

Morphological variability in *Epipactis purpurata s. stricto* (Orchidaceae) — an analysis based on herbarium material and field observations

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A wide range of phenotypic variability in the orchid *Epipactis purpurata s. stricto* was found based on analysis of herbarium material and field research. Twenty-three biometric features were analysed. New diagnostically important features of gynostemium as well as of petal and sepal sizes and colours were established. Thus *E. purpurata s. stricto* is redescribed, clarifying the taxonomic importance of several morphological features.

Introduction

Epipactis is one of the most taxonomically problematic genera in the tribe Neottieae within the family Orchidaceae. It includes ca. 50–70 species that occur in northern and central Africa, Asia, Europe and North America (Delforge 2006, Harrap & Harrap 2009, Fateryga *et al.* 2014). Its taxonomy is difficult due to the considerable phenotypic variability in e.g., shape and pigmentation of the lip, sepals and petals, shape and size of the gynostemium as well as size, shape and colouration of leaves, which impedes reliable identification of the species (Szlachetko 2001, Jakubská-Busse 2008, Jakubská-Busse *et al.* 2012).

The *Epipactis* group is currently in a particularly intensive stage of speciation, as is evi-

denced by genetic, morphological and anatomical studies (Harris & Abbott 1997, Ehlers & Pedersen 2000, Squirrell *et al.* 2002, Tranchida-Lombardo *et al.* 2011). A low rate of reproductive isolation and weak genetic barriers among taxa suggest a young age of the group, which is also supported by intra- and interspecific as well as intergeneric hybridization, often observed in the wild (Jakubská-Busse 2008).

All species of *Epipactis* are rhizomatous (clonal) perennial plants, whose characteristic feature is a so-called “occurrence variability”, when a plant produces variable numbers of ramets (shoots) in successive growing seasons, which impedes estimating the real size of the population and its risk level (Young 1949, Salmia 1986, Light & MacConaill 2006, Jakubská-Busse *et al.* 2009).

The cause of this phenomenon has not yet been unequivocally identified.

The target species *E. purpurata* grows in shady broad-leaved forests, mixed forests and sporadically in coniferous forests, on humus soils, moderately wet, acidic to neutral, and sometimes on calcium-rich carbonate substrates. It occurs mainly in submontane zones up to 1500 m a.s.l. (Vlčko et al. 2003, Delforge 2006) in almost entire Europe.

A characteristic epidermal cell type in these orchids, i.e. conical margin cells called papillae, is well developed in the *E. purpurata* group (Jakubská-Busse et al. 2008, Jakubská-Busse & Gola 2014). The papillae are usually arranged in three or four rows at the edge of the leaf and along the veins (Fig. 1B and G). They are of different sizes and shapes, upright or variably inclined, arching toward the leaf tip, forming clusters or occurring separately, even at the same leaf margin (Fig. 1B and G). Nevertheless, in all the taxa examined by Jakubská-Busse et al. (2008) and Jakubská-Busse and Gola (2014), the papillae show a tendency to group in undulated sectors forming more rows there, occurring in clusters and reaching the largest dimensions in these places (e.g., Fig. 1C).

Our detailed analysis of numerous herbarium specimens showed that many of them were misidentified. The available determination keys do not allow for identifying plants in pre-flowering or fruiting stages, but only flowering ones. The aim of this study was to demonstrate the full variability of *E. purpurata* s. stricto and compare it with published data from various geographical regions.

Descriptions of new species in *Epipactis* e.g. from Crimea (Fateryga et al. 2014) or Iberian Peninsula (Bernardos et al. 2004) motivated us to undertake the study. The results should aid in deciding whether proposing new taxa within this variable group is well-founded.

Material and methods

Plant material

We revised ca. 1300 specimens from diverse geographical regions in central Europe. Field research was conducted from July to August

in the years 2008–2011 in Poland, the Czech Republic and Slovakia, and from July to September in the years 2012–2016 in Poland. Our observations included the following 12 locations:

Southern Poland: (1) Góra Bucze, distr. Brenna near Cieszyn; (2) Vicinity of Kalwaria Zebrzydowska; (3) Ochotnica Dolna near Nowy Targ; (4) Vicinity of Pcim.

Southwestern Poland: (5) Nieszczyce, distr. Rudna near Lubin; (6) Pątnów Legnicki, distr. Legnica; (7) Straża near Wołów; (8) Vicinity of Mechnica near Kędzierzyn-Koźle; (9) Wałkowa, distr. Milicz.

Slovakia: (10) Bíle Karpaty, Strážovské Vrchy; (11) Bíle Karpaty, Strážovské Vrchy, SW Klepáč Mt.

Czech Republic: (12) Květná, distr. Uherské Hradiště.

The studies were carried out with the consent of the Regional Director for Environmental Protection (permissions WPN.6400.27.2015.IW.1, WPN.6400.29.2016.IJ and WPN.6205.122.2016.IJ). The material including old herbarium collections from selected herbaria (BR, C, FR, G, K, KTU, M, S, STU, WRSL, Z, ZT) was examined (see Appendix). Herbarium acronyms are cited according to *Index Herbariorum* (<http://sweetgum.nybg.org/ih/>).

Morphological analysis

Morphology of fresh and dried ramets was studied in order to establish the full range of phenotypic variability. Special attention was paid to the leaf edge, especially the shape, size and tilt of the cell papillae, because these features are considered diagnostically important in *Epipactis* (Mered'á 1999, Delforge 2006). The leaf margin was studied from fresh material as well as from herbarium specimens. Measurements of respective characters were made with a digital calliper (accuracy 0.01 mm). Micromorphological characters were observed using a Nikon SMZ800 microscope and photographed with a Nikon D90 camera. Papillae of fresh plants and the microscopic characters of the lip were also analysed in detail under SEM (Carl Zeiss EVO LS15,

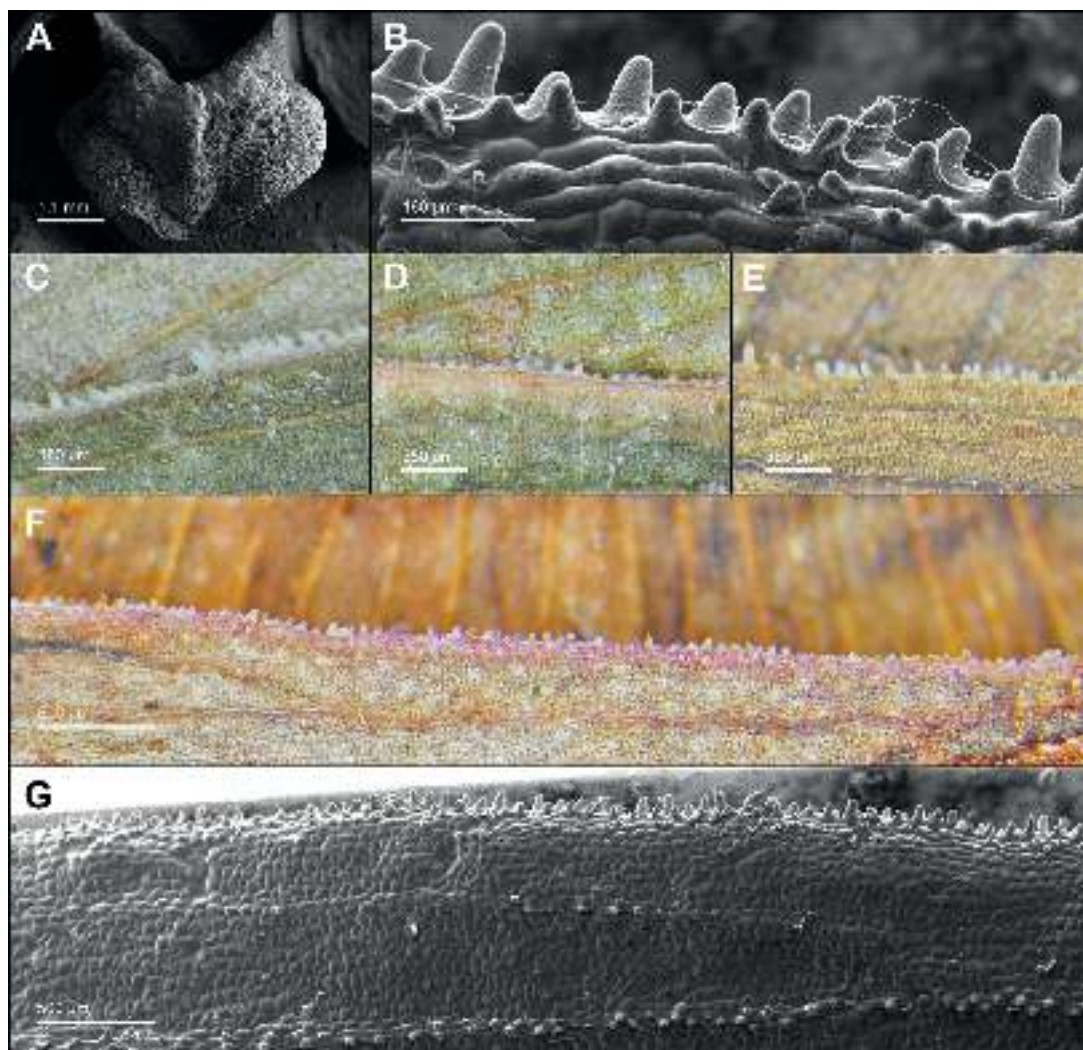


Fig. 1. Micromorphological features of *Epipactis purpurata*. — **A**: Close-up of flower lip. — **B–G**: Leaf margins with papillae of different sizes and shapes. **A**, **B** and **G** from freshly collected leaves (Nieszczyce, SW Poland, 5 August 2015); **C–F** from herbarium voucher WRSL s.n. (**C** and **E** southern Poland, Opole Province: Głubczyce, Kazimierz, 11 August 1917 *Focka* s.n.; **D** and **F** southwestern Poland, Lower Silesia: Rudna, Nieszczyce, 14 August 2015 *E. Żolubak*, *A. Jakubaska-Busse* s.n.).

GmbH, Germany) after fresh leaves and labelum were frozen in liquid nitrogen and coated with gold and platinum particles.

The study material was selected at random from the 12 localities cited above. The analysis included 152 undamaged, well-developed ramets, at the optimum stage of flowering, and 20 inflorescences (lacking stems), conserved in the Kew mixture. Twenty-three features were examined (Table 1). Accuracies of measurements were 0.01 mm for floral features and bracts, and 0.1 mm for the other features. Within

one ramet, we analysed the dimensions of the oldest flower and of a younger one located at a height (from the uppermost leaves) of ca. 40% of the inflorescence length. Therefore, the number of floral measurements was doubled to better represent their variability within the inflorescence. For each trait arithmetic mean, minimum, maximum and coefficient of variation (CV) were calculated.

We did not perform measurements on dried plants, because in them all parts of the flower are distorted and shrunken.

Results and discussion

Epipactis purpurata is a phenotypically variable species especially in flower colour, plant habit, number of leaves and type of leaf arrangement (Table 2, Figs. 2 and 3).

Ramets observed individually and in groups, before anthesis and in the fruiting stage, differed only in habit, stage of development and condition (Fig. 2C and D).

Identification of this *E. purpurata* in the field is not difficult, especially when it is possible to observe at least several ramets close to each other. However, herbarium specimens are not always representative; studying herbarium sheets we discovered that the plants were not always typical and frequently had features which did not allow to identify a given species correctly, particularly when one lacks experience or knowledge of the whole range of variability in the taxon.

The most variable feature in *E. purpurata* is the leaf shape, varying from ovate (Fig. 3A) to

lanceolate (Fig. 3B, C and G; for compilation of features see Table 2).

The leaf-length-to-internode-length ratio, often given in determination keys as a taxonomically reliable feature, should not be used (Fig. 3A and H) as it may lead to misidentifications, although according to Delforge (2006) the cauline leaves in *E. purpurata* are hardly longer than their respective internodes, while those leaves are shorter than their internodes in *E. rechingeri* and *E. distans*, both of which belong to the *E. purpurata* group. We observed that the cauline leaves in *E. purpurata* can be shorter than the respective internodes.

Alternate leaf arrangement is very frequent in *E. purpurata*, yet we observed that ramets with an opposite leaf pattern are not uncommon (Fig. 3I). The number of leaves seems to depend on genetic as well as ecological factors. An individual may have up to 13 (Fig. 3D) or even 15 cauline leaves, or a single one (Fig. 3E).

Morphological and anatomical leaf characters, such as the shape and size of papillae,

Table 1. Arithmetic means (Mean), minimum (Min), maximum (Max) and coefficient of variation (CV) of measured features in *Epipactis purpurata* s. stricto. Values set in boldface indicate diagnostically important features; $n = 152$.

| Feature | Mean | Min | Max | CV (%) |
|--|-------|------|-------|-------------|
| Vegetative | | | | |
| Stem height (including inflorescence) (cm) | 46.46 | 12.5 | 100.2 | 39.9 |
| Inflorescence length (cm) | 17.85 | 3.5 | 44.8 | 48 |
| Flower/bud number | 32.4 | 4 | 90 | 60.3 |
| Cauline leaf number | 5.9 | 1 | 15 | 46.5 |
| Median cauline leaf length (mm) | 55.82 | 25.5 | 87.5 | 23.4 |
| Median cauline leaf maximum width (mm) | 17.8 | 5.8 | 50.1 | 45.9 |
| Floral bract length (mm) | 23.25 | 8.18 | 54.9 | 49.4 |
| Floral bract width (mm) | 4.08 | 1.3 | 11.6 | 42 |
| Floral | | | | |
| Sepal length (mm) | 10.34 | 6.5 | 14.5 | 16.3 |
| Sepal width (mm) | 5.7 | 3.6 | 7.8 | 12.7 |
| Petal length (mm) | 8.63 | 5.7 | 12.2 | 16.3 |
| Petal width (mm) | 4.92 | 3.2 | 6.8 | 12.7 |
| Epichile length (mm) | 4.14 | 2.87 | 5.66 | 14.3 |
| Epichile width (mm) | 5.09 | 3.39 | 7.02 | 15.1 |
| Hypochile length (mm) | 4.49 | 3.33 | 5.92 | 13 |
| Hypochile width (mm) | 4.61 | 2.97 | 6.06 | 12.7 |
| Hypochile height (mm) | 3.05 | 1.86 | 4.48 | 18.3 |
| Ovary length (mm) | 8.21 | 4.71 | 14.5 | 20.1 |
| Ovary maximum width (mm) | 3.72 | 2.36 | 6.85 | 18.7 |
| Ovary pedicel length (mm) | 3.44 | 1.1 | 5.1 | 20.4 |
| Gynostemium length (mm) | 4.78 | 3.34 | 6.3 | 12.2 |
| Gynostemium width (mm) | 3.5 | 2.11 | 4.35 | 15.5 |
| Gynostemium height (mm) | 3.19 | 2.09 | 4.2 | 12.9 |

Table 2. Comparison of the morphological characters of *Epipactis purpurata* according to different authors and our study; – = measurement not given in the cited source; new ranges based on our results are set in boldface; * = preanthesis inflorescence.

| Character | Smith (1828: 41–42) | Buttler (1991) | Baumann <i>et al.</i> (2006) | Delforge (2006) | Harrap & Harrap (2009) | Our study | Full range in <i>E. purpurata</i> |
|---------------------|--|--|---------------------------------|---|--|--|---|
| Stem | | | | | | | |
| number | – | max. 10 | – | (1)5–30(38) | (1)6–8(38) | 1–15 | 1–30(38) |
| height (cm) | > 30 cm | 20–70 | 25–65 | 20–70(120) | 20–90 | 12.5–100 | 12.5–100 (120) |
| colour | red-lilac | dark grayish-green, washed purple | greenish-violet | greenish-grey, washed violet | grayish-green, often heavily washed purple | green to magenta, sometimes heavily washed purple | (dark) grayish-green, (heavily) washed purple, greenish-violet, greenish- grey, washed violet or green to magenta |
| indumentum | finely downy | – | poorly hairy at base | hairless at base; short, dense hairs at tip | short, dense, grey hairs at tip | almost smooth or poorly hairy at base; densely hairy at tip | almost smooth to poorly hairy at base; short, dense hairs at tip |
| Cauline leaf | | | | | | | |
| number | – | 4–10 | 4–10 | 4–13 | 4–14 | (1)2–15 | (1)2–15 |
| size | – | – | – | hardly longer than their respective internode | – | longer or shorter than their respective internode | longer or shorter than their respective internode |
| Median cauline leaf | | | | | | | |
| size (cm) | ca. 5 cm long | 5–10 × (1)1.5–3 | 3–7 × 1.2–3.2 | 5–10 × 1–3 | usually rather more than twice as long as wide | (2)2.5–8.8(10) × 0.6–5 | (2)2.5–10 × 0.6–5 |
| shape | ovate-lanceolate | large, narrow-oval or narrow-lanceolate | narrow to lanceolate | oval to lanceolate | more or less oval | lanceolate to oval | (narrow-)lanceolate to oval |
| Superior cauline | | | | | | | |
| leaf aspect or size | linear-lanceolate as they approach the flowers | – | 2–7 cm | narrow and bract-like | narrow and bract-like | 1.7–8 × 0.4–2 cm | 1.7–8 × 0.4–2 cm linear-lanceolate, bract- |
| Bract size | all twice as long as the flowers* | – | lower: longer than flowers | all longer than flowers | lower longer than flowers, upper becoming shorter | 8.1–5.5 cm × 1.3–11.6 cm lower longer than flowers, upper becoming shorter | 8.1–5.5 cm × 1.3–11.6 cm lower longer than flowers, upper becoming shorter (or longer) than flowers |
| Flower number | – | – | 8–45 | (6)20–50(100) | 7–40(100) | 4–90 | 4–90 (100) |

continued

Table 2. Continued.

| Character | Smith (1828: 41–42) | Buttler (1991) | Baumann <i>et al.</i> (2006) | Delforge (2006) | Harrap & Harrap (2009) | Our study | Full range in <i>E. purpurata</i> |
|--|--|--------------------------------------|---|---|--|---|---|
| Inflorescence length (cm) aspect | – dense, cylindrical, cluster a little drooping, at least before the flowers expand | – with dense, abundant flowers | 7–30 erect, one-sided, grey, tomentose, incompact | 10–50 dense, elongated, opening widely, slightly scented, pendant to near horizontal | – slightly to moderately one-sided | 3.5–4.5 lax or dense | 3.5–5.0 lax or dense, slightly to moderately one-sided, pendant to near horizontal |
| Sepal length (mm) width (mm) colour | – – – | 8–12 4–5 – | 12–15 6–8 green with purple-washed outside, brightly olive-green inside | 8–13 4–6 purplish, green to whitish | – – pale green, becoming paler towards edges and with a prominent green midrib on the outer surface | 6.5–14.5 3.6–7.8 grayish-green with violet ribs, sometimes purple | 6.5–15 3.6–8 grayish-green with violet ribs, sometimes purple/ purplish (Fig. 2A and B) or pale/brightly (olive-) green to whitish (or/and with purple-washed outside), becoming paler towards the edges |
| shape | – | oval | oval | oval-lanceolate | triangular-oval | oval, elongate to lanceolate | oval, elongate to lanceolate |
| indumentum | externally downy | – | – | hairy on outer surface | – | externally almost smooth to shortly hairy | externally almost smooth to hairy |
| Petal size (mm) colour | – – | narrower than sepal – | 10–12 × 5.5–7 green with purple | near equal as sepal hyaline | smaller than sepal whitish, becoming slightly greener towards the centre, with a fine green midrib | 5.7–12.2 × 3.2–6.8 whitish-green, green, pinkish, with green or purple midribs | 5.7–12.2 × 3.2–7 near equal to sepal whitish-green, green, pinkish, purple, with green or purple midribs |
| Hypochile size (L × W × H, mm) colour inside | – – | – grayish-pink or violet-pink | 4.5–6.5 (as long as broad) brightly red- brown | – shiny bright purplish-brown | – translucent-whitish | 3.3–6 × 2.9–6.1 × 1.8–4.5 grayish, violet or brownish | 3.3–6.5 × 2.9–6.1 × 1.8–4.5 grayish-pink or violet-pink to brownish |

continued

Table 2. Continued.

| Character | Smith (1828: 41–42) | Buttler (1991) | Baumann <i>et al.</i> (2006) | Delforge (2006) | Harrap & Harrap (2009) | Our study | Full range in <i>E. purpurata</i> |
|------------------------------|---------------------------|--------------------------------|---------------------------------|---|---|---|---|
| Epichile size (L × W, mm) | – | almost as long as wide | 4.5–6 × 5–6.5 | 3.5–5 × 4.5–6 | short | 2.9–5.7 × 3.4–6 | 2.9–6 × 3.4–6.5 |
| colour | – | whitish or slightly pinkish | porcelain-white | whitish to pale lilac | whitish | whitish to pinkish | whitish to pinkish |
| bosses | – | smooth | pink-washed | 2 well marked, purplish | prominent, smoothly pleated, pink | 2 (or 3) wrinkled or smooth bosses, pinkish | 2 (or 3) wrinkled or smooth bosses, pinkish |
| Labellum aspect or size | quite entire at margin | 8–10 mm | 9–12 × 5.5–6.5 mm | margins undulate- contorted | heart-shaped | heart-shaped, margins sometimes with undulation | 8–12 × 5.5–6.5 mm, heart-shaped, margins sometimes with undulation |
| Ovary size (mm) | – | – | 12–15 | – | – | 4.7–14.5 × 2.3–6.9 | 4.7–15 × 2.3–6.9 |
| colour | – | – | green | dark-green, sometimes washed violet | green, ribs washed purple | green, dark-green, grey, sometimes violet to magenta, ribs washed purple | green, dark-green, grey, sometimes violet to magenta, ribs washed purple |
| indumentum | downy | shortly hairy | poorly, shortly hairy | pubescent | sparsely hairy | poorly, shortly hairy, sometimes dense | poorly, shortly hairy, sometimes dense |
| pedicel | – | long | long, red-washed | rather short, 2–5 mm, tinted violet | variably twisted | (1.1)1.5–5.1 mm, variably twisted, more or less tinted violet | (1.1)1.5–5.1 mm , variably twisted, more or less tinted violet |
| Gynostemium size (mm) | – | – | – | – | – | L: 3.3–6.3 W: 2.1–4.4 H: 2–4.2 | L: 3.3–6.3 W: 2.1–4.4 H: 2–4.2 |

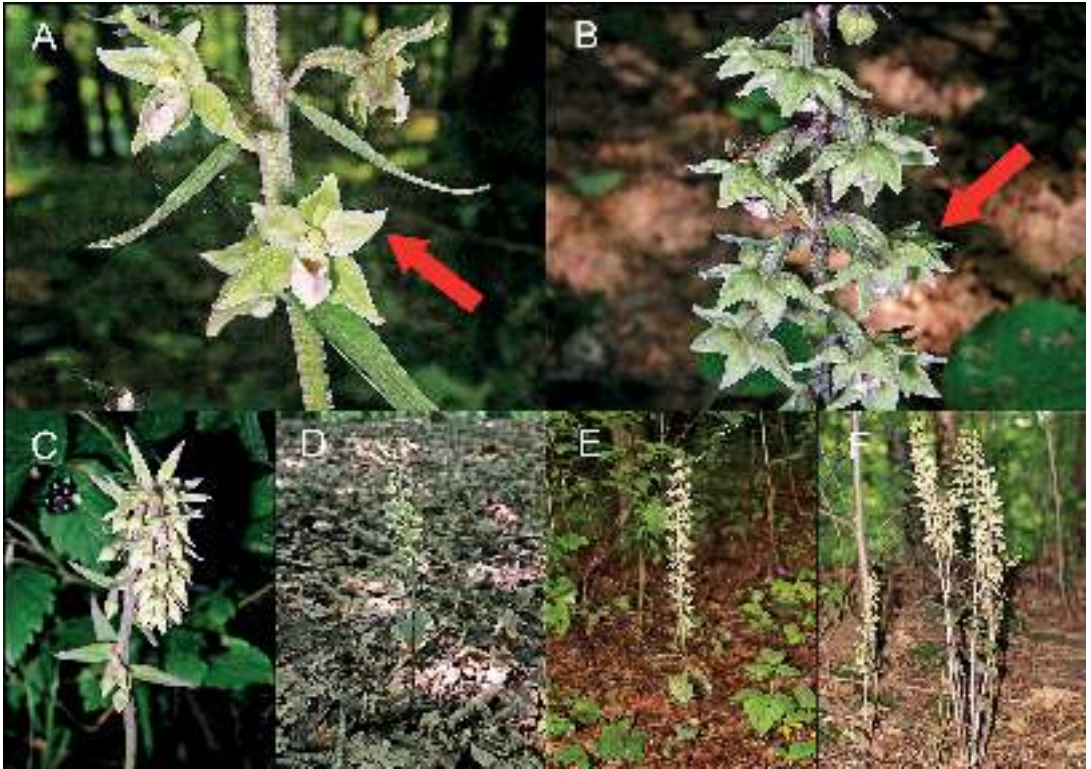


Fig. 2. Habit of *Epipactis purpurata* in central Europe. — **A:** Open flower, front view, Poland. — **B:** Inflorescence, Czech Republic. — **C–F:** Habit of different individuals.

should be used with caution in taxon identification. We found different types of papillae in all examined specimens. They differed in size, shape and often occurred close to each other (Fig. 1B and G). One should take into account the range of variability of papillae in a particular species and be critical using characters of papillae (see e.g. Delforge 2006).

Herbarium sheets often contain ramets in the flower-bud state (Fig. 3F), which renders correct identification practically impossible. Flower size and inflorescence length of the studied herbarium specimens varied greatly, the latter from 4.5 to 32.5 cm, although larger specimens are usually not collected for herbaria. In the field we occasionally found ramets ca. 100 cm high. Thus small ramets in herbarium sheets may not be representative of the whole population; at times it results from the ramet age or natural habitat. The ramet size varies also depending on the collection altitude (a.s.l.), and on the climatic region or habitat.

Ovary size often given in determination keys and descriptions is not a taxonomically reliable character, as its variation is considerable (Tables 1 and 2). Ovary size can only be estimated from fresh material, as ovaries in herbarium specimens are often distorted, ridged, or damaged (torn) due to the age of the material or improper drying. Inflorescences may in turn be densely packed/arranged or contain single, loosely arranged flowers, often within the same population (which we confirmed in the field), thus also this character varies much more than for example Delforge's (2006) account would allow.

Another presumably important character for the identification of *E. purpurata* is colour of the shoot. In the wild it varies from dark-green to magenta, or sometimes purplish. However, it should be borne in mind that the drying method may affect the retention of colour, as in high temperature the tint is oxidized to yellow. The original tinge of old specimens from the 19th

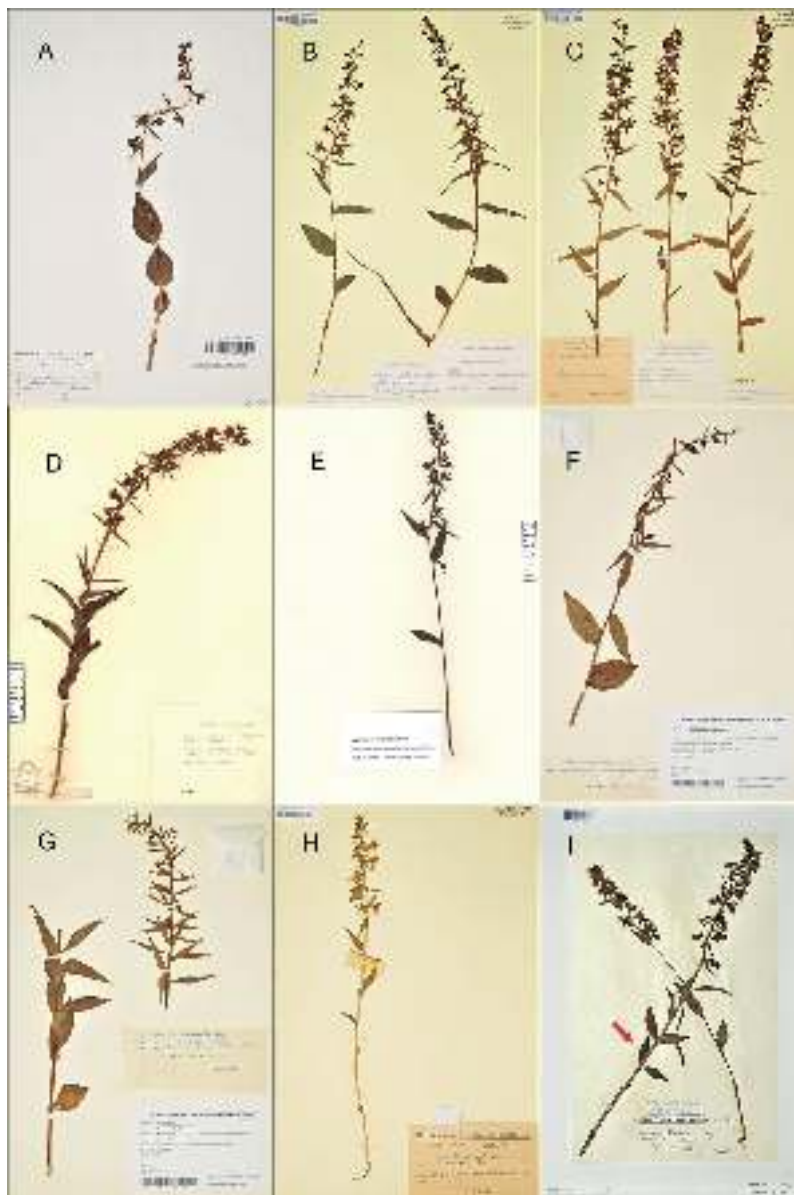


Fig. 3. Selected herbarium specimens of *Epipactis purpurata* with different leaf shapes. — **A:** From Spain (BR 13185244). — **B:** From Germany (M 0257838). — **C:** From Germany (M 0257847). — **D:** From England (C 2/2015I9). — **E:** From Poland, 14 August 2015 *E. Żolubak & A. Jakub-ska-Busse s.n.* — **F:** From Germany (STU 1 41897/2014 1). — **G:** From Germany (STU 1 42053/2014 1). — **H:** From Germany (M 0257837!). — **I:** From Switzerland (ZT 00071819!).

century is not preserved, which additionally hinders accurate determination.

We established full metric ranges for hypochile height, ovary width, as well as size of the column and floral bracts (Table 2).

We compared our results with those of Smith (1828: 41–42), Buttler (1991), Baumann *et al.* (2006), Delforge (2006), and Harrap and Harrap (2009) (*see* Table 2). Given the great intrageneric phenotypic plasticity (*cf.* Jakub-ska-Busse 2008, Jakub-ska-Busse *et al.* 2012), macro- and

micromorphological features that can be used in delimiting taxa should be carefully validated.

Due to the variation in *E. purpurata*, the data from different geographical regions differ from each other (often considerably), which is confirmed by comparing the morphometric ranges given by the authors referenced here with our results (Table 2).

Our field studies helped to establish new morphometric ranges for *E. purpurata* s. stricto, and also indicated metric values for 12 populations

from central Europe (Table 1). The results based on measurements of 152 specimens (ramets) from Poland, Czech Republic and Slovakia showed that vegetative features vary the most (see CV in Table 1). We showed that only fresh material of *Epipactis* should be used for morphometric analyses. Our results point out the difficulties in identifying the species, especially from herbarium material: vegetative as well as reproductive floral parts lose their natural size and proportions in the drying process as the cells become dehydrated.

Nomenclature

Epipactis purpurata Sm. is a *nomen conservandum* (Brummitt 2007) for the orchid which was described as *E. viridiflora* Hoffm. ex Krock. [nom. rej.] in 1814 from the Harz Massif in Germany. In many collections the obsolete nomenclature has not been updated, hence many herbarium specimens are named *E. latifolia* var. *viridiflora* (Hoffm.) Irmisch. (e.g. G00404722, G00404720). On the other hand, *E. latifolia* (L.) All. is a taxonomic synonym of *E. helleborine* (L.) Crantz, a species from a totally different group. Red ramets (with red flowers) of *E. helleborine* are usually identified as *E. purpurata* in herbaria.

Herbarium specimens named *E. latifolia* var. *varians* (Crantz) Asch. & Graebn. frequently belong to *E. helleborine*, the misidentification resulting from unfamiliarity with the whole range of phenotypic variability of the latter species, wrong interpretation of information in determination keys and descriptions, combined with the unclear nomenclature.

Epipactis purpurata Sm.

Engl. Fl. 4: 41. 1828, *nom. cons.* — *Epipactis latifolia* (L.) All. var. *purpurata* (Sm.) Nyman, *Consp. Fl. Eur.*: 688. 1882. — *Epipactis latifolia* (L.) All. subsp. *purpurata* (Sm.) K. Richt., *Pl. Eur.* 1: 284. 1890. — *Helleborine purpurata* (Sm.) Druce, *J. Bot.* 47: 28. 1909. — *Epipactis helleborine* [tax. infraspec.] *purpurata* (Sm.) H. Sund., *Eur. Med. Orchideen*, ed. 2: 209. 1975. — HOLOTYPE: England. Worcestershire, Parish of Leigh, a wood near Norris Farm, June 1807 *Abbot s.n.* (Herb. Smith 1395.7, LINN!).

Epipactis helleborine var. *varians* Crantz, *Stirp. Austr.* ed. 2, 6: 171. 1769. — *Epipactis varians* (Crantz) Fleischm.

& Rech., *Oesterr. Bot. Z.* 55: 267. 1905. — *Epipactis helleborine* subsp. *varians* (Crantz) Soó, *Magyar Növ. Kéz.* 1951. — *Epipactis latifolia* subsp. *varians* (Crantz) Asch. & Graebn., *Syn. Mitteleur. Fl.* 3: 863. 1907.

Epipactis viridiflora Hoffm. ex Krock., *Fl. Siles.* 3: 41. 1814, *nom. rej.* — NEOTYPE (designated by Baumann & Künkele in *J. Eur. Orch.* 31: 628 (1999): [icon] '*Epipactis latifolia* [var.] *brevifolia*', H. G. Reichenbach, *Icon. Fl. Germ. Helv.* 13/14: t. 134(II). 1851.

Epipactis sessilifolia Peterm., *Flora* 27(1): 370. 1844.

Epipactis violacea (Dur.-Duq.) Boreau, *Fl. Centre France* ed. 3, 2: 651. 1857.

Epipactis pseudopurpurata Mered'a, *Preslia* 68: 27. 1996. — *Epipactis viridiflora* Hoffm. ex Krock. subsp. *pseudopurpurata* (Mered'a) Kreutz, *Komp. Eur. Orchid.* 69. 2004. — HOLOTYPE: Slovakia, Strážovské Vrchy Mts., SW of Klepáč Mt., 400 m a.s.l., 28 July 1994 P. Mered'a (SLO). — Synonymized by Jakubská-Busse et al. (2012).

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Appendix

Examined herbarium specimens of *Epipactis purpurata*

Czech Republic. Moravia Orient, 30 August 1928 *G. Řičán 692* (BR!, G!, K!, S!). — **United Kingdom.** Berkshire: E of Hermitage, 16 July 1947 *B.L. Burt 13114* (K!); Devon: East Chillington, 6 August 1943 *E.F. Sanders s.n.* (K!); Devon: North Tawton, August 1932 *B.G.C. Bolland s.n.* (K!); Hampshire: West Tisted, 14 August 1927 *N.Y. Sandwith s.n.* (K!); Herefordshire: Aldbury Common 3 miles E of Tring, 21 August 1955 *V.S. Summerhayes 2836* (K!); Herefordshire: Breakspear, 15 September 1888 *R.A. Rolfe s.n.* (K!); Herefordshire: Chandlers Cross, 7 August 1955 *V.S. Summerhayes 2822* (K!); Herefordshire: Harpenden, September 1915 *E.J. Salisbury s.n.* (K!); Herefordshire: Rossway, 7 August 1955 *V.S. Summerhayes 2823* (K!); Herefordshire: Will Wood, *E.J. Salisbury s.n.* (K!); Kent: East Kent, 25 August 1958 *B.J. Brooke s.n.* (K!); Kent: in oakwood, 29 July 1947 *B.L. Burt 13115* (S!); Oxfordshire: Henley-on-Thames, Bowerdeux, 6 September 1909 *s. coll. s.n.* (K!); Oxfordshire: Earls Wood, 13 August 1946 *V.S. Summerhayes 1622* (K!); Oxfordshire: NE of Newbury, 3 August 1948 *S. Ross-Craig, J.R. Sealy, B.L. Burt 1577* (K!); Oxfordshire: Woods near Stoken Church, *H.J. Riddelsdell s.n.* (K!); Surrey: Box Hill, 6 August 1905 *J. Fraser s.n.* (K!); Surrey: Chelsham, 16 August 1953 *D.P. Young s.n.* (C!); Surrey: Reigate, August 1899 *Salmon E.S. s.n.* (S!); Surrey: Reigate Hill, 30 August 1913 *C.E.S s.n.* (K!); Surrey: Reigate, 5 August 1902 *J.M. Burton s.n.* (K!); Surrey: Road adjoining Ranmore Common, 29 August 1909 *C.C.B s.n.* (K!); Surrey: Woods on Ranmore Common, 4 September 1898 *C.E. Britton s.n.* (K!); Surrey: Woods towards upper Beeches West Horsley, 5 September 1915 *C. E. Britton 1527* (K!); Sussex: Ashurst, 30 August 1958 *D.P. Young 6579* (BR!); West Midlands: Aston Wood, 23 August 1953 *V.S. Summerhayes 2664* (K!). — **France.** Alsace: Haut-Rhin, 10 August 1951 *E. Berger s.n.* (STU!); Aquitaine: Basses-Pyrénées, June–July 1883 *D. Blanchet s.n.* (G!); Champagne-Ardenne: Marne, 6 November 1986 *J. Duvigneaud 86 F 573* (BR !); Île-de-France: Yvelines, 6 November 1898 *H.E. Janpert 4044* (BR!); Lorraine: Meuse, 10 August 1890 *L. De Bullemont s.n.* (BR!); Lorraine: Meuse, 4 September 1980 *J. Duvigneaud 80 F 465* (BR!); Lorraine: Meuse, 7 September 1980 *H.G. Rabyns 6312* (BR!). — **Germany.** Baden-Württemberg: Alb-Wutach-Gebiet, 3 August 1972 *S. Künkele s.n.* (STU!); Alb-Wutach-Gebiet, 1 August 1972 *S. Künkele s.n.* (STU!); Alb-Wutach-Gebiet, 6 August 1972 *S. Künkele s.n.* (STU!); Alb-Wutach-Gebiet, 1 August 1972 *S. Künkele s.n.* (STU!); Albuch und Härtsfeld, 7 August 1970 *S. Künkele s.n.* (STU!); Albuch und Härtsfeld, 7 August 1970 *S. Künkele s.n.* (STU!); Baaralb und oberes Donautal, August 1924 *E. Rebholz s.n.* (STU!); Bauland, 28 July 1970 *S. Künkele s.n.* (STU!); Bei Höschle (in Nenningen?), 1935 *A. Gscheidle s.n.* (STU!); Bodenseebecken, 11 August 1967 *G.W. Brielmaier s.n.* (STU!); Bodenseebecken, 1947 *K. Bertsch s.n.* (STU!); Bodenseebecken, 19 August 1965 *G.W. Brielmaier s.n.* (STU!); Boden-

seebecken, 1951 *K. Bertsch s.n.* (STU!); Dinkelberg, 7 August 1972 *S. Künkele s.n.* (STU!); Donauried, 16 August 1952 *K. Bertsch s.n.* (STU!); Hegau, 5 August 1970 *S. Künkele s.n.* (STU!); Hochschwarzwald, 5 August 1972 *S. Künkele s.n.* (STU!); Kocher-Jagst Ebene, 10 August 1970 *S. Künkele s.n.* (STU!); Kocher-Jagst Ebene, 1920–1922 *H. Mürdel 1973* (STU!); Kreichgau, 29 August 1969 *S. Künkele s.n.* (STU!); Markgräfler Hügelland, 7 August 1972 *S. Künkele s.n.* (STU!); Neckarbecken, 4 July 1969 *S. Künkele s.n.* (STU!); Niederstotzingen, 14 August 1961 *Doppelbaur 913* (M!); Oberschwäbisches Hügelland, 23 July 1974 *G.W. Brielmaier s.n.* (STU!); Oberschwäbisches Hügelland, 3 September 1955 *G.W. Brielmaier 8123/2* (STU!); Riß-Aitrach-Platten, 21 August 1957 *G.W. Brielmaier 8126/1* (STU!); Sandstein-Odenwald, 12 August 1970 *S. Künkele s.n.* (STU!); Schönbuch und Glemswald, 1 August 1939 *C. Maier s.n.* (STU!); Schwarzwald-Randplatten, 16 August 1977 *W. Wrede s.n.* (STU!); Schwäbisch-Fränkische Waldberge, 21 August 1972 *S. Künkele s.n.* (STU!); Schwenningen, August 1915 *s.coll. s.n.* (STU!); Südwestliches Albvorland, 30 July 1972 *S. Künkele s.n.* (STU!); Tübingen, August 1959 *R. Weber s.n.* (FR!); Westallgäu Hügelland, 4 September 1956 *G.W. Brielmaier s.n.* (STU!); **Bayern**: Moritzberg bei Nürnberg, August 1905 *Hautfuss 91* (S!); München, 12 August 1999 *A. Mayer 34* (M!); München, 23 August 1984 *O. Angerer s.n.* (M!); Schwaben, 1 September 1912 *Zinsmeister s.n.* (M!). **Hessen**: Edelsberg, 7 August 2004 *K. Baumann 4/419* (BR!); Gemeinde Schlitz, 31 July 2011 *T. Gregor, A. Dotzert 8716* (BR!, FR!); Kassel, 1 August 1973 *A. Nieschalk, W. Korbach s.n.* (BR!, FR!); Oberelsungen bei Wolfhagen, 1 September 1968 *C.&A. Nieschalk, W. Korbach s.n.* (BR!, FR!); Ziegenhain, 26 July 1964 *A. Nieschalk 931* (FR!). **Nordrhein-Westfalen**: Eifel, *H. Höppner II 32* (M!). **Thüringen**: Ettersberg (bei Weimar), 20 August 1916 *J. Bornmüller 9* (S!); Ilm-Saale-Platte, 6 August 1904 *M. Schutze s.n.* (STU!); Jena, 8 August 1907 *M. Schutze s.n.* (S!, G!). — **Luxembourg**. East of Sandweiler Contern Station, 27 July 1957 *D.P. Young, L. Reichling, M. Etlinger, R. Jungblut s.n.* (K!); Kroentgeshof, 21 August 1971 *W.J. Schrenk s.n.* (FR!). — **Poland**. Lower Silesia: Rudna, Nieszczyce, 14 August 2015 *E. Żotubak & A. Jakubská-Busse s.n.*; Schlesien: Löwenberg, 18 August 1877 *E.F. Dresler s.n.* (G!); Schlesien: Kreis Leobschütz, Fichtwalde bei Kasimir, 11 August 1917 *Focka s.n.* [Opole Province: Głubczyce, Kazimierz, 11 August 1917 *Focka s.n.*] (WRSL!); Schlesien: Löwenberg, 22 August 1879 *E.F. Dresler s.n.* (S!); Śląsk: Nadleśnictwo Koszęcin, 24 July 2007 *A. Rostański, L. Bernacki s.n.* (KTU!). — **Romania**. Transsilvania: Târnava Mică, 30 July 1940 *Al. Borza s.n.* (G!, K!, M!). — **Spain**. Aragón: Huesca, August 1972 *H.G. Rabyns 2944* (BR!). — **Switzerland**. Aargau: Rheinfelden, 31 July 1983 *A. Lawalrée 25051* (BR!); Sankt Gallen: Wil, 3 August 1972 *S. Künkele s.n.* (STU!); Zürich: Hasenreinzürichen Albisrieden und [...], 20 August 1916 *J. Bär s.n.* (Z!); Solothurn: Rüttenen, 5 September 1936 *M. Brosi s.n.* (ZT!); Zürich: Hausen, 1 August 2000 *E. Landort H22* (ZT!); Zürich: Horgen, 17 July 2001 *E. Landort J22*. (ZT!); Zürich: Stallikon, 31 July 1994 *E. Landort s.n.* (ZT!); Zürich: Waldegg, 10 August 1908 *J. Bucher s.n.* (Z!); Zürich: Waldegg, 16 August 1908 *J. Bucher s.n.* (Z!); Zürich: Waldegg, 20 August 1993 *E. Landort s.n.* (ZT!); Zürich: Wollishofen-Albisstrasse, 1913 *J. Bosshard s.n.* (Z!); Zürich: Zürichberg, 28 August 1927 *J. Bär s.n.* (Z!); Zürich: Zürichberg bei Zürich, August–September 1927 *J. Bär s.n.* (BR!, S!); Zürich: Zürichberg, 31 August 1913 *J. Bär s.n.* (Z!).