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Ecology and dynamics of *Herniaria incana* population at the northernmost locality of its current central and western European distribution

Ekologie a populační dynamika druhu *Herniaria incana* na jeho nejsevernější současné lokalitě ve střední a západní Evropě

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K e y w o r d s: *Herniaria incana*, isolated occurrence, border of distribution, ecology, 5 year population dynamics, nature conservancy, central Bohemia, Czechoslovakia

Herniaria incana Lam. var. *angustifolia* Fenzl in Ledeb. grows at only one locality in the Czech Republic, near the village of Hříměždice, central Bohemia, which is at present the species' northernmost occurrence in central and western Europe. The species population dynamics was studied during 1987-91. In the mown part of the dry grassland, the total area covered by the species increased considerably over the research period. In unmown sites, the population tended to retreat. Its spread was, however, encouraged by the hot and dry summer of 1990 in both unmown and mown areas. Considering the locality as a whole, an overall trend for the population to increase was a result of various dynamic processes (increase and decrease in both number and size, emergence and disappearance of individuals) at the level of individual plants. The population at the locality studied successfully reproduces by seed. It grows more frequently in sites with a shallow soil layer. The species occurrence is considered allochthonous at the locality. Some aspects relevant to the protection of the species are discussed.

Introduction

In the Czech Republic, *Herniaria incana* Lam. occurs at only one isolated locality, which is situated more than 350 km from the border of its more or less continuous distribution (Hlaváček 1989). It has long been recognized that rare species can be effectively protected only if their habitats are considered as objectives of nature conservancy efforts (Synge 1981, Kornaś 1983, Usher 1986). This is, however, for whatever reasons, not always possible. The knowledge of ecology and population dynamics of a given species is then of extreme importance as it can contribute to the successful management for species protection (Harper 1981). The analysis of species behaviour at the border of its distribution may provide a deeper insight into its biology and ecology, if compared with observations from other geographical regions (Margules et Usher 1981). These points are relevant to the species under study.

Our paper focuses on (1) evaluation of year-to-year variation and developmental trends in the *H. incana* population, (2) species ecology and its response to the management commonly used at the locality, and (3) description of the current state which may serve as a basis for future comparisons.

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Material and methods

Study species

Herniaria incana Lam. (syn. *H. besseri* Fisch., *H. macrocarpa* Sibth. et Sm., *H. millegrana* Besser and others) is a perennial herb with a stout woody caudex, prostrate stems up to 30 cm long and oblanceolate to narrowly oblong (5-10 x 2-4 mm) leaves. The population studied belongs to the var. *angustifolia* Fenzl in Ledeb. (Chaudhri 1968, Hlaváček 1989).

The species is widespread in the subcontinental part of meridional and submeridional zones of Europe, western Asia and northern Africa (Chaudhri 1968, Rothmaler 1976, Fig. 1). It grows on stony places and dry sandy soils (Janchen 1966,

Fig. 1. - Distribution of *Herniaria incana*.

' localities not confirmed by herbarium specimens or otherwise doubtful: Nikolčice, S Moravia, 1892 Formánek (Sutorý 1980, Hegi 1912); Opatow, Poland (Szafer et al. 1953).

+ localities not recently verified, probably vanished: Šoporňa, S Slovakia, 1929 J. Scheffer (Hlaváček 1989); Mainspitze, Germany (Thomé 1904, Hegi 1912); Breitensee, Austria, 1888 Dörfler (Janchen 1966, Hlaváček 1989).

• currently existing localities: Hříměždice (locality under study, 1986 Hlaváček), Kováčovské kopce (Burda) in South Slovakia and Esztergom in Hungary (C. Roemer) - these two sites represent presumably the same locality separated by the Danube river.

Jordanov 1966), from lowlands to high mountains at altitudes of 150-2500 m (Chaudhri 1968). Within the territory of Czechoslovakia, the species is known from the Kováčovské kopce hills, southern Slovakia (Sutorý 1980) where the northern border of species distribution in northwestern Europe has been considered to run at the latitude of 48-49°N (Brummit et Heywood 1964). In 1986, however, it was found by Hlaváček (1989, 1991) in central Bohemia, near the village of Hříměždice (49.41°N, 14.17°E). Although two more northernly located finds have been reported in the past (Fig. 1), both localities are either doubtful (Szafer 1953) or not recently verified (Thomé 1904,

Hegi 1912). It may be thus concluded that the Hříměždice locality is at present the northernmost confirmed occurrence of *H. incana* in central and western Europe. For more details on phytogeographical aspects see discussion in Hlaváček (1989).

Site description

The study site is located ca 0.3 km E from the village Hříměždice, district of Příbram, Czechoslovakia, at the altitude of 350 m (Fig.1). It represents a moderately warm climatic area with a mean annual temperature of 7-8°C and an annual precipitation of 500-550 mm (Mikyška et al. 1972, Table 1). The area is a part of

Table 1. - Summary of climatological data for the research period. Data on temperature (°C) are from the Sedlčany meteorological station, data on precipitation (mm) from the Kamýk nad Vltavou station. n.a. - not available.

month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Temperature:												
1986	-0.2	-7.7	2.9	9.0	15.7	16.4	17.6	17.7	12.0	8.4	4.2	0.7
1987	-7.0	-1.4	-1.9	9.0	11.1	15.4	18.1	15.7	15.4	9.0	4.3	1.4
1988	1.9	1.8	2.5	8.6	15.1	16.0	18.1	14.5	13.5	9.4	0.7	2.0
1989	0.5	3.2	6.5	8.9	13.8	16.2	18.8	17.6	14.6	9.5	1.1	0.9
1990	0.8	4.2	7.2	7.4	14.4	17.4	18.5	19.6	12.0	8.7	4.3	-0.1
1991	0.9	-3.7	6.1	7.4	9.9	15.6	19.7	18.1	14.5	7.2	3.0	n.a.
1901-1950	-2.1	-1.0	2.8	7.6	12.4	16.2	17.4	16.6	12.8	7.7	3.4	-0.3
Precipitation:												
1986	39	19	37	36	149	41	84	102	28	35	15	33
1987	62	46	34	21	83	72	131	53	63	19	16	44
1988	24	40	55	23	58	78	94	80	41	33	35	48
1989	9	20	23	59	27	50	89	76	91	32	37	16
1990	16	62	20	61	28	41	14	36	62	35	76	18
1991	13	17	41	43	41	85	112	83	24	10	55	n.a.
1901-1950	24	24	27	40	62	70	73	68	45	37	30	50

phytogeographical district 41: Střední Povltaví (Skalický 1988). Oak and hornbeam forests (*Quercion robori-petraeae, Carpinion betuli,* and *Quercetalia pubescentis*) represent the units of reconstructed natural vegetation (Mikyška et al. 1972).

H. incana grows in the dry grassland (*Festuco-Brometea*) on the slight (<5°) SE slope. The soil is mostly shallow (up to 40 cm), sandy to clayey, with occasional rock outcrops (granodiorite). Part of the area occupied by *H. incana* (approximately 30 x 30 m) is regularly mown. The community consists of the following main species: *Poa angustifolia, Festuca rupicola, Achillea millefolium* s.l., *Achillea* sp. (verg. *A. collina* Becker), *Agropyron repens, Cerastium arvense, Potentilla tabernaemontani, Centaurea stoebe, Dianthus carthusianorum, Scabiosa ochroleuca, Trifolium arvense, Coronilla varia, Geranium pusillum.*

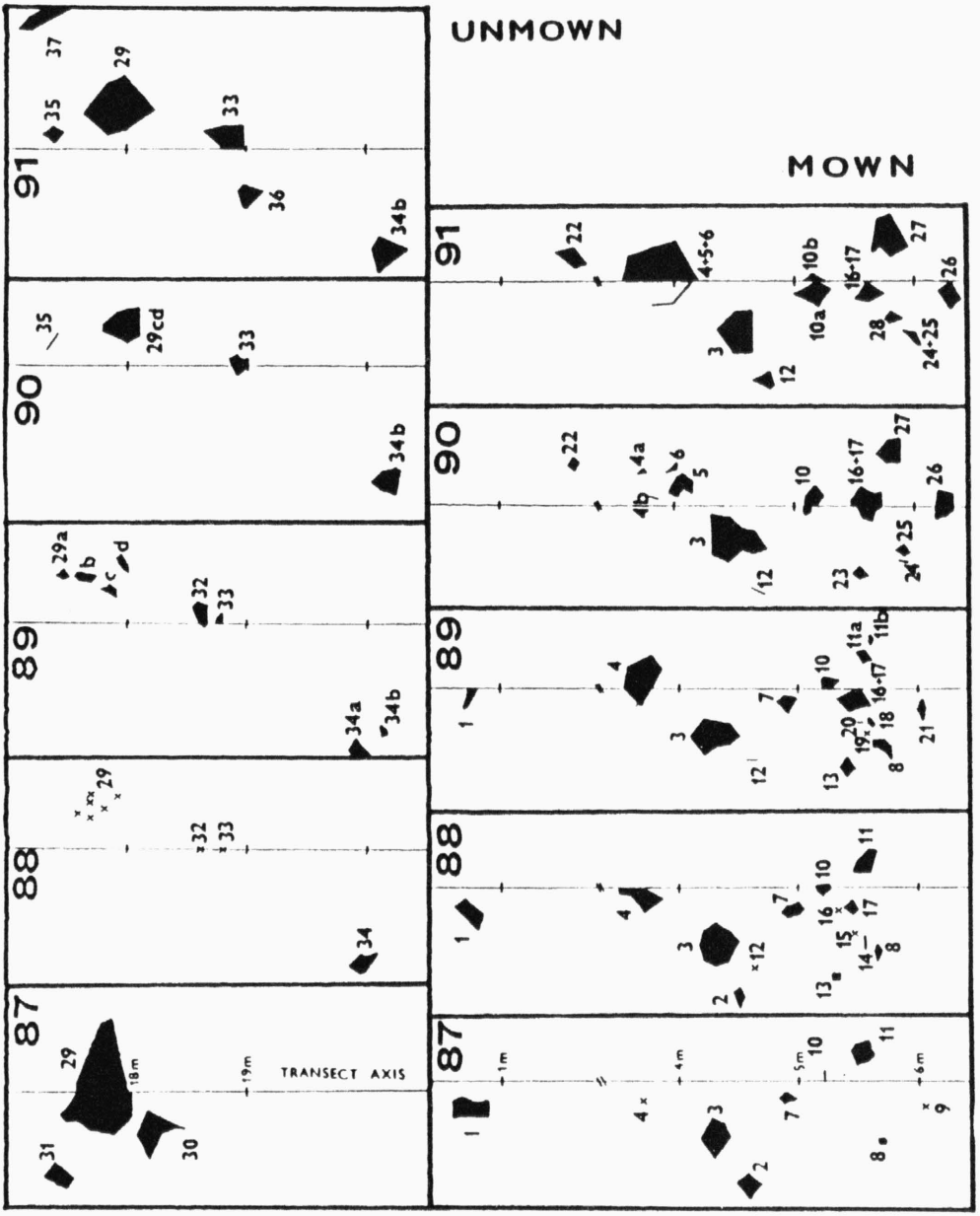

Fig. 2. - Five year dynamics of *H. incana* on the transect through the locality. Patch numbers correspond to those used in Table 2. Regular shapes of patches are due to the mapping method used: marginal points of each patch were recorded and idealized shapes were constructed. The numbers were ascribed to particular patches a posteriori on the basis of overlaying the respective maps. Patches occupying the same space as in the previous year were provided with the same numbers. A mown, B unmown.

Table 2. - Patch dynamics 1987-91. Patch sizes in cm^2 are given. Partings and subsequent connections of patches (visually estimated) are indicated by arrows. Patches that have disappeared are marked with crosses

Mown part

Patch no.	1987	1988	1989	1990	1991
1	378 →	264 →	70 →	+	
2	185 →	86 →	+		
3	447 →	784 →	730 →	1049 →	727
4	1 →	323 →	780 →	15 →	
				8 →	1562
5				105 →	
6				35 →	
7	71 →	128 →	106 →	+	
8	25 →	50 →	111 →	+	
9	1 →	+			
10	10 →	70 →	103 →	194 →	279
					67
11	249 →	235 →	96 →	+	
			24 →	+	
12		1 →	18 →	10 →	126
13		49 →	98 →	+	
14		10 →	+		
15		1 →	+		
16		1 →	263 →	388 →	189
17		66 →			
18			22 →	+	
19			1 →	+	
20			10 →	+	
21			66 →	+	
22				54 →	186
23				51 →	+
24				5 →	53
25				52 →	
26				250 →	221
27				269 →	582
28					68

Unmown part

Patch.no.	1987	1988	1989	1990	1991
29	2942 →	1 →	38 →	+	
		1 →	84 →	+	
		1 →	54 →	613 →	1550
		1 →	70 →		
		1 →	+		
30	556 →	+			
31	268 →	+			
32		1 →	164 →	+	
33		1 →	39 →	116 →	475
34		219 →	136 →	+	
			35 →	308 →	442
35				12 →	137
36					179
37					338

Sampling

The distribution of *H. incana* was recorded using a 20 m transect running through the marginal part of the area occupied by the species. Both mown and unmown parts of the grassland were sampled. It was suggested that eventual spreading or retreat of the population would have been recorded at first as a shift of the population boundaries. Location and size of *H. incana* patches[1] were mapped up to 1 m from the transect axis in both directions.

Five 2 m transects perpendicular to the axis of the main transect were carried out from the points of the most concentrated occurrence of *H. incana* and the soil depths were recorded at 10 cm intervals.

In addition, a more detailed mapping of species patches was made in the 1.6 x 1.6 m plot located in the mown area. In three more plots (0.4 x 0.6 m in size, two of them located in unmown, one in the mown part), the floristic composition was recorded and the cover of *H. incana* estimated. Unfortunately, the number of established plots and possible replicates was limited by the population size and resulting small number of *H. incana* plants.

Data were recorded from 1987 to 1991, mostly between August and October. Nomenclature follows Rothmaler (1976).

Results and discussion

The number of patches recorded on the transect and total area covered by *H. incana* increased remarkably in the mown part of the grassland during 1987-91 (Figs. 2 and 3). Table 2, however, reveals that overall spreading of the population is a dynamic process involving various changes in individual patches: unsuccessful establishments (Table 2: e.g. patches no. 9, 14 and 15), rapid and extensive spreading (e.g. nos. 4, 10 and 12) with subsequent decrease (no. 3) or gradual disappearance (nos. 1 and 2). Of 28 patches totally recorded on the transect, only 4 (i.e. 14.2% - nos. 3, 4, 10 and 29) persisted from 1987 to 1991. This supports the idea, that each level of study reveals patterns and processes which may be hidden at the next higher level.

In the unmown part of the locality, a considerable retreat of *H. incana* was recorded between 1987 and 1988, followed by a slight gradual increase in the total patch area in 1989. From 1990 on, this part of the locality was also mown, which might have contributed to the remarkable increase in the total patch cover (Figs. 2 and 3).

More detailed observations of the patch dynamics are given in Fig. 4. Considerable year-to-year changes in the spatial arrangement of patches were recorded. Shoots of *H. incana* die off in the autumn and vegetative spreading was not recorded. The population under study is producing viable seeds (Lhotská, personal communication). Year-to-year variations in patch size and position probably depend, to a certain extent, on the fine scale environmental heterogeneity experienced by plants at the time of emergence and during subsequent early growth. Possible growth direction of a

[1] Exact numbers of individuals within patches were not recorded to avoid disturbing plants. Individual shoots are often intermingled with other species or with each other which makes it difficult to separate them and find the shoot base. Patches, understood here as spatially more or less sharply defined areas covered by *H. incana* shoots, were thus considered as the mapping unit most convenient for the purpose of our study.

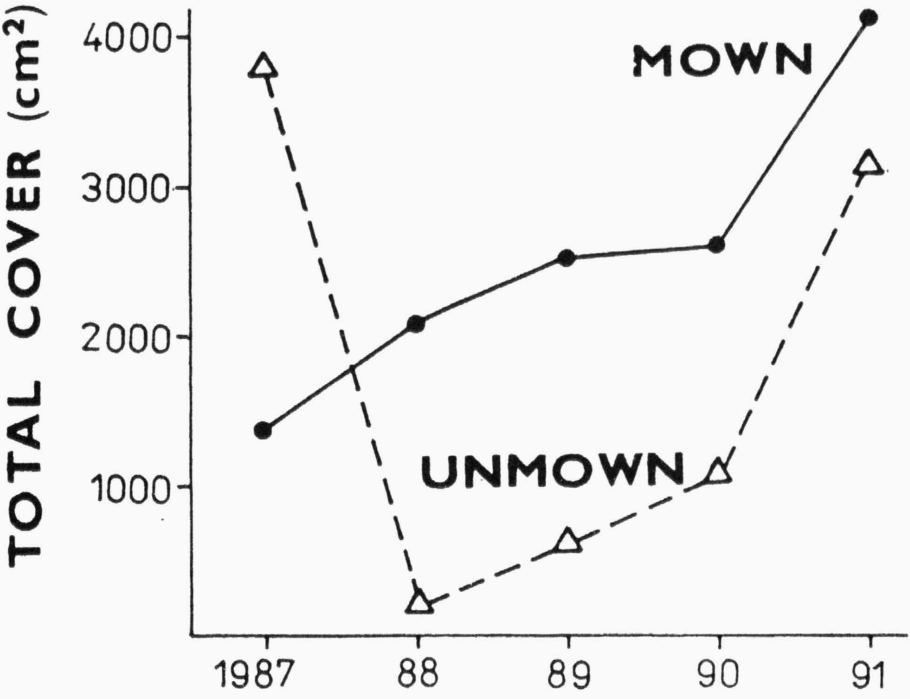

Fig.3. - Changes in the total cover of *H. incana* recorded on the transect: a comparison of trends in mown and unmown parts. Note that the area unmown till 1989 was mown in 1991 and probably also in 1990.

prostrate stem may be determined by the presence and spatial arrangement of its neighbours, especially grass tussocks.

The effect of mowing is apparent when plots under different treatments are compared (Table 3). The conspicuous decrease in *H. incana* cover found in unmown plots during 1988-89 was linked with an enlargement of *Festuca rupicola* tussocks, whereas in the mown plots the cover of *H. incana* remained approximately the same. However, the extremely hot and dry summer of 1990 (Table 1) encouraged *H. incana*. In the second half of the growing period (from July on) it was the only thriving species at the locality whereas the other species, including competitive grasses, were mostly dry or at least suffering from shortage of water. This indicates that the mowing effect may be overcome by extreme weather conditions. The climatic conditions in 1990 probably favoured *H. incana* so that the population increased conspicuously in the following year (1991) in both mown and unmown parts of the grassland (Fig. 3).

Disturbance of *H. incana* plants due to digging and biting from common voles (*Microtus arvalis)* was observed.

H. incana appears to be confined to shallow soils (Fig. 5). The maximum depth recorded under a species patch was 12.5 cm; the only exception are plants in patch no.1 (Fig. 5) which, whilst their shoots overlapped the deeper soil, rooted only in the shallower part of the soil profile. Mean soil depth under *H. incana* patches was 12.22±1.52 (mean±S.E., n=35), i.e. significantly lower (Kruskal-Wallis test, $P<0.01$)

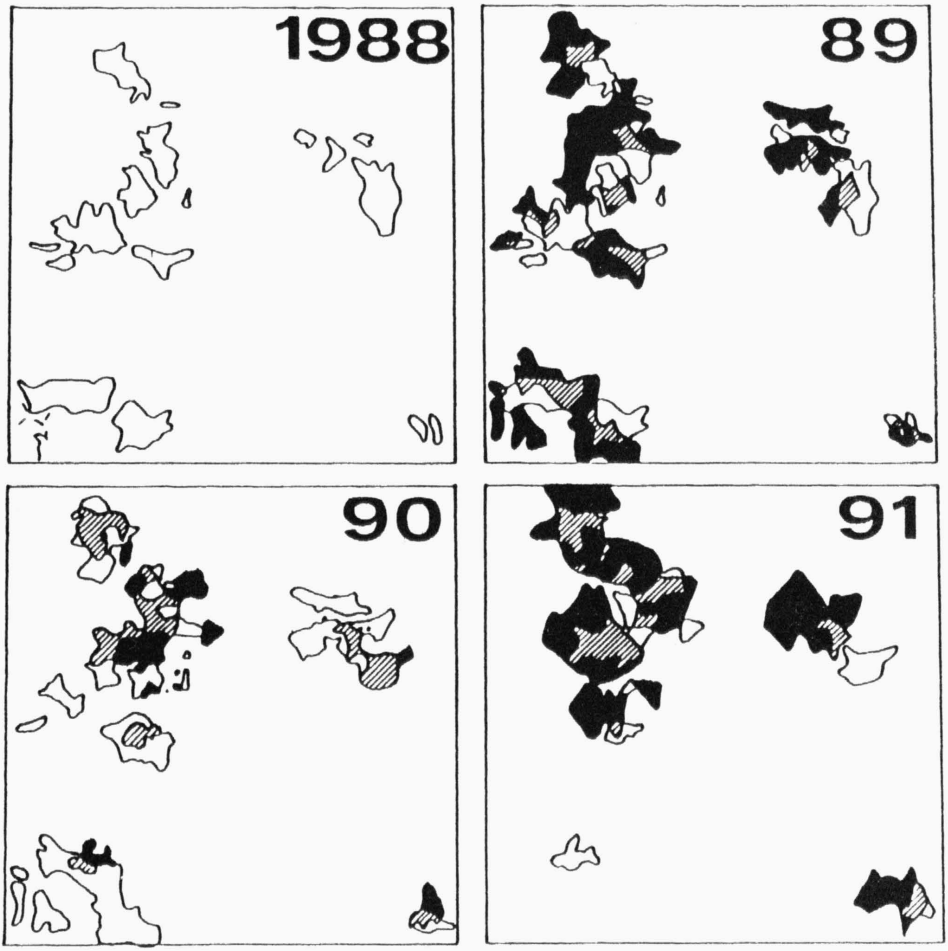

Fig. 4. - Four-year dynamics in the 1.6 x 1.6 m plot which was analysed in detail. Changes between subsequent years are indicated by black (spreading) or empty (retreat) areas, persisting occurrence is shown by hatching.

than the value from measurement points where the species was absent (16.7±1.21, n=70). It may be suggested that in the shallow soil the competitive ability of grasses (*Festuca rupicola, Poa angustifolia*) is reduced.

Relevance to the species conservation

The occurrence of *H. incana* at Hříměždice is considered allochthonous (Hlaváček 1989, 1991). The locality is situated far from the area of continuous distribution and it is highly improbable that eventual gradual spreading would not have been recognized in floristic reports. There is a very strong tradition in floristic research within the territory of Czechoslovakia and *H. incana* is difficult to overlook because of its conspicuous greyish colour. Moreover, there are many localities whose ecological conditions, with respect to possible occurrence of *H. incana*, are more convenient than

Table 3. - Species composition and *H. incana* cover in unmown (1-2) and mown (3) plots 0.4 x 0.6 m. D = species whose cover reached over 25% at least in one of the growing periods between 1988-90, d = dtto, 5%, + = species present at least once during the period of observations.

		Unmown		Mown
Plot no.		1	2	3
Festuca rupicola		D	D	d
Achillea sp.		+	+	.
A. millefolium s.l.		+	+	d
Artemisia campestris		+	.	.
Potentilla argentea		+	.	.
Poa angustifolia		.	.	d
Trifolium arvense		.	.	+
Potentilla tabernaemontani		.	.	+
Rumex acetosella		.	.	+
Erodium cicutarium		.	+	.
Taraxacum officinale		.	+	.
Cover of *H. incana* -	1988	20	25	15
	1989	1	5	15
	1990	15	17	20

those of the present locality. The question thus arises, why did it appear at precisely this locality? The way species introduction to the locality occurred is, however, difficult to clarify. Anthropogeneous transport of seeds (either unintentional or intentional due to gardening) seems to be the most probable reason (Hlaváček 1991).

In our opinion, despite its presumably allochthonous character, the locality is consequently worthy of protection. Within the territory of the Czech Republic, *H. incana* has been included among extinct and missing taxa (Holub et al. 1979). Moreover, the locality studied provides an opportunity to follow the dynamics of a geographically isolated population which may eventually be the source of further spread (considering the number of similar habitats available in the area). However, because of its small size and location in the agricultural landscape, it may be easily destroyed, unless appropriate management (regular mowing) is ensured. Human interference is considered the most important threat to rare species (Margules 1986). This threat mostly refers to the direct destruction by extrinsic factors such as land use changes (Ratcliffe 1977).

Conclusions

1. During 1987-91, the population of *H. incana* at the locality increased in size.
2. The population is reproducing successfully by seed. It prefers sites with a shallow soil layer and is encouraged by mowing and by hot and dry summers. It is suggested that these factors favour the species in competition with dominant grasses.

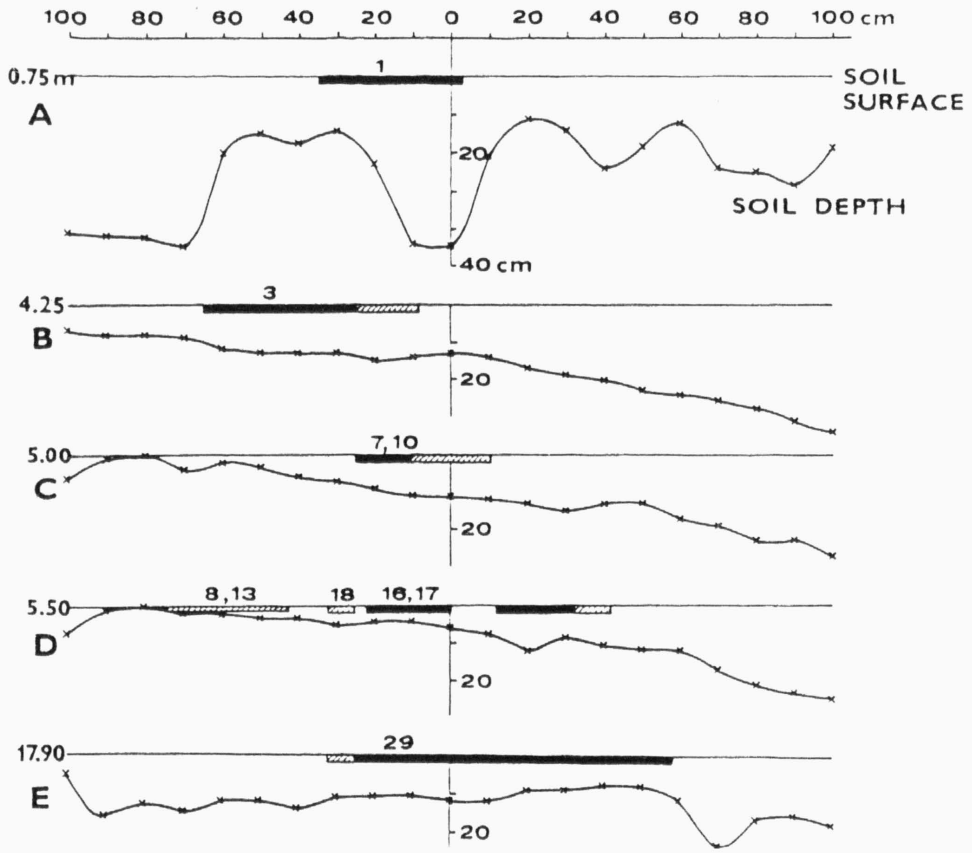

Fig. 5. - Occurrence of *H. incana* related to the depth of soil. Soil profile was estimated at 10 cm intervals on the transects A-E which were perpendicular to the main transect axis. Position of these transects is indicated by their distance from the beginning of the main transect. Patches of *H. incana* occurring directly on the transect axis are coloured black, presence of those growing up to 10 cm from the axis is indicated by hatching. Occurrence in the course of the whole study period (1987-91) was considered. Patch numbers are given and correspond to Fig. 2 and Table 2. A-D were located in the mown part, E in the initially unmown part of the locality.

3. At present, we are not aware of any other species locality in the Czech Republic. Despite its presumably secondary character, the locality should be included in the nature conservancy system.

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Shrnutí

Populace *Herniaria incana* Lam. var. *angustifolia* Fenzl in Ledeb. byla sledována poblíž Hříměždic, okr. Příbram, kde byl druh nalezen v roce 1986 prvním z autorů. V současnosti se jedná o nejsevernější známou

lokalitu tohoto druhu v západní a střední Evropě, značně vzdálenou od areálu druhu (ca 350 km). Biotopem je suchý, částečně kosený trávník třídy *Festuco-Brometea*.

Vývojové trendy byly zachyceny v letech 1987-91 pomocí 20 m transektu, zasahujícího do kosené i nekosené části, na němž byl zaznamenáván počet plošek s ± souvislou pokryvností *H. incana* (od mapování individuí bylo upuštěno vzhledem k obtížné manipulaci a možnému porušení rostlin). Vliv kosení byl dále sledován na trvalých plochách.

Na transektu v kosené části lokality vzrostla pokryvnost druhu během 5 let zhruba trojnásobně (obr. 2, 3), zatímco v nekoseném porostu byl pozorován zpočátku ústup. V posledních 2 letech však byla i tato část lokality kosena a druh začal opět přibývat. Kromě kosení podpořilo šíření druhu horké a suché léto r. 1990, které v některých případech umožnilo opětovný vzrůst pokryvnosti i na nekosených plochách, kde o rok dříve druh ustoupil. Celkově lze považovat populaci na lokalitě za stabilizovanou, s progresívní tendencí. Rostliny vytvářejí klíčivá semena, jejichž prostřednictvím se druh na lokalitě udržuje a šíří. Význam zvolené úrovně studia v ekologii potvrzuje zjištění, že v rámci jednotlivých plošek porostlých *H. incana* byla pozorována značná dynamika: během 5 let se 85,8% z celkového počtu zachycených plošek vyměnilo (zmizelo nebo se rostliny nově uchytily) a pouze zbývajících 14,2% bylo přítomno po celou dobu sledování. Druh vykazuje nápadnou vazbu na mělké půdy (většina rostlin na transektu se objevovala na půdách hloubky do 12,5 cm), kde má větší šanci se uplatnit v kompetici s vytrvalými trávami.

Výskyt na lokalitě je nutno považovat za allochtonní. Přesto se domníváme, že by si tato lokalita - v současnosti jediná známá na území Čech a Moravy, navíc se jedná o nejsevernější současný výskyt ve střední a západní Evropě - zasloužila pozornost státní ochrany přírody. Vzhledem k malé rozloze (ca 30 x 30 m) a díky tomu, že leží v zemědělsky intenzivně využívané krajině, může být snadno zničena jednorázovým zásahem (rozorání). Také při absenci kosení by byl druh pravděpodobně eliminován.

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