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Cardamine penzesii, a rediscovered taxon of the *C. pratensis* group (Cruciferae)

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Cardamine penzesii Ančev & Marhold *nom. nov*. (= *C. tuberosa* Pénzes & Vida *nom. illeg.*, non DC.), previously known only from the type locality, was discovered at four other localities in the southern part of the Bulgarian Black Sea coast. In addition, it is shown that distribution data for *C. pratensis* L. var. *dentata* (Schult.) Wimm. & Grab. from Bulgaria and those for *C. uliginosa* M. Bieb. from the European Turkey are based entirely on the misidentification of *C. penzesii*. Three specimens of *C. penzesii* from the Asian Turkey represent the first records for the *C. pratensis* group for this area. The unique character of *C. penzesii* seems to be the presence of globular tubers on the rhizomes. This taxon is also characterised by the white petals and by the appressed hairs on the rachis of leaves arising from adventitive buds and sometimes also on the rachis of leaves of young rosette leaves.

Key words: Brassicaceae, Bulgaria, chromosome numbers, *Cardamine*, Cruciferae, distribution, morphology, Turkey

INTRODUCTION

A. Pénzes and G. Vida described a new species of the *Cardamine pratensis* group, *C. tuberosa* Pénzes & Vida, from the material collected by the son of the former author, zoologist Bethen Pénzes during his excursion to Bulgaria in April 1960 (Pénzes 1965). The name, and the taxon itself, remained forgotten and it is mentioned neither in the *Flora of the PR of Bulgaria* (Assenov 1970), nor in *Flora Europaea* (Marhold 1993). It was, however, included in the *Red data book of the PR of Bulgaria* (Velčev 1984), with the reference to the type locality as the single locality and an accompanying illustration from Pénzes (1965). In *Atlas Florae Europaeae* (Jalas & Suominen 1994), *C. tuberosa* is included merely as a synonym of *C. pratensis* L. subsp. *pratensis* with a question mark. Pénzes and Vida (Pénzes 1965) were obviously not aware of the existence of the earlier

name, *C. tuberosa* DC. (Candolle 1821), and their name is, according to the Art. 53.1 of the *ICBN* (Greuter *et al*. 1994) illegitimate. The other homonym, cited by *Index Kewensis* (Jackson 1893), "*C. tuberosa* Bert[ero] ex Steud[el] in Flora 39: 409 (1856)" is not a valid name, but only a misidentification (Steudel 1856).

MATERIAL AND METHODS

Field studies were carried out in 1996 and 1997 in the southern part of the Bulgarian Black Sea coast, around the rivers Ropotamo and Veleka (for localities, *see* Appendix). Because of serious floods in 1997, we have not been able to check the type locality. Population samples of 35–40 plants were collected at three localities for detailed morphological studies. In addition, Bulgarian and Turkish material of the *Cardamine pratensis* group, including plants misidentified as *C. uliginosa* M. Bieb., were studied in the following herbaria: BM, BP, E, G, ISTE, K, L, SO, SOA, SOM, and W. Living plants of *C. uliginosa* (for which Turkish plants of *C. penzesii* were misidentified) from the Bolu province in Turkey (Bolu Mts., near the lake Abant Gölü, leg. J. Sádlo, vouchers in SAV) and herbarium specimens of this taxon from the herbaria E and TBI were also studied.

The chromosomes were counted using mitotic root-tip divisions (from cultivated plants or from those collected in the field), fixed in ethanol:acetic acid (3:1), hydrolysed in 1 N HCl for 10–12 min, and stained with haematoxylin after Gomori (Sharma & Sharma 1965). Vouchers are deposited in SOM.

Altogether 113 plants from three Bulgarian populations (Appendix: 1, 2 and 4) were used for the detailed morphometric measurements. The following characters were measured or counted: height of stem in cm; number of cauline leaves; number of segments of the third cauline leaf; number of leaflets of the rosette leaves; number of lateral inflorescences (longer than 1 cm); length of petals in mm; width of petals in mm; length of sepals in mm; length of filaments of longer stamens in mm; length of filaments of shorter stamens in mm. In addition, the position of the lower segments on the cauline leaves, orientation of the hairs on the rachis of the rosette leaves and on the leaves of plantlets arising from adventitive buds, and the petal colour were determined on each plant. The sizes of the petals, sepals and filaments were measured on fresh floral parts attached to adhesive tape and dried, so as to preserve their original size as far as possible. The characters measured and scored included those which proved to be useful in previous study of the *Cardamine pratensis* group in the Carpathians and Pannonia (Marhold 1996).

RESULTS AND DISCUSSION

Nomenclature

Cardamine penzesii Ančev & Marhold, *nom. nov., hoc loco*

≡ *C. tuberosa* Pénzes & Vida in Pénzes, Ann. Hist.-Nat. Mus. Natl. Hung., Bot. 57: 174–175, 1965, *nom. illeg*., *non* DC., Syst. Nat. 2: 254, 1821. — Holotype: Bulgaria in inundatis fluvii Kamcsia prope Mare Pontico, 24.IV.1960 *B. Pénzes s. n.* (BP).

Cardamine pratensis auct. non L. (*p.p.*?): Assenov, Fl. NRB 4: 433. 1970; Davis *et. al.,* Fl. Turkey 10: 49. 1988.

Cardamine pratensis var. *dentata auct. non* (Schult.) Wimm. & Grab.: Stojanov & Stefanov, Fl. Bălg. 1, 1 ed.: 508. 1924; 2 ed.: 464. 1933; 3 ed.: 510. 1948; Stojanov *et al.,* Fl. Bălg. 1, ed. 4: 469. 1966.

Cardamine uliginosa auct. non M. Bieb.: Cullen, Fl. Turkey 1: 442 [Turkey-in-Europe, A2(E)]. 1965; Jones & Akeroyd, Fl. Eur. 1, 2 ed.: 350. 1993; Jalas & Suominen, Atl. Fl. Eur. 10: 166. 1994.

Morphology

Description

Perennial herb, (20–)25–52(–59) cm tall. Rhizome short, usually with several globular tubers. Stem erect, usually branched at base and above, only exceptionally simple, glabrous. Rosette leaves usually glabrous, the youngest seldom with appressed hairs, pinnate to pinnatisect, with 7–15 (–16) shortly petiolulate leaflets or segments; lateral leaflets or segments broadly elliptic to subrotundate, usually crenate, cuneate at base; terminal leaflet, slightly to much larger than lateral ones, usually subrotundate, crenate, cuneate or truncate at base. Cauline leaves (5–)6–10(–12), glabrous, pinnatisect (lowermost ones usually pinnate), lower cauline leaves with 7–11(–12) segments or leaflets, the number of segments diminishing gradually up the stem; lateral segments or leaflets oblanceolate to broadly elliptic, entire or crenate, slightly ascending; terminal segment or leaflet usually obovate and crenate, cuneate at base. Rachis of leaves arising from adventitious buds on rosette leaves, in the axils of cauline leaves, and in inflorescences, with appressed hairs. Inflorescence racemose with 1–8(–10) lateral inflorescences; sepals (3.3–)3.5–4.5 mm long, with a

membranous margin, petals white, only very exceptionally tinged at the tip to pale reddish-violet, (9.7–)10.2–13.4(–13.7)×(4.9–)5.6–8.3(–8.8) mm; stamens 6, anthers yellow before anthesis, filaments of longer stamens 4.9–6.2(–6.4) mm long, those of shorter stamens (2.1–)2.3–4.2(–4.5) mm, anthers of the longer stamens in open flowers situated above the stigma level and oriented outside, anthers of the shorter stamens situated under stigma level and oriented inside the flower; short stamens have nectar ring at the base, pairs of longer stamens have small conical nectar gland at the base; stigma conspicuous, enlarged. Pedicels patent or erect-patent, siliquae divergent from axis at the same angle as pedicels or erect. Chromosome number 2n = 2x = 16.

Illustration: Fig. 1.

Discussion

A detailed morphometric analysis of the *Cardamine pratensis* group from the Carpathians and Pannonia, the area to the north of Bulgaria, was published recently (Marhold 1996), and thus there is now a possibility to compare the morphology of *C. penzesii* with the other related taxa of the *C. pratensis* group. Mean, mode, maximum and minimum values and standard deviations of the characters measured within the present study are presented in Table 1, while 5% and 95% percentiles, accompanied by 1% and 99% percentiles in brackets can be found in the description above (which should be compared with the data in Marhold 1994b, 1996: table 2).

Diploid populations of the *Cardamine pratensis* group occurring in south-eastern Europe and adjacent Carpathian and Pannonian areas are currently classified as *C. matthioli* Moretti (distributed in C and SE Europe, in the Carpathians, Pannonia and south of the Alps, from Piemont in the west to Romania and Bulgaria in the east) and *C. rivularis* Schur (restricted in its occurrence to the Romanian South Carpathians and the higher Bulgarian mountain ranges). In addition, two diploid races with rather restricted distribution area are currently taxonomically included into *C. pratensis* (race "*ucranica*" in the lower altitudes of

Fig. 1. Habit of *Cardamine penzesii* Ančev & Marhold. — Scale bars: 1.5 cm (shorter one) and 5 cm (longer one). Drawn by K. Cigánová.

the Ukrainian Eastern Carpathians and Eastern Carpathian foothills, and race "*C. rivularis auct.*" occurring in the upper montane and subalpine belt of the Eastern Carpathians, cf. Marhold 1994a, 1994b, 1996). Polyploid populations of C and SE Europe are classified as follows: those with 2n = 30, 38 and 44, occurring in the area to the north of Bulgaria, are treated as *C. pratensis*; *C. majovskii* Marhold & Záborský (2n = 32) is most probably an autotetraploid derivative of *C. matthioli* (cf. also Franzke *et al*. 1998), which has been confirmed from Slovenia, Burgenland (Austria), Transcarpathian Ukraine, E and SW Hungary, E Slovakia, and Romania (the occurrence of this taxon in Bulgaria is not yet confirmed); the high polyploid taxon, *C. dentata* Schult., reaches its southern distribution limit in the northern part of the Danube basin and does not occur in Bulgaria or Romania (Marhold 1994a, 1994b, 1999).

The unique character of *Cardamine penzesii* seems to be the presence of globular tubers on the rhizomes. Similar tuber-like structures on rhizomes, although of a different shape, were reported for *C. granulosa* All. (Italian endemic) and for the diploid populations currently classified as *C. pratensis* L., from the Atlantic coast of Portugal (Lövkvist 1956: 27, fig. 2).

Cardamine penzesii shares, together with three other taxa of Central and/or SE European distribution, *C. matthioli*, *C. majovskii* and *C. rivularis*, the taxonomically important character, that of appressed hairs on the rachis of leaves arising from adventitive buds and sometimes also on the rachis of leaves of young rosette leaves. Apart from these taxa, such a character can only be found in some populations of the polymorphic polyploid *C. dentata*, where it may occur as a result of introgression. Other taxa of the *C. pratensis* group invariably have patent hairs on the rachis of rosette leaves and on those from the adventitious buds. This might be evidence for the common origin of *C. matthioli*, *C. majovskii*, *C. rivularis* and *C. penzesii*. The results of the detailed molecular studies confirmed close relationships of *C. penzesii* and *C. rivularis*, while *C. matthioli* and *C. majovskii* seem to be more distant (Franzke 1999).

On the other hand, *Cardamine penzesii* clearly differs from *C. mattholi* and *C. majovskii* in the shape of the leaves (the segments of lower stem leaves of *C. matthioli* and *C. majovskii* are usually more narrow, horizontally spreading, the lower ones slightly deflexed, while those of *C. penzesii* are usually broader and always slightly ascending) and also partly in colour of the petals, which in *C. matthioli* and *C. majovskii* is not only white (as in *C. penzesii*), but quite often a pale reddish-violet. *Cardamine rivularis*, a species of mostly subalpine and alpine belts, clearly differs from the other taxa of the *C. pratensis* group, including *C. penzesii*, by having anthers purplish before dehiscence.

Cardamine pratensis s. str. differs from *C. penzesii* in having patent hairs on the rosette leaves and also by reddish-violet petals, although the race "ucranica", currently treated within *C. pratensis*, also has entirely white petals. *Cardamine dentata* clearly differs from *C. penzesii* by its high polyploid level (octoploids to dodekaploids) and by

Table 1. Results of the morphometric analysis of *Cardamine penzesii* Ančev & Marhold (*n* = 113, for the character NLR *n* = 181). H: Height of stem, cm; NL: Number of cauline leaves; NS: Number of segments of the third cauline leaf; NLR: Number of leaflets of rosette leaves; NI: Number of lateral inflorescences (longer than 1 cm); LP: Length of petals, mm; WP: Width of petals, mm; LS: Length of sepals, mm; LFS: Length of filaments of longer stamens, mm; LFL: Length of filaments of shorter stamens, mm.

Character	Mean	Mode	SD	Min.	Max.
H	37.05	39	7.58	17.5	64.5
NL	7.85	8	1.56	5	14
NS	9.43	9	1.48	7	15
NLR	11.70	13	2.05	7	17
NI	4.35	4	2.15	0	12
LP	11.60	10.9	0.96	9.7	14.2
WP	6.74	7.1	0.86	4.7	9.4
LS	3.84	3.8	0.32	3.1	4.7
LFS	3.29	3.3	0.56	1.7	4.5
LFL	5.49	5.4	0.43	4.7	6.8

the stem leaves (including the uppermost ones) being composed, with clearly developed leaflet stalks and deciduous leaflets. Both *C. dentata* and *C. pratensis* var. *dentata* are the names which have been very often confused and wrongly interpreted in the European literature and it is not surprising that Bulgarian authors misinterpreted them for *C. penzesii* as it is shown below (cf. Marhold 1994b for the history of the name *C. dentata*).

Certain trends in the quantitative morphological characters are apparent in *Cardamine penzesii* (Table 1, compare with Marhold 1996: table 2). In comparison with other diploid taxa of the *C. pratensis* group occurring in C and SE Europe, *C. penzesii* has clearly larger petals which are comparable in size with those of plants with 2n = 38 and 44 of *C. pratensis*. The stem is more often branched in comparison with other taxa of the *C. pratensis* group (even in comparison with *C. matthioli*, although the maximum number of branches on the stem of *C. penzesii* is lower than for either *C. matthioli* or *C. majovskii*).

Cardamine uliginosa M. Bieb., the other species for which *C. penzesii* was misinterpreted in the past, is rather distant from the *C. pratensis* group. It is close to *C. acris* Griseb., *C. raphanifolia* Pourr. and probably also to *C. tenera* C. A. Mey. According to Khatri (1988), who generally follows the classification by Spasskaja (1978), these taxa belong to the subsect. *Tenerae* Spasskaja of the sect. *Cardamine*, while the *C. pratensis* group is classified by Spasskaja (1978) within the subsect. *Cardamine*. The most apparent distinguishing character of *C. uliginosa* from the *C. pratensis* group is the thick, elongated and often branched ascending rhizome. *Cardamine uliginosa* has, like *C. penzesii*, a diploid chromosome number 2n = 16 (Gagnidze *et al.* 1985). This number was confirmed by us also on the Turkish plants from the Bolu Mts., near to lake Abant Gölü (voucher specimen *ex cult.* 1998, Marhold, SAV), which is the first report of the chromosome number for *C. uliginosa* from Turkey.

Chromosomes

Pénzes (1965) reported the diploid chromosome number 2n = 16 for *Cardamine penzesii* (under the name *C. tuberosa*) from the type locality near to the Kamčia River. This number was confirmed by our studies at three localities in Bulgaria (*see* Appendix). The karyotype is symmetrical, consisting of chromosomes of the m- and sm- type. They are relatively well differentiated in length: one pair of chromosomes is comparatively longer, exceeding the other ones, five pairs are of medium size, and two pairs of chromosomes are short. A pair of SAT-chromosomes with microsatellites was observed in plants from the "Ropotamo" population (A965).

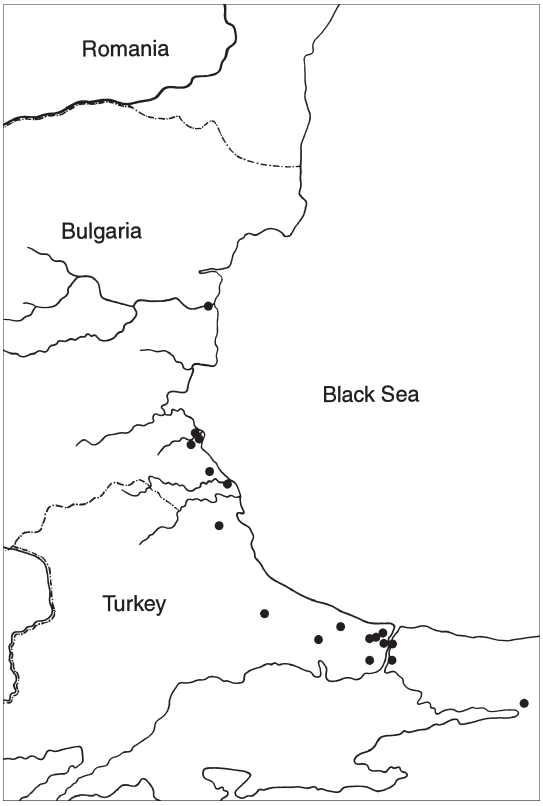

Fig. 2. Distribution map of *Cardamine penzesii* Ančev & Marhold based on revised herbarium specimens.

Distribution

Cardamine penzesii is probably restricted to the area of the Black Sea coast to the south of the Kamčia River in Bulgaria as far as the most western part of Asian Turkey (Fig. 2). A full list of the herbarium specimens studied is given in the Ap-

pendix. Few data in the literature can be referred to this taxon. The first certain record is that of Davidov (1915) who reported *C. pratensis* from Sinekli and Büyükhan ["Bijuk-Chan i Sineklii"] (NW of Istanbul) with a short note stressing the differences of those plants from "*C. hayneana* Welw." (= *C. matthioli*). He points out that the Turkish plants have larger segments of leaves and larger flowers in comparison with "*C. hayneana*". This description corresponds well with *C. penzesii* and two specimens from the second locality [collected by Davidov, in the herbarium SOM] (Appendix: 12) undoubtedly belong to this taxon.

Stojanov and Stefanov (1921a) reported "*C. pratensis* var. *dentata* Koch" as a new taxon for the flora of Bulgaria from the lower part of the Kargana River south of Sozopol and (Stojanov & Stefanov 1921b) from the Strandža Mts. (Kurprija, Urgari, Kosti). Later, Stojanov and Stefanov (1924) noted "*C. pratensis* var. *dentata* Schult." [the correct author citation is *C. pratensis* var. *dentata* (Schult.) Wimm. & Grab.] from the wet forests of the Strandža Mts. They characterised these plants as having "stem leaves $4^1/_2$–10 cm long, with broad oval segments (8–22 × 4–10 mm), with 3–5 large teeth or partite, usually with stalks, white flowers". The description corresponds well with *C. penzesii,* except that there are no stalks on the leaf segments at least within the upper part of stem on the plants of this taxon (the leaves are pinnatipartite with segments, and not composite with stalked leaflets). This is a clear misintepretation of the name *C. pratensis* var. *dentata* [= *C. dentata* Schult., *C. pratensis* subsp. *paludosa* (Knaf) Čelak.] as the taxon bearing this name, usually treated on the level of species or subspecies, occurs in Central and Northern Europe to the north of the Po River and the Danube Basin (cf. Jalas & Suominen 1994, Marhold 1994b) and does not reach Bulgaria. A taxon with the name "*C. pratensis* var. *dentata* Schult." appears also in Stojanov and Stefanov (1933, 1948) and Stojanov *et al*. (1966), except that in these editions the distribution is given as "wet forests on the Black Sea coast". Most probably following Stojanov and Stefanov (1924, 1933), Jordanov (1938, 1939) referred to our taxon as to "*C. pratensis* L. var. *dentata* Schult." in his study of the vegetation of the Strandža Mts. This record might be connected with the specimen collected by Jordanov in this area in 1934 (Appendix: 10) and possibly also with that collected in 1929 near to the Ropotamo River, south of Sozopol (Appendix: 7), both originally identified as *C. pratensis* var. *dentata* and belonging to *C. penzesii*. Assenov (1970) referred plants of the *C. pratensis* group from the Black Sea coast (*C. penzesii*) to *C. pratensis* L. *s. str.* (with the name "*C. pratensis* var. *dentata* (Schult.) Neilr." in synonymy).

Davis *et al.* (1988: 49) reported the occurrence of *C. pratensis* (*s. l.*) for European Turkey with the following references: "Tekirdağ: Saros Körfezi, Urumov. Kirklareli: Sinekli and Büyükhan, Davidov (as subsp. *matthioli* (Moretti) Hayek, = *C. matthioli* Moretti). Istanbul: Kağithane, Grisebach". The second record most probably refers to *C. penzesii*, as was shown above. The reference to *C. pratensis* subsp. *matthioli* is most probably based on a wrong translation of the Davidov's note. As it was pointed out above, he did not report the occurrence of *C. pratensis* subsp. *matthioli* (= "*C. Hayneana*") in Turkey, but stressed the differences of this taxon from what he found in Turkey and considered it to be *C. pratensis*. For the records of Urumov (1914: 138, "V okolnost'ta na Saroskija zaliv [vicinity of the Saros Körfezi]") and Grisebach (1843: 253, "In agro Byzantino: frequens in pratis convallis Kiahad-Chane [Kağithane]"), we have not been able to trace any herbarium specimens, but at least the second one most probably refers to *C. penzesii* as there is a specimen of this taxon from the locality very close to Kağithane (Appendix: 22), collected by Parquet in 1864.

In addition, Cullen (1965) reported the occurrence of *Cardamine uliginosa* for European Turkey with a note that "the occurrence of this species in Turkey-in-Europe is probably due to the introduction from Anatolia, as it occurs only near man-made reservoirs near Istanbul". The only locality mentioned is "Istanbul, Büyükdere, *Kranichfeld*". There are no other details in this work, but apparently the same record is referred to by Webb (1966: 26), who reported as its source the specimen(s) from the Post herbarium (G), collected or labelled by Aznavour and identified as *C. uliginosa* by J. Cullen. Surprisingly, there are six specimens from the wide area of Istanbul in the herbarium Post in G, originating in the herbarium of G. V. Aznavour, revised by Cullen as *C. uliginosa* (Appendix: 15, 19–21 and 23). They

were collected throughout the period of 1890–1906. Four of them were originally labelled as *C. pratensis* and two as *C. uliginosa*. Five of them are from the vicinity of the Büyükdere village (Appendix: 15, 19–21), but none of them bears the collector's name "Kranichfeld". They all clearly belong to *C. penzesii*. Maybe Aznavour was not sure about his identifications as he did not publish the occurrence either of *C. pratensis* or *C. uliginosa* in any of his many papers dealing with the flora of the Istanbul area (for references see Webb 1966: 98). In addition, there are specimens in K and L collected during the *Iter Leydense 1959* close to Büyükdere (*see* Appendix: 18), originally identified as *C. uliginosa*, and as such revised by Cullen, which beyond any doubt also correspond to *C. penzesii*.

Following Cullen (1965) and Webb (1966) the occurrence of *Cardamine uliginosa* in European Turkey was reported also by Jones and Akeroyd (1993). The occurrence of *C. uliginosa* in European Turkey in Jalas and Suominen (1994) is marked "status unknown or uncertain" with reference to the data of Cullen (1965), Webb (1966) and Jalas *et al*. (1976). Jalas *et al.* (1976) reported *C. uliginosa* from Belgrad Forest, ca. 25 km N of Istanbul. The corresponding specimens deposited in H are currently not available for study (P. Uotila, pers. comm.) and specimens identified as *C. uliginosa* were not among the duplicates sent to Greuter (cf. Jalas *et al.* 1976; W. Greuter, pers. comm.), but from almost the same location there are specimens of *C. penzesii* deposited in E, collected by Demiriz in 1962, and in ISTE, collected by A. and T. Baytop in 1956 and A. Baytop in 1974 (Appendix: 16 and 17).

In the Aznavour's material in G there is also one specimen of *Cardamine penzesii*, which was collected in the adjacent Asian part of Turkey, near to rivulet Küçük Gök Su (or Gök Su), NE of Beylerbeyi (Appendix: 23). Aznavour labelled the specimen as from "Gueuk Souyou" and from his papers cited by Webb (1966) it is clear that he used this name for the above-mentioned rivulet and not for that bearing the same name (Gök Su) in the European part of Turkey, N of Istanbul. Two other specimens of this taxon from the Asian part of Turkey are those from Hünkâr Iskelesi, NW of Beykoz, collected by Parquet in 1864 (Appendix: 24), and from between Izmit et Adapazari, collected by Rechinger in 1977 (Appendix: 25). These three specimens represent the first data about the occurrence of the *C. pratensis* group in Asian Turkey.

From the above analysis of available specimens identified as *Cardamine pratensis*, *C. pratensis* var. *dentata* and *C. uliginosa*, we assume that all the documented data on the occurrence of these taxa from the Bulgarian Black Sea coast and European Turkey are based on the misidentification of *C. penzesii*. Indeed, *C. uliginosa* is a species of subalpine and alpine belts occurring usually at 2 000–3 000 m altitudes, only rarely descending along the streams to about 1 000 m (Cullen 1965, Khatri 1988), and it is now clear that it does not occur in the lowland part of Turkey, not even as an introduced taxon. As all Turkish localities of *C. uliginosa* are restricted to the Asian part of Turkey, it should be excluded from the list of taxa occurring in Europe.

Ecology

Cardamine penzesii occurs on the Black Sea coast in the flood-plain forests, so called "longozi", "Longoswälder", or "Longosformationen", along the lower parts of the large rivers as Kamčia, Ropotamo, and Veleka. These forests were studied in detail by Stojanoff (1929) and Jordanov (1938, 1939). The latter author reported our taxon as "*Cardamine pratensis* L. var. *dentata* Schult." among the plants forming the herb layer of such communities. Among other taxa he mentioned *Equisetum telmateia* Ehrh., *E. arvense* L., *Scilla bithynica* Boiss., *Leucojum aestivum* L., *Montia fontana* L., *Cerastium dubium* (Bast.) Guépin, *Myosurus minimus* L., *Mercurialis perennis* L., *Symphytum tuberosum* L., and *Lathraea squamaria* L. Plants of *C. penzesii* at the localities studied by us grew mostly in places with shallow standing water. A detailed ecological study of the Belgrad forest N of Istanbul was published by Yaltirik (1966), however, neither *C. pratensis* nor *C. uliginosa* are mentioned in this work.

Reproductive biology

Plants of *Cardamine penzesii* reproduce by seeds, which was observed during the experimental cul-

tivation, and also by the production of plantlets arising from the adventitious buds. Such buds appear at the base of leaflets of the rosette leaves, in the axils of cauline leaves as well as in the inflorescence. This is a common feature of the *C. pratensis* group and was studied in detail by Salisbury (1965) on the British populations of this group of species. On the other hand, *C. penzesii*, like other species of the *C. pratensis* group does not have the ability to produce stoloniferous offshoots and to reproduce by them (which is typical of *C. amara* and *C. tenera*). Tubers which appear on rhizomes of *C. penzesii* might also have some role in the process of reproduction but this remains to be studied in detail.

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APPENDIX

List of *Cardamine penzesii* localities studied (localities of population samples are marked by asterisk). All localities are in Bulgaria.

1. *Border of the Nature Reserve Ropotamo, on the left (north) side of the Ropotamo River, flood-plain forest along the road, 0.5 km NW of the bridge of the road Primorsko-Carevo, 1997 *Marhold & Vassilev* (SAV, SOM A973).
2. Border of the Nature Reserve Ropotamo, on the right (south) side of the Ropotamo River, flood-plain forest near to the bridge of the road Primorsko-Carevo, 1996 *Ančev & Marhold* (SAV, SOM A965). 2n = 16.
3. *Ca. 2 km N of the road Jasna Poljana-Primorsko (ca. 6 km of Jasna Poljana), 1996 *Ančev & Marhold* (SAV, SOM A961). 2n = 16.
4. *Natural Park Strandža, Sinemorec, flood-plain forest on the right (south) side of the Veleka River, ca. 2 km W of the bridge of the road Sinemorec-Rezovo, 1997 *Marhold & Vassilev* (SAV, SOM A971). 2n = 16.

List of studied herbarium specimens of *Cardamine penzesii*

Bulgaria

5. Balkan orientalis, Ad Pontum prope riv. Kamčia, 1902 *A. Javašev* (SOM 96437, as "*Cardamine pratensis* L. var. *dentata* Schult.", det. B. Achtarov).
6. In inundatis fluvii Kamcsia prope Mare Pontico, 1960 *B. Pénzes* (BP).
7. Vlažnite mesta pokraj r. Ropotamo, južno ot Sozopol [wet places around the Ropotamo River, south of Sozopol], 1929 *D. Jordanov* (SO 28173, as "*Cardamine pratensis* L. var. *dentata* Schult.").
8. Černomorsko krajbrežie: do ustieto na r. Ropotamo [Black Sea coast, mouth of the Ropotamo River], 1992 *V. Nikolov* (SO 96031, as "*C. pratensis* L. var. *dentata* (Schult.) Neilr.").
9. V gorite medždu Siva i Urgari [Bălgari], Strandža [Strandža Mts., between the villages of Siva and Urgari], s. dat. et coll. [*Stojanov & Stefa-*

nov?] (SOM 32137, as "*Cardamine pratensis* var. *dentata* Koch").
10. Strandža: vlažni mesta do ustieto na r. Veleka [Strandža, wet places around the mouth of the Veleka River], 1934 *D. Jordanov* (SO 28172, as "*Cardamine pratensis* L. var. *dentata* Schult.").

European Turkey

11. Kirklareli, Demirköy, near Lake Hamam, 1974 *N. & E. Özhatay* (ISTE 27684, as *C. uliginosa*, det. A. Baytop).
12. In paludosis circa Constantinopolem: ad stationem Bijuk-Han [Büyükhan], 1913 *B. Davidoff* (SOM 32138, SOM 32136, both specimens as *Cardamine pratensis*).
13. Istanbul, Europe, Tayakadın kum Çukurları, 1967 *A. & T. Baytop* (ISTE 10943; E 40039, as *Cardamine uliginosa*).
14. Istanbul, Hisarbeyli, 1970 *A. Baytop & F. Öktem* (ISTE 16547, as *Cardamine uliginosa*).
15. Kilidjbounar [near Zekeriyaköy], 1906 *G. V. Aznavour* (G-Herbier de Bertram V. D. Post, as *Cardamine uliginosa*, orig. det.; "O.K.!" Cullen in 1965).
16. Istanbul, Belgrad forest, 1956 *A. & T. Baytop* (ISTE 4437, 4468) 1974 *A. Baytop* (ISTE 27342) (all specimens as *C. uliginosa*, det. A. Baytop).
17. Istanbul (Eur.), Belgrad forest, between Büyükbend and Müderris Neşet suyu, 1962 *H. Demiriz* (E 40061 — Ex ISTF Herbarium Demiriz, no. 4668, as *Cardamine uliginosa*, det. Cullen in 1964).
18. Flora Turcomaniae Asiaticae, Iter Leydense 1959, no. 495, Istanbul, Büyükdere (10 km N of Istanbul), along the road to Bahçeköy, along rivulet, altitude ± 30 m, 1959 *s. coll.* (K; L 962.303-238, as *Cardamine uliginosa*, det. W. J. M. Wader in 1961; specimen in L revised by Cullen in 1963).
19. De Buyukdéré [Büyükdere] à Soultansou, fossés, bord de la route, 1891 *G. V. Aznavour* (G-Herbier de Bertram V. D. Post, as "*Cardamine pratensis* L. var. *alba* Le Galla in Rouy", orig. det.; *C. uliginosa* det. Cullen in 1963).
20. Près Soultan Mahmoud Bend [N of Bahçeköy], Bord des eaux, 1890 *G. V. Aznavour* (G-Herbier de Bertram V. D. Post, as *Cardamine pratensis,* orig. det.; *C. uliginosa*, det. Cullen in 1963), 2 specimens.
21. Près vègne Gulmez, Buyukdéré [Büyküdere], 1894 *G. V. Aznavour* (G-Herbier de Bertram V. D. Post, as "*Cardamine pratensis* L. var. *alba* Le Galla in Rouy", orig. det.; *C. uliginosa*, det. Cullen in 1963).
22. Herb. Byzantinum, Ruisseau d'Aïaz-Haza [Ayazağa], près des Eaux douces d'Europe [Gök Su], 1864 *R. du Parquet* (BM-Herb. R. J. Shuttleworth., recd. 1877, as "*Cardamine* ?").

Asian Turkey

23. Vallée bend Gueuk Souyou [rivulet Küçük Gök Su (or Gök Su), NE of Beylerbeyi], 1895 *G. V. Aznavour* (G- Herbier de Bertram V. D. Post, as *Cardamine uliginosa,* orig. det.; "O.K.!" Cullen in 1965).
24. Hunkiar-Iskélessi (Asia) [Hünkâr Iskelesi, NW of Beykoz], 1864 *R. du Parquet* (BM, as "*Cardamine*, confer *C. pratensis* var.").
25. Turcia, Prov. Kocaeli, Inter Izmit et Adapazari, in ceduis humidis planitiei, 1977 *K. H. Rechinger, Iter Iranicum X., 54413* (W, as *Cardamine*).