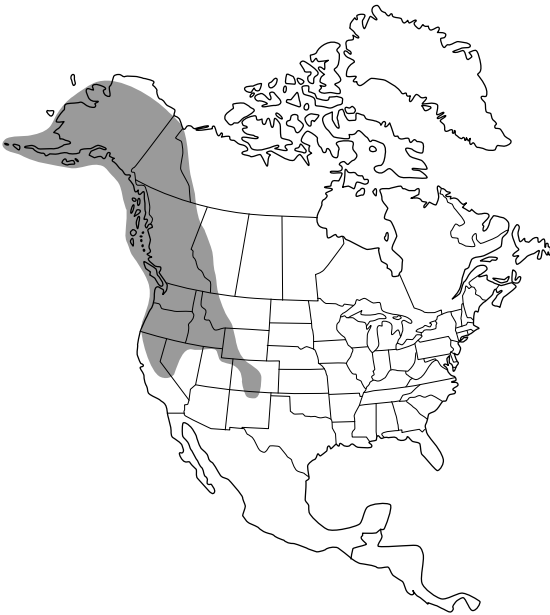


Botrychium pinnatum

Family:	Ophioglossaceae
Genus:	<i>Botrychium</i>
Species:	<i>Botrychium pinnatum</i> H. St. John
Synonym:	<i>Botrychium boreale</i> J. Milde subsp. <i>obtusilobum</i> (Ruprecht) R. T. Clausen
Common name:	Northwestern moonwort
Ploidy:	Tetraploid



Technical description—Plant slender or stout, 3-12 cm high; [common stalk] 3-7 cm tall; the sterile segment sessile or on large plants short stalked, not glaucous, once pinnate or on large plants twice pinnate, the blade oblong or somewhat narrowed to the tip, the simply pinnate blades having 7-11 pinnae which are sessile, broadly winged and confluent with the rachis, entire or frequently with large rounded pinnate lobings, the pinnae ovate or elliptical 3-5 mm long, prominently veined with twice forked veins; sterile segment of large plants ovate-deltoid, twice pinnate, 4 cm long, 3 cm wide, the pinnae pinnately cut and closely resembling the whole blade of a smaller plant; stalk of the fertile segment exceeding the sterile segment; fertile segment once to thrice pinnate, erect, narrow and with ascending branches; spores rounded tetrahedral 36-45 micrometers in diameter, rugose. (from H. St. John, 1929) Chromosomes $n = 90$. (F. S. Wagner, 1993)

Taxonomy

Botrychium pinnatum was described as a new species in 1929 by Harold St. John (American Fern Journal 19:11-15) based on specimens from the state of Washington. Clausen (1938) felt that the taxon was distinct from the European *B. boreale* only at the subspecies level and reduced it to *B. boreale* subsp. *obtusilobum*. W. H. and F. S. Wagner (1983) agreed with St. John's assessment that this North American taxon was not closely related to *B. boreale*. Silhouettes of *B. pinnatum* are included in comparison of pinnate-pinnatifid moonworts (Wagner and Wagner, 1983) and report of *B. pinnatum* in Colorado (Root and Montgomery, 1987).

Identification

Botrychium pinnatum is the only pinnate-pinnatifid to twice pinnate moonwort of the western contiguous United States that is not somewhat to highly glaucous. Rather, it has a highly lustrous surface similar to that of *B. lanceolatum*. Also unlike most allotetraploids having *B. lanceolatum* as one parent, the sporophore of *B. pinnatum* is regularly pinnate whereas the sporophore of similar species has a tendency to divide ternately into three large branches as it does in *B. lanceolatum*. Plants vary greatly in size with upper pinnae tending to be undivided in small plants, but all may be recognized by the above characters.

Prior to St. John's description of *B. pinnatum* this species was considered a subspecies of the European *B. boreale* and many herbarium collections and field records still bear this label. *B. boreale* differs from *B. pinnatum* in having shorter and broader (more triangular) pinnae with acute tips. This difference is reflected in Clausen's (1938) application of the subspecies name *obtusilobum*. Clausen believed however that this taxon intergraded with typical *B. boreale* in British Columbia and Alaska and thus did not warrant recognition at the species level. Recent studies in Alaska have clarified this situation with the recognition of a third distinct taxon, *B. alaskense* with morphology more or less intermediate between *B. pinnatum* and *B. boreale* (Grant and Wagner, 2002). *B. alaskense* can be distinguished from *B. pinnatum* by its sharply angular pinnae and ternately divided sporophore. Our recent work with these species indicates that *B. boreale* does not occur in North America except in Greenland (Farrar, 2001; Wagner and Wagner, 1993).

Distribution and Abundance

Botrychium pinnatum occurs widely throughout western North America from high elevations in east-central and northern California, northern Nevada, northern Arizona, Utah and New Mexico to near sea level in Alaska and northwestern Canada. Although rare in the southern part of its range, it increases in occurrence and abundance from Oregon and Montana northward. Though it occurs with many other moonwort species, it is seldom the most common moonwort at a given site.

In California, *B. pinnatum* is known from two sites in Siskiyou County, one in Tehama County and one Tuolumne County in Yosemite NP. Considering its relative abundance in Oregon, this species likely occurs more broadly in northern California.

Habitat

Botrychium pinnatum occurs in a range of habitats including closed canopy forests, but it is most commonly found in moist grassy sites in open forests and meadows. It often occurs near streams and other sites where soil moisture is constant.

Population Genetics

As an allotetraploid, *Botrychium pinnatum* is fixed for heterozygosity at loci where its ancestral parents *B. lanceolatum* subsp. *lanceolatum* and *B. neolunaria* have contributed different alleles. At several of these loci, plants of some populations display activity of only one of the parental alleles, the other presumably having experienced a silencing mutation. Through this process the species shows some genetic variation among populations but it is otherwise remarkably uniform in genotype throughout its range.

Phylogenetic Relationships

The confusion that has existed between the three taxa, *B. pinnatum*, *B. boreale* and *B. alaskense* is understandable. Each species has arisen by allotetraploid speciation from original hybridizations between *B. lanceolatum* subsp. *lanceolatum* and members of the *B. lunaria* species complex (see discussion of *B. neolunaria* ined.). Recent genetic examination of these tetraploids and their putative parents in Europe and Alaska has disclosed their probable relationships (Stensvold 2008).

The three tetraploid taxa are quite distinct genetically. Alleles contributing to the genotypes of *B. pinnatum* are found in American plants of *B. lanceolatum* and *B. B. neolunaria*. Alleles necessary to produce the genotype of *B. alaskense* are not present in American *B. neolunaria* but are present in European plants of *B. lunaria*. Furthermore, European genotypes of *B. lunaria* are present in the Aleutian archipelago and in high elevations in western Alaska. Stensvold's conclusion is that hybridization between American *B. lanceolatum* and American *B. neolunaria* has produced *B. pinnatum* whereas hybridization between European *B. lunaria* and American *B. lanceolatum* has produced *B. alaskense*. We hypothesize that hybridization between European *B. lanceolatum* and European *B. lunaria* has produced *B. boreale*.

Additional images of *Botrychium pinnatum*:

