CRYPTOGRAMMA BITHYNICA SPEC. NOV. (PTERIDACEAE, PTERIDOPHYTA) – A NEW FERN SPECIES FROM NORTHWESTERN ANATOLIA / TURKEY

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ABSTRACT
An octoploid taxon of Cryptogramma from the Uludağ Mts. in northwestern Turkey is described as a new species, Cryptogramma bithynica S. Jess., L. Lehm. & Bujnoch. An overview of the genus is given.

ZUSAMMENFASSUNG

INTRODUCTION
The taxonomy within the genus Cryptogramma has been in dispute for a long time. In most cases (Meusel et al. 1965, Dostál 1984, Kramer & Green 1990), the only distinction which has been made is that between the boreal Asian and North American Cryptogramma stelleri and the more widespread C. crispa, a species distributed in circumpolar regions and in southern Central and East Asia as well as in southern parts of South America. A subdivision of the latter into several taxa was made on the level of subspecies or varieties (Meusel et al. 1965, Dostál 1984). Cytological studies revealed that the different taxa are of different ploidy level: diploid, or tetraploid. The origin of polyploids is mostly unresolved. However, allopolyploidy seems to be important for speciation; apparently, the North American tetraploid Cryptogramma sitchensis has been derived by hybridization from C. acrostichoides and a second, now allopatric species, possibly C. raddeana of East Asia (Alverson 1993).

At present, eight to eleven species are distinguished (Alverson 1993). Most of them have been cytologically examined, are morphologically distinguishable and their ranges are known (Jeßen 2008):

- C. acrostichoides R. Br.: 2n = 60, diploid; central to north-western North America as well as outermost north-eastern East Asia
- C. brunoniana Wall. ex Hook. & Grev.: 2n = 60, diploid; southern Central Asia, eastwards as far as Taiwan.
• *C. cascadensis* E.R. Alverson: 2n = 60, diploid; western North America

• *C. crispa* (L.) R. Br. ex Hook.: 2n = 120, tetraploid; Europe as far north as northern Urals, Great Caucasus and Caucasus Minor, north-western and north-eastern Turkey as well as an unconfirmed area in northern Turkey (Meusel et al. 1965)

• *C. fumariifolia* (Phil. ex Baker) Christ: 2n = ?; south-western South America (Chile, Argentina)

• *C. raddeana* Fomin (*C. brunoniana* ssp. *raddeana* [Fomin] Fraser-Jenk.): 2n = 60?; south and south-eastern Siberia (region of Lake Baikal, Stanowoi Mountains, Primorje, region of Amur) and China (Hubei, Shaanxi, Sichuan, Xizang, Yunnan)

• *C. sitchensis* (Rupr.) Moore: 2n = 120, tetraploid; north-western North America

• *C. stelleri* (Gmel.) Prantl: 2n = 60, diploid; northern and eastern Asia, western and eastern North America; in Europe reaching only northern and eastern Urals as well as the Petschora valley and the Timan region


*Cryptogramma crispa* senso stricto is mostly restricted to Europe (Bennert 1999). The species reaches Western Asia only in the northern part of the Urals, the Caucasus and in Turkey. With 2n = 120 chromosomes it is tetraploid (Manton 1950). However it

Figure 1. *Cryptogramma bithynica* at its locus typicus: NW Turkey, Uludağ, 1770 m; photo: S. Jeßen 09-09-2009.
is unknown whether it is an auto- or allopolyploid. Of the putative diploid ancestors C. stelleri can clearly be excluded for morphological reasons. Therefore, diploids which may represent ancestors of the widespread C. crispa are missing, at least in Europe and neighbouring regions, a fact making the search for cryptic taxa within the range and for isolated populations outside the main range of great interest.

One such disjunct population, far from the main range, is situated in the Uludağ Mountains, at the so-called Bithynic Olympus in northwestern Turkey (Davis 1965). The plants growing there are morphologically different from C. crispa (Figure 1). This prompted cytological examinations which revealed (see below) that they represent a different ploidy level to C. crispa (4x), but do not represent a potential diploid progenitor. This degree of ploidy has not previously been recorded in the genus Cryptogramma. In the following, this taxon is accordingly described as a new species.

MATERIAL AND METHODS
A selected range of cultivated material of known wild origin and herbarium specimens representing the major Cryptogramma taxa were investigated. Their gross morphological characteristics were compared, spore sizes (an often reliable proxy for ploidy level) were measured and cytological investigations were performed on living material. The following comparative material was evaluated:

C. acrostichoides, SJ-2550; Canada: British Columbia, Pemberton; leg. C. Kohout 27-06-1992
C. acrostichoides, SJ-3498; USA: California, Sequoia NP near Mineral King; c. 2800 m; leg. P. Achnitz Sept. 2001
C. brunoniana, SJ-3779; N India: Sikkim, northern part: Yume, 3800 m; spores date from the Botanical Garden Brno 03/1; sown 22-09-2004 and cultured, pressed 10-06-2007
C. crispa, SJ-603; Bulgaria: Rila Mountains, Jakoruda, southern slope of Granchar, 2250 m; leg. S. Jeßen 23-07-1983

Figure 2. Mitosis in a root tip cell of Cryptogramma bithynica: SJ-3820, cult. in Chemnitz (left: photograph, right: explanatory diagram). Nearly 236 chromosomes are visible, some others are probably hidden in the dark part of the metaphase plate; preparation and photo: W. Bujnoch.
C. crispa, SJ-604; Bulgaria: Pirin Mountains, Vichren region, Mouratovo ezero, 2250 m; leg. S. Jeßen 21-06-1976

C. crispa, SJ-605; Bulgaria: E Pirin Mountains, Hleven Massif, Kornishki Circus, c. 2300 m; leg. S. Jeessen 03-07-1978

C. crispa, SJ-606; Poland: Karkonosze, silicate boulder field in Wielki Śnieżny Kocioł, 1300 m; leg. I. Schwerdtner & S. Jeessen 21-08-1977

C. crispa, SJ-2771; Italia: Tuscany Soarenaria, Apennino luccese-modenese-Dintorni dell’ Abetone (PT), M. Femminamorta, c. 1800 m; leg. D. Marchetti 29-08-1987

C. crispa, SJ-2920; France: Pyrenees, Cirque de Troumouse, 2150 m, silicate scree and rocks; leg. J. Hemmerling, S. Jeessen & L. Lehmann 18-08-1997

C. crispa, SJ-3099; Russia: northern Caucasus, Lakes of Baduk, Dombai-vally, c. 2000 m; leg. J. Hemmerling & W. Meusel 1965; cult., pressed May 2007

C. crispa, SJ-3819; Switzerland: Ticino, Brissago near Locarno, Piodina, climb from Cortaccio to Gridone, c. 1600 m; leg. S. Jeessen 10-07-2009

C. crispa, SJ-3874; Switzerland: Ticino, Val Serdena bei Isone, 1640 m; leg. S. Jeessen 10-07-2011

C. crispa, SJ-3865; NE Turkey: Prov. Artvin, southwestern precipice of Tyrial Dağ, boulder slope at 1600 m; 41°10’24,1”N, 41°35’33,4”E; leg. S. Jeessen & L. Lehmann 07-09-2011

Figure 3. Holotypus of Cryptogramma bithynica.
RESULTS

The determination of the spore length of different samples of *C. crispa* (SJ-3819, 3865, 3874) yielded values between (40–) 48–57 (–59) µm, those of the diploids *C. acrostichoides* (45–) 52–58 (–62) µm and *C. brunoniana* (50–) 51–60 (–66) µm. Remarkably is the comparable value between the diploid species and the tetraploid *C. crispa*. The spores of the plants from Uludağ measuring (64–) 66–76 (–80) µm (mean = 70.87 µm) proved to be noticeably longer. For these reasons, a sample of the taxon in question was sent together with several comparative samples of *C. crispa* on 27-09-2009 to Prof. R. Viane, Gent, for flow-cytometrical analysis. Material of the above listed plants SJ-2550, 2920, 3099, 3779, 3819 and 3820 was analysed using a flow cytometer (Partec PA-1, Partec GmbH, Münster, Germany), following the manufacturer’s protocol. This revealed nearly twice the quantity of DNA for the material from Uludağ in comparison to *C. crispa* from various other regions of Europe (pers. commun. R. Viane 06-10-2009).

For cytological examinations, fixations were performed using root tips from young plants of Uludağ (SJ-3820), cultivated in the Arktisch-Alpiner-Garten, Chemnitz/Germany. The analysis was carried out applying the method of Manton

![Figure 4. Locus typicus of Cryptogramma bithynica. NW Turkey, Uludağ, 1770 m. Photo: L. Lehmann 09-09-2009.](image-url)
The count of a metaphase plate of a mitotic cell revealed approximately 240 chromosomes (Figure 2). The basic number of chromosomes for the genus Cryptogramma is \( x = 30 \). Consequently, the plant is octoploid. This represents the first record of octoploidy within the genus.

**TYPIFICATION AND DESCRIPTION**

*Cryptogramma bithynica* S. Jess., L. Lehm. & Bujnoch **spec. nov.**, Bithynic Parsley Fern

**Locus:** Northwestern Turkey: Uludağ southeastern of Bursa: silicate scree near the roadway, NNE of the summit of Uludağtepe, 1770 m; 40°06’10,4’’N, 29°14’27,4’’E.

**Holotypus:** 09-09-2009, leg. S. Jeßen & L. Lehmann (SJ-3820), JE. (Figure 3).


**Derivation:** Derived from its appearance on the so-called Bithynic Olympus, Uludağ Mountains in northwestern Turkey.

**Description**
Rhizoma serpens ad surgens. Folia nuda, fasciculis ordinata. Folia sterilia crassiora, usque ad 17 cm longa; lamina plerumque lata et triangula, 3–7 cm longa, 3–7 cm lata, tripinnata. Petiolus folii maxime duplo longior lamina, minimum aeque longus; infra

![Figure 5](image-url). Habitat with patches of *Cryptogramma bithynica*. Photo: L. Lehmann 09-09-2009.
paucae squamae fulvae, 2–8 mm longae. Pinnae foliorum sterillium latae et triangulae, quattuor ad sex paribus ordinatae, plerumque spissae et saepe alterae super alteras latius patentes. Segmenta ultimi ordinis ovata ad rotundiora, aut desinientia in dentes latos sed acutos aut suborbiculata. Folia fertilia usque ad 22 cm longa. Lamina lata et triangula ad ovata, tri- aut quadripinnata. Petiolus folii maxime duplo longior lamina, minime aequus longus. Segmenta ultimi ordinis linearia ad oblonga, 3–9 mm longa et 1–3 mm lata. Sporae (64–) 66–76 (–80) μm longae. Planta octoploidea, chromosomatum numerus 2n = c. 240.

Rhizome creeping to ascending, dividing into bushy branches; leaves glabrous, standing in tufts, sometimes caespitose; sterile fronds relatively thick, up to 15 (–17) cm in length with mostly broad deltoid tripinnate lamina, 3–7 cm long and 3–7 cm in width; petiole 1–2 times longer than the lamina, at the base sparsely covered with light-brown scales of 2–8 mm length; pinnae of sterile leaves wide and deltoid, relatively stocky, stalked, sessile at the tip of the lamina, 4–6 pairs, in most cases arranged densely and often in large parts overlapping; ultimate segments ovate to orbiculate, ending in wide, pointed teeth or rounded; fertile fronds up to 17 (–22) cm long with wide deltoid to orbicular, three- to fourfold pinnately divided lamina; petiole 1–2 times longer than the lamina; ultimate segments lanceolate to oblong, 3–9 mm in length and 1–3 mm in width; length of spores: (64–) 66–76 (–80) μm; maturing of spores: August to September; cytology: 2n = c. 240, octoploid.

Distribution, ecology and sociology
Only known from the high mountains of Uludağ, southeast of Bursa in north-western Turkey, where the species is to be expected to occur in other places. The fern colonises clefts with fine-grained soil in rocks and between boulders at sub-alpine altitudes above 1770m (Figures 4, 5). In addition to the *locus typicus* at 1770 m it was found on silicate rock on a north-east facing slope of scree and rocks between Lake Karagöl and Uludağtepe (at 2230 and 2280 m). Other plants growing in the same habitat are *Polystichum lonchitis* (L.) Roth, *Asplenium septentrionale* (L.) Hoffm. subsp. septentrionale, *Gymnocarpium dryopteris* (L.) Newman, *Dryopteris filix-mas* (L.) Schott, *Juniperus communis* L. var. saxatilis Pall., *Daphne oleoides* Schreb., *Sibbaldia parviflora* Willd., *Paronychia* sp., *Festuca* sp.

**DIFFERENTIATION FROM CRYPTOGRAMMA CRISPA**

*Cryptogramma bithynica* is closest in morphology and in distribution area on the Balkan Peninsula and in northeastern Anatolia to *C. crispa*, but can be distinguished by the characters outlined below (Table 1).

*Cryptogramma brunoniana* is another species which might be related to *C. bithynica*, and whose Asian range reaches as far west as Pakistan and Afghanistan. It reaches a height of only 15 cm and has relatively thick winter-green sterile leaves with a blade length of only 2–5 cm whose last order leaflets end in strong, pointed teeth. But at present, apart from the presumption that *C. bithynica* has arisen. by chromosome doubling from a tetraploid ancestor there are no plausible insights into the parentage of the new species.
Table 1: Morphological comparison between Cryptogramma crispa and C. bithynica

<table>
<thead>
<tr>
<th>Trait</th>
<th>Cryptogramma crispa</th>
<th>Cryptogramma bithynica</th>
</tr>
</thead>
<tbody>
<tr>
<td>plant size</td>
<td>up to 30 (–45) cm</td>
<td>up to 17 (–22) cm</td>
</tr>
<tr>
<td>sterile leaves</td>
<td>summer-green, thin and fine</td>
<td>summer-green, slightly thick, relatively tough</td>
</tr>
<tr>
<td>lamina of sterile leaves</td>
<td>up to 9 cm wide and 16 cm long, ovate to deltoid-ovate</td>
<td>up to 7 cm wide and about 7 cm long, broadly deltate</td>
</tr>
<tr>
<td>ultimate segments of sterile leafs</td>
<td>narrowly ovate, ending in 2–4 blunt tips</td>
<td>ovate to orbicular, ending in little, broad, pointed teeth or rounded</td>
</tr>
<tr>
<td>spore length</td>
<td>(40–) 47–59 (–60) μm (see also Dostál 1984)</td>
<td>(64–) 66–76 (–80) μm</td>
</tr>
<tr>
<td>number of chromosomes</td>
<td>tetraploid, 2n = 120</td>
<td>octoploid, 2n = c. 240</td>
</tr>
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</table>

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