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Conservation of genetic resources of *Sorbus torminalis* in Poland

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Abstract: The paper presents the proposal of a strategy of conservation of genetic resources of wild service tree (*Sorbus torminalis*) in Polish forests. Some results of the recent studies on distribution, resources and genetic variability of wild service tree in Poland that make a scientific base of the programme are presented. Both *in situ* and *ex situ* methods should be applied in conservation of genetic resources of *S. torminalis*. Conservation affords should first to be focused on forest management oriented in favor of wild service tree (e.g. logging intervention, competition control, preparing of favorable sites for new establishments). Further, *in situ* measures should include selection of conservation areas (natural gene reserves) and preserving trees of the best quality (protected genotypes). These objects would provide seeds for new establishments and to feed populations of small size. The genotypes of the selected earlier preserving trees (about 250–300) would be protected in *ex situ* conservation objects – seedling and clonal seed orchards. These plantations would also provide seeds needed for future establishments. The genotypes of endangered populations or single trees of *S. torminalis* could be preserved in the Forest Gene Bank in Kostrzyca.

Additional key words: trees, Rosaceae, genetic conservation, *in situ* and *ex situ* measures.

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Introduction

The wild service tree (*Sorbus torminalis* (L.) Crantz) is one of the rarest and most interesting forest trees in Poland. It is a typical companion species, which increases the biodiversity of forests and is a valuable biocenotic species as well. Also its wood is highly valued, although in Poland it cannot be exploited, because the species is protected by law.

The need for protection of forest tree genetic resources and its justification on the pan-European and regional scale have been widely discussed, so this issue is familiar to foresters. Currently in Poland a programme of protection of forest genetic resources, which has been planned for 1991–2010 is being implemented in state-owned forests (Matras et al. 1993). Unfortunately, this programme does not include *S. torminalis*. Simultaneously, increasing interest in this species has been observed recently, as it is more and more often planted in forests.

This study was aimed to propose a strategy of conservation of genetic resources of *S. torminalis* in Poland. The strategy is based on results of earlier research (e.g. Bednorz 2004, 2006, 2007 a, 2007 b; Bednorz et al. 2006). General principles of protection of genetic resources of *S. torminalis* were elaborated within the European programme of protection of forest genetic resources EUFORGEN (Demesure-Musch and Oddou-Muratorio 2004).

Distribution and size of local populations of *S. torminalis* in Poland

The species reaches in Poland its northeastern limit of distribution, so its local populations are usually scattered and very small. *S. torminalis* is found mainly in western Poland, i.e. in the geographic regions of Wielkopolska and Pomerania, while in southern Poland it spreads south as far as foothills of the Sudety and Beskidy Mts. (Browicz and Gostyńska-Jakuszewska 1966). In Poland, *S. torminalis* grows mainly in lowlands, in broadleaved forests of the classes *Querco-Fagetea* and *Quercetea robori-petraeae*, most often in oak-hornbeam and oak forests, as a companion species (Bednorz 2007 b). According to the latest inventory, *S. torminalis* is found on 73 natural sites (Fig. 1) and its Polish population consists of ca. 2550 trees, not counting saplings and seedlings (Bednorz 2003, 2004). Local populations are generally small, composed of several or about a dozen trees. Population size exceeds 100 trees only on eight sites. During the 20th century the species has disappeared from many localities in Poland, and in some places its distribution limits have moved westwards (Bednorz 2004). This means that the Polish population of this species has been reduced, and at the same time the spatial isolation of its local populations has increased.

Important biological and ecological characteristics of the species

S. torminalis is a diploid species, at least partly self-incompatible, with hermaphrodite flowers pollinated by insects. Its succulent brown fruits (pomes) is readily eaten and dispersed by birds and mammals. The tree is photophilous, and does not tolerate full shade. Suitable light conditions are necessary for flowering and fruiting, as well as for seedling survival, and thus for reproductive success. The wild service tree is reproduced mainly sexually (from seeds), although asexual reproduction (by suckers) is also common in natural populations. Both its seedlings and suckers are readily eaten by various species of deer family. In forest ecosystems it usually does not compete effectively with other tree species.

Threat factors and protection of *S. torminalis* in Poland

In the past, the main threat factor affecting *S. torminalis* was logging activity in woodlands. Currently its threats include: the small size of local populations; fragmentation of habitats; spatial isolation of local populations and the resultant limitation of gene flow; low competitiveness of the species; and, sometimes, inappropriate forest management.

The wild service tree has been protected by Polish law since 1946. Some of its populations have been additionally protected as nature reserves (e.g. 'Bytyńskie Brzęki', 'Brzęki im. Z. Czubińskiego', 'Kawęczyńskie Brzęki', 'Rogóźno Zamek'), while some of the oldest and largest specimens are protected as 'monuments of nature'. Unfortunately, the applied forms of passive protection have proved to be unsuccessful, as some local populations of this species are gradually dying out (also within nature reserves) and many small populations are already extinct. Now we know that for effective protection of the species, it is necessary to apply active methods. In spite of the lack of recommendations in this field from any institutions responsible for nature conservation in Poland, some actions – often simple but effective – are undertaken in a number of forest districts and ranges. An example is the Jamy Forest District, where the active protective measures, applied for over a decade, have proved to be successful (Tarnawski 2001). They focus on initiation and protection of natural regeneration, and on improving the living conditions of mature trees.

Genetic variation of Polish populations of *S. torminalis*

It is common knowledge that genetic variation within species and populations ensures their survival in changing environmental conditions. Knowledge of the variation should form the basis for creation of programmes of protection of their genetic resources.

Research on the genetic variation of Polish populations of *S. torminalis*, based on isoenzyme variation, was initiated relatively recently, i.e. in the late 1990's (Krzakowa and Bednorz 1999; Bednorz and Krzakowa 2002; Bednorz et al. 2004). In 2004–2006, a large-scale study of genetic variation of *S. torminalis* was carried out in Poland. Results of the study form the scientific basis of the proposed strategy of protection and reintroduction of the species in Poland (Bednorz et al. 2006). The study included 20 populations of *S. torminalis* (Fig. 1), which varied in size, covered area, and many environmental factors. Analyses were based on 11 polymorphic enzyme loci (malate dehydrogenase MDH-B, malic enzyme ME-A, 6-phosphogluconate dehydrogenase 6PGD-B, alcohol dehydrogenase ADH-B, phosphoglucomutase PGM-A, PGM-B, phosphoglucose isomerase PGI-A, fluorescent esterase FLE-B, glutamate oxaloacetate transaminase GOT-C, glutamate dehydrogenase GDH-B, diaphorase DIA-C). That study revealed a

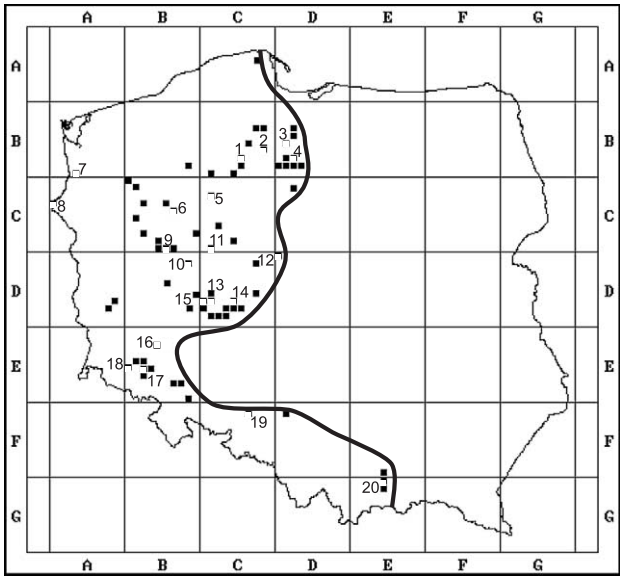

Fig. 1. Current distribution of *Sorbus torminalis* in Poland with its range limit; 1–20 populations investigated genetically (see Table 1)

surprisingly high genetic variation, both within populations (expected heterozygosity H_e=0.373), and within species (H_e=0.435). The highest genetic polymorphism was recorded in populations from the reserve 'Brzęki im. Z. Czubińskiego', reserve 'Kamień Śląski', Wielkopolska National Park, and the forest range Zielonagóra (Table 1). Analyses of the genetic structure of Polish populations of *S. torminalis* showed that most of the detected alleles can be found in all the studied populations, but their frequencies vary. Two alleles (GDH 3, PGI 4) were classified as rare. Allele GDH 3 was present only in two populations (Tuchola and Lubiechowa), while allele PGI 4 was found in four populations (reserve 'Brzęki im. Z. Czubińskiego', Opalenie, reserve 'Kamień Śląski', and Białowodzka Góra). Gene flow between the studied populations was low (Nm=1.25). This is unfavourable, and may indicate that the genetic resources of *S. torminalis* in Poland are threatened, despite the currently high genetic variation of the studied populations (Bednorz et al. 2006).

Strategy of protection of genetic resources of *S. torminalis* in Poland

Active protection of genetic resources of *S. torminalis* should be implemented on the basis of a long-term protection programme prepared for the whole country and individual regions. The programme should include several successive steps: (1) selection of the populations and trees to be specially protected; (2) protection of genetic resources *in situ*; (3) protection of genetic resources *ex situ*. The programme should accomplish two basic goals, which have been identified as a result of conducted studies. First, the size of natural populations and the area covered by them should be maintained at a safe level, by protective measures *in situ*. Second, the species should be properly introduced to new sites, in order to reduce the spatial isolation of populations, and to increase the possibility of gene flow between them. To achieve this goal, protective measures *ex situ* are necessary.

The basic criteria of population selection should be: a high level of genetic polymorphism, large population size (number of individuals and area covered), and possibility of sexual reproduction. Also the populations with rare alleles and genotypes should be protected (Lubiechowa, Opalenie) as well as the populations directly threatened with extinction (reserve 'Kamień Śląski'), even if they do not meet the other criteria. Next, small populations and single trees should be safeguarded. General selection criteria of the populations and individuals to be specially protected were described by Matras (2002).

For protection of genetic resources of *S. torminalis*, protective measures *in situ* are the most important. They should include mainly sylvicultural practices favourable for this tree species. In forest stands with wild service trees, canopy density should be reduced, to ensure good growth and abundant flowering and fruiting of *S. torminalis*. Natural regeneration should be initiated and promoted by creating some gaps in the canopy, removal of seedlings of other species, and fencing of those forest patches to protect them against browsing damage. If wild service trees are found in a plot assigned for felling, they should be protected by leaving around them a biogroup occupying an area of at least several ares. The protective measures listed above should be implemented both in managed forests and in nature reserves, preferably in all the present localities of this species. This would be the first step of the proposed strategy.

The second step of protection *in situ* would consist in selection of the forest stands and trees to be specially protected. The specially protected areas, as natural gene reserves, would protect populations representing various geographic regions and site types. They would include large natural populations that cover large areas, reproduce sexually, and have a high level of genetic polymorphism (*southern Poland*: Białowodzka Góra, reserve 'Kamień Śląski', Jawor; *Wielkopolska*: Piaski, Bytyń, Goraj; *Pomerania*: Bielinek, Tuchola, Zielonagóra, reserve 'Brzęki im. Z. Czubińskiego', Jamy). Specially protected trees (preserving trees), found in groups or singly, would be selected by forest districts on the basis of phenotypic features. The selected trees should be next subjected to genetic analyses in order to verify if their genotypes sufficiently represent the total gene pool of the Polish population of *S. torminalis*. On the basis of results of research carried out in Switzerland (Rotach 2000), I

Table 1. Parameters of genetic variability and inbreeding coefficients of Polish populations of *Sorbus torminalis* (after Bednorz et al. 2006); *P* – percentage of polymorphic loci, N_a – number of alleles per locus, N_e – effective number of alleles, H_o – observed heterozygosity, H_e – expected heterozygosity, F_{IS} – heterozygote deficit

Population		*P*	N_a	N_e	H_o	H_e	F_{IS}
1	Tuchola	44	2.182	1.597	0.432	0.348	-0.198
2	'Brzęki im. Z. Czubińskiego' reserve	44	2.455	1.882	0.441	0.442	-0.029
3	Opalenie	40	2.273	1.772	0.527	0.404	-0.229
4	Rogoźno – Jamy	36	2.182	1.519	0.270	0.286	0.086
5	Zielonagóra	40	2.273	1.908	0.425	0.445	0.000
6	Goraj	40	2.182	1.657	0.402	0.367	-0.085
7	'Puszcza Bukowa'	40	2.182	1.690	0.452	0.363	-0.223
8	'Bielinek nad Odrą' reserve	36	1.182	1.535	0.349	0.295	-0.134
9	Bytyń	44	2.273	1.759	0.421	0.404	-0.072
10	Wielkopolska National Park	44	2.182	1.895	0.530	0.473	-0.165
11	Promno	36	1.909	1.678	0.375	0.374	0.021
12	'Kawęczyńskie Brzęki' reserve	44	2.273	1.819	0.477	0.426	-0.118
13	Potarzyca	44	2.273	1.812	0.473	0.404	-0.101
14	Taczanów	44	2.273	1.754	0.399	0.388	0.016
15	Piaski	44	2.364	1.843	0.486	0.414	-0.158
16	'Brekinia' reserve	24	1.546	1.371	0.367	0.193	-0.360
17	Jawor	44	2.273	1.552	0.381	0.336	-0.112
18	Lubiechowa	40	2.091	1.599	0.391	0.346	-0.159
19	'Kamień Śląski' reserve	44	2.364	1.848	0.454	0.430	-0.091
20	Białowodzka Góra	44	2.182	1.592	0.395	0.329	-0.158
	Mean	40.8	2.146	1.704	0.422	0.373	-0.113
	Standard deviation	4.959	0.296	0.149	0.062	0.066	0.103

estimate that the optimum number of preserving wild service trees in Poland would be 250–300. When choosing the trees to be specially protected, it is necessary to take into account the populations where rare alleles and genotypes are present.

Gene reserves and preserving trees would be sources of seeds used for propagation in selected nurseries (e.g. nursery in Syców Forest District). The produced seedlings would be planted on the sites where the species is currently absent, but environmental conditions are suitable. The seedlings should originate mainly from the closest natural populations (preserving trees). It is also advisable to enrich small populations or those where sexual reproduction is ineffective (Wielkopolska National Park, reserve 'Brekinia').

The next step of the proposed programme would include protective measures *ex situ*, consisting mainly in establishment of seedling seed orchards (by propagation from seeds) and clonal seed orchards (by vegetative propagation). Such seed orchards should be created on a regional scale (Pomerania, Wielkopolska, Silesia, Sub-Carpathia). The seeds or clones planted in seed orchards would originate from the earlier selected preserving trees. Plantations *ex situ* would fulfil two functions: (1) conservation of genetic resources, and (2) production of propagation material characterized by a high genetic variation. Also emergency actions should be prepared, to be applied in case of a serious direct threat to whole populations or valuable single trees. To protect threatened genotypes, clonal seed orchards could be used, or if the trees bears fruit, their seed could be preserved in the Forest Gene Bank in Kostrzyca.

Conclusions

Until recently, *S.torminalis* trees in forests were treated as a dendrological curiosity. However, interest in this species markedly increased among foresters during the last decade. The species started to be propagated in nurseries and introduced to forest cultivation. Thus one could say that the situation has improved, but this is true only to some extent. In some cases, material deriving from southern Wielkopolska is planted in Pomerania, or a large number of seedlings is produced from a single, abundantly fruiting tree. These are only some examples.

Thus a well-thought-out programme is needed. Some professional foresters are experienced in propagation and cultivation of wild service trees. Their knowledge, experience and passion should be properly utilized. As a person who is worried about the future of wild service trees, I would like to ask the peo-

ple and institutions that are responsible for protection of genetic resources of native forest trees to discuss this problem and to initiate activities aimed at creation and implementation of a programme of protection of genetic resources of *S. torminalis* in Poland.

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