ABSTRACT: The knowledge of phenotypic response of rare and protected species provide useful information for the conservation and management strategies. *Doronicum austriacum*, a subalpine Central-European species has several lowland localities, which in Poland are regarded as glacial relicts. Diverse edaphic, climatic and coenotic conditions in particular localities give evidence to the broad ecological amplitude of the species. Based on data pertaining to three various populations occurring in different geographical regions (from South and Central Poland), different elevations a.s.l. (275–1350 m a.s.l.) and growing within different plant communities (subalpine tall-herb communities, mountain meadow, carr) an attempt has been made to characterise selected morphological, developmental and ecological features (like number of capitula and their diameter, effectiveness of reproduction, spatial distribution) and to test a hypothesis as to whether a lowland form of this species exists. The results indicate certain statistically significant differences (as number and diameter of capitula) between the study populations pertinent to plants at the generative stage. The distribution of the examined traits, however, falls within the range of species variability. The differences between averages are conditioned by the quality of the environment in terms of the soil moisture level, availability of mineral compounds and lighting, as well as by the degree of competition from other plants. The result of the experiment, involving transplantation of specimens into gardens, allow for the presumption that morphological features undergo environment-related modifications. At this stage of the studies, the idea of a morphologically different lowland form of the species cannot be supported.

KEY WORDS: *Doronicum austriacum*, subalpine species, isolated population, biometry, ecological amplitude, plasticity, macroforbes, Carpathians

1. INTRODUCTION

The phenotypic plasticity is a fundamental property of plant species (Schlichting 1986, 2002, Miner et al. 2005, Pigliucci 2005, Valladares et al. 2007). The morphological traits of plants are affected both by abiotic factors like light, temperature, water and nutrients availability as well as biotic factors including the role of competitors, predators and pollinators. The variability of traits along the environmental gradient is particularly interesting in plants with isolated populations when the site conditions are extremely different from range of the species. In case of rare or protected species the knowledge of their phenotypic response has the potential to provide useful biological information for the conservation and management strategies.
Doronicum austriacum Jacq., Austrian leopard's bane, is one of many Central-European species with the centre of its distribution in the mountains of Europe: the Carpathians, Balkans, Alps, Apennines and the Eastern Pyrenees (Kucowa 1971, Álvarez Fernández 2003). In Poland, the species occurs mainly in the Carpathians and rarely in the Sudety Mts., where it occurs only in central and eastern ranges (Zając and Zając 2001). However, there are some isolated populations of the species situated outside of the continuous range in the mountains. The localities north of the arch of the Carpathians are located in the mountain regions in Central Poland (the Świętokrzyskie Mts.) and in Southern Poland (the Silesian Upland, the Błędów Basin in the Kraków-Częstochowa Upland). The localities outside the Carpathians are regarded as glacial relict type localities, and the populations occurring there – as populations originating from the Carpathians (Szafer 1930, 1977). Inventories of lowland localities drawn up in the early 1990s showed a dramatic decrease in both the number of existing populations and the number of individuals of the species in particular localities; they also indicated real and potential threats (Bróż and Przemyski 1992).

Austrian leopard’s bane is regarded as a characteristic species of macroforb communities of the Adenostylion alliariae Br.-Bl. 1925 alliance (Medwecka-Kornaś et al. 1977, Matuszkiewicz 2005, Stachurska-Swakoń 2009). In the lower montane forest zone in the Carpathians, it co-participates in forming the Arunco-Doronicetum austriaci association (Kornaś and Medwecka-Kornaś 1967). In lower mountain sites, it grows sporadically in moist sycamore-beech forests, whilst in the Bieszczady Mts. (South-East Poland), it is also found in alder woods representing the associations of Caltho laetae-Alnetum (Zarz. 1963) Stuchlík 1968 and Alnetum incanae Lüdi 1921 (Jasiewicz 1965, Michalik and Szary 1998). In isolated relict localities, it grows in cool, swampy river valleys, mainly in the Fraxino-Alnetum W.Mat. 1952 association (Bróż and Przemyski 1992). The locality in the former spring area of the Biała river in the Błędowska Desert is an exception. The locality was discovered in 1924 by Piech (1924). The author wrote about ‘abundant forest vegetation’, which had developed due to an ‘abundance of water in sandy soil’. He listed Alnus glutinosa (L.) Gaerth., Corylus avellana L., Frangula alnus Mill., Ribes sp., and Salix sp. div. among the plants of the stream terrace and mentioned the presence of ‘humus typical of moist forests’. In 1975, the springs of the Biała river and its tributaries disappeared because of the lowering ground-water table following the development of industrial plants and the opening of the mine (“Pomorzany”, Wójcik 1997). At present, forest communities are greatly depleted, and the area occupied by the population of D. austriacum has been invaded by coniferous forest species and Calamagrostis epigejos (L.) Roth. Nevertheless, the population of Doronicum still remains there despite dramatic changes in substrate moisture and the quality of the communities. The above data indicate a wide broad ecological scale of the species and its ability to survive in changing environmental conditions.

In the study on the springs of the Biała river, Piech (1924) noted morphological differences between the specimens examined there and the plants growing in the mountains. The differences in the extrazonal appearance of specimens in the Świętokrzyskie Mts. and the Silesian upland were also noted by Bróż and Przemyski (1992), who even questioned the taxonomical identity of the species.

The objectives of these studies are: 1) to determine the scope of selected morphological and developmental features in the relict population versus mountain populations; 2) to provide ecological characteristics of the studied populations, and 3) to verify the hypothesis that there is a separate lowland form of the species.

2. THE STUDY SPECIES

Doronicum austriacum Jacq. (Asteraeae) has a short rhizome without runners with numerous adventitious roots. The abundantly leaved stem grows up to 120 cm high (Kucowa 1971). In the general distribution range, some reports say even of the
Phenotypic reaction of *Doronicum austriacum* height above 150 cm (Álvarez Fernández 2003). In the top part, the stem branches into a sub-umbelliferous form. The leaves have variable shapes. The basal leaves are ovate, obtuse, with shovel-cordate base and blunt apex, and petiolate. The lower cauline leaves can be similar to the basal leaves or sessile. The lower and middle cauline leaves have fiddle-shaped blades, they are semi-amplexicaul and their dimensions are 6.5–19.0 cm × 4.5–12.5 cm. The upper cauline leaves are small: 2.5–13.0 cm × 0.7–5.0 cm, they are ovate with an acute apex and amplexicaul. The capitula, 5–7 cm in diameter, sit on long peduncles. The female flowers are yellow, and ligulate, and the bisexual flowers are disc florets. The fruit is a single-seed, ribbed achene, up to 2 mm long. *D. austriacum* produces two types of achenes: those developing from disc florets have pappus and stiff hairs on the ribs whereas those developing from ligulate florets are naked and without pappi.

3. STUDY AREA

Three populations were selected for this study (Fig. 1):

1. Lowland population deemed to be a relict, situated in the former spring area of the Biała river on the Błędowska Desert (N50°20’, E19°31’). The site is situated at 275 m a.s.l. *Doronicum austriacum* grows within the former spring area and the terraces of the uppermost sections of the stream course. The location is overshadowed mainly by alder trees as well as hazel and alder buckthorn shrubs. The plant community on the site was a degraded riverine carr. In this paper it is designated as the BIAŁA population;

2. Mountain population on the Polana Bieniowa glade in the Gorce Mts. (N49°33’, E20°10’). The site is situated in the lower montane forest zone at 1100 m a.s.l. Here the species grows abundantly in a fully sun-illuminated site, within the macroforb association *Arunco-Doronicetum austriaci* Kornaś (1955 n.n.) 1967. This site is designated as the GORCE population;

3. Mountain population in the Babia Góra Mt. massif (N49°34’, E19°31’). The location is situated in the upper montane forest zone at 1350 m a.s.l. Here, *Doronicum* grows on a moist slope partly overshadowed by spruces, within the macroforb association *Ranunculo platanifolii-Adenostyletum alliariae* (Krajina 1933) Dúbravcová et Hadač ex Kočí 2001. This site is designated as the BABIA GÓRA population.

![Fig. 1. Locations of the study populations of *Doronicum austriacum*. The gray color indicates the distribution of the species in Poland.](image-url)
4. MATERIAL AND METHODS

4.1. Ecological and population data

To estimate the habitat conditions, soil analyses were completed for each of the localities following Kowalkowski et al. (1973), Lityński et al. (1976), Oleksynowa et al. (1976). The analyses included, *inter alia*: organic matter content, organic nitrogen, and soil absorbing complex. These studies were conducted in 2006–2007.

During the flowering period, 50 generative shoots and 50 vegetative shoots of *Doronicum austriacum* were randomly selected on each location. The height and number of leaves were determined for each shoot along with the dimensions (length and width) of the lowest leaf and one middle leaf (always the fifth from the bottom). Basal leaves wither fairly rapidly, so during the flowering period they have already withered, therefore their variability was not taken into account. In generative shoots, the number of capitula was counted and their diameters measured. All measures were taken on living plants growing in the wild. In each location, 5 small 1 m² plots were selected, again randomly, where the shoots in a generative or vegetative stage were counted. The biometric studies were carried out during season 2006 and 2007 in BIAŁA site and in season 2007 in BABIA GÓRA and GORCE sites. The effectiveness of reproduction was also estimated through measuring the germinating power. For this purpose, the collected seeds were sown either without freezing or after a two-day freezing period at −15°C in three repetitions, at different intervals after their collection. The seeds from the GORCE Mts. site were sown after two, three and four months following collection (with 35 seeds in each portion), whereas the seeds from the BABIA GÓRA population were sown after one, three and six months following collection (with 25 seeds in each portion). Owing to the small number of seeds collected from the BIAŁA population, these were not included in the tests for germinating power. The seed germination experiment was conducted in the laboratory on moist filter paper lined in 7-cm diameter petri-dishes. Only several individual plants were observed after they had been transplanted from the BIAŁA site to a substitutive habitat (home gardens).

The biology of this species is not well known, so the studies did not include the features related to age, only the shoots were separated into vegetative and generative categories.

4.2. Statistical analysis

The results were submitted to statistical analyses using the MVSP (Kovach 2007) and Statistica packages. The quantitative data showed normal distributions. Apart from basic descriptive statistics (average, maximum, minimum, standard deviation, and the coefficient of variation = CV%), the data were also submitted to analysis of variation by one-way ANOVA, in order to test the hypothesis regarding the lack of differences between the populations under study. The statistical significance of yearly differences in the BIAŁA site, where the studies were conducted during two seasons, was checked using a *posteriori* LSD (Least Significant Difference) test. The mutual relationships between shoots was analysed by the dentrended canonical analysis – DCA method.

5. RESULTS

5.1. Soil

The basic soil analyses indicated evident differences in soil quality at the study sites. The soil from the BABIA GÓRA site was the richest in terms of mineral and organic components (Table 1). The organic carbon content was 30.4%, nitrogen – 1.7%, and that of organic matter, 52.2% and it also contained large amounts of available substances such as K₂O and P₂O₅. The lowest contents of organic compounds were noted in the soil in BIAŁA site. There, only the content of CaO and the pH level were at their highest values at 103.6 mg CaO, and pH KCl 5.06, respectively. The hydrolytic acidity of the soil is associated with the presence of hydrogen and aluminium ions in the absorbing complex of the soil. It is closely related to the total sulphur content and assumes the values inversely proportional to the pH values. Therefore, the highest acidity of 61.86 mg occurred in the soil from BABIA GÓRA site that also had the lowest
Phenotypic reaction of *Doronicum austriacum*

pH, whereas the lowest acidity (2.38 mg) occurred in the soil from BIAŁA site that has the highest pH. The highest total of ion-exchange bases – 29.64 mg was found in the soil from BABIA GÓRA site, the lowest (4.10 mg) – in the soil from the GORCE site.

The measure showing the capacity to absorb ions is the exchange capacity expressed in mg per 100 g of soil. The percentage ratio of the total amount of basic cations absorbed in the soil to the exchange capacity (T) is an indicator of the level of soil saturation with bases (V). The exchange capacity of sands is 1–10 – as in the case of the soil from the BIAŁA site, loam soils – 10–20 (GORCE site) clay soils – up to 60, and peats – even 150 and more. As a rule, the degree of acidic soil saturation with bases in pine forests is low (such as in the case of BABIA GÓRA site – 32.39 and GORCE site – 19.53 mg), and much higher in the neutral or alkaline soils of deciduous woods – namely in BIAŁA sites where it stands at 79.09 mg (Table 2). The degree of saturation of the absorbing complex by basic cations determines the buffer capacity of the soil.

### 5.2. Morphological features

The heights of the generative shoots of *Doronicum austriacum* under study ranged from 51 (GORCE site) to 120 cm (BIAŁA site). On average, the tallest generative shoots were recorded in BIAŁA population – 90.4 cm (CV = 79%), and the shortest – in the GORCE population – 72.3 cm (CV = 19%; Fig. 2A). The vegetative shoots were markedly shorter, ranging from 29 cm (GORCE population) to 97 cm (BABIA GÓRA population). The lowest average for vegetative shoots was recorded in BIAŁA population – 48.2 cm (CV = 20%), whereas the highest was at BABIA GÓRA population – 56.6 cm, where the dispersion of values describing this feature was also the broadest (CV = 31%, SD = 14.2; Fig. 2A). The number of leaves on generative shoots ranged from 5 (BIAŁA population) to 20 (GORCE population). On average, the highest number values of leaves were found on generative shoots in BABIA GÓRA population – 19.53 mg, and much higher in the neutral or alkaline soils of deciduous woods – namely in BIAŁA sites where it stands at 79.09 mg (Table 2). The degree of saturation of the absorbing complex by basic cations determines the buffer capacity of the soil.

### Table 1. Soil properties of the study sites of *Doronicum austriacum*.

<table>
<thead>
<tr>
<th>Sites</th>
<th>Org. matter (%)</th>
<th>C org. (g·100 g⁻¹)</th>
<th>N org. (g·100 g⁻¹)</th>
<th>C/N</th>
<th>Available substances (mg·100 g⁻¹)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biała</td>
<td>3.0</td>
<td>1.0</td>
<td>0.03</td>
<td>53</td>
<td>0.2</td>
<td>4.6</td>
</tr>
<tr>
<td>Gorce</td>
<td>9.0</td>
<td>5.4</td>
<td>0.40</td>
<td>13</td>
<td>6.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Babia Góra</td>
<td>52.0</td>
<td>30.4</td>
<td>1.69</td>
<td>18</td>
<td>32.2</td>
<td>17.6</td>
</tr>
</tbody>
</table>

### Table 2. Absorbing complex of soil in the study localities of *Doronicum austriacum*. H – hydrolytic acidity, S – total of ion-exchange bases, T – exchange capacity, V – level of soil saturation with bases.

<table>
<thead>
<tr>
<th>Sites</th>
<th>H</th>
<th>S</th>
<th>T</th>
<th>V(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biała</td>
<td>2.38</td>
<td>9.00</td>
<td>11.38</td>
<td>79</td>
</tr>
<tr>
<td>Gorce</td>
<td>16.89</td>
<td>4.10</td>
<td>20.99</td>
<td>20</td>
</tr>
<tr>
<td>Babia Góra</td>
<td>61.86</td>
<td>29.64</td>
<td>91.50</td>
<td>32</td>
</tr>
</tbody>
</table>
Fig. 2. Biometric traits of *Doronicum austriacum* shoots in the studied populations.
Phenotypic reaction of *Doronicum austriacum*

In the GORCE population, the average value is much lower at 10.7 cm (Fig. 2C). The width of the lower leaves fell within the 4.0–13.4 cm range (GORCE and BIAŁA population, respectively). The average value was the highest at BABIA GÓRA population – 8.1 cm, and the lowest in GORCE population – 6.4 cm (Fig. 2D).

The length of the middle leaf ranged from 6.5 cm in GORCE population to 21 cm at BABIA GÓRA population. The lowest average

<table>
<thead>
<tr>
<th>Variable</th>
<th>Axis 1</th>
<th>Axis 2</th>
<th>Axis 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>0.064</td>
<td>0.000</td>
<td>0.051</td>
</tr>
<tr>
<td>Number of leaves</td>
<td>0.152</td>
<td>0.076</td>
<td>0.059</td>
</tr>
<tr>
<td>Lenght of lower cauline leaf</td>
<td>0.000</td>
<td>0.132</td>
<td>0.089</td>
</tr>
<tr>
<td>Width of lower cauline leaf</td>
<td>0.003</td>
<td>0.166</td>
<td>0.000</td>
</tr>
<tr>
<td>Lenght of middle cauline leaf</td>
<td>0.086</td>
<td>0.217</td>
<td>0.159</td>
</tr>
<tr>
<td>Width of middle cauline leaf</td>
<td>0.077</td>
<td>0.179</td>
<td>0.182</td>
</tr>
<tr>
<td>Diameter of the capitula</td>
<td>0.231</td>
<td>0.111</td>
<td>0.142</td>
</tr>
<tr>
<td>Number of capitula per one shoot</td>
<td>0.772</td>
<td>0.097</td>
<td>0.183</td>
</tr>
</tbody>
</table>

Table 3. Interset correlation of some variables with DCA axes.

Table 4. One-way ANOVA results for variables of *Doronicum austriacum* (*P* <0.001).

<table>
<thead>
<tr>
<th>Variable</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>11284</td>
<td>3</td>
<td>3761</td>
<td>17.54</td>
<td>0.999</td>
</tr>
<tr>
<td>Number of leaves</td>
<td>139.42</td>
<td>3</td>
<td>46.47</td>
<td>9.49</td>
<td>0.997</td>
</tr>
<tr>
<td>Lenght of lower cauline leaf</td>
<td>334.22</td>
<td>3</td>
<td>111.41</td>
<td>18.0</td>
<td>0.999</td>
</tr>
<tr>
<td>Width of lower cauline leaf</td>
<td>73.08</td>
<td>3</td>
<td>24.36</td>
<td>10.3</td>
<td>0.998</td>
</tr>
<tr>
<td>Lenght of middle cauline leaf</td>
<td>108.37</td>
<td>3</td>
<td>36.12</td>
<td>7.49</td>
<td>0.985</td>
</tr>
<tr>
<td>Width of middle cauline leaf</td>
<td>53.85</td>
<td>3</td>
<td>17.95</td>
<td>8.49</td>
<td>0.993</td>
</tr>
<tr>
<td>Diameter of the capitula</td>
<td>97.85</td>
<td>3</td>
<td>32.61</td>
<td>48.07</td>
<td>1</td>
</tr>
<tr>
<td>Number of capitula per one shoot</td>
<td>773.25</td>
<td>3</td>
<td>257.75</td>
<td>63.29</td>
<td>1</td>
</tr>
</tbody>
</table>

Fig. 3. DCA diagram of *Doronicum austriacum* generative shoots along 1st and 2nd axis. Circles – BABIA GÓRA population, squares – GORCE population, triangles – BIAŁA population.
length of the middle leaf equal to 11.6 cm was found in BIAŁA population, whereas the highest one close to 13.6 cm was found at BABIA GÓRA site (Fig. 2E). The width of the leaf correlated with its length, the average being 3.6 cm in the BIAŁA population and 7.9 cm in the BABIA GÓRA population (Fig. 2F). The length of middle leaves on the vegetative shoots fell within the 6–15 cm range (BIAŁA population and BABIA GÓRA, respectively). The lowest average was found in the leaves from BIAŁA population, and the highest – from BABIA GÓRA population. The width of this leaf was highest in GORCE site, and lowest in BIAŁA population (Fig. 2F). The width values showed less variability than leaf length values.

The largest differences were seen in the numbers of inflorescences. The number of capitula per one generative shoot ranged from 1 to 16. The maximum number was found in GORCE population (16) as well as the mean value (7). It was interesting to find that there, in GORCE site, were no shoots with less than three capitula. The lowest number of inflorescences on a single shoot was found in BIAŁA population – 2.3 (with the 1–7 range; Fig. 2G). The diameter of the capitula ranged from 2.0 to 7.7 cm, with the smallest capitula developing in the BIAŁA population was equal to 3.7 cm, and the largest in GORCE population – 5.4 cm (Fig. 2H).

The diagram of DCA analysis was prepared on the basis of features found for generative shoot groups of particular populations (Fig. 3). However, there are no clear-cut differences between the populations under study, with more similarity between the shoots from BIAŁA population and BABIA GÓRA sites than between BABIA GÓRA and GORCE sites. The first and second axes explain 52% and 17% of observed variability, respectively. The most significant are the generative features, and in particular the number of inflorescences. The effect of the study features on grouping is shown in Table 3. There is no grouping whatsoever of vegetative shoots (Fig. 4).

On the basis of the selected features, the results of ANOVA do indicate statistically significant differences between the studied populations (Table 4). The significance of differences between years was also tested, but these turned out to be statistically insignificant. The significance of the differences could only be tested for the BIAŁA population, because it was the only one where the studies were carried out in two seasons.

### 5.3. Group features

The populations under study showed clustered spatial distribution, which was most notable in the GORCE population. There, the population was also the most numerous. On the BABIA GÓRA site, the individuals of *Doronicum austriacum* grew either singly or in smaller clusters.

The number of generative shoots was higher than the vegetative ones in the GORCE and BABIA GÓRA sites. On the BIAŁA population, there was a prevalence of vegetative shoots (Table 5).

<table>
<thead>
<tr>
<th>sites</th>
<th>Shoots</th>
<th>Plots</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Biała</td>
<td>vegetative</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>generative</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Gorce</td>
<td>vegetative</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>generative</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Babia Góra</td>
<td>vegetative</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>generative</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
5.4. Reproduction effectiveness

In the pilot studies concerning reproduction, seeds were collected from the GORCE and BABIA GÓRA populations. Owing to the shortened vegetation period (drought), the seeds from the BIAŁA population could not be collected in sufficient numbers. In general, the capitula from the GORCE site had the highest (estimated) numbers of achenes. These achenes were also larger and thicker than the seeds collected from BABIA GÓRA site (also only estimated). These achenes, however, often contained seed-eating insect larvae. The seeds from the BIAŁA population site were the smallest, in relative terms.

In the samples, both frozen and non-frozen seeds germinated. The first seedlings emerged ca 8 days after sowing, and the germination lasted ca 7 days. The seeds from GORCE site germinated faster and there was also a higher percentage of germinating seeds. The germinating power after freezing was higher in the case of the seeds from BABIA GÓRA site, whereas among the seeds from GORCE site, it was higher in the group that was not frozen (Fig. 5). Also, these preliminary results might indicate that the viability of seeds decreases with time.

5.5. Ex-situ plant development

These observations were conducted in two home gardens: in Wojnicz (the Wielickie Foreland, Western Carpathians) and Andrychów (the Beskid Maly Mts., Western Carpathians), on several individuals (5 in each garden) transferred from the BIAŁA population at the beginning of the vegetation season in 2006. These individuals had already developed basal leaves. The growth started in April and proceeded rapidly. The beginning of flowering was noted as early as towards the middle of May and lasted till late June. In 2006, all the individuals had 3–5 capitula. The number of capitula increased in subsequent years: to 4–8 in 2007, and from 4 to 10 in 2008. The leopard’s bane cultivated in garden conditions (regular watering and fertile soil) reaches 65 to 120 cm in height. The average number of leaves did not change significantly in the subsequent years of observation, remaining at from 13–17.

6. DISCUSSION

The geographical distance between the BIAŁA population and the continuous distribution range in Carpathians as well as iso-
lated populations in the Świętokrzyskie Mts. allows one to assume that there is a barrier preventing gene flow between these populations. Therefore, the BIAŁA population can be considered to be a closed population (Mayr 1974), where genetic phenomena associated with small populations occur, such as: the founder effect, genetic drift, inbreeding, or an increase in homozygosis (Mitka 1997, Allendorf and Luikart 2007). More detailed studies will be needed to find whether speciation processes are currently at work in this population.

The results presented in this study indicate the wide ecological scale of the species concerned. The sites selected for the study differed significantly with respect to habitat conditions: climatic (elevation a.s.l. and related parameters: temperature, amount of precipitation, duration of vegetation season, etc.) and microclimatic (influx of solar radiation resulting from shadow or its lack of), soil and coenotic conditions. On the basis of the examined features, the results observed indicate statistically significant differences between the study populations. The differences are evident for generative shoots, whereas they are vague among vegetative shoots. The average and individual features stay within the variability of the species (Kucowa 1971, Alvarez Fernandez 2003). The preliminary studies completed to-date fail to support the existence of a separate taxonomic species, at least when concerning the features examined in this project. The differences identified in the number of inflorescences, diameters of the capitula and the heights of generative shoots could also be explained by habitat conditions. The abundance of nutrients, their quantities, quality and availability, as well as the quality of the environment itself are among the fundamental factors affecting the size structure of individuals in populations. Height is one of the most variable morphological plant features observed and modelled in many species (e.g. Harper 1977, 1980, Falińska 1979, Andrzejewska and Falińska 1983, 1986, Mitka 1988, Czarnecka 1995, 2006, Łukaszyńska 1998, Kostrakiewicz 2008). The differences in biometric traits for subalpine species were studied, inter alia, in Veratrum lobelianum Bernh. (Łukaszyńska 1998) and Adenostyles alliariae (Gouan) A. Kern. (Bylińska et al. 2000). They resulted from both climatic (elevation-related) and edaphic conditions.

D. austriacum seems to prefer open areas, and hence the generative shoots in the GORCE population are shorter but with higher numbers of leaves and capitula. Strong light decomposes the elongation hormones, which results in shorter stems under more intensive...
light, whilst at the same time the light enhances assimilation and thus generates larger quantities of assimilates, which in turn condition a higher number of branches and capitula (Kopcewicz and Lewak 2005). This adaptation may also be an illustration of the ‘trade off’ rule (Falińska 1990). Next, the superior soil properties in the BABIA GÓRA site may perhaps be suppressed by stronger competition from other macroforb plants (available ecological niches) and by the shorter vegetation season. These stems are shorter than in the GORCE population and have fewer numbers of leaves and capitula. The lower number of leaves in the BABIA GÓRA population is, however, compensated for by their size. Shadowing and a longer vegetation season resulted in elongation of stems in the BIAŁA population. The generative individuals growing in this locality are tall, reaching ca 86 cm on average but produce an average of 2.3 inflorescences and they have lower numbers of leaves. Shadow and low quantities of nutrients in the soil may intensify the competition between individuals in the habitat concerned. When analysing such a situation in the light of the ‘trade off’ rule, it can be found than in return for growing tall, the number of branches is limited, as the number of inflorescences is.

The reason for such a strategy adopted by the study *Doronicum* population could be the periodic adverse environmental conditions. The expansion of the leopard’s bane in the area occurs at the time of the lowering ground water table coupled with other profound changes in habitats (Bróż and Przemyski 1992, Wójcik 1997).

A similar relationship, i.e. the tallest plants correlated with the lowest number of capitula on sites with adverse habitat conditions, has also been observed e.g. in *Senecio rivularis* (Waldst. & Kit.) DC. (Czarnecka 1995, 2006, 2008). This species grew on dried-up carr although it prefers moist soil conditions. And similarly, the density of shoots was very high. This effect is probably also manifested in the case of the *Doronicum* population studied in the BIAŁA site. An additional factor promoting elongation of shoots is shadowing. More energy spent on growth results in a smaller number of capitula. Again, a similar case of the relationship between the height of shoots and amount of light and soil moisture has been observed in *Iris sibirica* L. (Sporek and Rombel-Bryzek 2005, Kostrakiewicz 2008).

The positive relationship between light availability and the production of generative structures has been described in numerous studies (e.g. Daubenmire 1973, Towpaśz and Szymisz 1983, Andrzejewska and Falińska 1986, Czarnecka 1986, 1995, Falińska 1990). The phenomenon can also be noted in the *Doronicum* populations under the study – the highest numbers of capitula were found in the GORCE site, where the studied population grows in full sunlight. The capitula there are also the best developed, namely, in terms of having the largest diameters. The seeds from this site are also the largest.

Although the Austrian leopard’s bane is one of the subalpine species, it turned out that its seeds do not need prior freezing to start germination. The seeds germinate as well without such freezing. What is definitely important is the size of seeds, as proven by the larger seeds from the GORCE site, which germinated faster and where the percentage of germinating seeds was also higher. Although the preliminary results indicate a declining number of germinating seeds with the laps of time, this hypothesis still needs more precise verification.

The spatial studies revealed differences in proportions of vegetative and generative shoots in particular populations. The number of vegetative shoots was much higher in the degraded habitat of the BIAŁA site. It would be interesting to find why such differences have occurred there. Probably one of the factors limiting the flower’s development was the poor quality of the habitat. This hypothesis is perhaps supported by the fact that after transplanting more than ten young individuals from the BIAŁA site in early spring (just after the beginning of the vegetation process) to substitute habitats (home gardens), the flowering plants which appeared in the summer displayed a greater number of capitula than in the parental populations (3–5). This number further increased in subsequent years to 4–7 in 2007, and 4–10 in 2008. Thus, it may be expected that limited flowering, i.e. the increased proportion of vegetative shoots and the small number of capitula, resulted from growth un-
under stress caused by dried-up soil and overshadowing. A number of studies indicate that there is a certain critical size of an individual, which determines the beginning of the generative reproduction phase (e.g. Werner 1975, Eliáš 1985, Mitka and Tumidajowicz 1993, Czarnecka 1995, Aarsen and Jordan 2001, Obeso 2002). This critical size may be conditioned by both ‘calendar’ age and individual features, or quality of habitats (e.g. Andrzejewska and Falińska 1983, 1986, Ballegaard and Warncke 1985, Czarnecka 1986, 2008, Mitka 1989, Hemborg and Karlson 1998a, b, Falińska 1989, 1990, 1997, Bühler and Schmid 2001).

7. CONCLUSIONS

1. *Doronicum austriacum* demonstrates a wide ecological amplitude and great tolerance towards adverse (changing) habitat conditions.

2. Habitat and coenotic conditions affect the height, quantitative and biometric features of leaves, and above all, the number and size of inflorescences. The proportions of generative and vegetative shoots and their spatial arrangements also change.

3. There were statistically significant differences between the populations under study. The results obtained in the experiment involving transplantation of wild plants into garden conditions allows for the assumption that these features are subject to environmental modification.

4. Despite the fact that *D. austriacum* is a mountain species, its seeds do not require freezing.

5. The present level of knowledge does not support the idea of a morphologically different lowland form of the species.

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