WHICH TYPES OF STOOLS (ACCORDING TO MORPHOLOGICAL FEATURES) CAN BE SEEN IN THE LANDSCAPE OF DRAHANSKÁ HIGHLAND?

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Abstract
We provide information on the results of mapping the relics of traditional coppice management in the Drahanská Highlands (Czech Republic). Three localities were selected where information on morphological features of stools and their occurrence in the landscape were collected. Stools were classified according to the established scheme with the aim to determine their cultural and historical value. It turned out that the final stool value is not affected by the locality, but by the tree species. European beech, sessile oak, small-leaved linden, and European hornbeam were evaluated. Oak and beech had a higher proportion of stools with lower values in comparison with linden and hornbeam. Differences in the average altitudes at which stools occurred essentially reflected different ecological demands of analysed species. The occurrence of stools could be sorted according to increasing altitude as follows: small-leaved linden – European hornbeam – sessile oak – European beech. European beech was the most widespread species. Its stools occurred from the lowest to the highest altitudes in the studied area. The authors recommend using the proposed classification scheme to determine the cultural and historical value of stools, especially with regard to planning their protection.

Key words: coppice, mapping, nature protection, cultural heritage, landscape protection

Introduction

The paper evaluates morphology and occurrence of stools - relics of traditional coppice management, in the Drahanská Highland. The idea to write this article was initiated by the fact that coppice have not been managed in our forests for at least 70 years. During this period, we have been losing the last remnants of this traditional management in the Czech landscape. We therefore believe that it is necessary to map the last coppice remnants, to determine their value and, if possible, to plan an adequate protection of these objects with high cultural and historical value. We consider the stools a part of our cultural heritage (Slach et al., 2021).

The coppice management (based on the resprouting ability of broadleaved trees after harvest) has traditionally taken place in our state for hundreds of years. According to the Czech National Forest Inventory (2001-2004) coppices occur on less than 1 % of the forest area (ÚHÚL, 2007). These forest stands (often called as quasi high forests) were originally coppice, but none of them are actively managed. If their occurrence will not further mapped and a procedure for their protection (management) will not be proposed, coppice will gradually disappear from our landscape (Slach et al., 2021).

The aim of the paper is to present:

a) a classification scheme for determining the cultural and historical value of the stools based on morphological features and verifying its use by field research,

b) a comparison of values of stools according to tree species (oak, beech, linden and hornbeam) and localities,

c) a comparison of the occurrence of stools in the field (defined by altitude) by tree species and localities.

Material and methods

Three localities with working titles: North (mainly includes cadastral areas Holštejn and Housko), Central (mainly cadastral areas Klepačov and Olomučany) and South (mainly the cadastral area Pozořice) were analyzed in the Drahanská Highland (Czech Republic).

Firstly, information about the distribution of the forest in the localities and in forest stands according to age and predominant tree species were obtained. Forest stands older than 80 years with predominant occurance of oak and beech were selected for field survey. The data were obtained from the Forest Management Institute Brandýs nad Labem. The ArcGIS Collector mobile application was used to collect data in the field, and the information was stored and subsequently evaluated in the ArcGIS

Online environment. Only structurally representative stools in the area were evaluated in the field (data collection did not involve capturing the occurrence of all stools). If there was a morphologically different stool in the vicinity of evaluated stool, this stool was also icluded; otherwise not. Every evaluated stool has classification values, GPS coordinates and a photograph in the database. The morphological features of stools were determined in the field based on the classification created for the given purpose (Table 1).

Tab. 1: Stool classification according to morphological features

Evaluated morphological features on the stool	Feature level	Feature level percentile (%)	Feature level value	Feature level description
Number of sprouts per stool	0	0	0	no sprout, but there are signs of a former stool at the base and the individual is visibly vital and viable (this is not a "stump torso")
	1	11.$\overline{11}$	1	one sprout (there are marks of the former stool at the base or trunk)
	2	22.$\overline{22}$	2	two sprouts
	3	33.$\overline{33}$	3	three sprouts
	4	44.$\overline{44}$	4	four sprouts
	5	55.$\overline{55}$	5	five sprouts
	6	66.$\overline{66}$	6	six sprouts
	7	77.$\overline{77}$	7	seven sprouts
	8	88.$\overline{88}$	8	eight sprouts
	9	100	9	nine and more sprouts
Original stump(s) presence	0	0	0	no (or not)
	1	50	4,5	(yes); visible cutting surface without noticeable stump disintegration
	2	100	9	yes, stump torso, partly decayed
Sprouts branching at the height of the original stump	0	0	0	no (there is only one sprout)
	1	33.$\overline{33}$	3	no (fork is formed about 1 m above the ground or higher); it does not have to be a stool, but a fusion
	2	66.$\overline{66}$	6	partially (some yes and some no)
	3	100	9	yes
Visible fusion of sprouts	0	0	0	no (there is only one sprout)
	1	33.$\overline{33}$	3	yes, they are
	2	66.$\overline{66}$	6	partial fusion only (former stool indication)
	3	100	9	not fused (sprouts far apart – indication of the former stool)
Presence of a dendrothelm	0	0	0	no
	1	100	9	yes

The percentiles were calculated for individual levels of morphological features. The range of values 0-9 was used as a rating scale for the levels of morphological features (this corresponds to the levels of the number of sprouts per stool that has the most levels). The resulting values for each feature level were calculated using the percentiles from this scale. The final stool value was determined as the sum of the values of the individual morphological features, and it ranged from 1 to 45. The final stool value is a discrete variable. For further analyses the stools were classified into three categories: stools with a value of 1-15, stools with a value of 16-30 and stools with a value of 31-45.

Four tree species (sessile oak, European beech, European hornbeam and small-leaved linden) were selected for the subsequent stool evaluations. In total, 431 stools were evaluated. Furthermore, altitude values (from the 5th generation digital relief model of the Czech Republic) were also assigned to every stool in the database.

As part of the data analysis, a comparison of the final stool values was performed between the studied tree species, resp. between the studied localities. Since both species and locality are categoric variables, the Pearson $\chi 2$ test of independence was chosen for this analysis. A comparison of the stool altitude values was performed between the studied tree species, resp. between the studied localities. Because the altitude did not meet the conditions of normal distribution and constant

variance, a nonparametric one-way Kruskal-Wallis ANOVA, supplemented by Dunn's multiple comparison test were used. The results were processed in the jamovi and R software environments (https://www.jamovi.org/) (https://cran.r-project.org/) at a significance level of α = 0.05.

Results and Discussion

The basic characteristics of stool values are presented in Table 2. The maximum stool value was found in sessile oak in the locality South (38), the minimum value in sessile oak in the locality South and for beech in the localities South and North (1), see Figure 1.

Tab. 2: Basic characteristics of the analysed data set (tree species: sessile oak, European beech, small-leaved linden, European hornbeam)

Tree species	Locality	Number of stools	Stool values			
			modus	interquartile spread	minimum	maximum
oak	South	132	14.00	6.00	1.00	38.00
beech		67	14.00	6.00	1.00	35.00
linden		2	multiple	25.00	10.00	35.00
hornbeam		0	---	---	---	---
oak	Central	14	14.00	7.50	10.00	27.00
beech		131	14.00	4.00	5.50	37.50
linden		17	multiple	6.00	12.00	25.00
hornbeam		24	14.00	8.50	8.00	32.00
oak	North	0	---	---	---	---
beech		41	14.00	2.00	1.00	25.00
linden		0	---	---	---	---
hornbeam		3	19.00	2.00	19.00	21.00

Based on the performed Pearson $\chi 2$ test of independence, it can be stated that the stool value is not affected by the locality, but by the tree species. It was found that beech and oak are ranked mainly in category 1-15, while linden and hornbeam are ranked in category 16-30. The representation of stool values in category 31-45 is approximately the same for all tree species (Figure 2, right). The novelty of this article is determining the stool value. The presented scheme allows to evaluate stools not only between individual features, but also within one specific feature level. We consider this to be essential from the point of view of possible planning of protection (management) of stools. The number of sprouts affects the final stool value from 20 %, its influence can be described as one of the key ones when comparing the stools values of different tree species.

Regarding the altitude influence, it was found that only the North locality differs significantly from the two remaining localities. The influence of tree species on the distribution of altitudes was evident for European beech, which differed in altitudes from all other tree species, and a difference (just above the significance level) between sessile oak and small-leaved linden was documented. Figure 3 (on the right) shows clearly that the pattern of stool occurence across the altitude gradient is in accord with ecological demands of studied species (where beach occupies higher altitudes and oak and hornbeam lower altitudes). Therefore, according to increasing altitude, we can rank the occurrence of stools as follows: small-leaved linden - hornbeam - sessile oak - beech. Beech was the most widespread, its stools occurred from the lowest to the highest positions in the monitored localities.

Tab. 3: Results of Pearson $\chi 2$ test of independence and Kruskal-Wallis ANOVA for comparison of stool values (resp. altitudes) between individual tree species and localities (DF – degree of freedom, $\chi 2$ - $\chi 2$-value of Kruskal-Wallis ANOVA or $\chi 2$-value of Pearson test, p - p-value)

Dependent variable	Factorial variable	DF	$\chi 2$	p
Stool value	Tree species	6	14.93	=0.021
	Locality	4	2.54	=0.638
Altitude (m a.s.l.)	Tree species	3	66.51	<0.001
	Locality	2	117.98	<0.001

sessile oak – stool value: 1, altitude: 406 m, locality: South

sessile oak – stool value: 38, altitude: 406 m, locality: South

Fig. 1: Stools with minimum (on the left) and maximum (on the right) value

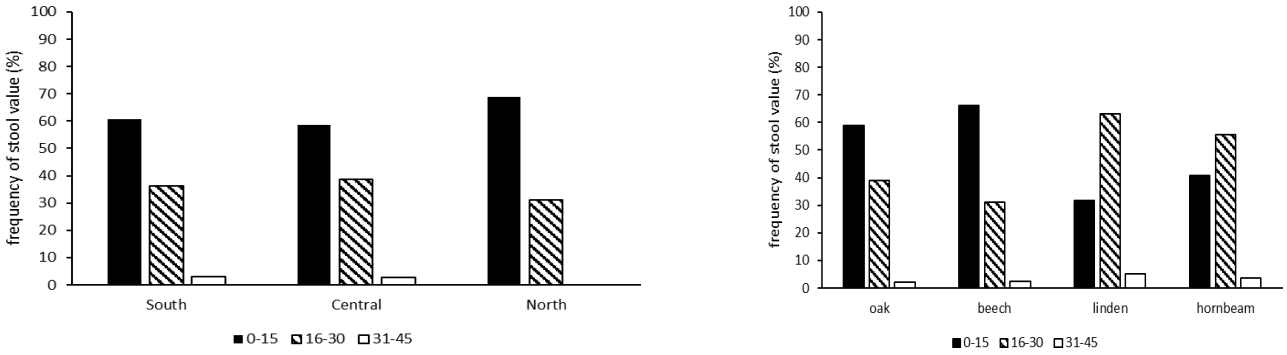

Fig. 2: Graphic representation of relative frequencies of stool values between compared localities (picture on the left) and tree species (picture on the right) (sessile oak, European beech, small-leaved linden, European hornbeam)

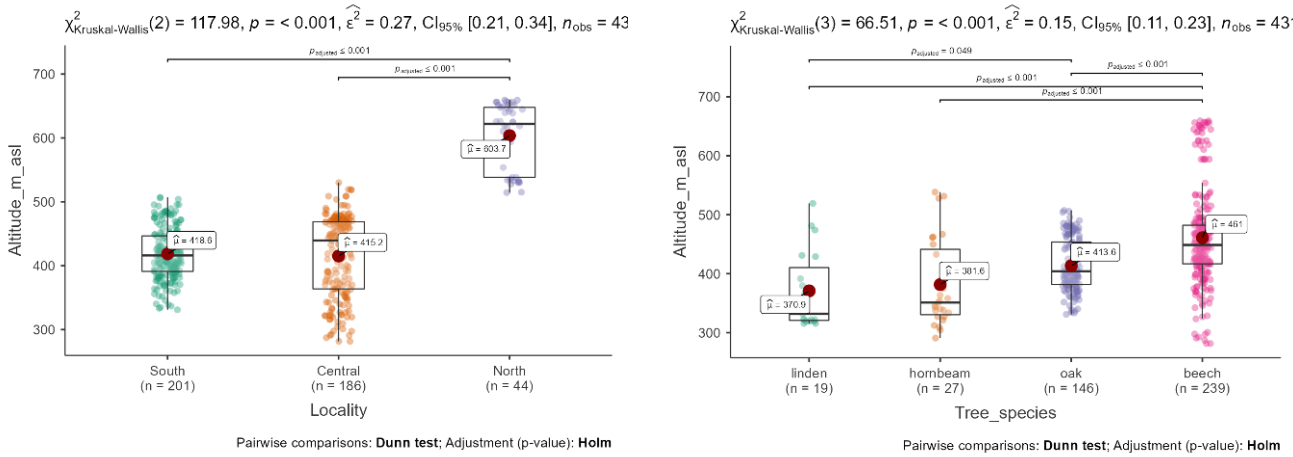

Fig. 3: Graphical representation of the results of Dunn's multiple comparison tests of stools altitudes between localities (picture on the left) and between tree species (picture on the right) (small-leaved linden, European hornbeam, sessile oak, European beech, n – number of evaluated individuals)

Conclusion

A new classification system for stool value assessment according to morphological features was established and verified in the field. The evaluation was performed at three selected localities in the Drahanská Highland. The system can be used to determine the stool values. We anticipate its use mainly with regard to protection (management) of stools - relics of traditional coppice management in forests. The aim of this contribution was to draw attention to stools in forests, emphasize their diversity and importance in the landscape. Coppices contribute to the diversity of the landscape. It is therefore important to preserve and protect these relics.

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Souhrn

Příspěvek podává informaci o hodnocení polykormonů, reliktů tradičního hospodaření pařezinami, v lesích na území Drahanské vrchoviny. Motivem k jeho napsání bylo povědomí, že se na našem území pařezinami již minimálně 70 let nehospodaří. Přitom hospodaření (těžba) je ale základním atributem existence pařezin. Proto, pokud opět nezačneme aktivně hospodařit v pařezinách, nebo pokud nezačneme plánovitě chránit poslední zbytky dokladů tohoto hospodaření (polykormony), pak o ně definitivně přijdeme. Domníváme se proto, že je zapotřebí poslední zbytky dokladů tohoto hospodaření dále mapovat, stanovit jejich kulturní a historickou hodnotu a pokud možno nastavit a naplánovat adekvátní ochranu (management) těchto objektů. Objekty polykormonů pařezin pokládáme za součást našeho kulturního dědictví v krajině.

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