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A New Species of Diploid Quillwort (*Isoetes*, Isoetaceae, Lycophyta)  
from Lebanon

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**ABSTRACT.** A new species, *Isoetes libanotica* Musselman, Bolin & R. D. Bray (Isoetaceae, Lycophyta), is described from Akkar District of northern Lebanon. It is a seasonal terrestrial species of basaltic soils, diploid ( $2n = 22$ ), with complete velum coverage. Megaspore diameter ranges from 338 to 477  $\mu\text{m}$  with remote, low tuberculate ornamentation and a low to obsolete equatorial girdle; microspore length ranges from 25 to 30  $\mu\text{m}$ , with echinate ornamentation. At the type locality of *I. libanotica*, two other *Isoetes* L. species occur sympatrically. These superficially similar *Isoetes* species can be differentiated from *I. libanotica* using megaspore characters; *I. duriei* Bory has larger alveolate megaspores and *I. olympica* A. Braun has a prominent equatorial girdle.

**Key words:** Isoetaceae, *Isoetes*, IUCN Red List, Lebanon, Lycophyta.

Like many other regions, our understanding of the diversity of quillworts in the flora of western Asia is limited. A review of the genus in this area, including Syria and Lebanon, reports the presence of four species (Bolin et al., 2008). This paper describes an additional new and largely cryptic species of *Isoetes* L. (Isoetaceae, Lycophyta) from Akkar District of northern Lebanon. This region includes an area of basalt spanning the border region of Lebanon and Syria at the northern terminus of the Mount Lebanon Ridge. The vegetation is typical eastern Mediterra-

nean garigue (degraded evergreen oak/*Pistacia* L. forest) that is heavily grazed. Much of the region is unsuitable for agriculture because of the numerous boulders and basaltic scree. Frequent small depressions fill with water in the winter. During the French Mandate, malaria was brought under control (Longrigg, 1958) reportedly by draining these small ponds (K. Knio, pers. comm.). Recently, Musselman and Al-Zein (2010) found extensive populations of *I. duriei* Bory in this area that represented an eastern range extension for this widespread Mediterranean quillwort. In this same area, on both sides of the Lebanon-Syria border were populations of *I. olympica* A. Braun, previously thought to be limited to one site each in Turkey and Syria (Bolin et al., 2008). From this same area we describe a new and possibly endemic species.

***Isoetes libanotica*** Musselman, Bolin & R. D. Bray, sp. nov. TYPE: Lebanon. Akkar Distr.: 339 m, 34°37.163"N, 36°14.976"E, 13 Apr. 2009, M. S. Al-Zein & L. J. Musselman 2009-39c (holotype, MO; isotype, BEL). Figure 1.

Haec species ab *Isoete duriei* Bory phyllopodiiis absentibus atquemegasporeis minoribus (diam. 338–477 vs. 600–800  $\mu\text{m}$ ) verrucosis, ab *I. olympica* A. Braun velo completo atque megasporae cingulo humili obsolete differt.

Periodically submersed rosettes, forming plants with (10 to)20(to 50) sporophylls (leaves) (2–)4(–6)

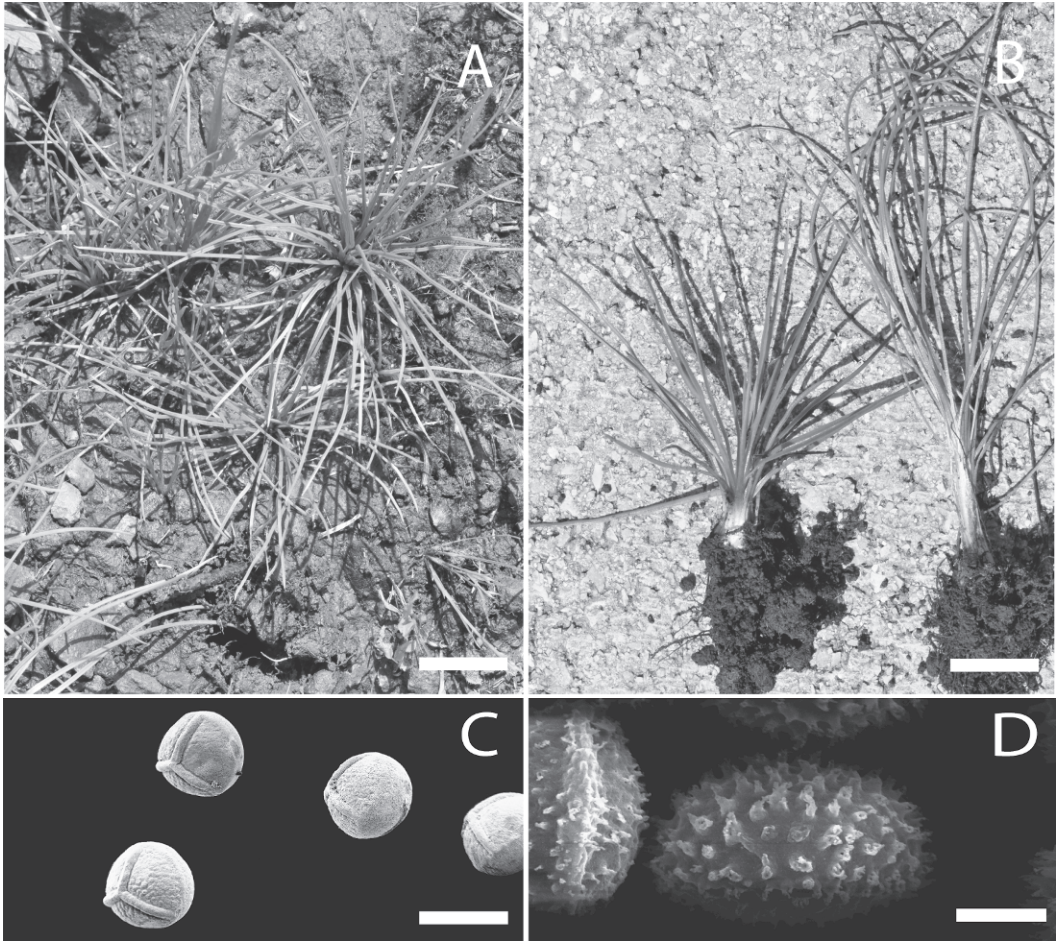


Figure 1. *Isoetes libanotica* Musselman, Bolin & R. D. Bray. —A. Habit. —B. Gross morphology showing variable depth of rootstock. —C. SEM of megaspores with low tuberculate ornamentation and low to obsolete equatorial girdle. —D. SEM of microspores with echinate ornamentation. Scale bars: A, B = 1 cm; C = 400  $\mu$ m; D = 10  $\mu$ m. Imaged from M. S. Al-Zein and L. J. Musselman *MSA 2006-11* (BEI).

cm (often much longer when submersed), semicircular in cross section with 4 vertical air chambers. Velum covering 100% of the sporangium. Scales tiny (ca. 0.5 cm), with acuminate apex, brown, readily falling from the 2-lobed rootstock. Phyllopodia not present. Roots numerous and dichotomously branched. Megaspores white, 338–477  $\mu$ m diam. (mean =  $339.2 \pm 5.2$   $\mu$ m diam.) with low, widely spaced tubercles; triradiate ridges smooth, equatorial girdle low or obsolete (Fig. 1C). Microspores tan to brown en masse, 25–30  $\mu$ m (mean =  $27.3 \pm 0.4$   $\mu$ m); widths 16–22  $\mu$ m (mean =  $19.4 \pm 0.3$   $\mu$ m), echinate (Fig. 1D). Chromosomes:  $2n = 22$ .

*Distribution and habitat.* *Isoetes libanotica* is known only from its type locality in Akkar District

of northern Lebanon. The type locality is in an area of intensive agriculture where *I. libanotica* is frequent in depressions among the large boulders characteristic of this basaltic area, as well as in ponds and roadside ditches. It is likely that *I. libanotica* is also present in Syria due to the close proximity of the border (< 1.5 km) and the similar land use and geology to adjacent Lebanon. *Isoetes olympica* is interspersed with *I. libanotica* at the type locality and occurs just across the border in the vicinity of Khirbet Ghazi, Syria. Other vegetation associated with *I. libanotica* were *Sarcopoterium spinosum* Spach, *Calycotome spinosa* Link, *Coix lacryma-jobi* L., *Onopordum acanthium* L., *Asphodelus aestivus* Brot., as well as species of *Trifolium* L., *Anthemis* L., and *Echium* L.

*IUCN Red List category.* *Isoetes libanotica* should be considered Data Deficient (DD), according to IUCN Red List criteria (IUCN, 2001). Because the type locality has a long history of intensive agriculture, it is unlikely that this taxon is under immediate threat of extirpation under current land use schemes. However, without a better understanding of *I. libanotica* distribution, its conservation status cannot currently be estimated.

*Phenology.* This new species was collected in fertile condition in April and May. *Isoetes libanotica* dies back to its rootstock at the end of the rainy season like other terrestrial Mediterranean quillworts.

*Diagnostic features.* *Isoetes libanotica* occurs in mixed populations with *I. olympica* and *I. duriei* and is superficially indistinguishable. The simplest way to separate these three species is by the size of the megaspores and the velum coverage. *Isoetes libanotica* (338–477  $\mu\text{m}$ ) and *I. olympica* (360–450  $\mu\text{m}$ ) have similarly sized and smaller megaspores than *I. duriei* (600–800  $\mu\text{m}$ ). Velum coverage can be used to discriminate *I. libanotica* (complete velum) and *I. olympica* (incomplete velum). Moreover, plants of *I. libanotica* lack phyllopodia, which are hardened and sclarified leaf bases characteristic of *I. duriei* at the end of the growing season. Phyllopodia of *I. duriei* are black, short (< 3 mm), and tridentate, but can be absent if sloughed off or may not form in a given season due to drought.

*Discussion.* Molecular ITS data support the recognition of *Isoetes libanotica* as a distinct taxon (Bolin et al., 2008: 450; annotated as “Lebanon Quillwort”). In the Bolin et al. (2008) ITS tree, *I. libanotica* forms a well-supported clade with *I. duriei* and *I. subinermis* (Durieu) Cesca & Peruzzi. *Isoetes libanotica* and *I. subinermis* share the base genus chromosome number of  $2n = 22$ , which suggests that either *I. libanotica* or *I. subinermis* (or both taxa) may have contributed to the parentage of the polyploid *I. duriei* (ca.  $2n = 55, 104, 110, 134$ ). Perhaps more likely is that *I. duriei* is polyphyletic and the result of numerous independent hybridization events. However, these hypotheses require validation using DNA-based parental lineage-sorting techniques.

Because *Isoetes libanotica* and *I. olympica* co-occurred at the type locality, we generated ITS sequences from representative individuals (*I. libanotica*: MSA 2009-39c, BEI, MO, GenBank accession GU591479; *I. olympica*: MSA 2009-39b, MO, GenBank accession GU591480). Molecular methods corresponded to those in Bolin et al. (2008), and our

results confirmed the identities of the two morphologically and molecularly distinct but superficially similar taxa.

Mouterde (1966) described two species of *Isoetes* from the Levant, *I. olympica* and *I. histrix* Bory f. *subinermis* Durieu, the latter elevated to specific level by Cesca and Peruzzi (2001), with the taxa distinguished by ploidy levels and spore morphology. The presence of *I. olympica* (Bolin et al., 2008), *I. duriei* (Musselman & Al-Zein, 2010), and *I. libanotica* in Lebanon are confirmed in this paper. However, the status of *I. subinermis* in Lebanon remains ambiguous. Major characters shared by *I. subinermis* and *I. libanotica* include ploidy level ( $2n = 22$ ), complete velum coverage, and tuberculate megaspore ornamentation. Thus, it was possible that the new species was mistaken by Mouterde for *I. subinermis* (Durieu) Cesca & Peruzzi [= *I. histrix* f. *subinermis* Durieu]. The megaspore tubercles of *I. subinermis* are densely arranged and low, while those in *I. libanotica* are widely spaced and low. Thus, the two species can be easily discriminated if *I. subinermis* is indeed present in Lebanon.

KEY TO *ISOETES* OF LEBANON

- 1a. Megaspores with alveolate ornamentation, > 600  $\mu\text{m}$  diam ..... *I. duriei*
- 1b. Megaspores with tuberculate ornamentation, < 500  $\mu\text{m}$  diam.
  - 2a. Velum incomplete; megaspore equatorial girdle height equal to height of triad arms ..... *I. olympica*
  - 2b. Velum complete; megaspore equatorial girdle low or obsolete relative to height of triad arms ..... *I. libanotica*

*Paratype.* LEBANON. **Akkar Distr.:** Menjez [as “Menges”], 16 May 2006, M. S. Al-Zein & L. J. Musselman MSA 2006-11 (BEI).

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