser White-fronted geese (LWfG) in their spring staging area in Finland (Markkola et al. 2003), but data on the diet of the species during migration is still lacking. The aims of our study are (i) to identify preferred feeding habitats of white-fronted geese in Hortobágy region in Hungary, and characterize food availability; (ii) to provide information about the diet of LWfG and (iii) to study the role of goose species in plant dispersal. For a complex analysis of the diet selection of the Lesser White-fronted Goose, a field survey was conducted in the feeding habitats, where the percentage cover scores and total species lists of vascular plant species was recorded. Then we collected droppings of Lesser White-fronted Geese to estimate which plant species are preferred by the geese from the species pools (total species list of vascular plants) of the feeding habitats. We characterised the size of the droppings, then we concentrated droppings and germinated their seed content. We compared vegetation of feeding patches and species found in the droppings to estimate diet selection.

General description of the feeding habitat types

The characteristic species of most alkali grassland types are widely distributed grass species with a wide range of humidity and salt tolerance (*Agropyron repens*, *Agrostis stolonifera*, *Alopecurus pratensis*, *Beckmannia eruciformis* and *Festuca pseudovina*). Alkali grasslands harbour several grassland species characteristic to Eurasian continental steppes and several endemics to the Carpathian basin. Large homogeneous stands of a single alkali grassland type can be rarely found; various types of grasslands form generally a heterogeneous mosaic in along the uneven pattern of soil salt contents, relief and water availability. In a landscape characterized by alkali grasslands near to the highest elevated plateaus with loess vegetation generally stands of *Achillea* alkali steppes are situated. Near to *Achillea* alkali steppes but at lower elevations on soils with higher salt content (solonetz or solonchak) typically Artemisia alkali steppe vegetation is located (Török et al. 2011). At the lowest elevations alkali meadows, while in the deepest depressions alkali marshes are situated. Cattle or sheep grazing is typical on all feeding habitats of LWfG, in all alkali grassland types.

METHODS

VEGETATION SURVEY IN THE FEEDING HABITATS

We surveyed the feeding habitats of LWfG in Hortobágy region in the spring, summer and autumn of 2012 and in the summer of 2014. We identified the most frequently used habitat types, which are open, intensively grazed grasslands (according to Borhidi et al. 2012):

- Alkali short grasslands dominated by *Festuca pseudovina* and *Artemisia santonicum* (Artemisio-Festucetum pseudovinae association)

- Alkali short grassland dominated by *Festuca pseudovina* and *Achillea collina* (Achilleo- Festucetum pseudovinae association)
- Heavily grazed, species-poor alkali wet meadows (Agrostio-Alopecuretum pratensis association
- Open vegetation patches characterized by forb species (*Rumex cripus, Rorippa kerneri, Polygonum lapathifolium*) in alkali wet meadows
- Open alkali grasslands (Puccinellietum limosae association) dominated by *P. limosa* and annual forbs (*Matricaria chamomilla, Lepidium ruderale, Myosurus minimus*).
- Temporal mud vegetation (in Kondás fishpond) characterised by pioneer weedy species (*Polygonum lapathifolium, Chenopodium* spp.) and aquatic plants (*Nymphoides peltata*)

Vegetation survey

Methods

In order to study food availability, we recorded the species lists of vascular plants in the most frequently used habitat patches by recording the percentage cover of vascular plants in 2×2-m sized plots. We used Simon (2000) for the nomenclature of taxa and Borhidi et al. (2012) for syntaxa.

Results

We recorded in total 81 vascular plant species in the feeding habitats (Tables 1-6; Fig. 2-7). Total species list and species frequency scores of all feeding habitats can be found in Appendix 1. We found that the most frequent species in the feeding habitats were *Festuca pseudovina, Alopecurus pratensis, Juncus compressus* and *Rumex crispus* (Fig. 1).

Fig 1. (A) *Festuca pseudovina*, the most frequent species in the feeding habitats of LWFG. (B) *Cirsium brachyephalum*, an endemic species present in feeding habitats of LWFG.

Table 1. Cover scores of vascular plant species in Artemisio-Festucetum pseudovinae feeding habitat in Rókás.

	ARF/1	ARF/2	ARF/3
Total vegetation cover (%)	35	40	75
Alopecurus pratensis	0	0	0.5
Artemisia santonicum	10	12	13
Camphorosma annua	0	0	15
Carex stenophylla	2	1.5	0
Descurainia sophia	0.3	0	0
Festuca pseudovina	22	25	40
Juncus compressus	2	1.5	0
Lepidium perfoliatum	0.3	0.7	0
Matricaria chamomilla	0.1	0.3	7
Podospermum canum	0	0	0.7
Polygonum aviculare	0.3	0.3	0

Fig 2. Recording percentage cover scores at an Artemisio-Festucetum pseudovinae feeding habitat in Rókás.

Table 2. Cover scores of vascular plant species in Achilleo-Festucetum pseudovinae feeding habitat in Rókás.

	ACF/1	ACF/2	ACF/3
Total vegetation cover (%)	70	80	75
Achillea collina	5	9	3
Achillea setacea	1	0.7	0
Agropyron repens	0	0	0.7
Alopecurus pratensis	20	15	5
Artemisia santonicum	0.3	0	0
Carduus nutans	0.5	0.7	1
Carex stenophylla	0.3	0.1	0
Descurainia sophia	0	1	0
Festuca pseudovina	40	50	55
Lepidium draba	0.3	0	0
Podospermum canum	2	1.5	1.5
Stellaria graminea	0.1	0.1	0.1

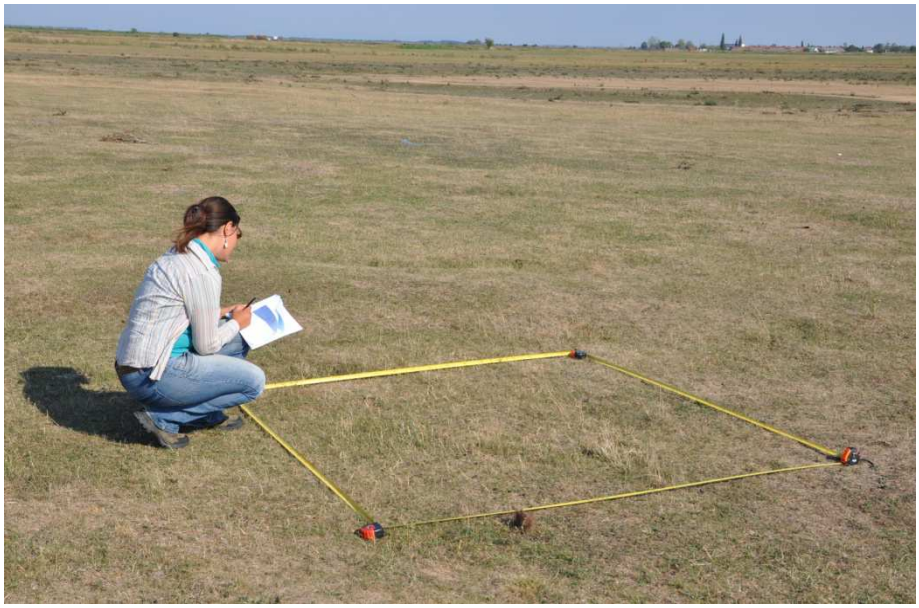

Fig 3. Recording percentage cover scores at an Achilleo-Festucetum pseudovinae feeding habitat in Rókás.

Table 3. Cover scores of vascular plant species in heavily grazed alkali meadow (Agrostio-Alopecuretum pratensis) feeding habitat in Rókás.

	AA/1	AA/2	AA/3
Total vegetation cover (%)	70	75	70
Agropyron repens	5	4	2
Alopecurus pratensis	55	60	53
Carduus nutans	4	2	3
Carex vulpina	2	2.5	4
Cerastium dubium	0.5	0.3	0
Epilobium tetragonum	0.3	0	0.3
Gagea pratensis	0	0.5	0.3
Inula britannica	2	1.5	3
Polygonum lapathifolium	0	0.1	0.7
Rorippa amphibia	3	1.5	1
Rumex crispus	5	8	7
Taraxacum officinale	0	0.5	0

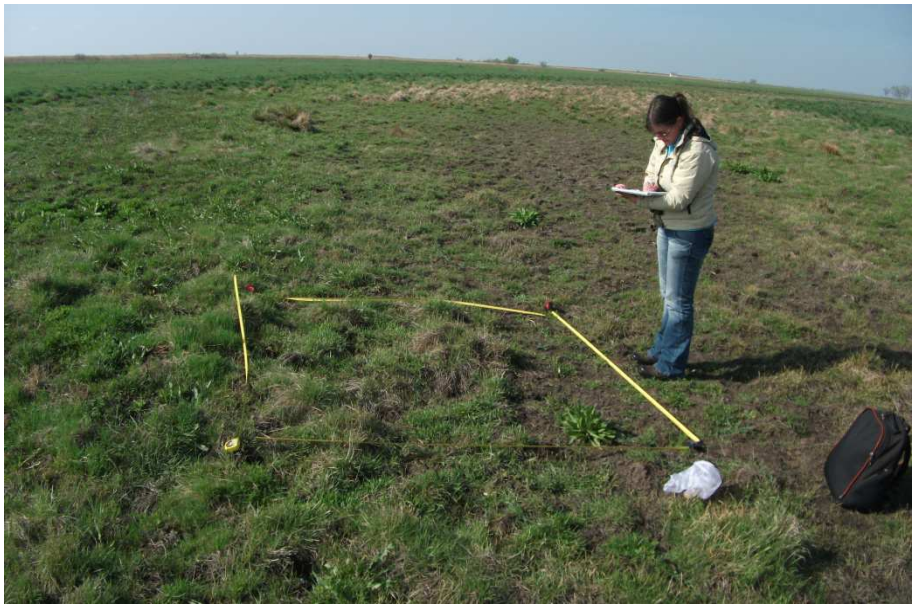

Fig 4. Recording percentage cover scores at a heavily grazed Agrostio – Alopecuretum stand in Rókás.

Table 4. Cover scores of vascular plant species in a degraded alkali meadow characterised by *Rumex crispus* in ‘Rókás’.

	RU/1	RU/2	RU/3
Total vegetation cover (%)	95	90	75
Agropyron repens	1.5	0	0
Agrostis stolonifera	0	2	0
Alopecurus geniculatus	0	0.5	0
Atriplex hastata	55	55	23
Carduus nutans	0	0.5	0.3
Cirsium vulgare	6	0	17
Lotus corniculatus	0	1	0
Matricaria chamomilla	25	3	1
Plantago major	0	1.5	0
Polygonum aviculare	2	0	2
Potentilla argentea	0	0	2
Rumex crispus	4.5	17	30
Xanthium spinosum	0	10	0

Fig 5. Recording percentage cover scores in a degraded alkali meadow characterised by *Rumex crispus* in ‘Rókás’.

Table 5. Open alkali grasslands (Puccinellietum limosae association) dominated by *Puccinellia limosa* and annual forbs (*Matricaria chamomilla*, *Lepidium ruderale*, *Myosurus minimus*).

	PL/1	PL/2	PL/3
Total vegetation cover (%)	5	10	8
Artemisia santonicum	0,7	1,5	1
Camphorosma annua	0,5	0,5	0,3
Juncus compressus	1,5	2,5	2
Lepidium perfoliatum	0,3	0,3	0,7
Matricaria chamomilla	2,5	4,5	3
Podospermum canum	0	1	0,3
Polygonum aviculare	0	0,3	0,3
Puccinellia limosa	0,5	0,7	1,5

Fig 6. Open alkali grasslands (Puccinellietum limosae association).

Table 6. Cover scores of vascular plant species in the temporal mud vegetation in Kondás fishpond.

	K/1	K/2	K/3
Total vegetation cover (%)	60	10	70
Agrostis stolonifera	1	0	18
Chenopodium album	0.3	0	0.7
Chenopodium strictum	0.5	0	0
Cirsium vulgare	0	0	0.7
Crypsis alopecuroides	6	0	0
Cynodon dactylon	0.5	0	0
Epilobium tetragonum	2	0	25
Juncus articulatus	0	4	2
Matricaria inodora	1	0	8
Nymphoides peltata	0	4	2
Peplis portula	1	0	0
Phragmites communis	0	0	2
Polygonum lapathifolium	50	2	16
Potentilla reptans	0.3	0	0.1
Sonchus arvensis	0	0	0.3
Trifolium angulatum	0.7	0	1

Fig 7. Recording percentage cover scores in the temporal mud vegetation in Kondás fishpond.

Table 7. Cover scores of vascular plant species in the alkali meadow vegetation in Bivaly-halom.

	B/1	B/2	B/3	B/4	B/5
Total vegetation cover	90	95	100	95	100
Agropyron repens	60	50	40	20	60
Agrostis stolonifera	20	30	40	50	25
Alopecurus pratensis	15	7	20	15	5
Atriplex hastata			0.1		
Cirsium brachycephalum				0.1	
Epilobium tetragonum		0,1			
Gypsophila muralis			0.1		
Inula britannica	0.3				
Poa angustifolia		8		20	10
Rumex crispus					0.1

Fig 8. Recording percentage cover scores in the alkali meadow vegetation in Bivaly-halom.

DIET ANALYSES

Methods

Collection of droppings

An alternative method for diet studies of threatened species is the determination of plant fragments in faecal pellets (Markkola et al. 2003, Karmiris et al. 2009). In order to characterize diet during spring and autumn migration we collected ca. 50 droppings of LWfG in each feeding habitat patch in Hortobágy in October 2011, April 2012, October 2012 and October 2013. As a control, we also collected droppings of other foraging goose-species (mainly GWfG, Greylag Goose and Red-brested Goose) in the same feeding habitats.

We have collected geese droppings (both LWfG and “other Geese” (mainly GWfG, Greylag Goose and Red-brested Goose) during migration in the Autumn of 2011, 2012 and 2013 as well as in the Spring of 2012. We searched for droppings in 6 sites, with more than 50 droppings from each site and each species/species group. We collected during the 3 years altogether more than 700 LWfG droppings and more than 500 droppings in the “other Geese” category.

Sample processing

The droppings were dried for two weeks. Then we measured dry weights, length and width of the droppings (Tables 8-9, Fig. 9). After the droppings were measured, they were concentrated on two different meshes according to the international protocol of teer Herdt el al. (1996). Rough plant particles were retained on a coarse mesh (2.8 mm), while seeds and fine plant tissue fragments were retained using a fine mesh (0.2 mm). The used method enabled us to concentrate the samples by washing out fine mineral and organic particles and to reduce sample volume.

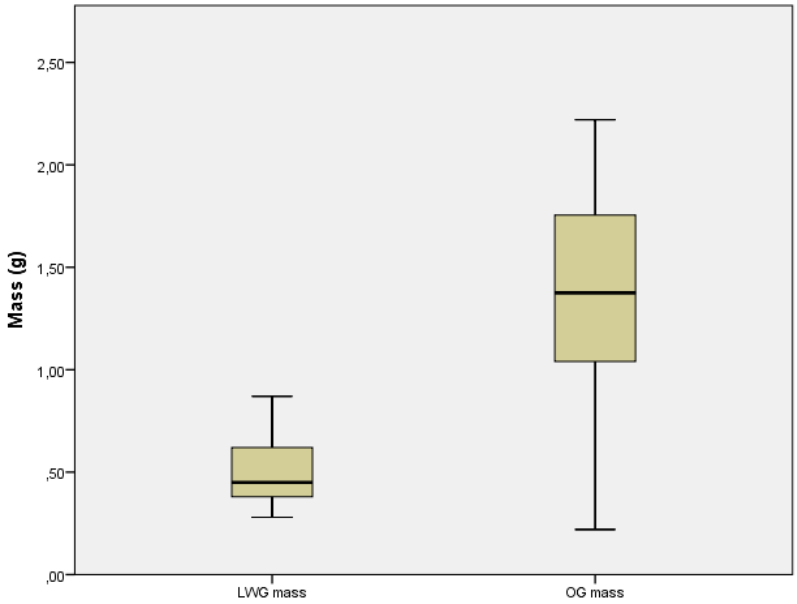

Fig 9. A box-plot of the average mass of droppings of Lesser White-fronted Geese and other foraging goose species.

Table 8. Size (length and width) and mass of identical droppings of the Lesser White-fronted Goose.

Code	Length (mm)	Width (mm)	Mass (g)
1	42	8	0.39
2	40	9	0.50
3	39	9	0.40
4	37	10	0.46
5	48	8	0.84
6	42	9	0.75
7	47	7	0.44
8	36	8	0.69
9	33	6	0.34
10	40	8	0.37
11	41	9	0.76
12	35	8	0.36
13	46	9	0.55
14	39	9	0.49
15	36	7	0.35
16	38	12	0.87
17	32	13	0.50
18	30	6	0.28
19	27	13	0.40
20	39	8	0.43

Table 9. Size (length and width) and mass of identical droppings of other geese species (mainly GWfG, Greylag Goose and Red-brested Goose).

Code	Length (mm)	Width (mm)	Mass (g)
1	39	8	1.43
2	39	12	2.04
3	44	10	1.88
4	39	9	1.93
5	34	10	1.10
6	42	13	2.22
7	44	11	1.44
8	36	9	1.37
9	32	8	0.98
10	33	13	1.33
11	40	10	1.57
12	31	8	0.26
13	31	10	1.27
14	35	14	1.25
15	41	9	1.77
16	44	10	1.74
17	36	10	0.88
18	30	10	0.60
19	30	9	0.22
20	44	10	1.38

Diet identification based on physical sorting of seed fragments

Methods

To enable the identification of seed fragments in droppings, we collected reference specimens of seeds for every species available at the feeding habitats (Fig 10). Seed fragments were retained either on the coarse or on the fine mesh after sample concentration were analysed using a Zeiss Stemi C-2000 high definition microscope. For species identification, besides the reference seed collection, we used also seed identification books (Schermann 1967, Bojnaňsky & Fargašová 2007). This method is suitable for the detection of relatively large and hard-seeded species.

Results

The identification based on seed fragments enabled us to identify 4 forb and 4 graminoid species in LWFG droppings, while 3 forb and 5 graminoid species in other geese droppings, respectively (Fig 11-12).

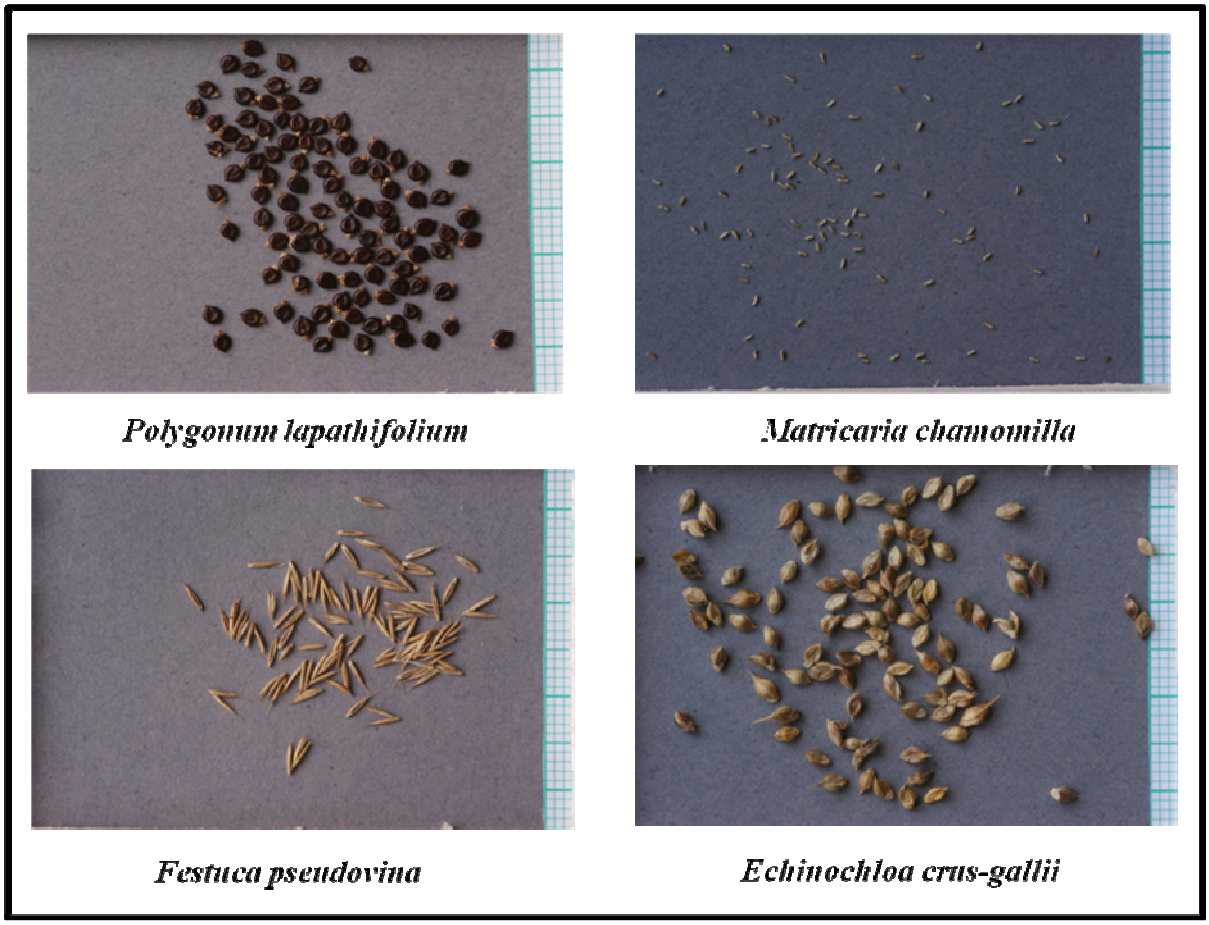

Fig 10. Seed samples of the reference seed collection.

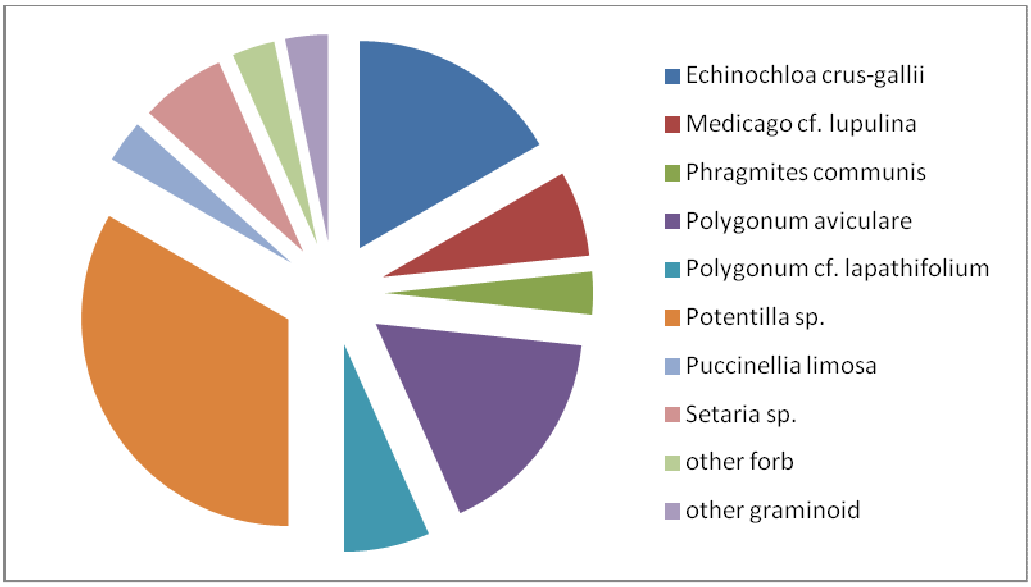

Fig 11. Seed content in the Lesser White-fronted Goose droppings identified by mechanical sorting.

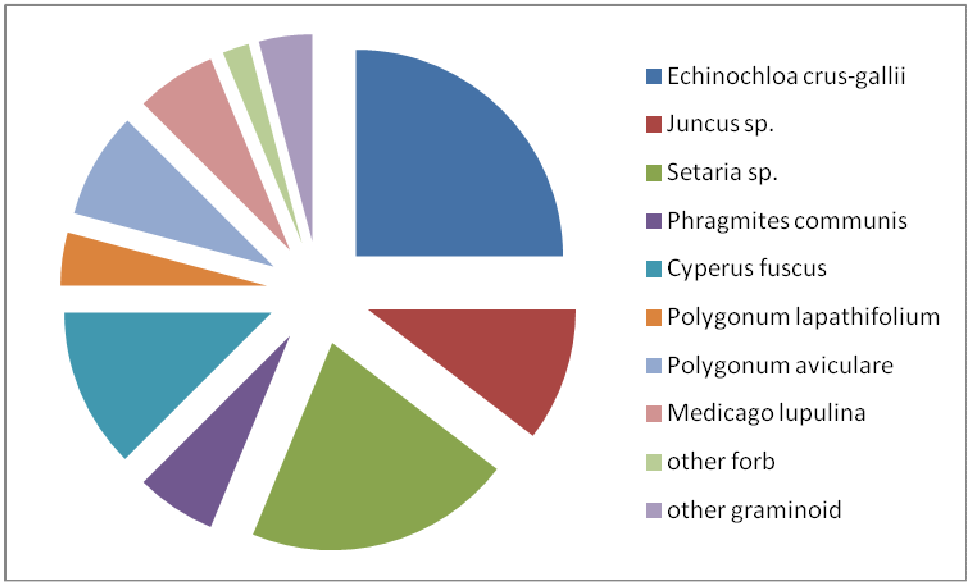

Fig 12. Seed content in the droppings of other geese species identified by mechanical sorting.

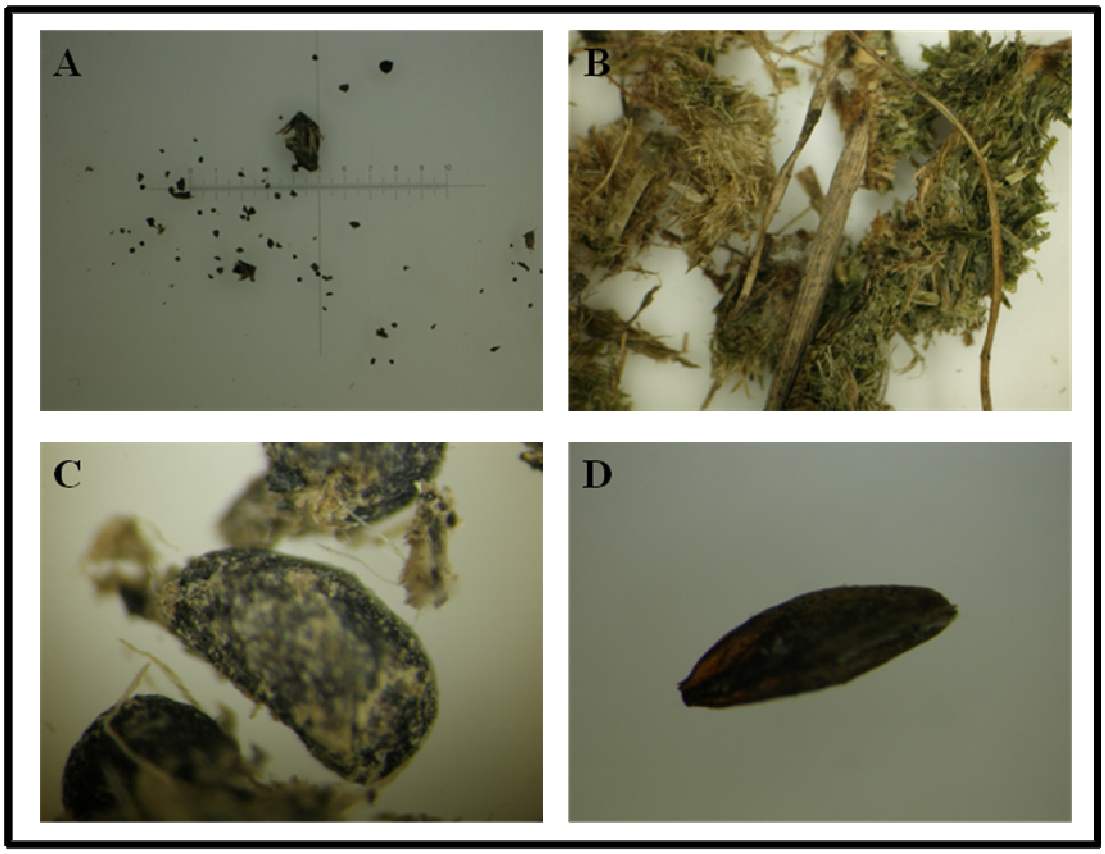

Fig 13. High definition microscope photos of (A) seed content of an autumn LWfG dropping, (B) seed-free plant material of a dropping, (C) identified *Potentilla* sp. seed fragment and (D) identified *Puccinellia limosa* seed fragment.

Germination experiment

Sample processing

Before sample concentration, dry mass of 40 droppings from the same sample site and date were measured (Table 10-11) and then were pooled and germinated together. After the separation of plant tissue fragments by sieving, concentrated samples were put in water in order to make them more feasible for further processing (Fig 14). Samples were spread in a thin layer on the surface of steam sterilised potting soil in germination boxes. Samples were germinated under natural light conditions in a mobile plastic greenhouse using the method of ter Heerdt et al. (1996). The method is very effective and reliable to identify very small and germinable seeds which cannot be separated using mechanical separation methods (e.g. small-seeded species belonging to Cyperaceae and Juncaceae plant families). The germination was started in February, 2013. Samples were regularly watered and all germinated seedlings were counted and identified regularly using the seedling identification

books of Csapody (1968) and Muller (1978). Unidentified seedlings were transplanted and grown till identification. Several specimens are still germinating, and there are also transplants which are still grown till they can be identified.

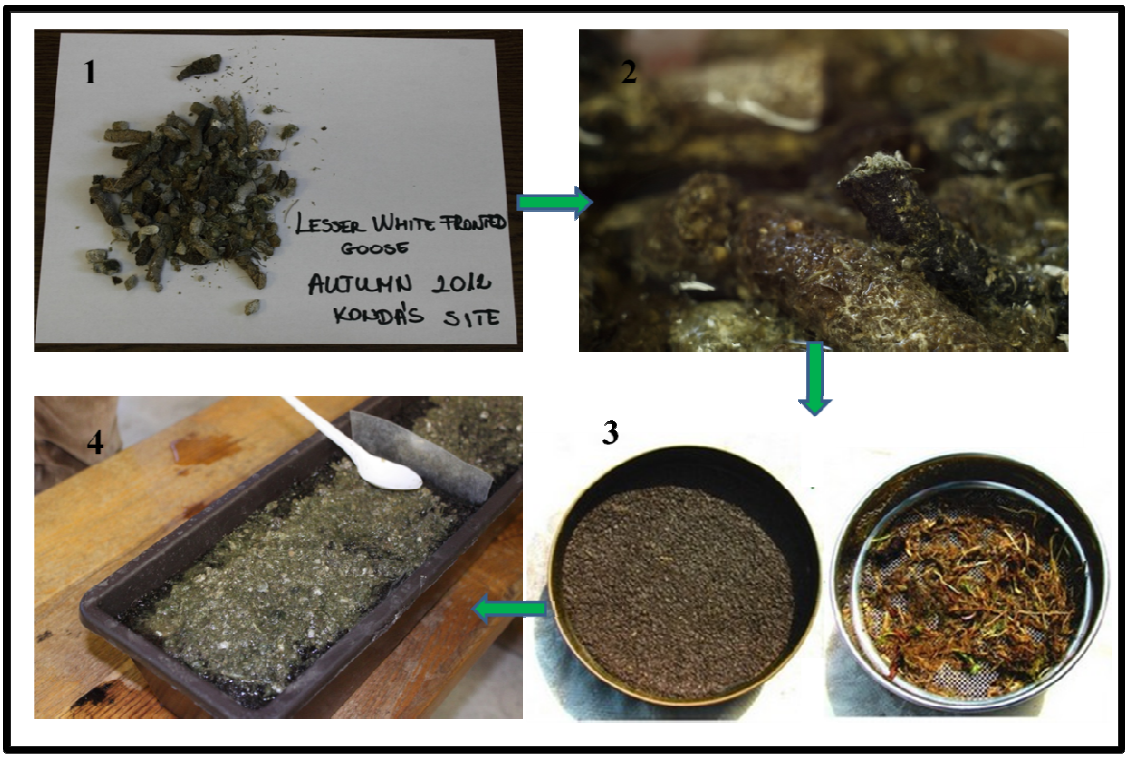

Fig 14. Sample processing procedure by sample concentration by washing. (1) collected and dried droppings after measurements; (2) watered droppings for concentration in the coarse mesh; (3) retained rough plant fragments on the coarse mesh and concentrated samples on the surface of the fine mesh; (4) concentrated samples spread in a germination pot on the surface of steam sterilised potting soil.

Table 10. Characteristics of Lesser White-fronted Goose droppings concentrated for germination. Mass refers to the mass of 40 droppings, which were further pooled, concentrated and germinated together. Notations for Code: S= spring, A= autumn, LW= Lesser White-fronted Goose.

Code	Mass (g)	Date of collection	Locality
SLW1	19.61	19.04.2012.	Rókás
SLW2	18.22	19.04.2012.	Rókás
SLW3	19.43	19.04.2012.	Rókás
SLW4	21.47	19.04.2012.	Rókás
ALW1	20.84	11.10.2012.	Kondás
ALW2	22.84	11.10.2012.	Kondás
ALW3	21.11	11.10.2012.	Kondás
ALW4	20.37	11.10.2012.	Kondás
ALW5	20.66	11.10.2012.	Kondás
ALW6	19.56	11.10.2012.	Kondás
ALW7	20.4	11.10.2012.	Kondás
ALW8	19.61	19.10.2012.	Rókás
ALW9	20.95	19.10.2012.	Rókás
ALW10	19.58	19.10.2012.	Rókás
ALW11	20.11	04.10.2011.	Kondás
ALW12	19.73	28.10.2012.	Rókás
ALW13	20.18	28.10.2012.	Rókás

Table 11. Characteristics of droppings of other geese species concentrated for germination. Mass refers to the mass of 40 droppings, which were further pooled, concentrated and germinated together. Notations for Code: S= spring, A= autumn, OG= other geese species (mainly GWfG, Greylag Goose and Red-brested Goose)).

Code	Mass (g)	Date of collection	Locality
SOG1	44.52	19.04.2012.	Rókás
AOG1	51.61	28.10.2012.	Rókás
AOG2	50.08	28.10.2012.	Rókás
AOG3	54.34	28.10.2012.	Rókás
AOG4	46.58	08.10.2011.	Szatmári-telek
AOG5	47.62	08.10.2011.	Szatmári-telek
AOG6	50.41	11.10.2012.	Kondás
AOG7	51.37	11.10.2012.	Kondás
AOG8	51.91	11.10.2012.	Kondás
AOG9	50.71	11.10.2012.	Kondás
AOG10	50.1	19.10.2012.	Rókás

Results

Germinated seeds from droppings of Lesser White-fronted Geese

We found that 94% of germinated seedlings from LWfG droppings belonged to 5 species (Fig. 15): *Chenopodium chenopodioides* (Chenopodiaceae), *Cyperus fuscus* (Cyperaceae), *Echinochloa crus-gallii* (Poaceae), *Myosurus minimus* (Ranunculaceae), *Poa angustifolia* (Poaceae) and *Setaria viridis* (Poaceae). The most abundant species in LWfG droppings was *Echinochloa crus-gallii*, possessing more than 58% of total seedling number.

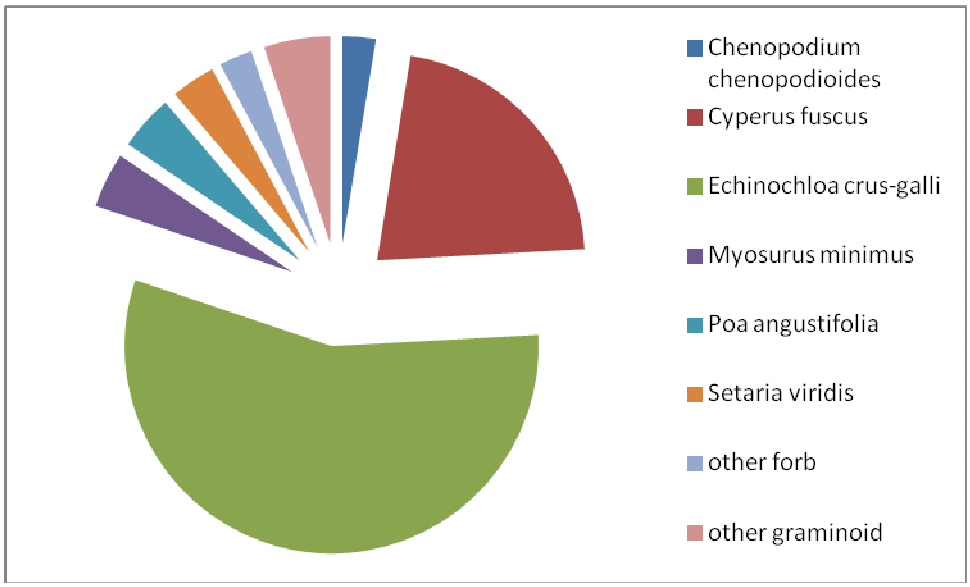

Fig 15. Germinated seedlings from the droppings of Lesser White-fronted Geese.

Fig 16. (A) Removal of seedlings from the germination pots; (B) a transplanted individual of *Myosurus minimus*, (C) transplanted plants grown for identification.

Germinated seeds from droppings of other geese species (mainly GWfG, Greylag Goose and Red-brested Goose)

We found that 96% of germinated seedlings from droppings of other goose species belonged to 4 plant species (Fig 17): *Amaranthus retroflexus* (Amaranthaceae), *Chenopodium chenopodioides* (Chenopodiaceae), *Echinochloa crus-gallii* (Poaceae), *Matricaria chamomilla* (Asteraceae), *Polygonum aviculare* (Polygonaceae), *Potentilla supina* (Rosaceae) and *Setaria viridis* (Poaceae). The most abundant species in LWfG droppings was *Echinochloa crus-gallii*, possessing more than 86% of total seedling number.

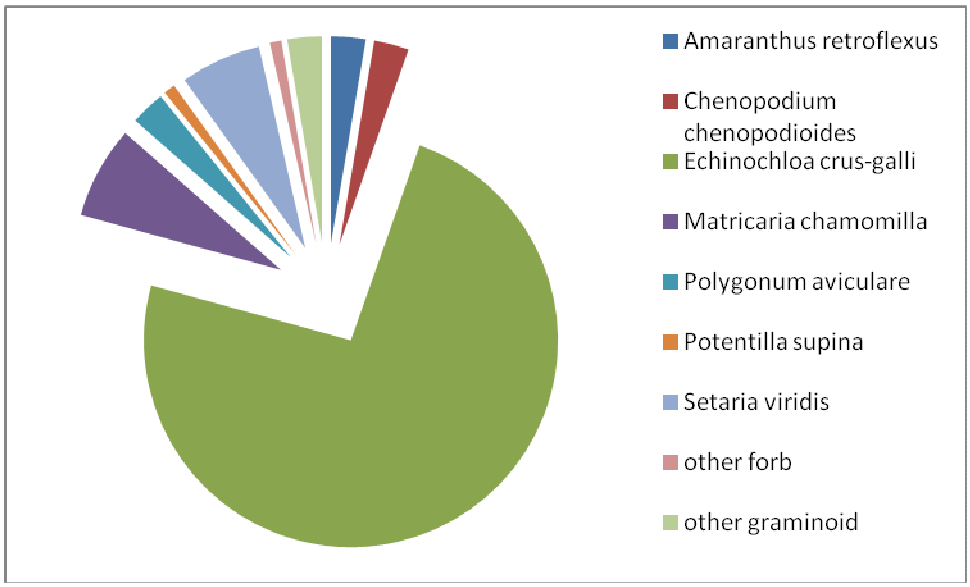

Fig 17. Germinated seedlings from the droppings of other geese species (mainly GWfG, Greylag Goose and Red-brested Goose).

Fig 18. Germinating seedlings of *Potentilla supina* (in the foreground) and *Setaria viridis* (in the background).

Fig 19. Germinating seedlings of *Cyperus fuscus* and *Echinochloa crus-gallii* in an autumn LWfG sample.

Fig 20. Germination pots in the greenhouse.

Conclusions

We studied diet selection of Lesser White-fronted Geese in Hortobágy National Park in Hungary. We identified the most frequently used spring and autumn feeding habitats of the species. We studied diet selection of the Lesser White-fronted Geese and other foraging goose species by collecting their droppings and analysing seed content of the droppings. We measured the physical characteristics (mass, length and width) of the droppings and analysed their seed content by physical sorting of seed fragments and also by the seedling emergence method. We germinated concentrated samples in a greenhouse and identified the emerged seedlings.

We found that for Lesser White-fronted Geese the most important feeding habitats include (i) various types of shortgrass **alkali grasslands** (Artemisio – Festucetum pseudovinae, Achilleo – Festucetum pseudovinae, Puccinellietum limosae), (ii) **alkali meadows** (Agrostio – Alopecuretum pratensis and also weedy, degraded patches of alkali meadows dominated by *Rumex crispus*) and also (iii) **temporary mud vegetation**. Lesser White-fronted Geese preferred short and open grassland and meadow stands as feeding habitats. For the management of open vegetation, extensive grazing by cattle or sheep is crucial in alkali landscapes. Grazing is necessary for the continuous removal of biomass and litter and also for maintaining short vegetation structure. It is also necessary to provide open muddy surfaces in fishpond systems to create suitable feeding habitats for Lesser White-fronted Geese. The species uses several grassland types as feeding habitats, therefore it is crucial to provide a mosaic structure of shortgrass steppes, meadows and temporary muddy surfaces. Traditional grazing regimes should be implemented at the landscape scale to provide the mosaic habitat structure necessary for Lesser White-fronted Geese.

We found that from the species pool of the feeding habitats, mostly Poaceae (*Echinochloa crus-gallii*, *Poa angustifolia* and *Setaria viridis*) species and also several Polygonaceae, Ranunculaceae and Cyperaceae seeds were found in the droppings. We could identify the species composition and amounts of seeds in the droppings, and we could make a rough estimation for the diet selection of Lesser White-fronted Geese. However, several species might be underrepresented in our analyses. There might be several species which are grazed by the geese, but they mostly eat the vegetative organs of the plant, e.g. in case of grass species (*Festuca pseudovina*, *Agrostis stolonifera* or *Puccinellia limosa*).

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Appendix 1. Total species list and frequency of vascular plant species in feeding habitats (in total 13 feeding habitats) of LWfG in Hortobágy National Park. Frequency scores are ranging from 1-13 indicating in how many feeding habitats was a certain species present.

Species	Frequency	Species	Frequency
Achillea collina	5	*Juncus compressus*	6
Achillea setacea	2	*Kochia prostrata*	1
Agropyron repens	9	*Lepidium draba*	1
Agrostis stolonifera	5	*Lepidium perfoliatum*	4
Alopecurus geniculatus	1	*Lepidium ruderale*	2
Alopecurus pratensis	7	*Limonium gmellinii*	1
Arabidopsis thaliana	1	*Lolium perenne*	1
Artemisia santonicum	7	*Lotus corniculatus*	1
Aster tripolium	2	*Lycopus europaeus*	1
Atriplex hastata	4	*Lythrum virgatum*	1
Atriplex litoralis	3	*Marrubium peregrinum*	1
Atriplex oblongifolia	1	*Matricaria chamomilla*	7
Ballota nigra	1	*Matricaria inodora*	2
Beckmannia eruciformis	1	*Myusurus minimus*	1
Bidens tripartitus	1	*Nymphoides peltata*	1
Camphorosma annua	3	*Peplis portula*	1
Carduus acanthoides	3	*Phragmites communis*	2
Carduus nutans	4	*Plantago major*	1
Carex stenophylla	4	*Poa angustifolia*	3
Carex vulpina	2	*Podospermum canum*	5
Cerastium dubium	4	*Polygonum aviculare*	5
Chenopodium album	2	*Polygonum lapathifolium*	2
Chenopodium polyspermum	1	*Portulaca oleracea*	1
Chenopodium strictum	2	*Potentilla arenaria*	1
Cichorium intybus	1	*Potentilla argentea*	2
Cirsium arvense	2	*Potentilla reptans*	1
Cirsium brachycephalum	2	*Puccinellia limosa*	5
Cirsium vulgare	5	*Pulicaria vulgaris*	1
Convolvulus arvensis	2	*Ranunculus repens*	1
Crypsis alopecuroides	1	*Rorippa amphibia*	5
Cynodon dactylon	5	*Rumex cripsus*	7
Daucus carota	1	*Salvia austriaca*	1
Descurainia sophia	3	*Sonchus arvensis*	1
Echinochloa crus-gallii	1	*Spergularia rubra*	1
Epilobium tetragonum	4	*Stellaria graminea*	1
Eryngium campestre	1	*Stellaria media*	1
Festuca pseudovina	7	*Taraxacum officinale*	4
Gagea pratensis	2	*Trifolium angulatum*	3
Galium verum	4	*Trifolium repens*	1
Gypsophila muralis	1	*Trifolium striatum*	1
Hypericum perforatum	1	*Urtica dioica*	1
Inula britannica	4	*Xanthium spinosum*	1
Juncus articulatus	1	*Xanthium strumarium*	1