RHIZOME SIZE STRUCTURE AND BELOWGROUND BIOMASS OF *Sambucus ebulus* L. POPULATIONS IN A MONODOMINATED PLANT COMMUNITY

PAVOL ELIÁŠ

Department of Ecology, Slovak Agricultural University, Mariánska 10, 949 76 Nitra, Slovak Republic, e-mail: pavol.elias@uniag.sk

Abstract

Eliáš P.: Rhizome size structure and belowground biomass of *Sambucus ebulus* L. populations in a monodominated plant community. Ekológia (Bratislava), Vol. 26, No. 4, p. 430–437, 2007.

Belowground organs of *Sambucus ebulus* L., a herbaceous perennial plant with clonal growth, were studied in dense stands with single dominant species in two localities in SW Slovakia, in Báb near Nitra (L1) and in Bratislava (L2). Diameter of rhizomes varied from less than 3 mm to more than 20 mm. In size structure thicker rhizomes prevailed by dry biomass. But if the frequency was expressed in length of rhizomes thinner rhizomes were more frequent. Total length of rhizomes in $1m^{-2}$ plot in L2 was 2.9 m. Specific rhizome length (SRL) was 2.8 cm g^{-1}. In the stands investigated, the dry biomass of *S. ebulus* rhizomes varied from 0.63 in L2 to 1.02 kg. m^{-2} in L1. The ratio of belowground to total above-ground dry mass was highly variable (1.08 to 1.4). High rhizome weight fraction (RWF) indicates importance of rhizomes in the dominance of the plant species in the monodominant community.

Key words: biomass production, rhizome size structure, belowground biomass, *Sambucus ebulus* L., dominance, resource allocation, rhizomes length, R/S ratio, rhizome weight fraction (RWF), specific rhizome lenght (SRL)

Introduction

Dominance-controlled communities demonstrate strong dominance: some species are competitively superior to others; usually one or two species with high competitive ability are very abundant and many other species are rare (Begon et al., 1996; Crawley, 1997; Eliáš, 1981). Dominance by various types of herbaceous plants has been associated with particular plant characteristics (Grime, 1979).

The species with high competitive ability – the competitors – are robust perennials which have the capacity for lateral vegetative spread by means of rhizomes or expanding tusssocks (Grime, 1979). The competitive ability has been associated with clonal, perennial growth

(lateral vegetative expansion) and a relatively high, dense leaf canopy and dense root system (Wilson, 1988; Fiala, 2001). Species formed larger root systems could be more successful in the competition for soil resources. It is, therefore, important to study the underground organs of the plants.

Most of the dominant plants are rhizomatous plants. Physiological integration among ramets of the herbaceous perennials *via* rhizome connections provides a likely mechanism by which clonal plants can invade heterogeneous environment, colonize it, form dense stands with a single dominant, persist in one place for many years. Edificators in litoral helophyte communities, e.g. *Phragmites australis* (Fiala, 1976) and *Acorus calamus* (Dykyjová, 1980), can be introduced as good examples of dominants with clonal growth. Dominants in ruderal and other disturbed habitats were also studied and discussed, e.g. *Urtica dioica, Pteridium aquilinum, Chamaenerion angustifolium* and *Petasites hybridus* by Grime (1979), *Solidago* and *Aster* species by Bazzaz (1996) and *Calamagrostis epigejos* by Fiala (2001). The long-lived perennial herbs form monospecific patches of a few to hundred individuals.

Sambucus ebulus L. was presented as a perennial plant with clonal growth and persistent connections between ramets (*via* rhizomes) (Eliáš, 1992). It is a herbaceous plant, in contrary to other *Sambucus* species, *Sambucus nigra* and *S. racemosa*, which are woody consistency (Bertová, 1985; Eliáš, 1986a; Helebrant, 1981). The shoots of the herb die back to ground level at the end of every growing season (Crawley, 1997; Eliáš, 1986b, 1997).

Shoot biomass, population structure, dynamics and ecology of *S. ebulus* L. have been studied in SW Slovakia for several years (Eliáš, 1978b, 1981, 1992, 2002, 2003; Slížová, 2002, 2003, 2004; Slížová, Eliáš, 2003). The data on the belowground biomass of *S. ebulus* presented in this paper were not yet published.

This paper deals with size structure of rhizomes and belowground biomass of the clonal plant species in SW Slovakia.

Material and methods

Plant material

Sambucus ebulus L. is a rhizome geophyte, it avoids environmental stressors by die-back of their above-ground parts and survives by means of belowground storage organs. The plant forms dense stands arising from an extensive belowground rhizome system which is differentiated into two major components. Longer and thinner rhizomes in deeper soil layers are capable of rapid elongation, and they did not produce ramets. Shorter and thicker rhizomes are major storage organs and they produced above-ground shoots (Slížová, Eliáš, 2003). Fig. 1 shows a segment of rhizome system structure of *S. ebulus* L. from a stand in L1 (September 27, 1975, Báb). The species produces every year more aboveground shoots (ramets) than can survied to close occupied area by its leaf-canopy (Eliáš, 1992) and this over-production resulted in high mortality of young shoots in early summer and summer months (Eliáš, 2003).

The plant can reproduce by asexual (vegetative) reproduction as well as by sexual (generative) reproduction. Vegetative reproduction is represented through rhizomes – the plant forms a system of polycormons. One stand (a patch) can be formed by one or more polycormons; it means a pure dense stand originated from one or more genets. All survived canopy forming plants (ramets) in the stand produced flowers in inflorescences and also many fruits (Eliáš, 1979, 2002).

Research sites and plant stands

Belowground organs of *S. ebulus* L. were studied in two localities in SW Slovakia, Central Europe. Locality 1 (L1) was Báb, ruderal habitats at former I.B.P. Forest Research Area at Báb near Nitra. For more detailed information on geographical position, climate and soils on L1 see Jurko, Duda (1970) and Biskupský (1975). Locality 2 (L2) was Bratislava, ruderal habitats near the buildings of the Institute of Botany, Slovak Academy of Sciences, at Dúbravská cesta, in Bratislava-Patrónka. For general information on Bratislava, the capital of Slovakia, see web page www.bratislava.sk.

The plant stand in L1 was located in arable land, in a transitional area between two agricultural blocks. The stand in L2 was grown on old deposit of arable soil near the building of the former Dept. of Ecology of the Institute. The stands were characterized by the dominance of *S. ebulus* L. and presence of relatively few other accessoric species. The uniform, nearly pure stands with high density of the dominant belong to the association *Artemisio-Sambucetum ebuli* (F e l f o l d y 1942) E l i á š 1979 (Eliáš, 1978a, 1986c). For classification of the plant communities dominated by *Sambucus ebulus* L. see paper of Eliáš (1986c).

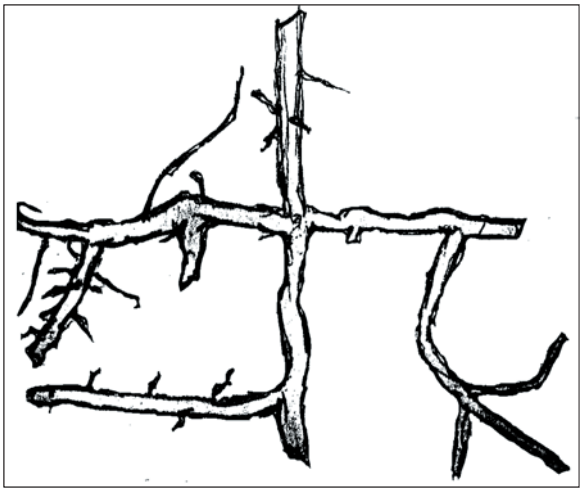

Fig. 1. Morphology (structure) of belowground organs (rhizomes and roots) of *Sambucus ebulus* presented by a segment excavated from a dense stand at Báb near Nitra, SW Slovakia (September 27, 1975). Two horizontal levels of rhizomes and a vertical rhizome connected with base of an above-ground shoot are shown.

Estimation of rhizome size structure

The biomass of belowground organs of *Sambucus* was estimated in September 1975 (L1) and September 1981 (L2). Destructive, excavation method was used to estimate size structure of rhizomes and biomass of belowground organs (Bohm, 1979). Plots of 1x1 m were selected randomly within the monodominant stands of *Sambucus ebulus* L. for biomass excavations from soil profiles. All living parts of plants in the plots were excavated up to 0.4 m deep in soil and more if it was necessary (according to the penetration of rhizomes into the substrate). The collected rhizomes (and other understory plant parts) were taken into the laboratory in Báb and/or in Bratislava, respectively, for washing and sorting.

Diameter (in mm) and length (in cm) of the rhizomes segments were measured by meter. The rhizomes were categorized into five rhizomes size classes. The diameter class interval was 3 mm in L1 and 5 mm in L2. The rhizome diameters varied in L1 a L2 from less than 3 and 5 mm to more than 14 and 20 mm, respectively.

Estimation of belowground biomass and resource allocation

All excavated plant material (rhizomes, roots, shoot base parts) was oven-dried at 75–80 °C for 24 hours in laboratories in Báb and/or Bratislava to estimate the belowground biomass. The dry mass is given in g m^{-2} (Eliáš, 1978b).

Investment of assimilates in root or shoot biomass was expressed by root : shoot ratio (R/S ratio). The term "root" is used for rhizomes and/or for all belowground organs (including rhizomes, roots and belowground-sub-

terranean parts of stems/shoots). R/S ratio was, therefore, calculated as ratio of belowground biomass to above-ground (shoot) biomass.

Root weight fraction (RWF) was calculated as root dry weight per total plant dry weight. The term "root" is here used for rhizomes.

Specific rhizomes lenght (SRL) is ratio of lenght to weight. It expresses rhizome lenght per unit weigth of rhizomes in cm g^{-1}. It is calculated by the same way as specific root lenght (Crawley, 1997).

Results and discussion

Population density

Stand density, i.e. total number of *Sambucus ebulus* L. shoots per square meter in the stands, varied from 12 shoots in L1 to 18 shoots in L2. The shoot length varied between 1.5 and 1.9 m in L1, and 1.2 and 1.5 m in L2. A seasonal peak of the above-ground (shoot) biomass varies from 0.57 to 1.5 kg. m^{-2} (Eliáš, 1978b, 1983, 1992).

Rhizome size structure

Fig. 2A,B show size structure of rhizomes by dry biomass, and Fig. 3 size structure in length of rhizomes in two localities in SW Slovakia. By dry mass, the most frequent were rhizomes with diameter larger than 10 mm in L1 (Fig. 2A) and 15 mm in L2 (Fig. 2B). Larger, thicker rhizomes accumulated more biomass, in comparison with thinner rhizomes (smaller diameters).

By length of rhizomes, the most frequent were rhizomes with smaller diameters (thinner rhizomes). The rhizomes were longer than rhizomes with larger diameters in the same plots (Fig. 3). Total length of rhizomes in L2 was 2.9 m m^{-2}. Mean specific rhizome length (SRL) for the plot was 2.8 cm g^{-1}. SRL values increased from lowest size category to the largest category.

Belowground biomass

In the stand investigated, the dry biomass of *Sambucus ebulus* rhizomes varied from 0.63 kg. m^{-2} in L2 to 1.02 kg. m^{-2} in L1. The ratio of belowground to total above-ground dry mass was highly variable (1.08 to 1.4). This amount is similar to biomass of an edificator in litoral communities: R/S ratio in pure stands of clonal plants forming dominated communities often exceeds 1, especially in mature invasion stand of *Phragmites australis* (Fiala, 1976). High rhizome weight fraction (RWF) indicates the importance of rhizomes in the dominance of the edificators.

"Over-production" of ramets in *Sambucus ebulus* populations can be a result of life strategy to form, by fast and more or less synchronized growth of individual ramets, closed dense canopy to persist in the occupied habitats – sites during the following growing season. Some of the produced ramets in the dense stand grow slowly (in shade of dominated plants)

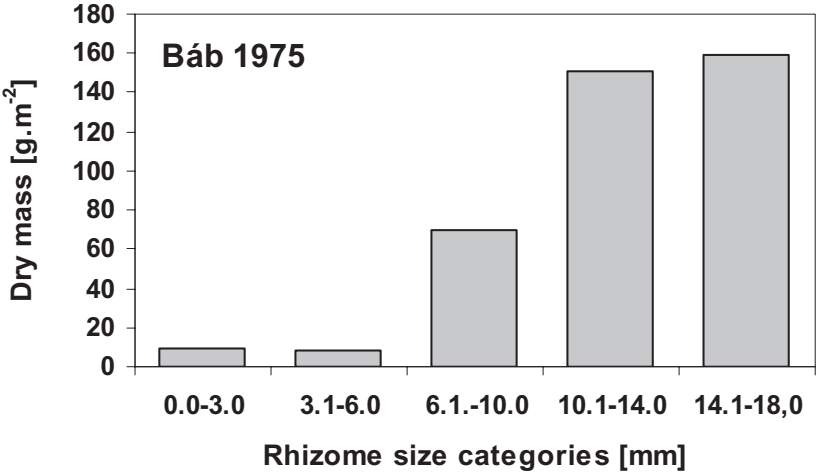

Fig. 2A. Size structure of rhizomes in population of *Sambucus ebulus* L. forming a monodominated stand in Báb near Nitra, SW Slovakia. Rhizome size is expressed in diameter of rhizomes. Frequency of the size categories is given in dry mass.

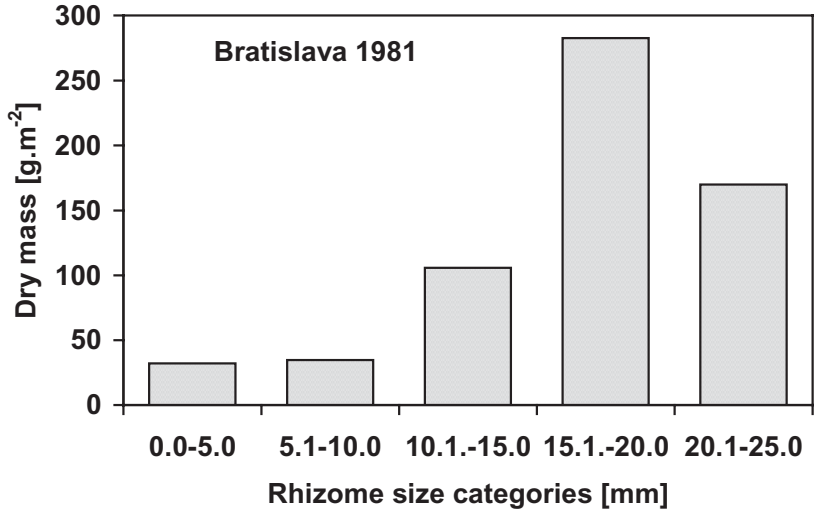

Fig. 2B. Size structure of rhizomes in population of *Sambucus ebulus* L. in a monodominated stand in Bratislava, SW Slovakia. Rhizome size is expressed in diameter of rhizomes (size class interval is 5 mm). For other legend see Fig. 2A.

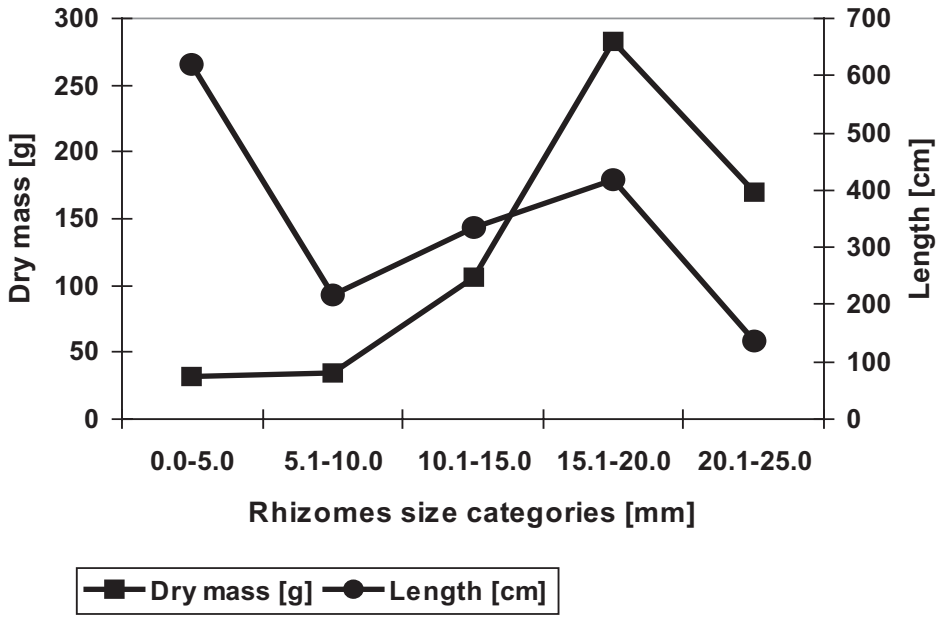

Fig. 3. Size structure of rhizomes in population of *Sambucus ebulus* L. in a monodominated stand in Bratislava, SW Slovakia. Diameter (in mm) and length (in cm) of rhizomes, Bratislava, 1981. Frequency of the size categories is given in dry biomass as well as in length (in cm) of rhizomes.

and some died later. The plant allocated large amount of assimilate into belowground organs (Shoots:"roots" ratio is close to 1.4, Eliáš, 1992).

Success in competition with other plant species for space and other sources and a long-term persistence on one site, as well as colonization of neighbouring areas, have a higher priority than internal control of meristematic activity and production of above-ground shoots. That is the difference from model clonal plant species (Herben et al., 1994; Fiala, 2001).

In colonizing populations of the species self-thickening of the population is not such intensive to be caused self-thinning. The plants form long belowground shoots which penetrate neighbouring communities and/or disturbed areas (Eliáš, 1998; Slížová, 2004).

Conclusion

In dense stands of *Sambucus ebulus* L. studied in SW Slovakia a diameter of the dominant-plant rhizomes varied from less than 3 mm to more than 20 mm. In size structure thicker rhizomes prevailed by dry biomass. But if the frequency is expressed in length of

rhizomes thinner rhizomes were more frequent. Total length of rhizomes in L2 was 2.9 m m^{-2}. Specific rhizome length (SRL) was 2.8 cm g^{-1}. In the stand investigated, the dry biomass of *Sambucus ebulus* rhizomes varied from 0.63 in L2 to 1.02 kg. m^{-2} in L1. The ratio of belowground to total aboveground dry mass was highly variable (1.08 to 1.4). High rhizome weight fraction (RWF) indicates the importance of rhizomes in the mechanism of dominance of the edificator.

Translated by the author

References

Bazzaz, F.A., 1996: Plants in changing environments. Cambridge Univ. Press, Cambridge, 320 pp.

Begon, M., Harper, J.L., Townsend, C.R., 1996: Ecology. Individuals, populations, communities. 3rd ed. Cambridge Univ. Press, Cambridge, 1068 pp.

Bertová, L., 1985: *Sambucus* L. Elder (in Slovak). In Bertová, L. (ed.): Flóra Slovenska, *4*/2, Veda, vydavateľstvo SAV, Bratislava, p. 70–76.

Biskupský, V. (ed.), 1975: Research Project Báb (I.B.P.). Progress Report II, Veda, vydavateľstvo SAV, Bratislava, 526 pp.

Bohm, W., 1979: Methods of studying root systems. Ecological Studies 33, Springer Verlag, Berlin, 188 pp.

Crawley, M.J. (ed.), 1997: Plant ecology. 2nd ed., Blackwell Sci., Oxford, 717 pp.

Dykyjová, D., 1980: Production ecology of *Acorus calamus*. Folia Geobot. Phytotax., *15*, 1: 29–57.

Eliáš, P., 1978a: *Sambucetum ebuli* and other ruderal plant communities in a town Trnava (in Slovak). Preslia, *50*: 225–252.

Eliáš, P., 1978b: Shoot biomass of the ruderal plant communities of human settlements. Acta Bot. Slovaca Acad. Sci. Slovacae, Ser. A., *3*: 127–132.

Eliáš, P., 1979: Elder (in Slovak). Naše Liečivé Rastliny, *16*, 2: 39–43.

Eliáš, P., 1981: Biology of *Sambucus ebulus* L. (in Slovak). Teze pracovní konference Čs. Bot. Společn. při ČSAV, Praha.

Eliáš, P., 1983: Production potential of spontaneous vegetation in cultural landscape (in Slovak). In Repka, J. (ed.), Production potential of cultural plants. Proc. Conf. Production Ecology of Plants, Nitra, p. 84–93.

Eliáš, P., 1986a: Our elders (in Slovak). Naše Liečivé Rastliny, *23*, 2: 39–43.

Eliáš, P., 1986b: A plant as a set of populations (in Slovak). In Repka, J. (ed.), Zborník príspevkov z ved. sem. produkčnej ekológii rastlín, Nitra, p. 84–93.

Eliáš, P., 1986c: A survey of the ruderal plant communities of Western Slovakia II. Feddes Repert., *97*, 3–4: 197–221.

Eliáš, P., 1992: Ecology of *Sambucus ebulus*, a herbaceous plant with clonal growth, in urban areas. In Clonal growth and biodiversity in severe environments, Conference Abstracts, Krkonoše, p. 7.

Eliáš, P., 1997: Functional types of plants in plant communities. Ekologické Štúdie, 1/97, SEKOS Bratislava, 152 pp.

Eliáš, P., 2002: Population dynamics of a herb with clonal growth (*Sambucus ebulus* L.). In Eliáš, P. (ed.), Populačná biológia rastlín VII. Abstrakty a program ved. konf., Nitra, 26.-28. jún 2002, SEKOS a Katedra ekológie SPU Nitra, p. 8.

Eliáš, P., 2003: *Sambucus ebulus* produced more ramets than can survive in one season. In Reproductive strategies, biotic interactions and metapopulation dynamics. Book of Abstracts, 7th Clonal Plants Workshop, August 1-5th, 2003, Kuusamo, Finland, p. 22.

Fiala, K., 1976: Underground organs of *Phragmites communis*, their growth, biomass and net production. Folia Geobot. Phytotax., *11*, 3: 225–259.

Fiala, K., 2001: Role of root system of *Calamagrostis epigejos* in its successful expansion in alluvial meadows. Ekológia (Bratislava), *20*, 3: 292–300.

Grime, J.P., 1979: Plant strategies and vegetation processes. John Wiley and Sons, Chichester, UK.

Helebrant, L., 1981: Study of morphological changeability and systematics of certain species of the genus *Sambucus* L. Studie ČSAV, *11*: 1–132.
Herben, T., Hara, T., Marshall, Ch., Soukupová, L., 1994: Plant clonality: biology and diversity. Folia Geobot. Phytotax., *29:* 113–122.
Jurko, A., Duda, M., (eds.), 1970: Research Project Báb (I.B.P.). Progress Report I. Inst. of Botany, Slovak Acad. of Sciences, Bratislava, 241 pp.
Slížová, J., 2002: Ramet density changes of a clonal plant *Sambucus ebulus* in some localities in SW Slovakia. In Eliáš, P. (ed.), Populačná biológia rastlín VII. Abstrakty a program ved. konf., Nitra, 26.-28. jún 2002, SEKOS a Katedra ekológie SPU Nitra, p. 21.
Slížová, J., 2003: Biological assumptions of clonal herb (*Sambucus ebulus*) expansion. In Reproductive strategies, biotic interactions and metapopulation dynamics, Book of Abstracts, 7th Clonal Plants Workshop, August 1-5th, 2003, Kuusamo, Finland, p. 72.
Slížová, J., 2004: Population dynamics of *Sambucus ebulus* in an experimental botanical garden (in Slovak). In Eliáš, P. (ed.), Population biology of plants. Nitra-Zvolen, *8*: 61–66.
Slížová, J., Eliáš, P., 2003: Architecture, longitudinal growth and biomass of underground organs of *Sambucus ebulus* L. Botanical underground, proceedings of the scientific conference on underground organs of plants, Praha, November 2003.
Wilson, B.J., 1988: Shoot competition and root competition. J. Appl. Ecol., *25*: 279–296.

Received 4. 5. 2004