

Abstract

Dioecious plants often show secondary sexual dimorphism, which may be a result of gender differences in expenditure on reproduction. It is assumed that females of dioecious species incur higher reproductive costs, because in addition to the expenditure on flowering, they also produce seeds and accompanying structures. The higher effort of female specimens may cause them to achieve lower growth parameters, due to the need to divide resources between functions related to growth, maintenance, defense, and the reproductive function. This is particularly important in woody plants, as their growth and reproduction take place simultaneously over a long period of their life. Expenditures for growth and reproduction are often incurred at the same time, which can be particularly stressful for female specimens that produce seeds and structures associated with them for a relatively long period during the season. Due to the necessity to divide resources directed to the main life functions, differences between the sexes are more often observed in stressful conditions, where resources are limited. In response to the challenges related to bearing the costs of reproduction, plants have developed various compensation mechanisms, which are more often observed in female specimens, due to higher costs of reproduction. The nature and time of the emergence of gender differences remains an open issue. First of all, a frequent question is whether sexual dimorphism is the result of reproduction, or it is an innate feature, existing regardless of the intensity of reproduction and already present in the early stages of development.

This study concerned two dioecious species: English yew (*Taxus baccata* L.) and common juniper (*Juniperus communis* L.). These species are similar in terms of needle life span, the pollination system and mode of seed dispersal, but they show differences in the occupied habitat and female cone life span.

The following research hypotheses were formulated:

- (1) the differences between sexes are influenced by the phenological phases of plants and the different reproductive functions of both sexes;
- (2) the differences between males and females in growth traits, morphology and chemistry are:
 - (2.1) dependent on the level of soil fertility, and
 - (2.2) visible before the period of intensive reproduction;
- (3) both species have similar patterns of sex difference in height, morphology and chemistry.

The research was divided into two main parts: observation of mature plants in two field experiments (D1 and D2) and observation of juvenile plants obtained by vegetative reproduction in a pot experiment (D3), with two variants of fertilization (lack or 6 g of Osmocote Exact 5–6 M yearly per L of soil). Field experiment D1 was carried out on mature plants of both species during one growing season. The research material consisted of yew and juniper needles, collected monthly from March to November. The needles were then subjected to morphometric and chemical analysis (determining carbon and nitrogen content). Field experiment D2 was carried out on sexually mature yews. For two seasons, needles were collected four times a year, and then subjected to morphometric and chemical analysis. Concentrations of carbohydrates, phenolic compounds and starch as well as carbon and nitrogen were determined. Pot experiment D3, concerning juveniles, was also conducted for two seasons, and the material was collected four times a year. Whole plants were collected, cleaned of soil, separated into roots, shoots, and needles, then the samples were analyzed morphometrically, and in the case of yew needles – chemically.

The results confirm the existence of secondary sexual dimorphism in both studied species. The first hypothesis that the phenological phases influence the sex differences in the nitrogen content of needles was confirmed. Sex differences in juniper are visible at the beginning of the season and in yew throughout the season, but they reach the greatest values during the period of intensive vegetative growth and maturation of seeds and arils. These differences can therefore be interpreted as a consequence of the gender-related differences in reproductive costs.

The research allowed confirming partly the hypothesis concerning the influence of soil fertility on sex differences in growth, morphology, and leaf chemistry. The results show the effect of fertilization (experiment D3) on sex differences in total plant mass in yew. In the fertilized variant, female individuals had a significantly higher total mass than male individuals. In the case of juniper, differences between the sexes were also visible in the fertilized variant, in which males showed higher root mass and root area, as compared to females. This may indicate a better adaptation to the fertile habitats of female yew and male junipers. However, many differences between the sexes were independent of the fertilization variants, e.g. greater needle area of female specimens, as well as higher levels of phenolic compounds and non-structural carbohydrates in needles of female yew specimens. Also, some of the differences observed in growth traits occurred regardless of the variant of soil fertility (higher root mass and allocation to the underground part and root area of female yew trees, and greater allocation to the roots and participation of the root area of fine roots of male junipers).

The differences between sexes were visible before the period of intensive reproduction for some of the growth traits of both species, as well as in relation to needle area as well as the level of phenolic compounds in yew needles.

The studied species showed large interspecific differences in occurrence of secondary sexual dimorphism, and the differences concerned most of the studied traits. Only the sex differences in needle area were similar in both species. Thus, except for this feature, the third hypothesis assuming that both species had similar patterns of sex differences was rejected, since the species did not respond according to one universal pattern. The issues related to interspecies differences require further research to explain the causes and mechanisms related to sexual dimorphism.

The results of the research fill some knowledge gaps about aspects related to secondary sexual dimorphism in the so far poorly studied group of gymnosperms, evergreen woody plants. The research allowed a deeper understanding of the sexual patterns of differences in both species in connection with phenology and fertilization, as well as the occurrence of sexual dimorphism in juvenile plants.